Tech Brief

U.S. Department of Transportation
Federal Highway Administration

June 2022 FHWA-HIF -24-056

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 The emergence of electronic technologies on highway construction projects has made the paper-based processes outdated, inefficient, and cumbersome.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

PUERTO RICO HIGHWAYS AND TRANSPORTATION AUTHORITY E-TICKETING PEER EXCHANGE

EDC-6 PEER-TO-PEER EXCHANGES

INTRODUCTION

The Puerto Rico Highways and Transportation Authority (PRHTA) has been modernizing its digital infrastructure to optimize the management of highway projects over their life cycles. PRHTA aims to streamline the business processes of highway project delivery through the implementation of innovative digital initiatives.

E-Ticketing is the next step in PRHTA's pathway to digital project delivery. PRHTA sought to implement e-Ticketing for asphalt paving mixtures, aggregates, and concrete in order to gain efficiencies from the digitalization of the ticketing process. The agency has been planning to conduct pilot e-Ticketing projects during the 2023 construction season. To implement a successful pilot, PRHTA consulted state departments of transportation (DOTs) that have 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 the College of Engineers and Surveyors of Puerto Rico (CIAPR) in San Juan, Puerto Rico, on June 22 and 23, 2022. The meeting included two FHWA representatives; representatives from two DOTs that had successfully implemented e-Ticketing: Delaware (DelDOT) and Pennsylvania (PennDOT) (i.e., the lead agencies); Lindy Paving, a contractor from Pennsylvania with experience in e-Ticketing; two subject matter experts from the EDC contractor's team; and participants from PRHTA, the Puerto Rico Local Technical Assistance Program (LTAP), and the local construction industry. LTAP served as the host agency with CIAPR. The meeting included a combination of presentations, panel discussions, question-and-answer sessions, and a participant survey.

IMPLEMENTATION OF E-CONSTRUCTION TECHNOLOGIES

In recent years, PRHTA has implemented a customized project management information system (PMIS), an electronic bidding system, and laboratory information management systems (IMS), and has upgraded its financial system.

PRHTA uses the customized PMIS, which is implemented on the Oracle® Unifier™ cloud-based enterprise solution, as a construction management system to administer highway projects from inception to successful completion. PRHTA has ongoing pilot projects for the integration of PMIS and laboratory information management systems. This integration also provided an opportune time for e-Ticketing pilots for pavement, concrete, and aggregates.

Through the peer-to-peer exchange, PRHTA wanted to gain knowledge from the peer agencies on the e-Ticketing implementation planning processes and its associated challenges in order to conduct successful pilots.

SUMMARY OF LEAD AGENCY PRACTICES

Representatives from PennDOT and DelDOT shared their e-Ticketing implementation experiences. These agencies implemented e-Ticketing as a step in their journey toward the digital transformation of their construction processes. While worker safety was a predominant motivating factor for adopting e-Ticketing, other factors were also addressed, including the efficiency associated with ticket digitalization in fleet management and for streamlining construction processes.

PennDOT conducted its first e-Ticketing pilot in 2017. Up to March 2020, all highway construction projects included in the first phase of pilots were from District 11. Since 2020, PennDOT expanded e-Ticketing to all districts and has completed more than 140 projects to date. The first phase of e-Ticketing pilots required the submittal of global positioning system (GPS) truck location data. Following the six-week shutdown of construction operations due to COVID-19, PennDOT conducted an assessment of how e-Ticketing can be leveraged to assist with contactless management. The agency solicited feedback from various stakeholders on their concerns, including material producers and field inspectors. The lessons learned from the earlier pilots led to key changes, including the removal of the GPS requirement, specification re-writing, and the in-house development of a web application. PennDOT also created a specification team, an IT team, and a hauling team to assist with the implementation of e-Ticketing.

DelDOT originally planned to conduct a pilot in 2017. However, funding-related challenges prevented this from occurring. After a three-year wait, DelDOT renewed its e-Ticketing implementation planning and completed the first set of pilots on asphalt paving projects in summer 2021. DelDOT adopted a commercially available off-the-shelf web application to receive tickets electronically from material producers. DelDOT connected all six asphalt producers to the web application by 2021 and made e-Ticketing a requirement on all asphalt paving projects in spring 2022. The agency has also been steadily expanding e-Ticketing to concrete, soils, and aggregates.

