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16. Abstract
The Michigan Department of Transportation (MDOT) manages a wide range of transportation assets throughout their lifecycle—spanning design, construction, operation, and maintenance. Effective asset management requires extensive data coordination across internal teams and external stakeholders. This creates challenges due to varied data storage practices, the use of various file formats, and manual data exchanges. These can lead to inefficiencies in asset-related information management. This report investigates these challenges, maps the digital data workflow and exchange requirements for multiple assets, and evaluates potential digital solutions—specifically Building Information Modeling (BIM), Industry Foundation Classes (IFC), and Common Data Environments (CDE)—as potential tools to improve workflows and improve data accuracy and consistency across all project phases. This project uses literature review to evaluate the state of the art, surveys to determine the current state of adoption of such technologies across state DOTs, interviews with MDOT personnel and contractors, and process mapping to identify key challenges. Such challenges include disconnected databases, manual data entry, and inconsistent updating of asset databases across the lifecycle of the studied assets. It also highlights the limitations of relying on 2D plan sets, where asset information is provided as text annotations, making retrieval and reuse difficult. From contractor interviews, feedback from contractors suggests the need for accurate, consistent data, whether in 2D plan sets or 3D models, and anticipates challenges related to technology adoption and workforce training, particularly for contractors, if such technologies are fully adopted. The report recommends potential pathways for adopting BIM, IFC, CDEs, including advantages and disadvantages of each. Finally, a detailed case study is presented on pavement asset management using IFC, supporting the feasibility and benefits of these digital approaches, but also demonstrating their limitations. Overall, the findings suggest that a transition toward integrated digital asset management systems would enhance efficiency, reduce manual errors, and support more effective long-term infrastructure management.

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EXECUTIVE SUMMARY

The Michigan Department of Transportation (MDOT) manages diverse transportation assets, ranging from pavement markings to culverts. Effective management of these assets throughout their lifecycle, encompassing design, construction, operation, and maintenance phases, involves substantial data management and collaboration among various internal teams and external stakeholders. This creates significant challenges in managing asset-related information due to fragmented data storage practices, use of multiple file formats, and manual information exchanges that can result in inefficiencies.

This report investigates these data management challenges and explores potential enhancements through advanced digital data management solutions. Specifically, it evaluates Building Information Modeling (BIM), Industry Foundation Classes (IFC), and Common Data Environment (CDE) systems as solutions for improving digital collaboration, reducing inefficiencies in the sharing and passing of information between teams internally and externally. Through detailed literature review, comprehensive survey data collection and analysis, stakeholder interviews, and workflow mapping, this research identifies critical points where data management inefficiencies and information loss occur within MDOT's current processes.

Findings revealed inefficiencies due to manual data entry, disconnected databases, and inconsistent updating practices. Notably, asset-related information stored as textual annotations within traditional drawing plans significantly hinders efficient data retrieval and utilization. Additionally, asset information is often not adequately updated in databases post-construction and maintenance phases, increasing the likelihood of information fragmentation and inaccuracies.

The implementation of digital solutions such as BIM, IFC, and CDE demonstrates potential to streamline data workflows, enhance interoperability among different software applications, and maintain continuous and accurate data exchange across various asset lifecycle stages. Recommendations include the transition to digital-centric project handovers between MDOT and contractors, leveraging BIM to centralize asset data, adopting IFC for improved interoperability and standardized data exchanges, and implementing CDE to facilitate consistent data access and management across project phases. In considering this transition, the results outlined in this report also suggest that feedback from contractors that utilize this digital information is valuable to consider in this transition. Specifically, they noted the importance of accuracy and consistency of data as well as potential technology challenges and workforce training needs if considering moving away from the use of plan sets to the use of BIM or 3D models.

This research indicates that adopting these digital methodologies can reduce manual data handling errors, improve asset data quality, and enable more effective asset management practices. By demonstrating practical applicability through a detailed case study of a specific asset (pavements) using pavement asset management, the research validates these digital solutions as viable improvements over existing methodologies, while also noting that there are some limitations as the technologies evolve over time. Ultimately, these results provide evidence to support a shift towards the use of advanced digital tools to support enhanced efficiency and asset management effectiveness at MDOT.

1. INTRODUCTION

The Michigan Department of Transportation (MDOT) is responsible for many different types of transportation assets. Similar to other Departments of Transportation (DOTs) throughout the U.S., these assets can be small and relatively inexpensive, such as pavement markings, to large and costly assets such as bridges. DOTs are typically responsible for the management of information for these assets, including from the design phase, to construction (in which data is shared with contractors), to operation and maintenance. Given the large number of types and counts of transportation assets overseen by DOTs, the amount of data associated with all of these assets that must be retained and tracked is significant. In addition, because of the uniqueness of each type of asset, the attributes and data associated with each asset also varies significantly. For example, data can include relatively simple text-based attributes (e.g. name, material type, year of construction), as well as complex 2D and 3D geometry (e.g. shape and placement of a guardrail in 3D). This range of information can be challenging to manage and track throughout the asset's lifecycle. This is particularly the case since historically, this data has been stored in multiple different files, formats, and/or databases.

Throughout this lifecycle, information associated with these assets must be passed between multiple internal bureaus, sections, units and/or other groups (hereafter called "teams") within MDOT and also shared externally to support different phases of a project. For example, the design of a culvert may be completed in 2D or 3D, then converted into PDF drawings and passed to another relevant internal team or external party for construction. This means that the detailed 2D or 3D models developed initially to represent these assets in the design phase may not be fully utilized to support the handoff of information between internal MDOT teams, and/or to external parties. This can also mean that in some instances that models of assets are re-created, such as by the contractors that construct these assets. This creates inefficiencies across internal teams and for external parties. This also results in additional operational costs to re-create such data. In addition, the original 2D or 3D model, its metadata, and any supplemental data are not digitally linked to one another, resulting in the separation of information over time if the files are not kept together. As such, the data that is not passed across the various steps in a transportation asset's various phases still exists but not necessarily all in the same place.

There is therefore a need to identify and map these digital data workflows and handoffs for each of the key DOT assets, and to determine where there are opportunities to improve efficiency and retention of data in a common format(s). As technologies have evolved in recent years, there also is an opportunity to work towards standardizing methods to digitally represent the diverse data and digital drawings associated with these assets. This can enable a smoother data flow and ensures retention of data throughout all phases of assets.

A review of transportation agency policies suggests that DOTs have begun moving towards digital delivery of data for larger transportation assets, such as bridge and road projects. This means that instead of the use of 2D plans, a 3D model is used for construction contractual documents. MDOT also has piloted the use of a contractual 3D model. A recent cost-benefit analysis suggests that the benefits are likely to outweigh the costs, particularly in reducing change orders during construction [1]. Considering these findings, it is likely that similar benefits can be achieved during the digital handover process between teams internally within DOTs. It is also likely that such benefits would also exist for less complex transportation assets, such as pavements, pavement markings, signs, guardrails, and culverts.

Examples of methods that can be used to represent such data throughout this workflow include the use of IFC, BIM, and a CDE. BIM is a software tool that enables the digital representation of assets and their properties [2]. Since it represents an asset with both physical and functional characteristics, BIM models can include information beyond just a 3D representation of an asset. IFC is an open, international standard for exchanging BIM data [3]. The IFC format includes information such as the geometry, materials, and quantities of elements of an asset, as well as the spatial relationships between these components. IFC files also enable interoperability between different software applications. This allows for better collaboration between different teams that may be using different software tools. In addition to BIM and IFC, CDE, also called Connected Data Environment, is another method to improve data management. CDE is a centralized platform to facilitate information exchange and collaboration among project members and collaborators [4].

The main goal of this research is twofold; first is to map the current MDOT data workflow and handover process of its various transportation assets and their attributes; second is to determine how this process can be improved by developing a digital project handover that utilizes IFC, BIM, and/or CDE to support long-term data availability and linkage throughout the assets' design, construction, and operation and maintenance. Table 1 lists the objectives of the research.

Table 1. Research objectives

No.	Description of the objectives
1	Determine the MDOT assets and required data for each asset including pavements, pavement markings, signs, guardrails, and culverts.
2	Determine the current MDOT data workflow and handover processes for each asset
3	Develop digital project handover process(es) by using recommended methods (e.g. BIM, IFC, CDE)
4	Conduct a use case to apply the developed digital handover process(es)
5	Develop a guideline comparing each digital handover process to show the advantages and limitations of each

The results of this work will benefit the many teams of professionals in MDOT that oversee the design, construction, use, and maintenance of transportation assets. Immediate benefits include a clear mapping of the attributes of all assets, allowing for a clearer understanding and tracking the data, including identification of where there are significant breaks in data continuity and thus opportunities for improvements. This project also provides a demonstration of the use of these technologies, using MDOT data, resulting in a tangible example of how such methods can improve efficiency in DOT asset design and management. Long term benefits include the eventual adoption of the use IFC, BIM and/or CDE that will improve data continuity, improve efficiency with MDOT and between MDOT and contractors, and improve standardization of management of all data.

This report consists of six chapters including this chapter, *Introduction*. The second chapter is the *Literature Review* presenting the background and significance of work, and summary of the previous related publications including journal papers, conference papers, and reports. After, the *Methodology* of the study is described in the next chapter. The *Findings* chapter presents the results of the study including the DOT survey summary, data workflow diagrams, points where data continuity could be improved, recommended solutions, and contractor interview summaries. The following chapter includes a case study of a recommended solution for one of the MDOT assets. Finally, the last chapter summaries the *Conclusions*, limitations and future work.

2. LITERATURE REVIEW

This section presents the results of the literature review including background and significance of work, previous efforts, and case studies by DOTs.

2.1 Background and Significance of Work

There are several tools and standards that have evolved and matured in recent years that can be used to support digital data workflows. This research discusses three digital solutions, including the use of BIM, IFC, and CDE to improve the data workflows.

BIM is a software process that enables the digital representation of assets and their properties [2]. Since it represents an asset with both physical and functional characteristics, building information models can include information beyond a 3D model. The main differentiation between BIM and a 3D model is the object-based structure [5]. In a basic 3D model, there are only geometrical shapes consisting of lines, surfaces and masses. A BIM model contains “smart” objects that include information on the attribute(s) of the asset(s) being modeled. When using a BIM model (Figure 1), it is possible for all members of a project team, including across different project phases, to have access and editing rights to the model. This enables the ability for a range of stakeholders across the asset’s lifecycle to be able to add or edit information within a single model [5]. The use of BIM supports the ability for all 2D or 3D information on the assets to be retained in the digital environment and compiled in a common format. It has been demonstrated that BIM can be a useful tool to create, store, and retain data efficiently and simultaneously deliver it to the stakeholders [2]. In addition, BIM's structure and graphic interface can be used to combine information and provide access using a single model and its associated metadata [6-9]. In recent years BIM has also become more commonly used for larger transportation assets [1].

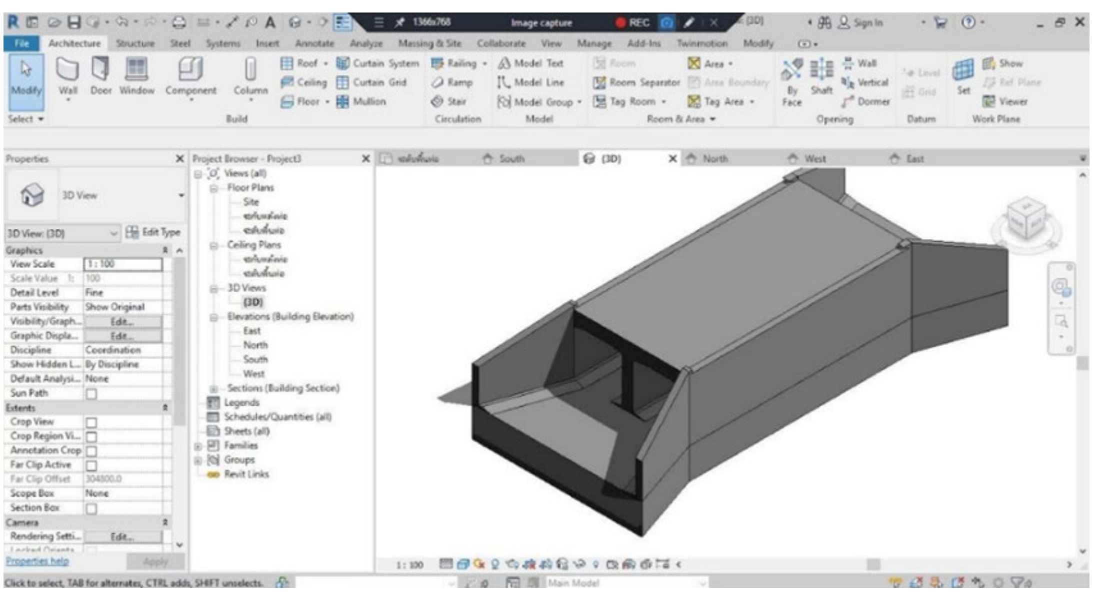

Figure 1. Example BIM model (in Revit) of a culvert

IFC was adopted by AASHTO in 2019 as the standard to exchange digital information, in particular across stakeholder lines (e.g. between DOTs and contractors). IFC is an open, international standard for exchanging BIM data [3]. It is managed by an organization called buildingSMART, with the original design being for the AEC (architecture, engineering, construction) and FM (facilities management) industries. Specifically, it was developed in response to concerns about the interoperability of different software tools being adopted and used. It was approved as an international standard, ISO 16739, in 2018. The use of IFC presents the opportunity to address interoperability challenges among internal MDOT teams and external parties that may be using a variety of software packages and tools, including BIM software applications, to represent various assets. IFC has an object-oriented structure and consists of objects representing the components and systems of a structure, along with the relationships among those objects. An IFC model can have physical structure components (e.g. guardrail support post or a top rail), as well as textual data (e.g. material type, or other specifications). Data created over the lifecycle of a project can be stored and exchanged using the IFC schema. When the data is represented in IFC format, it can be viewed and processed using IFC viewers or BIM-based software packages that are IFC compatible. There are also many IFC viewers [11] developed to visualize the geometry of the model with properties of elements. While there are limitations to IFC, it is a neutral standard which is compatible with a wide range of software packages [12-13] that can be used by DOTs.

Of importance to note when considering IFC, is that the IFC structure is continuously evolving. Currently, it does not necessarily cover all the information created and exchanged throughout the lifecycle of a transportation asset. Efforts are ongoing to develop new definitions that extend the IFC format based on industry needs. The IFC 4.3 schema is the most recent schema at the date of completing this project, which is approved and published as an ISO standard on April 2024 [14], thus IFC 4.3 is used as the basis for this project.

Third, Common Data Environment (CDE), also called Connected Data Environment, can be a solution to improve the data workflow throughout the entire lifecycle of an asset. CDE serves as a centralized platform for collecting, managing, and disseminating project information, ensuring all stakeholders have access to a single source of truth [45]. This is particularly valuable in construction projects, where fragmented data and isolated systems often lead to inefficiencies, errors, and delays [44]. By standardizing data exchange protocols and integrating processes like BIM, CDEs can enhance collaboration, reduce manual work, and improve traceability [43]. However, challenges such as project complexity, interoperability issues, and resistance to adoption among small and medium-sized enterprises (SMEs) remain barriers to widespread implementation [43-44]. Despite these hurdles, CDEs have significant potential to streamline workflows, mitigate risks, and support better decision-making across the asset lifecycle.

As BIM, IFC, and CDE have developed over time, while they are still relatively new, recent research has evaluated their use to support DOT asset management throughout their lifecycle [15-18]. While these studies primarily focus on bridges, airports, and roadways, rather than smaller transportation assets, they demonstrated that such methods of digital representation of all data, and use of such methods throughout and across different stages of transportation is beneficial. Another study conducted with the Iowa DOT aimed to map digital data flow of transportation assets [19-21]. The results of this research identified key attributes of signs, guardrails, culverts, pavements, and bridges,, breaks in dataflow between assets stages, and recommendations for improvements in dataflow. This research, however, was conducted prior to the adoption of IFC by AASHTO, and did not focus on the evaluation of the potential use of IFC and BIM. A recent study for the Indiana Department of Transportation [22] focused on developing BIM standards for transportation assets, specifically for drainage inlets and concrete pavement components that are IFC compliant. It also included the development of a quality assurance tool to check if the digital data was compliant. However, it did not study the workflow for all assets covered in the scope of this research.

In summary, while there have been efforts to work towards the use of standard digital data formats through the different stages of transportation assets, more work is needed to map the attributes for many of the smaller transportation assets, to propose standards for the passing and storing of this digital data throughout these assets' lifecycle, and to demonstrate how this process can work using real-world data. This project aims to work towards a solution to address these gaps in existing research, specifically for MDOT.

2.2 Previous Efforts

The growing adoption of digital delivery methods, BIM, IFC, and integrated data management strategies is transforming the construction and infrastructure sectors. Recent academic studies, national research efforts, and professional webinars have collectively emphasized the importance of enhancing information exchange, improving asset handover processes, and standardizing digital workflows. To better understand current practices and emerging trends, this literature review draws on a range of sources (Table 2).

Table 2. Literature review sources

Purpose	Sources	#
Technologies/methods used in Architecture, Engineering, and Construction (AEC) and transportation industry	Web of Science Google Scholar	21
Technologies/methods used by DOTs - Case studies, reports, programs, software, database	DOT Websites News Websites	43
	NCHRP Synthesis/Reports	18
IFC & BIM	BuildingSmart Webinars	12

2.2.1 AEC and Transportation Industry

The Architecture, Engineering, and Construction (AEC) and transportation industries are both experiencing significant changes as these industries work toward a transition to fully digital data, driven by advancements in BIM, interoperability standards, and data management frameworks. These technologies aim to enhance efficiency, reduce errors, and improve lifecycle management of infrastructure assets. This section reviews key methodologies and tools employed in these sectors, focusing on BIM applications, digital handover processes, interoperability solutions (i.e., IFC), and the role of Common Data Environments (CDEs). Table 3 lists the main tools used and discussed in recent literature.

Table 3. List of tools used in literature

Tools	References
Building Information Modeling (BIM)	[23-38]
Industry Foundation Classes (IFC)	[28, 31, 36, 37, 39, 40]
Common Data Environment (CDE)	[29, 34, 43, 44]
Asset Information Models (AIM)	[24, 30]
Construction-Operations Building Information Exchange (COBie)	[23, 25]

For BIM, Wetzel and Thabet [23] demonstrate the application of Autodesk Navisworks in transferring safety information across project phases, emphasizing a structured four-step workflow involving BIM-based safety frameworks and CSV/Excel exports. While their approach reduces safety incidents, they note inefficiencies in non-middleware methods, such as Navisworks' Selection Inspector tool. Similarly, Thabet and Lucas [24] evaluate BIM adoption for facility management, highlighting the use of spreadsheet-based data collection and integration with Computerized Maintenance Management Systems (CMMS) via the Pentaho tool. Their findings stress the importance of clearly defined owner requirements and standardized workflows to ensure successful data handover.

In complex infrastructure projects, a study [25] examines BIM implementation in underground rail transit, emphasizing the use of collaborative digital platforms like Ali Cloud and stringent quality control protocols to ensure model accuracy. Their study underscores the necessity of continuous training and organizational standards for effective BIM adoption. Complementing this, Thabet et al. [28] discusses an automated workflow using Revit Dynamo and Python to extract asset data for facility management systems, demonstrating significant reductions in manual entry errors and processing time. In highway and bridge projects, Bayar et al. [29] supports BIM adoption, referencing standards like PAS 1192-3 and Government Soft Landing policies. Their pilot projects also suggest gaps in granular data capture, emphasizing the need for comprehensive digital workflows.

The literature also emphasizes that while there is a move to improve interoperability, it remains a critical challenge in digital delivery. Mirarchi et al. [36] propose solutions for minimizing information loss in IFC-based workflows. Their study identifies barriers in BIM-to-IFC exchanges, particularly user customization difficulties, and suggests automated coding as a potential remedy. Another study extends this discussion by integrating parametric geometry into IFC-Bridge, improving interoperability between bridge design and structural analysis systems [37]. However, they note limitations in current IFC schemas, calling for further development to support advanced parametric modeling. Mitchell et al. [40] discusses AASHTO's efforts to develop IFC-based standards for bridge data exchange, aiming to replace traditional plan sets with digital models as legal contract documents.

The adoption of Common Data Environments (CDEs) is another key focus. Jaskula et al. [43] analyzes tools such as BIM 360 and ProjectWise, highlighting challenges in CDE standardization, including reliance on fragmented cloud repositories like SharePoint for handover processes. Succar and Poirier [27] introduce the Lifecycle Information Transformation (LIT) Framework, which integrates BIM with emerging technologies such as smart contracts and artificial intelligence to enhance asset lifecycle management. Collectively, these studies illustrate the potential of digital technologies in the AEC and transportation sectors while identifying ongoing challenges.

2.2.2 State Departments of Transportations (DOTs)

State Departments of Transportation (DOTs) are also increasingly adopting digital delivery methods to enhance project efficiency, reduce costs, and improve asset lifecycle management. As infrastructure demands grow and funding constraints persist, DOTs are leveraging advanced technologies, such as BIM/3D modeling, Common Data Environments (CDEs), Geographic Information System (GIS), LiDAR, and e-Ticketing, to streamline design, construction, and maintenance processes. Table 4 shows the list of tools used by DOTs.

Table 4. List of tools used by DOTs

Tools	References
BIM/3D Model	[46-58]
CDE	[50, 52]
GIS	[52, 53, 59-63]
LiDAR	[47, 49, 51, 64]
e-Ticketing	[65-67]

An examination of all 50 state's DOT websites (completed April 2024) reveals clear trends in digital procurement practices, as seen in Table 5. The data shows Bid Express is the dominant platform for contractor submissions, currently utilized by 27 state DOTs. AASHTOWare Project Bids Software follows as the second most popular option with 17 state DOTs. While digital submission methods are now standard practice, 6 states still accept hard copy submissions, based on guidelines posted on their websites.

Table 5. DOTs' contractor bid letting formats

Contractor Bid Letting Format	# of DOTs
Bid Express	27
AASHTOWare Project Bids Software	17
Integrated Contractor Exchange (iCX)	4
Hard Copy (Mailed and Signed)	6
Unique Online Bid Software	4
Email (PDF)	6

Recent initiatives demonstrate significant progress in implementing Industry Foundation Classes (IFC) as an open data standard for bridge and transportation infrastructure projects. The Iowa DOT appears to be a leader in this effort, researching IFC applications for bridges while developing an implementation guide for state DOTs [40]. This work aligns with AASHTO's broader vision to establish a national standard for open data exchange of bridge information. The manual positions IFC as a transformative technology that could eventually replace traditional plan sets by enabling legally valid digital bridge models. Technical advancements in IFC schemas show particular promise for bridge projects. The parametric IFC-Bridge schema facilitates improved interoperability between design and structural analysis systems. While this represents significant progress, limitations remain. In particular, the current IFC schema does not fully support parametric geometry, which creates barriers to widespread adoption. Ongoing work includes improving functionality to export bridges as IFC files, with dual support for IFC 4.1 (for parameterized geometry) and IFC 2.3 (for backward compatibility).

The literature review also suggests that State DOTs are taking strategic approaches to IFC implementation. Kentucky's Transportation Cabinet has outlined a four-phase plan that includes mapping their information delivery manual to IFC or openBRIM, while addressing critical implementation challenges such as entity approval processes and electronic signature standards [41]. PennDOT's digital delivery glossary reinforces IFC's role as an ISO-standardized, non-proprietary format for exchanging BIM data, with specific extensions being developed for roadway and bridge assets [42]. These coordinated efforts across multiple states suggest growing consensus on IFC's potential to transform infrastructure data exchange, though technical and procedural hurdles remain before full implementation can be achieved.

Recent studies sponsored by the National Cooperative Highway Research Program (NCHRP) and related reports also highlight evolving efforts to advance digital delivery, data management, and technology integration within state Departments of Transportation (DOTs). For example, one study [68] documents current practices in data governance and information management among transportation agencies. It suggests that many DOTs still face significant challenges in developing comprehensive data governance frameworks to support digital project delivery, indicating the need for systematic improvements. A report evaluating practices at the Utah DOT [69] summarizes findings regarding the development stages and model requirements for digital project delivery. The study identifies critical elements necessary for successful implementation, providing a model that could be adapted by other agencies nationally.

An emerging technologies synthesis [70] documents how state DOTs are adopting new tools for construction inspection and data collection. It highlights key lessons learned, with 63% of participating agencies reporting active exploration of innovative technologies such as drones and mobile applications. The development and use of as-built models are discussed in another synthesis report [71], which captures the state of practice for generating and managing as-built information. It notes that most agencies still rely heavily on paper-based or 2D as-built documentation, suggesting significant room for improvement in digital practices. Another synthesis [73] outlines the barriers and enablers of using 3D engineered models in construction workflows. It documents agencies' varying degrees of maturity in adopting model-based project delivery. Another study [72] focuses on the adoption of electronic ticketing (e-ticketing) systems for materials management in transportation projects. Although some agencies have piloted e-ticketing initiatives, widespread implementation remains limited, with states like Maryland DOT still in early exploration phases at the time of publications that were reviewed.

An extensive guidebook [74] provides a framework for integrating 3D engineered models throughout the construction and asset management lifecycle. It offers detailed strategies for transitioning from traditional document-based practices to fully model-based environments. Another NCHRP report [75] offers a comprehensive review of mobile device integration and real-time data capture technologies, identifying emerging practices for increasing construction site efficiency and data accuracy. A synthesis addressing 3D models and asset management integration [76] emphasizes how construction-phase data can be leveraged for long-term maintenance planning, bridging gaps between project delivery and lifecycle asset management. In the area of project data delivery, a study [77] reviews how digital deliverables are shared with contractors and stakeholders. It notes challenges in ensuring data compatibility and the need for standardized delivery protocols. Research on digital as-built data collection practices [78] demonstrates that although digital methods are gaining traction, traditional manual recording remains a common method across many agencies. Finally, in [79], this synthesis explores the application of advanced geospatial technologies, highlighting the increased use of tools such as LIDAR scanning, drone imagery, and real-time kinematic positioning in construction inspection and documentation.

2.3 Case Studies by DOTs

The integration of digital solutions into transportation infrastructure projects across the project delivery process offers significant opportunities for improvements in efficiency, cost savings, and stakeholder collaboration. Across the United States, Departments of Transportation (DOTs) have piloted and/or adopted advanced technologies such as digital twins, 3D modeling, Geographic Information Systems (GIS), and BIM to address challenges in planning, design, and construction. The following case studies highlight key implementations and their outcomes.

In New York City (NYC), the replacement of the 138th Street Bridge demonstrated the effectiveness of digital twins and 3D modeling in minimizing traffic disruption [80]. The NYC Department of Transportation used these tools to create simulations, enabling coordination among multiple agencies. The project's winning bid was 15% below estimates, and the digital review process eliminated the need for over 200 traditional plan sheets by allowing 180 reviewers to flag issues electronically. Similarly, Minnesota's Highway 169 expansion leveraged Bentley's Civil WorkSuite to develop a digital twin, which saved an estimated $18 million by reducing design iterations and enabling paperless asset management [50] (Figure 2). A case study of Alabama's I-59/I-20 interchange reconstruction demonstrated the value of clash detection in MicroStation, which identified 1,100 errors, saving an estimated $10 million and 65 construction days [51].

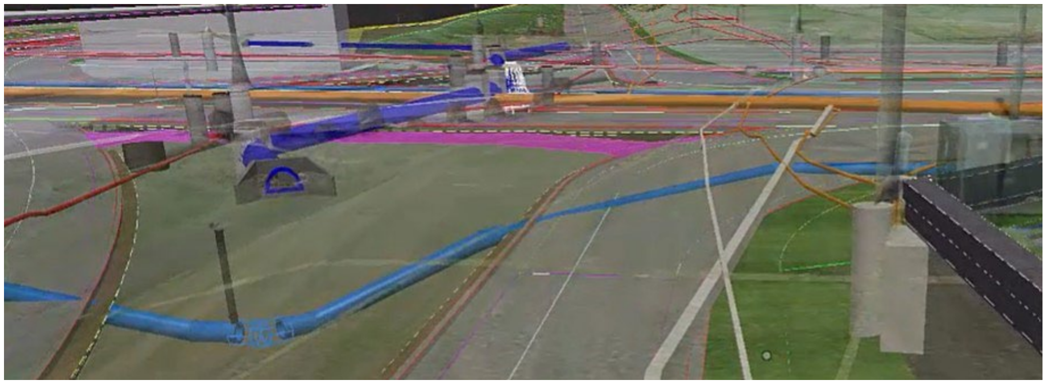

Figure 2. 3D modeling, visualization, and cross-discipline collaboration [52]

The adoption of GIS technology by the Connecticut DOT showcased its utility in consolidating real-time data for infrastructure planning. Their system, COMPASS, integrated diverse datasets, such as land use and environmental constraints, into a single platform, improving visualization and collaboration. This approach streamlined decision-making and provided engineers with a centralized repository for asset and project data.

Transitioning from 2D to 3D design models has also proven transformative. In one case study, the Kentucky Transportation Cabinet (KYTC) implemented 3D models as the primary contract document for the KY 7 rural roadway project, with 2D plans serving only as references. This shift was found to have enhanced accuracy, reduced earthwork costs, and facilitated GPS-guided construction. Likewise, Wisconsin's Zoo Interchange Project utilized 3D modeling for excavation and drainage, integrating 4D (scheduling) and 5D (cost) components [84]. WisDOT estimated that this approach could have saved $9.5 million on a prior project, suggesting the long-term financial benefits.

Advanced data collection and asset management techniques have further optimized infrastructure maintenance. The Utah DOT employed LiDAR imaging to catalog aboveground assets across 6,000 miles of roadway, reducing manual survey time from weeks to hours and achieving $600,000 in annual labor savings [85]. Centralized databases like UPlan and UGate enabled seamless data sharing across departments. Finally, the New York State DOT demonstrated the advantages of digital workflows in fabrication, replacing 2D paper drawings with automated CNC cutting for steel bridge girders [86]. Laser scanning ensured precision, while improved coordination among designers and fabricators minimized delays and rework.

These case studies collectively illustrate how digital solutions enhance project outcomes through cost and time efficiencies with reduced rework, streamlined approvals, and optimized workflows. In addition, improved accuracy with 3D modeling and clash detection minimizing errors before construction, and enhanced collaboration with digital platforms facilitating real-time data sharing among agencies, contractors, and engineers have potential to improve life cycle of transportation projects. The success of these initiatives suggests that broader adoption of digital methods could modernize infrastructure delivery with a variety of benefits.

3. METHODOLOGY

This research includes six main tasks to accomplish the objectives of the study (Figure 3). Each of these tasks is outlined below.

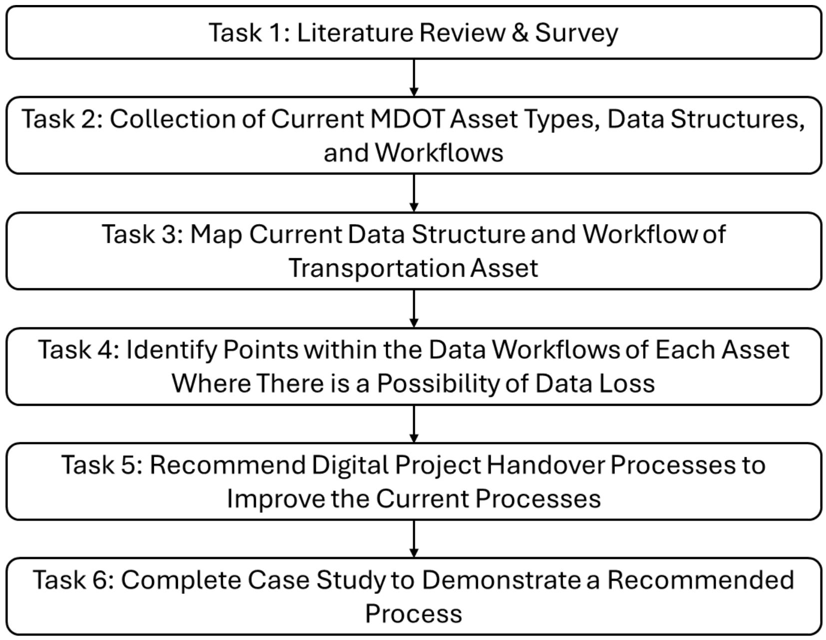

Figure 3. Methodology of the study

3.1 Task 1: Literature Review & Survey

A comprehensive literature review was conducted to document studies that can assist in meeting the objectives of this research project, outlining prior work that this research builds on. The literature review focused on manuals, guidelines, research and technical reports, handbooks, and research articles that have been conducted in the past 10-15 years. The research team used comprehensive resources available through the MSU Library, as well as publicly available information. Moreover, the research team reached out to MDOT to request any additional reports, guidelines, and specifications that may be relevant to this research project. The scope of the literature review mainly focused of the following topic areas: (1) the current and future use of digital data asset management both within and outside of transportation applications; (2) available technologies, methods, and software packages for digital asset management and data handover; (3) advantages and disadvantages of different methods used for digital asset management and data handover; (4) case studies showing the results of real-world implementation.

In addition, in this task an online survey was developed using a web-based survey tool (e.g., Qualtrics). This survey included a series of questions to document the current state of practice for digital data asset management and data handover. This includes understanding the state of adoption of the use of IFC, BIM and/or other methods both within the DOT internal teams, and between the DOT and external parties, as well as any plans for future adoption. The target audience of the survey was state DOTs. The survey was first developed and piloted to ensure the wording of all questions was clear and appropriate, then the draft was sent to the advisory board for feedback. Finally, it was then sent out to state DOTs. As needed, the follow-up with participants was completed to ensure sufficient data was collected.

3.2 Task 2: Collection of Current MDOT Asset Types, Data Structures, and Workflows

This task focused on collecting all necessary data to enable mapping of the data structure and workflow of the following DOT assets: pavements, pavement markings, signs, guardrails, and culverts. This data was used for creating visual representations in Task 3. This data was collected through interviews of DOT personnel, and review of DOT databases and example documentation for each asset type. Completing this task required significant coordination with and cooperation from MDOT personnel across multiple groups.

First, in collaboration with the research advisory panel (RAP), the key groups that participate in data development and management for each of the above-mentioned assets were determined. Online meetings were then set up with each team, with the support of MDOT. The research team prepared a list of questions to be discussed in advance, then reviewed these questions during each interview meeting. In addition online meetings were set up with multiple contractors across the above-listed asset types, to ask a similar list of questions.

Following the interviews, the research team reviewed relevant MDOT asset databases. This access allowed the research team to review asset attribute types and formats, and if there were variations in such formats that should be noted. The structure of the database(s) was reviewed, to understand the ease in which this structure can be translated to an IFC-compliant structure. Simultaneously, the research team reviewed any relevant documents within MDOT that pertain to data handover processes and workflows. This review encompassed existing manuals, guidelines, specifications, and reports, which can offer insights into the existing practices and challenges within MDOT. This aimed to establish a dataset that accurately reflects MDOT's asset types, data structures, and workflows.

3.3 Task 3: Map Current Data Structure and Workflow of Transportation Asset

This task focused on using the information gathered in Task 2 to create maps of the data structure and workflow of each studied transportation asset. The stages of planning, design, bidding, construction, and operation were included as a part of this mapping. Once the data structure has been comprehensively analyzed, the research team created visual representations of the workflows specific to each asset type. Information was organized by each of the internal DOT offices and/or external contractor, and by each of the stages of the asset.

In parallel with visualization, a textual narrative was written that complements the visual representations and captures essential information such as who is responsible for data at each stage, how data is transferred between stakeholders, and what tools or software are utilized in the process. The research team also created data exchange matrix tables to show which data is generated when and how it is stored and shared.

3.4 Task 4: Identify Points within the Data Workflows of Each Asset Where There is a Possibility of Inefficiencies

Task 4 focused on the examination of potential lack of data continuity and/or challenges within the data workflows mapped for each asset. This task was built from the data and mapping completed in Task 3. It aimed to identify specific points within these workflows where lack of data continuity or inefficiencies may occur, particularly in data handoff between MDOT groups and/or contractors, understanding the underlying causes, and identifying how the use of IFC, BIM, and related methods/technologies can support reducing data inefficiencies.

The research team reviewed the full data workflow for each asset type. While this was preliminarily completed during Task 2 meetings and interviews, once Task 3 was complete and the full workflow was mapped for each asset, this was revisited in further detail. The goal was to identify stages, processes, or interactions where lack of data continuity may occur, including areas where information may be omitted, distorted during file conversions, or not adequately transferred between different stakeholders. Using the identified points of data loss, the research team worked with MDOT staff to understand why this data continuity concerns occurs and to obtain feedback from groups on the benefits and challenges of changing the data handoff from the currently used methods to another method such as the use of IFC or BIM.

3.5 Task 5: Recommend Digital Project Handover Processes to Improve the Current Processes

Drawing from the insights gained through Task 4, in this Task, the research team formulated recommendations for improving data continuity and data management efficiencies within MDOT's data workflows and handovers. These recommendations encompassed a range of strategies, including the adoption of specific software tools and/or file formats (i.e., IFC). This task included two steps, identifying the range possible technologies and/or standards that could be used, and determining the advantages and disadvantages of each recommendation.

First, the research team conducted an evaluation of the emerging technologies relevant to digital project handover. This included an assessment of the use of IFC, BIM software tools (i.e., Bentley OpenRoads Designer), and CDE tools (i.e., Bentley iTwin). The evaluation considered their capabilities, suitability for MDOT's asset types, and their potential to improve data workflows for the studied transportation assets, while minimizing potential barriers to adoption and use throughout the asset’s lifecycle. Next, each was evaluated to determine advantages and disadvantages. This helped to understand how well they align with the asset data structures within MDOT. Based on the findings, the research team formulated a set of recommendations for digital project handover processes.

As a result, modified process maps of the studied MDOT assets were created that show the data flow with use of the proposed alternative processes. The resulting processes were designed to improve data exchange, improve data integrity, and enhance the overall efficiency of project handovers in MDOT.

3.6 Task 6: Complete Case Study to Demonstrate a Recommended Process

This task focused on a demonstration of the use of one of the proposed improvements to one of the MDOT assets studied. This helped to assess how the recommended process performs in a practical setting and to provide tangible evidence of their value.

The initial step in this task involved selecting a representative MDOT asset and a recommended process. These were selected in consultation with the RAP. Next, the research team gathered the appropriate data from each step in the lifecycle of the asset, and converted this into the proposed formats, following the modified process maps generated in Task 5.

As a result, documentation including screenshots and explanation of the steps was generated.

4. FINDINGS

This section presents the results of the survey and the findings of interviews with MDOT offices for data workflow diagrams with potential challenges/problems within the current data flow. It also includes the recommended solutions with a demonstration. Finally, contractor interviews are given at the end of this section.

4.1 Survey

An online survey was developed using the web-based tool, Qualtrics. Appendix VIII outlines the questions and information included in the survey, while Appendix IV outlines the full responses. The questions within this survey were developed from multiple sources. These include utilizing reviews of NCHRP project reports that conducted similar types of online surveys of DOTs, using project objectives to derive questions, and based on feedback from the BIM for Infrastructure Pooled Fund team members, and the MDOT project RAP. The final online survey contains 24 questions with various response styles: short answer, essay-style, matrix tables, multiple choice questions, and tables. The survey is organized in four sections: (1) background and contact information, (2) current application and knowledge, (3) how data is shared externally, and (4) recommendations and experiences. The survey underwent multiple rounds of revisions and changes before the questions were finalized. The final survey was shared with MDOT in a PDF and through an external link. The survey was then distributed to state DOT members of the BIM for Infrastructure Pooled Fund through MDOT.

The purpose of the survey was to determine the current state of adoption of digital handover and of IFC/BIM, how data is shared externally (outside of DOTs), what challenges are currently faced, and what software/tools/databases are being used currently for different processes within their departments. A total of 36 respondents completed the survey from a total of 26 different state departments of transportation. Below in Table 6 are the participating state departments of transportation. The recipients had 3 weeks to complete and submit the survey. Collaboration within the respondents' state DOT was encouraged while completing the survey for more descriptive responses. The results from state DOTs that submitted more than one response were combined within the aggregated survey results. The most common category of job titles of those that completed the survey were associated with digital data delivery, BIM or CAD, followed by the second most common, which was structural or bridge engineer. Please see "

APPENDIX IV. FULL SURVEY RESULTS” for the full survey results. Graphs, tables and/or figures depicting the results of each question are included in the Appendix, whereas a summary and select figures and tables are included in this section.

State DOTs reported employing a wide array of technologies and methods for asset management, including 2D and 3D models, GIS, CDE, and point cloud data (see Appendix IV for more details). Data storage technologies mostly commonly reported to be ProjectWise, followed by Oracle and ESRI, as well as AASHTO products, with fairly similar distributions across all asset types. Software tools such as Bentley OpenRoads, MicroStation, and Civil 3D products were the most commonly used for asset creation and modification, as shown in Figure 4; other software tools used beyond these are listed in the responses in the Appendix.

Table 6. Participating State Departments of Transportation in the online survey

Participating State DOTs		
Alabama	Iowa (2)	Ohio
Arizona (2)	Kentucky	Oklahoma
California (2)	Michigan	Pennsylvania (2)
Connecticut	Minnesota (2)	Texas
Delaware	Mississippi	Utah
Florida	Montana	Vermont (2)
Georgia	Nebraska (2)	Washington (2)
Illinois (2)	New York	Wisconsin

Data sharing with external parties primarily occurred through shared links, email, and cloud-based platforms like SharePoint, with some states utilizing proprietary systems such as BidX and PennDOT’s ECMS. The most common was though sharing a link to a document or file through a CDE, followed by sending an email with an attachment. In terms of where the DOTs house their CDEs, as shown in Figure 5, most DOTs housed their Common Data Environments (CDEs) in cloud-based servers in the U.S.

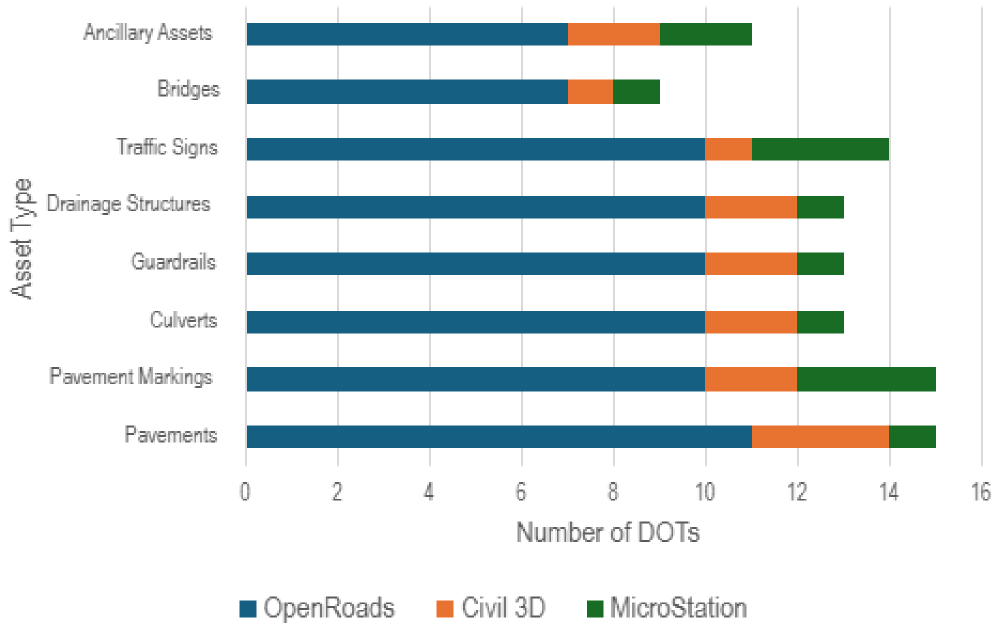

Figure 4. Software packages used to create and modify the listed assets at each DOT

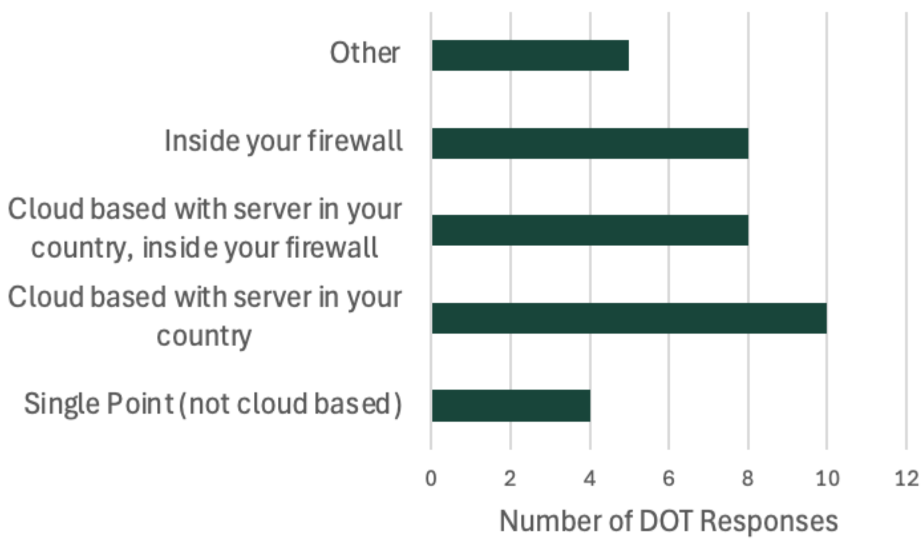

Figure 5. Where each state DOT houses their common data environments

DOTs were next asked to indicate if data shared with external parties is typically contractual, non-contractual or both. The most common response was that this data was shared contractually, and second most common was “both”. This suggests there is a variety of data being shared, including some DOTs that share both data that is contractual and other data that is more for informational purposes. Among different types of data that is typically shared externally, the most common types of files were CAD files and digital documents, followed by 3D models and GIS files. Interestingly, 10 of the DOTs that participated also indicated they shared printed documents as well, suggesting that many DOTs still are not fully digital in the passing of information external to the DOT. Among digital file types most commonly cited, PDF plans were most common, followed by DGNs, then CAD and XML files, among many others file types.

