Technology Brief

# e-Construction and Partnering: *A Vision for the Future*



## Peer-to-Peer Exchange

## *Delaware, Michigan, and Utah Departments of Transportation; Kentucky Transportation Cabinet; Ohio Facilities Construction Commission; and New York State Thruway Authority*

**Dover, Delaware**
March 5–6, 2019

U.S. Department of Transportation
**Federal Highway Administration**

On-Ramp to Innovation
every day counts

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# Background

The Delaware Department of Transportation (DelDOT) recently began implementing a construction management system to move away from aging, custom-developed applications. DelDOT has also established a statewide unmanned aircraft systems (UAS) program. Though the agency has a robust technology deployment program, there is a desire to collaborate with peers to share and learn effective practices. DelDOT hosted a 2-day, face-to-face e-Construction and Partnering (eCP) peer exchange to discuss topics related to commercial off-the-shelf (COTS) construction management software, e-bidding and digital signatures, e-ticketing, and UAS implementation ideas. Representatives from the Kentucky Transportation Cabinet (KYTC), supported by the University of Kentucky; the Michigan Department of Transportation (MDOT); the Utah Department of Transportation (UDOT); the Ohio Facilities Construction Commission (OFCC); and the New York State Thruway Authority (NYSTA) participated.

The Federal Highway Administration (FHWA) sponsored the eCP peer exchange, which was held March 5–6, 2019, in Dover, Delaware, as part of round four of the Every Day Counts (EDC-4) technical assistance program. FHWA staff from the Delaware Division and the Resource Center were present. Table 1 showcases the different technology solutions used by each agency represented.

*Table 1. e-Construction technologies at participant organizations.*

| | DelDOT | KYTC | MDOT | UDOT | OFCC | NYSTA |
|---|---|---|---|---|---|---|
| **Construction Management System** | Custom suite of applications<br>Oracle® Primavera Unifier | AASHTOWare® | AASHTOWare® | AASHTOWare® | Oracle® Primavera Unifier | Custom suite of applications<br>Oracle® Primavera Unifier (implementing) |
| **e-Bidding** | AASHTOWare® Project Expedite™ | Info Tech® Bid Express® | Info Tech® Bid Express®<br>QUADS[1] | Custom | Info Tech® Bid Express® | AASHTOWare® Trns•Port® |
| **e-Signature** | None | None | DocuSign® | DocuSign® | DocuSign® | None |
| **e-Ticketing** | Pilot planned | Pilot underway: Earthwave Technologies® Fleetwatcher™ | None | Pilot planned | None (facility/buildings-focused) | None |
| **UAS efforts** | Informal program under Transportation Management Center | Ad hoc; no formal program | Ad hoc; no formal program | Formal committee and operational structure | None | None |

[1] Quality Assurance Database System

# Delaware DOT e-Construction Implementation Approach

## Strategy and History

DelDOT oversees nearly all roadways in the State, including local roads. It is responsible for approximately 1,600 bridges and about 13,000 lane miles of highway. The agency has about 2,800 employees, with a total operating budget of nearly $1 billion. Typically, DelDOT awards between 40 and 70 construction contracts for roadway projects each year.

Before e-Construction, DelDOT construction staff carried paper plans, with copies made at the agency's central office. Shrinking budgets and workforce retention challenges accelerated the agency's plan to implement new innovations. In 2014, DelDOT drafted and approved its e-Construction charter, which was formalized the following year. The agency then used FHWA State Transportation Innovation Council Incentive funds to help establish and expand its e-Construction program.

Implementation of SharePoint® was DelDOT's first e-Construction initiative for document management; however, system and website access issues and inconsistent folder structures created challenges for DelDOT staff and contractors that required modifications. In the fall of 2015, DelDOT started evaluating mobile devices through a pilot effort. The pilot focused first on familiarizing construction staff with the basics of using the mobile devices before installing the specialized software applications.

