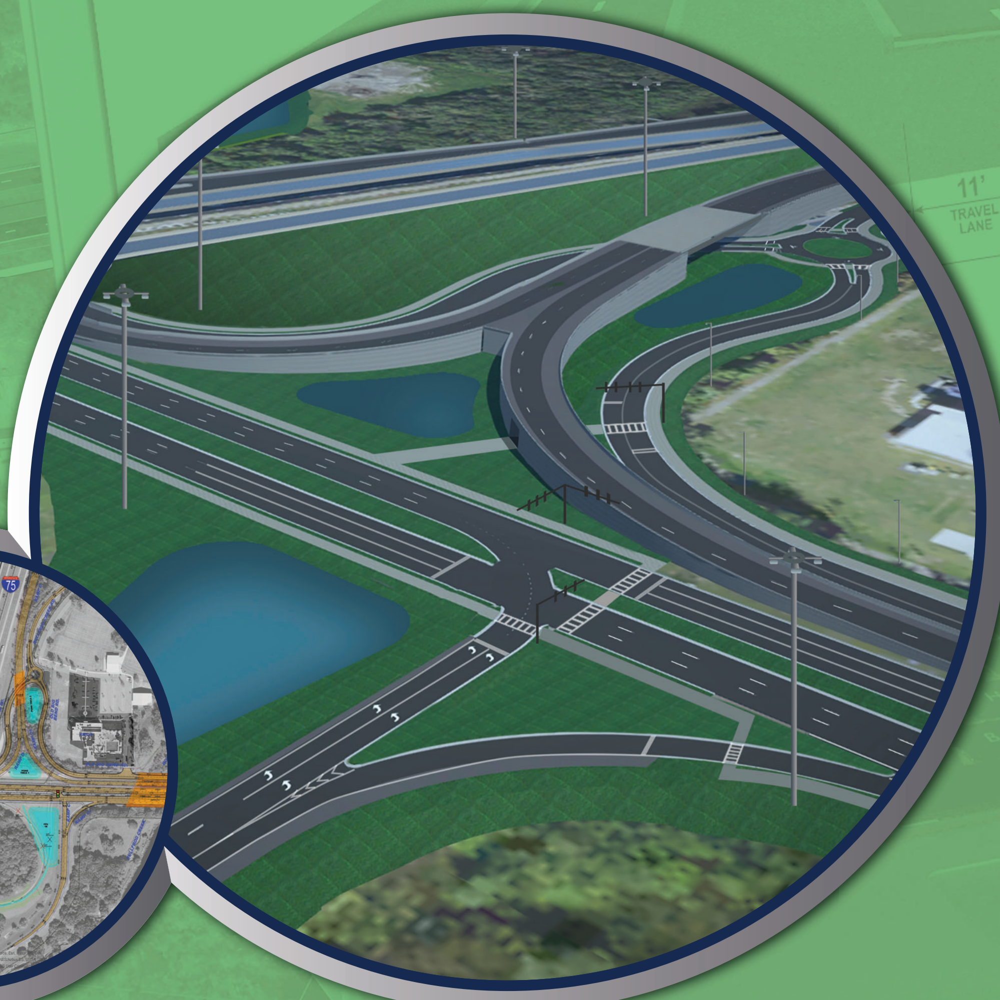
3D in PD&E Guidebook

Prepared for:
Florida Department of Transportation
Office of Environmental Management
605 Suwannee Street
Tallahassee, FL 32399



FDOT

Florida Department of Transportation

3D in PD&E Guidebook

Prepared for:
Florida Department of Transportation
Office of Environmental Management
605 Suwannee Street
Tallahassee, FL 32399

August 2021

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 Introduction

The Project Development and Environment (PD&E) Study process considers several design alternatives and concepts to meet the project purpose and need and satisfy applicable laws and regulations. A significant amount of time, expertise, and effort are spent developing and evaluating concepts and alternatives before a preferred alternative is selected. During the PD&E study several exhibits are developed utilizing geographic information system (GIS), computer aided design and drafting (CADD) data, and available survey information to convey design intent to the public, stakeholders, and subsequent design team. Enhancing design practices during PD&E [i.e., leveraging three-dimensional (3D) design and data, etc.] can help teams produce higher quality, more accurate concepts and can facilitate better decision-making. Additionally, improving the handover process from concept to design can reduce rework, minimize duplicative effort, increase efficiency, reduce costs, and positively impact project schedule.

1.1 Background

PD&E source data is extremely valuable to the design phase, but current delivery practices lack consistency. Additionally, while technological advancement in the industry has improved quality in the design phase, the PD&E concept and alternative processes have remained relatively unchanged. Where appropriate, the PD&E teams can be encouraged to utilize Florida Department of Transportation (FDOT) CADD standards and applicable guidance, which includes 3D design, to facilitate seamless transfers to the design phase.

1.2 Purpose

The results of a survey conducted by the Federal Highway Administration (FHWA) in 2015 identified the items listed below as some of the continuing challenges organizations are facing regarding the implementation of 3D[1] Design:

- Creating best practices, guidelines, etc. (60% +/- of respondents)
- Filling knowledge, skill, and resource gaps (55% +/-)
- Upgrading the information technology (IT) infrastructure for new technology and processes (52% +/-)
- Defining how 3D technologies relate to core business functions (45% +/-)
- Defining the business case for investing in 3D modeling (42% +/-)
- Identifying the right scale for investing in 3D technologies (36% +/-)
- Perception that 3D technologies are cost prohibitive (36% +/-)

Creating best practices and guidelines ranked as the greatest challenge among these respondents. The purpose of this guidebook is to publish guidelines and best practices for the implementation of 3D design during PD&E and the efficient transfer of source data from PD&E to final design phase. Note that this document will not answer every question or address every project nuance. It is intended to be a living document that will grow and mature as these technologies advance and users put them into practice.

This guidebook applies to 3D design and technologies in PD&E only. Where there are overlaps with two dimensional (2D) graphical standards please refer to the separate guidance for 2D graphic standards during PD&E in FDOT's 2D PD&E Materials Guidebook.

1.2.1 Provide guidance on workflow changes to incorporate 3D in PD&E

Incorporating 3D into PD&E beyond public involvement exhibits is a relatively new concept for the typical PD&E workflow. As such, there are PD&E workflow changes that will be required. A few considerations are provided below:

1. Fill the knowledge and skills resource gaps of PD&E engineers or utilize highway designers that are familiar with FDOT 3D modeling to assist during PD&E development. There are several 3D tools with varying costs, complexity, and application. See **Section 4** for more information.
2. Explore and leverage free 3D data. See **Section 3** for a detailed look at 3D data that is often overlooked but could add value to PD&E study process.
3. Move beyond the use of 3D as simply a tool for public involvement exhibits. PD&E projects typically include a graphic designer who is tasked with turning 2D line work into a 3D representation or beautifying simple 2D graphics. While these representations are pleasing to the eye, they typically lack design value since they are not globally positioned and often the dimensions and perspectives are arbitrary. Moving beyond this means leveraging the power of 3D tools to develop accurate designs. Those accurate 3D models can be used to develop eye-catching graphics, increasing the usefulness of the content and reduces wasted efforts.

1.3 Goals

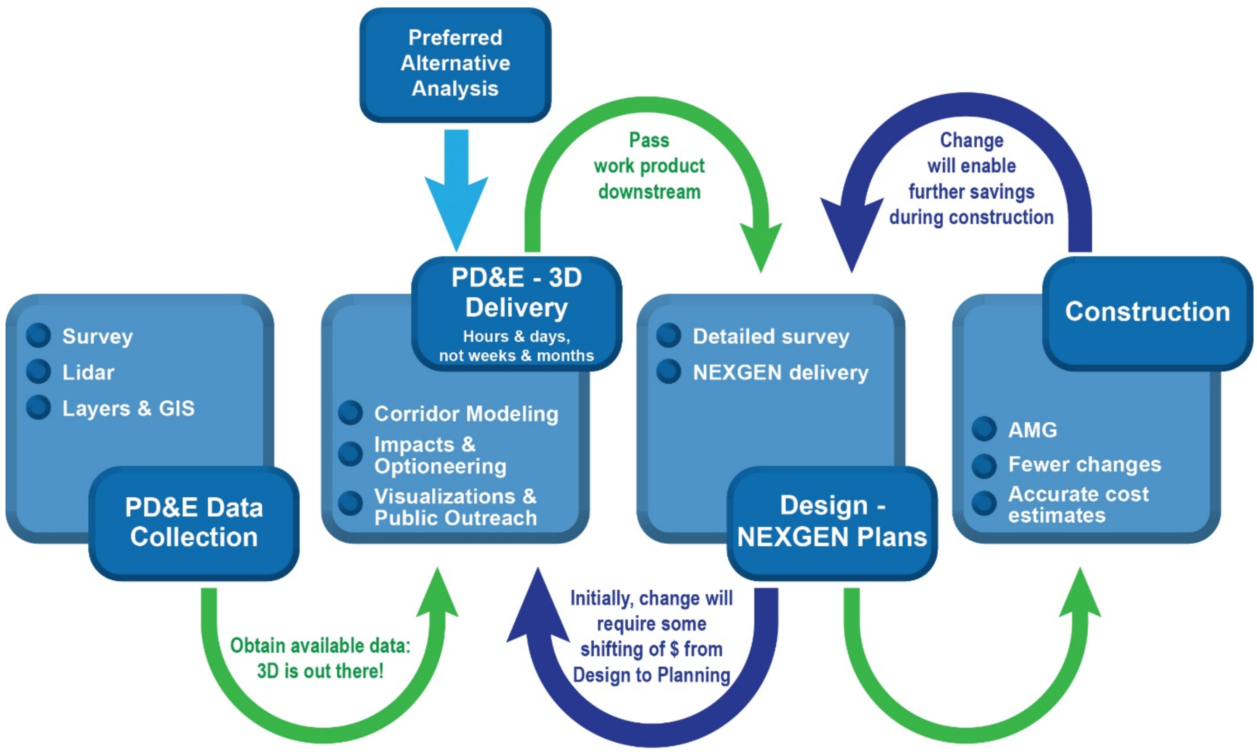
The overarching goal of this document is to provide high-level 3D guidance regarding the implementation of 3D tools, data, and workflows in PD&E. The document is purposely generic to allow for wider application of the technologies presented, however, where helpful, some specific guidance is provided. Two main goals are discussed in the following sections.

