



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 The emergence of electronic technologies on highway construction projects has made the paper-based processes outdated, inefficient, and cumbersome.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

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION E-TICKETING PEER EXCHANGE

EDC-6 PEER-TO-PEER EXCHANGES

INTRODUCTION

North Dakota Department of Transportation (NDDOT) conducted its first e-Ticketing pilot on a paving project in the Devils Lake district in 2018. As a result of this experience, NDDOT felt that the costs of e-Ticketing deployment posed a significant barrier to continuing the pilots. After a pause, NDDOT went on to deploy e-Ticketing in two pilots in the Bismarck and Williston districts in 2021 through change orders with contractors that had used e-Ticketing on projects in a neighboring state and had purchased an e-Ticketing solution on their own.

These two pilot projects provided NDDOT with proof of the e-Ticketing concept and its business value. NDDOT received positive feedback from both field personnel and contractors. Since that time, the agency has been engaging with the stakeholders and plans to institutionalize e-Ticketing by 2026. However, several challenges to statewide adoption must be addressed: paying for e-Ticketing, communicating the business value of e-Ticketing to contractors and suppliers, overcoming internet connectivity issues, and determining the effective use cases for e-Ticketing. To get e-Ticketing right, NDDOT consulted State 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 Bismarck, North Dakota, on March 29 and 30, 2022. The meeting included two FHWA representatives; representatives from DOTs that had successfully implemented e-Ticketing (i.e., the lead agencies)—Indiana (INDOT), Iowa (IOWADOT), Minnesota (MNDOT), and North Carolina (NCDOT); two subject matter experts from the EDC contractor's team; and participants from NDDOT and the local construction industry. NDDOT served as the host agency and provided meeting room facilities. The meeting included a combination of presentations, panel discussions, questions and answers, and a participant survey.

SUMMARY OF LEAD AGENCY PRACTICES

Representatives from the four lead agencies, INDOT, IOWADOT, MNDOT, and NCDOT, shared their e-Ticketing implementation experiences. These agencies implemented e-Ticketing as a step in their journey toward digital transformation of their construction processes. While worker safety was a predominant factor that motivated these agencies to adopt e-Ticketing, other factors, including efficiency associated with digitalization of tickets and fleet management for streamlining construction processes, were important factors.

Iowa DOT conducted its first e-Ticketing pilot in 2015 with asphalt mixtures, its first concrete pilot in 2017, and since then, has scaled up significantly to complete hundreds of e-Ticketing projects with asphalt, aggregates, and concrete. Iowa DOT's practice has evolved over the years with a revised developmental specification for e-Ticketing, deploying a commercially off the shelf (COTS) web portal on a pilot basis that receives e-Ticketing data via an application programming interface (API) from authenticated suppliers, moving away from installing multiple vendor applications on the field inspectors' mobile devices to a single application; and testing a technology-driven verification process.

Indiana DOT, which conducted its first set of pilots with asphalt in 2016 and 2017, has been steadily expanding its use of e-Ticketing. Similar to Iowa, Indiana DOT adopted a COTS portal to receive tickets from pre-authenticated vendors. North Carolina has completed fewer pilots comparatively; nonetheless, NCDOT developed an in-house API-based web portal and a mobile application to receive tickets electronically. NCDOT has also developed an alternative for use in areas with low or no internet connectivity.

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 serves the additional purposes of quantity reconciliation, labor compliance and civil rights-related audits, and material flow rate determination.

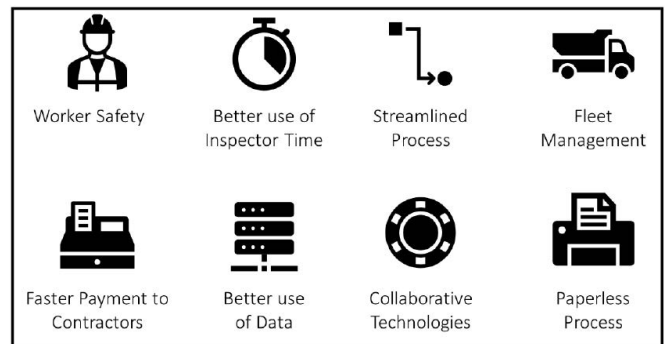
SUMMARY OF IMPORTANT ISSUES AND KEY OBSERVATIONS

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 (see figure 1).

Worker safety was the foremost problem that the agencies sought to solve with e-Ticketing. In addition, 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.

Figure 1. Benefits of e-Ticketing



Source: 2022 WSP

Eliminating paper tickets also allowed both the 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.

