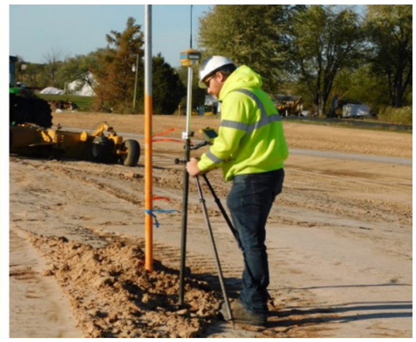
Technology Brief

e-Construction and Partnering

e-Construction and Partnering: *A Vision for the Future*





Images: FHWA

Peer-to-Peer Exchange

Indiana, Oregon, Pennsylvania, Utah, and Wisconsin Departments of Transportation

Indianapolis, Indiana
August 28–29, 2018

U.S. Department of Transportation
Federal Highway Administration

On-Ramp to Innovation
every day counts

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Background

Although the Indiana Department of Transportation (INDOT) has implemented several technologies to support its e-Construction and Partnering (eCP) initiatives to date, the agency continues to seek out new eCP practices to improve efficiency in its construction program. To exchange ideas and learn more about eCP practices, INDOT hosted a 2-day, face-to-face peer exchange with the Oregon Department of Transportation (ODOT), Pennsylvania Department of Transportation (PennDOT), Utah Department of Transportation (UDOT), and Wisconsin Department of Transportation (WisDOT).

The eCP peer exchange, sponsored by the Federal Highway Administration (FHWA) as part of round four of the Every Day Counts (EDC-4) technical assistance program, was held August 28–29, 2018. Representatives from ODOT, PennDOT, and UDOT traveled to Indianapolis, IN, to meet with INDOT staff. Three representatives from WisDOT participated remotely via a web-conference connection. In addition, staff from FHWA's Indiana Division, headquarters office, and Resource Center were present.

One of INDOT's goals is to use intelligent three-dimensional (3D) computer-aided design (CAD) models to support the life cycle of transportation assets (roads and bridges) and provide data-driven predictive analysis and reporting capabilities to enable the agency to make better operational and strategic management decisions. The peer exchange focused on the use of digital data during project delivery, including using 3D engineered models as the legal contract; integrating model information with construction inspection applications; and implementing technology to track material delivery, placement, and conditions. INDOT was also interested in learning about the return-on-investment (ROI) of e-Construction technology.

INDOT has made significant progress toward meeting its e-Construction goals, but staff recognize there is much more to be accomplished. The agency has taken the definition of e-Construction beyond paperless workflows, adopting a data-centric philosophy to leverage digital data throughout project and service delivery. To that end, INDOT staff invited counterparts from other State DOTs knowledgeable in this area to learn and craft INDOT's next steps in implementing intelligent digital models to support the life cycle of transportation assets.

ODOT, UDOT, and WisDOT have significant experience implementing e-Construction and have taken advantage of the digital data that originates in design for construction applications. These States shared both success stories and the challenges still faced. PennDOT shared its vision for capturing digital data during construction specific to materials quality control test results, delivery, location, and conditions.

Table 1. INDOT, ODOT, PennDOT, UDOT, and WisDOT e-Construction technology and practices.

Application	INDOT	ODOT	PennDOT	UDOT	WisDOT
3D engineered models	Bentley® InRoads® Produce models, but only deliver paper plans.	Bentley® InRoads® Deliver 3D models for AMG[1] as reference information documents.	Bentley® InRoads® Deliver 3D models for AMG as reference information documents.	Bentley® InRoads® Deliver 3D models using 3D models as the legal document (pilot phase).	Autodesk® Civil 3D® Deliver 3D models for AMG as reference information documents. Develop BIM[2] execution plans by milestones.
Construction inspection	SiteManager™	MicroSurvey® FieldGenius® (pilot)	Custom iOS® applications	Bentley® OpenRoads® Navigator® and Aurigo® Masterworks®	Autodesk® BIM 360®
e-Ticketing	No	No	Earthwave Technologies® Fleetwatcher™ Zonar® GPS tracking system and Libra Systems e-ticketing	No	No
Mobile devices in field	Yes	Yes	Yes	Yes	Yes

