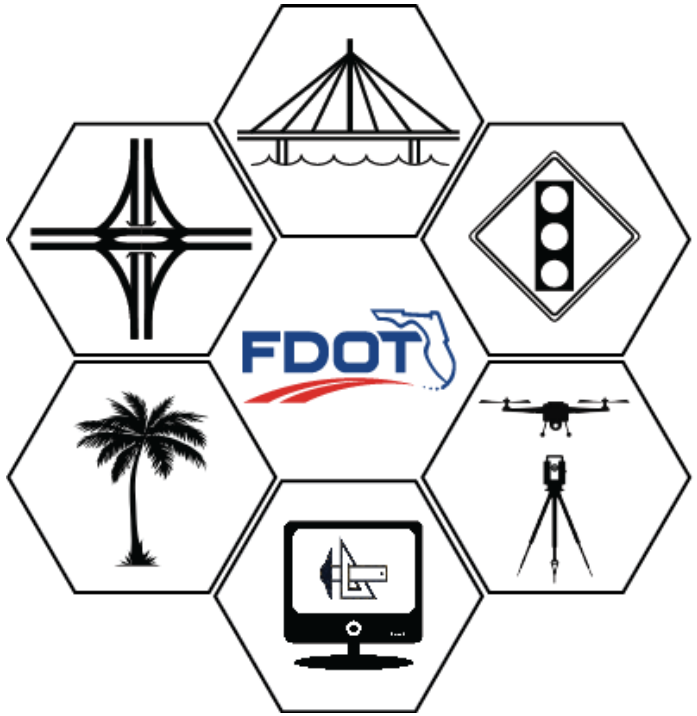


FDOT TRANSPORTATION SYMPOSIUM 2019

Project Management for 3D Engineered Models

Vern Danforth, Mariano Amicarelli, and Bobby Bull

Outline

Objectives & Overview of Concepts

Scoping

QA/QC & QARs

Examples of Projects

FDOT 3D INITIATIVES

Mission

The FDOT 3D Initiatives mission is to move the department toward designing and delivering integrated 3D models.

3D Design Objectives

1. To provide a higher quality of design intent for:
   - reduced cross component conflicts
   - better clash detection
   - improved constructability
   - less field design changes and delays

3D Design Objectives

2. To provide for Automated Machine Guidance (AMG) in construction of earthwork, paving, resurfacing, and concrete

3. To provide digital model the Legal Contract Document, digitally signed by the EOR

4. To support Construction, Business and Asset Information Modeling data (CIM/BIM/AIM)

What are 3D Engineered Models and 3D Deliverables?

An important place to start

Working definition of 3D Models and 3D Deliverables

- 3D geometries in a basic CADD format or LandXML*
- Files extracted from a model used for AMG

*A LandXML file is a non-proprietary file format that stores civil/survey data making it easier to share surfaces between different programs.

What makes a deliverable 3D ?

No longer a 2D representation of a plan set in drawings, but rather digital data files containing functional 3D geometry of the project

FDOT TRANSPORTATION SYMPOSIUM

3D DELIVERABLES SUPPORTING AMG for 3D PROJECTS *(Store in project folder: 3DDeliverables)*		
Category	**File Name**	**Description**
Design Alignments and Profiles	AMG-ALGN##.xml	All Alignments and Profiles exported from the \Roadway\ALGNRD, PROF or model files and \Roadway\DSGNRD or CORRRD files in LandXML format.
2D Proposed Planimetrics Design	AMG-2DSGN##.dwg/dgn	2D proposed Roadway design exported from the \Roadway\DSGNRD file. (Production of this file for construction is at the designer's discretion.)
	AMG-2DRPR##.dwg/dgn	2D proposed Drainage design exported from the \Roadway\DRPRRD file. (Production of this file for construction is at the designer's discretion.)
	AMG-2PDPL##.dwg/dgn	2D proposed Pond design exported from the \Roadway\PDPLRD file. (Production of this file for construction is at the designer's discretion.)
2D Existing Survey *Note: These are being considered to merge into a single survey Planimetrics file.*	AMG-2TOPO##.dwg/dgn	2D existing Topography exported from the \Survey\TOPORD file. (Production of this file for construction is at the designer's discretion.)
	AMG-2DREX##.dwg/dgn	2D existing Drainage exported from the \Survey\DREXRD file. (Production of this file for construction is at the designer's discretion.)
	AMG-2UTEX##.dwg/dgn	2D existing Utilities exported from the \Survey\UTEXRD file. (Production of this file for construction is at the designer's discretion.)
3D Existing Survey *Note: Single survey Planimetrics file.*	AMG-3SURFACEEX##.xml	3D existing terrain surface to be exported from the \Survey\GDTMRD file as LandXML format. (Production of this file for construction is at the designer's discretion. This file will be produced if the 3D Existing Surface dwg/dgn file(s) are not produced.)
3D Proposed Surfaces_	AMG-3SURFACEPR##.xml	3D proposed finished (top) surface to be exported as LandXML format from the \Roadway\MODLRD file.
	AMG-3SURFACEEW##.xml	3D proposed finished (bottom) surface to be exported as LandXML format from the \Roadway\MODLRD file. This file will be used to generate surface to surface earthwork volumes.
3D Proposed Break Lines	AMG-3DSGN##.dwg/dgn	3D proposed Roadway break lines exported from the 3D model.

