



e-Construction



Peer Exchange on e-Construction

Oregon and Michigan Departments of Transportation

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Cover photo: K&E Excavating of Salem, Oregon constructing the Oregon Department of Transportation’s OR140 Bly Mountain Project. *(ODOT photo, May 2015)*

Introduction

The e-Construction Peer Exchange provided a forum to discuss the Michigan Department of Transportation's (MDOT's) e-Construction program processes, challenges, and successes, as well as those of the Oregon Department of Transportation's (ODOT's) Automated Machine Guidance (AMG) and 3D modeling efforts. This report highlights the key information and the questions and answers from the meeting.

Joe Squire, ODOT State Construction and Materials Engineer, started the meeting by providing introductions and outlining the meeting goals. "One of Michigan's mottos is 'Advancement of Knowledge,' and I think that is very appropriate for what we are doing here; advancing knowledge and moving the ball forward for all of our DOTs," he said.

ODOT Director Matt Garrett provided a welcome message, explaining that the stimulus for this peer exchange was the EDC-3 Summit in Sacramento in Oct. 2014. "We saw an opportunity to partner with MDOT, a leader in terms of innovating and moving into the digital age of construction," said Garrett. He stated that ODOT takes pride in being pioneers and, similarly to the Michigan DOT, in being an agency that delivers infrastructure and innovation.

Garrett encouraged participants to challenge each other to continue finding opportunities to innovate. "Let's make things better. Let's be proud of what we do. Let's walk away from this meeting knowing that we are going to advance the cause and make the delivery of infrastructure in the state of Oregon and the state of Michigan that much better for both sides of the table—the public sector and the private sector."

A welcome message from *Phillip Ditzler, the Federal Highway Administration's (FHWA's) Oregon Division Administrator*, followed. He noted that in organizing the peer exchange, Joe Squire (ODOT) and Cliff Farr (MDOT) expanded the original topic from MDOT's e-Construction program to include an overview of ODOT's expertise in 3D modeling and Automated Machine Guidance. "Collaborations such as this," he said, "are key to our success, both as an industry and a community, in supporting the nation's transportation system."

MDOT is participating with the FHWA and the American Association of State Highway and Transportation Officials (AASHTO) to share e-Construction innovations through the FHWA's Every Day Counts initiative, the AASHTO Innovation Initiative, and through support from the Michigan Infrastructure & Transportation Association (MITA).



Matt Garrett, Director, Oregon Department of Transportation, provided opening remarks on March 11.

MDOT's e-Construction Program: Organization and Background

The MDOT e-Construction Evolution: What Brought MDOT to e-Construction?

Conversation Leader: Cliff Farr, MDOT e-Construction Coordinator

Cliff Farr provided the background and actions taken to achieve e-Construction in Michigan. He said that the process began as an effort to solve problems with lost documentation that resulted in contractors not being paid promptly. In Michigan, if a contractor does not have updated materials information on file to prove that they are using quality materials, then MDOT cannot pay them until they obtain that information. The e-Construction solution stemmed from an electronic document management tool called ProjectWise® that was already in use by MDOT's design team. The Department took that solution and used it to establish a paperless system for DOT projects from start to finish. MDOT is now championing e-Construction for other DOTs that are ready to move forward into a paperless environment.

"The opening remarks for this meeting were exactly right—the decisions we make today are going to affect generations of DOTs, so we have got to do this right. The outcome of all the things we have done, such as developing document name standards, filing systems, and workflows, can help other DOTs. We've already developed it, so they shouldn't have to redevelop the wheel." — Cliff Farr, MDOT

In addition to decreasing paperwork volume and eliminating the lost paperwork that caused delays in payments to contractors, e-Construction has made the process transparent for the many stakeholders involved in construction projects.

“We’ve developed one document that is a sole source; everybody knows where it is and can get to it all the time. But once you get there, you haven’t arrived. As with any other software solution that you implement, you can wait until it’s perfect and implement it seven years later, and then the technology is old, or you can get it on the streets and grow it into a success story. That’s where we are right now. We’ve got it out there, we’ve learned a lot from the users, and we are growing it into a successful program.” — Cliff Farr, MDOT



Paper Storage can be reduced with e-Construction. (Darcy Bullock, Joint Transportation Research Program)

All of MDOT’s construction and materials offices are now using the paperless document management system. This amounts to 175 contracting firms (500 contractor users), 41 construction consultant firms (250 consultant users), and 22 FHWA users – 2,644 total users on 195 contracts.

The first production contract to use the paperless system was [96fix](#), one of MDOT’s largest projects valued at about \$176,000,000 with only 160 days of construction. It involved the reconstruction of I-96 in metro Detroit. The six-month project, which opened to traffic in Sept. 2014, was 7 miles long and included 37 bridges.

Farr showed one of several [videos](#) MDOT has produced detailing their e-Construction process, including information on its use for the I-96 project.

Every MDOT office had at least one e-Construction contract in 2014. By Oct. 2014, all trunkline contracts were paperless. MDOT’s e-Construction priorities for 2015 include a comparison between the capabilities of the currently used iPads versus the Windows tablets.

Andy Esch, MDOT Information Security Officer: There are pros and cons to both the iPad and Windows devices. We are not being as prescriptive as we used to be – we are providing a list of tools and applications and letting the users decide which is best adapted for their specific use.

There are limitations with both devices in terms of digitally encrypted electronic signatures (software versions and updates—Florida DOT has a solution they are happy with and MDOT will be talking to them soon) and remote connectivity (areas of the state with weak internet signals).

Joe Squire, ODOT: Ron Singh, ODOT's Chief of Surveys and Geometronics Manager, has pioneered digital stamping and digital signatures in ODOT, so we have that capability right now.

Michigan's law was changed about two years ago to allow for digital stamps and signatures. Oregon has had a law in place for several years permitting their use. The law was written with guidance provided by Ron Singh.

Next Steps: Paper delivery tickets – FHWA still requires MDOT to maintain them for tracking weight on trucks (aggregate levels, hot mix asphalt, and concrete, etc.). MDOT is working on an electronic solution for this with FHWA. Local Agency Programs – Michigan Tech University helps MDOT administer Local Agency Programs, and they have volunteered to train locals around the state. The training for the contracting community and inspectors is straightforward, but for those in the office managing the files, they need more in-depth training.

Comment: One of the solutions being talked about for the delivery tickets that has potential is using QR codes associated with an automated database.

ProjectWise®: From Design to Construction

Conversation Leader: Heather VerHage, MDOT ProjectWise Administrator

Heather described MDOT's adoption of the software, a project collaboration tool developed specifically for design and construction of infrastructure projects.

MDOT's design staff has been using ProjectWise for about 12 years, and now almost every division uses the software. MDOT adopted it for their e-Construction system because it was already in place within the Department, and they required software that could interact with CAD drawings and reference documents. While some of the necessary staff and servers were already in place, they needed to add more servers and gain access through the MDOT firewall to allow for external users.

The Department recently began using it for external invoicing, and this has resulted in faster payments and increased ability to track information. They plan to begin working with local agencies in late spring or early summer to get them on board as well.

Pilot Stage: Getting Started

Before MDOT opened up external access to the headquarters server via ProjectWise, DOT users had to have a firewall security token (a hardware device that updates periodically with a passcode, or authentication code, which must be input when logging into a network) for access when they were off the state network. The IT Department was very concerned about opening a port for ProjectWise users, but they worked together with the e-Construction team to provide access.

Firewall tokens were suggested at first, but ultimately were not an option due to the DOT's large number of consultants and contractors. MDOT provided a lot of security documentation to the IT Department, working with the ProjectWise vendor (Bentley) to obtain some product-specific details, to ensure information going over that particular port would be secure while maintaining the integrity of the systems outside of ProjectWise.

MDOT currently has a strict security structure, but they have had ProjectWise in production for over a decade. It took them five years to get external access.

Terry Molyneaux, ODOT IT: ProjectWise is currently a pilot at ODOT, but we have two concerns about pilots: First, is that it will go pilot to production without an appropriate vetting process. This can happen when the business gets excited about something and pushes for adoption before we have a good production system in place. The second is reduced security posture. We can fix all the security posture pieces, but we want people to work with us in exploring options, for example, functionality with one-time passwords, for maintaining a high level of security, but not one that causes so much friction that it is difficult for our customers to use. We also want to make sure that once we provide access, they will receive access to only those areas to which they are supposed to have access.

