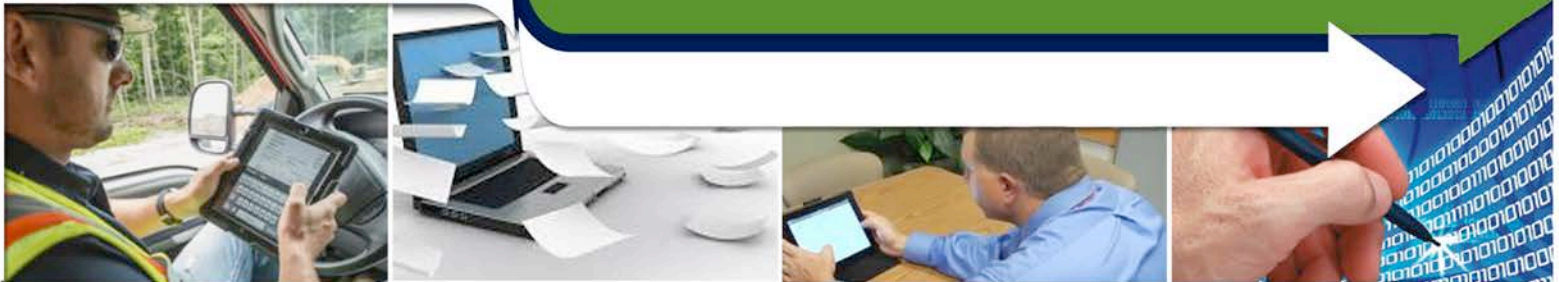




e-Construction



Facilitation and Documenting of FHWA Division Office e-Construction Pilot

Interim 7-Month Report
January 2016

MS Surface Pro 3: Texas and Utah
Apple iPad: Florida, Iowa and Michigan
Control: West Virginia



U.S. Department of Transportation
Federal Highway Administration

Table of Contents

1. Background on the FHWA e-Construction Pilot Project	2
1.1 FHWA Division Office Pilot Goals and Anticipated Benefits	3
1.2 Description of Devices in Use by Participating Division Offices.....	3
1.2.1 <i>Overview by Device Type</i>	4
2. Analysis and Performance Measurement for FHWA’s Application of e-Construction	5
2.1 FHWA Division Office Construction Business Processes Using e-Construction Technology	7
2.2 Differences between Shared and Individually Assigned Devices.....	8
2.3 Tested Mobile Device Applications List	8
2.4 Security and Durability of IT Equipment for Field Applications	10
2.5 Technology Impacts on Business Processes	10
3. Conclusions and Recommendations	12
Appendix A – Division Office Anecdotes, Challenges, and Solutions	16
Appendix B – Raw Performance Measures Data.....	21

1. Background on the FHWA e-Construction Pilot Project

Highway construction project and program implementation historically has involved paper plan sets, paper documentation for change orders, and wet ink signatures for contract documents and other approvals. With the addition of computer-based management systems, some documentation may have been scanned and stored electronically, but the original documents were generated on paper. Agencies also printed much of the documentation that was developed originally in electronic format, such as with computer-aided design (CAD) files for plans sets, cross sections, and profiles. Concepts for paperless project delivery, both for the owner-agency and the contractor, came about as stakeholders began to ask themselves the question – “why are we printing so much documentation?”

By utilizing the full potential of technology, construction stakeholders can reduce paperwork, reduce costs, and provide for more efficient project delivery. A true “paperless” environment is also possible given the technology applications available; however, most agencies still rely on some paper documentation to some degree. Construction programs can also benefit from the mobility of new technology such as smartphones, tablets, and associated wireless internet capabilities that provide real-time access to data and information and also encourage better data collection and archiving through enhanced mobility, portability, and ease of use.

Technology applications for construction management include systems for storing documents, materials certifications, testing results, as well as archiving through collaboration sites that incorporate digital signatures for approvals. Project inspectors and other field personnel are using mobile devices to document project characteristics and populate such management systems with data and information that can be used for the entire project lifecycle – from project development through asset management and maintenance.

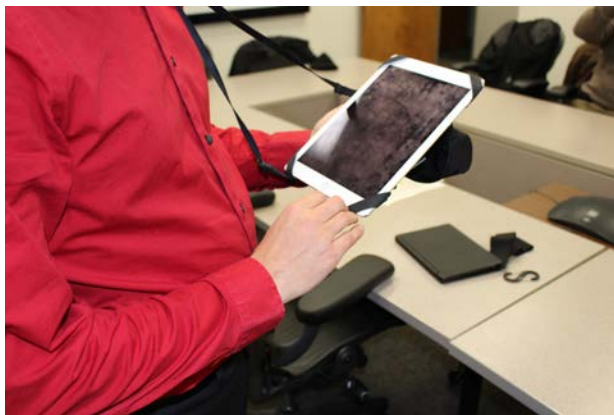


Figure 1. FHWA iPad Demonstration in Iowa

State departments of transportation (DOT) use e-Construction for paperless contract administration and management functions and incorporate linkages to outside entities such as contractors and consultants. e-Construction is the collection, review, approval, and distribution of highway construction contract documents in a paperless environment.

The Federal Highway Administration (FHWA) Division Offices lead the implementation of the Federal-aid Highway Program, delivering Federal-aid reimbursements to the States as well as providing oversight, technical support, and approval for highway construction expenditures on Federal-aid projects. Through stewardship agreements, FHWA and its State and local partners outline the process for ensuring adequate transportation infrastructure while improving operations, safety, and the environment and effectively and efficiently managing public funds. FHWA Division Office personnel also access these systems to perform activities such as approving change orders or providing comments on plans or other documentation on Federal-aid projects. In

addition, FHWA personnel manage and approve Federal-aid reimbursements through the General Services Administration (GSA) Financial Management Information System (FMIS), and the tablet devices can be used to access this system remotely.

When fully realized, e-Construction has the potential to reduce costs significantly while improving project and program delivery in each State and territory. As the Division Offices work closely with their State DOT counterparts, there is an opportunity to provide seamless project delivery and allow for the electronic integration of the various functions provided by each organization, including electronic approvals by FHWA personnel.

1.1 FHWA Division Office Pilot Goals and Anticipated Benefits

To assist with implementation of e-Construction, FHWA initiated a pilot project to test tablet devices in several Division Offices. The purpose of the pilot project is to evaluate the use of two types of mobile devices and provide recommendations to the FHWA Investment Review Board (IRB) on the potential for agency-wide implementation of mobile devices. Key stakeholders meet bi-monthly to report on the status of the pilot, how the devices are working, and to suggest issues and challenges in implementation and how they were overcome.