Staff were trained on the basic functions of operating the device, such as using a web browser, downloading apps, and navigating the out-of-the-box interface. After staff became familiar with and were encouraged to use the devices, they were then loaded with spreadsheet forms for collecting data in the field. DelDOT experienced an adoption rate of approximately 40 percent for the devices in the first year. However, because the Field Data Collection program used to document field information was not mobile-enabled, data entry was duplicated once staff returned to the office.

DelDOT's Field Data Collection program is a custom-developed application behind the agency's firewall that collects inspector daily reports (IDRs) and links to the agency's payment system. DelDOT's other in-house developed applications, which reside behind the security firewall, include the Project Payment Tracking program and the Funds Allocated for Capital Transportation System (FACTS) program. FACTS receives data from Oracle® Primavera P6 and Project Payment Tracking to evaluate fund allocation for all projects. These systems were outdated and maintained by a single DelDOT staff member, which underscored the urgency and need within the agency to deploy a more sustainable software solution. As a result, DelDOT initiated procurement for an enterprise construction management solution, ultimately selecting Oracle® Primavera Unifier in 2015. Figure 1 illustrates DelDOT's transition from its legacy applications to the Primavera Unifier program.

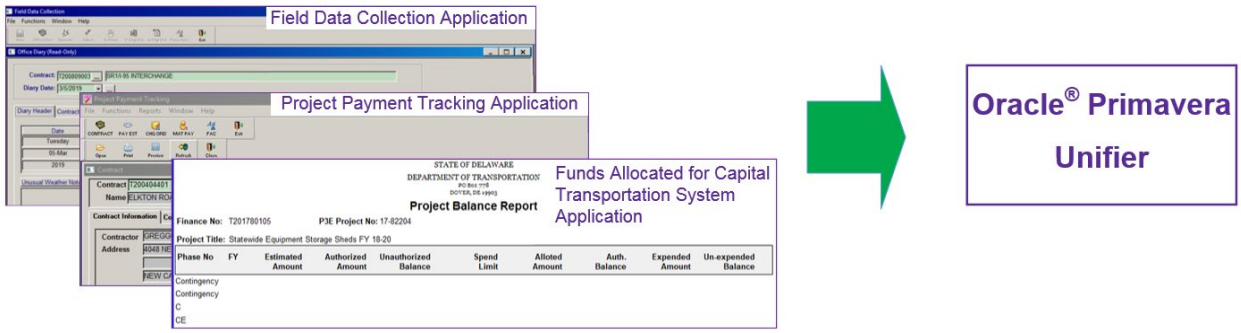


*Figure 1. Illustration. DelDOT's transition from legacy applications to Oracle® Primavera Unifier. Source of application screenshots: DelDOT*

DelDOT began processing IDRs through Primavera Unifier as the first step in its implementation. This process initially took about 8 months to complete due to inconsistencies with completing IDRs and validating requirements, which have since been resolved.

DelDOT uses an outdated version of Project Expedite™ software to prepare bidding files, which are available as a download from its website. The agency is investigating the use of Bid Express® for online bidding.

The agency also has an informal UAS program under its Transportation Management Center. DelDOT currently has 9 remote UAS pilots on staff and 16 variations of UAS aircraft and sensor pairings to support 9 different State and local agencies. DelDOT has a Certificate of Authorization (COA) to fly in Class D airspace and can fly most anywhere in the State.

DelDOT's greatest challenge during the transition from paper to digital is the management of interim paper documents and archival of records. In addition, challenges remain in obtaining buy-in from all DelDOT sections for implementing new initiatives, integrating various COTS programs used throughout the agency, and managing personal/functional preferences such as with device use (laptop vs. tablet).

## Current Efforts

Although DelDOT has made significant strides in implementing its e-Construction program, the agency is still working toward meeting its overall goals. Currently, DelDOT is piloting UAS for earthwork computations and is evaluating e-ticketing technology for hot-mix asphalt projects. Also, DelDOT continues to add functionality and process improvements to the Primavera Unifier construction management system. Specifically, the agency plans to add automated processes for electronic submittals and contract execution, contractor submittals of construction documentation, and project closeout.

