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Infrastructure Modeling and Data Management: The Road to Digital Delivery

Jacquelyn Brown, P.E.
Microdesk

Robert “Butch” Loncar
Pennsylvania Turnpike Commission

Stephanie Rindosh, P.E.
Microdesk

Learning Objectives

- Discover how data management is critical with implementing BIM on a large-scale effort for a highway government agency.
- Discover the value of 3D models with intelligent data and how they are integrated to feed GIS and Facility Management systems.
- Discover the value of CAD/BIM standards and development of workflows for intelligent modeling.
- Discover best practices for data management solutions for a highway government agency.

Description

The Pennsylvania Turnpike Commission is a state agency responsible for more than 550 miles of highway. As design and construction projects increase in complexity, the Commission faces multiple challenges with data management and variations in project deliverables. With advancing technology, their final goal is to implement digital models as a requirement for project bidding. In congruence with current challenges and goals, they partnered with Microdesk to integrate organization standards and initiate the process of building intelligent 3D model designs using Civil 3D software. The solutions included creating master files of all 550+ miles of highway, CAD/BIM standards for project deliverables, and development of intelligent modeling workflows for Corridors, Drainage, and ROW, all with intelligence that is used to feed geographic information systems (GIS) and asset management systems. These solutions provided a reduction in rework, easier access to data, and an integrated system between departments.

Speakers

Jacquelyn Brown, P.E.

Jacquelyn Brown is a registered Professional Engineer holding licenses in New Jersey and Arizona. She has worked at Microdesk based out of their New York City office for 7+ years, first as a Civil Solutions Specialist Consultant and now as a Strategic Implementation Manager. Prior to working at Microdesk, Jacque worked for 9 years in the Land Development industry where she performed design on a variety of projects including small and large scale residential and commercial developments, solar energy projects, as well as master-planned communities. Jacque now manages projects for a variety of clientele in the Transportation, Land Development, Power and Energy, and Port Authority (Airports, Tunnels, Bridges, Ports, Mass Transit Rail) industries. She assists these clients in managing and organizing data, developing and establishing standardized content and procedures, BIM model development and coordination and she provides consulting and advisory support as well as staff training and mentoring services.

Robert Loncar

Robert "Butch" Loncar is the Engineering Automation Coordinator for the Pennsylvania Turnpike Commission. Butch is a 34+ year employee of the Commission with 28 years within the Engineering Department. Starting out in 1992 as a Draftsman using AutoCAD Release 10 and progressing through each successive new version including DCA, SoftDesk, Land Desktop to Civil 3D. For the last 20 years he has been the Engineering Automation Coordinator whose responsibilities are overseeing the operation and maintenance of the CADD system and other engineering software and hardware within the Engineering Department. He also plans, designs, installs, integrates, tests, maintains and supports Engineering Department equipment, systems, hardware and software. Also included are the development and maintenance of the PTC Engineering Technology Standards which includes the CAD/BIM, Graphics and Lidar Standards. Butch oversees the Engineering Departments Records Retention and Data Management processes. He serves as liaison to the Commission's IT Department to ensure that Engineering application and desktop technology needs are met and maintained in accordance with Commission policies. Butch is the Project Manager for the Commission’s Digital Delivery initiative.

Stephanie Rindosh, P.E.

Stephanie Rindosh is a Solutions Specialist for Microdesk’s Infrastructure Services. She holds a M.S. Civil Engineering degree from Villanova University and B.S. Civil Engineering degree from The College of New Jersey. She has her Professional Engineering license from the state of California and holds a certification in Urban Water Resources Design. She has 5+ years of industry experience in major highway design and construction. Previously, she led a team on the stormwater design for a major highway project. Her experience includes highway project planning, stormwater basin modeling and design, drainage plan and profile design, highway profile design, field construction coordination, and erosion & sediment plans. At Microdesk, she provides highly skilled consulting, training and mentoring for engineering firms to ensure the most up-to-date AEC technologies are integrated into their design workflows.

