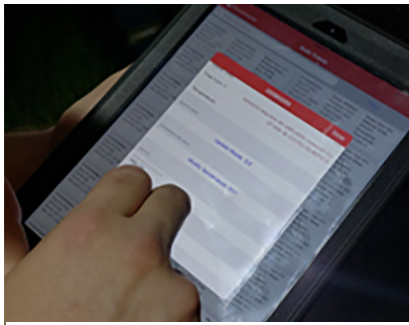![eCP logo - e-Construction and Partnering]

e-Construction and Partnering:
A Vision for the Future

Peer-to-Peer Exchange

Vermont Agency of Transportation and Alabama Department of Transportation

Montgomery, Alabama
February 20–21, 2019

U.S. Department of Transportation
Federal Highway Administration

eCP
e-Construction and Partnering

Table of Contents

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Background

The Vermont Agency of Transportation (VTrans) began deploying e-Construction in 2012. Its e-Construction vision is to become more transparent, optimize limited resources, and increase mobility. Since 2012, VTrans has incrementally added digital tools and practices, including a cloud-based system for submitting and managing construction documents with mobile devices. It has also committed key staff to overseeing all e-Construction technological advances. In early 2019, VTrans began preparing to implement a new construction management system (CMS) and pilot e-ticketing technology. As part of its effort to seek input from other agencies with experience in these areas, VTrans requested a peer exchange with the Alabama Department of Transportation (ALDOT) to discuss and share strategies for these upcoming efforts.

ALDOT hosted the 2-day peer-to-peer exchange on February 20–21, 2019, in Montgomery, Alabama. The Federal Highway Administration (FHWA) sponsored the event as part of round four of the Every Day Counts (EDC-4) technical assistance program for e-Construction and Partnering (eCP). In addition to three delegates from VTrans, representatives from FHWA's Alabama Division and the Resource Center also attended. Both agencies shared the history and current efforts of their e-Construction programs, and ALDOT shared strategies for mitigating challenges when implementing a new CMS and piloting e-ticketing. Other discussions included challenges and potential solutions for workforce recruitment and retention of construction field personnel. Table 1 showcases different e-Construction technologies at each DOT.

Table 1. e-Construction technologies at VTrans and ALDOT.

Technology Category	VTrans	ALDOT
e-Bidding	Info Tech® Bid Express®	Info Tech® Bid Express®
Construction Management System	Transitioning from AASHTOWare® SiteManager™ to ExeVision® integrated Project Development (iPDWeb™) software	Construction and Materials Management System (CAMMS) [1]
Digital Signatures for Contract Execution	Paper–based with ink signatures	Paper-based with ink signatures
Document Management System / Routing of Documents	Info Tech® Doc Express®	Investigating solutions
Inspector Daily Reporting	Fillable forms that are manually entered into AASHTOWare® SiteManager™. Transitioning from AASHTOWare® SiteManager™ to ExeVision® iPDWeb™	CAMMS
Materials Management System	Transitioning from AASHTOWare® SiteManager™ to ExeVision® iPDWeb™	CAMMS
Mobile Applications	Bluebeam® Revu® (for collaboration on as-built plans creation)	Earthwave Technologies® Fleetwatcher™ (for e-ticketing)
Mobile Devices	Apple® iPad®	Apple® iPad®

[1] CAMMS is a custom-developed CMS.

VTrans Implementation Approach

e-Construction Strategy and History

VTrans has a centralized Construction & Materials Bureau (CMB) under its Highway Division. The CMB includes Regional Construction Engineers (RCE) and Resident Engineers (REs) who oversee construction projects and support staff who provide expertise in key areas such as construction services, material testing and certification, geotechnical engineering, and e-Construction.

The main drivers for implementing e-Construction were reducing or eliminating duplicate work, increasing document accessibility, and funneling information easily and efficiently. While e-Construction has benefited field personnel and improved relationships with contractors, it has also created additional work for REs, who are using the newly available information and data to produce reports for managers. Overall, VTrans said it has been a great innovation for the agency to implement.

VTrans first dabbled in e-Construction in 2007, when the agency developed an application called eBooks to document quantity payments, replacing the double documentation of paper field books and SiteManager™. The eBooks program was not fully adopted until 2012, but has since helped VTrans accelerate the completion of final quantity payments to 1–3 months compared to 6 months or more.