DelDOT did not adopt the truck GPS location data as a requirement for its e-Ticketing program as the agency was interested only in receiving the ticket data electronically, with no consideration for the fleet management solutions provided by e-Ticketing used by the contractors and material producers. By spring 2022, DelDOT had completed 13 projects and collected 12,000 tickets, and was preparing to begin 15 to 20 construction projects. To date, the agency has made progress on using digitalized tickets for the automation of construction administration processes within the Oracle Unifier environment.

Lindy Paving provided the contractor perspective on e-Ticketing. The deployment of e-Ticketing was challenging for contractors initially because of a lack of clear understanding of the scope of e-Ticketing and the DOT needs. The contractors recognized the benefits of e-Ticketing, including access to real-time ticket information and organized ticket data, and the ability to verify mix and check on projects. However, the contractors were resistant to providing GPS truck tracking data to the DOT because they were unsure how the truck tracking data would be used.

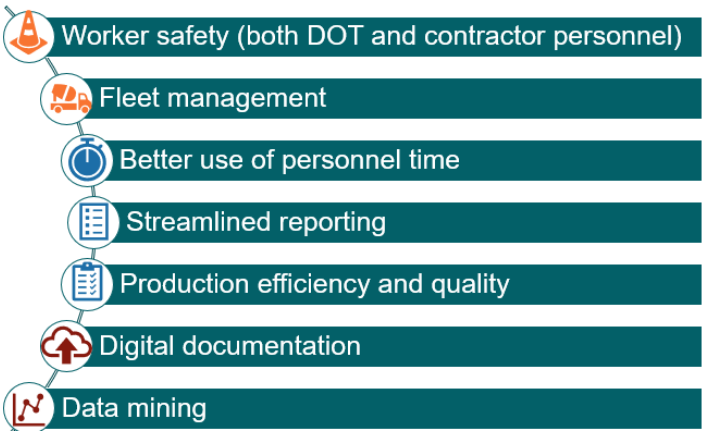
Multiple vendor products are available in the market for the contractors to choose from, and the costs of enabling an e-Ticketing solution are mostly related to the initial setup of e-Ticketing. Once the plant loadout system is set up with a vendor product, the contractors and material producers do not experience high maintenance costs. Partnering allowed both the DOT and contractors to work together to develop the e-Ticketing scope, train contractors, and overcome challenges, which eventually led to broad industry support of e-Ticketing.

MAKING A BUSINESS CASE

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

Worker safety was the foremost issue that the agencies sought to improve through e-Ticketing. The agencies also determined that digitalizing tickets would provide them the ability to manage data over the lifetime of a project. Eliminating paper tickets also allowed both the DOTs and contractors to repurpose the time inspectors spent collecting paper tickets, and eliminated the need to reconcile tickets for daily summaries. Repurposing personnel time is a significant benefit, particularly when there is a nationwide shortage in construction workforce.

Figure 1. Benefits of e-Ticketing



Source: WSP 2022

In addition, contractors have already been using e-Ticketing solutions for fleet management. Many contractors rely on third-party haulers for transporting materials from material production plants to construction jobsites. The GPS tracking allows the contractors to monitor cycle times of hauling, unauthorized truck stops, and delays. In some states, such as Pennsylvania, paper tickets may still be needed, as truck drivers are required legally to present bills of lading when stopped for law enforcement purposes.

IMPLEMENTATION PLANNING PROCESS

The implementation planning process associated with e-Ticketing consist of two major steps:

- Define the material types, technologies, vendors, procurement and pay methods, technology features, data considerations, control and verification, and connectivity.
- Consider the "Technology – People – Process" aspects of e-Ticketing.
  - *Technology*: Review the technology barriers, including mobile devices, internet connectivity, e-Construction platforms, and information systems.
  - *People*: Secure both internal and external stakeholder buy-in for e-Ticketing implementation. Conduct field inspector training before the pilots begin.
  - *Process*: Review the current process with paper tickets and devise a process of collecting and accessing the information electronically accordingly.

