

Tech Brief



U.S. Department of Transportation
Federal Highway Administration

FHWA-HIF-24-028

E-TICKETING

The sixth round of the Every Day Counts (EDC-6) initiative selected electronic ticketing (e-Ticketing) for rapid deployment among highway agencies to enhance work zone safety, improve quality, and realize cost savings through digitalization.

Highway construction projects generate massive amounts of valuable data that historically were communicated via paper. Paper tickets to track the delivery of materials at a construction site is one such source of data. The emergence of electronic technologies on highway construction projects has made the paper-based processes outdated, inefficient, and cumbersome. Highway agencies are integrating paper processes into electronic and digital workflows. Earlier rounds of EDC successfully promoted the deployment of e-Construction technologies.

E-Ticketing is a market-ready digital innovation that automates the recording and transfer of information and quantities in real-time, in lieu of paper tickets, as materials are moved from the plant to the site. E-Ticketing simplifies handling and integration of materials data into information systems for acceptance, payment, and source documentation. The overarching goal of the EDC-6 initiative is to facilitate the adoption of e-Ticketing by state and local highway agencies.

FHWA initiated peer-to-peer exchanges to deliver technical assistance to highway agencies exploring to implement e-Ticketing. The peer-to-peer exchanges provide opportunities for an exploring agency to learn from the experience of states that have successfully adopted e-Ticketing. The peer-to-peer exchanges facilitate interactions among participating agencies to share effective practices and address challenges and barriers relating to e-Ticketing implementation. The discussions focus on various critical success factors, including a business case, planning for pilots, field readiness, stakeholder engagement, data management, and specifications. The peer-to-peer exchange facilitates dialogue with stakeholders and decision-makers on the next steps of implementation.

ILLINOIS DEPARTMENT OF TRANSPORTATION E-TICKETING PEER EXCHANGE

EDC-6 PEER-TO-PEER EXCHANGES

INTRODUCTION

The Illinois Department of Transportation (IDOT) has been actively involved in e-Construction initiatives for more than six years. During this period, IDOT initially focused on electronic documentation related to construction and materials. The agency is now working on implementing an electronic payment system and transitioning toward a completely paperless approach in the management of construction projects. However, IDOT has identified several challenges it will need to overcome to achieve this objective. With its Construction & Materials Management System (CMMS) in place, IDOT aims to shift its focus to e-Ticketing to further progress toward its goals of paperless management.

IDOT was interested in e-ticketing prior to the COVID-19 pandemic but gained limited experience during that time as a result of varying issues, including staff turnover. IDOT supports e-Ticketing use, and the agency currently "softly" encourages its adoption by allowing contractors to use an e-Ticketing solution if desired. IDOT has conducted pilots and achieved some successes, but results have varied based on contractors' individual systems and practices. IDOT sought this peer exchange because the agency is eager to learn from other states' experiences and avoid potential pitfalls.

The Federal Highway Administration (FHWA) sponsored a day-and-a-half-long peer-to-peer exchange in Springfield, Illinois, on June 21 and 22, 2022. The meeting included representatives from FHWA, State Departments of Transportation (DOTs) that have successfully implemented e-Ticketing (i.e., the lead agencies), three subject matter experts from the EDC consultant team, and participants from IDOT and the local construction and material industries. The lead agencies included in-person attendance from Delaware (DelDOT), Iowa (IOWADOT), and Pennsylvania (PennDOT), with Nebraska (NDOT) and Virginia (VDOT) participating virtually. The local FHWA division office hosted and provided a meeting room. The meeting included presentations, panel discussions, question and answer sessions, and a participant survey.

IDOT'S E-TICKETING STATE OF THE PRACTICE

To date, contractors or suppliers have driven the initiation of e-Ticketing projects in Illinois. IDOT has not actively pushed for e-Ticketing adoption but has encouraged its use. The feedback received from IDOT field offices experiencing e-Ticketing has been positive, with a desire for further adoption. While IDOT's experience with e-Ticketing is still minimal, the agency is interested in pursuing an e-Ticketing solution with additional motivation from the Illinois Tollway's recent adoption of e-Ticketing, inquiries from various industry associations, and the desire for paperless processes.

IDOT's Vision for e-Ticketing

Provide an e-Ticketing solution that is inclusive, provides ample opportunities to small suppliers and disadvantaged businesses; provides a level of uniformity across Illinois; and works seamlessly with other IDOT systems in their desire to become a paperless.

In working toward this vision, IDOT is seeking the insights of other DOTs on establishing reasonable time frames for implementation, and for identifying potential FHWA funding sources and approaches, particularly for reimbursement on federal-aid highway projects. IDOT's e-Ticketing pilot projects have varied and have not provided opportunities for significant learning or progress for a variety of reasons. While IDOT does not anticipate specifying a specific e-Ticketing application, the agency wants to build uniformity among e-Ticketing approaches that may be used by its suppliers, contractors, and other agencies in the region, and is interested in an online portal system.

