

Technology Brief



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



Peer-to-Peer Exchange

*Kentucky Transportation Cabinet,
Missouri and Oregon Departments of
Transportation, and Purdue University*

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Table of Contents

Background 1

Project Approach..... 2

Workflow 4

Cost and Benefits..... 6

Key Takeaways and Effective Practices..... 7

Background

The Kentucky Transportation Cabinet (KYTC) has implemented several technologies to support e-Construction and partnering initiatives to date, and KYTC staff requested to participate in a 2-day, face-to-face peer exchange with staff from the Missouri Department of Transportation (MoDOT), Oregon Department of Transportation (ODOT), and Purdue University to explore other effective practices and initiative improvement options.

The peer exchange, sponsored by the Federal Highway Administration (FHWA) as part of the fourth round of the Every Day Counts (EDC-4) e-Construction and Partnering (eCP) technical assistance program, was hosted by KYTC on July 17–18, 2018. A delegation of two MoDOT representatives, one ODOT representative, and one Purdue University representative traveled to Frankfort, KY, to meet with several KYTC representatives. FHWA staff from the Kentucky Division and the Resource Center were also present. The peer exchange focused on effective practices specific to improving data/information flow through document management systems (including external access), electronic as-built plan-sheet markups, and risk-based construction inspection.

KYTC staff recognize their agency will continue to be challenged with meeting its transportation program performance requirements and expectations with fewer resources. Staffing levels have decreased significantly, but the duties to meet State and Federal requirements have not changed. KYTC is already using technology to help fulfill its mission. The agency’s goal for this peer exchange was to validate the direction of e-Construction efforts currently underway and to understand any gaps in their trajectory.

Representatives from MoDOT and ODOT also shared their vision for continuing to adopt paperless practices during the project delivery process. The e-Construction programs and applications used by each of these States are summarized in table 1.

Table 1. KYTC, ODOT, and MoDOT e-Construction practices.

e-Construction Application	Technology Used by KYTC	Technology Used by ODOT	Technology Used by MoDOT
Advertisement and bidding	Bid Express®	Bid Express®	Bid Express®
Document management	Bentley® ProjectWise®	Doc Express® and Bentley® ProjectWise®	Microsoft® SharePoint®
Devices for accessing various systems	Apple® iPad® with Mobile Inspector® or Dell® tablets with Citrix®	Apple® iPad®	Laptops or Windows®-based tablets
Change order processing	AASHTOWare® ¹ Project SiteManager™ and AgilePoint®	Form-based	AASHTOWare® Project SiteManager™

As-built drawings	Bluebeam® Revu®	Adobe® Acrobat® DC	Adobe® Acrobat® DC and Bluebeam® Revu®
Other notable technologies	Collector for ArcGIS® ²	Apple® iPad® with Adobe® dynamic forms	CRE2O ³

¹AASHTOWare® is a product of the American Association of State Highway and Transportation Officials (AASHTO).

²Collector for ArcGIS® is a Geographic Information System (GIS) product of ESRI®. KYTC uses it for checking compliance with the Americans with Disabilities Act.

³Contractor Reporting Excel2Oracle (CRE2O) is a software tool developed by MoDOT for converting Microsoft® Excel® -based inputs from contractors and staff into data that is imported into an Oracle® database.

Project Approach

Participants were in consensus that being able to leverage technology to manage workforce utilization is one key factor driving the adoption of e-Construction. Other drivers mentioned included having a secure and single collaborative source of truth for digital documents and information, improving turnaround times for document approval, and increasing transparency and stakeholder collaboration. However, each State has different implementation plans based on unique situations within their organization.