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 PRHTA explore several existing FHWA grant programs to fund pilot initiatives, including those from the State Transportation Innovation Council, Accelerated Innovation Deployment Demonstration Program, Accelerating Market Readiness program, and Infrastructure Investment and Jobs Act (FHWA, 2022).

PennDOT used a bid item "Electronic Ticketing System" that allows material suppliers to recover the costs of e-Ticketing. The bid item costs for e-Ticketing were higher in the earlier phase, but declined significantly over time as more contractors and material producers used e-Ticketing. The agency plans to phase out the bid item by 2024 and make e-Ticketing incidental to the material being delivered. DelDOT makes e-Ticketing incidental to the material being delivered; however, for suppliers who find the use of a commercially available off-the-shelf fleet management solution cost-prohibitive, DelDOT pays for IT-related services to enable a connection between the DOT web application and the supplier's central database of plant loadout system records.

Pilot Approach and Project Selection

Piloting is an essential stage that lays the groundwork for system-wide implementation of e-Ticketing. Not only does piloting present an opportunity for technology demonstration, it also helps identify specific problems and bottlenecks early on. Selecting candidate projects is important for a successful pilot program. It is recommended that PRHTA select the candidate projects considering the following factors: material type, project size and geographic location, contractor buy-in, locations with good internet coverage, and procurement approach. Starting small and keeping it simple are both success factors in e-Ticketing pilots.

The lead adopters considered the following factors when selecting projects for their pilots: cellular connectivity, DOT staff and contractor interest in e-Ticketing, and suppliers in the project vicinity who already had e-Ticketing solutions in their plants. To limit potential issues, PennDOT selected projects with nearby suppliers that used e-Ticketing technology and that were in locations with good cellular connectivity. DelDOT looked for asphalt projects with contractors who would be receptive to piloting e-Ticketing. Other state DOTs have selected projects using similar criteria.

Stakeholder Engagement

Early engagement with stakeholders is critical for e-Ticketing implementation. Many lead adopters reached out to both internal and external stakeholders early in the process. Through these engagements, the DOTs used effective communication strategies to keep stakeholders informed on the implementation plans, solicit their perspectives and alleviate concerns, and share successes and challenges in order to secure stakeholder buy-in. Both PennDOT and DelDOT have established a stakeholder group in their states to facilitate regular outreach and communications.

Training and Feedback

Lead adopters have leveraged training and feedback opportunities to complete their pilots successfully. The agencies collected feedback both from contractors and DOT inspectors after each pilot project.

The agencies have devised a plethora of training techniques, including vendor training program videos, vendor on-site assistance, construction manual Wikis, on-demand how-to videos and user guides, Frequently Asked Questions, as well as a dedicated person available to provide online and in-person training, and telephone and email support. The agencies have also conducted just-in-time training on a project-by-project basis and delivered presentations at events such as workshops and annual meetings, and across their state.

PRHTA conducts PMIS training for those participating in pilot projects. PRHTA has an e-learning tool available in the system, as well as videos explaining how to navigate the system. PRHTA can make use of customizations in the Oracle Unifier platform to meet its training needs and receive feedback.

TECHNOLOGY AND FIELD READINESS

E-Construction technologies are the backbone of e-Ticketing. The “must-haves” of e-Construction are:

- 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.

Use of Mobile Devices

PRHTA supplied 13 iPad Pro® devices to the inspectors for use in pilot projects for e-Construction implementation. PRHTA continually seeks feedback from construction staff on any connectivity issues within Puerto Rico and then incorporates the feedback in the specifications. The event participants discussed the following issues associated with the use of mobile devices:

- Secure support from the leadership of the agency. Every inspector will need a mobile device with internet connectivity to carry out the business functions in the field electronically. Some state DOTs have provided a mobile phone or tablet. Consultant inspectors typically carry a laptop and are allowed to be reimbursed for cellular connections.
- Secure buy-in from the DOT inspectors who are the end users of the devices. Demonstrating how mobile devices will improve their productivity would assist in securing buy-in from inspectors who are resistant to adopting new technologies.
- Develop a plan for device replacement. Mobile devices have a lifecycle of three to five years. DelDOT currently uses devices until they are broken, but plan to implement a three-to-five-year replacement cycle. Based on manufacturer software and security update practices, PennDOT has forecasted that devices would last for four years.

