

Technology Brief



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



Peer-to-Peer Exchange

Virginia and Pennsylvania Departments of Transportation

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

Background

The Virginia Department of Transportation (VDOT) recently renewed its focus on e-Construction activities by dedicating several staff to assessing construction management solutions, mobile device/application use in the field, and other notable e-Construction practices. VDOT's first attempt to deploy e-Construction involved custom development of an enterprise solution. However, that effort proved to be much more complex than anticipated. Now, VDOT's e-Construction strategy is focused on adopting a mobile commercial-off-the-shelf (COTS) application.

With a new strategy in hand, VDOT invested in a research project to pilot a COTS mobile application solution with functionality that allows field staff to document project site activities, access electronic plans, and collaborate with stakeholders. To gain insight on successful strategies to pilot and deploy mobile technology, VDOT requested an in-person peer exchange with staff from the Pennsylvania Department of Transportation (PennDOT).

PennDOT hosted the 2-day peer-to-peer exchange on December 4–5, 2018, in Pittsburgh, PA. 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 representatives from VDOT and PennDOT, staff from FHWA's Virginia Division and the Resource Center attended. PennDOT shared the history of its e-Construction program and strategies for gaining support to invest in mobile technology.

Table 1 showcases different e-Construction technologies at each DOT.

Table 1. e-Construction technologies at participant DOTs.

Technology Category	VDOT	PennDOT
Construction Management System	AASHTOWare® SiteManager™	Engineering and Construction Management System (ECMS) ¹ Construction Documentation System (CDSv3)
Document Management System	Cadac Organice Suite ² Microsoft® SharePoint® Paper	PennDOT Project Collaboration Center (PPCC) ²
Materials Management System	Paper and Spreadsheets	Electronic Construction and Materials Management System (eCAMMS) ³
Mobile Applications	PlanGrid® ³ HeadLight® ³	MC Docs ⁴ App ¹ (accesses PPCC documents) Project Site Activity (PSA) App ¹ Punchlist App ¹ Concrete Inspectors Diary (CID) App ¹ Force Account App ¹ Erosion and Sediment Visual Site Inspection (E&S VI) App ¹ GeoSnap App ¹ Material Sample ID App ¹ Maintenance and Protection of Traffic (MPT) App ¹
Mobile Devices	Apple® iPad® PlanGrid® (pilot project only)	Apple® iPad®

¹ custom-developed

² Microsoft® SharePoint®-based

³ piloting

⁴ MC = mobile construction

VDOT e-Construction Approach

Strategy and History

VDOT implemented e-bidding and advertising in 2001, becoming one of the first States to do so. The agency employed e-Construction practices for the pre-construction phase, but challenges with funding and stakeholder support led to delays with e-Construction plans for the construction and post-construction phases. In 2018, the agency established a small team to oversee all e-Construction initiatives. The strategy is to prioritize activities to evaluate best value efforts for potential investment. Over the next 2–3 years, VDOT will focus on technology deployment efforts to improve inspection and testing, construction management, and acceptance and closeout. The timeline for these activities in the strategic plan is given in figure 1.

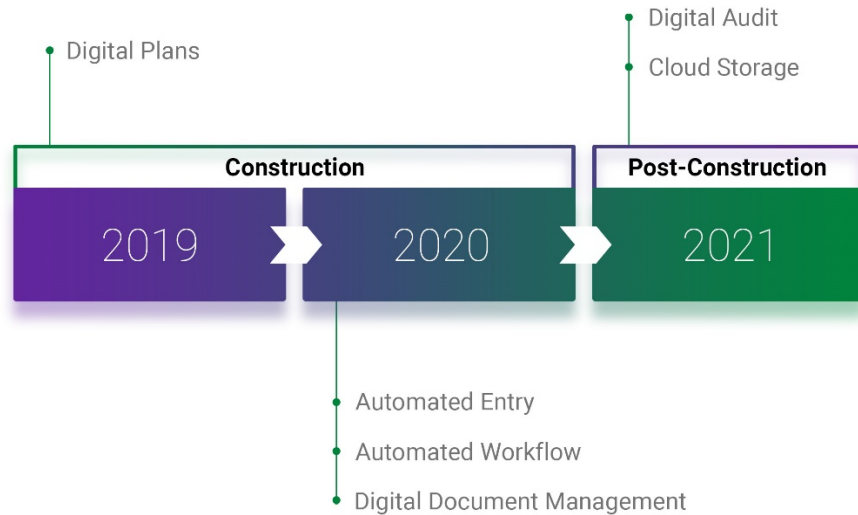


Figure 1. Timeline. VDOT's planned e-Construction activities from 2019–2021.