Several primary benefits are being reported through the use of mobile devices, including:

- Enhanced mobility – entering data in real-time in the field compared with transferring information from hand-written notes later
- Instant access to detailed information – specifications, manuals, and guidelines
- Enhanced field review data – capturing photos, locations, key field review findings
- Reduced processing times – change order approvals can occur in days instead of weeks

1.2 Description of Devices in Use by Participating Division Offices

With the identification of six lead States (five using tablets), FHWA is realizing the benefits of using these devices. The enhanced mobility and real-time access to information has proven effective for FHWA, and there is an opportunity to provide agency-wide implementation of e-Construction in order to contribute to enhanced Federal-aid project delivery.

Table 1 outlines the specifics on types of devices in use as part of the pilot project.

Table 1. Type of Technology in Use by Each Participating Division Office

Lead State FHWA Division Office	Pilot Technology in Use	Division Office Usage and Features
Florida	iPad Air (6) – shared pool/platform	Used to load training for users and also document the results of project reviews.
Iowa	iPad Air (7) – individually assigned	Used routinely on field inspections and CAP reviews and to access Iowa DOT’s document management system.
Michigan	iPad Air (7) – individually assigned (two replaced computers)	Obtained access to MDOT sites outside FHWA’s firewall through a policy exception.

Lead State FHWA Division Office	Pilot Technology in Use	Division Office Usage and Features
Texas	Surface Pro (6) – 3 individually assigned and 3 in shared pool/platform	Not using applications, rather using tablet as the main interface to capture information and data.
Utah	Surface Pro (4) – individually assigned (two replaced computers)	Laptop replacement with MS Surface Pro. Primary benefit cited as greater mobility as compared with laptop. Microsoft operating system allows for uses similar to a laptop but with extra portability.
West Virginia	No devices assigned – will serve as control for comparison to others	Using laptops and working with the State Division of Highways to implement electronic signatures for change orders and other documents.

1.2.1 Overview by Device Type

Apple iPad Air – Pros:

- Video capability for demonstrations or to have a video-meeting or share a field visit finding in real-time (FaceTime)
- Activation lock security
- iCloud backup
- Remote erase feature
- Built-in cellular and assisted GPS

Apple iPad Air – Cons:

- Users cited a learning curve for file storage, modification, save, and retrieval functionality
- Less compatibility with Windows-based software
- Difficulties for users in manipulating spreadsheets and documents

Microsoft Surface Pro – Pros:

- Good file manipulation (saving, modifying, commenting and distributing) due to Windows-based interface
- Secure login based on individual credentials

Microsoft Surface Pro – Cons:

- No built-in cellular (requires hotspot)
- GPS is not configured out of the box



Figure 2. iPad Air Device Features



Figure 3. Microsoft Surface Pro 3 Features

In some Divisions, FHWA personnel are sharing devices, while in others they are individually assigned to one person. In addition, some FHWA personnel are using the tablet devices in place of a personal computer or laptop. This report documents the type of device in use, the applications used, whether they give FHWA the ability to use digital signatures for approvals, the pros and cons of each device type, and related performance measures that quantify the efficiencies of the technology applications. The results are designed to assist FHWA with an agency-wide implementation for use of e-Construction technologies.

2. Analysis and Performance Measurement for FHWA’s Application of e-Construction

The study team developed a list of performance measures in close coordination and consultation with FHWA. The performance measures focus on efficiencies that may be realized through the use of the tablet devices. Initially, FHWA anticipated that Division Offices would see improvements in business processes based on data availability, data quality, and enhanced mobility. Data availability due to the unlimited wireless data plans for each device provided efficiencies by allowing for direct access to project documents in the field that might have otherwise required a trip to an office. Division Offices also realized mobility improvements based on the ability to have all project documentation (plan sets, checklists, specifications, etc.) on the tablet device that was easier to carry due to the smaller size and portability. Data quality was not as easily measured in that laptops would have also had air cards for access to electronic files, email, and applications that connect with the State DOT systems. However, anecdotes are included to describe individual experiences in using laptops for field use as a means of comparison with tablet device use.

The following table highlights the performance measures and data sources developed for this pilot project. This list was scaled back to a priority set of data sources identified through input from users as shown in the Appendix forms.

Table 2. Performance Measures and Data Sources

Performance Measure	Data Sources
Reduction in paper needs	Number of paper plan sets eliminated through access to electronic versions via tablet, or reduced time needed to access construction manuals, specifications, and references from the field
Reduction in processing times and approval times	FMIS and change order approval time savings (estimated hours), if users are performing this activity with the tablet device
Reduction in time spent by activity	Number of times electronic files are accessed from the field due to increased availability of data (data plan use)
Increased efficiency and productivity from enhanced mobility	Number of additional activities undertaken remotely Baseline transit time for accessing project documents/Current time spent accessing project documents in the field Number of hours of tablet use and photo processing time

Performance Measure	Data Sources
Improved hardware durability	Incidents with laptops (baseline) and incidents with tablets (current) and estimated damage Issues encountered
Qualitative assessment of benefits	Anecdotes on job performance

In Utah, the primary metrics impacted through use of the Surface Pro are number of hours of use and number of times electronic files are accessed from the field. One user noted accessing files from the field two additional times per month for the last quarter of 2015 while using the Surface Pro full time for performing job functions (since this was a laptop replacement). Another user noted that the Surface Pro replaced paper plan sets once in September of 2015 and three times in October of 2015, lessening printing needs. The same user took 12 photos with the Surface Pro in September of 2015 and, as the first user did, indicated accessing electronic files from the field twice and using the device full-time for job functions.

The original configuration for the pilot in the Texas Division Office was to individually assign three and have a shared pool for three additional MS Surface Pro devices. Shortly after receiving the devices, the Texas Division changed the configuration to assigning four to Area Engineers, one to Major Projects Engineer, and one Engineering Coordinator as laptop replacement. This new configuration was the result of the dynamic acceptance of the new technology as a laptop replacement. As noted in Table 3, a primary benefit of the Surface Pro included elimination of paper plan sets and printing costs saved. Additionally, users noted key benefits such as ease of transport, ability to provide approvals remotely, and ability to review plans, specifications, and estimates for new projects while on travel.

Table 3. Performance Measures Reported by Texas Division Office (Combined Totals)

Performance Measure	Measured Value (August 17, 2015 through January 18, 2016)
Number of paper plan sets eliminated through access to electronic versions via tablet	47,815 pieces of paper
FMIS and change order approval time savings (estimated hours)	655 hours saved
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	183 times files accessed
Number of hours of tablet use	4,760 hours of use
Number of documentation photos taken using tablet	287 photos taken

In 2015, the Iowa Division noted a reduction in printing needs for 51 plan sets through use of the iPad and also captured 100 photos on the iPad for use in inspection documentation and reporting. The Iowa Division also changed the process for filling out inspection forms on the tablet rather than printing and writing on blank inspection forms. They also reported that while the iPad eliminates the need for a separate camera, it takes about the same amount of time to incorporate photos into inspection reports.