Internet Connectivity

Some geographical areas may have intermittent connectivity, weak cellular signals, or dead zones that might disrupt e-Ticketing operations. To mitigate internet connectivity issues, PennDOT communicates with contractors, suppliers, and the DOT staff to prepare for situations where connectivity is lost. DelDOT relies on the offline capabilities of the vendor solution to auto-populate the tickets once the mobile device is able to reconnect. Both agencies use paper tickets as the backup option when alternatives become unviable. Other agencies are exploring other alternatives, such as quick-response codes printed on paper tickets, cellular signal boosters in areas with weak cellular signals, and low-earth orbit satellite internet.

Other Pertinent Factors

Every truck load for which an e-Ticket has been generated must be accounted for in the field to ensure the delivery of that truckload to the jobsite. Many

contractors and material producers who use third-party vehicle operators for material hauling do not have control over the labeling of haul trucks for identification. Consequently, the inspectors have a significant and reoccurring challenge in associating the haul truck with the truck number on the ticket. The lead agencies require contractors to determine the means of labeling trucks using options such as license plates, truck numbers displayed on the side of trucks, and quick-response codes, and print the same on the tickets. If the trucks are not equipped with GPS tracking, the contractor is responsible for identifying the trucks at the jobsite.

Construction Specifications

PRHTA is in the process of developing a provisional specification for e-Ticketing. The key requirements of a good e-Ticketing specification include the systems that suppliers can use, the data attributes required by the DOT, internet connectivity at the jobsite, how the DOT will pay for e-Ticketing, and the validation of the information provided on the e-Ticket. As many as five samples of e-Ticketing specifications are available from the adopter states for PRHTA's consideration.

In addition to the specifications developed by lead adopters, PRHTA could also use the American Association of State Highway and Transportation Officials (AASHTO) Material Delivery Management System (MDMS) for reference. MDMS is an AASHTO provisional specification that agencies could use to manage data associated with the delivery of material to a contract (AASHTO, 2022). MDMS presents a library of data attributes for e-Tickets: loading and delivery events; hauler; testing and contract administration; and independent field verification.
PRHTA could make use of the MDMS's data attribute library to develop the data requirements for its specification. 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.

If necessary, PRHTA could consider including additional language in the specification regarding internet connectivity requirements in areas with poor or no cellular connectivity, and a pre-bid or preconstruction meeting to provide clarity.

Federal Aid Requirements and Source Documentation

Source documents record the quantities of completed work and form the basis for approving partial payments to contractors. Federal regulations do not define or specify the source document. Therefore, DOTs need to determine their source document in coordination with their FHWA Division Office based on their payments system and their recordkeeping methods. Before the introduction of e-Ticketing, paper tickets served as source documents, but image-based reproductions such as photographs and scans did not. FHWA considers e-Ticketing source documents because the tickets are created electronically with the information, and transmitted, stored, and manipulated in an electronic environment, which creates a chain of custody of events and a chain of alterations. FHWA enumerated pertinent laws, statutes, and memoranda relating to source documentation and records retention. This information is codified under Title 23 Code of Federal Regulations (CFR) § 635.123 and 2 CFR § 200.334 (CFR 2013a, CFR 2013b).

DATA MANAGEMENT

PRHTA's PMIS serves as an electronic project management system and a single source of information. The PMIS has been integrated with internal PRHTA accounting and laboratory information systems. Over 120 business processes have been integrated to date to promote standardization. PRHTA uses the PMIS to manage documents, foster collaboration, facilitate tracking, and enable audit trails.

