

# Digital Construction Technology will be the catalyst to take streamlining project delivery in the Federal Aid Highway Program to the next level – Digital Delivery is the road to get there!

By Gregory G. Nadeau

August 2021

**T**wenty-five years ago – when many of today’s aging bridges were built – a typical construction site would look like what you’d expect: workers in hardhats pouring over paper blueprints, adjusting sextants, operating heavy machinery and cranes.

Today’s work site looks similar with some additions – laptops and iPads, cells phones with GPS connections, augmented reality headsets making the workers look more like a video gamer than a construction worker, maybe even a drone or two flying overhead.

More than just a “gee-whiz” factor, digital construction technology is helping contractors lower costs and build faster and more efficiently while enhancing worker safety. The cost savings and resulting efficiencies accrue not only to the benefit of the contractor, but in the case of public infrastructure, the taxpayers.



*Field worker using Trimble’s XR10 with HoloLens 2, which uses mixed reality technology to take 3D content off the screen and into the real world to perform immersive pre-construction walk-throughs.*

“Today you can take a 3D model of a bridge, incorporate it into an augmented reality platform like HoloLens glasses,” says Cyndee Hoagland, senior vice president of Trimble, “and your field workers and your stakeholders can all be viewing at the site, at the physical location, that bridge, in a reality type environment to identify where the problems are, where the design inconsistencies are. This reduces rework and saves time and money.”<sup>1</sup>

Advanced digital construction management systems are defined as commercially proven digital technologies and processes for management of construction and engineering activities. These include commercial cloud-based advanced decision-support technologies for infrastructure planning and coordination, commercial alignment planning systems, commercial building information modeling, digital 3D

---

<sup>1</sup> “California Transportation Commission Meeting 8/14/19 Part 1 of 2.” 16 Aug. 2019, <https://www.youtube.com/watch?v=tCUrdYijEMk>

design software and systems; specialized software, technologies, and systems for planning, construction, maintenance, modernization and management, and asset management systems for machines, site equipment, and personnel; and project delivery systems for project management.

Spurred by a program called Every Day Counts (EDC) – a partnership between state departments of transportation and the Federal Highway Administration (FHWA) which since 2010 has worked to identify and deploy proven innovations – digital technology has slowly worked its way into today’s highway and bridge construction projects. This includes 3D modeling, AI and robotics, virtual and augmented reality, building information modeling (BIM) and cloud computing, drone monitoring and more. And not just in the design phase.

More state and local infrastructure agencies are working with the private sector to enable and encourage engineers and contractors to connect at a whole new level. These technologies are now in the field, revolutionizing not just how roads and bridges are modeled and configured but how they are built.

***Digital construction technology can lower the cost of major infrastructure projects by as much as 25%***

Digital construction technology is being utilized to avoid mistakes, speed up the construction process and ensure efficiency in project delivery. Because mistakes take time and time is money, not only in the context of sequencing of construction, but in the context of how much longer it takes to complete a project. The longer that takes, the more costly it is to the environment, to commerce and overall congestion in our daily lives. So, the more efficiency you bring to project delivery, the more everyone benefits, including users and taxpayers.

As the COVID-19 pandemic presented new workplace challenges that will continue to evolve, the move toward on-site digital construction technology has accelerated. Indeed, recent data suggests that we have vaulted five years forward in consumer and business digital adoption in a matter of around eight weeks.<sup>2</sup> Companies are utilizing existing software and database technology, along with wearable trackers, to monitor the health of workers and ensure compliance with distancing rules. For example, distributed working has intensified the need for teams to share information and collaborate remotely, leading 1.2 million users to join Trimble Connect, an example of a cloud-based platform that makes it possible for people to connect and work together from anywhere in the world.<sup>3</sup>

