TECH**NOTE**
E-TICKETING HANDOUT

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TABLE OF CONTENTS

WHAT IS E-TICKETING?

Electronic ticketing (e-Ticketing) is a market-ready digital innovation that automates the recording and transferring of information in real time for materials as they are moved from a plant or supplier yard to a construction site or storage facility. This paperless process uses technological solutions to create, share, track, document, and archive material information, such as quantities, sources, and delivery information, in electronic or digital format. The process typically involves the transfer of data to a server for immediate access by multiple stakeholders, via mobile devices, for material verification and real-time operational decisions. Using electronic means simplifies the handling and integration of material data into information systems for acceptance, payment, and source documentation.

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WHAT PROBLEMS DOES E-TICKETING SOLVE?

e-Construction practice highlights the drive toward paperless construction. Paper-based load delivery tickets on highway construction projects are a cumbersome and outdated practice. Collecting paper tickets from haul vehicles exposes construction inspectors and contractor personnel to safety hazards in work zones. Paper-based ticketing is a linear and resource intensive practice that entails multiple "touchpoints" for handoff. These touchpoints include recreating information from paper tickets through manual entry with little traceability and few downstream data uses. Lost or damaged tickets are not an uncommon phenomenon.

Both departments of transportation (DOTs) and the private sector spend considerable resources to produce, deliver, sort, and archive paper tickets. With the chronic shortage of inspection staff facing DOTs, the paper-based practice demands an in-person "ticket taker" to collect tickets from truck drivers, record tonnage and location, calculate yield, and report daily summaries. Allocating that "ticket taker" to higher order activities improves the overall efficiency of the inspection process.

The 2020 construction season has made the move to e-Ticketing even more relevant by increasing the need for touchless operations and expanding the amount of project information that can be accessed digitally.

BENEFITS

e-Ticketing offers a safer, faster, less resource-intensive, sustainable, and streamlined process using technology. e-Ticketing data can be transmitted in real time directly or to the cloud for access by mobile devices to enable operational decisions in real time. This information creates a "single source of truth" that can be exchanged, via an application program interface, with DOT information systems such as construction management, asset management, or financial systems for data mining purposes. e-Ticketing facilitates integration with complementary technologies, such as intelligent compaction, density meters, and thermal profilers. e-Ticketing offers a unique opportunity to collect critical quality and productivity data that is otherwise difficult to capture.

e-Ticketing saves lives, money, and time. Specifically, e-Ticketing:

- Reduces work zone risk.
- Improves data collection and prevents information loss.
- Enables data-driven decision making.
- Advances digital delivery and information management.

STATE OF THE PRACTICE

Since the first e-Ticketing pilot in 2015, the number of State DOTs adopting this technology has increased steadily. Two surveys published in 2020 by the National Cooperative Highway Research Program Synthesis 545 and the National Asphalt Pavement Association found that 24 agencies use e-Ticketing (Dadi et al. 2020; National Asphalt Pavement Association 2020). Of those 24 agencies, 13 piloted e-Ticketing prior to the 2020 construction season, and 11 agencies began using e-Ticketing during the 2020 construction season. Five additional agencies are currently preparing for or considering pilot projects. While the impetus for initiating e-Ticketing varies with each agency, most DOTs agree that availability of real-time data in a digital format and the added safety benefits offered

by e Ticketing are significant motivators. Some DOTs are also using e-Ticketing as a gateway to future enhanced integration with their construction management systems.

Iowa DOT

Iowa DOT conducted its first e-Ticketing pilot in 2015 on asphalt projects and added concrete projects in 2016 and aggregate projects in 2020 (Dadi et al. 2020). Currently, e-Ticketing is being used on more than 80 projects.