PRHTA's PMIS (Oracle Unifier) is "mobile ready" for e-Ticketing and allows authorized PRHTA users to access information 24/7. Furthermore, PRHTA recognizes the business value of the use of e-Ticketing dashboards, reports, and integration of data within PMIS for various business functions. PRHTA also recognizes the need of implementing security protocols for both Oracle Unifier and e-Ticketing data. The agency proposes to define workflows for data management, including credentials for user access, data entry, and ticket approvals. The agency also intends to capture e-Ticketing file metadata, store e-Ticketing files in a single location, enable audit trails for tracking changes, and cross-reference actions. Oracle Unifier supports these customizations for e-Ticketing.

Similar to PRHTA, DelDOT also uses Oracle Unifier to manage the construction program. DelDOT has developed customized process in Oracle Unifier for more than 35 live business practices. In addition to creating more than 160,000 Inspector Daily Reports since 2017, DelDOT has enabled business processes for contractor payments and change orders in Unifier environment.

DelDOT has also implemented HaulHub, a commercially available off-the-shelf product, for an e-Ticketing web portal. An authorized supplier, who has received an authentication key from DelDOT, can send tickets electronically in the JavaScript Object Notation file format through the use of a web-based, industry-standard application programming interface. The web application is connected through Dell® Boomi™, which connects with on-premises applications and data (Dell, 2023). Both field inspectors and contractor personnel can access data on the vendor's cloud through an application on their mobile devices. This mobile application is housed on mobile application stores and is available to be installed on any phone or tablet. The inspectors can view the ticket in a mobile application and can accept, reject, or void the tickets and add comments.

Within HaulHub, metadata is available directly from the supplier within DOTSlip for further analysis. The portal application allows the users to create summary reports and export data to another information system. DelDOT created two business processes in Unifier Integration and Creating Ticket Package, one to collect tickets marked "delivered" and another to package tickets according to product type and other criteria.

PennDOT has also created User Acceptance Testing (UAT), an in-house web application for e-Ticketing. The UAT application went live in July 2021. Similar to DelDOT's web application, the UAT receives tickets electronically from pre-authorized suppliers through an application programming interface. The electronic data is then posted on a Microsoft Azure portal. PennDOT inspectors can access data using a mobile application and can accept, reject, or void the tickets and add comments.

PennDOT provided a demonstration of the e-Ticketing application at the event. PennDOT's e-Ticketing application has the ability to handle offline tickets. In the event of internet outage, the inspectors can enter data fields and then use a Link Ticket button to tie the entry from the paper ticket to the e-Ticket when back in cell service. The application is housed on Apple's App Store, and is therefore available to be installed on any iPhone or iPad.

Unlike PRHTA and DelDOT, PennDOT does not use Oracle Unifier. PennDOT uses a suite of in-house applications, including Engineering Construction Management Systems, Electronic Construction and Materials Management System, PennDOT Project Collaboration Center, and iPads for mobile construction. These systems are rule-based and determined by assigned roles of authorized users.

The event participants discussed the following challenges relating to data management: legal issues relating to procuring portal, data privacy and security, and identifying data requirements. Legal evaluation should be conducted as part of the procurement process. Legal issues relating to software procurement should be addressed; however, addressing such issues can be challenging without agency leadership support.

Data ownership should be transferred to the DOT once the agency receives the ticket. PRHTA could implement security protocols to preserve the integrity of the data, and if changes are needed, enable the tracking of such changes. In many agencies, paper tickets are public information that are subject to the public disclosure requirements of the state government. Bringing electronic tickets under the Sunshine laws can result in new challenges, particularly related to GPS tracking data, if collected. PRHTA could take out legally impermissible information from the tickets when the tickets are disclosed to the public.

For identifying data requirements for the ticket, two different approaches are being followed. Some agencies require only the data that are captured on paper tickets. Other agencies, recognizing opportunities with digitalization of tickets, work with their stakeholders to determine what additional data attributes can be captured on the ticket.

