U.S. Department of Transportation
Federal Highway Administration

e-Construction & Partnering Case Study

Michigan DOT Digital Delivery Work Group

Programmatic Partnering: Driving toward a Digital Future

Over the last decade, the Michigan Department of Transportation (MDOT) has implemented digital workflows for project delivery, with a major focus on producing engineering data models. In 2012, to be responsive to industry requests, MDOT began providing engineering digital data in the form of three-dimensional (3D) models as part of the reference information documents (RID).

Michigan contractors use these RID digital models to formulate bid estimates, to compare against the information communicated via the contract plans, and to prepare files for automated machine guidance (AMG) earthwork and paving equipment, even though the traditional two-dimensional (2D) plan sheets are the contractual documents. MDOT's ultimate goal is to make the digital data contractual, and a key element to achieving this outcome is gaining the full support of local consultant and contractor associations.

Because MDOT has created a culture of collaboration with industry to implement innovations at the highest levels of the agency, the Design Services Section—which leads all of MDOT's digital project delivery efforts—was empowered to establish partnerships to drive the agency toward a digital future. The idea started with a few MDOT employees with a shared vision to bring external partners to the table to help create a strategy for evolving the agency's current digital delivery practices.

Key Takeaways

- Instilling a culture of collaboration is a critical component for partnering.
- Empowering technical champions keeps innovation at the forefront of business.
- Using programmatic partnering enables agencies to be scalable for current and future technology capabilities.

In June 2016, MDOT created the Digital Delivery Work Group (DDWG), composed of members from MDOT, the Michigan Infrastructure and Transportation Association (MITA), and the American Council of Engineering Companies (ACEC), to evaluate and advance digital delivery concepts from incubation to full implementation.

MDOT's collaborative approach to advancing digital delivery practices is a model of programmatic partnering that is not technology specific and can be adapted for a variety of innovations. Programmatic partnering is the practice of working with stakeholders to collaborate on finding solutions to address problems at the enterprise level, as opposed to project partnering, where the objective is to find solutions to mitigate risk at the project level.

Every Day Counts (EDC), a State-based initiative of FHWA's Center for Accelerating Innovation, works with State, local, and private sector partners to encourage the adoption of proven technologies and innovations aimed at shortening and enhancing project delivery.

On-Ramp to Innovation
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Collaborative Technology Adoption

The vision is now set to implement a process that establishes accountability for producing digital data and recommendations for making it a contractual project deliverable. With a clear direction in place, the DDWG reviews and evaluates concepts then makes recommendations to MDOT for adopting specific practices. Upon review and acceptance, MDOT uses these recommendations to establish authoritative guidelines and policies for full adoption.

> *"MDOT realizes that collaboration with industry is paramount for successfully implementing changes in processes due to technological advances."*
>
> John Wilkerson, PE
>
> MDOT Engineering Support Manager

Description of the Practice

Initial members of the DDWG included six delegates from MDOT, three representatives from ACEC, and five from MITA. While no official charter has been established, the DDWG meets on a quarterly basis and uses the following as guiding principles:

- Advance digital delivery concepts in a way that values stakeholder perspectives in order to control risks and achieve maximum benefits.
- Promote collaboration among stakeholders to be inclusive, accountable, and fiscally responsible.
- Embrace solutions that benefit all stakeholders and are equitable in meeting the basic requirements of public infrastructure projects.
- Encourage, evaluate, and incorporate modern technologies that improve quality and efficiency in delivering projects.
- Examine any processes, procedures, and policies affected by proposed digital delivery concepts/technology.
- Direct pilots involving digital delivery concepts and evaluate the outcomes to guide policy.

DDWG Objectives

The main objective for the DDWG is to review and evaluate concepts and make recommendations to adopt specific practices for contractual digital delivery.

MDOT then reviews and considers these recommendations for implementation.

Digital Delivery Initiatives

Since its inception, the DDWG has taken on three major efforts:

- Advance development of the MDOT special provision for Automated Machine Guidance.
- Evaluate the Project PDF Digital Delivery Initiative.
- Generate level of development (LOD) specifications for digital delivery.

Credit: Surveying Solutions, Inc.