KYTC has already implemented many e-Construction practices. The agency started its e-Construction program in 2009 with the deployment of a digital plans room that allows contractors to have access to electronic plan sheets and contract documents prior to the letting. This was followed by the implementation of electronic bidding in 2010. As an AASHTOWare® Project software owner, KYTC has been practicing e-Construction management, and in 2015 the agency started piloting the use of iPad® devices and Dell® tablets to access SiteManager™ directly from the field. Today, KYTC has approximately 300 inspectors using Mobile Inspector® on iPad® devices to access SiteManager™, although some field staff prefer to use Dell® tablets with Citrix®. However, this is not where the e-Construction efforts end. KYTC has several initiatives underway to keep progressing and improving the use of digital data, including:

- Updates to document storage platforms to allow better data flow and accessibility to internal and external partners (e.g., contractors and consultants).
- Evaluation of technology to improve inspection of materials properties and delivery, such as e-ticketing, infrared scanning, and intelligent compaction.
- Implementation of an in-house developed electronic workflow for approving contract documents and change orders.
- Deployment of a geographic information system (GIS) application to collect information for as-built ramps, sidewalks, and crosswalks to inventory and assess compliance with Americans with Disabilities Act (ADA) requirements.
- Investigation of effective practices to document as-built conditions.

Similarly, MoDOT started their evolution with e-Construction in the mid-2000s by implementing electronic bidding, providing access to electronic plan sheets, and hosting

an online plans room. Also, as a longtime AASHTOWare® Project user, MoDOT relies on SiteManager™ for all its construction management practices.

In 2007, MoDOT collaborated with industry to pilot quality management (QM) on designbuild projects. QM is a process for giving the contractor the primary role and responsibility for incorporating quality into the project. MoDOT instituted a statewide QM policy in 2013 that led to the development of additional e-Construction tools and practices, such as the CRE2O application.

In 2014, MoDOT made SharePoint® its official statewide document management system, and in 2016 a team was formed to plan the implementation of a centralized project documentation site. This new electronic document management system would house all documents related to project delivery, from conception to closeout.

On the other hand, ODOT contract administration had, until recently, been heavily dependent on paper-based processes. However, ODOT did start using Bid Express® for e-bidding in 2005 and started using their own electronic bidding information distribution system (e-BIDS) five years later in 2010 for distributing bidding plans, specifications, and technical reference documents. The deployment of e-bidding and e-BIDS enabled ODOT to set up of workflows and digital signatures and deploy mobile devices for field personnel. ODOT started piloting Doc Express® in 2017 and implemented in 2018. Local agency projects awarded after January 1, 2019 are required to use Doc Express®. By the end of 2019, ODOT plans to implement AASHTOWare® Project Construction and Materials™ and other software packages to augment their e-Construction Program. ODOT indicated that the deployment of the AASHTOWare® software suite will simplify data exchange by reducing the burden of multiple databases.

Purdue University is in the final stages of a research project sponsored by Indiana Department of Transportation (INDOT) related to risk-based inspection. INDOT, like many other agencies, is struggling to keep up with the construction inspection of their increasing construction program due to lack of resources. INDOT is suffering a shortage in experience because of retirements, competition for recruitment and retention of employees seeking employment in the private sector. The objective of the research is to create a risk-based inspection guide that contains specific instructions for inspectors to know what, when, and how to inspect the contractor's work. The outcomes of this research include a list of 90 critical items with quantified risk, a checklist that connects the inspection activity to the check/pay item (aligned with the specifications), guidance on frequency/duration of inspection activities, integration of risk-based inspection processes into INDOT e-construction initiatives, and spurred development of a modelbased inspection application.

The peer exchange participants engaged in dialog regarding risk-based inspection and expressed interest in understanding how miscellaneous pay items would be handled in the inspection application, but researchers have not looked at those yet. Another question posed was whether or not the inspection application differentiates between

two different activities and indicates which activities the inspector should inspect. It was noted that the application differentiates activities using a risk assessment¹ that informs the inspector so they can prioritize. Lastly, a question was posed about evolving the research to items such as the relationship of risk-based inspection to BIM, data linkages, and GPS. It was noted that collecting GPS coordinates of tests, locations, and condition of assets to supplement the asset management would be valuable.

Workflow

KYTC’s electronic change order process using AgilePoint® is illustrated in figure 1. AgilePoint® is an application Platform as a Service (PaaS) that allows creation of custom functions and interfaces to interact with legacy systems. KYTC has used this service to create a workflow to take change orders started in SiteManager™ and route the documents for review and approval tasks via e-mail notifications. The 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. 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.