In Iowa DOT's construction projects, e-Tickets are created at the plant and include important batch information for each truck. Using a mobile device, the inspector can access this information before the truck's arrival at the project site. The inspector adds test data to the ticket via a mobile device and accepts the material delivery. The data from the project tickets can be analyzed and sorted by mix, date, or other variables. The data can also be reviewed by the geolocation of the accepted tickets. At this time, Iowa DOT is not focusing on Global Positioning System (GPS) truck tracking, but it is exploring other technologies for electronic proof of delivery. The challenges around e-Ticketing for Iowa DOT are focused on managing various e-Ticketing vendors (i.e., having inspectors using different software and workflows), working with suppliers who have outdated load-out systems, standardizing the required data, and managing the reliability of mobile access in the field.

Iowa DOT is currently working with vendors to pilot the integration of e-Ticketing data directly transferred into the American Association of State Highway and Transportation Officials' (AASHTO) software suite called AASHTOWare Project ™ (AASHTO 2021). In the future, Iowa DOT plans to create specifications for moving e-Ticketing to a standard practice for all major infrastructure projects (Wilkinson 2020).

Alabama DOT

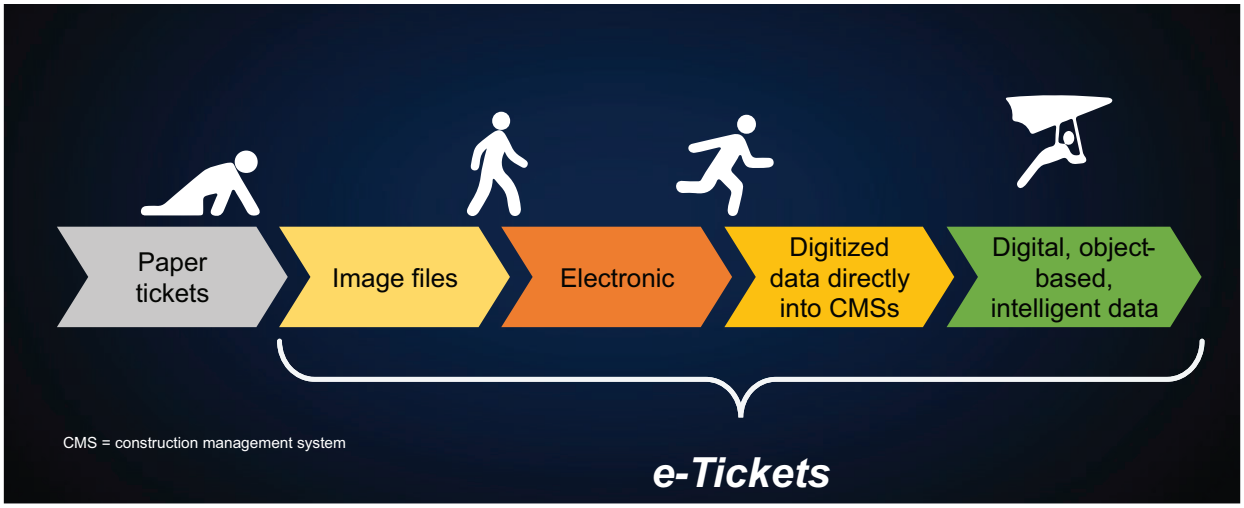
Alabama DOT (ALDOT) piloted its first e-Ticketing project in 2017 on an asphalt project (Dadi et al. 2020). As of 2020, it has used e-Ticketing on nine projects and has plans to expand to more pilots. ALDOT piloted e-Ticketing to improve reliability, quality, and efficiency of the ticketing process. Moving to e Ticketing eliminates the traditional ticket taker and reduces the number of project staff exposed to hazards around delivery trucks. According to ALDOT estimates, eliminating paper tickets could save between $4 million and $8 million per yr, or 1 to 2 percent of construction costs, which could be fed back into other projects (Powe 2020).

ALDOT initially procured mobile devices for 60 percent of its inspection staff (currently, 79 percent of inspection staff are equipped with mobile devices). The mobile devices positioned ALDOT to implement both e Ticketing and other e-Construction initiatives in a move away from paper (Powe 2020).