In 2017, VTrans began utilizing Windows® File Explorer set up with standard folder templates as an interim, custom e-Construction solution. This file sharing system, which VTrans called eBox, enabled staff to upload documents to a centralized location while in the field. In 2019, VTrans chose to fully adopt Doc Express® to replace the use of the eBox file sharing solution. Other e-Construction initiatives being implemented by VTrans include a document management system that supports automatic document routing for approvals and a cloud-based solution that improves the process for creating as-built plans.

Document Management System

In 2016, VTrans began investigating solutions for managing and routing documents submitted by contractors and field personnel. The agency selected Doc Express®, and pilots began later that year.

By Spring 2017, VTrans had implemented Doc Express® statewide to supplement their use of eBox. The agency had more than 100 contracts in the system by the end of 2018. All documents except delivery material tickets are uploaded to Doc Express®. Supported file types include Microsoft® Excel® and Word™, Adobe® Portable Document Format (PDF), Tagged Image File Format (TIFF), and Joint Photographic Experts Group (JPEG). The maximum file size allowed by the system is 50 megabytes.

According to VTrans, the functionality of the selected system includes the following:

- Web-based access anywhere with an Internet connection.
- Transparency for all stakeholders (agency, consultants, and contractors).
- Single source of truth: eliminates duplication of documents.
- Accountability via a transparent tracking system.
- Construction Engineering & Inspection consultants can see certifications and other documents as they are entered in the system, without accessibility issues.

Also, VTrans noted certain requirements for the agency's successful implementation of Doc Express®, specifically:

- Simplicity and ease of use of the system.
- Full management support.
- Use of FHWA State Transportation Innovation Council (STIC) Incentive Program funds for the pilot projects.
- Standardization of naming convention for system drawers.

VTrans keeps contract documents, certifications, materials test results, and non-compliance reports in the Doc Express® system. The documents are organized by drawers using document types of the same categories (e.g., certifications, materials test results).

Once a document is submitted, it is tracked using standard workflows and states, such as received—ready for review, rejected—see remarks, and accepted as noted. The workflow for a document in the *Submittals* drawer is illustrated in figure 1. VTrans has also developed workflows for the *Certifications* and *Materials* drawers.
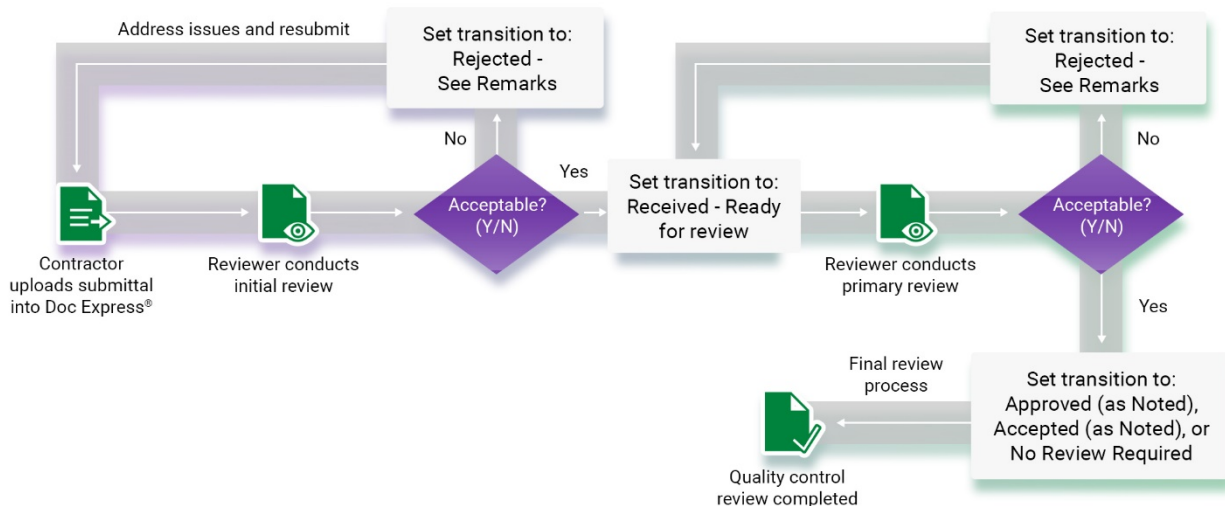

Figure 1.Flowchart. VTrans workflow for the Submittals drawer.

Construction Management System

At the time of the peer exchange, VTrans was transitioning from AASHTOWare Trns•port® software to a new CMS called iPDWeb™ by ExeVision®, rather than upgrading to AASHTOWare® Project Construction and Materials™ software. The *Estimation and e-Contracting* modules are designed and full deployment of the tool is scheduled for Winter 2019/2020.