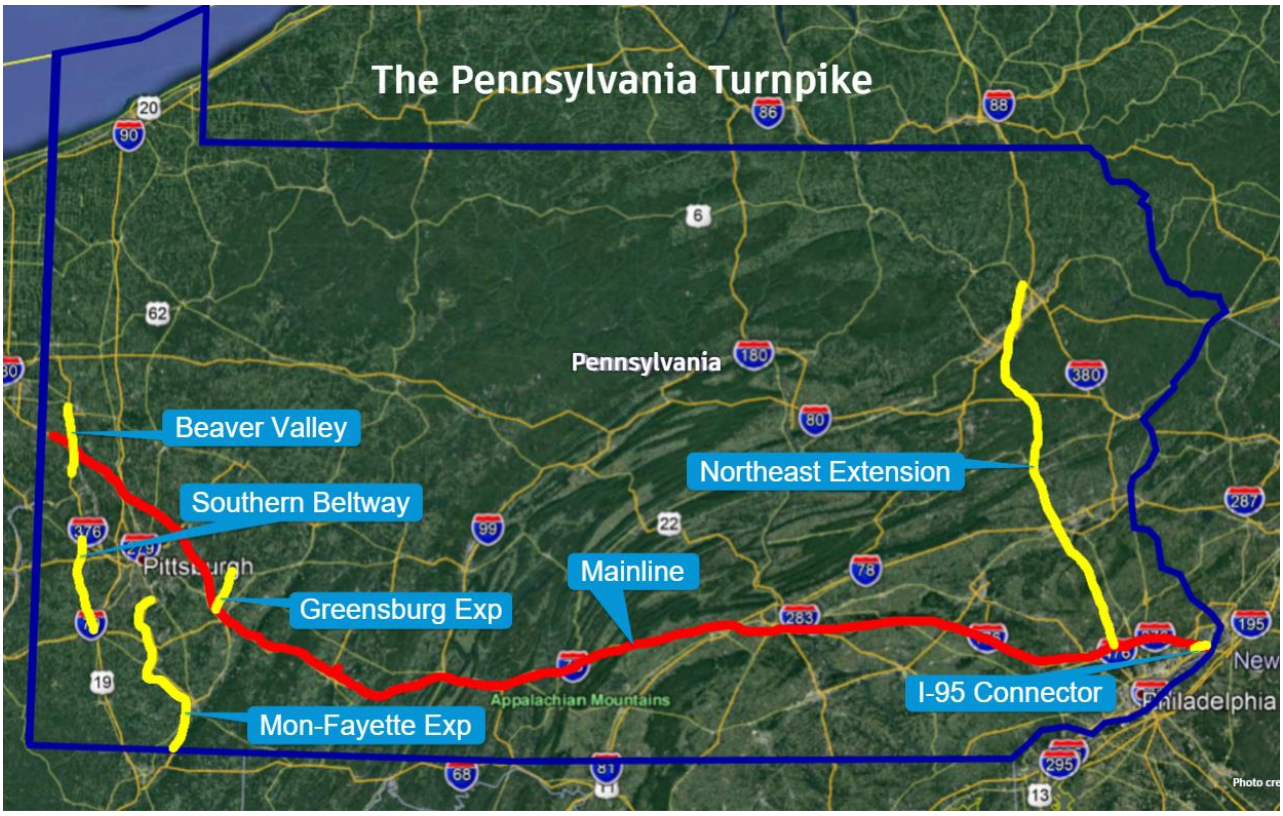
Introduction

The Pennsylvania Turnpike Commission, or PTC, is a state agency responsible for over 550 miles of highway extending across the state of Pennsylvania. They strive to be a technology leader and pride themselves on constantly keeping up with the latest technologies for their industry. But as design and construction projects increase, the PTC faces multiple challenges with data management and variations in project delivery. With constant advancing technology, their ultimate goal is to implement digital models as a requirement for project bidding for the turnpike. This document discusses the steps they are taking to get to this goal and a little bit of the history of the PTC and some solutions that have been implemented as of today.

What is the PTC Responsible For?

The Pennsylvania Turnpike is comprised of over 553 miles of highway. The following are the primary roadways of the Turnpike:

- The mainline of the Turnpike extends across the state of Pennsylvania from the Ohio state line to the New Jersey state line. This is approximately 356 miles.
- Beaver Valley is approximately 18 miles.
- Southern Beltway is currently about 6 miles that has been designed to extend to approximately 19 miles.
- Mon-Fayette Expressway is about 54 miles.
- Greensburg Expressway is about 13 miles.
- Northeast Extension is approximately 110 miles.
- Most recently constructed is the I-95 Connector which is about 2.5 miles.



Along with the primary roadways, PTC is also responsible for the secondary roadways which include interchange ramps, access roads, service plaza roads, maintenance roads, etc. The PTC currently owns and maintains 75 Fare Collection Facilities and 17 service plazas along the turnpike. The amount of data that has been accumulated over time to manage this highway system is massive and requires organized and systematic methods for data management.

The PTC and Microdesk Partnership

PTC partnered with Microdesk to assist in creating solutions for streamlining and organizing data that has been accumulating since the Pennsylvania Turnpike Commission was established. Not only did they need the data to be gathered and organized, they needed this data to have intelligence and have dynamic interoperability between CAD and GIS.
This was a multi-step process in which the most up-to-date designs and as-builts were located and organized. These were typically in the form of pdf plan sets located in PTC's various storage systems. These pdfs were transformed into master files for the 550+ miles of highway. The solutions for data management and infrastructure modeling will involve a cloud-based document management system, establishing Engineering Technology standards for project deliverables, and creating intelligent 3D BIM models and workflows to feed their GIS and Facility Management systems. The ultimate purpose for the PTC/Microdesk partnership is to provide the PTC solutions for a reduction in rework, easier access to data, and an intelligent integrated system between departments at PTC for the entire turnpike.

Overview of the Pennsylvania Turnpike Commission

Vision and Mission

The Pennsylvania Turnpike's Vision is "Driving the standard for safety, customer service and mobility. Their Mission is "To operate a safe, reliable, customer-valued toll road system that supports national mobility and commerce.

One of the methods that the Turnpike Commission is using to meet these goals is through the PTC Innovation Council which was created to foster a collaborative environment for the rapid implementation of ready to deploy and beneficial innovations to efficiently deliver a high-quality transportation system. The goals of the council are to foster a culture of continuous improvement and to have a process to facilitate the rapid implementation of technologies, equipment, materials, and approaches within the PTC. The council also strives to get innovation into practice quickly so users of PTC system are able to gain the benefits of an improved transportation system that is safer and more efficient.

Innovation at PTC

An innovation is deemed as something that enhances the Commission's ability to meet its vision such as; innovations in processes, workflow, project delivery or operations and maintenance that results in substantial cost savings. Also, innovations are consistent with the PTC's mission and values that improve safety, reliability and customer value.

