Tech Brief

U.S. Department of Transportation
Federal Highway Administration

October 2022 **FHWA-HIF-24-067**

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 The emergence of electronic technologies on highway construction projects has made the paper-based processes outdated, inefficient, and cumbersome.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

CALIFORNIA DEPARTMENT OF TRANSPORTATION E-TICKETING PEER EXCHANGE

EDC-6 PEER-TO-PEER EXCHANGES

INTRODUCTION

The California Department of Transportation (Caltrans) has been progressing towards the implementation of e-Ticketing. The need for contactless delivery during the COVID-19 pandemic of 2019-2022 was the initial catalyst for e-Ticketing. Furthermore, e-Ticketing aligns with Caltrans' vision for e-Construction and better information management.

As of 2022, Caltrans completed 12 pilots to evaluate e-Ticketing and planned to conduct 10 additional pilots in the 2023 construction season. Caltrans deployed a web portal using two commercial off-the-shelf (COTS) products to receive e-Tickets from contractors and material producers. After the pilots are complete, Caltrans planned to deploy either a single COTS product or a non-commercial product that is accessible to all contractors and material producers.

Piloting is an essential step in Caltrans's pathway to full-scale e-Ticketing implementation. Through the pilots, Caltrans's goals are to evaluate the e-Ticketing technology, fine-tune the business processes, identify and troubleshoot unforeseen issues, and demonstrate the successes. Caltrans focused on asphalt mixtures for its current set of pilot projects, and conducted an e-Ticketing pilot with Portland Cement concrete upon a material producer's initiative.

Piloting provided Caltrans with proof of the e-Ticketing concept. The agency also received positive feedback from both field personnel and contractors. Building on the experience of pilots, Caltrans intends to take piloting forward with business process changes, such as developing specifications, evaluating the COTS portal solutions, leveraging training opportunities, and aligning e-Ticketing with larger, enterprise-level data integration efforts. To further advance with the e-Ticketing piloting, Caltrans 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 Sacramento, California, on October 18 and 19, 2022. The meeting included two representatives from FHWA, representatives from State DOTs that had implemented e-Ticketing (i.e., the lead agencies)—Indiana (INDOT), and Minnesota (MnDOT); a material producer from Iowa; two subject matter experts from the EDC contractor's team; and participants from Caltrans and the local construction industry. Caltrans served as the host agency and provided meeting room facilities. The meeting included presentations, panel discussions, questions and answers, and a participant survey.

STATE OF THE PRACTICE

E-Ticketing was first piloted by the Iowa Department of Transportation (Iowa DOT) in 2015 with asphalt mixtures, and with concrete in 2017. The safety of ticket takers is the primary reason for piloting e-Ticketing. Following the Iowa DOT pilot, many other State DOTs, including Pennsylvania, Minnesota, and Utah, piloted e-Ticketing to demonstrate the proof of concept. In the earlier phase of e-Ticketing, the State DOTs required location tracking of delivery trucks using global positioning systems (GPS). Most of the State DOTs also depended on multiple contractor-focused fleet management solutions to access e-Tickets.

Amidst the increased need for contactless ticketing because of the COVID-19 pandemic, the State DOTs' use of web portals and dropping of GPS tracking changed the e-Ticketing landscape significantly. Many State DOTs began to use an application programming interface (API) based web portal to receive tickets electronically from pre-authorized material producers who can send e-Tickets to the portal from their plants irrespective of the fleet management solutions they use.

To deploy e-Ticketing, some State DOTs, including for Pennsylvania, North Carolina, and Utah, developed a web solution using in-house resources. Other State DOTs, including Iowa and Delaware, procured COTS products for the portal. Iowa and Pennsylvania DOTs had expanded e-Ticketing to hundreds of construction projects in all geographies within their State, while the Delaware DOT had fully implemented e-Ticketing statewide for asphalt mixtures. While many earlier e-Ticketing challenges were addressed, some challenges remained, such as poor or lack of internet connectivity, lack of data standards, and on-site verification without an inspectors' physical presence.