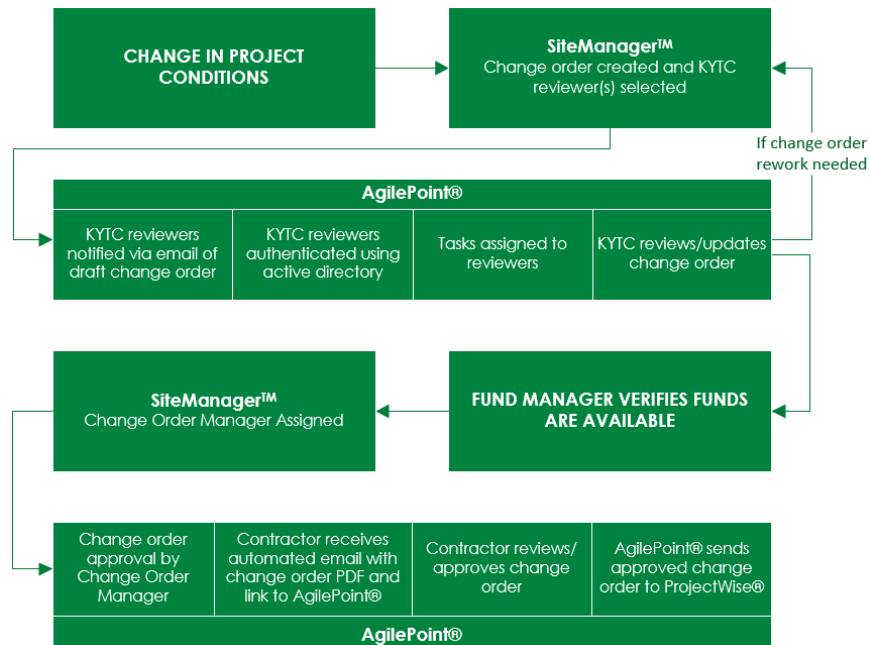
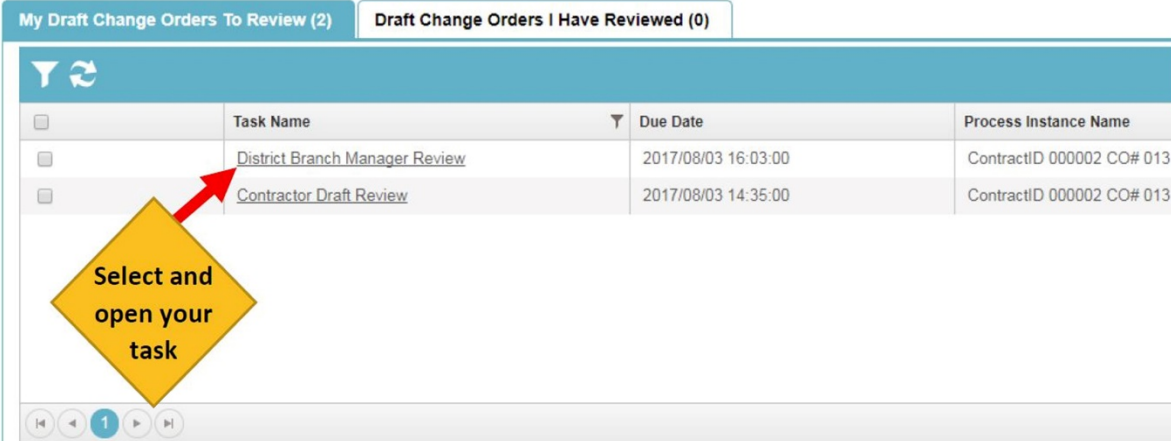


Figure 1. Flowchart. KYTC electronic change order workflow.

¹ Likelihood of not meeting the requirements and the severity of the consequences for not meeting the requirements in terms of safety, quality, time and cost.

As illustrated in figure 3, reviewers can keep track of change orders pending review as well as those already reviewed. KYTC is in the early stages of transitioning to AASHTOWare® Project Construction and Materials™ (implementation target is 2020), and there is uncertainty as to how AgilePoint® will be used and/or integrated with the new Project platform.