In the PTC's partnership with Microdesk, they have undertaken the journey that will deliver that "innovation" to implement Infrastructure modeling and data management that will assist them in meeting their goals of achieving full digital delivery of projects.

A Brief History

The Turnpike opened on October 1st, 1940 and within its first year, 2.4 million vehicles had traveled the system averaging over 6,500 vehicle per day. With this October being their 80th anniversary, over 210 million vehicles travel the Turnpike annually with an average of 570,000 vehicles per day.

Major PTC Projects

Total Reconstruction Project

The Turnpike has undertaken the total reconstruction of the original system which includes:

- Miles Completed = 144.5
- Miles in Construction = 8.5
- Mile in Design = 79.5

Expansion Projects

Southern Beltway:
US 22 to I-79 is a 13 mile stretch of new highway in Southwest Pennsylvania and is slated to open in the Fall of 2021. This is an extension of the first 6-mile section which runs from I-376 to U.S. 22.
Mon-Fayette Expressway:
The current portion of the Mon-Fayette Expressway runs from the PA/WV boarder to PA51 in Southwest Pennsylvania. Currently in design is the section from PA51 to

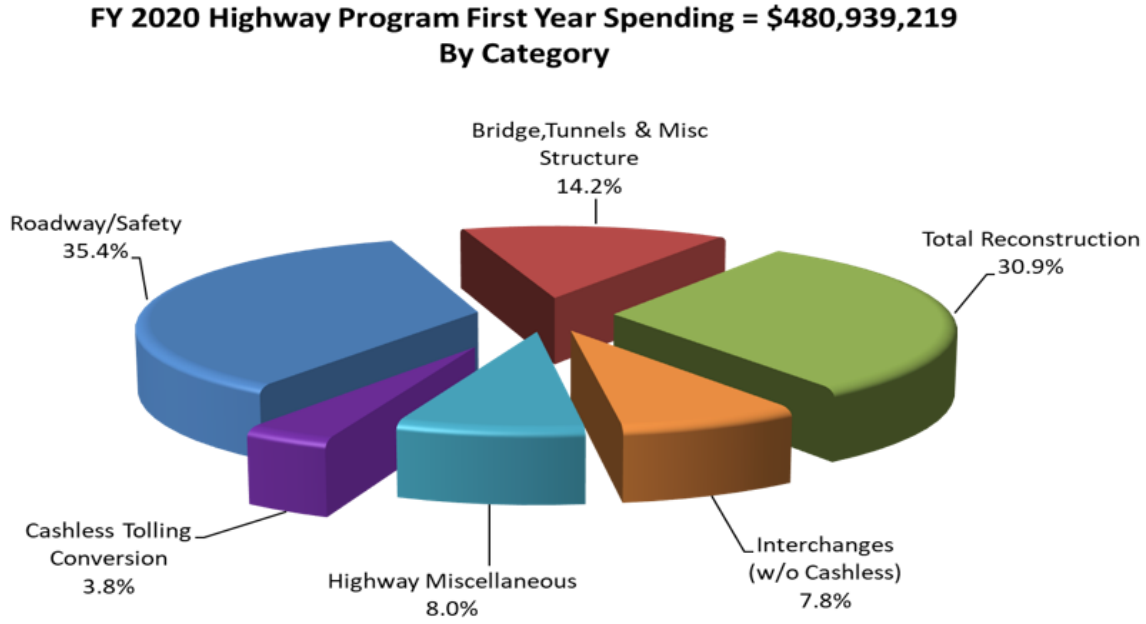
PA837. The third section will run from PA837 to I-376. When completed the Mon-Fayette Expressway will stretch 68 miles.
I-95 Connector:
The PA Turnpike/I-95 Interchange Project now directly connects the PA Turnpike and Interstate 95, thus making Interstate 95 continuous throughout the Mid-Atlantic Region.

PTC Facts and Numbers

- The Pennsylvania Turnpike currently consist of 553 miles of highway.
- There are 75 fare collection facilities which use E-ZPass and Toll By Plate to collect fares.
- There are 23 maintenance buildings and 5 tunnels.
- As of 2018, there are 576,284 vehicles per day that travel the Turnpike.
- The most heavily used interchange is Mid-County in Southeast Pennsylvania with an average of over 84,000 vehicles per day.
- There are 202 contracted emergency resource units for fire, EMS, Haz-Mat and Towing.

PTC Highway Program

The PTC Highway program for FY2020 alone allocated over $480 million dollars for projects. In this chart you can see how that funding was allocated:



Currently there are over 100 individual design and construction firms working on over 200 projects:

- 54 Construction projects
- 74 Design projects
- 42 Miscellaneous projects
- 31 Total Reconstruction Design and Construction projects

Between August 2020 and September 2021 there are 36 projects scheduled to be bid for construction.

Challenges at PTC

Data management challenges begin with identifying key data that exists within 80 years' worth of data such as as-built drawings, inspection data in spreadsheets, and hard copy files.

Current Data Management Problems:

Existing Record Formats:

- Hard Copies
- CAD Files
- GIS Files
- Databases
- Spreadsheets
- Survey Data
- Document Archive System

Location of As-Built Information:

- Existing information systems
- Network folders
- User home folder or hard drive of PC
- File cabinets
- Warehouse archive
- Floppy disks, CD's, DVD's, etc.

There were issues with data consistency that occurred over 80 years as project data such as coordinate data, curve data and such that did not always match to later projects done in the same location. This required research starting with the original construction drawings and following through successive project plans that covered that same location and identifying the errors that occurred in recording the data and developing a single source of truth that initially became the master centerline, master right-of way and the beginning of the creation of the initial corridor and drainage models.