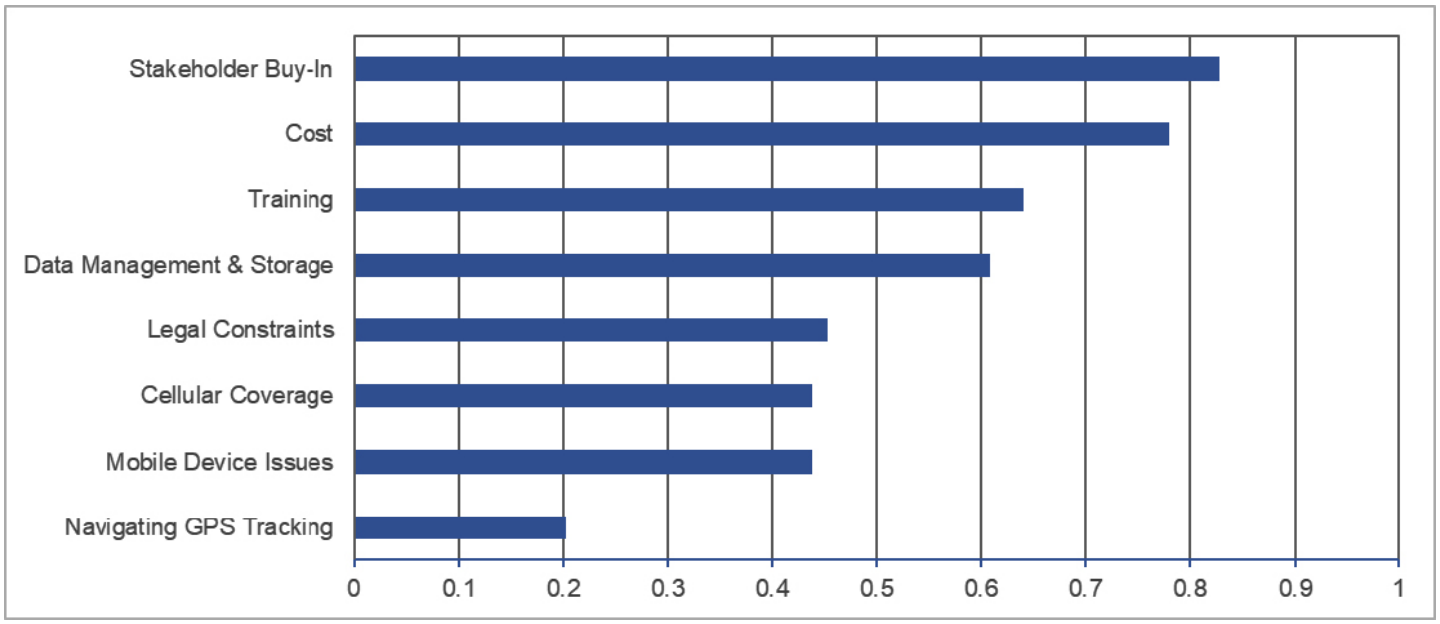
STAKEHOLDER ISSUES

PRHTA recognizes the importance of partnering with industry. PRHTA has been continuously engaging with the construction industry, including the representatives of Associated General Contractors of Puerto Rico (AGC-PR), to communicate the agency's plans, near-term activities, commitment, and timeline. The construction industry could collaborate with PRHTA by identifying opportunities and weaknesses of the actual systems, participating in pilot projects, and providing feedback and sharing lessons learned that could improve full implementation. The construction industry also recognizes the benefits of e-Ticketing. The industry is receptive to collaborating with PRHTA, such as in identifying information requirements for e-Tickets.

The real-time survey, conducted at the event, captured how the DOT and contractor participants perceived potential challenges of implementation (Figure 2 and Figure 3). The most challenging issue with e-Ticketing for PRHTA is stakeholder buy-in. The other key