In terms of sharing data back from contractors to DOTs, the survey also asked participants to indicate how contractors were asked to share as-built documents. In many cases DOTs indicated that as-built documents were not required. However, in the scenarios where they were shared back, most indicated that this data was shared via email or using a CDE. Among types of as-built data that DOTs stated they required, the most common was digital documents/PDF plans, followed by CAD files, DGNs and XMLs.

Another question asked was associated with the levels of BIM maturity among state DOTs. Most responded that their DOT was operating at Level 1 (Object-Oriented) or Level 2 (Federated Models), and only a few indicated their DOT had reached Level 3 (Integrated Lifecycle), as shown in Figure 6.

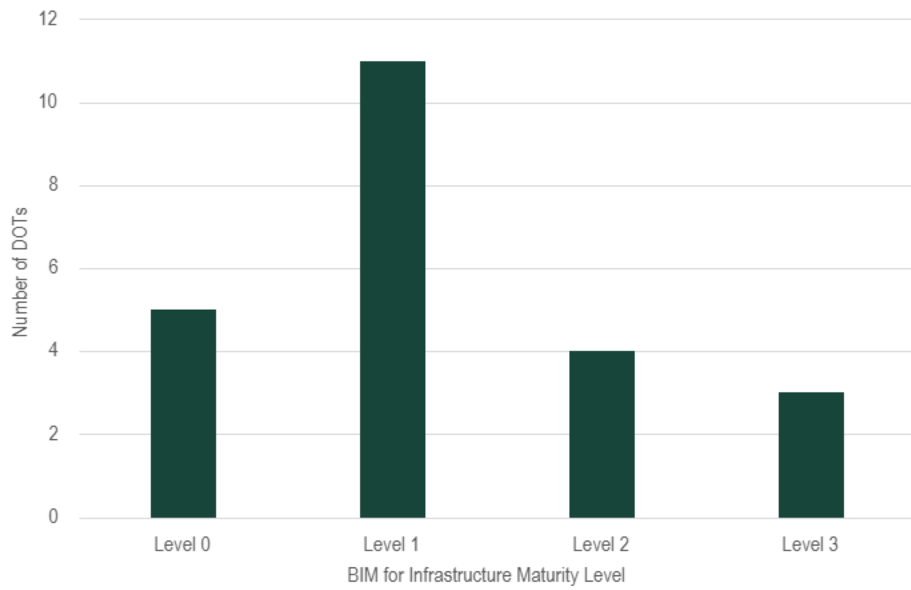

Figure 6. Individual DOTs BIM for Infrastructure Maturity Level

The final questions in the survey asked DOTs to indicate their current state of adoption of BIM/IFC, their anticipated challenges, and their path forward. Several states had conducted one or more pilot projects to test BIM and IFC applications, with several stating they had mixed success. Several also stated that they recognized that IFC and other technologies were still developing and that their DOT was still early in the process of considering adoption of such technologies and a plan to do so, but were actively aware of the technologies. Common challenges stated were a lack of standardization of file formats/interoperability, siloed operations, the need for upskilling (particularly contractors) and the need for dedicated personnel/resources to support these activities. In summary, the survey findings illustrate a growing adoption of digital delivery and BIM across state DOTs, although results suggest this is in the early stages of adoption.

4.2 Data Workflow Diagrams

Interviews with various offices, bureaus, groups and teams at MDOT of specific asset were conducted through Microsoft Teams meetings with each meeting lasting approximately 60-90 minutes, with some additional follow-up interviews or questions completed after, as needed. These meetings began with a project overview that introduced the objectives, tasks and desired outcome of the interview. The objective of each MDOT interview was to map, from start to finish, the current data workflow and handover process of different transportation assets within MDOT. The outcome of each interview was a process map demonstrating the flow of information during the preconstruction process. Coordination with interviewed MDOT personnel took place to verify the validity and correction of the data workflow diagrams. Figure 7 provides a legend for data flow maps that were developed. In the following subsections the developed process maps are discussed by asset.

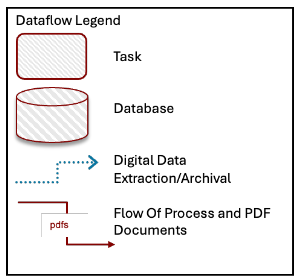

Figure 7. Dataflow diagram legend

4.2.1 Pavement Asset

The process map in Figure 8 demonstrates the flow of information for the MDOT transportation asset of pavements. It is divided into five different phases: Planning & Programming (P0), Design (P1), Contract Development (P2), Construction (P3), and Operation & Maintenance (P4). Actors within the different phases are on the left which include Region/TSC, design team or consultant, contract services division, pavement management office, CE team, and the contractor. Databases are shown as a separate row at the bottom. Details of the asset fields, data creation, data location, and data exchange requirements are provided in Appendix V.

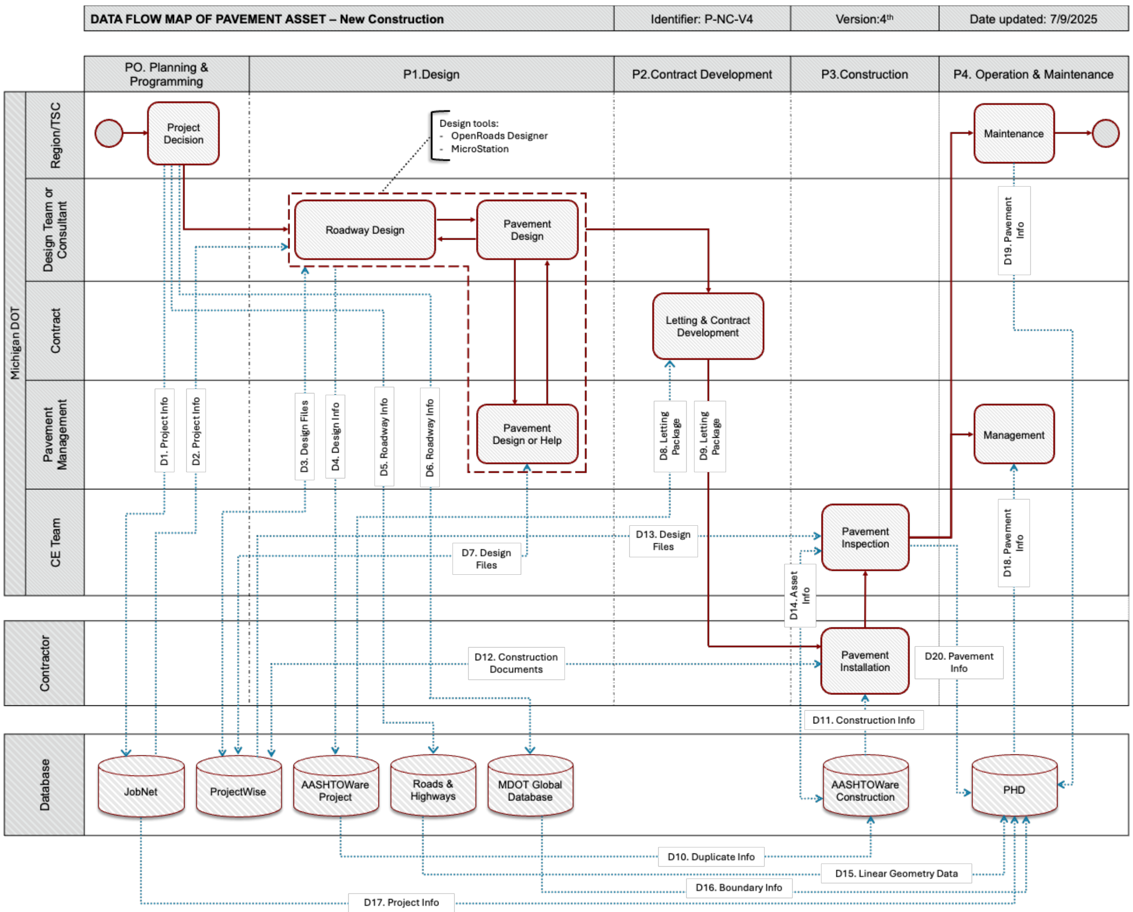

Figure 8. Process map of the MDOT's pavement asset

This process map has the following actors:

- **Region/TSC:** MDOT's region offices and Transportation Service Centers (TSC) oversee regional operations and ensure compliance with state and federal standards. They act as the local point of contact for projects, coordinating between MDOT offices and external stakeholders. They approve project scopes, provide regional data, and support inspection/maintenance activities.
- **Design Team or Consultant:** MDOT's design team or external consultant firms develop and plan project designs by creating design files and ensuring designs meet specifications.
- **Contract:** The Contract Services Division manages the bidding and awarding process for construction contracts. They prepare letting packages and ensure legal/compliance requirements are met.
- **Pavement Management:** Pavement Operations provides expertise on pavement assets. They review design inputs and manage related databases.
- **CE Team:** The Construction Engineering (CE) team, a part of the TSC, supervises on-site construction to ensure adherence to construction contract requirements.

- **Contractor:** The Contractor is an external entity hired to execute construction/installation. They coordinate with the CE Team for approvals and inspections.

This process map has the following databases:

- **JobNet:** MDOT's internal project tracking system.
- **ProjectWise:** A document management and collaboration platform. It stores and shares design files, construction documents, and project plans in a centralized repository by ensuring version control and access for project teams.
- **AASHTOWare Project:** A contract and bidding management software.
- **Roads & Highways:** A database to store linear geometry data.
- **MDOT Global Database:** A database that stores boundary information related to projects.
- **AASHTOWare Construction:** A construction project management software.
- **PHD:** Pavement Historical Database (PHD) is a centralized electronic data warehouse for MDOT's pavement assets.

This process map has the following stages (see Appendix V for details):

- **P0. Planning and Programming:** In the planning and programming part of a new pavement project, a pavement construction project is decided by the Region/TSC. A job is then created by submitting the project information (D1) into the JobNet database. The Region/TSC decides whether the project will be designed internally or by a consultant. Relevant roadway information (D5 and D6) is entered into the Roads & Highways and MDOT Global databases.
- **P1. Design:** The roadway design team receives the project information (D2) from the JobNet database and designs the roadway project with its assets, including pavements using OpenRoads Designer and MicroStation. During the design process, the design files (D3) are uploaded into ProjectWise, design information (D4) is entered into the AASHTOWare Project database. During the design phase, the Pavement Management team either directly participates or helps in the design using design files (D7).
- **P2. Contract Development:** The letting package and contract are developed from the design information (D8). The contractor that won the bid receives the available information on this pavement system (D9).
- **P3. Construction:** The design information is duplicated (D10) from the AASHTOWare Project database into the AASHTOWare Construction database for the contractor to use the construction information (D11) for pavement installation. Additionally, for the pavement installation, the contractor gains access to the ProjectWise database to see the construction documents (D12). Once the pavement is installed, it is inspected by the CE team by referring to the design files (D13) from the ProjectWise database and the asset information (D14) from the AASHTOWare Construction database. Inspectors manually enter asset

information (D20) into PHD. The required documentation for AASHTOWare is not the same documentation that is required for PHD, thus the inspectors must manually enter information about the same asset into both AASHTOWare and PHD.

- **P4. Operation & Maintenance:** Once construction is complete, the pavements are managed by the pavement management team. The PHD extracts the linear geometry data (D15) from the Roads & Highway database, boundary information (D16) from the MDOT Global database and the project information (D17) from the JobNet database. During the management phase, Pavement Management receives data (D18) from PHD to make decisions. Additionally, if any maintenance needs to be done on the pavements, this data and information (D19) is entered into the PHD.

4.2.2 Pavement Marking Asset

The process map in Figure 9 demonstrates the flow of information for the MDOT transportation asset of pavement markings. It is divided into five different phases, similar to pavements: Planning & Programming (PO), Design (P1), Contract Development (P2), Construction (P3), and Operation & Maintenance (P4). Actors within the different phases are on the left which include Region/TSC, design team or consultant, contract services division, pavement marking office, CE team, and the contractor. Details on the asset fields, data creation, data location, and data exchange are provided in Appendix V.

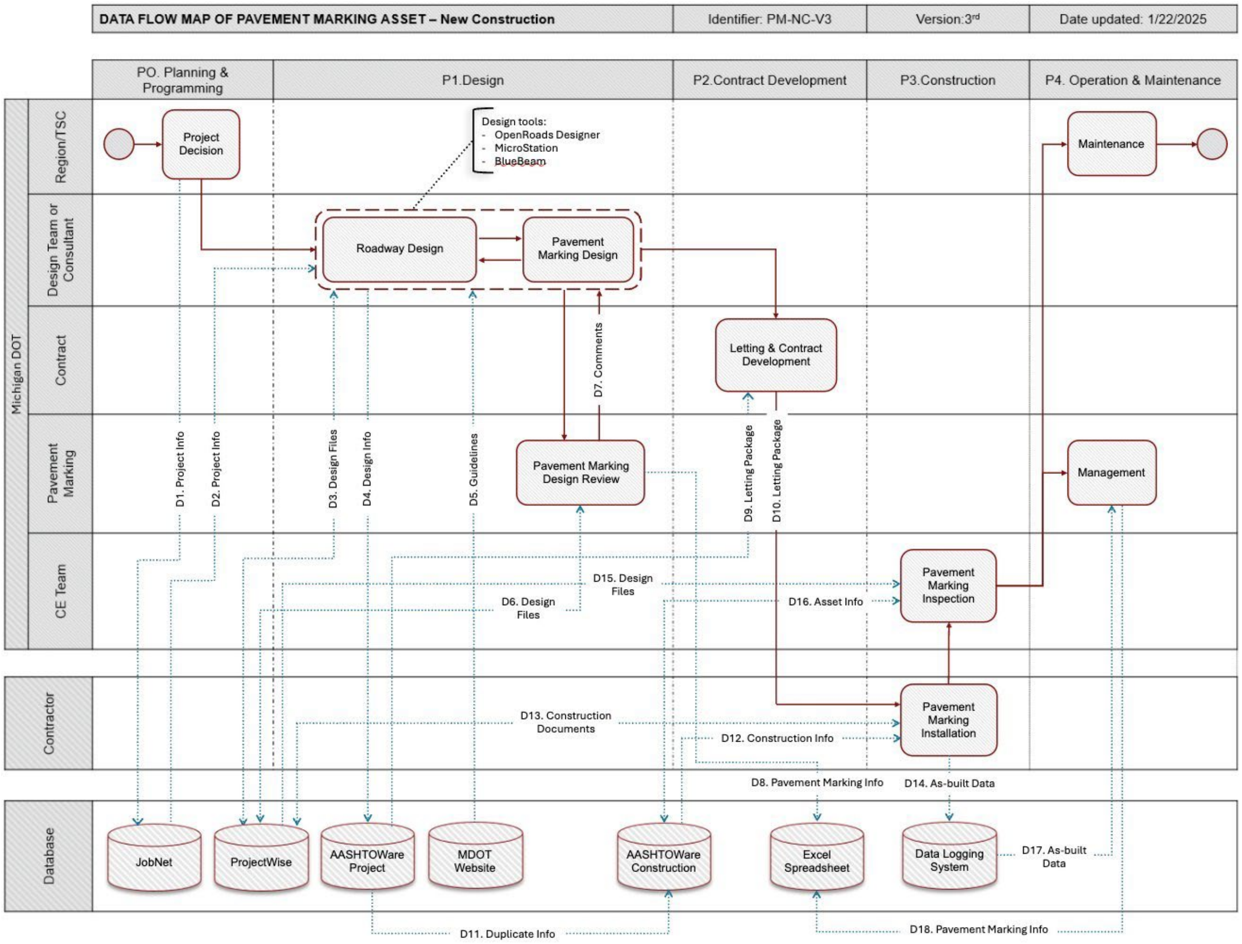

Figure 9. Process map of the MDOT's pavement marking asset

This process map has the following actors:

- **Region/TSC:** *See previous description*
- **Design Team or Consultant:** *See previous description*
- **Contract:** *See previous description*
- **Pavement Marking:** Pavement Marking Office provides expertise on pavement marking assets. They review design inputs and manage related databases.
- **CE Team:** *See previous description*
- **Contractor:** *See previous description*

This process map has the following databases:

- **JobNet:** *See previous description*
- **ProjectWise:** *See previous description*
- **AASHTOWare Project:** *See previous description*
- **MDOT Website:** MDOT's website where guidelines are published online.

- **AASHTOWare Construction:** *See previous description*
- **Excel Spreadsheet:** A spreadsheet to store pavement marking data.
- **Data Logging System:** A system used by contractors to collect as-built data from pavement marking paint trucks.

This process map has the following stages (see Appendix V for details):

- **P0. Planning & Programming:** A road construction project is decided by the Region/TSC. A job is then created by the Region/TSC by entering the project information (D1) attributes into the JobNet database. The Region/TSC decided whether the project will be designed internally or externally by a consultant.
- **P1. Design:** The design team receives the project information (D2) from the JobNet database and designs the roadway project with its assets, including pavement markings, by using OpenRoads Designer, MicroStation and Bluebeam. The design files (D3) are uploaded into the ProjectWise database and the design information (D4) are entered into the AASHTOWare Project database. The designers use the pavement marking guidelines (D5) from the MDOT Website database. Once the design is ready for review, the pavement marking team reviews and makes comments using Bluebeam on PDFs of design files (D6) from the ProjectWise database. Their comments (D7) are sent back to the designers for any final revisions. The information/data (D8) is uploaded into the Excel spreadsheet. This information includes design information, including quantities, materials and locations.
- **P2. Contract Development:** The letting package and contract are developed from the design information (D9). The contractor that won the bid receives the available information on this pavement system (D9).
- **P3. Construction:** The design information within the AASHTOWare Project database is duplicated (D11) into the AASHTOWare Construction database for the contractor to have read-only access to the construction information (D12). Additionally, the contractor will use the construction documents (D13) from the ProjectWise database. During the installation, as-built data (D14) are created and uploaded into the Data Logging system. Once the pavement markings are installed, they are inspected by CE team by looking at the original design files (D15) and asset information (D16).
- **P4. Operation & Maintenance:** The pavement markings are managed by the pavement marking office. They use the as-built data (D17) for reference and enter any data on the pavement markings (D18) into the Excel spreadsheet. Maintenance of the assets is done by the Region/TSC.

4.2.3 Sign Assets

The process map in Figure 10 demonstrated the flow of information for the MDOT transportation asset of signs. It is divided into five different phases, similar to the previous assets: Planning & Programming (PO), Design (P1), Contract Development (P2), Construction (P3), and Operation & Maintenance (P4). Actors within the different phases are on the left which include Region/TSC, design team or consultant, contract services division, signing office, CE team, and contractor. Details of the asset fields, data creation, data location, and data exchange are given in Appendix V.

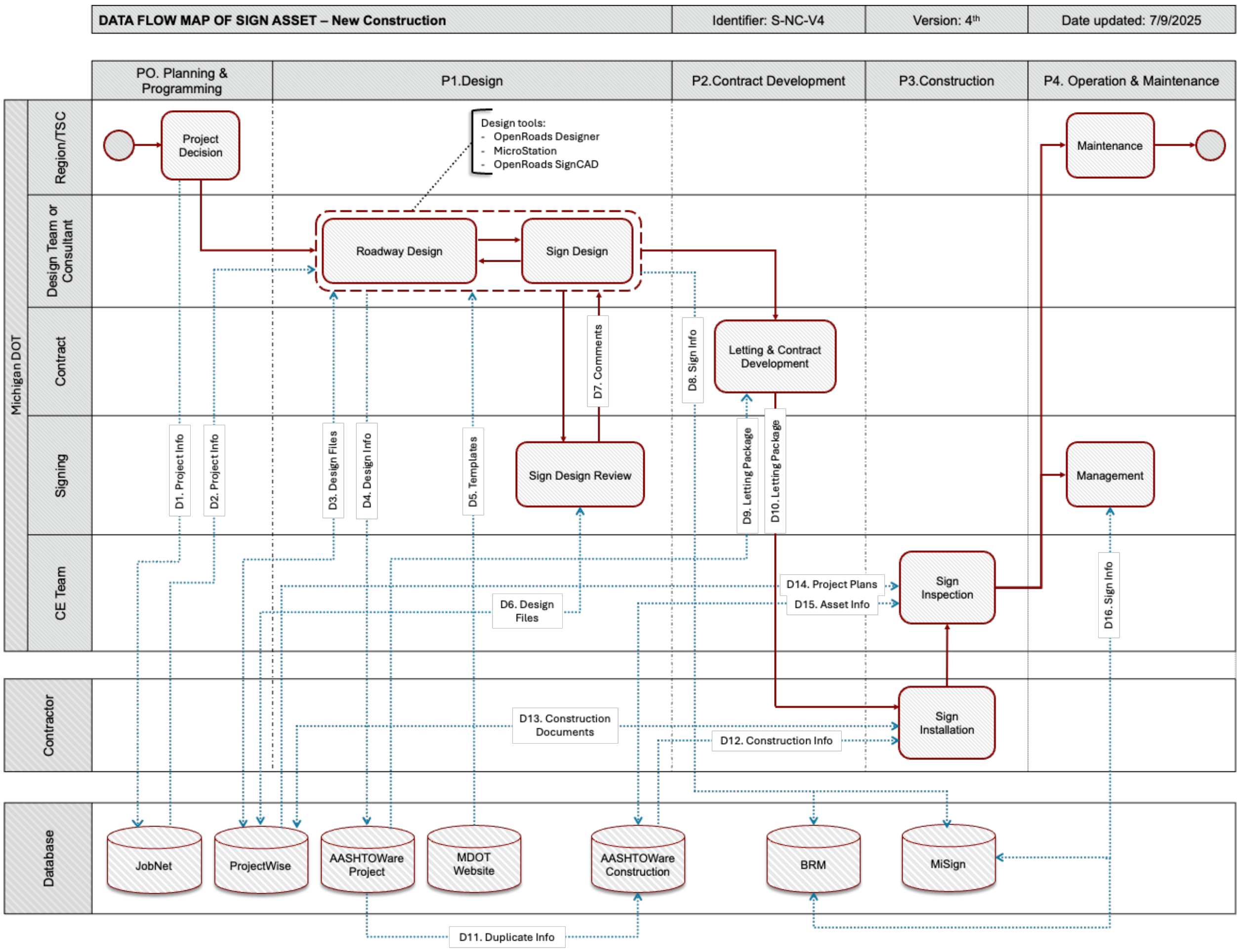

Figure 10. Process map of the MDOT's sign asset

This process map has the following actors:

- **Region/TSC:** *See previous description*
- **Design Team or Consultant:** *See previous description*
- **Contract:** *See previous description*
- **Signing:** Signing Office provides expertise on sign assets. They review design inputs and manage related databases.
- **CE Team:** *See previous description*
- **Contractor:** *See previous description*

This process map has the following databases:

- **JobNet:** *See previous description*

- **ProjectWise:** *See previous description*
- **AASHTOWare Project:** *See previous description*
- **MDOT Website:** *See previous description*
- **AASHTOWare Construction:** *See previous description*
- **MiSign:** It is a centralized electronic data warehouse for MDOT's sign assets.

This process map has the following stages (see Appendix V for details):

- **P0. Planning & Programming:** A road construction project is decided by the Region/TSC. A job is then created by the Region/TSC by entering the project information (D1) attributes into the JobNet database. The Region/TSC decided whether the project will be designed internally or externally by a consultant.
- **P1. Design:** The design team receives the project information (D2) from the JobNet database and designs the roadway project with its assets, including signs, by using OpenRoads Designer, MicroStation and OpenRoads SignCAD. The design files (D3) are uploaded into the ProjectWise database and the design information (D4) are entered into the AASHTOWare Project database. The designers use the sign templates (D5) from the MDOT Website database. Once the design is ready for review, the signing team reviews and makes comments using Bluebeam on PDFs of the design files (D6) from the ProjectWise database. Their comments (D7) are sent back to the designers for any final revisions. Even though this is not proceed as planned, the sign information (D8) is entered into the MiSigns database. Additionally, some of the sign assets (e.g., truss, cantilever, and bridge signs) are also considered ancillary assets and are stored in the BRM (D8).
- **P2. Contract Development:** The letting package and contract are developed from design information (D9). The contractor that won the bid receives the letting package (D10).
- **P3. Construction:** The design information within the AASHTOWare Project database is duplicated (D11) into the AASHTOWare Construction database for the contractor to have read-only access to the construction information (D12). Additionally, the contractor will use the construction documents (D13) from the ProjectWise database. Once the signs are installed, they are inspected by looking at the original design files (D14) and asset information (D15).
- **P4. Operation & Maintenance:** The signing office manages the signs with sign information (D16) from the MiSign database. Maintenance of the signs is done by the Region/TSC.

4.2.4 Guardrail Assets

The process map in Figure 11 demonstrates the flow of information for the MDOT transportation asset of <u>guardrails</u>. It is divided into five different phases, similar to the other assets: Planning & Programming (PO), Design (P1), Contract Development (P2), Construction (P3), and Operation & Maintenance (P4). Actors within the different phases are on the left which include Region/TSC, design team or consultant, contract services division, traffic and safety office, CE team, and contractor. Details of the asset fields, data creation, data location, and data exchange are given in Appendix V.

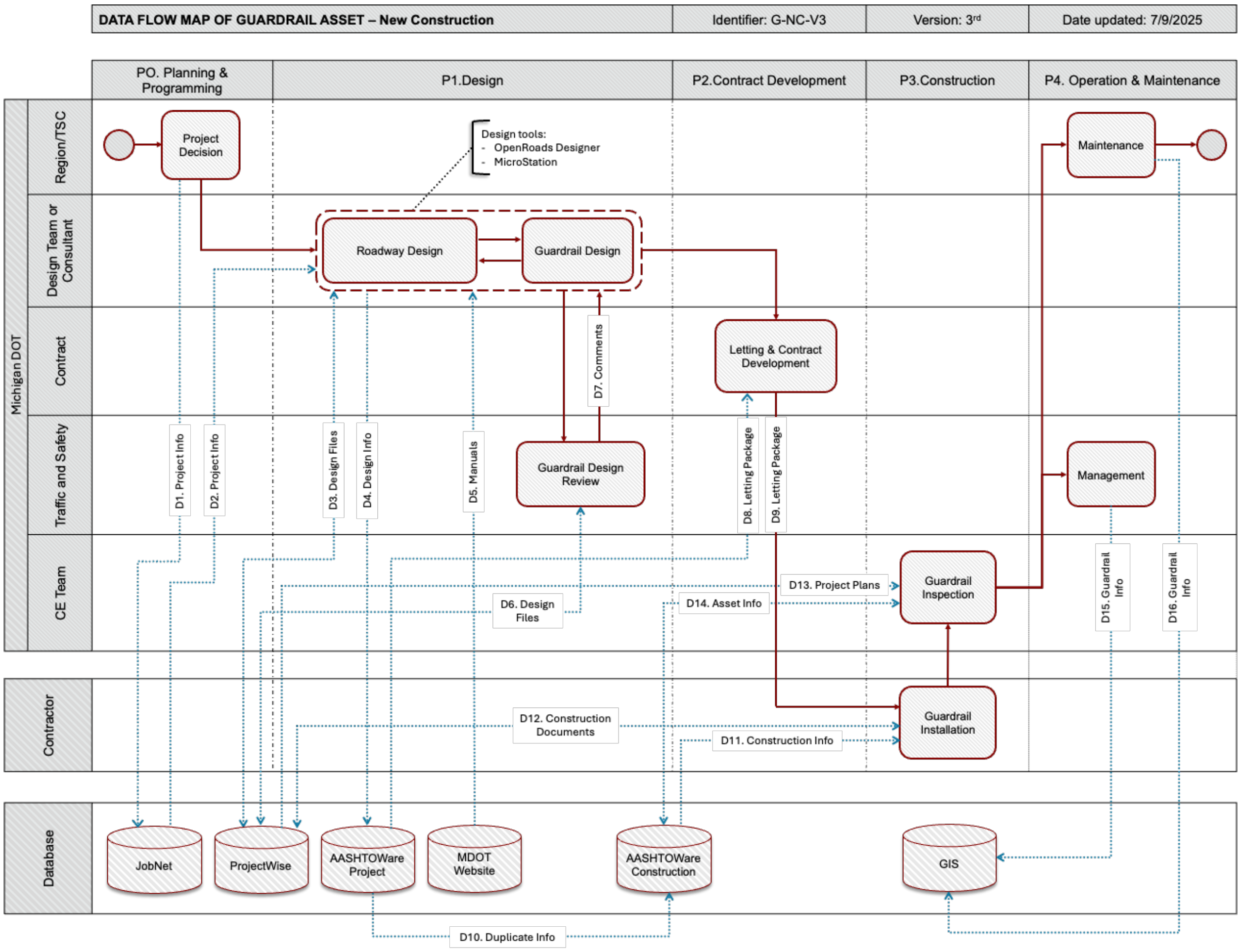

Figure 11. Process map of the MDOT's guardrail asset

This process map has the following actors:

- **Region/TSC:** *See previous description*
- **Design Team or Consultant:** *See previous description*
- **Contract:** *See previous description*
- **Traffic and Safety:** Traffic and Safety Office provides expertise on guardrail assets. They review design inputs and manage related databases.
- **CE Team:** *See previous description*
- **Contractor:** *See previous description*

This process map has the following databases:

- **JobNet:** *See previous description*
- **ProjectWise:** *See previous description*

- **AASHTOWare Project:** *See previous description*
- **MDOT Website:** *See previous description*
- **AASHTOWare Construction:** *See previous description*
- **GIS:** A tool to visualize the data on a map. GIS database is also used to store guardrail data.

This process map has the following stages (see Appendix V for details):

- **P0. Planning & Programming:** A road construction project is decided by the Region/TSC. A job is then created by the Region/TSC by entering the project information (D1) attributes into the JobNet database. Then the Region/TSC decides whether the project will be designed internally or externally by a consultant.
- **P1. Design:** The design team receives the project information (D2) from the JobNet database and designs the roadway project with its assets, including guardrails, by using OpenRoads Designer and MicroStation software packages and manuals (D5) from the MDOT website. Before finalizing guardrail design, design files (D6) are shared with Traffic and Safety office through ProjectWise for their review. When the design review is completed, their comments (D7), which are made in Bluebeam on PDFs of the design files, are sent back to the designers. When the design is completed, the project design files (D3) are uploaded to the ProjectWise database. Design information, including quantities (D4), are entered into AASHTOWare Project through an automated spreadsheet.
- **P2. Contract Development:** Quantities, project plans (D8) and the letting package in AASHTOWare Project are used for bidding through the e-Bidding system. The contractor receives the project letting package (D9) and gains access to the ProjectWise for document sharing (D12). The project within AASHTOWare Project is duplicated (D10) into AASHTOWare Construction where the contractor has read-only access (D11).
- **P3. Construction:** When the contractor is completed with installation, CE team inspects and approves the job using project planes in ProjectWise (D13) and quantity items (D14) in AASHTOWare Construction.
- **P4. Operation & Maintenance:** After the project is handed over, the Traffic and Safety office enters the asset information (D15) into the GIS database. Maintenance of the asset is done by Region/TSC, and the up-to-date guardrail information (D16) is entered.

4.2.5 Culvert Assets

Process map in Figure 12 demonstrated the flow of information for the MDOT transportation asset of culverts. It is divided into five different phases, similar to other assets: Planning & Programming (PO), Design (P1), Contract Development (P2), Construction (P3), and Operation & Maintenance (P4). Actors within the different phases are on the left which include Region/TSC, design team or consultant, contract services division, ancillary structures office, CE team, and contractor. Details of the asset fields, data creation, data location, and data exchange are given in Appendix V.

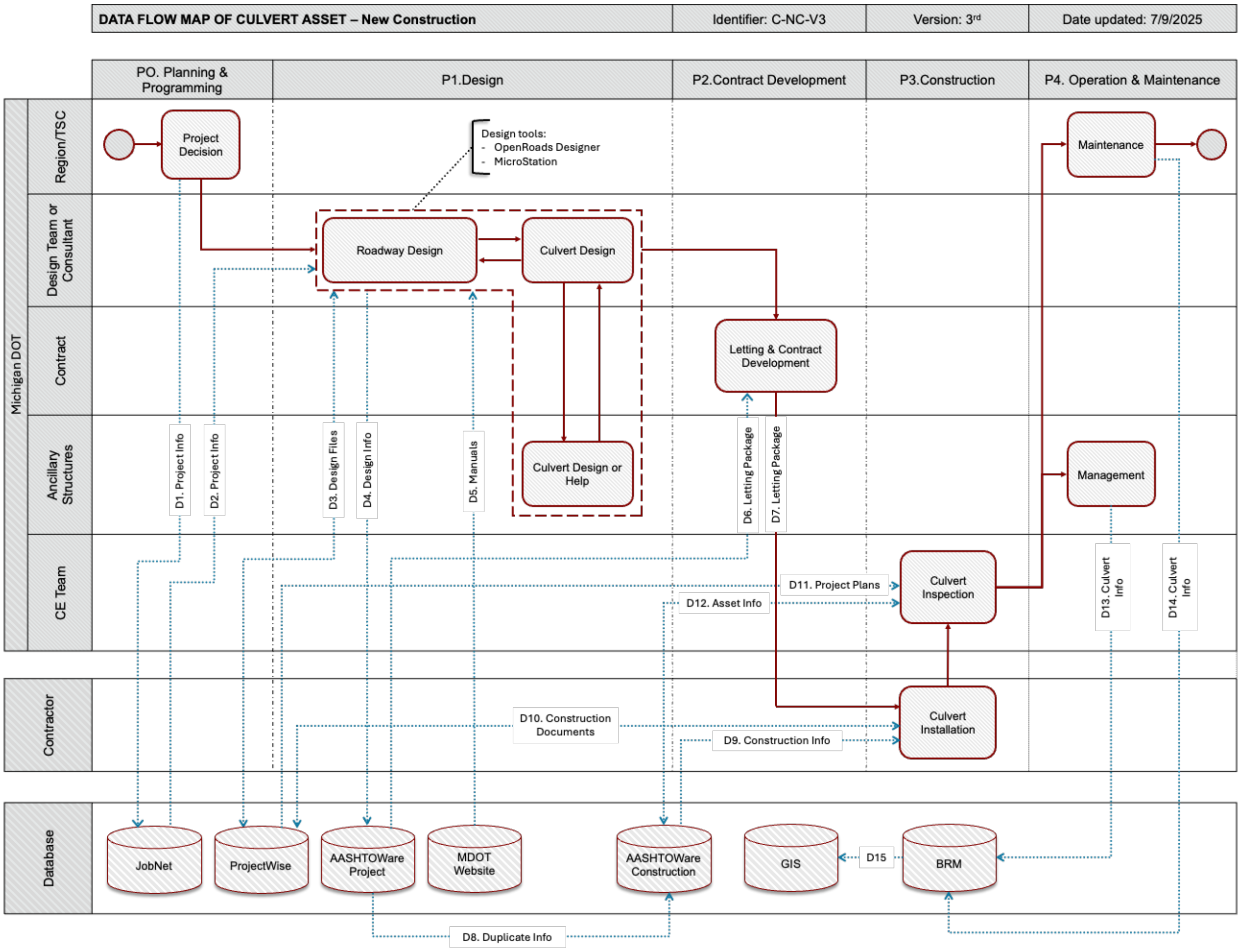

Figure 12. Process map of the MDOT's culvert asset

This process map has the following actors:

- **Region/TSC:** *See previous description*
- **Design Team or Consultant:** *See previous description*
- **Contract:** *See previous description*
- **Ancillary Structures:** Ancillary Structures Office provides both expertise on culvert assets and design on selected projects. They manage related databases.
- **CE Team:** *See previous description*
- **Contractor:** *See previous description*

This process map has the following databases:

- **JobNet:** *See previous description*
- **ProjectWise:** *See previous description*
- **AASHTOWare Project:** *See previous description*
- **MDOT Website:** *See previous description*

- **AASHTOWare Construction:** *See previous description*
- **BRM:** It is a centralized electronic data warehouse for MDOT's culvert assets.
- **GIS:** *See previous description*

This process map has the following stages (see Appendix V for details):

- **P0. Planning and Programming:** A road construction project is decided by the Region/TSC. A job is then created by the Region/TSC within the JobNet database, and the project information (D1) attributes are entered. The Region/TSC decides whether the project will be designed internally or by a consultant.
- **P1. Design:** The Design team receives the project information (D2) from the JobNet database and designs the roadway project with its assets including culverts by using OpenRoads designer and MicroStation software packages and manuals (D5) from the MDOT website. Additionally, on selected projects, Ancillary Structures Office provides both expertise and design. When the design is completed, the project design files (D3) are uploaded to the ProjectWise database. Design information, including quantities (D4), are entered into AASHTOWare Project through an automated spreadsheet.
- **P2. Contract Development:** Quantities and project plans (D6) in AASHTOWare Project are used for bidding through the e-Bidding system. The contractor receives the letting package (D7) and gains access to ProjectWise for document sharing (D10). The project within the AASHTOWare Project is duplicated (D8) into AASHTOWare Construction where the contractor has read-only access.
- **P3. Construction:** When the contractor is completed with installation, MDOT site teams inspect and approve the job using project plans in ProjectWise (D11) and quantity items (D12) in the AASHTOWare Construction database.
- **P4. Operation & Maintenance:** After the project is handed over (currently at least one year later), the Ancillary Structures office enters the culvert information (D13) into BRM which is connected to the GIS database (D15). Maintenance of the assets is done by the Region/TSC, and then up-to-date asset information (D14) is entered by them.

4.3 Contractor Interviews

Interviews with contractors within the state of Michigan were next conducted through Microsoft Teams meetings with each meeting lasting approximately one hour. Names of suggested contractors were provided by the MDOT, the Michigan Infrastructure & Transportation Association (MITA), and other collaborators. These contractors have experience on previous or current MDOT projects. Each contractor was individually interviewed with various asset specialties, including the following: pavement markings (2 contractors), pavement markings (1), signs (2), and underground assets (5). Of the studied assets, those contractors that were in the "underground items" category worked with culverts as well as typically also were involved in earthwork, as well as non-underground assets. In most cases, while contractors had more experience with one of the asset types, they also typically worked with the others in some capacity.

The purpose of these interviews was to better understand the current data workflow and handover process for each asset of focus within this project from the contractor's perspective. These interviews provided insight when developing the data workflow diagrams and a complementary perspective to those from MDOT, in terms of the opportunities and challenges of implementing different 3D modeling tools for different stages within an asset lifecycle. The full contractor interview results are given in Appendix III, with the questions asked listed in Appendix VII.

When asked the question: "*What data is being used from MDOT for the <u>bidding</u> process*?", there were common responses for each asset type. Common data used for the bidding process included PDFs, DWGs, DGNs (converted to AutoCAD) and RID files. Additionally, Bluebeam and Trimble Business Center (TBC) were commonly mentioned tools for this stage. There was consistent feedback regarding challenges with the bidding process, with contractors stating that there are often discrepancies between 2D plan sets and 3D drawings. Many noted that if 3D drawings are provided, some of the contractors created their own 3D models either in-house or by sending out to a third party, then also compared these models to the 3D drawings provided. It should also be noted that contractors that specialized in smaller and less complex assets (e.g. pavement markings, guardrails, signs) did not see a benefit to using or creating 3D models for transportation projects, as compared to the contractors that specialized in more complex assets, including earthwork and/or pavements. When converting files or adding information to these plan documents, contractors discussed that there are often errors, and that it is time consuming to assess discrepancies. Another challenge stated is that there can be software compatibility issues. For example, Bentley software-based files originating from MDOT are not compatible with Trimble Business Center. Several contractors suggested that the bidding package include CAD/TIN files for every project as it is highly time efficient (e.g. "95% time is saved"). The final suggestion, for the related assets, was to include cross streets, side streets, and traffic shift details within the plan sets to may it easier for those in the field to interpret and determine locations.

Following, when asked "*What data is being used from MDOT for the <u>construction</u> process*?", responses discussed both the primary data sources and some challenges associated with this data. The primary data used during this process are PDFs, RID files, and downloads from ProjectWise; some contractors used 3D surfaces/DWGs if they are provided. Some challenges mentioned when discussing the construction process include that there are often discrepancies between the 2D project design files and the 3D models, similar to what was mentioned during the bidding phase (see previous paragraph). Many also discussed that many field teams prefer to use paper plans or simple digital formats in 2D rather than 3D. It was also stated that the software tools used out in the field must work well. Another difficulty discussed was that contractors and subcontractors need to rebuild the models in Trimble Business Center, a software tool that many of those interviewed used.

For the next phase of an asset's lifecycle, the contractors were asked: *"What data is generated during construction?"*. The physical data collected for each asset varied. However, it was common that contractors hired third-party surveyors for larger jobs. Each asset also had varied quantities that are tracked during construction, for example, asphalt tonnage and earthwork quantities. As-builts were generated if requested or significant changes were made to the plans which were either marked-up PDFs or survey shots. Finally, daily progress reports were completed and reported.

Asked next, *"What data is provided back to MDOT after construction is completed"*. The data provided included as-builts (pipe inverts, coordinates, cross-sections, etc.), quantity reports for payment and marked-up PDFs using ProjectWise.

The remaining questions were opinion- and experience-based. The contractors were asked *to share their previous experience (if any) using BIM/3D models*. Several had some experience with 3D models, and one stated that they have found success using 3D models for bridges, utilities and large interchanges. Other contractors stated that they had either not used BIM/3D models, and some also stated that such models are not useful for pavement markings or signs.

The contractors were next asked to *hypothetically describe the success of a project if they were only provided with a 3D model without having a 2D plan set*. Consistently, the responses were not optimistic towards this scenario or the success of a project with only 3D models. Specifically, pavement and sign contractors stated that PDF plans are crucial. Additionally, underground and utility contractors think this could be possible if the proper training and education took place for the contractors that had to use these models in the field. There was also uncertainly around whether or not current tools used in the field would be able to appropriately and quickly navigate a 3D model, so as to provide sufficient information for construction in the field.

Finally, the last question during these interviews asked *to identify the challenges with the use of 3D models*. The first challenge discussed was related to software compatibility and version control. Meaning, each person who is using the 3D model must be certain that they have the most up-to-date version of the model and the proper software to view and/or edit the plans. Second, there was much concern about accessibility within the field when using tablets, offline use, and hiring enough IT staff. Specifically for IT staff, one company discussed that they could hire IT staff to support but dedicated personnel for this purpose was costly and can be challenging to staff if multiple sites require this personnel to support and/or troubleshoot. Third, there was what appeared to be an issue of trust when using 3D models. This is "newer" technology that many people in industry are not comfortable with or are currently unwilling to learn; it was suggested this would require significant education and upskilling to be successful. Learning a new software takes a considerable amount of time that many people are not willing to "waste" when in their view, the current methods work well. Finally, cost was a significant concern. New software, training, technology and staff all require a significant amount of money, both in terms of initial costs and ongoing operational costs.

4.4 Data Continuity Challenges

The development of the data workflows for each MDOT asset demonstrated the points where data lost/problem occurs. These points are marked (purple) on the previously created workflow diagrams.

4.4.1 Pavement Assets

Figure 13 shows the pavement data workflow where points of data continuity challenges were identified.

