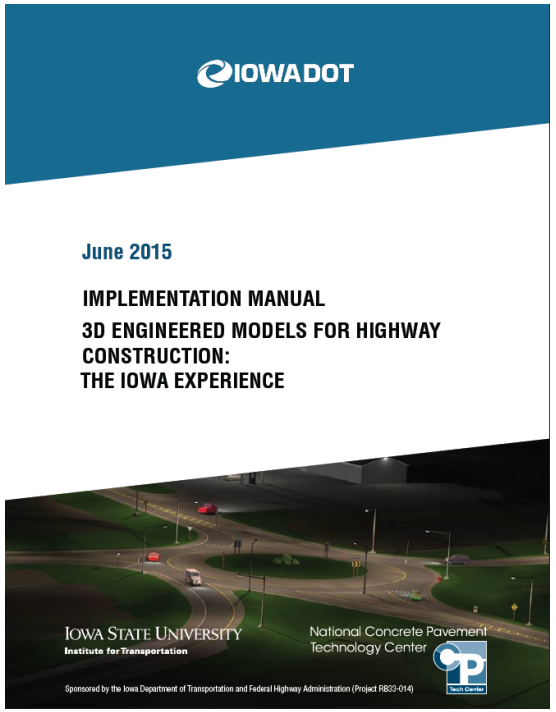
SNYDER & ASSOCIATES

NOVEMBER 14, 2019

DIGITAL DESIGN AND INSPECTION OF CONCRETE PAVEMENTS

Background

- CP Tech Center/Snyder & Associates team
- EDC-2 3D Engineered Models
- EDC-4 e-Construction (Digital Construction Inspection)



Overview

- What is Digital Design and Inspection
- Understanding Deliverables
- Quality Control of 3D Deliverables
- Survey Tools for Inspectors

What is Digital Design?

- I thought it was called:
  - BIM (for Infrastructure)
  - BrIM
  - CIM
  - MBDC
  - VDC
  - e-Construction
- It's all about the data!

How to Get Started

- Establish Goals up Front:
  - Calculation of Quantities
  - Visualization/Virtual Reality
  - Design Analysis/Quality Control
  - Automated Machine Guidance
  - BIM Execution Plan
    - What are we modeling?
    - When are we modeling it?
    - To what level of detail are we modeling it?

Level of Detail

- 100 – Conceptual
- 200 – Approximate Geometry
- 300 – Precise Geometry
- 400 – Fabrication
- 500 – Asbuilts

Table 4 - 3D CADD, 4D and 5D CIM MODEL LEVEL OF DEVELOPMENT BY DISCIPLINE

Discipline	Model	LOD
Exist Conditions	Surface Terrain DTM	300
Exist Conditions	Bathymetry DTM	300
Exist Conditions	Elevated Structure including foundations, piers, abutments, main truss, approach framing and decking	200
Exist Conditions	Buildings to be demolished	200
Exist Conditions	Buildings – Context	100
Exist Conditions	Local Streets, other topographic features required for context	100
Proposed Civil	Local Streets – Paving	200
Proposed Civil	Local Streets – Relocated	300
Proposed Civil	Grading	300
Proposed Civil	Utilities	200

