e-Construction

Facilitation and Documenting of FHWA Division Office e-Construction Pilot

Final Project Report
March 2017

MS Surface Pro 3: Missouri, North Carolina, Pennsylvania, Texas, Utah, Virginia, and West Virginia
Apple iPad Air 2: Florida, Iowa, and Michigan

U.S. Department of Transportation
Federal Highway Administration

Table of Contents

1. Executive Summary

State departments of transportation (DOT) have demonstrated the benefits and return on investment of using mobile devices for highway construction project management and inspection activities. Access to software systems from the field provide for expanded and enhanced data collection and faster workflow processes. Connectivity is possible in most locations, allowing for real-time information gathering and data collection to support e-Construction. In remote locations with limited connectivity, some software tools and apps allow for data input to the mobile device that is synchronized when a connection is restored. Overall, transportation agencies are gaining significant efficiencies through mobile devices for construction administration.

The Federal Highway Administration (FHWA) Division Offices work closely with their respective State DOTs to implement the Federal-aid highway program, making FHWA a key stakeholder in the project delivery process. FHWA Division Offices perform a variety of functions, including reviewing and approving plans (preliminary and final), specifications, and estimate (PS&E) packages, and Interstate Access Justification reports; conducting inspections; managing project financials through the Financial Management Information System (FMIS); and approving contract change orders for Federal-aid projects. Many processes have a direct connection to the State DOT e-Construction systems—a "touch point" to the DOT, and FHWA identified the need to investigate mobile device application of e-Construction at the Federal level.

To assist with e-Construction implementation, FHWA initiated a pilot project to test the Apple iPad Air 2 and the Microsoft Surface Pro 3 in several FHWA Division Offices in 2015. A project team convened bi-monthly to discuss the benefits and lessons learned as well as evaluate and document results from the pilot project. The interim report[1] on this pilot project is posted to FHWA's e-Construction website and highlights the many benefits initially realized by FHWA. This final report supplements the interim report by providing documentation and analysis of the full pilot study along with final recommendations for agency-wide implementation of mobile devices.

During the first phase of implementation, the FHWA Division Offices in Texas and Utah piloted the Surface Pro, and the Florida, Iowa, and Michigan FHWA Division Offices piloted the iPad. Given the initial success of the pilot project, FHWA expanded the use of the Surface Pro (in May 2015) to Missouri, North Carolina, Pennsylvania, Virginia, and West Virginia Division Offices. Additionally, FHWA Headquarters and Resource Center personnel also tested the Surface Pro as a laptop replacement device. Primary benefits from use of the tablet devices include print cost savings, enhanced data collection on project inspections, and overall greater mobility provided by the tablet devices with data plans.

[1] Federal Highway Administration, *Facilitation and Documenting of FHWA Division Office e-Construction Pilot: Interim 7-Month Report*, January 2016. Available at: http://www.fhwa.dot.gov/construction/econstruction/do_pilot_interim.pdf

Success from this pilot project is attributed to several FHWA planning efforts:

- Both construction and IT personnel from FHWA communicated actively and visited with several Division Offices before and during the pilot, obtaining key information on the best tablet configurations and software tools that would maximize the success of the pilot.
- FHWA initially asked each Division Office to provide input on the type of device that would work best for them. The Division Offices primarily selected devices that matched those in use by their corresponding State DOT. FHWA stipulated that each user replace their existing device.
- DOT IT security policies evolved during the study. Access to various software apps through the corresponding app store was the primary reason to use a device similar to that of the State DOT. While the Apple store was accessible to users, the Windows store was not accessible due to USDOT policy.
- Local FHWA management had flexibility to develop processes for how to use the tablet devices that best fit their needs, with guidance and support from FHWA Headquarters project sponsors.
- The FHWA team included Headquarters IT personnel to assist with common challenges including iPad personal identity verification (PIV) card limitations, use of hotspots for devices without built-in cellular, and the Surface Pro Location Services, which enables users to capture location when documenting construction projects. Verizon Jetpacks were originally distributed to multiple users in an office, but FHWA determined that one or two Jetpacks per office were sufficient in a shared resource pool.
- Business processes for construction contract administration vary across States, and FHWA Division Offices adapted to their respective State DOT systems and business processes. Flexibility in being able to accommodate such processes was an important part of the success of the pilot.

Although users reported efficiencies in using both devices, iPad users reported the need for a Windows-based device in addition to the iPad for day-to-day activities and job functions. A Windows-based device such as the Microsoft Surface Pro 3 provides greater functionality and benefits than the Apple iPad Air 2. This is primarily due to:

Users of the iPad as a laptop replacement device in Michigan cited benefits but also identified the need for some type of supplemental Windows-based computer for day-to-day work activities due to the documented iPad limitations.

- Secure access needs that current USDOT iPads do not support.
- USDOT iPads that do not support the PIV card configuration.
- Greater user familiarity with Windows-based tools such as Microsoft Excel, Word, and PowerPoint.

Other issues reported were compatibility with the State DOT tools and systems, reliability of the PIV card reader, and intermittent PIV connectivity. Overall there was a mixed response in using the iPad as a laptop replacement based on individual needs and contexts.

In the future, FHWA's Investment Review Board and other decision-makers will determine how to best make use of available mobile devices and how to distribute them to employees. For new employees, a determination can be made as to the extent of field visits and time spent working at alternate locations

(such as telecommuting schedules, conferences, and travel). For existing employees, computer refresh cycles can include the option of a Windows tablet such as the Microsoft Surface Pro with external monitor and docking station in lieu of a laptop or desktop. Additionally, the data plans are also critical to maximizing effectiveness of the tablet devices.

Figure 1 presents the primary findings of this study. For groups with "touch points" to a State DOT and their e-Construction systems, users should select a version of the Surface Pro 4 as a laptop replacement device, or standard laptop with a shared iPad for field activities. This can be determined based on the time spent in the field, telecommute time, or time spent on travel. In addition, the user should also have a desire to use such a device to perform their work.

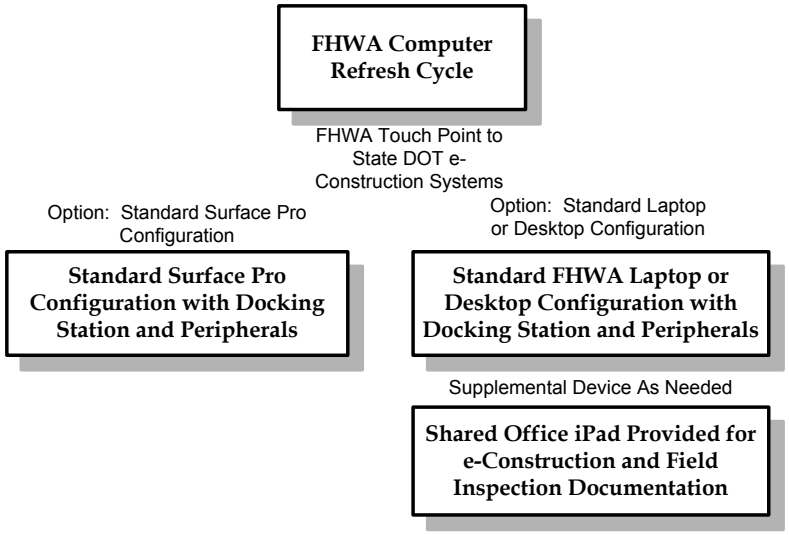


Figure 1. Recommended Options for Laptop or Desktop and Tablet Devices for FHWA Employees

1.1 Goals and Benefits from Expansion of the Tablet Device Pilot

The primary goal of the pilot study was to determine whether FHWA Division Offices could improve efficiencies by using e-Construction technologies similar to those of their corresponding State DOTs. Users that spent more time in the field obtained greater efficiencies in reporting – one such example of benefits was in application of the Mobile Solution for Assessment and Reporting (MSAR) tool for documentation and reporting on Federal emergency funding to States.

The bi-monthly conference calls provided new users with a forum to report on and learn about how to overcome challenges associated with transitioning from a laptop to a tablet. No major issues were reported by users that limited their ability to perform daily job functions, and each user experienced benefits from the tablet device that could not be attained using just a laptop computer. In the off months, the respective groups of iPad and Surface Pro users held conference calls to share lessons learned among themselves about the technology features.

The interim report from this pilot project highlighted value to users from increased mobility for the iPad and the Surface Pro 3. However, limitations in applying digital signatures and accessing systems due to the iPad's non-PIV card reader, issues in using Microsoft Office software tools, and functionality and readability issues on the iPad outlined the need to focus on use of the Surface Pro.