SUMMARY OF LEAD AGENCY PRACTICES

The Indiana DOT (INDOT) conducted its first set of pilots with asphalt using a single vendor between 2015 and 2018. Since then, INDOT steadily expanded its use of e-Ticketing. INDOT adopted a COTS web portal to receive tickets from pre-authenticated vendors and a COTS mobile application for inspectors to access the tickets. After thorough testing, INDOT rolled out the web portal in 2021 to both asphalt and concrete mixtures.
The web portal can be accessed by pre-authorized material producers or e-Ticketing vendors that material producers use. In 2022, INDOT also developed a construction memorandum and special provision with e-Ticketing to allow for acceptance of e-Tickets. Besides the successful implementation of e-Ticketing, INDOT was still working on addressing the following persisting challenges: lack of cellular coverage at construction sites, lack of internet or cellular service at remote supplier plants, and getting buy-in from additional construction staff, suppliers, and contractors. INDOT planned to expand e-Ticketing to a wider user base of material producers in asphalt, concrete, and aggregate industries.

MnDOT was one of the early adopters of e-Ticketing. In addition to digitalizing the data captured at the production plant, MnDOT expanded e-Ticketing to include additional data, such as hauler data and split, partial, or rejected loads. MnDOT also leveraged its current practice of using paver-mounted thermal profiling and intelligent compaction technologies with e-Ticketing to streamline paving operations. This expanded scope, called Material Delivery Management System (MDMS), primarily served the additional purposes of quantity reconciliation, labor compliance and civil rights-related audits, and material flow rate determination. By 2022, MnDOT had completed 83 MDMS asphalt projects MnDOT was using paper tickets as the basis of payment and schedule of material control.

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 Iowa DOT in 2017 and 2018. In 2019, the supplier expanded e-Ticketing to a large concrete construction project and completed the roll-out to all plant locations by spring 2021. Manatt's plant load systems became connected with Iowa DOT's web portal.

SUMMARY OF IMPORTANT ISSUES AND KEY OBSERVATIONS

Making a Business Case

The State DOTs discussed the value that e-Ticketing would generate to all stakeholders, including for the respective DOT, material producers, and third-party haulers (Figure 1).

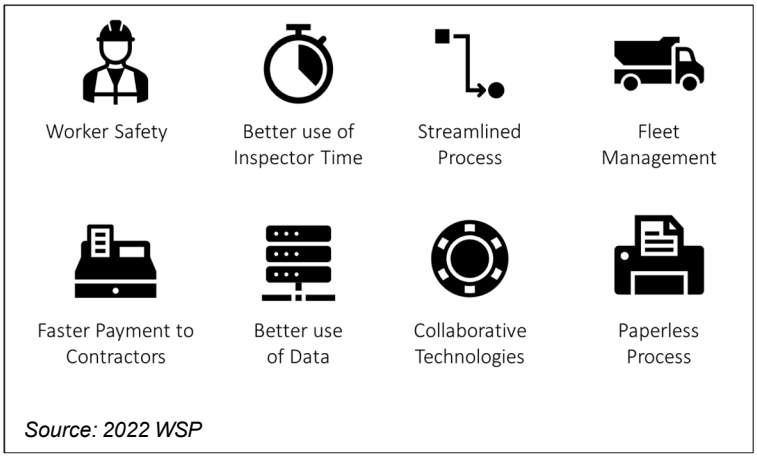
Worker safety was the foremost issue that the State DOTs sought to solve with e-Ticketing. Eliminating paper tickets also allowed State DOTs and contractors to repurpose the time inspectors spent collecting paper tickets, save costs by avoiding ticket printing and storage, and avoid reconciling tickets for daily summaries.

Beyond safety and digital project records, e-Ticketing can open many opportunities in material tracking, forensics, accountability, and future project planning.

Caltrans was interested in adopting many proven and demonstrated applications of e-Ticketing data.

The material placement locations on e-Tickets create a trail of information from material sources and mix designations to as-constructed quality characteristics.

Figure 1. Benefits of e-Ticketing



Source: 2022 WSP

Furthermore, the material placement locations can be integrated with various intelligent construction techniques, such as intelligent compaction and thermal profiling.

Contractors have been using e-Ticketing solutions for fleet management. The GPS tracking allows them to monitor cycle times of hauling, unauthorized truck stops, and delays, which in turn creates better quality and productivity gains in paving operations.

E-Ticketing also aids in auditing needs of an agency. E-Tickets can be used to monitor truck weights, and to audit prevailing wages of truck drivers and contractor payments to disadvantaged business enterprises. E-Ticketing has many big data applications, such as productivity rate determination for cost estimation and scheduling, asset condition modeling, and long-term performance evaluation of construction materials.