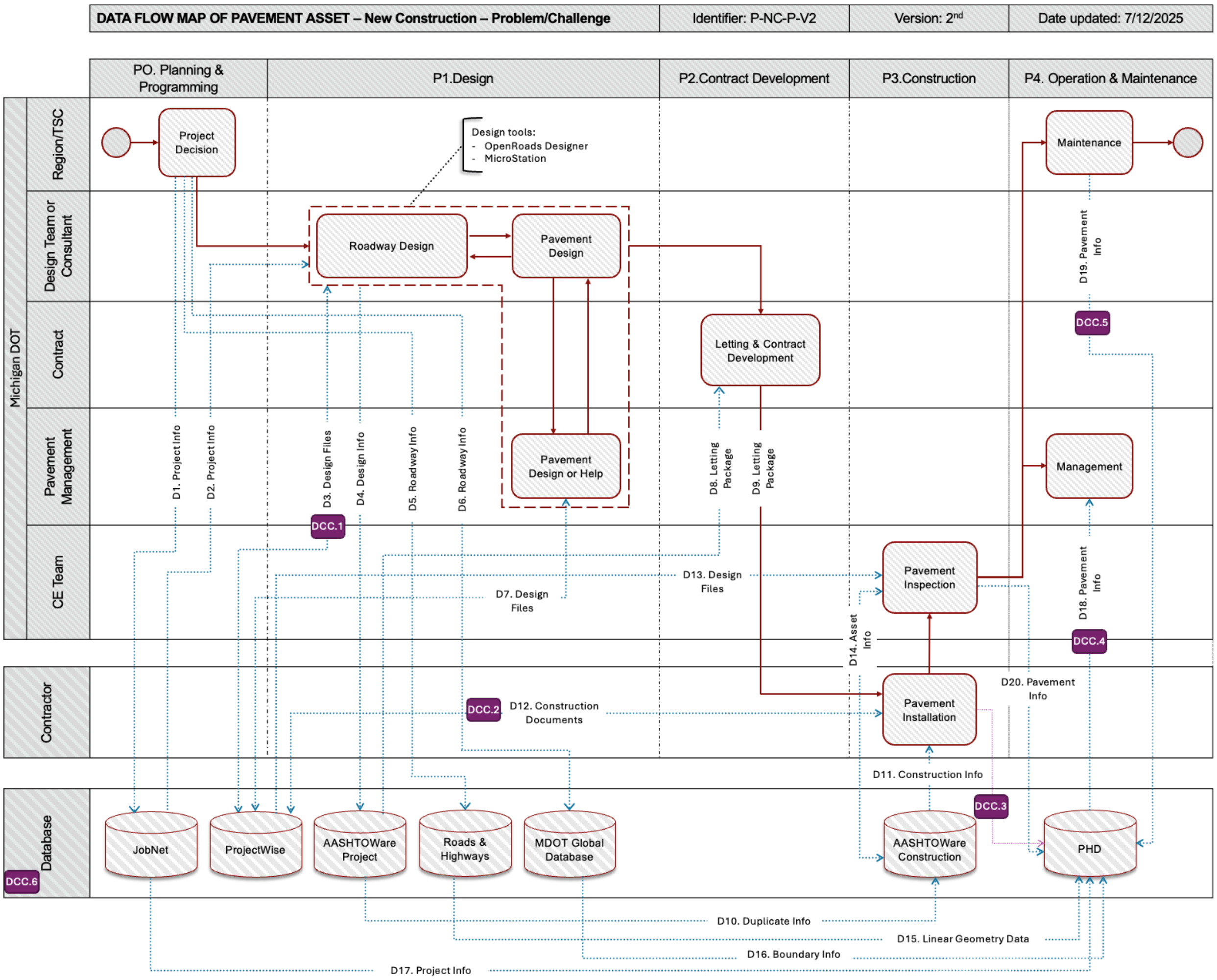

Figure 13. Points of data continuity challenges within pavement data flow diagram

This data flow diagram includes below data continuity challenge points:

- **DCC.1:** Information is being stored as text within the drawing plans. This makes information hard to find within the plans, can create duplication of information, and requires manual data entry if data is used elsewhere.
- **DCC.2:** New or modified asset information may not be included in as-built drawings. This leads to the as-built drawings not being up-to-date and potentially inaccurate as compared to what is in the field.
- **DCC.3:** There is no party currently responsible for updating the asset database with as-built information which causes a missing link between updated information and what is being stored.

- **DCC.4:** Most of the data is manually entered into the PHD by looking at the project files which takes time and can lead to errors.
- **DCC.5:** There is no formal structured way to update the asset information after maintenance and service efforts occur.
- **DCC.6:** There are several connections between different databases.

4.4.2 Pavement Marking Asset

Figure 14 shows the pavement marking data workflow where points of data continuity challenges were identified.

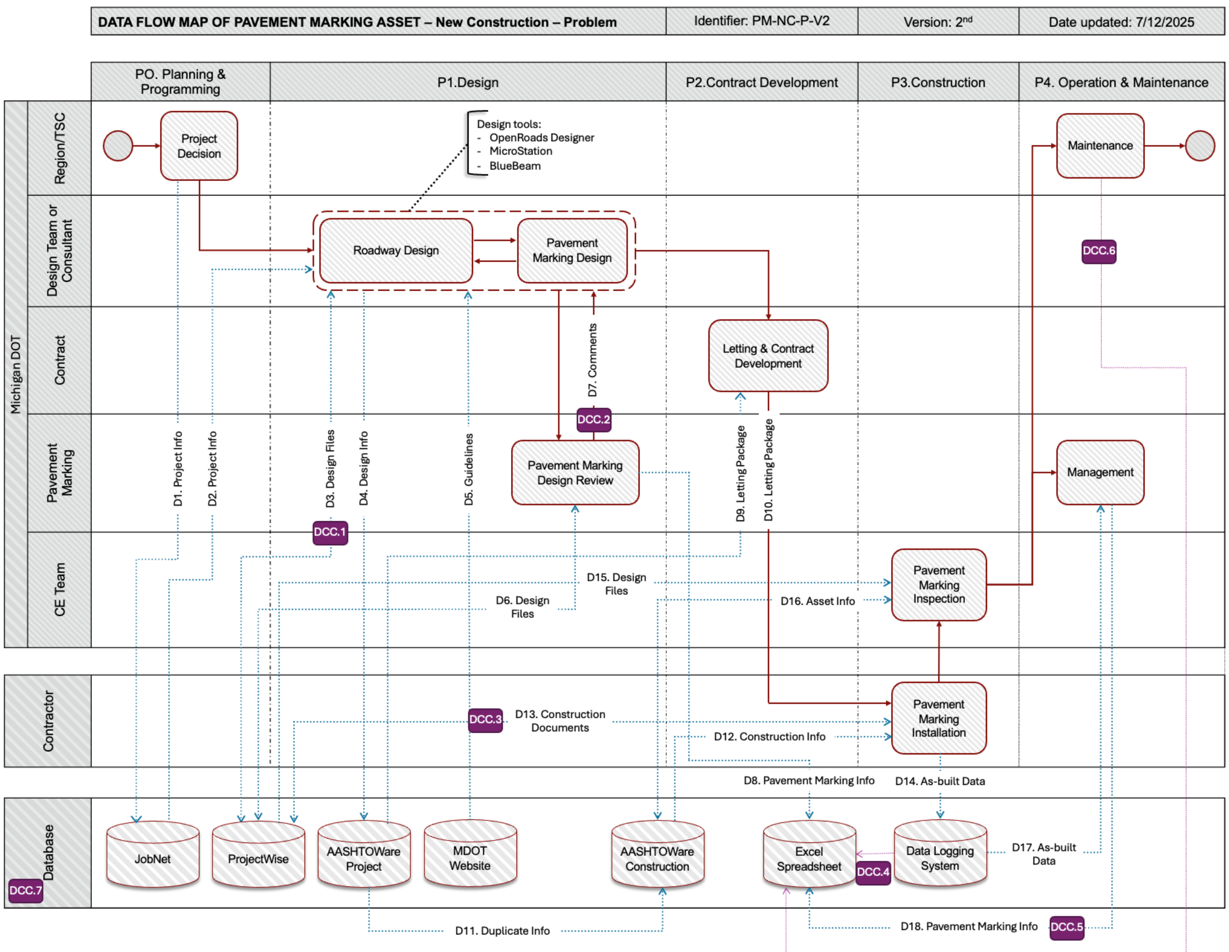

Figure 14. Points of data continuity challenges within pavement marking data flow diagram

This data flow diagram includes below data continuity challenge points:

- **DCC.1:** Information is being stored as text within the drawing plans. This makes information hard to find within the plans, can create duplication of information, and requires manual data entry if data is used elsewhere.

- **DCC.2:** There is a lack of knowledge on whether the comments are considered and/or implemented by the design team from the pavement marking review team.
- **DCC.3:** New or modified asset information may not be included in as-built drawings.
- **DCC.4:** There is no connection between the datalogging system and database (missing link).
- **DCC.5:** The majority of the data is manually entered into the Excel database by looking at the project files.
- **DCC.6:** Asset information is not updated or entered into the database after maintenance and service is performed (missing link).
- **DCC.7:** Not all the databases relate or are linked to each other.

4.4.3 Sign Asset

Points of data continuity challenges within <u>sign</u> data flow diagram

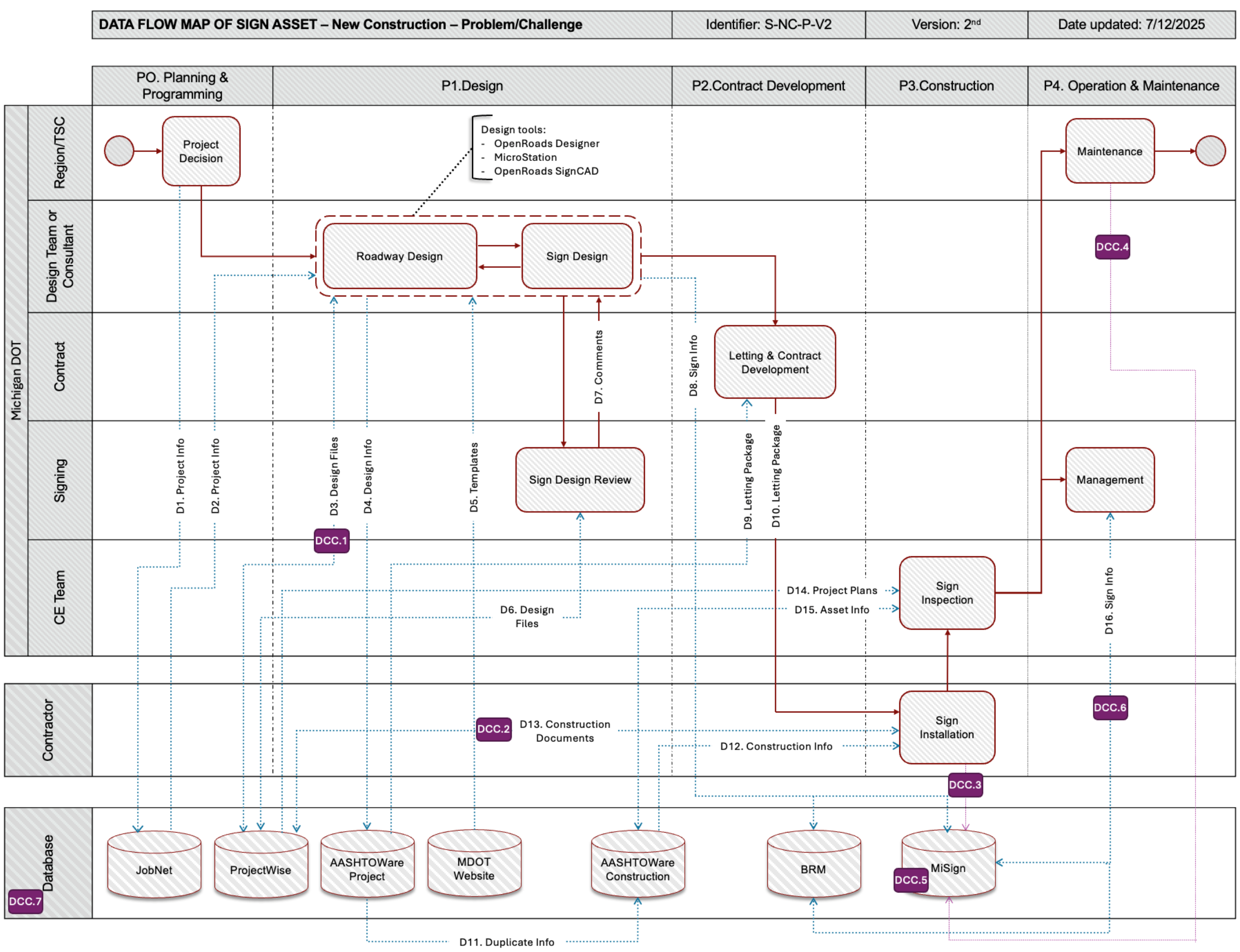

Figure 15. Points of data continuity challenges within sign data flow diagram

This data flow diagram includes below data continuity challenge points:

- **DCC.1:** Information is being stored as text within the drawing plans. This makes information hard to find within the plans, can create duplication of information, and requires manual data entry if data is used elsewhere.
- **DCC.2:** New or modified asset information may not be included in as-built drawings.
- **DCC.3:** There is no party currently responsible for updating the asset database with as-built information which causes a missing link between updated information and what is being stored.
- **DCC.4:** Asset information is not updated or entered into the database after maintenance/service (missing link).
- **DCC.5:** A sign includes 3 different datasets: signs, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated.
- **DCC.6:** The majority of the data is manually entered into the MiSign database by looking at the project files.
- **DCC.7:** Not all the databases are connected and some of the sign assets (e.g., truss, cantilever, and bridge signs) are stored in both BRM and MiSign which would result in duplicated info between two systems without connection.

4.4.4 Guardrail Asset

Figure 16 shows the guardrail data workflow where points of data continuity challenges were identified.

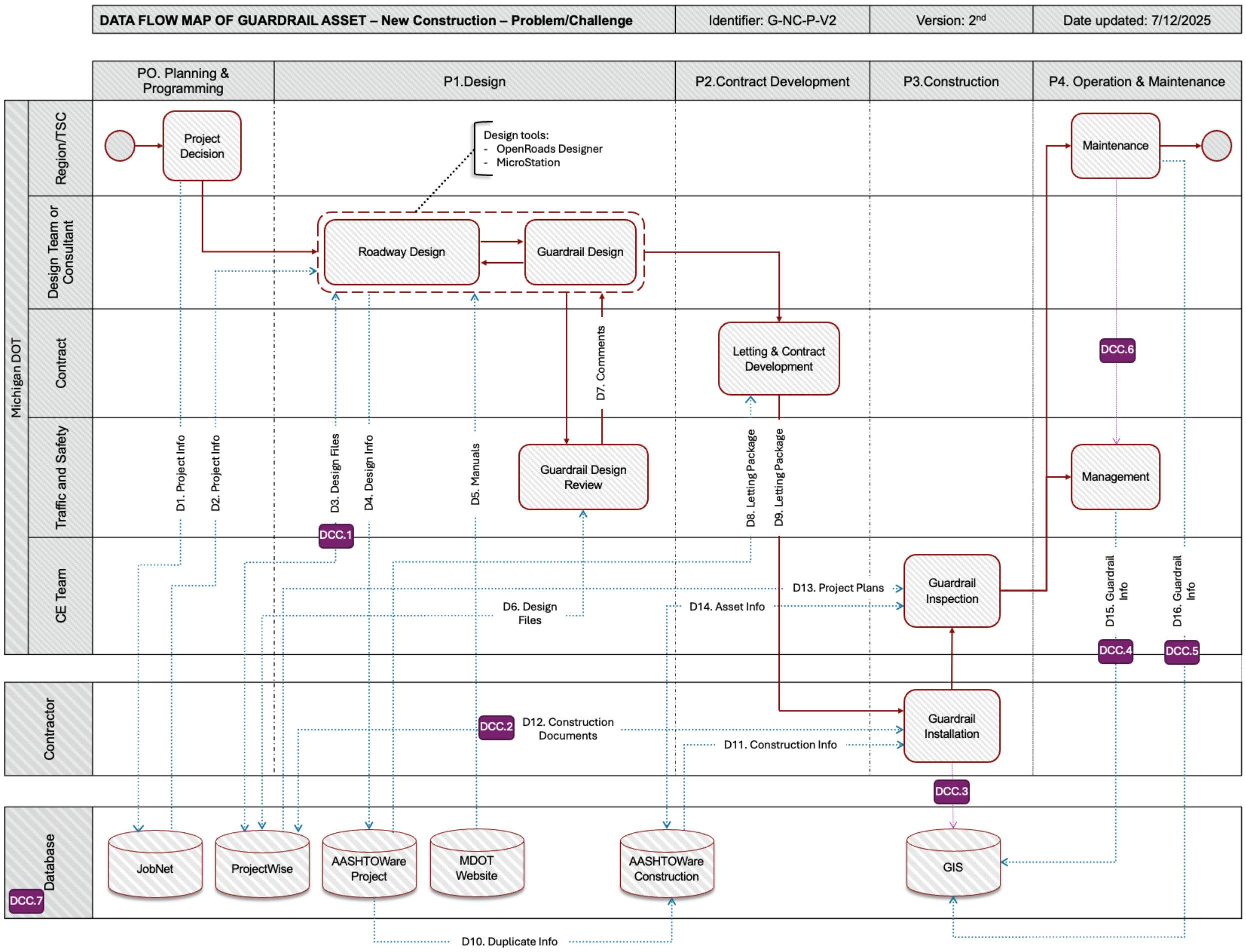

Figure 16. Points of data continuity challenges within guardrail data flow diagram

This data flow diagram includes below data continuity challenges points:

- **DCC.1:** Information is being stored as text within the drawing plans. This makes information hard to find within the plans, can create duplication of information, and requires manual data entry if data is used elsewhere.
- **DCC.2:** New or modified asset information may not be included in as-built drawings.
- **DCC.3:** The contractor is not entering new or changed asset information into the GIS database (missing link).
- **DCC.4:** A field team needs to go to the site to collect asset information.
- **DCC.5:** It is not known whether asset information is updated or entered into the database after maintenance and/or service is completed.
- **DCC.6:** The office responsible for the asset is not receiving updates from the maintenance team (missing link).

- **DCC.7:** Not all of the databases are connected.

4.4.5 Culvert Asset

Figure 17 shows the culvert data workflow where points of data continuity challenges were identified.

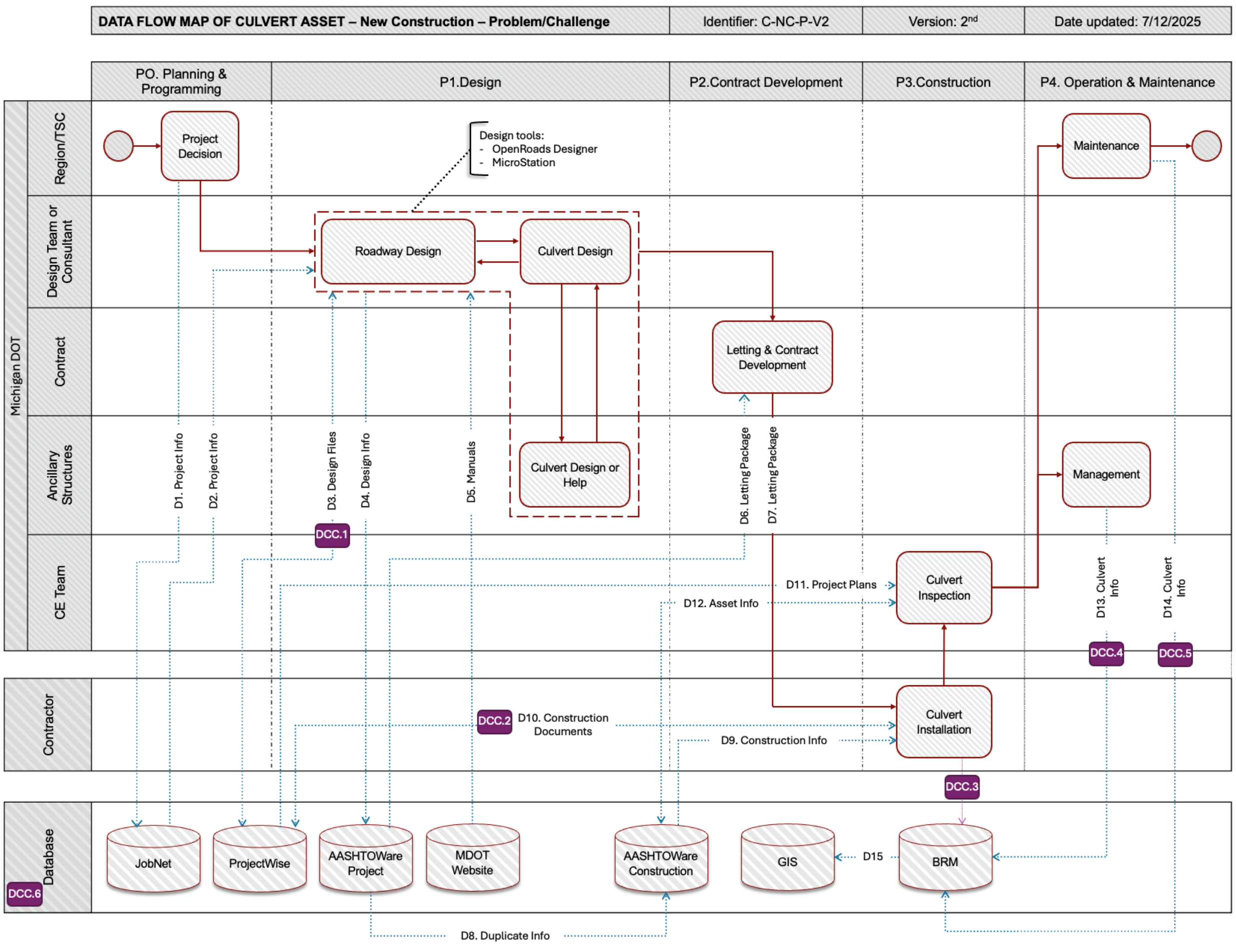

Figure 17. Points of data continuity challenges within culvert data flow diagram

This data flow diagram includes below data continuity challenge points:

- **DCC.1:** Information is being stored as text within the drawing plans. This makes information hard to find within the plans, can create duplication of information, and requires manual data entry if data is used elsewhere.
- **DCC.2:** New or modified asset information may not be included in as-built drawings.
- **DCC.3:** The contractors are not entering new or changed asset information into the BRM database (missing link).
- **DCC.4:** The majority of the data is manually entered into the BRM database by looking at the project files.

- **DCC.5:** It is not known whether the asset information is updated or entered into the BRM database after maintenance or service is completed.
- **DCC.6:** Not all databases are connected.

4.5 Recommended Solutions

After the points of data loss were identified, the research team investigated the possible solutions. The recommendations provided in the following lifecycle diagrams involved the adoption of BIM, IFC, and CDE into these processes. For each recommendation, the advantages and disadvantages were evaluated. A data flow map of each recommendation contains all MDOT assets investigated (e.g., pavement, pavement marking, sign, guardrail, culvert).

4.5.1 Building Information Modeling (BIM)

Figure 18 demonstrates the usage of BIM as a possible digital solution to improve the data workflow process of MDOT assets. The main update in this proposed workflow is placing the BIM model as a centralized database and design tool. While the BIM model is used as a collaboration platform between project actors through each project stage, it can also be linked to other databases, as needed.

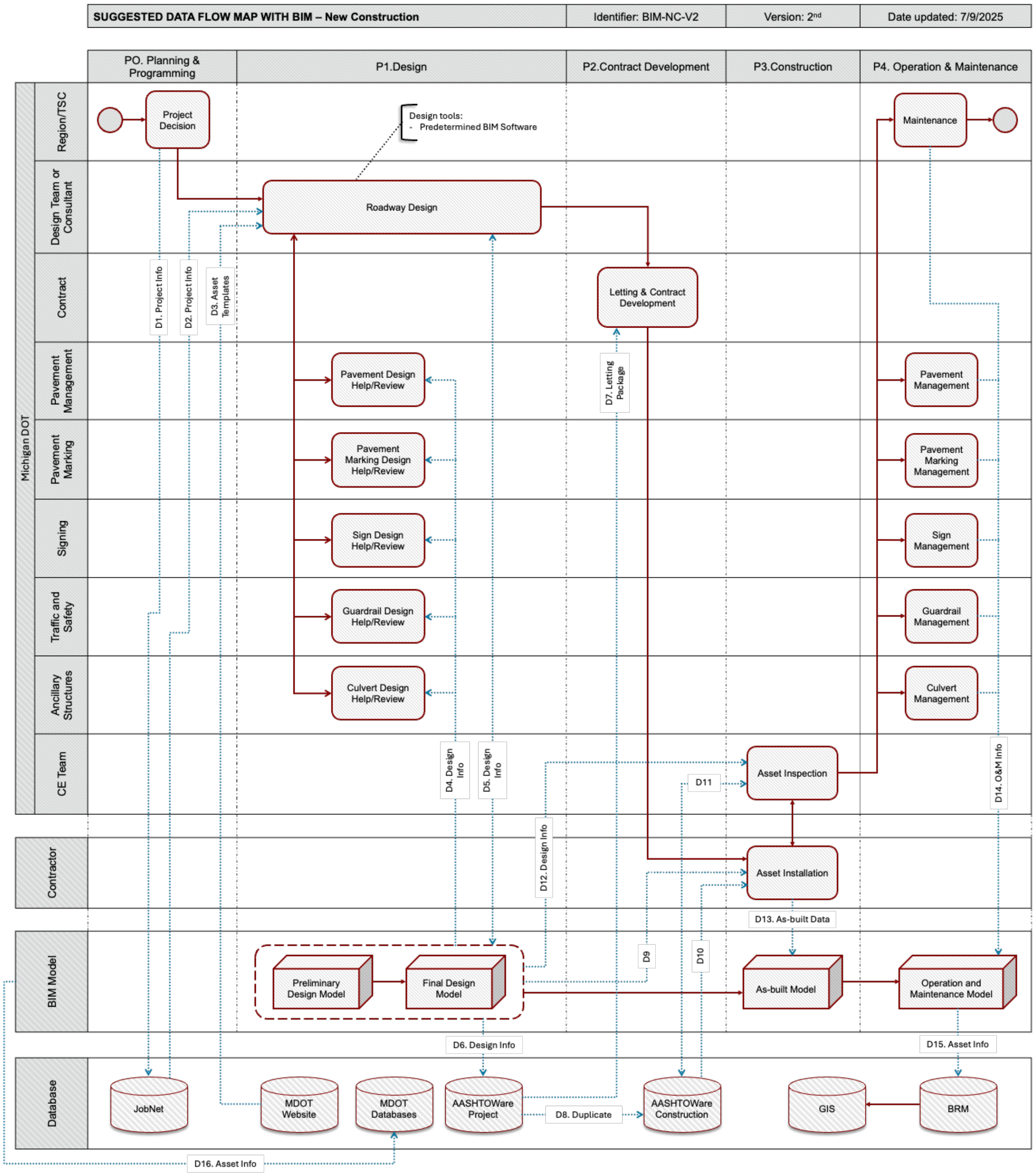

Figure 18. Data flow diagram demonstrating BIM as a digital solution for MDOT assets

This improved process map has the following actors:

- **Region/TSC:** MDOT's region offices and Transportation Service Centers oversee regional operations and ensure compliance with state and federal standards. They act as the local point of contact for projects, coordinating between MDOT offices and external stakeholders. They approve project scopes, provide regional data, and support inspection/maintenance activities.

- **Design Team or Consultant:** MDOT's design team or external consultant firms develop and plan project designs by creating design files and ensuring designs meet specifications. They collaborate with the MDOT Offices.
- **Contract:** Contract Services Division manages the bidding and awarding process for construction contracts. They prepare letting packages and ensure legal/compliance requirements are met.
- **Pavement Management:** Pavement Operations provides expertise on pavement assets. They review design inputs and manage related databases.
- **Pavement Marking:** Pavement Marking Office provides expertise on pavement marking assets. They review design inputs and manage related databases.
- **Signing:** Signing Office provides expertise on sign assets. They review design inputs and manage related databases.
- **Traffic and Safety:** Traffic and Safety Office provides expertise on guardrail assets. They review design inputs and manage related databases.
- **Ancillary Structures:** Ancillary Structures Office provides expertise on culvert assets. They manage related databases.
- **CE Team:** Construction Engineering team, a part of the TSC, supervises on-site construction to ensure adherence to design specs.
- **Contractor:** Contractor is an external entity hired to execute construction/installation. They coordinate with the CE Team for approvals and inspections.

This process map has the following databases:

- **BIM Model:** An object-oriented database including 3D visualization and asset information. This can be used as a centralized database and be linked to other databases, if necessary.
- **JobNet:** *See previous description*
- **MDOT Website:** *See previous description*
- **MDOT Databases:** Any database that is currently in use and intended to be used together with the proposed workflow, including ProjectWise, Excel spreadsheets, MiSigns, BRM, PHD, MDOT Global, Roads & Highways.
- **AASHTOWare Project:** *See previous description*
- **AASHTOWare Construction:** *See previous description*
- **BRM:** *See previous description*
- **GIS:** *See previous description*

This process map has the following stages:

- **P0. Planning and Programming:** A road construction project is decided by the Region/TSC. A job is then created by the Region/TSC within the JobNet database, and the project information (D1) attributes are entered. The Region/TSC decides whether the project will be designed internally or by a consultant.
- **P1. Design:** The Design team receives the project information (D2) from the JobNet database and designs the roadway project with its assets including pavements, pavement markings, signs, guardrails, and culverts by using the predetermined BIM software package and asset templates (D3) from the MDOT website. Entire design process is done on a BIM model. First, the design team creates the preliminary design model and enters design information (D5) into the model. During the design, related MDOT offices access the model and review the design information (D4). They can provide feedback to the design team for the asset they are dealing with. When the design is completed, the final design model is created. Design information, including quantities (D6) are entered into the AASHTOWare Project database through an automated linkage from the BIM model. Alternatively, this last step can be skipped, and the model can be used directly.
- **P2. Contract Development:** Quantities (D7) in AASHTOWare Project and BIM models are used for bidding through the e-Bidding system. The contractor receives the letting package (D7) and gains access to the final design model (D9). The project within the AASHTOWare Project is duplicated (D8) into AASHTOWare Construction where the contractor also has read-only access. Alternatively, this last step can be skipped, and the model can be used directly.
- **P3. Construction:** When the contractor is completed with installation, CE Team inspects and approves the job using the final design model (D12) and quantity items (D11) in the AASHTOWare Construction database. When the construction is completed, the contractor enters the as-built data (D13) into BIM model, creating the as-built model.
- **P4. Operation & Maintenance:** After the project is handed over, the as-built model is turned into an operation and maintenance model by entering the necessary information (D14) by the related MDOT offices. Maintenance of the assets is done by the Region/TSC, and they update the BIM model by entering the information after any maintenance activities (D14). This model may be linked to the BRM (D15), and the data can be visualized in GIS platform, if necessary. Additionally, any database that is planned to be used can be connected to the BIM model for data exchange (D16).

Utilization of BIM into MDOT’s asset workflow has the following advantages:

- No compatibility issues
- Data can be exported/imported easily

Utilization of BIM into MDOT’s asset workflow has the following disadvantages:

- Everyone must use the same software and version/software must be compatible

- When the software changes or updates, there might be problems with opening and modifying previous project models if there is not forward and backwards compatibility

4.5.2 Industrial Foundation Classes (IFC)

Figure 19 demonstrates the usage of IFC as a possible digital solution to improve the data workflow process of MDOT assets. The main update in this proposed workflow is placing the IFC model as a centralized database and the final file format from the BIM model. While the IFC model is used as a collaboration platform between project actors through each project stage, it can also be linked to other databases, as needed.

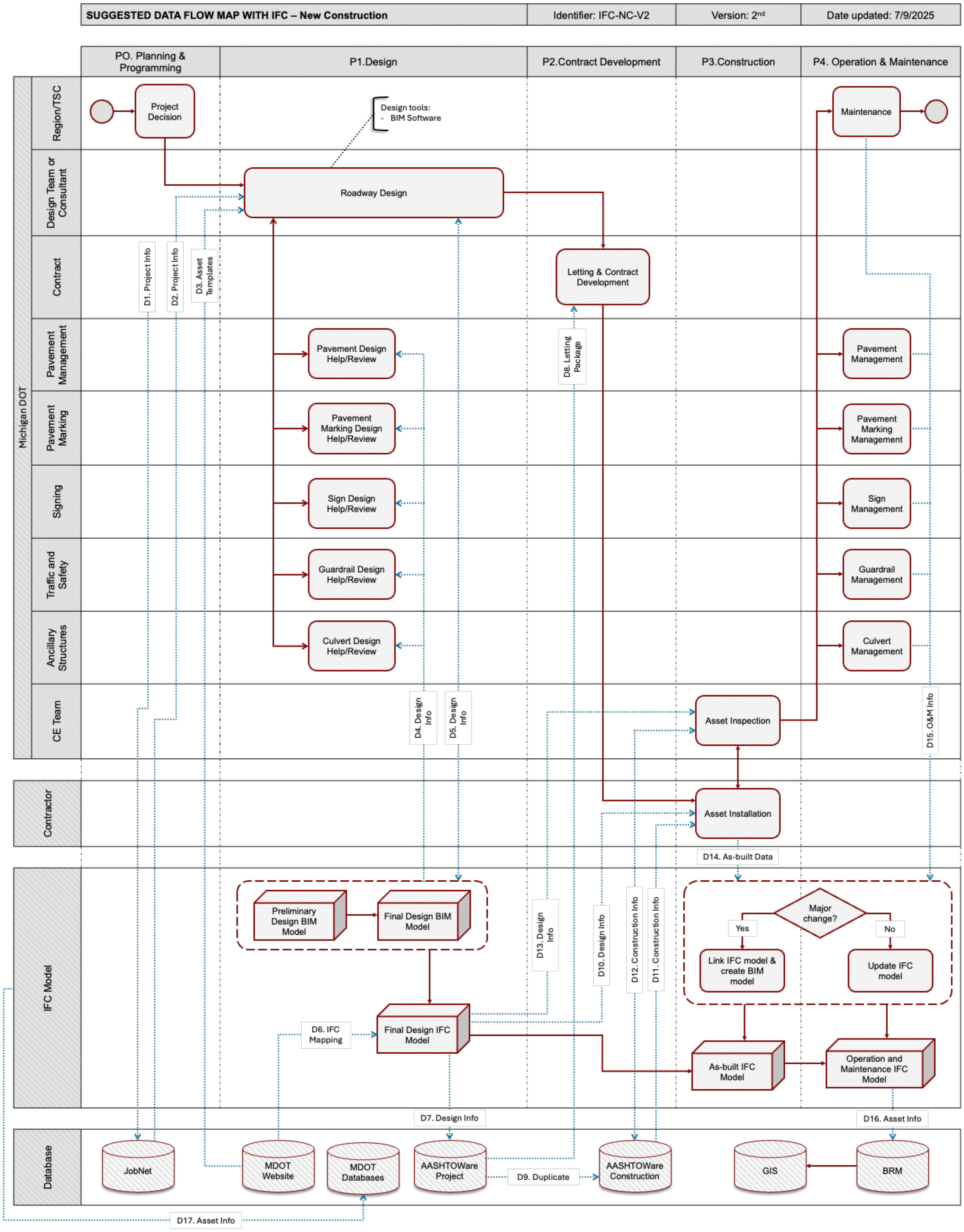

Figure 19. Data flow diagram demonstrating IFC as a digital solution for MDOT assets

This improved process map has the following actors:

- **Region/TSC:** *See previous description*
- **Design Team or Consultant:** *See previous description*
- **Contract:** *See previous description*
- **Pavement Management:** *See previous description*
- **Pavement Marking:** *See previous description*
- **Signing:** *See previous description*
- **Traffic and Safety:** *See previous description*
- **Ancillary Structures:** *See previous description*
- **CE Team:** *See previous description*
- **Contractor:** *See previous description*

This process map has the following databases:

- **IFC Model:** It is an object-oriented database including 3D visualization and asset information, where all project information is stored in a predefined structure. It is first created as a BIM model and then exported to its file format following the officially defined structure (i.e., IFC 4x3). This can be used as a centralized database and be linked to other databases. IFC model should be located in a shared location (e.g., server or cloud-based system) that is accessible to all project actors.
- **JobNet:** *See previous description*
- **MDOT Website:** *See previous description*
- **AASHTOWare Project:** *See previous description*
- **AASHTOWare Construction:** *See previous description*
- **BRM:** *See previous description*
- **GIS:** *See previous description*

This process map has the following stages:

- **P0. Planning and Programming:** A road construction project is decided by the Region/TSC. A job is then created by the Region/TSC within the JobNet database, and the project information (D1) attributes are entered. The Region/TSC decides whether the project will be designed internally or by a consultant.
- **P1. Design:** The Design team receives the project information (D2) from the JobNet database and designs the roadway project with its assets including pavements, pavement markings, signs, guardrails, and culverts by using a BIM software package and asset templates (D3) from the MDOT website. The entire design process is completed using a BIM model. First, the design team creates the preliminary design model and enters design information (D5) into the model. During the design, related MDOT offices access the model and review the design information (D4). They can provide feedback to the design team for the asset they

are dealing with. When the design is completed, the final design model is created, and it is exported to an IFC format using the IFC mapping guidelines and files (D6) from the MDOT website. Design information, including quantities (D7) are entered into the AASHTOWare Project data through an automated linkage from the IFC model.

- **P2. Contract Development:** Quantities (D8) in AASHTOWare Project and IFC models are used for bidding through the e-Bidding system. The contractor receives the letting package (D8) and gains access to the final design model (D10). The project within the AASHTOWare Project is duplicated (D9) into AASHTOWare Construction where the contractor also has read-only access.
- **P3. Construction:** When the contractor is completed with installation, CE Team inspects and approves the job using the final design model (D13) and quantity items (D12) in the AASHTOWare Construction database. When the construction is completed, the contractor enters the as-built data (D14) into IFC model, creating the as-built model. While minor changes can be applied to IFC file, it is challenging to apply major changes to the IFC file. In that case, the IFC model can be linked to BIM software and a new BIM model can be created reflecting the changes. After, this BIM model is exported to an IFC file again as an as-built model. This could be done by the contractor or design team.
- **P4. Operation & Maintenance:** After the project is handed over, the as-built model is turned into an operation and maintenance model by entering the necessary information (D15) by the related MDOT offices. Maintenance of the assets is done by the Region/TSC, and they update the IFC model by entering the information after any maintenance activities (D15). While minor changes can be applied to the IFC file, it is challenging to apply major changes to the IFC file. Similar to P3, the IFC model can be linked to BIM software and a new BIM model can be created reflecting the changes. After, this BIM model is exported to an IFC file again as an operation and maintenance model. This model may be linked to the BRM, and the data can be visualized in GIS platform, if necessary.

Utilization of IFC into MDOT's asset workflow has the following advantages:

- Any BIM software can be used (so long as it is compatible with IFC)
- There is a predefined data structure

Utilization of IFC into MDOT's asset workflow has the following disadvantages:

- There may be missing IFC classes and property sets for certain assets, if IFC does not yet officially define these assets in their classes and/or property sets.
- This process may require some manual mapping to ensure the BIM model is fully mapped to IFC, if it contains elements that are not represented in the IFC structure.
- There may be limitations if a major update is needed, resulting in turning back to BIM model and exporting the IFC file again

4.5.3 Common Data Environment (CDE)

Figure 20 demonstrates the usage of CDE as a possible digital solution to improve the data workflow process of MDOT assets. The main update in this proposed workflow is placing the CDE as a centralized platform where models (e.g., BIM and IFC) and all related project documents are stored and shared with project actors. It can also be linked to other databases, if necessary.

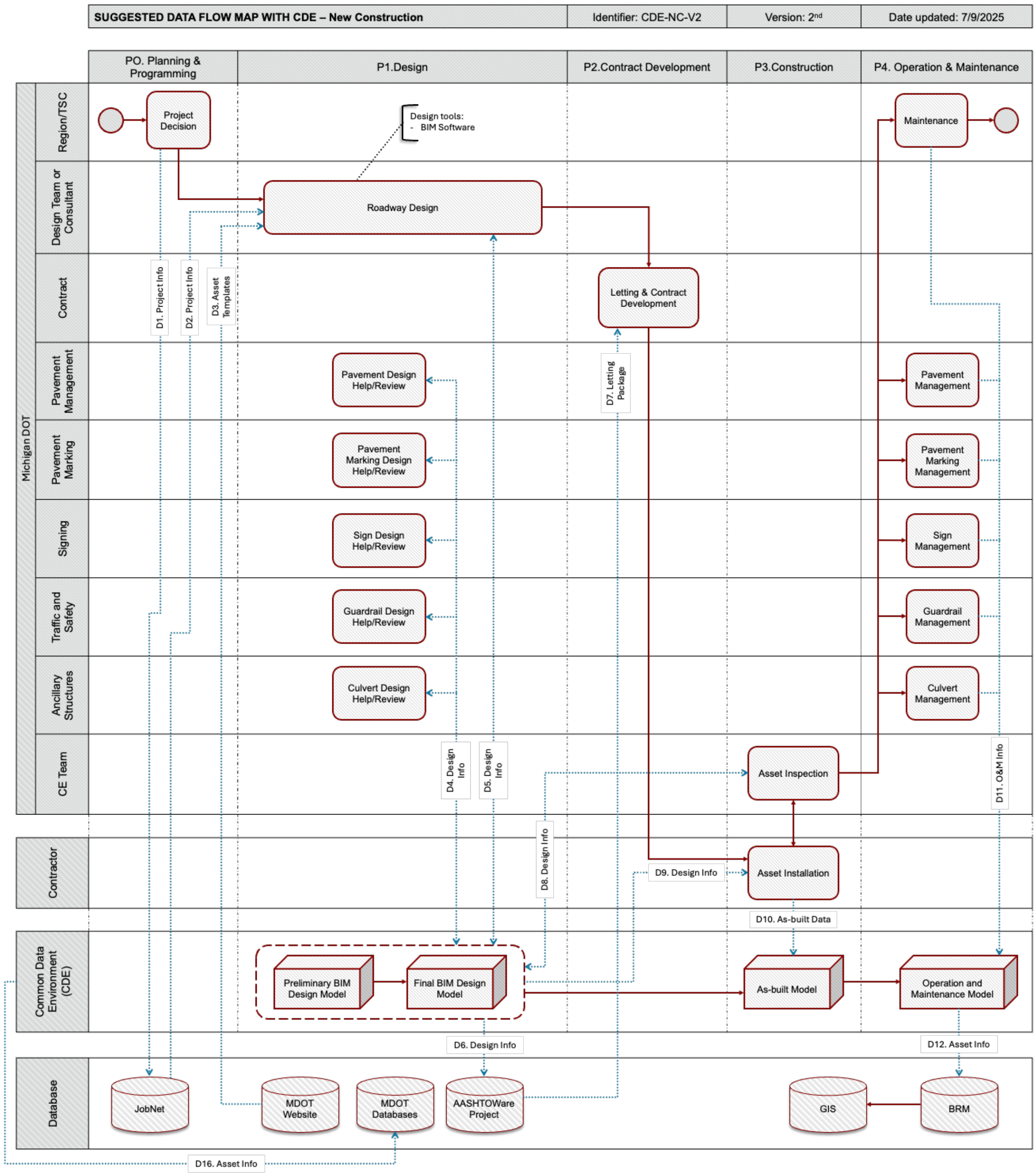

Figure 20. Data flow diagram demonstrating CDE as a digital solution for MDOT assets

This improved process map has the following actors:

- **Region/TSC:** *See previous description*
- **Design Team or Consultant:** *See previous description*

- **Contract:** *See previous description*
- **Pavement Management:** *See previous description*
- **Pavement Marking:** *See previous description*
- **Signing:** *See previous description*
- **Traffic and Safety:** *See previous description*
- **Ancillary Structures:** *See previous description*
- **CE Team:** *See previous description*
- **Contractor:** *See previous description*

This process map has the following databases:

- **CDE:** Common (or Connected) Data Environment is a centralized digital platform to store, manage, and share project-related information. It serves as a single source for all stakeholders, facilitating collaboration. Its functions can be customized with custom APIs. For example, it can be used for construction and quantity approvals for contractor payments. It can also be linked to other databases, if necessary.
- **JobNet:** *See previous description*
- **MDOT Website:** *See previous description*
- **AASHTOWare Project:** *See previous description*
- **BRM:** *See previous description*
- **GIS:** *See previous description*

This process map has the following stages:

- **P0. Planning and Programming:** A road construction project is decided by the Region/TSC. A job is then created by the Region/TSC within the JobNet database, and the project information (D1) attributes are entered. The Region/TSC decides whether the project will be designed internally or by a consultant.
- **P1. Design:** The Design team receives the project information (D2) from the JobNet database and designs the roadway project with its assets including pavements, pavement markings, signs, guardrails, and culverts by using a BIM software package and asset templates (D3) from the MDOT website. Entire design process is done on a BIM model. First, the design team creates the preliminary design model and enters design information (D5) into the model. During the design, related MDOT offices access the model and review the design information (D4). They can provide feedback to the design team for the asset they are dealing with, which is done by leaving design comments on CDE (D4). When the design is completed, the final design model is created. Design information, including quantities (D6) are entered into the AASHTOWare Project data through an automated linkage from the CDE. Alternatively, this last step can be skipped, and the model can be used directly.