Expansion of the pilot to 5 new Division Offices was in effect a smaller-scale version of the final recommendation of agency-wide implementation of the Surface Pro. In States where the climate allowed for nearly year-round construction activities, and where multiple high-profile projects are underway, the

corresponding FHWA Division Offices anticipated maximum benefit from the use of the tablet devices. Having the devices on hand also encouraged users to apply them when walking on grade or when on travel, thus maximizing the mobility benefits provided by the device. Some users reported spending significant time on construction project sites, while others noted that they perform their job functions primarily in an office environment. Some Divisions also had Wi-Fi available in their offices during the pilot study, and the mobility of the tablet allowed for greater collaboration among office staff.

A list of primary goals for the original Division Office Pilot concept includes:

- Decrease time expended in administrative functions of construction activities within the Division Office.
- Decrease the amount of paper consumed and stored by the Division Office.
- Accelerate response by FHWA Division Office personnel to required actions.
- Improve communications within FHWA Division Offices and with industry partners.

FHWA Division Office personnel reported several primary benefits on 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

FHWA expanded the use of the Surface Pro to five additional Division Offices. Initially, the West Virginia Division Office did not receive tablet devices but joined the bi-monthly meetings to provide for comparison to the other Division business processes and to help determine how the tablets could improve practices. As part of the pilot expansion, Division Offices in Missouri, North Carolina, Pennsylvania, Virginia, and West Virginia all received Surface Pro devices and tested and reported on their application and findings. Verizon Jetpacks were also redistributed across Division Offices so that they could be shared among employees and used for connectivity in the field.

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

FHWA Division Office	Pilot Technology in Use and Number of Users	Pilot Study Highlights
Florida	iPad Air (6) – shared pool/platform	Florida Division developed training for users of the iPad.
Iowa	iPad Air (7) – individually assigned	Iowa Division uses devices to access Iowa DOT DocExpress System and also to approve documents electronically.

FHWA Division Office	Pilot Technology in Use and Number of Users	Pilot Study Highlights
Michigan	iPad Air (7) – individually assigned (two were tried as computer replacement)	Michigan Division users cited tablet benefits, but noted that laptop replacement is not achieved most efficiently with the iPad.
Missouri	Surface Pro (5) – individually assigned 1 device broken	One user reports preferring the Surface Pro to a laptop even with PIV and other issues. The inability to access SiteManager and MoDOT SharePoint is a significant drawback. Several users reported issues with taking photos in the field, with one suggesting it is easier to use a camera and import the photos to the tablet.
North Carolina	Surface Pro (4) – individually assigned	One user cited a preference for a laptop due to greater experience with use. The SP does not have the same synchronized functionality or tools as that of the NCDOT iPads.
Pennsylvania	Surface Pro (8) – individually assigned	A user found the ability to quickly respond to needs in the field highly beneficial, and access to FHWA systems and web-based systems was generally seamless, but file sharing was challenging due to lack of a CD ROM drive.
Resource Center	Surface Pro (1 user) – individually assigned	Device is used for full-time telecommuting and functions the same as the laptop it replaced. Allows for greater mobility for project reviews and while on travel. Investigated use of phone as hotspot.
Texas	Surface Pro (6) – 6 individually assigned (3 were originally planned for use in a shared pool platform)	The Surface Pro replaced laptops with no loss of functionality.
Utah	Surface Pro (4) – individually assigned 1 device broken	Users want access to apps using the Windows store to maximize functionality.
Virginia	Surface Pro (4) – individually assigned	Users consider them to be a great tool for field inspections, and with improved consistency and predictability in performance and network connections it could gain wider acceptance.
West Virginia	Surface Pro (5) – individually assigned	Originally served as the “control” for the pilot, as this Division did not initially receive tablets. Later, they were added to the Surface Pro user group.

The two devices implemented during the pilot had varying features and hardware components. The iPad has 128GB of internal storage capacity, while the Surface Pro has 256GB with 8GB of internal memory. No users reported any issues with storage of files or meeting capacity on either device. Each type of device included a keyboard, folio case, rugged case, and stylus. The Surface Pro included a docking station and allowed for the connection of an external monitor. Surface Pro users were also provided with a PIV-SMART card reader, a universal display adapter, and a Bluetooth mouse.

Additionally, FHWA provided the following links to tablet help and support resources at the start of the pilot:

Link to iPhone/iPad Tips & Tricks - http://dotnet.dot.gov/technology/mobilize_iphone.html

Link to the specifications on the iPad Air 2 - www.apple.com/ipad-air-2/

Link to the specifications on the Surface Pro 3 - www.microsoft.com/surface/en-us/support/getting-started/get-started-with-surface-pro-3

2. Analysis and Performance Measurement for the FHWA e-Construction Application

Each Division Office collected data on performance metrics to quantify the benefits of using the tablet devices and to support final recommendations from the pilot project. The initial list of metrics was developed with input from each user, and each Division Office was afforded flexibility in defining the measures that were most appropriate for their respective business processes.

While the original focus was on metrics such as data availability and data quality, results showed that enhanced mobility was the primary benefit from the tablet device. For e-Construction at the State DOT level, one of the primary benefits noted was real-time access to project specifications and document reference libraries as compared with trips back to an office. This metric was included in this study as well, but the processes for FHWA inspections relied more on pre-loading plan sets as opposed to unique reference documentation needs in real-time as issues arise in the field.

The following table highlights the performance measures and data sources developed for this pilot project. The data sources were modified slightly from the previous report, and a primary data source was the focus of Division Offices that reported on performance measures.

Table 2. Performance Measures and Data Sources

Performance Measure	Data Sources
Reduction in paper needs	***Primary:*** Number of paper plan sets eliminated through access to electronic versions via tablet *Secondary:* Reduced time needed to access construction manuals, specifications, and references from the field
Reduction in processing times and approval times	***Primary:*** 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	***Primary:*** Number of times electronic files are accessed from the field due to increased availability of data (data plan use)

Performance Measure	Data Sources
Increased efficiency and productivity from enhanced mobility	***Primary:*** Number of hours of tablet use Number of additional activities undertaken remotely *Secondary:* Baseline transit time for accessing project documents/Current time spent accessing project documents in the field and photo processing time
Improved hardware durability	***Primary:*** Incidents with tablets and estimated damage (reported on as needed and related subjectively to laptop experiences)
Qualitative assessment of benefits	Anecdotes on job performance

* Not applicable to the iPad, as login to FMIS requires the PIV card reader.

The following sections provide detailed usage information for each Division Office.

2.1 FHWA Florida Division Office Findings

Representatives from the Florida Division Office used the iPad devices in a shared pool among office personnel, as needed, with their existing workstation configuration. The devices were used in the field to capture photos and access electronic plan sets for Florida DOT construction projects. 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. Florida Division Office personnel also developed PowerPoint slides to train newer employees and others with limited iPad experience. The iPad accessories include protective Otter Box case, external keyboard, chargers, stylus, and shoulder harness.

Users noted frequent use of third party file transfer tools; Horizon Virtual Desktop Interface for accessing email; Microsoft Office products for the iPad such as Word, Excel, and PowerPoint; the device camera; and Google Earth for map access. While logged into Horizon, users can access email through Microsoft Outlook without the need for a PIV card. Additionally, users were able to access FDOT's ProjectSolve SP site to gather and review project documentation prior to National Bridge Inspection Standard (NBIS) field reviews.

Users in Florida noted that the iPad's built-in cellular, integrated camera, and enabled GPS provided benefits over that of a laptop computer. Some users also noted benefits from voice to text software, although construction equipment noise impacted use. Site visit durations were shortened through use of the iPad, and the ability to record photos, measurements, and other data while on site proved beneficial for Americans with Disabilities Act-complaint investigations. The iPad reduced the need for other external devices such as a camera, pens, and paper. The Horizon application allowed users to perform individual login during each use of the device, thereby ensuring that users only accessed their own email accounts to facilitate sharing of the tablets. FaceTime was also tested successfully over Wi-Fi by at least one user.

Some disadvantages of the iPad include limitations on battery life (requires interim charging for a full day's use), limitations in exporting files from the iPad to another device such as a daily use laptop, and file synchronization from the iPad to network drives or to the users' laptop

Additional investigation into field data collection and measurement apps would be useful for the iPad users.

due to the shared nature of each device. One user noted scratching the screen while carrying tools such as a level and measuring tape along with the iPad. Apps that could alleviate the need for such tools would be beneficial. Users also noted challenges with screen glare in the field and the impact on photo quality. Access to FMIS was a major issue due to lack of a PIV card reader on the iPad.

