Digital Delivery Directive 2025

Final Strategic Plan

Version 1.0

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pennsylvania
DEPARTMENT OF TRANSPORTATION

Foreword

"One of the most rewarding aspects of engineering to me is that at its core it is about turning an idea into reality that meets the needs of the user. Despite the evolution of sophisticated tools and advancing technologies, we have thus far relied on static plans such as plan views, profiles/elevations, and cross-sections to transfer our ideas to the contractors to build, and to our maintenance teams to operate and maintain after they are built. It is time to evolve. PennDOT has always been a national leader when it comes to using advancing technologies to transform how we serve the public. From being one of the first adopters of electronic bidding and contracting to leveraging GIS in planning our maintenance work, we lead the pack. It is time to shed the restrictions of the traditional plan set and embrace the data rich engineering model in all we do. Digital delivery will allow us to move our designs seamlessly to those who construct them and collect accurate asset information from construction to our maintenance teams. The Digital Delivery Directive 2025 will transform all of our operations and remain at the forefront of technology and innovation."

Melissa J. Batula, P.E.
Deputy Secretary for Highway Administration

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Executive Summary

The technology for the development, delivery, and construction of our built assets is changing. The focus is moving from 2D paper-based products to 3D data-based products. The new technologies bring advantages in the form of better quality and lower costs. Achieving the full benefit potential of digitally delivering asset information through all project development phases requires a carefully-managed process.

This strategic plan establishes the roadmap for the Pennsylvania Department of Transportation (PennDOT) to implement the processes, technology, and workforce development needed to execute the Digital Delivery Directive 2025 (3D2025). The 3D2025 will digitize PennDOT's project delivery processes and contract document media.

Strategic Planning Process

PennDOT has retained a consultant team to execute the 3D2025. The consultant team works with the PennDOT project lead and the statewide digital delivery committee. The committee includes representatives from across PennDOT's Districts and business units.

The strategic planning process involved three steps:

1. **Assess** the organization's needs, desires, and current state of maturity by engaging with district and central office managers and staff, and external partners,
2. **Align** the needs to defined solutions and redesigned processes based on the feedback collected from engagement activities; and
3. **Advance** by defining a roadmap to develop the necessary technology, information requirements, policies, and training.

Vision

By 2025, construction projects will be bid using 3D technology and will no longer be in a traditional construction plan format.

Objectives

1. Use 3D technology to create high quality, data-rich models of our projects;
2. Use accessible digital processes and tools to support all project development functions by all stakeholders that replace legacy business systems; and
3. Develop and implement new information management processes for capturing asset information from projects and using the information to improve inspections and asset management.

Roadmap

The 3D2025 will be executed using national and international guidelines for implementing digital delivery within a comparable agency. It will also address PennDOT's unique needs and be implemented as a collaborative effort between staff at all levels and across all PennDOT Districts and PennDOT's consultants.

The roadmap includes:

1. A list of “Quick Start Tasks” to create ready-to-use digital delivery tools so that staff can begin building foundational skills and to provide a feedback mechanism.
2. Detailed implementation planning to identify the processes affected by digital delivery.
3. Recommendations for incremental development of specific use cases that are selected based on PennDOT’s priorities and the information flow through the project delivery process.

Deployment will use an agile workflow to implement digital delivery. The agile workflow breaks down digital delivery into narrowly-defined tasks that are tackled in short iterations, called “sprints.” The sprints will be based on discrete use cases for digital data, such as roadway model authoring and construction verification and acceptance. Each year there will be a cycle of defining requirements for use cases, piloting use cases, processing feedback, and documenting successfully tested workflows into new or updated Publications. The roadmap also includes ongoing stakeholder engagement and performance monitoring. This publication will be updated with yearly amendments.

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Introduction

This strategic plan establishes the roadmap for the Pennsylvania Department of Transportation (PennDOT) to implement the processes, technology, and workforce development needed to execute the Digital Delivery Directive 2025 (3D2025). This detailed plan is intended for the PennDOT project sponsor, project lead, and implementation team, as well as for the consultant. The executive summary is intended for the wider PennDOT project development community.

Digital Delivery Directive 2025

The 3D2025 will modernize PennDOT's project delivery processes and contract document media to incorporate digital data. Simply stated, the initiative is that by 2025, construction projects will be bid using 3D technology and no longer be in a traditional construction plan format. This will help PennDOT to incorporate streamlined processes to manage asset information as it changes through project development.

While PennDOT is currently a leading state for electronic construction management, the construction contract documents are comprised of 2D plans in PDF format. By 2025, PennDOT will design projects using 3D engineered models and deliver the design intent to construction using 3D engineered models as the primary document of truth. All project elements—including what would typically be shown on so-called "also plans"—will be contained within a digital model that would include 2D and 3D model elements with attached attributes and references. By selecting elements within a digital model, users could access 2D representations of related traditional details or call outs along with relevant calculation data. Users would be able to attach photos, videos, documents, hyperlinks, etc. to model elements.

Contractors and construction inspectors will use the digital models on the project site. The contractor's as-built deliverable will be an accurate representation of the constructed project. A core value enabler is the use of structured, object-oriented data within the digital models. Object-oriented data provides the capability to define the context within which the object is used and thereby align contextual data across the asset lifecycle. For example, connecting the construction tolerance, specification section, pay item number, and performance standards to unify the asset information across the lifecycle.

Purpose

The use of 3D engineered models for construction has evolved over the past decade. PennDOT is ready to take advantage of the following attributes of a digital delivery process:

- Improved design quality,
- Reduced risk and project cost,
- Increased construction efficiency, and
- Improved as-built records.

IMPROVED DESIGN QUALITY

PennDOT is currently rolling out new road design software that automatically generates a 3D model during the design process. This makes it easier to review the design intent and develop

high-resolution 3D visuals. When bridges are designed in 3D using the same coordinate system, it is possible to view the road and bridge designs together.

REDUCED RISKS AND PROJECT COSTS OR DELAYS

While the majority of change orders arise from scope changes and unforeseen conditions, digital delivery can make a significant impact on reducing project cost over-runs. Since 2018, PennDOT has spent on average over $1 million per year in change orders due to design errors and almost $15 million per year in change orders due to design omissions. Digital delivery reallocates the designer's time from detailing 2D sheets to developing a more mature design. The automatic change propagation with 3D design enables designers to test "what if?" scenarios to refine constructability and optimize project cost.

INCREASED CONSTRUCTION EFFICIENCY

Contractors benefit from a more complete representation of the design intent delivered in a more directly usable format. This enables enhanced construction planning and less time extracting information, e.g. for estimating and construction layout. The contractor's field staff and PennDOT's inspectors will use the model elements to reference information such as the pay item name, number, and units and connect to the appropriate part of the specification.

IMPROVED AS-BUILT RECORDS

The digital technology associated with using digital models on the construction site creates an opportunity to reform the as-built record documentation. Instead of marking up PDF plans, contractors will collect digital as-built records that are formatted ready for PennDOT's maintenance and asset management business systems to receive the information they need.

Planning Committee

PennDOT has retained a consultant team, led by HDR Inc., to execute the 3D2025. HDR's team is working closely with the PennDOT project lead and the statewide digital delivery committee formed from representatives from across PennDOT's Districts and business units. PennDOT's liaison for IT support at the PA Office of Administration (OA) is also represented in the statewide digital delivery committee.

PennDOT Statewide Digital Delivery Committee

There are 26 members of the statewide digital delivery committee. Committee members were selected because they:

- Believe PennDOT is ready to capitalize on digital delivery,
- Are knowledgeable about PennDOT's current business processes,
- Are a subject matter expert of tools and technology for digital delivery, and/or
- Are knowledgeable about PennDOT's culture and business partners.

Table 1 lists the roles of the committee members based on their knowledge and expertise.

Table 1: Composition of the PennDOT Statewide Digital Delivery Committee

Stakeholder Category	Examples of Personnel	Role and Responsibilities
District Champions (11)	Management team (ADE, Design Services Engineer, etc.) and staff representing various departments.	Provide support in assessing current maturity and prioritize future goals and help develop and deploy the initiative. **Responsibility**: Work with district teams to carry out activities.
Central Office Staff (7)	IT, Office of Chief Counsel, Asset Management, Bridge, Systems Management, and Survey	Provide business/technical support as it relates to process, procedures, policies and regulations. **Responsibility**: Consulted for input throughout the duration of the project.
Digital Delivery Staff (2)	Digital Delivery Lead Project Sponsor	Provides management support, and manage and coordinate activities related to project scope of work throughout initiative. **Responsibility**: Accountable for the work.
Industry (6)	ACEC/PA and APC	Provide support in assessing current maturity and prioritize future goals and help develop and deploy the initiative. **Responsibility**: Consulted for input throughout the duration of the project.

Committee members have made a long-term commitment to see the successful execution of the 3D2025 over the five-year delivery period. They will serve as champions of the 3D2025 amongst their colleagues and peers. They will help to set the direction for how PennDOT uses digital delivery and work with small task forces through their activities on the committee.

Consultant Team

The HDR team will assist PennDOT to determine the strategic direction, technical basis, and workforce development for implementing digital delivery comprehensively throughout PennDOT's districts and business areas for project delivery. Work may include assignments such as, but not limited to:

- Develop the strategic plan for the 3D2025.
- Develop workflows to pilot digital delivery for design through construction.
- Develop workflows to pilot for post-construction activities such as digital as-builts for maintenance and asset management.
- Develop quality management workflows.
- Assist with the development of and/or revisions to existing PennDOT policies, standards, publications and other guidance.

- Support the development of CADD standards, processes and procedures.
- Assist with the development of specific contract language for design and construction.
- Assist with the development of engineering documents and presentations to be shared with various stakeholders.
- Provide part time on-site assistance on assignments, if needed.
- Work with stakeholders to assist in advancing the 3D2025.

Outcomes

The outcome of this strategic plan is a roadmap to execute the 3D2025 that:

- Effectively implements the vision of the PennDOT statewide digital delivery committee,
- Identifies specific digital delivery use cases, and tests solutions to address pain points,
- Provides an incremental approach to developing, piloting and deploying digital delivery,
- Builds buy-in from PennDOT project development staff across all Districts, and
- Incrementally develops capability and capacity for digital delivery across PennDOT's business partners.

Deliverables

This strategic plan represents the deliverable from the first phase of the 3D2025. It comprises the following parts:

1. A roadmap for the development and deployment phases,
2. The digital delivery maturity assessment worksheet,
3. A summary of the regional workshops, and
4. A definition of each identified digital delivery use case.

Process

This chapter introduces the strategic planning process that led to the creation of the roadmap for executing the 3D2025.

Guiding Process

The 3D2025 will be executed using national and international guidelines for implementing digital delivery within a comparable agency. It will also address PennDOT's unique needs and be implemented as a collaborative effort between staff at all levels and across all PennDOT Districts and PennDOT's consultants. Figure 1 illustrates the guiding process for executing the 3D2025. Figure 2 outlines the core milestones.

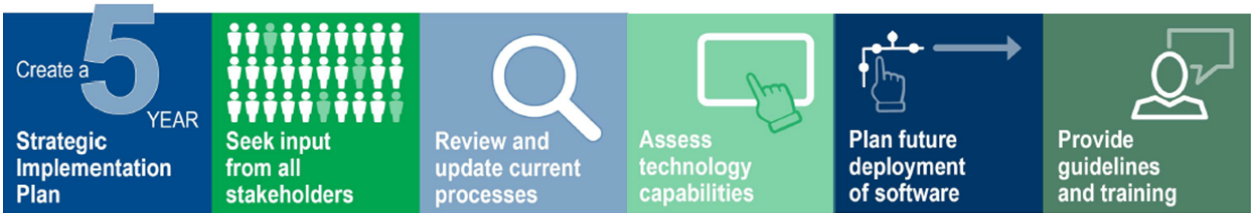

Figure 1: The Guiding Process for Executing the 3D2025

Figure 2: The Strategic Planning Process

The delivery period for the 3D2025 is five years. The directive is being implemented in three phases: Strategic Planning, Development, and Deployment. The development and deployment phases will be staggered; some prerequisite elements—like creating roadway models—will advance to deployment while other dependent uses—like design reviews—will be developed once the prerequisite use is in the deployment phase. The roadmap is described in the Roadmap section and graphically represented in Appendix A.

This document, the 3D2025 Strategic Plan, is the culmination of the first phase of this initiative. This strategic plan was developed according to the process outlined in the *Building Information Modeling (BIM) Planning Guide for Facility Owners*, which presents a structured approach to effectively integrating digital delivery within an organization. The guide establishes three planning procedures for the first phase which include:

1. Assess the organization's needs, desires, and current state of maturity;
2. Align the needs to defined solutions and redesigned processes; and
3. Advance through the development of an incremental approach to deliver the necessary technology, organizational infrastructure, and training.

The second phase uses an approach based on formal guidelines to develop the digital delivery use cases that meet PennDOT's objectives for the 3D2025. This will include the development of common requirements, organizational process standards, and well-defined Organizational Information Requirements (OIRs) to support the use cases. In this phase, PennDOT will also start to pilot individual use cases and processes, documenting successful workflows and technical solutions for both design and construction.

In the third phase of 3D2025, the workflows and technical solutions will be incorporated as updates to PennDOT's policies, standards, and publications to formalize the new, digital delivery approach. Specific use cases will be developed incrementally, in a coordinated manner. Some use cases will advance to the third phase while others remain in the second phase.