My Draft Change Orders



	Task Name	Due Date	Process Instance Name
<input type="checkbox"/>	District Branch Manager Review	2017/08/03 16:03:00	ContractID 000002 CO# 013
<input type="checkbox"/>	Contractor Draft Review	2017/08/03 14:35:00	ContractID 000002 CO# 013

Source: KYTC

Figure 2. Screenshot. The KYTC change order application user interface offers the option to start a change order review task or see previously reviewed change orders.

ODOT's objective for deploying Doc Express® was to implement an electronic document exchange service that would provide a secure digital filing cabinet for documents and allow easy-to-use collaboration and accessibility. It is important to note that Doc Express® is a Software as a Service (SaaS), which requires an organization to allow the use of cloud-based services. Also, Doc Express® is a Web-based digital filing cabinet that allows management of contracting documents. So, it cannot mine data, but it allows contracting partners access to a workflow to submit, review, comment on, approve, and digitally sign documents.

MoDOT's implementation of the SharePoint®-based e-Projects system was driven by a request from the agency's executive management to help manage all documents for project delivery, including post-award construction documents and routing of transmittals. Construction contracts are all electronic and signed using DocuSign®, but post-award construction documents and transmittals are signed using Adobe® Sign. e-Projects had to be implemented in 18 months and needed to provide document storage from "cradle to grave." System requirements included the following:

- Use of document sets, metadata, and templates to assign content type.
- Versioning to avoid losing information accidentally.
- Auto-populations from other legacy systems to avoid duplicate entry.
- Use of one location to store all statewide project documents.
- Easy navigation.

One mandatory key requirement from the MoDOT executive team was to avoid duplication of entry. Therefore, the implementation team worked with their information technology group to pull as much information as possible from the State Information Management System (SIMS) to populate the metadata for each project within the e-Projects system. Examples of the metadata pulled from SIMS include route name, county, and district; project description, contract ID, and award date; and the names of the project manager and resident engineer assigned to the project.

The system, which currently stores 2,111 projects containing 221,000 documents, connects with Microsoft® Outlook® via a plug-in called harmon.ie®. The harmon.ie® application is a collaboration tool that makes it easier for MoDOT staff to interact (access, save, search, and link) with e-Project documents through Outlook® by leveraging e-Project metadata. Documents can be saved directly from an email to the site, and documents can be searched directly through the Outlook® window to attach to an email.

The e-Project system resides behind the MoDOT firewall so that it can be used to store sensitive documents. However, a separate SharePoint-based system was created to allow external collaboration with contractors. In addition, MoDOT's CRE2O tool permits contractors to submit documentation for quality control (QC) materials tests for aggregates, asphalt surfaces, culvert performance, earthwork, miscellaneous concrete, non-Superpave asphalt, and tensile strength ratio. CRE2O is not a single program, but rather a number of macro-enabled spreadsheet forms that allow contractors to submit testing information directly into MoDOT's SiteManager™ Oracle® database. The data are automatically retrieved every two hours. The inspector accesses the Oracle® server directly using the SiteManager™ software to review all reporting as part of the QA process.

Cost and Benefits

KYTC staff noted that there has not been any formal initiative to document savings from implementing e-Construction improvements; however, they are looking closely at the time savings resulting from implementing an electronic change order approval application.

ODOT staff noted that the cost for using Doc Express® was \$50 per month, per project. The agency estimates how long each project will last and adds a 6-month contingency. Before the implementation of Doc Express®, ODOT made it a priority to close-out projects within 160 days to minimize the cost of the solution. Pilot projects started in December 2017, and the system was institutionalized in February 2018. ODOT currently has 50 projects in Doc Express®.

Doc Express® training costs included required training for internal and external users (1 hour from InfoTech® staff and 1 hour from ODOT staff) and consultant training material development by InfoTech.

Aligning with ODOT's vision for e-Construction focused on developing and managing digital data throughout project delivery, ODOT emphasizes an integrated approach using 3D design; mobile lidar for design surveys, asset inspection and inventory, and bridge clearances; inspection positioning tools, AMG for grading, paving, and milling; digital as-builts; and intelligent compaction. ODOT staff noted that they had very little data to quantify return on investment due to the early stage deployment of e-Construction improvements, but they are working on ways to identify quantifiable benefits, such as reductions in paper and ink costs and reduced turnaround times for document approval. They said the biggest benefits so far are being able to spend more time on inspection tasks rather than on chasing paperwork, as well as improved communication capabilities among ODOT units and contractors. e-Construction enhances partnering within the organization and with contractors and allows for transparency. ODOT is committed to work with industry as one team to find solutions to common problems and improve processes.