The Michigan Division Office also captured data related to the performance measures for September through December of 2015. The following table highlights the aggregate data from four iPad users as captured during the months of September, October, November, and December of 2015.

Table 4. Performance Measures Reported by Michigan Division Office (Combined Totals)

Performance Measure	Measured Value (September through December 2015)
Number of paper plan sets eliminated through access to electronic versions via tablet	11,200 pieces of paper
Change order approval time savings (estimated hours)	92 hours saved
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	484 times files accessed
Number of hours of tablet use	794 hours of use
Number of documentation photos taken using tablet	54 photos taken

As noted in the Appendix, Florida Division Office personnel noted benefits from use of the iPad such as capturing photos and having access to electronic plans. The ability to access templates while in the field and transfer photos to attach to inspection reports are time-saving benefits also noted through use of the iPad.

iPad and Surface Pro users are reporting benefits from use of each type of device compared with traditional processes and activities performed without the tablets.

2.1 FHWA Division Office Construction Business Processes Using e-Construction Technology

The following list captures the types of activities undertaken by FHWA Division Office representatives. It also includes specific anecdotes from some of the tablet device users based on experience. A full list of challenges and solutions from each Division Office is provided in the appendix to this report.

- The Iowa Division Office is using the iPads assigned for Compliance Assessment Program (CAP) projects. Users are also able to access Iowa DOT's ProjectWise and DocExpress tools to approve contract modifications electronically.
- CAP reviews are simpler with the tablet in that data and information can be entered directly in the field rather than transferring hand-written information into electronic systems later in the office environment.
- The break-in period for all devices was relatively short (2 to 3 days at most) as reported by each Division Office.
- The Florida Division Office noted that users are able to load training programs on various topics for immediate access, which results in process efficiencies.
- Decisions are made faster due to document reviews taking place in the field.
- Data plans provide ease of access to data and eliminate the need for uploading information later by eliminating the need for establishing a wireless internet connection.
- The Texas Division Office noted that a primary benefit is the ability to work in various locations more easily, including the ability to access project files and information during trips between projects.
- Devices can be connected to multiple displays.

- The tablets provide everything in a compact format – taking photos, accessing data wirelessly from anywhere, accessing communications such as emails, and logging information. One tradeoff is the compact nature of the tablet as compared with the greater functionality of a larger device such as a laptop (easier software inputs, larger keyboards, etc.).
- Exceptions must be made to open links to State DOT websites that are outside the FHWA firewall. Two examples of sites that required an exception include:
 - MDOT’s electronic proposal website: <http://mdotcf.state.mi.us/public/eprop/login/index.cfm>, and
 - MDOT’s FTP site: <ftp://ftpmdot.state.mi.us/>.

Representatives from the West Virginia Division Office participated in bi-monthly meetings to discuss the benefits of e-Construction. However, this Division Office did not receive devices during the pilot, allowing them to serve as the “control” for comparison of standard processes with those Divisions that received tablet devices. One area with a direct link to this pilot is inspection – the West Virginia Division Office has a construction inspection report in PDF format that allows users to input information directly as a fillable form. This process may prove more difficult on the iPad.

West Virginia reported that Division staff members commonly take laptops to field office meetings but not to the actual project site. Sites are often remote and wooded, and access to wireless connection is limited. Currently the focus is on implementing electronic signatures that are initiated by the West Virginia Division of Highways.

2.2 Differences between Shared and Individually Assigned Devices

In some Divisions, FHWA personnel are sharing devices while in others they are assigned to one individual. In addition, some FHWA personnel are using tablet devices in place of a personal computer or laptop. In a shared pool/platform, multiple engineers are assigned one or more devices to share. This requires separate login information for each user, and this process uncovered some limitations for users in the shared pool.

The iPad users noted issues with shared devices and logging in to individual accounts. The Florida Division Office noted that the Good application does not allow multiple user accounts on the same device. This was not an issue in Michigan since the iPads were individually assigned.

It was planned for the Texas Division Office to individual assign 3 MS Surface Pro and share the other three received. However, shortly after receiving the devices and overwhelming acceptance of the devices, the Division Office assigned all devices as a replacement to their workstation. This technology has been overwhelmingly accepted within the TX Division Office.

2.3 Tested Mobile Device Applications List

Some of the applications and technologies mentioned in this section are not a part of the DOT COE (Common Operating Environment) baseline. Applications or technologies should be reviewed by the COE for possible baseline consideration. Many of the technologies listed below are utilized by State DOTs to facilitate work.

Good For Enterprise – Is used by the COE to manage mobile devices. Good (Good For Enterprise) is available in three service plan options:

- Option A (Connection Only Plan) was implemented as a standard configuration for individually assigned iPad users. Plan A includes infrastructure support, secure access to email, calendar, and contacts through the device.
- Option B (The Apps Plan) includes everything from the Connection Only Plan and adds both the app bundle with Quick Office and Good Reader applications (Good Dynamics – See definition below) and the annual app management license fee for up to a total of ten applications.
- Option C (The All Inclusive Plan) adds Help Desk and desktide troubleshooting support. Includes all the features of Plan A and Plan B.

It was determined that the iPad users needed the applications within the Good Dynamics option to facilitate their work. Option B was implemented shortly after deploying the iPad devices. Further, shared platform devices require applications that allow multiple users. The Florida Division Office is unable to use the Good application because tablets are assigned in a shared platform and the device will only accept one user ID in the application. The Horizon application solves this issue through VPN access, as reported by iPad users in Iowa's FHWA Division.

Good Dynamics – An application management program that facilitates obtaining secure applications such as Quick Office (Word, Excel, PowerPoint) and Good Reader, manages encryption of application data on the device, and prevents cut/copy/paste of application data to unapproved applications. Also allows remote wipes of application data.

Good Reader – Allows viewing of PDF and TXT files, including manuals, reports, and large file-size renderings. Also allows mark-up of PDF files using text boxes and drawing tools.

VMWare Horizon Mobile – Extends an enterprise's directory services into the cloud and third-party software-as-a-service (SaaS) applications, allowing the IT administrator to enforce policies and security settings through active directory.

- Electronic signatures are implemented through the VMWare Horizon Application Manager in Michigan.
- This application solves the multiple user login issue on shared platforms.
- Also allows secure access to shared drives for transferring files.

Citrix Receiver – Provides virtual private network (VPN) access to AASHTOW are products such as SiteManager, document management systems, and other tools including a user's desktop and profile on another machine.

New file transfer application: The Secure Large File Transfer solution (SLFTS) is a large file transfer application. It provides an efficient way of sending and managing large files. To be granted access to the SLFTS, users can send an email to a group and request access. A support person then provides access instructions. This has not been tested but will be evaluated and reported on at the end of the pilot.

Suggested application: The Florida Division noted that a voice-recognition app that would capture spoken field information without the need to type would be useful.