# Shared Effective e-Construction Practices

## Ohio Facilities Construction Commission

The Ohio Facilities Construction Commission (OFCC) primarily works with buildings/facility construction, repair, and rehabilitation. Roadway, bridges, and transportation-related assets are not under the purview of OFCC. OFCC implemented Primavera Unifier as its construction management system in 2008. The system was selected through a competitive procurement process. Internally, the system is known as the Ohio Administrative Knowledge System Capital Improvements module (OAKS CI).

OFCC uses Primavera Unifier for many discrete activities, including procurement and contract administration (e.g., requests for proposals, contractor/consultant selection, and vendor evaluations), construction management, payment processing, program management, project collaboration and communication, and closeout. Although Primavera Unifier does have a bidding module, OFCC standardized the Bid Express® software application.

OFCC implemented Bid Express® in 2014 for all construction projects. OFCC averages 121 bid packages and 500 bids per year. Use of Bid Express® on local projects is encouraged, but it is not required. The OFCC bid openings are held online using Web conferencing.

OFCC uses DocuSign® for electronic signatures on all contracts, agreements, and contract modifications. These documents are created in OAKS CI as a custom print and imported to DocuSign® using a template to add signature data. DocuSign® then manages the signature gathering process, with OFCC staff uploading the signed and sealed PDF to OAKS CI.

## New York State Thruway Authority

The New York State Thruway Authority (NYSTA) is responsible for one of the largest tollways in the country. It contracts approximately 50 to 80 capital projects per year, including bridge, highway, and architectural categories. NYSTA updated its previously isolated and outdated contract management and capital planning systems to allow better data workflows between stakeholders. The agency partnered with a system implementation consultant in 2019 to implement Primavera Unifier using a two-phased approach.

Under phase one, NYSTA will replace three custom-developed legacy systems: capital planning management system, contract management system, and construction management system. Also, NYSTA intends to improve workflows, integrate fiscal and field data, improve reporting (including regulatory compliance), enhance cash flow management and contract forecasting, and improve document management.

NYSTA plans to implement two distinct user interfaces: one for contract management (progress payment, approval, and execution, etc.) and one for capital planning (planning, cash flow management and modeling, scheduling, budgeting, etc.). These distinct interfaces define the collaboration workspaces that have their own business processes, cost worksheets, reports, dashboards, document repositories, and users and groups. These interfaces will be connected through a tool being developed by the implementation consultant. The objective in connecting the two systems is to automate reconciliation of planning and contract finances and improve cash flow management/contract forecasting.

Under the planned phase two of implementing Primavera Unifier, NYSTA intends to expand its capability by adding external access for certain functions, building an interface between planning and asset management, and integrating with its budgeting system. NYSTA anticipates that Primavera Unifier will become fully integrated into its planning, design, and construction phases, as illustrated in Figure 2.


*Figure 2. Diagram. NYSTA desired state for Primavera Unifier implementation.*

NYSTA has not made significant progress toward formalizing a UAS program, although there is interest.

## Michigan DOT

The Michigan DOT (MDOT) developed an electronic proposal website (eProposal) containing all documents and files associated with each project letting, making them available to download at any time. The notices, plans, and proposals are available in PDF format, and the reference information documents (design models and supporting data) are available in .dgn or other applicable format. These files are stored and managed through the Bentley® ProjectWise® system and published to the eProposal website. MDOT transitioned to Bid Express® over a 4-year period and has not accepted paper bids since 2005. The timeline of MDOT's various e-Construction initiatives is shown in Figure 3.