ALDOT has experienced the following issues with e-Ticketing:

- Having problems with Internet access in remote areas.
- Getting process buy-in from stakeholders to eliminate paper records and replacing them with digital sources.
- Getting the U.S. Department of Agriculture and industries to agree that paper can be eliminated.
- Overcoming the fear that contractors will provide ALDOT with too much data.

Figure 1. e-Ticketing developmental stages.



Source: FHWA.

ALDOT's goals around e-Ticketing include expanding pilots to get more contractor buy-in and including smaller contractors who lack sophisticated load-out systems.

Utah DOT

Utah DOT (UDOT) conducted its first e-Ticketing pilot in 2019, and 36 projects have used e Ticketing as of 2020 (Talbot and Sellars 2020). UDOT is using a solution developed in-house to pilot e-Ticketing. No new commercial e-Ticketing software has been purchased. UDOT's Feature Manipulation Engine server receives digital tickets (in JavaScript Object Notation (JSON) file format) from the supplier and sends the information to a UDOT geographic information system (GIS) database for storage. Construction inspectors can access the ticket information on their mobile devices in real time using a data gathering software application and update the ticket with additional data.

UDOT has identified several issues to resolve as it continues to pilot e-Ticketing. These issues include process logistics when the prime is not the material supplier, implications of bypassing ports of entry, and concerns in automation and scalability.

UDOT plans to develop standard operating procedures to document best practices for e Ticketing, guidelines for problem-solving, and methods around data governance and integration into construction management systems. UDOT also plans to expand e-Ticketing to concrete and aggregates (Talbot and Sellars 2020).

Pennsylvania DOT

Pennsylvania DOT (PennDOT) piloted its first e-Ticketing project in 2017 on four hot mix asphalt/warm mix asphalt paving and milling projects in Allegheny County as part of a larger ongoing e-Construction initiative (Dadi et al. 2020). These four projects were also pilots for GPS tracking of equipment using multiple vendors.

As of 2020, PennDOT has used e-Ticketing on more than 17 projects. PennDOT looked to e-Ticketing to eliminate paper tickets and the need to sort them, verify materials and tonnage, summarize tickets for contractor payments, and reduce worksite hazards for inspectors.

PennDOT is working to implement e-Ticketing statewide through a steering committee with members from the Federal Highway Administration (FHWA), highway contractors, material producers, and the hauling industry. The committee has four subteams investigating specifications, information technology solutions, haulers, and maintenance issues (Myler 2020). PennDOT's plans include:

- Implementing the newly developed statewide specifications on four to five projects in each district.
- Expanding e-Ticketing specifications to include concrete and aggregate.
- Providing maintenance material requirements for five materials (asphalt, liquid asphalt, concrete, aggregate, and salt).
- Developing strategies to address limited or no cellular or data service on construction sites.

One of PennDOT's goals is to provide a real-time data feed to engineering and construction management systems, smart data, and applications.

Minnesota DOT

Minnesota DOT (MnDOT) started piloting e-Ticketing in 2018 and has completed more than 40 projects as of 2020 (Dadi et al. 2020). MnDOT piloted e-Ticketing to improve the logistics performance of delivery trucks and initially targeted projects that were using intelligent compaction and paver-mounted thermal profilers. MnDOT focused on safer ticket collection, real-time verification of material placement, and electronic documentation of construction data. MnDOT is currently leading an AASHTO task force on developing recommendations for the standardization and integration of digital e-Ticketing data. Future efforts will be focused on the integration of e-Ticketing with the AASHTOWare Project ™ suite of applications to create an intelligent construction data management system.

