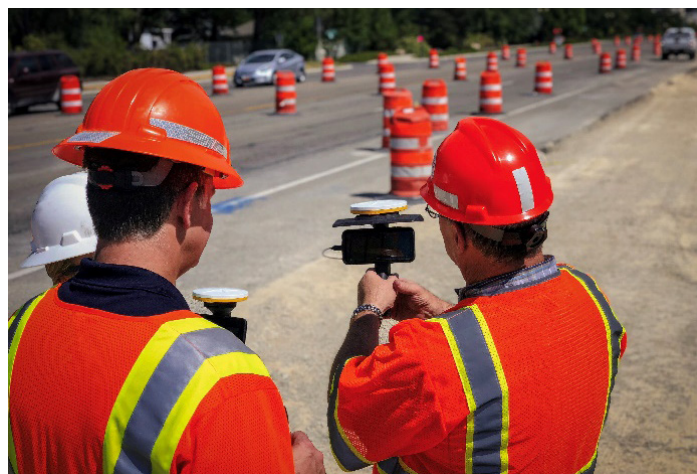




Partnering for Technology-Immersed Process Improvement

The Utah Department of Transportation (UDOT) benefits from an institutionalized partnering culture to advance innovations. The agency is implementing a new approach to construction contract documents that it calls digital delivery of Model-Based Design and Construction (MBDC). UDOT's digital delivery initiative includes the use of three-dimensional (3D) models as the official construction contract documents.

UDOT's partnering culture enables it to "push the envelope" of technological feasibility and adopt digital delivery of MBDC as a process that benefits both the agency and its partners. UDOT has used digital delivery on 10 awarded construction projects since 2015. It has used MBDC with both traditional and alternative procurement models. Figure 1 shows one way the digital MBDC contract documents could be used on the jobsite.



Credit: Adrien Patané/Irimble®

Figure 1: Inspectors access MBDC contract documents on the jobsite.

Key Takeaways

- Programmatic partnering may be necessary to resolve technology issues.
- Programmatic partnering builds broad support for the innovation roadmap.
- Project-level partnering is an effective strategy to remove technological barriers.
- Institutionalized partnering supports a culture of constant innovation.

MBDC is a technology-immersed process improvement with a steep learning curve. UDOT uses both programmatic and project-level partnering to foster the collaboration needed to implement MBDC and other digital delivery goals with an acceptable level of risk. Examples of the agency's partnering strategy include the following:

- **Programmatic partnering** with vendors to resolve data interoperability issues.
- **Programmatic partnering** to guide and monitor MBDC implementation.
- **Project-level partnering** to resolve technical issues on projects.
- **Project-level partnering** to manage project risks proactively.

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.



UDOT's Partnering Approach to Implementing Digital Delivery

In the past, a combination of partnering and strategic use of alternative contracting methods (ACM)¹ helped UDOT institutionalize accelerated bridge construction (ABC) methods. UDOT is now using a similar approach to develop and institutionalize digital delivery of MBDC. The agency is partnering at various levels and through different ACM to work toward its ambitious technology-immersed process improvement goals.

Description of the Practice

When UDOT implemented ABC, the agency initially used construction manager/general contractor (CM/GC) procurement. This enabled the design consultant to receive input from a qualified contractor regarding constructability of the design. Using CM/GC also fostered collaboration that was nurtured through partnering.²

UDOT captured lessons learned from the CM/GC projects and applied them to projects using design-build (DB) procurement and then design-bid-build (DBB) procurement. UDOT incorporated ABC into its *Structures Design and Detailing Manual* and now uses ABC routinely, where warranted.

The agency is reprising this successful strategy to implement digital delivery, another high-impact innovation with risks for both UDOT and its partners. Digital delivery of MBDC changes the medium of the contract documents, which initiates a major change to the technology and software skills needed to access contractual information. Figure 2 illustrates three different ways to view information provided through MBDC.

While developing the digital delivery approach, UDOT needed to work with partners in a trusting and problem-solving environment, with appropriate risk allocation. Using CM/GC procurement enabled the design team to interact transparently with a contractor to understand how they would use the 3D models to estimate and, if contracted to do so, build the project. CM/GC also gave the contractor an opportunity to help determine which contractual information would be in the form of 3D models.