Additional documentation on benefits and challenges to using the iPad in Florida is included in Appendix A. Overall, users noted significant benefits through this shared device pool when using the tablets in conjunction with FHWA standard issue laptops.

2.2 FHWA Iowa Division Office Findings

The Iowa Division is using the iPad with success and has been able to connect remotely to the Iowa DOT DocExpress system for workflows and approvals with electronic signatures. During phase 2 of the pilot, one iPad was transferred to a new engineer for use and testing. Iowa also accesses ProjectWise to download documents and share information on projects. The Division uses Good Share to securely access, download, and share documents, and the software engages other applications such as email in the Good Environment. Iowa Division personnel have also downloaded 3D plans in an effort to integrate 3D models into business processes.

During the pilot, the Iowa Division Office experienced a local network outage. During the network outage they were able to position the iPads and use their hotspot capabilities to maintain network access to a majority of the office. This redundancy in data systems allowed continuity of operations during the outage.

2.3 FHWA Michigan Division Office Findings

The Michigan Division Office also captured data related to the performance measures for January through November of 2016 to supplement the reporting included in the interim report. The following table highlights the aggregate data from six iPad users.

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

Performance Measure	Measured Values from 1/1/16 through 11/30/16
Number of paper plan sets eliminated through access to electronic versions via tablet	74,600 pieces of paper (based on 200 pages per plan set)
Change order approval time savings (estimated hours)	44 hours saved
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	1,449 times files accessed
Number of hours of tablet use	1,873.5 hours of use
Number of documentation photos taken using tablet	35 photos taken

One user accounted for 30 paper plan sets eliminated per month, representing a majority of the paper prints saved of all six users. The number of hours saved on change order approval processes decreased from 2015 data due to the business process change that no longer requires approval each contract

modification. One user noted that the iPad is too large to use to take photos, although FaceTime was used once to view a road washout in a remote location and saved a trip to the site. One user took 15 photographs and another user took 20 photographs with the iPad, and the same metric in the interim report was 54 total photos taken. The iPad also allowed personnel to join web conference meetings after having issues accessing the meetings on their laptop. The iPad was also more beneficial for use while on business travel compared with taking a laptop. During a partnering meeting with Michigan DOT, Division Office personnel were able to avoid confusion and show specific locations of non-conforming signs along an Interstate by accessing Google Earth on the iPad. This kept the conversation moving forward, and the iPad was vital in illustrating the point and leading to a win-win situation.

Users noted limited use of the iPad's camera, citing difficulties in taking photographs due to its size.

2.4 FHWA Missouri Division Office Findings

The Missouri Division Office initially had some issues with Outlook freezing, and a suggestion was made to reinstall software to alleviate the issue, which, when completed, did resolve the issue. Users noted that the glare on the screen in the field made it challenging to view and read information on the Surface Pro display, and this remains an issue. One device was broken due to an incident, and one person is using a mobile phone as a hotspot for connectivity in the field. Users in Missouri also had issues with the Surface Pro mapping network drives, and the device would often take longer than a laptop upon log in. Placing a batch file on the desktop where users run it after logging in solved the issue, and the appendix has a list of actions that users can take to solve the issue.

The Missouri Division Office used the tablet successfully in a variety of situations, such as using the stylus to take notes as well as easily changing from the on screen keyboard to the attached keyboard. One Verizon Jetpack was shared among the users with no reported issues. The connectivity was greatly improved while utilizing the Jetpack. A personal cell phone used as a hotspot by one uses and was found to be very beneficial for mobile access. Users were able to prepare draft inspection reports and attend webinars while traveling. One user found it extremely useful to download the plans and proposals to the tablet allowing access during inspections instead of carrying around bulky hardcopy sets. Some users found that working from home and checking emails remotely was very easy. The small portable packaging of the tablet made traveling easy, and the connectivity to one or two larger monitors for multi-tasking and document editing ease. Overall the Division would support giving staff the option of using a tablet.

The Missouri Division Office also captured data related to the performance measures for June through November of 2016 to supplement the reporting included in the interim report. The following table highlights the aggregate data from six iPad users.

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

Performance Measure	Measured Values from 6/1/16 through 11/30/16
Number of paper plan sets eliminated through access to electronic versions via tablet	2,160 pages
Change order approval time savings (estimated hours)	16 hours saved
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	450
Number of hours of tablet use	3,615 hours
Number of documentation photos taken using tablet	261 photos taken

2.5 FHWA North Carolina Division Office Findings

The North Carolina Division Office works closely with the North Carolina Department of Transportation e-Construction systems. The Division Office has four Surface Pro devices assigned for use primarily in the field on inspections. Users are experiencing benefits from the devices but noted that since NCDOT uses iPads with specific apps, additional benefits would be realized through investigation of additional apps on the Surface Pro once the Windows Store becomes available. North Carolina DOT has e-Construction tools in place, including an electronic materials certification system.

The primary challenge for the Division Office is limited connectivity in remote locations within the State where cellular service may be intermittent or unavailable. Users connect using the Verizon Jetpack with the Surface Pro and through AnyConnect software. Users have successfully accessed the North Carolina DOT SharePoint system and will continue testing file access, approvals, and file transfer activities with the Surface Pro.

2.6 FHWA Pennsylvania Division Office Findings

Pennsylvania Division Office representatives implemented Surface Pro devices in 2016 with a primary connection to Pennsylvania DOT through the DOT Engineering and Construction Management System (ECMS). The Division Office used the devices for electronic design reviews and project reviews as well as to download copies of plans. After some initial issues, access to the interface to the State DOT system over Division Office Wi-Fi was found to be due to Division Office Wi-Fi settings, not device related, was resolved and worked well. Access to FHWA systems and any web-based systems was generally seamless and no different than connecting from a laptop or desktop PC. Tablet use was reported as primarily beneficial in that it provided connectivity in nearly any location through the Jetpack. The jet pack allows multiple connections, but efficiency decreases with too many connections. Although the screen and keyboard are very small, and the device is too large for easily and safely taking photos during field inspections, the ability to quickly respond to needs in the field is highly beneficial in use of the Surface Pro. One Surface Pro was returned to Headquarters for reimaging and returned for use.

Sharing files with PennDOT is challenging. The use of thumb drives is prohibited, and the Surface Pro does not have a CDROM drive. The FHWA Secured Large File Transfer (SLFT) tool was found to be a useful way to receive large files from PennDOT. PennDOT's ECMS is useful where signatures can be provided by clicking an approval button for PS&E's and most construction approvals such as change orders and time extensions. Users were also able to install Adobe Acrobat Professional for use on the Surface Pro device. Most project inspections are performed at project field offices. Users have successfully found structures for inspection based on the coordinates from National Bridge Inventory (NBI) data using the Surface Pro.

The Pennsylvania Division Office captured performance measures data for June through November of 2016. The following table highlights the aggregate data from the eight Surface Pro users.

Table 5. Performance Measures Reported by Pennsylvania Division Office (Combined Totals)

Performance Measure	Measured Values from 1/1/16 through 11/30/16
Number of paper plan sets eliminated through access to electronic versions via tablet	164 Paper Copies
Change order approval time savings (estimated hours)	0
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	223
Number of hours of tablet use	1,884 hours
Number of documentation photos taken using tablet	174 photos taken

2.7 FHWA Texas Division Office Findings

The Texas Division Office noted significant benefits from tablet device use in 2016 and with cumulative data since the fall of 2015. Table 3 highlights the primary measures tracked, along with cumulative data supporting each, for the six Surface Pro users throughout the pilot duration.

Table 6. Performance Measures Reported by Texas Division Office (Combined Totals)

Performance Measure	Measured Values from 8/17/15 through 11/30/16
Number of paper plan sets eliminated through access to electronic versions via tablet	116,627 pieces of paper
FMIS and change order approval time savings (estimated hours)	1,380 hours saved
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	791 times files accessed
Number of hours of tablet use	13,213 hours of use
Number of documentation photos taken using tablet	609 photos taken

Users in Texas noted that start-up, shut-down, and file-access speed was faster with the Surface Pro over that of the previously used laptop. In addition, users requested electronic files from Texas DOT for project reviews to eliminate the need for printing, carrying copies, or shipping to other office locations. One user noted that the CAP review times in Fort Worth in 2016 were significantly streamlined due to access to the Surface Pro, and the tablet device portability was a telecommuting benefit as well. The Surface Pro docking station also allows users to connect multiple external monitors in addition to using the built-in display as a screen. When power was not available due to storms, the Wi-Fi was useful for communicating with Texas DOT officials and FHWA Leadership during network disruptions (as part of the Emergency Relief Program). Users also applied digital signatures on documents for timely FHWA approvals and some use the stylus to sign documentation electronically. The Surface Pro also benefitted users during an FHWA transition to a newer email client, as email was then no longer accessible on smart phones.