Rachelle VanDeventer, MDOT: When we started piloting, we used the web version without the contractors/consultants having access into the Explorer version of ProjectWise. This lasted about 8 months, and we were seeing some success, but once we got them into Explorer, it blew all of our doubts away. I don't think you could do this any other way and be successful.

MDOT offered to provide ODOT with their network schematic, as well as the information they gathered in setting up a secure network for external user access. MDOT also presented a timeline showing steps taken along the way to obtaining the external access port.

Cost and Licensing

Cost and licensing were other issues that came up during the pilot stage. MDOT decided that the many benefits of using the system overrode the licensing costs, so they decided to pay for external user accounts. It costs approximately \$72 per year for each person who is signed into the system.

MDOT's ballpark numbers are \$12M saved annually so far in paper (7 million pieces), postage, envelopes, and storage. Electronic document access also provides time savings by streamlining change orders and public records requests and by providing project status notifications.

ODOT: We can use any cost/benefit savings data that MDOT may have in order to help sell the program to our Legislature. MDOT has some data and FHWA is generating some as well.

Comment: Contractors should be willing to invest because, from their perspective, they have accurate, timely payments to gain.

Tip: ProjectWise has resulted in changes in organizational job functions – be open to this from the beginning. It creates efficiencies. For example, a lot of the construction paperwork that may have been resolved during the winter off-season is now completed electronically during the construction season, freeing people up to focus on other things.

MDOT originally set up a user name for a company. However, that created accountability problems because different people were logging in using the same user name, checking out documents, and forgetting to check them back in, etc. MDOT now uses one desktop license per user and no group users, every user is an individual account. For example, a consultant/contractor has a group folder, and then all the users granted access are listed within that folder.

TIP: Set up individual user names rather than a company user name for contractors.

Folder and File Structure

MDOT provided a demo of ProjectWise. It looks similar to Windows Explorer with folders on the left and contents/files on the right. Twelve years ago, MDOT sat down with everyone involved on the preconstruction side to come up with a folder structure that would best help the Department statewide and standardize the entire process.

Projects are divided by office. Michigan normally does not have any statewide projects; they have region-wide projects. Security is set up to allow for region-wide projects. For a statewide project, they would need to go in and set the permissions manually.

Folders are listed by contract (one folder per contract). Job numbers are issued for each project under that contract (job numbers remain the same from development through construction), and those folders are listed by job. Users only see the folders they have permission to access. Contractors/consultants only see the jobs they are awarded.

Document Access and Security

The way security is set up on each folder in ProjectWise dictates permission/access. Security for MDOT is active directory – inside the firewall. ProjectWise is single sign-on. Outside user security is both

active directory and additional firewalls through vendor/ProjectWise securities. MDOT uses four layers of firewalls.

Tip: Don't wait until you have rectified the firewall issue to get started. There are a lot of other details that need to be worked well beforehand.

The IT department manages the security all the way through, assisting MDOT with tracking and accountability, as well as revoking access when users leave the company.

A key lesson learned regarding how ProjectWise works is that when a user gets an account, they are automatically assigned to an "Everyone" group. The "Everyone" group is MDOT's "NO ACCESS" group; a separate "MDOT Everyone" group was created for staff.

Tip: Create a separate group for internal staff (or other groups as needed).

MDOT has an "INTERNAL USE ONLY" folder that includes documents that are not shared: financials, evaluations, etc. Emails are pulled into an "INTERNAL USE ONLY Correspondence" folder as needed.

Document security: "File Read" – user can read contents of the file, print, etc. "Read" – user can only see that the file exists in the system. "Write" – user can modify the metadata but cannot physically modify the contents of the file.

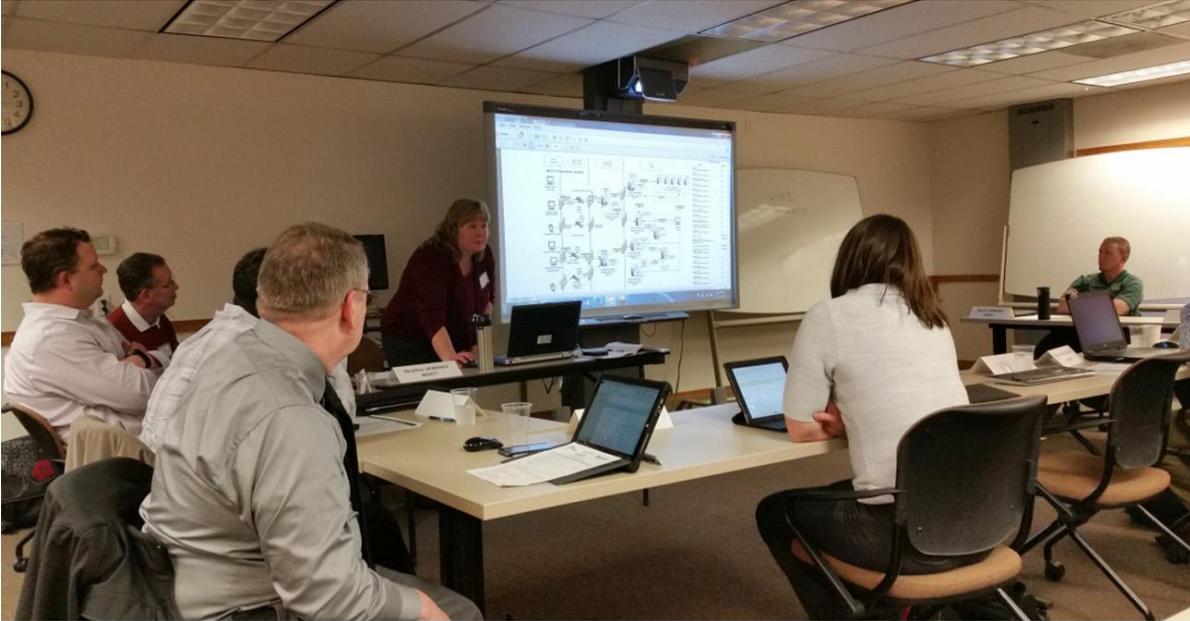
Q: Does MDOT have regional auditors that are in the "MDOT Everyone" group? Yes, for internal MDOT certification reviews for engineers at the Transportation Service Centers (TSCs). There is another group that performs local agency materials documentation reviews, but they travel to the locals.

Q: Do you get requests from other state agencies or the Governor's office to have access to your project files? Yes, for example, the Attorney General's staff. We are looking at opening it up to the Department of Environmental Quality as well as Natural Resources. However, they will not be able to see everything. They are set up similarly to a contractor. There are special provisions/securities enabled for what they can see/access.

Q: Is there a "system administrator"? Yes, we have five system administrators. System administrators cannot be locked out of any part of the system.

Q: How are all the projects set up with appropriate folders and protocols? We use templates that have already been established, so folders are automatically created based on those saved templates. All the securities are available in the templates; therefore when a folder is added, those securities can be customized.

Q: How do you limit access to privileged folders/files? We have protocols to make sure the correct document goes into the correct file with the correct permissions. Projects that are sensitive can be set up with stricter access restrictions.



Heather VerHage, MDOT, described how the Department uses ProjectWise software.

Q: Can you show us an example of the Access Control Screen? There are two areas where we grant/remove access: The Project Folder Security where you give a user access to the folder, and Document Security, which gives them access to documents within the folder. You can grant access to a folder without issuing document security or access.

Q: Do you manage internal users based on project number? No. They are managed under office and business area.

Q: Do you have different issues or challenges when working with consultants? The scope of services specifies that they will use ProjectWise. The consultants are on board. They generally are more experienced in electronic document management than some construction contractors are. Consultants work with MDOT's Stuart Laakso and go through the training. Their access is then limited to the projects to which they are assigned.

Q: Who decides what the sub-contractors look at? All contractors are treated the same under this system. Subs have read-only access to most of the documents and can upload new documents. The Prime requests which Subs should be added in the system. The Prime determines what the Subs are able to do, not MDOT.

Q: Can a contractor add a folder? No.