Over 80 years, projects were completed using the standards and specifications of that time. While coordination was done with as-built information from previous projects in a location, the system was never looked at as a single comprehensive whole. Also, the accuracies that can be obtained today are greater than what was recorded 80 years ago. This made evident discrepancies in the data and the PTC was forced to reconcile these discrepancies and record the solutions used to "close the gap".

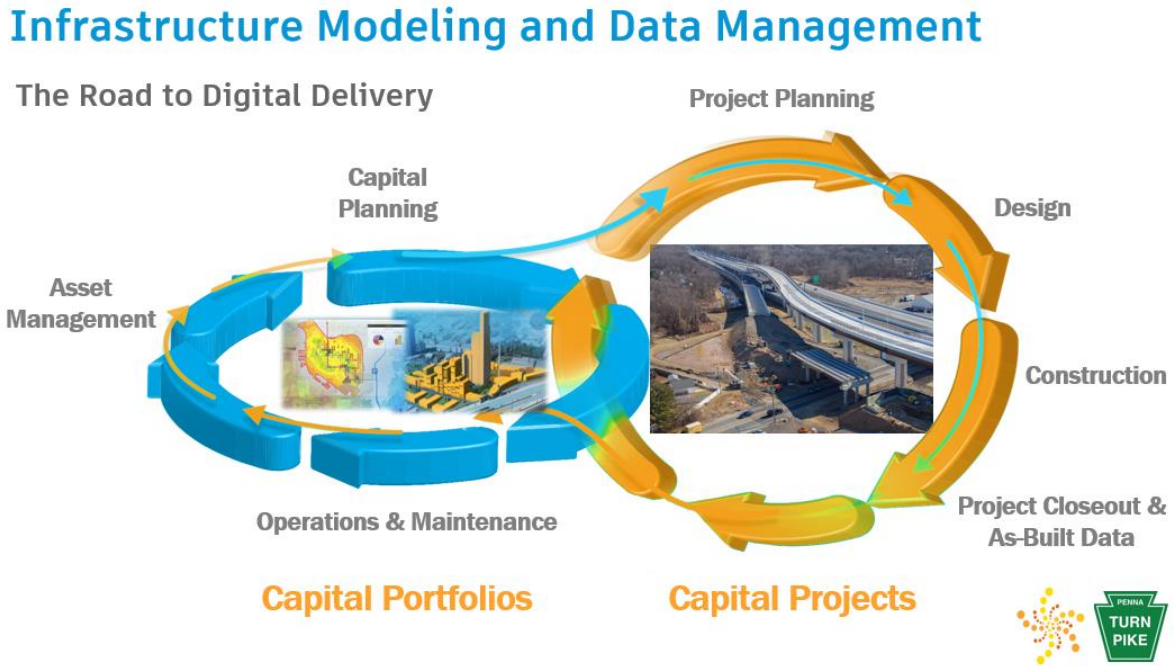
Solutions for Challenges

Once master models are created, the next step is to export the data so that it can be consumed by other systems such as GIS and the Pavement Management System. This coupled with inspection data allows the Engineering department at PTC to analyze the highway data and predict and plan maintenance or rehabilitation projects, all based off data that is consistent and true.

By implementing model-based design and moving towards digital delivery the PTC anticipates improvements in as-built data, more accurate data, and a complete set of information that is stored and integrated with various systems so that when changes occur through maintenance or major projects, they always have a true model that reflects what is actually out on the highway system.

Project Lifecycle

Below is the lifecycle of the PTC's infrastructure from Capital Planning through Project Planning, Design, Construction, and As-Builts to Operations and Maintenance to Asset Management and back to Capital Planning. At each step, information is shared and updated so that regardless of the task, everyone has the latest and most accurate information to make the best decisions in support of the infrastructure.