Figure 1. *Concrete paving operation with AMG using special provision 12SP-824A-03.*

Advance Development of the MDOT Special Provision for Automated Machine Guidance

The DDWG's first task was to update MDOT's Automated 3D Positioning for Construction–Pilot special provision, which the agency had drafted in 2013 to pilot the use of contractor AMG construction methods. With the recommendations from the DDWG, the document was approved by MDOT and the Federal Highway Administration in August 2017 as the Special Provision for Automated Machine Guidance (12SP-824A-03).

The special provision details the requirements for contractors to meet should they elect to use AMG for earthwork activities and material placement. It includes contractor requirements and responsibilities for submitting the intent to use AMG and the associated work plan, holding planning meetings with the project engineer, developing and using AMG models, providing construction surveying control and staking, and meeting contract minimum requirements.

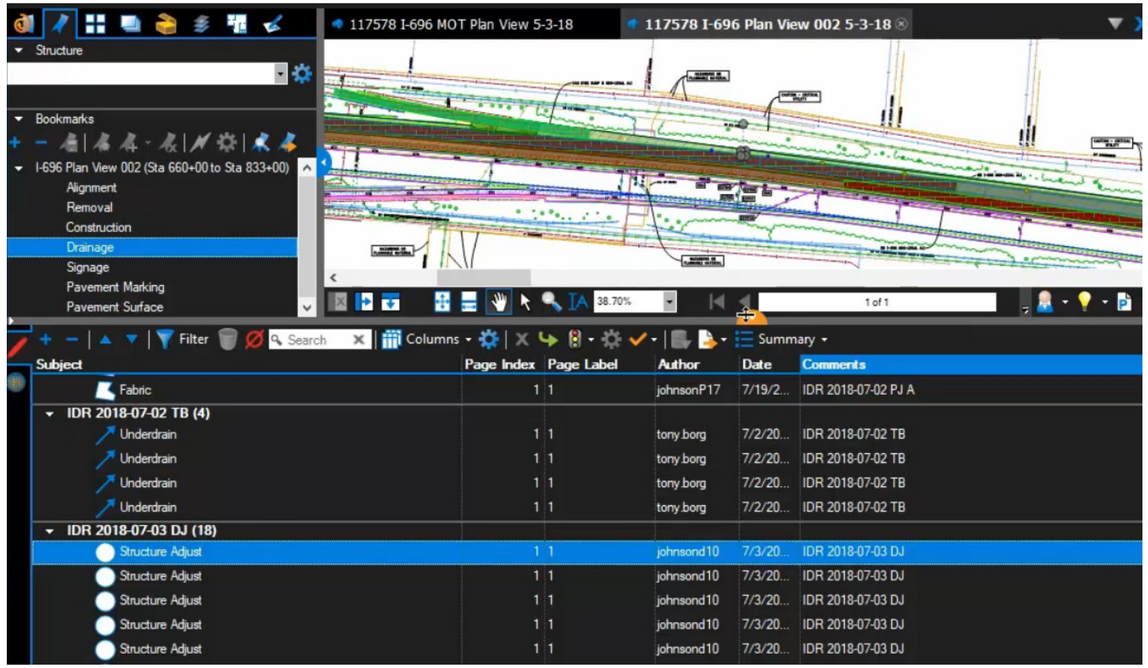
The special provision also outlines how changes due to project engineer-directed alterations to the AMG model should be handled and paid. It was successfully adopted in October 2017.

Evaluate Project PDF Digital Delivery Initiative

The second charge for the DDWG was to provide input for an initiative MDOT started to pilot in 2018 that will serve as an intermediate step to adopting full digital delivery. The initiative, known as the Project PDF pilot, introduces a process and set of tools for conducting design reviews using one electronic document containing the entire project rather than segmented plan sheets. Project reviewers will use the Project PDF and Bluebeam® Revu® (the selected PDF editor) to review geometric design (i.e., alignments, superelevation, and typical section element components) using common tools such as pan and find functions as part of the traditional pre-construction review process. Unique key features of the selected PDF editor that will enhance the pre-construction review process include the following:

- Provides software interface similar to that of computer-aided design (CAD) products.
- Allows electronic tracking of all comments made by each reviewer.
- Facilitates real-time collaborative sessions.

Another objective of the Project PDF Digital Delivery initiative is to help designers transition to developing the data model instead of spending hours labeling all



Credit: Michigan DOT

Figure 2. *View of a Project PDF using Bluebeam® Revu®.*

the sheets. It is expected that construction staff, who currently print plan sheets and tape them together to get a full view of the project, will also benefit from the initiative. Construction staff will be able to access the Project PDF in the field from a mobile digital device (Apple® iPad®) or laptop computer by opening Bentley® ProjectWise® (MDOT's official e-Construction solution) or a Bluebeam® Revu® Studio Session.