1.3.1 Maximize data reuse and efficiencies for the Design Phase

Data waste over the life of a project or asset is a significant issue in the transportation industry. Per FDOT[2], the Transportation Development Process can be described in five steps or phases, as shown in **Figure 1-1**:

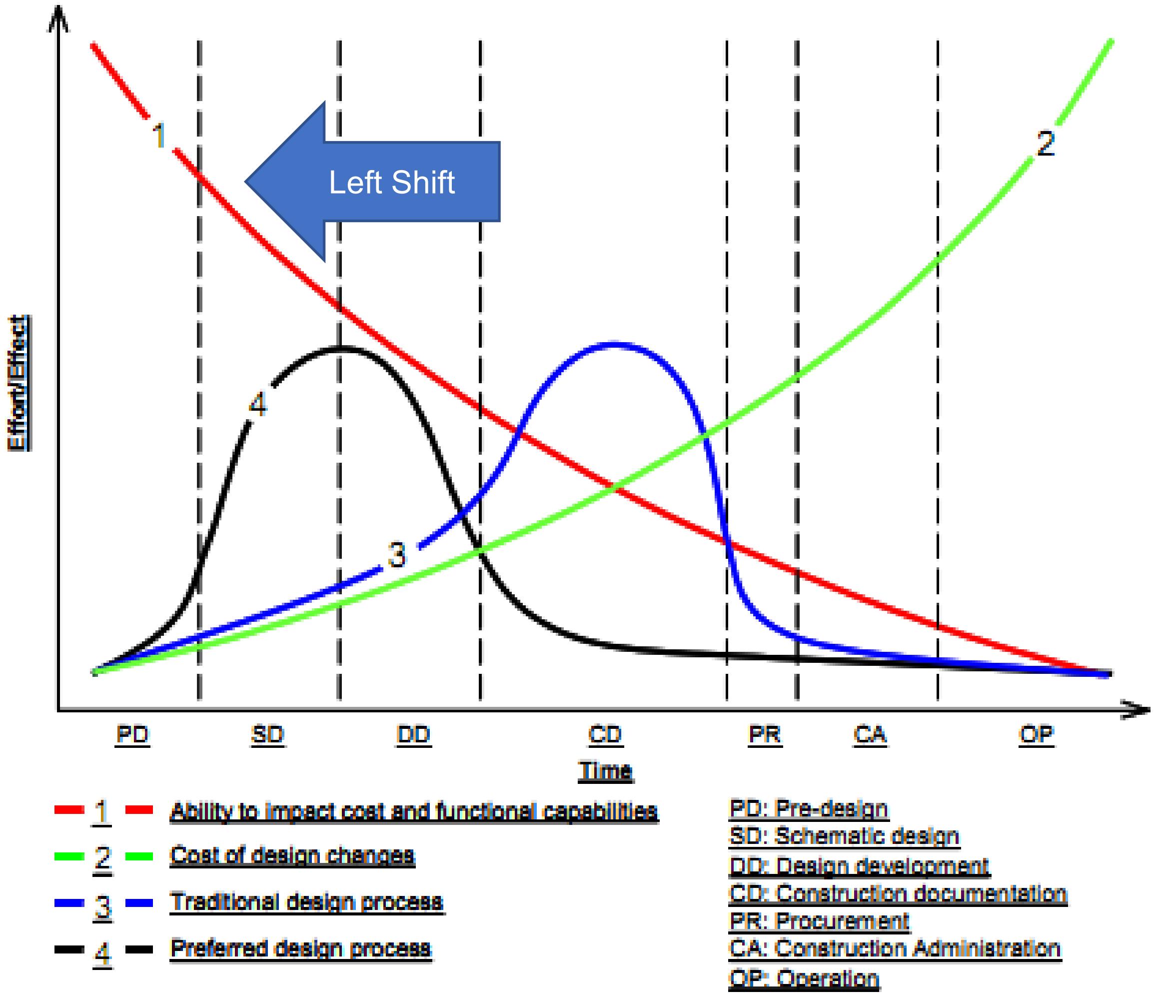
1. Long Range Planning
2. PD&E Study
3. Design
4. Right-of-Way (R/W) Acquisition
5. Construction

Figure 1-1 – 3D in PD&E Concepts



Currently, each phase operates independently with little consideration for data reuse and efficiencies for subsequent phases. Some work is already being done by the FDOT to better connect the phases and drive efficiencies. For example, the FDOT has introduced Concurrent (or Combined) PD&E and Design Phases. Since 3D is the standard for most design projects for the FDOT, that means 3D would be developed concurrently with the PD&E process. This guidance document seeks to extend the concept of 3D to traditional PD&E projects. This concept shifts work that would be completed in the design phase traditionally to a location earlier in the project lifecycle. This is often referred to as a "Left Shift" in the technology industry, as illustrated in **Figure 1-2**. Shifting decision making earlier in the process allows the team to solve problems earlier while project costs and impacts are lower.

Figure 1-2 – Macleamy Curve (2004)



1.3.2 Improved analysis and decision making in PD&E

The Construction Industry Institute (CII) published research on 3D CADD in FIAPP (fully integrated and automated project process)[3] and provided recommendations for success in leveraging 3D models. They identified the development of a 3D CADD model early in the pre-project planning phase as a recommendation for success. This coincides with the PD&E phase in FDOT projects. Many PD&E alternative analyses include value engineering, and the principle outcome is to assure stakeholders that project decisions are well supported, and funds are spent wisely. As a result, PD&E processes should be continuously refined to support more accurate analyses where appropriate to facilitate better decision making. 3D models are great candidates to showcase the benefit of enhanced analysis.

1.4 Intended Use

This guidance document is intended for use by PD&E Engineers, Designers, Planners and other practitioners (FDOT staff and consultants) responsible for the scoping, preparation, or review of PD&E study materials. This document supplements the requirements for CADD in PD&E outlined by the FDOT in the CADD Manual (Refer to the CADD Manual for the latest requirements).

1.4.1 Guidance document, not regulation

Please note that this document is released as guidance, not regulation at this time to encourage and support the use of advanced technologies in the development of PD&E deliverables. The FDOT PD&E Manual, FDOT Design Manual, and CADD Manual are the official regulatory documents for FDOT project development.

2 Current Guidance and Potential Applicability to PD&E

Currently-approved FDOT documents and standards for PD&E and standard design were reviewed to identify published requirements and guidance regarding CADD, 3D visualizations, and plans/exhibit development. The evaluated documents are listed in **Table 2-1** below along with weblinks to the source materials. The fourth column includes a summary of the current guidance, if any, as well as language that may provide opportunities for 3D innovation or expansion. In some cases, the exact language is added to provide context and where helpful, critical information is bolded to draw the reader's attention to important information.

Keywords used to search the standards included the following: 3D, Visualization, Fly-Through, CADD, Google Earth, Rendering, 3-Dimensional, PD&E and KMZ. The purpose of this evaluation is to capture potential 3D efficiencies that can be implemented during PD&E with benefits into the design phase. As noted earlier, where there are overlaps with 2D graphical standards please refer to the separate guidance for 2D graphic standards during PD&E in FDOT's 2D PD&E Materials Guidebook.

Table 2-1 – FDOT Standards Review Matrix

#	FDOT Approved Document	Location	Current 3D/Visualization Guidance and Opportunities
1	Standard Scope of Services for PD&E Studies	https://www.fdot.gov/designsupport/Scope/	Section 2.2.11 Computer Automation, page A-16 • The CONSULTANT **shall develop concept plans and alternatives designs utilizing Computer Aided Drafting and Design (CADD) systems**. The DEPARTMENT makes software available to help assure quality and conformance with the policy and procedures regarding CADD. **It is the responsibility of the CONSULTANT to meet the CADD production requirements in the FDOT CADD Manual**. The CONSULTANT must submit final documents and files as described in the CADD Manual. Additional related information is found in the FDM. **Concept plans and alternatives designs shall also be displayed using Google Earth-ready KMZ files**. The concept plans must have both existing and proposed engineering and environmental features. Upon DEPARTMENT approval, **the CONSULTANT may also use computer tools and software to conduct some of the engineering and environmental analyses.** Prior to using these tools, the CONSULTANT must agree to provide original electronic files in a format and standard consistent with the DEPARTMENT's policies and procedures. Section 3.6 Additional Public Involvement Requirements, page A-24 • Scope developer to identify and list any special public involvement requirements such as the small group meetings, preparation of a separate comments and coordination package, preparation of newsletters or fact sheets, development of websites, or special coordination with specific stakeholders. Examples include: • General Public Correspondence • Frequent Asked Questions (FAQs) • **Videos, Rendering, Fly-Through, 3-Dimensional Visualization** • **Microsimulation** • Speakers bureau • Design charettes
2	PD&E Staff Hour Estimation (SHE) Guidelines	https://www.fdot.gov/designsupport/Scope/	Tab 3. Public Involvement, 3.6 Additional Public Involvement Requirements, Videos, Rendering, etc. • Low Range- Additional Power Point presentation and aerial displays