- **P2. Contract Development:** Quantities (D7) in AASHTOWare Project are used for bidding through the e-Bidding system. The contractor that won the bid receives the letting package (D7) and gains access to CDE including the final design model (D9).
- **P3. Construction:** When the contractor is completed with installation, CE Team inspects and approves the job using the final design model (D8) and quantity items (D8) in the CDE. When the construction is completed, the contractor enters the as-built data (D10) into BIM model, creating the as-built model.
- **P4. Operation & Maintenance:** After the project is handed over, the as-built model is turned into an operation and maintenance model by entering the necessary information (D11) by the related MDOT offices. Maintenance of the assets is done by the Region/TSC, and they update the model by entering the information after any maintenance activities occur (D11). CDE and/or the models may be linked to the BRM, and the data can be visualized in GIS platform, if necessary.

Utilization of CDE into MDOT's asset workflow has the following advantages:

- BIM Authoring Software
- Improved collaboration between project stakeholders may result
- The CDE platform can be improved with the use of custom APIs that are developed for specific purposes of clients and projects

Utilization of CDE into MDOT's asset workflow has the following disadvantages:

- There may be limitations to platform selected.

5. CASE STUDY

This section presents a case study that demonstrates how a road project with multiple assets (e.g., pavement, pavement marking, sign, culvert, guardrail) can be represented in the IFC structure. The demonstration also shows how the IFC structure can be used as a database for a pavement asset with the attributes of the PHD database used by MDOT.

5.1 IFC for a Road Project

IFC has multiple versions. For this case study, the latest version at the time of the project completion, IFC 4x3, is used. IFC structure includes many classes to represent an entire project. These classes can be for an element, space, spatial element, attribute, information, or relationships. To define the IFC structure and classes, official documents released by BuildingSmart are used [87].

To represent a road project, two main IFC classes are used in its hierarchical structure:

- **IfcElement:** An element is a generalization of all components that make up a facility [88]. For example, IfcPavement is an element to represent a pavement asset.
- **IfcSpatialElement:** A spatial element is the generalization of all spatial elements that might be used to define a spatial structure or to define spatial zones [89]. For example, IfcRoad represents a spatial structure of a road with multiple elements and spatial elements. Figure 21 illustrates the spatial structure element composition.

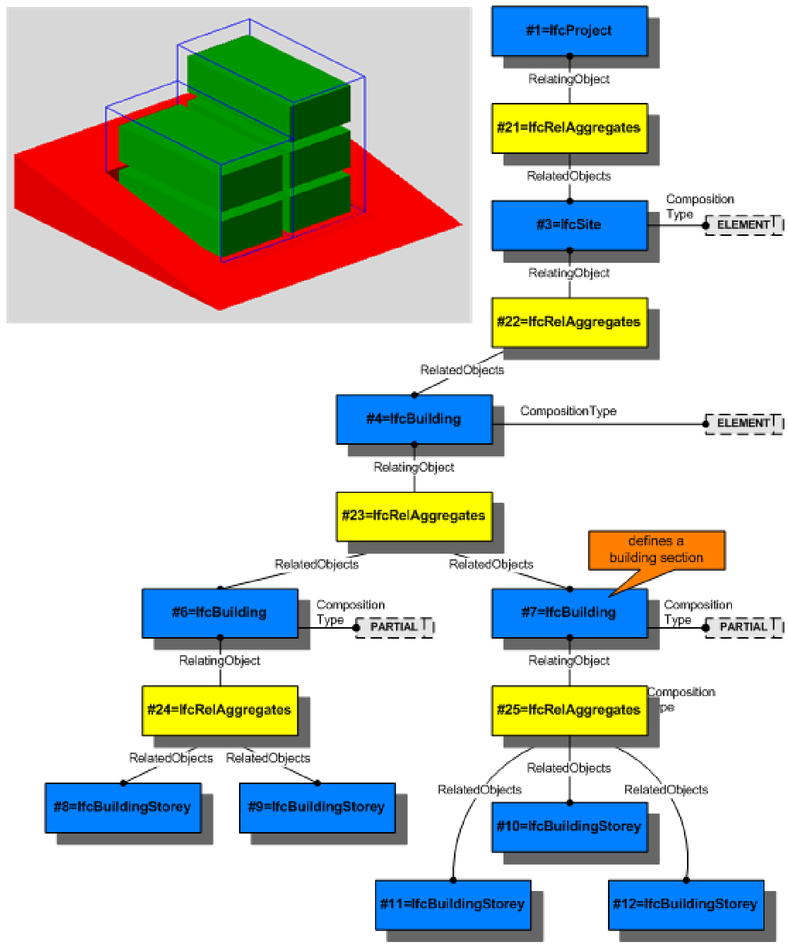

Figure 21. Spatial structure element composition [90]

Besides the elements and spatial elements, two main relationship classes are used to define the relations between elements and spatial elements:

- **IfcRelContainedInSpatialStructure:** This objectified relationship is used to assign elements to a certain level of the spatial project structure [91].
- **IfcRelAggregates:** The aggregation relationship is a special type of general composition/decomposition (or whole/part) relationship [92].

These above defined classes can be visualized as toys stored in boxes (Figure 22). Different kinds of boxes represent spatial elements, while toys themselves represent elements. When an element is inside one of the boxes, this relationship is defined by *IfcRelContainedInSpatialStructure* class. If an element or spatial element aggregates to their same type (e.g., a big box containing multiple small boxes), this relationship is defined by I*fcRelAggregates* class.

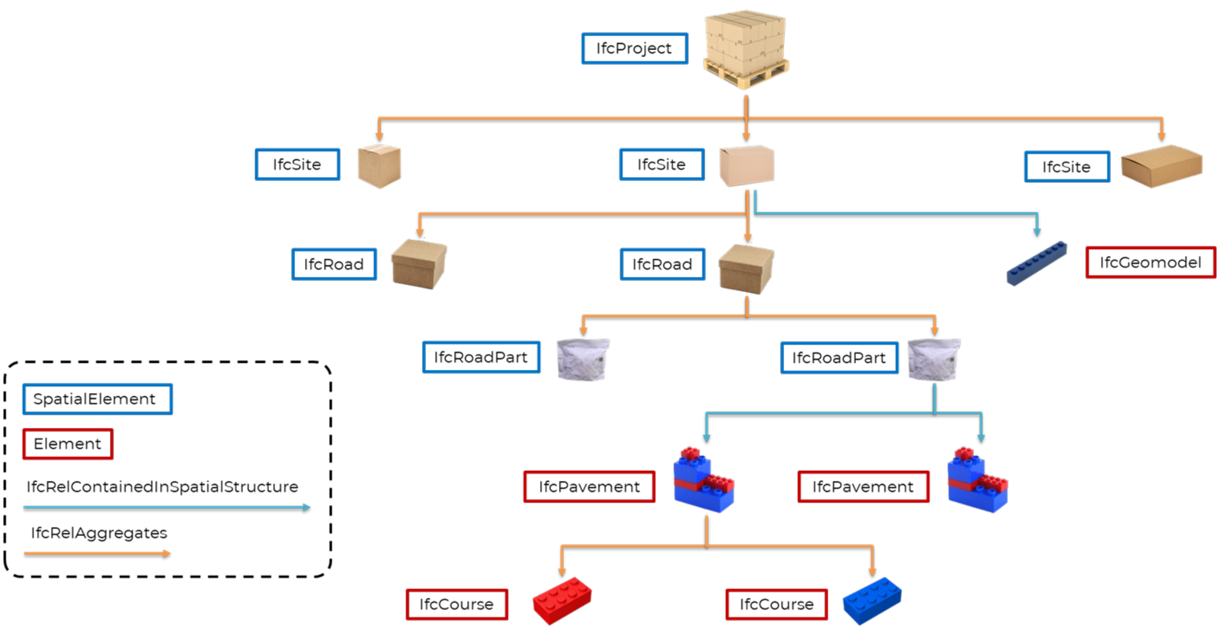

Figure 22. Representation of IFC Classes with Example

Next, the IFC structure is explained for a road project by focusing on a pavement asset from top to bottom. Through referring the BuildingSmart documentations for *IfcRoad* [93-95], the hierarchical IFC structure is illustrated in Figure 23.

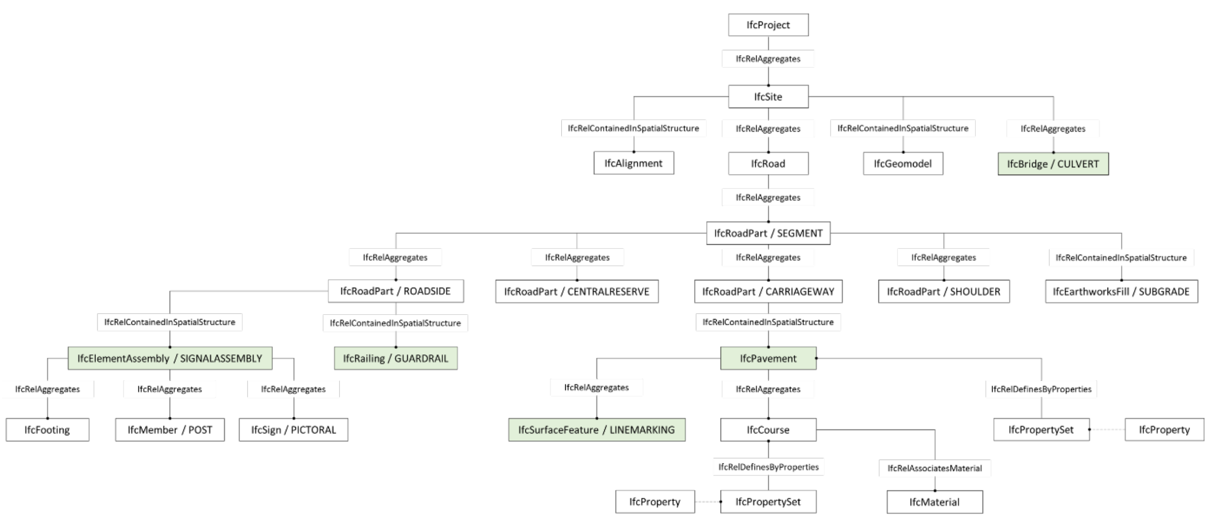

Figure 23. IFC Structure of a Road Project

First, the project is represented by *IfcProject* class which is a spatial element. A project may include one or more than one site represented by the *IfcSite* class which is also a spatial element. Since this is an aggregation, the relation between the project and site(s) is defined by *IfcRelAggregates* class. Similarly, a site in a project may include more than one road which is represented by *IfcRoad* class (spatial element). Figure 24 shows a visualization for this hierarchy. In addition to roads, a site can also include elements such as geographical map(s) represented by *IfcGeoModel* and road alignment represented by *IfcAlignment*. Since these are element in a spatial element, the relationship is defined by

IfcContainedInSpatialStructure class. If the site includes a culvert structure, this is defined under *IfcBridge* class (spatial element) which needs to be related to the site with *IfcRelAggregates* class.

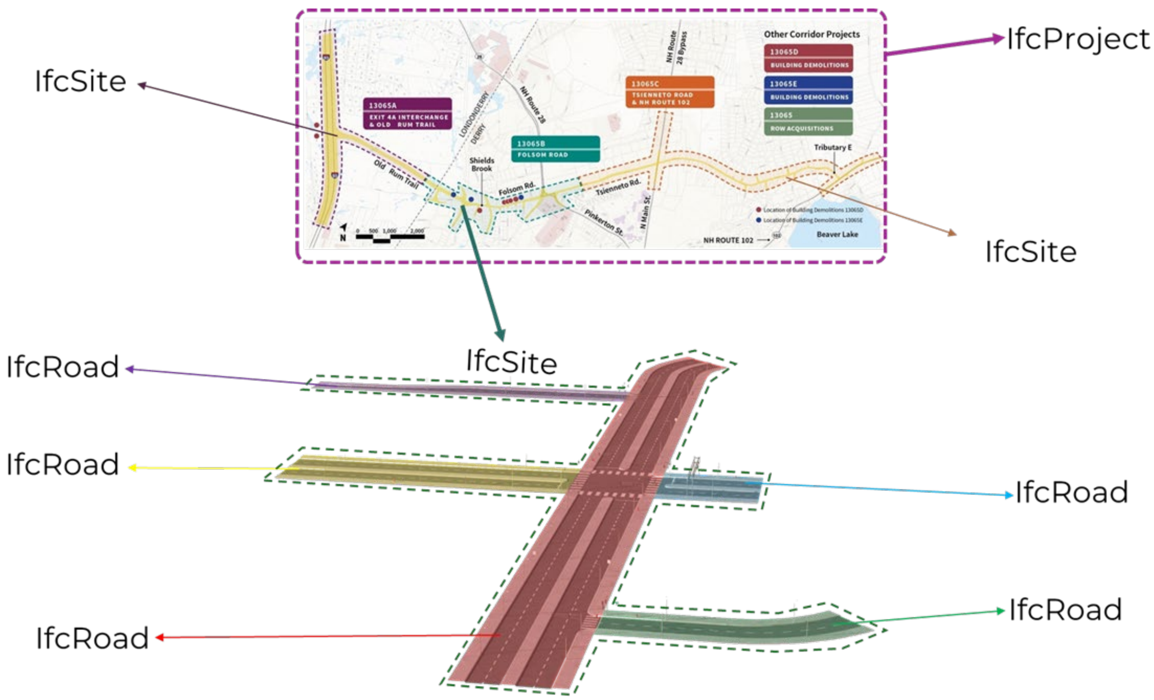

Figure 24. IFC Hierarchy between IfcProject, IfcSite, and IfcRoad

Each road is first divided into longitudinal sections represented by *IfcRoadPart* class (spatial element) with a type of ROADSEGMENT (Figure 25). These longitudinal sections consist of different lateral road parts as *IfcRoadPart* class with different types such as *ROADSIDE, SIDEWALK, SHOULDER, and CARRIAGEWAY*. It may also include earthwork filling represented by *IfcEarthworksFill* class (element). While the pavement is mostly included in shoulder and carriageway, sign and guardrail assets are included in roadside by using the relation class of *IfcRelContainedInSpatialStructure*. Guardrails are represented by *IfcRailing* class (element) with type of GUARDRAIL. Since signs are the combination of footing, post, and sign itself, they are represented by an assembly class, *IfcElementAssembly* with type of *SIGNALASSEMBLY*. This assembly class has relations with its components defined by *IfcRelAggregates* class.The footing is represented by *IfcFooting*, the post is represented by *IfcMember* with type of *POST*, and sign itself is represented by *IfcSign* with type of *PICTORAL*.

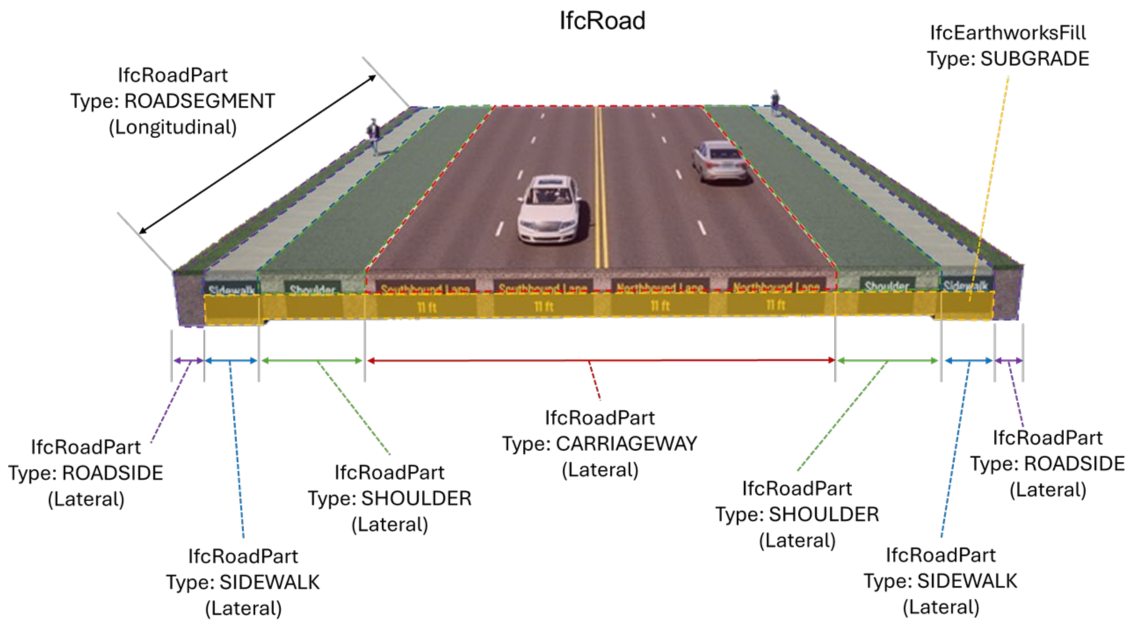

Figure 25. Structure of IfcRoad

Each lane and shoulder in road structure includes a pavement system with multiple layers (Figure 26). Pavements are represented by *IfcPavement* class. They aggregate to different layers using *IfcRelAggregates*. Each layer is represented by *IfcCourse* class with type of PAVEMENT. They are related to a material, represented as *IfcMaterial*, which depends on the layer type. The relationship is built by the *IfcRelAssociatesMaterial* class. In addition, multiple properties under different property sets can be linked to a pavement, layer, or material using the *IfcRelDefinesByProperties* class. Each property is represented by *IfcProperty* and they assigned a property set represented by the *IfcPropertySet* class. In addition, pavement marking assets are defined as an aggregation of the pavement. They are represented by *IfcSurfaceFeature* with type of *LINEMARKING* by relating them to a pavement with *IfcRelAggregates* class.

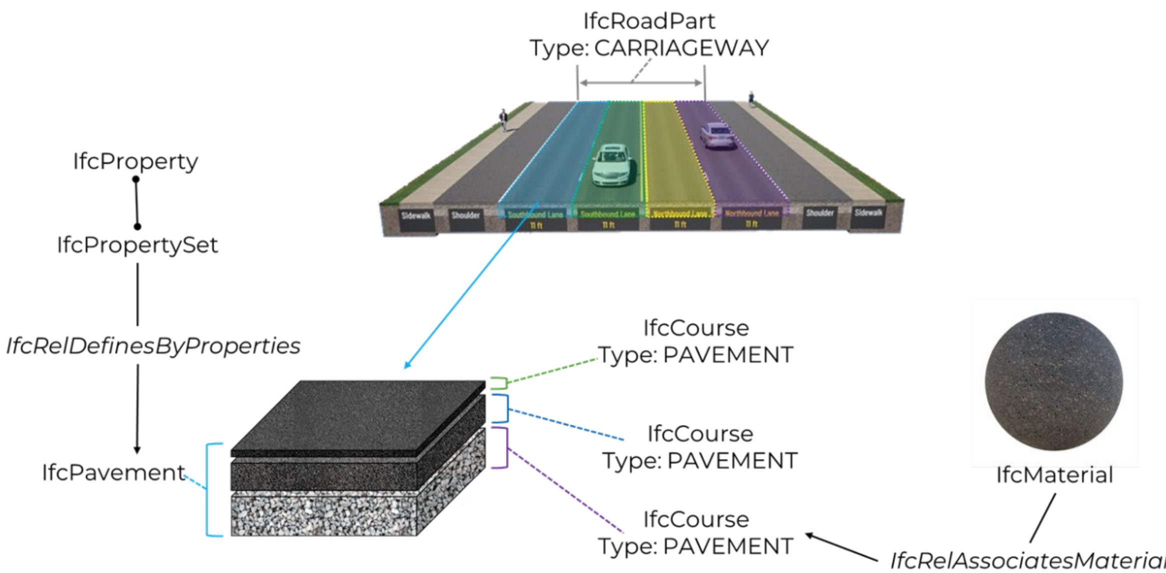

Figure 26. Structure of IfcPavement

5.2 IFC Properties for Pavement Asset

Currently, MDOT stores information related to their pavement assets in the PHD database. There are 231 attributes for MDOT's pavement assets. To represent these attributes in the IFC structure, predefined property sets with properties can be used. If there is no predefined property for any of the PHD attributes, custom property sets can be created and linked to pavement assets. To find the related predefined property sets, *IfcPavement*, *IfcCourse, IfcMaterial, IfcRoad*, and *IfcRoadPart* classes were examined.

Figure 27 shows the related property sets and class attributes of *IfcPavement* and *IfcCourse*. There are 29 property sets with 192 properties, including 3 quantity sets with 19 quantities.

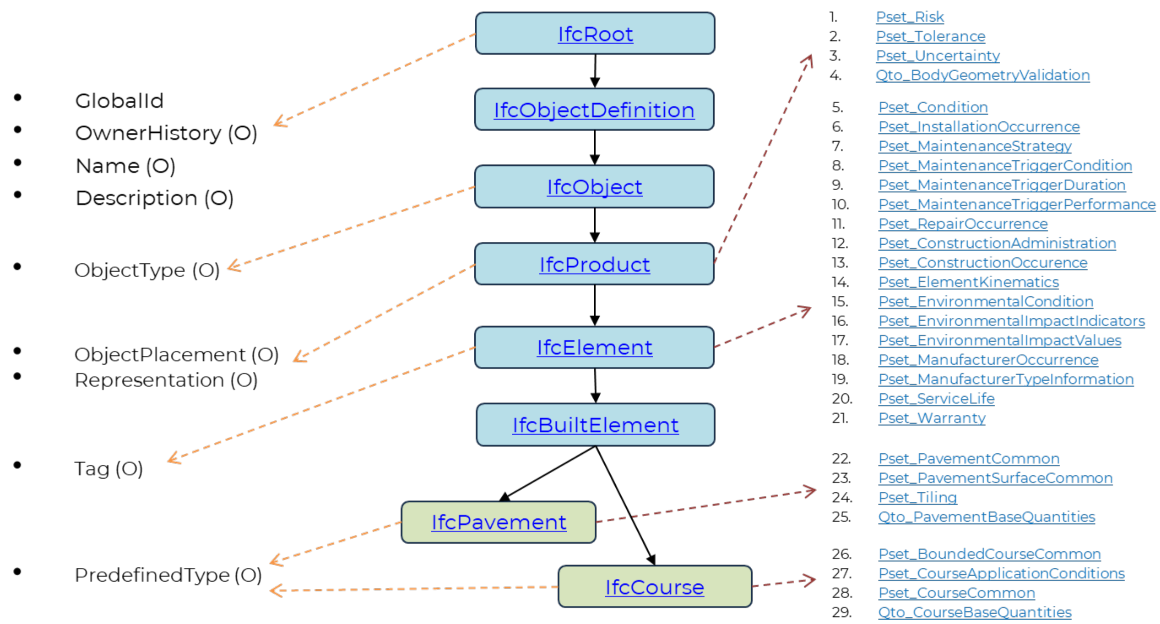

Figure 27. Property Sets and Attributes of IfcPavement and IfcCourse

Figure 28 shows the related property sets and class attributes of *IfcMaterial*. There are 19 property sets with 153 properties.

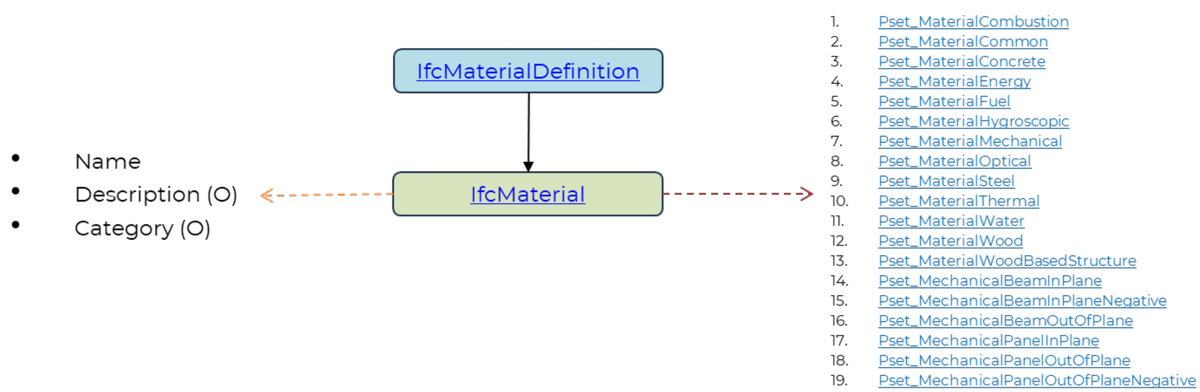

Figure 28. Property Sets and Attributes of IfcMaterial

Figure 29 shows the related property sets and class attributes of *IfcRoad* and *IfcRoadPart*. There are 19 property sets with 198 properties, including 2 quantity sets with 11 quantities. Since *IfcRoad* and *IfcRoadPart* includes similar super classes as *IfcPavement* and *IfcCourse*, they share 3 property sets with 39 quantities and 1 quantity set with 6 quantities.

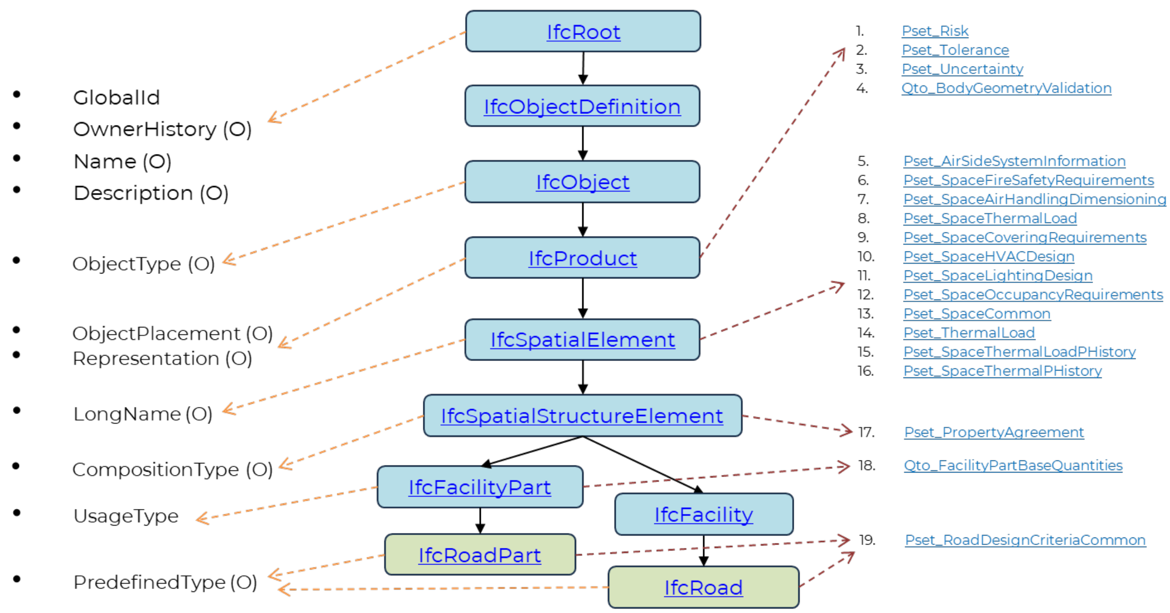

Figure 29. Property Sets and Attributes of IfcRoad and IfcRoadPart

Totally, there are 63 property sets with 498 properties (see Appendix IX). When these properties matched with the PHD properties, only 20 of them can be mapped properly. For the remaining 211 properties, custom property sets need to be created. Figure 30 shows an example for mapped PHD properties and IFC properties (see Appendix IX).

		Field Name	Property/Quantity Set	#*	Name	Property Type	Data Type
Segment		Route	MDOT_Segment	C	Route	IfcPropertySingleValue	IfcLabel
		PR #	MDOT_Segment	C	PRNumber	IfcPropertySingleValue	IfcLabel
		PR BMP	MDOT_Segment	C	PRBMP	IfcPropertySingleValue	IfcLabel
		PR EMP	MDOT_Segment	C	PREMP	IfcPropertySingleValue	IfcLabel
		Begin Station	MDOT_Segment	C	BeginStation	IfcPropertySingleValue	IfcLabel
		End Station	MDOT_Segment	C	EndStation	IfcPropertySingleValue	IfcLabel
Median		Medain Type	MDOT_Median	C	MedainType	IfcPropertyEnumeratedValue	IfcLabel
		Median Width (ft)	MDOT_Median	C	MedianWidth	IfcPropertySingleValue	IfcPositiveLengthMeasure
Lane		Lane #	MDOT_Lane	C	LaneNumber	IfcPropertySingleValue	IfcInteger
		Surface Type	MDOT_Lane	C	SurfaceType	IfcPropertyEnumeratedValue	IfcLabel
		Lane Width (ft)	Pset_RoadDesignCriteriaCommon	496	LaneWidth	IfcPropertySingleValue	IfcPositiveLengthMeasure
		Lane Type	MDOT_Lane	C	LaneType	IfcPropertyEnumeratedValue	IfcLabel
		Year Paved/Placed	Pset_ConstructionOccurence	80	InstallationDate	IfcPropertySingleValue	IfcDate
		Partial Width Paving	MDOT_Lane	C	PartialWidthPaving	IfcPropertySingleValue	IfcBoolean
		Paving Width (ft)	Pset_PavementCommon	166	NominalWidth	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
Layer of a lane or a shoulder	Each Layer	Layer Name	MDOT_Layer	C	LayerName	IfcPropertyEnumeratedValue	IfcLabel
	Aggregate Base Course	Thickness	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
		Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
	HMA Top Course	Mix Type	MDOT_Layer	C	MixType	IfcPropertyEnumeratedValue	IfcLabel
		Mix Design No (Case Sensitive)	MDOT_Layer	C	MixDesignNo	IfcPropertyListValue	IfcLabel
		Application Rate	MDOT_Layer	C	ApplicationRate	IfcPropertyEnumeratedValue	IfcLabel
		Asphalt Binder	MDOT_Layer	C	AsphaltBinder	IfcPropertyEnumeratedValue	IfcLabel
		Asphalt Binder Cert. Supplier	MDOT_Layer	C	AsphaltBinderCertSupplier	IfcPropertyEnumeratedValue	IfcLabel
		Asphalt % (Total)	MDOT_Layer	C	AsphaltPercentageTotal	IfcPropertySingleValue	IfcReal
		Asphalt Binder %Added (Virgin)	MDOT_Layer	C	AsphaltBinderPercentageAddedVirgin	IfcPropertySingleValue	IfcReal
		AWI (Actual)	MDOT_Layer	C	AWIActual	IfcPropertySingleValue	IfcReal
		Warm Mix?	MDOT_Layer	C	WarmMix	IfcPropertySingleValue	IfcBoolean
		If Warm Mix, Water Foaming?	MDOT_Layer	C	IfWarmMixWaterFoaming	IfcPropertySingleValue	IfcBoolean
		If Warm Mix, select Additive	MDOT_Layer	C	IfWarmMixSelectAdditive	IfcPropertyEnumeratedValue	IfcLabel
		Shingles used in the mix?	MDOT_Layer	C	ShinglesUsedInTheMix	IfcPropertySingleValue	IfcBoolean
		Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel

Figure 30. Example for PHD and IFC mapping

5.3 Demonstration for Pavement Asset

This section presents a demonstration of how the IFC structure can be used for an MDOT pavement asset created in Bentley OpenRoads software. The IFC file was modified using *Blender 4.2.8* software with the *Bonsai 0.8.1* add-on. As an IFC viewer, *Open IFC Viewer 25.3.0* was used.

First, a pavement was created, and was exported as an IFC file using "Corridor to IFC" button in OpenRoads (Figure 31). It can be exported to different IFC versions (i.e., IFC2x3, IFC4, IFC4x3). Even if it is exported to older versions, it can be upgraded to a more recent version such as IFC4x3 which is suitable for a road project and its assets such as pavement.

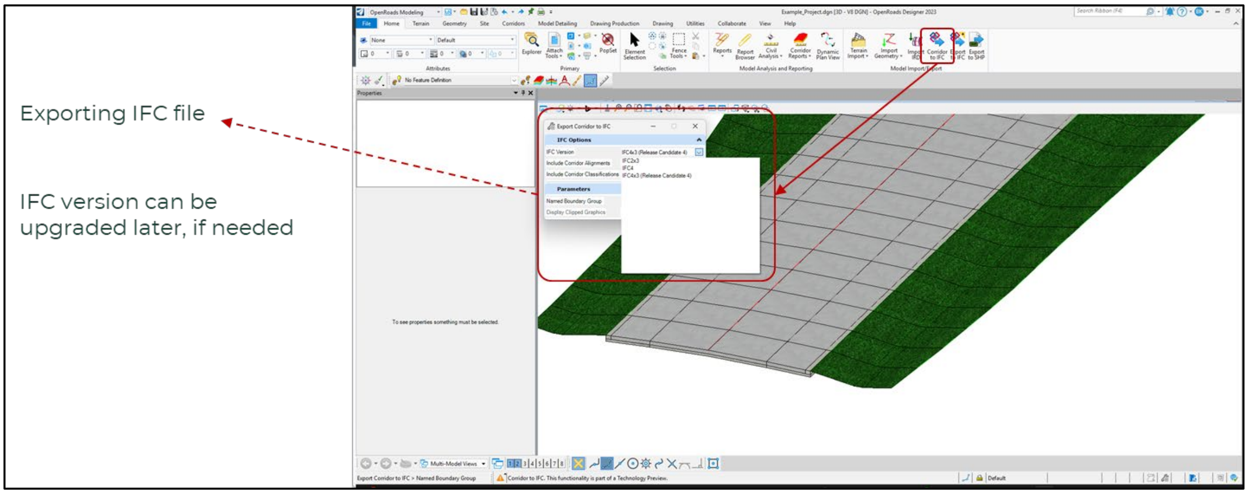

Figure 31. Exporting IFC file from OpenRoads

The exported IFC file was then opened in the *Blender* software (Figure 32), upgrading it to IFC4x3, if applicable.

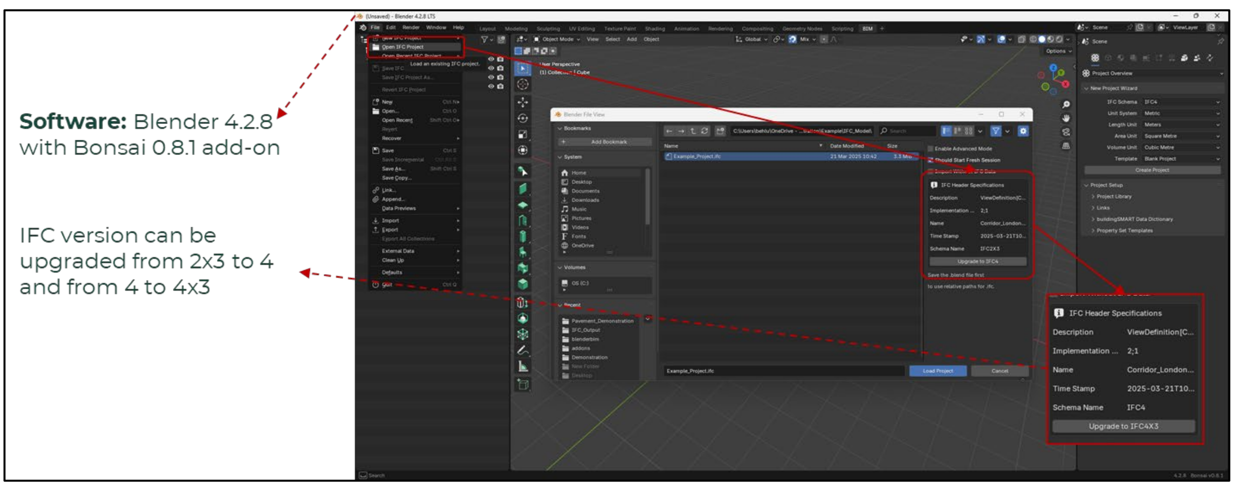

Figure 32. Opening IFC file to modify in Blender

Spatial structures such as *IfcRoad* and *IfcRoadPart* can be created under the Spatial Decomposition tab (Figure 33) in Blender. An *IfcRoad* was created with name of “Road_1” (Figure 34).

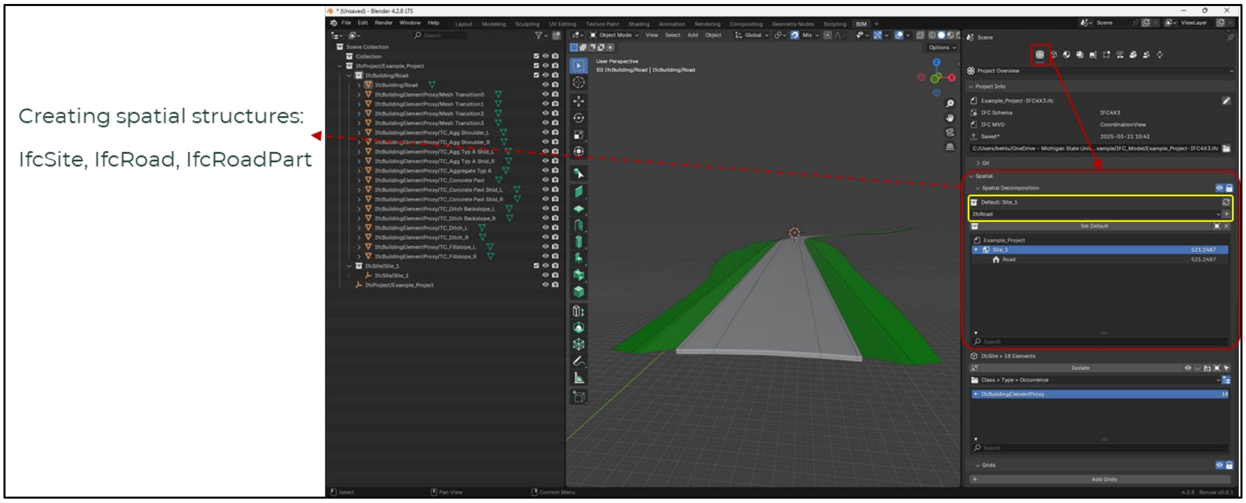

Figure 33. Spatial structures created under the Special Decomposition tab

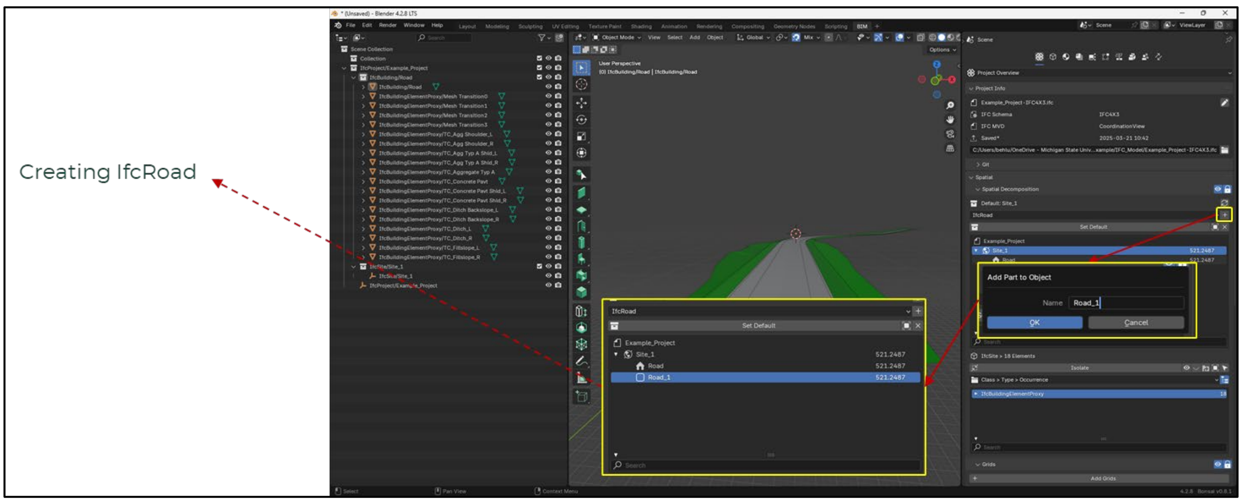

Figure 34. Creating IfcRoad

All elements related to Road_1 were then assigned to it (Figure 35).

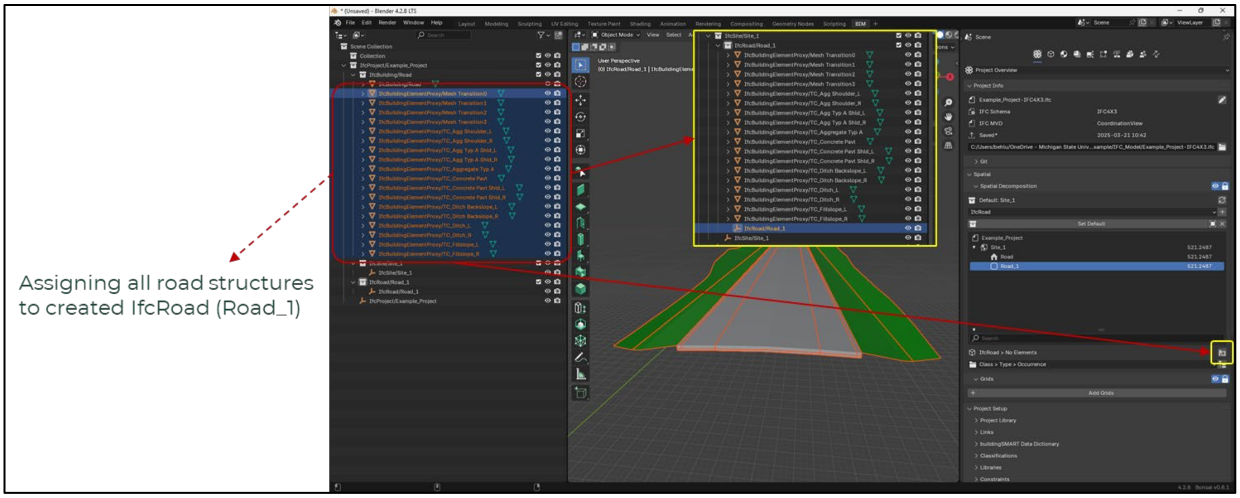

Figure 35. Assigning elements to Road_1

If there are any unused spatial structures created after the IFC export from OpenRoads, they can be deleted in Blender, as shown in Figure 36.

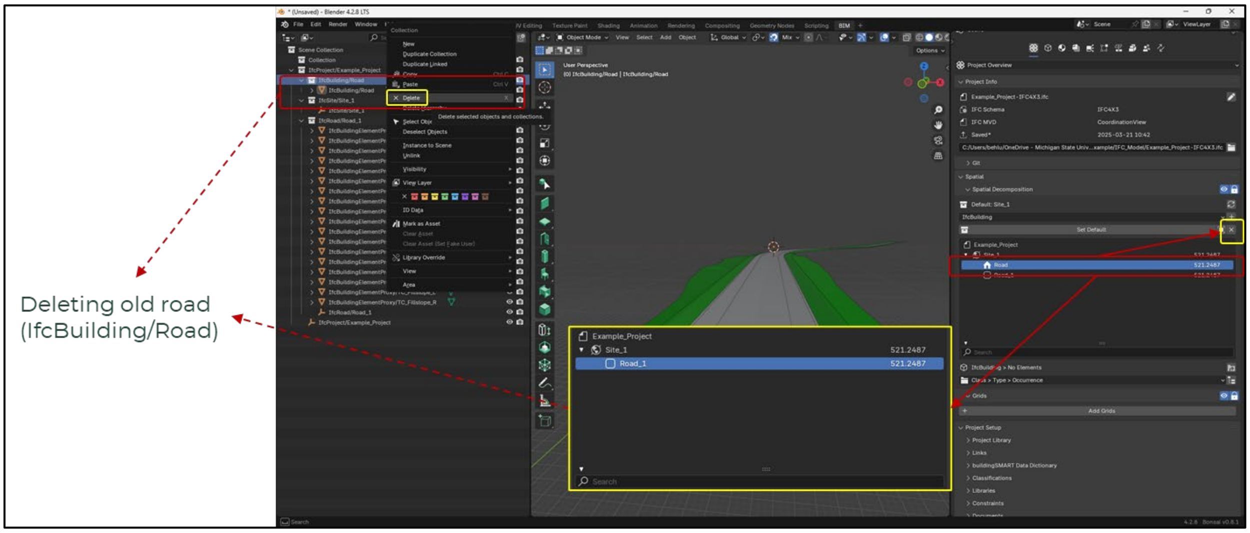

Figure 36. Deleting unused spatial structures

When a new spatial structure is created, its relation, if any, with other spatial structures needs to be defined under Aggregate Decorator tab (Figure 37). For example the created Road_1 (*IfcRoad*) was aggregated from *IfcSite*.

