

Technology Brief



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



Peer-to-Peer Exchange

New Jersey, Georgia, Indiana, and Ohio Departments of Transportation and Kentucky Transportation Cabinet

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Unless otherwise stated, FHWA is the source for all images and figures presented in this document.

Background

The New Jersey Department of Transportation (NJDOT) is interested in adopting e-Construction practices such as electronic approvals and signatures, electronic document management, and electronic collection of inspection information via mobile devices. To learn from other State departments of transportation (DOTs), NJDOT invited one representative each from four peer agencies to exchange ideas and solutions for overcoming challenges with implementation. NJDOT hosted a 2-day, face-to-face peer exchange with the Georgia DOT (GDOT), Indiana DOT (INDOT), Kentucky Transportation Cabinet (KYTC), and Ohio DOT (ODOT).

The e-Construction and Partnering (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, took place June 11–12, 2019, in Trenton, New Jersey. The State DOT representatives were joined at the peer exchange by staff from FHWA's New Jersey Division and the FHWA Resource Center.

NJDOT's e-Construction vision is to implement solutions that deliver the most value. The agency wants to capture and use information throughout the entire project delivery process, not just during construction.

During the peer exchange, GDOT shared the agency's perspectives on its document management solution and electronic signatures. KYTC discussed work with electronic approvals and signatures and e-ticketing. INDOT and ODOT shared information on their efforts with collaborative solutions for mobile device use and mobile application development.

Table 1. Participating State DOT e-Construction technology and practices.

Application	NJDOT	GDOT	INDOT	KYTC	ODOT
Construction Management	AASHTOWare® SiteManager™	AASHTOWare® SiteManager™	AASHTOWare® SiteManager™	AASHTOWare® SiteManager™ AgilePoint Change Orders	AASHTOWare® SiteManager™
Document Management System	Bentley® ProjectWise® for Design files e-Builder Enterprise™ for project management ¹	Bentley® ProjectWise® e-Builder Enterprise™ for public-private partnership and design-build projects	Bentley® ProjectWise® Custom-developed Electronic Records Management System ²	Bentley® ProjectWise®	Bentley® ProjectWise®
Electronic Daily Reporting	AASHTOWare® SiteManager™	AASHTOWare® SiteManager™	AASHTOWare® SiteManager™	AASHTOWare® SiteManager™ ³ Info Tech® Mobile Inspector®	GoFormz® ⁴ Info Tech® Mobile Inspector®
e-Ticketing	None	None	None	Earthwave Technologies® Fleetwatcher™	None
e-Signatures for Construction Contracts	None	Custom-developed Contract Authorization Tracking System ⁵ DocuSign®	None	None	User-based authentication for document approvals, wet ink signatures for contracts
Mobile Devices	Dell® Tablets	HP® Tablets	HP® Tablets and Apple® iPad® Tablets	Dell® Tablets (for Citrix®) Apple® iPad® Tablets (for Mobile Inspector®)	HP® Tablets for pilot demonstration

¹ Implementation into construction has not yet started.

² Long-term storage

³ Using Citrix®

⁴ Application programming interface (API) to move data to SiteManager™

⁵ For electronic workflow for contracts

NJDOT e-Construction Approach

Strategy and History

NJDOT's driver for adopting e-Construction as a standard practice is the desire to access project information efficiently during pre-construction and construction phases. Further, NJDOT had outgrown its legacy Project Reporting Systems (PRS) and started exploring new options. Figure 1 shows the legacy PRS interface.