Paying for e-Ticketing

NDDOT initially relied on volunteering contractors to each of its pilots at no e-Ticketing-related costs to the agency; however, because of its impracticability, the agency explored the possibility of incentivizing contractors for deploying e-Ticketing through a change order or making e-Ticketing a bid item. The contractors at the peer exchange noted that making e-Ticketing incidental to the materials of interest in the early phases of implementation puts the interested contractors at a disadvantage.

In response, representatives from 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 NDDOT explore several existing FHWA grant programs, including State Transportation Innovation Council (STIC), Accelerated Innovation Deployment (AID) Demonstration Program, Accelerating Market Readiness (AMR) program, and Infrastructure Investment and Jobs Act (IIJA) to fund pilot initiatives (FHWA, 2022).

Representatives from the other agencies 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. NCDOT is focused on getting e-Ticketing data from suppliers to the DOT system and is exploring cost-sharing options for suppliers who need help enabling the connections. NCDOT is looking at the cost-sharing option for suppliers who need help, but they need to work on more details. INDOT invested in deploying a web portal, which offsets the suppliers' costs of acquiring

vendor solutions. IOWADOT used change orders on its projects to offset the e-Ticketing costs of contractors and suppliers. Change orders associated with e-Ticketing cost in the range of \$40,000 and \$50,000 in the initial phases of the pilot; however, costs declined over time to approximately \$800 to \$1,000. If suppliers cannot send tickets electronically because of cost-related challenges, IOWADOT offers them basic information technology services to enable the connection between the supplier's database that stores the ticket data and the web portal.

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. NDDOT supplied mobile devices with cellular connections (iPads® and iPhones®) to field inspectors. The inspectors frequently face 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 the workarounds. 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.
- **Contractor hardware and software requirements**—Contractors must have the capabilities at their plants to send e-Tickets to the portal in near real-time. IOWADOT requires the plant to transmit the ticket before the truck leaves the plant, with any updates transmitted within 5 minutes of a change. Some states, such as NCDOT, require a certified weighmaster seal on the e-Ticket, while IOWADOT require electronic signatures.
- **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. Instead of GPS locations, MNDOT uses geofences of the source and the job site to capture the time stamps of when a truck enters and exits a geofence, duration of travel, and waiting time for loading and unloading to calculate the cycle times of trucks.
- **Cellular coverage**—NDDOT selected project locations with good internet connectivity for its pilots. While internet coverage has improved throughout the state, dead zones still exist and are most prevalent in quarry pit locations. Other DOTs in

attendance, who also experience similar challenges, have been testing alternatives in areas with no or intermittent cellular coverage. INDOT requires an offline mode on mobile applications that inspectors can rely on in areas with intermittent cellular coverage; the e-Tickets synchronize later when the device connects to the internet. The offline mode in e-Ticketing mobile application is effective in locations with spotty or intermittent loss in coverage. The offline mode will not be effective in dead zones. NCDOT uses quick response (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. IOWADOT purchased cellular signal boosters using STIC funds and anticipates deploying them in the future construction seasons. IOWADOT also identifies project locations with weaker cellular signals and notifies cellular service providers in Iowa for further mitigation.

- **Inspector Notes and Data Needs**—NDDOT currently requires the same data attributes that are printed on paper tickets. The agency also acknowledged the benefits of capturing inspector notes on e-Tickets. MNDOT representatives discussed the various data attributes that are collected for testing and contract administration and independent field verification (Embacher, 2022).

Material Delivery Management System

MNDOT led the development of a Material Delivery Management System (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.