Q: Do you show information through the bidding period? Not directly in ProjectWise. We use eProposal. We use our website to FTP the documents between ProjectWise and eProposal. When

contractors are bidding, they have to agree to specific document permissions for using the associated documents.

Q: When a contract is financially completed, can users look at the files? Yes, but permissions are changed to read-only. This follows MDOT's document retention policy.

Tip: Tools like ProjectWise can only map to the business rules of the agency. Start permissions out tight and then change as the process directs.

Storage and Archiving

Q: Are you using FileNet for your archiving? No. Completed projects are archived within ProjectWise with their permission, search, and update parameters changed.

Q: How much storage capacity is being used for archiving? On a large project such as I-96, it was about 64 gigabytes (gB), of which 20 gB was for design and 44 gB was for construction. Static or archived documents are backed up on a weekly or monthly plan. This decreases the storage cost.

Q: What does MDOT do with the remaining documents that are still kept in paper form? For the areas where paper documents are still used, we have paper files in our project offices. Some offices are scanning them in, but not where the amount of paper is prohibitive time-wise, and we still have to retain the paper. This is primarily just the delivery tickets. There are paper forms still in use in some areas, such as sample ID forms, but they are not required project documentation. You have to evaluate technically what needs to be in your system and what does not.

Q: Have you had any claims or disputes that you've had to dive back into your ProjectWise records to help resolve, or public record requests that might be outside of the contract, for example a third-party crash in a work zone? In MDOT the collaboration has been so efficient on e-Construction contracts that we have not had any claims to date.

Ron Singh, ODOT: There are several different varieties of PDF files, and PDF/A can be used for archival quality PDFs.

MDOT e-Construction Special Provisions

MDOT developed a Special Provisions document that provides users with the details for e-Construction. It does not take the place of other specifications. It is meant to be simple, and MDOT uses it for training. The three-page document includes the following:

- Electronic signature requirements
- Fillable forms
- Prime contractor responsibilities such as granting access to their project to other contractors and notification of the project engineer if the ProjectWise user changes (e.g., if an employee leaves)

- References to MDOT's Construction Wiki for the Construction Manual
- Training procedures
- Workflow descriptions and steps the contractor must complete
- Descriptions of the folders to which they have access
- Document naming conventions
- Document formats that the project engineer may determine are unsuitable
- Paper delivery ticket requirements

MDOT used unique provisions during the pilot projects and, once they were vetted or approved, placed them in the general provisions document. Not all provisions made it into the general document. MDOT also had to ensure there were no contradictions with other existing special provisions, or add a paragraph notifying that it overrides an earlier special provision.

ProjectWise® Workflow

Conversation Leaders: Cliff Farr, MDOT; Heather VerHage, MDOT; Stuart Laakso, MDOT

MDOT developed their e-Construction process based on their old paper process; they did not invent anything new, but they have added process improvements as they proceeded. The workflow process is based on interviews with their different business areas and offices. The **workflow** is the electronic equivalent of the paper process; a **state** is a step within that process.

MDOT showed a [video](#) illustrating the Department's e-Construction workflow process.

Q: Can you walk through some of the details of the workflow and naming conventions?

MDOT used their historical "manila folder" file structure as the basis for determining what the new electronic filing system should look like and how the folders should be named for both external and internal documents. The construction staff helped determine the file naming conventions through the pilot projects.

Now that all of the offices have had an e-Construction contract, people are dialing in to help look at what can be done better to potentially make the folder structure more efficient (possibly reduce the number of folders in the system) and make changes to some of the contract naming conventions.

Tip: Naming conventions are critical in finding documents using the search feature if, for example, a user makes a mistake and drops a file in the wrong folder.

Rachelle VanDeventer, MDOT: The naming conventions were a big deal in MDOT. There was a lot of ownership in this area, so it was hard to come up with a consensus, and this held up progress for a while.

Q: Have you worked on workflow management for the internal survey design processes? Yes, we are currently completing this step. The current design workflows have developed over time since MDOT implemented ProjectWise 12 years ago.

TIP: Don't create sub-folders because you think you want them – let the workflow/business process determine what the hierarchy will look like.

Stuart Laakso, MDOT Construction ProjectWise Analyst, presented a sample workflow for a standard Design-Bid-Build project workflow process – about 99% of MDOT's projects. Design-Build and Construction Manager/General Contractor projects are handled a bit differently.

- Workflows consist of a series of connected steps known as **states**.
- Within the "Construction Folder" there is an inbox where the contractor adds all their documents (drag and drop). A document wizard allows the addition of attributes during production.
- Once added, the document is in the PENDING state. A pencil icon indicates the document is editable. Read-only is indicated by an open book icon.
- An automated email notification is generated that offers room to provide explanations or details. Emails are sent with a *link* – documents remain in their folder spot at all times.
- The "MDOT e-Construction Resource" group mailbox is included on every email. This helps the team verify and mitigate any issues with MS Outlook and monitor workflow. Rules are set up to send the emails to different categories of inbox folders for storage.
- Once the email is sent, the **state** changes from PENDING to SUBMITTED. At this point, the contractor no longer has the ability to go in and edit the document.

MDOT uses an **inquiry desktop shortcut function** that shows PENDING or SUBMITTED status files. This allows users to see project status at a glance and avoid large volumes of email notifications by creating a customized search within the ProjectWise environment. Users can keep shortcuts to folders on their desktop.

MDOT provided an example of how the PENDING/SUBMITTED interface works using searchable metadata connected to MDOT's corporate database. The fields are programmable. This allows for automated field fill-in based on job number.

Q: Why would a contractor submit something in a pending state? It does not always happen, but the option is there just in case. In the initial workflow state, all the initial steps are labeled as PENDING. MDOT receives the automated email once the contractor's document is SUBMITTED.

Q: When the email is sent, is that captured in ProjectWise? No, it is solely captured in MS Outlook. ProjectWise does have a messaging agent, but users did not want to use two systems. The message would need to be dragged and dropped to add it to ProjectWise.

On the MDOT side, once the document is received and opened, there are two options:

- If changes need to be made, MDOT can edit and include notes on the (Adobe PDF) document then check it back in, changing the state to PREVIOUS. MDOT then notifies the contractor that the document is available for editing (it is possible to add an email notification for this). The contractor makes the changes and submits again. MDOT receives an email notification.
- MDOT checks the document in and moves it to the file structure. MDOT's standard folder structure includes Administrative, Field Record, and Materials Testing.

FHWA signatures are also worked into this process, with FHWA staff entering their approvals in ProjectWise.

Q: Does this work on a document that the contractor has signed? It can. Adobe digital signature properties will show you how the document looked when it was signed and show any changes made after the document was signed. It offers the ability to lock out changes after signatures, but we ask that this feature not be used so that we can make comments and sign multiple times if necessary.

Q: If the contractor is directed to revise a submitted document, how is that handled? They (the contractor) can make changes on the previously submitted document or be directed to submit an entirely new document.

Q: How do you lock the document so that the details are not changed? It is a function of Adobe, outside of ProjectWise.

ProjectWise has an audit trail function that allows the user to set what they want captured, for example, where a document is in the workflow process and when it is viewed, checked out, changed, or signed. It also has a version control option/function, but MDOT does not have this turned on at this time. Version control is captured in the file naming conventions.

Q: How do you maintain readability of scanned documents? There are tools that can be used such as OCR. MDOT does not currently have the character recognition function turned on in ProjectWise, but if we did, you could search all the PDF documents for different words. Our Special Provisions require that the documents be readable and submitted in a certain format. If it is not readable, MDOT can reject it. MDOT is also working on having contractors submit only project-relevant material and not extra pages, because this is not efficient to sort through and costs more to store. Once a document has been rejected a couple times, everybody gets on the same page.



MDOT field staff use iPad apps that allow them to take/scan images of paper documents that can then be added to electronic reports such as certifications and delivery documents. Contractors can then verify that their documents have been received.

Q: Have you had to deal with any notarized documents? Not on the design side.

Comment: The number of forms under the business process has not been reduced necessarily, however efficiencies in filling out the documents — using a fillable form that has been automated — makes it much easier. It also helps reduce redundancies.