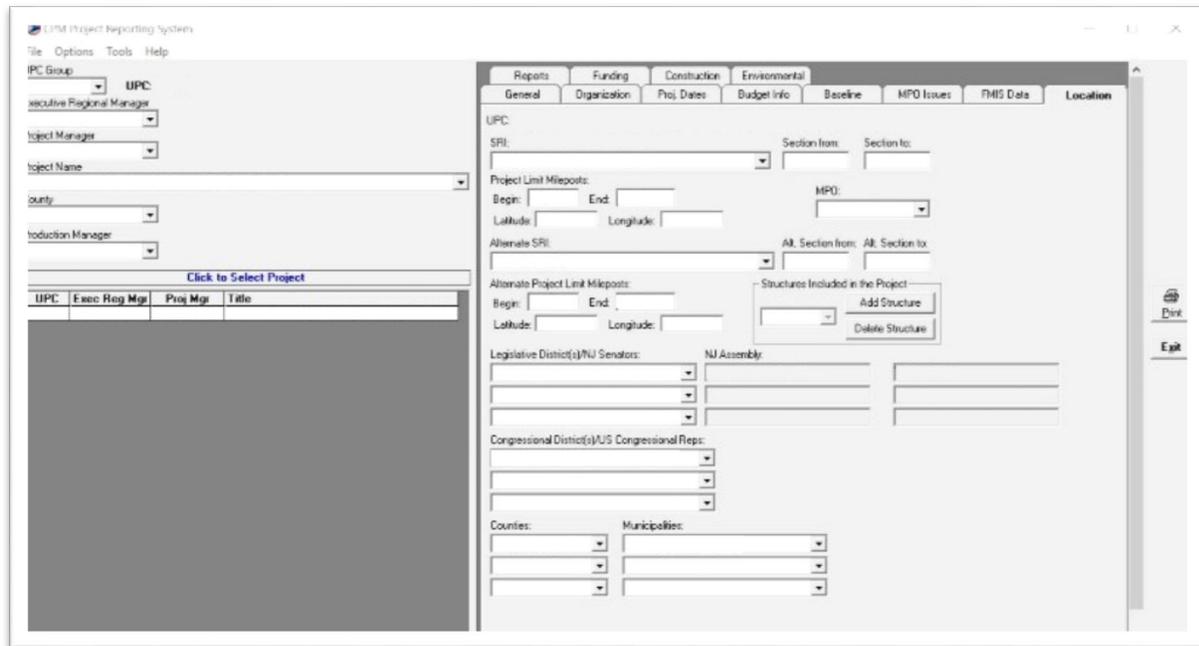


Figure 1. Screen capture. NJDOT's legacy PRS interface. Source: NJDOT

NJDOT's leadership team recognized that investing in e-Construction software applications was a high priority, and this led to the agency's overall strategic implementation plan. The first step of the plan was to identify stakeholders who could help map processes and outline areas of improvement that would benefit from electronic workflows. The result of these engagements was a decision to implement a system that could combine project management and reporting, including document management and project administration.

Project Management and Reporting System

In 2013, NJDOT moved forward with defining business and system requirements. The top requirements for the system are summarized in Table 2.

Table 2. NJDOT desired business and functional requirements for new system.

Document Management Requirements	Project Reporting Requirements
Unlimited file size and storage	Dashboards for key metrics
Storage of all file types used at NJDOT	Program- and project-level reporting
Document history and version control	Acknowledgement of completion
Standard metadata and folder structure	Real-time change order tracking
Check-out/in and document routing workflows	Reminders and notifications

The agency explored several solutions, eventually selecting e-Builder Enterprise™. NJDOT issued a contract to purchase e-Builder Enterprise™ in May 2016. The agency worked with e-Builder to implement an enterprise Project Management Reporting System (PMRS) that would combine electronic document management and project reporting. The implementation of the system was carried out in two phases, as illustrated in Figure 2.