Users also noted some disadvantages to the Surface Pro compared with a laptop, including lack of an external CD drive, only one USB port, and the need for an external PIV card reader. While the multi-USB-port adapter and external PIV reader solved the issue, users noted that they were not as durable as expected. Also, one user noted that the camera is not easily and readily accessible in the field due to the PIV card security login requirements (the PIV card is a requirement to access the device). The need to restart the device, intermittent connection loss to network drives, and wired/wireless connection switching while in the office with the Surface Pro docked. One user also noted that the smaller touch screen on the Surface Pro takes some time to adjust to as compared with the larger laptop screen. On several occasions, users were unable to login to the Surface Pro and noted a message stating that the domain specified is not available. Returning the device to the docking station alleviated this issue. Users recommend the Surface Pro despite the common noted disadvantages over the laptop.

> Users noted that access to the Windows store to download apps would maximize the functionality of the Surface Pro and take its use to the next level. Also a more stable PIV card configuration is needed.

2.8 FHWA Utah Division Office Findings

In Utah, three staff members used the Surface Pro as a laptop replacement device for the entire duration of the pilot. While four devices were originally purchased, one was damaged. Users captured a list of common issues as noted in the appendix, and most issues were resolved while some are ongoing. For example, users noted that working on one screen is slower than having multiple displays connected— an issue that should be considered in agency-wide implementation. At least one external monitor may be considered as part of future standard issue equipment with the Surface Pro. Another consideration is to issue a multi-USB-port adapter to allow connection of the PIV card reader as well as other USB devices. The Verizon Jetpack was useful in the field, but the 3G connection was noted as too slow for the data being accessed. The Jetpack was also sporadic on connectivity at times depending on the location of use. Users also suggested that access to apps would maximize the functionality of the Surface Pro as a tablet device. Without access to the

> One user in Texas cited an *80% reduction in paper consumption* by using the tablet.

Windows store, the Surface Pro is similar in functionality to a smaller version of a laptop with a touch screen. A more stable PIV card configuration would also be beneficial, as the reliability of the connection has caused users to print necessary documents prior to field visits to ensure they are accessible.

Performance measures reported for the last quarter of 2016 indicated one Utah user saved over 1200 pages by using the tablet. Two users accessed files electronically from the field 40 times and 39 times, respectively. Another user noted eliminating the need to print 7 plan sets by accessing them on the Surface Pro in the field. The same user also captured 218 photographs with the tablet.

2.9 FHWA Virginia Division Office Findings

In Virginia, the tablets have been tested as complete replacements of laptops and as companion devices for laptops when Area Engineers perform project inspections. Engineers have replaced their laptops with Surface Pro tablets and report that the tablets are performing well in the office given their speed and lightweight design. The ability to take notes on OneNote is a great benefit as opposed to a traditional note pad, and the notes are accessible from any device. The tablets help streamline reviews and increase productivity due to their mobility and power, and the tablets are invaluable in terms of time and resource savings for users.

Some challenges include the predictability and dependability of the device. Users have experienced login issues when out of the office. If locked, the user would have to bring it back and connect it by cable directly to the network for the tablet to unlock. The reliability of the PIV card reader connection proved to be an issue in Virginia as well.

Access to the Virginia DOT e-Construction systems is available, but concurrent access with both FHWA and Virginia DOT systems created connectivity issues when linking into VDOT's network. Virginia DOT can provide Wi-Fi access to their e-Construction system, but the firewall prevents connectivity to the agency's virtual private network (VPN). Overall, the tablet is considered a great device, and with improved consistency and predictability in performance and network connections it could gain wider acceptance among users.

2.10 FHWA West Virginia Division Office Findings

During phase 1 of the pilot, the West Virginia Division Office did not receive tablet devices, allowing for a "control" comparison to the other participating Division Offices. In phase two of the pilot, five users in West Virginia tested the Surface Pro. The devices are used in addition to standard issue laptops instead of as a laptop replacement device. Initially, users had some issues with signing in to the devices for the first time, and FHWA IT provided assistance and noted that this can happen on the first attempt to log in. FHWA reimaged devices to fix the initial issues.

The West Virginia Division of Highways (DOH) uses SiteManager for inspection reports with electronic signatures, with wet ink signatures on change orders. AASHTOWare is also being considered by the

DOH for materials certifications. These are areas where the Surface Pro will allow the Division to make full use of technology applications in line with DOH processes. Microsoft OneNote is also used as a digital note-taking application on the Surface Pro. This software tool is only available when the Surface Pro is docked and is not available when used remotely. The DOH is also investigating use of Bluebeam Revu for electronic plan mark-ups, and a similar tool would benefit the Division Office by allowing annotations on PDF files.

In parallel to this study, the West Virginia Division Office also used an iPad with the MSAR app for documentation and reporting on $80 million in emergency relief funding for flood events. The application is used for detailed flood reports and was developed for FHWA by a third party. The MSAR app is available for Windows devices, but FHWA does not currently allow users to access the Windows Store. Access to a web-based version of the MSAR software solved this current issue for another Division Office.

The West Virginia Division Office was the only participant in the pilot that was able to compare both the iPad and the Surface Pro. The Division Office noted that the iPad is better for graphics and photographs. Both devices are also user friendly, and the iPad provided great assistance in generating detailed damage reports and made the process faster and more efficient.

3. Differences between Shared and Individually Assigned Devices

The Surface Pro is recommended for future application as a laptop replacement device. The iPad could provide certain users with benefits in the future, especially those in locations where the State DOT has robust applications currently in use on the iPad and where those are not available for Windows-based tablets. Initially, users selected the iPad in locations where the State DOT used the iPad for e-Construction activities. If implemented, users would need an FHWA standard-issue laptop or desktop configuration while using the iPad in a shared office pool. This has been tested successfully in the pilot.

4. Updated Mobile Device Applications List

Users tested a variety of software tools and applications on both the Surface Pro and the iPad. This list is cumulative for both phases of the pilot.

AnyConnect – Software that provides secure endpoint access on most devices, allowing users to securely log in to network systems.

Citrix Receiver – Provides VPN access to AASHTOWare products such as SiteManager, document management systems, and other tools, including a user's desktop and profile on another machine.

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 they are free-ware.

- 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 uploaded into SiteManager.
- Tiny Scan and Genius Scan are two free applications to convert picture formats into PDF files.

Good For Enterprise – Is used by the Common Operating Environment (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 deskside 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, and 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.

Secure Large File Transfer Solution: The FHWA SLFTS 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. FHWA uses this software system agency-wide, and access will provide Division Office users with the ability to store and transfer large files.

Suggested applications: The Florida Division noted that a voice-recognition app that would capture spoken field information without the need to type would be useful. Users also noted that a PDF mark-up tool would also provide benefits in easier annotation of drawings.

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.

5. Equipment Cost Comparisons

Technology changed over the duration of this 2-year pilot study. Originally, the Surface Pro 3 and iPad Air 2 were tested, while the current model is the Surface Pro 4, with the Surface Pro 5 scheduled to be released spring of 2017. The standard FHWA laptop prices did not change. The current costs for each device, along with peripherals, are summarized in the following table.

Table 7. Peripheral and Data Plan Costs by Configuration - Year 2

Configuration	Itemized Costs	Total Costs
Dell Latitude E6440 (8GB Standard) – FHWA Standard Laptop Configuration	$1,532	$1,859
Dell Latitude E6540 (16GB Engineering) – FHWA Engineering Laptop Configuration	$1,903	$2,230
Apple iPad Air 2 Base Cost	$934	$1,229
Microsoft Surface Pro 3 Base Cost – without Data Plan	$1,471	$1,851

*Costs were obtained from the DOT 2016 approved desktop/laptop configuration list

These costs are updated for Year 2 of the pilot and are similar to year 1 costs, with the exception of a price difference for current Surface Pro and iPad Air models. Tablets are comparable in price or lower cost than that of a standard issue laptop.