IDOT understands that e-Ticketing implementation affects a diverse set of stakeholders. The agency has strong relationships with its industry partners and holds a quarterly joint committee meeting with industry stakeholders and its FHWA division office. IDOT also has a policy committee where industry stakeholders meet with the IDOT Secretary and Executive Team.

However, IDOT faces several challenges to implementing e-Ticketing, as the agency moves away from DOS-based legacy systems and integrates data across multiple existing systems. In addition, specific challenges with IDOT's e-Ticketing objectives, such as connectivity and navigating strict Illinois procurement laws also need to be addressed. IDOT is looking to approaches of other DOTs to assist in navigating these challenges.

IDOT is interested in establishing e-Ticketing policies and guidance to ensure consistency with surrounding states. The agency also wants to foster a collaborative environment with contractors and material suppliers. Consistency with surrounding states benefits stakeholders across state lines as well as stakeholders internal to Illinois. IDOT's motivation for implementing e-Ticketing has increased as a result of the Illinois Tollway's recent implementation of e-Ticketing.

IDOT requested this peer-to-peer exchange to gather feedback from other state agencies regarding their approaches to e-Ticketing, particularly around addressing connectivity and procurement issues, developing specifications and guidance, and understanding technologies that could be used to support e-Ticketing. As part of its focus on e-Construction, IDOT has been updating some of its other legacy systems and is now sighting e-Ticketing as its next objective for statewide implementation.

SUMMARY OF LEAD AGENCY PRACTICES

Representatives from the five lead agencies—PennDOT, DeIDOT, IOWADOT, NDOT and VDOT—shared their e-Ticketing implementation experiences. Each agency used a slightly different approach as it adopted e-Construction and progressed toward digital project delivery.

PennDOT

PennDOT began its e-Ticketing pilots in 2017. The first phase of pilots included approximately a dozen projects within the Pittsburgh area of District 11 and required the submittal of Global Positioning System (GPS) truck location data. Following the six-week shutdown of construction operations caused by the COVID-19 pandemic, PennDOT assessed how e-Ticketing could be leveraged to assist with contactless construction management. The agency solicited feedback from various stakeholders (from material producers to field inspectors). Lessons learned from the earlier pilots led to key changes, including removing the GPS requirement and re-writing specifications.

Since its first pilot projects, PennDOT has expanded e-Ticketing to all districts and has completed more than 140 e-Ticketing projects. To facilitate the acceptance of vendor-supplied tickets, PennDOT developed its own in-house software solution. An internal information technology (IT) team created an application programming interface (API) to establish a seamless connection between suppliers and PennDOT's systems for ticket transmission. The data from these tickets are stored in PennDOT's material system Electronic Construction and Materials Management System (eCAMMS). PennDOT launched its e-Ticketing application in July 2021, the application is available for download through the Apple App store. Both PennDOT and consultant inspectors have access to this mobile application.

PennDOT also created three teams to assist with its e-Ticketing implementation—a specification team, an IT team, and a hauling team. In expanding PennDOT's construction specifications, the team added concrete, aggregate, maintenance materials, and limited or no service on construction sites. PennDOT also included a bid item for an “Electronic Ticketing System” to allow suppliers to recover costs. However, as the e-Ticketing program expanded, the bid prices for e-Ticketing rapidly came down to as low as \$1.00. PennDOT plans to make e-Ticketing incidental to the material delivered in 2024.

In December 2020, FHWA approved the 2020 PennDOT specification for use of e-Ticketing in statewide pilots in 2021. Throughout 2021, 33 pilots were conducted, with 3 projects per district using 1 material per project. PennDOT collected feedback on the pilots, and modified the specification. In 2022, a new modified specification was introduced, expanding the scope to include more pilots for carryover, new, and additional projects. As PennDOT progresses toward full implementation, it is targeting suppliers with limited PennDOT work, those facing network connectivity issues, additional costs for plant upgrades and outdated computers, and using a HaulHub contract to assist these suppliers in updating their data.

DeIDOT

DeIDOT originally planned to conduct a pilot of e-Ticketing in 2017, but was stymied by funding-related challenges, and the agency did not resume e-Ticketing implementation planning for three years. DeIDOT completed its first set of pilots on asphalt paving projects in summer 2021 and implemented the HaulHub web portal application to receive tickets electronically from material producers. DeIDOT connected many asphalt producers to the web application by 2021 and made e-Ticketing a requirement on all asphalt paving projects in spring 2022. DeIDOT concurrently began efforts to interface with suppliers of Portland cement concrete. During winter 2022–2023, additional ready-mix concrete suppliers were connected to the system. By spring 2023, the portal connection was fully operational. The agency has also been steadily expanding e-Ticketing to soils and aggregates. Currently, DeIDOT's portal has received approximately 24,000 e-Tickets for 50 projects for hot-mix asphalt, ready-mix concrete, and aggregate/soil.

