

Tech Brief



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Federal Highway Administration

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KENTUCKY TRANSPORTATION CABINET E-TICKETING PEER EXCHANGE

EDC-6 PEER-TO-PEER EXCHANGES

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 The emergence of electronic technologies on highway construction projects has made the paper-based processes outdated, inefficient, and cumbersome.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.

INTRODUCTION

The Kentucky Transportation Cabinet (KYTC) is an early adopter of e-Ticketing. KYTC conducted its first pilots on five asphalt resurfacing projects in the summer of 2018, and completed 41 e-Ticketing projects between 2018 and 2022. KYTC used a special note and bid item to include a fleet management solution for e-Ticketing for these projects. In response to the COVID-19 pandemic, KYTC released Construction Memorandum 20-01, Contactless Ticketing, which permitted other forms of electronic tickets, including pictures, and PDFs to meet contactless and social distancing needs on construction projects.

KYTC has been advancing with the implementation of e-Construction technologies since 2009, and has already implemented the use of electronic plan sheets and contract documents, electronic bidding, and ProjectWise® for a document management system. KYTC has also equipped its field inspectors with iPhones® and iPads® for mobile devices and Dell® tablets with Citrix® with access to AASHTOWare® SiteManager™.

After a series of pilots, KYTC paused the pilot program to conduct an evaluation of the pilots and solicit feedback from the contractors and KYTC staff on their experiences. KYTC has been signing into mobile applications of the contractors' fleet management products to obtain e-Tickets. Recognizing the challenges with handling multiple products, KYTC decided to procure a vendor-based web portal solution to receive tickets electronically from preauthorized material suppliers regardless of the fleet management products they use. After completing an internal testing of candidate vendor portal solutions, KYTC is gathering user feedback and is in the process of procuring a portal. To advance the e-Ticketing practice to the next level, KYTC consulted the Iowa Department of Transportation (IOWADOT), who successfully adopted e-Ticketing, through a peer-to-peer exchange.

The Federal Highway Administration (FHWA) sponsored a day-and-a-half-long peer-to-peer exchange in Ames, Iowa, on December 13 and 14, 2022. The meeting included representatives from FHWA, KYTC, and IOWADOT; Manatt's, a concrete producer from Iowa; and two subject matter experts from the EDC contractor's team. IOWADOT was the host and provided meeting room facilities. The meeting included a combination of presentations, panel discussions, and question and answer sessions.

SUMMARY OF IOWA'S E-TICKETING PRACTICES

IOWADOT conducted its first e-Ticketing pilot in 2015 with asphalt mixtures and its first concrete pilot in 2017. Since then IOWADOT has scaled up significantly to complete hundreds of e-Ticketing projects with asphalt, aggregates, and concrete. To date, IOWADOT completed more than 300 e-Ticketing pilots. The agency intends to deploy e-Ticketing in 200 construction projects in 2023.

IOWADOT's practice has evolved over the years significantly. In the earlier phase of e-Ticketing, IOWADOT was dependent on fleet management products to access e-Tickets. Recognizing the challenges with handling multiple products, IOWADOT decided to move away from installing multiple vendor applications on the field inspectors' mobile devices to a single application. IOWADOT deployed a commercially available off-the-shelf (COTS) web portal on a pilot basis that receives e-Ticketing data via a JavaScript Object Notation application programming interface (API) from authenticated suppliers. To date, 25 vendors are connected to the portal. The portal is connected with all major suppliers via APIs and small suppliers via direct connections.

Building on piloting experience, IOWADOT is seeking to deploy an advanced version of the e-Ticketing portal. IOWADOT has released a Request for Proposals soliciting the development of vendor-based solutions for an e-Ticket handling system for its next phase in December 2022. IOWADOT anticipates deploying its next-generation portal in the summer of 2023. IOWADOT has developed business and technical requirements that entail but are not limited to archiving, data analytics, document management, integration with applications, technical and user documentation, and performance and security enhancements. The next-generation portal implementation also will enable automatic data exchanges between the portal's cloud and IOWADOT's information systems and other applications. IOWADOT also envisions a two-way API-based communication to share construction test data from the e-Ticketing portal with contractors.