6. Conclusions and Recommendations

The interim report for this project documented key factors in the decision to expand the pilot with only the Surface Pro. However, iPad users have also documented benefits from the availability of the device, especially for those in States where DOT inspectors also use iPads. The Surface Pro is preferred by users as a laptop replacement device, while the iPad can be implemented successfully in a shared office pool in addition to a standard workstation for each employee.

Primary Recommendations:

> Windows-based tablets can fully replace a standard laptop or desktop configuration, increasing the quantity and quality of field documentation, and providing process efficiencies.

- **Device Management:** Develop a process to allow new employees to select between a laptop or Windows-based tablet such as the Microsoft Surface Pro based on the estimated amount of time expected to be spent in the field inspecting projects, performing project reviews, or time spent away from the office such as for travel or teleworking. The mobility and efficiency of the tablet are key benefits and often encourage greater use compared with a laptop or desktop.

- **Connectivity:** Establish a policy for data plans and data usage. iPad users have unlimited cellular data with built-in Wi-Fi, while Surface Pro users have Verizon Jetpacks as hotspots. Offices may share a hotspot device, and apps are available that can synchronize data collected in the field (during a period of no connectivity) when a user returns to a location with wireless connectivity.

FHWA can further enhance benefits by developing guidance on specific apps, software tools, and processes that can be used to improve efficiency with mobile devices.

- **Document Management and Storage:** FHWA would benefit from implementation of an enterprise-wide document management system and its functionality, similar to that of the State DOTs. For large file storage and sharing, guidance to users on the Secure Large File Transfer System (SLFTS) is key to agency-wide implementation, as documents can be stored and updated and third party users can be provided access to certain folders as necessary.
- **Software Tools:** A common set of software tools and apps that can be used on the tablet devices such as the MSAR app, Microsoft OneNote for free form documentation and collaboration, the FHWA SLFTS instead of emailing files, and virtual desktop tools such as Horizon Virtual Desktop Interface. Consideration of apps that allow users to input data and then synchronize with other devices and databases on the network once a connection is restored. This will help with remote locations where cellular service may not be available or may be intermittent. The MSAR app is another tool frequently cited by users as beneficial for use.
- **Further Peer Collaboration:** Development of a forum such as a listserv, email group, or other peer support mechanism for new users to gain insights from more experienced users to maximize the effectiveness of the tablet.
- **Training:** Development and implementation of self-paced, web-based training for new tablet device users with examples similar to the Texas Division's training on use of the MSAR app for Detail Damage Inspection Reports (DDIR) and the Florida Division's training on use of the iPad for inspection and reporting.
- **How-To Guidance:** Provide outreach materials to each Division Office on the primary uses of the tablet, including benefits information and how to gain efficiency in job performance, such as through application of digital signatures on change orders and approval and documentation on federal-aid expenditures. Include information and tips on how to handle daily business processes and functions electronically.

This pilot project has proven very valuable to FHWA Division Offices and the benefits show that further use of tablet devices will enhance mobility and efficiency for personnel. Additionally, agency-wide implementation based on the needs of field personnel will continue to build momentum nation-wide for e-Construction implementation.

Appendix A. Division Office Observations and Recommendations

Florida Division Observations (iPad Air 2):

The Florida Division used iPads under the shared resource platform. Sections with the Division (Project Delivery, Technical Services, Planning, ROW, and Financial teams) have volunteered to participate in this study. The division used iPads for CAP, PODI and project inspections (QARs), Emergency Repair (ER) and Finance related reviews. Also, iPads were used while conducting project meetings, Task Team meetings, attending conferences and peer exchanges. Each user was asked to provide his/her feedback (pros and cons) after each usage. Below are summary of each user's feedback.

PROS:

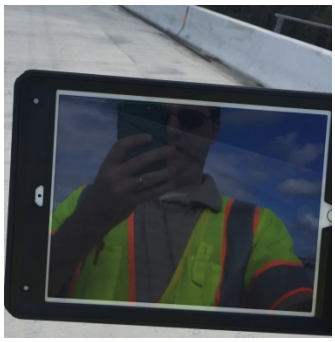
- The camera is excellent and not having to fumble between notebook, tools, and a separate camera was a *major* benefit.
- The Word application is great for note taking and much more convenient than paper. Plus, voice to text software worked well even with ambient noise, though not when heavy equipment 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 Florida 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.
- Accessing required data from State/FHWA web sites while in field was very helpful.
- This week I used the iPad for field interviews, pictures and reading an excel spreadsheet. I also used it to complete my E2 travel, even uploading my hotel folio to the system. Everything worked well.
- The camera is better than the one issued to civil rights and it's nice to not have to carry multiple items (paper, pen, and camera) onto a job site. Even the rain didn't stop the effectiveness of note taking.
- As I've noted before, the battery life is too short for a full day of use. I twice ran out of power before completing my work. Another downside is that, without a responsive, touch-typist keypad, it's difficult for me to use it in place of my laptop. (Action: wireless keyboard was provided to the user. He is comfortable with using it.)

- Overall, I enjoy the benefit of the iPad during meetings, rather than our bulky laptops. Being able to stay connected, review the State's procedures and manuals during discussions, and pulling up specific project locations on Google Earth were some of its uses.
- The Horizon app was somewhat beneficial. This app allowed me to have a virtual desktop. I used this app mostly to get into my outlook mail and the Division's network drives (H, M, T and U drive). This does not allow access to my laptop C drive, even when it is plugged into my docking station in my office. The positive of this app is that no one will be able to come back in after me and access my Outlook mail. You need to have your password each time that you start a new Horizon session. Also it was beneficial to be in a meeting and look through our Reviews folder to see when was the last time we performed a process review on a subject being discussed.
- Overall, I had difficulty deciding how to export my work from the iPad to anything else. I took notes throughout the conference using the Notes app, but then found it difficult to export those notes for use. I ended up just opening my outlook via Horizon app, creating a draft email, and then using the Notes copy function to paste into an email. Again, it seems like a rather lengthy process.
- As an experiment, I used the FaceTime app with my family at home from my hotel room and it worked out really well. This was over Wi-Fi instead of using the Verizon data. This could be quite beneficial for a TE that is on a construction project and needs someone at the Division technical lead or Resource Center to view an issue they are dealing with.
- I'm a big fan of the iPads after having used them on my seven ROW PARs this year. It was very convenient being able to complete my ROW PAR Checklists and check my office email while at the FDOT district offices, something I normally can't do given FDOT's very restrictive Wi-Fi access policy. I now reserve an iPad for all my trips in order to keep up with my email while in the field. They are quite useful devices. I highly recommend we continue our use of the IPads.
- Able to easily connect to email.
- Able to use Skype for Business while away from the office.
- Able to open and edit Microsoft Office documents easily while using the horizon app.
- Able to use LAPIT for reviews while in the field.
- Able to take pictures and immediately paste them to documents.
- Good for reviewing documents and reading them.
- Able to use Adobe connect via the Connect application and through the Horizon App with ease.
- Able to look and upload TIGER monthly reports.
- OneDrive App is beneficial and allows remote access to uploaded documents.
- Use of the iPad for travel authorizations with E2 was possible and just as easy as on a computer.
- Able to keep connected to the network while being away from the office.
- Able to use iPad as a Wi-Fi hotspot to use my computer to sign into FMIS and approve funds.
- Able to use the iPad as a GPS.
- I used the following applications and features:
    - "Word" App - taking notes during the review meetings
    - "Horizon" App - accessing emails
    - Camera - I took pictures that I will include in my report.
    - Remote access to Outlook.
    - Meeting notes without the use of paper and store electronically.

    - Keyboard– I really like it over the onscreen keyboard.
    - Convenient, light device.
- I was able to take pictures easily with the iPad. Recommend that a protective iPad case be used when taking pictures in the field.
- I was able to begin the inspection report write-up on the iPad and completed most of the reporting while sitting in the car.
- The draw feature was used to draw arrows within the pictures as shown in the export. It was easy to do this with the iPad stylus.
- I also had no problems accessing the report with Dropbox.
- I also loaded reference materials and referred to these items when I was in meetings. The iPad could be a good tool for reference uses.
- I have taken the iPad out on several occasions. The iPad worked pretty well to get onto the cellular network and then connect to the email server. I was able to check emails during the breaks and using the Horizon app, which worked pretty well. I have been able to take electronic notes relatively easily. The difficulty comes when syncing back up at the office. The apps and features allow for this, but because of the "shared" status most things are set up for everyone to be able to use, which reduces the efficiency of the process. I can see how this would be a beneficial tool for frequent travelers as a dedicated resources.
- Quick access to email allowed prompt response to customers, as needed.
- Light weight, which is great for mobility. Screen is large enough to read and review files.