---

<sup>2</sup> Baig, Aamir, et al. *The COVID-19 Recovery Will Be Digital: A Plan for the First 90 Days*. McKinsey & Company, 14 May 2020, [www.mckinsey.com/business-functions/mckinsey-digital/our-insights/the-covid-19-recovery-will-be-digital-a-plan-for-the-first-90-days#](https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/the-covid-19-recovery-will-be-digital-a-plan-for-the-first-90-days#)

<sup>3</sup> “The next Generation of Workers to Improve Efficiency of Construction.” *ME Construction News*, 16 June 2020, [https://meconstructionnews.com/41973/the-next-generation-of-workers-to-improve-efficiency-of-construction#\\_ftn1](https://meconstructionnews.com/41973/the-next-generation-of-workers-to-improve-efficiency-of-construction#_ftn1)

**FHWA Accelerated Innovation Deployment (AID) Program**  
*Notice of Financial Opportunity*  
*Section A, Program Description*

The AID Demonstration Program is one aspect of the multifaceted Technology and Innovation Deployment Program (TIDP) approach and provides funding as an incentive for eligible entities to accelerate the implementation and adoption of proven innovation in highway transportation. The AID Demonstration provides incentive funding for activities eligible for assistance in any phase of a highway transportation project between project planning and project delivery including planning, financing, operation, structures, materials, pavements, environment, and construction that address the TIDP goals:

- A. Significantly accelerate the adoption of innovative technologies by the surface transportation community;
- B. Provide leadership and incentives to demonstrate and promote state-of-the-art technologies, elevated performance standards, and new business practices in highway construction processes that result in improved safety, faster construction, reduced congestion from construction, and improved quality and user satisfaction;
- C. Construct longer-lasting highways through the use of innovative technologies and practices that lead to faster construction of efficient and safe highways and bridges;
- D. Improve highway efficiency, safety, mobility, reliability, service life, environmental protection, and sustainability;
- E. and develop and deploy new tools, technique, and practices to accelerate the adoption of innovation in all aspects of highway transportation.

[https://www.fhwa.dot.gov/innovation/grants/docs/NOFO\\_693JJ321NF\\_AIDDP\\_508.pdf](https://www.fhwa.dot.gov/innovation/grants/docs/NOFO_693JJ321NF_AIDDP_508.pdf)

But there is much the industry and Congress can do to accelerate the adoption of this time and money-saving technology. As Congress and the Administration develop bipartisan legislation to provide the elusive significant new investment in our nation's infrastructure, there is *a once-in-a-generation opportunity for federal and state leadership to accelerate the transformation of the nation's public infrastructure agencies responsible for delivering projects in an integrated digital world.*

Resources were directed by Congress in the Further Consolidated Appropriations Act 2020, which prioritized incentive grant funding toward the application of "Advanced Digital Construction Management Systems" through FHWA's Technology and Innovation Deployment Program (TIDP) that could help accelerate the implementation and delivery of this category of innovations and technologies to state DOTs and local transportation infrastructure agencies delivering projects under the FAHP. This technology has

been extensively validated through research and development (in the public and private sector) for more than a decade, as well as extensive outreach and engagement with state and local agencies through EDC. The TIDP program provides funds for states and localities to acquire technologies, train personnel, and utilize digital delivery technology in projects.

The FHWA recently published a "Notice of Financial Opportunity" (NOFO) (see sidebar above) and expect to provide up to \$10 million for the current fiscal year.

**Florida DOT is a Digital Leader**  
*Facilitating e-Construction*

Florida DoT is using digital construction technologies to implement e-Construction workflows based on its desire to use more efficient and state of the art technology.