IOWADOT has updated to DS-15095, the developmental specification for e-Ticketing, and intends to include e-Ticketing in the standard specifications. In response to data-related challenges, IOWADOT is planning changes to data processes, including standardizing ticket data with set definitions for data attributes and creating the data sharing rules. IOWADOT is also testing technology-driven alternatives to meet on-

site internet connectivity needs using cellular signal boosters and verification of truck delivery using cameras. IOWADOT has been communicating their successes by speaking to the industry, understanding stakeholder needs in the field, providing support, and investigating long-term uses of e-Ticketing data.

Manatt's, a concrete supplier from Iowa, shared the e-Ticketing experience from a material producer's perspective. Manatt's first deployed e-Ticketing on two pilot projects with IOWADOT in 2017 and 2018. In 2019, the supplier expanded e-Ticketing to a large concrete construction project. The COVID-19 pandemic accelerated the rollout of e-Ticketing and the supplier completed the rollout to all plant locations by spring 2021. The supplier uses different vendor products for asphalt and ready-mix concrete. Manatt's plant load systems are now connected with IOWADOT's web portal. The supplier is also maintaining cohort paper tickets temporarily to make sure the system works correctly. The supplier has begun to realize the benefits of e-Ticketing. The supplier has reduced the fleet size because of the efficiencies gained on fleet management.

SUMMARY OF IMPORTANT ISSUES AND KEY OBSERVATIONS

Paying for e-Ticketing

FHWA indicated that both e-Ticketing and enabling internet connectivity at the construction site are eligible expenses for reimbursement under the federal-aid highway program and suggested that KYTC explore several existing FHWA grant programs, including State Transportation Innovation Council, Accelerated Innovation Deployment Demonstration Program, Accelerating Market Readiness program, and Infrastructure Investment and Jobs Act to fund pilot initiatives (FHWA, 2022).

Rollout and Training

Training is a vital part of any pilot implementation. The DOTs provide training sessions to inform field inspectors about the pilot project, introduce the technology, and help them adequately prepare to handle e-Tickets on the construction job. The best practice for the DOTs is to develop a training plan that includes what personnel need training, whether training is on-site or off-site, training schedule, testing requirements, and the level of vendor support. Some DOTs require the on-site presence of a technical representative of the e-Ticketing product to assist and train construction personnel with the initial set-up, pre-construction verifications, and data management and processing.

IOWADOT has a need to have adequate personnel to support field operations, as well. IOWADOT hired an e-Construction Coordinator to serve as a dedicated resource for e-Ticketing. Furthermore, IOWADOT has made in-person training, on-demand training videos, quick reference guides, and telephone and email support available to support field operations.

Field Readiness

Successful implementation of e-Ticketing builds/relies/depends on the successful implementation of e-Construction technologies, which include:

- Electronic bidding and contracts
- Electronic and digital signatures
- Document management systems
- Construction management systems
- Mobile devices

Mobile devices and construction management systems are the prerequisites for e-Ticketing. Mobile devices allow field personnel to receive, accept, reject, validate, and add notes to e-Tickets. Construction management systems allow agencies to use the received data effectively in construction-related business functions, including in creating daily summary reports and automating quantity-based payments processing.

Five factors related to field readiness for e-Ticketing include:

- Mobile devices — Both KYTC and IOWADOT provide mobile devices with cellular connections (iPads® and iPhones®) to field inspectors. Several issues relating to the use of mobile devices, such as lower battery life, sun glare, overheating, and device replacement plan, were discussed.

IOWADOT buys battery packs as supplementary power sources to help inspectors use the devices through the day. The DOTs also use suitable color schemas to maximize contrast between the text and background of the device screen for better readability. The field inspectors also handle the overheating of iPads® with workarounds.

Similar to KYTC and IOWADOT, Manatt's has rolled out cellular-enabled tablets to truck drivers and quality control personnel. The tablets are also enabled to access wireless internet at the plant locations and mobile hotspots in the field. Manatt's is using a mobile device management solution to manage and support devices using Android or iOS. Manatt's also offers web

browser access and remote desktop to support issues.