The *Construction and Materials* modules are in the requirements gathering phase. The VTrans e-Construction Section is working with subject matter experts (SMEs) and the vendor to produce the requirements. The cloud-based system will be fully integrated with document management, task lists, dashboards, and automated workflows functionality to meet the agency's business needs. Full implementation of iPDWeb™ is targeted for 2023.

Real-Time Collaboration Tool for Creating As-Built Plans

Another initiative underway at VTrans is the use of PDFs to perform real-time, as-built electronic markups during inspection using Bluebeam® Revu® for iPad®. Office staff will use the Bluebeam® Revu® cloud-based solution on their computers. The purpose is to streamline the *Finals* process and accelerate the completion of tasks.

In the past, the redlined as-built plans were submitted to the Finals Unit upon project completion. The Finals Unit staff would then draw the new plans using computer-aided drafting and design (CADD) software, plot, and submit to the RE for approval and signature before archiving. This multi-step process was tedious and time consuming, taking up to 6 months or more. The new system reduced the *Finals* process to 1 month or less. It eliminated the need for field staff to wait until project completion to redline the as-let plan sheets, and it reduced the time needed for the Finals Technician to update the drawings using CADD and complete the as-built plan sheets.

VTrans is working with the vendor to improve the process. The software is fairly easy to use and allows for real-time collaboration. As-built plans document any changes to project pay items and are approved and signed by the RE before being archived for maintenance use. The VTrans maintenance staff update the records every time they perform improvement activities.

VTrans plans to continue innovating with e-Construction and fine-tuning what has been implemented to date. The agency plans to add functionality as needed, improve the document management system, and pilot e-ticketing soon. Figure 2 provides a timeline of the e-Construction initiatives at VTrans.
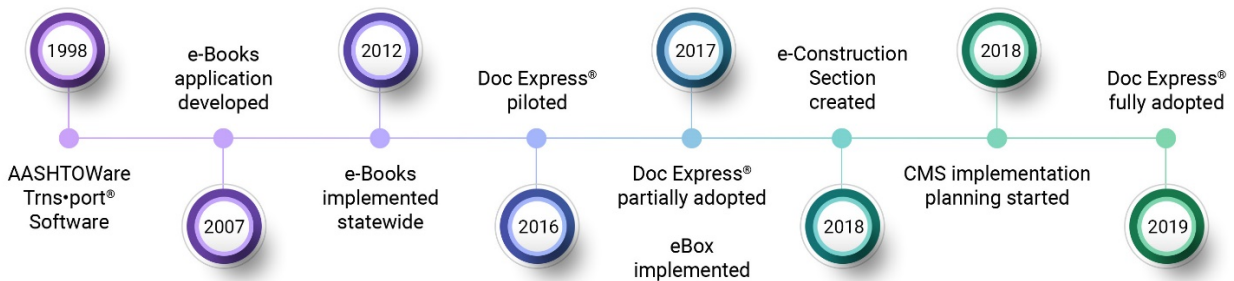
Figure 2. Timeline. VTrans e-Construction initiatives.

ALDOT Implementation Approach

e-Construction Strategy and History

ALDOT's workload has steadily increased since 2016, but the available workforce has decreased. Construction staff are difficult to recruit and retain. Thus, the main driver for e-Construction as a high-priority initiative is to increase workforce utilization and identify tasks to eliminate that add little to no value to the construction inspection process.

ALDOT began its first e-Construction initiative in 2014 when planning to replace AASHTOWare® SiteManager™. Ultimately, ALDOT decided to develop a custom CMS called the Construction and Materials Management System (CAMMS).

In late 2016, the agency created an e-Construction Engineer position within its Construction Bureau to accelerate the advancement of digital solutions. The e-Construction Engineer is responsible for oversight of all e-Construction initiatives, including investigating solutions and making recommendations for prioritizing activities.

ALDOT has identified the following e-Construction initiatives:

- Mobile devices.
- Electronic plans.
- Electronic forms.
- e-Signatures and document management.
- Document submittals, workflows, and retention.
- e-Ticketing.
- e-Construction systems coordination.

- Unmanned aircraft systems (UAS) for construction inspection.
- Radio-frequency identification (RFID) / bar codes for materials.
- Three-dimensional (3D) modeling for design and construction.
- Construction inspection with UAS.
- Construction manual and standard specification updates.
- Contractor education and integration into ALDOT's CAMMS.