#	FDOT Approved Document	Location	Current 3D/Visualization Guidance and Opportunities
			• Middle Range- 3-D typical / aerial rendering • High Range- Computer animated simulation and video
3	Design Staff Hour Estimation (SHE) Guidelines	https://www.fdot.gov/designsupport/Scope/	3D Modeling Guidelines Tab 1. Model development- Whoever develops the model will need good engineering judgment and 3D modeling experience 2. Multiple Discipline Coordination a. Onboard staff early b. Most of design work is reflected in modeling effort c. Cannot approach 3D modeling the same way as non-modeling project 3. Initial Model- What you think will work for initial concept will get vetted by a well-developed 3D model a. 3D modeling is iterative 4. Additional Controls- When 3D modeling you will realize that you need more alignments and profiles than 2D design.
4	Concurrent PD&E and Design Phases- User Guide to Prepare Scope of Services	https://www.fdot.gov/designsupport/Scope/	• No specific direction regarding 3D or Visualization.
5	Concurrent (or Combined) PD&E Study and Design Standard Scope of Services	https://www.fdot.gov/designsupport/Scope/	See Section 36 3D Modeling • Phase I 3D Design Model- 3D interactive model, comprised of, but not limited to: Existing features (pavement, shoulders, sidewalk, curb/gutter, utilities-if required per scope, drainage - if required per scope) and proposed corridor(s) • Phase II 3D Design Model- 3D model, comprised of, but not limited to: Modification of the Phase I model to update the model to comply with changes based on the Phase I review comments and to include the addition of ponds, floodplain compensation sites, retaining walls, barrier walls, guardrail terminals, cross overs, gore areas, side street connections, roundabouts and driveways. • Phase III 3D Design Model- comprised of, but not limited to: Modification of the Phase II model to update the model to comply with changes based on the Phase II review comments and to further refine areas of transition between templates, detailed grading areas, bridge approaches and end bents, median noses, shoulder transition areas, retaining walls, barrier walls and guardrail. • Final 3D Model Design- comprised of, but not limited to: Modification of the Phase III model

#	FDOT Approved Document	Location	Current 3D/Visualization Guidance and Opportunities
			to update the model to comply with changes based on the Phase III review comments and to accurately generate, export and otherwise prepare the final 3D deliverable files as described in the FDOT CADD Manual.
6	Project Development and Environmental (PD&E) Manual	https://www.fdot.gov/environment/pubs/pdeman/pdeman-current	• No specific direction regarding 3D or visualization. Further research required to identify potential opportunities.
7	FDOT Design Manual	https://www.fdot.gov/roadway/FDM	Development and Processes • Section 111.3.1 Three-Dimensional Models- If horizontally and vertically controlled cross sections are required for plans production to communicate design intent and construct the project, then that section of the project should be three-dimensionally (3D) modeled. NexGen Plans Production • Section 911 Model Management
8	FDOT CADD Manual	CADD Manual - FDOTConnect And FDOT2021C3D	Chapter 3- CADD Software Chapter 5- CADD Standards Chapter 6- CADD Production Prerequisites Chapter 7- CADD Production Support Chapter 8- CADD Delivery

2.1 FDOT CADD Manual

The FDOT CADD Manual is a great starting point for the adoption of CADD standards into the PD&E process for both 2D and 3D deliverables. The Scope in Section 1.5 indicates that the CADD Manual is to be utilized by all persons using CADD to produce projects for the FDOT. It goes on to clarify that the manual applies to all FDOT offices and all consultants: essentially no one is exempt. Since the FDOT's supported CADD platforms are all model-centric, 3D development is expected for most projects with only a few exceptions.

2.2 FDOT CADD Manual Supplement for 3D in PD&E

The FDOT CADD Manual is primarily focused on standardizing the work to be done during the design phase. As a result, some of the requirements may be excessive for some PD&E processes. Section 6.3 of the FDOT CADD Manual provides some reasonable flexibility for the PD&E practitioner. It states, "Project alternatives and design concepts are developed using CADD Standards, where appropriate, to facilitate a seamless transfer of PD&E CADD files to the final design phase," emphasis added. It maintains that the objective is to minimize duplicative efforts.[4] However, it does not currently provide guidance for PD&E.

This guidebook seeks to supplement the CADD Manual and provide direction to PD&E practitioners until PD&E production directives are formally adopted. For example, the CADD Manual provides general definitions regarding model delivery in Section 5.16.4. However, the "Use Case" column could be expanded to include project types like PD&E to help the practitioner get a better idea of where that work fits in the Building Information Modeling (BIM) economy. See below for PD&E guidance to implement CADD Manual Sections 5.16.4 & 6.3.1.

- Model Delivery Guidance for PD&E Projects:
  - Level of Accuracy (LOA) – LOA 100 or higher is acceptable for 3D elevation and surface data for PD&E development. LOA 100 definition includes United States Geological Survey (USGS) data and surfaces from Rapid 3D Modeling Tools. Refer to CADD Manual Section 5.16.5 for more LOA definitions.
  - Level of Detail (LOD) – LOD 200 to LOD 300 is acceptable for 3D model development during PD&E development. LOD 200 is acceptable in early stages since the Rapid 3D Modeling Tools do not have libraries of FDOT-specific content. For example, they have barrier walls, but they likely do not match FDOT Standards precisely and are generic placeholders. Conversely, if modeling using the Detailed 3D Modeling Platforms, FDOT standard walls, etc. are included in the FDOT CADD workspaces. Most design phase elements will likely be LOD 300, so less detail in the concept phase is acceptable. Refer to CADD Manual Section 5.16.6 for more LOD definitions.

- 3D Deliverables – 3D Deliverables from the PD&E phase to Final Design phase should include the following:
  - Project 3D CADD files (includes corridors and survey files)
  - Project 3D existing ground surfaces (in design file or XML format)
  - Project Alignments (in XML format)
  - Project Template or Assemblies Libraries (in native format)
  - Project Visualizations and Exhibits

3 3D Data

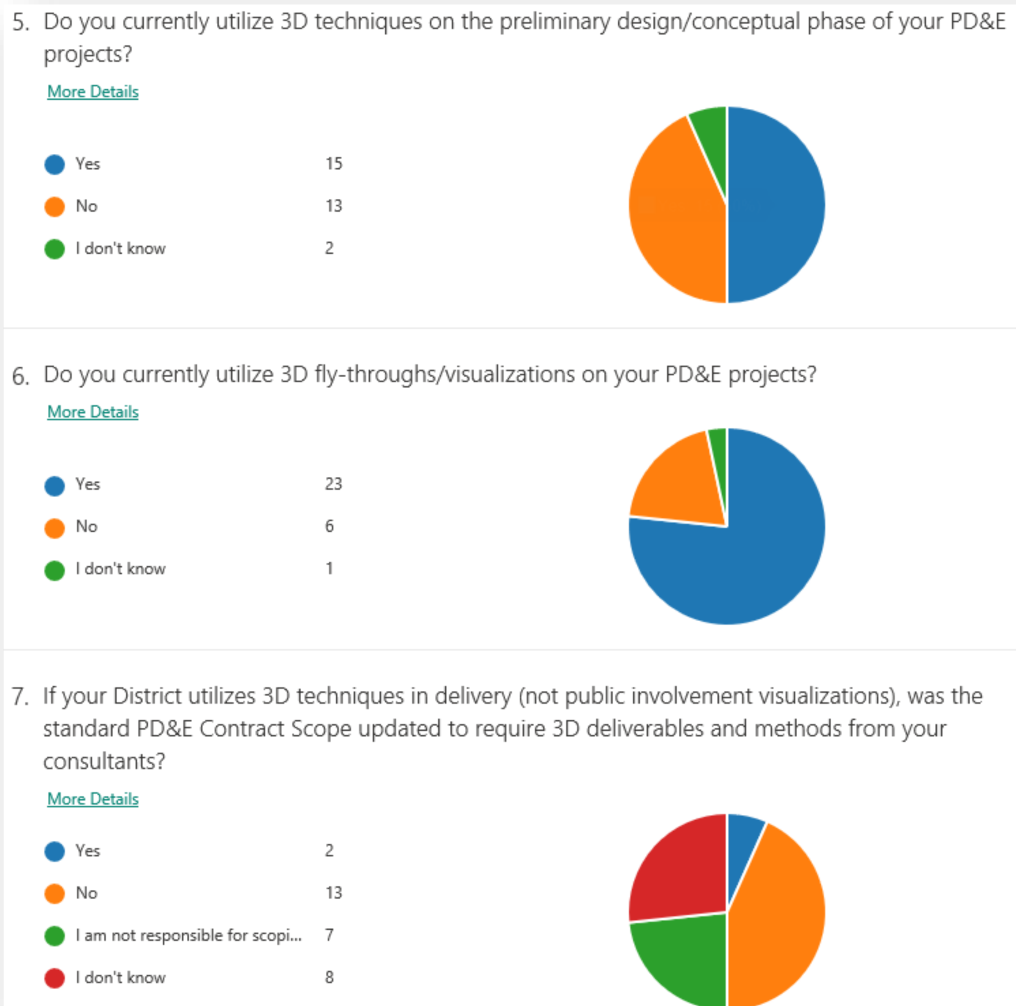
Considering the requirements of the FDOT CADD Manual listed above, 3D in PD&E is a natural derivative of the 3D requirements in standard design and should be adopted. Section 6.3.1 of the FDOT CADD Manual outlines the CADD Deliverables that may be produced in the preparation of the PD&E. Some of them have an obvious 3D relationship that should extend into PD&E development. The 3D candidate deliverables are listed below:

- Digital terrain model or 3D surface
- Alternative alignments
- Alternative concept layouts/plans
- Intersection/Interchange concepts
- Profiles
- Typical Sections
- Conceptual drainage and storm water pond plans
- Utilities
- GIS-KMZ files
- Visualization files

In preparation for the development of this document, a survey was taken and yielded 31 respondents. The purpose of the survey was to gather data regarding processes and tools used by FDOT Districts for 3D in PD&E. As shown in **Figure 3-1**, a significant proportion of respondents (74%) are using 3D for delivery of visualizations on their projects, but only about 48% of them utilize 3D for preliminary design and concept phase. It is also notable that among those who are actively utilizing 3D for their projects, only 6% could point to contract language that support those efforts. This expresses 2 things:

1. Practitioners are taking it upon themselves to utilize 3D techniques for their projects with little to no contract language providing 3D expectations.
2. There is a statewide need to provide 3D contract language and standards that meet the unique needs of PD&E.