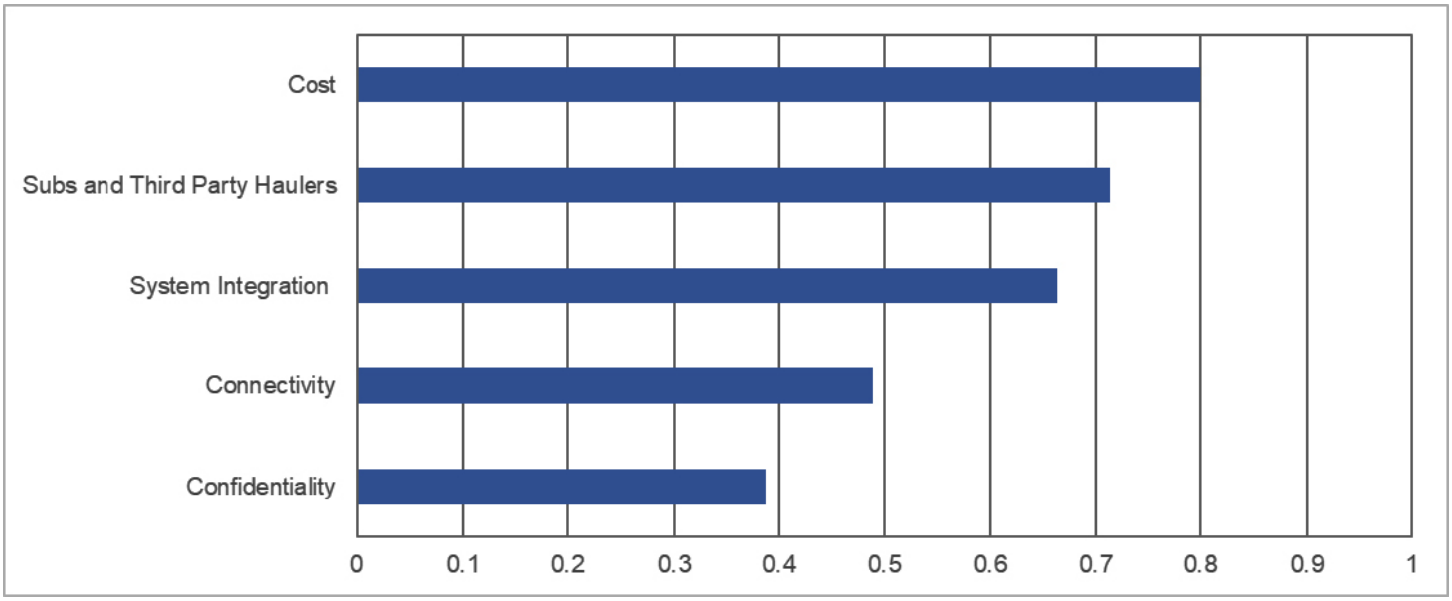
challenges for the PRHTA stakeholders included the implementation costs, training, and data storage and management. The most common challenges for contractors and suppliers were cost, subcontractors and third-party haulers, system integration, connectivity, and confidentiality (Figure 3).

Figure 2. DOT Participants' Ranking of e-Ticketing Implementation Challenges



Source: WSP 2022

Figure 3. Contractor Participants' Ranking of e-Ticketing Implementation Challenges



Source: WSP 2022

ROADMAP DEVELOPMENT

PRHTA selected three projects for its upcoming e-Ticketing pilots. The planning for pilots was underway at the time of the event. PRHTA was confident that transition to e-Ticketing would be smooth because the agency had already acquired the e-Construction "must-haves" and the inspectors already have experience with mobile devices. Furthermore, PRHTA had leadership commitment and support for its e-Ticketing efforts, and the construction industry supported the overall implementation effort.

PRHTA leveraged the peer-to-peer exchange event to facilitate further partnering with the construction industry. The participants discussed the key challenges associated with the costs of e-Ticketing and implementation needs. PRHTA was encouraged to take advantage of federal-aid program funding as the costs of enabling e-Ticketing, mobile devices, and internet connectivity at construction sites are reimbursable.

The following best practices of e-Ticketing implementation were discussed at the peer exchange:

- Secure buy-in from internal stakeholders, including the leadership, field staff, and data users.
- Dedicate staff to research/pilot/implement/manage.
- Partner with industry associations throughout the implementation process to keep them informed, solicit their feedback, and secure their buy-in. Consider establishing PRHTA/industry joint working groups to supplement implementation. Work with financially constrained small suppliers to connect their plant loadout systems to PRHTA's information systems.

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