Tech Brief

U.S. Department of Transportation
Federal Highway Administration

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 The emergence of electronic technologies on highway construction projects has made the paper-based processes outdated, inefficient, and cumbersome.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

VIRGINIA DEPARTMENT OF TRANSPORTATION E-TICKETING PEER EXCHANGE

EDC-6 PEER-TO-PEER EXCHANGES

INTRODUCTION

E-Ticketing is not a new technology to Virginia Department of Transportation (VDOT). The agency has had experience in using the contractors' e-Ticketing products on its paving projects. VDOT permitted the use of electronic tickets as a substitute for printed paper tickets through its 2019 e-Ticketing special provision "SP109-000130-00." Recognizing the challenges associated with using a plethora of contractor-subscribed e-Ticketing products available in the market, VDOT decided to adopt a web-based portal that offers a single-point solution to receive material-delivery tickets from contractors and material producers irrespective of the commercial products they use.

VDOT initiated a Request for Quote (RFQ) project to procure a commercially-off-the-shelf (COTS) solution for the e-Ticketing portal. While piloting of the portal was delayed because of the procurement challenges, VDOT adopted a systematic approach to implementing e-Ticketing. The agency has developed a vision, established goals, and created an implementation plan for e-Ticketing. To further refine the approach to implementation, VDOT consulted state departments of transportation (DOT) 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 Richmond, Virginia, on November 1 and 2, 2022. The meeting included the following representatives from FHWA and state DOTs that had successfully implemented e-Ticketing (i.e., the lead agencies): Delaware (DelDOT), Iowa (IOWADOT), and Pennsylvania (PennDOT); three subject matter experts from the EDC contractor's team; and participants from VDOT and the local construction industry. VDOT was the host and provided meeting rooms. The meeting included presentations, panel discussions, question and answer sessions, and a participant survey.

VDOT's E-TICKETING STATE OF PLAY

VDOT has established a broader vision for e-Ticketing. Beyond the operationalization of paperless process for tickets, VDOT seeks to make e-Ticketing data-centric and to adopt positive material delivery – in the far future – where the agency envisions an alternative to VDOT personnel being required on-site to receive material and using some other means of real-time visual validation for material delivery at construction sites. The agency envisions positive material delivery where no VDOT personnel is needed on-site to receive, accept, and validate material delivery at construction sites.

VDOT's Vision for e-Ticketing:

Develop a standardized, data-centric, e-Ticketing solution that is web enabled, cloud hosted and accommodates all material types that can be acted upon while out in the field, regardless of internet connectivity [wifi or cellular] and that enables material providers to use any software they choose; initially including the submission of .pdf tickets.

To achieve this vision, VDOT has set three major goals for its phased implementation approach:

1. Pilot e-Ticketing using a web portal and rollout statewide for three materials: asphalt mixtures, portland cement concrete, and aggregates.
2. Use the e-Ticketing data effectively by exporting them from a data repository to DOT information systems.
3. Achieve positive material delivery in the next five years.

VDOT has made the statewide rollout of the e-Ticketing web portal as its first major goal of implementation. The agency is waiting for the completion of the procurement process to initiate the pilot program. The original time for procuring the web portal was spring 2022 as VDOT released the RFQ in winter of 2021-22 and selected a vendor. However, the piloting was paused because of challenges associated with Virginia's procurement laws. The procurement for the pilot program has been completed. As of April 2023, the procurement timeline for the full program is currently uncertain.

In the interim, VDOT has been concurrently progressing other facets of the implementation process. The software requirements for the web portal and the RFP preparation are complete. VDOT's draft e-Ticketing specification is being reviewed internally. The agency has released a preliminary schedule for the rollout (Table 1).

Table 1. VDOT Preliminary Rollout Schedule

# of Materials Supplied	If Supplier Name Starts With	Example Months
1 material	A-F G-P Q-Z	November/Dec December/Jan January/Feb
2 materials	A-Z	October
3 or more materials	A-Z	September

VDOT has completed the software evaluation of the COTS product in accordance with Virginia's laws. Enterprise Cloud Oversight Service (ECOS)—a Virginia government regulation that evaluates security and management of cloud-based services—conducted a security assessment on the e-Ticketing portal solution before procurement.

To facilitate rollout, VDOT has been conducting stakeholder engagement. In coordination with the vendor, VDOT has identified logistics and workflows for enabling connections between the plant loadout systems and the web portal. VDOT has also developed checklists for the VDOT project team and suppliers. VDOT seeks to pilot four projects per district, and preferably for multiple materials. The agency is soliciting candidate projects from the agency personnel for these pilots.