When to Use 3D & Why

Process and Philosophy

FDOT Guidelines and Documentation

- Project Suite Ent. Ed. – Work Program Database: ***Item Segment Group "3DPR"***
- FDOT Design Manual – ***FDM 111***
- Scope of Services – ***Activity 36***

FDOT TRANSPORTATION SYMPOSIUM

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.

Scope of Services

36 3D MODELING

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 plans as required in the DEPARTMENT's CADD Manual.

The CONSULTANT shall prepare a 3D model using the latest FDOT software in accordance with the FDOT CADD Manual. Includes all efforts required for developing files for 3D deliverables supporting automated machine guidance for design models. This includes importing survey data and creation of existing 3D surface features and models, and developing proposed corridor models with necessary detail of features to depict the proposed project in 3D to comply with the DEPARTMENT CADD Manual.

The CONSULTANT shall add detail to the corridor and design model for 3D design. Includes many elements that contribute to this including but not limited to slope transitions, typical section transitions, changes in pavement depth, berms, swales/ditches, and other feature transitions. Extra corridor structure leads to extra assemblies, extra targeting, etc. Dynamic relationships must be maintained. Frequency must be increase to achieve a useable model.

The CONSULTANT shall create an accurate roadway design model which includes modeling the intersections.

The CONSULTANT shall provide sufficient detail in the 3D model to account for driveways, Guardrail Terminal Locations, etc. and other graded areas where surface triangles are delivered as break lines.

Scope of Services

36.1 Phase I 3D Design Model (30% Plans)

The CONSULTANT shall prepare, submit and present for approval by the DEPARTMENT, 30% complete 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).

36.2 Phase II 3D Design Model (60% Plans)

The CONSULTANT shall prepare, submit and present for approval by the DEPARTMENT, 60% complete 3D model, comprised of, but not limited to: Modification of 30% model to update the model to comply with changes based on 30% 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.

[List optional services to be included, i.e. Curb Ramps, Closed Drainage Network, Bridge Modeling, Bridge Abutment, Overhead sign post/structures with foundation, Toll gantry and overhead DMS structures with foundation, proposed utilities (pressure pipe/gravity), etc.].

36.3 Phase III 3D Design Model (90% Plans)

The CONSULTANT shall prepare, submit and present for approval by the DEPARTMENT, 90% complete 3D model, comprised of, but not limited to: Modification of 60% model to update the model to comply with changes based on 60% 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.

FDOT Design Criteria for 3D Models

Lower Range

One Typical Section and up to two edge conditions
C1 Natural or C2 Rural

Middle Range

Two Typical Sections and with two edge conditions per typical
C2T Rural Town, 3CR Suburban Residential, C3C Suburban Commercial, T4 Suburban or C4 Urban General

Upper Range

More than two typical sections and more than two edge conditions per typical
C5 Urban of C6 Urban Core

FDOT Design Criteria for 3D Models

Phase I

- All existing features model(s)
- Progress proposed corridor(s)
- No swales, utility lines, cross-overs, intersection grading, driveways, roundabouts, side roads

Phase II

- Corridor elements
  - Side ditches, medians, traffic separators, guardrail terminals, walls
- Required details
  - SMF & Floodplain Comp
  - Driveways
  - Side Road Connections
  - Intersection Grading
  - Roundabouts
  - Bridges
- Optional Details
  - Curb ramps
  - Closed drainage network
  - Bridge abutment
  - Overhead sign posts and foundation
  - Proposed utilities

Phase III

- Template transition areas
  - Shoulder transitions
  - Roadway transitions
  - Bridge approaches and end bents
- Detailed grading areas
  - Median noses
  - Retaining walls
  - Barrier walls
  - Guardrail

Phase IV

- Prepare 3D Deliverables
- Prepare AMG surfaces

FDOT Design Criteria for 3D Models

Phase I

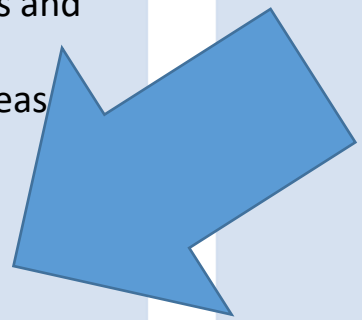
- All existing features model(s)
- Progress proposed corridor(s)
- No swales, utility lines, cross-overs, intersection grading, driveways, roundabouts, side roads

Phase II

- Corridor elements
  - Side ditches, medians, traffic separators, guardrail terminals, walls
- Required details
  - SMF & Floodplain Comp
  - Driveways
  - Side Road Connections
  - Intersection Grading
  - Roundabouts
  - Bridges
- Optional Details
  - Curb ramps
  - Closed drainage network
  - Bridge abutment
  - Overhead sign posts and foundation
  - Proposed utilities

Phase III

- Template transition areas
  - Shoulder transitions
  - Roadway transitions
  - Bridge approaches and end bents
- Detailed grading areas
  - Median noses
  - Retaining walls
  - Barrier walls
  - Guardrail
- **Preliminary 3D Deliverables**
- **Preliminary AMG surfaces**