Paying for e-Ticketing

Caltrans relied on volunteering contractors for the first set of e-Ticketing pilots. However, to further incentivize contractors, Caltrans planned to deploy e-Ticketing through change orders for its next set of e-Ticketing pilots.

FHWA representatives indicated that both e-Ticketing and enabling internet connectivity at the construction site may be eligible for reimbursement under the Federal-aid highway program, and Federal grants may be available.

Representatives from the other State DOTs in attendance shared how they handle costs and support vendors/suppliers to use e-Ticketing on projects. MnDOT has a pay item to help with contractors' costs, while INDOT makes e-Ticketing incidental to the material. INDOT invested in deploying a web portal, which offsets the suppliers' costs of acquiring vendor solutions.

Implementation Planning

The implementation pathway entails two 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.
    - Process: Review the current process with paper tickets and accordingly devise a process of getting the information electronically.
    - Technology: Review the technology barriers, like mobile devices, internet connectivity, e-Construction platforms, and information systems. Determine the type of tickets. Assess how the tickets will be collected, tracked, stored, and used.
    - People: Secure both internal and external stakeholder buy-in for e-Ticketing implementation. Conduct training to field inspectors before the pilots begin.

The key implementation considerations are engagement with external and internal stakeholders, procurement, contract administration, and paying for e-Ticketing.

Portal Procurement

INDOT worked with the Indiana Office of Technology (IOT) to evaluate the vendor products for the web portal. Upon selecting the vendor, INDOT and IOT conducted security reviews and audits in order to approve the product for procurement. INDOT procured the vendor product through purchasing. INDOT developed software requirements and acquired the ownership of the data, while the vendor maintained the intellectual property rights for the software.

Once deployed, INDOT conducted significant testing and security auditing of the portal features and connections. INDOT had established user credentials and roles for staff so that only those assigned on the projects were given access to tickets.

INDOT worked with the Asphalt Pavement Association of Indiana subcommittee on e-Ticketing to identify volunteer participants for the e-Ticketing pilots. With the vendor's assistance, INDOT conducted training to field inspectors, contractors, and material producers. The vendor was contacted first to troubleshoot portal or data transmittal related issues. INDOT also continued to share updates with the industry, received feedback from individual contractors and material producers, and released a construction memo and a revised specification for e-Ticketing.

Field Readiness

The group discussed five factors related to field readiness for e-Ticketing:

- Mobile devices—Mobile devices in the field raise a variety of issues. Caltrans has deployed more than 1,500 mobile devices with cellular connections (tablets and smart phones) to field inspectors. The inspectors frequently faced lower battery life, sun glare, and overheating challenges with their mobile devices. The lead agencies also acknowledged the common issues with mobile devices and shared workarounds. The State DOTs and suppliers used battery packs as supplementary power sources to help inspectors use the devices through the day. Manatt's swapped tablets on trucks and in the field every few hours and also provided wired power supply. The State DOTs also used suitable color schemas to maximize contrast between the text and background of the device screen for better readability. The field inspectors also handled the overheating of tablets with workarounds.
- Contractor hardware and software—Contractors and material suppliers must have the capabilities at their plants to send e-Tickets to the portal in near real-time. Manatt's provided cellular-enabled tablets to truck drivers and quality control personnel. The tablets were also enabled to access wireless internet at the plant locations and mobile hotspots in the field. Manatt's was using a mobile device management solution to manage and support devices using Android or iOS. Manatt's also offered web browser access and remote desktop to support issues. The material producers had the ability to wipe or track devices to prevent or limit loss or theft.
- Location tracking of trucks using GPS—GPS tracking feature of trucks was not enabled in most States. Field inspectors could record the latitude and longitude of the delivery locations at the job site. Instead of GPS locations, MnDOT used geofences of the source and the job site to capture the time stamps from when a truck entered and exited a geofence, duration of travel, and waiting time for loading and unloading to calculate the cycle times of trucks.
- Cellular coverage—The State DOTs typically had selected project locations with good internet connectivity for their pilots. While internet coverage had improved throughout each Sate, dead zones still existed and were most prevalent in plants and quarry pits in remote locations. The DOTs were also testing alternatives in areas with no or intermittent cellular coverage. INDOT had an offline mode on mobile applications that inspectors could rely on in areas with intermittent cellular coverage. The e-Tickets synchronize later when the device connects to the internet. The offline mode in the e-Ticketing mobile application was effective in locations with spotty or intermittent loss in coverage. The offline mode would not be effective in dead zones. MnDOT was exploring the use of Virtual Reference Station network for data transmission to address cellular coverage issues. Other alternatives included cellular signal boosters, quick response (QR) codes, and low- earth orbit satellite internet. Iowa DOT purchased cellular signal boosters using State Transportation Innovation Council funds and anticipated deploying them in the future construction seasons. Iowa DOT also identified project locations with weaker cellular signals and notified cellular service providers in Iowa for further mitigation. North Carolina DOT used QR codes printed on paper tickets for areas with weak or poor coverage. The DOT inspectors scan the QR codes on paper tickets using a QR reader device that deciphers the ticket data embedded in the code.
- Inspector notes and data needs—For pilots, Caltrans in 2022 required the same data attributes that are printed on paper tickets. Caltrans has been eliciting feedback from the construction industry on a proposed list of data attributes on e-Tickets.
  MnDOT discussed the various data attributes that are collected for testing, contract