ALDOT has spent the last several years developing and transitioning to CAMMS. The system's development was managed and performed with internal Information

Technology (IT) resources. The agency hosts the data inside its firewall. Construction staff have a positive relationship with the IT group, which is centralized within the agency.

ALDOT's Office of Information Technology has approximately 200 staff, whose responsibilities include telecommunications, programming for business systems, quality assurance, computer services, and integrating systems. The agency also has key staff dedicated to support construction for IT solutions.

Construction and Materials Management System

ALDOT started investigating a new CMS solution in 2014. After deciding to create a custom application with agency IT resources, the plan was set in motion. The first pilots of the system were conducted in 2015, with full statewide implementation in June 2018. All desired project data was transferred from the SiteManager™ software to CAMMS. ALDOT decommissioned its SiteManager™ system in July 2018.

CAMMS is the single source of truth for all construction records—a one-stop shop that hosts all construction documentation. All contract information is pulled from the financial systems or other source data systems to eliminate duplicate entry.

CAMMS supports all construction administration, including contracts and reference documents, certifications, subordinates, worker assignments, change orders, equipment documentation, material items, item lists, item mix IDs, standards, vendors, concrete placement and testing reports, contract samples, daily work reports (DWR), daily item quantities, diary field books, estimates, and forecasts. The system uses active directory credentials for users inside the ALDOT network, but assigns a login and password to external users.

CAMMS accelerates the estimate submittal process. Examples of the system's functionality include:

- **Daily Item Quantities:** Allows the project manager to review daily pay item quantities and accept, reject, or deny.
- **Daily Summary:** Combines the DWR for project manager approval each day.
- **Estimates:** Summarizes what has been approved and not approved. Line item adjustments were set up similar to the old system.
- **Contract Payment Summary:** Shows the contractor a report of the state of estimates.
- **Documents:** Stores reference information, such as special provisions, and scanned copies of plan sets.
- **Field Book Summary:** Provides the project manager with a one-stop shop for needed actions.

The next step to implement CAMMS is to integrate contractors, so ALDOT is performing testing protocols for external access. Force Accounts remain paper based. CAMMS is

an ongoing effort for ALDOT and is regularly being updated with new enhancements, features, and updates.

Though ALDOT has made significant strides in its e-Construction practices, the agency does not yet have a solution for document management. The peer exchange served as a collaborative session with VTrans on its successful deployment of Doc Express®.

Other e-Construction efforts by ALDOT include:

- Working with the Design Bureau to develop PDF vector plans and evaluate mobile applications to access plan sets using iPad® mobile digital devices.
- Using FHWA STIC Incentive Program funds to hire a consulting firm to help update its construction manual.
- Working on system coordination to implement bar codes / RFID for material tracking.
- Collaborating with its FHWA Division Office to find more opportunities for peer exchanges and innovation advancement using Technology Transfer (T2) funds.

Piloting e-Ticketing for Hot Mix Asphalt Materials

ALDOT began examining the use of e-ticketing for hot mix asphalt (HMA) projects in 2015. The agency's vision is to eliminate paper, leverage digital data, and improve quality and efficiency of paving operations, while increasing the safety of the field personnel collecting the tickets next to live traffic. Four pilots helped ALDOT validate the technology as a market-ready tool that will enable it to accomplish this vision.

The e-ticketing technology uses an electronic system to monitor, track, and report loads of HMA materials and a Global Positioning System (GPS) to track its fleet in real time. The software used by the materials plant to manage operations issues the paper tickets at the source. The e-ticketing system integrates with the plant software and GPS technology, making the information on the e-ticket available via a cloud-based environment to anyone with access. This enables field personnel to obtain information in real time via tablets, provided a cellular or Wi-Fi® connection is available. In that way, e-ticketing allows personnel to step away from heavy delivery trucks and live traffic.

e-Construction Benefits
• Improve field personnel safety.
• Track delivery trucks in real time.
• Verify material quantities in real time.
• Increase accessibility of information at all organizational levels.
• Expedite contractor payment.