Phase IV

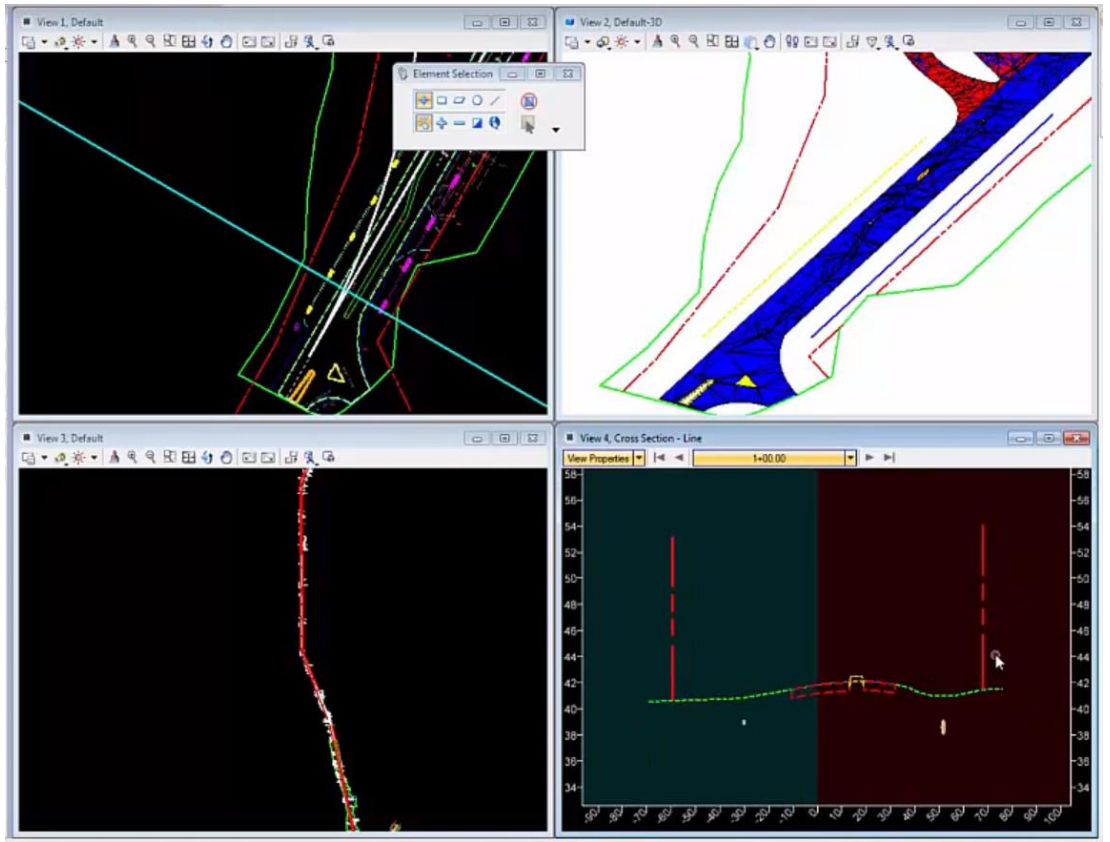
- Prepare 3D Deliverables
- Prepare AMG surfaces

FDOT Design Criteria for 3D Models

Phase I

- All existing features model(s)
- Progress proposed corridor(s)
- No swales, utility lines, cross-overs, intersection grading, driveways, roundabouts, side roads

Existing Features Modeling	• 25 – 40 hrs.
Lower Range	• 8 – 12 hrs. per mile per alignment or corridor
Middle range	• 10 – 20 hrs. per mile per alignment or corridor
Upper Range	• 18 – 35 hrs. per mile per alignment or corridor



FDOT Design Criteria for 3D Models

Phase II

- Corridor elements
  - Side ditches, medians, traffic separators, guardrail terminals, walls
- Required details
  - SMF & Floodplain Comp
  - Driveways
  - Side Road Connections
  - Intersection Grading
  - Roundabouts
  - Bridges
- Optional Details
  - Curb ramps
  - Closed drainage network
  - Bridge abutment
  - Overhead sign posts and foundation
  - Proposed utilities

Corridor Elements

Lower Range
- 4 – 10 hours per mile per alignment or corridor

Middle Range
- 6 – 12 hours per mile per alignment or corridor

Upper Range
- 10 – 35 hours per mile per alignment or corridor

Required Details

SMF / Floodplain Comp
- Low (1-4hrs each) Mid (4-8 hrs. each) Up (8-12 hrs. each)

Roundabouts
- Single lane: 20 – 48 hrs. each
- Multi lane: 28 – 88 hrs. each

Driveways
- 1 – 8 hrs. each (Commercial high range)

Intersection Grading
- 16 – 48 hrs. each

Side Road Connections
- 4 – 8 hrs. each

Bridge Model
- 1 – 80 hrs. each

Optional Details

Curb Ramps
- 1 hr. new construction
- 1-3 hrs. RRR safety modifications

Closed Drainage Network
- 1 – 4 hrs. per node (manhole or inlet)

Bridge Abutment
- 1 – 40 hrs. each

Overhead Sign / Foundation
- 0.5 – 3 hrs. per sign structure

Proposed Utilities
- Pressure: 2 – 12 hrs. per mile
- Gravity: 1 – 4 hours per node