Q: How does ProjectWise populate those forms? ProjectWise is not a database, it is a document storage facility. The forms are located on the MDOT website, from which documents can be pulled and filled out electronically in the field via electronic devices such as iPads, tablets, etc.

Tip: Write it once – use it many times.

Contractor Payments and Project Closeout

Q: How do you handle your contractor payment system? The Inspector's Daily Report information comes in electronically, and then once every two weeks the system looks at what needs to be paid and brings up the estimate. It is an electronic process with the proper edits in place.

Q: Once the Inspector has written their document, does that information translate directly into the payment system? The Inspector's Daily Report is filled out and sent electronically to the construction management tool (FieldManager) and reviewed/signed off on. Then, every two weeks, the estimate is sent for review by the field engineer, and then sent to payment. The quantity has only been entered once (by the Inspector).

Comment: FieldManager, an AASHTO product, is a separate software solution for construction management, but it is 15-year-old technology; some states use AASHTO's SiteManager. Inspectors in the field use the Mobile Inspector app.

Q: If a prime contractor or a sub submits a payroll that has potentially personally identifiable information such as social security numbers or birthdays, is it in a PENDING mode in ProjectWise, so you can reject it? Yes, and all of the construction forms have been modified so that those fields are no longer on that form.

Q: What about retainage? MDOT has not withheld retainage for at least five years. There was an FHWA directive to ensure contractors are paid promptly. One option to achieve this was to do away with retainage.

Q: When the project is over, do you close off access? MDOT has a document retention schedule that spells out how long access will be available and when the document will be destroyed. If a ProjectWise user leaves a company, the contractor is required to notify us and we will remove their access.

Q: Project close-out — has there been a time reduction? On the I-96 Project, for example, the time spent was minimized because corrections were completed in real-time. Close-out averages around 120 days. Overwhelmingly, the reaction has been that project close-out has become easier/more efficient.

“MDOT’s relationship with the contracting community couldn’t be better. We’ve recognized the value of working collaboratively.” — Glenn Bukoski, VP Engineering Services, MITA

Digital Signature Specification

Digital signatures require a certain size, font, logo size, etc. and the use of supportable programs. MDOT Form 1979 is what everyone signs to verify they are authorized to sign for their company on a contract. MDOT Form 5600 is a validation of their digital signature. The validation steps are in line with the Federal Digitally Encrypted Electronic Signature Act, which also states it is illegal to refuse an electronic signature that is done properly. This doesn't force contractors to use digital signatures, but it means the state cannot tell them that they cannot use it. The easy way to encourage contractors to use them is to show them how much more quickly they can be paid. It can shrink the timeframe down significantly.

Additional Discussion/Questions

Q: Have you implemented a geospatial search? This is on our list. We are trying to complete this by the end of summer 2015. We are currently discussing how to achieve this feature.

Q: How long has the streamlining process taken? We met with all the offices and labs in the different areas to discover how they do things. We identified the best practices and implemented them.

Initially, it took us about six months to get the process ready to pilot. There was a lot of learning that happened during the pilot phase, and many changes were made.

Comment: A lot of positive things came out of the I-96 pilot. It was both one of the largest projects in MDOT's history and the first e-Construction production project. A few contractors were on board right away; others were more negative. In the end, there was agreement that they would not have been able to accomplish the project without e-Construction.

Rick McGowan, MDOT Construction Technician/Inspector: An additional benefit of the e-Construction process, both on the I-96 project and in general, is the added interface and collaboration it brings about between younger staff and the more experienced staff.

"As a younger, more technologically savvy guy, it's been gratifying helping older staff get up to speed with some of the new technology, making their job a little easier, and then gaining experience from them in return." — Rick McGowan, MDOT

Partnering with IT

Headquarters Server Access

Conversation Leader: Terry Molyneaux, ODOT IT

MDOT administers the business process side of ProjectWise, because it is a business tool. IT handles the server issues.

ODOT has had ProjectWise stand up in their IT environment for a few months as a pilot program. ODOT's IT department does not have the years of experience with ProjectWise that MDOT's does, and they do not have some of the pieces that MDOT has, such as an external gateway.

ODOT plans to get past the barriers, as MDOT did, by starting with a manual process and following that with hard tokens and, when the application is trusted, backing down some of the security. Eventually, this standardization among the regions will help both engineering and IT.

"I believe that the opportunities before us are probably much greater than the problems that we have." — Terry Molyneaux, ODOT IT

MDOT provided ODOT with a copy of their architecture document and set up a separate IT-oriented conference call during the peer exchange to go over some of the "deep dive" technical questions such as backups and restores, packet flow in and out, on-boarding and off-boarding policies, vendor policies, and other security and operations questions.

Tip: Engage early and often with IT.

Q: Is the whole MDOT system scanned in ProjectWise? How much space does that require? Yes, I think we're under 20 terabytes.

Q: SharePoint, FileNet, and ProjectWise are each controlled by a different group at ODOT. How do you get continuity of enterprise content management? There is a right tool for a job, and I think we just need to have a strategy under one heading. FileNet can be the system-of-record for departments such as HR, SharePoint is a collaboration tool also used for content management, and ProjectWise is made for engineering.

Firewall Tokens

Conversation Leader: Andy Esch, MDOT IT

Contractor organizations are still struggling with the hole in the firewall because that port has to be open for them as well as for the DOT. This is one of the points MDOT covers in training.

ODOT currently has access through their firewall, on a technical basis, similar to what MDOT had for the first two years of their construction implementation: if one has a firewall security token (for example an RSA SecurID token) that provides two-factor authentication, then they can access ProjectWise remotely.

For MDOT's internal staff, plugging in the six-number access code was reasonable, but for the approximately 100 contracting companies and their 1,000 employees, it was not practical to require them all to obtain tokens. This is why MDOT invested effort into this as an IT project, so that two-factor identification would not be needed and one could simply log-in through the ProjectWise client.

ODOT Comment: For the pilot, once we identified the winning contractors, we would pick up the tokens at ODOT's cost. We provided the contractor with two tokens, in the event they lost one. There was a \$75 charge. The numbers last for three years. Once the project is finished, we shut down the contractor's access, and we like to get the tokens back. We are working toward expanding the pilot program and eventually going outside the token world.

ProjectWise Pilot Project: M-231 Over the Grand River

Conversation Leader: Stuart Laakso, MDOT

Stuart Laakso provided a walkthrough of MDOT's use of ProjectWise on the M-231 Over the Grand River Project, which was one of four e-Construction pilot projects that started construction in 2012. This project involved construction of a new highway and included two bridges. Documentation was fully electronic.

"We basically took our paper files and said, 'Alright, they are not going to be paper anymore, they are going to be electronic.' We gave our contractor access to our ProjectWise system so they could

input their documents and moved on from there. The project is still going on, but it has been a good project for us.” — Stuart Laakso, MDOT

Q: What was the makeup of that office? The Grand Rapids Transportation Service Center has a construction engineer, three assistant engineers, and probably 15 construction technicians who work in that office. On this project, an assistant engineer managed it with maybe eight MDOT employees.

Q: What hardware did you use? They provided us with cell-enabled iPads; all configured with iPhones so that we had instant communication. The iPhones allowed us to take photographs and convert to PDF.

Q: Are MDOT inspectors or quality control folks generally equipped with smart phones or old-style flip phones? They are all smart phones, statewide.

Cliff Farr, MDOT: The way we got the contractors indoctrinated was with a special provision calling for a mandatory pre-construction meeting. Only contractors who were at that meeting were allowed to bid the contract. We wanted to give them a heads up on everything we were doing to make sure everyone was on the same page and comfortable bidding that job. We didn’t anticipate a lot of problems, but you can’t tell with a pilot. The contractor that got on board was already working on the I-96 project, so they had a head start in knowing what paperless systems are about.

Q: How big was this project? It was a \$60 million job. It started at \$40 million but we added \$20 million in change orders when Michigan found money to add multi-use lanes.

Laakso provided an example of one of their first runs at developing a ProjectWise file structure. He noted that, in the beginning, they started out with very tight security. This caused some issues over the life of the project, where at first they did not want the contractor to see certain documents, but then later when they did want the contractor to see them, they couldn’t.