Assessment Process

The assessment used the process outlined in the *BIM Planning Guide for Facility Owners* and a modified maturity matrix that tailored the capabilities and maturity levels to PennDOT's business environment. The objective was to assess PennDOT's current state of maturity and preparedness for digital delivery.

There was an extensive stakeholder engagement program to capture the information needed to assess the current state and to identify priorities for digital delivery. The stakeholder engagement reached PennDOT's project development staff in each District, the Central Office, and PennDOT's consultant and contractor partners. There was also a workshop with the digital delivery committee to provide confirmation of the assessment and to review prioritization.

Appendix B describes the Assessment process in detail. Appendix H contains a summary of the information captured during the workshops.

Alignment Process

The Alignment used the output from the Assessment process, the maturity matrix, and a workshop with the digital delivery committee. The objective was to document PennDOT's target maturity state and align the desired maturity growth to specific digital delivery use cases to be developed. A digital delivery use is a method of applying digital delivery during the asset lifecycle to achieve specific objectives. Appendix G contains a comprehensive list of digital delivery use cases. Appendix C describes the Alignment process and outcomes in detail.

Maturity Assessment

The Assessment and Alignment processes were documented using a maturity matrix that was modified from the *BIM Planning Guide for Facility Owners*. The maturity matrix distills digital delivery maturity down into a variety of capabilities with defined maturity levels. Appendix D contains the results of the maturity assessment. The capabilities are grouped into the following categories:

- Strategy
- Process
- Information
- Infrastructure, and
- Personnel

Advancement

The Advancement process involved documenting the overall vision, objectives, mission, and goals for the 3D2025 and developing a roadmap to reach from the current state to the desired state by 2025.

The vision, objectives, mission, and goals guide the roadmap and the metrics used to monitor the progress of implementing the 3D2025. The Introduction section identified strategic reasons for digital delivery. The mission and goals are tactical and relate specifically to the 3D2025,

rather than the overarching digital delivery environment that will be the result of implementing the directive.

Vision
By 2025, construction projects will be bid using 3D technology and no longer be in a traditional construction plan format.

Objectives
1. Use 3D technology to create high quality, data-rich models of our projects;
2. Use accessible digital processes and tools to support all project development functions by all stakeholders that replace legacy business systems; and
3. Develop and implement new information management processes for capturing asset information from projects and using the information to improve inspections and asset management.

Mission
Our mission is to support the digital transformation of project development within PennDOT by developing modeling requirements, processes, and workforce development to enable improved asset information transfer by using 3D data-rich information models.

Goals
1. By 2022, execute “Quick Start Tasks,” map project development processes affected by digital delivery, begin new roadway design projects using OpenRoads Designer, and develop roadway design authoring and existing conditions modeling requirements.
2. By 2023, pilot bridge design authoring, visualization for planning, and model-based design review. Develop requirements for asset inventory, engineer’s estimate, and construction inspection and evaluate software to view models in construction. Formalize roadway model development standards.
3. By 2024, pilot drainage model authoring, 3D coordination, engineer’s estimate, visualization for all phases of project development, as-built record models, asset inventory, construction inspection uses, and selected information as contract documents. Formalize bridge model development standards and guidelines for design review.
4. By 2025, have tested digital delivery standards with wide-scale piloting. Formalize standards for drainage model authoring, engineer’s estimate, visualization, as-built record models, asset inventory, construction inspection uses, and expanded contract document content.

Progress Monitoring
Throughout the implementation of the digital delivery process, various metrics will be collected to assess the progress and effectiveness of the digital delivery solutions. The specific metrics and the plan to collect and monitor them will be developed in the next phase.

Metrics to consider include:

- Number of projects using elements of the “Quick Start Tasks,”
- Number of feedback forms received,

- Number of workflows from feedback forms being evolved into standards,
- User satisfaction reported in the midyear survey,
- Number of pilot projects for each use case,
- Number of pilot projects by District,
- Number of consultants participating in pilots
- Number of contractors participating in pilots
- Number of PennDOT publications updated,
- Number of business system modernization plans developed,
- User satisfaction rating for accessibility and sharing,
- User satisfaction ratings from Disadvantaged Business Entities.

Roadmap

This chapter describes the roadmap at a high-level. It introduces activities that will need to be performed over the next four and a half years to achieve the goals of the 3D2025. Appendix A contains a schematic of the high-level roadmap. The roadmap is described in more detail in the next two chapters.

Keys to Success

The technical aspects of implementing the roadmap are manageable. The human factors and behavioral economics drive the degree to which users will engage with the process, support the development, and accept the solutions created in executing the 3D2025.

The following recommendations address the human aspect of implementing digital delivery. District project and program managers should be mindful of these people-focused strategies to ensure success with implementing digital delivery in their District.

Manage the Pace of Change
Proceeding too quickly makes people feel overwhelmed, but proceeding too slowly makes people frustrated that nothing is happening. It is important to manage people's expectations, especially if they will not be affected for some time. User satisfaction and comfort with the pace of change can be monitored through the mid-year survey.

Help People Perceive Progress
Even if every District is involved in a pilot, most staff will not be directly affected by digital delivery in the first year. Monitor the digital delivery website or Sharepoint page that provides updates and reports progress helps those who are not directly affected to perceive progress.

Create a Safe Space for Experimentation
Create a culture where people can speak up when things do not work and ask for and receive support when needed. This empowers people to opt-into piloting, which is important for scaling piloting in 2023 and 2024. Open and honest feedback is important to improve and refine workflows and tools.

Empower Pilot Project Teams
Maintain an open dialog with pilot project teams and monitor progress towards key project development milestones such as advertising and letting. Initial pilot projects should be low risk and low complexity. Establish a contingency budget and schedule so project managers feel empowered, rather than burdened, to deliver the pilot objectives.

Use Construction Partnering
Construction Partnering has been an important part of making digital delivery projects successful in construction in other states. Partnering provides the collaborative environment and clear issue resolution processes to solve issues that may arise with accessing and trusting the information embedded within digital models.

Quick Start Tasks

The roadmap begins with the implementation of “Quick Start Tasks.” These are a set of tools and tactics that are quick to implement and can be put to immediate use. These tools help build momentum for the longer, more strategic development and delivery activities that form the bulk of the work.

The Quick Start Tasks fall into two categories. These are:

- Tactical tools for use in project delivery, and
- Strategic tools that support long-term stakeholder engagement.

Programmatic Tasks

There are a number of tasks that need to occur up front or throughout the deployment window. Upfront tasks include detailed process analysis and development, creating a digital delivery online presence (e.g. website or Sharepoint portal), and establishing metrics and monitoring protocols. Ongoing tasks include stakeholder engagement, progress monitoring, and project management.

Development Tasks

The development tasks are organized to implement a series of specific digital delivery use cases over four years. The development cycle occurs in three phases:

1. Explore: examine the processes and requirements and develop a digital solution,
2. Pilot: test the digital solution, monitor, receive feedback, refine, and retest, and
3. Document: formalize the successful digital solution in policy or guidance documents.

The digital delivery use cases are sequenced for deployment based on the baseline maturity state, dependent enabling infrastructure and uses, and PennDOT priorities. The agile development process for each use case is described in Appendix F. The core elements are:

- Create a team and define roles and responsibilities,
- Define the project planning protocols and templates,
- Document the information requirements in detail,
- Determine the enabling infrastructure needs, and
- Define the education and training competencies.

The development process is based on the fundamentals of agile project management. PennDOT cannot interrupt the project development process to implement digital delivery. The agile workflow breaks down digital delivery into narrowly-defined tasks that are tackled in short iterations, called “sprints.” The project development cycle is longer than the 3D2025 deployment period. Digital delivery solutions need to be tested quickly, on projects that are already underway. The agile project management approach was developed for this type of circumstance.

Priority Use Cases

The highest priority use cases are Existing Conditions Modeling and Roadway Design Authoring. These two design-phase use cases that capitalize on PennDOT's level of maturity to support them. They are also core dependent use cases for some of the other priority use cases.

The second highest priority use cases are Bridge Design Authoring, Visualization for Planning, Design Review, and the Engineer's Estimate. These uses either need work to be done to prepare the software or they depend on the highest priority uses being matured first.

The third highest priority use cases are Drainage Design Authoring, 3D Coordination, Visualization for all disciplines, Quantity Verification, Construction Documentation, and Contract Documents. Additional work is needed on the software maturity level for drainage design. The other uses have dependent uses that need to be matured before they can be developed.

The final group of priority use cases are Record Model and Asset Inventory. These use post-construction cases have design and construction-phase prerequisite uses.

Summary

There are other use cases listed in Appendix G that are also prerequisite uses to a comprehensive digital delivery solution. These include Right-of-Way, Shop Drawing/Model Review, and Permitting. As contractors develop their uses, they may have additional requirements to feed back into the design-phase use cases.

The roadmap needs to be a dynamic tool that evolves in response to the progress being made within the Districts to implement digital delivery. The roadmap will be visited at a minimum each year to plan out the following year's work in detail.

Detailed Work Plan for 2021

Appendix A contains a schematic of the detailed work plan for 2021. Figure 3 is a summary graphic of the work plan for 2021. The first part of the work plan involves developing a list of "Quick Start Tasks." Subsequent activities establish the foundation for longer-term, strategic development to support the priority use cases.

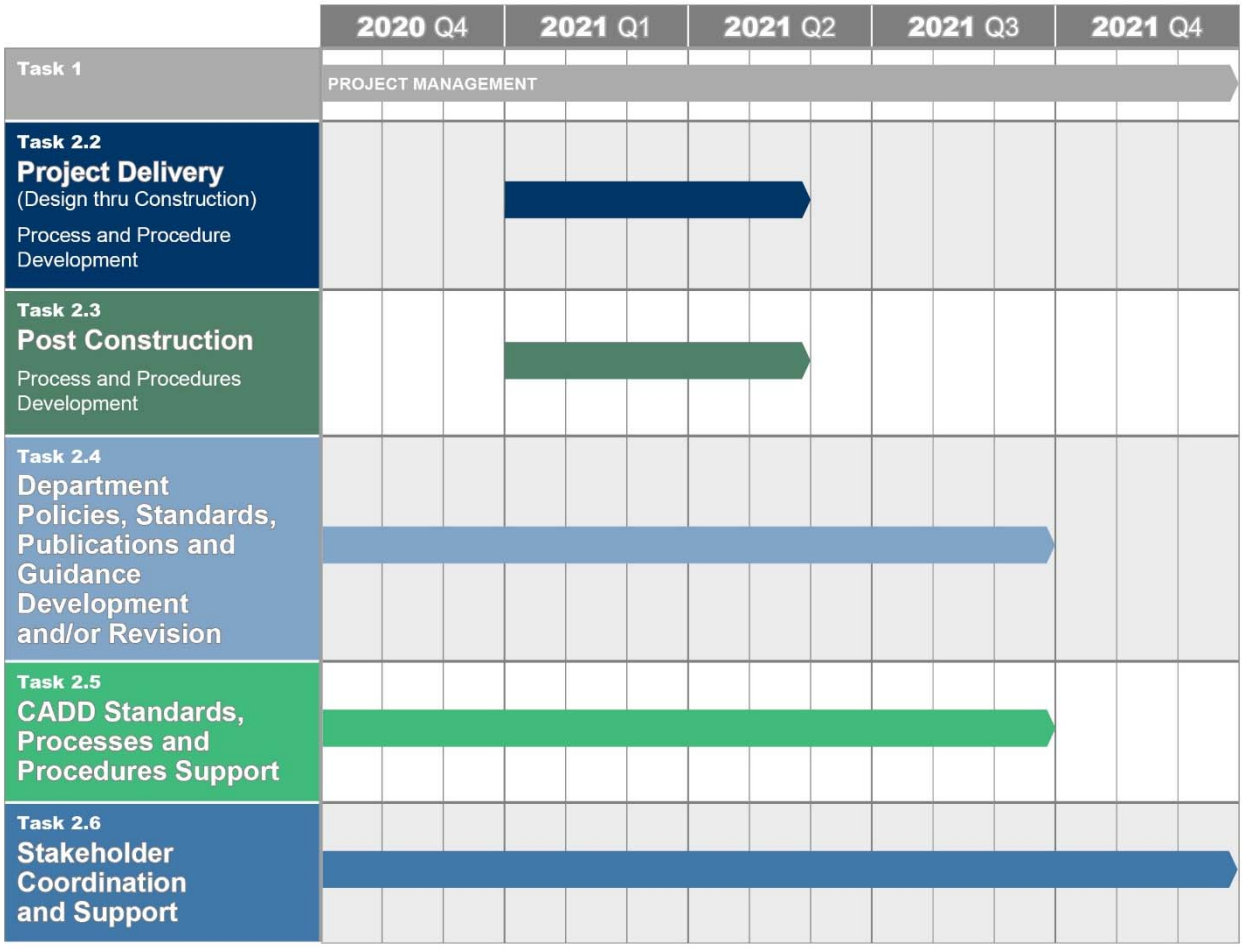

Figure 3: Summary of 2021 Workplan Tasks

Quick Start Tasks

These tasks are intended to provide immediate resources for project development staff to begin using on projects before formal piloting begins. The tools will be based on practices that have been used successfully by other DOTs. They provide small investments of time and introduce users to elements of digital delivery, building confidence, capacity, and capability to support the strategic investments that follow. The Quick Start Tasks follow.