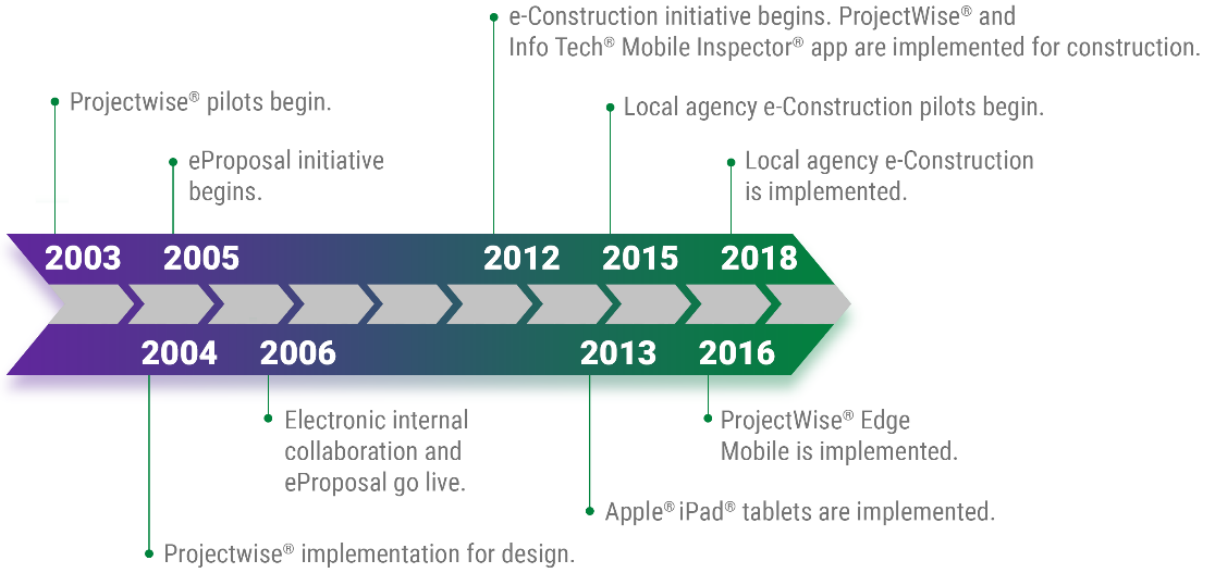


*Figure 3. Timeline. MDOT e-Construction initiatives from 2003-2018.*

MDOT uses its custom-developed, Microsoft® Access-based system, called Quality Assurance Database System (QUADS), for proposal review and contract compilation. Once the contract is compiled in QUADS, it is uploaded to ProjectWise®. Once an award is executed, the contract documents are routed for signatures through the system using automated workflows, which include email notifications for the next approver.

MDOT adopted DocuSign® (formerly CoSign®) as its digital signature tool. The agency chose DocuSign® because it is a well-established digital signature tool used by many organizations. The system is centrally managed, and MDOT incurs the cost for all stakeholder signatures. There are three ways to use DocuSign® to affix a digital signature to a document: through a computer software program (Omnisign®), through MDOT's website, and through the DocuSign® mobile application.

Omnisign® is a DocuSign® client application (included as part of the DocuSign® license agreement) installed on an MDOT user's computer to digitally sign local documents. External MDOT DocuSign® users (e.g., contractors, consultants, and local agencies) have a dedicated, secure website for digitally signing documents at no cost using their MDOT-provided credentials. These users select local documents from their computer, affix the digital signature, and save the signed document locally or send the document through the website. Also available for MDOT users is the DocuSign® mobile application, which allows for affixing digital signatures in the field or away from the office. This mobile application is available on iOS®, Android®, and Windows® mobile operating systems.

DocuSign® also provides customizable signature blocks that enable use of professional seals (Professional Engineers, Professional Surveyors, etc.) and integrate well with other software programs. MDOT manages the user's digital signature, so when the user signs a document, information is sent to MDOT's server to confirm identity and securely

encrypt/validate the signature. MDOT has more than 3,000 signatures in its system (1,096 State of Michigan signatures, 974 consultant signatures, 649 contractor signatures, and 435 local agency signatures).

MDOT has a small, ad hoc UAS program, but the agency has not formalized the use of the technology.

## Utah DOT

Since 2008, all projects advertised by the Utah DOT (UDOT) require digital signatures. In 2016, UDOT Consultant Services sought a software solution to manage contract workflows and electronic signatures, and so began compiling use cases to create a new workflow. DocuSign® was selected as the solution, based on this new workflow and other requirements.