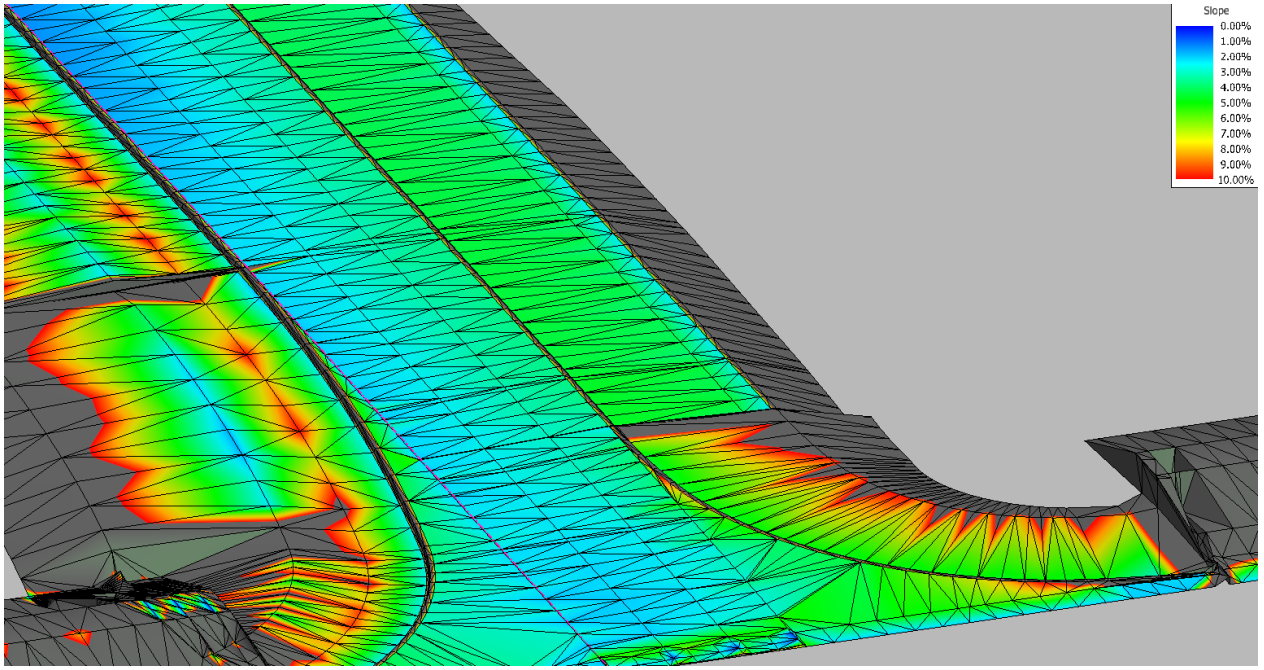
Level of Accuracy

ITEM 625.1001 11 - 3D CADD MODEL

MSE-Proposed					
Straps	DGN / XML	<18 mm	3D	3D	Yes
Footings	DGN / XML	<18 mm	3D	3D	Yes
Top	DGN / XML	<18 mm	3D	3D	Yes
Coping	DGN / XML	<18 mm	3D	3D	Yes
Cast-in-Place-Proposed					
Stone	DGN / XML	<18 mm	3D	3D	Yes
Piles	DGN / XML	<18 mm	3D	3D	Yes
Top of Footings	DGN / XML	<18 mm	3D	3D	Yes
Face of Wall	DGN / XML	<18 mm	3D	3D	Yes
Coping	DGN / XML	<18 mm	3D	3D	Yes

