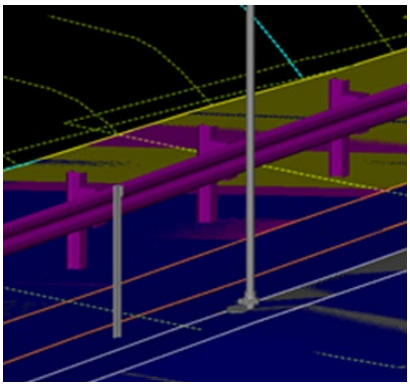
Technology Brief

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


Peer-to-Peer Exchange

Model-Based Digital Project Delivery Approaches and Partnering Considerations

Salt Lake City, Utah
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U.S. Department of Transportation
Federal Highway Administration

On-Ramp to Innovation
every day counts

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Background

The New Mexico Department of Transportation (NMDOT) is seeking to evolve its practice of using digital information for construction to the next level by investigating the use of three-dimensional (3D) models throughout project delivery. Along with this effort, the agency is looking for ways to cultivate a strong partnership with contractors to implement the practice. To learn via peer exchange from another State that has undertaken similar challenges, NMDOT identified the Utah Department of Transportation (UDOT) as the peer agency best aligned with its e-Construction and partnering vision.

UDOT hosted NMDOT to exchange ideas and share information based on its journey to pilot 3D engineered models for construction applications. Staff from the two agencies met in Salt Lake City, Utah, for a 2-day, face-to-face peer exchange sponsored by the Federal Highway Administration (FHWA) as part of round four of the Every Day Counts (EDC-4) technical assistance program. The State DOT representatives were joined at the peer exchange by staff from FHWA's New Mexico Division and the FHWA Resource Center. The peer exchange took place May 8–9, 2019, and included a combination of interactive dialogs and site visits to two construction projects where the use of 3D engineered models was showcased.

This Technology Brief summarizes information shared at the peer exchange by NMDOT and UDOT regarding their policies and practices. See page 11 for further information on certain limitations of this document and the non-binding nature of its contents.

NMDOT's vision is to maximize the value and use of 3D models during project delivery. Also, NMDOT is looking to mandate electronic plans, specifications, and estimate packages at production (including digital Professional Engineer's stamp and signature). Table 1 showcases different e-Construction technologies at each DOT.

Table 1. e-Construction technologies at participant DOTs.

Technology Category	NMDOT	UDOT
Electronic Bidding	Info Tech® Bid Express®	Custom
Construction Management System	AASHTOWare® Project SiteManager™	Aurigo® Masterworks®
Document Management System	Autodesk® BIM 360® Document Management Module	Bentley® ProjectWise®
Surveying Hardware and Software for Inspection Tasks	Hardware: Trimble® GNSS[1] rovers and Trimble® Robotic Total Stations Software: Trimble® Business Center and Trimble® Access	Hardware: GNSS rovers provided by contractor (Trimble® equipment is typically provided) Software: Trimble® Business Center
Mobile Devices	Apple® iPad®	Apple® iPad®
Mobile Applications for 3D Models	Autodesk® BIM 360® Quality Management Module	Bentley® Navigator®

[1] GNSS = Global Navigation Satellite System

NMDOT e-Construction Approach

Strategy and History

NMDOT has deployed several e-Construction innovations, including electronic bidding and electronic signatures for internal forms and change orders. Electronic bidding was implemented in September 2015 using Bid Express®. NMDOT uses the AASHTOWare® suite of products, but the systems are not configured for processing payments to the contractor. Contractor payment processing is handled through a statewide, centralized financial and supply chain management platform. Additionally, NMDOT construction staff tracks Disadvantaged Business Enterprise Program compliance through a third-party software. Also, the agency does not have an official document management system for project documents. Project documents and data are stored on the agency network drives. NMDOT has recently acquired Autodesk® BIM 360® products to enable 3D model coordination and electronic construction document management.