In April 2016, UDOT Consultant Services started piloting DocuSign® and quickly realized savings in overhead costs and efficiency throughout the contract signature process. For example, UDOT reduced contract execution time from months or weeks to just days or even hours. Consultants and local governments have also experienced reduced time and cost when processing transactional documents with UDOT. UDOT now provides DocuSign® digital certificates and a DocuSign® digital certificate revocation list on its website for download and use, although a digital signature is not required to bid a UDOT construction project using the agency's Electronic Bid System.

UDOT began testing UAS in coordination with Utah State University in 2010 and formalized the program in January 2016. UDOT purchased three aircraft in June 2016 and established policy and procedures in March 2017. The agency has a mature and robust UAS program formalized as a UAS committee with representatives from key Divisions. UDOT's governance structure for UAS operations is shown in Figure 4.

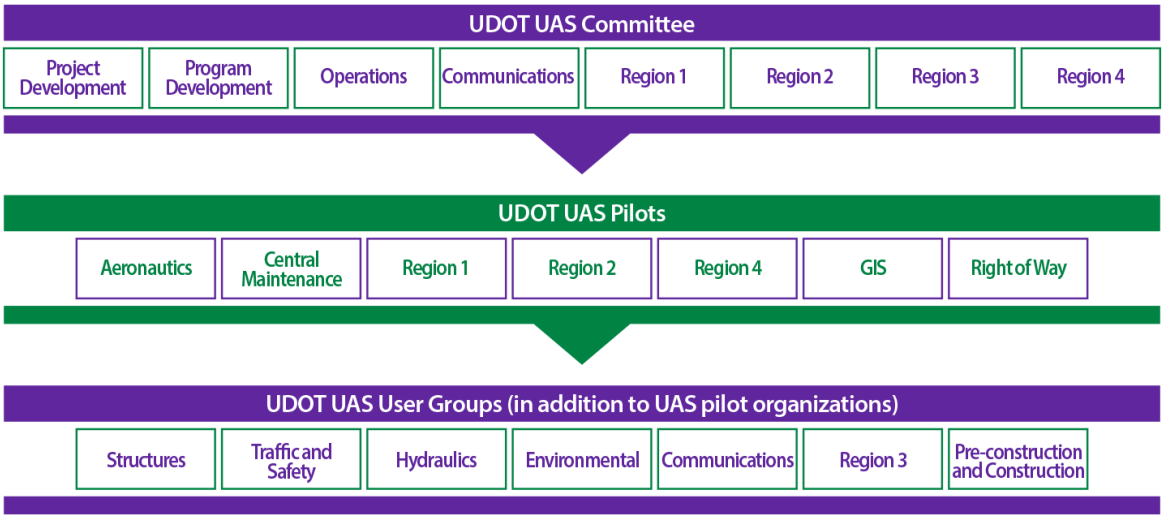


*Figure 4. Concept map. UDOT's UAS governance structure.*

In 2018, UDOT had 10 remote UAS pilots and 40 more (many being incident managers) projected. The pilots are located in various UDOT Divisions in a matrixed organizational model. UDOT's diverse fleet of UAS aircraft includes multi-copter, fixed wing, and vertical takeoff and landing platforms to suit different uses.

Deployment-ready applications include general site analysis, progress monitoring, traffic monitoring, stockpile volume assessments, quantity measurements (linear and area), construction pit, landslides, land surveying (imagery and point cloud), environmental (wetlands, etc.), crack detection, inspection (fencing, etc.), bridge inspection, and live streaming. Table 2 lists important considerations for UDOT's UAS flights.