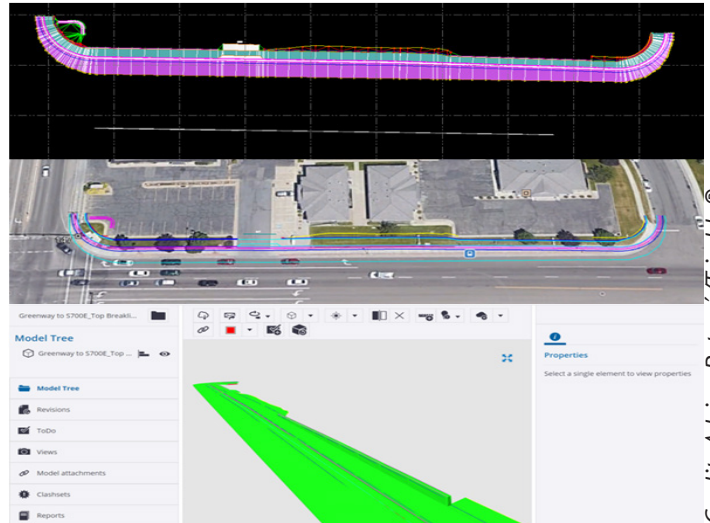


Figure 2: Contractual 3D model information displayed for different applications.

UDOT initially chose roadway projects that were simple and low risk, but used CM/GC to select a highly qualified team to prepare the MBDC information. While CM/GC inherently uses a collaborative process, partnering fosters good communication.

MBDC creates a software fluency barrier that parties must scale to fully access the contractual information. Partnering builds relationships and streamlines communication to avert situations where inequity could invoke suspicion. Using partnering, UDOT and its partners work through technology and skill barriers to restore universal access to contractual information.

¹ Refer to FHWA's ACM Library at <https://www.fhwa.dot.gov/construction/contracts/acm/>

² *Collaboration Using the CM/GC Process to Find Solutions for Accelerated Bridge Construction* (Reasch, Bowden, and Wells, 2010)

UDOT has continued to refine the MBDC process through more complex scopes and use of D-B-B procurement. MBDC is now maturing for roadway construction. The first MBDC bridge project, using CM/GC procurement, is now under construction.

Noteworthy Procedures and Methods

At UDOT, collaboration is the first strategy for solving problems, whether on the jobsite or on strategic initiatives that affect business practices. Working with industry to set the roadmap ensures UDOT and industry coordinate the pace and direction of their technology investments to balance risk and maximize outcomes for all parties.

UDOT's institutionalized partnering has evolved over two decades. By UDOT's estimation, most—if not all—of its partners have completed both levels of the agency's partnering training. UDOT is fully committed to forging effective partnering relationships on every project.

Selecting the Facilitation Mode

In 2015, UDOT updated its field guide to define more partnering options in addition to formal partnering (where a certified partnering facilitator guides partnering meetings). Now, UDOT can use semi-formal partnering or even informal, internally facilitated partnering (based on a collaborative approach to identifying and resolving issues).

Choosing the level of facilitation is one method the agency uses to streamline its partnering process. UDOT worked with the Associated General Contractors (AGC) of Utah to create a scoresheet approach to selecting the appropriate facilitation tier for each project. The short score sheet is used to assess project risks, and the score informs the choice of facilitation type. Only the most complex projects use a certified partnering facilitator. Most projects

“Our partners know that if something goes wrong on a pilot digital delivery/MBDC project, we will work to find an equitable resolution. Further, they know we will debug the issues together and push forward the lessons learned for future projects. Our partners are invested and recognize digital delivery/MBDC is the future and that the future is here, now.”

George Lukes, UDOT, State Design & Standards Engineer

are semi-formally facilitated, and the simplest projects are internally facilitated.

Partnering For Risk Management

Partnering is a central element of UDOT's project risk management process.³ The agency has developed modified partnering processes for ACM. These processes are used for CM/GC and DB because the risk allocation for those procurement models differs from that of D-B-B.