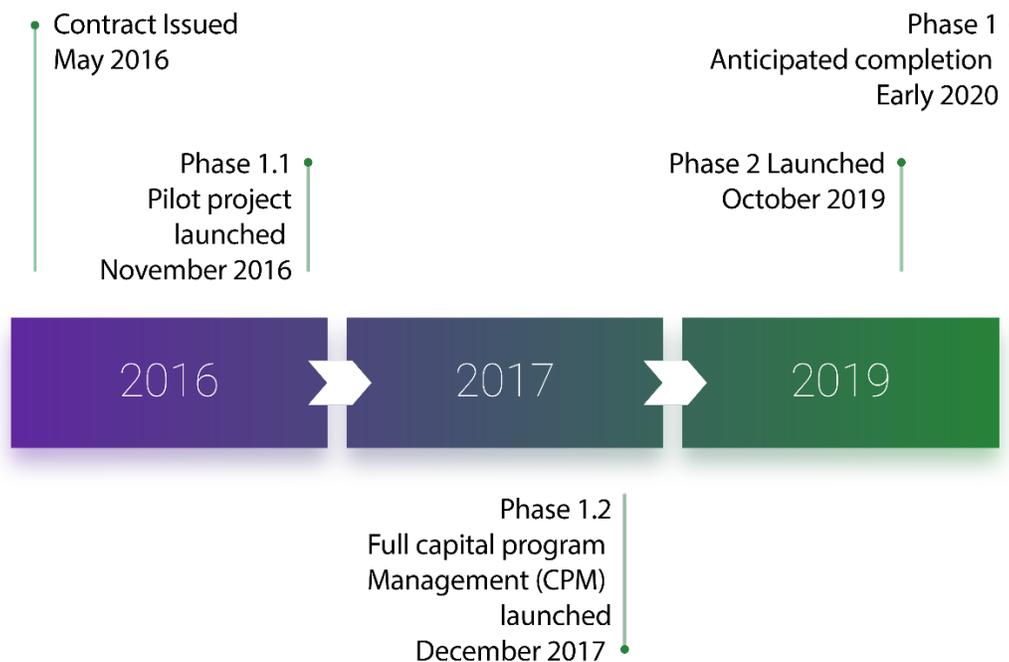


Figure 2. Timeline. NJDOT implemented an enterprise PMRS.

Phase 1 looked at implementing more than 20 processes, including job number requests, scope statement, and document review and approvals. Digital signatures are not yet being implemented. Phase 2 consists of implementing PMRS for NJDOT's Local Aid Program and developing more automated workflows for CPM projects.

Construction Administration System

NJDOT implemented Bid Express® for e-bidding in 2005 and has been entering project documentation electronically for years via AASHTOWare® Project SiteManager™. Initially, field personnel had to return to the office to enter information in the system. In 2017, NJDOT received FHWA State Transportation Innovation Council (STIC) incentive funds to purchase Dell® tablets for accessing SiteManager™ directly from the field. Field personnel are each issued a phone that serves as a hot spot for the mobile tablets. NJDOT also uses AASHTOWare Project™ products including Project Estimation™, Preconstruction™, and Civil Rights & Labor™.

Current Efforts

NJDOT is investigating the State requirements for managing digital signature certificates. The agency plans to use user-based authentication in the e-Builder system in lieu of digital signatures for documents that do not require raised signatures, such as professional engineering seals. NJDOT is also interested in e-ticketing.

Once the PMRS has been fully implemented in the Project Management Division, the Construction Division will begin investigations to integrate information from the contract administration system. PMRS is also being designed to integrate with tools, such as Bluebeam® Revu® and geographic information systems (GIS), to enable collaborative plan review and georeferencing project data.

NJDOT is in the beginning stages of adopting AASHTOWare Project Construction & Materials™. Use of the new system will only be required on new projects to avoid migrating SiteManager™ data. This decision was made to avoid additional implementation time and cost. NJDOT plans to re-create all the report templates, which will take significant effort. The agency anticipates the rollout to be completed in the next 3 years.

GDOT e-Construction Approach

Strategy and History

Approximately 95 percent of GDOT construction administration processes are paperless. As part of the journey toward paperless processes, GDOT developed a custom application called Contract Authorization Tracking System (CATS) in 2015. The original purpose of CATS was to be an electronic validation of paper processes, but it evolved into a robust workflow management system. As a result, GDOT stopped sending paper documents to contractors in October 2016, and in December 2017, GDOT District offices stopped receiving paper contracts. Figure 3 shows the timeline of GDOT's implementation of electronic contract and change order routing.