NMDOT is working on a pilot project to provide 3D model files to the contractor. The project is currently funded in Fiscal Year 2020, with construction letting scheduled for September 2020. In 2017 and 2018, NMDOT received FHWA State Transportation Innovation Council (STIC) Incentive program funds to purchase tablets for construction inspectors in support of e-Construction activities on projects. Implementation was temporarily delayed to allow for changes in NMDOT leadership and securing support across necessary business groups. The tablets (Apple® iPad® devices) were purchased through the STIC program and issued to construction staff in August 2019 for use on the pilot project.

Current Efforts

Although NMDOT typically relies on consultants for approximately 60 percent of its design needs, the agency plans to design the pilot project in-house to build the necessary capabilities and tailor them to its needs. The contractor community has influenced NMDOT to move toward delivering 3D models, and one of the major hurdles is defining the optimal process of getting the models to the contractors.

NMDOT noted that there is leadership support for innovation, so an opportunity exists to advance several e-Construction initiatives (including 3D modeling and mobile device use in the field) and address some of the obstacles to progress. Challenges identified included bridging organizational divides, obtaining State legislation enabling the construction manager/general contractor (CM/GC) project delivery method (as allowed by FHWA at 23 CFR Subpart E), and managing change within the organization.

NMDOT also reported that it is working closely with the contractor community through deliberate outreach, and preliminary feedback it has received indicates contractors are in favor of the agency's e-Construction initiatives.

UDOT e-Construction Approach

Strategy and History

UDOT reported that it has made significant strides with e-Construction innovations since 2002. Figure 1 illustrates UDOT's evolution of e-Construction innovations.