Programmatic Partnering

When UDOT started the digital delivery initiative, designers and contractors both used 3D models, but exchanged information with 2D plans. This process required designers to invest time documenting the 3D designs in 2D plans and required contractors to invest time creating their own 3D models based on their interpretation of those 2D plans. Conceptually, UDOT's designers and contractors could save time if contractors could use the design models for construction.

UDOT's designers and contractors use different software products with different, incompatible data formats. Without a vendor-neutral data format,

³ *Partnering Field Guide* (Utah AGC and UDOT Partnering Task Force, 2015).

UDOT had to rely on a proprietary data exchange format developed by one software vendor in collaboration with other vendors. It was supposed to enable reliable data exchange with the contractor's software. However, initially, it did not work as intended. UDOT reached out to the various vendors to help resolve technology issues on the first pilot project and included these and other vendors in a programmatic partnering process.

UDOT is proceeding with digital delivery by embracing willing partners. MBDC is still reserved for selected projects only. This enables UDOT to engage interested contractors that have the capability to demonstrate MBDC on projects and develop effective workflows.

Initial industry input guided UDOT to focus on MBDC for automated machine guidance (AMG), a roadway construction method where an onboard computer guides the equipment. UDOT provided MBDC data on a handful of projects as supplemental, non-binding information. This gave the agency initial insights on processes for delivering MBDC data. UDOT then held a Contractors Summit in 2017 where seven contractors met with agency staff and software vendors over 2 days.

Receiving honest feedback—both positive and negative—from contractors, coupled with the CM/GC procurement model, led to more contractors bidding on MBDC pilot projects. Software industry partners gained an understanding of the gaps and challenges both UDOT and its contractor partners were having.

Digital Delivery Workshop

Currently, UDOT is working on the as-built record process and improving the use of MBDC information for estimating. UDOT has held back on using MBDC on major interstate projects because MBDC data utilization for estimating and quantity management is still low. Quantity management is an important

part of project management for both contractors and UDOT. UDOT uses quantities to manage sampling and testing, while contractors use quantities for work planning and scheduling.

So far, at least six vendors are part of the MBDC paradigm shift, many traveling from other States. UDOT's consultants, contractors, fabricators, and the Federal Highway Administration (FHWA) are also involved.

UDOT visited participating contractors to delve into their estimating processes. The agency then held a workshop in February 2019 to further brainstorm how it can better support estimator workflows with MBDC. UDOT's partners made up three-quarters of the workshop participants.

The workshop focused specifically on using MBDC data in the estimating process. Six contractors sent representatives from their 3D modeling and estimating departments. Consultants sent representatives from their design and construction inspection departments. UDOT invited estimating software vendors as well as the vendors it has partnered with since the beginning of the MBDC initiative when the focus was on design, AMG, and construction surveying uses. UDOT brought representatives from its in-house design, contracts, and construction departments. The FHWA and academics also participated.

The workshop used facilitated, interdisciplinary roundtable discussions. Vendors were able to hear firsthand what features estimators need, while UDOT and its consultants heard what information estimators need and how they use it. The workshop's outcomes included the following:

- Less frustration with current limitations.
- Clearer understanding of estimator workflows and information needs.
- Managed expectations for using 3D models for estimating at present.
- A commitment to accommodate the objectives of digital delivery.



Credit: Adrien Patané/Trimble®

Figure 3: A demonstration of augmented reality using the 9000 South project MBDC data.

Project-Level Partnering

Early in the digital delivery implementation process, UDOT’s contractor would sit with the designer and compare models. This level of cooperation was possible because of the partnering culture. The technology and processes have matured over the course of five CM/GC and five D-B-B MBDC projects. Now, UDOT is working with consultants to improve processes for construction inspection.

In 2018, UDOT started the 9000 South project (a \$13.6 million D-B-B capacity improvement project) in Salt Lake County with MBDC requirements. UDOT provided the MBDC data as part of the request for qualifications for the construction engineering services (CES) contract.

The agency alerted prospective firms that there were no plan sheets, that they would be required to use the MBDC data, and that the data would be updated throughout construction to reflect the as-built conditions accurately. UDOT required the CES firm to use survey tools to verify the contractor’s survey and construction activities, as well as to capture feedback for the agency to update its Construction Engineering Management manuals.