SUMMARY OF LEAD AGENCY PRACTICES

Representatives from the three lead agencies—DelDOT, IOWADOT, and PennDOT—shared their e-Ticketing implementation experiences. These agencies implemented e-Ticketing as a step in their journey toward digital transformation of their construction processes.

DelDOT originally planned on conducting a pilot in 2017, but it did not happen because of funding related challenges. After a three-year wait, DelDOT renewed the implementation planning of e-Ticketing and completed the first set of pilots on asphalt paving projects in summer 2021. DelDOT adopted a COTS web application to receive tickets electronically from material producers. DelDOT connected many 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.

Since the onset of implementation planning, DelDOT decided not to make the Global Positioning System

(GPS) truck location data a requirement for e-Ticketing. The agency was interested only in receiving the ticket data electronically without any consideration to the fleet management solutions that the contractors and material producers use. DelDOT engaged both internal and external stakeholders. The DelDOT e-Ticketing team conducted ad hoc meetings with the leadership. DelDOT also held bi-monthly meetings with the Delaware Contractor's Association and ad hoc meetings with the Delaware Asphalt Pavement Association.

By 2022, DelDOT completed 32 projects and collected over 20,000 tickets for asphalt mix delivery. DelDOT rolled out an automated workflow for payment processing using digitalized tickets in Oracle® Unifier™, the agency's cloud-based enterprise platform for construction management.

IOWADOT 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. IOWADOT's practice has evolved with a revised developmental specification for e-Ticketing, deploying a 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. As of 2022, IOWADOT has 100 contracts and has connected 25 vendors to the portal. The agency intends to deploy e-Ticketing in 200 construction projects in 2023.

PennDOT conducted its first e-Ticketing pilot in 2017. The first phase of pilots included approximately projects all in District 11 until March 2020. Since then, 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 GPS truck location data. Following the six-week shutdown of construction operations caused by the COVID-19 pandemic, PennDOT conducted an assessment on how e-Ticketing can be leveraged to assist with contactless management. The agency solicited feedback from various stakeholders (from material producers to field inspectors) on their concerns. The lessons learned from the earlier pilots led to key changes, including the removal of the GPS requirement and the re-writing of specifications.

PennDOT's homegrown e-Ticketing web application, which was developed to accept e-Tickets via an API and make them available to inspectors in the field through

mobile applications, went live on July 1, 2021. PennDOT also created three teams—a specification team, an IT team, and a hauling team—to assist with implementation. PennDOT allows the contractors to price their e-Ticketing expenses using a lump sum bid item to incentivize them. As the e-Ticketing program expanded, the bid prices rapidly came down to as low as $1.00. PennDOT plans to make it incidental to the material delivered in 2024.

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 (Figure 1).

Figure 1. Benefits of e-Ticketing

Source: 2022 WSP

Worker safety was the foremost problem that the agencies sought to solve with e-Ticketing. The agencies that digitalize tickets would provide them with the ability to manage data for the lifetime of a project. Eliminating paper tickets also allowed both the DOTs and contractors to repurpose the time that inspectors spent collecting paper tickets and to avoid reconciling tickets for daily summaries. Repurposing of the personnel time is a significant benefit particularly when there is a nationwide shortage in construction workforce.

In addition, contractors have 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.

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

Field Readiness

VDOT is field-ready to deploy e-Ticketing in its pilot projects. The group discussed four factors related to field readiness for e-Ticketing:

- Mobile devices and software requirements—VDOT has rolled out Apple® iPads to all inspectors. VDOT inspectors use their iPads and PlanGrid to prepare inspection reports, collect field data, and collaborate with others. Like Virginia, IOWADOT inspectors use Apple® iPhone SE and cellular-enabled iPads in the field. IOWADOT is exploring a transition from iOS devices to Microsoft® Surface tablets.

- Cellular coverage—Though available in many areas, cellular coverage can be erratic in others. Lack of internet connectivity at some plant and quarry locations is also a concern; however, the extent of this problem is unknown. VDOT also intends to use the offline capabilities of the e-Ticketing mobile application when required in areas with erratic coverage. Both DelDOT and PennDOT use an offline mode where internet is erratic. To address internet connectivity, IOWADOT contacts the districts to screen for dead zones on upcoming projects. This prescreening will help IOWADOT prepare for such scenarios. The agency will also contact cellular service providers for possible fixes. IOWADOT is also piloting the use of cell signal boosters with the aid of State Transportation Innovation Councils' funds. VDOT also plans to explore the use of cellular signal boosters.