Though MDOT had used ProjectWise for design for 10 years at this point, it was completely new to almost all of the construction people on the project. ProjectWise staff understood and were familiar with the design people, but they were not sure if the construction people should be allowed to do things like delete documents. In certain situations, for example in order to move a document, you have to be able to delete. In order to do the work, they had to learn the issues quickly and make changes in the system.

Q: Do the file numbers (provided in the file name) correlate to an MDOT specification number? No, they do not. They are there because in the old system you had a paper folder, and the easiest way to find and organize a paper folder was by numbers. The office techs got good at finding documents based on folder number, but the new staff, consultants, and contractors coming on board had no idea what the numbers meant, and therefore the numbers didn’t mean anything to them. However, the

old-timers want to see the numbers. We are going with numbers at the back to appease them for the time being.

Rachelle VanDeventer, MDOT: It was a learning process. If you look at any of the pilot projects, you are going to see differences.

Q: Did you create templates and template folders for construction documents? I tried to model what I have on my iPad to reflect what is in ProjectWise. A generic template was provided to us to use in ProjectWise already.

Q: Until that document was final or ready to be submitted, did you keep it in SharePoint? We definitely leveraged cloud capability in terms of transitioning forms between us. The thing we used SharePoint for was to collaborate on production logs and to transition some documents in their temporary state and get them to a final state for ProjectWise. We used other services as well, such as OneDrive for Business. The idea behind this was to keep this traffic off the server and leave room for the traffic that was supposed to be going into ProjectWise. At the time, we didn't know what kind of demand it was going to put on our system.

Tip: Since ProjectWise is the repository for final documents rather than documents in transition, consider server size and location for sharing transition documents outside of ProjectWise.

Q: Do you know what direction you are going to go in, in terms of hardware (iPad vs Windows environment)? There is a lot of personal preference involved. We are going to stop being prescriptive because we don't know what everyone's job entails. They can choose to use a laptop, a desktop, a tablet, or a laptop with an iPad.

Rachelle VanDeventer, MDOT: The phones are all iPhones; they don't get a choice with that. The iPhone 6 allows for hotspot and phone function simultaneously, which is a big deal if you are trying to work with documents on the internet and talk on the phone.

Q: Is this hardware supplied by MDOT, or is it part of the BYOD (Bring Your Own Device) program? Everything we are talking about is supplied by the Department.

Q: Did you have compatibility issues going from paper forms to electronic in the Apple format? Adobe digital signatures on Apple products are an issue. If you receive an email with a document that has an Adobe digital signature, it will look blank, even though it is there. Apple and Adobe don't play well together.

MDOT purchased an app for \$9.99 for everyone that could handle what they needed to do with PDFs. The app is called PDF Expert. It works very well. They set up folders on their iPad using PDF Expert and save documents there as pre-filled templates, which saves them time.

There are still issues with Apple to Windows and converting MS Excel and Word, especially Excel, to Apple format. Apple has an app called Numbers that is the equivalent of Excel and compatible. Using digital signatures on the iPad is not a smooth process but it does work. It requires opening a separate app MDOT uses called FormApp. One other issue is that file names are truncated on the iPad.

Q: Have you done anything with geospatial PDFs? All of our PDFs are geospatial. One thing they did in some of the pilots was bring the plans into Google Earth. Also on the pilot, MDOT tried AutoCad 360. It worked pretty well.

ProjectWise Explorer Mobile does not do everything MDOT needs it to do, but it does work to add and review documents in the system remotely. However, it sorts documents differently than the Explorer version. The mobile version is an iPad only application.

Each of the pilot projects ended up being a bit different. They started at different times, MDOT allowed them to create the template themselves. MDOT used lessons learned from one project to help with the next. Standard naming conventions came out of the field. MDOT has a guidance document on naming conventions. [Form # or document acronym, date and description]

Q: Have you looked into ProjectWise Transmittals? The way we do business, it is not something that we want to incorporate at this time.

MDOT developed a list of the most commonly used documents, as well as a list of general contractor submittal forms. They developed a document describing their current ProjectWise folder structure and what files go in each folder.

Copy URN (Uniform Resource Name) option — no matter where you move the folder or document in the system, it is still linked. The unique identifier follows the original file/document no matter where it is located.

Q: Where did the concept of the MDOT Wiki come from? We used our Construction Manual to develop the Wiki. It is not a true open/public wiki. We have a design wiki as well.

MDOT presented a timeline showing the evolution of e-Construction within the Department to total electronic documentation over the past four years (including meetings, pilot projects, ProjectWise, etc.). It illustrated the areas that took significant amounts time as well as the things that need to be considered early on.

Q: What are some things you would do differently? What are things to look out for?

- **Have a small, key team – use SMEs (Subject Matter Experts) as needed.**

You have to have champions on board, and that's not something we would change but something we would structure differently. We have a team of three people driving this, and we call in SMEs as needed.

- **Review and validate communication prior to release.**

Establish a good review process for presentations and dissemination of information. We did go to marketing and ask that anything that goes out on e-Construction go through the "team of three" first, so we can validate it.

- **Establish a partnering relationship with the IT team**

It took MDOT a couple years to establish a partnership with IT, rather than feeling like they were working against each other.

- **Think about additional positions that will need to be established or filled.**

Convincing an agency to acquire a new position is significant. In Michigan, it can take two years to establish and fill a brand new position.

- **If an issue is really a game changer — treat it like one and get it rectified.**

Funding for servers, IT project staff, and other issues may need a champion or high-level support to get timely results within the Department.



e-Construction Peer Exchange participants on March 11, 2015.

ODOT Automated Machine Guidance Program Overview

Automated Machine Guidance: where ODOT is today

Conversation Leader: Ron Singh, ODOT, Chief of Surveys and Geometronics Manager

Ron Singh presented information on Automated Machine Guidance (AMG) based on his paper, [“Engineering Automation: Key Concepts for a 25 Year Time Horizon.”](#)

ODOT Started automating the engineering process (survey, design, and construction) in the mid-1980s. Their goal was to speed up the process. From the 80s until 2008, they began establishing a foundation that positioned the Department for the future. For example, in the late 80s they started surveying using geospatial coordinates in 3D.

The next 25 years was essentially a new paradigm. Everything was about real time data and developing technologies that allowed for collaborative engineering. A 3D model is a product that can be owned jointly by all those involved in construction.

In the lifecycle of a highway, design and construction are a small blip in its life, but the data is important to us from that point on for many, many years. The next 25 years will also bring automated construction and, eventually, intelligent highways and intelligent vehicles.

Intelligent vehicles will rely on things, such as real-time information, that the DOT may be the appropriate providers of. To enable this, the DOTs will need to accept some disruptive technology.

“The word ‘disruptive’ sounds negative, but it means anything that requires change. We not only want to accept it, we want to require it from our hardware manufacturers and software developers. We need a complete transformation and changes to long-standing, established processes. We need to redefine the nature of our work — how it is conducted and what we consider final products.”
— Ron Singh, ODOT

Things that must be considered: digital signatures for both documents and data and standardized data formats. For structured data exchange, XML shows a lot of potential. In addition, to create dynamic (real time) documents, a robust IT infrastructure, with access through the firewall managed very carefully, is needed.

Engineering data management, which is different from document management, requires data management tools, such as ProjectWise, that provide the ability to not just manage a project but also to search for data years later, and not just by project number, but by geospatial position.

Future systems should capture as-built data that can be trusted and used. That engineering data can be developed, maintained, and utilized for the life cycle of the highway.

“If data is collected properly during construction, we can feed the asset management system. I am proposing that post-construction surveys replace as-built (red-line plans) with a 3D as-built model. It may seem expensive up front, but the value of it is huge.” — Ron Singh, ODOT

AMG requires a survey system that provides high-accuracy GPS. Both the Oregon DOT and Michigan DOT have real-time GPS networks. AMG also requires a high performance, low distortion coordinate system. This is a huge hurdle for machine control.

3D point cloud data (from LIDAR) can be used for many different things. This may eventually be replaced with virtual worlds, but it is useful now for asset management. ODOT has the entire state highway system collected. Visualization, full 3D/4D/5D design, and construction automation are part of Civil Integrated Management (CIM), which brings everything together for use over the life of the highway.