Document Conversion Applications – There are free applications available to convert file formats into more generally accepted formats such as PDF files. These applications often do not provide reliability for users, possibly due to the fact that there may be no cost associated with using these software functions.

- Some software systems such as SiteManager do not allow uploading pictures. However, if a photograph can be converted into a PDF file, the file can be shared with software tools.
- Tiny Scan and Genius Scan are two free applications that have been tested as part of this pilot to convert picture formats into PDF files.

One Drive – This app has been used successfully for file sharing and to sync files from the tablet for download later onto a personal computer. This app can be downloaded to mobile devices and is also included in Windows 8.1 and Windows 10. FHWA is testing this application as part of the pilot. It functions via Cloud storage and is not currently supported by FHWA IT.

2.4 Security and Durability of IT Equipment for Field Applications

Firewall policy exceptions that allow users to access State DOT project collaboration sites and file transfer sites should be considered during initial device setup. This may require a case-by-case policy exception or could be alleviated through a list of sites that Division Office personnel require access to. For example, the Michigan Division Office originally had issues accessing Michigan DOT sites, including an ftp site for file transfer. Policy exceptions are granted on an as-needed basis and by request to IT support.

In Utah, one Surface Pro was damaged beyond repair, and FHWA decided against pursuing a retroactive warranty for the device. Consideration of initial warranty purchase during agency-wide implementation may show that, with the appropriate cases and protective devices, the risk of damage beyond repair does not outweigh the cost of individual warranties. This cost analysis should be performed when the magnitude of investment in tablet devices (number, total cost, etc.) is formalized. Users reported no other issues with durability, although some users do not attach the protective case due to limitations on attaching an external keyboard when the case is in place. A second purchase was issued for some protective cases that did allow keyboard attachment. However, a majority of the MS Surface Pro are being used without a protective case.

Back-ups were also requested for some Surface Pro hardware components, including stylus' and PIV card readers. Users felt as though losing or damaging a PIV card reader without a back-up would cause significant impact to job functions.

2.5 Technology Impacts on Business Processes

Mobility is a key aspect of the pilot implementation, and FHWA's agency-wide implementation should be designed to maximize mobility as this encourages greater use of each device. As several State and FHWA personnel have noted, users generally do not carry laptops around a project site; they both use and leave the devices inside a parked work vehicle. As Division Office personnel noted from past experience prior to the pilot, users of laptops did not take the device onto the project grade when performing inspections. If taken to the project site, the laptop was stored in a work vehicle while inspections were performed. With the addition of the tablet, cellular connectivity, and the enhanced mobility associated with use, Division Office personnel are able to have real-time access to plans, specifications, manuals, and other documentation at all times. They may download these files prior to a field visit, but they also

have direct access via the internet at all times. The pilot has shown great success in data availability through the tablet devices. The tablet devices provide greater mobility, and, when used with a utility latch, they are extremely mobile (the utility latch allows users to walk with the tablet restrained over the shoulder of the individual for a hands-free setup, which is especially beneficial when walking over the steep or difficult terrain that is common around bridges). This peripheral also fits over the rugged case initially provided with each iPad.

Users described a relatively short start-up time to get acquainted with both the iPad and the Surface Pro, citing a 2- to 3-day break-in period to become oriented to the functionality of each device. Users also developed forms, templates, and tools to assist with data gathering in the field, such as an Excel template for reporting that can be transferred into final reports. Users also easily found work-arounds for issues most of the time, such as for attaching photos from the iPad to inspection reports.

FHWA currently makes a standard investment in a laptop or desktop configuration for each employee. Gathering input from employees about preferences, or providing options to employees, will help expand the use of mobile devices, thereby realizing greater benefits from using e-Construction processes.

The current costs for each device, along with peripherals, are summarized in the following table.

Table 5. Standard Configuration, Peripheral, and Data Plan Costs Year 1 Pilot

Configuration	Itemized Costs	Total Costs
Dell Latitude E6440 (8GB Standard) – FHWA Standard Laptop Configuration*	\$1,532	\$1,859
Peripherals – keyboard/case, docking stations, etc. (when replacing a desktop with a laptop)	\$327	-
Dell Latitude E6540 (16GB Engineering) – FHWA Engineering Laptop Configuration*	\$1,903	\$2,230
Peripherals – keyboard/case, docking stations, etc. (when replacing a desktop with a laptop)	\$327	-
Apple iPad Air 2 Base Cost	\$934	\$1,229
Peripherals – keyboard/case, screen protector, cover, stylus, lightning adapters	\$295	-
Annual DOT Software Fee – Apps Plan B) – Year 1	\$499	Software Year 1: \$499
Annual DOT Software Fee – Apps Plan B) – Year 2	\$240	Software Year 2: \$240
Annual Data Plan	\$758/year	\$758/year
Microsoft Surface Pro 3 Base Cost – without Data Plan**	\$1,471	\$1,851
Peripherals – docking station, case, screen protector, stylus, and HDMI adapter	\$380	-
Verizon Jetpack Data Plan	\$758/year	\$758/year

*Monthly DOT support costs are not included.

**Annual DOT support costs are not included.

One primary limitation of the iPad Air 2 is that there currently is not a standard DOT configuration for the PIV card reader. Users are only able to apply credentials using the PIV card reader on the Surface Pro. A VPN connection may be a solution for this, and some users have tested VPN access with success on the iPad.

3. Conclusions and Recommendations

The following lists outline key findings by device type.

Key Findings: iPad Air 2

- **iPad users cited general benefits** to using the devices similar to benefits provided by other tablets such as the added mobility, ease of use for most applications, and the enhanced mobility. However, **iPad users would also need a standard computer configuration** in addition to the iPad in order to adequately perform work functions. The Iowa Division Office also reported that the battery life on the iPad was less than a full day of inspection activities.
- **Assisted GPS functionality is good** for location stamps on photographs and information. This functionality is configured out of the box. Assisted GPS means that the device uses cellular towers instead of satellites overhead to triangulate positions, resulting in relatively accurate latitude and longitude data without the delay caused by the device seeking a satellite.

- **Built-in cellular** eliminates the need for a separate hotspot. Alternatively, a phone or other device with cellular access can be used as a mobile hotspot, eliminating the need for built-in cellular on the iPad.
- **The iPad's lack of a PIV card configuration** is limiting for users. Without the PIV card, users are unable to access government legacy systems (i.e. FMIS, RASP, Castle, etc.) and must develop a work-around for transferring photos (e.g., email the file using a personal account to the FHWA account). Secure digital signatures, with a PIV card, are also not possible on the iPad due to this issue.
- **Users found work-arounds for issues with the iPad.** For example, the Iowa Division modified their inspection reporting process to incorporate use of the iPad, and also adapted to the PIV card issue through process change that added efficiencies to inspection reports by incorporating pictures.
- **The ability of the device to act as a Wi-Fi hot spot is an added benefit.** In one particular Division Office that did not have a Wi-Fi network, the network went down. When this occurred people then connected to the hot-spot capabilities of the iPad and were able to continue with routine business.
- **Transferring of work on the device was challenging because of the good environment.** When photos are taken, they are on the non-secure of the Good environment and it took several steps to move the photo to the secure side of the environment. This also applied to down loading files and moving documents around on the device between the secure and non-secure environment.