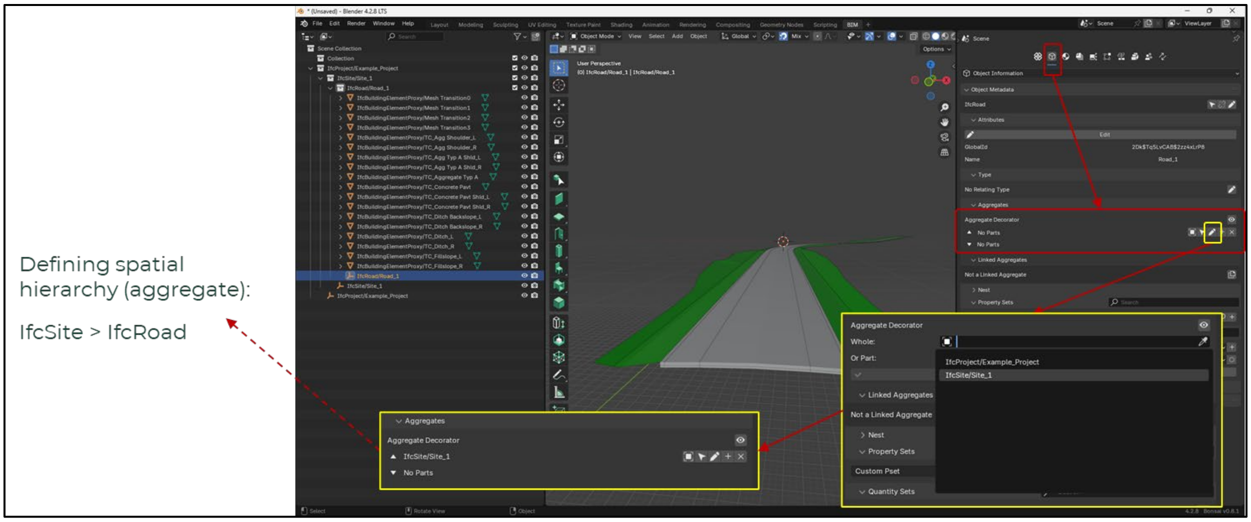

Figure 37. Defining aggregation among spatial structures

Each road is then divided into longitudinal parts as segments and then lateral parts. For example, a longitudinal road segment was created as Segment_1 (*IfcRoadPart*) with type of *ROADSEGMENT* as a spatial structure (Figure 38). Its relationship with Road_1 was assigned and its attributes were entered. In addition, a roadway and right and left shoulders were created, and they were assigned as an aggregation from the created Segment_1 (Figure 39).

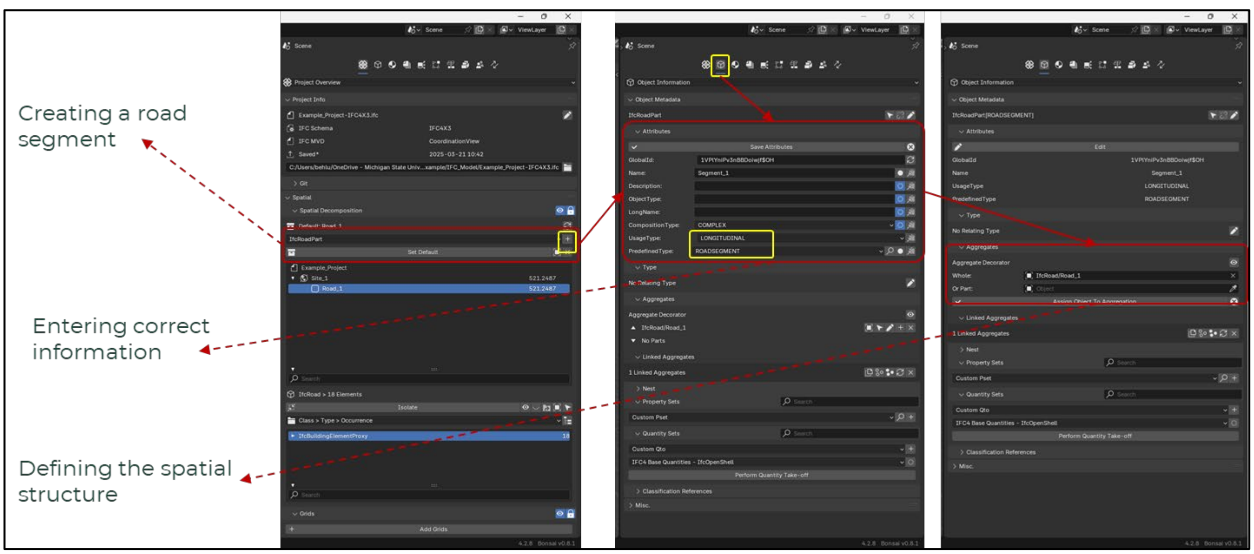

Figure 38. Creating IfcRoadPart for road segment

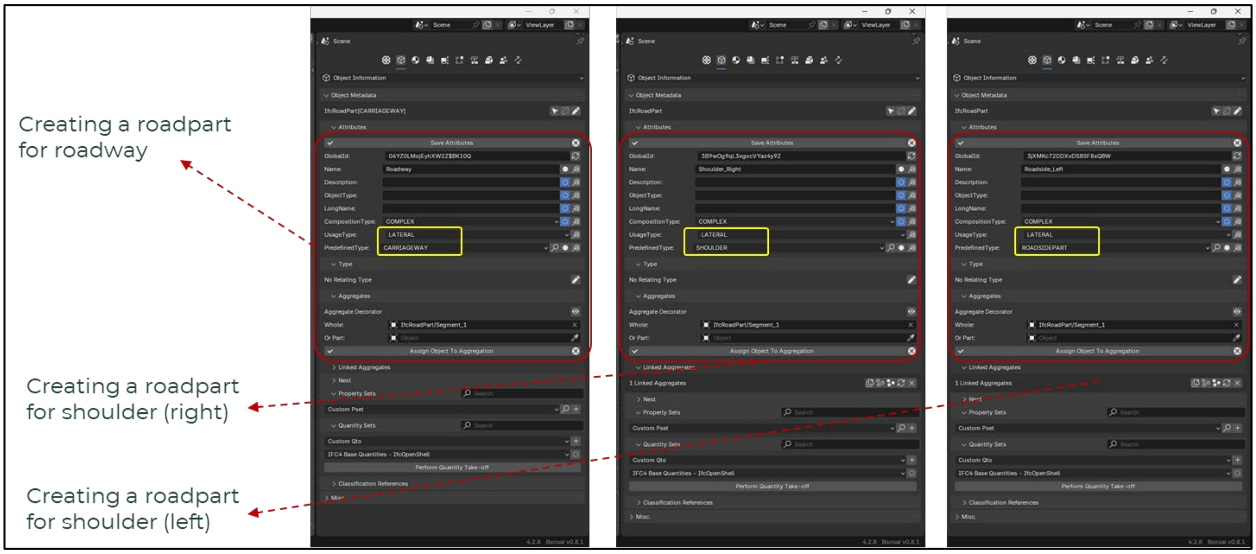

Figure 39. Creating IfcRoadPart for roadway and shoulders

In IFC 4x3 pavement layers are represented by *IfcCourse*. Therefore, all layer objects were reassigned as *IfcCourse* under Object Metadata tab (Figure 40).

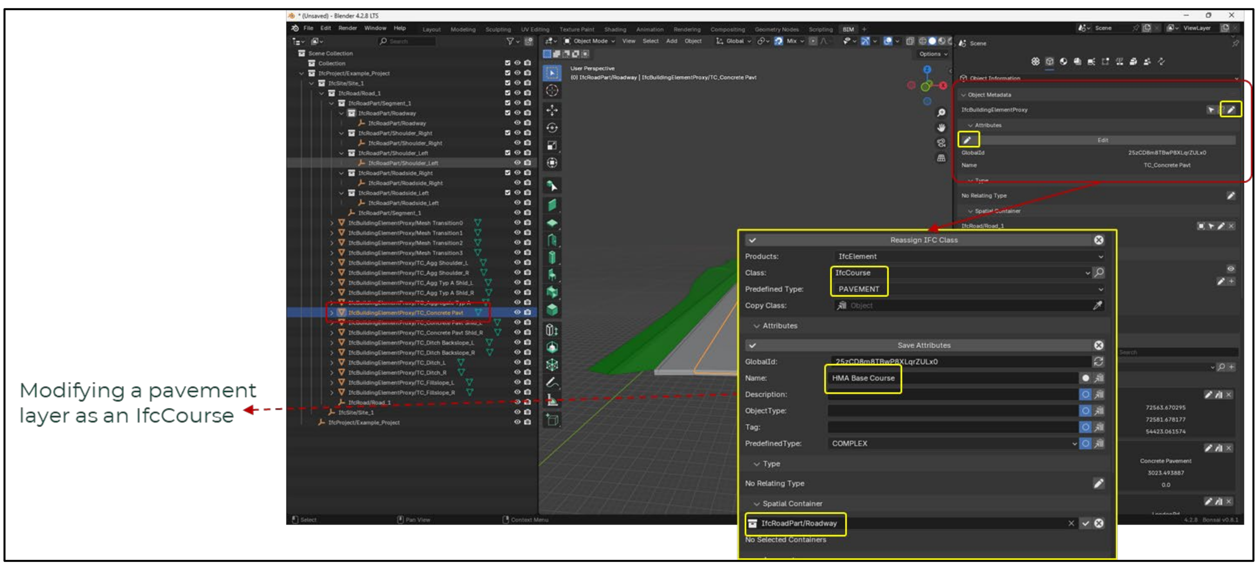

Figure 40. Reassigning pavement layer's class to IfcCourse

IfcPavement is combination of multiple layers. For the created *IfcCourse* classes, an *IfcPavement* was created as an aggregate under Aggregate Decorator tab, and their relationship was defined (Figure 41).

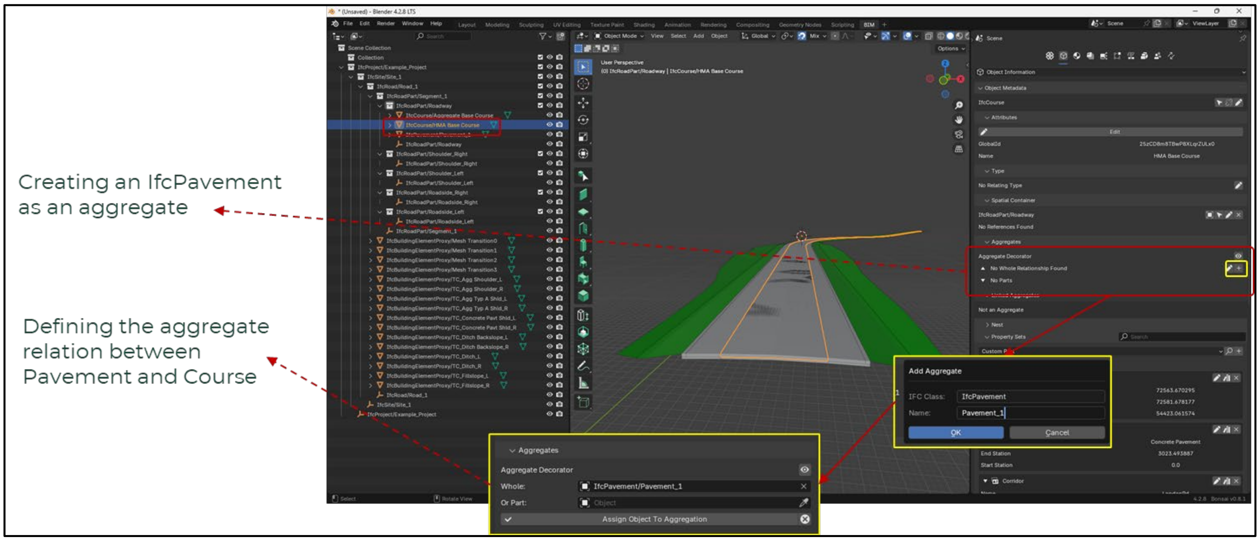

Figure 41. Creating IfcRoadPart for a road segment

Since the main purpose is storing the PHD attributes in IFC structure, these attributes were linked to pavement assets with property sets. Property sets were created under Property Set Template tab (Figure 42). For example, a template file was created with name of “MDOT”, and a property set with name of “MDOT_Layer” was created. After this, all custom properties were added with proper types (Figure 43).

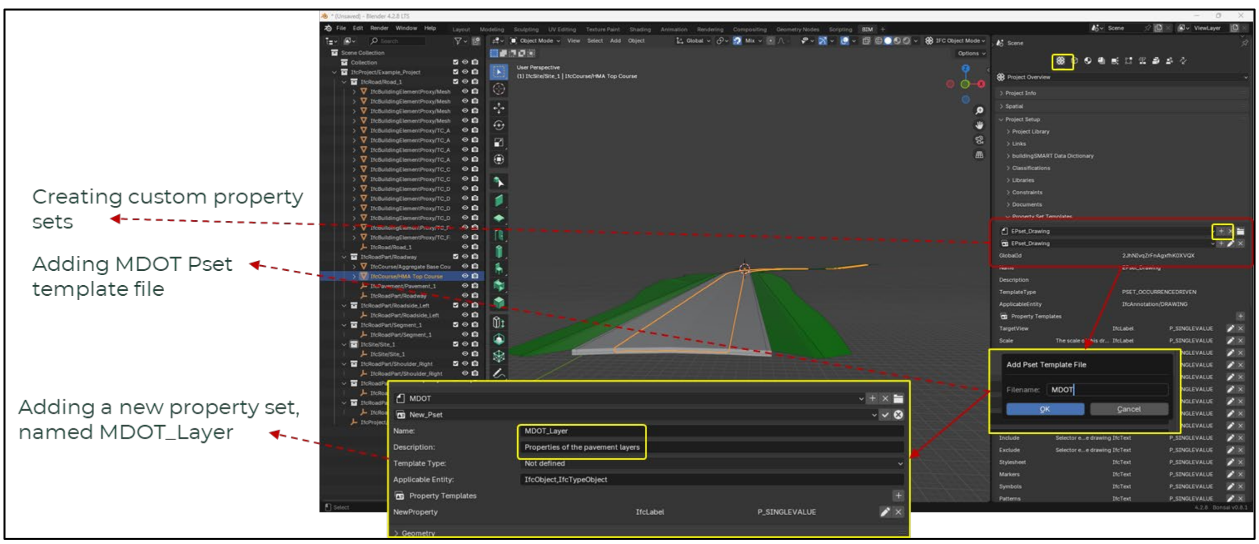

Figure 42. Creating custom property sets

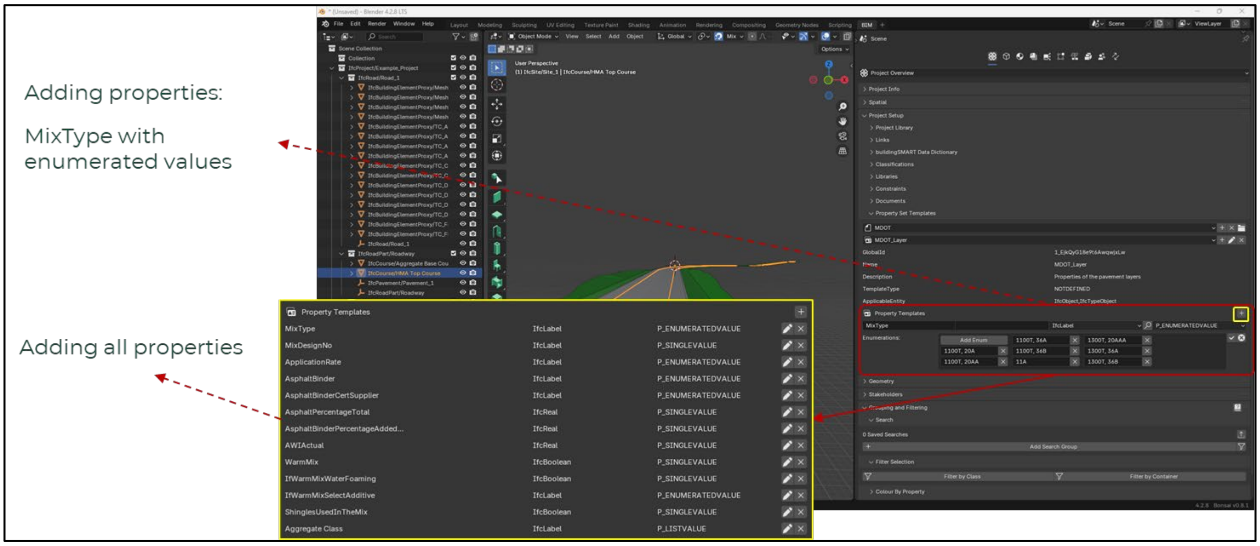

Figure 43. Adding properties

Created property sets can be assigned to any object. For example, the MDOT_Layer property set was assigned to an *IfcCourse* (Figure 44). After, property values related to the assigned pavement layer were entered (Figure 45).

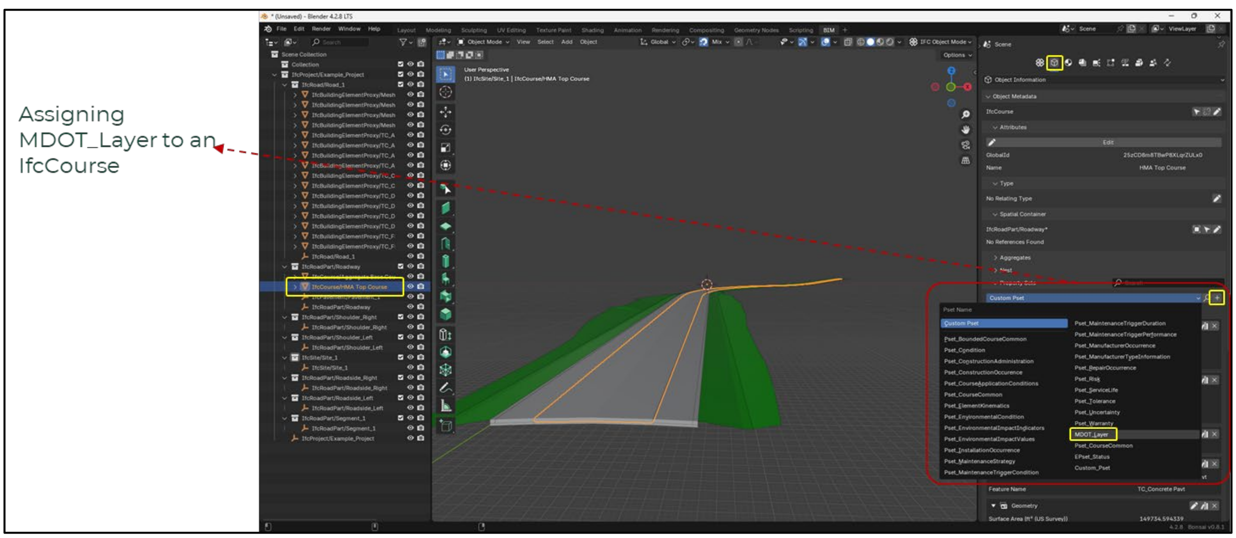

Figure 44. Assigning created property set to an object

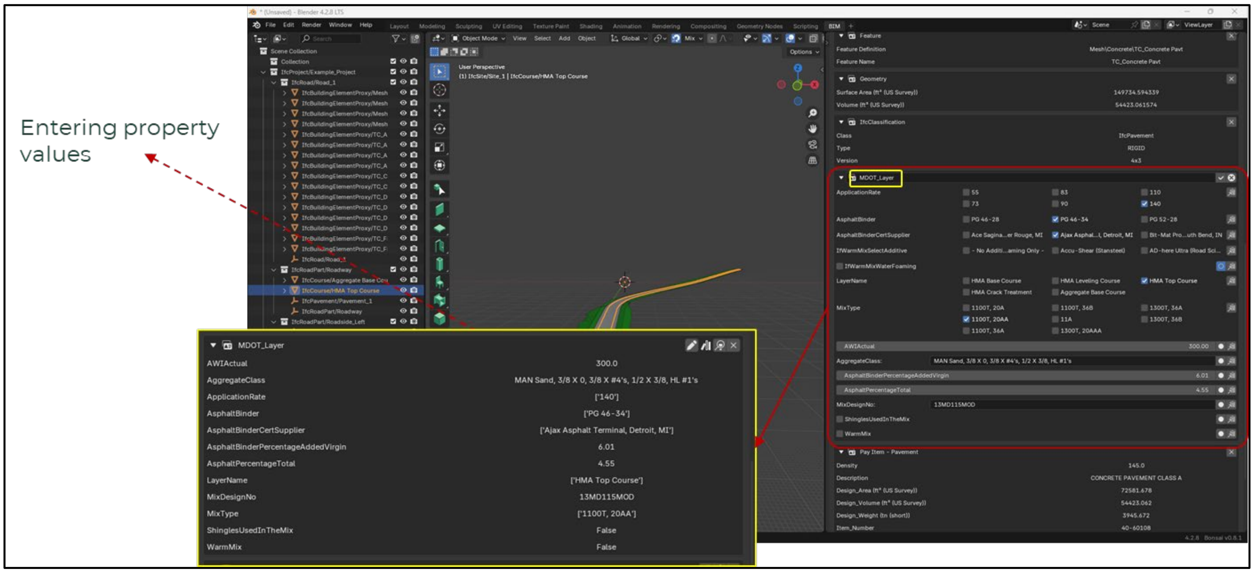

Figure 45. Entering property values to an object

For each pavement layer (*IfcCourse*), material is assigned. For example, "*HMA_Top_Course*" material was created under Material tab of the selected *IfcCourse* object (Figure 46). If necessary, any property set can also be assigned to materials.

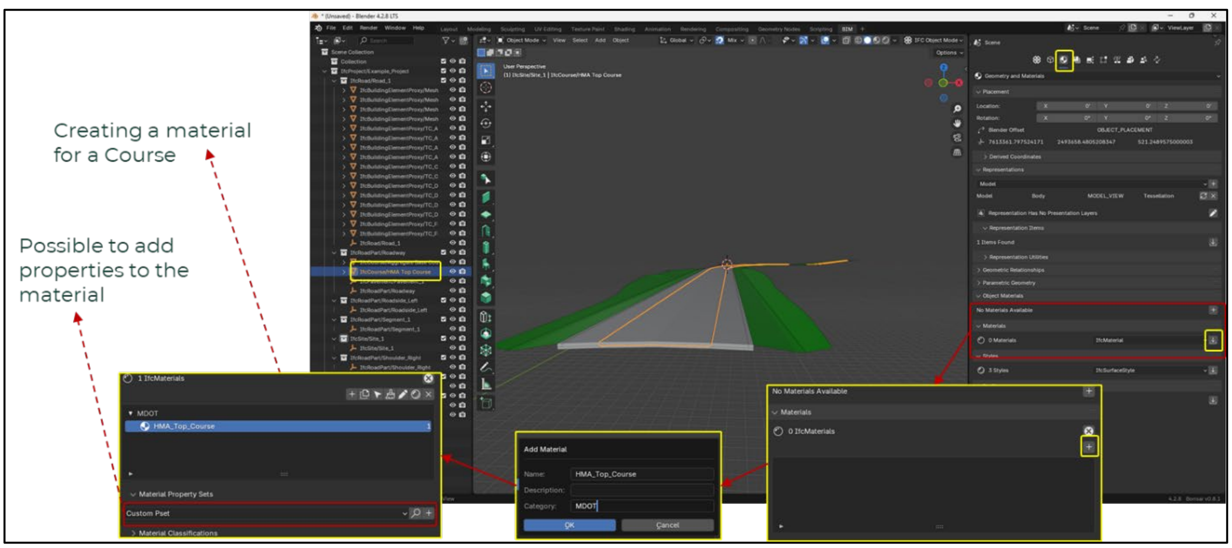

Figure 46. Creating material for the objects

Finally, when the IFC file is modified, a proper spatial hierarchy is structured with all assets (Figure 47). This IFC file can also be opened in any IFC viewer such as "Open IFC Viewer 25.3.0" (Figure 48).

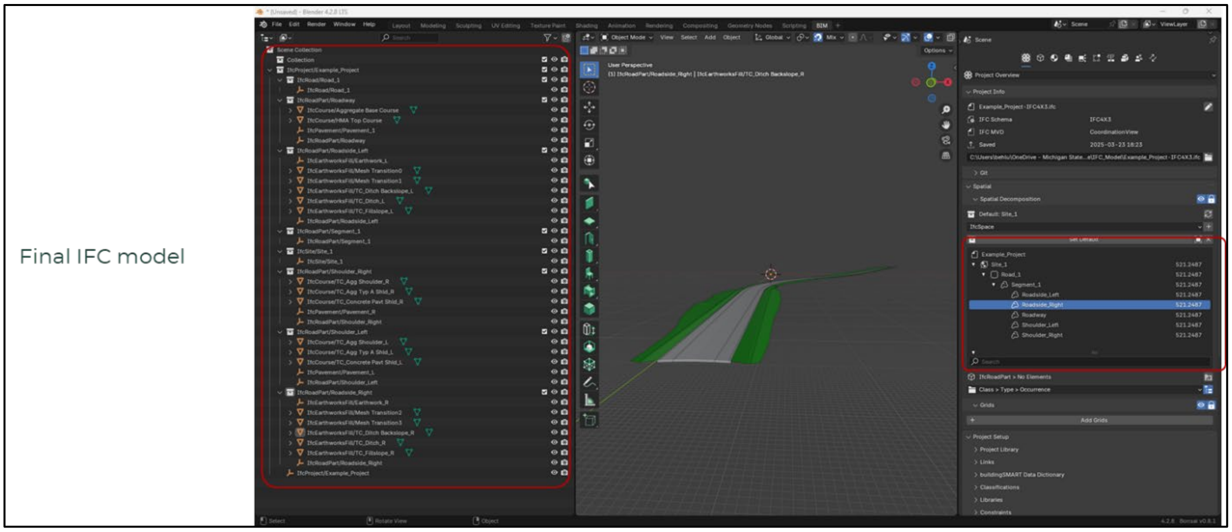

Figure 47. IFC file in Blender

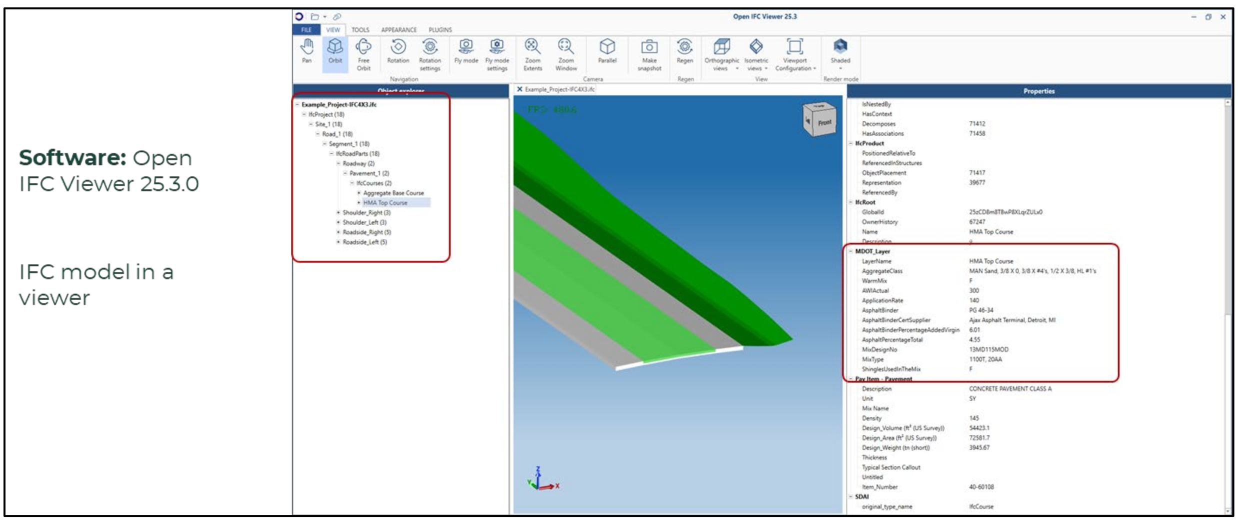

Figure 48. IFC file in IFC viewer

In the IFC viewer, selected object's IFC structure with links can be viewed (Figure 49).

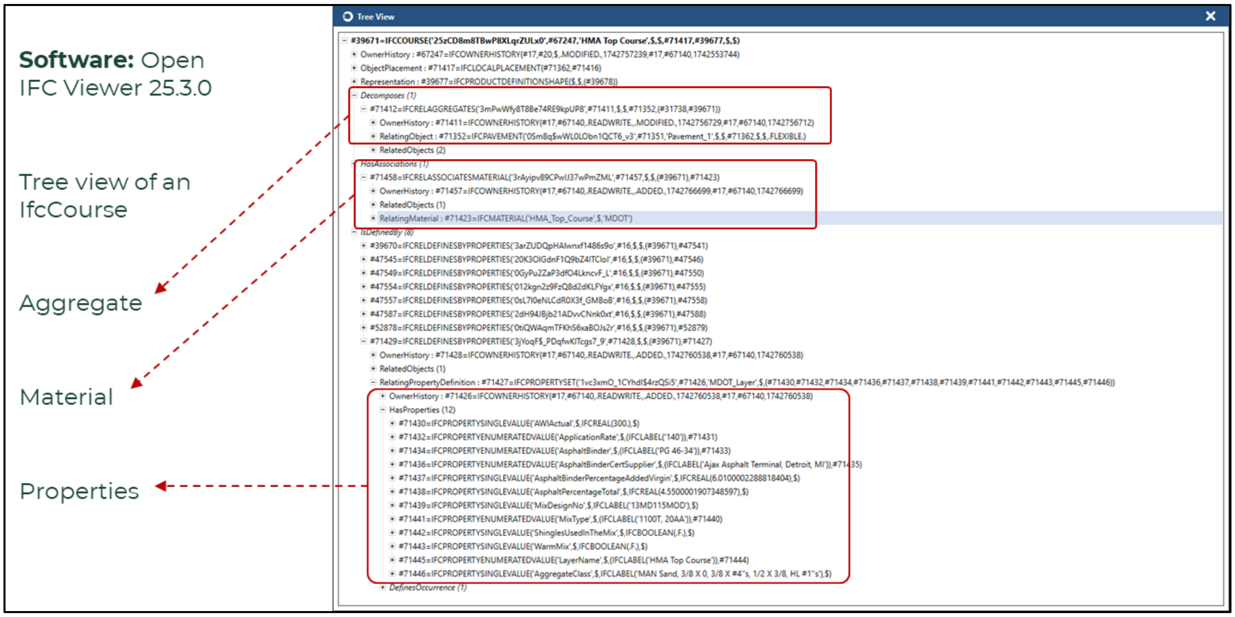

Figure 49. Tree view of an IfcCourse

If properties of objects such as pavement are to be exported to connect to any database, this can be performed under the "Quality and Coordination" tab (Figure 50). They can then be exported to the WEB module and then to a CSV file, respectively (Figure 51).

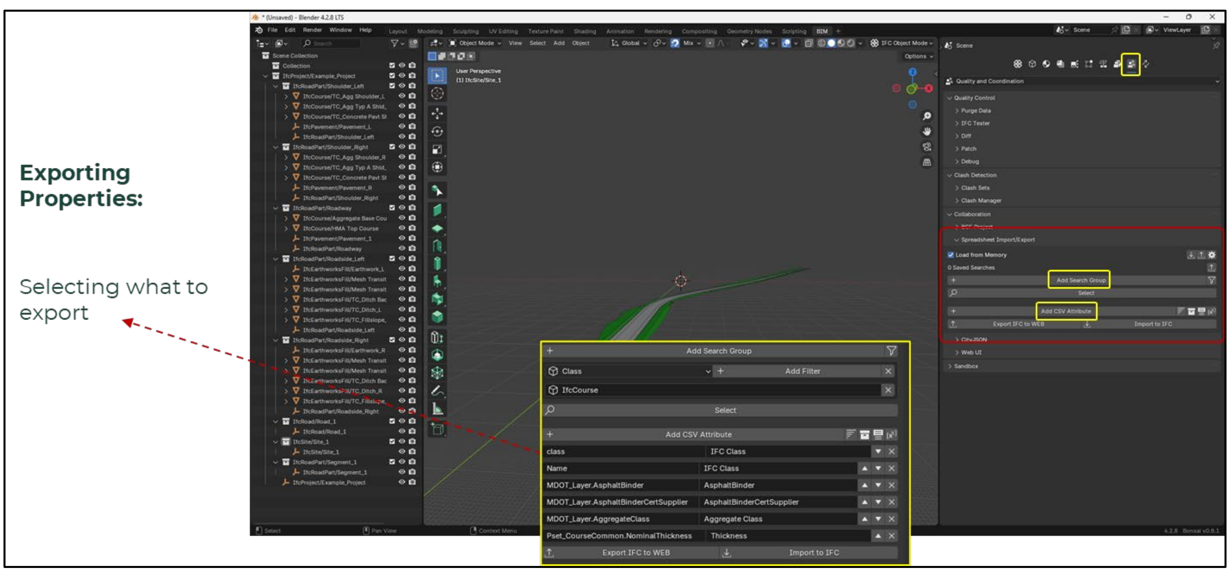

Figure 50. Selecting which properties to export

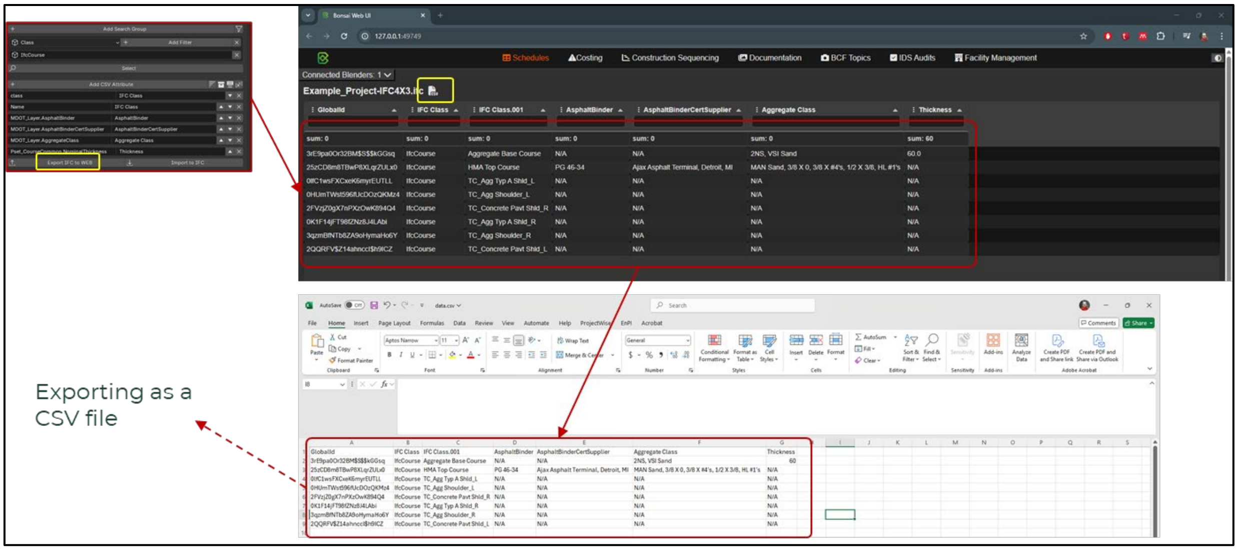

Figure 51. Exporting selected properties as a CSV file

6. CONCLUSIONS

The research conducted in this project first highlights the current methods used to create, save, organize, and exchange information on MDOT transportation assets both internally with MDOT, and externally with contractors and consultants. From the compilation of this information, it also highlights that there are inefficiencies and data management challenges within the current practices at MDOT. While there are efforts dedicated to continuous improvement of these processes, analysis also suggests that there are several opportunities to improve these processes, including reducing reliance on manual data entry and/or exchanges, and disparate database systems that contribute to operational inefficiencies, potential inaccuracies, and data continuity concerns at various stages. These challenges are identified across the studied asset types including pavements, pavement markings, signs, guardrails, and culverts.

The identified inefficiencies primarily stem from several key factors. One is the storage of asset information as textual notes within traditional drawing plans. This practice makes data retrieval more challenging, increases the likelihood of duplication errors, and requires additional manual data entry. Another is the lack of updating of asset information within databases following construction or maintenance activities, which creates information gaps that require substantial efforts to recreate, including needing field teams to survey the current state of assets to update this information. These gaps require manual interventions for corrections and updates, resulting in inefficiencies and potential error.

Analysis of the existing data workflows suggested specific points at which data continuity concerns are more common. Contractors do not necessarily enter updated or modified asset information in MDOT databases post-construction for some assets, resulting in discrepancies between field conditions and recorded data. Additionally, some databases are not connected to one another, making effective data management more challenging.

The recommended digital solutions of BIM, IFC, and CDE offer alternatives to current practices that should help to address the above-mentioned challenges. However these solutions also have their own advantages and disadvantages. BIM enables centralized digital representation of asset information, providing stakeholders with accessible, comprehensive data models throughout an asset's lifecycle. By leveraging BIM, MDOT can maintain more accurate and up-to-date data, reducing manual data entry and retrieval inefficiencies. However, using BIM requires the use of a specific software and maintaining the current version of the software across all parties which may present some challenges.

IFC adoption is a similarly beneficial option to consider. IFC addresses interoperability challenges by providing a standardized data exchange format compatible across various software applications that may be utilized by internal teams and external contractors. IFC's structured and object-oriented schema facilitates consistent data handling and substantially improves data accuracy and accessibility. The adoption of IFC standards can significantly reduce data fragmentation and enhance collaborative project delivery. However, there are also challenges to consider. IFC is still evolving, thus some software platforms may or may not be IFC compatible. In addition, some components of MDOT assets may not have any pre-defined components in the current version of the IFC schema, meaning these components must be customized in the software, which may present challenges.

The implementation of a CDE offers a unified platform for all stakeholders involved in asset management. CDE systems facilitate consistent and secure data exchange, support version control, and provide transparency across project phases, substantially improving data traceability and accountability. However, the successful deployment of CDE solutions, similar to the other options, requires strategic planning to overcome potential adoption challenges, particularly from smaller stakeholders unaccustomed to integrated digital platforms.

A case study focused on pavement asset management was then completed to demonstrate the practical applicability and benefits of these digital solutions, specifically focusing on the use of IFC. The case study demonstrated substantial improvements in data accuracy, reduced manual handling, and streamlined operational processes. It also illustrated that implementing a cohesive digital workflow can enhance MDOT's ability to manage transportation assets effectively, ensuring data continuity, accuracy, and accessibility across asset lifecycle stages. However, it also demonstrated that due to IFC still being developed, there are multiple software tools required to use to make this solution work currently, in addition to OpenRoads Designer. In addition, there are multiple steps that are required after exporting a pavement file from OpenRoads Designer, to make it fully and accurately represented in IFC. It is anticipated, however, that as IFC and other compatible software develop further, these steps will be reduced and the process simplified.

Finally, interviews were conducted with contractors involved in the construction of transportation assets throughout Michigan. Results from these interviews suggest that the transportation construction industry in Michigan does not view itself as ready for receiving only 3D models. 3D models are highly valuable for some tasks, such as surveying and automated machine guidance, but it is not seen as being as valuable for assets such as pavement markings, signs and guardrail.

In conclusion, transitioning to BIM, IFC, and CDE-centric practices holds substantial potential to address many of the current inefficiencies within MDOT’s asset management processes. The recommendations outlined in this report offer insights that will help MDOT move towards the next steps of implementing comprehensive digital transformation, more effective asset management, reduced data loss, and enhanced overall operational efficiency.

There are opportunities to further act on the findings of this research to continue advance efforts toward full digital delivery and implementation of BIM/IFC/CDE within MDOT and as a whole within Michigan. Further efforts are needed to achieve this. Specifically, this could include the following:

- *Strategy development within MDOT across teams to determine how to address internal inefficiencies and data management challenges for transportation assets*: This could be done by focusing first on one or more transportation assets determined to be most important to update, such as based on the number of points where data continuity challenges were identified (see Section 4.4, e.g. signs, pavement markings) or based on the relative readiness or value placed on implementation of digital delivery and 3D models (e.g. Section 4.3, e.g. pavements). This effort could include a focus on commonly identified needs, such as integration of databases, changing where attributes of assets are stored and in what format, reducing manual entry of data through automation, etc. Upon piloting and successful integration, then, given that there are overlaps and similarities in challenges across assets, MDOT could then proceed to focus on other assets.

- *Digital data updating for as-builts and asset maintenance:* This effort could focus specifically on addressing the need for improved integration of updates to project 2D and 3D models with as-built information, as well as updates to asset data after the completion of maintenance on assets. This may include determining what party is responsible for updating asset information and appropriately linking databases.
- *Improving matching between MDOT-produced data shared in 2D data and plan sets and 3D models*: As pointed out in contractors discussions, there are opportunities to improve data agreement and details between 2D project plan sets and design files and the developed 3D models. This effort could focus on analysis of recent efforts within MDOT to produce both on recently completed projects, identify where there were data disagreements, and determine a path forward to improve this process further.
- *Piloting of 3D model contractual documents, focused first on complex assets such as pavements, bridges, and/or projects involving significant earthwork*: MDOT is in the process of completing pilot(s) on this already. This could include further efforts both to implement transportation projects with 3D models as contractual documents, and to establish continuous feedback and improvement mechanisms throughout this process (e.g. a requirement within a contract for contractors to participate in this feedback effort), to continue to work out challenges and improve 3D model integration.
- *Contractor-MDOT technology integration analysis:* In response to feedback from contractors regarding integration between technologies used by contractors (e.g. Trimble Business Center) and those used by MDOT (e.g. Bentley software), efforts could be completed to work toward solutions to better integrate software solutions to improve digital delivery. This may be an effort where engagement with technology solution providers/companies may also be beneficial.
- *Contractor engagement for improved 3D model/BIM/IFC/CDE integration:* In contractor interviews it was clear that industry within Michigan does not yet view itself as ready for receiving only 3D/BIM/IFC/CDE models as contractual documents for transportation construction projects. (Survey results also suggest that 3D model-only data shared for project construction purposes is not common across the U.S., thus Michigan is similar to other states in this way.) Contractors also suggested that significant staff education and collaboration would be needed to be able to use just such models for construction. Further efforts could include engagement with one or more contractors and related stakeholders that interface with these models during the construction process to receive detailed feedback on advantages and challenges in this transition. This could include interviews and regular feedback sessions that document these advantages and challenges, and

pinpoint the educational needs across stakeholders (e.g. what key information is “lost” or “missing” from documents that are needed for construction field work if 3D models are used; what technology functions are not yet available/do not work well to support viewing of critical information in 3D models in the field)

Addressing IFC/CDE/BIM technology development gaps: As demonstrated with the case study completed as a part of this project, there is a need to further improve the abilities of tools and methods used by MDOT to support the use of IFC/CDE/BIM. For example: Some of the asset properties do not have a corresponding property set in the current version of IFC and thus require custom property sets to be created; Exporting of data from MDOT-created files in OpenRoads into IFC results in the need for additional software to modify the IFC files (Blender was used in the case study). Addressing these and other identified challenges would help to reduce additional technology needs and educational needs when using these potential solutions.

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APPENDIX I. GLOSSARY

Table 7. Acronyms and definitions

AASHTOWare	American Association of State Highway and Transportation Officials' cooperative software development program.
AGTEK	A construction estimating and takeoff software company
DGN	A file format primarily used by Bentley Systems software, MicroStation (CAD) files
DWG	A file format primarily used by Autodesk AutoCAD software
KML Files	An XML-based file format used for representing geographic data and features
PDF Files	Portable Document Format
TIN Files	Triangular Irregular Network is a form of vector-based digital geographic data.