administration and independent field verification (Embacher, 2022). For ready-mix concrete, Manatt's followed the Iowa DOT data requirements to capture batch weights of mix ingredients from the plant batch systems and record the amount of water added to concrete during transit. Other data attributes collected at the ready-mix concrete plant include air, slump, concrete temperature, and unit weight.

Material Delivery Management System

MnDOT led the development of MDMS, an American Association of State Highway and Transportation Officials (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 from which agencies can select elements that work best for the agency. MDMS covers data attributes for e-Tickets, loading and delivery events, haulers, testing and contract administration, and independent field verification. The latest version of the MDMS included material-specific data attributes for asphalt, aggregates, concrete paving, and ready-mix concrete. AASHTO has successfully balloted MDMS and approved it for publication.

Stakeholder Issues

Caltrans has been continuously engaging with the construction industry to communicate Caltrans's plans, near-term activities, commitment, and timeline. To date, Caltrans has engaged with Associated General Contractors of California, California Asphalt Pavement Association, California Construction and Industrial Materials Association, United Contractors and Southern California Contractors Association.

Caltrans has received positive feedback from the construction industry from the first phase of 12 pilots. The 2022 peer exchange provided Caltrans an opportunity to receive feedback from the construction industry and discuss key challenges.

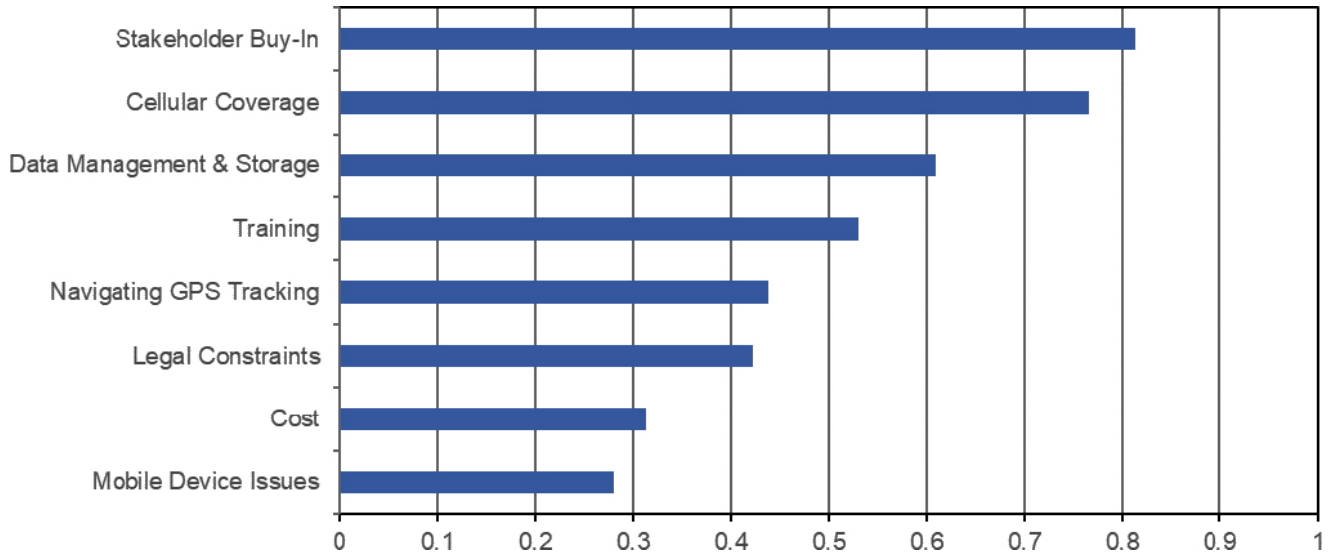
The construction industry representatives were supportive of Caltrans's overall implementation efforts. Those representatives shared their perspectives on the piloting approach, operational challenges, and data requirements. The industry representatives suggested Caltrans adopt an incremental approach to piloting by starting small, gradually scaling up with advance notice, soliciting stakeholder feedback, and keeping the stakeholders informed.