MDOT began investigating interim solutions to implementing real-time, collaborative reviews in December 2016 when staff were introduced to the software platform. In July 2017, MDOT officially approved the procurement of Bluebeam® Revu®. A month later, the agency joined the American Association of State Highway and Transportation Officials (AASHTO) Innovation Initiative program in promoting a new plans, specifications, and estimates (PS&E) collaborative review process called **Project PS&E C-Rev.**

Then, in November 2017, MDOT started developing the process to be used for its pilot. While the software platform is intuitive and the interface is user friendly, MDOT developed training material in the form of short documents and videos. The initial training was conducted in January 2018, and the pilot for milestone reviews began in March of the same year. At the end of the pilot (July 2018), MDOT solicited feedback and evaluated lessons learned to improve the process. MDOT implemented the Project PDF initiative in October 2018.

Generate Level of Development (LOD) Specifications for Digital Delivery

The third assignment for the DDWG is to develop an LOD Rating System, which is a set of fundamental guidelines that define content and reliability of the digital data, for example, accuracy of existing topographic survey data. The MDOT LOD Rating System will guide designers to produce digital design model data to be delivered contractually for construction applications. The objective of the LOD Rating System is to define the quality risk management and acceptable uses of the digital model, both in terms of original ground surface and engineering design intent. Developing LOD specifications for digital delivery is now the main area of emphasis for the DDWG and has the highest priority. The desired outcome is to have specifications ready for when MDOT is in a better position to evolve its collaborative review process to leverage digital data to the next level.

Noteworthy Procedures and Methods

By far, the most noteworthy action of the DDWG is the effort to establish the LOD specifications for digital delivery. Without this guidance in place, it would be virtually impossible for MDOT to move forward with its objective of leveraging digital data as a contractual deliverable for construction projects.

Specifically, the DDWG is working to deliver final recommendations for implementing an LOD Rating System by the end of 2019, so MDOT can pilot projects early in 2020 or 2021. The outlined milestones and specific tasks to meet the desired implementation goal are shown in figure 3.

An LOD subcommittee was formed to define the specific criteria for the LOD Rating System to include definitions for Original Ground Surface Quality (OGSQ), and Design LOD. The subcommittee started by defining the OGSQ following performance-based specifications, rather than stipulating specific means and methods to achieve the quality. The OGSQ specifications are intended to describe overall surface data accuracy and its level of confidence in reliability. Table 1 describes the proposed OGSQ definitions.

In addition, the quality of the design model will be defined by its content and intent for authorized uses (what to model and for what the model may be used). The LOD subcommittee is still working on developing rating system definitions and has not made any final decisions. The current definitions being discussed are described in table 2. LOD specifications will be

Figure 3. *LOD Rating System implementation timeline.*

assigned to each individual model element (e.g., pavement and drainage structures) rather than the entire design model and may be different for specific sections of roadway (e.g., LOD B for Section A and LOD A for Section B). Part of the LOD specifications will eventually include a matrix that will help downstream users of the data understand the quality of each design element. The goal is to develop an easily adaptable rating system that can be used as a foundation for national specifications to support roadway construction projects.

MDOT is one of the States currently serving on the AASHTO Joint Technical Committee on Electronic Engineering Data (JTCEED). The JTCEED is identifying data needs, information requirements, and industry standards that will enable the transition from plan sheets to digital data delivery.

Table 1. *DDWG proposed OGSQ definitions.*[1]

Defined Survey Quality	Description
Quality A	Interpolated mapping generally meets the following specifications: hard surfaces < 0.05´ soft surfaces < 0.25´ It is expected that the model will be developed for all areas of disturbance. Generally used for reconstructs and widening with ditching or critical components; typically used for projects with an independent profile.
Quality B	Interpolated mapping generally meets the following specifications: hard surfaces < 0.05´ soft surfaces < 0.50´ It is expected that a model will be developed from hinge point to hinge point (break point away from roadway, which is usually 1–2 feet past shoulder or curb and gutter). Generally used for mill and resurface, crush and shape, and minor front slope correction.
Quality C	Overall surface quality is not defined, old survey data is utilized, and there is a low probability that field conditions have changed. Can generally apply to a range of projects and is not preferred.
Quality D	Basis of original ground survey is unknown, or there is a low probability that original ground survey accurately reflects field conditions. Acceptable on log projects[2]. Generally, no RID data provided.