MoDOT did not incur any direct costs for purchasing SharePoint®, as the State already owned an enterprise license for the software and leveraged it for the e-Projects. However, internal staff from the Information Systems Division and all the e-Projects team members spent significant effort in deploying the tool. The cost of this effort was not captured and is therefore not available.

MoDOT construction staff used MicroStation® to do final plan as-builts, but when MoDOT reduced staffing levels, it was decided to change this process to markup PDFs that were already being delivered. MoDOT started piloting Bluebeam® Revu® in 2016 as a potential solution for marking up PDFs. MoDOT has now adopted Bluebeam® Revu® for final as-built markups, but some users still prefer to use MicroStation®. MoDOT staff also reported that Bluebeam® Revu® has three options depending on the level of functionality. Basic mark-up functionality costs \$140 per license plus \$25 per license subscription for annual maintenance and technical support.

It was noted that a DOT may be able to charge indirect technology usage costs to a federally funded project for reimbursement, and that States should work with their FHWA division offices to discuss what can and cannot be charged to a project.

Key Takeaways and Effective Practices

All peer exchange participants agreed that while each State has unique situations, being able to leverage digital data collected during construction for future applications is extremely valuable. The consensus among the group was that one key success factor is having executive support from the very beginning, as it enables the path to investigate solutions and create teams with strong technical champions. Also, a firm vision for e-Construction is paramount—strategies and objectives can change as conditions change, but they should always support the vision. Other lessons learned that were shared included the following:

- Mapping current processes helps in identifying added value and function requirements.
- Collaborating with all stakeholders during the early stages of any e-Construction initiative provides a mechanism for understanding both technical and institutional challenges and opportunities for successful implementation.
- Communicating the status of change initiatives informs stakeholders, making them active participants, and is thus critical for obtaining buy-in.
- Standardizing wherever possible increases ease of use and system functionality.
- Limiting customization saves on cost, so defining incremental improvements may be more appropriate than full customization out of the box.
- Understanding that there may be a steep learning curve for certain stakeholders minimizes unrealistic expectations and helps set reasonable timelines for full adoption.
- Providing technical support in the form of training and reference material and updating specifications and manuals increases the rate of acceptance and adoption.
- Piloting technology prior to full implementation allows issues to be identified and resolved before full deployment.
- Requesting feedback facilitates system improvements from which everyone benefits.
- Platform-as-a-service (PaaS) computing services (i.e. AgilePoint®) are an effective way to develop a sufficient level of customization of systems and interfaces that support e-Construction efforts. The platform (environment in which the application is run) is provided as a means to simplify the programming and infrastructure demands, which further empowers organizations with the ability to develop, run, and manage applications with limited software development resources.
- Document management systems may impose file size restrictions that require additional mechanisms for transmitting data. For example, MoDOT's e-Project system restricts data transfer of files over 2-gigabytes in size, so they use Microsoft® OneDrive® to share these files instead.
- Using a third-party digital plan room may enable cost savings, staff time, and paper costs.
- Leveraging mobile applications for field inspections of assets (e.g. sidewalks, retaining walls, lighting, etc.) reduces costs associated with forms and paper trails.
- Rebranding and improving the interface of COTS systems (e.g. MoDOT's e-Project system) helps minimize negative bias towards applications and systems.
- Leveraging small plug-ins such as harmon.ie® with COTS e-Construction solutions improves the user experience, which increases acceptance and buy-in.

Additionally, thoughtful investments made early are valuable for any future initiatives, because waiting for the right solution will prohibit incremental advancements. It is

important to evolve with technology and define implementation plans to meet the vision and to become creative in recruiting staff with the necessary skill sets to implement and deploy technology. One strategy for building technical teams to help with implementation may be to identify tech-savvy employees and offer them the opportunity to be an active participant in moving the organization forward.

Lastly, e-Construction provides an opportunity to capture processes and document effective practices, helping to minimize the loss of institutional knowledge due to retirements and eliminate single points of failure.

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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