- Inspector's Handling of Tickets—While the acceptance of tickets under normal operating conditions is straightforward, handling unanticipated situations, such as incorrect tickets and internet outage, need attention. When an incorrect ticket is accepted, the inspector can withdraw the ticket and communicate with the contractor on the status of the ticket. Geotagging also helps with the inspector's decision. When connectivity becomes erratic, the inspector utilizes the offline mode which turns on

automatically, verifies the arrival of a truck (including truck number and time stamp) on the mobile device. Once the connectivity returns, the truck number and time stamp are correlated with the electronic ticket. Most vendor solutions send out notifications to the DOTs on the status of transactions. The project engineers should have the ability to ask for or switch to paper tickets when necessary.

- Training—The lead adopters have developed a plethora of training products, including training guides, construction manual Wikis, on-demand how-to videos, and portable document format (PDF) user guides and Frequently Asked Questions. These agencies also conduct just-in-time training on a project-by-project basis. IOWADOT had a dedicated person available to provide online and in-person training, and telephone and email support.

Stakeholder Issues

VDOT has been partnering with industry organizations, including Virginia Transportation Construction Alliance and Virginia Asphalt Association to advance the implementation of e-Ticketing. VDOT has forged strong relationship with the construction industry through an e-Ticketing task force and statewide cooperative meetings with asphalt and aggregate associations as well as contractors and suppliers. VDOT has been speaking at various association meetings to communicate the implementation plans with the industry. Per VDOT, the key communication challenges were to ensure consistent and accurate messaging about the change to the industry.

The construction industry provided overall support to VDOT's implementation activities. Through Virginia Transportation Construction Alliance and Virginia Asphalt Association, the industry can contact approximately 90 percent of the contractors and material producers in Virginia. The construction industry desired to get all the contractors and material producers to transition to e-Ticketing. The key challenges for the construction industry are weak or no internet connectivity and the need for consistency in implementation.

Chemung Contracting, a highway construction contractor and asphalt producer, has been using e-Ticketing pilot since 2015. The e-Ticketing vendor provided training to both Chemung and VDOT team. While the contractor has become paperless with e-Ticketing adoption, some concerns related to data usage and security were noted.

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). Weak or lack of cellular connectivity was a top ranked challenge for both VDOT and industry participants. Other top challenges include data management and storage and legal constraints for DOT participants, and third-party haulers and system integration for the industry participants.

Figure 2. DOT Participants' Ranking of Implementation Challenges
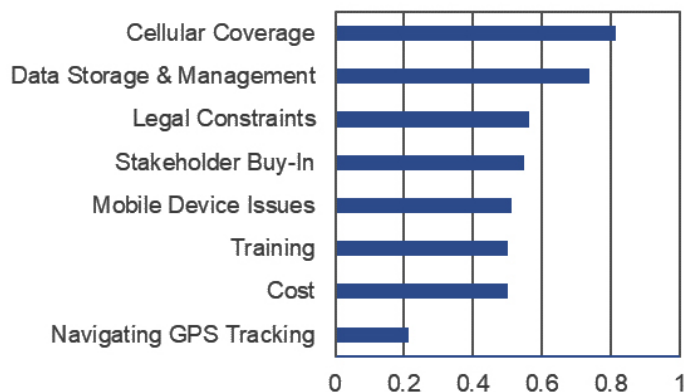
Source: WSP 2022

**Figure 3. Contractor Participants' Ranking of Challenges**
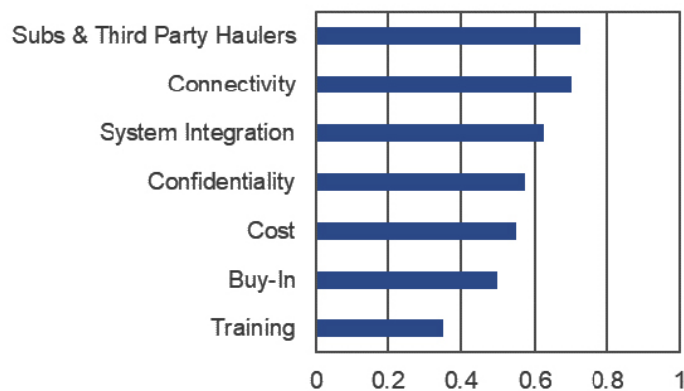
Source: WSP 2022

Data Management

VDOT's immediate goal is to deploy an industry-standard API-based web portal and a secure cloud to receive and hosting e-Ticketing data. As part of phase two of the e-Ticketing initiative, the data will be shared across software systems within the agency, such as AASHTOWare® Project™, for various applications. VDOT has laid out the material delivery (see Figure 4), data requirements, and data flow using process

diagrams to communicate how the data will be transmitted and managed.