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 was provided.)
- 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 was 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 was 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 the 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, due to lack of PIV card reader.
- Connecting to offices drives was not automatic.
- Slow or no multitasking.
- Small screen compared to the office computer.
- Some applications could be difficult to use for a person that has big hands.
- Battery life is not as good as computer.
- Unable to print documents from the iPad.
- Not a laptop replacement.
- Commands easily done with a mouse are not simple in the iPad (e.g., right clicks for spell checking).
- Difficult to enter data and edit documents.
- Keyboard doesn't have the F1-F12 keys like on regular keypads.
- Spell checking is not as easy as on a regular computer.
- To delete an email, I had to drag/drop to deleted folder. The email could not be deleted by using the "DELETE" key. Pressing this key takes you to the deleted folder.
- Some webinars require an Adobe connect account and could not be accessed with the Connect App but could be accessed via the Horizon App.
- Because the IPad is a shared resource, there is no email assigned to each iPad, and we are unable to send documents via email unless the user created the document in the Horizon App.
- The need for the OneDrive app adds another step to upload and look for documents.
- Unable to sign into FMIS.
- Network drives were not mapped for the Orlando office and required a separate script to be run within the Horizon App.
- The screen has too much glare while in the field or in bright rooms.
- While performing CAP reviews, I could not look for the files on the network drives. I had to send the documents to my email first, then save the documents to the desktop (while using the horizon App) and open the document.
- Relatively slow connecting to VPN through the "Horizon" App. (see lessons learned below). I was not able to access the network drives. Once we completed the review, I was not sure how to send my meeting notes and pictures to my computer. Because there is no email account on the iPad, my options were limited. As an alternate solution, I followed these steps:
    - Using **"AirDrop"** from the iPad to my personal iPhone.
    - Using my **personal email** from my iPhone to my Outlook account.
- Manipulating and arranging the pictures on the iPad within the Word document was difficult at times. It is easier to do this on the laptop.
- It is not practical to use for everyday assignments, email and project reporting and correspondence required by a Transportation Engineer.
- An additional hurdle is the password information. Because the same account was used for all the devices, changing the password on one device effectively locked other people out. This can be overcome with some closer coordination, but it is a good example of where the dedicated resource application would have been more efficient and had increased functionality.

- Not a laptop replacement; still utilized my laptop, including keypad and mouse, for full network access.

Emergency Repair (ER) Inspection/Damage Assessment after the Hurricane Mathew:
I used the iPad and the MSAR App for my inspections of the Hurricane Matthew damages. Below are some of my preliminary thoughts and observations.

MSAR App notes:

- The longitude/latitude device feature was nice.
- The ability to add the photo directly to the report (as opposed to the convoluted approach needed for our regular inspection reports) was a nice feature.
- I still found myself not wanting to spend precious field time filling out all the form information fields while on-site. Some information was required just to save it, but it appears I'm going to need to modify some of that information (DDIR #'s versus project descriptions, damage summaries, and repair summaries).
- In a lot of cases, work was already completed. The Florida DOT provided a DVD with pictures of site damages to date, which will need to be incorporated into the reports. It appears the only way to do this will be to upload the reports to the website, and then add the pictures manually that way.
- I might have accidently deleted a report by hitting the delete button twice due to a perceived lag. There is no "delete confirmation" prompt so I'm not positive, and there does not appear to be any way to access any other MSAR features from the app other than the "report preparation" feature. The photos taken do not appear to be saved on the device's normal camera.
- I can't upload the report without having cost information entered. Costs were not immediately available, so I had to enter "preliminary placeholder" information of $1 just to upload.
    - However, once a report is "uploaded"…. it is removed from the device, thereby making it inaccessible to see or modify without going directly to the MSAR website.
    - Logging into the software and website was not without its own problems and issues.
- None of the pictures were actually saved on the device, so I have no access to them once they are uploaded to the web server. Additionally, transferring the photos over to my electronic files on the network from the website looks to be a cumbersome and slow process.
- Using this device/process seems to be adding a lot of additional steps into the process versus the normal procedure.
- What is the expectation upon the division staff for keeping these reports "up-to-date" once the initial "final" DDIR is prepared? Are we expected to update costs and progress status as the project proceeds?
- There were some areas that I wasn't entirely sure were even eligible. I didn't want to create a report for them until I had a chance to discuss their eligibility internally. Therefore, I pulled out my camera and took pictures with that.
- I still prefer a camera versus an iPad. A camera is more compact, less cumbersome, and lighter. I was limited to one hand maneuvering around on the construction site because I was forced to carry this thing in the other.

- The Florida DOT is already preparing the DDIRs with the necessary information filled out. I'm not sure how we would get all the signatures on this DDIR to make it the "official" document without manually printing the DDIRs out. Florida DOT has to complete all the information from their end before sending to us for our signatures and final approvals. Therefore, we are actually just creating extra work for ourselves trying to use this software to create and track the DDIRs, which would never actually be the "official" DDIR for lack of signatures.

Supporting Activities:

- A training presentation was developed and used in training individual users. It became a very helpful tool in the implementation activities.
- Inspection forms for each office discipline within the Division were transferred to fillable forms.
- Other than project delivery team, personnel from technical support staff, finance team, planning team and civil rights team participated in this study.

Recommendation:

- Standardize fillable project inspection forms/reports that can be used by all Divisions and Federal Lands.
- Develop FHWA Apps for e-Construction – for sharing, reporting, accessing forms, documents and training related materials for project inspection, CAP and PODI reviews.

Michigan Division Observations (iPad Air 2):

- Accessed remote email and reference documents while out of office at meetings.
- WebEx meetings available on iPad and not working on PC.
- E2 Voucher completed with iPad.
- Used on vacation to keep on top of e-mails and contract mods & meeting minutes at Grand Construction conference.
- Used for BRT discussion and accessing draft plans.
- Keep up-to-date on e-mails. Used for minutes and notes at Safety Conference.
- DOT highway extension and revised terminals at I-75.
- DOT highway plans and used Google Earth, etc.
- Various meetings and minutes; emails on vacation.
- Google Earth and ops improvement proposed at I-94 from US-23 to M-14 and US-127 from I-96 to I-496.
- Meeting minutes and e-mail checks.
- Used to review plans and not print out plans.
- CAP reference manuals and Google Earth.
- Construction approvals.
- iPad was useful for staying in touch during a 3-day conference.
- iPad allowed me to stay in touch and multitask during an out of State peer exchange in a way that a laptop could not have.
- iPad was useful during a meeting with the state as I had access to e-mail and my calendar.
- iPad was useful for multitasking during all-day training.

- iPad allowed me to stay in touch and multitask during a peer exchange in a way that a laptop could not have.
- iPad made my CAP review much easier.
- During a meeting with the State, I was able to avoid confusion and show the State specific locations of non-conforming signs along the interstate using Google Earth. This kept the conversation moving forward and led to a win-win situation. I felt the iPad was vital to helping me illustrate the point I was making.
- During meetings at the State, the iPad allowed me to be more effective since I had access to my e-mail and calendar.
- I have given up trying to use the iPad as a replacement for my laptop. It's just not feasible. However, I do still use it when at meetings to pull up plan sheets and studies. It is great for teleworking as well. The limitations with Good can be frustrating.
- Can't see fillable .pdf's through Good. Also, no longer approving each Contract mod.
- Having a data plan on this iPad has been a HUGE asset. I can't stress this enough!
- Having the iPad at meetings has been essential. I no longer use paper notepads to take notes. Being able to store notes electronically and email them instantaneously has helped a great deal. Being able to pull up Google Earth and Street View during emergency relief events, CAP reviews, project meetings and meetings with leadership helps everyone have a better understanding of what is being discussed. This is probably the most valuable way I have used the iPad since getting it.
- In general, the iPad is too big to use to take photos, although I have used it once this year to FaceTime a remote location to view a road washout with the DOT.