Template and Assembly Development (Task 36.6)
- 10% of Phase I and II total hours

FDOT Design Criteria for 3D Models

Phase II

- Corridor elements
  - Side ditches, medians, traffic separators, guardrail terminals, walls
- Required details
  - SMF & Floodplain Comp
  - Driveways
  - Side Road Connections
  - Intersection Grading
  - Roundabouts
  - Bridges
- Optional Details
  - Curb ramps
  - Closed drainage network
  - Bridge abutment
  - Overhead sign posts and foundation
  - Proposed utilities

Cross Section Design Files

Lower Range

- 20 – 40 hours per mile

Middle Range

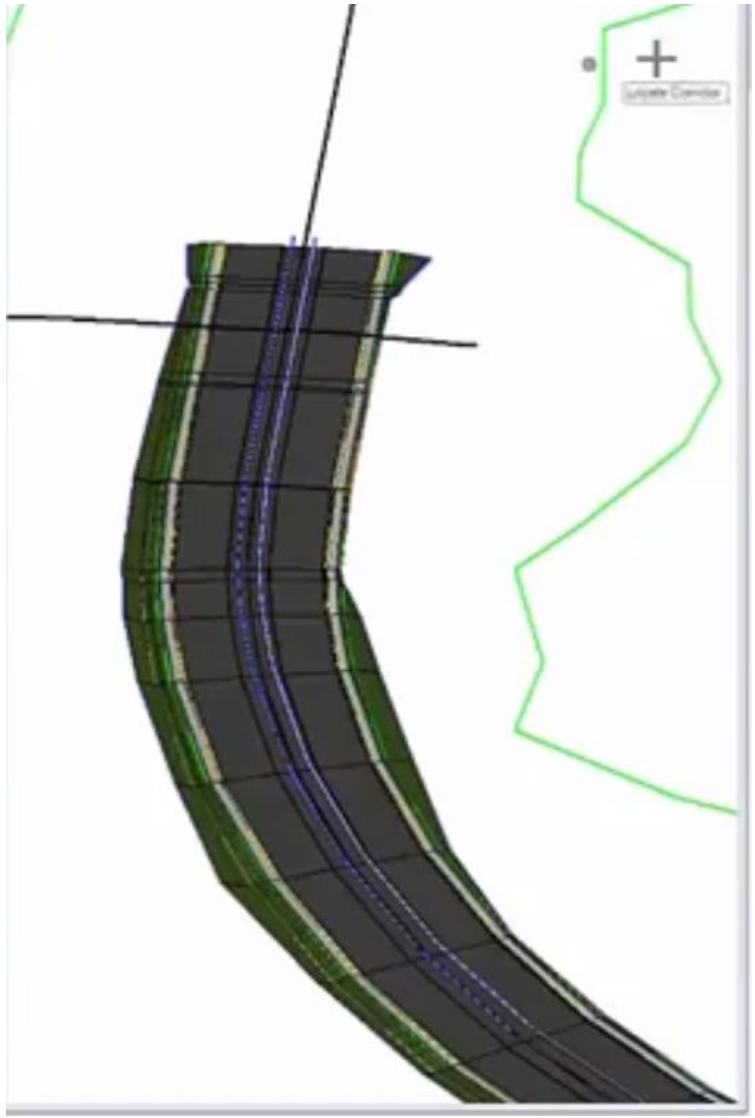
- 30 – 60 hours per mile

Upper Range

- 50 – 80 hours per mile

SMF / Floodplain Comp

- 8 – 18 hours each



FDOT Design Criteria for 3D Models

Phase III

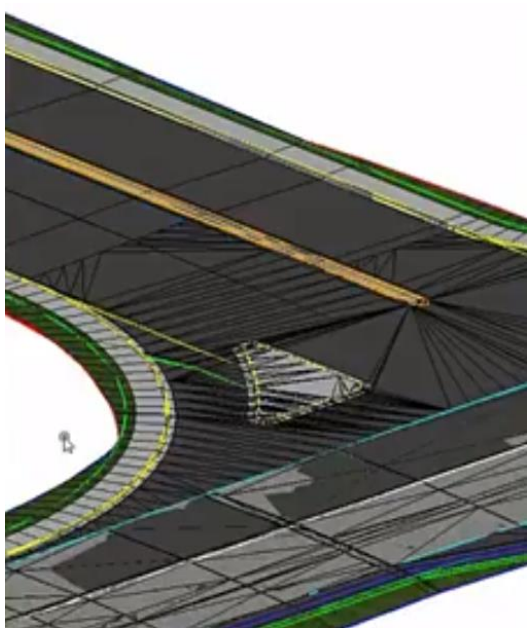
- Template transition areas
  - Shoulder transitions
  - Roadway transitions
  - Bridge approaches and end bents
- Detailed grading areas
  - Median noses
  - Retaining walls
  - Barrier walls
  - Guardrail