In 2012, VDOT hired a consultant to develop a Project Document Management System (PDMS) based on the SharePoint® 2010 platform. The initial vision included automated workflows for proposal creation, advertisement, and bid letting through contract award and execution. However, overly ambitious expectations and other challenges led to the termination of the information technology (IT) contract before the software development could be finished. VDOT is now looking at commercial off-the-shelf (COTS) software for all future solutions and not considering any custom-developed applications.

Although VDOT is no longer expecting a single, integrated solution to solve all its needs, the agency wants to ensure any solutions chosen are capable of integration so that inspectors do not have to access multiple disparate systems. The goal is to look deeper at one or two COTS systems that either already provide all the tools to address all (or most) agency needs or can be adapted to do so. VDOT recognizes that with COTS products, the agency will have to depend on the vendors when making major changes.

Current Efforts

VDOT is currently engaged in multiple e-Construction initiatives, specifically:

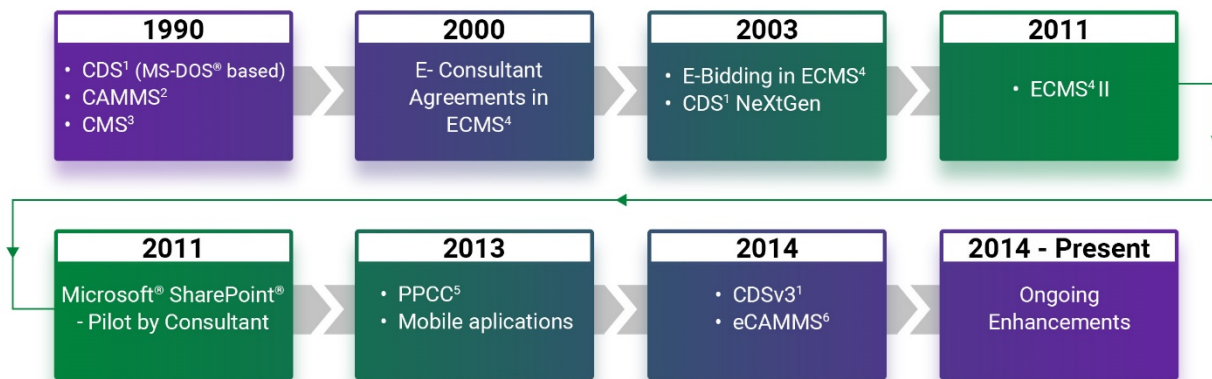
1. An 18-month pilot project to evaluate the PlanGrid® mobile application. The project, funded through the Virginia Transportation Research Council, started in 2018. This pilot project aligns with VDOT's plans to have digital plans and make better use of iPad® devices in 2020. VDOT has also explored HeadLight® and Mobile Inspector®, but has not decided which solution best fits its business needs.
2. Deployment of AASHTOWare® Project Construction & Materials™. As the agency transitions to this from SiteManager™, it is looking to other States that have fully implemented it to understand the process and challenges.

- In the future, VDOT wants to explore e-ticketing, unmanned aerial systems use, augmented reality, automated machine guidance, three-dimensional (3D) printing, and civil information modeling.

Other major focus areas of VDOT's e-Construction implementation strategy include conveying the value of e-Construction internally, leveraging 3D/4D modeling specifications to improve 3D model maturity, project planning and visualization, paperless and data-centric field inspection and testing, improved workflows for project construction management, post-construction document management and reporting/analytics, and capturing and applying lessons learned from previous and ongoing efforts.