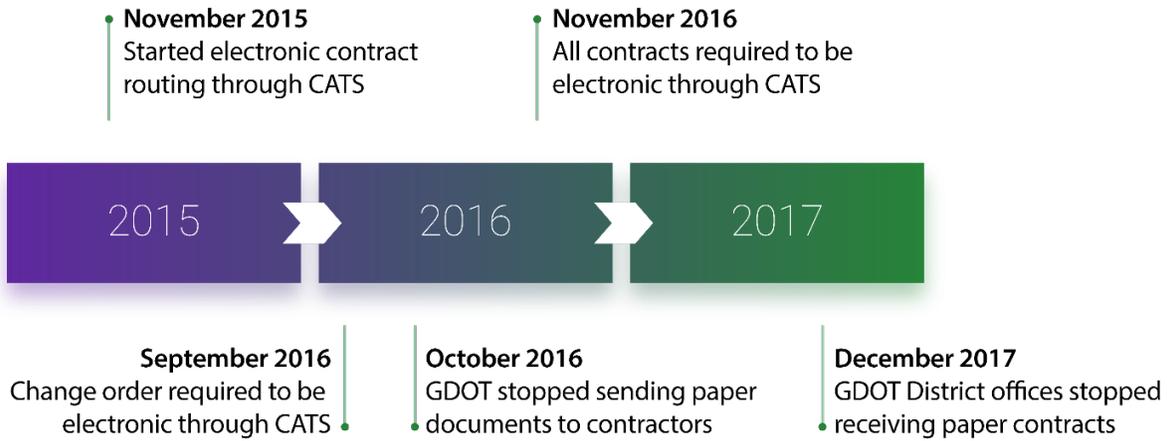


Figure 3. Timeline. GDOT's electronic contract routing implementation.

Current Efforts

Routing construction contracts through CATS was reduced from approximately 50 to 6 days. Additionally, GDOT's change order process was reduced from approximately 6 to 9 months to about 42 days. Figure 4 illustrates the change order routing process using CATS.

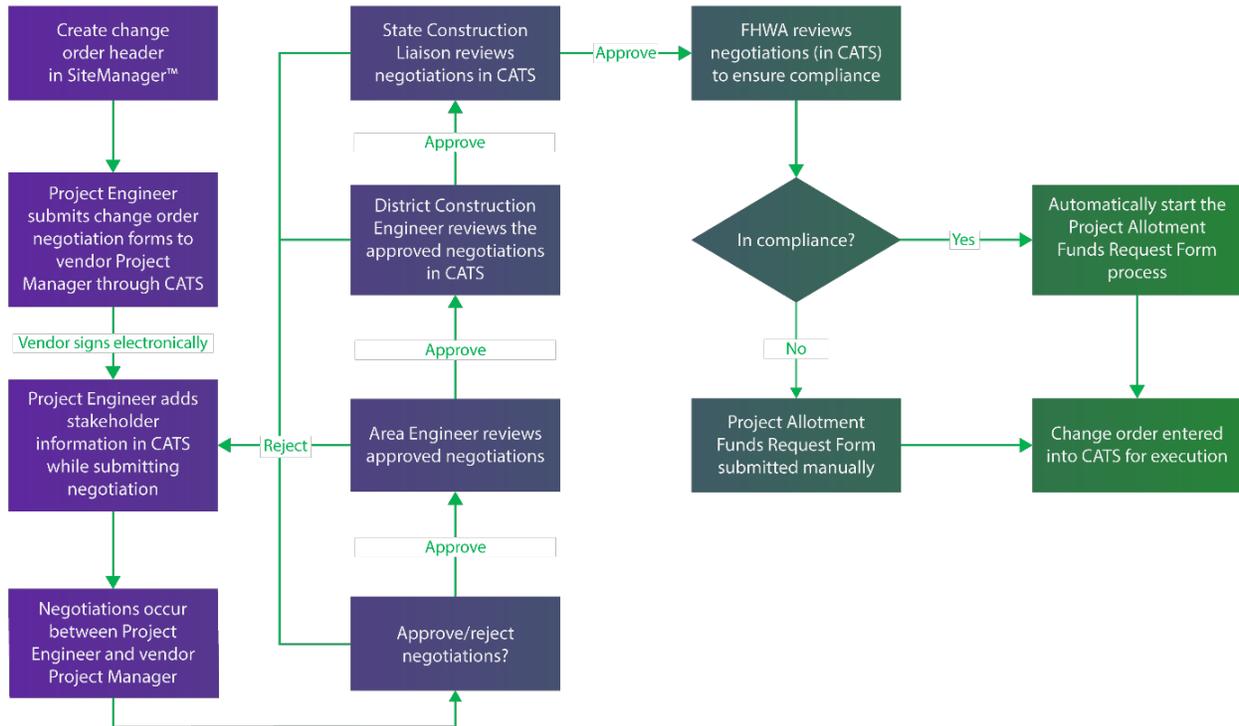


Figure 4. Process. GDOT's change order process.