Figure 3-1 – Respondent 3D Capability

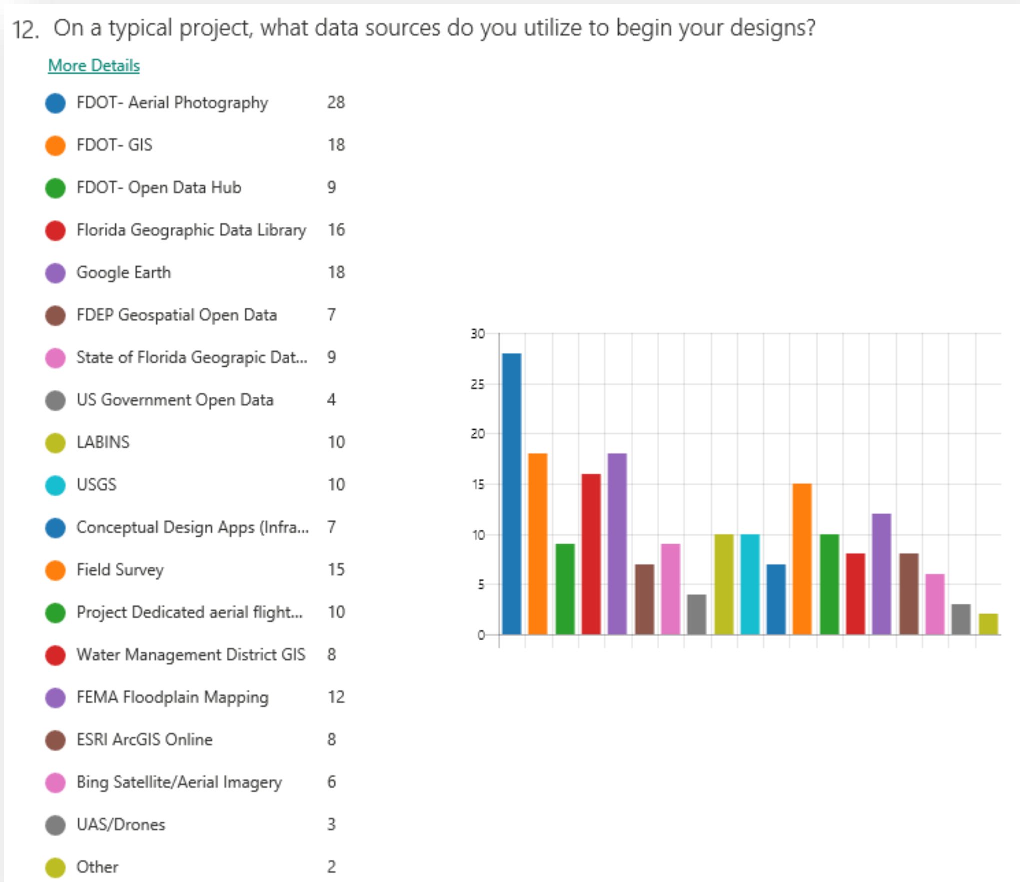


3.1 Data Sources

Having established the case for 3D development in PD&E based on available standards, the next step is to explore ways to expand the use of 3D in PD&E beyond the basic CADD requirements in order to meet PD&E specific needs.

Interestingly, data source use is well distributed across a large range of repositories, with the FDOT-provided data and imagery platforms being the most consistently relied upon by respondents, see **Figure 3-2**. This suggests that among the PD&E community in Florida there is significant awareness of data repositories. However, it is also apparent that less than one-third (1/3) of the respondents utilize conceptual design apps, USGS, or LABINS data sources in their designs. This is notable because they are prominent sources of 3D content.

Figure 3-2 – Data Sources



3.2 Data Types

Several of the data sources listed above provide access to multiple data types including 3D. Data is generally categorized into one of the types listed below:

- Imagery
- 2D CAD graphics
- 3D CAD graphics
- Shape Files
- Terrain Models
- Point Clouds

Since 3D is the focus, a summary of the 3D data types provided by some of the prominent data sources is shown below:

- USGS
    - Digital Elevation Models (DEMs)
    - IfSAR Digital Surface Model
    - LiDAR Point Cloud
- LABINS
    - DEMs
    - LiDAR
- Florida Geographic Data Library
    - USGS National Elevation Dataset
    - Florida DEM
- Google Earth/ OpenStreetMap
    - Available 3D Buildings and structures
- Field Survey
    - Terrain Models
    - 3D of existing drainage and utilities
    - 3D survey of pavement, structures, and fixtures
- Conceptual Design Apps (i.e., InfraWorks, ConceptStation)
    - Terrain models from a variety of sources
    - 3D building
    - 3D draped roadways
    - 3D bridges
    - 3D draped hydrology

To assist users in determining data source applicability to a variety of needs and uses, a data source matrix table is provided in **Table 3-1**. The matrix provides applicability as well as some indication of the data type(s) that can be leveraged. Most of them are free, open, and easily accessible; however, there are a few that require a fee, subscription, or special software.

Table 3-1 – Data Sources Matrix

Data Source	Applicability to 2D	Applicability to 3D	Applicability to Public Involvement	LiDAR/Contours/Elevations	Imagery	Layers/Levels/Shapes	Cost/Subscription/Software Required?
FDOT - Aerial Photography	X		X		X		No
FDOT- GIS	X		X		X	X	No
FDOT- Open Data Hub	X	X	X	X	X	X	No
Florida Geographic Data Library (FGDL)	X	X	X	X	X	X	No
Google Earth	X	X	X	X	X	X	No
Florida Department of Environmental Protection (FDEP) Geospatial Open Data	X	X	X	X	X	X	No
LABINS	X	X	X	X	X	X	No
USGS	X	X	X	X	X	X	No
Conceptual Design Apps (Infraworks/ConceptStation)	X	X	X	X	X	X	Yes
Field Survey	X	X	X	X		X	Yes
Project Dedicated aerial flights/light detection and ranging (LiDAR)	X	X	X	X	X	X	Yes
Water Management District GIS	X	X	X	X	X	X	No
FEMA Floodplains Mapping	X	X	X	X	X	X	No
Environmental Systems Research Institute (ESRI) ArcGIS Online	X	X	X	X	X	X	Yes
Bing Satellite/Aerial Imagery	X	X	X	X	X	X	No
Unmanned Aircraft System (UAS)/Drones	X	X	X	X	X	X	Yes
County Aerials	X		X	X	X	X	No

4 3D Tools

Building on the currently available guidance from FDOT and the previous discussion on 3D Data, this section takes a looks at PD&E deliverables and identifies direct or potential 3D tool applicability. The first step in this process is to provide an appropriate list of tools and categorize them by their typical usage and limitations. Since costs and skills required are always important considerations, Licensing and Skills Needed columns are also provided. However, it should be noted that most production teams will have access to multiple tools on this list, so license costs are likely less important. The Skills Needed section will likely be a higher priority for project managers considering how to expand their use of 3D. Conversely, PD&E teams that are new to 3D will find value in the table as it provides a simplified introduction to the technology stack.

4.1 Software Applications

Although not specifically identified in the table, the tools below are from five well known vendors in the engineering industry: Bentley, Autodesk, Environmental Systems Research Institute (ESRI), Google, and Adobe. The list of software tools along with specific requirements and limitations is shown in **Table 4-1**.

Table 4-1 – Software Tools Requirements & Limitations

Software Tool	Licensing	Skills Needed	Usage & Limitations
AutoCAD	Purchase	Moderate Technical	Primarily focused on AEC
Civil 3D	Purchase	Advanced Technical	Primarily focused on AEC
Revit	Purchase	Advanced Technical	Primarily focused on AEC
MicroStation v8i	Purchase	Moderate Technical	Expiring technology
MicroStation Connect	Purchase	Moderate Technical	Primarily focused on AEC
InRoads/GeoPAK	Purchase	Advanced Technical	Expiring technology
OpenRoads Designer	Purchase	Advanced Technical	Primarily focused on AEC
OpenBridge Modeler/ Designer	Purchase	Advanced Technical	Primarily focused on AEC
OpenRoads ConceptStation	Purchase	Minimal Technical	Concept only
InfraWorks	Purchase	Moderate Technical	Concept only
ArcGIS	Purchase	Advanced Technical	Data viewer, not for design
Google SketchUp	Freeware	Minimal Technical	Primarily for planar objects
Adobe Illustrator	Purchase	Moderate Technical	Primarily for creative graphics
Adobe Photoshop	Purchase	Moderate Technical	Primarily for image editing
Google Earth	Freeware	Minimal Technical	Data viewer, not for design

AEC = Architectural, Engineering and Construction

The next step is to identify PD&E deliverables and begin to draw general connections to 3D tools. It is important to note that the groupings and characterizations of these software tools are for the sole purposes of simplicity and ease of use. There are several software applications that are supported or recognized by FDOT that may not be listed explicitly below. It is also true that a tool listed below may have capabilities that fit multiple categories. The list below is not exhaustive but should provide adequate insight into typical or generally accepted use. The groupings also serve as potential placeholders for applications that fit the general use cases of the product and any past, present, or future released products within the same category.

The tools have been grouped as follows:

<u>Traditional 2D CAD Platforms</u> – Primarily used for detailed drafting, 2D geometry, annotations, etc.