Utah Observations (Surface Pro 3):

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

Function	Issue
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	Because login is not reliable, I am not confident that the tablet will work in the field right when I need it. I often print copies of forms and necessary documents anyway to make sure that I have them when I get to my inspection.
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 Division Observations (Surface Pro 3):

- One concern I had was the screen protection. In Texas, pilot users did not use the rugged case with hand strap because of the inconvenience. We were however a bit lucky/cautious when using the tablets. However, using the tablet more in the field or state dot offices increases the chances. We may encourage tablet users to use the rugged case on construction sites.
- I have used the Surface-Pro since August 2015 for almost every day use at work and on field. I have completely stopped using my laptop during this pilot program.
- Generally, this program has been a good experience. The ease of portability and better performance than the regular laptops makes it a superior machine to use.
- Advantages:
    - Very fast computer (start up, file access, etc.) compared to laptops.
    - Easily portable during field use and teleworking (light weight, small size).
    - Can do everything a laptop can do (as opposed to iPad).
    - Seems to have less performance issues than a laptop in general.
- Disadvantages:
    - No CD Drive.
    - No PIV card slot (provided reader is one more thing to carry and not very durable).
    - Only one USB port, but could be resolved by a multiple USB adapter (it is also one more thing to carry).
    - Camera not easily accessible for field use because of log-in requirements with PIV card.
- During the PY 2016 CAP reviews in Fort Worth Texas, I had to visit several offices and project sites within a few days, many times more than one site per day. Because of the fast performance of this device, I was able to conduct the review almost seamlessly. A similar review using the

traditional laptop would not have been as easy because of longer startup/shut down times as well as slower response times accessing files. For the purposes of this review, I informed the state to provide me the required back-up documentation electronically. Since the state also keeps most of their records electronically, it made it easier for them to share and avoided printing thousands of pages of paper and physically carrying or shipping them. The electronic transfer of files made it a much better review and saved a lot of time.

- I have been participating in the e-construction pilot program since the beginning of the pilot. Microsoft Surface Pro 3 (MSP3) is faster machine than the laptop I had. Also, the light weight and size made it easy to take between telework site (home), field, and office. The docking station allowed the use of two monitors at work, and with a purchase of an adapter (by me), I was able to connect to a large monitor at home. The Wi-Fi was very useful to me during emergencies with no power at home (telework site) or during disruption in the network service, to be able to communicate with State DOT and Texas Division Leadership on the Emergency Relief Program. Also, the MSP3 and Wi-Fi allowed me to work from various locations (such as hospitals) to respond to emails, etc. during extended absences due to family emergency. I have found MSP3 to be compatible with all applications that I needed to access and use.
- I had issues with the PIV card reader not working always; often times had to re-boot MSP3 to read the card.
- If I have to go back to my laptop it would feel like going to dinosaur age!
- Easy boot up and log-on.
- Digital Signature and Ink Signature.
- Ease to open multiple excel files.
- Easy to access all applications and FHWA network or VDI.
- I have been on the e-construction pilot program for four months, and I truly believe this is a great initiative. The Surface Pro 3 allows me to have faster access to my documents, and to review and approve them while I'm out of the office. It is portable equipment that I can take with me to meetings, project inspections, trainings and contract reviews, reducing my paper consumption by 80 percent.
- I have noticed some technical issues while using the Surface Pro 3, like startup delays of up to 30 minutes (it happened twice during the last month), and battery drain issues. I also have had problems accessing the W drive. Sometimes it is not connected and I have had to restart the device several times.
- I recently did the CAP reviews for the Bryan District using the Surface Pro. I filled out all the questionnaires using the tablet, and the people from the district sent me the supporting documentation via Dropbox. I had the opportunity to download all the documents while I was on the district office to verify the information and avoid future delays in the process. This paperless initiative avoided the consumption of more than 8,000 pages.
- The Microsoft Office Surface Pro has been an immense help in both efficiency and portability. The Surface Pro's efficiency is seen through it's faster speed compared to the FHWA-issued laptop. It processes much quicker, and applications are much more reliable and easier to navigate. This leads to much less downtown with the current laptop which tends to slow down and often needs to be rebooted. The Surface Pro has a longer battery life, allows for multiple connections, has capability to be stored and carried in a small space, and is very lightweight for travel. This unit has been easy to carry and tote to project sites and meeting and was easily able to connect

wirelessly to the internet for working virtually outside the office. Touchscreen capability and fold out keyboard also allows for efficient use of the computer without hooking up mouse. The stylus pen is great for signatures and writing notes.

- The disadvantage is the small screen, which makes it difficult to read; however, over time you do get used to it. The unit also carries hardware for USB ports and PIV card. The contraption is a bit clunky and gets in the way if not using on a flat surface. The screen must be turned off and on twice in order to get a prompt to log in. The other disadvantage (if you are not used to it) is finding applications and troubleshooting the computer as you must pull from the side or top to open additional screens for computer accessories. This is a bit awkward and cumbersome if you are not used looking up things on your computer using the Surface Pro.
- I have used the Microsoft Surface Pro for over a year and find it a very efficient over the traditional FHWA laptop.
- Looking forward at a tool that you never have used and saying I sure wish I had that tool rarely carries the impact of looking back at a tool that you no longer have and saying I sure do miss it. That's what happened to me November 1st through 4th. I brought my SP to the field and, being this is Texas, it was a day's drive from the office. I had inadvertently failed to bring my PIV card with me for a construction audit. The SP can't be accessed without the PIV so I found myself without the most important work tool I have. I was able to perform the audit, I asked a coworker in the office to email the questions to the TxDOT, who then printed them out for me. This resulted in a duplication of effort, I took notes on all of the responses to the questions and of course I'll have to transcribe them into the electronic forms used in our office. I felt helpless without the SP as I check my email on travel. I also can verify the presence and status of projects from the field when I have the SP. I can check construction, planning, environmental and fiscal records in the audit when I have the SP in an audit. To be caught without the SP presents a stark realization of how useful it is when in the field. I now use it in ways I never imagined I would before I was a part of the pilot. I guess they are right: “you don't miss the water until the well runs dry.”
- My take on the e-construction pilot program has been a positive one. The ability to have a device that is small enough to be mobile anywhere I go (office, meeting rooms, state DOT offices, district offices, construction projects, etc.) but is powerful to do various tasks has changed the way I work. While there were minor technical shortfalls in PIV connectivity or the ability to use the Surface Pro without PIV, the benefits outweighed the shortfalls. As more new technology and apps are available, the Surface Pro could be used more to FHWA’s benefit. Lastly, the ability to connect into a docking station with two additional monitors allowed for three total screens. It enhanced the ability to multi-task and view various applications simultaneously.
- Throughout the pilot, my job required quite a bit of travel and various tasks (reviewing documents; providing comments; providing customer service to TxDOT, consultants, FHWA, etc.). While this might not have been fully measured in the data criteria, having the surface pro allowed me to stay on top of information and work on things during layovers or off time. It also allowed me to have the mentality of taking it wherever I went. All the credit goes to the light weight and powerful capability of the Surface Pro 3 unit. Lastly, since we transitioned into a new email/Outlook, accessing email from mobile phone was no longer available. The light weight Surface Pro 3 unit allowed me to stay informed.

Appendix B. Raw Performance Measures Data

FHWA Division: Florida		August 2015 to November 2016
Data Collected	**Quantity**	**Comments**
Number of paper plan sets eliminated through access to electronic versions via tablet	2400 Pages	Since FDOT has moved towards to paperless submittals (plans and specification) several years ago, major savings on paper copies have not anticipated in this study
FMIS and change order approval time savings (estimated hours)	0	Due to lack of PIV reader, Division was unable to use iPads for FMIS and change order approvals
Number of times electronic files are accessed from the field due to increased availability of data (data plan sets)	800	
Number of hours of tablet use	2200	
Number of documentation photos taken using tablet	350	

Florida total data collected: iPads were used under the shared platform.

FHWA Division: Michigan	User						Jan to Nov 2016	
Data Collected	1	2	3	4	5	6	Totals	
Number of paper plan sets eliminated through access to electronic versions via tablet	4	330	21	16	0	0	371	Paper Copies
FMIS and change order approval time savings (estimated hours)	2	0	38	0	0	0	40	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	414	660	62	31	0	199	1366	Times Accessed
Number of hours of tablet use	134	660	398	499	66	87.5	1844.5	Hours
Number of documentation photos taken using tablet	0	0	0	0	15	18	33	Photos

Michigan is a user of the iPad.

Summary of Texas Division Data Collected

FHWA Texas Division Personnel using the Microsoft Surface Pro 3 included 5 Area Engineers and 1 Engineering Coordinator.