Contractors can provide detailed earthworks quantities and reports in a format more easily utilized by the Florida DoT, streamlining construction workflows. This workflow will allow FDOT to take advantage of 3D data models and the benefits of automated machine guidance resulting in better quality roads, improved safety during the construction process and reduction in rework costs. **Construction cost savings of up to 25% relating to estimating, scheduling, and value-engineering can be achieved using these technologies.**

<http://www.fdot.gov/construction/eConstruction/Trimble.shtm>

## Early in the Digital Construction Revolution

The introduction of digital construction technology in the transportation sector didn't happen overnight. Every Day Counts (EDC) was launched in 2010 when the Federal Highway Administration (FHWA) partnered with state DOTs and the private sector to help usher in a new era of innovation in the highway and bridge sector. I served as the FHWA Deputy Administrator during that time. EDC works with state transportation departments, county and local governments, tribes, private industry, and other stakeholders to identify and rapidly deploy proven, yet underutilized innovations to shorten the project delivery process, enhance roadway safety, reduce traffic congestion, and integrate automation.<sup>4</sup> Proven innovations promoted through EDC facilitate greater efficiency at the state and local levels, saving time, money and resources

that can be used to deliver more projects.

In 2012, Round 2 of EDC included the 3D modeling initiative which launched six years of commitment by FHWA and states to build toward digital project delivery in the Federal Aid Highway Program (FAHP). The first round of EDC initiatives was all about tools to help accelerate and streamline delivery of projects.

Each successive round of EDC initiatives, however, offered even more advanced technology initiatives, like 3-D modeling. That was something contractors were advocating for to encourage state DOTs to accelerate their understanding of the opportunities and benefits digital construction technology could provide. Because all these innovations are designed to eliminate mistakes, streamline construction, increase efficiency, and ultimately save time and money.

More of the nation's state DOTs are exploring the use of 3D engineered models in construction, and several have developed mature practices. (*I've highlighted examples in Florida and Utah that are among the leaders nationally.*) As a result, the tools and techniques used to collect and process data to build 3D models during various stages of the project — planning, surveying,

---

<sup>4</sup> "About Every Day Counts (EDC)." U.S. Department of Transportation/Federal Highway Administration, [www.fhwa.dot.gov/innovation/everydaycounts/about-edc.cfm](http://www.fhwa.dot.gov/innovation/everydaycounts/about-edc.cfm).

design, construction, and asset management — are rapidly maturing.<sup>5</sup> However, the reality today is that we need to pick up the pace. Importantly, FHWA included in the current round of EDC initiatives a technology initiative focused on Digital As-builts and e-Ticketing.

The FHWA EDC website describes the initiatives as follows: “Converting paper-based materials ticketing systems and as-built plans into electronic (e-Ticketing) workflows and digital as-builts enhances the accessibility of highway project data. e-Ticketing improves the tracking, exchange, and archiving of materials tickets. Digital information, such as 3D design models and other metadata, enhances the future usability of as-built plans for operations, maintenance, and asset management.”

Implementing e-Ticketing and digital as-builts into project delivery enhances safety, quality, and cost savings by improving the accessibility of project data.”

([https://www.fhwa.dot.gov/innovation/everydaycounts/edc\\_6/](https://www.fhwa.dot.gov/innovation/everydaycounts/edc_6/))

EDC-6 is in the first of a two-year cycle. According to the recently published EDC -6 Summary and Baseline Report: (May 2021)

FHWA reports:

- “Forty-three States plan to be at the demonstration, assessment, or institutionalized stages of e-Ticketing at the end of EDC-6, compared to 18 at the beginning.” (An all-time record of participation for an EDC initiative.)
- “The number of States attaining the demonstration, assessment, or institutionalized stages of digital as-builts is expected to grow from 10 to 27.” (A significant number, but we can do better.)

The EDC program has stood the test of time. FHWA staff and former Deputy Administrator Brandye Hendrickson are to be commended for their leadership in transitioning EDC to a new Administration in 2017. I fully expect the Biden Administration under the leadership of FHWA Acting Administrator Stephanie Pollack to continue this commitment to accelerating innovation throughout the Federal Aid Highway Program (FAHP). EDC has made a significant and positive impact in accelerating the deployment of underutilized innovations and in contributing to an evolving culture of innovation within the highway infrastructure community. Since the program’s inception, each state has used 19 or more of the 52 innovations promoted through Every Day Counts, and some states have adopted more than 40. Many of these innovations have become mainstream practices across the country. (See case study sidebars)<sup>6</sup>