Key Findings: Microsoft Surface Pro 3

- **Windows-based programs such as Excel and Word are present on this device and familiar to users.** Most users are more familiar with a Windows-based environment, making laptop replacement possible with the Surface Pro.
- **The PIV card configuration allows for digital signatures and access to FHWA legacy systems.** The PIV card readers demonstrated some stability issues, but we are not testing different devices. In addition, the DOT profile was changed such that the device now stays on when the PIV card is removed, but does disconnect from the network.
- **The Surface Pro lacks GPS,** and Wi-Fi location services must be configured/enabled by DOT IT prior to use. At the time of this initial findings report, users are working on enabling it, but no users have successfully activated the Wi-Fi location services.
- **The Surface Pro could easily replace a laptop or desktop configuration.** At a work station multiple monitors and full size keyboard are easily attached such that one does not notice they are working on a tablet type device.

While the base cost for the iPad Air 2 is less than the Surface Pro, users that need mobility for site visits and other functions are better served using the Surface Pro or similar Windows-based tablet as a laptop replacement. FHWA would typically spend a similar amount for the standard laptop configuration for each employee as for a tablet device, and the tablet can both support individual mobility needs as well as serve as a primary computer. Conversely, an iPad Air 2 requires an annual software fee and users would still require a laptop configuration for other job functions. Using only the Surface Pro, users are able to

easily develop reports, generate spreadsheets, and manage files and documents. This is not the case with the iPad Air 2.

If using the Surface Pro as a laptop replacement device, users would also need a separate monitor, docking station, and external keyboard. With dual external monitors, the Surface Pro allows for two connections – one from the device and one from the docking station. The Texas Division noted that they had one monitor with a DVI port and one monitor with an HDMI port. The Surface Pro has a mini display port connection and the docking station has a separate mini display port connection, which requires an adapter to connect to either the standard HDMI or DVI connection. The iPad lightning port provides access through an adapter to various devices capable of receiving video outputs from the iPad and also USB connections to other devices.

The following recommendations are provided based on the assessment of device use.

Recommendations

- **Expand the pilot with additional Surface Pro devices** to include additional FHWA Division Offices. This could begin with West Virginia, Missouri, North Carolina, and Pennsylvania. Capturing additional performance measures and data from this expanded pilot will help with final recommendations in the 20-month report.
- **Develop a standard Surface Pro hardware configuration** for users that will replace the standard PC configuration (docking station, peripherals, cables, chargers). Recommendations for this standard configuration are included in the next section.
- **Develop a list of standard applications** to be included on every Surface Pro, and add these to the new devices in the expanded pilot with guidance to users on the functions of each software application. Recommendations for this standard configuration are included in the next section.
- **Gather input from new users prior to implementation** of the Surface Pro as a laptop replacement. FHWA leaders consulted with the Division Offices prior to purchase of devices and gathered input on the types of devices desired for the pilot. It may also be possible to expand the pilot to additional Division Offices, such as those suggested specifically in this report in the first bullet above, further disseminating the benefits of e-Construction while reducing costs compared with the standard DOT PC configuration.
- **Gather input from existing iPad users on their interest in continuing use of the iPad.** It may be less feasible to switch to a Surface Pro at this stage in the pilot, and iPad users are realizing benefits of the mobile devices and developing work-arounds for challenges and limitations. Benefits will continue to be realized for iPad users.

Recommended Mobile Device Configuration

The following table outlines the recommended mobile device configuration for the expanded pilot program.

Table 6. Recommended Mobile Device Configuration for Expanded Pilot

Type of Device	Microsoft Surface Pro (additional Windows-based tablets may also be feasible as laptop/desktop replacements but are not being tested as part of this pilot project)
Applications	Standard FHWA configuration.
IT Security	Listing of site access exceptions should be provided by each user to allow access (for example, State DOT resource libraries and systems); PIV card will allow access to email and DOT systems
Peripherals	Additional power cable, different PIV card readers (clam and butterfly), card case with ability to attached keyboard, Bluetooth mouse, and key board cover.

The pilot program has been a success in assisting FHWA Division Offices with greater efficiencies gained from implementation of e-Construction. A final report for this project will be published in 2017 and will document the issues and successes observed for the duration of the pilot (2 years). This report will also provide recommendations for agency-wide implementation of tablet devices.

Appendix A – Division Office Anecdotes, Challenges, and Solutions

Michigan Users (iPad Air 2):

- Went on a week trip to the Upper Peninsula. Did 7 CAP reviews and 3 construction inspections. Did not need to print out any plans or specs. Was able to access all data needed from iPad. Also used iPad in meetings instead of printing out sheets to discuss. I took all meeting note on iPad instead of having to use a notebook.
- Used to review contract mods and pre-approvals and sign them.
- Used for CAP reviews, in meetings and doing construction inspections. Very handy. Having a data plan is a must!
- Used for the CAP reference documents (manuals, etc.) during reviews.
- Took photos of docs for cap reviews. Also took photos on construction inspections.
- Used to review the plan sets and didn't print out the plans. Took iPad to the meetings instead of the plans.
- Used to review contract mods and sign them.
- Used the iPad to telework, able to keep up with things during training and conferences (on breaks).
- Working through Horizon to telework. All day accessing files and emails, reference docs etc. Taking notes and pulling up past meeting minutes, etc. during meetings. Pulling up maps (Google Earth) during meeting to discuss projects, pulling up TSLs when reviewing plans to make sure what we approved is in the plans and so on.
- Having a data plan is essential when using a mobile tool like this as most Wi-Fi access points are public and therefore not secure. Also, many are not free, or the strength makes working with the Wi-Fi slow and iffy.
- No longer using iPad to e-sign (I'm now using the PIV card on my laptop).
- Used regularly during weekends and evenings to keep current with e-mails and take meeting notes.
- Really never used to take photos due to size.
- Used to review contract mods but signed them in the office. FMIS needs to have PIV Card to use.
- Took pictures of the Detroit Projects to document progress.
- Used during Management Meetings and Development Conference & ADTM workshop to keep current and take notes.
- Routinely use it on the weekends to catch up on e-mails.
- Took pictures of progress of projects that were delayed.
- Used to review the plan sets and didn't print out the plans or proposal – saving of at least 500 pages per set.
- Used the iPad to keep current with e-mails and approvals during sick leave to take care of a family member.
- Used it at the AEM and Development Conference to keep current and take notes. Routinely use it on the weekends to catch up on e-mails etc.
- Didn't print out the plans or proposal ~300 pages each. Took iPad to the meetings instead of the plans.