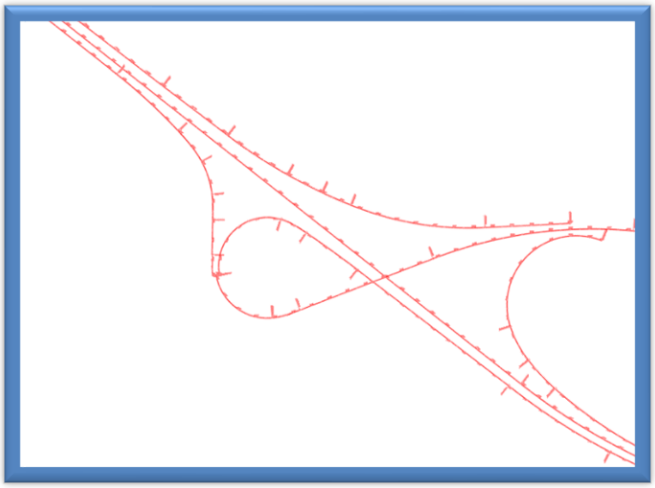


Infrastructure Modeling and Data Management Solutions

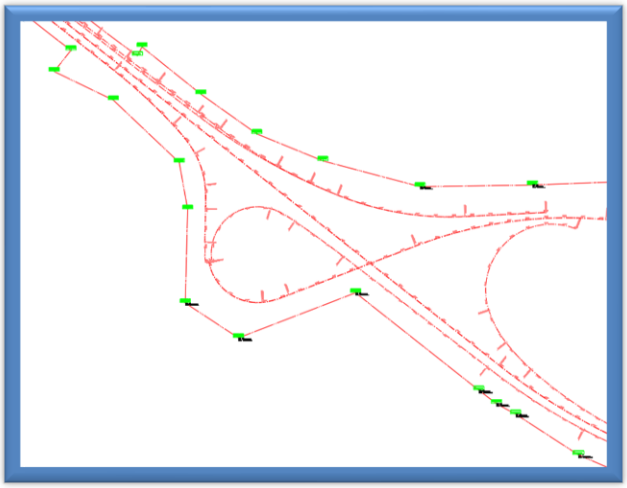
Master LRS and ROW Drawings in Civil 3D

The first step in this process was to create master drawings for the turnpike. To effectively manage this, the 553 miles of primary roadway were split into approximately 50-mile increments for the drawings created in Civil 3D. Master LRS (Linear Referencing System) and ROW (right-of-way) drawings were created for the entire turnpike including primary and secondary roadways (being ramps, access roads, service plaza roads, etc.). To start, all of the most up-to-date pdf drawings for the alignments and ROW were locate and utilized to "map in" each alignment and ROW line and node for the entire turnpike.

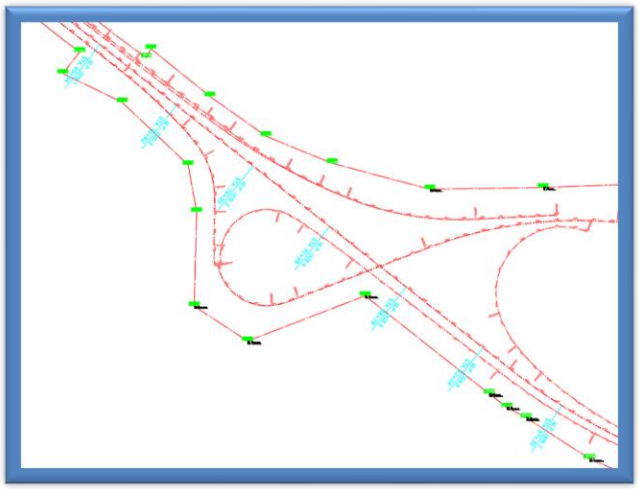
- First, the alignments were drawn using the coordinate sheets within the pdf plan sets that listed northings and eastings for each alignment geometry point. From there, the curve data was taken from the roadway plan sheets to draw all of the curves, including spiral curves. The alignments were then dynamic, intelligent alignments representing the designs and as-builts.



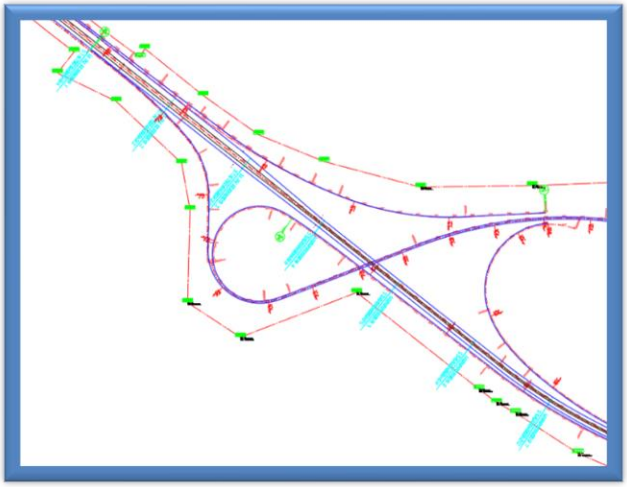
- From there, the geometry of the ROW could be drawn based on stations and offsets from the dynamic alignments.



- Then, master milepost symbols were created utilizing stations from the pdf plan sets.



- Then from there, travelway lines were developed for all primary and secondary roadways to represent the line of travel for vehicles on the turnpike.



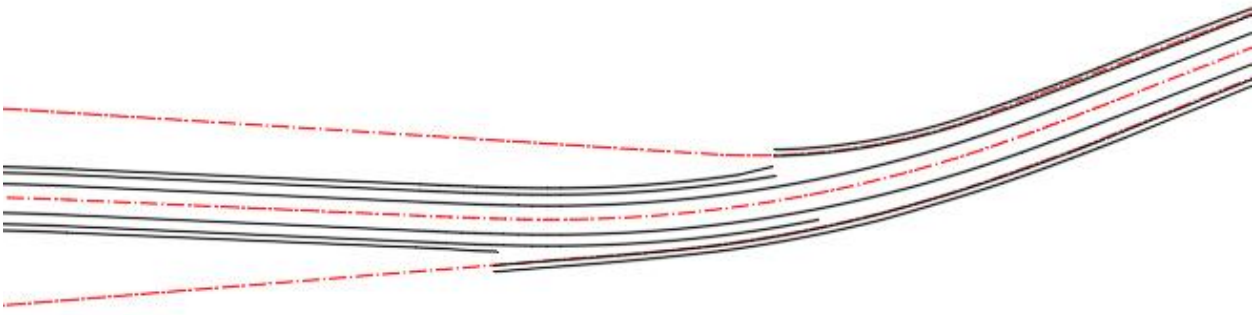
With all of the construction projects constantly occurring at the PTC, a system for updating the master drawings and tracking the updates has been developed. These updates typically occur on a quarterly basis.