The term “machine guidance” means that the operator is controlling everything using a control system display that helps guide them. “Machine control” means that the operator can switch to machine control of the cutting surface, etc. There are three pieces to this: design, machine/sensors, and positioning system.

For the positioning system, people tend to focus on GPS. GPS is a good tool for position and has a big place in the AMG world, but it does not provide extreme accuracy (for concrete paving, etc.) unless something is done to augment it, for example laser augmentation. Otherwise, there is limited accuracy because satellites are moving and geometry is changing.

High precision positioning for accurate work requires a total station, but there are drawbacks to that as well. The ultimate machine control system is one that does not require stakes or grade checkers, but one that could record data and transmit it in real time. The [Design to Paver](#) event hosted by ODOT in July of 2014 demonstrated this type of connected site technology.

Q: If we are providing quality models to the field, why are we deciding to survey the whole thing? It does not mean we are going to survey everything — you could do the whole thing or you could rely on your model for part of it. However, if you capture the model that you designed, it may not represent exactly what was built.

State of the Practice: 3D Roadway Digital Design — the (Virtual) Oregon Trail

Conversation Leader: Della Mosier, ODOT Region 4 Roadway/Hydro Unit Manager

Della Mosier’s office delivers the contract plans, specifications and estimates for the region. When she joined ODOT in 2009, there was no documentation on digital data as far what was required for production for InRoads or MicroStation data. She worked with designers and construction staff to determine what information was needed and in what format.

Designers who do not want “scope creep” should use 3D models. Their preliminary engineering models provide for visualization and communication of ideas and designs—and show that the design can be built.

ODOT uses 3D models because they save time and money. FHWA has estimated a time savings of 30–40% and a 6% construction savings. The time savings is realized during construction/earthwork operations. 3D models also help generate better bids.

Q: How much increase in time does it require in the front end with development? With our current process, a negligible PE (Preliminary Engineering – a term ODOT uses for its design phase) of .1% per bid package. For the construction survey handout package for full AMG on the Bly Mountain Project, where we provided a full digital model and grade reports, that project was approximately \$23M in construction, and we spent \$1.5M on PE. This includes quality control and AMG support and construction support.

AMG benefits both large and small projects: Mosier provided an example of AMG’s use on a small downtown utility project where time constraints for staging required the contractor to get in and out quickly.

3D vs. 2D roadway design: 2D designs leave room for a lot of interpretation by the contractor. So the question is — How much is 2D already costing you in mis-interpolated data and change orders?

“What we are really talking about with 3D is moving the PE to the front end — taking 1% of the CE budget and finishing the digital design package before bid. This process began as an effort by our office to do our share and not leave coworkers or the construction crew hanging in the field.”

— Della Mosier, ODOT

For constructible 3D engineered models, the aspect that ODOT has been doing consistently for more than 10 years is providing a roadway prism.

“What we are delivering is a 2^{1/2}D model; we call it that because it still requires some interpolation. What our package consists of is the digital information that supports the cross sections. When we give this to contractors, they have more time to be innovative and can provide better bids. ODOT has talked with small earthwork companies, and they prefer the digital package (land.xml) as well. Even if they aren’t going to build it with AMG, they can bid it.” — Della Mosier, ODOT

Mosier said that the “elephant in the room” for the roadway design community, is that they have not been delivering finished work for a long time.

“We’ve been putting out paper plans with inaccurate quantities, with ramps that don’t tie in, with edge conditions that weren’t checked to ensure they went in the right way. So we are hearing pushback from the roadway design community and consultants, because we haven’t developed the

skillset to create the level of design needed to keep up with changing technology.” — Della Mosier, ODOT

When ODOT posts the digital package early in the process and provides it to the whole bidding community, rather than providing it after the bid, they get the savings benefit.

Q: How many designers does ODOT have? We have about 80 dedicated roadway designers across five tech centers.

Comment: Contractors using machine control are increasing efficiencies, thereby lowering their prices to ODOT. It is driving the market towards using it. However, there is still a point in the market where contractors are sorting out their costs, due to the high cost of equipment.

Comment: The equipment suppliers are chasing one another down in price, like anything else with new technology. What they are working on now is compatibility between different suppliers' equipment. This trend is helping contractors mix equipment to get the best price.

Comment: For jobs where the data package is not provided at bid time, some contractors will go and spend the money themselves to develop information. This is not nearly as accurate as what ODOT provides, and it is costly (more than \$100 per hour). So, we are excited that ODOT is providing this.



ODOT's Della Mosier presented Oregon's 3D roadway digital design.

Q: Is there a standard in ODOT that provides a format for machine-controlled services? Yes. In 2014, we established a 3D Roadway Design [TechBulletin](#). The purpose of the bulletin is to provide clarification concerning the required content, process/workflows, delivery timelines, and quality control of digital 3D Roadway Design data for Statewide Transportation Improvement Program (STIP) projects. We made it voluntary in 2014, and then we updated the document before 2015 when it took full effect.

ODOT required delivery of a digital data bidding reference package for most roadway construction projects effective Jan. 1, 2015. To help communicate the change, they added a letter notifying contractors to ODOT's Electronic Bidding Information Distribution System, or eBIDS.

Mosier said that generating the construction survey handoff package requires a lot of effort for large projects, but someone in the department has to do it anyway in order for a project to be built, so ODOT decided that the Roadway Sections would design the grade and provide that information. They provide the land.xml files as "reference documents" in eBIDS. Designers are protected contractually by the data being used as a reference document.

There is currently no standard for quality control of land.xml files. ODOT has an on-call contract with five design consultants who QC their eBIDS packages. This is producing five different opinions on how to accomplish the QC, and ODOT will combine this feedback with inputs from the regions and collaborate on a general standard for QC this fall. Concepts for QC best practices for AMG are being tested on current projects.

ODOT's public outreach [website](#) includes important links for design and 3D models, including [3D Roadway Design FAQs](#) and Chapter 16 of the Highway Design Manual on How to Develop a 3D Package and Appendix M, which provides an example data package. Links to Just-in-Time training will be available in July.

Mosier said that working to keep up with rapidly changing technology has increased collaboration among stakeholders. One result of the roadway designers developing the construction survey handoff package, is that the designer now attends the pre-survey meeting and meets the contractor surveyor. The designer can make sure everyone understands what is available and how it can be used, or find out if they needed something they were not given. It helps them understand how their information is being used, and what is needed so that the project is built correctly.

Q: Who is developing the Just-In-Time training? We have a vendor, and ODOT is involved in the output.

Q: Are the project leaders in ODOT making room for the designers to have more time to develop their plans? What we've found for most projects, is there are 100 days from final plans to bid-add. Usually, most of the scope change stops at final plan, and we can start developing a finished grade surface, get it quality control checked and posted. Typically, it is a six-week process and we have 100 days to accomplish it. For the construction survey handoff package, we generally have four months. The issue is generally not with PS&E but with roadway managers to resource appropriately.

Q: Are we addressing the fact that we have multiple roadway designers and they all differ on the level of detail they deliver — how do we standardize and get everyone on board with getting the same level of product to the construction office? Biddable vs. Buildable is a problem we are having in

ODOT. We are stuck in a transition right now, going from providing a biddable set of plans to now delivering a buildable set. We are evolving and learning what we can do better.

Q: Does Michigan have a similar issue?

Cliff Farr, MDOT: In Michigan, I think overall construction is pretty happy with the designs, but we do have different varieties of people putting out the designs, just as you have been talking about. It is a little bit of a challenge.

Rachelle VanDeventer, MDOT: It also varies based on who is using the information. Some contractors feel like the information they are getting is great, but then some of the MDOT offices are not using it yet. There is still a lot of work that needs to be done to get all of the offices up and running with rovers and that type of construction.

Comment: Another issue is statewide consistency in the types of equipment available, plans delivered, etc.

Q: In your experience in dealing with machine control, have contractors been requesting a driveway drops model and ramps model? We are modeling them so we can figure out what the control points are, so we can hand over a grade sheet. You can do it in an Excel spreadsheet or in the model, to figure out you need these six points to get this right, or we are trying to figure out right of way.