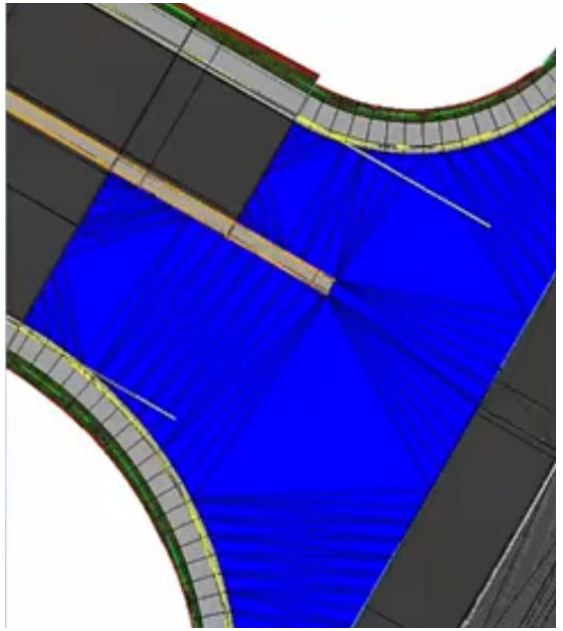
Lower Range

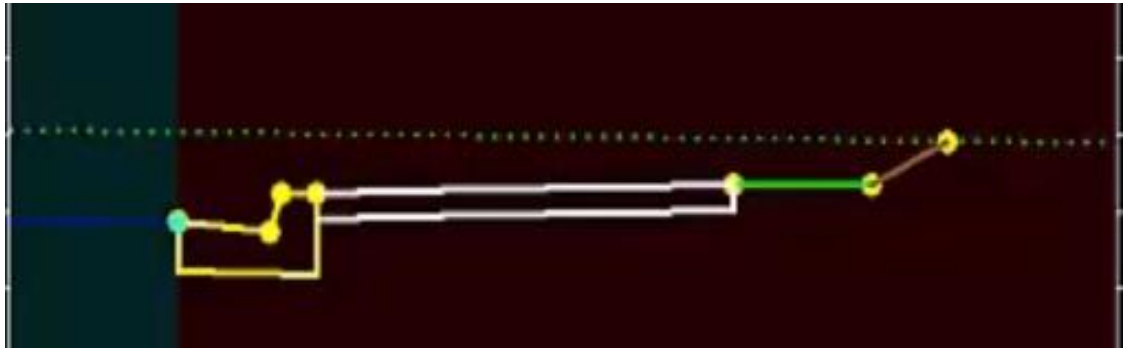
10 hrs. per mile per alignment or corridor

Upper Range

20 hrs. per mile per alignment or corridor







FDOT Design Criteria for 3D Models

Phase IV

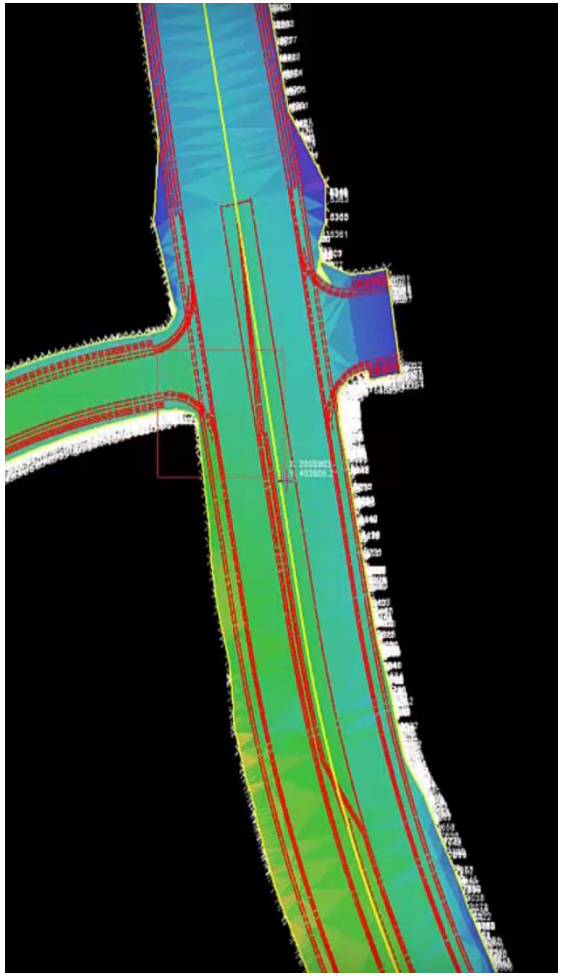
- Prepare 3D Deliverables
- Prepare AMG surfaces

Lower Range

8 hrs. per mile per alignment or corridor

Upper Range

16 hrs. per mile per alignment or corridor



Roles & Responsibilities

Key members and the QC Checklist

Quality Management Plan

FLORIDA DEPARTMENT OF TRANSPORTATION

FDOT Financial Project Number _____

Date: _____

Phase/ Submittal _____

EOR: _____

3D Engineered Model QC Checklist

Implementation Items	Originator	Reviewer	Comments
	Initials	*Initials*	
Geographical Coordinate System has be defined in the model(s)/design file			
3D Baseline/Centerline has been displayed in the model(s)			
Referenced 3D model break lines match the 2D planimetric lines			
Review of model(s) for completeness, visually: ○ Gaps along the model ○ Spikes or lips along seams ○ Overlapping components ○ Transitions between corridors and templates ○ Transitions between varying slope values ○ Slopes harmonization with existing surface ○ Median Crossovers ○ Separator Islands			
Component Depths match the Typical Section: ○ Pavement Layers ○ Driveway ○ Sidewalk ○ Concrete			
Verify Station Offset Elevation at Critical Location:			