- While performing a CAP inspection up North, I realized I forgot to bring an inspection form. Using the wireless capability of the iPad, I was able to download the form on my iPad instead of having to reschedule.
- During a plan review I was able to pull up an environmental document to ensure changes in design did not violate the environmental document. This made it a lot easier and I was able to address the issue quickly.
- I was able to keep up on my e-mails during down time at an NHI class (using the wireless capability of the iPad). During a force account meeting I needed to be in 2 places at the same time. The iPad allowed me to attend a required meeting and follow up with my team leader at the same time. The wireless capability of the iPad was very useful.

Florida Users (iPad Air 2):

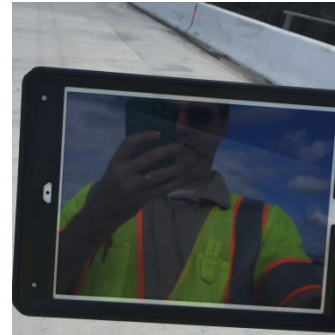
PROS:

- The camera is excellent and not having to fumble between notebook, tools and a separate camera was a major benefit.
- The Word application is great for note taking and much more convenient than paper. Plus, voice to text software worked well even with ambient noise, though not when heavy equipment was operated.
- Using interview forms in both adobe and word was convenient, but took a bit of time to open, locate and begin using. The consultant with me had the first part of the interview finished and on paper by the time I had the labor form pulled up.
- Using this for the ADA investigation was unexpected but fantastic! I intend to check out an iPad for all future complaint investigations. One of the biggest problems is not being able to record photos, measurements, witness data, etc. in one location while also accessing complaint files. The iPad solves that problem and with such an excellent camera, the site visit was much faster than usual.
- Accessing inspection forms from OneDrive was easy. Photos taken during the inspections were able to attach to the documents without any difficulty.
- Since FL shares iPads among users (Good service not used), accessing e-mail was done via Horizon. It needed extra step to access e-mails, but it was easy to access and overall had a positive experience with it.
- So far, close to 200 photos have been taken.
- Accessing required data from state/FHWA web sites while in field was very helpful.

CONS:

- Carrying tools (smart level, measuring tape, etc) and the iPad was kind of awkward. I actually scratched the screen in two places trying to hold them all.
- Lid to otter box covers camera if snapped on the back – otherwise it has to be left in the truck.
- Recording information from desk audit is still much easier on a laptop. Maybe the addition of a keyboard makes it more effective – especially since all site visits also involve some office work. (Action: keyboard has been supplied)

- Battery life was poor, especially using multiple apps. TIGER inspection alone (2 hours) consumed 80% of the battery and I had to charge it before using it on the second segment of the project. (Action: Car charger has been provided)
- Carrying the tablet around is unwieldy. My hands got tired and started cramping while holding the tablet. I couldn't "store" it anywhere when I needed both hands because it's too big. Traversing steep slopes was difficult because I had to keep a hand on the tablet. (Action: shoulder strap belt has been provided)
- Screen glare in the field made it nearly impossible to see anything on the screen. Taking pictures was somewhat of a guess as to whether or not I got what I wanted.
- At one point the screen got flipped and I couldn't really tell because of the glare. So I got some pictures of myself. The picture to my right shows how bad this glare is outside. I wouldn't be able to look at plans in the field without a cover hood to block out exterior light sources.
- Horizon software logs out after being idle for a little while.
- Not having a mouse is inconvenient.
- Unable to sign submittals/documents electronically, since iPad doesn't support PIV card reader.
- Unable to access FMIS.



Iowa Users (iPad Air 2):

- In addition to the plan sets, the Iowa Division also has changed our process to fill out inspection reports on the tablet in the field rather than printing blank inspection forms to take with us. This has saved even more paper by eliminating at least 89 copies of our inspection report form.
- Approval time savings: This is not easily measured for the Iowa Division, but anecdotally we can say that change order concurrence notices and approvals have been expedited by use of the tablet. Many users have reported multiple times that they have used the tablet to expedite our prior concurrence and/or approval while we were out of the office. This would not be possible without the tablet (w/ data package).
- All seven Iowa Division tablets have been used to access electronic files and job-related information available on the web on a weekly basis. This is the most significant benefit of having the tablets: availability of information at meetings and in the field.
- To date the iPad camera has provided convenience to our engineers because they do not need to bring a camera with them on inspections; however, attaching the iPad photos to reports has taken about the same amount of time as before, because we still need to download them.

Utah Users (Surface Pro):

Function	Issue
Running FMIS	"This site uses a plugin (Java™) that is unsupported"
Google Earth	Add program
MS Visio	Add program

Function	Issue
AnyConnect	Add program
MS Office Programs	"This copy of MS Office is not activated"
Camera	Needs user account control Not initially working. Had to run updates.
Productivity	Working on just 1 screen is slow Outlook "not responding". Disconnected Jetpack and used Local Wi-Fi. Need multiple USB Hub (only available USB uses PIV). Needs a car charger. Cannot open PC Settings Cannot access "Task Manager" Connecting VPN and Jetpack is sporadic in the field Tried accessing information in the field, but the connection was only 3G. It was too slow to obtain the data.
AnyConnect	Error message with NAC Client, but connection works anyway
Lync (Skype)	Lync opened once, now it is my default IM program, even if I change default in the registry to Communicator I have to do it each time I boot up Opens as default IM app, but doesn't let me log in. I have to close it in several places, then open Communicator manually any time I boot up
Dual Monitors	Docking doesn't accommodate two side-by-side monitors, only the Surface and an additional monitor
Rugged Case	When the Surface is in the case, it holds down the power button and shuts it off.
APPS!	The tablet part of the Surface is really the most useful with Apps. We don't have apps. We're not getting the max functionality out of them. They're basically really thin laptops.
PIV	Card reader must be in computer during VPN access, or VPN connection is lost. Impractical in active field applications. PIV card recognition is spotty. Must re-boot several times
PDF Annotation	No good way to annotate PDFs if we are replacing printed plans with PDF plans. Would be great to have an application that allows us to annotate PDF using the Surface pen.
UPACS	Does not function properly with Google Chrome (Java Issue)

Texas Users (Surface Pro)

- When not in docking station, internet connection can be lost using jet pack and kick secured PIV AnyConnect connection off.
- PIV reader login doesn't let user get into computer...solution has been to restart or hard restart and try again.