The industry representatives observed that a five-to-seven-year timeframe might be necessary to prepare for full-scale implementation. This timeframe might be necessary for both Caltrans and industry stakeholders to learn together, and address operational issues, such as delays in data transmittal, late arrival of tickets, etc. The material producers also need time to have their plant systems integrated in order to be ready for e-Ticketing. Planning for plant upgrades is challenging for material producers because of high investment needs and the lack of cost pass-through mechanisms, such as change orders and bid items. Industry stakeholders also recognized the potential of e-Ticketing data but suggested to start small with data attributes required on paper tickers and inspector notes.

The real-time survey, conducted at the peer exchange, captured how State DOT and contractor participants perceived potential challenges of implementation (Figure 2 and Figure 3). Among the State DOT participants, the top challenges were stakeholder buy-in, cellular coverage, data management and storage, and training. The top challenges for the industry participants were high costs, internet connectivity, subcontractors and third-party haulers, and resources for system integration.

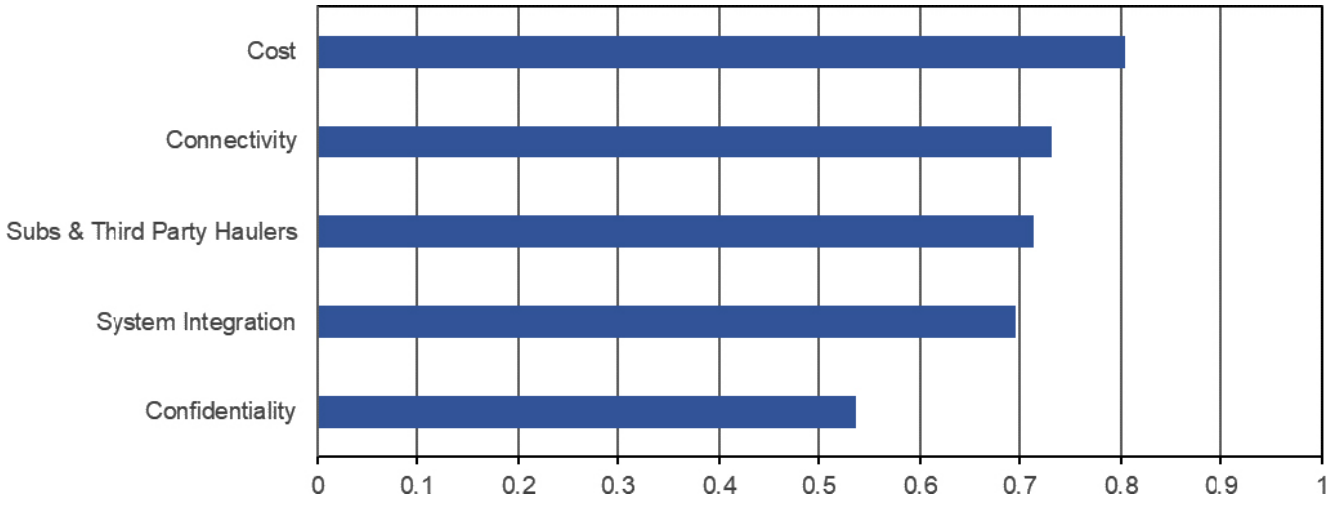
The participants were unanimous on asphalt and concrete mixtures as their preferred material types for pilots, while their responses were divided equally between bid line item and change order as the preferred method for procuring e-Tickets on construction projects.