Quality Assurance: 3D Deliverables

General Checks

- ✓Files provided are consistent with FDOT seed file

Design Alignments and Profiles (.xml)

- ✓Verify schema, working units, coordinates, stationing

2D Proposed Planimetrics Design (.dgn)

- ✓Lane configurations, Shoulder, Curbs, Barriers

3D Overview

- ✓Core modeling content **>** Terrain Models, LandXML files

3D Proposed Surfaces (.xml)

- ✓Same as alignments and profiles

Quality Assurance: 3D Proposed Design

Roadway

- ✓Check core modeling content is displayed, smooth, and consistent
- ✓Check the maximum process interval is appropriate for the facility and design speed
- ✓Check that the PGL match the controlling vertical alignment geometrics
- ✓Check that proposed components tie to 3D existing survey surface at construction limits

Drainage

- ✓Check that existing to remain and proposed drainage core modeling content is displayed (for example inlets, manholes, and pipes)
- ✓Check the plan based drainage core modeling content
- ✓Check the elevation based drainage core modeling content
- ✓Check if core modeling content of special ditches match the vertical alignment controlling geometrics

Quality Assurance: 3D Proposed Design

Structures

- ✓Check that existing to remain and proposed structural core modeling content is displayed (for example piles, piers, and beams)
- ✓Check if walls match the vertical alignment controlling geometrics

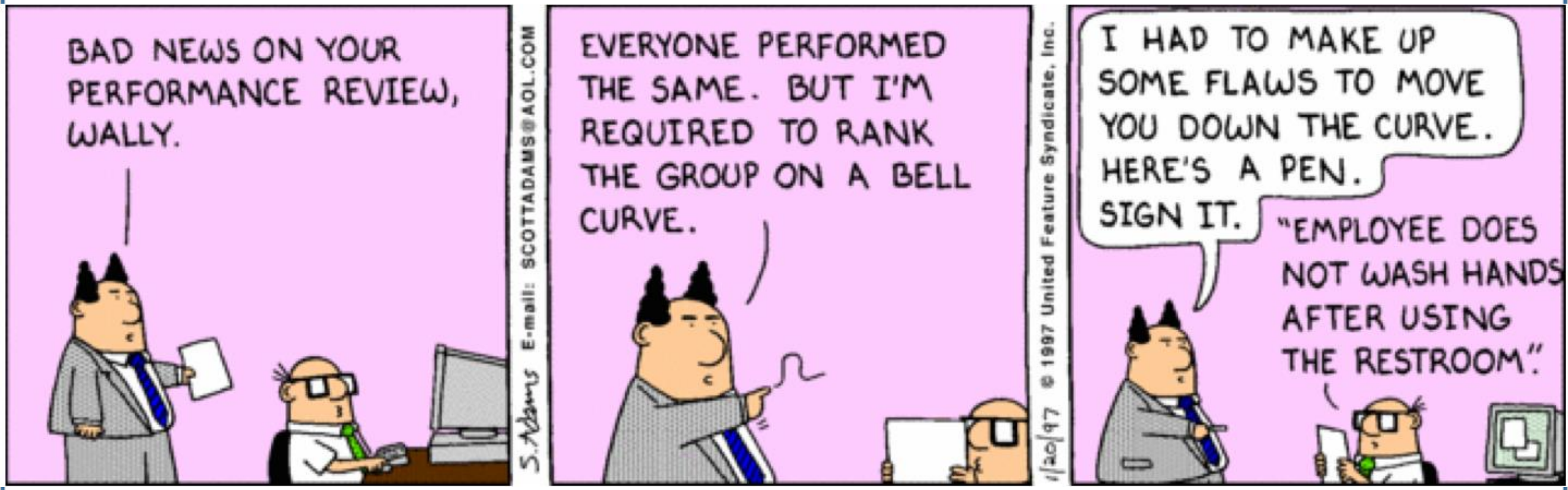
Utilities

- ✓Check that existing to remain and proposed utility core modeling content
- ✓Check the plan-based utility core modeling content
- ✓Check if the size is accurate
- ✓Check the vertical-based utility core modeling content
- ✓Check that utility features follow below ground surface between potholes

Helping Improve Quality Assurance with Hands-on Training

- Over-the-shoulder review
- One-on-one reviews and project review training with 3D models
- Google Earth KML/KMZ files for permit reviews

QAR Lessons Learned



QAR Lessons Learned

- CO has conducted the same QAR for 3 years
  - Projects with 3DPR code
  - Projects that need cross sections
  - All District-let projects

- Reviewed
  - 3D engineered models
  - 3D deliverables produced

Recommendations

Any projects that have cross sections should be designed as a 3D Model and should be scoped accordingly and coded with the 3DPR code in Project Suite.

Project Managers should use the 3D Design Deliverables Staff Hour Task List developed by the Production Support Project Management Office to plan and estimate work during the development of the project plans and stage review submittals

Project Managers should agree on a model management plan during project scoping for project estimating and project reviews.

Project Managers, reviewers, and/or consultants should develop a checklist for quality control of 3D deliverables to be used during the development of the project plans and stage review submittals.