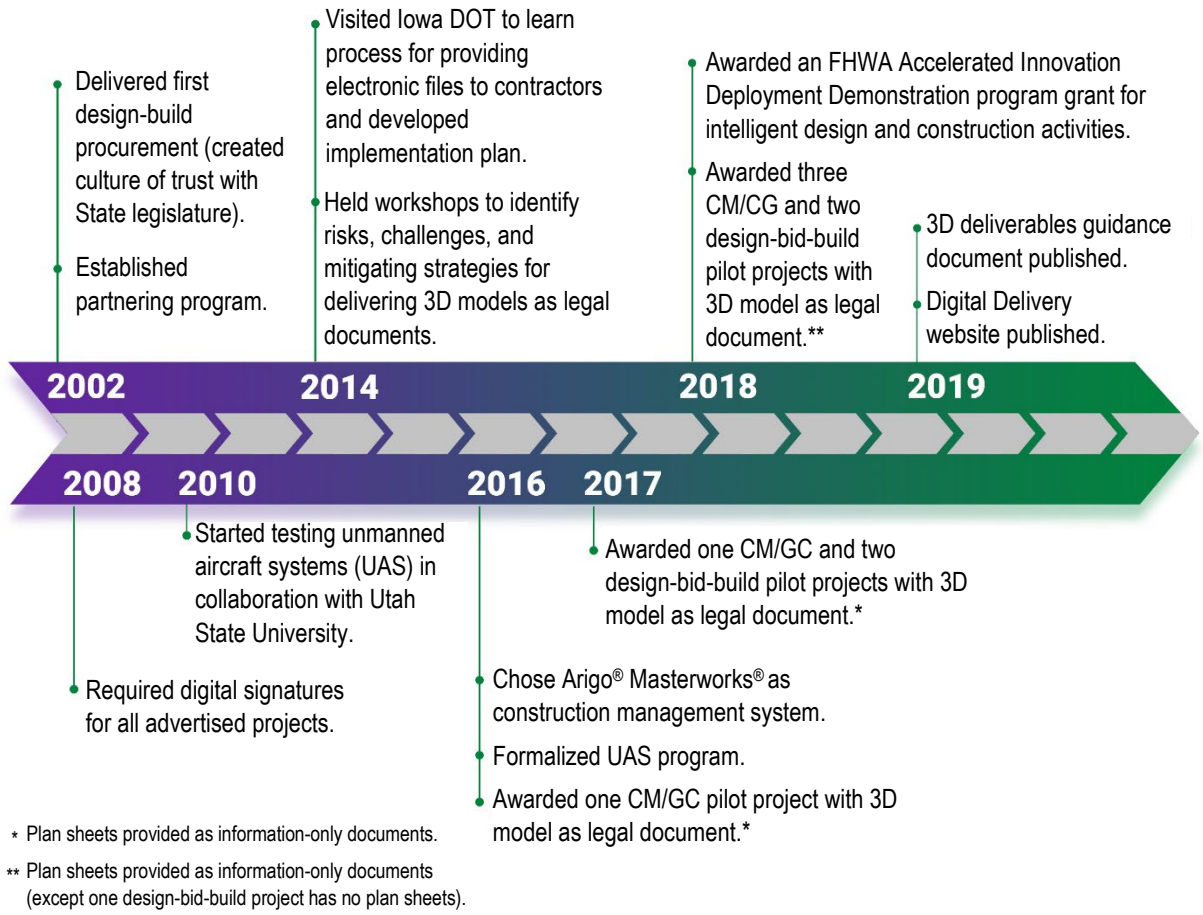

Figure 1. Timeline. UDOT's e-Construction evolution. Source: Information provided by UDOT.

In preparation for the 2002 Winter Olympics, UDOT completed its first design-build procurement for the reconstruction of Interstate 15. This project included the reconstruction of 16.2 miles of interstate mainline and 130 bridges, among many other components. The significance of the project with respect to e-Construction was that UDOT's successful delivery of its first design-build procurement resulted in visibility with the State legislature for proven, innovative project delivery methods. UDOT receives approximately 80 percent of its funding from State revenue, so a strong relationship with the legislature is important, especially in terms of securing investments for innovations.

UDOT's efforts toward implementing model-centric workflows started in January 2014 with a visit to the Iowa DOT to understand its processes for distributing electronic plan sets to contractors as information-only files. The takeaways from this visit for UDOT included a better understanding of data availability, documentation of lessons learned,

and key activities to engage all stakeholders and improve processes. Upon returning from Iowa, UDOT worked with FHWA to host an EDC-3 workshop on 3D models, which was held in April 2014. The outcome of the workshop was the development of UDOT's implementation plan to outline objectives and short-, mid-, and long-term actions to achieve those goals.

In December 2014, UDOT held a second workshop with experienced design and construction staff to identify risks and challenges with delivering its 3D model as the legal document (MALD). Once the risks and challenges were documented, UDOT convened a different group during a third workshop to brainstorm ideas for mitigating the risks previously identified. This third group was composed of UDOT staff, consultants and contractors, software vendors/developers, hardware manufacturers, and academia. Their charge was to come up with solutions to the challenges preventing UDOT from implementing MALD.

MALD specifications allow UDOT to construct and inspect projects using 3D models directly incorporated into the legal document, which eliminates the need to convert between 3D design, 2D (paper) legal documents, and 3D construction. This can improve decision making and efficiency. MALD specifications may also allow 3D models to be updated during construction and for transfer of feature information to asset management systems following construction.[1]

In 2016, UDOT awarded its first pilot project (UDOT Project SR-20) with MALD specifications. The SR-20 project was awarded as a CM/GC procurement and included plan sheets as information-only documents. Some of the challenges identified when implementing MALD included lack of data standards to develop consistent data exchange, embedding data in the model for later extraction and exchange, addressing unknown/unexpected items that arise during design and construction, and importing data into asset management systems. Figure 2 shows the 3D model and certain asset information from the SR-20 project.