VDOT has also laid out the requirements of the vendor product. The software vendor is required to provide an API-enabled web portal and data backup services. Once received, the agency will have the full ownership of the ticket data in hosted repository. VDOT also requires full and complete access to all data. The agency requires the software vendor to maintain the cloud hosting the data with an uptime of 99.5 percent. Maintaining a list of such requirements and related risks is a good procurement practice.

PennDOT has deployed User Acceptance Testing, an API-based web application developed in-house, for the e-Ticketing portal. The User Acceptance Testing receives tickets electronically from pre-authorized suppliers through an API, which are then posted on a Microsoft Azure portal. The e-Ticketing data will feed into the applications automatically to assist inspectors in simplifying data entry. To date, PennDOT has four vendors connected to its system for asphalt and aggregates, three vendors in progress for asphalt, aggregates, and concretes, and is planning to include additional vendors.

Figure 3. VDOT Process Flow Diagram of Material Ticketing Process
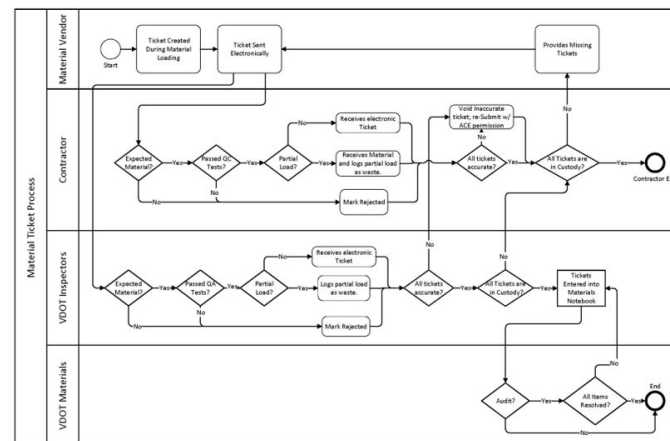
PennDOT has been developing mobile applications in-house since 2013 as a part of its digitization goal. Using the mobile application developed for e-Ticketing, PennDOT inspectors can access, accept, reject, or void the tickets and add comments. The application is housed on Apple's App Store, available to be installed on any iPhone or iPad.

PennDOT's e-construction initiative also involves many enterprise systems and applications, including Engineering and Construction Management System

(ECMS), Construction Documentation System, PennDOT Project Collaboration Center, Electronic Construction and Materials Management System (eCAMMS), and Mobile Construction. The agency has been linking several of its legacy and new systems. PennDOT is working on integrating e-Ticketing data with ECMS and eCAMMS systems.

DelDOT has deployed an API-based COTS product for an e-Ticketing web portal. An authorized supplier, who received an authentication key from DelDOT, can send tickets electronically, in the JavaScript Object Notation file format, through the API. The web application is connected with a cloud through Dell® Boomi™ that 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 Apple's App Store and is available to be installed on any iPhone or iPad. The inspectors can see the ticket in a mobile application and can accept, reject, or void the tickets and add comments.

DelDOT also uses Oracle® Unifier to manage the construction program with more than 160,000 Inspector Daily Reports created since 2017. DelDOT has also used Unifier to enable business processes for contractor payments and change orders. This business process gathers delivered tickets, checks for spilt tickets, prepares ticket packages, and creates summaries of batch tickets by pay items and non-pay items along with their corresponding quantities for payment processing. DelDOT's future plans include receiving automatic yield checks that use pavement data captured by pavers and appending quality test results with ticket data.

Beyond piloting its current COTS web portal, IOWADOT is procuring a web portal through an RFP process. In the future, e-Tickets will be integrated with DocExpress® and AASHTOWare® Project, and overlaid via a GIS (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 comma separated values (CSV) format and summarizes all data attributes on e-Tickets. IOWADOT also exports e-Ticketing to OnStation, a digital stationing application, that allows users to pinpoint the exact location using station coordinates where each load of asphalt is placed on a jobsite. The agency also exports e-Ticketing to a proprietary geographic information system for further applications.