[1] automated machine guidance
[2] building information modeling

INDOT e-Construction Implementation Approach

The main driver for e-Construction at INDOT is the desire to make data-driven decisions for construction and operations. INDOT indicated its priorities are to transfer data from 3D design models to construction, and from construction to asset management, and implement findings from INDOT-sponsored research conducted by Purdue University. However, INDOT has identified specific challenges with achieving this vision. These include working with 3D models, investing in change management, and cultivating a culture of change. INDOT's leadership is supportive, which has facilitated progress on a communication plan for engaging all stakeholders involved in project delivery (i.e., industry and INDOT design staff). INDOT will work with stakeholders to find ways to modify project delivery methods (including collaboration and partnering).

Currently, INDOT manages construction contracts from preconstruction to closeout using the AASHTOWare® suite of products, including Project Preconstruction™, Project Expedite™, Project BAMS/DSS™, and Project SiteManager™. SiteManager™ was recently linked to a custom field assistant application to assist construction inspectors with mobile devices. However, the agency is planning to move to the AASHTOWare® Project Construction & Materials™ web-based application, which is in development. INDOT also uses Bid Express® for electronic bidding, Bentley® ProjectWise® and Microsoft® SharePoint® for document management, and a custom electronic records management system (ERMS) for long-term document archiving.

Other technologies that INDOT is investigating include e-ticketing for material tracking and quantity payments for hot-mix asphalt (HMA), concrete, and aggregate; 3D engineered models for construction inspection; and dynamic 3D modeling tools for design, utilities, and drainage applications.

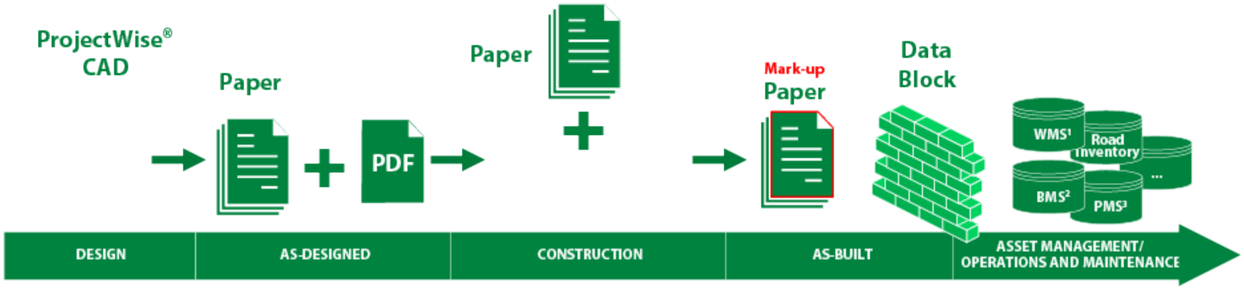
Lastly, INDOT is working with the Ohio DOT on a cost-share project to fund the development of a construction inspection application that views 2D and 3D models on a mobile device. The application is being designed to guide the inspector with instructions based on inspection activities that correlate to a model component, then provide an inspection checklist based on the construction steps. The application will then instruct the inspector to enter INDOT pay items and other asset attributes useful for asset management.

Specific details on how some of these technologies are being used by peer exchange participants are explained in the next section.

Shared Effective e-Construction Practices

INDOT

INDOT's current data flow through project delivery (shown in figure 1) relies heavily on paper. Typically, INDOT designs projects using Bentley® InRoads® within a ProjectWise® environment and issues paper plans and Adobe® PDFs for construction. INDOT construction staff use a combination of paper forms and AASHTOWare® Project SiteManager™ for their documentation and payments. Once construction is complete, the paper plans are marked up with redlines and archived. Digital data is not exchanged from construction to asset management/operations and maintenance databases. The objective of the 3D model construction inspection application currently being developed is to guide the inspector with instructions for inspecting specific activities that correlate to a model component through an inspection checklist.