APPENDIX II. LIST OF ACRONYMS AND ABBREVIATIONS

Table 8. List of commonly used acronyms and abbreviations

BIM	Building Information Modeling
BRM	Bridge Asset Management System
CAD	Computer-Aided Design
CDE	Common Data Environment
GIS	Geographic Information System
GPS	Global Positioning System
IFC	Industry Foundation Classes
MDOT	Michigan Department of Transportation
PHD	Pavement Historical Database
RAP	Research Advisory Panel
TBC	Trimble Business Center
TPF	Transportation Pooled Fund
TSC	Transportation Service Centers

APPENDIX III. FULL CONTRACTOR INTERVIEW RESULTS

The following tables include overview summaries of each contractor's responses sorted by individual questions asked during the contractor interviews. The displayed data is not a direct representation of each individual contractor, instead it provides an overview of their responses. Table 9 shows the participating contractors (n = 10) and their related assets. All Michigan-based contractors' names and companies are not included to preserve anonymity.

Table 9. Contractor participants, by primary asset type that contractor works with

Contractor Responses	
A	Pavements
B	Pavements
C	Pavement Markings
D	Signs
E	Signs
F	Underground Items
G	Underground Items
H	Underground Items
I	Underground Items
J	Underground Items

The first question asked during each contractor interview was "*What data is being used from MDOT for the bidding process?*" Responses are summarized in Table 10.

Table 10. Summary of data being used from MDOT for the bidding process

What data is being used from MDOT for the bidding process?	
A	Data from e-proposal website, construction documents; mark up in Bluebeam for takeoffs. Use Box for sharing information with subcontractors.
B	MDOT plans/files, nearly 100% of time PDFs are used for takeoffs (quantities, binder contents, application tables). Cross sections and plans are most helpful.
C	Data provided by MDOT (PDFs, plan sets to get information on pavement markings). Plans marked up in Bluebeam and the use of Google Earth. Do not currently use DGN files. Suggestions: providing cross streets and side streets is very valuable, many cannot read stations; information on traffic shifts and temporary markings at each stage (every stage has its own plan set); overlay with Google Earth.
D	Plans using PDF software, looking for quantities to match takeoffs. Challenge: issues of condensed information on plan sheets – hard to read.
E	Pay items from the e-bidding website – this information is placed into the database. Their quote sheets are uploaded onto their company website. Each pay item is numbered individually directly on the PDF plan sheets.
F	Proposal items, bid items, progress, schedule, existing plans, standard details, Geotech investigations/soil borings.
G	RID documents from bidding websites, alignments, finish surfaces, dgn files, linework. Data is created and imported/exported using Trimble Business Center. Bentley files from MDOT do not import correctly with Trimble Business Center.
H	Estimates are put together with downloaded plans and project proposals. They have 4 estimators in-house where 75% of them use paper plans and are used to create bid takeoffs. Bluebeam is used to calculate irregular shapes (driveways, intersections, etc.). RID files, XMLs of alignments, existing ground topography, 2D survey of linework existing conditions into the Trimble Business Center. The proposed model and verified earthwork is also entered into the Trimble Business Center. MDOT plans do not have a lot of contours, but they are organized into sections which makes them easier to work with and read. 3D linework for underground is nice to have, but is not necessary.
I	Multiple estimators (internal), Trimble Business Center, RID files (often). XML and DGN of terrain models (dot not always import well into TBC). 3D line files for existing surfaces, 3D and 2D CAD files (generally clean), plan PDFs.
J	DWGs, DGNs (transferred to AutoCAD), PDFs (they most likely redesign the PDF plans, do not use the provided OpenRoads), use AGTEK/Earthwork 4D. Use 2D linework and 3D surfaces

Following this question, the contractors were asked to describe data that is used from MDOT for the construction process. These responses are summarized within Table 11 below.

Table 11. Summary of what data is used from MDOT for the construction process

What data is used from MDOT for the construction process?	
A	Use RID and DWG files (if provided); otherwise, will have a 3rd party create. Trimble used in the field. Bluebeam Studio used to allow collaboration.
B	Data from MicroStation files to TBC (Trimble, often converting issues). Project managers and estimators only use PDFs (no 3D or CAD files). Challenges are that software licenses are costly. Overlays are done with KML files. Drones are sometimes used for large areas if CAD files are not provided.
C	Data provided by MDOT (PDFs, plan sets to get information on pavement markings). Plans marked up in Bluebeam and the use of Google Earth. Do not currently use Dgn files. Suggestions: providing cross streets and side streets is very valuable, many cannot read stations; information on traffic shifts and temporary markings at each stage (every stage has its own plan set); overlay with Google Earth.
D	They know what items they have onsite, but they do not know where these items are at on site as there are too many to track. Since they do not collect GPS shots, there are no as-builts.
E	The foreman enters information back into the company website to report what they have done each day. There is an app that the foreman uses offline that automatically uploads this information onto the website.
F	RID files (used by surveyors), PDF plans, PDF proposal, Geotech information and the existing bridge plans. They hire our surveying companies that use the RID files for staking.
G	Information is downloaded from ProjectWise. Rebuild/build in Trimble Business Center to look at alignments and finished surfaces. Cross sections and profiles. Check errors by comparing the plans and specs with the RID documents. During construction, there are physical plan sets and iPads.
H	RID documents are used to create 3D models. MDOT plans are not contractual, so there is information that is not needed or is not accurate to create 3D models from. They compare the paper plans to the MDOT plans to find differences, determine why there are differences. They stressed the importance of having precise data. There are not many people who are comfortable with 3D models, but most can look at an excel file and determine if they can do it – mistakes happen when models become overcomplicated.
I	RID, CAD model files, water surfaces, finish surfaces and models.
J	Any files provided by MDOT from ProjectWise.

Table 12 summarizes the results of the third question which asked the contractors to describe the data that they are generating during the construction process.

Table 12. Summary of what data is generated during the construction process

What data are they generating during construction processes?	
A	The Trimble crew takes shots on joints, pavements, as-builts, to generate quantities and to check elevations. For asphalt, collect tonnage tickets and plug this into track software.
B	All of the submittal information is done through ProjectWise. Most of the larger jobs typically have a 3rd party surveyor doing the as-builts.
C	Quantities, tracking the progress throughout the day, entering quantities, all based on MDOT pay items.
D	They know what items they have onsite, but they do not know where these items are at on site as there are too many to track. Since they do not collect GPS shots, there are no as-builts.
E	They send daily reports back to MDOT. Send back quantity reports to get paid. As-builts are not typically provided by the contractors.
F	Material certifications and complex designs. Surveyors shoot the bottom of the beams and generate as-builts for the roadways. As-builts are created from anything that changed from the original plans.
G	N/A.
H	Marked up PDFs for as-builts using Bluebeam on the PDF plans. If applicable, staking for cross sections.
I	Survey model to verify earthwork quantities, material quantities, sometimes as-builts (not much with MDOT).
J	Typically use a 3rd party model builder (rather than using RID or TIN files); only 1-2% of the time if small/quick will use what is provided by MDOT (noted there are often differences between 3D plans and PDFs). Data is put into GPS for field work.

Table 13 summarizes the results of the question "*What data is provided back to MDOT*?" from the contractor, after construction is completed.

Table 13. Summary of data that is provided back to MDOT

What data is provided back to MDOT?	
A	The crew will collect data, but MDOT also has representatives onsite, both teams work together to collect data from the field.
B	N/A.
C	Quantities.
D	N/A.
E	N/A.
F	N/A.
G	Pipe inverts and coordinates for structures, sometimes cross-sections. Current standards are to submit marked-up PDFs. They save their own data within their local server and upload this to MDOT using XML files. As-built data and implementation of changes based on plan revisions.
H	N/A.
I	N/A.
J	As-builts; based on top pipes measured in the field.

The next question in the interview is summarized below in Table 14 which outlines the contractors' previous experience(s) using 3D modeling or other similar modeling formats. Additionally, the contractors were asked if they use models if they are provided to them within the project plans.

Table 14. Summary of contractors' previous experience using 3D models

What is your previous experience using 3D models or something of similar format? Do you use models if they are provided within the project plans?	
A	Have not worked on any projects where 3D models have been provided. [*identifying information removed*] project, but only the bridge had 3D models.
B	They have worked with both 3D models and OpenRoads, but not MicroStation. For large reconstruction projects might be helpful. Concern about cost effectiveness with the licensing.
C	3D models would make things difficult because project managers prefer to look at paper plan sets and to only see the relevant information.

What is your previous experience using 3D models or something of similar format? Do you use models if they are provided within the project plans?	
D	No, they have not worked on a project with 3D models, or if they did, they did not use or look at them.
E	N/A.
F	For building construction: used for a long time in building construction, helpful to determine where the utilities come in and help determine possible conflicts, helpful for when participating in design process (especially design build, design assist in project delivery methods vs. Design/bid/build) – hardest because do not have input into model. For bridges/roads: they have more luck being a design assist partner.
G	They do use 3D models but not BIM. Useful with vertical construction but less useful for horizontal construction.
H	Not contractually, just the RID documents.
I	Currently working on a project *[identifying information removed]* that requires BIM; the piping is done with DWG files for as-builts. Have always thought that having a BIM/3D model would be useful especially if it included everything (e.g., underground utilities) not noted that they usually don't.
J	For every job they bid request CAD files (95% time saved if provided, use TIN surface). Quality checks comparing 2D and 3D plans. If only PDFs are provided, they have to vectorize the plans and manually enter in all of the information (takes 1-3 days). Most of the time 2D models do not match the 3D models (which is a challenge).

Summarized in Table 15 are the responses to the question "*If you just had a 3D model and no plan set, would this work? What are the critical details*?".

Table 15. Summary of contractors' opinion on 3D models without the use of plan sets

If you just had a 3D model and no plan set, would this work? What are the critical details?	
A	N/A.
B	If there are no plan sets, this would be a problem as the PDFs are crucial. They would not feel comfortable just receiving the 3D model files.
C	It would be difficult.
D	Maybe. They would be able to figure it out by passing information to crew leaders with the use of tablets.
E	Advantages: huge time saver for input of information, could be helpful for guardrails. Disadvantages: they require high tech laptops with high storage in the field, lots zooming and scrolling. They are not against the improvement of technology; they just think paper is better in this situation.
F	Would be great to have as a contractor but need to make sure that the model is perfect. But some people don't have smart phones/tablets in the field. Main contractor could work with model, but some subs would struggle (need technology and education). Would be a challenge if every job needed and IT person.
G	N/A.
H	It would be more work on their end. They enjoy having the plans in their hands to help visualize. They enjoy having plans in their hands to help visualize. They think having both a 3D and 2D model of the linework could mesh together well.
I	There would likely be some discomfort, fear of missing information. It could be helpful if proper training too place, especially for field workers.
J	Maybe this can be done. There is a learning curve to finding information in the models (e.g. material sizes, pipe sizes, spot elevations)

The next question asked, "*What scenarios are great for 3D/similar models*?" which was summarized below in Table 16.

Table 16. Summary of when 3D models would be beneficial

What scenarios are great for 3D/similar models?	
A	They were not able to think of a scenario where 3D models would be beneficial. Suggest useful for bridges, excavations, pipes, roadways, sewage structures and earthwork.
B	To connect pay items and the drawings. Otherwise, they cannot think of any other scenarios.
C	Not very useful; possible helpful during transitions.
D	Unsure, but possibly traffic control.
E	To look at reports.
F	Larger interchange projects where there is the most conflicts with existing or new construction.
G	Anytime within an urban environment that has a lot of preexisting utilities. Tighter tolerances, Earth walls and tiebacks, bridgework that has a lot of piling. Would be nice to click on a pipe, for example, and to see all the associated information.
H	Construction – to see how their models compare to the models that MDOT makes. Bidding – to see the existing ground and the proposed surface.
I	Knowing where the existing utilities are (so that more design can occur before rather than calling in after a mis-dig.
J	Larger jobs would greatly benefit from the use of 3D models. They would love to see CAD/TIN files for every project. Counts of structures is better.

The final question of the interview asked the contractors to describe the challenges that they faced with the use of 3D/similar models. This is summarized in Table 17.

Table 17. Summary of challenges with the use of 3D models

What are the challenges with the use of 3D/similar models?	
A	N/A.
B	N/A.
C	N/A.
D	N/A.

E	N/A.
F	Education: it takes time to learn how to use this tool properly and tablets/iPads to view. Communication and building everything together: MDOT + contractors. Always needing IT personnel available to fix technology issues on the site and in the office.
G	Having people that are willing to learn. Collecting all the required data to build the model. The financial setbacks.
H	Much better off making their own 3D model and then checking for accuracy. Making the model usable and accessible to anyone.
I	Training and using BIM viewers on mobile tablets in the field (most people have tablets but use PlanGrid not 3D model viewers).
J	For collaborating on models (pre-construction), making sure that everyone has the same version of the model and software. Sharing information to those in the field; many people are “old school”/prefer prints.

APPENDIX IV. FULL SURVEY RESULTS

Figure 52 – Figure 65 and Table 18 - Table 31 contain aggregated survey results for each individual question. The survey was distributed to the Transportation Pooled-Fund members through email that contained a direct link to the Qualtrics online survey or a PDF version of the survey for a marked submission. All responses from the survey were recorded within a spreadsheet and were analyzed. Survey recipients had the option to skip questions and to partially complete a question, and were asked to complete to the best of their ability. Due to this, each question may not have a response from each individual. Additionally, states that had multiple responses had their submissions compared and combined for cleaner data. Any written responses that had the possibility of revealing the identity of a survey respondent was removed from their response.

The purpose of questions 1-5 was to collect contact information of the survey respondents and to better understand the professional background behind each response.

Question 1 asked the respondent to provide their name (Last, First) – this information is not shared here to protect the identity of the participants. Question 2 asked the respondent to provide which state DOT they are an employee through. See Table 18 below for the participating state DOTs. There was a total of 36 respondents (n = 36) to this survey, with some states submitting multiple responses.

Table 18. Participating State Departments of Transportation within the online survey

Participating State DOTs		
Alabama	Iowa (2)	Ohio
Arizona (2)	Kentucky	Oklahoma
California (2)	Michigan	Pennsylvania (2)
Connecticut	Minnesota (2)	Texas
Delaware	Mississippi	Utah
Florida	Montana	Vermont (2)
Georgia	Nebraska (2)	Washington (2)
Illinois (2)	New York	Wisconsin
Indiana	North Carolina (2)	

Figure 52 shows the categories of job titles of the respondents who work at the state DOTs and their BIM related role, if it was applicable.

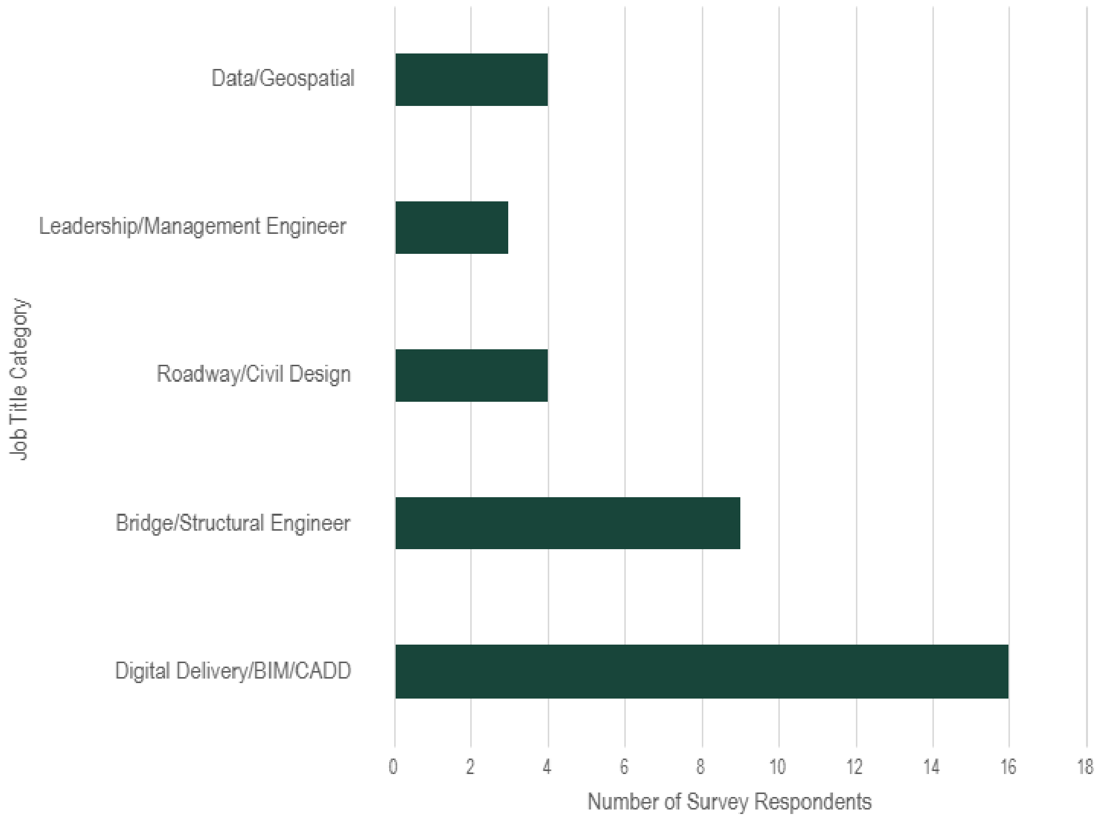

Figure 52. Categorized job titles within the state DOT of each survey respondent

Question 4 within the survey asked the respondents to provide their email which was used to either a) follow-up with additional questions and/or b) to express gratitude for the respondent's participation in and knowledge in digital delivery. Question 5 asked the respondents to provide their phone number (optional) as another source of contact. Their emails and phone numbers remained confidential in the results of this survey.

The purpose of questions 6 – 17 was to understand what tools each state DOTs were currently using for data handover.

Below in Figure 53, are the results to question 6 that states "*Please select which of the below technology(s) or method(s) you are using* <u>*within*</u> *your state DOT for the below-listed assets*".

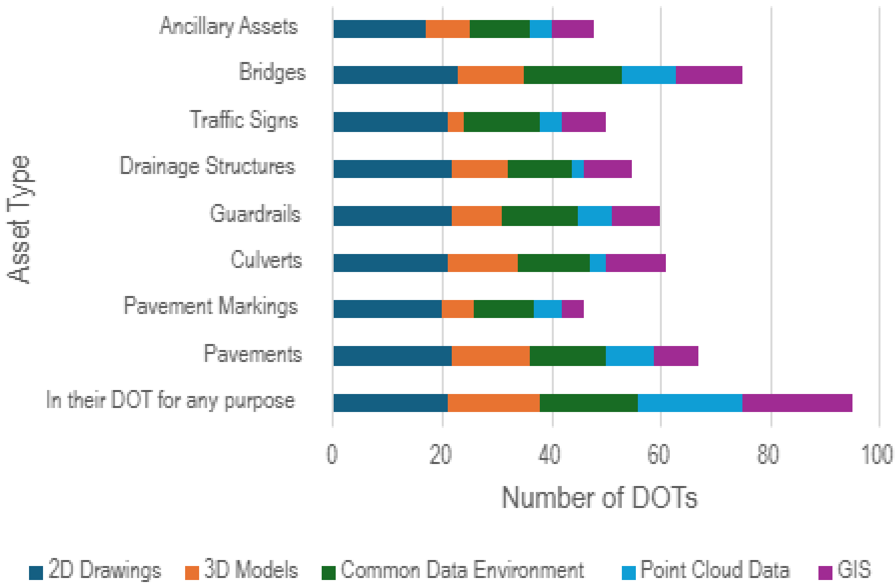

Figure 53. Technologies and methods used for each asset type within each state DOT

The respondents were asked, in question 7, to "*Please define what ancillary assets means for your DOTs (as it related to the questions in the survey). If not applicable, write N/A*". Table 19 shows these responses.

Table 19. Definitions of ancillary assets for each state DOT

Ancillary Assets Definition for DOTs	
Arizona	ROW, ownership, boundaries, locations of facilities, traffic & counter locations, safety data (crashes), federal required data to support HPMS and other federal purposes, shoulders
California	Ancillary assets are some of those items listed in Q6 that we track for asset management purposes. Other assets include AC dikes, concrete curbs, ADA ramps, concrete barrier, landscape items, other traffic items (pull boxes, loop detectors)
Connecticut	Non-bridge and non-pavement assets
Illinois	Right of way, Medians/Islands
Iowa	Lighting and manholes, retaining walls, ITS devices, subdrain outlets, sign truss structures, pedestrian bridges, retaining walls
Kentucky	KYTC defines ancillary assets as features such as signs, lighting, and message boards
Michigan	Structural elements not classified as a major structure
Minnesota	Lighting, signals, noise walls, ITS structures, median barriers, sidewalks, pedestrian ramps
Mississippi	Traffic signals, lighting devices, and retaining walls
Nebraska	N/A
New York State	Assets outside the roadway and bridge envelope such as underground utilities, sidewalks, ADA ramps, stormwater drainage, overhead sign structures, traffic signals, retaining walls
North Carolina	Utilities, erosion control, geotechnical, lighting and electrical, railroad, traffic signals, overhead signs
Oklahoma	Other items besides bridge and road
Pennsylvania	Any asset beyond what is listed above
Texas	Signs
Utah	N/A. Not sure what features are being sought by the survey
Vermont	N/A
Wisconsin	N/A
Washington	N/A

Question 8 asked the respondents "*What database system(s) is your DOT using for storing of information on each asset type? (e.g. ProjectWise, Oracle, ERMS, etc.)*". The responses are demonstrated below in Figure 54.

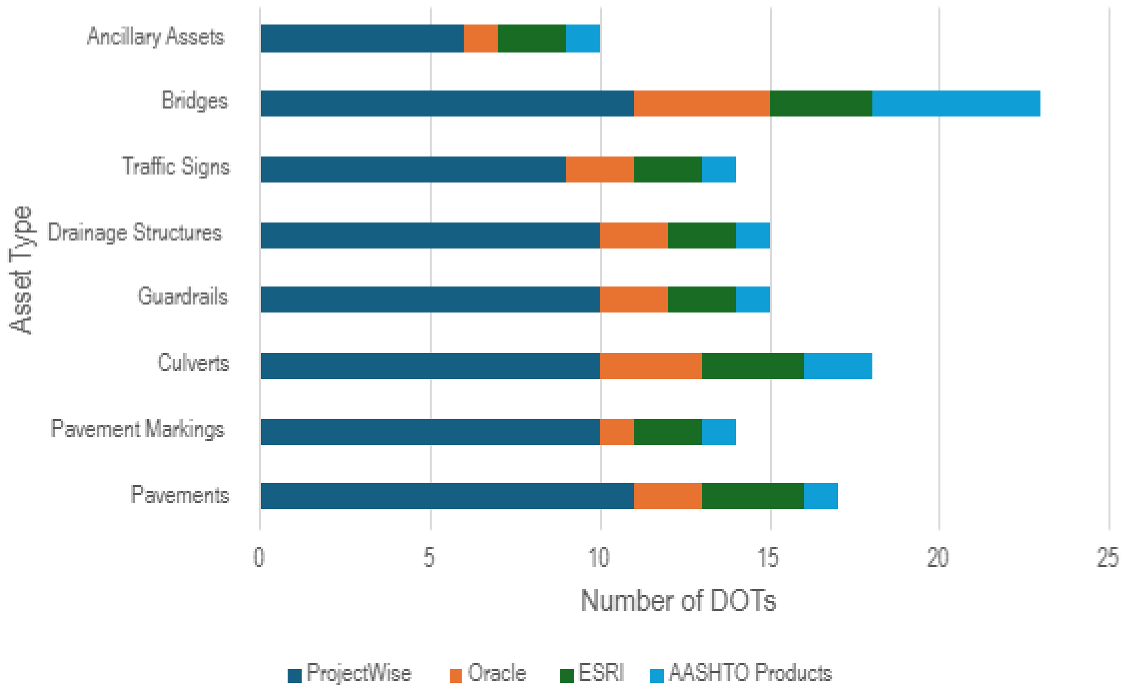

Figure 54. Databases used in each DOT for the listed assets

Table 20 outlines the text responses to question 8 for each listed asset.

Table 20. Typed responses to the databases used in each DOT for the listed assets

Other - Text	
Pavements	dTIMS, SQL Server, GIS, Adobe Workfront, SYNCHRO, Trimble Agile Assets, AssetWise, Doc Express, OnStation, Pix4D Cloud, Propeller Aero, Highway Pavement Management System, Custom Products
Pavement Markings	Custom products, Adobe Workfront, Hyland OnBase, Doc Express, OnStation, Haul Hub, Trimble Agile Assets, TAMS, None, EDMS, VAMIS, SharePoint
Culverts	ESRI Roads & Highways, Bentley AssetWise Inspections, LARS, Doc Express, OnStation, Haul Hub, Pix4D Cloud, Propeller Aero, Trimble Agile Assets, TAMS, GIS, Custom Products, SharePoint, VAMIS
Guardrails	Custom products, SYNCHRO, Hyland OnBase, Doc Express, OnStation, Pix4D Cloud, Propeller Aero, Trimble Agile Assets, TAMS, None, ArcGIS, SharePoint, EDMS, VAMIS
Drainage Structures	InspectTech, Custom products, Adobe Workfront, SYNCHRO, Hyland OnBase, Doc Express, OnStation, Pix4D Cloud, Propeller Aero, Trimble Agile Assets, TAMS, ArcGIS, SharePoint, VAMIS
Traffic Signs	Custom products, Adobe Workfront, SYNCHRO, Hyland OnBase, Doc Express, OnStation, Pix4D Cloud, Propeller Aero, TAMS, None, ArcGIS, SharePoint, EDMS, VAMIS
Bridges	InspectTech, Internal systems, Bentley AssetWise Inspections, LARS, Doc Express, Bentley SUPERLOAD, SYNCHRO, Hyland OnBase, Haul Hub, Pix4D Cloud, Propeller Aero, Bentley OpenRoads Designer, Bentley STAAD, PSBeam, Midas Civil, LARSA, ArcGIS, Custom Products, VAMIS, SharePoint
Ancillary Assets	Custom products, ESRI Roads & Highways, Bentley AssetWise Inspections, LARS, Doc Express, SYNCHRO, Hyland Onbase, Doc Express, OnStation, Haul Hub, Pix4D Cloud, Propeller Aero, TAMS, None, ArcGIS, SharePoint

Question 9 asked the respondent to define what software packages that are used to create/modify the listed assets at their state DOT. Common responses are graphed in Figure 55).

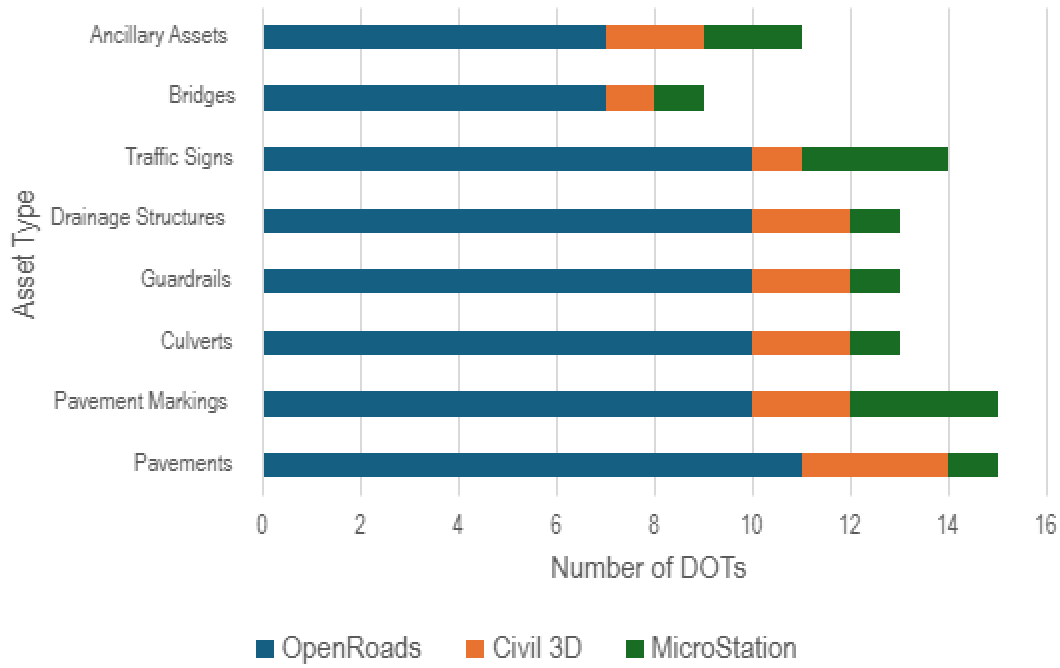

Figure 55. Software packages used to create and modify the listed assets at each DOT

Unique and individual responses to question 9 are listed below in Table 21 for each listed asset.

Table 21. Individual software packages used to create and modify the listed assets at each DOT

Other - Text	
Pavements	ESRI, SQL Server, AASHTOWare Pavement, ME Design, Internal products, Bentley ProjectWise
Pavement Markings	None
Culverts	AASHTOWare, Bentley CuvlertMaster, Bentley FlowMaster, Eriksson Culvert, HY8, Hydro CAD, Bentley OpenBridge Designer
Guardrails	Internal systems
Drainage Structures	HydroCAD, Bentley STAAD, Bentley OpenBridge Designer
Traffic Signs	GuideSIGN, Bentley SignCAD
Bridges	ALLPLAN, Trimble Tekla Structures, OpenBrIM, Rhino, RSLog, BT Beam, Ensoft, FB-Pier, Midas Civil, Bentley OpenBridge Designer
Ancillary Assets	Visual Lighting, Lighting Analysts, Bentley OpenBridge Designer

In question 10, the respondents were asked "*How does your DOT share data with external parties (bidders, contractors, and consultants) on DOT construction projects including* *both contractual and non-contractual documents? Please select all that apply*". Below are selected results of question 10 in Figure 56.

Figure 56. Methods of sharing data with external parties from each state DOT

Table 22 lists the text responses that were provided by each state DOT when they selected the "other" option within question 10.

Table 22. Other listed methods of sharing data with external parties from each state DOT

Other - Text Responses	
Georgia	BidX
Iowa	BidX, Bentley AssetWise
Kentucky	Lynn Imagining Plan Room
Mississippi	Using exchange file transfer server
Nebraska	Data is provided through a link on our website for data delivered pre letting
New York State	Agency Website
North Carolina	SharePoint, FTP
Pennsylvania	PennDOT's, ECMS System for bidding
Texas	FTP Site

Below in Figure 57 are the responses to question 11 that asked the respondents where their state DOT houses their common data environment.

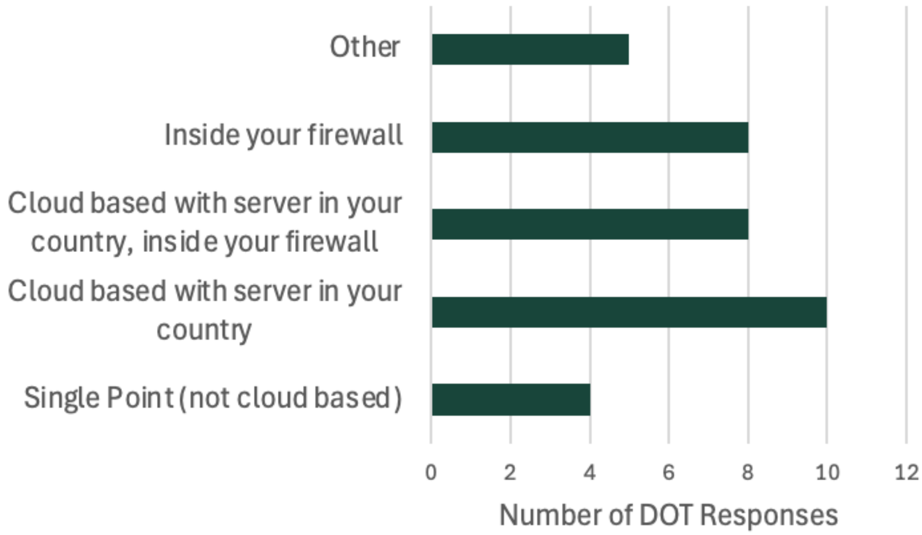

Figure 57. Where each state DOT houses their common data environments

Table 23 lists the typed responses to question 11 that were provided when the respondent selected the "other" option.

Table 23. Other listed locations of each state DOTs common data environments

Other - Text	
California	Our current environment is inside our firewall, but our future CDE will be cloud based
Georgia	We do not have one
Iowa	We do not have a true CDE at the DOT
North Carolina	Bentley ProjectWise, SharePoint
Utah	Bentley ProjectWise

Figure 58 shows the responses to question 12 which asks, "*For each asset, how is information on these assets typically shared with external parties (bidders, contractors, and consultants)? Please check all that apply*".

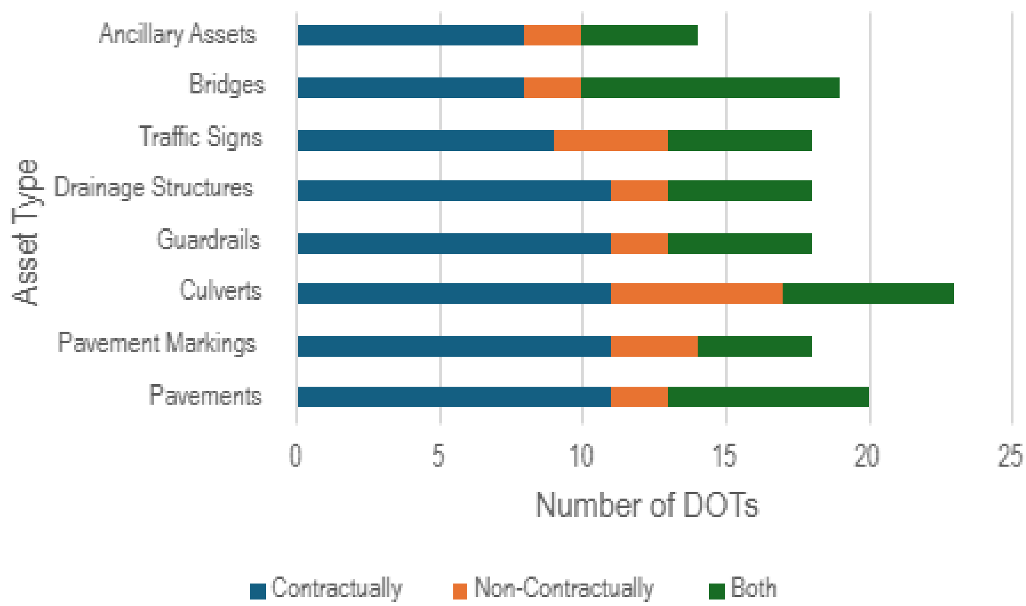

Figure 58. How information for each listed asset is shared with external parties

In question 13, the respondents were asked "*What type of data does your DOT share with external parties (bidders, contractors, and consults)? Please select all that apply*". Displayed below in Figure 59 are the results to this question.

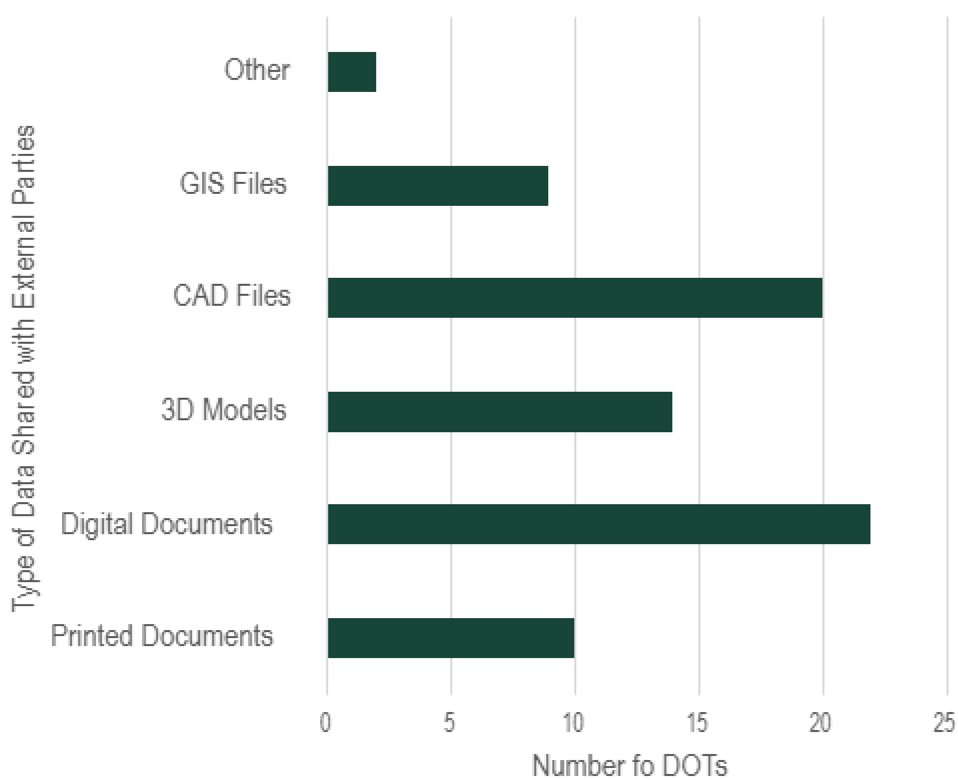

Figure 59. Type of data that each state DOT shares with external parties

When the respondent selected the “other” option within question 13, they provided a written response to what type of data they share with external parties. The written responses for each state DOT that provided additional information are shown below in Table 24.

Table 24. Other listed types of data that each state DOT shares with external parties

Other - Text	
Iowa	Sharing between consultants and contractors is different for legal reasons
New York State	Typically, one format is considered the legal contract document (2D PDF plans) and the CAD files used to create the PDFs are supplemental information, non-contractual

Figure 60 shows the responses to question 14 which asked the respondents “*What file/document types does your DOT share with external parties (bidders, contractors, and consultants) for the listed assets? For example: DWG, PDF, etc.*.”. The common responses to this question are represented in the figure below.

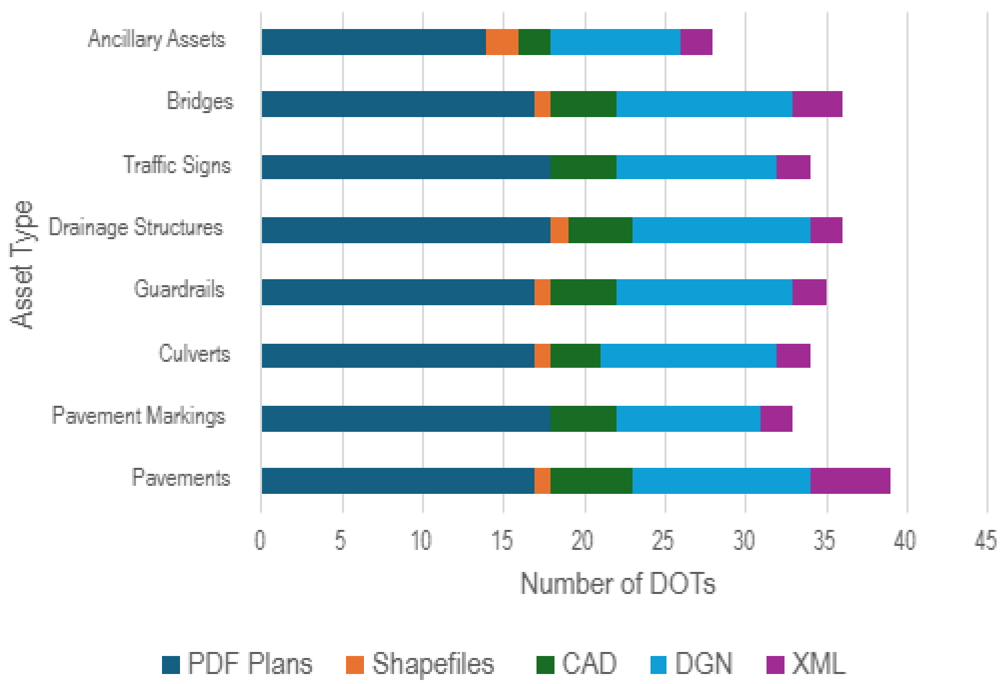

Figure 60. Document types that are shared with external parties for each state DOT

The individual and least common responses to question 14 are listed below in Table 25 for each listed asset.

Table 25. Other listed document types that are shared with external parties for each state DOT

Other - Text	
Pavements	Cloud-based dashboards, geodatabases, KML, OnStation Project Code, SYNCHRO License, DXF, Excel File
Pavement Markings	KML, OnStation Project Code
Culverts	Geodatabases, iTwin, KML, OnStation Project Code, SYNCHRO
Guardrails	KML, OnStation Project Code, SYNCHRO
Drainage Structures	KML, OnStation Project Code, SYNCHRO
Traffic Signs	KML, OnStation Project Code, SYNCHRO
Bridges	Geodatabases, DGN without borders, model as information only, iTwin, Excel files, IFC, OnStation Project Code, SYNCHRO
Ancillary Assets	Geodatabases, iTwin, Excel files, KML, OnStation Project Code, SYNCHRO

Question 15 asked the respondents the question "*How does your DOT require contactors to share as-built documents after the construction project is complete? Please select all that apply*". Figure 61 display the responses to this question.

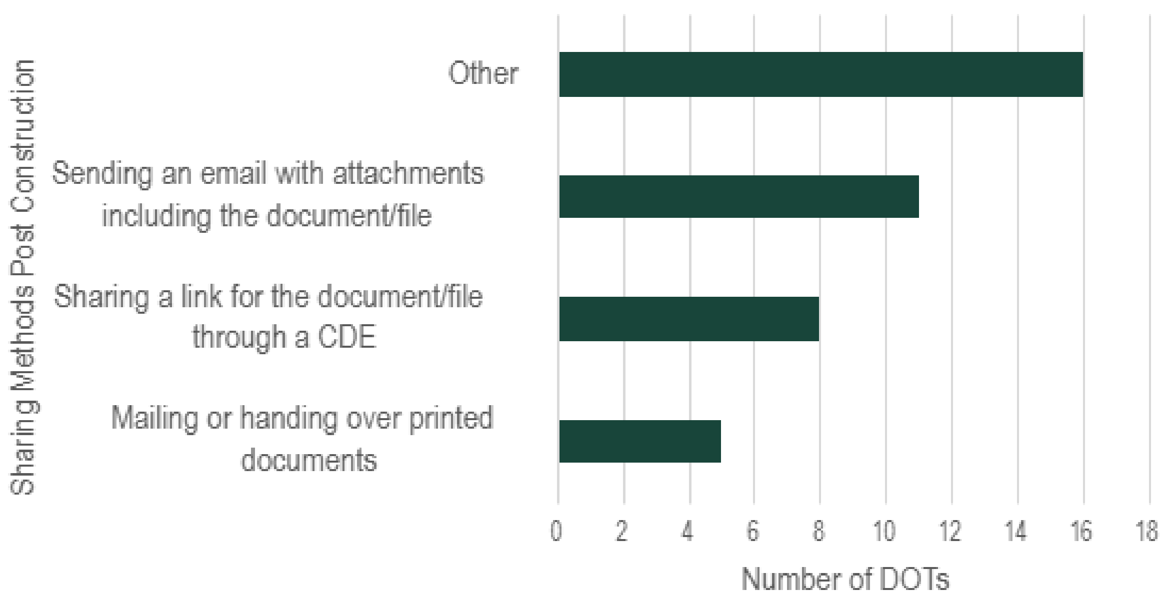

Figure 61. Required methods of shared as-built documents by contractors from each state DOT

When the respondent selected the “other” option within question 15, they were provided with the opportunity to provide a short-answer response. These responses for the below-listed DOTs are shown in Table 26.

Table 26. Other listed required methods of shared as-built documents by contractors from each state DOT

Other - Text	
Connecticut	Contractors do not perform as-builts
Georgia	Placing on Bentley ProjectWise
Iowa	Internal staff completes as-builts, contractor surveyors submit survey books or data. Completed by DOT for standard projects or CEI for complex projects.
Minnesota	SharePoint for Design-Build
Mississippi	Web based search engine (requires access)
Nebraska	Not requiring contractors to share as-built information at this time
New York State	Typically, NYSDOT is responsible for creating as-built plans unless required by special specification in contract
North Carolina	SharePoint
Oklahoma	Not required
Pennsylvania	PennDOT manages as built with construction unit
Texas	Hand drawn on current plans
Utah	Modified design or construction platform software files
Vermont	We do the as-built through redlined pdf and Bluebeam, but once in a while we will require contractor as-builts for a particular component. As-builts completed in house
Wisconsin	Contractors provide construction surface models upon request; they are not required to submit as-built data

Figure 62 shows the results of question 16 which asks "*What type of as-built data do you officially request from the project contractors to handover after a project is complete, for the above-discussed assets? Please select all that apply*".