Master LRS and ROW Statistics

1,671	6,507,493	14,776	1,419
ALIGNMENTS	LINEAR FEET OF RIGHT-OF-WAY	MILEPOST LABELS	MILES OF TRAVELWAY
Total Alignments Including 92 Primary 1,008 Secondary 272 State Roads 299 Access/Maintenance	Total Linear Feet of Right-of-Way Linework	Includes 11,327 Primary and 3,449 Secondary Mileposts	Includes 1,128 Miles of Primary and 291 Miles of Secondary Travelway

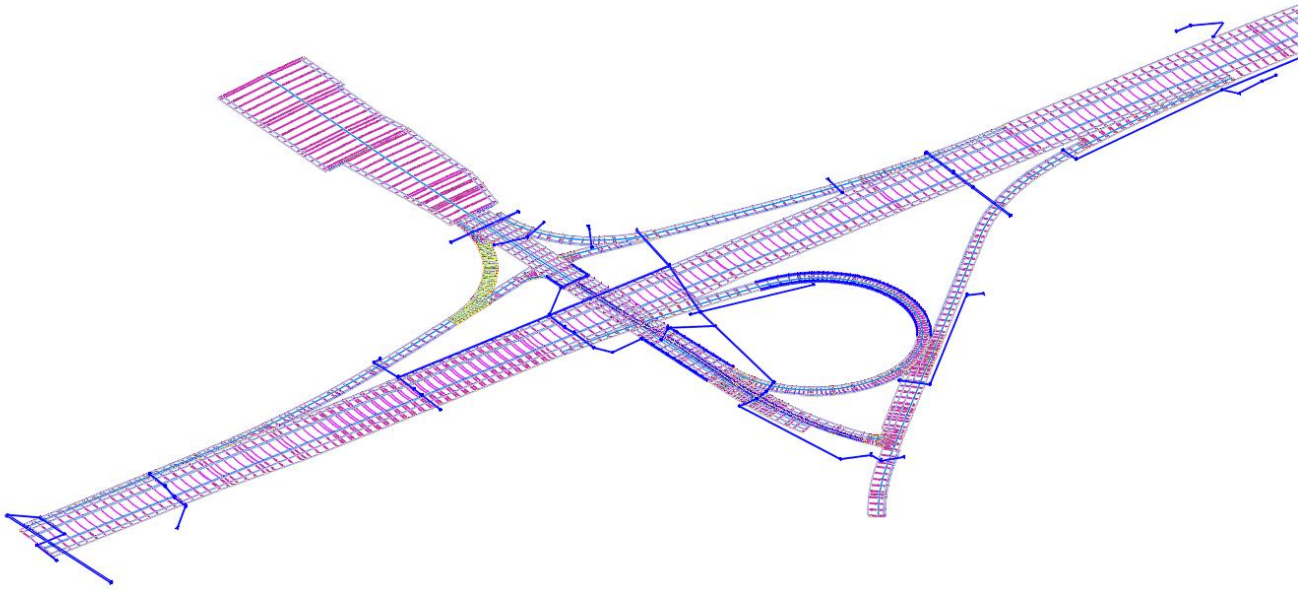
Pavement Linework

A subcontractor was used to develop Light Detection and Ranging (LiDAR) scans of the primary roadways utilizing mobile Lidar. The mobile lidar data was converted and processed in Autodesk Recap to prepare it for import into Civil 3D. The processed scan data along with scan images totaled 5.1 TB of data. Once imported into Civil 3D, linework was drawn for the edge of median, edge of shoulder, and edge of pavement from the lidar scans. The pavement linework was drawn utilizing a combination of offsetting and manual manipulation to match the pavement markings and edges indicated on the scans.



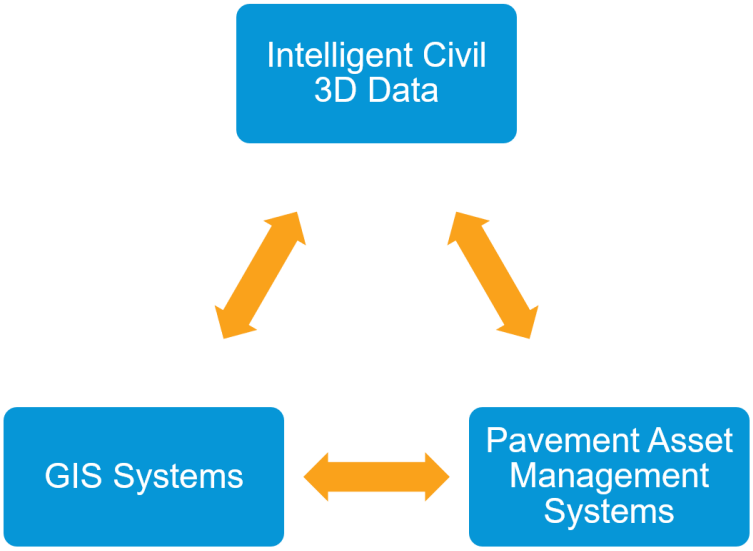
BIM/3D Models

The next step in the process was to model the turnpike with corridors using the master files. PTC specified three of their projects that they wanted to be modeled in 3D. Profiles and assemblies were developed based on the pdf design and as-built plans. From there, corridors and drainage systems were developed. As of now, approximately 30 miles of the turnpike has been modeled in 3D.



GIS and Pavement Asset Management Systems

All of this data; alignments, ROW, mileposts, travelways, pavement linework, corridors, and drainage systems have been equipped with object data attached that is used to feed GIS and Pavement Asset Management Systems for the PTC. Pavement asset management system spreadsheets link the Civil 3D data to GIS.