A relatively new and particularly cool example of digital construction technology is Trimble’s SiteVision, a user-friendly outdoor augmented reality system that combines geospatial referencing with 3D visualization to provide context to building models. It allows users to view

---

<sup>5</sup> “3D Engineered Models: Schedule, Cost and Post-Construction.” *U.S. Department of Transportation/Federal Highway Administration*, [www.fhwa.dot.gov/innovation/everydaycounts/edc-3/3D.cfm](http://www.fhwa.dot.gov/innovation/everydaycounts/edc-3/3D.cfm)

<sup>6</sup> “About Every Day Counts (EDC).” *U.S. Department of Transportation/Federal Highway Administration*, [www.fhwa.dot.gov/innovation/everydaycounts/about-edc.cfm](http://www.fhwa.dot.gov/innovation/everydaycounts/about-edc.cfm).

new designs, reveal existing hidden infrastructure (like underground utilities) or visualize how new landscapes may change over time, without having to interpret multiple drawings and maps.



*Trimble's SiteVision Augmented Reality System allows workers to easily visualize, explore and understand complex geospatial information right from their mobile device.*

“Trimble delivers innovative, intelligent technology solutions enabling on time, on budget and high-quality infrastructure projects,” said Cyndee Hoagland, senior vice president of Trimble, “We connect the physical world to the digital worlds. You can save time and money if you design and construct digitally before you break ground and construct in the real physical world.” Hoagland explains that large infrastructure projects have a built-in 20% rework – redoing or correcting work that was not done correctly the

first time. Two factors alone (poor communication and poor access to project data) accounted for \$31.3 billion of rework costs in 2018 in the US market.<sup>7</sup> “Using technology allows you to reduce that rework by 50%,” said Hoagland. “There are significant cost savings by leveraging technology.”

## **The 2D-3D-2D Shuffle: Highway and Bridge Project Streamlining through Digital Delivery**

Like nearly everything else in today’s world, the future of construction is digital. As we’ve seen, the advantages of using digital technology over traditional methods in the design and even the actual construction of major projects have been amply demonstrated. A comprehensive study by the University of California at Davis and CalTrans, (California’ Department of Transportation) found that utilizing advanced highway maintenance and construction technology – 3D and building information modeling (BIM), computer aided design, automated machine guidance, etc. – “increased efficiencies for tax dollars, cost savings, reduce(d) construction conflicts, decrease(d) construction time, and enhanced workers’ and public safety.”

Why then have many state DOTs been relatively slow to evolve their requirements, technologies, and practices (with several notable exceptions) and sticking for the most part with legacy design and construction methods – 2D paper drawings and blueprints that on a major construction project can number into the thousands of individual sheets of paper?

---

<sup>7</sup> Imerso. “How to Reduce the Cost of Construction Mistakes.” *Medium*, Medium, 23 Mar. 2020, [medium.com/@imerso/how-to-reduce-the-cost-of-construction-mistakes-9551a4027696](https://medium.com/@imerso/how-to-reduce-the-cost-of-construction-mistakes-9551a4027696)

State DOTs and other infrastructure agencies across the country should be prioritizing the conversion of their project management platforms by adopting these proven technologies and accelerating the transition from legacy design and construction methods. In our world, the term project streamlining is often associated with addressing alleged inefficiencies caused by environmental regulation. Digital project delivery technology is the ultimate streamlining tool that can have a range of impacts on the project delivery continuum as well as transparency, accountability, and sustainability.

After several conversations with knowledgeable professionals in the field and who helped inform much of this paper, the following are a few thoughts that capture what I consider to be some of the opportunities and challenges to advance the state of practice in public transportation infrastructure project delivery:

In many departments and agencies, the problem begins with outdated business models and an antiquated paper process that's linked to the business model along with the age-old focus in the highway and bridge sector, that of assignment of risk. There is the legal document for construction, and in most cases today the legal document is a piece of paper. "So, the old model is, I have a designer build these 2D paper sheets, and then I hand them to the contractor, and they can't change them, because if they change anything then I have risk and I don't want that. I don't want the liability," according to one knowledgeable practitioner. He went on to say, "The Europeans figured out years ago that you don't need a piece of paper to be a legal document - you could actually have a 3D model that's a legal document. This is what you're going to build, this is the legal model. That's standard practice in Europe today."