*Table 2. UDOT's UAS flight considerations.*

| Preflight Planning | Ground Control Point (GCP) Considerations | Flight Operations | Postflight Review |
|---|---|---|---|
| • Ground sampling distance helps determine altitude and number of ground control points required.<br>• Overlap (side and front) parameters.<br>  ○ UDOT uses 80% side and 80% front<br>• Four angle measurements for simple objects.<br>• Nine angle measurements for complex objects.<br>• Flight planning software:<br>  ○ Pix4Dcapture®<br>  ○ Map Pilot<br>  ○ eMotion® X<br>  ○ WingtraHub | • Variety of targets available.<br>• Can use existing objects.<br>• Needs to be highly visible from altitude.<br>• High contrast.<br>• Type of ground material (will the marking stay?)<br>• Targets cannot always be painted.<br>• Potential shadows and tree locations.<br>• Ensure targets can be seen from the air.<br>• Make numbers large enough to read from the air.<br>• Create a mark in the middle for easier selection.<br>• Placement: people tend to park over GCPs.<br>• Keep GCPs no more than 1,000–1,500 feet apart.<br>• Five-sided die configuration: control points on edges create additional distortion.<br>• Randomize throughout flight area.<br>• Do not place them on the edges of the flight data except when accounting for overlap on multiple days.<br>• Have targets large enough for ground sampling distance.<br>• Avoid obstructions and shadow areas. | • Use checklists.<br>• Select suitable takeoff and landing location.<br>• Use aviation radio to monitor traffic.<br>• Have pilot focus on flying.<br>• Use visual observer.<br>• Battery life and endurance.<br>• Initial test flight to scout for obstacles and heights prior to autonomous flight mapping.<br>• Understand radio link characteristics in multiple environments.<br>• Know how to fly manually if needed.<br>• Looks can be deceiving.<br>• Establish good relationships with other entities and the public.<br>• Plan for the worst, hope for the best. | • Aircraft inspection: props, gimbal, fuselage or frame, camera lens, landing gear/skids, and sensors.<br>• Mapping check: check points for coverage and quality of images in the field. |

UDOT requires all remote UAS pilots to complete a practical test in addition to the current regulations. There is a 90-day proficiency requirement for all UDOT remote UAS pilots. DelDOT noted that they have a similar requirement where the remote UAS pilots are required to do 10 maneuvers every 30 to 40 days, including 3 takeoffs and landings of each UAS platform they will operate.

The FAA provides extensive resources and information to help guide UAS operators in determining which laws, rules, and regulations apply to a particular UAS operation. More information is available on the FAA website at https://www.faa.gov/uas/.

## Kentucky Transportation Cabinet

The Kentucky Transportation Cabinet (KYTC) has implemented many e-Construction practices. The agency started its e-Construction program in 2009 with the deployment of a digital plans room that allows contractors to have access to electronic plan sheets and contract documents prior to project letting. In 2015, KYTC started piloting the use of iPad® devices and Dell® tablets to access SiteManager™ directly from the field and now equips 300 inspectors with tablets.

KYTC implemented Bid Express® in early 2010 and required a 3-month transition to make electronic bids the only acceptable method. However, the execution of the contract is still a paper-based process.

KYTC recognized that inspecting paving projects lacked efficiency, with inspectors covering multiple projects with limited experience and training. Also, KYTC emphasized the dangers of working on paving projects, including walking adjacent to traffic, close proximity to large equipment with limited visibility, and climbing on trucks. As a result, KYTC partnered with the University of Kentucky on researching and piloting e-ticketing technology. Two pilot projects are complete, and 14 additional pilots focusing on resurfacing projects are expected.

While some issues need to be resolved, including defining data ownership, defining when KYTC has ownership of the material, and the presence of ghost tickets, the benefits of e-ticketing are profound. E-ticketing is a collaborative environment for tracking location-enabled fleet/material delivery and exchanging data through Web-based platforms. Specific features of e-ticketing include the following:

- Geozones, subzones, and geofences (These are geographic areas and boundaries defined through a Web-mapping interface. When a truck enters or leaves a geozone/subzone or crosses a geofence boundary, its location and time data are recorded using a truck-mounted Global Positioning System [GPS] device).
- Bread crumbing (a digital trail of truck location and time data along a haul route).
- Truck shift data (source and destination geozones, start/end time of day, net tons, etc.).

- Fleet optimization/load cycle analysis (shows travel time, when a truck has its engine on/off, when a truck is moving, when a truck receives its load, and how much time a truck spends within a geozone).
- Animations of truck locations along route.
- Material summary reports (waste loads, etc.).
- Adding mix designs.
- Individual ticket summaries.
- Outputs to CSV/PDF.

Figure 5 shows a graphical analysis from the Earthwave® Fleetwatcher™ application of a fleet of trucks on a sample day.