Engineering Technology Standards Development

Another separate but equally important effort in this partnership was to develop an Engineering Technology Standard for the PTC. Microdesk assisted in a preliminary effort for this back in 2015. But the most current iteration is much more detailed and specific. With this effort, a 275-page document was developed to outline the standards for deliverables, naming conventions, practices and procedures, drawing management, plot setup, etc.

In congruence with the creation of the document, AutoCAD and Civil 3D templates were developed to establish uniform layers, linetypes, symbology, styles, and settings. This also included the development of sheet templates that utilize sheet set manager for contract borders of various types and sizes. PTC also allows consultants to use Bentley software so MicroStation and OpenRoads templates and CAD standards were also included in this effort. Which also brought on the challenge of creating standards for both software entities that are cohesive and coincide with one another as seamlessly as possible.

The purpose of developing these standards and templates is to establish requirements and procedures for the preparation and submission of CAD based drawings to the PTC. Adherence to the standard ensures that all divisions of the PTC, as well as outside consultants, will produce data in a consistent format. This consistency will improve the compatibility of this data within each discipline and office and the efficient exchange of data between disciplines and offices. As a part of the standards development, Microdesk has established a process for checking compliance with the standards. When an outside consultant submits a project to PTC, there is a process for checking if that submittal complies with PTC's standard. The consultant will be given a pass or fail status for the project submitted based on the compliance checking process.

PTC plans to continue developing standard initiatives for all aspects of the Design and Construction process. This will include Surveying and As-built standards to create consistent practices and procedures for conducting surveys and collecting data as well as workflows for producing as-built plans. Another future directive for standardization is to develop BIM and 3D modeling standards. This will include guidelines as to what will be required to be submitted in a three-dimensional format as well as consistency in how the 3D models will look. Some of this has been included in the standard Civil 3D templates as far as styles and so on, but a BIM standard will take it a step further to lay out all 3D requirements and standards.

Every step and solution that has been developed so far has been leading up to accomplishment of goals and directives for the future of PTC.

Looking Forward

The following is an explanation of the future directives at the Pennsylvania Turnpike Commission.

This quote has been adopted by the Turnpike Commission as an inspiration for future project design. The drive for this change is that there are higher demands for project requirements, specifications, types of plan sets, and an increase in data that all has to be managed. With less capital planning, budget restrictions and increase in project timelines, the solution to be efficient is to utilize BIM technology to create more efficient workflows so that the PTC can 'Do More, Do Better, With Less'. With this motivation, as a government agency, the Turnpike Commission is truly a technology front runner. They are looking at ways to make design, project, and asset management more efficient by adopting technology that will get them there.

Goals

Implementing Digital Delivery by 2023

The expectations of digital delivery are for project submissions to the PTC to have a 3D intelligent model of the highway design. This 3D model will serve as the primary source document and any plan sets that are included in the submission must have all information extrapolated from the 3D model.

3D intelligent models provide many benefits for the design process including:

- Better visualization of the project. This is particularly advantageous with subsurface features, and also provides an easy visual for PTC, stakeholders, and contractors to understand the design intent.
- Reduction in project errors and costs. 3D intelligent models provide clash detection with certain features, so that the designer can catch a problem early before it gets sent to construction. Thereby minimizing potential errors and reducing costs to fix these errors.
- More information and greater accuracy. Quantities become easier and more accurate for submissions. Furthermore, if there are any questions where plan sets may lack information, a 3D model can easily reference the location in question. For example, Cross Section Sheets are provided at particular intervals up to the designer's discretion. If a contractor needs to view a cross section that is not included within the Cross Section Sheets, then a 3D model can quickly provide that cross section at the necessary station.
- Stronger communication between designer and construction teams. 3D intelligent models provide ways to have a deeper understanding of the project from designer, construction team, and the Turnpike Commission. As a result, this leads to saving time for all teams by creating less RFIs (Request for Information) and building stronger communication.

Taking this a step further, post-construction a BIM model will have useful benefits as a base map for future maintenance of the roadway, future planning of reconstruction projects, and efficiently update asset management systems.

3D Models of the Entire Turnpike

The second goal is to have 3D models of the entire turnpike (all 550+ miles). This process has already begun and the objective here is to create 3D models of everything already existing in the field. The big picture for these models is that the Turnpike Commission can supply a 3D model to a design firm and depending on the project type, they can make the necessary updates to the 3D model. Not every project type at PTC is total reconstruction. For example, adding guiderail or perhaps resurfacing a portion of the highway. With a pre-existing 3D model, a design firm can receive the existing model and make the necessary changes. Thereby, reducing costs and saving time by not recreating an entire section of the highway that is out of the project's scope.

Implement a Cloud-Based Data Management System

With this much information and data, organization and file management will be crucial for success. There needs to be a data management system with an easy way to share 3D models and organize all existing information necessary for projects. This goal is currently under research and that is because assurance in selecting the best product or products is crucial for the Turnpike's needs. However, there are some known requirements for the data management system. The data management system will be a cloud based software and there needs to be a security system that complies with the Turnpike's regulations. It also needs to have information easily accessible among multiple teams and, more importantly, it needs to handle the 3D models from Civil 3D.

Project Evolution

2015 to 2017

The first two years highlighted initial research. This included looking at the current workflows used at the Turnpike Commission and determining the best solutions for future design. From there, information was gathered and compiled to start organizing all existing data into Master files. This way there is one location for all information. The alignment data was the primary focus.