Glossary of Terms and List of Frequently-Asked Questions

DESCRIPTION		
A resource for all project development staff to understand the terminology of digital delivery. It would provide a consistent language to describe digital delivery and answer common questions like “Will we still use 2D plans for right-of-way and “also” plans?”. It would serve as a resource for stakeholder engagement, training development, and standards and guidance development.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
N/A	N/A	Q4 2020
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	A medium to distribute the Glossary of Terms to the project development community	N/A
OUTCOMES		
Policy	**Technology**	**Workforce**
A standard list of terms and meanings to provide a common reference point for policy/guidance documents, training materials, and contract language.	N/A	A common understanding of core digital delivery terminology and outcomes as a basis for developing digital delivery skills.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
Digital Delivery Consultant	Digital Delivery Lead	Digital Delivery Committee

Procurement Language

DESCRIPTION		
Work with the Department to provide the technical input to develop scopes of work for digital delivery that can be incorporated into task orders and on-call contracts. The content may include schedules of deliverables, references to specific Publications, and core competencies for digital delivery-specific key staff.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
N/A	N/A	Q4 2020
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	N/A	Availability from staff in the Office of Chief Council to develop the contract clauses.

Procurement Language (Continued)

OUTCOMES		
Policy	**Technology**	**Workforce**
A library of contract clauses to incorporate digital delivery provisions into consultant contracts.	N/A	A means to incorporate digital delivery requirements into consultant contracts.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • Department	Digital Delivery Lead	Digital Delivery Committee

Feedback Tool

DESCRIPTION		
An evaluation framework and post-pilot review form. Initially, it would be used to assess the success of using one of the elements of the Quick Start Tasks. It would ask questions like: What did you try? Did it work as expected? What would you do differently? How would you improve the tool/workflow? Would you recommend the tool/workflow to your peers?		
PREREQUISITE TASKS N/A	**COREQUISITE TASKS** N/A	**TIMING** Q4 2020
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	A medium to distribute the feedback tool to the project development community and capture the feedback.	N/A
OUTCOMES		
Policy	**Technology**	**Workforce**
A means to capture feedback on the effectiveness of/refinements to piloted workflows and processes.	A means to capture feedback on the effectiveness of/refinements to piloted technology solutions.	A means to provide feedback to the 3D2025 deployment team and with their peers.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
Digital Delivery Consultant	Digital Delivery Lead	Digital Delivery Committee

Model Review Checklist

DESCRIPTION		
A model review checklist provides a structured approach to reviewing the supplemental digital files that are currently delivered to contractors as reference information. It will help designers to understand how their models will be examined by different users. Anticipated benefits include more consistent files for bidding, improved confidence in 3D models, and increased capacity for interacting with models.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
N/A	N/A	Q4 2020
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	A medium to distribute the model review checklist to the project development community and track its use.	N/A
OUTCOMES		
Policy	**Technology**	**Workforce**
A means to track the quality and consistency of supplemental files being provided with advertised project information.	N/A	A means to evaluate supplemental files being provided with advertised project information.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
Digital Delivery Consultant	Digital Delivery Lead	Digital Delivery Committee

Existing Ground Confidence Level

DESCRIPTION		
A tool for designers and contractors to assess their confidence that the existing conditions model matches actual field conditions. This helps designers to identify when they need to request supplemental survey and to understand the margin of error in quantities and design elements (e.g. tie-ins). It helps contractors to understand the level of risk and level of effort developing their estimating and construction layout (incl. Automated Machine Guidance) models. Anticipated benefits include fewer delays, fewer quantity changes, fewer field changes, and improved confidence in digital delivery.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
N/A	N/A	Q4 2020

Existing Ground Confidence Level (Continued)

ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	A medium to distribute the evaluation tool to the project development community and capture the feedback.	N/A
OUTCOMES		
Policy	**Technology**	**Workforce**
A means to assess the risk of designs being advertised based on an inaccurate reflection of the existing field conditions.	N/A	A means to assess the need for updated existing conditions information.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
Digital Delivery Consultant	Digital Delivery Lead	Digital Delivery Committee

Project Execution Plan Template

DESCRIPTION		
A digital data management plan for project managers to plan the use of digital delivery and manage the model development process. It will start to develop the model element breakdown structure, level of development and information definitions, and increase understanding of how project models are created and used		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
N/A	N/A	Q4 2020
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	A medium to distribute the plan template to the project development community and track its use.	N/A
OUTCOMES		
Policy	**Technology**	**Workforce**
A consistent approach to incorporating digital delivery on projects.	N/A	A guided means to plan for, execute, and manage the use of digital delivery on projects.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
Digital Delivery Consultant	Digital Delivery Lead	Digital Delivery Committee

Demonstration and Mini Case Study of Visualization for Planning

DESCRIPTION		
PennDOT is beginning to pilot ConceptStation, which is a rapid visualization tool that produces planning-level visualizations that help with alternatives assessment and public engagement. The task documents the pilot as a demonstration to illustrate to Planners how they can get started with digital delivery and the mini case study provides information to help them assess the level of effort and manage expectations.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
N/A	N/A	Q4 2020
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	A medium to distribute the mini-case study to the project development community.	N/A
OUTCOMES		
Policy	**Technology**	**Workforce**
N/A	N/A	An example to manage expectations for planning-level visualization and assess the level of effort and applicability to a project.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
Digital Delivery Consultant	Digital Delivery Lead	Digital Delivery Committee

Programmatic Tasks

The programmatic tasks involve ongoing stakeholder engagement, ongoing project management, and initiating the process investigation and mapping to guide the development tasks. These are organized by the contract work breakdown structure.

Task 2.2: Project Delivery (Design through Construction) Process and Procedure Development

DESCRIPTION		
Conduct an initial process investigation and a target process mapping workshop to develop the requirements for project delivery use cases and document a transition plan.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
N/A	N/A	Q1-Q2 2021
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	Online collaboration platform (e.g. Zoom).	N/A

Task 2.2: Project Delivery (Design through Construction) Process and Procedure Development (Continued)

OUTCOMES		
Policy	**Technology**	**Workforce**
A visual understanding of the pre-construction and construction project development processes that will be changed by digital delivery.	N/A	A visual understanding of the pre-construction and construction project development processes that will be changed by digital delivery.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • Selected Digital Delivery Committee members	Digital Delivery Lead	• Remaining Digital Delivery Committee members • Central office Design & Construction stakeholders

Task 2.3: Post Construction Process and Procedures Development

DESCRIPTION		
Conduct an initial process investigation and a target process mapping workshop to develop the requirements for post-construction use cases and document a transition plan.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
N/A	N/A	Q2-Q3 2021
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	Online collaboration platform (e.g. Zoom).	N/A
OUTCOMES		
Policy	**Technology**	**Workforce**
A visual understanding of the post-construction project development processes that will be changed by digital delivery.	N/A	A visual understanding of the post-construction project development processes that will be changed by digital delivery.

Task 2.3: Post Construction Process and Procedures Development (Continued)

TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • Selected Digital Delivery Committee members	Digital Delivery Lead	• Remaining Digital Delivery Committee members • Central office Design & Construction stakeholders

Task 2.6: Stakeholder Coordination and Support

DESCRIPTION		
• Create a stand-alone graphic to communicate the roadmap and 3D2025 initiative. • Continuously monitor feedback and support ongoing stakeholder engagement with conference presentations. • Conduct a midyear survey to capture structured stakeholder feedback. • Establish metrics to measure progress and provide a midyear update. • Provide input to develop a digital delivery website or Sharepoint page that provides a single point of access for information and to provide feedback on the 3D2025.		
PREREQUISITE TASKS N/A	**COREQUISITE TASKS** N/A	**TIMING** Q4 2020 – Q4 2021
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	N/A	N/A
OUTCOMES		
Policy	**Technology**	**Workforce**
A means to track the progress of implementing the 3D2025.	A medium to distribute the information about the 3D2025 and the resources produced to the project development community.	Access to information about the 3D2025, a place to provide feedback, and access to tools to start using digital delivery on projects.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • PA OA IT	Digital Delivery Lead	Digital Delivery Committee

Development Tasks

The remaining tasks for 2021 begin the development of the highest priority use cases. These are organized by the contract work breakdown structure.

Task 2.4: Department Policies, Standards, Publications and Guidance Development and/or Revision

DESCRIPTION

Design Authoring–Roadway use case: analyze the hardware and software infrastructure for all phases and develop a model element breakdown structure and minimum modeling requirements for roadway design authoring. Pilot roadway modeling requirements on design projects in 2021.

PREREQUISITE TASKS	COREQUISITE TASKS	TIMING
• Model Review Checklist • Existing Ground Confidence Level	• Evaluate OpenRoads Designer workspace • Review OpenRoads Designer training	Requirements: Q1 2021 Pilot Req's: Q2-Q4 2021 Infrastructure: Q1-Q3 2021

ENABLING INFRASTRUCTURE

Policy	Technology	Workforce
N/A	OpenRoads Designer software and workspace deployment.	OpenRoads Designer training for roadway designers

OUTCOMES

Policy	Technology	Workforce
• A means to clearly define the technical and managerial roadway design model requirements. • Draft project execution plan template for roadway design.	N/A	A means to clearly understand the technical and managerial roadway design model requirements.

TASK EXECUTION

Responsible	Accountable	Consulted
• Digital Delivery Consultant • PennDOT CADD Support	Digital Delivery Lead	• Digital Delivery Committee • Pilot project leads

Task 2.4: Department Policies, Standards, Publications and Guidance Development and/or Revision

DESCRIPTION		
Contractor use cases: analyze construction specifications and special provisions to identify areas to revise to enable contractor use cases. Provide input to draft special provisions for digital delivery.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
Process investigation and mapping for construction	N/A	Q4 2021
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	N/A	N/A
OUTCOMES		
Policy	**Technology**	**Workforce**
Draft project execution plan template for roadway design.	N/A	A means to clearly understand the technical and managerial roadway design model requirements.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • Office of General Council	Digital Delivery Lead	Digital Delivery Committee

Task 2.4: Department Policies, Standards, Publications and Guidance Development and/or Revision

DESCRIPTION		
Policy & Legislative Review: review Pennsylvania statutes and PennDOT policies related to digital delivery. Work with PennDOT to provide subject matter expertise for any necessary language related to digitally signing and sealing construction contract documents and for utility companies to provide 3D as-built records as part of their permit requirements.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
N/A	N/A	Q1-Q3 2021
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	N/A	N/A

Task 2.4: Department Policies, Standards, Publications and Guidance Development and/or Revision (Continued)

OUTCOMES		
Policy	**Technology**	**Workforce**
A legal framework for new digital media for construction contract documents.	N/A	N/A
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Office of General Council • Digital Delivery Consultant	Digital Delivery Lead	Digital Delivery Committee APC, ACEC/PA

Task 2.5: CADD Standards, Processes and Procedures Support

DESCRIPTION		
Design Authoring–Roadway use case: evaluate the OpenRoads Designer workspace needs and provide support where needed. Review the training plan for OpenRoads Designer and provide input.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
N/A	N/A	Q1-Q2 2021
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	OpenRoads Designer software and workspace deployment.	OpenRoads Designer training for roadway designers
OUTCOMES		
Policy	**Technology**	**Workforce**
A list of OpenRoads Designer training competencies aligned to the design authoring job functions.	Input on OpenRoads Designer workspace and training plan.	A job function-aligned OpenRoads Designer training plan that meets the needs of digital delivery.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • PennDOT CADD Support	Digital Delivery Lead	• Digital Delivery Committee • Pilot project leads

Work Plan for Subsequent Years

In subsequent years, use cases will be developed in three phases.

Programmatic Tasks

The programmatic tasks involve ongoing stakeholder engagement and ongoing project management. These are organized by the contract work breakdown structure.