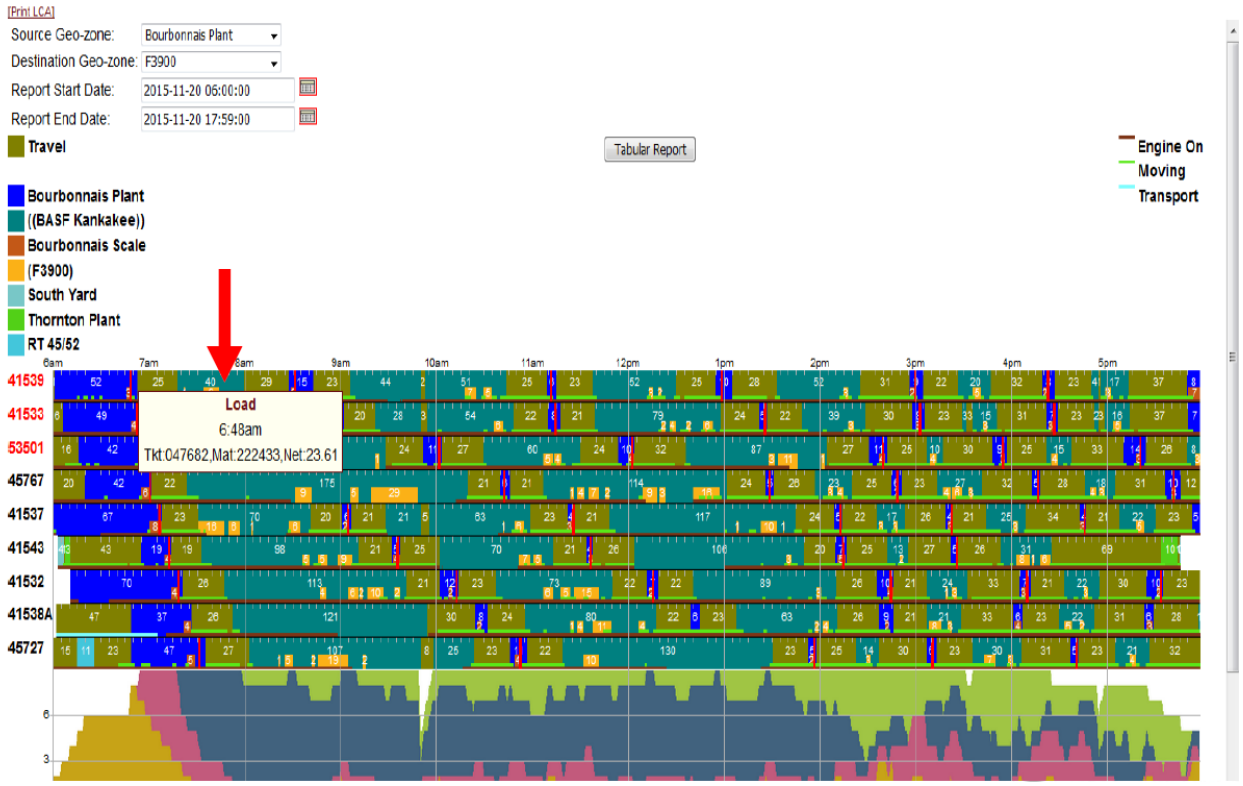


*Figure 5. Graph. Analysis of a single day of truck fleet tracking (with scale integration). Source: KYTC*

There is a concern as to the amount of data shown as well as the level of detail about the data visible to KYTC. Some DOTs noted issues with suppliers, privacy, and Freedom of Information Act (FOIA) compliance. Establishing restricted views for DOTs may potentially mitigate FOIA issues by allowing only certain data and information to be viewable to DOTs, consistent with the specifications.

# Cost and Benefits

## Oracle® Primavera Unifier

There are various cost models for implementing Primavera Unifier, depending on subscription and licensing options (e.g., hosting services) and professional services for configuration and implementation support. The licensing model is scalable depending on users/concurrent licensing. The implementation costs for Primavera Unifier at DelDOT and NYSTA were approximately $1 million, including consultant support. However, DelDOT focused more on its system configuration and did not use customization services, as did NYSTA. Also, DelDOT chose to license the software based on individual licenses as opposed to NYSTA's concurrent licensing model. OFCC pays approximately $500,000 per year for its cloud-based software-as-a-service subscription model.