- Power outage in Austin during a storm occurred during a telework day, but having the surface pro and jetpack allowed the engineering coordinator to review documents and communicate with TxDOT and Texas Division Administrator on a high priority ER project.
- Despite not having to travel on construction sites, the engineer coordinator has a critical role which reviews various documents submitted by Area Engineers and needs to process them in a timely manner. An accident that involved a spouse being hospitalized, allowed our dedicated engineering coordinator to use surface pro and jet pack during down times/waiting times. It allowed project documentation to move forward. No time savings was accounted for this situation, but I assume it would be signification amount.
- In meeting with high level management, the major projects engineer was able to bring in Surface Pro 3 into a meeting and demonstrate live conflicting issues. (Sometimes it's easier to explain things when you see it visually rather than words.)
- Major projects engineer was able to sign and send an electronic document for TxDOT through the Surface Pro before the expedited physical paper copy arrived to the Texas Division office. (This was a document TxDOT needed within 5 days but got it the same day electronically.)
- Area engineer used surface pro 3 and jetpack while waiting at airport lobby or on airplane to review documents and for checking email because of the lightweight as mobility advantages. (Area Engineer traveled multiple times out of state)
- Area engineer stated laptop weighs too much, and has taken Surface Pro 3 unit more often to sites and home. It allows access to Texas Division network. Not much of a need to print things, or have paper on desk countertops...everything is on the surface pro and easily transportable.
- During two separate week long training courses, one in Oklahoma City, OK and one in Dallas, TX area engineer got an email from TxDOT to review a PS&E and requested approval. Area engineer was able to review PS&E on downtime in sessions and was able to approve project in FMIS while in the back seat of the GOV vehicle on the drive back to Texas Division. With the assistance of the surface pro and jet pack, it allowed area engineer to accomplish that task.

Appendix B – Raw Performance Measures Data

FHWA Division: Utah

Utah is a user of the Surface Pro.

Data Collected	Week (or Partial Week) Within Each Month					September Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0	0	0	0	0	0	Paper Copies
FMIS and change order approval time savings (estimated hours)	0	0	0	0	0	0	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	0	1	0	1	0	2	Times Accessed
Number of hours of tablet use	40	40	40	40	40	200	Hours
Number of documentation photos taken using tablet	0	0	0	0	0	0	Photos

Data Collected	Week (or Partial Week) Within Each Month					October Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0	0	0	0	0	0	Paper Copies
FMIS and change order approval time savings (estimated hours)	0	0	0	0	0	0	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	1	0	1	0	0	2	Times Accessed
Number of hours of tablet use	40	40	40	40	0	160	Hours
Number of documentation photos taken using tablet	0	0	0	0	0	0	Photos

Data Collected	Week (or Partial Week) Within Each Month					November Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0	0	0	0	0	0	Paper Copies
FMIS and change order approval time savings (estimated hours)	0	0	0	0	0	0	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	1	0	0	1	0	2	Times Accessed
Number of hours of tablet use	40	40	40	40	0	160	Hours
Number of documentation photos taken using tablet	0	0	0	0	0	0	Photos

Data Collected	Week (or Partial Week) Within Each Month					December Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0	0	0	0	0	0	Paper Copies
FMIS and change order approval time savings (estimated hours)	0	0	0	0	0	0	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	1	0	0	1	0	2	Times Accessed
Number of hours of tablet use	40	40	40	40	0	160	Hours
Number of documentation photos taken using tablet	0	0	0	0	0	0	Photos

Data Collected	Week (or Partial Week) Within Each Month					September Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0	1	0	0	0	1	Paper Copies
FMIS and change order approval time savings (estimated hours)	0	0	0	0	0	0	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	0	0	0	0	2	2	Times Accessed
Number of hours of tablet use	27	44	36	44	36	187	Hours
Number of documentation photos taken using tablet	0	0	0	0	12	12	Photos

Data Collected	Week (or Partial Week) Within Each Month					October Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0	0	1	1	1	3	Paper Copies
FMIS and change order approval time savings (estimated hours)	0	0	0	0	0	0	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	0	1	0	0	0	1	Times Accessed
Number of hours of tablet use	9	44	27	44	10	134	Hours
Number of documentation photos taken using tablet	0	0	0	0	0	0	Photos

Data Collected	Week (or Partial Week) Within Each Month					November Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0	0	0	0	0	0	Paper Copies
FMIS and change order approval time savings (estimated hours)	0	0	0	0	0	0	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	0	0	0	0	0	0	Times Accessed
Number of hours of tablet use	27	18	19	24	9	97	Hours
Number of documentation photos taken using tablet	0	0	0	0	0	0	Photos

Data Collected	Week (or Partial Week) Within Each Month					December Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0	0	0	0	0	0	Paper Copies
FMIS and change order approval time savings (estimated hours)	0	0	0	0	0	0	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	0	0	0	0	0	0	Times Accessed
Number of hours of tablet use	35	36	42	0	0	113	Hours
Number of documentation photos taken using tablet	0	0	0	0	0	0	Photos

Iowa is a user of the iPad.

FHWA Division: Iowa	Summary	Units
Data Collected	1	n/a
Number of paper plan sets eliminated through access to electronic versions via tablet, or reduced time needed to access construction manuals, specifications, and references from the field	51	Paper Copies or Hours
FMIS and change order approval time savings (estimated hours), if users are performing this activity with the tablet device	?	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	12 Gig	Data used
Number of documentation photos taken using tablet	100	Photos

FHWA Division: Michigan

Michigan is a user of the iPad.

Data Collected	Week (or Partial Week) Within Each Month					September Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0	2	1	0	0	3	Paper Copies
FMIS and change order approval time savings (estimated hours)	2	2	2	2	0	8	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	0	3	1	4	0	8	Times Accessed
Number of hours of tablet use	15	15	15	15	0	60	Hours
Number of documentation photos taken using tablet	0	0	0	0	0	0	Photos

Data Collected	Week (or Partial Week) Within Each Month					October Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0	1	0	1	1	3	Paper Copies
FMIS and change order approval time savings (estimated hours)	2	2	0	2		6	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	1	1	0	1	1	4	Times Accessed
Number of hours of tablet use	5	15	5	15	15	55	Hours
Number of documentation photos taken using tablet	0	0	0	0	0	0	Photos

Data Collected	Week (or Partial Week) Within Each Month					November Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	1	0	1	0	0	2	Paper Copies
FMIS and change order approval time savings (estimated hours)	2	2	2	2	0	8	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	4	3	1	0	0	8	Times Accessed
Number of hours of tablet use	10	20	20	5	8	63	Hours
Number of documentation photos taken using tablet	0	0	0	0	0	0	Photos

Data Collected	Week (or Partial Week) Within Each Month					December Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0	0	0	0	0	0	Paper Copies
FMIS and change order approval time savings (estimated hours)	0	0	0	0	0	0	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	0	1	0	0	0	1	Times Accessed
Number of hours of tablet use	8	10	8	8	8	42	Hours
Number of documentation photos taken using tablet	0		0	0	0	0	Photos