Since the onset of implementation planning, DeIDOT decided not to make GPS truck location data a requirement for e-Ticketing. The agency was interested only in receiving the ticket data electronically without any consideration of the fleet management solutions that the contractors and material producers use.

DeIDOT engaged both internal and external stakeholders in planning its e-Ticketing implementation. The DeIDOT e-Ticketing team conducted ad hoc meetings with leadership. DeIDOT also held bi-monthly meetings with the Delaware Contractor's Association and ad hoc meetings with the Delaware Asphalt Pavement Association.

DeIDOT bears the primary costs associated with the e-Ticketing portal and individually approached each supplier to ensure their participation before going live. To facilitate the implementation, DeIDOT upgraded inspectors' phones to smartphones and developed a single application for inspector use. Senior management, primarily driven by the goal of improving safety, supported the implementation of these tools.

To ensure buy-in from field staff, DeIDOT conducts annual workshops and provides online videos. DeIDOT emphasized the importance of field staff support in the successful implementation of the e-Ticketing system. The agency also emphasized the need for buy-in and additional discussions with Materials/Lab personnel.

DeIDOT has made several advancements during e-Ticketing implementation. The agency has effectively integrated the DeIDOT Plant Inspector view into the HaulHub DOTSlip application, ensuring smooth access to crucial information. Furthermore, the agency has enabled a connection between the GPS location of DeIDOT field inspectors and the project station number, which is now included in the ticket for enhanced tracking capabilities. The DOTSlip application has also been enhanced to enable ticket data audit review.

DeIDOT is actively working on automating the creation of projects and assigning users through Oracle® Unifier™, the agency's cloud-based enterprise platform for construction management. It has rolled out an automated workflow for payment processing using digitalized tickets. The agency is also making advances in data gathering, auditing, and analysis by using the API with Oracle® Unifier™. Furthermore, DeIDOT is dedicated to improving its training process and used WhatFix, a digital adoption platform, to streamline user onboarding and provide support.

IOWADOT

IOWADOT conducted its first e-Ticketing pilot in 2015 with asphalt mixtures and its first concrete pilot in 2017. In 2020, with the onset of the COVID pandemic and the need for social distancing, the importance of e-Ticketing became even more evident. Since then, IOWADOT has scaled up significantly to complete hundreds of e-Ticketing projects with asphalt, aggregates, and

concrete. In 2021 and 2022, the agency completed about 186 e-Ticketing projects. IOWADOT added 25 different e-Ticketing vendors to its portal and deployed e-Ticketing to 200 contracts in 2023.

IOWADOT's practice has evolved with a revised developmental specification (DS-15095) for e-Ticketing. While IOWADOT had used the Command Alkon portal for piloting purposes, the agency engaged in a procurement process for a formal solution in late 2022 and early 2023 and implemented the HaulHub solution. Alongside the portal, IOWADOT has been exploring integration with other technologies such as OnStation and Google Earth to enhance the visualization and tracking of ticket data. The IOWADOT web portal receives e-Ticketing data via an API from authenticated suppliers—moving away from installing multiple vendor applications on the field inspectors' mobile devices to a single application and testing a technology-driven verification process.

NDOT

In its pilots, NDOT looked at the options of in-house development versus commercial-off-the-shelf solutions. After weighing the pros and cons of both options, NDOT decided to go with an in-house portal, which was modeled after Utah DOT's (UDOT) e-Ticketing solution. NDOT's primary focus was on ticket data, and the agency wanted consistency across its information systems and in how the staff would use these systems. The agency believed that choosing an in-house solution would provide opportunities for future expansion into other technologies and facilitate data sharing with stakeholders to gain industry support.

NDOT worked with the Associated General Contractors of Nebraska (AGC Nebraska) to establish a task force to collaborate in building its e-Ticketing solution. This group identified key elements to address with e-Ticketing, including cellular connectivity, data sharing and security, and GPS tracking.

NDOT held virtual meetings with UDOT to discuss the development of the e-Ticketing project. Challenges were identified, particularly regarding NDOT's increased use of mobile plants and potential connectivity issues. NDOT also conducted an interview with a vendor, Command Alkon (Connex).

To mitigate connectivity concerns, NDOT explored customized solutions such as boosters and point-to-point connections and discovered that connectivity could be achieved anywhere with sufficient effort. Data-over-power solutions were considered, including Paige Wireless and a LoRaWAN solution. The agency tested a

prototype system, involving transmitters on trucks and receivers at the paver and plant. During the pilot phase, projects with good connectivity were prioritized, especially those that had already been approved. Paper tickets were kept as official documents during this proof-of-concept stage.