ALDOT met with Iowa DOT construction leadership to better understand the technology and obtain lessons learned from the agency's pilots. ALDOT made light modifications to the Special Provisions provided by Iowa DOT. ALDOT started the e-ticketing pilots in 2017 and, at the time of the peer exchange, had conducted four so far. The agency

selects the pilots after an award has been made, as it is difficult to know before bids are received if the winning contractor will be knowledgeable enough for a successful pilot. Upon award, ALDOT works with the contractor to issue a change order to pay for the equipment and software to pilot the e-ticketing technology. ALDOT collects paper and electronic tickets concurrently during the pilots. Figure 3 illustrates a comparison between the two methods for collecting material tickets.
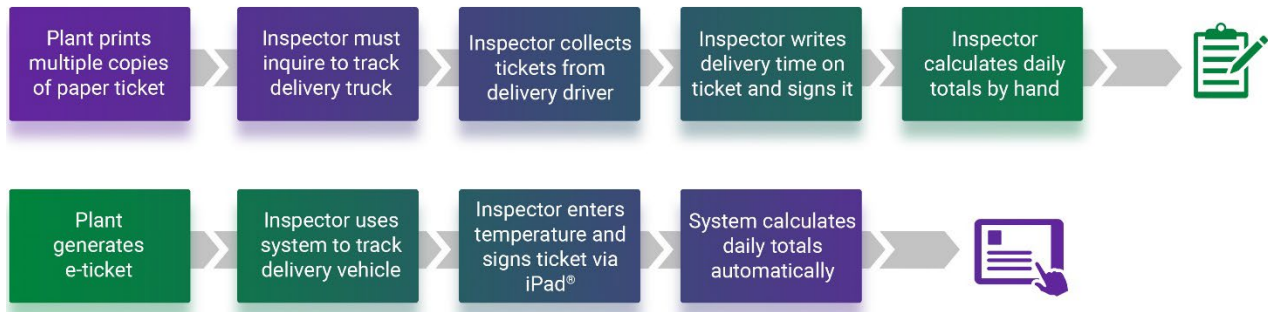

Figure 3. Infographic. Paper versus electronic material delivery tickets.

A large percentage of ALDOT's work is resurfacing projects, and e-ticketing has helped the agency manage the limited workforce to do more. Because the information is available in real time, an inspector can track the materials being delivered to multiple sites from a single location. Some challenges have yet to be resolved, for example, documenting asphalt temperature when it is delivered. Nevertheless, the technology is market ready, and all inspectors at ALDOT are now equipped with iPad® mobile digital devices (272 total statewide).

Partnering with Industry to Pilot e-Ticketing

The success of piloting e-ticketing on roadway projects is heavily dependent on the relationships the State DOTs have with their respective contracting communities. One of the lessons learned from ALDOT's visit with Iowa DOT was the importance of partnering with contractors to test e-ticketing technology. In Alabama, both parties have mutual interest in the technology, but for different reasons. Contractors are interested in the productivity of the trucks and their operation, as most of them contract the work to independent providers, while ALDOT wants the material information in a digital format. The e-ticketing portion is not important for the contractor's operation. Most contractors already own the software to manage plant operations, so, in general, e-ticketing will be easier to adopt when the State DOT is willing to absorb the cost of the solution.

ALDOT incurred the cost of the e-ticketing solution as a project cost on all pilot projects, but allowed the contractor to investigate multiple solutions that would integrate with its plant software. The solution selected for the pilots was Earthwave Technologies® Fleetwatcher™. ALDOT does not specify the software solution.

Although both ALDOT and contractors have been satisfied with the result of the pilots, remaining concerns they would like to have addressed before making e-ticketing a statewide requirement include the following:

- Information is stored on the mobile app for only 1 day, so inspectors must download information before it is no longer available.
- Each GPS unit is specific to each truck and must be returned at the end of the operation, if not returning to the project the next day.
- It is difficult to manage the GPS units when the independent trucker chooses to go home after delivering the material instead of going back to the plant to return the GPS unit. This only happens on projects far away from the plant.
- Accessibility to proprietary information on the contractor side is a concern. Contractors do not want others to see their productivity reports or other information that gives them a competitive advantage.

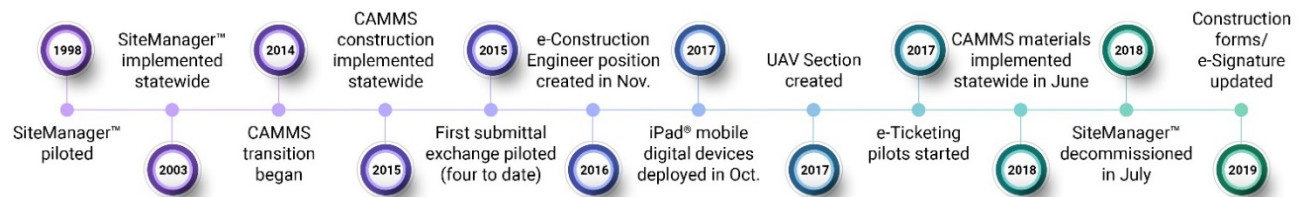A summary of ALDOT's efforts is illustrated in figure 4.