Utah and Florida are two examples of states leading the way toward Digital Delivery in the FAHP. (see sidebars). But some states are slow to transitioning away from traditional methods, even when they cost more and can lengthen the time for project delivery. To illustrate, on a large highway construction project there can be as many as 6,000 individual drawings for that single project – one drawing for geologic data, one for materials data, one for environmental data, etc.

And then there are change orders. Every project has any number of change orders and every change order adds a minimum of one more sheet of paper, which also adds time and money.



So, there is a need for agency policy leadership to understand the full scope of benefit Digital Delivery can bring to project delivery. Back to our 6,000 sheets of paper. When you're

working on 6,000 sheets of a design, things get missed, you have to go back and rework them, there are more change orders because you didn't catch stuff early because it's hard to go through 6,000 pieces of paper and make sure you don't have any gaps in the design.

3D modeling makes the process much easier, more accountable, and transparent. With a 3D model, you can link it to everything about that project. I can literally put an unlimited amount of information linked into that model. Everything is in one place, all your data for that project accessed in that one model. The digital twin of your infrastructure. Instead, I've got 6,000 sheets of just the design information. If I want the geological information, that's another 6,000 sheets of paper. Oh, and then I've got to figure out what street signage is in this project, now that's another thousands of sheets of paper I need to manage. Why would you want to do that to yourself? Wouldn't you want all the information in one place?

And you can even be a layperson like me and not need engineering or construction experience to look at a model and go, "Oh, that's a road with a bridge!" But with 6,000 sheets of paper, it's hard to tell what is what.



## **FHWA EDC-6 / e-Ticketing and Digital As-Builts Initiative**

[https://www.fhwa.dot.gov/innovation/everydaycounts/edc\\_6/](https://www.fhwa.dot.gov/innovation/everydaycounts/edc_6/)



### **UtahDOT: Facilitating 3D Engineered Modeling Construction Workflows**

In 2014, by working together using the Bentley Developer SDK, and collaborating on the development of Bentley's i-model schema, Trimble and Bentley created the first end to end workflow from initial feasibility study planning through design, bidding and construction for road and rail projects. The workflow achieved supported the FHWA's "Every Day Counts" initiative for e-Construction. Leading adopters of the solution have begun using e-Construction through the design, bid, and construct process providing digital design data for contractors to improve both the bidding and construction processes using a paperless methodology.

UDOT is also pioneering MALD (Model As Legal Document) methodology across many of their road construction projects. The highly successful SR-20 Pilot study involved Trimble digital construction technologies to streamline intelligent transfer of construction designs directly to the contractor via paperless plans. Trimble estimates that this approach resulted in a 17% reduction in time and up to 50% reduction in rework costs.

UDOT is now applying this methodology to the I-80 Widening project as well as four Construction Management General Contractor studies. By leveraging digital construction technologies, UDOT has a goal to ensure all future projects will be paperless based on 3D modelling construction workflows.

[https://www.udot.utah.gov/main\\_old/uconowner.gf?n=28020407138819186](https://www.udot.utah.gov/main_old/uconowner.gf?n=28020407138819186)