In 2021, NDOT sought contractor volunteers and incentivized their participation, eventually securing one volunteer. AGC Nebraska offered \$2,000 to a contractor to participate, and NDOT matched that offer. The pilot experienced challenges but was successful overall in proving the concept worked.

In 2022, many projects and volunteers were selected for piloting, but due to a series of issues, only one pilot project was conducted. In 2023, NDOT made e-Ticketing mandatory for five projects but received strong pushback both internally and from the industry because of plant connectivity issues. NDOT added a cancellation clause to address potential connectivity issues.

Recently, NDOT and the Nebraska Asphalt Industry began exploring the HaulHub DOT Portal solution. The Asphalt Industry expressed a high level of interest in the HaulHub solution. NDOT held multiple meetings with HaulHub to discuss the portal, applications, reports, and training and support services. Following these discussions, the agency conducted a one-month trial period to evaluate the system. Based on the positive experience during the trial, NDOT decided to acquire a subscription to the HaulHub DOT Portal solution through the AASHTOWare Project (AWP) Catalog licensing. NDOT is now discussing its transition from a pilot phase to full implementation, including deciding between voluntary and mandatory adoption, among other considerations.

VDOT

VDOT developed a comprehensive plan in preparation for e-Ticketing pilots that included a targeted scope and implementing the system in three phases. Phase 1 involves conducting pilots and subsequently rolling out the system statewide. In Phase 2, the focus will be on bringing the collected data into the VDOT repository to enable data sharing. Phase 3 will focus on implementing Positive Material Delivery and leveraging the information gathered from the system.

VDOT wants a data-centric, web-enabled, and cloud-hosted solution that supports field operations from any supplier and offers mobile applications with synchronization capabilities when offline. In the initial phases, VDOT's focus is on asphalt, aggregates, and concrete, with a goal of minimizing the impact on

suppliers. Only design bid build projects are included in the pilots, although the system will be accessible for design build projects. Some aspects were considered out of scope, including material test data, district-held contracts, local assistance projects, public-private partnerships, fleet management, GPS tracking, and driver/DMV requirements.

VDOT conducted a field readiness assessment to identify any device, software, or connectivity issue that needed to be addressed. VDOT also evaluated the availability of mobile devices and software for inspectors. VDOT had already issued iPads to all inspectors due to the PlanGrid initiative. The agency also examined field internet connectivity, considering spotty coverage in some areas. In cases where connectivity was limited, offline processing capabilities of the software were deemed necessary. (VDOT is evaluating cellular signal boosters.) The field readiness assessment also addressed internet connectivity at plant or quarry sites. The extent of this problem is unknown, but VDOT assumes that lack of connectivity at plant sites is unlikely, but with a high impact if the opposite is true.

As part of the comprehensive plan, VDOT established special provisions and specifications. It developed minimum data requirements for e-Tickets to ensure that the necessary data will be collected consistently across the pilots and subsequent implementation phases.

VDOT emphasized the importance of partnering and maintaining effective communication with stakeholders throughout the process. VDOT sent letters to all suppliers, informing them that they might be contacted by a prime contractor to gauge their interest in participating in VDOT's e-Ticketing pilot and created a one-page "fact sheet" summarizing essential information about the pilot program. The fact sheets include a program overview, benefits, timelines, portal description, requirements to suppliers, and a flowchart of the implementation process.

Pilots were initiated in 2023, with an initial plan of having four pilots in each district; however, the number of pilots exceeded the original intention. District Construction Engineers selected the initial projects, starting with asphalt, and later expanding to include concrete. Various scenarios are being tested during the pilots, such as contractor-as-supplier and separate arrangements. VDOT provided training using HaulHub, and the pilots are using paper tickets as a backup for instances of connectivity issues.

As part of the pilots, VDOT conducted surveys to collect issues and feedback to help determine the best

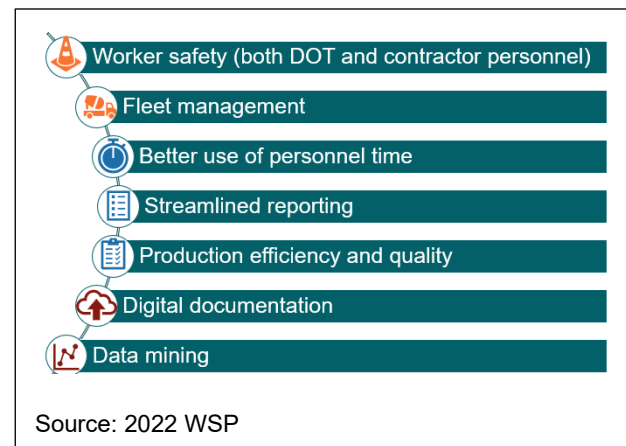
approach for the statewide rollout. Field visits were also conducted to observe the implementation firsthand. The pilots are serving as a learning experience for understanding the functionality of the tools and identifying any necessary changes. VDOT is conducting supplier evaluations that focus on security, connectivity, training, and ensuring alignment of data with DOT forms. VDOT District teams are examining their processes, data security, reports, data viewing capabilities, and methods of effectively leveraging the collected data. These data are being prepared to improve VDOT's next phases of its e-Ticketing implementation.