- AutoCAD
- MicroStation v8i
- MicroStation Connect

<u>Detailed 3D CAD Platforms</u> – Primarily used to model geometry in 3D and additionally for automated plan production and creation of detailed final deliverables.

- Civil 3D
- InRoads / GeoPAK
- OpenRoads Designer
- OpenBridge Modeler / Designer
- Revit

<u>Geospatial Database Software</u> – Primarily used to consume and identify multiple data sources for a given project.

- ArcGIS
- Google Earth

<u>Rapid 3D Modeling Tools</u> – Spatially accurate, template-driven design layout creation tools. Primarily used for initial layouts and public outreach visualizations.

- OpenRoads ConceptStation
- InfraWorks
- SketchUp

<u>Graphic Layout and Presentation Software</u> – Primarily used for project visualizations for public outreach.

- Adobe Illustrator
- Adobe Photoshop

4.2 3D Applicability

To determine the applicability of these software applications to PD&E projects and/or the subsequent design phase, a detailed analysis of the most common PD&E deliverables is provided below. **Table 4-2** identifies 3D applicability based on the type of PD&E deliverable, while **Table 4-3** connects 3D applicability to specific sections of the PD&E Manual. This helps the practitioner by providing two perspectives from which to consider implementation of 3D in PD&E.

The tables below identify where 3D software programs would result in the development of accurate, content-rich 3D deliverables for PD&E projects. Notice in Tables 4-2 and 4-3 that 3D applicability is classified as either Direct, Potential, or Unlikely. The Direct ranking applies to the most probable areas of 3D tool applicability and where users will likely see the most benefit from implementation. These are the areas where PD&E professionals have some experience or where there is clearly a benefit from 3D implementation that extends to the design phase. The Potential ranking was selected to identify the areas and deliverables with the most 3D growth potential and 3D data for these areas is generally available. However, this is new territory for most and will require exploration and guidance to fully realize the design and presentation benefits of 3D. The Unlikely ranking identifies those areas and deliverables for which there is limited or no 3D applicability. The application of 3D to these subjects is limited to certain circumstances and these circumstances are of little benefit to subsequent work phases.

Table 4-2 – 3D Applicability by PD&E Deliverable Type

Deliverable Type	Applicability to 3D
• Concept plans ○ Plan Profile Sheets • Base Maps • Typical Sections • Graphic Typical Sections • Renderings • Flythroughs • Geotechnical Report	Direct 3D applicability

• Utility Impact Assessment Report
• Railroad Coordination
• Pond Siting Report
• Location Hydraulics Report
• Project Traffic Analysis Report (or Traffic Memo)
    ○ Calibration Report
    ○ Project Traffic Forecasting
    ○ Alternatives Analysis
    ○ Interchange Documents
• Bridge Hydraulics Report
• Contamination Screening Evaluation Report
• Traffic Noise Study Report
	Potential 3D applicability

• Design Variations • Natural Resources Evaluation Report • Air Quality Technical Memorandum • Sociocultural Evaluation Technical Memorandum • Conceptual Stage Relocation Plan • Cumulative Effects Report • Cultural Resources Assessment Survey Report • Environmental Document (Environmental Assessment/Environmental Impact Statement/Type II Categorical Exclusion/State Environmental Impact Report) • Re-Evaluation • Comments and Coordination Report	Unlikely 3D applicability

Table 4-3 – 3D Applicability by PD&E Manual Section

Part 2: Topics and Analysis	Applicability to 3D
• 02- Traffic Analysis	Potential 3D applicability
• 03- Engineering Analysis 　○ Drainage / Stormwater Management 　○ Floodplain Analysis 　○ Landscaping 　○ Existing Bridge Condition Display 　○ Build Alternatives Typical Sections 　○ Complete Streets Display 　○ Interchanges	Direct 3D applicability
• 05- Aesthetic Effects 　○ Outdoor Advertising Opportunities 　○ Roadway/Directional Signage 　○ Trees/Canopies 　○ Changes in Viewshed	Direct 3D applicability
• 12- Wild and Scenic Rivers	Potential 3D applicability
• 18- Highway Traffic Noise 　○ Noise Receptors and Noise Walls	Potential 3D applicability
• 20- Contamination 　○ Display locations, depths and extent of contaminated soils 　○ Groundwater contamination plume	Potential 3D applicability
• 21- Utilities and Railroads 　○ Utilities: Some metropolitan areas may have 3D modelling of their above and below ground utilities. 　○ Railroads: Railroads and crossings can be displayed in 3D to provide perspective of existing, proposed and future roadway and overpass characteristics.	Direct 3D applicability
• 01- Project Description and Purpose and Need • 04- Sociocultural Effects Evaluation • 06- Farmland • 07- Section 4(f) Resources • 08- Archaeological and Historical Resources • 09- Wetlands and Other Surface Waters • 11- Water Resources • 13- Floodplains • 14- Coastal Zone Consistency • 15- Coastal Barrier Resources	Unlikely 3D applicability

Part 2: Topics and Analysis	Applicability to 3D
• 16- Protected Species and Habitat • 17- Essential Fish Habitat • 19- Air Quality	

4.3 Software Tools and PD&E Deliverables Matrix

Based on the software tools listed in Table 4-1 and the PD&E deliverables in Table 4-2 that were determined to have Direct or Potential 3D Applicability, a matrix of the applicability of the generic tool groupings to the various PD&E deliverables having potential benefit to the design phase is provided as **Table 4-4**. Please refer to the tool groupings following Table 4-1 for a summary of tool group capabilities.

Table 4-4 – Software Tools and PD&E Deliverables Matrix

PD&E Deliverables	Traditional 2D CAD Platforms	Detailed 3D CAD Platforms	Geospatial Database Software	Rapid 3D Modeling Tools	Graphic Layout and Presentation
Concept Plans (including Alternatives Evaluation)	X	X	X	X	
Base Maps	X	X	X	X	
Typical Sections	X	X			
Graphical Typical Sections					X
Renderings		X		X	X
Flythroughs		X		X	X
Utility Impact Assessment Report	X	X	X		
Railroad Coordination	X	X		X	
Pond Siting Report	X	X			
Location Hydraulics Report		X			
Project Traffic Analysis Report		X		X	X
Bridge Hydraulics Report	X	X			
Contamination Screening Evaluation Report	X	X	X		
Noise Study Report	X	X	X		
Geotechnical Report	X	X	X		

5 PD&E Example Workflows

The delivery of 3D in PD&E can be expressed both in software-specific workflows or as software-agnostic workflows where no specific software vendor is identified. Since the FDOT supports multiple platforms and with an industry focus on Open BIM standards and deliveries, this Guidebook will provide example workflows that are common to the platforms currently supported by the department. It is anticipated that training guides and learning materials will need to be produced in the future to further support adoption where gaps exist in current standards. See Section 7 for more detail.

5.1 Overview of the PD&E Workflow Process and 3D Applicability

As pictured in **Figure 5-1**, the typical PD&E workflow begins with data collection and progresses through several steps ultimately culminating in reports. This guidebook seeks to challenge how that process is accomplished today specifically as it relates to 3D. The "Improvements for the Future" section (green shapes) simply expands what practitioners have done traditionally to embrace 3D content and deliverables more fully. Note that the traditional PD&E workflow is 2D-centric. There is some 3D, but it typically has little engineering value since it is developed primarily for visualization. Improvements for the future are detailed below in five steps. In this context, the "Future" is now.

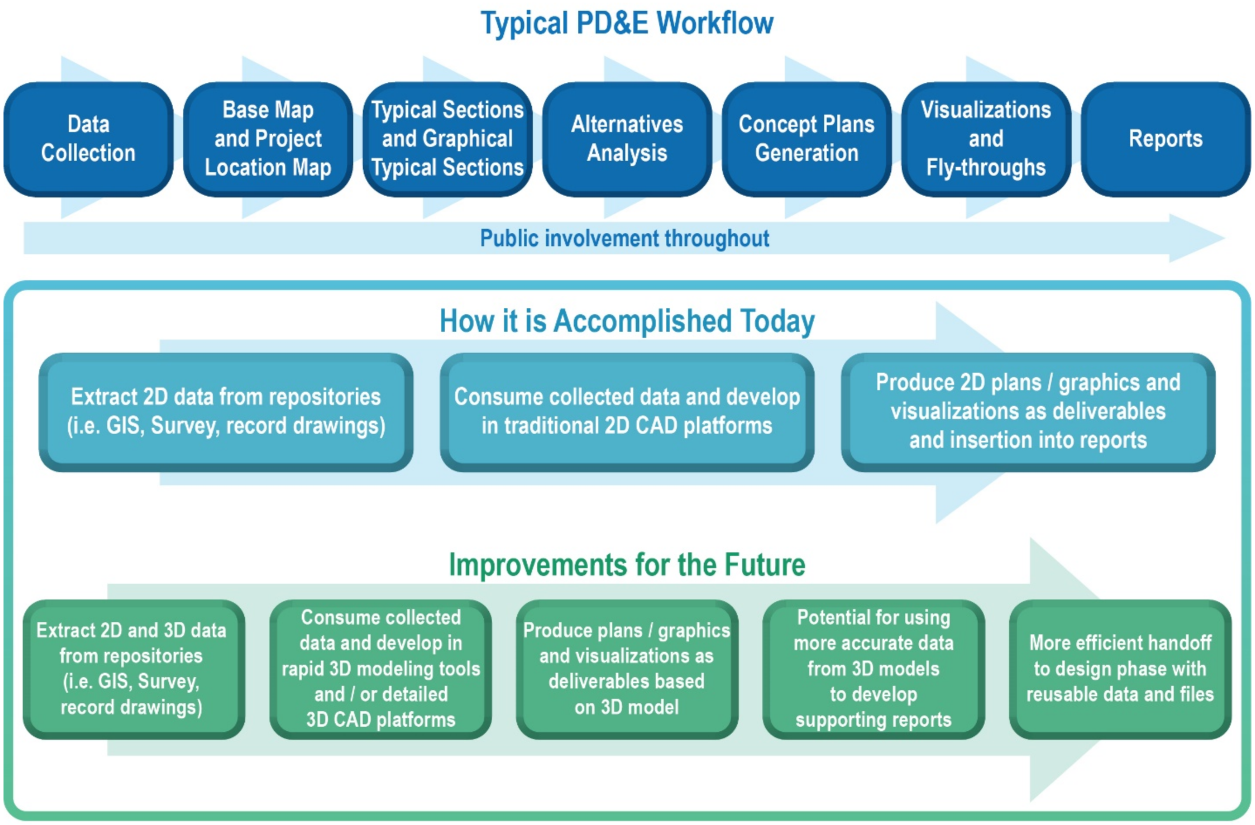
- <u>Step 1</u>: *Extract 2D & 3D Data from Repositories* – Refer to Section 3 for sources that can be explored for content including 3D elevation data. Some examples include data from Rapid 3D Modeling Tools which locates and provides available terrain information for a particular project area, USGS elevation data downloads, and field survey data.
- <u>Step 2</u>: *Consume and Develop Collected 3D Data* – For quick alternatives analysis and quantities, Rapid 3D Modeling Tools are recommended. These tools are rather easy to learn and do not require extensive training or CADD skills to produce engineering content that is more accurate in most cases than traditional 2D-only methods. Content produced in these tools is also visualization-ready as they have capture, animation, and video fly-through capabilities built into or provided alongside the applications.