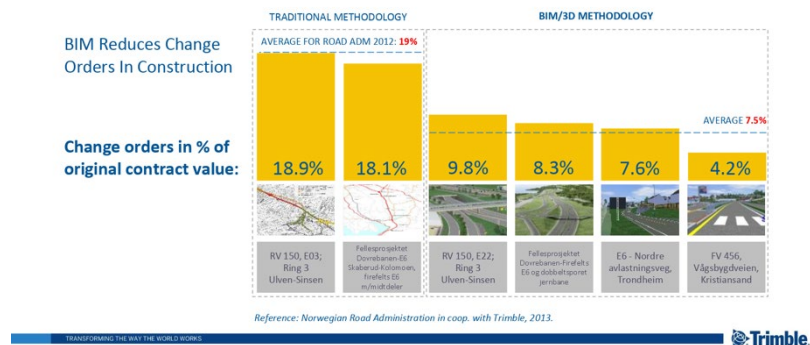
Because some contractors are taking advantage of digital construction technology while some DOTs are not, the situation leads to almost absurd time and money-wasting complications. For example, a lot of contractors want to use automated machine guidance technology. But to use it, they must convert the 2D plans to a 3D model. But then because the legal document is a 2D plan, they must take the 3D model and convert it back to a 2D plan due to the antiquated nature of their procurement process – I call it the 2D-3D-2D shuffle.

The technology is not all that esoteric or hard to use. A colleague put it to me this way, "There are child toy sets today that you can buy off the shelf where a kid can build a 3D model on her/his computer and print it out." We have homeowners using 3D modeling to design their kitchens. Public infrastructure owners of course face much more complex applications and challenges and

therefore must consider it an imperative to accelerate the advancement of the state of practice in Digital Delivery in their states. It will be the most valuable project streamlining tool in their project delivery efficiency tool chest. Which is why public infrastructure owners should compel this transformation in our sector within the life of the next multi-year surface transportation bill. To achieve that, states need the support and encouragement of the Federal Government.

The savings in time as well as cost for utilizing Digital Technology are well documented. An analysis of construction projects in Norway using digital construction methods found the number of change orders on a project decreased from almost 19% to just 4%, with a 90% reduction in produced drawings.

## III A More Productive Industry with BIM



Every DOT right now is being asked to get ready for autonomous vehicles on their roads. But to do that, they are going to need to capture an accurate, real-world model of their network of roads, and that means using 3D modeling. More DOTs are working on getting there, but we need more, and the pace needs to be accelerated.

So, what will it take to get more public infrastructure owners to catch up with their European counterparts and adopt digital construction technology on a wider scale? The consistent answer I get to that question, from public and private sector experts, is that information is the key along with policy level commitment. Just decide to do it! Policymakers need to understand the benefits, support their agency's digital delivery champions, and accelerate the adoption of Digital Delivery as standard practice as a matter of policy. Governments need to include incentives in their highway funding to accelerate the adoption of digital delivery as standard because it saves taxpayers' money, speeds up project delivery and enhances sustainable practices and outcomes – among other benefits.

In the context of the federal Aid Highway Program, it is important to understand that state DOTs and other public infrastructure owners are not in this alone. There is a robust and innovative digital construction technology sector where departments and agencies can go and get state of practice advice, technology, and training in every state. The resulting skill sets that public sector engineers and technicians along with their private sector partners will acquire result in significant professional development opportunity for our engineering and planning communities. Millennials will be leading these efforts and the Zoomers who follow them will demand it. State DOT's must employ state of practice digital delivery if they hope to attract and compete for the engineers of the future – a future which is here as Baby Boomers continue to retire at a rapid rate.

The future is digital, but how long should it take to get there? Because every construction season that we're not there, we're unnecessarily contributing to less efficiency, more costs, and more time in project delivery. And it is completely unnecessary because the technology exists today, the practices are well known, and the construction industry wants to go there. But they are not going to go there by the numbers we need unless the owners are essentially requiring the integration of Digital Construction Technology throughout the project delivery continuum. That is how you streamline project delivery.

*Gregory G. Nadeau is Chairman of Infrastructure Ventures, former Administrator of the Federal Highway Administration under the Obama-Biden Administration, and a former Deputy Commissioner of MaineDOT. Infrastructure Ventures partners and alliances in the digital world can be found at [www.infrastructurventures.com](http://www.infrastructurventures.com).*