- Cellular coverage — In Kentucky, the quality of internet connectivity is good in many places, but some solutions may not work in all places. To address internet connectivity, IOWADOT will reach out to the districts to screen for dead zones on upcoming projects. This prescreening will help IOWADOT prepare for such scenarios. The agency will also reach out to cellular service providers for possible fixes. With the aid of State Transportation Innovation Council funds, IOWADOT is piloting the use of cell signal boosters and pop-up networks for temporary connectivity.
- E-Construction and Other Applications — KYTC uses a variety of different e-Construction tools and applications. KYTC uses AASHTOWare® SiteManager™, a client-server system that supports a suite of construction management applications, and OnStation, a digital stationing application. IOWADOT also exports e-Ticketing to OnStation.
- Requiring location tracking of trucks using global positioning system (GPS) — GPS tracking of trucks is not required in most states. Field inspectors can record the latitude and longitude of the delivery locations at the job site. However, considering the high costs of trucking, contractors require that third-party-operated trucks must have GPS location services on.
- Inspector's Handling of Tickets — The acceptance of tickets under normal operating conditions is straightforward. However, the DOTs are recommended to have business processes in place to handle unanticipated situations (e.g., rejection of tickets, internet outages) and to verify the delivery of trucks for which tickets were issued. Some DOTs, such as Virginia DOT, have documented business processes using flowcharts.

Stakeholder Issues

Stakeholder inputs and buy-in are essential elements to successfully move forward with implementation. Most DOTs face a common set of implementation challenges: lack of internet connectivity, pushback from contractors, small suppliers, and third-party trucking companies, and higher costs of implementation. These DOTs have also engaged their internal and external stakeholders successfully through a plethora of communication approaches to overcome these challenges. As a part of implementation planning, the DOTs worked towards

securing leadership commitment and buy-in from internal partners.

The DOTs conduct regular outreach with their external stakeholders to advance the implementation of e-Ticketing. They have forged strong relationships with industry associations, including the local chapters of Associated General Contractors, Road Builders Association, Asphalt Pavement Association, and Concrete Pavement Association. Many DOTs have established an e-Ticketing task force to support implementation activities. Through these joint working groups, the DOTs work with their industry groups to share the vision and short-term plans, communicate successes and benefits, provide updates on pilots, discuss challenges, and solicit industry inputs and volunteers for pilots. The DOTs also use other opportunities, such as conferences, industry events, industry coordination meetings etc., to reach out to industry partners and communicate the benefits and successes of e-Ticketing.

Maintaining consistent and accurate messaging about the change is critical for the DOTs. Furthermore, as e-Ticketing technologies rapidly evolve, education plays an important role in keeping all the stakeholders informed and communicating the success of the pilots.

To support the implementation activities, IOWADOT devised a plethora of stakeholder engagement and training activities. IOWADOT has effectively used the opportunities to engage with the construction industry at various events to explain the vision, highlight successes, and discuss failures. IOWADOT works with the contractors and their representative at pre-construction meetings to identify and discuss solutions to issues. IOWADOT encourages open communication during the kick-off and duration of the project.

IOWADOT has successfully worked with the industry to address the challenges of small suppliers. IOWADOT offers direct connections between the suppliers' load out systems and the IOWADOT portal, thereby alleviating supplier concerns of higher costs associated with vendor solutions.

Data Requirements

E-Ticketing enables an electronic workflow of construction administration data. In the near future, e-Ticketing will contribute to a common data environment that houses all the construction data in digital as-builts. It is envisioned that the common data environment will allow users to use this information for a plethora of use cases. Therefore, data requirements of e-Ticketing gain prominence beyond the immediate need of capturing ticket data in an electronic format.

The DOTs could undertake data requirements analysis to determine the data attributes required on e-Tickets. A data requirements analysis is a structured approach to identify, prioritize, and validate the data needed to achieve business objectives. Reviewing the reason for, users of, and usage of a given data attribute would guide the requirements analysis. The DOTs can use this approach to ensure that the identified data requirements are feasible and relevant for collection and business use.

Many DOTs typically begin with the list of data attributes that are currently captured on their paper tickets. The commonly collected data attributes typically include project details, plant name and location, product description, quantities, date and time stamps, plant and delivery locations, truck identification number, and inspector notes. Furthermore, the DOTs could take into consideration various factors, such as material type and verification, to identify additional attributes that they want to capture. In addition, the American Association of State Highway and Transportation Officials (AASHTO) Material Delivery Management System (MDMS) presents a library of data attributes for further consideration. The MDMS standard also presents data definitions, such as attribute name, type, length, and description, to ensure consistency.