[1]*Specifications are in draft form and are subject to change.*
[2]*MDOT log jobs are projects in which a pre-construction survey is not performed, and the contract only includes written scope of work documents and a few plan sheets detailing the general location of the begin and end points of the projects based on log miles.*

Table 2. *DDWG proposed Design LOD definitions.*[3]

Design LOD	Description
A	The modeled data is a complete representation of the model element in three dimensions, and it is tied to the project coordinate system. Two- and three-dimensional information can be reliably measured directly from the model without the need for plan sheet notes or dimensions.
B	The modeled data is a complete representation of the model element in two dimensions (plan view), and it is tied to the project coordinate system. Plan view information such as radii, length, area, station, and offsets can be reliably measured from the model without the need for plan sheet notes or dimensions. Elevations generally fall within the tolerance of the OGSQ.
C	The modeled data is a complete representation of the model element in two dimensions (plan view), and it is tied to the project coordinate system. Plan view information such as radii, length, area, station, and offsets can be reliably measured from the model without the need for plan sheet notes or dimensions. Elevations are not provided, or their design was based on OGSQ C.
D	The design element is not modeled, or the design of the model element was based on OGSQ D.

[3]*Specifications are in draft form and are subject to change.*

Challenges and Successes

Some of the main productivity roadblocks for the DDWG are coordination of meetings that accommodate everyone's schedule and finding available resources to lead activities that address the great ideas coming out of each meeting. To overcome these challenges, the DDWG has implemented virtual (Web-based) meetings during the summer months when members' time is more limited. Also, the group created a small task force to focus on LOD-specific assignments, which then reports overall progress to the DDWG.

Another challenge for the DDWG is to align its efforts with other statewide initiatives to optimize the use of digital data outside of project development. For now, the DDWG is focusing its attention on defining digital data quality in hopes that MDOT can use recommendations from the group to align with the agency's overall data governance strategy. Also, the DDWG is providing additional value to MDOT as a trusted advisor and sounding board to assess and develop interim solutions that will enable the agency to implement incremental use of technology and to provide recommendations for addressing lessons learned from pilot projects.

Research Efforts

MDOT initiated a study in July 2017 (which was completed in February 2019) as a parallel effort to advance digital delivery. The goals of the research were as follows:

- Compare the costs and benefits of 3D digital data and calculate return-on-investment (ROI).
- Collect information to summarize how digital data is being used by consultants and contractors during design and construction phases.
- Identify areas of opportunity to streamline the project delivery process.
- Make recommendations for enhancing MDOT's implementation plan for adopting contractual digital deliverables for construction.

The results of the study provided quantitative evidence that digital design models communicate design intent more accurately, which positively affects contract bids and ultimately saves money in construction projects by reducing the amount of change orders.

In addition, the study revealed that to make digital design models contractual, MDOT will need to do the following:

- Educate stakeholders about the value of multi-disciplinary collaboration and automation in highway construction.
- Adopt processes for meticulous tracking of changes to the digital models.
- Establish LOD specifications for the digital design model, data management protocols, and contractual language that outline detailed requirements and responsibilities for all stakeholders.
- Update its digital delivery implementation plan to incorporate lessons learned from the study.

Future Outlook

The combination of MDOT research activities and current programmatic partnering efforts through the DDWG to develop LOD specifications for transportation digital delivery will have local and national impact. Locally, the LOD specifications will allow MDOT to finally adopt digital delivery workflows and bring value to the agency by streamlining processes and increasing efficiencies for project review and plan production. It will also help consultants and contractors manage risk by properly describing the quality of the information and exactly defining its authorized uses.

With a framework in place to define, manage, and use digital data for project delivery, MDOT will be closer to creating plans to use the digital data across the enterprise. Nationally, the MDOT-adopted LOD specifications will serve as the foundation for a national standard that other State DOTs can adopt.

The work of the DDWG has just begun, but MDOT's programmatic partnering approach to adopting digital project delivery is only the beginning of a valuable practice to facilitate the deployment of new technologies and innovations.

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e-Construction and Partnering resources:
www.fhwa.dot.gov/construction/econstruction

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Key Words

- 3D modeling
- Digital data
- Level of development
- Programmatic partnering
- Michigan Department of Transportation

Notice

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