Task 2.4: Department Policies, Standards, Publications and Guidance Development and/or Revision

DESCRIPTION		
Define digital delivery competencies by job function. This task is ongoing to incorporate new competencies as new use cases are developed.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
N/A	All	2022-2024
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	N/A	N/A
OUTCOMES		
Policy	**Technology**	**Workforce**
A means to manage workforce development, prioritize training investments, define project key staff requirements, etc.	N/A	Defined competencies to guide training development and delivery.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
Digital Delivery Consultant	Digital Delivery Lead	• Digital Delivery Committee • AFSCME representative

Task 2.4: Department Policies, Standards, Publications and Guidance Development and/or Revision

DESCRIPTION		
Review and update Work Breakdown Structure (WBS) tasks for consultants in preconstruction and construction.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
N/A	All	2022-2024
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	N/A	N/A

Task 2.4: Department Policies, Standards, Publications and Guidance Development and/or Revision (Continued)

OUTCOMES		
Policy	**Technology**	**Workforce**
WBS that reflects revised workflows for digital delivery to better estimate and manage consultant contracts.	N/A	N/A
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Lead • ACEC/PA	Digital Delivery Lead	Digital Delivery Committee

Task 2.6: Stakeholder Coordination and Support

DESCRIPTION		
• Continuously monitor feedback and support ongoing stakeholder engagement with conference presentations. • Conduct a midyear survey to capture structured stakeholder feedback. • Track and report metrics to measure progress and provide a midyear update.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
Task 2.6: Stakeholder Coordination and Support from previous year	N/A	Q1 2022 – Q1 2025
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	N/A	N/A
OUTCOMES		
Policy	**Technology**	**Workforce**
Current 3D2025 strategic plan with annual work plan. Continuous monitoring of 3D2025 execution.	N/A	Access to information about the 3D2025, a mechanism to provide feedback, and a place to access current information about 3D2025.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
Digital Delivery Consultant	Digital Delivery Lead	Digital Delivery Committee

Task 2.6: Stakeholder Coordination and Support

DESCRIPTION		
PennDOT Digital Delivery lead(s) to meet quarterly with peers in neighboring states to coordinate and share lessons learned on Digital Delivery implementation. Consultant and contractor representatives could also participate.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
N/A	All	2022-2024
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	N/A	N/A
OUTCOMES		
Policy	**Technology**	**Workforce**
A uniform approach to digital delivery policy within regions that share suppliers and business partners.	N/A	A uniform approach to digital delivery practices to accelerate workforce development by enabling partners transfer skills from one state to another.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
Digital Delivery Lead	Digital Delivery Lead	• Digital Delivery Committee • ACEC/PA and APC

Task 2.6: Stakeholder Coordination and Support

DESCRIPTION		
PennDOT Digital Delivery lead(s) to meet quarterly with OA IT support to develop and maintain IT procurement and delivery plan that synchronizes IT schedules with planned projects.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
N/A	All	2022-2024
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	N/A	N/A
OUTCOMES		
Policy	**Technology**	**Workforce**
N/A	OA is ready to deliver business systems as PennDOT needs them.	N/A

Task 2.6: Stakeholder Coordination and Support (Continued)

TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Lead • PA OA IT	Digital Delivery Lead	• Digital Delivery Committee • ACEC/PA and APC

Development Tasks

The development tasks for the remaining priority use cases will take multiple years to complete. The tasks are organized by use case, not project task. The "timing" reflects the time line for each of the three phases in the development cycle. These three phases are:

1. Explore: examine the processes and requirements and develop a digital solution,
2. Pilot: test the digital solution, monitor, receive feedback, refine, and retest, and
3. Document: formalize the successful digital solution in policy or guidance documents.

Note that piloting will initially be on a small scale and as the solution is refined, piloting will expand in scale until the policy is updated and the practice is institutionalized.

Visualization–Planning

DESCRIPTION Develop guidance for creating visual representations of the project to communicate with technical and non-technical stakeholders during planning.		
PREREQUISITE TASKS Demonstration and Mini Case Study of Visualization for Planning	**COREQUISITE TASKS** N/A	**TIMING** Explore: Q3-Q4 2021 Pilot: 2022 Document: 2023
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
N/A	ConceptStation software	N/A
OUTCOMES		
Policy	**Technology**	**Workforce**
Guidance on when to use visualization in planning and an estimate for level of effort.	Guidance for using software to develop planning-level visualizations.	Resources to improve the planning process.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • PennDOT CADD Support	Digital Delivery Lead	• Digital Delivery Committee • Pilot project leads

Design Authoring–Roadway

DESCRIPTION		
Incorporate feedback into the roadway design authoring requirements and expand piloting. Formalize requirements as policy once the co-requisite tasks advance.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
Develop design model requirements	Pilot design model requirements	Explore: Q1 2021 Pilot: 2021-2022 Document: 2023
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
Draft project execution plan template for roadway design.	OpenRoads Designer software and workspace deployment.	OpenRoads Designer training for roadway designers
OUTCOMES		
Policy	**Technology**	**Workforce**
• Technical and managerial roadway design model requirements. • Project execution plan template for roadway design.	N/A	Clear technical and managerial requirements for roadway design and project execution plan template to implement requirements on projects.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • Select members of the Digital Delivery Committee	Digital Delivery Lead	• Remaining members of the Digital Delivery Committee • Pilot project leads

Design Authoring–Bridge

DESCRIPTION		
Evaluate bridge design authoring software, develop bridge modeling requirements and technical infrastructure, pilot bridge design authoring, and formalize requirements as policy.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
Existing Conditions Modeling	Design Authoring-Roadway	Explore: Early 2022 Pilot: 2022-2023 Document: 2024

Design Authoring–Bridge (Continued)

ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
Draft project execution plan template for roadway design.	OpenRoads Designer software and workspace deployment.	OpenRoads Designer training for roadway designers
OUTCOMES		
Policy	**Technology**	**Workforce**
• Technical and managerial bridge design model requirements. • Project execution plan template for bridge design.	Preferred bridge design software and workspace for bridge design authoring.	Clear technical and managerial requirements for bridge design and project execution plan template to implement requirements on projects.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • PennDOT CADD Support • Select members of the Digital Delivery Committee	Digital Delivery Lead	• Remaining members of the Digital Delivery Committee • Pilot project leads

Design Authoring–Drainage

DESCRIPTION Evaluate drainage design authoring software, develop drainage modeling requirements and technical infrastructure, pilot drainage design authoring, and formalize requirements as policy.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
Existing Conditions Modeling	Design Authoring-Roadway	Explore: 2022 Pilot: 2023 Document: 2024
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
Draft project execution plan template for roadway design.	OpenRoads Designer software and drainage workspace deployment.	OpenRoads Designer training for drainage designers

Design Authoring–Drainage (Continued)

OUTCOMES		
Policy	**Technology**	**Workforce**
• Technical and managerial drainage design model requirements. • Project execution plan template for drainage design.	Drainage design workspace.	Clear technical and managerial requirements for drainage design and project execution plan template to implement requirements on projects.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • PennDOT CADD Support • Select members of the Digital Delivery Committee	Digital Delivery Lead	• Remaining members of the Digital Delivery Committee • Pilot project leads

3D Coordination

DESCRIPTION		
Develop guidance and technical infrastructure for using 3D coordination both during design authoring and design review. This includes workflows to detect and avoid clashes during design authoring and using software to analyze a federated model of design models using rule sets to identify collisions between design elements.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
Existing Conditions Modeling Design Authoring-Roadway	Design Authoring-Bridge Design Authoring-Drainage Design Review	Explore: 2023 Pilot: 2023-2024 Document: 2024
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
Technical and managerial requirements for design authoring (all disciplines).	Design authoring and design review software and workspace deployment.	Design authoring and design review software training
OUTCOMES		
Policy	**Technology**	**Workforce**
Technical and managerial requirements for 3D coordination.	Software and workspace configuration for 3D coordination.	Clear technical and managerial requirements for 3D coordination.

3D Coordination (Continued)

TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • PennDOT CADD Support • Select members of the Digital Delivery Committee	Digital Delivery Lead	• Remaining members of the Digital Delivery Committee • Pilot project leads

Model-based Design Review

DESCRIPTION		
Develop guidance and technical infrastructure for executing model-based design reviews, including documenting the reviews. This includes workflows manual reviews and automated reviews using software to analyze design models using rule sets to check design codes.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
Existing Conditions Modeling Design Authoring-Roadway	Design Authoring-Bridge Design Authoring-Drainage 3D Coordination	Explore: 2023 Pilot: 2023-2024 Document: 2024
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
Technical and managerial requirements for design authoring (all disciplines).	Design authoring and design review software and workspace deployment.	Design authoring and design review software training
OUTCOMES		
Policy	**Technology**	**Workforce**
Technical and managerial requirements for design review.	Software and workspace configuration for design review.	Clear technical and managerial requirements for design review.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • Select members of the Digital Delivery Committee	Digital Delivery Lead	• Remaining members of the Digital Delivery Committee • Pilot project leads

Visualization–All Disciplines

DESCRIPTION		
Develop guidance and technical infrastructure for creating visual representations of the project to communicate with technical and non-technical stakeholders during all phases of project development.		
PREREQUISITE TASKS Existing Conditions Modeling Design Authoring-All disciplines	**COREQUISITE TASKS** N/A	**TIMING** Explore: 2023 Pilot: 2024 Document: 2024
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
Technical and managerial requirements for design authoring (all disciplines).	Visualization software and workspace deployment.	Visualization software and workflow training
OUTCOMES		
Policy	**Technology**	**Workforce**
Guidance on when to use visualization and an estimate for level of effort for specific visualization products.	Workspace for using software to develop visualization products, e.g. videos, simulations, and images.	Resources to implement visualization where warranted.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • PennDOT CADD Support • Select members of the Digital Delivery Committee	Digital Delivery Lead	• Remaining members of the Digital Delivery Committee • Pilot project leads

Engineer's Estimate

DESCRIPTION		
Develop guidance and technical infrastructure for taking off quantities from the design according to a schedule of bid items to estimate the construction cost.		
PREREQUISITE TASKS Existing Conditions Modeling Design Authoring-All disciplines	**COREQUISITE TASKS** N/A	**TIMING** Explore: 2022 Pilot: 2023 Document: 2024

Engineer's Estimate (Continued)

ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
Technical and managerial requirements for design authoring (all disciplines).	• Design authoring software and workspace deployment. • Object-oriented model breakdown structure aligned to pay item classification.	Design authoring software training
OUTCOMES		
Policy	**Technology**	**Workforce**
Consistent approach to develop engineer's estimates.	Software and workspace configuration for partially automating the extraction of pay item quantities.	Consistent approach to develop engineer's estimates with partial automation of quantity extraction.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • PennDOT CADD Support • Select members of the Digital Delivery Committee	Digital Delivery Lead	• Remaining members of the Digital Delivery Committee • Pilot project leads

Contractor Use Cases

DESCRIPTION		
Develop special provisions to enable contractors to make use of digital delivery.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
Analyze construction specifications and special provisions Model Review Checklist Existing Ground Confidence Level	All tasks that enable digital data to be passed to construction	Pilot: Q4 2021 Document: Q4 2023
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
Policies to provide digital data at advertising and policies to review that data.	A medium to distribute the model files without disconnecting reference files.	Design review and model quality assurance skills.

Contractor Use Cases (Continued)

OUTCOMES		
Policy	**Technology**	**Workforce**
Contractors are unencumbered from incorporating digital delivery in their means and methods.	N/A	Clear and consistent roles and responsibilities when the contractor uses digital delivery.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • Bureau of Project Delivery, Project Schedules, Specifications and Constructability Section (PSSCS) • Select members of the Digital Delivery Committee	Digital Delivery Lead	• Remaining members of the Digital Delivery Committee • Pilot project leads • Office of Chief Counsel

Verification and Acceptance

DESCRIPTION		
Develop guidance and technical infrastructure for construction inspectors to accesses the design information in the contract documents to verify that the project is constructed per plan and in accordance with the pay item quantities and specifications.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
All tasks that enable digital data to be passed to construction	Contract Documents Engineer's Estimate	Explore: 2022 Pilot: 2023 Document: 2024
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
Policies to provide digital data for construction.	A medium to distribute the model files without disconnecting reference files. Mobile model viewer software.	Design review and model-based quality take-off skills.

Verification and Acceptance (Continued)

OUTCOMES		
Policy	**Technology**	**Workforce**
Technical and managerial requirements for verification and acceptance.	Software and workspace configuration for verification and acceptance.	Clear technical and managerial requirements and supportive resources for verification and acceptance.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • PennDOT CADD Support • Select members of the Digital Delivery Committee	Digital Delivery Lead	• Remaining members of the Digital Delivery Committee • Pilot project leads

Construction Documentation

DESCRIPTION		
Develop guidance and technical infrastructure for construction inspectors to document the construction process. This includes documenting daily diary records and compliance, as well as the process of seeking remedies to work that was not in conformance with requirements.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
All tasks that enable digital data to be passed to construction	Contract Documents	Explore: 2022 Pilot: 2023 Document: 2024
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
Policies to provide digital data for construction.	A medium to distribute the model files without disconnecting reference files. Mobile model viewer software.	Design review and model-based quality take-off skills.
OUTCOMES		
Policy	**Technology**	**Workforce**
Technical and managerial requirements for construction documentation.	Software and workspace configuration for viewing models and extracting information.	Clear technical and managerial requirements and supportive resources for viewing models and extracting information.