[1] work management system,[2] bridge management system, [3] pavement management system

Figure 1. Workflow. INDOT's current data flow through project delivery.
Source: Adapted from graphic provided by INDOT.

UDOT

UDOT is in the final piloting stages of model-based design and construction. The process is to design in 3D, construct in 3D, and provide feature information to the asset management database using the 3D model (see figure 2). UDOT's 3D design process is to develop the design (DGN) files and advertise the project using the model as legal document (MALD). Supplemental files, such as alignment (ALG) and surfaces (DTM), are provided for informational use only.

It is estimated that the final dirt/asphalt quantities from the Integrated Consensus Model (ICM) were within 1 cubic yard of real-quantity values. During construction, the ability to eliminate construction stakes with stringless paving systems was an immediate benefit. However, additional surveying may be needed in high-terrain relief areas.

UDOT uses Bentley® OpenRoads® Navigator® and Aurigo® Masterworks® in the field on mobile devices to work with and update models. After construction, the feature information is exchanged to asset management databases by means of feature manipulation extraction algorithms using the 3D model.

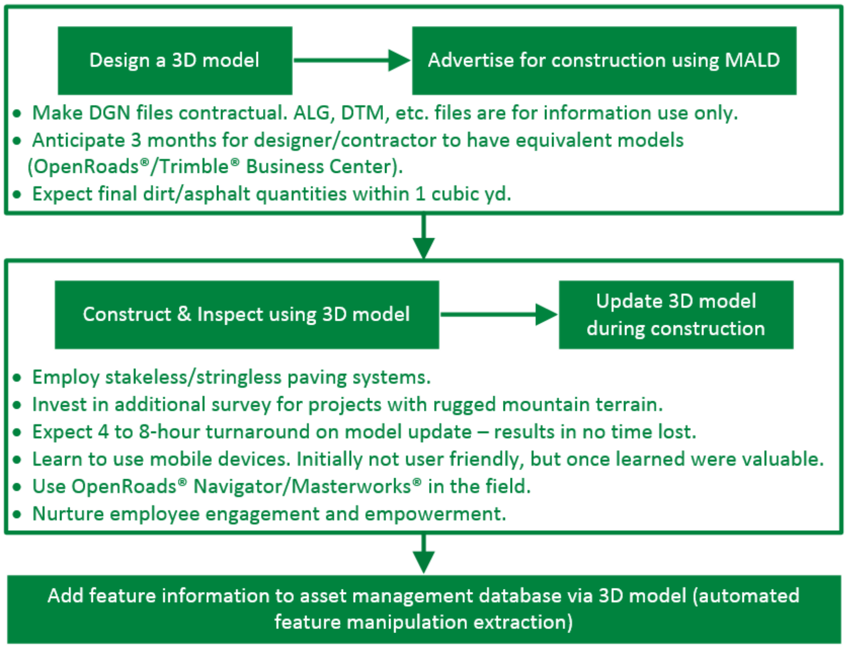


Figure 2. Workflow. UDOT model-based design and construction.

PennDOT

PennDOT is piloting e-ticketing technology on several projects using two different systems: Earthwave Technologies® Fleetwatcher™ and the combination of a Zonar® GPS tracking system and Libra Systems' e-ticketing software. The agency developed special provisions to enable the use of e-ticketing and GPS tracking of equipment (paving and milling) and milled materials delivery to a specified plant or stockpile site. The special provisions also require GPS integration with plant-scale systems, offer the ability to measure and track material from plant to final placement, and provide real-time data through a web-based system compatible with iOS® and Windows® environments.

PennDOT described four pilot projects (three with Fleetwatcher™ and one with Zonar® GPS/Libra e-ticketing). Figure 3 illustrates the setup of PennDOT's e-ticketing pilot initiatives and provides some detail on the data collected from each system.