An important component of the CATS application (Figure 5) is the electronic signature functionality, mainly for vendor signatures. GDOT was looking for an intuitive interface, interoperability (including custom integrations), high security, and sufficient data storage in its evaluation of several electronic signature solutions. The agency chose DocuSign® for electronic signatures, which is integrated with its CATS application.

The screenshot displays the GDOT CATS interface. At the top, the GDOT logo is on the left, and the system name 'Contract Authorization Tracking System (CATS)' is on the right. Below the header is a navigation bar with 'Home', 'Actions', 'Views', 'Advanced Search', and 'Help'. The main content area is titled 'Main Section' and contains several sections of input fields:

- Contract Information Section:** Includes radio buttons for 'Electronic Routing' and 'Manual Routing', a 'Contract Number' dropdown menu, a 'Contract Type' field, a 'Description' text area, 'GDOT Obligation Amount', 'Current Approved Amount', and 'Specified/Anticipated term of Agreement' with 'From' and 'To' date pickers.
- Selected Vendor's Information Section:** Includes 'Vendor's Full Name', 'PS Vendor ID', and 'Tax ID' fields.
- GDOT Submitter Information Section:** Includes 'Submitted By', 'Office', 'Title', and 'Phone' fields.

Figure 5. Screen Capture. GDOT CATS interface. Source: GDOT

INDOT e-Construction Approach

Strategy and History

INDOT's initial e-Construction philosophy was focused on paperless workflows, but it is evolving toward intelligent design and construction. The agency's mission is to use intelligent, three-dimensional (3D) computer-aided design (CAD) models to support the life cycle of transportation assets (roads and bridges). The models provide data-driven predictive analysis and reporting capabilities that allow the agency to make better operational and strategic management decisions.

Digital signatures for construction contracts are not standard practice at INDOT; however, consultant contracts use Adobe® with a Microsoft® Windows® Certificate protected by Windows® login security protocols.

Today, INDOT uses AASHTOWare® SiteManager™ and its custom-developed Field Assistant Application. The agency also uses several AASHTOWare® modules, Bid Express® for electronic bidding, and Bentley® ProjectWise® and Microsoft® SharePoint® for content management. INDOT also developed an enterprise record management system for a statewide document repository.

INDOT developed the Field Assistant Application in 2015 to provide a mobile interface for inspection reporting. The application works offline and enables construction inspectors to capture daily work reports and material test forms. Field Assistant is web-based and independent of any device, which allows for easier updates and improvements. During the development of this application, construction staff was proactively engaged. Data entered into this application is pushed automatically to the INDOT network when the device achieves internet connectivity. Most of the data is sent to SiteManager™ to support relevant reporting requirements. Additional data fields were added to supplement other reporting. This information is stored in a separate table within INDOT's data warehouse.

In 2016, INDOT implemented its storm water, erosion, and sediment control inspection reporting module. Then in 2019, INDOT added a hot-mix asphalt (HMA) tracker module for testing, ticket reporting, and approved design mix formula.

INDOT contracted with Bentley® in December 2017 to develop a construction inspection mobile application to use with CAD models. The project kicked off in February 2018, with INDOT deciding which assets to test for the prototype: storm sewer pipes and structures, concrete panels, and HMA approaches. Construction inspection checklists were also to be developed as part of this effort. Since Bentley® was working on a parallel and related effort for ODOT, INDOT decided to focus on the portion of application development meant to work with two-dimensional (2D) CAD files. ODOT was focused on automating manual processes during inspection by integrating 3D models into field activities. Figure 6 shows the 2D CAD elements that, once selected, will display the pay items for that component within the application.