Construction Documentation (Continued)

TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • PennDOT CADD Support • Select members of the Digital Delivery Committee	Digital Delivery Lead	• Remaining members of the Digital Delivery Committee • Pilot project leads

Record Model

DESCRIPTION		
Develop guidance and technical infrastructure for documenting any changes to the design plans, specifications, and quantities in a comprehensive record of the as-built condition.		
PREREQUISITE TASKS	**COREQUISITE TASKS**	**TIMING**
All tasks that enable digital data to be passed to construction	Contract Documents	Explore: 2022 Pilot: 2023 Document: 2024
ENABLING INFRASTRUCTURE		
Policy	**Technology**	**Workforce**
Policies to provide digital data for construction. Specification or special provision identifying contractor responsibilities for delivering as-built records.	A medium to distribute the model files without disconnecting reference files. Mobile model editing software.	Clear technical and managerial requirements and supportive resources for model management and model editing.
OUTCOMES		
Policy	**Technology**	**Workforce**
Technical and managerial requirements for as-built records with responsibilities differentiated between the contractor and the engineer.	Software and workspace configuration for updating models. A medium to receive the as-built model files.	Clear technical and managerial requirements and supportive resources for developing and delivering as-built records.
TASK EXECUTION		
Responsible	**Accountable**	**Consulted**
• Digital Delivery Consultant • PennDOT CADD Support • Select members of the Digital Delivery Committee	Digital Delivery Lead	• Remaining members of the Digital Delivery Committee • Pilot project leads

Asset Inventory

<table>
<tr><td colspan="3">DESCRIPTION
Develop guidance and technical infrastructure for creating an inventory of the assets removed, modified, and constructed to hand over to the maintenance, operations, and asset management departments' business systems.</td></tr>
<tr><td>PREREQUISITE TASKS
All tasks that enable digital data to be passed to construction</td><td>COREQUISITE TASKS
Contract Documents
Record Model</td><td>TIMING
Explore: 2022
Pilot: 2023
Document: 2024</td></tr>
<tr><td colspan="3">ENABLING INFRASTRUCTURE</td></tr>
<tr><td>Policy</td><td>Technology</td><td>Workforce</td></tr>
<tr><td>Specification or special provision identifying contractor responsibilities for delivering as-built records.</td><td>Software and workspace configuration for extracting asset information.
A medium to receive the as-built model files.</td><td>Clear technical and managerial requirements and supportive resources for model management and model editing.</td></tr>
<tr><td colspan="3">OUTCOMES</td></tr>
<tr><td>Policy</td><td>Technology</td><td>Workforce</td></tr>
<tr><td>Technical and managerial requirements for asset handover information.
Data governance policies for delivering asset information.</td><td>Software and workspace configuration for extracting, reviewing, and delivering asset information.</td><td>Clear technical and managerial requirements and supportive resources for extracting, reviewing, and delivering asset information.</td></tr>
<tr><td colspan="3">TASK EXECUTION</td></tr>
<tr><td>Responsible</td><td>Accountable</td><td>Consulted</td></tr>
<tr><td>• Digital Delivery Consultant
• Asset inventory owners
• Select members of the Digital Delivery Committee</td><td>Digital Delivery Lead</td><td>• Remaining members of the Digital Delivery Committee
• PennDOT CADD Support
• Pilot project leads</td></tr>
</table>

Appendices

Appendix A: Digital Delivery Directive 2025 Roadmap

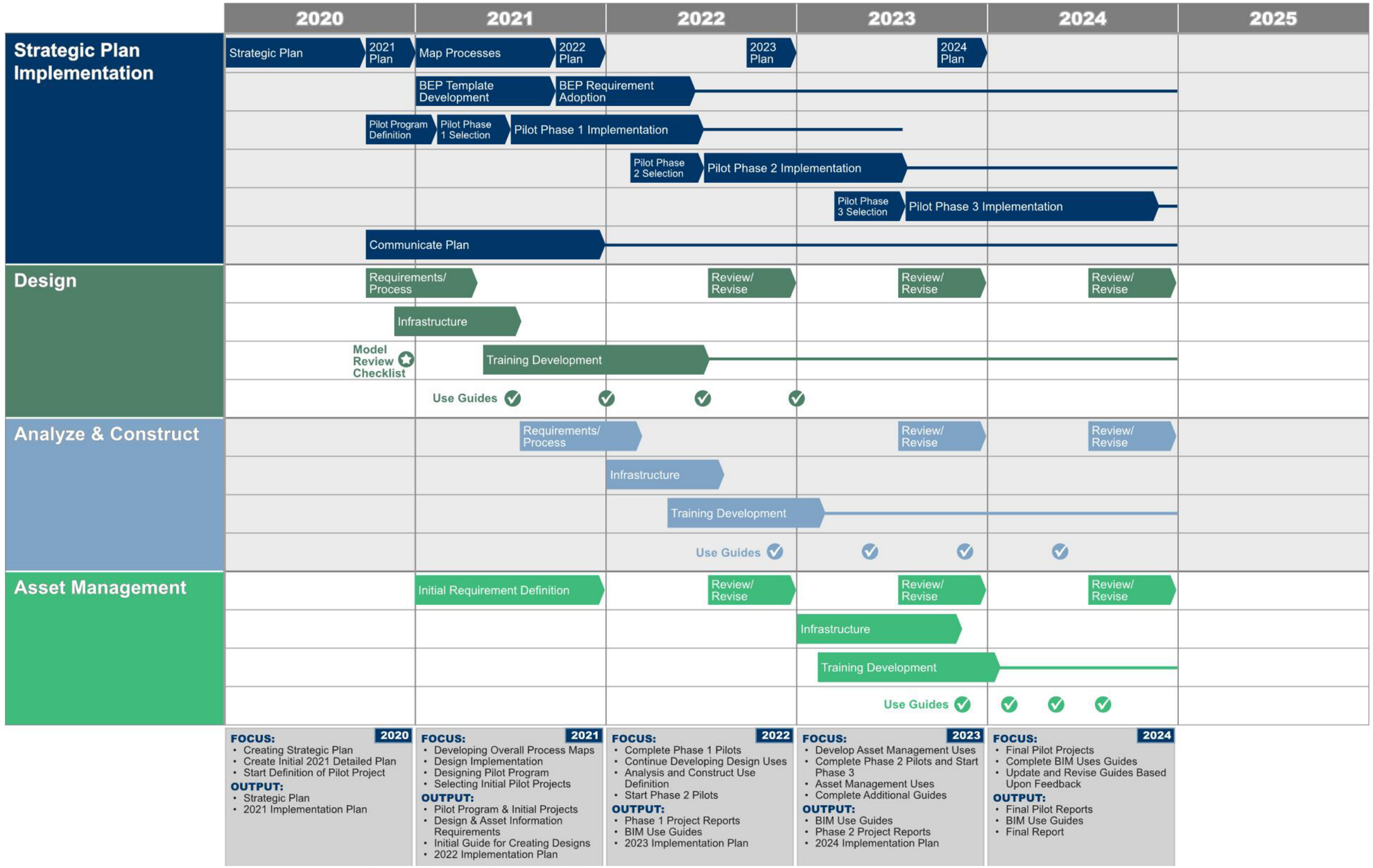

Figure 4: High-level Roadmap to Implement the Digital Delivery Directive 2025

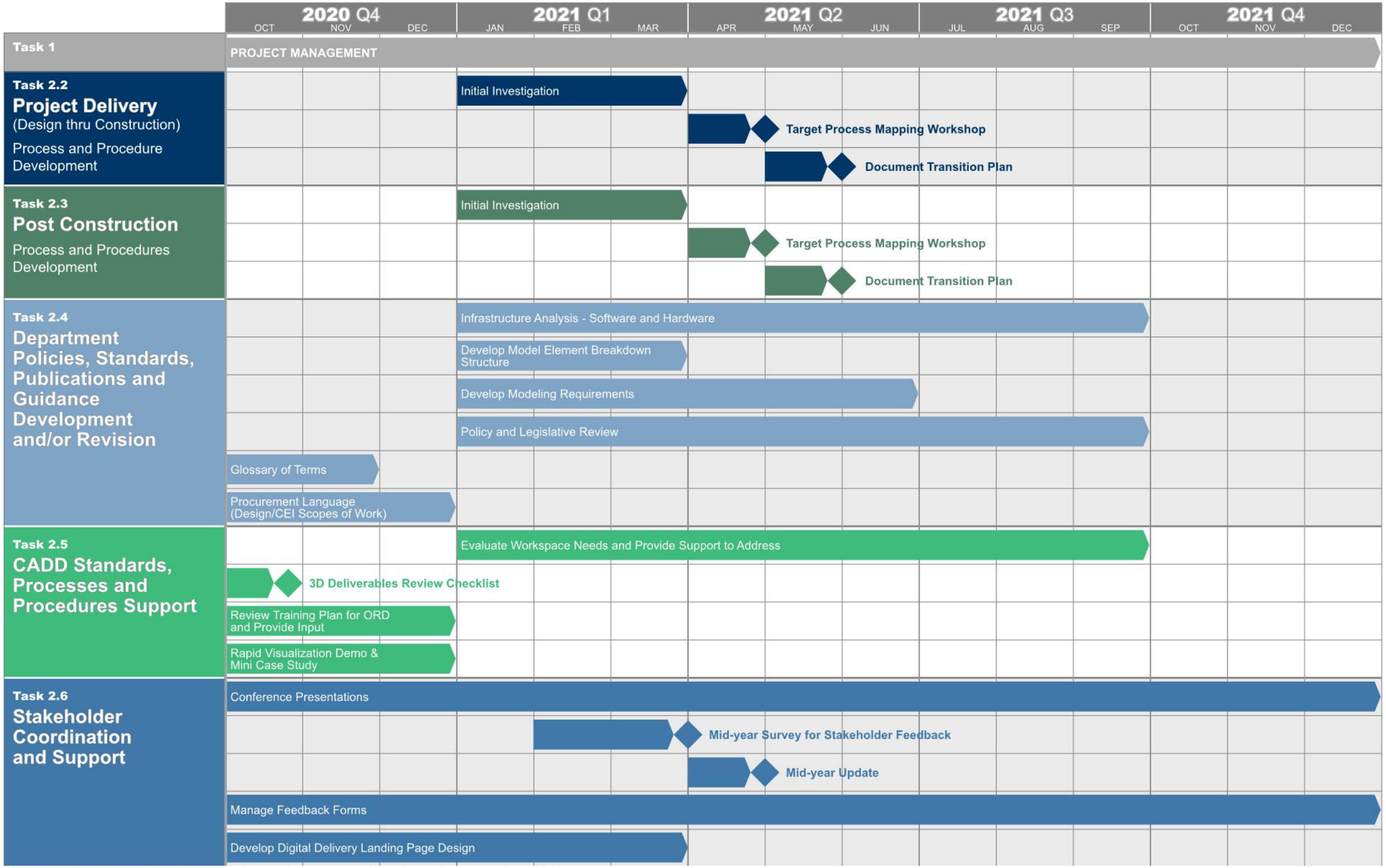

Figure 5: Roadmap for the period fourth quarter 2020 though the end of 2021

Appendix B: Assessment

This section assesses PennDOT's current state of maturity and preparedness for digital delivery.

Assessment Process

The assessment used the process outlined in the BIM Planning Guide for Facility Owners, a modified maturity matrix to tailor the capabilities and maturity levels to PennDOT's business environment, and a comprehensive stakeholder engagement process.

Stakeholder Engagement

The stakeholder engagement process occurred in four stages:

1. Outreach to introduce Digital Delivery Directive 2025 and digital delivery to PennDOT's business partners, District managers and project development staff,
2. Conduct regional workshops capturing broad input from every district,
3. Conduct a central office workshop, and
4. Conduct a strategic planning workshop with the digital delivery committee.

OUTREACH

The purpose of the outreach was to inform PennDOT's staff and business partners about digital delivery in general and about the Digital Delivery Directive 2025 specifically. There were two primary outreach activities. The first was a presentation at the TMTW on March 4, 2020. The second was the statewide webinar on May 27, 2020.

VIRTUAL WORKSHOPS

The HDR team captured broad stakeholder engagement through a series of virtual workshops that were organized by region and included each district, as well as representatives from the consulting and contracting communities. A separate workshop was held for central office input to tailor the discussion to central office issues. Table 9 lists the calendar of regional workshops.

Table 2: Calendar of Regional Workshops

Region	Districts Represented	Workshop Dates
Eastern	4-0, 5-0 and 6-0	June 10-12, 2020
Central	2-0, 3-0, 8-0 and 9-0	June 17-19, 2020
Western	1-0, 10-0, 11-0 and 12-0	June 24-26, 2020
Central Office	N/A	July 8-10, 2020

Purpose

The purpose of the regional workshops was to collect input from all stakeholders to identify:

- Opportunities to obtain better or more information from others to perform everyday work,
- Ability to accelerate exchange of information/transactions (turnaround times),
- Tools and methods used today to exchange information, and
- Current staff skill sets and competencies to conduct their work.

Process

The workshops took place over two and a half days. There was a general session for all participants, followed by five break-out sessions, concluding with a general session to discuss organizational readiness and to close the workshop.

The five breakout sessions were for the following processes:

1. Planning and National Environmental Protection Act (NEPA),
2. Model development,
3. Model delivery,
4. Asset management, and
5. Construction administration.

A diverse cross-section of District managers and staff participated in the virtual workshops. Specifically, representatives were selected to include the following disciplines:

- Planning, Environmental, Right-of-Way,
- Surveys and Design (including both roadway and bridge disciplines),
- Construction,
- Maintenance/Asset Management, and
- Legal Counsel, Information Technology (IT) and CADD.

Staff were selected because of their knowledge and experience with:

- Current business processes,
- Tools and technologies being used today, and
- Current standards and policies.

The workshops were conducted virtually using the Zoom platform. For each session, there was a brief presentation and then facilitated discussion. After the workshop, participants completed an online survey. The survey captured information for the strategic planning process and to inform later phases of the initiative. After the workshops, the HDR team did the following:

1. Compiled information gathered during the workshops into detailed documentation and a mind map of the discussion topics,
2. Validated and prioritized workshop feedback using the survey results, and
3. Organized and analyzed information to prepare for Strategic Planning Workshop.

Outcomes

The workshop outcomes were:

- A preliminary maturity assessment,
- A list of pain points for each discipline, and
- A list of potential uses.

The workshop outcomes were summarized through the development of a detailed content map documenting each session. These provided input to the strategic planning workshop. Appendix C includes a summary of the workshop input and outcomes.

Strategic Planning Workshop

The results of the stakeholder engagement were assimilated to prepare for a strategic planning workshop with the digital delivery committee.