E-Ticket data is currently used in developing daily summaries and verifying quantities of materials. The e-Tickets also serve as the source documents for making payments to contractors. In the future, e-Tickets will be used in digital as-builts, forensic investigations, performance evaluation of paving materials, and asset management purposes. To enable these future use cases, KYTC could consider adding geospatial data that locate material placement, material source data, and other better information management considerations.

Many DOTs consult with contractors and material producers, as well as various business programs within the agency, who are the suppliers and consumers of e-Ticketing data, respectively. The stakeholder consultation will inform the DOT of any limitations associated with collecting the data in accordance with the proposed data requirements plan. KYTC can establish a data growth plan that communicates the immediate and future data needs, which would help the stakeholders prepare for the change.

Portal and Data Management

KYTC is looking forward to deploying an API-based web portal to handle e-Tickets. In the first phase of pilots, KYTC was using the contractors' fleet management solutions to access e-Tickets. KYTC received feedback

from the earlier pilots. Based on this feedback, KYTC paused the piloting activities to discuss with the DOT's Office of Information Technology and contractors and suppliers on the path forward. KYTC intended to establish information requirements, identify data needs, and define data flows. KYTC anticipates that the e-Ticketing data would be fully integrated with other information systems in the future. KYTC is currently using AASHTOWare® SiteManager™ for construction management but plans to migrate to AASHTOWare® Project™, a web-based platform.

KYTC is also aware of the need to routinely face and troubleshoot issues, such as split loads, waste, and rejections, and troubleshoot them routinely. Some of these issues can be attributed to the lack of automation and two-way communication between the DOT portal and the contractor. Laying out the data flows and work flows, such as using flowcharts, would help KYTC identify process-related bottlenecks and accordingly streamline them effectively. In the future, KYTC is also interested in automation of work flows and two-way communications where decisions about rejected loads, partial loads, or multiple dump locations would be communicated automatically to the contractors.

IOWADOT is currently piloting a COTS web portal. The e-Ticket data received through the portal is hosted in a cloud. In the future, e-Tickets will be integrated with DocExpress®, AASHTOWare® Project, and overlaid on a geographic information system (GIS) application. However, in the interim, IOWADOT has developed a temporary solution using Microsoft® Excel to summarize and use e-Tickets. The Excel solution captures the ticket data from contractor-supplied files in PDF or CSV format and summarizes all data attributes on e-Tickets. IOWADOT also exports e-Ticketing to OnStation, a digital stationing application that allows users to pinpoint the exact location using station coordinates where each load of asphalt is placed on a jobsite. The agency also exports e-Ticketing to a proprietary GIS for further applications.

Beyond piloting its current COTS web portal, IOWADOT is procuring a web portal through a Request for Proposals process. Once the deployment of the new portal is complete, the e-Ticketing data will directly feed to DocExpress®, and eventually to AASHTOWare® Project for tracking daily summaries and trucking by disadvantaged business enterprises. The data will also feed into a GIS application via a feature manipulation engine for long-term asset management.

Specifications

KYTC e-Ticketing Specification. KYTC includes a special note for e-Ticketing on asphalt paving projects.

The special note, which is based on an earlier version of e-Ticketing, allows the use of GPS fleet management solutions. The special note requires a list of data attributes that include unique Truck ID, date and time stamps, net weight of asphalt mixtures, mix temperature at the time of loading, and GPS tracking of truck. Many of these data attributes are currently required on paper tickets. KYTC removed the GPS tracking requirement in the special note during the 2022 construction season.

In addition to procuring a portal solution, KYTC intends to include a bid item for a limited period of time that allows contractors to pass on their costs of e-Ticketing deployment to the agency. KYTC is interested in integrating e-Ticketing data with AASHTOWare® SiteManager™ and other information systems.

IOWADOT e-Ticketing Specification. IOWADOT discussed its development specification for e-Ticketing (DS-15091) (IOWADOT, 2021). IOWADOT's specification has evolved significantly over time as updates were made using the lessons learned from the pilot program. The developmental specification described the rules for transferring information, including the portal address, testing prior to the project start, and acceptable transmittal latency. The specification requires a 5-minute latency for delivery considering the time required for an API to receive a ticket and deliver the tickets in batches. The GPS truck tracking, which was mandated in the earlier versions, was no longer required.