[1] See pages 17–19 of https://intrans.iastate.edu/app/uploads/sites/7/2019/08/02a-UDOTDigitalDeliveryIrvine.pdf

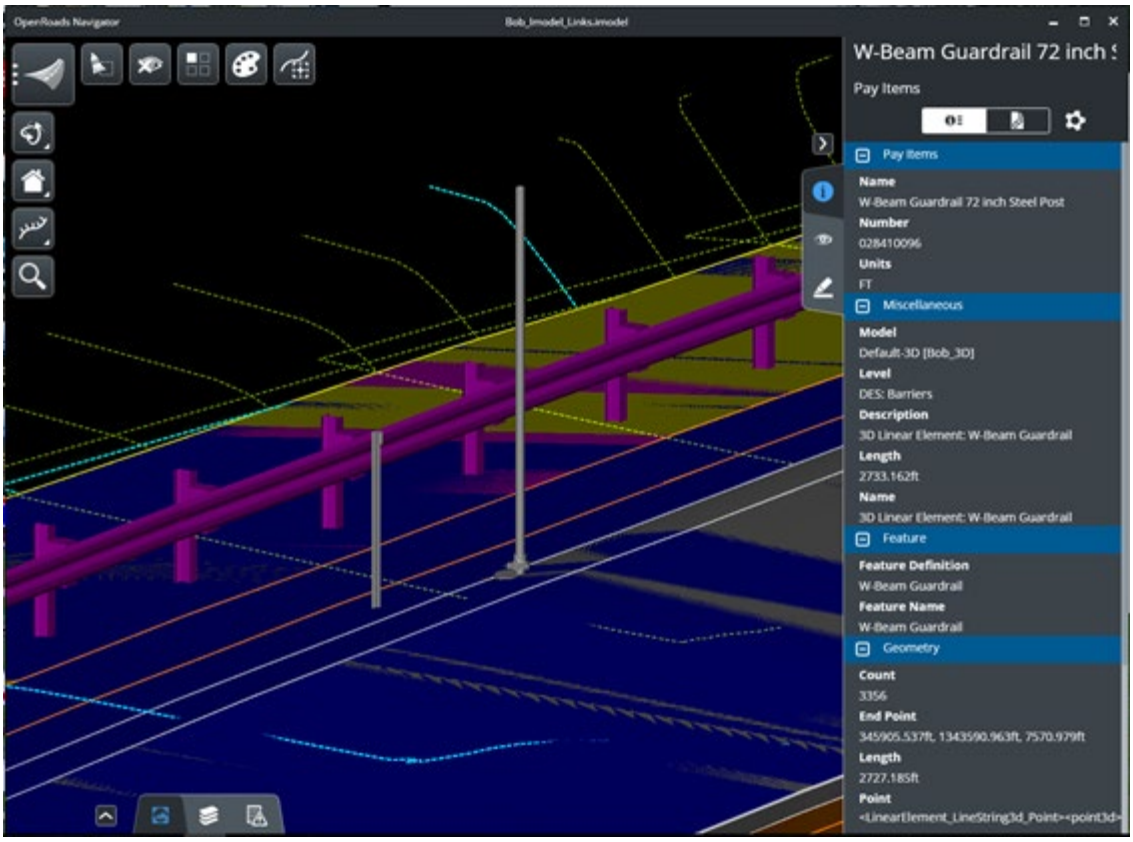

Figure 2. Screen Capture. 3D model for UDOT Project SR-20. Source: UDOT

UDOT reported achieving several significant milestones in 2017 and 2018, including the following:

- Awarded an FHWA Accelerated Innovation Deployment Demonstration program grant to develop and implement a program for intelligent design and construction with expected benefits to asset management and future planning.
- Became the first DOT in the Nation to award a design-bid-build (D-B-B) project using MALD.
- Began developing a Geographic Information System (GIS) solution for mobile device use in the field.
- Designed two D-B-B projects and three CM/GC projects for construction in 2018.
- Collaborated with contractors and the software industry to utilize an .icm format, which substantially reduces contractor model development time.
- Developed a model-based design and construction guidance document (published in 2019) that reports lessons learned and provides processes.