Designers or Project Managers should review the created XML surfaces in Trimble, or equivalent software that a contractor would use.

Designers should ensure that corridor models, including templates or assemblies, are left intact and provided with the submitted CADD files so reviewers can verify the quality of the 3D model.

Project Reviewers should review 3D corridor models with VR goggles in software such as Bentley's LumenRT for DGN models or Autodesk Revit Live for DWG models.

SHOW ME THE MODEL

Project Example – State Road 9B

We are working with FDOT-Awarded Design/ Build Construction Contractor, *Superior Construction*, for this project south of Jacksonville, FL. Phase 2 is complete and Phase 3 will finish this spring, ahead of schedule. We delivered models as .XML files to Superior for this phase. They used them to grade the road, place asphalt and concrete using automated machine guidance.

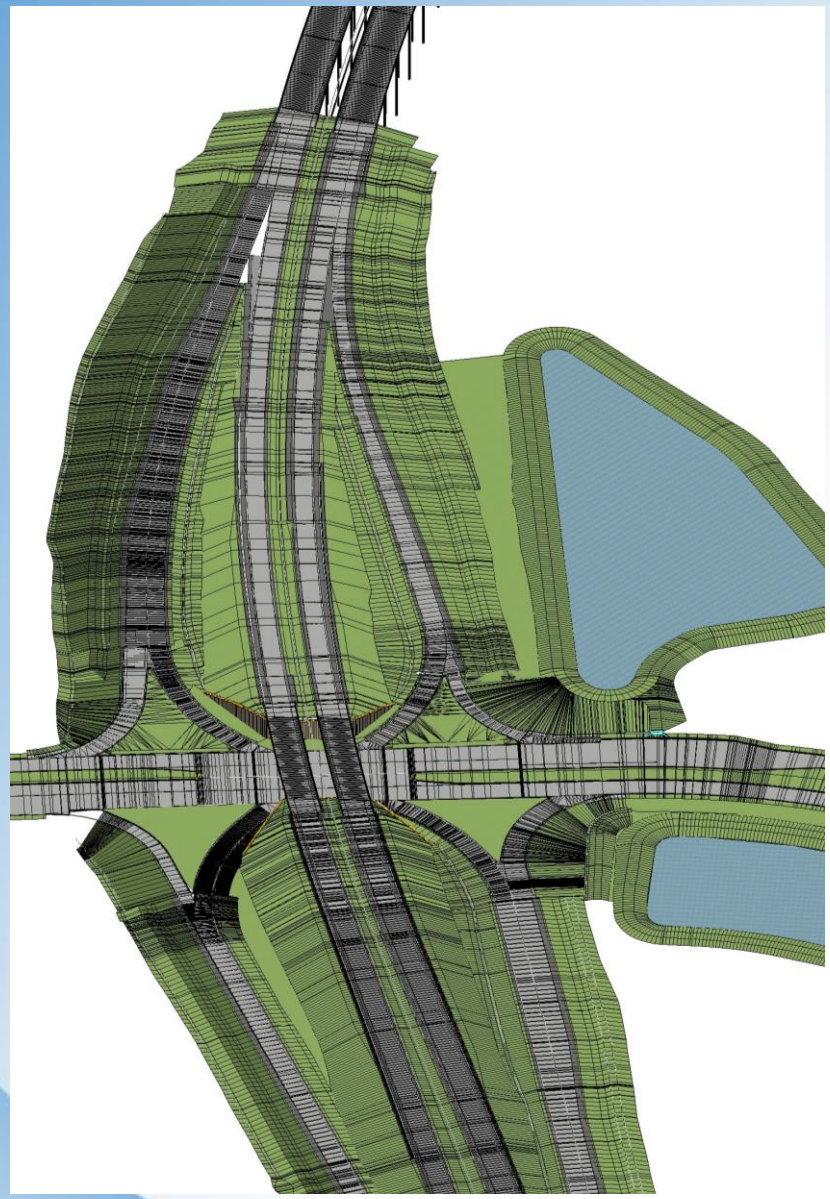
Project Example – State Road 9B

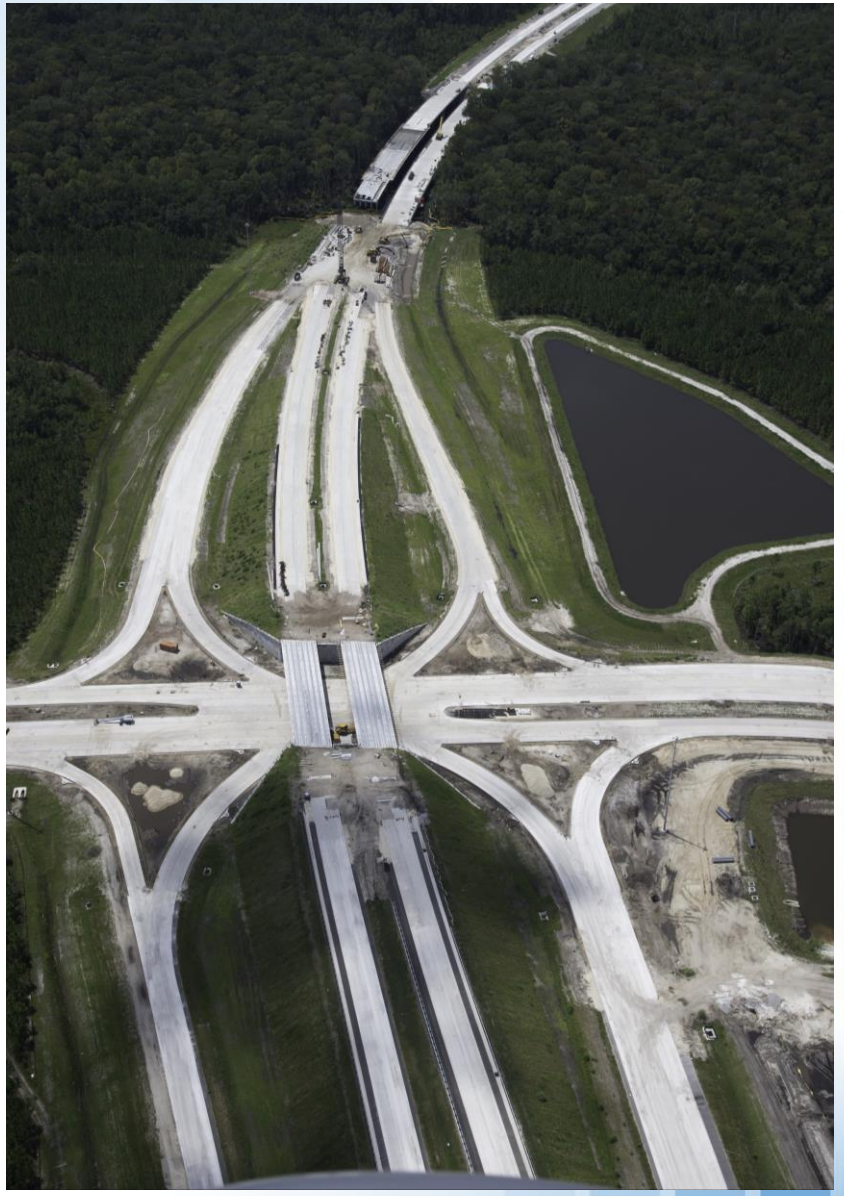
Checking the Model

Superior Construction created a spreadsheet they formerly used to build the 3D model from the 2D plans. We used the same format to compare the plans to the model to check the models before delivering the surfaces to them for construction.

SR 9B Right - Russel Sampson to Station 441+25

Lane 1 EOP Left				PGL				Station	Lane 1 EOP Right				Lane 2 EOP Right			
Calculated from Plans	Arcadis Model	O/S	Difference	Calculated from Plans	Arcadis Model	O/S	Difference		Calculated from Plans	Arcadis Model	O/S	Difference	Calculated from Plans	Arcadis Model	O/S	Difference