Data Collected	Week (or Partial Week) Within Each Month					September Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	1	1		0		2	Paper Copies
FMIS and change order approval time savings (estimated hours)			2.5	2.5		5	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	2	1	4	4		11	Times Accessed
Number of hours of tablet use	10	10	20	20		60	Hours
Number of documentation photos taken using tablet	0			0		0	Photos

Data Collected	Week (or Partial Week) Within Each Month					October Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0		1	0		1	Paper Copies
FMIS and change order approval time savings (estimated hours)	1	1	1	1		4	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	1	1	1	1		4	Times Accessed
Number of hours of tablet use	10	10	10	10		40	Hours
Number of documentation photos taken using tablet	0			0		0	Photos

Data Collected	Week (or Partial Week) Within Each Month					November Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0		1	0		1	Paper Copies
FMIS and change order approval time savings (estimated hours)	1	1	1	1		4	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	1	1	1	1		4	Times Accessed
Number of hours of tablet use	10	10	20	3		43	Hours
Number of documentation photos taken using tablet	0			0		0	Photos

Data Collected	Week (or Partial Week) Within Each Month					December Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	2		0	0		2	Paper Copies
FMIS and change order approval time savings (estimated hours)	3	3	1	1		8	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	1	1	1	1		4	Times Accessed
Number of hours of tablet use	10	10	3	3		26	Hours
Number of documentation photos taken using tablet	0		5	0		5	Photos

Data Collected	Week (or Partial Week) Within Each Month					September Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0	1	0	0		1	Paper Copies
FMIS and change order approval time savings (estimated hours)	1	1	1	1		4	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	1	1	1	1		4	Times Accessed
Number of hours of tablet use	10	10	10	10		40	Hours
Number of documentation photos taken using tablet	1			0		1	Photos

Data Collected	Week (or Partial Week) Within Each Month					October Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0	0	1	0		1	Paper Copies
FMIS and change order approval time savings (estimated hours)	2	1	1	1		5	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	1	1	1	1		4	Times Accessed
Number of hours of tablet use	10	10	10	10		40	Hours
Number of documentation photos taken using tablet	0			0		0	Photos

Data Collected	Week (or Partial Week) Within Each Month					November Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0		1	0		1	Paper Copies
FMIS and change order approval time savings (estimated hours)	1	1	1	1		4	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	2	2	2	2		8	Times Accessed
Number of hours of tablet use	10	10	20	10		50	Hours
Number of documentation photos taken using tablet	0	4		0		4	Photos

Data Collected	Week (or Partial Week) Within Each Month					December Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0	0	0	0		0	Paper Copies
FMIS and change order approval time savings (estimated hours)	1	1	1	1		4	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	0	0	1	0		1	Times Accessed
Number of hours of tablet use	10	10	20	10		50	Hours
Number of documentation photos taken using tablet	4	5	0	0		9	Photos

Data Collected	Week (or Partial Week) Within Each Month					September Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	10	2	2	2	0	16	Paper Copies
FMIS and change order approval time savings (estimated hours)	2	3	3	3	0	11	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	50	25	25	25		125	Times Accessed
Number of hours of tablet use	40	20	20	20	0	100	Hours
Number of documentation photos taken using tablet	35	0	0	0	0	35	Photos

Data Collected	Week (or Partial Week) Within Each Month					October Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	0	2	3	1	1	7	Paper Copies
FMIS and change order approval time savings (estimated hours)	2	2	2	2	2	10	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	10	10	10	10	10	50	Times Accessed
Number of hours of tablet use	20	20	20	20	20	100	Hours
Number of documentation photos taken using tablet	0	0	0	0	0	0	Photos

Data Collected	Week (or Partial Week) Within Each Month					November Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	2	0	1	2	0	5	Paper Copies
FMIS and change order approval time savings (estimated hours)	2	2	2	2	0	8	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	25	25	25	25	25	125	Times Accessed
Number of hours of tablet use	20	20	20	20	20	100	Hours
Number of documentation photos taken using tablet	2	0	2	0	0	4	Photos

Data Collected	Week (or Partial Week) Within Each Month					December Total	Units
	1	2	3	4	5		
Number of paper plan sets eliminated through access to electronic versions via tablet	1	4	4	1	1	11	Paper Copies
FMIS and change order approval time savings (estimated hours)	2	2	2	2	2	10	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	25	50	30	25	10	140	Times Accessed
Number of hours of tablet use	20	30	20	20	10	100	Hours
Number of documentation photos taken using tablet	1	2	1	0	0	4	Photos

FHWA Division: Texas

Unit: 42999 User: Area Engineer Duration: August 17, 2015 to January 18, 2016

Data Collected	Quantity	Units
Number of paper plan sets eliminated through access to electronic versions via tablet	12,258	Pages
FMIS and change order approval time savings (estimated hours)	48	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	29	Times Accessed
Number of hours of tablet use	800	Hours
Number of documentation photos taken using tablet	30	Photos

Unit: 43000 User: Engineering Coordinator Duration: August 17, 2015 to January 18, 2016

Data Collected	Quantity	Units
Number of paper plan sets eliminated through access to electronic versions via tablet	800	Pages
FMIS and change order approval time savings (estimated hours)	144	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	51	Times Accessed
Number of hours of tablet use	800	Hours
Number of documentation photos taken using tablet	0	Photos

Unit: 43001 User: Major Projects Engineer Duration: August 17, 2015 to January 18, 2016

Data Collected	Quantity	Units
Number of paper plan sets eliminated through access to electronic versions via tablet	8,299	Pages
FMIS and change order approval time savings (estimated hours)	50.5	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	34	Times Accessed
Number of hours of tablet use	760	Hours
Number of documentation photos taken using tablet	45	Photos

Unit: 43002 User: Area Engineer Duration: August 17, 2015 to January 18, 2016

Data Collected	Quantity	Units
Number of paper plan sets eliminated through access to electronic versions via tablet	3,539	Pages
FMIS and change order approval time savings (estimated hours)	192	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	10	Times Accessed
Number of hours of tablet use	800	Hours
Number of documentation photos taken using tablet	132	Photos

Unit: 43003 User: Area Engineer Duration: August 17, 2015 to January 18, 2016

Data Collected	Quantity	Units
Number of paper plan sets eliminated through access to electronic versions via tablet	11,804	Pages
FMIS and change order approval time savings (estimated hours)	0	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	18	Times Accessed
Number of hours of tablet use	800	Hours
Number of documentation photos taken using tablet	0	Photos

Unit: 43005 User: Area Engineer Duration: August 17, 2015 to January 18, 2016

Data Collected	Quantity	Units
Number of paper plan sets eliminated through access to electronic versions via tablet	11,115	Pages
FMIS and change order approval time savings (estimated hours)	220	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	41	Times Accessed
Number of hours of tablet use	800	Hours
Number of documentation photos taken using tablet	80	Photos