  Once an alternative has been selected, Detailed 3D CADD Platforms are recommended as they provide the most seamless transitions into the Design Phase. If field survey data is not available, the surfaces from the Rapid 3D Modeling Tools can be exported and consumed by the Detailed 3D CADD Platforms. Note that it is possible to utilize Detailed 3D CADD Platforms during alternatives analysis, but that workflow will be more time consuming than advisable for work that will not be progressed. However, both options are acceptable.
- <u>Step 3</u>: *Produce Plans & Graphics* – The plans, graphics, and visualizations should be based on the 3D model content developed in the previous step. These

deliverables should utilize and comply with the FDOT CADD Manual, FDOT Design Manual (FDM), and the allowable adjustments for PD&E described in Section 2.2 of this guidebook. Special consideration should be giving to Part 9 of the FDM which covers NexGen Plans Production. Part 9 is tentatively scheduled to be completely built out by Fall 2022. However, several important chapters are already available for use. PD&E plans production should align with Part 9 where practical to support hand-offs to the design stage that meet current standards. This can result in reduced rework downstream.

- Step 4: *Consider 3D Potential to Support Report Development* – 3D tools and development can support both analysis and documentation. The extent to which this is practical will vary from project to project. However, 3D earthwork and impacts calculations are prime examples. Other 3D potential includes more accurate pavement and wall quantities which implies more accurate cost estimates. The method to accomplish quantity take-offs will vary depending on the tool selected. However, the Rapid 3D Modeling Tools and the Detailed 3D modeling Platforms both provide this functionality. Refer to **Appendix A** for more workflow process improvement ideas and efficiencies.
- Step 5: *Efficient Handoff to Design Phase* – This is the culmination, benefit, goal, and outcome of all the previous efforts and activities. The success and growth of PD&E in this area especially regarding 3D aligns PD&E development with the BIM vision of the Department.

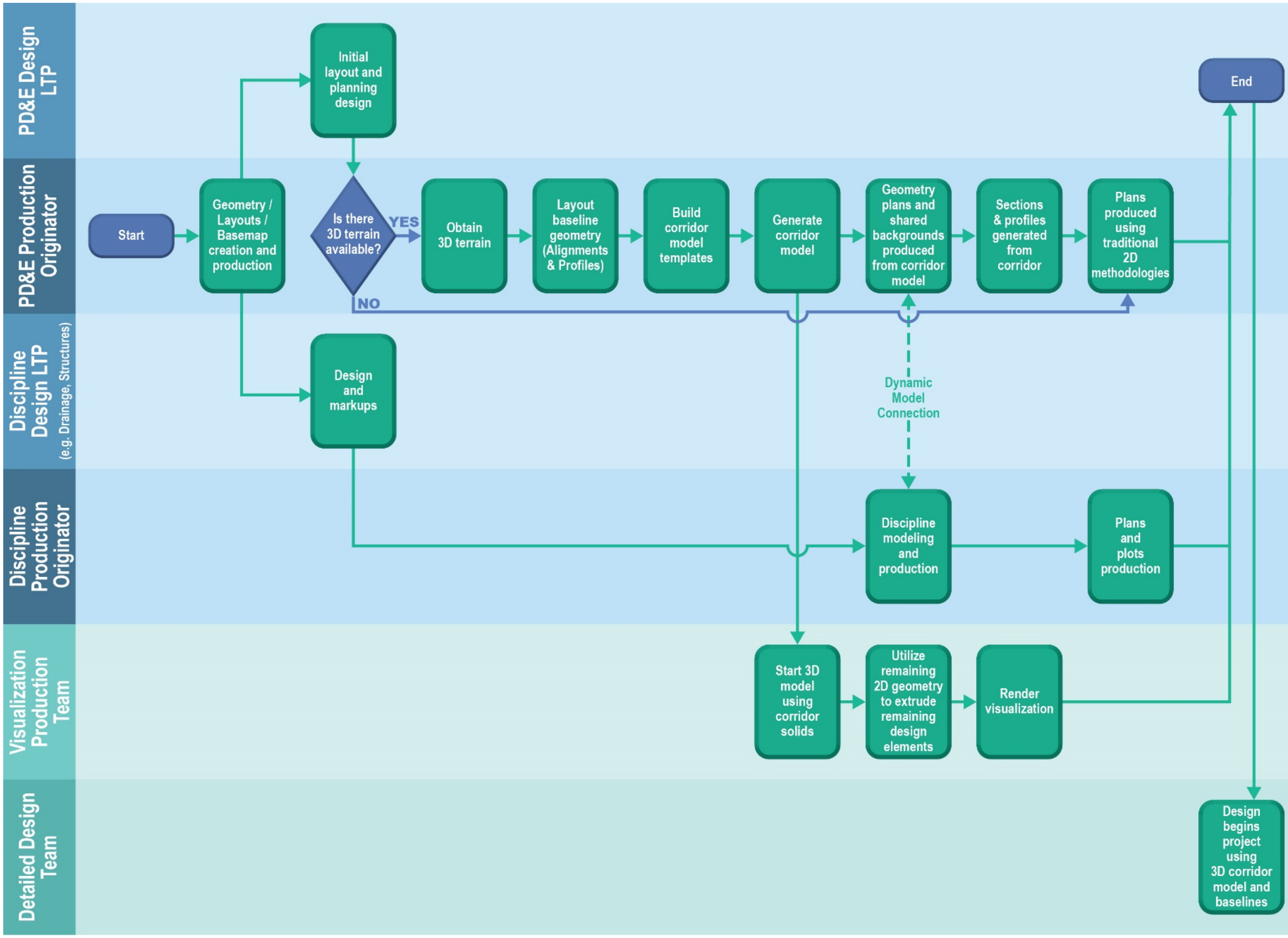
Figure 5-1 – Typical PD&E Workflow Comparison



5.2 3D Delivery in PD&E Workflow

A high-level workflow is shown below to assist practitioners in process decision making, as depicted in **Figure 5-2**. Each row represents a unique persona, role, or team; not all roles will be utilized on every project, but the potential is there to expand and customize it for specific project needs. Notice that the key question surrounding the ability to leverage 3D is depicted as a blue-colored diamond. If there is 3D terrain available for the project area, several 3D capabilities are opened including the development of 3D alignments and the generation of corridors. The answer regarding the availability of terrain is almost always yes. The next question becomes, what is the quality of the data? Most of the terrain data sources available offer low, medium, and high-quality elevation surface data. Quality means accuracy which is typically represented by the distance between the ground shots.

Figure 5-2 – PD&E Delivery Workflow Process

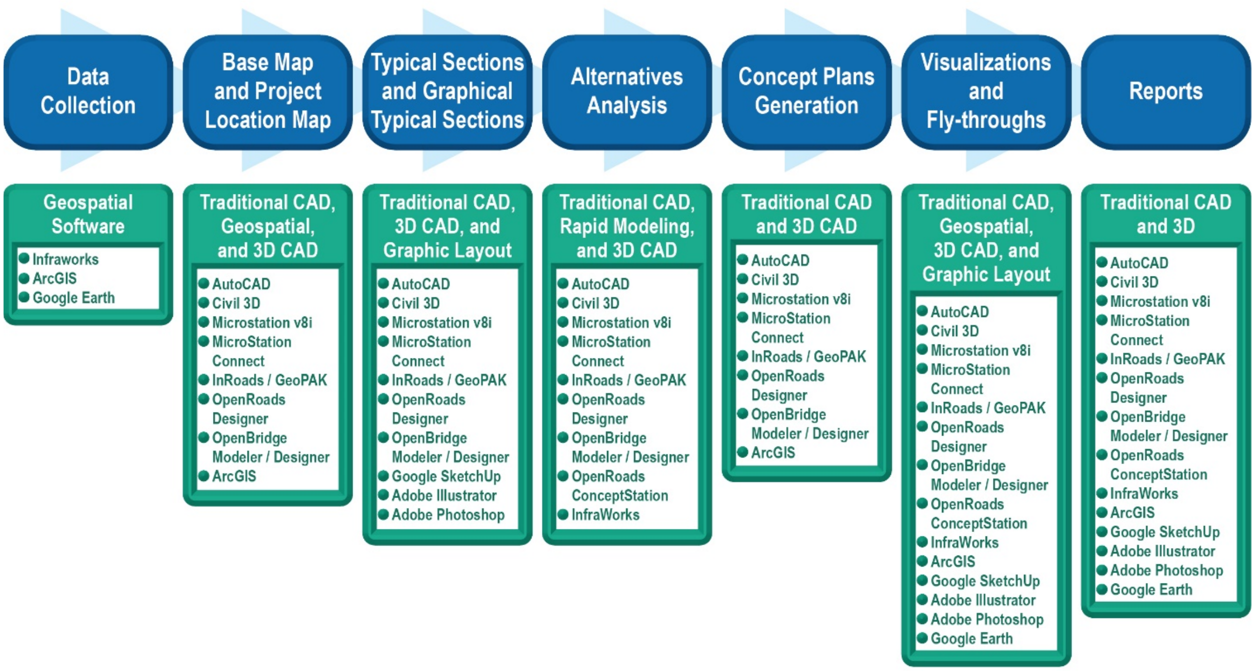


The PD&E team must determine if the level of accuracy available is suitable for their project needs. However, teams should not be overly concerned here as having some form of surface data is better than no surface data at all. Note that whatever is produced by the PD&E team is all pushed forward for use by the detailed Design Team. This is essentially the hand-off to the Design Phase.