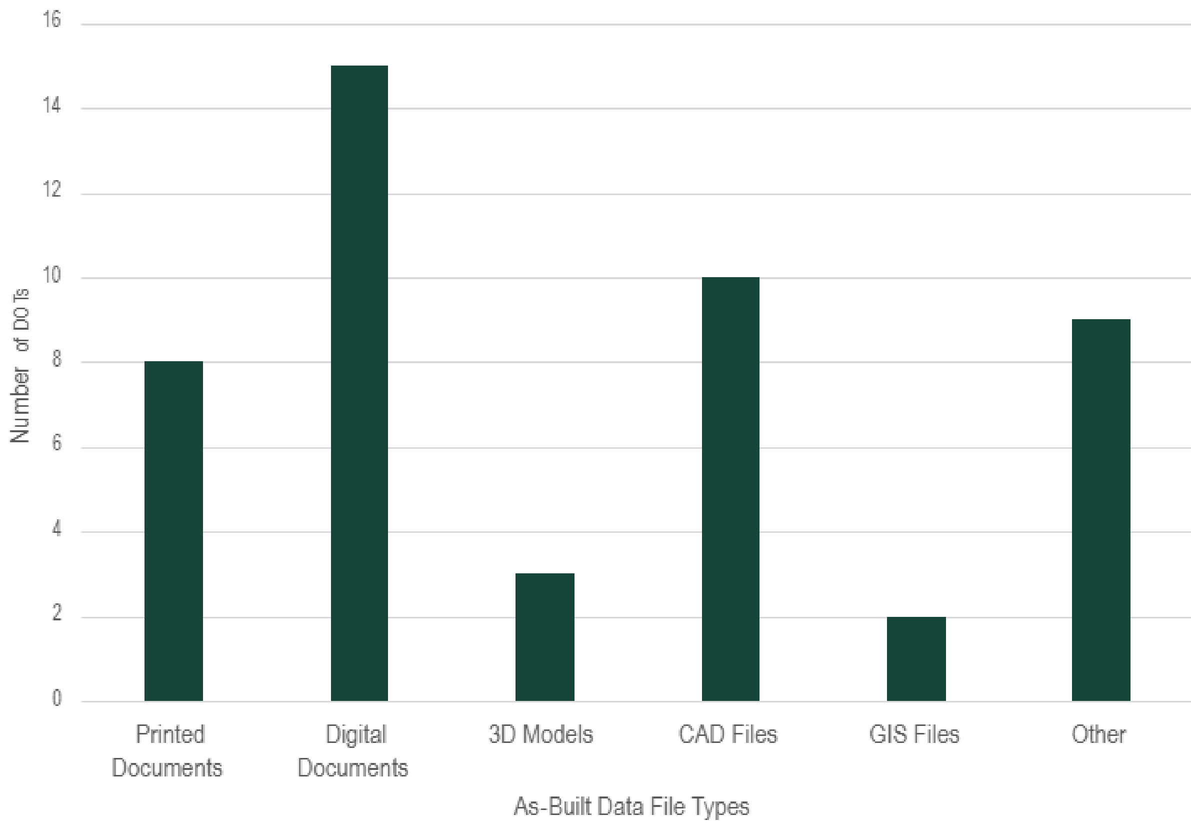

Figure 62. Requested as-built data to handover from project contractors for each listed asset for each state DOT

Table 27 lists the short-answer responses for the below-listed state DOTs when the respondents selected the "other" option for question 16.

Table 27. Other listed officially requested as-built data to handover from project contractors for each listed asset for each state DOT

Other - Text	
California	We do not request as-built data from the contractor. Our as-builts are provided by our staff in PDF and dgn format
Connecticut	None
Georgia	None, except for drainage structures in some permit areas, in GIS
New York State	Limited requests for CAD or BIM files
Oklahoma	Inspectors collect as built red marks
Pennsylvania	Currently we are not placing this on the contractor to provide. Inspection staff or design team is handling the models
Vermont	None
Washington	Note, as stated in Q15, this is done by WSDOT's Construction Office
Wisconsin	Project contractors are not officially required to provide as-built data

Figure 63 displays the results to question 17 which asked "*What file/document types does your DOT require to be shared by the contractor back to your DOT for the listed assets*?". The most common responses to this question were graphed below.

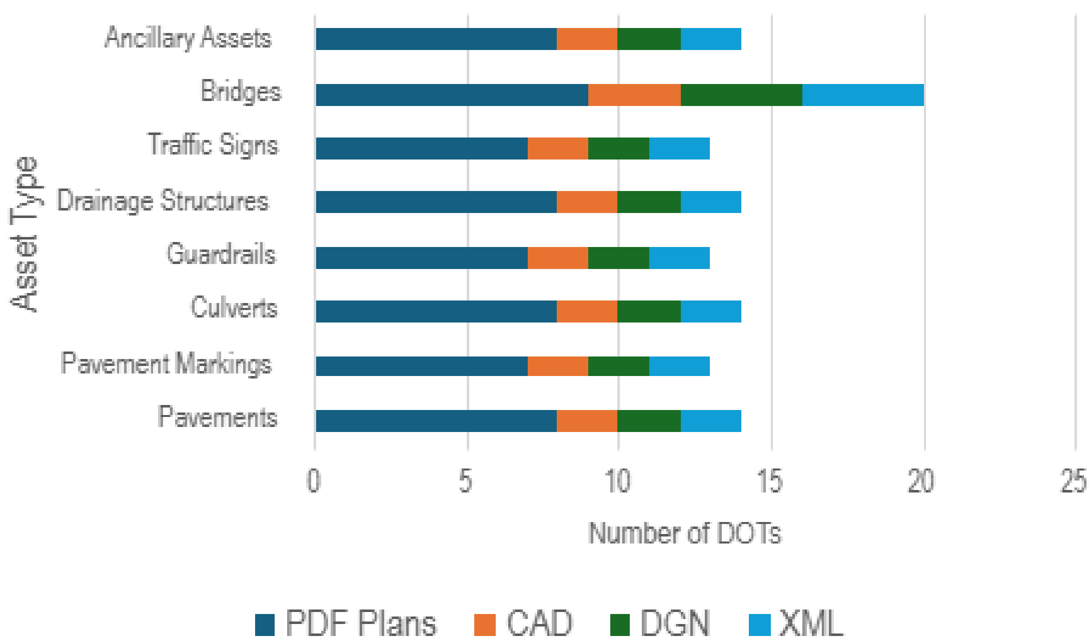

Figure 63. File/document types that are required to be shared by the contractor back to each state DOT for each listed asset

Table 28 listed the responses for each listed asset that were not listed frequently for question 17.

Table 28. Other listed file/document types that are required to be shared by the contractor back to each state DOT for each listed asset

Other - Text	
Pavements	Do not require contractors to share files, approved source and certifications, Profilometer data, vibration monitor records, plant reports, e-tickets, CSV, GIS
Pavement Markings	Do not require contractors to share files, approved source and certifications, quantities are compared and reviewed, CSV, GIS
Culverts	Do not require contractors to share files, approved sources and certifications, plant reports, survey data, CSV, GIS
Guardrails	Do not require contractors to share files, approved sources, certifications, plant reports, survey data, CSV, GIS
Drainage Structures	Do not require contractors to share files, as-builts, GIS, approved sources and certifications, plant reports, survey data, CSV
Traffic Signs	Do not require contractors to share files, approved sources and certifications, plant reports, CSV, GIS
Bridges	Land XML, Profilometer data, vibration monitor records, e-tickets, plant reports, approved sources and certifications, CSV, DGN GIS, As-Builts
Ancillary Assets	Do not require contractors to share files, e-tickets, plant reports, test forms, utility data, approved sources and certifications, CSV

The remaining survey questions focused on the recommendations and experiences of each stat DOT. Figure 64 displays the results to question 18 which asked, "*Within the next five years, what percentage of your DOT's transportation related data is anticipated to be stored and managed completely in digital environment?*" for each below-listed asset type.

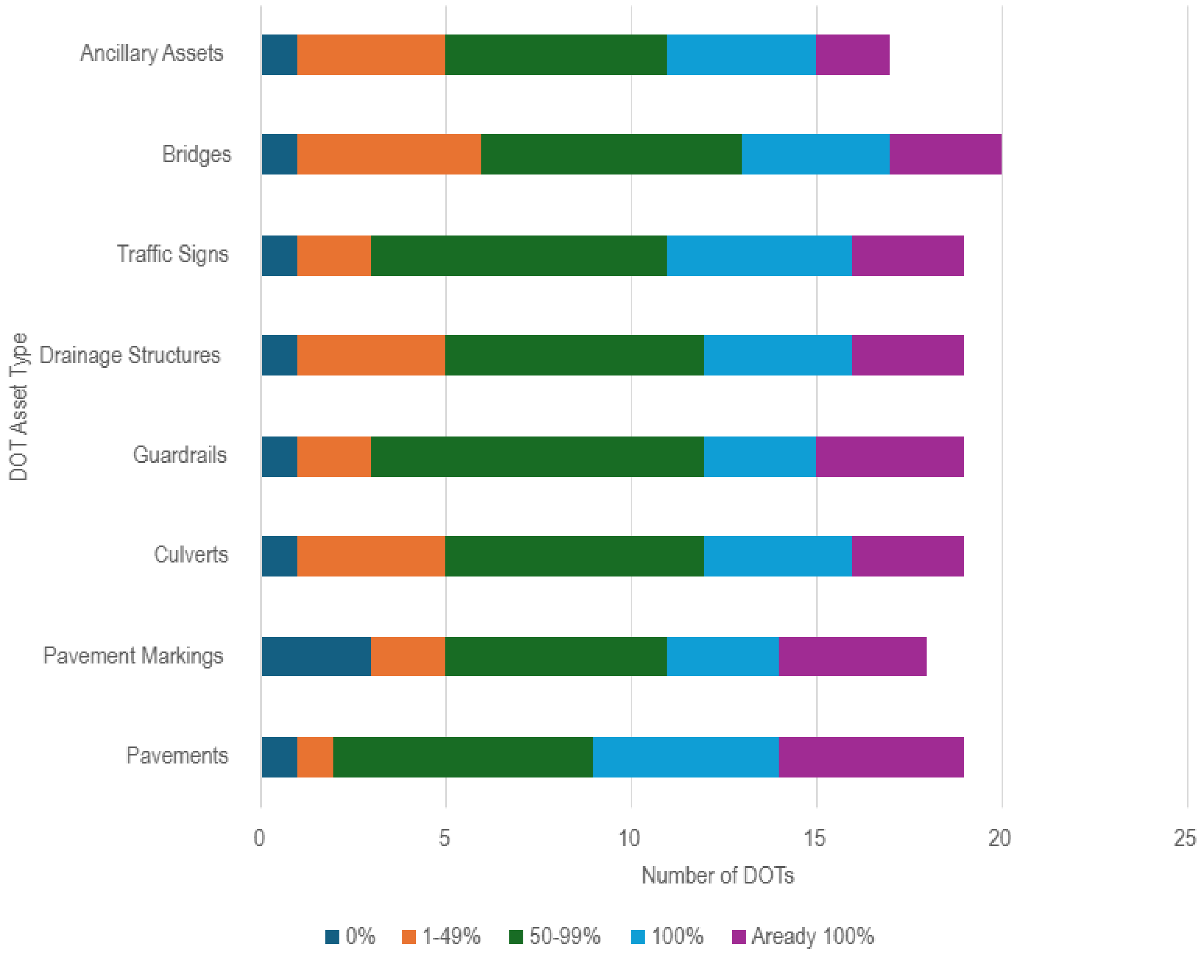

Figure 64. Predicted percentage of each state DOTs listed assets to be stored and managed digitally within the next five years

The responses to question 19 are graphed below in Figure 65 which asked "*What is your DOT's BIM for Infrastructure Maturity Level?"*

- Level 0: Document-Oriented, physical and functional characteristics of highway assets managed across multiple documents (or files)
- Level 1: Object-Oriented, physical and functional information about assets managed in "disintegrated" data models (or databases)
- Level 2: Federated Object Models and Databases, physical and functional information about assets managed in "integrated: enterprise data models (or databases)
- Level 3: Integrated Lifecycle, physical and functional information about assets managed in "integrated" internal and external enterprise data models (or databases

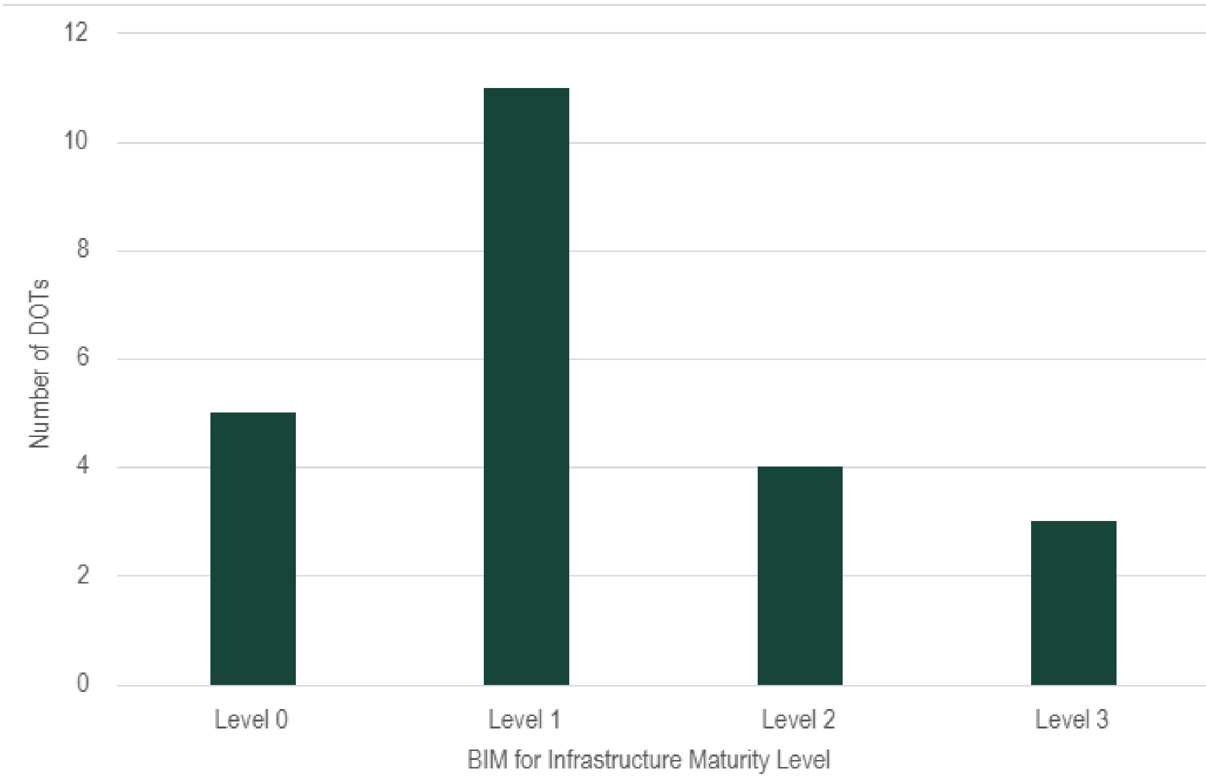

Figure 65. Individual DOTs BIM for Infrastructure Maturity Level

Question 20 was a free-response question that asked the respondent to consider their DOT and the describe the current state of adoption of the use of BIM and IFC within DOT processes. Table 29 contains the responses for each below-listed state DOT.

Table 29. Each state DOTs current BIM and IFC adoption

Text Responses to Question 20	
Connecticut	Almost none
Arizona	Internal agency wide digital delivery initiative on the ground running - currently finalizing ISO naming standards for projects
California	We are moving forward with BIM4I in the department. We are committed to implementing and integrating BIM4I throughout the project delivery process and its lifecycle management. Since IFC is still in its infancy related to roadway, we are not using it to share data. While Software developers are involved in establishing and adopting IFC, the version in their software is still not reliable as not all the information is transferred 100%. Will continue to rely on XML until IFC is further developed and tested.
California	BIM Uses implemented in pilot projects: Clash Detection / Model Coordination, Modeling Existing Structures, 4D Simulations working with CMGC contractors, Use of BIM on Emergency Projects to support collaborative working, deriving bill of quantities from 3D model, using model on data collectors in the field and collecting as-built attributes digitally (location data, date inspected, inspector name, etc...), working with bridge architects to include site development components and enhance engineering model for presentations for public outreach, responding to RFIs with model, working with environmental to incorporate environmental study limits and work windows in model.
Delaware	BIM: we are early in this process. We deliver 3D break lines digitally (in DGN format), but they are currently for information only. IFC: we do not currently deliver IFC in any capacity
Georgia	Aware of both, participating in FHWA Pooled Funds (BIM for bridges, BIM for infrastructure). Aware of AASHTO's resolution supporting IFC. Look forward to moving in this direction
Illinois	IDOT has initiated a Digital Delivery Program which will institutionalize the use of BIM and investigate the potential use of IFC. We are still in very early stages
Iowa	We are only doing BIM pilot currently. This fall we will be letting a project with an IFC 43.3.2 model as part of the digital deliverables. We are continuing to use a AID and ADCMS grant to keep our digital delivery effort moving forward.
Iowa	We lead both Pooled Fund Studies TPF 5(523) Building Information Modeling (BIM) for Bridges and Structures - Phase II and TPF-5(480) Building Information Modeling (BIM) for Infrastructure. We are actively piloting a few models as a legal document project and have created IFC files for additional projects and testing.
Kentucky	We are currently testing and doing proof of concepts with IFC, which overall have been successful from a data exchange standpoint. The current version of 4.3 includes a lot of infrastructure related objects but does not encompass everything needed. We are hoping the next release will be more comprehensive. One of our pain points is vendors adapting to the newer releases in a timely and functional manner.

Minnesota	MnDOT is using ORD to create 3D road and 3D drainage models. Bridge models are designed in 2D, as are other discipline models. We use Bluebeam for digital model review. MnDOT is doing some hybrid digital delivery, providing alignment files and surfaces in XML contractually alongside traditional PDF plans. Although MnDOT is interested in future use of IFC, there is little understanding about what that would look like or how it would be implemented.
Mississippi	BIM: currently all our roadway projects are completely designed in 3D modeling software. Bridge pilot projects for full 3D modeling are underway. IFC is being explored but no formal adoption or implementation.
Nebraska	Developing plan for BIM now, devoting staff to it etc.
New York State	Adopting BIM models that support construction activities such as automated machine guidance and global positioning systems. Waiting on further development and testing of IFC
North Carolina	Planning/setup phase
North Carolina	Still figuring out which one will be best suitable however looking closely at BIM (Building Information Modeling): 3D model-based process that helps architecture, engineering, and construction (AEC) professionals plan, design, construct, and manage buildings and infrastructure.
Oklahoma	We are working on getting our BIM life together, many new processes need to be put into place and data governance implementation is happening at the same time
Pennsylvania	FC deliverable BIM models
Pennsylvania	The Department is well underway in the adoption of BIM. The goal was to be able to deliver a project completely digitally by 2025. This is only the beginning, and we will continue to add additional projects as we advance. We currently have approximately 25 Digital Delivery projects underway. IFC is being developed with our ADCMS grant. We will be delivering 2 projects this year utilizing IFC as the contractual deliverable.
Texas	We are adopting Digital Delivery (BIM) and will continue to explore IFC. However, IFC is not ready for use on all projects.
Utah	We are likely the leaders in BIM and IFC. Our adoption of IFC is still less mature due to mapping of our workspace.
Vermont	We have a pilot project for model as the legal document that is going out to bid this fall. We have developed full 3D models for components of projects but to date they have only been given to the Contractor for informational purposes only
Vermont	One Pilot Project
Washington	We are currently in the process of researching how to get our traffic signs into a BIM environment for the entire lifecycle. We are developing a data dictionary for traffic signs and investigating how to get that data dictionary into IFC. Once we figure out how to do traffic signs, we will expand to other assets.
Wisconsin	We are exploring BIM and IFC through the Transportation Pooled Fund for Infrastructure. We do not have a set timeline in place when that adoption may occur.

Question 21 asked "*What challenges are faced within your state DOT with the selection and use of their methods and procedures for the tracking of transportation asset* *documents, and sharing of this information between your DOT and contractors?”.* Below in Table 30 contains the free-response answers for the below-listed state DOTs.

Table 30. Faced challenges within each state DOT with their current methods and procedures for tracking of transportation assets

Text Responses to Question 21	
Arizona	IT regulations hamper the ability to move forward with technology. Some people are stuck in old ways. Lack of communication with technology across teams and groups within agency. Lack of standards or understanding of standards from varying teams within agency
California	There is no current reliable data exchange schema. Will be meeting with construction industry to how best address this need and what we can do in the meantime with digital delivery.
California	1) lack of interoperability between different brands of site equipment (Trimble versus Topcon, etc..) 2) making sure prime contractors includes / upskills smaller subcontractors and suppliers to benefit from the efficiencies in the BIM process 3) making sure fabricators can use the data developed in design and continue to detail the model and support the fabrication process 4) IFC standard for Bridges and Structures is still being developed & implemented in the software products
Connecticut	Maintenance activities against assets
Georgia	Dedicated roles within DOT working on these efforts
Illinois	Multiple siloed business areas (surveys/design, construction, operations, asset management, land acquisition, office of planning and programming, Bureau of Information processing)
Iowa	If it did not federate without a single source of truth
Iowa	We are in the Bentley environment, and they are in the Trimble and Autodesk environment. There still seems to be some discrepancy between the IFC file in the different viewers that we are adapting to. Fabricators have had difficulty knowing what to do with this file instead of specific drawings for components. Hardware in the field isn't easiest to utilize, the model or cell service is slow, and files are large creating load time waits. Model cross section cuts at 90 degrees to alignment is not a default so depending on angle of view, measurements could be inaccurate simply by viewing the model. Rebar schedule is requested. Model staging capabilities such as closure pour where slab may appear to be floating in space is needed, unless everyone has capability.

Kentucky	We currently don't have a robust process in place to track asset information post-construction. Our Maintenance group is currently working to develop a small drainage structure inventory, and we are currently revisiting our as-built process to focus in on the pertinent details for various asset types and shift the thought from "as-built plans" towards "as-built information." We currently are working on one of our digital delivery pilot projects to determine how the DOT and contractors can collaborate to provide better as-built data coming out of construction to feed asset management systems, which could then facilitate future projects by delivering higher quality information to the DOT once the asset is in-place on the network and the contractor when the next project begins.
Minnesota	Internally, we're working on connecting ORD with AASHTOWare Project & our Transportation Asset Management System (TAMS) so they can pass asset data to each other.
Mississippi	Bidding and paying out projects to contractors, pay items, tracking models through construction, post construction delivery of as-built models.
Nebraska	Making sure the information is useable by the contractor. Finding long term viable storage solutions for said data
New York State	Return on investment. Also, migration of data from CAD to GIS asset environment. IFC file compatibility across all structures design, modeling, and fabrication software is also slowing down the process. Lack of expertise in what is required for using/requiring an IFC file as a deliverable. Do not know how to use the IDM or IDS.
North Carolina	1. Knowing what deliverables Contractors can consume to set procedures in place for developing those deliverables. 2. Training Staff and Consultants on those procedures. 3. Change mindset of creating and using those procedures.
North Carolina	Different software and platform integration across the board, workflow challenges that used to closely align with paper deliverables for certain agencies and digital for others.
Oklahoma	Everyone wanting to use different software, no one common place to keep stuff, no organization to files, many items being individually emailed around
Pennsylvania	Ensuring a true and accurate data exchange when using non-native software
Pennsylvania	A lot of legacy systems are located in the state. It is trying to pull all that data together and being able to deliver that data seamlessly.
Texas	User acceptance; technology not being 100% ready
Utah	The lack of full adoption of a standard e.g. IFC. We have been fortunate that our contractors have partnered with us to develop a deliverables package that can be consumed by contractors regardless of platform e.g. Trimble, Leica, Topcon, AGTEK, etc.
Vermont	The need for a standardized file format and nomenclature

Vermont	We need evidence that Contractors and fabricators are able to stay competitive and consume the data for bidding and construction.
Washington	Right now, we are determining how we can do this with traffic signs. The challenge is there is no central document or guide for how to accomplish this. As a result, it is building everything from scratch. The IFCs are pretty much devoid of traffic sign attributes, and we need to expand the abilities of the IFC to accommodate our robust traffic sign data dictionary.
Wisconsin	Lack of resources that could commit to undertaking and managing these tasks.

Below in Table 31 are the free-response answers to question 22 that asked "*What challenges are faced within your state DOT with the selection and use of their methods and procedures for the tracking of transportation asset documents, and sharing of this information between your DOT and contractors?*".

Table 31. Current trials/pilot projects for digital handover for each state DOT

Text Responses to Question 22	
Connecticut	None
California	We now have a Mandatory Specification that will provide our contractors with some digital design intent to be used for AMG, such as horizontal and vertical alignments, break lines, digital design model of finished grade, and digital terrain model.
California	Yes, we've handed over 4 bridge and earth retaining systems pilot projects to construction and used IFC as the exchange format. In our structure models we've included attributes like bid item number and are working on a standardized model object naming convention ("Object ID") in the IFC file, so construction can target the asset in the field and collect as-built data, which requires the object's bid item number.
Delaware	We are currently doing a pilot for use of Roll Plans. These are large format (200"x200") PDFs. We are testing this with 3 internal projects going through the internal review process and one project in construction. For the one in construction, the Roll Plans are for information only and the Cut Sheets are still the legal document
Georgia	No formal pilots - only providing non-contractual surface models at the time of bidding
Illinois	No pilots at this time.
Iowa	For our bridge pilot projects we have used .dgn files and will be using an IFC 4.3.2 file this fall. We have supplied models as FOI with success on major projects. We have a research project currently using IFC to create digital as-built connecting construction records from E-ticketing, Headlight, shop drawing, and Mill test report.
Iowa	Different viewers yield different results and show varying levels of metadata. Data structure may not match- for example, I pulled in an IFC to a Pix4D map, and it placed it in the ocean- we loaded the same

	file in Propeller, and it located correctly. Both had ground control. Generally, most contractors would be for it if the viewer could create a plan view similar to the ones we create with dimensional information at all points. If a contractor could generate their own cut sheets, they would be happy (and I am not talking about a screenshot or "saved view" it's not the same. Work disciplines should be able to be separated. Construction staff needs the ability to update with as-built data and deviations from plan.
Kentucky	More information about KYTC's pilot projects can be found here (https://transportation.ky.gov/Digital-Project-Delivery/Pages/Pilot-Program.aspx). Overall, we have conducted a couple pilot projects that have focused on the design-construction handoff with varied success. We have been able to provide feedback to designers about level of detail (which will aid as we determine statewide modeling requirements in the future) and reinforce standards of practice such as construction surveying that will be critical to success in a future with digital deliverables that are part of the construction contract. However, some of our field offices haven't had great success utilizing tools to visualize model data, so we are continuing to pilot solutions that will eventually aid in a transition to digital contractual construction deliverables. In the meantime, though, we have continued to provide traditional 2D plans to aid construction, although we have varied the format of the deliverables on some pilot projects (i.e., manuscript roll plot plan sets instead of traditional sheets). And we are just beginning to consider the construction-asset management handoff with one of our newer pilot projects that just began construction at the beginning of March.
Mississippi	Working on two pilot projects with 2026 lettings.
Nebraska	Have delivered data on numerous projects to date, but always For Information Only. Working on getting a project delivered in 2026 that is Model as the legal document
New York State	Right of way acquisition process is a very paper-oriented process that inhibits full model-based approach. Results in duplication of effort to still provide PDF plans of the project. Right of way laws require information (i.e. printed paper) to be left behind with reputed owners. There is a big lift with regard to staff being comfortable with something different. I have gotten negative feedback from construction staff thinking we are requiring the use of digital inspection devices (tablets) in the field. Letting go of the paper is very hard for some.
North Carolina	ongoing piloting with contractors, asset management and maintenance. The piloting has proven very useful in understanding the end-to-end needs and planning the workflows and deliverable formats accordingly.
Oklahoma	We are still mostly in the design phase right now, we have implemented technology assessment processes, we are re-building bot PW and workspace to be more conducive to modeling and align better with ISO 19650, to improve the flow of information, also working on collecting asset data and what that process should be.

Pennsylvania	We are currently working in two ADCMS grant funded BIM (IFC deliverable) pilot projects. We have not completed this process yet.
Pennsylvania	We have been advancing the use of Digital Delivery and BIM for about 6 years at this point. A lot of information on projects, resources, and information can be found on our website https://www.pa.gov/agencies/penndot/programs-and-doing-business/digital-delivery.html
Utah	We have done almost 30 projects with the model as the legal document and almost 20 fully constructed without providing a plan set. Projects have used various digital design review techniques and used mobile devices/base stations in the field utilizing Bentley OpenRoads Navigator, Autodesk BIM360, Trimble solutions and GIS (Collector/FieldMaps and CMaps which is a customized version of Fieldmaps)
Vermont	We have a pilot in process (see above) and a report will be developed for early next year
Vermont	The pilot project is in Final design. Coordination with 4 contractors through a process called Contractor involved during design (CIDD) is being used to train the contractor, fabricator, and suppliers on how to consume the project model so the digital deliverable is both biddable and buildable.
Washington	We have not done this at this juncture in our process.
Wisconsin	We have not conducted any trials/pilots related to IFC or BIM.

APPENDIX V. EXCHANGE REQUIREMENTS

The following are the developed data exchange requirement tables, in the same order of assets discussed in the report (pavements, pavement markings, signs, guardrails, culverts).

				Data Location							Data Exchange																		
Field Name	Field Description	Data Creation	Challenge/Problem	JobNet	ProjectWise	AASHTOWare Project	Roads & Highways	MDOT Global Database	AASHTOWare Construction	PHD	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19
HMA Base Course - Mix Type		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Base Course - Mix Design No (Case Sensitive)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Base Course - Application Rate		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Base Course - Asphalt Binder		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Base Course - Asphalt Binder Cert. Supplier		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Base Course - Asphalt % (Total)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Base Course - Asphalt Binder %Added (Virgin)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Base Course - Warm Mix?		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Base Course - If Warm Mix, Water Foaming?		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Base Course - If Warm Mix, select Additive		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Base Course - Shingles used in the mix?		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Base Course - Aggregate Class		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Leveling Course - Mix Type		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Leveling Course - Mix Design No (Case Sensitive)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Leveling Course - Application Rate		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Leveling Course - Asphalt Binder		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Leveling Course - Asphalt Binder Cert. Supplier		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Leveling Course - Asphalt % (Total)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Leveling Course - Asphalt Binder %Added (Virgin)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Leveling Course - Warm Mix?		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Leveling Course - If Warm Mix, Water Foaming?		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Leveling Course - If Warm Mix, select Additive		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Leveling Course - Shingles used in the mix?		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Leveling Course - Aggregate Class		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Top Course - Mix Type		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Top Course - Mix Design No (Case Sensitive)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Top Course - Application Rate		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Top Course - Asphalt Binder		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Top Course - Asphalt Binder Cert. Supplier		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Top Course - Asphalt % (Total)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Top Course - Asphalt Binder %Added (Virgin)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Top Course - Warm Mix?		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Top Course - If Warm Mix, Water Foaming?		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Top Course - If Warm Mix, select Additive		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Top Course - Shingles used in the mix?		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
HMA Top Course - Aggregate Class		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
PCC Pavement - Cement Content		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
PCC Pavement - Continuously Reinforced?		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
PCC Pavement - Fly Ash Content		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
PCC Pavement - GGBFS		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
PCC Pavement - Portland Cement Supplier		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
PCC Pavement - Portland Cement Type		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
PCC Pavement - Thickness		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
PCC Pavement - Transverse Joint Spacing		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
PCC Pavement - Transverse Joints Sealed		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X
PCC Pavement - Aggregate Class		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P4: Majority of the data is manually entered into database by looking project files		X	X			X	X			X (P1)	X	X			X	X	X	X	X	X	X				X (P4)	X

				Data Location					Data Exchange																	
Field Name	Field Description	Data Creation	Challenge/Problem	JobNet	ProjectWise	AASHTOWare Project	AASHTOWare Construction	Excel Spreadsheet	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18
Long Line - Seq#		Automatically generated						X																		X
Long Line - MAT		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - Type		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - TSC		Decided by Region/TSC when a project decision is made		X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X		X	X		X
Long Line - County		Decided by Region/TSC when a project decision is made		X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X		X	X		X
Long Line - CS		Decided by Region/TSC when a project decision is made		X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X		X	X		X
Long Line - CS_BMP		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - CS_EMP		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - Route		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - Miles		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - PR		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - PR_BMP		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - PR_EMP		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - Exit_No		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - Ramp_ID		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - Loc_Des		Entered by Pavement Marking office when they created the asset						X																		X
Long Line - Gores		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - Ramps		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - 4" White		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - 6" White		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - 8" White		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - 12" White		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - 4" Yellow		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - 6" Yellow		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - 4" Blue		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - 4" Black		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - ACC		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Long Line - Year		Entered by Pavement Marking office when they created the asset						X																		X
Long Line - Comments		Entered by Pavement Marking office when they created the asset						X																		X
Special Marking - SEQ#		Automatically generated						X																		X
Special Marking - MATL		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - TSC		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - County		Decided by Region/TSC when a project decision is made		X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X		X	X		X
Special Marking - City/Twp/Village		Decided by Region/TSC when a project decision is made		X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X		X	X		X
Special Marking - CS		Decided by Region/TSC when a project decision is made		X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X		X	X		X
Special Marking - BMP		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - Route		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - Location		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - Leg		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - 6" CW		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - 6" WTGL		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - 6" YTGL		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - 12" CW		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - 12" White XH		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - 12" White		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - 12" Yellow XH		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - 12" Yellow		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - 24" White SB		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - 24" Yellow SB		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - WWA		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - CANADA		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - USA		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - AHEAD		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - BUS		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - LTA		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - BIKE		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)

Special Marking - PED		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - EXIT		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - XING		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - MERGE		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - LANE		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - ONLY		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - STOP		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - NO		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - RIGHT		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - LEFT		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - RLA		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - TURN		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - YLD TRI		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - YIELD		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - SMBX		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - TPRS		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - HOV		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - RR		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - Sm Bike		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - MA		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - RTA		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - SCHOOL		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - TRAIL		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - TLA		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - TRA		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)

Special Marking - TA		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - RTLA		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - LRBA		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - Lg Bike		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - BDA		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - SHAR		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - TLRBA		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - RLRBA		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - RTLRBA		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - SHLD		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P3: New or modified asset information may not be included in as-built drawings P5: Majority of the data is manually entered into database by looking project files		X	X	X	X			X (P1)	X		X		X	X	X	X	X	X (P3)		X	X		X (P5)
Special Marking - Year		Entered by Pavement Marking office when they created the asset						X																		X
Special Marking - Comment		Entered by Pavement Marking office when they created the asset						X																		X

				Data Location					Data Exchange															
Field Name	Field Description	Data Creation	Challenge/Problem	JobNet	ProjectWise	AASHTOWare Project	AASHTOWare Construction	MiSign	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16
Active Project		Entered by Signing office or TSC/Regions when it is created or there is a service for the asset	P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated					X (P5)																X
Minimum Component Year		Entered by Signing office or TSC/Regions when it is created or there is a service for the asset	P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated					X (P5)																X
Maximum Component Year		Entered by Signing office or TSC/Regions when it is created or there is a service for the asset	P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated					X (P5)																X
CS #		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
CS Branch		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
CS MP		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Ramp ID		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
PR #		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
PR MP		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Latitude		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Longitude		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Region		Decided by Region/TSC when a project decision is made		X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X
TSC		Decided by Region/TSC when a project decision is made		X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X
County		Decided by Region/TSC when a project decision is made		X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X
Device Accuracy (ft)		Entered by Signing office or TSC/Regions when it is created or there is a service for the asset	P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated					X (P5)																X
Lateral Offset (ft)		Entered by Signing office or TSC/Regions when it is created or there is a service for the asset	P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated					X (P5)																X
Lat Long Source of Data		Entered by Signing office or TSC/Regions when it is created or there is a service for the asset	P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated					X (P5)																X
Lat Long Quality Indicator		Entered by Signing office or TSC/Regions when it is created or there is a service for the asset	P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated					X (P5)																X
PR Source of Data		Entered by Signing office or TSC/Regions when it is created or there is a service for the asset	P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated					X (P5)																X
PR Quality Indicator		Entered by Signing office or TSC/Regions when it is created or there is a service for the asset	P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated					X (P5)																X
Side of Road		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Sign Installation Roadway Type		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Side Road Name		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Related CS		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Valid		Entered by Signing office or TSC/Regions when it is created or there is a service for the asset	P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated					X (P5)																X
Installation Component		Entered by Signing office or TSC/Regions when it is created or there is a service for the asset	P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated					X (P5)																X
Sign Installation ID		Automatically generated						X																X
Sign - Sign Code		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Sign - Modified		Entered by Signing office or TSC/Regions when there is a service for the asset	P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated					X (P5)																X
Sign - Cluster location		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Sign - Width (in)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Sign - Height (in)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Sign - Square Footage		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Sign - Sign Facing		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Sign - Arrow		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Sign - Legend/Description		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Sign - Legend Sheeting		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Sign - Legend Sheeting Color		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Sign - Substrate		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Sign - Background Sheeting		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Sign - Background Sheeting Color		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Sign - Test Sign		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Sign - Sign Year Installed		Entered by Signing office or TSC/Regions when it is created or there is a service for the asset	P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated					X (P5)																X
Support - Support Name		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Support - Support Type		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Support - Support Overhead Classification		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Support - Number of Supports		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Support - Support Length (ft)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Support - Structure ID		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Support - Diaphragm		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Support - Skew (deg)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Support - Arm Length (ft)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Support - Truss Span (ft)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Support - Left Upright Length (ft)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Support - Right Upright Length (ft)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Support - Sign Position (ft)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Support - Sign Placement Description		Entered by Signing office or TSC/Regions when it is created or there is a service for the asset	P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated					X (P5)																X
Support - Reflective Support Panel		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Support - Reflective Support Panel Color		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Support - Reflective Support Panel Length (ft)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Support - Support Year Installed		Entered by Signing office or TSC/Regions when it is created or there is a service for the asset	P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated					X (P5)																X
Foundation - Foundation Name		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Foundation - Foundation Type		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Foundation - Foundation Overhead Classification		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Foundation - Number of Foundations		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Foundation - Quantity (Depth / Volume)		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated P6: Majority of the data is manually entered into database by looking project files		X (P1)	X	X	X (P5)			X (P1)	X		X		X (P6)	X	X	X	X	X (P2)	X	X	X (P6)
Foundation - Foundation Year Installed		Entered by Signing office or TSC/Regions when it is created or there is a service for the asset	P5: A sign includes 3 different datasets: Sign, support, and foundation. If support or foundation is changed or updated, MiSign is generally not updated					X (P5)																X

				Data Location					Data Exchange															
Field Name	Field Description	Data Creation	Challenge/Problem	JobNet	ProjectWise	AASHTOWare Project	AASHTOWare Construction	BRM	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16
ApproachEnding	Approach Ending	Contractor decides and includes on as-built drawings	P2: New or modified asset information may not be included in as-built drawings P3: Contractor not entering new/changed asset information into the database (missing link) P4: A field team needs to go to the site to collect asset information		X (P2)			X (P3)												X (P2)			X (P4)	
GuardrailMaterial	Guardrail/HTCB Material	Contractor decides and includes on as-built drawings	P2: New or modified asset information may not be included in as-built drawings P3: Contractor not entering new/changed asset information into the database (missing link) P4: A field team needs to go to the site to collect asset information		X (P2)			X (P3)												X (P2)			X (P4)	
PostType	Post Type	Contractor decides and includes on as-built drawings	P2: New or modified asset information may not be included in as-built drawings P3: Contractor not entering new/changed asset information into the database (missing link) P4: A field team needs to go to the site to collect asset information		X (P2)			X (P3)												X (P2)			X (P4)	
BlockType	Offset Block Type	Contractor decides and includes on as-built drawings	P2: New or modified asset information may not be included in as-built drawings P3: Contractor not entering new/changed asset information into the database (missing link) P4: A field team needs to go to the site to collect asset information		X (P2)			X (P3)												X (P2)			X (P4)	
DepartureEnding	Departure Ending	Contractor decides and includes on as-built drawings	P2: New or modified asset information may not be included in as-built drawings P3: Contractor not entering new/changed asset information into the database (missing link) P4: A field team needs to go to the site to collect asset information		X (P2)			X (P3)												X (P2)			X (P4)	
Guardrail Type	Guardrail/Cable Barrier Type	Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans		X (P1)	X	X	X			X (P1)	X		X		X	X	X	X	X	X	X	X	
CurvedGuardrail	Curved Guardrail with 150' Radius (R) or less?	Contractor decides and includes on as-built drawings	P2: New or modified asset information may not be included in as-built drawings P3: Contractor not entering new/changed asset information into the database (missing link) P4: A field team needs to go to the site to collect asset information		X (P2)			X (P3)												X (P2)			X (P4)	
Date	Installation Date - If installation date is unknown, enter 1900	Site teams enter the installation date into the system	P3: Contractor not entering new/changed asset information into the database (missing link)				X	X (P3)												X		X	X	
SystemCreateDate	Asset Collection Date - Automatically populated through GIS	Automatically generated						X															X	X
ConditionIndex	Overall Condition, Condition Rating 10-0, Calculated and pushed from Vueworks	Decided by site teams and entered into Vueworks which is linked to the inventory database						X																X
Route	This list will have all M, I, US, BL and BR routes	Decided by Region/TSC when a project decision is made.		X	X	X	X	X	X	X	X	X		X		X	X	X		X	X	X	X	X
RoadType	Road Type	Decided by Region/TSC when a project decision is made.		X	X	X	X	X	X	X	X	X		X		X	X	X		X	X	X	X	X
OrigGuardrailId	This will auto populate for each guardrail/cable barrier run	Automatically generated						X															X	X
OBJECTID		Automatically generated						X															X	X
GuardrailId		Automatically generated						X															X	X
PRBegin		Design team decides and includes on design drawings.	P1: Information is stored as text in drawing plans		X (P1)	X	X	X			X (P1)	X		X		X	X	X	X	X	X	X	X	
PRBmp		Design team decides and includes on design drawings.	P1: Information is stored as text in drawing plans		X (P1)	X	X	X			X (P1)	X		X		X	X	X	X	X	X	X	X	
PREnd		Design team decides and includes on design drawings.	P1: Information is stored as text in drawing plans		X (P1)	X	X	X			X (P1)	X		X		X	X	X	X	X	X	X	X	
PREmp		Design team decides and includes on design drawings.	P1: Information is stored as text in drawing plans		X (P1)	X	X	X			X (P1)	X		X		X	X	X	X	X	X	X	X	
ServiceStatus		Entered by Traffic and Safety office or TSC/Regions when there is a service for the asset	P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X															X	X (P5)
Comments		Entered by Traffic and Safety office or TSC/Regions when there is a comment for the asset	P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X															X	X (P5)
InspectionDate		Entered by Traffic and Safety office or TSC/Regions when there is an inspection for the asset	P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X															X	X (P5)
UserEditedDate		Entered by Traffic and Safety office or TSC/Regions when the asset is edited	P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X															X	X (P5)
SpatialQualityIndex		Entered by Traffic and Safety office						X															X	
SystemModifiedDate		Automatically generated						X															X	X
UserCreate		Entered by Traffic and Safety office when they created the asset						X															X	
UserModified		Entered by Traffic and Safety office or Region/TSC when they modified the asset						X															X	X
Shape		Entered by Traffic and Safety office, and used for storage in the geodatabase purpose						X															X	
Shape.STLength()		Entered by Traffic and Safety office, and used for storage in the geodatabase purpose						X															X	

Field Name	Field Description	Data Creation	Challenge/Problem	Data Location					Data Exchange													
				JobNet	ProjectWise	AASHTOWare Project	AASHTOWare Construction	BRM	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14
OBJECTID		Automatically generated						X													X	X
GlobalID		Automatically generated						X													X	X
strc_num		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
strc_num_seq		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
strc_type_cd		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
CulvertMaterial		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
Culv_dsgn_type_cd		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
ServiceStatus		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
strucname		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
dsgn_std_cd		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
invt_field_vrfy_date		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
invt_field_vrfy_user		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
invt_field_vrfy_cmpy_cd		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
invt_field_comm		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
next_insp_freq		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
insp_grp_cd		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
antcp_insp_date		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
crewhrs		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
aadt		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
aadt_yr		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
owner_cd		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
owner_name_cd		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
custodian_cd		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
custodian_name_cd		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
acs_cd		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
acs_note		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
trfc_ctrl_cd		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
trfc_ctrl_note		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
rail_coord_cd		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
rail_name_cd		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
rail_phne_num_cd		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
JobNumber		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
CulvertInstallationDate		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
yearrecon		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
prmy_xstr		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
location		Decided by Region/TSC when a project decision is made		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
legal_cd		Decided by Region/TSC when a project decision is made		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
nrst_rte_drtn_cd		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
mile_mrkr		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
PR		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
PRMP		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
cs		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
cs_mp		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
placecode_cd		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
mdot_regn_cd		Decided by Region/TSC when a project decision is made		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
mdotcnty_cd		Decided by Region/TSC when a project decision is made		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
mdot_tsc_cd		Decided by Region/TSC when a project decision is made		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
grg_cd		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
precise_lat_barrel_start		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
precise_lon_barrel_start		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
precise_lat_barrel_end		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
precise_lon_barrel_end		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
lat_lon_src_cd		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
SpatialQualityIndex		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
Beneath		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
Comments		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
ConditionIndex		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
CulvertGroupID		Automatically generated						X													X	X
CulvertHeight		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
CulvertShape		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
CulvertWidth		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)

culv_span		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
DepthOfCover		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
depth_cover_feet		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
DitchVegetation		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
UserEditedDate		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
InspectionDate		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
Liner		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
LinerDiameter		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
LinerMaterial		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
AssetCollectionDate		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
Route		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
StreamSubstrate		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
Surface		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
rdwy_surf_cd		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
WaterDepth		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
flow_dir_cd		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
NumberofBarrelsCells		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
CulvertLengthCalculated		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
skew_ang		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
NumberofLanes		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
DesignDischargeCFS		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
DrainageAreaAcres		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
InletProtection		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
OutletProtection		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
perch_outlet_cd		Design team decides and includes on design drawings	P1: Information is stored as text in drawing plans P2: New or modified asset information may not be included in as-built drawings P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service		X (P1)	X	X	X			X (P1)	X		X	X	X	X	X (P2)	X	X	X (P4)	X (P5)
last_insp_date		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
last_insp_user_cd		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
last_cpnt_rating_cd		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
last_insp_qc_stat_cd		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
last_insp_qa_stat_cd		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
num_work_rec_open		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
rfa_stat_cd		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
rr_op_name		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
rr_div		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
rr_mp		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
rr_xstr		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
rr_num_trck_cross		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
created_user		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
created_date		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
last_edited_user		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)
last_edited_date		Entered by Ancillary Structures or Region/TSC office when they created/modified the asset	P4: Majority of the data is manually entered into database by looking project files P5: It is not known whether asset information is updated or entered into the database after maintenance/service					X (P4, P5)													X (P4)	X (P5)

APPENDIX VI. MDOT INTERVIEW QUESTIONS

MDOT Project # OR24-010

Interviews within MDOT Offices/Bureaus/Groups/Teams

Purpose: The purpose of this research is to improve data continuity during handover both within MDOT and between MDOT and external parties (e.g. contractors, consultants). Potential methods considered may be through the use of IFC, BIM, and/or others. One of the first steps in this research project is to map, from start to finish, the current data workflow and handover process of different transportation assets within MDOT. We are looking to interview offices/bureaus/groups/teams within MDOT to better understand this workflow and handover process

Who: Those who are involved in the development, storage, and use of data used for the following transportation assets: *pavements, pavement markings, culverts, guardrails, drainage structures, traffic signs, bridges, ancillary assets.* This may be in any stage of development or use of these assets (e.g. planning, design, contract development, construction, operation and maintenance)

Interview Logistics: We would like to schedule a 1-2 hour meeting with your team to ask your team a series of questions on how the data associated with the transportation asset(s) you work with is developed, stored, used, and passed to others. We may also follow up with your team to confirm details or with additional questions.