SUMMARY OF IMPORTANT ISSUES AND KEY OBSERVATIONS

Making a Business Case

The agencies discussed the value that e-Ticketing generates to all stakeholders, including the DOT, suppliers, and third-party haulers (Figure 1).

Figure 1. Benefits of e-Ticketing



Worker safety was the foremost problem that the agencies sought to solve with e-Ticketing. In addition, agencies that digitalize tickets have the ability to manage data for the lifetime of a project. Eliminating paper tickets also allows both the State DOTs and contractors to repurpose the time that inspectors spent collecting paper tickets and to avoid reconciling tickets for daily summaries. Repurposing personnel time is a significant benefit, particularly in light of a nationwide shortage in construction workforce.

Field Readiness

The conversation about IDOT's field readiness for e-Ticketing included a discussion of existing guidance within the construction manual on receiving e-Ticketing data via email. Two topics of discussion were field devices and cellular connectivity.

- Mobile devices and software requirements—IDOT field staff use Apple iPhones and iPads; however, some inspectors still use flip phones. IDOT intends to poll the districts on iPhone usage. The lead agencies discussed their field technology and noted smart devices as a fundamental need for successful implementation of e-Ticketing.
- Cellular coverage—While cellular is mostly reliable, IDOT did identify some connectivity issues. Both DelDOT and PennDOT use an offline mode in situations where internet is erratic. To address internet connectivity, IOWADOT contacts the districts to screen for dead zones on upcoming projects. This prescreening helps IOWADOT prepare for such scenarios. The agency also contacts cellular service providers for possible fixes. IOWADOT is piloting the use of cell signal boosters with the aid of State Transportation Innovation Council (STIC) funds.

Solution Selection and Procurement

IDOT described strict procurement laws that could be obstacles to achieving its e-Ticketing objectives. The lead agencies discussed the features of their systems and their procurement processes.

IOWADOT noted its desire for a portal approach to limit the number of applications needed by field staff. Originally, IOWADOT proposed a layout of the portal (e-Ticketing Handling system) that it would implement in-house. The portal system would entail taking ticket load-out information and sending it through an e-Ticketing vendor, either via the cloud or a direct connection, into the IOWADOT portal. From there, the ticket data could be transferred to the agency's pay software, geographic information system (GIS) site, and Doc Express. IOWADOT was seeking a solution with features including visibility to all raw e-Ticket data, a single interface for multiple bulk materials, the ability to receive/reject loads, delivery status if available, test result and photo enrichment, data export, standard reports, paper tickets digitization, and real time data sharing with connected suppliers and contractors. In the workflows, IOWADOT highlighted the necessity of having a two-way API or connection to enable communication of rejected loads or other information.

As it related to the selection of a solution, IOWADOT emphasized the need to work out the data flows and ensure that smaller suppliers and contractors were not excluded. The agency emphasized the importance of having staff and efficient tools, such as quick email communication, fact sheets, and webinars.

Ultimately IOWADOT opted for a software as a service approach, with support and training from the vendor. During the request for proposals (RFP) phase, the agency sought a solution with flexibility for future enhancements and dashboards. The checklist included integration, data archiving, analytics, reporting, document management, performance, security, and user documentation. IOWADOT developed an RFP with specific requirements in mind, including connectivity to AWP systems and mapping capability.

Pricing structure was important to IOWADOT, and the price accounted for 20 percent of the evaluation score. The agency also investigated the payment structure and preferred a flat price (lump sum) for a specific number of projects, which is a common practice in the industry. The agency initially targeted to cover 200 contracts. Other evaluation criteria included the vendor's experience and the ability to collaborate with other stakeholders. References and presentations played a role in the evaluation process.

Once HaulHub was selected from the response to the RFP, IOWADOT IT conducted a risk assessment. Additionally, IOWADOT developed a guidance framework to establish connections with 100 suppliers in just two months. Throughout the process, HaulHub provided positive support, and the desired changes were implemented effectively.

IOWADOT ultimately selected HaulHub as the vendor based on various factors and its positive experience with their products. Iowa DOT requested certain changes to be implemented and received excellent support from the vendor throughout the process.

The agency acknowledged the need for an early start to the RFP process due to procurement rules and opted for a one-year contract with multiple extensions. The agency was satisfied with the RFP process overall and had a positive experience working with different vendors in the past.