The specification also required general ticket information, such as project numbers, plant name, and truck status times, as well material-specific information such as mix design number for asphalt and batch weight for portland cement concrete. In the future, IOWADOT intends to include additional requirements for internet connections, verification of delivery, and third-party integration.

Other State Specifications. Many samples of specifications from other states are available for KYTC's consideration. AASHTO MDMS is an approved national standard that KYTC could use. Like Iowa, the lead adopters (e.g., Pennsylvania, Indiana, and Kansas) updated their specifications as their practices matured with piloting. These specifications describe the agency's requirements on the type of systems that suppliers can use, data attributes that the DOT requires, internet connectivity at the job site, basis of payment for different materials, and validation of the information on the e-Ticket. The GPS truck tracking was no longer mandated in the later versions.

The agency specifications have also included clauses relating to the display of truck number for the inspectors' identification, handling of wasted quantities, managing internet outages, and on-site training requirements. Pennsylvania DOT uses a bid item "Electronic Ticketing System" that allows material suppliers to recover the costs of e-Ticketing; however, the agency plans to phase out the bid item by 2024 and make e-Ticketing incidental to the material being delivered.

Material Delivery Management System

Minnesota DOT led the development of a MDMS, an AASHTO provisional specification, to manage data associated with the delivery of material to a contract (AASHTO, 2022). Serving as a standard and industry best practice, MDMS presents a library of data attributes that allow agencies to select elements that work best for the agency. MDMS covers data attributes for e-Tickets; loading and delivery events; hauler; testing and contract administration; and independent field verification. The current version of the MDMS includes material-specific data attributes for asphalt, aggregates, concrete paving, and ready-mix concrete. The MDMS has successfully completed AASHTO's balloting process and was approved for publication.

Electronic Proof of Delivery

To create verification approaches, a DOT could consider what the current requirements for paper tickets are (e.g., weigh scale certification and on-site verification) and how other technologies, such as cameras, applications, and GPS, can be leveraged to assist with verification.

To date, field inspectors have been performing visual verification to ensure that the vehicle, for which a ticket has been issued, delivers the material to a job site. Because this process is inefficient, IOWADOT has been conducting pilots on camera-based electronic proof of delivery. Camera-based verification is 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 trucks at the plant and at the job site. This technology verifies that a truck with a specific ticket has left the plant, when arrives at the job site, and when the truck dumps the material into a material transfer vehicle or paver. The cameras capture visual proof of delivery 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 what the source document is, but 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 source documents because the tickets are created electronically with the information, transmitted, stored, and manipulated in an electronic environment, creating a chain of custody of events and a chain of alterations. FHWA enumerated various laws, statutes, 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, CFR 2013b).

MAINSTREAMING E-TICKETING

KYTC has had significant experience with e-Ticketing prior to the peer-to-peer exchange event. KYTC had leadership commitment, construction industry support, e-Construction must-haves, draft specifications, material delivery and data flow processes, and a rollout plan in place for deployment.

The peer-to-peer exchange event provided an opportunity for KYTC to share and learn from the experiences of IOWADOT, which has not only successfully implemented e-Ticketing statewide, but is also investigating several technology-assisted solutions to address the implementation challenges. As KYTC is looking forward to advance e-Ticketing with a procurement of a web portal solution, KYTC would benefit from the following best practices:

- Internet connectivity still remains a foremost challenge for e-Ticketing. Exploring technology-based alternatives and devising workflows to handle outage situations would be helpful.
- Partner with industry associations throughout implementation to keep them informed, solicit their feedback, and secure their buy-in.
- Develop data specifications and work plans to troubleshoot data-related issues.
- Prepare workflows to handle unforeseen situations, such as during internet outages, offline mode, incorrect and missing tickets, split loads and rejecting loads, etc.
- Develop business processes to verify and validate information on e-Tickets.
- Enable data integration with information systems and applications for further use.

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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
13530 Dulles Technology Drive #300
Herndon, VA 20171
suri.sadasivam@wsp.com

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