PennDOT e-Construction Approach

PennDOT keeps its custom-developed systems separate because of complications that arise by having a single, integrated solution. The evolution of the Engineering and Construction Management System (ECMS) and other PennDOT systems is shown in figure 2.



¹ Construction Documentation System

² Construction and Materials Management System

³ Contract Management System

Figure 2. Timeline. PennDOT's system evolution.

Source: Graphic is based on information provided by PennDOT.

ECMS is a web-based system that covers actions from bidding through construction closeout. Embedded within the system are modules for e-bidding, estimates, contract documents, project site activity reports, work orders, time extensions, punch lists, closeout, consultant agreements, source of supply, etc. Access to both the system and approval workflows is role-based authentication and does not require any digital signatures. Each user (PennDOT, consultant, or contractor) is provided with certain permissions, depending on his or her role as defined in the system.

PennDOT Project Collaboration Center (PPCC) is a SharePoint[®]-based document management system. It tracks review time and benchmarks against established

durations, has dynamic multi-step/multi-reviewer workflows, and alerts reviewers through notifications at each step of the submittal process. Essentially, PPCC provides all team members online access to project-specific documents, contact information, and other useful resources to ensure collaborative interactions.

The Electronic Construction and Materials Management System (eCAMMS) is a materials management system to input and track key information about materials (samples, mix designs, etc.). To date, PennDOT has processed over 14,000 samples with more than 1,000 users of the system. PennDOT's concrete app sends data to eCAMMS, which reduces the amount of the plant inspector's handwritten notes. eCAMMS now includes the ability to respond to workflow deviations, for example when a material fails testing, a response is required explaining the failed test. Final material review through eCAMMS includes ensuring all materials paid for have source of supply and certification, which was formerly done through paper forms. eCAMMS also has a database of pre-approved materials, for which suppliers can apply through eCAMMS to be added. PennDOT wants to use eCAMMS to track performance and quality trends by material.

Mobile Applications

PennDOT's custom-developed mobile applications are developed by the agency's mobile computing team (both consultants and internal staff), which supports several business areas including construction and driver licensing. PennDOT entered into an agreement with Apple® to host its applications on the company's business-to-business (B2B) program, which makes the applications available to PennDOT consultants free of charge as long as the consultants are part of the B2B program as well. Given that the applications are Apple® iOS®-based, PennDOT is subject to iOS® updates and has to validate/update applications accordingly.

The mobile applications are integrated with ECMS, PPCC, and eCAMMS to some extent, which improves efficiencies by reducing paper, reducing duplicate entry, and leveraging automated workflows. PennDOT is able to track and monitor system use and perform some data analysis to extract meaningful insights that help improve applications and service to stakeholders (internally and externally).

PennDOT's mobile computing team employs an agile method of development for its applications and ensures there is some improvement every four weeks, even if it is small. This agile approach, combined with a proactive mindset of engaging users and other stakeholders, has contributed to the success and growth of its mobile applications.

PennDOT's PPCC system is used for submittals and exchanging documents between PennDOT and the contractor. PPCC is accessed by business partners using their ECMS credentials and accessed by PennDOT staffers using their Commonwealth of Pennsylvania credentials.

The submittal workflow (shown in figure 3) starts with the contractor accessing the system to initiate the submittal. Once the submittal is uploaded, it appears in a

designated reviewer's queue for review. The reviewer then adds approver notes, which are accessible by the contractor. If any changes are needed, the submittal must be downloaded in order to make them. Once the changes are made, the file is uploaded with the same file name, so the audit trail is maintained. The approval workflow indicates what actions have been taken, as well as the remaining actions required.