PennDOT implemented its first mobile application in January 2013 as part of an initiative to improve data quality, reduce data entry, and provide user-friendly interfaces. Challenges arose when introducing Apple devices into a Microsoft-dominated environment; these challenges required technical support and the recruitment of experienced team members. Business and executive champions were identified to drive the initiative, and efforts were made to manage senior executives' expectations and change existing culture and policies.

The discussion also covered PennDOT's e-Construction system, which includes eCAMMS, Mobile Construction, and additional applications. PennDOT developed a library of applications to streamline various e-Construction tasks such as punch lists, inspection reports, consultant hours reports, and e-Ticketing. Implementation of each application involved re-engineering the business process. PennDOT noted that eCAMMS was not initially ready to handle e-Ticketing data, which led to the development of a PennDOT portal that could export data into a comma-separated values (CSV) format. Eventually, the goal is to integrate the e-Ticketing information into the concrete inspection application, which covers the entire contract construction process. Work is also underway on an asphalt application. Lastly, PennDOT emphasized the importance of forward-thinking about data use for purposes like forensics and problem-solving.

VDOT had undertaken various pilots in the past. Previous pilots gave inspectors logins for the vendor software; however, this arrangement was challenging and created scenarios where inspectors needed access to multiple applications. For e-Ticketing, VDOT explored an in-house option but decided to use the HaulHub portal. iPads are widely distributed among VDOT staff; however, Virginia faces cell coverage issues. To overcome this, VDOT uses HaulHub's offline mode and paper tickets.

For VDOT's e-Ticketing implementation, the agency developed a specification accompanied by a data dictionary supplement. However, there have been some challenges in populating certain data fields.

System procurement at VDOT faced a year-long delay when the IT procurement section deemed the pilot to be a free demonstration, which is not allowed. VDOT went through the procurement process and had to go through the Enterprise Cloud Oversight Service (ECOS) assessment. The procurement of VDOT's portal was further delayed by an additional year because of the lengthy RFP process. ECOS provides oversight functions and management of cloud-based services, specifically focused on software as a service. The service assures compliance and improved security by providing transparency through Virginia Information Technologies Agency oversight.

VDOT considered several portal vendors, including FleetWatcher, HaulHub, and Command Alkon and ultimately chose HaulHub because they met the quote timeline and did not impose limitations on the portal's use. The requirements for the portal included security, functionality, reports, administration, and support. As of

early June 2023, 12 projects have started, and an additional 28 projects are set to commence, including a concrete job.

VDOT used Virginia Transportation Research Council funds to pay for the HaulHub portal. VDOT is currently evaluating the AWP catalog for an extended contract. The goal is to support a statewide rollout of the AWP system across VDOT's operations.

Specification and Data Requirements

IDOT discussed Articles 109.01 and 1020.11(a)(7) of the Illinois Standard Specifications for Road and Bridge Construction, which outlines the necessary information to be included on tickets. IDOT also mentioned the construction manual, and the agency recognizes the need for updates to the manual after considering the discussions held during the peer exchange. IDOT wants to collect data beyond receiving ticket information in an email PDF form and expressed interest in the ticket data for future use in digital as-builts and other purposes, although GPS tracking was not a priority for the agency.

Subject matter experts discussed the key features of various state specifications, highlighting five elements:

- The first element was system requirements, which encompass data exchange methods, file formats, and considerations such as latency.
- The second element focused on data requirements, including the necessary ticket data and additional desired information.
- The third element was internet connectivity, with several options for offline modes, cellular boosters, and low orbit satellites. These solutions were site-specific.
- The fourth element covered the basis of payment, whether it involved pay items or incidental aspects, and highlighted the e-Ticket as a source document.
- The final element discussed verification of quantities, emphasizing the similarities in approaches between plant and job site verifications.

IOWADOT and PennDOT offered sample specifications for reference. The peer exchange attendees also discussed the AASHTO Materials Data Management System (MDMS), which provides a list of data considerations and a data dictionary.

IOWADOT discussed its developmental specification for e-Ticketing (DS-15091) (IOWADOT, 2021), which is focused on the material of interest, lists the required data attributes by material type, and describes the rules for transferring information. IOWADOT's specification

requires a 5-minute latency for delivery to consider the time an API requires to receive a ticket and deliver the tickets in batches. IOWADOT noted, when developing a specification, an agency should consider ticket handling during erratic internet connectivity, instructions for contractors, and the importance of consistent project numbering.

Additional discussions were held regarding the collection of load delivery locations. IOWADOT clarified that GPS tracking is not the only technology for truck identification and tracking. However, verifying delivery and the location of delivery proved useful for other purposes. IOWADOT suggested that when devising verification approaches, State DOTs should consider the existing requirements and fields found on paper tickets, such as information from weigh-scale operators and geological data. Additionally, IOWADOT highlighted the potential contribution of various technologies, including cameras, applications, and GPS, in facilitating the verification process. The agency also discussed "OnStation," which FleetWatcher has integrated with its e-Ticketing functionality. This integration enables users to precisely determine the location, using station coordinates, where each load of asphalt is placed on a job site. IOWADOT also discussed how tickets could be integrated into AASHTOware or pulled into GIS layers or Google Earth.