2017 PennDOT E-Ticketing Pilots: Electronic Delivery Management System for HMA/WMA Material		
Materials Special Provision: e-ticketing and GPS tracking of equipment	**Additional Special Provision:** track delivery of milled materials to a specified plant or stockpile site	**2018 Modifications** • Improve vehicle identification. • Consider appropriate asset management when dual mill or paving operations take place to insure appropriate vehicle registration. • Allow space on each delivery ticket for inspectors to add information.

Earthwave Technologies® Fleetwatcher™		
Real-time mapping	Load cycle analysis	Mobile apps/customizable
Information collected • Load cycle analysis report. • Tracking information (time/location, shift name, source/destination geozone, etc.) on trucks from the plant during transport and delivery to the site. • Custom field enhancements. FleetWatcher™ is designed/marketed to industry rather than DOTs, so PennDOT worked with Earthwave Technologies® to add field enhancements relevant to the agency.		

Zonar® GPS + Libra Systems e-ticketing		
Real-time fleet monitoring/ optimization	Trucking payroll	Available in 80% of Pennsylvania plants
Information collected • Tracking information (time/location, shift name, source/destination geozone, etc.) on trucks from the plant, transport and delivery on site cycle. • Ticket information and location information in separate Web-based systems.		

Figure 3. Illustration. PennDOT e-ticketing pilot initiative.

WisDOT

WisDOT convened a team of subject matter experts to advance the use of 3D models. Working within the model (figure 4), milestone reviews were conducted and comments integrated. WisDOT implemented an enhanced plan, specification, and estimate (PS&E) review process to use 3D models and BIM 360® Field as review tools. Once the project was awarded, a design liaison and 3D model technician were assigned to the construction team to collaborate and stay engaged throughout construction to address any model issues. Inspectors were equipped with BIM 360® for working with models.

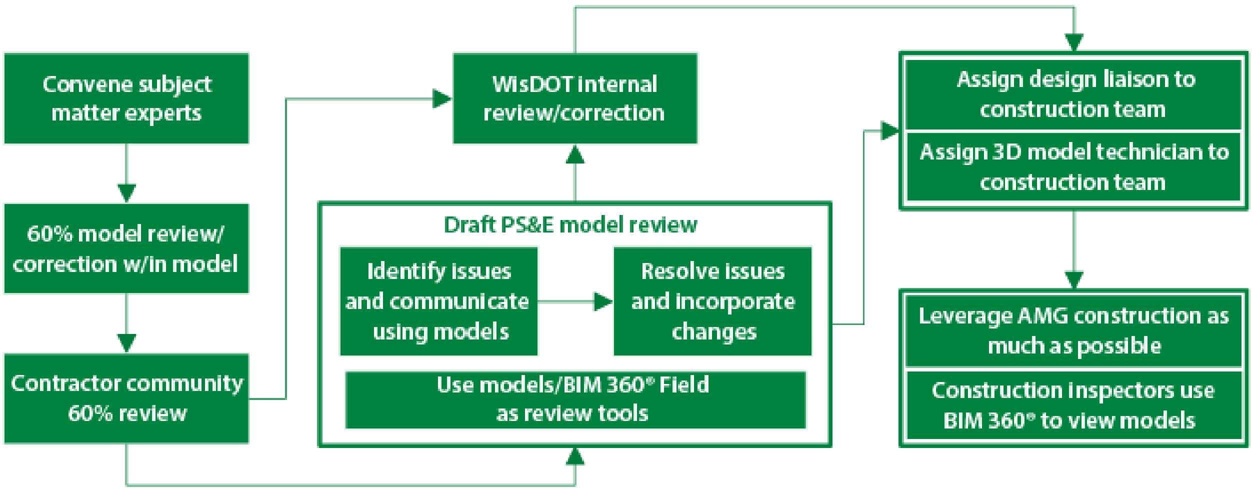


Figure 4. Process. WisDOT 3D model development/use and review process.