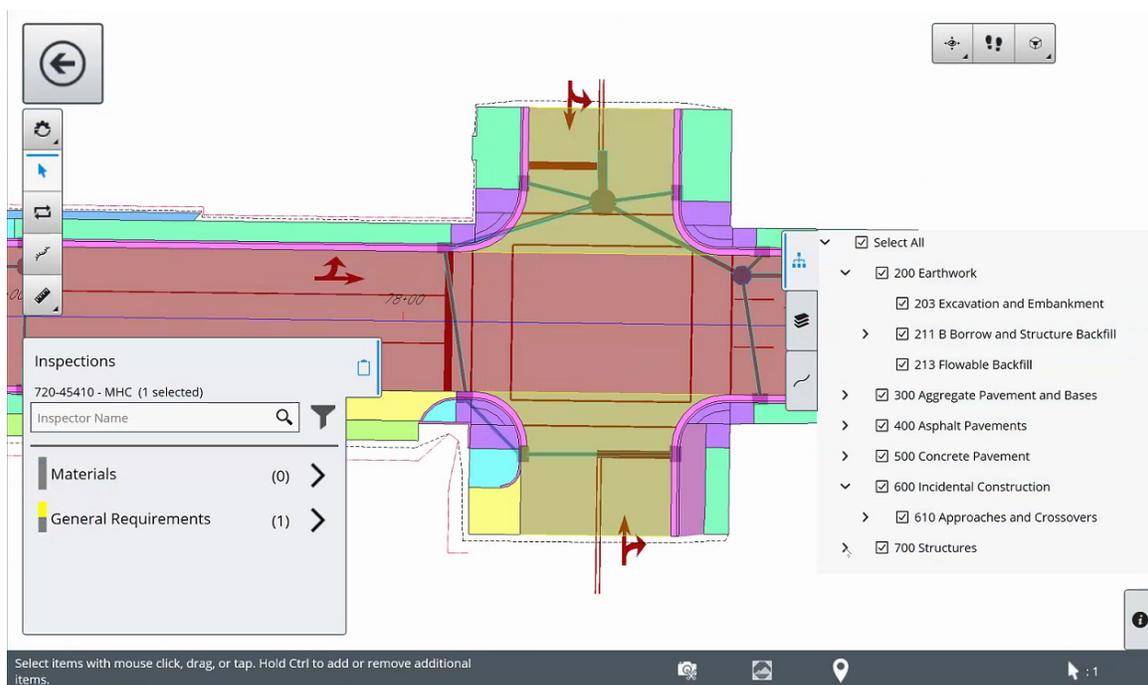


Figure 6. Screen Capture. 2D CAD elements with associated pay items in mobile application. Source: INDOT

Current Efforts

INDOT wants to improve its construction inspection mobile application, digital as-builts capturing, e-ticketing for materials delivery, integration of maintenance of assets, and other new technologies.

The agency is working with Bentley® on testing the prototype mobile application through a pilot project, with plans to deploy it in production by the end of 2019. The pilot project tested the 2D model prototype in April 2019 on a project that recently completed construction. This was not an active project, so the test was limited. In fall 2019, INDOT worked with Bentley® to determine suitable projects with which to test the form-based functionality. Tests of the 3D model functionality was to follow in spring 2020.

KYTC e-Construction Approach

Strategy and History

KYTC has grown its e-Construction practice significantly over the last decade. The timeline is shown in Figure 7.

To-date, KYTC has implemented electronic bidding and a digital plans room, mobile devices, and electronic document management and change order approvals. The agency is also developing new applications for data collection for sidewalk and ramp compliance with Americans with Disabilities Act (ADA) standards. KYTC is committed to continued improvement through innovation and has been working with the University of Kentucky on investigating and piloting e-ticketing and other related technologies.

In 2017, KYTC started transitioning toward electronic change order approvals and has not completed a paper change order since spring 2018. KYTC uses a custom-developed application based on AgilePoint® rapid application development technology. This platform-as-a-service (PaaS) allowed KYTC to build a custom application and implement its electronic change order approval process.

The electronic change order approval process is triggered by the creation of the change order in SiteManager™ and the selection of KYTC reviewer(s). The AgilePoint® system then automates notification and assignment of tasks to reviewers to enable the review process. Also, KYTC uses AgilePoint® workflow management for approving change orders as an alternative to electronic signatures. Once the review tasks are complete, the workflow determines whether the change order proceeds to the next reviewer or approver, or if rework is required in SiteManager™. The final approval task is not assigned until the fund manager indicates the funds are available. Once the change order has been fully executed, the system exports the final document to ProjectWise® for long-term storage.