PURPOSE

The purpose of the strategic planning workshop was:

- Confirm the vision for digital delivery,
- Inform the committee of the regional workshop results,
- Prioritize digital delivery use cases,
- Capture input for strategic goals,
- Review and confirm the prioritization outcomes,
- Capture input on preferred approaches to piloting in Phase 2, and
- Discuss the schedule for Phase 2

PROCESS

The workshops took place in three, 3-hour sessions held over one and a half days on July 29-30, 2020 using Zoom. The workshop involved presentations, facilitated discussion, and interactive polling to capture further quantitative and qualitative information using Mentimeter.

OUTCOMES

The workshop provided input to confirm the baseline (current) maturity assessed after the regional workshops and to assess the desired target state. The results are included in the full maturity matrix in Appendix B. The digital delivery committee defined hallmarks of success for the Digital Delivery Directive 2025 as:

- More predictable construction outcomes (i.e. scope, schedule, and budget),
- Accessible information,
- A process and tools that are easy to use,
- Accelerated project delivery, and
- A solution that is a replacement for legacy business systems.

The digital delivery committee indicated a preference for beginning piloting using low complexity, low budget projects. There was also a preference for each District to pilot projects concurrently.

The digital delivery committee assessed pain points identified during the regional workshops and potential attributes of the digital delivery solution—all were considered to be urgent and important. The prioritization results will be aligned to specific use cases of digital delivery in the Alignment section. The results are presented in Table 10. The assessment ranges were from zero to ten, where zero was the least urgent and important and ten was the most urgent and important.

Table 3: Digital Delivery Attributes Prioritization Results

Digital Delivery Attributes	Urgency	Importance
Design reviews are user friendly for non-CADD users	8.7	8.8
Projects can be bid using 3D technology	8.5	8.9
Ability to share files easily	8.3	8.9
Collaborative design review tools	8.1	8.7
Design interferences with existing utilities automatically detected	7.9	8.7
Cross-sections are dynamically extracted from the model	7.9	8.7
Road Stationing from models easily aligns with LRS locations	7.9	8.4
Inspection results are able to be visualized with 3D models	7.8	8.9
Design review software tracks status of issues	7.7	8.9
Archived files remain stable and accessible	7.5	8.9
Web based, easy to use visualizations	7.4	8.4
Basic 3D terrain and surrounding geometry is readily accessible	7.4	8.5
Accessible utility, easement, and right-of-way models	7.3	7.6
As-built automatically populates all asset management systems	7.3	8.7
Quantities load into ECMS automatically from the model	7.2	8.5
Model performs design validation against geometric standards	6.8	8.0
Best in class modeling computer	6.6	7.3
Automatic item number assignment	5.6	7.0
Augmented reality tools used in the field	5.3	7.2
Non-standard items self-populate in ECMS	5.3	6.1

Summary

The assessment evaluated PennDOT's baseline (i.e. current) maturity in the areas of strategy, process, information, infrastructure, and personnel. PennDOT's readiness for digital delivery is most mature in the area of Strategy and least mature in the area of Process. A summary of the baseline maturity state in each area follows.

STRATEGY

PennDOT is most mature in the Management Support category, with an executive-level champion for the initiative. Organizational Mission and Goals, Digital Delivery Champion, and Digital Delivery Planning Committee are defined relative to the Digital Delivery Directive 2025, but not for ongoing management of a digital delivery program. Digital Delivery Vision and Objectives is the least mature, with just a basic vision established.

PROCESS

Project processes for digital delivery have the lowest level of maturity, and no organizational defined processes for digital delivery. Process development will be an initial task on the roadmap, as well as a component of the development process for each use case.

INFORMATION

Asset data is at a “defined” level, with asset data models aligned to industry standards. The CADD requirements for digital delivery are at an “initial” level of maturity, with general support for using 3D modeling on projects. Regional workshop participants expressed concerns with a lack of interoperability.

INFRASTRUCTURE

Software and IT procurement are at a relatively low maturity; there is dedicated software for digital delivery for roadway design, but not for other disciplines or project development phases. IT Procurement is at an "initial" level of maturity, coordinating sporadically with PennDOT. By contrast, Hardware is at a high level of maturity; staff recently received new work stations. Concerns about the cost of software were expressed in the regional workshop.

PERSONNEL

In general, there is low maturity in the area of personnel readiness. The lowest maturity was for Roles and Responsibilities, which do not exist yet for digital delivery at the District level. Industry Receptiveness was the highest maturity level, in that industry is willing to help create a plan for Digital Delivery. Awareness and Training were at the "initial" level. User Support and Change Readiness slightly more mature; user support is provided by a small, centralized team, but team members have other responsibilities. PennDOT’s staff generally recognize the need for digital delivery, but some of PennDOT’s staff have concerns regarding the pace of change. Regional workshop participants expressed concern for a lack of digital delivery skills in the current workforce and identified a need for ongoing support.

Appendix C: Alignment

This section aligns the priorities identified through the regional and strategic planning workshops to specific use cases for digital information. In prioritizing these specific use cases, we also align them to the information flow through the project delivery process.

Alignment Process

The assessment process identified a wide range of urgent and important pain points to resolve, as well as a long list of urgent and important attributes for the digital delivery solution. These were reconciled with the digital delivery committee's input to define the target maturity state. Next, the target maturity state was used to prioritize the specific digital delivery use cases that need to be incorporated into the organizational information requirements for digital delivery. A digital delivery use, is a method of applying digital delivery during the asset lifecycle to achieve one or more specific objectives.

The alignment process involved:

1. Defining the target maturity state.
2. Defining a set of use cases throughout the project development process.
3. Identifying the prerequisite uses of digital data to support other use cases.
   For example, roadway design authoring has existing conditions modeling as a prerequisite use as the roadway design must tie into the existing facility.
4. Identifying secondary uses that become available when the prerequisite use is satisfied.
   For example, visualization and 3D coordination become available when the prerequisite design modeling use is satisfied.
5. Reconciling the target maturity state to specific use cases to create a prioritized list of use cases to include in the roadmap.

Maturity Assessment

The digital delivery committee would like to expand maturity in all areas to a high level. Appendix B contains the full maturity matrix that reflects both the baseline and target states.

STRATEGY

The target state is a mature solution where the PennDOT culture supports the mission and vision of digital delivery, and the vision is supported by Specific, Measurable, Achievable, Relevant and Time-based (SMART) objectives. The target state anticipates management fully supporting an ongoing digital delivery program; an executive champion who coordinates with District-level champions; and a committee that implements a routinely-updated strategic plan.

PROCESS

The target state anticipates significant work to document detailed project and organizational processes for all digital delivery workflows.

INFORMATION

The target state does not anticipate changes to the asset data, which is already aligned to industry standards. However, the CADD requirements for digital delivery would be detailed and defined for all project types. Interoperability issues would be addressed through the use of open data standards with available and clear procedures for data exchange.

INFRASTRUCTURE

While committee members are satisfied with current hardware, the target state recognizes the need for an IT process that is nimble and adapts to changing business needs to keep software and hardware updated to serve the business needs.

PERSONNEL

In the target state, all PennDOT project development staff and business partners would have a clear understanding of the digital delivery objectives and scope in the context of their role. They would recognize their role and responsibilities related to digital delivery and there would be dedicated support staff in each District. PennDOT project development staff and business partners would embrace digital delivery at the right pace of change.

Digital Data Use Cases

The information flow through highway and bridge project delivery is well documented in PennDOT's publications. US Highway infrastructure owners follow a consistent, high-level project development process. However, information exchange between stages or "actors" along the project development process is often electronic but not digital. That is, the information may be shared electronically—such as in a PDF file—but the information is extracted manually.

Digital delivery planning typically focuses on these information exchanges, but the exchange requirements are defined based on the needs of the recipient user. A digital data use case is an application of project information that occurs using digital data. Some applications—like survey and mapping—already use digital data and exchange that data for the designer's use. Some applications—like design review—use paper and ink. Other applications—like documenting as-built records—may be electronic, like marking up PDF plans in an editing software, such as Bluebeam Revu. Specific use cases like these need to be prioritized as they cannot all be implemented at the same time.

The project definition grows through the planning, scoping, and design process. With digital delivery, the model progresses with increasing development along the pre-construction project milestones. Currently, there is often a discontinuity of the digital data at each pre-construction milestone. However, with digital delivery, the model uses could be incrementally developed and implemented. There may be technical or procedural reasons not to prioritize such an exchange. For example, the existing conditions used in planning and NEPA is unsuitable for design authoring; it is more expedient to initiate a new existing conditions survey. Appendix D contains descriptions for the digital delivery uses discussed below.

PROJECT DELIVERY USE CASES

Figure 6 illustrates the model uses through project delivery. Use cases in blue indicate those performed by PennDOT or PennDOT's consultant representatives. Use cases in green indicate Contractor uses.

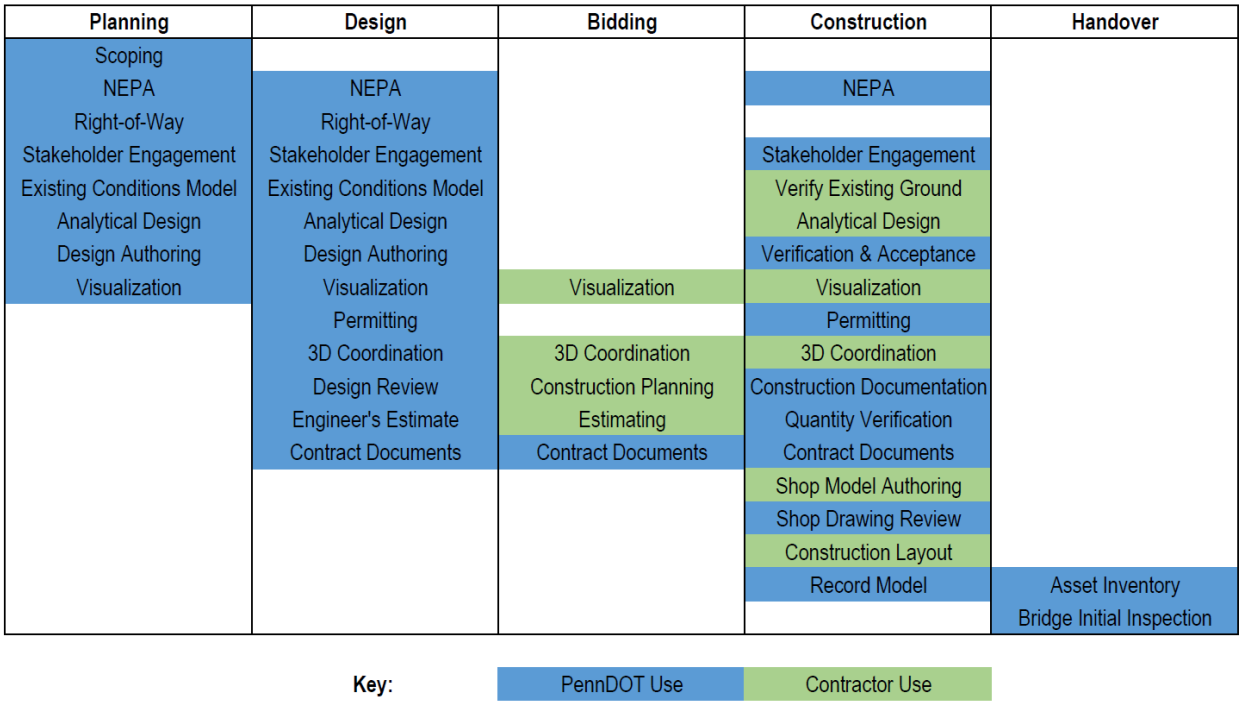

Figure 6: Digital Delivery Use Cases Throughout Project Development

The road map will develop a staged plan to build the capability and capacity for each dependent use and incrementally build to a full digital delivery solution. The use cases will be developed by documenting detailed processes (including prerequisite uses) and information requirements.

USE CASE PRIORITIZATION

Table 5 lists the prioritized use cases for development. The prioritization reflects building off PennDOT's existing maturity and current investments (e.g. OpenRoads Designer workspace and training) and the logical sequence based on prerequisite uses and investments.