Current Efforts

3D Modeling

Following the 3D model pilot projects, UDOT's plan is to complete and refine its strategy and implementation efforts. Lessons learned from the pilots were incorporated into the *UDOT Model-Based Design and Construction (MBDC) Guidelines for Digital Delivery*, which was published in June 2019. UDOT's long-term goal is to standardize model-centric design, MALD specifications for advertisement of construction projects, construction and inspection protocols, and feature information for asset management systems. The agency anticipates the defined standards will enable a seamless modeling and exchange of digital information to populate business intelligence systems.

Partnering

Under UDOT's July 2019 *Partnering Field Guide* (a State reference manual that provides details on the agency's partnering program), all UDOT projects regardless of size should consider partnering founded on a risk-based approach. Projects with a risk score below 14 points on UDOT's scale may be facilitated with internal personnel. A semi-formal facilitation is selected when the risk score is 14–27 points, and projects with a risk score of more than 28 points should generally use formal facilitation.

UDOT has identified partnering as an effective way to establish relationships to deploy innovations. For example, the agency is collaborating with contractors to conduct an e-ticketing pilot project, although the low-bid environment presents many challenges.

Pilot Projects

Peer exchange participants visited two UDOT pilot projects. One, the State Route 209 (SR-209) construction project in Salt Lake City, was a D-B-B procurement with a project value of approximately $13.6 million. The scope of the project included widening the roadway to improve connectivity and traffic flow, intersection improvements, and upgraded utilities. Some of the challenges with model-centric workflows on this project included familiarizing the construction management consultant and contractor with the process and with working within the model-centric environment. The consensus of UDOT and the construction management consultant was that the complexity and size of this project was ideal for model-based design and construction. Figure 3 shows a segment of a roadway being widened and the UDOT inspector displaying the model components of that widening segment in real time on a mobile device.

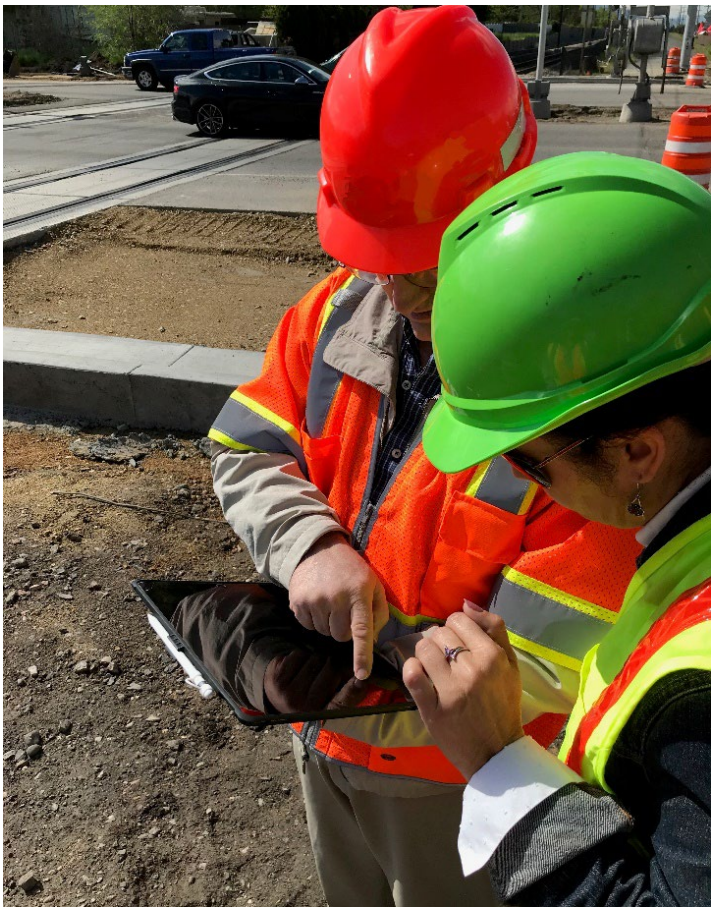

Figure 3. Photo. UDOT inspector displaying model elements on a mobile device in context of the project.