NDOT described its experience with LoRaWAN, an Internet of Things (IoT)-based long-range wide-area network commonly used in the agricultural industry. LoRaWAN could handle many signals but could only transmit small packets of data, excluding photos or videos. The primary purpose of LoRaWAN was to address connectivity issues. NDOT encountered challenges during prototype development and funding approaches. Matching e-Tickets to trucks proved to be a significant challenge. NDOT pursued collaboration with a vendor to find a solution, and efforts were made to secure a STIC grant to support the project. By implementing a system with receivers and Bluetooth tabs on trucks, e-Tickets could be associated with specific vehicles. Although NDOT transitioned to using HaulHub, preventing the agency from evaluating the LoRaWAN system with an e-Ticketing system, NDOT aims to conduct additional trials and potentially integrate it with HaulHub, noting that challenges remain in identifying and matching e-Tickets to trucks, particularly when they accumulated at a location.

PennDOT demonstrated the use of radio-frequency identification (RFID) tags. The agency highlighted various applications of RFID tags and discussed how the tags could function through materials such as concrete and walls but not steel or double-paned windows.

PennDOT addresses RFID security concerns by using the tags solely for linking to secure online systems that require credentials to sign in to access the information. For non-authorized users, the tag only reads the tag numbers. The demonstration revealed the extensive potential of RFID technology for inventory management, asset tracking, and other related purposes, in addition to e-Ticketing.

These technologies were all discussed as verification approaches. State DOTs should consider what the current requirements for paper tickets are (such as weigh-scale certification and on-site verification) and how other technologies (such as cameras, applications, and GPS) can be leveraged to assist with verification.

For the lead agencies, field inspectors have been performing visual verification to ensure that the vehicle (for which a ticket has been issued) delivers the material at a job site. Because this process is inefficient, IOWADOT has been conducting pilots on camera-based electronic proof of delivery as an alternative to GPS-based proof of delivery.

Cameras are installed at the plant and on material transfer vehicles or pavers at the job site. Cameras are automatically triggered to capture the license plates of the trucks at the plant and at the job site. This technology verifies that a truck with a specific ticket has left the plant, when it gets to the job site, and when the truck dumps the material into a material transfer vehicle or paver. The cameras capture visual proof of delivery of a truck and the cycle times of a truck. The technology drops both latitude-longitude data with cellular connectivity and time stamps. However, IOWADOT noted that the application of this technology for concrete and aggregates would be challenging because there is no single dump location.

Federal-Aid Requirements

Source documents record the quantities of completed work and form the basis for approving partial payments to contractors. Federal regulations do not specify the source document; however, State DOTs need to determine the source document based on their payments system and their recordkeeping methods in coordination with their FHWA division office. Before e-Ticketing was introduced, paper tickets served as source documents, but image-based replicas (such as photographs and scans) did not. FHWA considers e-Tickets as source documents because the tickets are created electronically with the information, and then transmitted, stored, and manipulated in an electronic environment, creating a chain of custody of events and a

chain of alterations. FHWA representatives enumerated various laws, statues, and memoranda relating to source documentation and records retention. This information is codified at 23 Code of Federal Regulations (CFR) § 635.123 and 2 CFR § 200.334 (CFR 2013a,b).

ROADMAP DEVELOPMENT FOR IDOT

IDOT is planning its approach to procuring an e-Ticketing solution but is limited in its ability to share information because of procurement laws. The agency is being intentional in its approach but indicated that the peer-to-peer exchange provided valuable input to its roadmap planning.

IDOT initiated a discussion on stakeholder outreach for e-Ticketing, and during the peer exchange, there was a discussion of forming a subgroup or task force to discuss the path forward. IDOT also discussed the possibility of implementing e-Ticketing in stages, potentially starting with one material type, and based on the readiness and response of the stakeholders, expanding to include other materials. IDOT again emphasized uniformity and aligning stakeholders on e-Ticketing. The lead agencies discussed stakeholder issues around three main topics:

- Source documentation and cohort tickets. Cohort tickets were identified as a means of establishing a sense of confidence in e-Tickets among the stakeholders during construction.
- Data management and security to ensure the accuracy and reliability of the source information.
- Achieving buy-in from internal and external stakeholders.

Polling conducted at the peer exchange identified the lack of training as IDOT's primary concern, followed by connectivity issues and the need for widespread collaboration and partnership. Contractors, on the other hand, expressed greater concern about the costs associated with the implementation process, as well as the practicality of executing the new technique. After the polling, the discussion centered around two primary challenges: training and stakeholder buy-in.