One of the vendors UDOT partnered with on MBDC used the project MBDC data to demonstrate augmented reality (AR) as a potential tool for CES. AR is a visualization technology that displays a 3D model over an image. Figure 3 is an example of what is displayed on an AR device on the jobsite. The AR device demonstrated on the 9000 South project, shown in Figure 4, could navigate through the 3D model in real time based on the location and the orientation of the device.



Credit: Adrien Patané/Trimble®

Figure 4: A hand-held augmented reality device in use on the 9000 South project.

The 9000 South project involved widening five lanes to seven and included utility upgrades, intersection improvements, sidewalk reconstruction, new curb and gutter, signing and striping, and landscaping improvements. The AR demonstration showed stakeholders can use this technology to investigate disruptions likely to be caused from large projects such as this for residents, businesses, and motorists.

The benefit of AR for construction inspection is it lowers the level of software skill needed to navigate and interpret the MBDC data. UDOT's inspectors are not experienced with the complex tools used for developing and reviewing design within a model. Finding a user-friendly tool for inspectors is a necessary step toward full-scale digital delivery of MBDC.

Challenges and Successes

UDOT defines digital delivery of MBDC as *an interconnected, fully electronic compilation of project assets that have detailed attributes*.⁴ The intent is that the digital contract documents will include interlinked and/or embedded content that all parties access via a single master document. The embedded content would include 3D models, such as surface models representing existing conditions and the proposed top of final grade. Other interlinked documents might include design details, tables of quantities, and the relevant sections of the standard specifications.

Changing the Contract Medium

Digital delivery of MBDC is a disruptive change. Previous changes affected the process of producing contract documents, but not the documents themselves. When the digital 3D model becomes the contract document, it changes the medium through which contracting parties communicate.

⁴ *Intelligent Design & Construction (IDC)* (Page and Wheeler, 2016)

Supportive Technologies

Previously, contract documents were paper based or used the open Portable Document Format (PDF) standard,⁵ which gave parties flexibility in choosing from a range of certified software products that could access contract documents reliably. There is not yet an open standard for MBDC information. Thus, supportive technologies are required to access the MBDC contract documents.

These supportive technologies include the software and hardware needed to create, review, share, and read the contract documents. Supportive technologies are used both in the office and on the jobsite. For example:

- The contractor could use the 3D models directly with AMG equipment to grade and pave the road or with survey equipment to check the grade for quality control.
- UDOT's inspection team could use the 3D models with survey equipment to measure quantities for interim or final payments.

When the contract medium changes, the as-built medium changes, too. UDOT has been piloting survey technologies, such as unmanned aerial systems (UAS), to collect point clouds to extract as-built features to store in its asset inventory.

Future Outlook

Digital delivery of MBDC affects every aspect of the construction process because the contract documents use a new medium. Not all of UDOT's partners are ready for digital delivery. Each MBDC project spreads the capability further into UDOT's network of subcontractors and into peer agencies such as railroads and canal companies. Figure 5 provides an example from a model review meeting where different project stakeholders explored the model together. Institutionalized partnering creates