Peer exchange participants also visited the Interstate 80 (I-80) pilot project, which was also in Salt Lake City. This was a CM/GC procurement with a project value of approximately $36.5 million. The project scope included replacing several major bridges on I-80 to increase capacity for future travel demands and improve safety for drivers. Some of the challenges with model-centric workflows on this project involved gaining familiarity with the process, exchanging information between stakeholders, and extracting measurements of skewed elements (e.g., difference between straight-line distances and diagonal distances). The CM/GC contractor emphasized that the most complicated aspect for staff was understanding the technology, and this was driven more by their attitude than age. Figure 4 shows one of the project bridges under construction and the CM/GC surveyor displaying project model elements on the Global Navigation Satellite System (GNSS) rover in real time.

Figure 4. Photo. CM/GC surveyor showing model elements on GNSS rover in context of the project.

Cost and Benefits

UDOT has not documented cost and benefit information nor performed a formal cost/benefit analysis for MALD and construction automation efforts. However, UDOT recognizes that it is in the investment phase of process development and technology implementation. There is broad understanding and commitment within UDOT that model-based design and construction will benefit its project delivery responsibilities. UDOT is satisfied with the consistent progress and plans to continue investing in the initiatives.

Some costs associated with implementing e-Construction innovations for UDOT include mobile devices, additional software, outreach and education of consultants and contractors, and consultant contracts for pilot projects (independent cost estimates, quality assurance, etc.).

UDOT identified reduction of paper, improved design intent, and readily available data information as the top benefits of model-centric workflows. The ability to communicate design intent through visualization and contextualize construction activities using the model in the field enables construction staff to identify and resolve conflicts quickly.

Also, model-centric workflows can help meet accelerated schedules and improve pay item measurements.

The construction management consultant for one of UDOT's pilot projects noted that by using model-centric workflows, all design intent information is contained within the model and that places the responsibility on the contractor to ensure proficiency with extracting the information.

The CM/GC contractor for one of UDOT's pilot projects noted that the model-centric workflows created a more cohesive project delivery team because most stakeholders were at the same level of proficiency and understanding. In order to achieve the objectives for the project, the team had to work together to navigate unexpected technical and process challenges.

Key Takeaways

Participants put forth the following recommendations at the peer exchange, based on lessons learned from their programs.

Leverage open data standards to mitigate uncertainty with data exchange. Most proprietary software accepts limited open data formats for exporting certain types of data to exchange between systems. UDOT noted that a comma separate value (*.csv) file is used extensively for exchanging bid item and daily inspection data from field to office.

Utilize Enterprise License Agreements (ELAs) to the maximum extent possible. Often ELAs have provisions that allow for enhanced services, such as customization and configuration, which may help with model-based design and construction maturity.

Find the right partner in industry to advance innovation. UDOT noted that finding the right partner to advance innovation is important so that honest feedback is provided and progress is made toward its vision of model-based design and construction. Contractors also shared the sentiment that model-based design and construction has created a more cohesive project team with all stakeholders (contractor, subcontractors, UDOT, and consultants).

Empower construction staff by equipping them with tools and expertise. UDOT construction staff exposed to the use of GNSS rovers and model-based processes appeared to be more engaged by actively contributing to the success of the project. Staff members are more likely to volunteer for projects that include these innovations over other more traditional projects.

Take the time to pilot innovations. UDOT spent the last 4.5 years piloting model-based design and construction and developing processes, which helped the agency reach its current level of maturity. This, combined with typical projects lasting a single construction season, allowed UDOT to conduct several pilots and achieve success and progress.

Retain the designer through construction. UDOT discovered there is not a significant increase in cost to bring the designer through construction. Exposing the designer to the construction environment improves the overall coordination of model use. Also, ensuring the contractor has direct access to the designer helps mitigate delays or issues quickly.

Elevate surveying activities as a priority during design and construction. UDOT and its consultants are recognizing the need for making surveying activities a critical part of any project during design and throughout construction.

e-Construction and Partnering: A Vision for the Future

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

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