## DocuSign®

MDOT's implementation of DocuSign® to provide digital signatures for all State of Michigan employees and partners (local agencies, contractors, consultants, etc.) cost approximately $1.4 million. This cost provides the ability to host all signatures (up to 10,000) on MDOT servers.

## e-Ticketing

For e-ticketing, KYTC found that a contractor using the Fleetwatcher™ system realized a $60,000 savings compared to paper tickets on pilot projects. Earthwave Technologies® offers two pricing models for Fleetwatcher™, although this may change in the future:

- $60 per GPS unit per month with a 3-year agreement.
- $150 per GPS unit per month with a 3-month agreement.

On its two pilot projects, KYTC found that the lump sum bid items for e-ticketing were around $20,000 using Fleetwatcher™ and $5,000 for Libra Systems.

KYTC and the University of Kentucky provided some benefits of e-ticketing, including:

- Real-time electronic information.
- Automated processes.
- Easy setup (some front-end work to configure the system).
- Web-based.
- Integrated with mobile field applications.
- E-ticketing system supports company-owned or third-party trucks.
- Contractors are able to extract data to be used in trucking payroll, fleet optimization and monitoring/driver behavior, eliminate bottlenecks, etc.

## Key Takeaways

Participants offered the following recommendations at the peer exchange, based on lessons learned from each other's programs.

**Dedicated staffing structure**. Dedicate a team (as opposed to this being another duty as assigned) to ensure sustainable development and support for programs such as Primavera Unifier. OFCC has five to seven full-time equivalents providing Primavera Unifier administration, end-user support and training, development of new functionality and updates, and reporting.

**Allowable electronic logging device documents.** Ensure contractors have physical bills of lading or have an alternative practice acceptable to the agency. The U.S. DOT has an electronic logbook that may help mitigate this issue. The Federal Motor Carrier Safety Administration allows five different categories of electronic logging device documents, including bills of lading. (Federal Motor Carrier Safety Administration, 2017).

**Train all stakeholders who interact with the systems**. Train all stakeholders to ensure consistent use of systems and to identify issues early to mitigate downstream risks.

**Collaboration on access and implementation of e-ticketing technology and practices.** Work with e-ticketing vendors and contractors to gain access to the technology, actively communicate with the various stakeholders, ensure all trucks have GPS device (for e-ticketing), and download necessary mobile applications. Other lessons learned provided by the University of Kentucky include:

- System, crew, and shift setup are critical to the accurate collection of data and cycle times and may require daily adjustment.
- All trucks and equipment to be tracked must have a GPS device installed.
- Care must be given to the setup of geozones prior to the project, and the user must understand the function of these geozones (static and mobile).
- Most common issues with e-ticketing can be resolved easily through open communication between parties.
- Providers, DOTs, and contractors should collaborate on this technology for optimal benefits.

**Effective practices for successful UAS flights.** Be sensitive to environmental effects (time of day, weather, and temperature) and flight settings (overlap parameters, sensor/camera settings, batteries, and charging capabilities). Manufacturers often oversell capabilities, so due diligence is required to uncover the facts of the systems. For successful flights, it is important to consider these effective practices:

- Understand radio link characteristics in multiple environments.
- Know battery life and endurance.

- Plan for the worst, hope for the best.
- Understand that looks can be deceiving.
- Conduct an initial test flight to scout for obstacles and heights prior to autonomous flight mapping.
- Use an aviation radio to monitor traffic.
- Establish good relationships with other entities and public.
- Plan for large datasets.
- Have adequate data storage.
- Utilize a document management system.
- Utilize geographic information system tools.
- Find multiple uses for data.
- Share data.

**e-Construction and Partnering: A Vision for the Future**

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FHWA e-Construction and Partnering innovation resources
https://www.fhwa.dot.gov/construction/econstruction

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