Specification and Verification

VDOT has developed a draft specification for e-Ticketing. The draft specification addresses core requirements of e-Ticketing: system-related (including file format, uptime and latency requirements, data requirements, scale, and weigh-person requirements for validation), countermeasures during poor GPS satellite or cellular coverage, and basis of payment. The draft specification also includes technical requirements for data exchange between the material producer and the DOT. The draft specification describes requirements for each data attribute to ensure clarity, completeness, and consistency. See Table 2 for sample data requirements in the draft specification.

Table 2. VDOT Proposed Sample Data Requirements in Draft Specification

Reference Field No.	Description	Examples	Data Type	Required
1	Ticket Number	5126349, 101R, 539-19	String	Yes
2	Contract Number	T202011001	String	No
3	UPC Number	123456	String	Yes

IOWADOT representative discussed their development specification for e-Ticketing (DS-15091) (IOWADOT, 2021). The developmental specification focused on the material of interest, listed the required data attributes by material type, and described the rules for transferring information. IOWADOT's specification required a 5-minute latency for delivery, considering the time an API requires to receive a ticket and deliver the tickets in batches. When developing a specification, an agency should consider ticket handling during erratic internet connectivity, instructions for contractors, and importance of consistent project numbering.

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

To date, field inspectors have been performing visual verification to ensure that the vehicle (for which a ticket has been issued) delivers the material at a job site. Because this process is inefficient, IOWADOT has been conducting pilots on camera-based electronic proof of delivery. Camera-based verification is an alternative to GPS-based proof of delivery

Cameras are installed at the plant and on material transfer vehicles or pavers at the job site. Cameras are automatically triggered to capture the license plates of the trucks at the plant and at the job site. This technology verifies that a truck with a specific ticket has left the plant, 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 the source document; however, 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, and then transmitted, stored, and manipulated in an electronic environment, creating a chain of custody of events and a chain of alterations. FHWA 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 FOR VDOT

VDOT is waiting for the procurement to initiate the pilot program. Overall, VDOT is well prepared with a clear vision and systematic implementation approach in place to achieve its first major goal of statewide rollout of e-Ticketing.

VDOT has the leadership commitment, construction industry support, e-Construction must-haves, draft specifications, material delivery and data flow processes, and rollout plan in place for deployment. VDOT seeks to pilot at least four projects per district, and for multiple materials.

VDOT leveraged the peer-to-peer exchange event to further its partnering with the construction industry and refine the implementation plan. VDOT conducted a roundtable discussion with both internal and external stakeholders to discuss the success factors, opportunities, and challenges of e-Ticketing implementation.

The success factors for e-Ticketing implementation are securing stakeholder buy-in, putting robust business practices in place, addressing connectivity issues, training and communicating success, and making e-Ticketing a standard practice. The following key best practices that shape the implementation plan were discussed:

- **Piloting:** Use piloting as a learning opportunity to identify unanticipated issues, working through them, and thereby, fine-tuning the business processes. VDOT was recommended to adopt an incremental approach to implementation by starting small with basic requirements and gradually scaling up, making training available, and devising a feedback loop for pilot projects. This incremental approach would help VDOT to find successes in the beginning and to work around the challenges gradually.

- **Business Process:** Be prepared with clear workflows to handle unforeseen situations (such as eliminating redundancies, finding alternatives during internet outage, ticket acceptance with offline mode, incorrect and missing tickets, split loads and rejecting loads, and on-site validation of delivery), ensuring that the inspectors are adequately trained to handle normal operations and contingencies.

- **Stakeholder Outreach and Communications:** Reach out to all approved contractors and suppliers through industry associations and district personnel to the extent possible. The district personnel, who inspect all approved plants, could complement the outreach by the industry associations. VDOT could also continue the outreach through written communication from State Construction and Material Engineers, District Construction and Maintenance Engineer meetings, inspector conferences, Mid Atlantic Asphalt Expo, and other forums.

  Developing a stakeholder outreach and communication plan would aid in achieving effective engagement with the external stakeholders. In addition to continuing the current outreach activities, having a dedicated resource in place, as a DOT primary point of contact, would ensure continued communications to the industry and for troubleshooting, resolving, and avoiding project-related issues. Communicating the success of pilots plays an important role in securing broader stakeholder buy-in and motivating other suppliers to adopt e-Ticketing.

U.S. Department of Transportation
Federal Highway Administration

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