Table 4: Prioritized Use Cases

Priority	Use Case	Rationale
1	Existing Conditions Modeling	Prerequisite to Design Authoring
1	Design Authoring–Roadway	Prerequisite to downstream uses
2	Design Authoring–Bridge	Need to implement software
2	Visualization–Planning	Need to implement software
2	Design Review	Model Authoring is a prerequisite
2	Engineer's Estimate	Model Authoring is a prerequisite
3	Design Authoring–Drainage	Need to implement software
3	3D Coordination	Requires models from multiple disciplines
3	Visualization–All Disciplines	Requires models from multiple disciplines
3	Quantity Verification	Engineer's Estimate is a prerequisite
3	Contract Documents	Design Review, Engineer's Estimate prerequisites
3	Documentation–Construction	Contract Documents is a prerequisite
4	Record Model	Contract Documents is a prerequisite
4	Asset Inventory	Record Model is a prerequisite

Appendix D: Capability-Maturity Matrix

Planning Element	Level of Maturity					
Strategy	**0 Non-Existent**	**1 Initial**	**2 Managed**	**3 Defined**	**4 Quantitatively Managed**	**5 Optimizing**
Organizational Mission and Goals	None	Basic Mission established	Basic Goals established	Mission addresses purpose, services, and values	SMART Goals established	Mission and Goals are regularly revisited and updated
Planless Delivery Vision and Objectives	None	Basic Vision established	Basic Objectives established	Vision addresses Mission, Strategy, and Culture	SMART Objectives established	Vision and Objectives are regularly revisited and updated
Management Support	None	Support for a feasibility study	Limited Support for Digital Delivery Roll-out	Full Support for Digital Delivery Roll-out	Limited Support for ongoing Digital Delivery Program	Full Support for ongoing Digital Delivery Program
Planless Delivery Champion	None	Champion Identified with limited time commitment	Champion allotted appropriate time commitment	Champions assigned from each District	Executive Level Champion assigned with limited time commitment	Executive Champion working closely with District Champions
Planless Delivery Planning Committee	None	Small Ad-Hoc Committee	Committee is formalized but does not include all Districts	Committee is formalized with each District represented	Committee includes executive team member(s)	Committee operates by using and updating an organizational Strategic Plan
Process	**0 Non-Existent**	**1 Initial**	**2 Managed**	**3 Defined**	**4 Quantitatively Managed**	**5 Optimizing**
Project Processes	None	High Level processes documented for some workflows	High Level processes documented for all workflows	Detailed Processes Documented for some workflows	Detailed Processes Documented for all workflows	Detailed Processes regularly reviewed and updated
Organizational Processes	None	High Level processes documented for some workflows	High Level processes documented for all workflows	Detailed Processes Documented for some workflows	Detailed Processes Documented for all workflows	Detailed Processes regularly reviewed and updated
Information	**0 Non-Existent**	**1 Initial**	**2 Managed**	**3 Defined**	**4 Quantitatively Managed**	**5 Optimizing**
Asset Data	None	Asset Data defined but not standardized across Districts	Asset Data defined and standardized across districts	Asset Data aligned with industry standards (e.g. AASHTO)	Asset Data aligned with open standards (e.g. IFC)	Asset Data updated with open standards
CAD / BIM Requirements	None	General Support for 3D Modeling	Basic Requirements for some project types	Detailed Requirements for some project types	General Requirements for all project types	Detailed Requirements for all project types

Planning Element	Level of Maturity					
Infrastructure	**0 Non-Existent**	**1 Initial**	**2 Managed**	**3 Defined**	**4 Quantitatively Managed**	**5 Optimizing**
Software	None	Some software capable of producing Digital Delivery deliverables	Dedicated software for producing Digital Delivery deliverables	Some Software for consuming Digital Delivery deliverables	Dedicated software for consuming Digital Delivery deliverables	Program for continuous updating of software systems
Hardware	No Hardware capable of running Digital Delivery Software	Some Hardware capable of running basic Digital Delivery software	All Hardware capable of running basic Digital Delivery software	Some hardware capable of running advanced Digital Delivery software	All hardware capable of running advanced Digital Delivery software	Program established for continuous updating of hardware
IT Procurement	Out of sync with business needs	Sporadically coordinates with agency at high level	Syncs to business needs sporadically	Syncs to business needs every 2 years	Syncs to business needs every year	Nimble and adapts to changing business needs
Personnel	**0 Non-Existent**	**1 Initial**	**2 Managed**	**3 Defined**	**4 Quantitatively Managed**	**5 Optimizing**
Roles and Responsibilities	No Roles defined	Digital Delivery is the responsibility of the District Engineer	Digital Delivery is the responsibility of the Project Manager	Digital Delivery is the responsibility of the project team	Digital Delivery is the responsibility of all PennDOT personnel	Responsibilities are regularly reviewed to ensure proper distribution
User Support	Digital Delivery not supported	Digital Delivery Champion in Central office with other job functions	Small Digital Delivery user support team in central office with other job functions	Dedicated Digital Delivery team in central office	Digital Delivery power users in each District with other job functions	Dedicated Digital Delivery support staff in each District
Awareness	No prior exposure to Digital Delivery initiative	Heard of Digital Delivery but not sure what it is	General Understanding of Digital Delivery objectives and scope	Basic understanding of Digital Delivery but not sure how it applies to me	Basic understanding of Digital Delivery and how it applies to me	Clear understanding of Digital Delivery objectives, scope, and how it applies tome
Training	No Digital Delivery training available	Generic vendor-created training available to a limited number of people	One-size-fits-all training available to all staff	Workflow-aligned training available to some districts	Workflow-aligned training available for all districts	On-demand workflow-aligned training available just-in-time to all
Industry Receptiveness	Digital Delivery is being forced on the industry	Industry has serious concerns about DigitalDelivery	A small part of industry is ready for DigitalDelivery	Industry is willing to help create a plan for DigitalDelivery	Industry embraces Digital Delivery at the right pace	Industry is ahead of us and is asking for Digital Delivery
Change Readiness	Digital Delivery is being forced on us	Serious concerns about readiness for Digital Delivery	Some concerns about readiness for Digital Delivery	Recognize need, but concerned about the pace of change	All staff embrace Digital Delivery at the right pace	Willingness to change is part of the culture of the organization

Figure 7: Capability-Maturity Matrix for Digital Delivery at PennDOT

Appendix E: Comparison of Digital Delivery Frameworks

	BIM Planning Guide for Facility Owners (2013)	National BIM Guide for Owners (2017)	ISO 19650 (2018)
Strategic Planning	• Assess readiness • Align goals to BIM uses • Create a Roadmap		
Implementation Planning	• Establish an implementation team • Design BIM processes • Document Information Requirements • Determine enabling infrastructure needs • Define education and training needs	• Define Processes: o Define BIM requirements o Establish roles & responsibilities o Define project BIM planning requirements o Develop quality management plans • Define Infrastructure & Standards o Define technology needs o Develop standards o Update CADD standards o Define information organization requirements o Create modeling guidance • Execution o Develop project BIM plan templates o Define BIM use cases	Define Organizational Information Requirements: • Management requirements o Standards and guidelines o Project BIM planning protocol o Establish roles & responsibilities o Define information delivery requirements o Define modeling and model management guidelines • Technical requirements o Software o IT & system performance constraints o Data exchange formats o Coordinate system Element-based Level of Development o Element-based attribute information • Commercial requirements o Information exchanges aligned to project delivery milestones o Business partner capability assessment framework o Procurement-based capability & capacity evaluation framework
Procurement Planning	• Define contractual requirements • Develop contract language • Create project BIM plan templates		

Appendix F: Development Process

The development process uses the formal frameworks for organizational implementation provided by the BIM Planning Guide for Facility Owners, the National BIM Guide for Owners, and ISO 19650. Appendix E contains a comparison of these frameworks. The common elements of the three formal digital delivery planning frameworks are:

- Create a team and define roles and responsibilities,
- Define the project planning protocols and templates,
- Document the information requirements in detail,
- Determine the enabling infrastructure needs, and
- Define the education and training competencies.

The process uses the five steps identified above to define the work that needs to be done. The work will be sequenced according to the use case prioritization and the dependency analysis. For each use case, the information requirements and enabling infrastructure need to be defined. The roadmap schedule will plan for the timelines for developing the information requirements and procuring the enabling infrastructure.

Define Team Roles and Responsibilities

The team and the team member responsibilities were identified in the first section. In Phase 2, the detailed responsibilities will be allocated as Responsible, Accountable, Consulted or Informed (RACI) for each task in the roadmap. We will create a RACI matrix for each use case development so that we use the digital delivery committee members' time effectively.

Project Planning Protocols

We will add content to the Project Execution Plan template incorporate the organizational information requirements as we develop the use case. This includes software, hardware, exchange formats, model element breakdown, minimum modeling requirements (i.e. level of development and attribute information definitions) as they are developed for each use case.

Detailed Information Requirements

For each use case, the detailed, element-level LOD and attribute information need to be defined.

LEVEL OF DEVELOPMENT

Level of Development (LOD) communicates the geometric accuracy and reliability of a model element. Level of Development for roadway elements incorporates a dimension that communicates the level of confidence that the existing ground survey matches the actual field conditions at the start of construction. The degree to which the existing ground is accurately represented affects the reliability of earthwork and paving costs, the likelihood of design changes or field fits, and the likelihood of delays. General LOD and confidence definitions can be used, but to be truly meaningful, these need to be developed for each element.

ATTRIBUTE INFORMATION

The attribute information is the information that users will look up within the model. It may include the specification section, pay item, pay item quantity, and asset information necessary

at handover. The data model for each element needs to be developed based on the asset inventory needs.

Enabling Infrastructure
The enabling infrastructure is the policy, technology, and workforce requirements to execute a use case. These need to be defined for each use case so that they can be programmed and procured.

Education and Training
Workforce development is a substantial component of digital delivery implementation. Switching from plans to digital delivery means that every stakeholder in project development needs to adapt to a new medium. This requires education and training at multiple levels, statewide, and across PennDOT's business partners. The education and training needs need to be defined for each use case and each stakeholder. For example, what education and training is needed to use digital delivery to tie rebar?

Appendix G: Comprehensive List of Use Cases

This appendix describes a comprehensive list of digital data use cases for highway and bridge construction. The list is divided into PennDOT uses (which includes PennDOT's consultant partners) and contractor uses.

PennDOT Uses

SCOPING

Dependencies: none. Capture digital information about the asset inventory, condition and other performance information (e.g. traffic, safety) and evaluate alternatives to determine the scope and estimated cost of the project. For bridge projects, conducting a "type, size, and location" study that includes preliminary structural design. The digital data includes GIS, CADD, documents, raster files, and analytical models.

NEPA

Dependencies: Scoping, Right-of-Way, Design Authoring, Construction Documentation. Conduct the environmental analysis to comply with the National Environmental Protection Act. The digital data includes GIS, CADD, documents, and raster files.

RIGHT-OF-WAY

Dependencies: Scoping, NEPA, Design Authoring. Conducting a deed search for the existing right-of-way property boundaries and easements, determining construction limits to assess the right-of-way acquisition or vacation requirements, and executing the surveying and platting to document these changes, as well as the acquisition/vacation process. The digital data includes GIS, CADD, documents, and raster files.

STAKEHOLDER ENGAGEMENT

Dependencies: Scoping, NEPA, Design Authoring. A process that uses digital information to communicate the project to technical and non-technical stakeholders and document their input throughout project delivery. The digital data includes GIS, CADD, documents, and raster files.

EXISTING CONDITIONS MODELING

Dependencies: Scoping, Right-of-Way. A process to document the existing conditions for a project to form the basis of design and construction. Existing conditions may include the existing ground surface, surface features such as edges of pavement, surface assets such as signs and fences, legal boundaries and property corners, subsurface utilities, structures, and subsurface features—both ground characterization and the existing pavement layers. The digital data includes GIS, CADD, documents, raster files, and analytical models (e.g. geotechnical).

ANALYTICAL DESIGN

Dependencies: Existing Conditions Modeling, Design Authoring. The process of capturing the existing and proposed alternatives in analytical models to design the proposed facility. Analytical models include geotechnical, traffic, safety, structural, drainage, noise, and air quality. The digital data includes GIS, CADD, documents, raster files, and analytical models.

DESIGN AUTHORING

Dependencies: Scoping, NEPA, Existing Conditions Modeling, Analytical Design. The process of developing a model to define and document the design. Typically, each individual discipline

(i.e. roadway, structures, drainage, etc.) develops a discipline model using a common coordinate reference frame. The individual discipline models are then referenced together into a single, federated model. This is an essential model use case to support many downstream uses. The digital data includes CADD, documents, and raster files.

VISUALIZATION

Dependencies: Scoping, NEPA, Existing Conditions Modeling, Design Authoring. The process of creating visual representations of the project to communicate with technical and non-technical stakeholders throughout the project lifecycle. Related uses include Scoping, NEPA, Stakeholder Engagement, Permitting, Construction Planning, and Verification and Acceptance. The digital data includes CADD, other types of 3D models, raster files, and videos.

PERMITTING

Dependencies: Scoping, NEPA, Existing Conditions Modeling, Design Authoring. The process of coordinating with other agencies to secure permits to conduct the construction activities. Many permitting agencies are not prepared for digital delivery and require 2D plans. The digital data includes GIS, CADD, documents, and raster files.

3D COORDINATION

Dependencies: Design Authoring. The process of software to analyze a federated model of design models using rule sets to identify collisions between design elements. 3D coordination also includes performing a visual analysis to identify potential spatial design issues. 3D coordination may also refer to referencing discipline models into a design model to proactively avoid collisions in the design authoring process. The digital data includes GIS, CADD, and documents (i.e. collision reports).

DESIGN REVIEW

Dependencies: Design Authoring, Analytical Design, 3D Coordination. The process of reviewing the design to determine compliance with codes and guidelines. Design review may include the use of software to analyze design models using a rule set that checks code requirements, as well as the outputs of analytical design and 3D coordination. Design review is the responsibility of specific project stakeholders such as the engineer of record and a designated design reviewer. Often, the engineer of record and design reviewer are responsible for specific discipline models. There are additional design review procedures for federally-funded projects. The digital data includes CADD, analytical models, and documents (i.e. reports).

ENGINEER'S ESTIMATE

Dependencies: Design Authoring. The process of taking off quantities from the design according to a schedule of bid items and estimating a price for each bid item to estimate the construction cost. The digital data includes CADD and documents, such as a database of historic bid prices that can be queried by District and pay item number.

CONTRACT DOCUMENTS

Dependencies: Design Authoring, Analytical Design, 3D Coordination, Design Review, Engineer's Estimate. The process of documenting the existing conditions, design, construction specifications, and engineer's estimate for the purposes of bidding and construction. Currently, the process uses documents such as plans, specifications, and spreadsheets. With digital

delivery, plans could be replaced with digital data which may comprise CADD or documents like spreadsheets with tables of data. The digital data includes CADD and documents.