43.29	43.29	-19.59'	0.00	42.49	42.49	0.00'	0.00	1434+40	41.51	41.51	24.00'	0.00	41.03	41.03	35.58'	0.00
43.09	43.09	-18.00'	0.00	42.41	42.41	0.00'	0.00	1434+60	41.50	41.50	24.00'	0.00	41.12	41.12	34.00'	0.00
43.02	43.02	-18.00'	0.00	42.37	42.37	0.00'	0.00	1434+69.40	41.49	41.49	24.00'	0.00	41.12	41.12	34.00'	0.00
42.73	42.73	-12.00'	0.00	42.31	42.31	0.00'	0.00	1434+80	41.48	41.48	24.00'	0.00	41.41	41.41	26.00'	0.00
42.58	42.58	-12.00'	0.00	42.20	42.20	0.00'	0.00	1435+00	41.44	41.44	24.00'	0.00	41.37	41.37	26.00'	0.00
42.42	42.42	-12.00'	0.01	42.08	42.07	0.00'	0.01	1435+20	41.38	41.38	24.00'	-0.01	41.33	41.32	26.00'	0.01
42.24	42.24	-12.00'	0.00	41.94	41.93	0.00'	0.00	1435+40	41.32	41.31	24.00'	0.00	41.27	41.26	26.00'	0.00
42.05	42.05	-12.00'	0.00	41.78	41.78	0.00'	0.00	1435+60	41.23	41.23	24.00'	0.00	41.19	41.19	26.00'	0.00
41.96	41.96	-12.00'	0.00	41.70	41.70	0.00'	0.00	1435+69.40	41.19	41.19	24.00'	0.00	41.15	41.15	26.00'	0.00
41.87	41.87	-12.00'	0.00	41.63	41.63	0.00'	0.00	1435+77.79	41.15	41.15	24.00'	0.00	41.11	41.10	26.00'	0.00





ARCADIS

FDOT TRANSPORTATION SYMPOSIUM

Contacts

Vern Danforth, P.E.

State CADD Engineer

Production Support Office

CADD Office

vern.danforth@dot.state.fl.us

850-414-4897

Bobby Bull, P.E.

Project Manager

Production Support Office

Project Management

Bobby.Bull@dot.state.fl.us

850-414-4373

Mariano Amicarelli, P.E.

PM Resources Engineer

Production Support Office

Project Management

Mariano.Amicarelli@dot.state.fl.us

850-414-4346