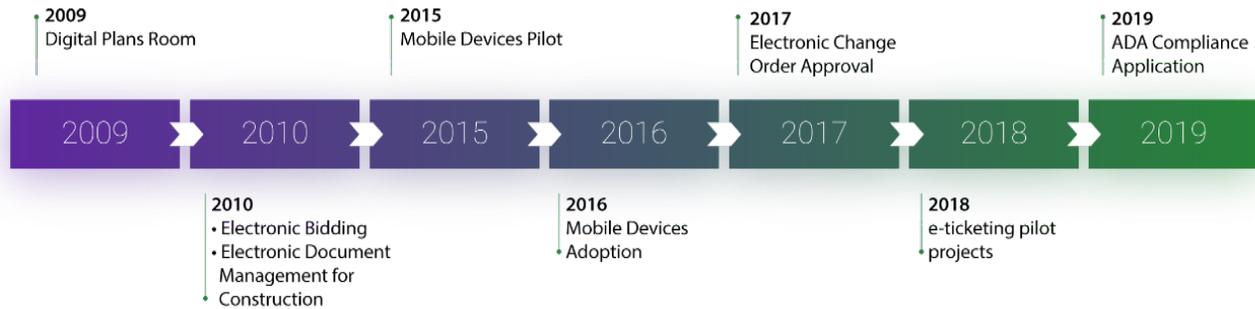


Figure 7. Timeline. KYTC's e-Construction progress.

In 2018, KYTC piloted e-ticketing technology (Fleetwatcher™ software) on two asphalt resurfacing projects. The main driver was the need to improve safety and increase workforce utilization for construction inspection. E-ticketing technology reduces inspector exposure to adjacent live traffic and large equipment during the collection of material tickets. Because e-ticketing provides the needed documentation for material quantities, it frees the inspector to focus on the most demanding tasks.

The two pilots served as an initial comparison of data collection for material tickets. Both paper and electronic material tickets were collected and compared to assess the accuracy of the information being captured and the financial benefits.

In addition to e-ticketing, KYTC is investigating other technologies such as a thermal profiler and intelligent compaction.

Current Efforts

KYTC is conducting 12 more e-ticketing pilot projects. The agency anticipates expanding the use of e-ticketing to HMA materials as a standard practice, and possibly to ready-mix concrete and aggregates.

In general, KYTC is pleased with the results of the pilot projects, especially with data alignment, exposure time, and theoretical tonnage (yield calculations). There were some differences between the construction inspector's log and the timestamps. These were likely due to the inspector recording the time at the paver, whereas the Fleetwatcher™ application recorded the time leaving the geozone (geographic areas defined through a Web-mapping interface).

KYTC plans to transition from AASHTOWare® SiteManager™ to AASHTOWare® Project Construction & Materials™ in early 2021. It is expected that the data in SiteManager™ will be migrated over to the new system.

ODOT e-Construction Approach

Strategy and History

ODOT's e-Construction initiative began in 2016 when Mobile Inspector[®] was introduced as the mobile interface to SiteManager[™]. The agency's e-Construction initiative included three other efforts:

- Implementation of risk-based inspection via checklists to prioritize inspection activities and documentation.
- Development of GoFormz[®] (an electronic field documentation form).
- Adoption of an enterprise construction document management and routing system.

The first two efforts were successfully implemented and now are part of ODOT's standard inspection process. In 2016, ODOT started working on the third effort after receiving an FHWA Accelerated Innovation Deployment (AID) Demonstration grant for piloting enhancements to the ProjectWise[®] platforms to support construction. The project objectives were to set up an enterprise document management and routing system to move digital data seamlessly throughout the project life cycle. Effective practices were identified for processing, storing, transferring, and archiving information once a project is constructed.