Stakeholder Issues

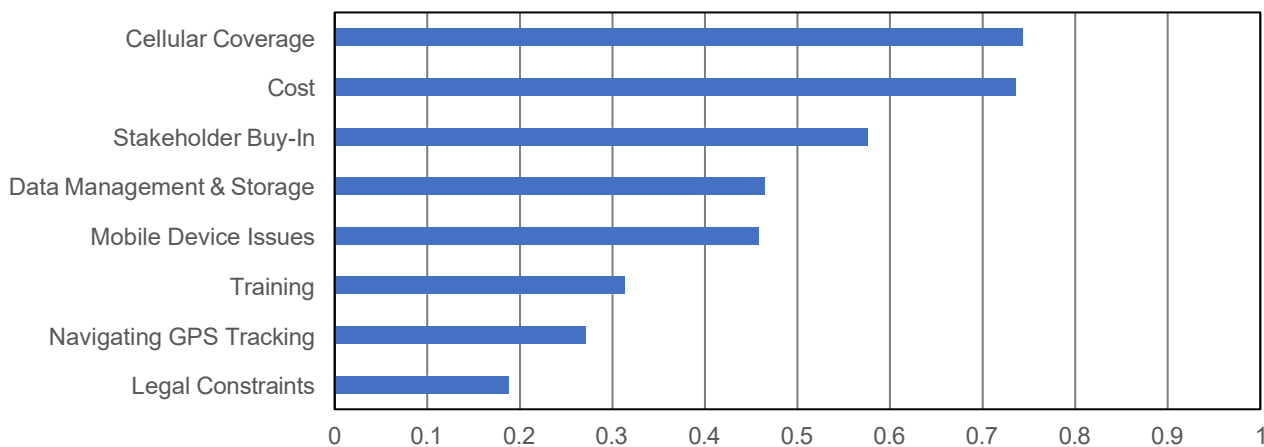
NDDOT engaged with the construction industry to communicate the agency's plans, near-term activities, commitment, and timeline. NDDOT also coordinated with its districts regularly. The key challenges related to e-Ticketing for NDDOT were industry buy-in, costs for technology upgrades, paying for e-Ticketing, and internet connectivity. Despite the overall positive reception, the contractors wanted to phase in e-Ticketing gradually.

NDDOT noted that some material suppliers are fully equipped with e-Ticketing capabilities but were concerned about potential challenges associated with interfacing with the DOT system, such as data integrity issues. Though concerned about potential costs, some material suppliers decided to implement e-Ticketing because of benefits associated with fleet management and in response to market trends. Additionally, some

material plants required significant investments in upgrading plant loadout systems to make them conducive for e-Ticketing.

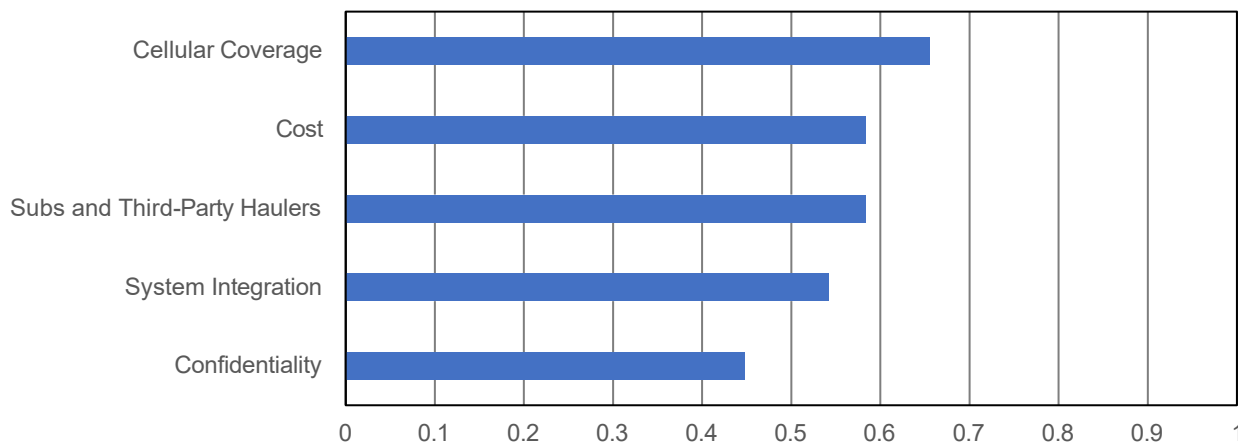
The real-time survey, conducted at the event, captured how the DOT and contractor participants perceived potential challenges of implementation (see figure 2 and figure 3). Among the challenges, the DOTs shared their experiences regarding stakeholder engagement. To manage change, MNDOT ensures that the provisions are not too restrictive and provides DOT inspectors with some flexibility to handle unplanned circumstances. IOWADOT summarized potential hurdles of e-Ticketing implementation, including standardizing the needs of the data attributes and data processes, using alternative technologies for internet connectivity, devising countermeasures to handle mobile device-related issues, connecting all suppliers, handling multiple products, and putting a consistent process in place.

Figure 2. 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

NDDOT has been advancing steadily through the implementation of various e-Construction and intelligent construction technologies. Construction Automated Record System (CARS) is the agency's construction management system, and FILENET, an application within CARS, stores all the project-specific construction records for a period of 10 years. CARS, which was built in-house in early 2000 using the old Java code, needs to be updated. NDDOT is exploring a new portal system for handling e-Tickets.