“The cultural shift is happening on every level. The good designers are getting better; the great designers are getting excellent.” — Della Mosier, ODOT

Grade Control Verification of Machine Control Surfaces

Conversation Leader: Jason Armstrong, ODOT Construction Specialist

Jason Armstrong provided an overview of the [OR 140: Ritter Road – Deer Run Road \(Bly Mountain\) Project](#): a three-year, nine-mile modernization project over a mountainous pass. Using machine control, they knew there would be less staking in the field, so in the beginning ODOT asked the contractor ([K&E Excavating](#)) to take some independent alignments that included the archaeological no-work boundaries, the right of way alignments, and the clearing limits. Once those were staked out in the field, K&E followed with the stage construction and later with the logging operation.

The theoretical model slope catches were used to establish grubbing limits, perimeter erosion control devices, and adjust boundaries of the no work areas. Traditional slope stakes were used in critical no work areas, including blast areas.

Confidence points (random points measured in the field used to verify that a constructed grade has been built according to the design .dtm) were submitted by the contractors during construction. Armstrong evaluated the confidence points and plotted them back into the model, where he could

review them graphically for location, coverage, and tolerance. Two-thirds of the points must pass the tolerance with no points failing three times.

Verification in the field was provided by a GPS rover loaded with the design data. GPS runs in real time were on the Oregon Real-time GPS Network (ORGN). Armstrong had the cross sections printed and all the grade reports on hand — he said these are a must for the PM offices when using machine control grading. They used the rover loaded with the updated design data to review or check anything in the field.

“The project design was based on using machine control. The hand-off package was very detailed and complete, surfaces were machine control ready in land.xml and .dtm format, and staging plans were very detailed, and we received great construction support from the tech center on re-design work.” — Jason Armstrong, ODOT

Glenn Bukoski, MITA: It’s clear that automated grade control is a significant advantage in projects like this where a lot of earth needs to be moved.

Kerry Kuenzi, K&E: We use automated control at any scale. It helps us in all phases of our construction. It’s a versatile tool that we enjoy using, and the support we’ve gotten from ODOT has increased greatly over the years.

Comment: We need to develop standards for verification — when and how you use slope stakes.

Jaime Viramontes, ODOT: These projects that Jason and I presented today are such a huge success because we had accurate designs and great support at the construction level.

Comment: The design staff needs enough time during design to produce accurate products. When we are creating these types of deliverables, we need the time to move accurate products to construction. This is another part of the culture change.

Q: How are you maintaining integrity of the signals the machines are giving on rural sites? The machines are set up to give the estimated error in the signals. If that goes above a certain level, it will not allow you to use automatic control. You can override it to do rough grading.

Q: How do you get signals in rural areas when satellites are moving; do you have to shut down from time to time? There are occasions when the satellites are in a position that won’t allow us to work, but every year it seems new satellites come online, so we don’t have that problem as much. We still run into problems in forested areas and up against buildings. In that case, you put away the GPS tool and bring out the total station control tool. There are different tools for different situations.

Comment: Machine control makes a good operator a great operator.

Comment: Operators don't want to go back to anything else. They have a set of plans right in their machines.

Q: Can you give an estimate of what the production savings are, percentage-wise? On certain machines like a motor grader where you are doing the final passes, production savings are up to 2 to 3 times because you know where you are at all times. We do check behind the machines. However, it's expensive to equip the machines. We have millions of dollars invested in it, but we know it's the way things are going, and it works.

Comment: It decreases the wait time for inspections; jobs are scheduled more efficiently.

Comment: There is an increase in quality because machine grading decreases segregation.

When 3D and AMG Merge: A Project Level Perspective

Conversation Leader: Derryl James, ODOT Lead Senior Roadway Designer

Derryl James has worked on all phases of the [US 20 \(Pioneer Mountain to Eddyville\) Project](#), a large earthwork project involving realigning 10 miles of rugged, narrow roadway with no shoulders and an ugly crash history. One of the biggest challenges was that each phase of the project was under a very short timeline (in addition to environmental impacts and right of way). They had four months to design the entire project.

K&E Excavation was awarded the bid, and they requested digital design files because they were going machine controlled. ODOT's specifications say they will provide finish grade, but they design other surface layers (subgrade, top of aggregate base) as well, and there are other parts outside the roadway prism that need to be designed to — ditch systems, swales, full catches, etc. — that are independent from the horizontal-vertical alignment.

Concerning the level of detail that the design engineers are working on, James said that what the construction office and field support personnel need to understand is that the designers' cross sections and grade reports should marry exactly to the machine control model that they are also providing. He said that, in the future, he hopes to see construction offices being able to utilize machine controlled models or tools to determine the same things that a grade sheet and a cross section do.

ODOT is moving toward standardization in development and delivery of drawings that produce grade-stakeable projects or machine controlled projects without a problem.

"The intent of 3D modeling is to become more accurate, produce highly biddable plans, and get the best bid. 3D modeling gets us to where we can produce one of two things: surfaces that are amazingly useful and produce very good projects, whether or not they are grade staked or machine controlled, or a model that looks good on paper or in a 3D view but is relatively useless in the field."

— Derryl James, ODOT

Q: Are there standards for what each designer provides? Sort of. We're getting closer. In the past, no two sets of engineers' cross sections looked the same. Chapter 16 of our Highway Design Manual is really helping us get a lot closer. Many things standardized within ODOT engineering have to do with development of biddable plans, the paper plans that Della talked about is where we have had a major focus on standardization. Standardization of the electronic design files was never really understood enough to be developed, but we are currently working on that process. I think it's very important that each region produce electronic design files plans that are familiar to everyone in the industry, so we can get the best bid we can get.

Q: Have you started thinking about not providing grade books anymore; do people still use them? People are still using them. The process that we are piloting does not include physical grade books. We are looking at a way to move away from that. As the contractors go more and more machine controlled, they will not be using them, so ODOT needs to be able to shift along with them.

Machine Control Guidance/Integration

Conversation Leader: Jaime Viramontes, ODOT Assistant Project Structure Services Engineer

Jaime Viramontes presented ODOT's use of 3D modeling and AMG on construction of Phase 2 of ODOT's U.S. 20 project ([US20 PME: Upper-Eddyville project](#)).

For confidence points taken with machine control, the accuracies are increasing day to day and different GPS satellites are now available. By the end of this project, ODOT was using a hybrid of both total station confidence points and confidence points taken with rovers with GPS.

The project involved challenges with pipe and rock procurement and possible short construction season length due to heavy rainfall. ODOT worked closely with geotechnical engineers to expedite construction for the Phase 2 contractor (K&E Excavating).

Viramontes said that machine control allowed them to reach the slope depth they wanted without having to go back over it – traditionally the slopes would have been laid a little “fat” and then they would go back later and trim as needed. He added that machine control allowed them to control quantities, therefore reducing overrun.

“Machine control provided an accurate reading of the excavation, allowed us to reach the depth we wanted and to attain the accuracies we wanted.” – Jaime Viramontes

Q: How many stakes were needed on the ground? The contractor said none, but ODOT asked them to set enough slope stakes so that inspectors could verify measurements.

3D Modeling and Machine Control: A Contractor's Perspective

Conversation Leader: Alex Culbertson, Machine Control Manager, K&E Excavating, Inc.

Alex Culbertson presented the following benefits of 3D modeling with examples from K&E Excavating's recent projects:

- Improved estimating — ODOT has recently started handing out models pre-bid, allowing contractors to analyze information and get high accuracy quantities. It reduces uncertainty, and therefore cost.
- Improved pre-construction grade checking — 3D visualization allows for better identification of possible issues and revising profiles before construction; building correctly the first time.
- Reduced human error in the field — manually produced data increases the likelihood of human error. 3D visualization/machine control decreases those opportunities.
- Works well for as-builts — especially in areas where it is dangerous or impossible to survey.
- Faster design revisions during construction — previously they would have to issue a design change and wait for a survey. 3D modeling designers issue a high quality .XML file that can be translated directly into the machine file.