5.3 Example Software Tools & Workflow

This section provides a graphical resource (**Figure 5-3**) to align the potential tools discussed earlier with the established PD&E process. Notice that there are several options and tools that can be leveraged under a given process. It should also be noted that there are a few Bentley application on the list that are considered 'Expiring Technology' and are no longer actively supported by Bentley nor FDOT CADD Office. Those applications are MicroStation v8i, InRoads, and GeoPAK. They are provided for reference as the technology uses are still relevant if the PD&E project was begun before the Department migrated to Bentley CONNECT applications.

Figure 5-3 – PD&E Process 3D Software Tools



6 Incorporating 3D into PD&E Scope, Schedule, and Budget

6.1 PD&E Scope

FDOT currently has 3D Modeling Scope language for the Design Phase in Section 36. This language can be modified to better align with the needs and limitations of PD&E. The suggested modifications are included below for consideration.

- The CONSULTANT shall analyze and document Roadway Tasks in accordance with all applicable manuals, guidelines, standards, handbooks, procedures, and current design memorandums.
- The CONSULTANT shall deliver all master design files, 3D surface design models, and all supporting digital files for the development of the concepts and exhibits.
- The CONSULTANT shall prepare a 3D model using the latest FDOT software in accordance with the FDOT CADD Manual and the 3D in PD&E Guidebook. Optionally, the CONSULTANT may use Rapid 3D Modeling Tools as described in the 3D in PD&E Guidebook. Includes all efforts required for developing files for 3D in PD&E deliverables. 3D in PD&E deliverables include XMLs of alignments and profiles, and existing terrain models (in XML, TIN, or DGN formats).
- The CONSULTANT shall establish and develop cross section design files in accordance with the FDOT CADD manual and FDOT Design Manual. Includes all work required to establish and utilize intelligent/automated methods for creating cross sections including determining the locations for which all cross sections will be shown, as well existing and proposed features (i.e., pavement, slopes, curbs, etc.), R/W lines, and other labeling.

6.2 Schedule

Schedule impacts and limitations are always an important consideration. Developing 3D may negatively impact traditional project schedules especially for those groups that are entirely new to 3D production. There will also likely be marginal impacts for those groups who are extending 3D use cases beyond what is required for standard design project.

Project scheduling should be negotiated to account for the implementation of 3D. 3D items should be clearly scoped to allow sufficient time to complete 3D tasks during the allotted time. Department PD&E Project Managers should encourage teams to adopt and implement 3D workflows, especially those tools and processes already outlined by the CADD Office for standard design.

Where practical, PMs should encourage and support 3D implementation in PD&E where there is potential for advancement and benefits for downstream users. The potential schedule impacts in PD&E should be recovered or reduced in the Design phase by reducing the work required to recreate the PD&E project design in the Detailed 3D Modeling Platform during Design phase activities.

6.3 Budget

Budget is a major concern for the implementation of 3D in PD&E. A workshop was held in preparation for the development of this guidebook, and budget was top of mind for several participants. They expressed that PD&E scopes are seldom liberal and there is little to no budget for "extras". It's important for FDOT PD&E PMs to acknowledge the need in the Staff Hour Estimate to include sections and line items for 3D model development.

7 Potential Future Process Improvements

This guidance document is only the first step toward 3D in PD&E process improvements. Some potential future process improvements are included below. Please reach out to your District Environmental Management Office or Central Office Office of Environmental Management to make additional suggestions for process improvements.

- Expansion of the Guidance Document Content - As the PD&E community adopts this guidance document, the guidebook will be revisited to include additional topics and clarifications borne out of implementation.
- Custom FDOT Templates for Rapid 3D Modeling Tools - The guidance document encourages the use of these tools, but there are currently no published, FDOT-specific templates or assemblies for ConceptStation and InfraWorks. This will aide adoption of the processes by allowing for faster implementation of FDOT-specific 3D templates.
- Tool-Specific Training - The scope of this document is to provide the "What" and introduce practitioners to the "How". The "how" will require the development of training guides and/or video instructions to help PD&E teams navigate the development 3D in PD&E where clear instructions do not currently exist.
- In-Depth Exploration of Potential 3D Applicability Items - This guidance document is primarily focused on items with Direct 3D Applicability and simply identifies those with Potential 3D Applicability. These are items where the concept of moving into 3D is understood by most but implemented by only a few. In future releases the Potential items will be studied and directions for leveraging 3D for those deliverables.

8 References

1. Utilizing 3D Digital Design Data in Highway Construction – Case Studies, Figure 3: Chart. Continuing challenges to implementing 3D modeling. Publication No. FHWA-HIF-17-027, April 2017, pg. 6 Utilizing 3D Digital Design Data in Highway Construction - Case Studies (dot.gov)
2. What is a PD&E Study? | FDOT District 7 Studies (fdotd7studies.com)
3. CII - Topic-Summary-Details (construction-institute.org)
4. FDOT CADD Manual, In reference to the FDOT Design Manual (FDM) for FDOTConnect and FDOT2021C3D, published August 21, 2020 caddmanualconnect-2021c3d.pdf (windows.net)

Appendix A – PD&E Process Improvements

Figure A-1 – Challenge Typical PD&E Workflow Processes

Typical Workflow

PD&E Process	Description	Process Improvement Challenge
Data Collection	• GIS Data collection- project specific data layers	• *What could change in data collection efforts to allow for 3D analyses and deliverables? Could we expand the use of available data from common repositories?*
Project Location and Base Maps	• Compile data into understandable maps to begin alternatives development	• *What programs could be used to develop 3D base maps? What changes in the workflow?*

Typical Section Development	• Preliminary Typical Sections developed to determine ROW limits and footprint of impacts
	  • CAD generated Typical Section Package
	  • Graphic Typical Sections
		• *Could a 3D model be used to develop more accurate typicals?*
		• *What tools could be used for 3D typicals?*

Alternatives Analysis	• Adding alternative(s) to the base maps • Calculating alternatives impacts • Refinements of alternatives and alignments	• *Could the use of 3D make the alternatives analysis process more efficient? Could we utilize the 3D model to improve the accuracy of quantity estimates?*

Concept Plan Development	• Develop preliminary concept plans of one or more alternatives to refine impacts and provide constructability information
	  • Plan & Profile sheets
	  • Cross Sections
		• *Could we use 3D to make Plan & Profile Sheets and Cross Section Sheet development more efficient? Could all of this be linked to the 3D model and updated automatically?*

Public Involvement Materials	• Renderings • Fly-throughs	• *Could we use the 3D model to create more accurate renderings and fly-throughs?*