NCDOT developed an in-house e-Ticketing solution that includes a web portal with an API. The agency also enabled a cloud platform to host the data and developed a SharePoint application for inspectors to view e-Tickets, synchronize the tickets, add inspector notes, and read QR codes using their mobile devices. In the future, NCDOT will export e-Tickets from the API into Highway Construction and Materials System (HiCAMS), the agency's construction management system (NCDOT, n.d). INDOT adopted a COTS solution to receive e-Tickets from material suppliers and download them in Portable Document Format (PDF) or Comma Separated Value (CSV) format. INDOT uses several data analytics platforms. Using these platforms, INDOT plans to pull e-Ticketing data, sort, filter, and analyze pay items and quantities for various use cases. MNDOT has been developing Veta, a desktop platform that overlays geospatial data from asphalt pavement construction for viewing and analysis (MNDOT, n.d.)

Beyond piloting its current COTS web portal, IOWADOT plans to deploy a web portal to receive tickets through APIs, use a cloud service to host raw data, and an e-Ticketing handling system. In the future, e-Tickets will be integrated with DocExpress®, AASHTOWare® Project, and overlaid on a geographic information system (AASHTOWare, n.d). 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. Data can be sorted and filtered and include latitude-longitude, batch weights, slumps, inspector notes, import and export options, and audits.

Specification and Verification

NDDOT developed an e-Ticketing special provision for DOT-let contracts. The special provision requirements allow the contractor to provide the same information on a paper ticket in an electronic format. The special provision also has an optional clause for both parties.

Recognizing specification development as an evolutionary process, the agency observed the need for a comprehensive review of the special provision to ensure that all requirements are captured. The special provision will be adopted as NDDOT gains additional experience with e-Ticketing. The key requirements of a good e-Ticketing specification are related to the systems that suppliers can use, data attributes that the DOT requires, internet connectivity at the job site, how the DOT will pay for e-Ticketing, and validation of the information on the e-Ticket. While many samples of e-Ticketing specifications are available for consideration, AASHTO MDMS is an approved national standard that NDDOT could use. Furthermore, MDMS contains a library of data attributes for NDDOT's use.

IOWADOT representatives discussed their development specification for e-Ticketing (DS-15091) (IADOT, 2021). To date, field inspectors have been performing visual verification to ensure that the vehicle, for which a ticket has been issued, delivers the material at a job site. Because this process is inefficient, IOWADOT has been conducting pilots on camera-based electronic proof of delivery. Cameras are installed at the plant and on material transfer vehicles or pavers at the job site. Cameras are automatically triggered to capture the license plates of the trucks at the plant and at the job site. This technology verifies that a truck with a specific ticket has left the job site; when it gets to the job site, and when the truck dumps the material into a material transfer vehicle or paver. The cameras capture visual proof of delivery of a truck and the cycle times of a truck. The technology drops both latitude-longitude data with cellular connectivity and time stamps. However, IOWADOT noted that the application of this technology for concrete and aggregates would be challenging because there is no single dump location.

Federal Aid Requirements

Source documents record the quantities of completed work and form the basis for approving partial payments to contractors. Federal regulations do not specify 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).

ROADMAP DEVELOPMENT FOR NDDOT

As noted above, NDDOT envisions full implementation of e-Ticketing by 2026. In the near term, the agency plans to develop a special provision, generate a list of pilot projects, and make e-Ticketing fully optional in the 2023 construction season.

NDDOT is considering piloting e-Ticketing on at least one project for each of the eight districts. The initial focus is on deploying e-Ticketing for asphalt mixtures, but the agency intends to expand e-Ticketing to other materials thereafter. In terms of project selection, the DOT anticipates working with the districts to locate projects with no cellular coverage issues. NDDOT is

field-ready for e-Ticketing pilots. DOT inspectors are equipped with mobile devices; however, the data integration is contingent on the modernization of the agency's construction management system.

Noting that the contractors working across multiple states have historically made technology deployment easier, NDDOT anticipates that the contractors that are already equipped with e-Ticketing products and have worked with MNDOT would be receptive to volunteering e-Ticketing for the early pilots; however, the DOT felt the need to incentivize other contractors and material suppliers to get them on board. NDDOT will engage with internal and external stakeholders to seek their perspectives on the implementation approach and needs. NDDOT plans to communicate the agency's vision, goals, training needs, and implementation plan for e-Ticketing through industry outreach such as industry coordination meetings, conferences, and other events.

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

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KEY WORDS

e-Ticketing, peer-to-peer

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