2017 to 2019

Additional master files were created including the master ROW files and travel ways for the linear referencing system. Once completed, the focus shifted from gathering all this information in one place (C3D drawings) to primarily how to get all this data in Civil 3D to be interoperable with the GIS System. Thereby, giving other agencies and stakeholders, who need to have access to this information, the most current data.

2019 to 2021

Developing 3D BIM models in congruence with the development of the Engineering Technology Standards began. These are 3D intelligent models, which is more than just providing a 3D representation of a highway design. There is a wide range of information that is included with these models that all has BIM Interoperability. The road map includes to further develop the Engineering Technology Standards, not just to specify what styles need to be utilized, but also what information is needed and to provide ways of ensuring this information can be interoperable with other systems that will be part of the Turnpike's success.

Looking at the progression of this project into the year 2020, a lot has been accomplished over the past five years. These initial years have been crucial for preparing the Turnpike for the digital delivery initiative and is the base for accomplishing even more in the next three years.

2021 to 2023

In a few short months the 2021 to 2023 timeline will begin in which Corridor and Drainage Models will continue to be developed and eventually these projects will be integrated with the recommended Data File Management System.

Part of the digital delivery initiative will involve onboarding consultants and Turnpike employees to help create efficient digital review procedures. This will entail ensuring that design consultants and contractors understand what is required of the digital delivery submission as well as ensuring there is a well-organized method to provide comments and complete reviews.

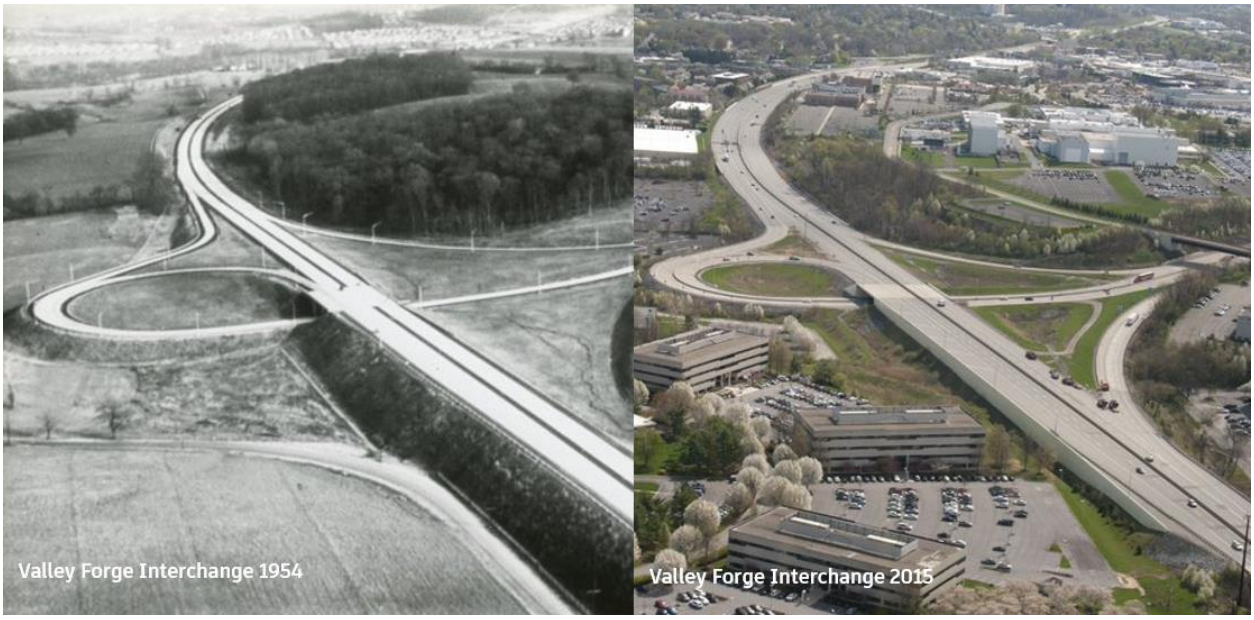
Ultimately, there will be a pilot project in which a design firm will be utilizing the developed standards and following all the requirements for a digital delivery submission. The goal of the pilot project is to uncover any challenges and to see if the workflows can be optimized and if updates to the BIM Standards and Engineering Technology Standards will be necessary.

Now, this initiative may have an ambitious timeline. However, we are confident that it is achievable by executing all these items so that the Turnpike can implement Digital Delivery in 2023.

The Future of the PTC and Microdesk Partnership

Infrastructure has significantly changed over time. With increasing population along with the necessity to improve current infrastructure systems in the United States, the demand for its further development is at an all-time high.

Technology is also changing, and it is at an even faster rate. The tools that were used 10 years ago for design are not the same tools used today. Therefore, as a long term goal, Microdesk plans to continue to assist the Pennsylvania Turnpike Commission with intelligent models, data management, and any other future technology directive. Especially as technology evolves, Microdesk wants to ensure that the methods in place at PTC are the most efficient and up to date with the current technology.



In Conclusion

As you can see, this was and continues to be a challenging and rewarding effort to take PTC to the ultimate goal of full digital delivery. The Pennsylvania Turnpike Commission strives to be a technology and industry front-runner in the highway and transportation industry and with the help of Microdesk and Autodesk Software, they will continue to lead the future of highway design and construction. We hope you can take away some unique perspectives and initiatives for your projects.