Figure A-2a – PD&E Process Improvement

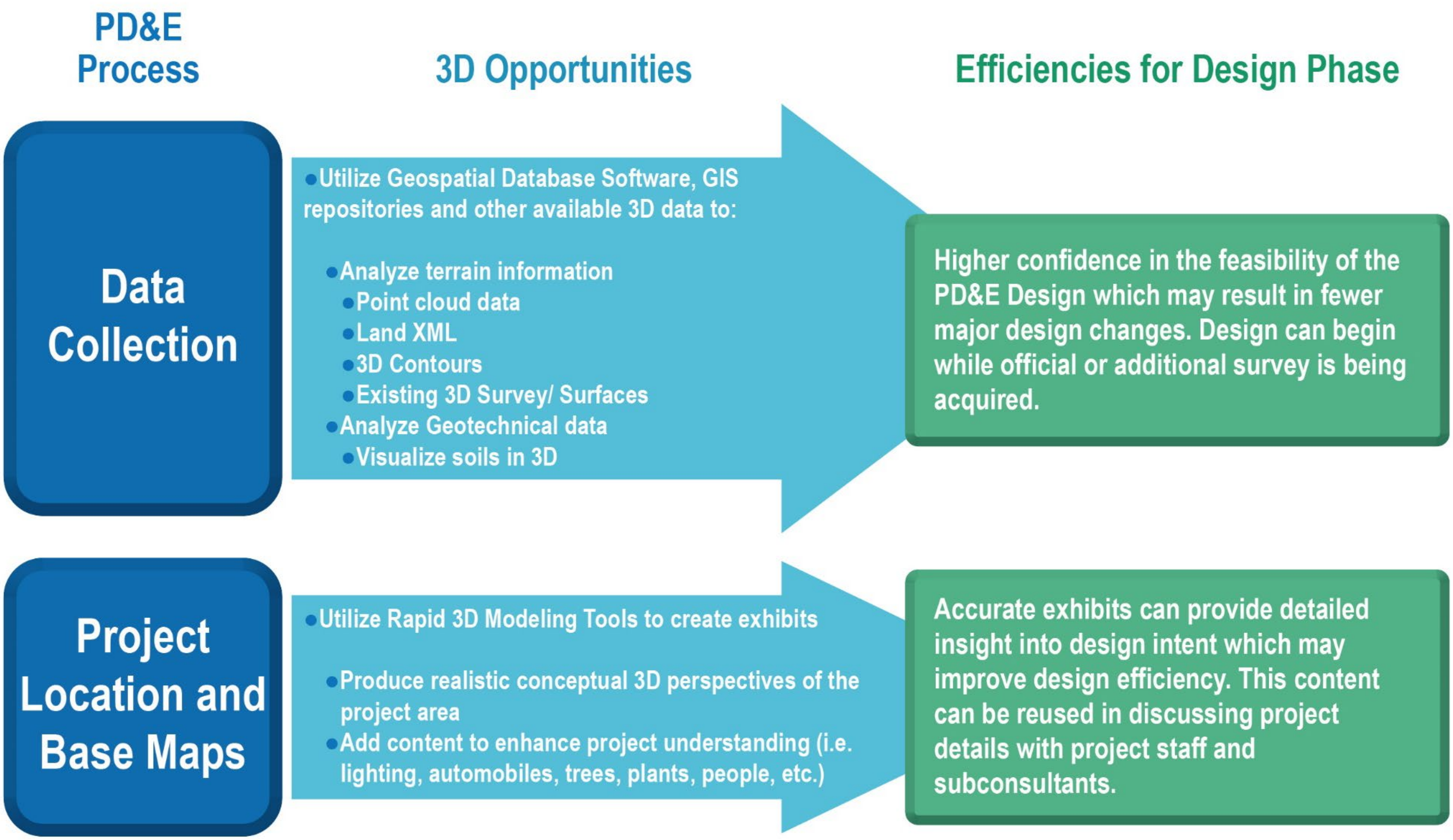


Figure A-2b – PD&E Process Improvement

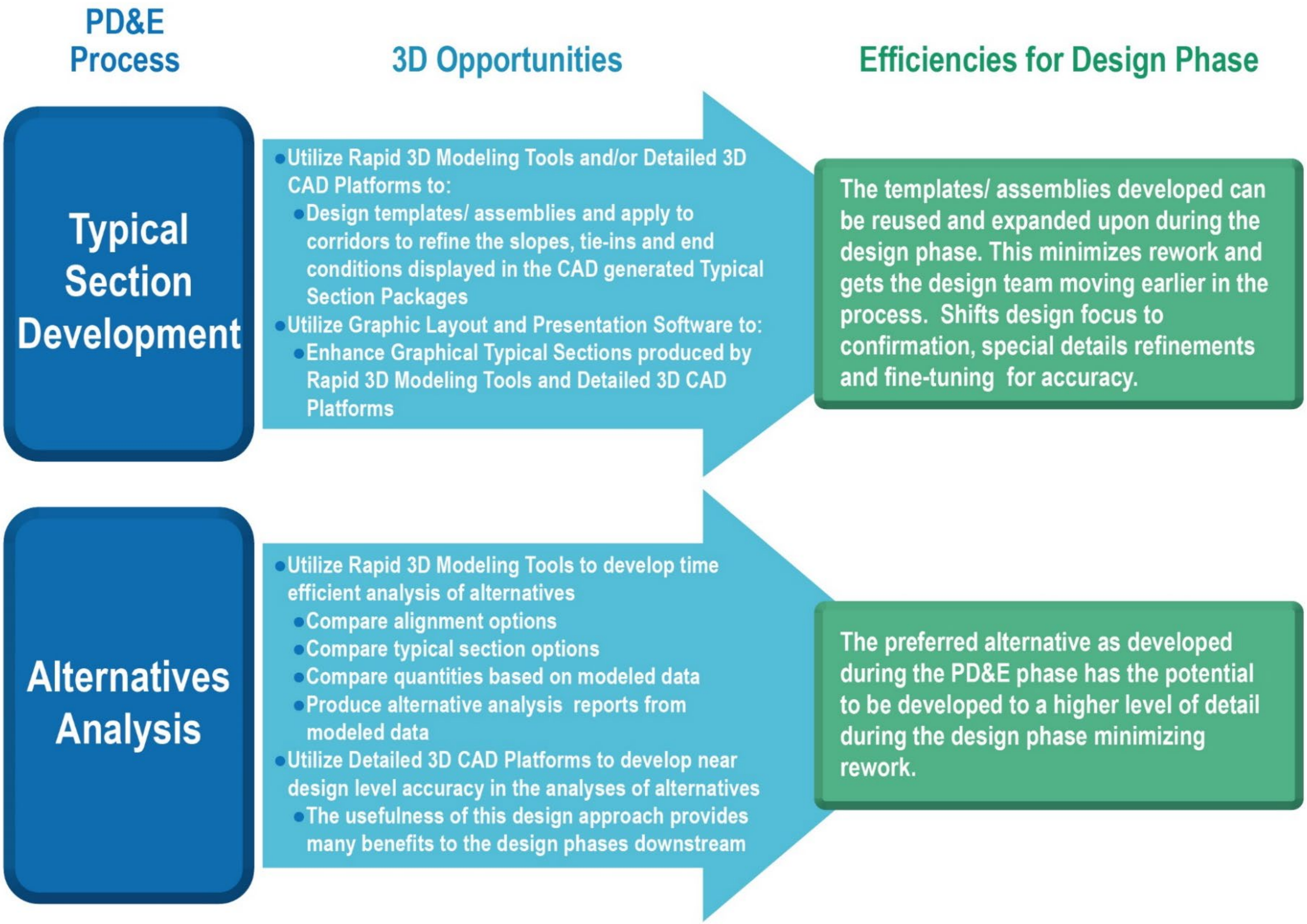


Figure A-2c – PD&E Process Improvement

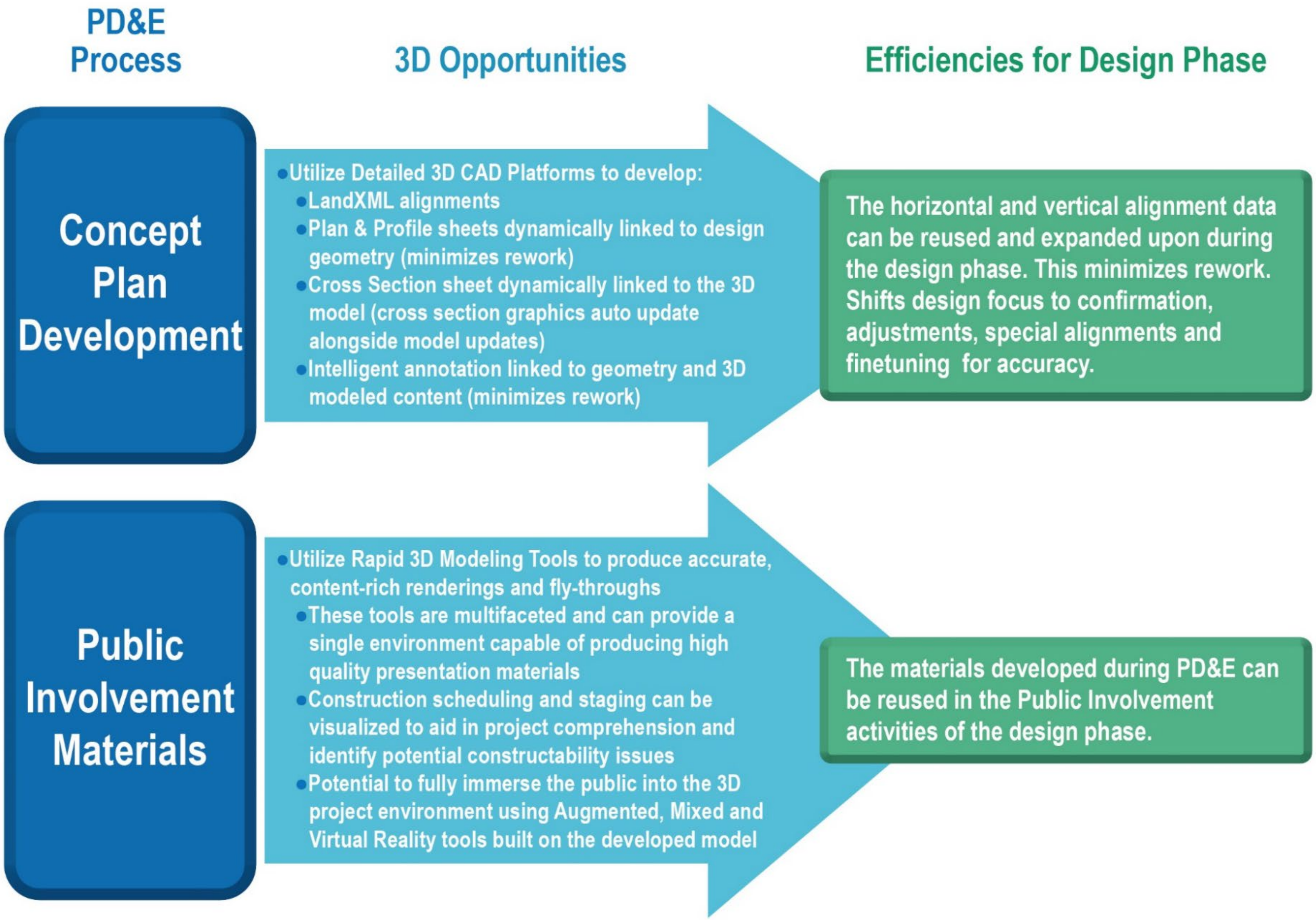


Figure A-2d – PD&E Process Improvement