ODOT

In 2014, ODOT started delivering 3D engineered models for construction as reference information documents used by contractors for AMG construction methods. ODOT is also in the process of implementing other e-Construction initiatives using a modular approach, starting with deployment of Info Tech® Doc Express® as the official document management system. Other e-Construction initiatives include the deployment of mobile field tools and a data management system.

Cost and Benefits

ODOT conducted an ROI study for its advanced technologies and e-Construction efforts. Both a direct ROI and a social ROI were defined in order to capture a comprehensive perspective on value for a particular technology or practice. The direct ROI included a primary and secondary benefit classification. The primary benefit classification included those benefits directly attributable to an investment and, therefore, easier to calculate. The secondary benefit classification included those benefits indirectly attributable to an investment. If primary benefits were sufficient to justify investment, secondary benefits were not calculated. The social ROI included social and environmental factors, which are often described qualitatively.

While ODOT used its ROI framework for various advanced technologies such as mobile mapping and 3D design, it also looked at how 3D engineered models impact AMG, e-Construction, and electronic data management. The 3D engineered models for AMG ROI analysis used ODOT direct costs (implementation costs were minimal) and bid results as a proxy for construction benefits. The direct ROI for each area of investment is summarized in table 2. The qualitative (social ROI) benefits of the advanced technology used by ODOT include faster project delivery and higher product quality.

Table 2. ODOT direct ROI for advanced technology.

Area of Investment	Cost (dollars)	Benefits (dollars)	Calculated ROI
Mobile Mapping System (5-year ROI)	$1,398,286	$4,778,171	242%
3D Models for AMG (3-year ROI)	$190,526	$4,512,760	2,269%

ODOT's e-Construction and electronic data management technologies are in early development. There is less data available for these compared with other technologies, so a reliable ROI is not yet quantifiable. ODOT is looking at benefits and costs in published findings from other DOTs. Expected benefits include reductions in paper and ink, reduced overtime spent on paperwork, improved communications, improved efficiencies, better quality, and broader access to archived project histories.

WisDOT discussed use of BIM 360® as the agency's preferred platform for cloud-based plan review and documentation, which enables timely decision-making on request for information and design issues. The positive ROI WisDOT noted was a reduction of change orders by approximately 1.2 percent on a multi-million dollar project. WisDOT also suggested that to truly maximize ROI, it is critical to identify what must be modeled to realize benefits with collaboration, coordination, and decision-making. To accomplish this, WisDOT uses BIM execution plans with milestones that define the suite of software applications required for specific needs, reference guiding information from national studies, identify key items for 3D model-based design for all disciplines (including visualization), and outline cost and schedule management using multidimensional modeling.

Key Takeaways

The INDOT participants' main takeaways included learning more about their design process and the importance of extracting meaningful insights to continue advancing. Specifically, they see a valuable opportunity to take advantage of current knowledge about their project delivery and document processes. They said the agency has several pieces in place, so the next step is to determine how to fit them together to maximize value. Recognizing that e-Construction is broad, INDOT staff are encouraged by the incremental advancements some DOTs have made. They also believe it will be important for them to clarify what electronic deliverables mean to them and what the expectations are from specific approaches.

They said the most valued outcome of the peer exchange was learning how other States are using different technologies for different aspects of e-Construction, as well as what other technologies exist in the marketplace. Adopting the latest version of the 3D modeling design software to gain improved functionality in deploying these innovations was identified as a key takeaway, as was WisDOT's approach for improving clash detection, especially with utilities.

Some participants noted there are several areas where adjustments can be made in current practice. These include defining processes so obstacles can be removed or mitigated, encouraging others to use the technologies or to blend in newer technologies and practices with traditional methods to help transition, continuing to demonstrate how to use 3D models, and using opportunities to introduce e-Construction to encourage participation in helping advance initiatives.

Some suggestions for INDOT going forward included setting goals (short-term and long-term) for e-Construction efforts, identifying timeframes and the stakeholders and implementation teams necessary to create and execute an actionable plan to achieve short-term goals, prioritizing next initiatives, planning for managing knowledge transfer and training, and reaching out to FHWA for assistance with planning.

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

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