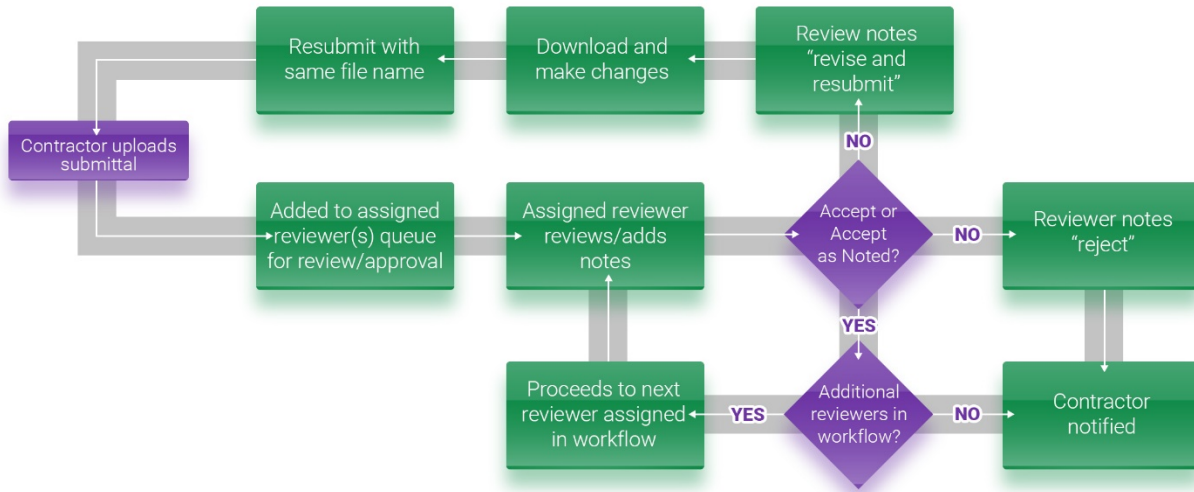


Figure 3. Flowchart. PennDOT PPCC submittal workflow.
Source: Graphic is based on information provided by PennDOT.

VDOT's pilot project for PlanGrid® started from a request from the field to look at the technology, as current paper-based documentation of project activities are cumbersome and inefficient. In order to validate the request from field staff, VDOT's e-Construction team develop the business case to obtain research funds for piloting PlanGrid®, with the objective of having digital plans available and completing reports both in the field. Business requirements for the pilot were for the application to capture field data, document project site activities, access digital plans, and allow collaboration between staff.

PlanGrid® was selected as the first COTS solution to pilot due to its intuitive interface, compliance with business needs, and key features such as issue tracking, collaboration capability, and photo/data capture. VDOT will evaluate the pilot project through user feedback, gathering benefit and cost information to determine efficiencies and comparing to other solutions. Also, continued engagement from the PlanGrid® team is planned through regular conference calls and feature requests. An example feature request that was implemented quickly was providing VDOT with the ability to do concurrent reviews of contractor submittals.

After the pilot is completed, VDOT IT staff will be involved in determining requirements for statewide implementation through the standard agency competitive procurement process.

Cost and Benefits

The initial costs of the pilot are summarized in table 2. PlanGrid® offers two types of subscriptions:

- Unlimited sheets, which costs \$1,200 per year, per device.
- A 5,000-sheet limit, which costs \$840 per year, per device.

For the pilot, VDOT selected the latter subscription because it is unlikely to go over the 5,000-sheet limit. The use of PlanGrid® may be reimbursable by FHWA, provided the charges for licenses are clearly related to construction engineering and inspection (CEI) on a specific project. A total of 40 iPads will be deployed as part of the pilot. The investment per device for the pilot project is shown in table 2.

Table 2. VDOT initial investment per device.

Item	Estimate
iPad®	\$450
iPad® data	\$51 per month
PlanGrid® license	\$70 per month

While VDOT has not conducted a benefit-cost analysis, it is expected that it will be an overall benefit both financially and operationally. Today, VDOT's annual expenditure for printing paper plans is approximately \$2 million, and construction staff must carry all the paper plans and reference materials in their vehicles. The process to access information is cumbersome and time consuming. Thus, having access to plans and documents in the field is invaluable. Going paperless is a high priority for VDOT. It is estimated that statewide implementation will equip approximately 350 VDOT staff with iPad® devices and a mobile platform that provides the same functionality of PlanGrid®.