SHOP DRAWING REVIEW

Dependencies: Contract Documents, Shop Model Authoring. The process of reviewing the contractor's proposed fabrication process to determine if it is in compliance with the requirements. Currently, shop drawings comprise 2D plans. With digital delivery, the shop "drawings" may be 3D models. The digital data includes CADD and documents.

VERIFICATION AND ACCEPTANCE

Dependencies: Contract Documents. The process whereby a construction inspector accesses the design information in the contract documents to verify that the project is constructed per plan and in accordance with the pay item quantities and specifications. Acceptance includes accessing material testing results and comparing them to the specifications. If there are deviations to plan, quantities, and/or specification, then the inspector initiates the appropriate remedy, which may include creating a record of the as-built condition. The digital data includes CADD and documents.

CONSTRUCTION DOCUMENTATION

Dependencies: Contract Documents, Verification and Acceptance. The process whereby a construction inspector documents the construction process. This includes daily diary records, materials testing results, pile driving reports, monthly payments, routine erosion prevention and sediment control inspections, NEPA compliance, and the process of seeking remedies to work that was not in conformance with plans, quantities, and/or specification. The digital data includes CADD, documents, and raster files (e.g. photographs).

RECORD MODEL

Dependencies: Contract Documents, Shop Drawing Review, Verification and Acceptance, Construction Documentation. The process of documenting any changes to the design plans, specifications, and quantities in a comprehensive record of the as-built condition. Currently, the process involves manual mark-ups on 2D plans in either PDF document or raster format. With digital delivery, the design models and shop models could be updated to reflect the as-built condition. The digital data includes CADD, documents, and raster files (e.g. scanned plans).

ASSET INVENTORY

Dependencies: Record Model. The process of creating an inventory of the assets removed, modified, and constructed to hand over to the maintenance, operations, and asset management departments' business systems. The asset information is defined within the organizational asset information requirements. Currently, this process may be performed by many different actors from many different departments. With digital delivery, the asset information requirements may be built into the design authoring and record modeling process to facilitate outputting data in a format that it can be imported into the receiving business systems that house the asset inventories. The digital data includes GIS, CADD, documents, and raster files.

INITIAL BRIDGE INSPECTION

Dependencies: Record Model, Asset Inventory. Per 23 CFR 650.315, agencies must maintain an inventory of the structure inventory and appraisal for all bridges in accordance with the

National Bridge Inspection Standards. The FHWA recommends that agencies conduct an initial inspection on all bridges that are constructed or rehabilitated bridges are opened to traffic. The process involves creating or modifying the structure inventory and appraisal data in the bridge management system. With digital delivery, the structure inventory and appraisal fields could be incorporated into the Record Model so that a suitably-qualified inspector can populate that data during Verification and Acceptance and the information delivered with the asset inventory information in a format compatible with the bridge management system. The digital data includes GIS, CADD, documents, and raster files.

Contractor Uses

CONSTRUCTION PLANNING

Dependencies: Contract Documents. The process by which the contractor determines the means and methods for constructing the facility. This may include scheduling, workforce planning, equipment selection, and procuring materials. With digital delivery, this may also include 3D lift planning (including analysis), 3D coordination, and other applications of visualization. The digital data includes CADD, other types of 3D models, analytical models, raster files, documents, and videos.

ESTIMATING

Dependencies: Contract Documents, Construction Planning. The process of taking off quantities from the design to verify the pay item quantities and to develop an estimate for the cost of executing the work in accordance with the contractor's selected means and methods. During the estimating process, the contractor typically packages work items and receives bids from sub-contractors to perform the work. Many small sub-contracting firms are unprepared for digital delivery and need plans to bid. The digital data includes CADD, documents, and raster files.

CONSTRUCTION LAYOUT

Dependencies: Contract Documents. The process in which the contractor extracts the information needed to lay out the work on the site. This may include extracting information to place stakes string lines, and reference points for laying out form work. It also includes the information required for real-time layout using Automate Machine Guidance. The digital data includes CADD and documents (including tables of survey point and break line data).

SHOP MODEL AUTHORING

Dependencies: Contract Documents, Construction Planning. The process in which the fabricator develops and documents the fabrication information. Currently, many fabricators subcontract to detailers who use 3D models to develop 2D shop drawings. A lack of interoperability means that fabricators manually extract and code the digital data that is loaded onto fabrication equipment. The National Steel Bridge Institute and the Precast/Prestressed Concrete Institute are both working on extending the IFC standard to provide an interoperable solution to remove the manual data extraction process. The digital data includes CADD, documents, and raster files.

Appendix H: Summary of Stakeholder Workshops

For each workshop performed, a detailed content map was developed. The following information summarizes key information extracted from the workshops as an illustration of important information. Most feedback raised in the workshops focused on concerns and suggestions from the participants during upcoming implementation.

Central Office Workshop:

PLANNING & NEPA

- Pilot projects for cost estimating using ConceptStation will start in Fall 2020
- Workforce challenges identified include:
  - The steep learning curve,
  - Potential resistance to change,
  - Number of retiring employees, and
  - The lack of educational programs teaching necessary information.
- Procurement concerns included:
  - The challenge to keep up with technology,
  - Incompatibility among different systems,
  - Initial costs of implementing new solutions, and
  - Funding support.

MODEL DEVELOPMENT

- QA reviews:
  - There is a need for new guidelines for quality assurance/control;
  - The hardware will need to support efficient review; and
  - There is a need for training for the new workflow/standards.
- Digital Design Files:
  - It will be important to have a single source of truth, and
  - There is a need to ensure that files are secure, compatible and not corrupt.
- Utility Information:
  - There is a lack of quality information by the utilities, partially caused by the utility having limited data; and
  - There are access challenges in obtaining 3D utility data/files from the utility organizations to include in design models.
- Procurement:
  - There were concerns regarding procurement limitations to keep up with technology, specifically,
    - Training will need to be updated, and
    - Will require funding – testing – implementing.
- Workforce challenges:
  - Ensure that we are not just asking employees to continue to learn and do more without a way to promote or compensate,
  - Knowledge retention; concern expressed about becoming more reliant on consultants instead of building in-house capabilities
- Training:

  - There will be a need to maintain training for new programs as they are being tested and developed, and
  - Training should include both in-person training and web-based training.

MODEL DELIVERY

- QA reviews:
  - Concern regarding familiarity with the new workflow,
  - A need to establish checklist(s),
  - The potential that model content could be changed during review process, and
  - A need to document the reviews
- Need champions to drive the effort, letting people get familiar with the new workflow, and understand what new final deliverables should include
- Training Recommendations:
  - Training should be updated periodically, and easily accessible, and
  - Training should be differentiated based on people's job function.

ASSET MANAGEMENT

- Data security was an important concern, e.g., homeland security concerns related to detailed bridge information
- Network connectivity everywhere is critical for supporting receiving and updating information for asset management process
- Challenges regarding asset management systems:
  - Outdated RMS user interface, and
  - Most systems were not specifically designed for asset management, but they contain data needed for asset management.

CONSTRUCTION ADMINISTRATION

- Concerns related to Digital Design Files:
  - Steep learning curve for interacting with files,
  - Challenges with efficiency of reviewing model electronically,
  - There is a need for new workflows/standards for model updating/validation, and
  - Need to avoid file corruption
- Software/hardware procurement concerns:
  - Need to develop clear contractual document of what hardware products should be purchased, and what is the upgrade cycle, and
  - There are challenges with the amount of time for testing and validating the current software versions due to frequent updating by vendors
- Suggested using STIC funding initiatives to investigate additional tools and to get products tested and approved.

ORGANIZATIONAL READINESS

- Need to determine when the changes need to happen in addition to what changes need to occur due to the chains of dependencies, i.e. ECMS -> CE Experts
- Concerns about the cybersecurity as well as the accessibility.
- The group highlighted:
  - The importance of the interconnections of each part of the project delivery process and the need to interface with all parts of the process,
  - The importance of communication and staying updated, and
  - The need and importance of training to bring people into the process.
- There is an anticipated significant knowledge drain over the next five years, while recruiting young people is challenging. Younger employees may have technology knowledge, but they may lack technical skills and experience.
- Support from Central Office to district projects includes:
  - Providing technical personnel,
  - Software support, including guidelines, and
  - Training.
- Concerns:
  - Keeping all of the different business areas going in the same direction,
  - Data overload causing inefficiency and duplication,
  - Basic data hygiene, and
  - How to minimize the cost of failure of pilot projects.
- Resources needed include training, staff time, and mobile devices.
- Communication must be tangible and shared with all employees
- Pilot projects will be critical and must include both successes along with identifying the issues and approaches to learn from challenges

Regional Workshops

PLANNING & NEPA

- There is value to leverage GIS/Reality Capture to add environmental resources to the design models.
- Need to have easy access for agencies to view large-scale environment models
- Values for Using 3D Representation:
  - alternatives analysis for larger projects,
  - Good for context sensitive projects,
  - Effective for conveying information to the public, and
  - Reduces the likelihood of project scope changes, which further reduces the costs from scope changes.
- Concerns:
  - Model progression from a conceptual model to a design model,
  - Need to better understand Level of Development (LOD) in different phases, and
  - Communication prior to model development is needed to prevent over-design/over-development.

- Need to differentiate between the need to use models to develop alternatives versus to look at options with each alternative.
- Training is needed for using models in the NEPA process.
- Concern that the public may not be ready to accept the change.
- Need to identify ways to successfully communicate design concepts through virtual engagements.
- Digital delivery is not all about 3D, it is about choosing options and exchanging information.

MODEL DEVELOPMENT

- 3D representations can alleviate concerns with unknown underground utilities. If accurate 3D utility models are collected, it would be helpful in the future.
  - There was a concerned raised about the amount of inaccurate or incomplete utility location data.
- Concerns:
  - Too much data collection could cause problems for projects,
  - Data segmentation is needed, and
  - Designing workflows for data acquisition and data utilization is important.
- Concerns with Reality Capture:
  - Who will be liable for accuracy of LiDAR data,
  - there is an increasing level of effort with 3D capture and detail of modeling with the new survey technologies (LiDAR, photogrammetry), and
  - Will inaccurate survey lead to more time/cost.
- Legal Concern: what are the approaches to sign/seal the final deliverable.
- It would be very valuable to have boring information within the 3D model for geotechnical work, but it is hard to model the subsurface based only on core borings.
- Design Process Concern:
  - Level of detail/time/effort need to put in the design model, and
  - How to keep track of the changes of the design model over the years.
- Liability Concerns:
  - Who has the liability for corrupted files,
  - Who has the ability to make changes to the design files, and
  - Who should be responsible for keeping the 3D models up to date.
- Need to maintain the same standards during model QA reviews (as with current practice). The model should be read-only, with an ability to track comments / annotations.
- Usability Concern: Will the software and procedures be user friendly enough to cover the range of users from engineers and designer to field supervision.
- Training and Technology Concerns: There is a current lack of training; current hardware limitations; need compatible software among different parties.

MODEL DELIVERY

- AutoTAB creates the Summary and Tabulation Sheets, and ensures that pay items are accurate and consistent in verbiage and pay item numbers.
- It takes a lot of time and effort to update information in ECMS after making changes to the design plans.

- Quantity Tracking Concern: With the amount of changes, the process to develop each pay item and assign every item an item number in a 3D model could be cumbersome.
- Review Productivity: There may be a productivity reduction due to having to review sheets electronically.

ASSET MANAGEMENT

- General requirements for asset management:
  - Need a central repository, and
  - Need a user-friendly interface.
- Challenges for inventory data collection:
  - Accuracy in the data provided from third parties,
  - Incompatibility among different types of collection tools/apps,
  - Changing items in the field, and
  - Funding.
- Challenges with current asset management system: Incompatibility among systems, causing duplicate entries and data transfer difficulties.

CONSTRUCTION ADMINISTRATION

- Construction Concerns:
  - How will information about constructability be accessed during the bidding process when using new contractual model, and
  - Will quantities and tabulations still be provided to the contractors.
- There will be a need to rely on GPS to inspect projects if a contractor stops using stakes, string lines, and hubs. PennDOT should rethink the tools we are using in the field.
- PennDOT Central Office typically is responsible to provide information and training on new processes and procedures.
- Both the contractor and PennDOT inspectors should play a part in creating a complete set of as-built records.
- Seeking more participation from the contractor community through process will help reduce the learning curve for adoption.
- Contractors will need for people with a technology background.
- There will be a need have dedicated staff that address digital delivery.

ORGANIZATIONAL READINESS

- There is a desire to learn about more successful pilot projects, and to train people step-by-step.
- Workforce Concerns:
  - There is a knowledge drain caused by the aging workforce,
  - There is a need to capture knowledge from experienced employees, and apply the knowledge to the new workflows,
  - Are there enough people to implement the new technology, and
  - The need for trade schools to create special programs for highway construction and highway construction inspection.

- Technology Concerns:
  - Initial costs of new equipment and software,
  - Connectivity, and
  - Stability of hardware and software.
- Having a team instead of individuals gain core knowledge of digital delivery may be valuable, then train other people.
- Change Concern: Not being able to meet schedule and cost requirements when changing to the new delivery method.
- Digital delivery does not mean developing 3D models for every aspect of the project. Key is the information.
- For pilot projects, starting with less complex projects, going slow with the projects, and only doing one piece of the entire project may be most effective.

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