During initial discussions about e-Construction and paperless workflows, ODOT found it was necessary to integrate 3D data into inspector workflows. Working with Bentley[®], ODOT sought to demonstrate a construction inspection application with integrated field and office capabilities utilizing digital design data, regardless of connectivity. Also, it was important to increase access and mobility of project data. Figure 8 illustrates ODOT's vision for information mobility through project delivery and asset management. The results of the demonstration project

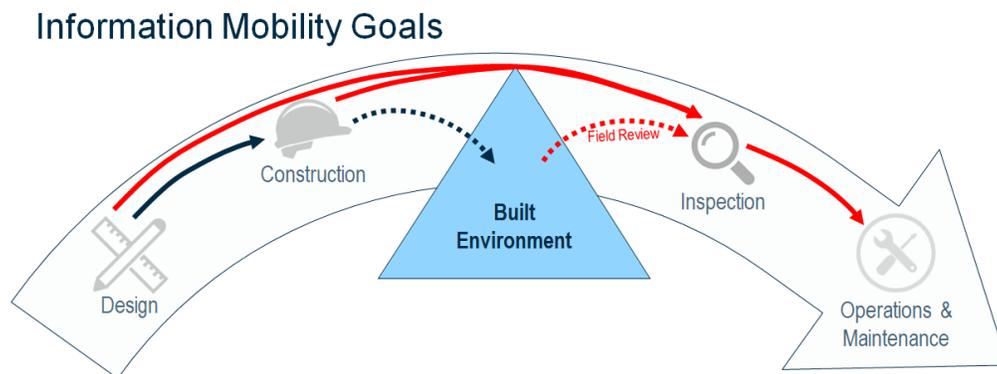


Figure 8. Illustration. ODOT's vision for information mobility. Source: ODOT

ODOT recognized early in the planning stages that the application could significantly benefit other DOTs. ODOT invited representatives from INDOT to attend a demonstration event. During the event, INDOT could see conceptual functionality and alignment with its e-Construction initiatives.

Current Efforts

ODOT is moving forward with its ProjectWise® enhancements, but in a more limited way than originally envisioned. Eventually, the agency will likely develop an application programming interface (API) to move data from SiteManager™ to ProjectWise®. ODOT anticipates continuing this effort in 2020 when it transitions to OpenRoads Designer® and ProjectWise® CONNECT Edition.

Other efforts being planned for future e-Construction initiatives include the use of digital signatures for signing contracts and deployment of Bluebeam® Revu® Studio Sessions.

Cost and Benefits

NJDOT's enterprise license fee for e-Builder® is approximately \$1 million. This business model allows the agency to provide contractors and consultants access to the system without incurring any additional cost. NJDOT pays approximately \$400–\$600 per year for each concurrent license for Bluebeam® Revu® and Studio Sessions. It has a concurrent license agreement for a pool of 50 instances of the product. NJDOT is in the initial phase of the PMRS implementation and has not captured quantitative benefits.

GDOT spent internal resources to develop CATS, and the development cost was not captured. However, CATS helps GDOT save approximately \$200,000 per year in paper and printing for construction contracts and costs related to records retention and delivering contracts for manual execution.

INDOT invested over \$50,000 (2D model functionality) in State funds and ODOT invested a small portion (final costs are not currently available) of Federal funds from its AID Demonstration grant (convert 2D plans to 3D models and improve workflows/processes) on the ProjectWise® demonstration project. INDOT has also spent approximately \$500,000 in both State and Federal funds for the development and implementation of Field Assistant over the past 6 years. No quantitative benefits have been captured.

Other costs involved in all the State e-Construction initiatives include the purchase of tablets and accessories and data plans.

Key Takeaways

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

Communicate effectively. Looking beyond the immediate value of streamlined information and data exchange, agencies can incorporate communication protocols built on these efficiencies to create a lasting benefit to all stakeholders. Proactive communication often resolves any conflicts quickly and encourages open feedback for continued improvement of e-Construction practices.

Implement innovations that can provide quick returns. The tasks most likely to succeed with little investment in time and costs (e.g., electronic signatures) will have an immediate positive impact on business processes and generate momentum toward the agency's vision.

Educate information technology (IT) staff on intricacies of construction systems. It is important the appropriate construction staff are educating and informing IT staff responsible for system administration or integrations. This improves system performance and grows a culture of trust.

Empower the right staff to make decisions on system development/configuration and integrations. Evaluating solutions as objectively as possible is important so that what is implemented will be successful and sustainable for the agency. Construction staff can provide this perspective and can offer practical insight on construction system functionality and integrations.

Cater to end-user experiences and functionality. Less customization of applications will allow for easier updates and improvements. Achieving a base level of functionality that meets end-user needs will get the initial deployment and subsequent improvements in their hands quicker.

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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