⁵ See ISO 32000-2:2017,

<https://www.iso.org/standard/63534.html>

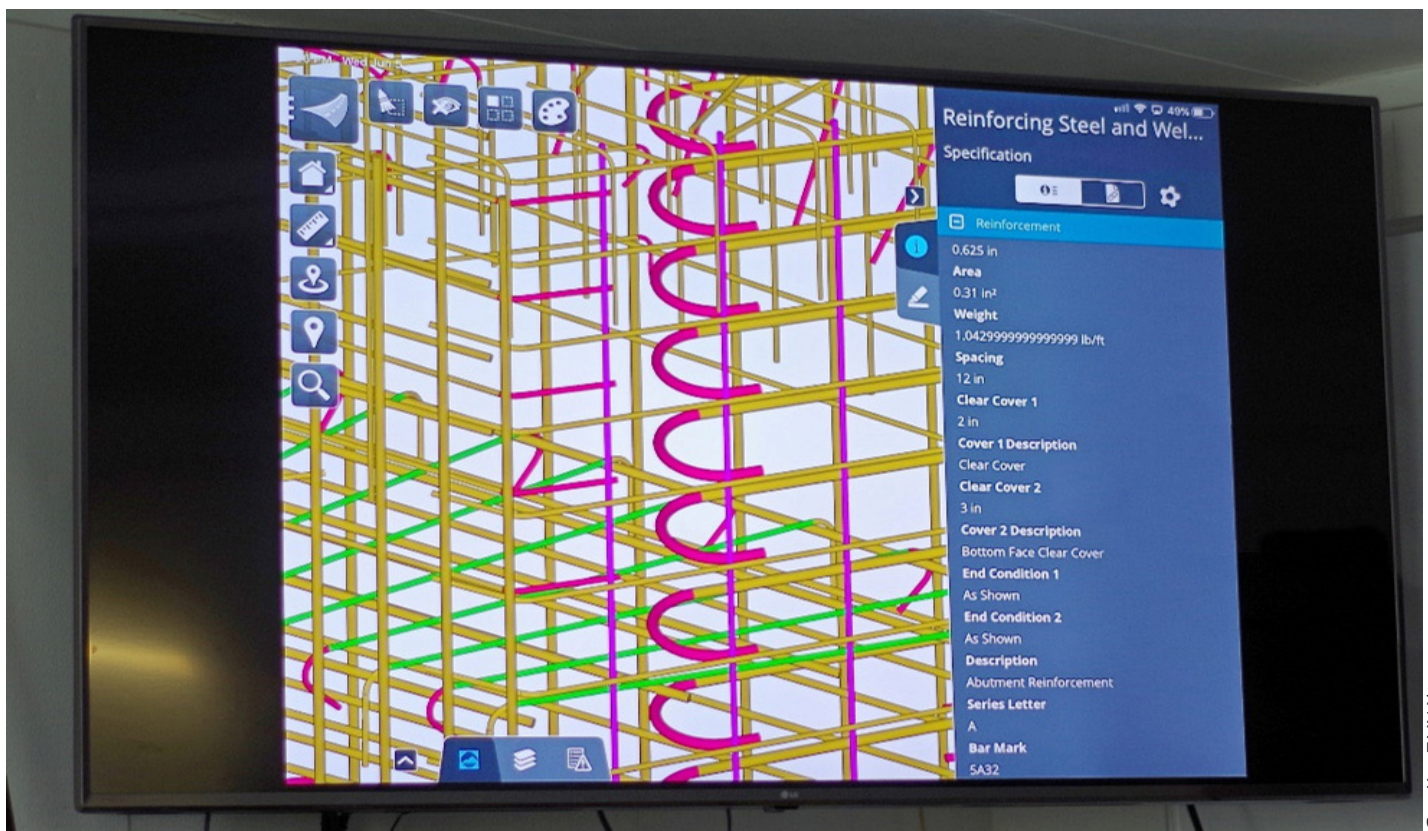
the atmosphere that fosters an organic transfer of skills within and across organizations in Utah.

Working through the challenges of reliable information exchange requires enhanced collaboration and a strong commitment to both the project goals and the broader objective of process improvement. UDOT will continue to use programmatic partnering to develop a roadmap with which to engage vendors to resolve technical issues with the appropriate urgency.

Internationally and nationally, industry is developing data standards for 3D models for roads and bridges. These standards will create an open data format that will enable vendor-neutral access to the MBDC contract documents. Ultimately, contracting parties

may have the same user experience with 3D model information as they currently have with PDF-based contract documents. The intention is to create a means to use the contractual information directly, without needing to extract and convert contractual information manually.

Using MBDC is a high-impact innovation, but it comes with risks to UDOT and its business partners. UDOT's digital delivery process improvement will not be final until industry adopts open data standards. In the meantime, UDOT is successfully using project-level partnering in combination with ACM to make leaps in efficiency in how information is exchanged from design to construction.



Credit: FHWA

Figure 5: The reinforcing steel model for the Blackrock Bridge Replacement project, UDOT's first MBDC bridge project.

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Key Words

- Construction partnering
- Programmatic partnering
- Digital delivery
- Model-based design
- 3D engineered models

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