IDOT mentioned the need for training tools, which may include PDF guides and videos. The discussion with the

lead agency representatives highlighted the importance of individualized support through direct communication. Lead agencies noted that dedicated personnel should be assigned to assist with training and provide ongoing support. It is important to have someone who can devote sufficient time and effort to managing the implementation process effectively.

IDOT plans to focus e-Ticketing on asphalt and concrete first and will host stakeholder discussions regarding the implementation with these industry groups. IDOT also plans to have these discussions with the aggregates industry. The agency plans to pilot e-Ticketing in different districts, although the Chicago area is more amenable for the first set of pilots, to gain a better understanding of challenges and ensure connectivity.

IDOT is also planning for internet connectivity challenges and the ability to provide connectivity through either satellite or cellular boosters. The lead agencies also discussed the need to include internet connectivity requirements in the specification.

IDOT will be working on its e-Ticketing specification, considering a pay item component, perhaps even for connectivity, and necessary changes to the construction manual. During piloting, IDOT will use cohort paper tickets as the document of record in the short term.

IDOT used this peer exchange as a fact-finding mission, stating that decision-making and conclusions will not be reached immediately. IDOT noted that e-Ticketing is a priority and mentioned its openness to voluntary pilot projects. In terms of specifications, the immediate goal of IDOT is to achieve a paperless system, with future considerations for diverse data uses. The starting point will be the Material Delivery Management System (MDMS) and standardization of data attributes, as suggested by the subject matter experts during the peer exchange, leveraging the existing data dictionary provided by MDMS.

The agency is working toward a long-term vision of a technology solution for e-Ticketing and will continue conversations and to share lessons learned with surrounding states. IDOT's objective is a 100 percent paperless approach.

August 2023

This tech brief was developed under Federal Highway Administration contract 693JJ319D000030/693JJ321F000325.

CONTRACTING OFFICER'S REPRESENTATIVE

Antonio Nieves Torres
Maintenance Program Manager
Federal Highway Administration
1200 New Jersey Ave. SE E73-446
Washington, D.C. 20590
202-366-4597 / Antonio.Nieves@dot.gov

AUTHOR

Suriyanarayanan Sadasivam
WSP USA

Roy Sturgill
Iowa State University

DISTRIBUTION AND AVAILABILITY

This tech brief can be found at
<https://www.fhwa.dot.gov/construction/econstruction/peer.cfm>

KEY WORDS

e-Ticketing, peer-to-peer

NOTICE

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The U.S. Government assumes no liability for the use of the information contained in this document. The U.S. Government does not endorse products or manufacturers. Trademarks or manufacturers' names appear in this document only because they are considered essential to the objective of the document. They are included for informational purposes only and are not intended to reflect a preference, approval, or endorsement of any one product or entity.

NON-BINDING CONTENTS

The contents of this document do not have the force and effect of law and are not meant to bind the public in any way. This document is intended only to provide information to the public regarding existing requirements under the law or agency policies. However, compliance with applicable statutes or regulations cited in this document is required.

QUALITY ASSURANCE STATEMENT

The Federal Highway Administration (FHWA) provides high-quality information to serve Government, industry, and the public in a manner that promotes public understanding. Standards and policies are used to ensure and maximize the quality, objectivity, utility, and integrity of its information. FHWA periodically reviews quality issues and adjusts its programs and processes to ensure continuous quality improvement.



U.S. Department of Transportation
Federal Highway Administration

REFERENCES

AASHTOWare. n.d. AASHTOWare Project (webpage).
<https://www.aashtowareproject.org/>, accessed March 10, 2023.

CFR. 2013a. "Determination and Documentation of Pay Quantities." 23 CFR § 635.123. <https://www.govinfo.gov/content/pkg/CFR-2013-title23-vol1/xml/CFR-2013-title23-vol1-sec635-123.xml>, accessed March 10, 2023.

CFR. 2013b. "Retention Requirements for Records." 2 CFR § 200.334. <https://www.ecfr.gov/current/title-2/subtitle-A/chapter-II/part-200/subpart-D/subject-group-ECFR4acc10e7e3b676f/section-200.334>, accessed March 10, 2023.

Dell. 2023. Boomi (webpage). <https://boomi.com/>, accessed March 10, 2023.

Federal Highway Administration (FHWA). 2022. Center for Accelerating Innovation (webpage). <https://www.fhwa.dot.gov/innovation>, accessed March 10, 2023.

Iowa Department of Transportation (IOWADOT). 2021. *Developmental Specifications For e-Ticketing*. Ames, IA: Iowa Department of Transportation. https://iowadot.gov/specifications/dev_specs/2015/DS-15091.pdf, accessed March 10, 2023.