PATH FORWARD

Highway agencies have used multiple pathways to adopt e-Ticketing. The various developmental stages in the evolution and advancement toward the highest maturity levels in e-Ticketing are described in the following list and illustrated in figure 1:

- Paper tickets: The traditional process is to print delivery tickets on paper. Contractor or construction inspectors collect the tickets from truck drivers (originating from the batch or supplier plant systems) when the materials are delivered at the project site. The paper tickets serve as a bill of lading for the hauler and a source document to communicate material information and quantity and provide a basis for payment. The information from the paper ticket must be manually extracted and entered into the agency's construction management systems (CMS) for further processing and applications.
- Image files: The paper tickets are converted into an image form, such as a photo, portable document format, scan, or fax, to enable electronic transmittal. Some agencies have adopted this approach to ensure contactless delivery during the 2020 construction season. The original paper

ticket is still needed to serve as the source document and must eventually be delivered to the project or retained by the contractor or supplier. Because the image files contain unstructured data, the information must still be manually extracted and entered into the agency's business information systems.

- Electronic tickets: The tickets are produced in an electronic format through an in-house developed or commercially available technology-based solution. The electronic tickets are transmitted in real time from load-out systems directly to field inspectors or through a server. The data may be compiled in comma-separated values, text, or dBASE formats and stored, queried, and used for further applications. Agencies that have implemented e-Ticketing solutions have at least achieved this developmental stage. The electronic ticket serves as a source document and must be securely stored and archived in electronic form.
- Digitalized tickets: Electronic tickets are digitalized into semi-structured data using compatible file formats, such as JSON or extensible markup language, using a standard data scheme for transmittal and exchange. The data fields are automatically extracted, transformed, and loaded via an application program interface into an agency's CMS for further applications and archived under the CMS's protocol.
- Object-based tickets: The ticket data are structured as defined elements that are grouped intelligently, organized hierarchically, and linked with other datasets using GIS or building information modeling file formats, such as shapefiles, file geodatabase, InfraGML, or IFC Alignment. The object-based ticket enforces data quality rules to validate data attribute and relationship requirements. The object-based ticket also allows some operations, such as data retrieval or updating, to be automated using a set of procedures. These procedures make the data easier to use in extensive data mining applications. Using this approach, processes such as payment can be automated based on the e-Ticket data transfer.

An agency can adopt an incremental approach by acquiring new capabilities gradually to advance through each developmental stage. Alternatively, an agency can "leapfrog" advancements, bypassing one or more of the developmental stages when it can leverage a combination of its current e-Construction technologies and market receptivity. For example, an agency can move from paper-based tickets to digitalized tickets when its information systems are aligned to receive data directly from the supplier and the contractor and can simultaneously exchange data with field inspectors through mobile devices.

An agency that is interested in e-Ticketing should consider adopting the following strategies as first steps toward implementation:

- Learn about e-Ticketing practices, benefits, and experiences with peer agencies through participation in Every Day Counts (EDC) activities such as webinars and peer exchanges.
- Communicate e-Ticketing benefits to agency leadership to gain buy-in and identify an implementation champion.
- Partner with industry groups to secure buy-in from contractors, plant producers, material suppliers, and third-party haulers.

- Develop an implementation approach. Consider an in-house developed or commercially available technology solution for electronic tickets. Also, select the material type(s) for piloting. Decide whether real-time tracking of material delivery is required or desired.
- Train leadership, internal staff, contractors, plant operators, and other stakeholders.
- Prepare special provisions or developmental specifications that outline the equipment, construction, data, transmittal, and technological requirements.
- Pilot e-Ticketing on construction projects using a project specification or contract modification.
- Ensure that the field inspectors are equipped with mobile devices to access real-time ticket information and have been properly trained.
- Ensure that the project is equipped with internet or cellular services via a tower, landline, or satellite provider. Include the use of wireless networking technology hotspots as needed. Ensure access to internet connectivity for data transmission at the project location in rural areas, when needed, by using wired or wireless technology services via cellular, antenna-based fixed wireless, cables, fiber optic lines, digital subscriber lines, and satellites.
- Investigate the use of e-Ticketing information in agency operations. This FHWA EDC Phase 6 (EDC-6) initiative will provide technical support and assistance to highway agency practitioners and industry stakeholders through webinars, peer exchanges, technical literature, informational videos, and vendor and data standards forums (Federal Highway Administration 2021).

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