Data/information we want to discuss with your team for MDOT transportation assets:

- Data types/formats/attributes
- Where the data comes from
- Flow of data from one person/group to another
- Storage of data during each step/shared passed between groups
- Which data is used by group data is passed to and what is/isn't
- Issues with data flow/data loss

Types of Questions: *The following are the kinds of questions we would like to discuss with your team:*

- What transportation asset(s) does your team work with from the above list? (*pavements, pavement markings, culverts, guardrails, drainage structures, traffic signs, bridges, ancillary asset)*
- In what stages of development or use does your team work with these asset(s)? (e.g. planning, design, contract development, construction, operation and maintenance)

- Can you explain, from start to finish, how your team typically interfaces with these assets?
- Do you receive any data or information on these asset(s) from anywhere else?
    - What data do you receive,
    - Where does it come from,
    - What format is it in
    - How do you access it
    - Are you using all of the data provided to you or only certain attributes/components? If so, which ones are you using and what is extraneous?
- Does your team develop/create any of your own data on these transportation assets?
    - What data do you develop
    - What format is the data you create in
    - What attributes do you create/populate to describe these assets
    - Where do you save your data/how is it saved?
- Does your team share any of the data you have developed with others within MDOT or external parties?
    - What data do you share
    - What format is it in when shared? Is it different than its original format? Is there any data lost if switching to this format as opposed to its original format?
    - What attributes do you share? All of them? Some?
    - How is the data you have created shared? Where is it saved when it is shared (e.g. shared folder?)
    - Who do you share this data with?
    - What is the data used for? What is its purpose?
    - Do you know what attributes are used by whomever is receiving the data? What are not used?
- What data formats are used when receiving, saving, and sharing data?
- What issues does your group notice with sharing and receiving data?
- Do you have any suggestions on better ways to save, organize, and/or share data within MDOT and between MDOT and external parties?
- Does your team have familiarity with IFC? BIM? What are your thoughts on using these as potential solutions for helping improve digital data handover?

APPENDIX VII. CONTRACTOR INTERVIEW QUESTIONS

Michigan Department of Transportation Project #OR24 – 010 with Michigan State University

Interviews with Contractors within Michigan

Purpose: The purpose of this research is to improve data continuity during handover both within MDOT and between MDOT and external parties (e.g. contractors, consultants). Potential methods considered may be through the use of IFC, BIM, and/or others. One of the first steps in this research project is to map, from start to finish, the current data workflow and handover process of different transportation assets within MDOT. We are looking to interview contractors who are willing to share their insights, expertise, opinions and thoughts on data transfer, communication, suggestions on improvement and problems experienced in the field. We hope to gain a better understanding of how contractors use current plans to bid and construct their work, specifically wondering about what software and tools that are used during these processes.

Who: Those who are involved in the development, storage, and use of data used for the following transportation assets: *pavements, pavement markings, culverts, guardrails, drainage structures, traffic signs, bridges, ancillary assets.* This may be in any stage of development or use of these assets (e.g. planning, design, contract development, construction, operation and maintenance)

Interview Logistics: We would like to schedule an approximately 1 hour meeting with your team to ask your team a series of questions on how the data associated with the transportation asset(s) you work with is developed, stored, used, and passed to others.

Data/information we want to discuss with you for MDOT transportation assets:

- Specific tools and software that are used
- Where the data comes from
- Flow of data from one person/group to another
- Storage of data during each step/shared passed between groups
- Which data is used by group data is passed to and what is/isn't
- Issues with data flow/data loss

Types of Questions: *The following are the kinds of questions we would like to discuss with your team:*

Current Practices

- What transportation asset(s) does your team work with from the above list? (*pavements, pavement markings, culverts, guardrails, drainage structures, traffic signs, bridges, ancillary asset)*
- What is your current role in receiving, collecting, providing and storing data?
- Do you receive any data or information on these asset(s) from anywhere else?
    - What data do you receive,
    - Where does it come from,
    - What format is it in
    - How do you access it
    - Are you using all of the data provided to you or only certain attributes/components? If so, which ones are you using and what is extraneous?
- Does your team develop/create any of your own data on these transportation assets?
    - What data do you develop
    - What format is the data you create in
    - What attributes do you create/populate to describe these assets
    - Where do you save your data/how is it saved?
- Does your team share any of the data you have developed with others within your organization, MDOT or other external parties?
    - What data do you share
    - What format is it in when shared? Is it different than its original format? Is there any data lost if switching to this format as opposed to its original format?
    - What attributes do you share? All of them? Some?
    - How is the data you have created shared? Where is it saved when it is shared (e.g. shared folder?)
    - Who do you share this data with?
    - What is the data used for? What is its purpose?
    - Do you know what attributes are used by whomever is receiving the data? What are not used?

Challenges and Opportunities

- Can you explain, from start to finish, how your team typically interfaces with these assets?
- What data formats are used when receiving, saving, and sharing data?
- What issues does your group notice with sharing and receiving data?
- What are the difficulties that are being faced currently when coordinating with designers, consultants, contractors, administrators, etc.?
- Are there any scenarios throughout these processes where there is loss of data, issues entering in data, data flow, missing data, manual efforts, errors in data, etc.
- What are the things that are currently working great?
- What are the things that need major improvement and effort?
- Do you have any suggestions on better ways to save, organize, and/or share data within your organization and between MDOT and other external parties?

Opinions

- Do you have any experience using 3D models for construction related to your assets? What was your experience and your thoughts about this process?
- Are 3D models helpful to use for collecting data, storing data, reading data, etc? Are they efficient to use in the field? Are they easy to edit and use?
- Would your staff feel comfortable working with 3D models (for as built modifications) by entering in data and interacting with the models? Is this feasible?
- How does the data work when integrated with 3D models?
- Does your team have familiarity with IFC? BIM? What are your thoughts on using these as potential solutions for helping improve digital data handover?
- Would our proposed solutions be beneficial, practical, feasible, easily adapted?
- What do you think are the best options in terms of solutions from your point of view?

APPENDIX VIII. SURVEY OF DOTS

Michigan State University, in collaboration with the Michigan Department of Transportation (MDOT), is conducting research on digital collaboration using Industry Foundation Classes (IFC) and Building Information Modeling (BIM) technology.

The objective of this survey is to document the current state of practice for digital data asset management and digital handover. This includes (1) understanding the state of adoption of the use of IFC, BIM and/or other methods both within the DOT internal teams and between the DOT and external parties (e.g. contractors), (2) evaluating the experience of participants in using such solutions, including the challenges faced with selection and use of their methods and procedures for transportation assets.

Please take the time required to complete this survey by March 28th. This survey is estimated to take 15 minutes to complete. Best results occur when taken on a computer or laptop, however it can also be taking via mobile device. Here is a link to the online survey: https://msu.co1.qualtrics.com/jfe/form/SV_9zcpGnzT1wTsC6a. If you have any questions, please contact Dr. Kristen Cetin by phone: (517) 353-2345 or email: cetinkri@msu.edu.

Contact Information

1. Last, First Name

2. State of DOT Employment (Full State Name)

3. Job Title (and BIM related role, if applicable)

4. E-mail

5. Phone Number (optional)

Current Application and Knowledge

The purpose of the following questions is to understand what tools state DOTs are using for data handover.

Please note that we recognize multiple people may need to be consulted within your DOT to answer these questions. If you may wish to answer these questions as a team, or you may answer these questions for the assets you work with and suggest someone else in your DOT to answer the rest. Question 23 at the end provides space for you to provide contact information for others within your DOT that may be helpful to reach out to.

6. Please select which of the below technology(s) or method(s) you are using within your state DOT for the below-listed assets.

	2D Drawings (e.g. CAD)	3D Models (e.g. BIM)	Common Data Environment (e.g. ProjectWise)	Point Cloud Data (e.g. LiDAR)	GIS
In your DOT for any purpose	☐	☐	☐	☐	☐
Pavements	☐	☐	☐	☐	☐
Pavement Markings	☐	☐	☐	☐	☐
Culverts	☐	☐	☐	☐	☐
Guardrails	☐	☐	☐	☐	☐
Drainage Structures	☐	☐	☐	☐	☐
Traffic Signs	☐	☐	☐	☐	☐
Bridges	☐	☐	☐	☐	☐

Ancillary Assets	☐	☐	☐	☐	☐

7. Please define what ancillary assets means for your DOTs (as it relates to the questions in the survey). If not applicable, write N/A.

____

____

8. What database system(s) is your DOT using for storing of information on each asset type? (e.g. ProjectWise, Oracle, ERMS, etc.)

Pavements	
Pavement Markings	
Culverts	
Guardrails	
Drainage Structures	
Traffic Signs	
Bridges	
Ancillary Assets	

9. What software package(s) are used to create and/or modify the listed assets at your state DOT? (e.g. Autodesk-Naviswork, Autodesk-Civil 3D, Autodesk Infraworks, Bentley-Open Roads CE, Autodesk-BIM 360, Trimble-Connect, Bentley-iTwin, etc.)

Pavements	
Pavement Markings	
Culverts	
Guardrails	

Drainage Structures	
Traffic Signs	
Bridges	
Ancillary Assets	

The purpose of the following questions is to understand how data is shared externally (format, method, etc.)

10. How does your DOT share data with **external parties** (bidders, contractors, and consultants) on DOT construction projects including both contractual and non-contractual documents? Please select all that apply.
    - ☐ Mailing or handing over printed documents
    - ☐ Sharing a link for the document/file through a Common Data Environment (CDE) (Please enter the tool(s) you use [i.e. ProjectWise, Google Drive, Esri ArcGIS, Bluebeam Revu, Trimble Connect, etc.])

      ____
    - ☐ Sending an email with attachments including the document/file
    - ☐ Using shared software (Acrobat reader, AutoCAD Map 3D, etc.)
    - ☐ Other: ______________________________
11. Where does your DOT house your common data environment?
    - ☐ Single point (not cloud based)
    - ☐ Cloud based with server in your country
    - ☐ Cloud based with server in your country, inside your firewall
    - ☐ Inside your firewall
    - ☐ Other: ______________________________
12. For each asset, how is information on these assets typically shared with **external parties** (bidders, contractors, and consultants)? Please check all that apply.

	Contractually	Non-Contractually
Pavements	☐	☐

Pavement Markings	☐	☐
Culverts	☐	☐
Guardrails	☐	☐
Drainage Structures	☐	☐
Traffic Signs	☐	☐
Bridges	☐	☐
Ancillary Assets	☐	☐

13. What type of data does your DOT share with **external parties** (bidders, contractors, and consultants)? Please select all that apply.

    - ☐ Printed documents
    - ☐ Digital documents (PDF, spreadsheet, etc.)
    - ☐ 3D Models (BIM, etc.)
    - ☐ CAD Files (dgn, dwg, xml, csv, etc.)
    - ☐ GIS Files
    - ☐ Other: ______________________

14. What file/document types does your DOT share with **external parties** (bidders, contractors, and consultants) for the listed assets? For example: DWG, PDF, etc...

Pavements	
Pavement Markings	
Culverts	
Guardrails	
Drainage Structures	
Traffic Signs	
Bridges	

Ancillary Assets	

15. How does your DOT require **contractors to share** as-built documents after the construction project is complete? Please select all that apply.
    - ☐ Mailing or handing over printed documents
    - ☐ Sharing a link for the document/file through a Common Data Environment (CDE) (i.e. ProjectWise, Google Drive, etc.)
    - ☐ Sending email with attachments including the document/file
    - ☐ Other: ________________________________

16. What type of as-built data do you officially request **from project contractors** to handover after a project is complete, for the above-discussed assets? Please select all that apply.
    - ☐ Printed documents
    - ☐ Digital documents (PDF, spreadsheet, etc.)
    - ☐ 3D Models (BIM, etc.)
    - ☐ CAD Files (dgn, dwg, xml, csv, etc.)
    - ☐ GIS Files
    - ☐ Other: ________________________________

17. What file/document types does your DOT require to be **shared by the contractor** back to your DOT for the listed assets?
    For example: DWG files, schedules of the material used, GIS file containing geolocation data, etc.

Pavements	
Pavement Markings	
Culverts	
Guardrails	
Drainage Structures	

Traffic Signs	
Bridges	
Ancillary Assets	

Recommendations and Experiences

18. Within the next five years, what percentage of your DOT's transportation related data is anticipated to be stored and managed completely in digital environment?

	0%	1-49%	50-99%	100%	Already 100%
Pavements	☐	☐	☐	☐	☐
Pavement Markings	☐	☐	☐	☐	☐
Culverts	☐	☐	☐	☐	☐
Guardrails	☐	☐	☐	☐	☐
Drainage Structures	☐	☐	☐	☐	☐
Traffic Signs	☐	☐	☐	☐	☐
Bridges	☐	☐	☐	☐	☐
Ancillary Assets	☐	☐	☐	☐	☐

19. What is your DOT's BIM for Infrastructure Maturity level?
    - **Level 0: Document-Oriented**, physical and functional characteristics of highway assets managed across multiple documents (or files)
    - **Level 1: Object-Oriented**, physical and functional information about assets managed in "disintegrated" data models (or databases)

- **Level 2: Federated Object Models and Databases**, physical and functional information about assets managed in “integrated: enterprise data models (or databases)
- **Level 3: Integrated Lifecycle**, physical and functional information about assets managed in “integrated” internal and external enterprise data models (or databases)

20. Considering your DOT, what is the current state of adoption of the use of BIM and IFC within your DOT processes?
BIM (Building Information Modeling): 3D model-based process that helps architecture, engineering, and construction (AEC) professionals plan, design, construct, and manage buildings and infrastructure.
IFC (Industry Foundation Classes): a data exchange schema intended for description of architectural, building and construction industry data. It is a standardized file format (.ifc) for digital description of the built asset industry. It is used for transferring model data between different 3D modeling software packages.

____

____

21. What challenges are faced within your state DOT with the selection and use of their methods and procedures for the tracking of transportation asset documents, and sharing of this information between your DOT and contractors?

____

____

22. Even if you don't generally use BIM, IFC or any other technology for digital data handover in your projects, if your DOT has done any trials/pilots for digital data handover (e.g. using IFC, BIM, or others), please share your experiences.

____

____

23. If you were not able to answer all of the questions, is there someone else within your DOT that would be helpful for this project? Please provide their name and email address.

- ☐ First Name: ______________________________

- ☐ Last Name: ____
- ☐ Email: ____
- ☐ What questions were you not able to complete?____

24. Is there any other information or comments that you would like to provide that have not been discussed within this survey?

____

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APPENDIX IX. IFC DEMONSTRATION

The following are the IFC property sets and IFC mapping used in the IFC case study demonstration.

		Field Name	Property/Quantity Set	#*	Name	Property Type	Data Type
Segment		Route	MDOT_Segment	C	Route	IfcPropertySingleValue	IfcLabel
		PR #	MDOT_Segment	C	PRNumber	IfcPropertySingleValue	IfcLabel
		PR BMP	MDOT_Segment	C	PRBMP	IfcPropertySingleValue	IfcLabel
		PR EMP	MDOT_Segment	C	PREMP	IfcPropertySingleValue	IfcLabel
		Begin Station	MDOT_Segment	C	BeginStation	IfcPropertySingleValue	IfcLabel
		End Station	MDOT_Segment	C	EndStation	IfcPropertySingleValue	IfcLabel
Median		Medain Type	MDOT_Median	C	MedainType	IfcPropertyEnumeratedValue	IfcLabel
		Median Width (ft)	MDOT_Median	C	MedianWidth	IfcPropertySingleValue	IfcPositiveLengthMeasure
Lane		Lane #	MDOT_Lane	C	LaneNumber	IfcPropertySingleValue	IfcInteger
		Surface Type	MDOT_Lane	C	SurfaceType	IfcPropertyEnumeratedValue	IfcLabel
		Lane Width (ft)	Pset_RoadDesignCriteriaCommon	496	LaneWidth	IfcPropertySingleValue	IfcPositiveLengthMeasure
		Lane Type	MDOT_Lane	C	LaneType	IfcPropertyEnumeratedValue	IfcLabel
		Year Paved/Placed	Pset_ConstructionOccurence	80	InstallationDate	IfcPropertySingleValue	IfcDate
		Partial Width Paving	MDOT_Lane	C	PartialWidthPaving	IfcPropertySingleValue	IfcBoolean
		Paving Width (ft)	Pset_PavementCommon	166	NominalWidth	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
Shoulder		Shoulder	MDOT_Shoulder	C	Shoulder	IfcPropertySingleValue	IfcLabel
		Has Corrugations	MDOT_Shoulder	C	HasCorrugations	IfcPropertySingleValue	IfcBoolean
		Is Parking Lane	MDOT_Shoulder	C	IsParkingLane	IfcPropertySingleValue	IfcBoolean
		Paved Width (ft)	Pset_PavementCommon	166	NominalWidth	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
		Total Width (ft)	Pset_RoadDesignCriteriaCommon	496	LaneWidth	IfcPropertySingleValue	IfcPositiveLengthMeasure
		Paved Surface Type	MDOT_Shoulder	C	PavedSurfaceType	IfcPropertyEnumeratedValue	IfcLabel
		Curb & Gutter Work Done	MDOT_Shoulder	C	CurbGutterWorkDone	IfcPropertySingleValue	IfcBoolean
		Curb Type	MDOT_Shoulder	C	CurbType	IfcPropertyEnumeratedValue	IfcLabel
Layer of a lane or a shoulder	**Each Layer**	Layer Name	MDOT_Layer	C	LayerName	IfcPropertyEnumeratedValue	IfcLabel
	Agg. Base Course- Cement Stab.	Cement Content	MDOT_Layer	C	CementContent	IfcPropertyEnumeratedValue	IfcLabel
		Fly Ash Content	MDOT_Layer	C	FlyAshContent	IfcPropertyEnumeratedValue	IfcLabel
		GGBFS	MDOT_Layer	C	GGBFS	IfcPropertyEnumeratedValue	IfcLabel
		Portland Cement Supplier	MDOT_Layer	C	PortlandCementSupplier	IfcPropertyEnumeratedValue	IfcLabel
		Portland Cement Type	MDOT_Layer	C	PortlandCementType	IfcPropertyEnumeratedValue	IfcLabel
		Thickness	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
		Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
	Aggregate Base Course	Thickness	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
		Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
	Brick Pavers	Thickness	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
	Brick Seal	Brick Seal	MDOT_Layer	C	BrickSeal	IfcPropertySingleValue	IfcBoolean
	Chip Seal	Emulsion	MDOT_Layer	C	Emulsion	IfcPropertyEnumeratedValue	IfcLabel
		Emulsified Asphalt Supplier	MDOT_Layer	C	EmulsifiedAsphaltSupplier	IfcPropertyEnumeratedValue	IfcLabel
		Number of Courses	MDOT_Layer	C	NumberOfCourses	IfcPropertySingleValue	IfcInteger
		Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
	Cold In Place Recycled Asphalt	Emulsion	MDOT_Layer	C	Emulsion	IfcPropertyEnumeratedValue	IfcLabel
		Thickness	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
	Cold Milling	Cold Milling Depth	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
		Cold Milling Texture	MDOT_Layer	C	ColdMillingTexture	IfcPropertyEnumeratedValue	IfcLabel
		Cold Milling Type	MDOT_Layer	C	ColdMillingType	IfcPropertyEnumeratedValue	IfcLabel
	Concrete Pavement Crack/Joint Sealing	Crack Sealing, Conc Pavt	MDOT_Layer	C	CrackSealingConcPavt	IfcPropertySingleValue	IfcBoolean
		Resealing Longitudinal Joints	MDOT_Layer	C	ResealingLongitudinalJoints	IfcPropertySingleValue	IfcBoolean
		Resealing Transverse Joints	MDOT_Layer	C	ResealingTransverseJoints	IfcPropertySingleValue	IfcBoolean
	Concrete Pavement Repairs (Detail 7's & 8's)	Detail 7's placed?	MDOT_Layer	C	Detail7placed	IfcPropertySingleValue	IfcBoolean
		Detail 7 Mix Type	MDOT_Layer	C	Detail7MixType	IfcPropertyEnumeratedValue	IfcLabel
		Detail 8's placed?	MDOT_Layer	C	Detail8placed	IfcPropertySingleValue	IfcBoolean
		Detail 8 Mix Type	MDOT_Layer	C	Detail8MixType	IfcPropertyEnumeratedValue	IfcLabel
	Concrete Pavement Repairs (Full Depth)	Cement Content	MDOT_Layer	C	CementContent	IfcPropertyEnumeratedValue	IfcLabel
		Concrete Grade	MDOT_Layer	C	ConcreteGrade	IfcPropertyEnumeratedValue	IfcLabel
		Portland Cement Supplier	MDOT_Layer	C	PortlandCementSupplier	IfcPropertyEnumeratedValue	IfcLabel
		Portland Cement Type	MDOT_Layer	C	PortlandCementType	IfcPropertyEnumeratedValue	IfcLabel
		Reinforcement Steel Mesh?	MDOT_Layer	C	ReinforcementSteelMesh	IfcPropertySingleValue	IfcBoolean
		Thickness	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
		Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
	Conc Pavt Peprs(Partial Depth)	Cementitious Repair?	MDOT_Layer	C	CementitiousRepair	IfcPropertySingleValue	IfcBoolean
		[if no]->Noncementitious Product	MDOT_Layer	C	NoncementitiousProduct	IfcPropertyEnumeratedValue	IfcLabel
		[if yes] ->Prepackaged Mortar?	MDOT_Layer	C	PrepackagedMortar	IfcPropertySingleValue	IfcBoolean
		Prepackaged Mortar Product	MDOT_Layer	C	PrepackagedMortarProduct	IfcPropertyEnumeratedValue	IfcLabel
		Portland Cement Supplier	MDOT_Layer	C	PortlandCementSupplier	IfcPropertyEnumeratedValue	IfcLabel
		Portland Cement Type	MDOT_Layer	C	PortlandCementType	IfcPropertyEnumeratedValue	IfcLabel
		Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
	Concrete Penetrating Sealer	Silane Material	MDOT_Layer	C	SilaneMaterial	IfcPropertyEnumeratedValue	IfcLabel
	Crack Relief Interlayer/DRM	Thickness	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
	Cracked and Seated Concrete	Thickness	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
	Crushed and Shaped HMA	Thickness	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
	Diamond Grinding	Diamond Grinding	MDOT_Layer	C	DiamondGrinding	IfcPropertySingleValue	IfcBoolean
		Longitudinal Grooving?	MDOT_Layer	C	LongitudinalGrooving	IfcPropertySingleValue	IfcBoolean
	Dowel Bar Retrofit	Dowel Bar Retrofit	MDOT_Layer	C	DowelBarRetrofit	IfcPropertySingleValue	IfcBoolean
	FiberMat	Emulsion	MDOT_Layer	C	Emulsion	IfcPropertyEnumeratedValue	IfcLabel
		Emulsified Asphalt Supplier	MDOT_Layer	C	EmulsifiedAsphaltSupplier	IfcPropertyEnumeratedValue	IfcLabel
		FiberMat Type	MDOT_Layer	C	FiberMatType	IfcPropertyEnumeratedValue	IfcLabel
		Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
	Fog Seal	Fog Seal	MDOT_Layer	C	FogSeal	IfcPropertySingleValue	IfcBoolean
	Geotextile Fabric	Geotextile Type	MDOT_Layer	C	GeotextileType	IfcPropertyEnumeratedValue	IfcLabel
	High Friction Surface	High Friction Surface Placed?	MDOT_Layer	C	HighFrictionSurfacePlaced	IfcPropertySingleValue	IfcBoolean
	HMA Base Course	Mix Type	MDOT_Layer	C	MixType	IfcPropertyEnumeratedValue	IfcLabel
		Mix Design No (Case Sensitive)	MDOT_Layer	C	MixDesignNo	IfcPropertySingleValue	IfcLabel
		Application Rate	MDOT_Layer	C	ApplicationRate	IfcPropertyEnumeratedValue	IfcLabel
		Asphalt Binder	MDOT_Layer	C	AsphaltBinder	IfcPropertyEnumeratedValue	IfcLabel
		Asphalt Binder Cert. Supplier	MDOT_Layer	C	AsphaltBinderCertSupplier	IfcPropertyEnumeratedValue	IfcLabel
		Asphalt % (Total)	MDOT_Layer	C	AsphaltPercentageTotal	IfcPropertySingleValue	IfcReal
		Asphalt Binder %Added (Virgin)	MDOT_Layer	C	AsphaltBinderPercentageAddedVirgin	IfcPropertySingleValue	IfcReal
		Warm Mix?	MDOT_Layer	C	WarmMix	IfcPropertySingleValue	IfcBoolean
		If Warm Mix, Water Foaming?	MDOT_Layer	C	IfWarmMixWaterFoaming	IfcPropertySingleValue	IfcBoolean
		If Warm Mix, select Additive	MDOT_Layer	C	IfWarmMixSelectAdditive	IfcPropertyEnumeratedValue	IfcLabel
		Shingles used in the mix?	MDOT_Layer	C	ShinglesUsedInTheMix	IfcPropertySingleValue	IfcBoolean
		Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
	HMA Crack Treatment	Cut and Seal Method	MDOT_Layer	C	CutAndSealMethod	IfcPropertyEnumeratedValue	IfcLabel
		HMA Crack Seal Manufacturer	MDOT_Layer	C	HMACrackSealManufacturer	IfcPropertyEnumeratedValue	IfcLabel
		Was Overband also used?	MDOT_Layer	C	WasOverbandAlsoUsed	IfcPropertySingleValue	IfcBoolean
		Overband Crack Fill Product	MDOT_Layer	C	OverbandCrackFillProduct	IfcPropertyEnumeratedValue	IfcLabel
	HMA Leveling Course	Mix Type	MDOT_Layer	C	MixType	IfcPropertyEnumeratedValue	IfcLabel
		Mix Design No (Case Sensitive)	MDOT_Layer	C	MixDesignNo	IfcPropertySingleValue	IfcLabel
		Application Rate	MDOT_Layer	C	ApplicationRate	IfcPropertyEnumeratedValue	IfcLabel
		Asphalt Binder	MDOT_Layer	C	AsphaltBinder	IfcPropertyEnumeratedValue	IfcLabel

	Asphalt Binder Cert. Supplier	MDOT_Layer	C	AsphaltBinderCertSupplier	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt % (Total)	MDOT_Layer	C	AsphaltPercentageTotal	IfcPropertySingleValue	IfcReal
	Asphalt Binder %Added (Virgin)	MDOT_Layer	C	AsphaltBinderPercentageAddedVirgin	IfcPropertySingleValue	IfcReal
	Warm Mix?	MDOT_Layer	C	WarmMix	IfcPropertySingleValue	IfcBoolean
	If Warm Mix, Water Foaming?	MDOT_Layer	C	IfWarmMixWaterFoaming	IfcPropertySingleValue	IfcBoolean
	If Warm Mix, select Additive	MDOT_Layer	C	IfWarmMixSelectAdditive	IfcPropertyEnumeratedValue	IfcLabel
	Shingles used in the mix?	MDOT_Layer	C	ShinglesUsedInTheMix	IfcPropertySingleValue	IfcBoolean
	Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
HMA Separator Course	Mix Type	MDOT_Layer	C	MixType	IfcPropertyEnumeratedValue	IfcLabel
	Mix Design No (Case Sensitive)	MDOT_Layer	C	MixDesignNo	IfcPropertySingleValue	IfcLabel
	Application Rate	MDOT_Layer	C	ApplicationRate	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt Binder	MDOT_Layer	C	AsphaltBinder	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt Binder Cert. Supplier	MDOT_Layer	C	AsphaltBinderCertSupplier	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt % (Total)	MDOT_Layer	C	AsphaltPercentageTotal	IfcPropertySingleValue	IfcReal
	Asphalt Binder %Added (Virgin)	MDOT_Layer	C	AsphaltBinderPercentageAddedVirgin	IfcPropertySingleValue	IfcReal
	Warm Mix?	MDOT_Layer	C	WarmMix	IfcPropertySingleValue	IfcBoolean
	If Warm Mix, Water Foaming?	MDOT_Layer	C	IfWarmMixWaterFoaming	IfcPropertySingleValue	IfcBoolean
	If Warm Mix, select Additive	MDOT_Layer	C	IfWarmMixSelectAdditive	IfcPropertyEnumeratedValue	IfcLabel
	Shingles used in the mix?	MDOT_Layer	C	ShinglesUsedInTheMix	IfcPropertySingleValue	IfcBoolean
	Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
HMA Skip Patching	Mix Type	MDOT_Layer	C	MixType	IfcPropertyEnumeratedValue	IfcLabel
	Mix Design No (Case Sensitive)	MDOT_Layer	C	MixDesignNo	IfcPropertySingleValue	IfcLabel
	Application Rate	MDOT_Layer	C	ApplicationRate	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt Binder	MDOT_Layer	C	AsphaltBinder	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt Binder Cert. Supplier	MDOT_Layer	C	AsphaltBinderCertSupplier	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt % (Total)	MDOT_Layer	C	AsphaltPercentageTotal	IfcPropertySingleValue	IfcReal
	Asphalt Binder %Added (Virgin)	MDOT_Layer	C	AsphaltBinderPercentageAddedVirgin	IfcPropertySingleValue	IfcReal
	AWI (Actual)	MDOT_Layer	C	AWIActual	IfcPropertySingleValue	IfcReal
	Warm Mix?	MDOT_Layer	C	WarmMix	IfcPropertySingleValue	IfcBoolean
	If Warm Mix, Water Foaming?	MDOT_Layer	C	IfWarmMixWaterFoaming	IfcPropertySingleValue	IfcBoolean
	If Warm Mix, select Additive	MDOT_Layer	C	IfWarmMixSelectAdditive	IfcPropertyEnumeratedValue	IfcLabel
	Shingles used in the mix?	MDOT_Layer	C	ShinglesUsedInTheMix	IfcPropertySingleValue	IfcBoolean
	Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
HMA Top Course	Mix Type	MDOT_Layer	C	MixType	IfcPropertyEnumeratedValue	IfcLabel
	Mix Design No (Case Sensitive)	MDOT_Layer	C	MixDesignNo	IfcPropertySingleValue	IfcLabel
	Application Rate	MDOT_Layer	C	ApplicationRate	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt Binder	MDOT_Layer	C	AsphaltBinder	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt Binder Cert. Supplier	MDOT_Layer	C	AsphaltBinderCertSupplier	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt % (Total)	MDOT_Layer	C	AsphaltPercentageTotal	IfcPropertySingleValue	IfcReal
	Asphalt Binder %Added (Virgin)	MDOT_Layer	C	AsphaltBinderPercentageAddedVirgin	IfcPropertySingleValue	IfcReal
	AWI (Actual)	MDOT_Layer	C	AWIActual	IfcPropertySingleValue	IfcReal
	Warm Mix?	MDOT_Layer	C	WarmMix	IfcPropertySingleValue	IfcBoolean
	If Warm Mix, Water Foaming?	MDOT_Layer	C	IfWarmMixWaterFoaming	IfcPropertySingleValue	IfcBoolean
	If Warm Mix, select Additive	MDOT_Layer	C	IfWarmMixSelectAdditive	IfcPropertyEnumeratedValue	IfcLabel
	Shingles used in the mix?	MDOT_Layer	C	ShinglesUsedInTheMix	IfcPropertySingleValue	IfcBoolean
	Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
HMA Ultra-Thin Overlay	Mix Type	MDOT_Layer	C	MixType	IfcPropertyEnumeratedValue	IfcLabel
	Mix Design No (Case Sensitive)	MDOT_Layer	C	MixDesignNo	IfcPropertySingleValue	IfcLabel
	Application Rate	MDOT_Layer	C	ApplicationRate	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt Binder	MDOT_Layer	C	AsphaltBinder	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt Binder Cert. Supplier	MDOT_Layer	C	AsphaltBinderCertSupplier	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt % (Total)	MDOT_Layer	C	AsphaltPercentageTotal	IfcPropertySingleValue	IfcReal
	Asphalt Binder %Added (Virgin)	MDOT_Layer	C	AsphaltBinderPercentageAddedVirgin	IfcPropertySingleValue	IfcReal
	AWI (Actual)	MDOT_Layer	C	AWIActual	IfcPropertySingleValue	IfcReal
	Warm Mix?	MDOT_Layer	C	WarmMix	IfcPropertySingleValue	IfcBoolean
	If Warm Mix, Water Foaming?	MDOT_Layer	C	IfWarmMixWaterFoaming	IfcPropertySingleValue	IfcBoolean
	If Warm Mix, select Additive	MDOT_Layer	C	IfWarmMixSelectAdditive	IfcPropertyEnumeratedValue	IfcLabel
	Shingles used in the mix?	MDOT_Layer	C	ShinglesUsedInTheMix	IfcPropertySingleValue	IfcBoolean
	Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
HMA Wedge Course	Mix Type	MDOT_Layer	C	MixType	IfcPropertyEnumeratedValue	IfcLabel
	Mix Design No (Case Sensitive)	MDOT_Layer	C	MixDesignNo	IfcPropertySingleValue	IfcLabel
	Application Rate	MDOT_Layer	C	ApplicationRate	IfcPropertyEnumeratedValue	IfcLabel
	Variable Thickness	MDOT_Layer	C	VariableThickness	IfcPropertySingleValue	IfcReal
	Asphalt Binder	MDOT_Layer	C	AsphaltBinder	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt Binder Cert. Supplier	MDOT_Layer	C	AsphaltBinderCertSupplier	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt % (Total)	MDOT_Layer	C	AsphaltPercentageTotal	IfcPropertySingleValue	IfcReal
	Asphalt Binder %Added (Virgin)	MDOT_Layer	C	AsphaltBinderPercentageAddedVirgin	IfcPropertySingleValue	IfcReal
	Warm Mix?	MDOT_Layer	C	WarmMix	IfcPropertySingleValue	IfcBoolean
	If Warm Mix, Water Foaming?	MDOT_Layer	C	IfWarmMixWaterFoaming	IfcPropertySingleValue	IfcBoolean
	If Warm Mix, select Additive	MDOT_Layer	C	IfWarmMixSelectAdditive	IfcPropertyEnumeratedValue	IfcLabel
	Shingles used in the mix?	MDOT_Layer	C	ShinglesUsedInTheMix	IfcPropertySingleValue	IfcBoolean
	Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
Hot In Place Recycled Asphalt	AWI (Actual)	MDOT_Layer	C	AWIActual	IfcPropertySingleValue	IfcReal
	Asphalt Binder	MDOT_Layer	C	AsphaltBinder	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt Binder Cert. Supplier	MDOT_Layer	C	AsphaltBinderCertSupplier	IfcPropertyEnumeratedValue	IfcLabel
	Mix Design No (Case Sensitive)	MDOT_Layer	C	MixDesignNo	IfcPropertySingleValue	IfcLabel
	Thickness	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
	Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
Joint/Crack Repair Mastic	Asphalt Repair Mastic Product	MDOT_Layer	C	AsphaltRepairMasticProduct	IfcPropertyEnumeratedValue	IfcLabel
Micro-surface	Emulsion	MDOT_Layer	C	Emulsion	IfcPropertyEnumeratedValue	IfcLabel
	Emulsified Asphalt Supplier	MDOT_Layer	C	EmulsifiedAsphaltSupplier	IfcPropertyEnumeratedValue	IfcLabel
	Number of Courses	MDOT_Layer	C	NumberOfCourses	IfcPropertySingleValue	IfcInteger
	Rut Fill Layer	MDOT_Layer	C	RutFillLayer	IfcPropertySingleValue	IfcBoolean
	Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
Overband Crackfill	Overband Crack Fill Product	MDOT_Layer	C	OverbandCrackFillProduct	IfcPropertyEnumeratedValue	IfcLabel
Pavement Jacking	Poly Pavement Jacking	MDOT_Layer	C	PolyPavementJacking	IfcPropertySingleValue	IfcBoolean
Paver Placed Surface Seal	AWI (Actual)	MDOT_Layer	C	AWIActual	IfcPropertySingleValue	IfcReal
	Application Rate	MDOT_Layer	C	ApplicationRate	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt Binder	MDOT_Layer	C	AsphaltBinder	IfcPropertyEnumeratedValue	IfcLabel
	Asphalt Binder Cert. Supplier	MDOT_Layer	C	AsphaltBinderCertSupplier	IfcPropertyEnumeratedValue	IfcLabel
	PPSS Mix Type	MDOT_Layer	C	PPSSMixType	IfcPropertyEnumeratedValue	IfcLabel
PCC Pavement	Cement Content	MDOT_Layer	C	CementContent	IfcPropertyEnumeratedValue	IfcLabel
	Continuously Reinforced?	MDOT_Layer	C	ContinuouslyReinforced	IfcPropertySingleValue	IfcBoolean
	Fly Ash Content	MDOT_Layer	C	FlyAshContent	IfcPropertyEnumeratedValue	IfcLabel
	GGBFS	MDOT_Layer	C	GGBFS	IfcPropertyEnumeratedValue	IfcLabel
	Portland Cement Supplier	MDOT_Layer	C	PortlandCementSupplier	IfcPropertyEnumeratedValue	IfcLabel
	Portland Cement Type	MDOT_Layer	C	PortlandCementType	IfcPropertyEnumeratedValue	IfcLabel
	Thickness	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
	Transverse Joint Spacing	MDOT_Layer	C	TransverseJointSpacing	IfcPropertySingleValue	IfcReal
	Transverse Joints Sealed	MDOT_Layer	C	TransverseJointsSealed	IfcPropertySingleValue	IfcBoolean
	Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel

	Precast Concrete Pavement	Cement Content	MDOT_Layer	C	CementContent	IfcPropertyEnumeratedValue	IfcLabel
		Fly Ash Content	MDOT_Layer	C	FlyAshContent	IfcPropertyEnumeratedValue	IfcLabel
		GGBFS	MDOT_Layer	C	GGBFS	IfcPropertyEnumeratedValue	IfcLabel
		Portland Cement Supplier	MDOT_Layer	C	PortlandCementSupplier	IfcPropertyEnumeratedValue	IfcLabel
		Portland Cement Type	MDOT_Layer	C	PortlandCementType	IfcPropertyEnumeratedValue	IfcLabel
		Post-Tensioned?	MDOT_Layer	C	PostTensioned	IfcPropertySingleValue	IfcBoolean
		Pre-Stressed?	MDOT_Layer	C	PreStressed	IfcPropertySingleValue	IfcBoolean
		Precast System	MDOT_Layer	C	PrecastSystem	IfcPropertyEnumeratedValue	IfcLabel
		Reinf Bar Steel, longitudinal	MDOT_Layer	C	ReinfBarSteelLongitudinal	IfcPropertyEnumeratedValue	IfcLabel
		Reinf Bar Steel, transverse	MDOT_Layer	C	ReinfBarSteelTransverse	IfcPropertyEnumeratedValue	IfcLabel
		Reinforcement Steel Mesh?	MDOT_Layer	C	ReinforcementSteelMesh	IfcPropertySingleValue	IfcBoolean
		Repair (work<50' & non-cont.)?	MDOT_Layer	C	RepairWorkSmaller50AndNonCont	IfcPropertySingleValue	IfcBoolean
		Slab Length(typ joint spacing)	MDOT_Layer	C	SlabLengthTypJointSpacing	IfcPropertySingleValue	IfcReal
		Thickness	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
		Transverse Joints Sealed	MDOT_Layer	C	TransverseJointsSealed	IfcPropertySingleValue	IfcBoolean
		Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
	Roadway Embankment	Embankment placed below pvmt?	MDOT_Layer	C	EmbankmentPlacedBelowPvmt	IfcPropertySingleValue	IfcBoolean
	Rubblized Concrete Pavement	Thickness	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
		Rubblizing Equipment Type	MDOT_Layer	C	RubblizingEquipmentType	IfcPropertyEnumeratedValue	IfcLabel
	Scrub Seal	Emulsion	MDOT_Layer	C	Emulsion	IfcPropertyEnumeratedValue	IfcLabel
		Emulsified Asphalt Supplier	MDOT_Layer	C	EmulsifiedAsphaltSupplier	IfcPropertyEnumeratedValue	IfcLabel
		Number of Courses	MDOT_Layer	C	NumberOfCourses	IfcPropertySingleValue	IfcInteger
		Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
	Subbase	Thickness	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
		Aggregate Class	MDOT_Layer	C	AggregateClass	IfcPropertyListValue	IfcLabel
	Subgrade Stabilization	Application Rate	MDOT_Layer	C	ApplicationRate	IfcPropertyEnumeratedValue	IfcLabel
		Stabilization Material	MDOT_Layer	C	StabilizationMaterial	IfcPropertyEnumeratedValue	IfcLabel
		Stabilization Material Type	MDOT_Layer	C	StabilizationMaterialType	IfcPropertyEnumeratedValue	IfcLabel
		Thickness	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
	Subgrade Undercut	Thickness	Pset_CourseCommon	185	NominalThickness	IfcPropertySingleValue	IfcNonNegativeLengthMeasure
	Void Reducing Asphalt Membrane	VRAM Application (per PR dir.)	MDOT_Layer	C	VRAMApplicationPerPRDir	IfcPropertyEnumeratedValue	IfcLabel

*C: Custom property