Figure 4. Timeline. ALDOT e-Construction initiatives.

Cost and Benefits

While no benefits have been quantified, both ALDOT and VTrans shared the cost of implementation of their e-Construction solutions.

ALDOT used internal resources to develop CAMMS and did not estimate cost associated with the hours spent by staff to plan, develop, test, or train field personnel on using the system.

ALDOT's e-ticketing solution vendor, Earthwave Technologies® offered two pricing models, although this may change in the future:

- Lower cost option per GPS unit per month with a 3-year agreement.
- Higher cost option per GPS unit per month with a 3-month agreement.

ALDOT documents the cost of e-ticketing as a pay item, and thus it may be reimbursable by FHWA on projects receiving Federal aid. As of the writing of this case study, pilots are still underway and cost has not been calculated yet.

In addition, ALDOT invested State funds to purchase mobile devices for the entire inspection workforce and invested internal resource time to implement CAMMS. The

iPad® mobile digital devices (with protective cases) were selected for inspectors and deployed to 272 staff statewide. In addition, each iPad® device has a monthly data plan.

VTrans used a combination of State and STIC funds to pilot its various e-Construction initiatives. VTrans negotiated an annual fee for its Doc Express® use for up to 200 contracts. Similar to ALDOT, iPad® mobile digital devices (including accessories and a monthly data plan) were selected for 40 staff statewide. Bluebeam® Revu® was selected as the document markup solution and deployed as a desktop client application and as a mobile application for the iPad® devices. VTrans negotiated a per desktop license (up to 50 computers statewide). The mobile application is purchased by each iPad® user for a fixed fee.

VTrans is also investing in its new CMS, iPDWeb™. The agency expects the main benefit of this CMS will be a single source of interaction for its construction data and information.

Key Takeaways

Participants offered the following recommendations:

Define expectations for systems development. When developing new systems, it is important to define the scope of the specific desired functionality. Having well-defined systems requirements will make negotiation with a consultant much more effective.

Prioritize the type of data to be collected. It is easy to collect all information available, but it is important to understand why it is being collected. Who will use the information? Which stakeholders will have access to it? Will it be usable by others in the form in which it is collected? As the saying goes, "just because you can, doesn't mean you should."

Consider collaborative development methods. It is important for SMEs to meet with developers often to test functionality incrementally and communicate needed improvements. Weekly meetings to discuss updates and improvements to the system helped ALDOT tremendously.

Collaborate often with stakeholders. Whether it is agency field personnel, consultants, or contractors, make sure there is a clear communication plan so everyone is on the same page. Industry is ready to innovate if they are involved from the beginning and are part of the team.

Invest in the right resources. Assuming staff can take on additional duties to oversee e-Construction sets false expectations and can create frustration when results do not happen quickly. Both ALDOT and VTrans have invested in dedicated resources to oversee e-Construction. The e-Construction Lead or Manager is responsible for prioritizing and keeping the momentum of the initiatives. However, they do not work in isolation. Having both an executive and technical champion will help accelerate adoption.

Establish standards. Data is produced and consumed by different stakeholders, but everyone needs a specific set of information. Spend the extra effort to establish clear standards for document management and data collection. This will make it easier for field users to adopt new practices, and for contractors and vendors to provide exactly what is desired.

Create performance-based specifications. When developing data requirements that are specific to individual software packages, ensure the requirements are not too prescriptive.

Determine acceptable deliverables for FHWA. As each agency transitions into digital processes, it is important to revisit what is considered the source document, and what FHWA will accept as the new standard.

Create proper training and be patient. Paperless processes are transforming the way field staff conduct their tasks; they may be apprehensive about taking on something new. By providing clear guidance and training, and expressing that help is available, field staff will be more successful in adopting new technology and processes. Also, it is important to rethink the way training is conducted. On-demand training is most effective because people will use the information learned right away. Also, training must be a priority for the organization, as many staff feel they are too busy to attend.

Continue engaging with peers. Both agencies learned much from each other and were encouraged to see each other's progress. Reach out to peer States and FHWA to connect with others and continue sharing information.

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

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