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



Source: 2022 WSP

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



Source: 2022 WSP

Data Management

Caltrans had been moving from paper-based to digital project delivery. The implementation of three-dimensional digital models, document management systems, and Data Interchange for Materials Engineering (DIME) are examples of Caltrans's advancements in the last few years. Since July 2021, Caltrans had specified an electronic document management system (FalconDMS) mandatory on awarded projects to store and access project records electronically. FalconDMS would eventually enable an automated workflow to store e-Tickets.

Caltrans's digital as-built pilots, which were under way, would also utilize data from multiple technologies, including e-Ticketing, Unmanned Aerial Systems, and Light Detection and Ranging.

DIME is a web application, developed and maintained by Caltrans Materials Engineering & Testing Services that facilitates the submittal of construction materials sampling and testing data to an enterprise database. DIME also allows contractors to view test data of their projects. Caltrans was working on automating many of the workflows in the DIME system, such as

notifications of test results to contractors. Caltrans planned to eventually integrate e-Ticketing data with the DIME system for further use.

INDOT was using AASHTOWare SiteManager for construction management. The SiteManager data was being stored in the Indiana DOT data warehouse, which could be accessed by the Department's personnel. INDOT was also transitioning from SiteManager to AASHTOWare Project.

INDOT's e-Ticketing portal had yet to be integrated with AASHTOWare products. INDOT was coordinating with both the e-Ticketing vendor and AASHTOWare on the integration. INDOT was working on using e-Ticketing data in AASHTOWare Project and AASHTOWare Construction Materials to autofill pay quantities and material records, respectively. At the time of the peer exchange, INDOT was storing e-Ticketing data in Bentley ProjectWise as PDF files and summaries. After project awards, the contract numbers are exported to the portal for auto-filling. In the future, INDOT intended to automate data transfer from the e-Ticketing portal to the data warehouse in order to advance the integration efforts with other information systems.

MnDOT was working towards standardizing MDMS in Veta. Veta, a geo-spatially enabled software that maps and analyzes intelligent construction techniques data, was funded under two transportation pooled-fund studies. The vision of MnDOT was to use Veta as the standardized platform to host all construction data, including those from MDMS, intelligent compaction, thermal profiles, dielectric profiles, ground penetrating radar, and spot tests. The integration is achieved in Veta through mapping of material placement locations with mix design, lab test data, compaction and temperature data. This information would be accessible and readily exportable to other information systems for further use. Veta had the potential to integrate e-Ticketing, paver data, and other metrics into digital as-builts. The beta module of MDMS was anticipated to be released in June/July 2023.

Specification and Verification

Caltrans used a no-cost change order to procure e-Ticketing on the first set of pilots. The change order contained a simple language to facilitate the use of e-Ticketing on the pilot projects. Caltrans was beginning with the development of specifications for e-Ticketing.

Many examples were available for Caltrans' consideration. In particular, the lead adopters, such as Pennsylvania and Iowa DOTs, updated specifications as their practices evolved. MDMS is an AASHTO approved national standard that Caltrans could use. The key factors for a good e-Ticketing specification are related to the systems that suppliers can use, data attributes that the State DOT requires, internet connectivity at the job site, how the State DOT will pay for e-Ticketing, and validation of the information on the e-Ticket.

The State DOTs have clauses on e-Ticketing systems in their specifications. These clauses describe that State DOT's practices for approval and testing of e-Ticketing solutions, ticket latency, file formats, preconstruction meeting, system outage, and training and vendor support. Many State DOTs have dropped the GPS tracking requirement from their specifications. The State DOTs have additional clauses to handle loss of internet connectivity, such as switching to offline mode, requiring paper tickets, or developing alternative means for enabling connectivity. The basis of payment for e-Ticketing could be a lumpsum bid item or incidental to the material that is delivered.

Suggestions from the peer exchange were to determine data attributes using a structured approach. In addition to those currently required on paper tickets, Caltrans should conduct an assessment to identify data attributes that would serve various business functions, such as for forensics and asset management. Such an assessment would include consultations with both contractors and Caltrans' internal departments that are the suppliers and consumers of e-Ticketing data, respectively. Caltrans could use the library of data attributes that MDMS had developed for various materials.