During the EDC-4 summits in 2016, PennDOT showcased costs and benefits of its various systems (see table 3). The cost and benefit calculations included development costs, but not software maintenance. Additionally, the calculation looks at cost savings for things like driving around to get wet signatures from consultants (Mitchell & Lee, 2016).

Table 3. PennDOT cost/benefit analysis. Source: FHWA¹

System	Initiation Dates	Development Cost	Overall Savings
CDSv3/ECMS	August 2012	\$2.74 million	\$5 million/year
Mobile Applications	July 2012	\$1.67 million	\$28 million
PPCC	October 2011	\$5.2 million	\$29.1 million
eCAMMS	January 2012	\$6.9 million	Not available

¹ FHWA TechBrief: Addressing Challenges and Return on Investment (ROI) for Paperless Project Delivery (e-Construction) (Mitchell & Lee, 2016).

Key Takeaways

After learning about PennDOT's e-Construction implementation experiences, VDOT plans to finish gathering business requirements for each technology initiative, showcase how technology can be implemented, define long-term objectives for meeting business needs, and define a roadmap ensuring incremental and deliberate maturity.

VDOT is not in the same position PennDOT was in when starting the journey toward a custom-developed suite of applications, so it was recommended that VDOT start small with its technology deployment activities, but keep the desired end-state in mind to ensure progress is made in the right direction. Understanding the business requirements is paramount to not only ensure successful implementation and use, but also to set the foundation for a federated ecosystem of applications.

Undertaking a custom-development effort is a heavy lift for any agency. It requires substantial up-front planning, coordination, and stakeholder engagement throughout the process to be successful. The use of consultants is an effective way to manage costs and risks, but it is important to coordinate with IT and business units to help develop requirements that will be feasible. It is recommended to conduct the requirements gathering phase using an iterative approach. Frequent interactions with IT and business leads will generate a mutual understanding of expectations.

Sourcing and engaging champions throughout various levels of the organization (field to executive) is recommended for the deployment of a new technology, software, or tool. These champions serve as the ambassadors and advisors, helping to limit any barriers and navigate organizational ambiguity.

It was also recommended to consider the desired state for the e-Construction effort 5-10 years ahead and build small, foundational pieces along the way. This is much easier to manage and pivot if needed. Integrating any training needs and feedback mechanisms will strengthen the user base and result in higher usage by demonstrating a commitment to ensuring their proficiency as well as listening to their issues/challenges.

Regardless of whether a COTS or custom-developed solution is selected, engaging the various stakeholders is critical to a successful technology deployment. Solidifying relationships and nurturing a culture of innovation through education and targeted outreach will get end-users excited about the technology and entice them to use it. Equally important is to ensure there is a mechanism for soliciting and receiving feedback that contributes to improvements in not only functionality, but also the user experience.

Both VDOT and PennDOT agreed that bringing IT staff into the field to experience user-level processes and workflows is important when finding a solution for their needs. When IT understands the issues, challenges, and successes the users encounter, there is a better chance that the solution can become an enabler rather than a hindrance.

It was recommended that mobile devices are not provided to consultant staff. They can bring their own as it is a cost of doing business. Agency staff should be supplied with the mobile devices and let the districts/regions select peripheral accessories; however, establish rules to ensure there is consistency across districts/regions.

Another recommendation was to not get too complicated, too fast. Focus on consistency, simplicity, and intuitive processes/workflows. Also, procurement rules may dictate which commercial products can be purchased, even if it is the more expensive option.

Reference

Mitchell, A., & Lee, D. (2016). *TechBrief: Addressing Challenges and Return on Investment (ROI) for Paperless Project Delivery (e-Construction)*. Retrieved from <https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/16068/16068.pdf>.

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Contacts for More Information:

FHWA Office of Infrastructure, Chris Schneider — christopher.schneider@dot.gov

FHWA Resource Center, Kat Weisner — kathryn.weisner@dot.gov

FHWA e-Construction and Partnering innovation resources

<https://www.fhwa.dot.gov/construction/econstruction>

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Key Words — e-Construction, mobile devices, mobile applications, custom application development, document management system

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