K&E Excavating of Salem, Oregon, used Automated Machine Control from 3D Design on ODOT's Oregon Highway 140 Bly Mountain Project. (ODOT photo, May 2015)

“On our Pioneer Mountain project, we got to where within an hour of the construction change being issued, we were moving dirt in the field. Cell phone downloads could have made it even quicker, but this project was located too far from cell towers for them to be useful.” — Alex Culbertson, K&E Excavating

On a typical project workflow, K&E normally requests information (there can be too little, but there can never be too much) and builds the model, tying together different surfaces into one model for the benefit of the operator. They then perform grade checking, site setup and control verification, and check ODOT's survey against what is on the ground. Once that is complete, every machine onsite is checked to see that the position information it is receiving is accurate. They then build the surfaces and record confidence points (elevation measurements taken by the contractor's surveyor per the spec from a random location and compared to the model) to prove that it was constructed per the grades in the plan.

"We are not relying solely on the machine. We double-check at every step along the way so that we have high accuracy and confidence in what we are building." – Alex Culbertson, K&E Excavating

Culbertson said that the pushback he sees is mainly from inspectors on the ground who have spent most of their career using visual feedback on the jobsite. He said they typically go through five stages as they progress through the project:

1. Denial – "This AMG couldn't possibly work. It couldn't be accurate. We still need stakes."
2. Anger – "You're not putting stakes in the ground! I'll make you put in stakes!"
3. Bargaining – "Okay, maybe just a few stakes to make sure."
4. Depression – "Nobody understands the old way. It was just fine the way it was."
5. Acceptance – "Machine control can do THAT?!?! It's amazing, why didn't I get on board sooner?!"

Q: What are you doing now since ODOT is providing 3D models, will you continue to build your own? Rather than building from scratch, it's switching more from building to verification. I will do a visual check to make sure they are triangulating properly and they are smooth, and I will check the paper plans and paper cross sections because those are the legal documents. Right now, the 3D model is above and beyond what is required by the specifications.

Comment: For K&E's project in Lincoln City, we have been getting confidence points back, and there has never been a failure. It is amazing how tight they can get the surfaces. Tolerances become tighter the closer you get to the finish.

Shooting the toe key — The toe key is a feature designed by a geotechnical engineer, but he does not know how deep it needs to be. Information on how big and how deep needs to be captured. With machine control, the excavator itself did an as-built survey for us, which was then pulled into our collection of survey data. We now have a 3D model — and the geotech engineer can use it to help validate his model.

Concluding Remarks

Joe Squire closed the meeting, stating that the participants planned to continue to grow their relationship and learn from each other, and he reiterated the driving force behind their push to adopt e-Construction:

“With e-Construction, we save time and money, but the bigger savings is in safety and in saving lives.” — Joe Squire, ODOT

Appendix A: Peer Exchange Agenda



Oregon – Michigan

e-Construction Peer Exchange

Sponsored by:



U.S. Department of Transportation
Federal Highway Administration

Oregon Division

Wednesday – Thursday, March 11-12, 2015

885 Airport Rd. SE, Building X Conference Meeting Room, Salem Oregon

Agenda	Time
Day 1 - Wednesday, March 11, 2015	-
Welcome and Introductions Matt Garrett, Director Oregon Department of Transportation Phillip Ditzler, Division Administrator Federal Highway Administration Goals for the Peer Exchange Joe Squire, ODOT, State Construction and Materials Engineer	8–8:30
What is e-Construction to MDOT? <ul style="list-style-type: none"> • MDOT e-Construction Evolution, What brought MDOT to e-Construction? • What is ProjectWise (PW)? • PW usage for design led to PW use for Construction? • How does MDOT use PW? 	8:30-9:15

Agenda	Time
ProjectWise – Governance Documents / Specifications <ul style="list-style-type: none"> • If MDOT had to do it over again <ul style="list-style-type: none"> - What to do more of? - What to do less of? 	9:15-9:40
HQ Server <ul style="list-style-type: none"> • Firewall or not to Firewall – what convinced MDOT its IT to open the Firewall? • Any use of tokens to get past Firewall? • Working Servers with back up on what frequency? • Data / files always current and up to date – who does this? 	9:40-10
BREAK	10-10:15
Access <ul style="list-style-type: none"> • PW Web Server • PW Explorer • Permissions and Authorities • Public Record Requests (aka Freedom of Information Act – FOIA) • Archiving through State Archivist, procedure once project is complete • Business process or policies • Security and sharing • Any Contractor Costs? 	10:15-11
PW Workflow Examples and Demonstration <ul style="list-style-type: none"> • How to construct a workflow? Who constructs a workflow? • How are workflows monitored? Audit trail of a workflow? • Workflows and automatic notifications, how does this work? • Do PW workflows pull FHWA into the workflow process? • PW states? Explain please 	11-noon

Agenda	Time
Lunch	Noon-1
<p>PW File Structure and File Naming Conventions</p> <ul style="list-style-type: none"> • Outline of PW file structure • Outline of PW file naming conventions • Did MDOT mirror MDOT pre-e-Construction paper process? • PW Attribute usage – what worked, what has been modified • MDOT's e-Construction File System on MDOT Wiki site <p>Forms</p> <ul style="list-style-type: none"> • What did MDOT do with paper forms in converting to e-Documents? • Signature Blocks, how handled? 	1-2
<p>How has MDOT Staff and Contractors reacted?</p> <ul style="list-style-type: none"> • Training issues? • Nomenclature issues? • Complexity? • Cost? • Any small business or DBE issues? • If MDOT had to do it over again <ul style="list-style-type: none"> - What to do more of? - What to do less of? 	2-3
Break	3-3:15
<p>What group do your MDOT PW staff report to (4-PW and 1 IT)?</p> <ul style="list-style-type: none"> • What are the roles and responsibilities? • How is time charged, to indirect or project? • Has this group become a state-wide resource? • How do the peer exchange participants tie to the MDOT PW Group? • Who monitors compliance with PW protocol and digital signatures? 	3:15-4

Agenda	Time
<p>Mobile Devices</p> <ul style="list-style-type: none"> • Recommendations for hardware <ul style="list-style-type: none"> - What does MDOT provide its staff, does this vary given different roles? - What to avoid? - Apple, Microsoft, Android operating systems? - Popular or most used features? - Shock and water resistant case, suggestions? • PW remote connection • PW applications <ul style="list-style-type: none"> - What does MDOT use, what does MDOT avoid? - PW Field Supervisor? - PW Explorer Mobile? - PW or other Apps? • Software <ul style="list-style-type: none"> - ODOT is thinking of current email system MS Outlook, MS Office – Word, Excel, PowerPoint; Adobe Pro - Suggestions or modifications or avoidance? 	4-5

Appendix B: Peer Exchange Participant List

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Appendix C: Resources

MDOT e-Construction Website Links

video: “e-Construction on the 96 Fix”

<https://www.youtube.com/watch?v=ScB1b3fqjQo>

video: “e-Construction Process at MDOT”

<http://youtu.be/HAbYgggnyB8>

video: “Mobile Devices in the Field”

http://youtu.be/y_9XCy2lQ2w

video: “MDOT e-Construction Technologies”

<https://www.youtube.com/watch?v=ScB1b3fqjQo>

ODOT 3D Modeling and AMG Website Links

Post-event materials from the Design to Paver Intelligent Construction Systems and Technologies Demonstration, including videotaped classroom and field presentations

<http://designtopaver.org/post-event-materials/>

“Engineering Automation: Key Concepts for a 25 Year Time Horizon,” by ODOT Chief of Surveys and Geometronics Manager Ron Singh

<http://www.oregon.gov/ODOT/HWY/GEOMETRONICS/docs/engautokeyconcepts.pdf>

Video explaining the Jan. 1, 2015, requirement for delivery of a digital data bidding reference package for most roadway construction projects.

<http://youtu.be/AuA63YW7eug>

3D Roadway Design Technical Services Bulletin

http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/docs/tech_bulletins/RD13-03b.pdf

ODOT public outreach 3D Roadway Design website

<http://www.oregon.gov/ODOT/HWY/3DRDM/Pages/index.aspx>

US 20 (Pioneer Mountain to Eddyville) Project

<http://www.oregon.gov/ODOT/HWY/REGION2/Pages/US20-PME-UPRR-to-Eddyville.aspx>

OR 140: Ritter Road – Deer Run Road (Bly Mountain) Project

http://www.oregon.gov/odot/hwy/region4/pages/or140_ritter_rd_deer_run_rd/or140_ritter_rd_deer_run_rd.aspx

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