To date, field inspectors had been performing visual verification to ensure that the vehicle for which a ticket was issued delivers the material at a job site. Because this process was inefficient, Iowa DOT had been conducting pilots on camera-based electronic proof of delivery. Cameras were installed at the plant and on material transfer vehicles or pavers at the job site.

Cameras were 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 job site, 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 of a truck and its cycle times. The technology drops both latitude-longitude data with cellular connectivity and time stamps.

Until e-Ticketing becomes a standard practice, Caltrans could consider cohort paper and electronic tickets to ensure that the information is captured correctly. Furthermore, MDMS offers specific data attributes for

independent verification of e-Tickets, such as verifying that correct information has been entered, or flagging incorrect or blank data entry. MDMS also includes a workflow and schedule for agency verification. MDMS also includes data attributes for contract administration. Project and funding categories can be recorded. In addition, MDMS allows for recording of split loads and rejected loads.

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 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 to be 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 representatives at the peer meeting 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, CFR 2013b).

ROADMAP DEVELOPMENT

Caltrans completed 12 e-Ticketing pilots in 2022 and planned to conduct additional pilots. Caltrans was well positioned to achieve its goal of mainstreaming e-Ticketing statewide and for various material types, and has been steadily advancing towards this goal.

Caltrans had secured leadership commitment and support as well as construction industry support for the overall implementation efforts of e-Ticketing. The Department had also acquired the “must-haves” of e-Ticketing, such as dedicated resources, portal deployment, mobile devices, document management systems, and plans for data integration.

Caltrans leveraged the peer-to-peer exchange event to further fine-tune its implementation roadmap. Participants in the peer exchange encouraged Caltrans to evaluate and update e-Ticketing implementation plans through the following:

Vision: Setting a vision for e-Ticketing will be helpful in developing short, medium, and long-term implementation plans. If the objective of e-Ticketing is beyond the elimination of paper tickets, Caltrans should identify what data it wants to collect and how it wants to use the data.

Learning from pilots: Pilots provide an excellent learning opportunity to fine-tune the business processes, identify and troubleshoot unforeseen issues, and demonstrate the successes. For pilots, selecting a diverse group of projects can be beneficial to understanding how projects with different characteristics (e.g., small versus medium and large projects or urban versus rural settings) would bring different sets of challenges. Similarly, proceeding with data attributes that Caltrans needs now and expanding the data attributes incrementally would be beneficial.

Stakeholder inputs: Partnering with the construction industry is a critical successful factor for e-Ticketing. Caltrans was encouraged to establish a task force with industry representatives to secure industry stakeholders’ buy-in, solicit their feedback, and keep them informed on implementation activities. Putting a communications plan in place was suggested. Caltrans planned to conduct internal discussions to layout vendors, select pilots, identify data needs, and plan for data usage.

Operational considerations: Caltrans was encouraged to take advantage of Federal-aid program funding as the contractor costs of e-Ticketing and internet connectivity at construction sites may be reimbursable. The Department could also use examples from other State DOTs for specifications development.

Training: Training is critical for successful implementation of lead adopters. Caltrans could leverage training opportunities to solicit user feedback, address common problems, and secure buy-in. The DOTs have devised a plethora of training techniques, such as vendor training program videos, vendor on-site assistance, construction manual Wiki, on-demand how-to videos and PDF user guides, Frequently Asked Questions, and making a dedicated person available to provide online and in-person training, and telephone and email support.

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
13530 Dulles Technology Drive #300
Herndon, VA 20171

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

U.S. Department of Transportation
Federal Highway Administration

REFERENCES

American Association of State Highway and Transportation Officials (AASHTO). 2022. Standard Specification for Material Delivery Management Systems. Draft. Last Updated November 28, 2022. Under Publication.

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, last accessed May 25, 2022.

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, last accessed May 25, 2022.

Embacher, R. 2021. *Use of Material Delivery Management System (MDMS) for Asphalt Paving Applications*. Report No. MN 2021-10. Maplewood, MN: Minnesota Department of Transportation. https://mndot.gov/research/reports/2021/202110.pdf, last accessed May 25, 2022.

Federal Highway Administration (FHWA). 2022. Center for Accelerating Innovation (webpage). https://www.fhwa.dot.gov/innovation, accessed March 6, 2023.