FHWA Division: Texas Division	August 17, 2015 to November 23, 2016	
Data Collected		**Units**
Number of paper plan sets eliminated through access to electronic versions via tablet	116,627	Pages
FMIS and change order approval time savings (estimated hours)	1,380	Hours
Number of times electronic files are accessed from the field due to increased availability of data	791	Times Accessed
Number of hours of tablet use	13,213	Hours
Number of documentation photos taken using tablet	609	Photos

Texas is a user of the Surface Pro.

User 1 Texas Division

FHWA Division: Texas Division	Duration	Units
Data Collected	November 1, 2016 to November 23, 2016	
Unit: 43000	User: Engineering Coordinator	
Number of paper plan sets eliminated through access to electronic versions via tablet	0	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)	5	Times Accessed
Number of hours of tablet use	125	Hours
Number of documentation photos taken using tablet	0	Photos

User 2 Texas Division

FHWA Division: Texas Division	Duration	Units
Data Collected	November 1, 2016 to November 23, 2016	
Unit: 42999	User: Area Engineer	
Number of paper plan sets eliminated through access to electronic versions via tablet	1,500	**Pages**
FMIS and change order approval time savings (estimated hours)	1	**Hours**
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	6	**Times Accessed**
Number of hours of tablet use	112	**Hours**
Number of documentation photos taken using tablet	0	**Photos**

User 3 Texas Division

FHWA Division: Texas Division	Duration	Units
Data Collected	November 1, 2016 to November 23, 2016	
Unit: 43001	User: Area Engineer	
Number of paper plan sets eliminated through access to electronic versions via tablet	2,239	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)	6	Times Accessed
Number of hours of tablet use	120	Hours
Number of documentation photos taken using tablet	0	Photos

User 4 Texas Division

FHWA Division: Texas Division	Duration	Units
Data Collected	November 1, 2016 to November 23, 2016	
Unit: 43002	User: Area Engineer	
Number of paper plan sets eliminated through access to electronic versions via tablet	60	Pages
FMIS and change order approval time savings (estimated hours)	20	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	0	Times Accessed
Number of hours of tablet use	108	Hours
Number of documentation photos taken using tablet	0	Photos

User 5 Texas Division

FHWA Division: Texas Division	Duration	Units
Data Collected	November 1, 2016 to November 23, 2016	
Unit: 43003	User: Area Engineer	
Number of paper plan sets eliminated through access to electronic versions via tablet	635	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)	27	Times Accessed
Number of hours of tablet use	125	Hours
Number of documentation photos taken using tablet	0	Photos

User 6 Texas Division

FHWA Division: Texas Division	Duration	Units
Data Collected	November 1, 2016 to November 23, 2016	
Unit: 43005	User: Area Engineer	
Number of paper plan sets eliminated through access to electronic versions via tablet	373	Pages
FMIS and change order approval time savings (estimated hours)	4	Hours
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	4	Times Accessed
Number of hours of tablet use	128	Hours
Number of documentation photos taken using tablet	0	Photos

Summary of six Users from Texas in November 2016

FHWA Division: Texas Division	Duration	Units
Data Collected	**November 1, 2016 to November 23, 2016**	
Number of paper plan sets eliminated through access to electronic versions via tablet	4,807	**Pages**
FMIS and change order approval time savings (estimated hours)	25	**Hours**
Number of times electronic files are accessed from the field due to increased availability of data (data plan use)	48	**Times Accessed**
Number of hours of tablet use	718	**Hours**
Number of documentation photos taken using tablet	0	**Photos**

Summary of three Utah Users from September to November 2016

FHWA Division: Utah	Sept.-Nov.	
Data Collected	Totals	Units
Number of paper plan sets eliminated through access to electronic versions via tablet	1250	Paper Copies
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)	79	Times Accessed
Number of hours of tablet use	1357	Hours
Number of documentation photos taken using tablet	218	Photos

Utah is a user of the Surface Pro

Utah User 1

FHWA Division: Utah	Week (or Partial Week) Within Each Month					Month:	September	
Data Collected	1	2	3	4	5		Total Monthly	Units
Number of paper plan sets eliminated through access to electronic versions via tablet			1				1	Paper Copies
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)							0	Times Accessed
Number of hours of tablet use	18	18	42	36	42		156	Hours
Number of documentation photos taken using tablet			16				16	Photos

FHWA Division: Utah	Week (or Partial Week) Within Each Month					Month:	October	
Data Collected	1	2	3	4	5		Total Monthly	Units
Number of paper plan sets eliminated through access to electronic versions via tablet		5					5	Paper Copies
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)							0	Times Accessed
Number of hours of tablet use	40	24	16	34	8		122	Hours
Number of documentation photos taken using tablet		155					155	Photos

FHWA Division: Utah	Week (or Partial Week) Within Each Month					Month:	November	
Data Collected	1	2	3	4	5		Total Monthly	Units
Number of paper plan sets eliminated through access to electronic versions via tablet		1					1	Paper Copies
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)							0	Times Accessed
Number of hours of tablet use	13	20	31				64	Hours
Number of documentation photos taken using tablet		47					47	Photos

Utah User 2

FHWA Division: Utah	Week (or Partial Week) Within Each Month					Month:	September	
Data Collected	1	2	3	4	5		Total Monthly	Units
Number of paper plan sets eliminated through access to electronic versions via tablet							0	Paper Copies
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)	4	2	5	1	0		12	Times Accessed
Number of hours of tablet use	18	40	40	40	40		178	Hours
Number of documentation photos taken using tablet							0	Photos

FHWA Division: Utah	Week (or Partial Week) Within Each Month					Month:	October	
Data Collected	1	2	3	4	5		Total Monthly	Units
Number of paper plan sets eliminated through access to electronic versions via tablet							0	Paper Copies
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)	3	1	7	1	1		13	Times Accessed
Number of hours of tablet use	40	40	40	40	9		169	Hours
Number of documentation photos taken using tablet							0	Photos

FHWA Division: Utah	Week (or Partial Week) Within Each Month					Month:	November	
Data Collected	1	2	3	4	5		Total Monthly	Units
Number of paper plan sets eliminated through access to electronic versions via tablet							0	Paper Copies
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)	2	2	3	6	1		14	Times Accessed
Number of hours of tablet use	20	40	40	40	9		149	Hours
Number of documentation photos taken using tablet							0	Photos

Utah User 3

FHWA Division: Utah	Week (or Partial Week) Within Each Month					Month:	September		
Data Collected	1	2	3	4	5		Total Monthly	Units	
Number of paper plan sets eliminated through access to	10	10	20	10	20		70	Paper Copies	
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							0	Times Accessed	
Number of hours of tablet use	16	40	40	40	36		172	Hours	
Number of documentation photos taken using tablet							0	Photos	

FHWA Division: Utah	Week (or Partial Week) Within Each Month					Month:	October		
Data Collected	1	2	3	4	5		Total Monthly	Units	
Number of paper plan sets eliminated through access to	20	10	25	1069	1		1125	Paper Copies	
FMIS and change order approval time savings (estimated hours)				0			0	Hours	
Number of times electronic files are accessed from the field due to increased availability of data (data				25			25	Times Accessed	
Number of hours of tablet use	40	40	40	40	8		168	Hours	
Number of documentation photos taken using tablet				0			0	Photos	

FHWA Division: Utah	Week (or Partial Week) Within Each Month					Month:	November		
Data Collected	1	2	3	4	5		Total Monthly	Units	
Number of paper plan sets eliminated through access to	15	10	10	10	3		48	Paper Copies	
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	10			5			15	Times Accessed	
Number of hours of tablet use	36	40	40	36	27		179	Hours	
Number of documentation photos taken using tablet							0	Photos	

Surface Pro Drive Mapping Fix:

1) Open regedit and in the following container:

HKEY_LOCAL_MACHINE\SOFTWARE\Microsoft\Windows\CurrentVersion\Policies\System

add this:
EnableLinkedConnections = 1 (DWord)

You don't need to make it a Qword entry. Just the 32bit Dword type of registry entry.

2) Go to Start\Run\gpedit.msc

Under LOCAL COMPUTER POLICY\COMPUTER CONFIGURATION open the SYSTEM folder. Now click on GROUP POLICY.

Open CONFIGURE LOGON SCRIPT DELAY, set it to DISABLED, click APPLY.

While still in the LOCAL COMPUTER POLICY\COMPUTER CONFIGURATION\SYSTEM folder, click on LOGON.

Open ALWAYS WAIT FOR THE NETWORK AT COMPUTER STARTUP AND LOGON. Set it to ENABLE. Click APPLY.

Close gpedit.msc. Now in RUN, type in

gpupdate /force

Reboot the computer TWICE.

Have the user logon.