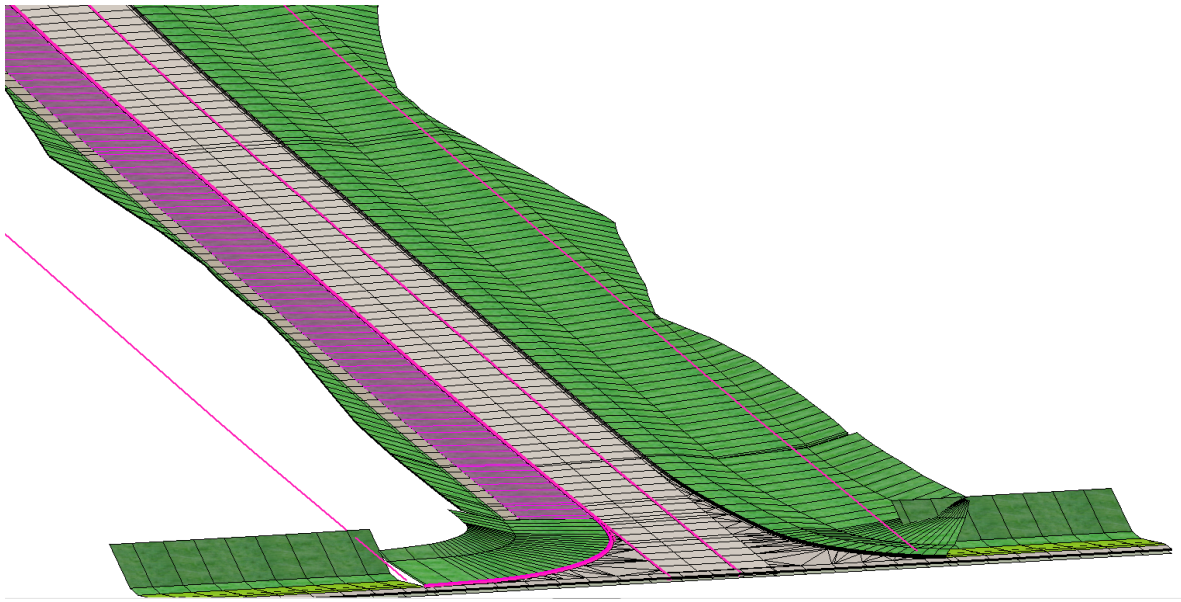
Enhanced Quality Assurance in Design

- 3D and Drivethrough views
- Clash Detection
- Clearance Measurements



Understanding Deliverables

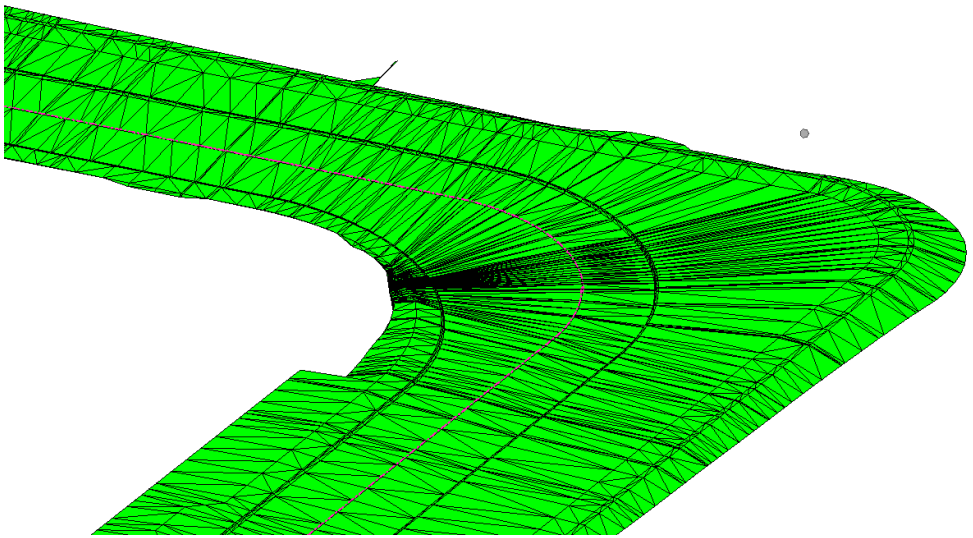
- Deliverables are Different for Grading and Paving
- Surfaces
- Accuracy
- 3D Breaklines
- Alignments



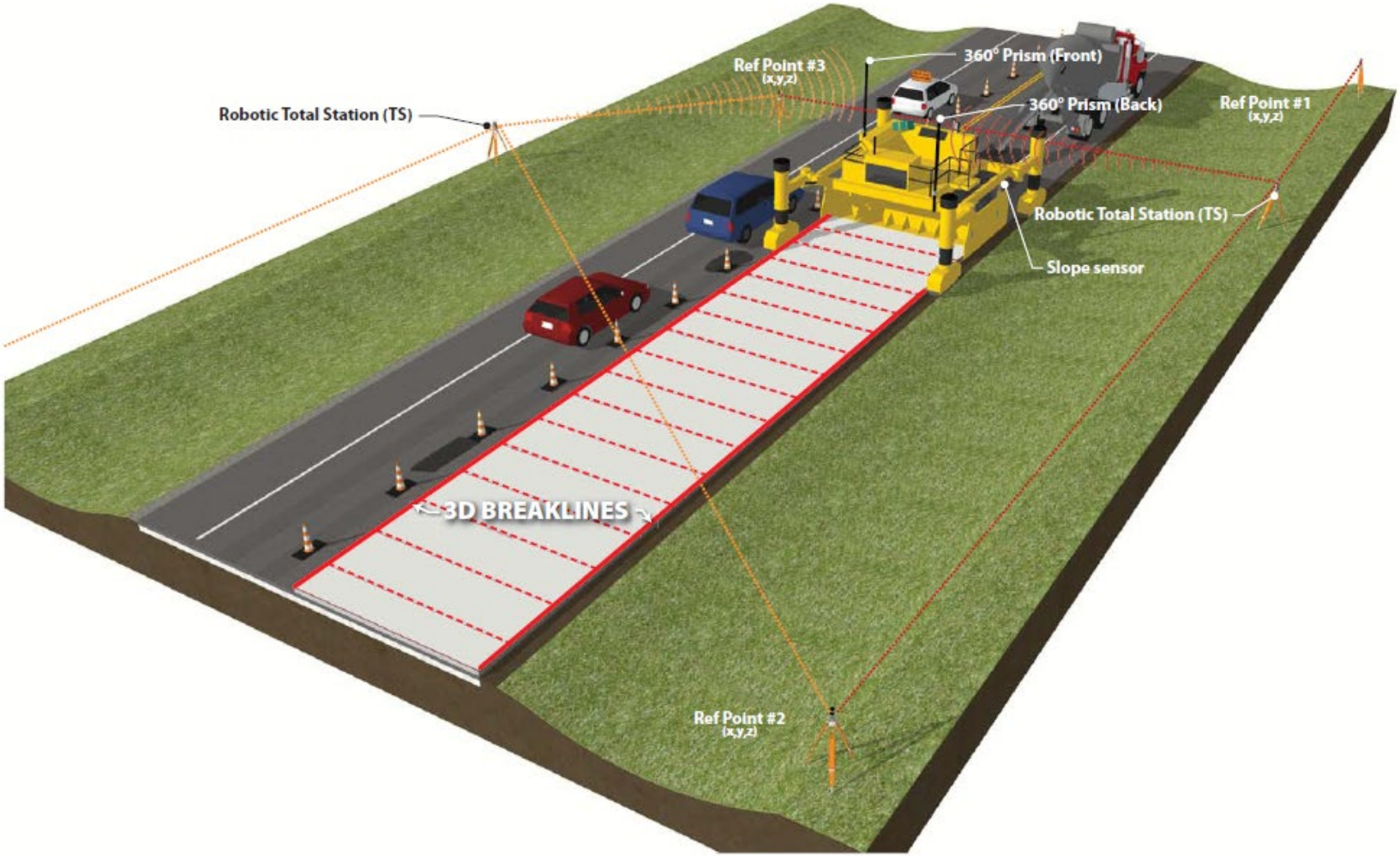
Automated Machine Guidance

- Grading Deliverables
  - Surface – Triangulated Network (LandXML)
  - 3D Breaklines
- Paving Deliverables
  -

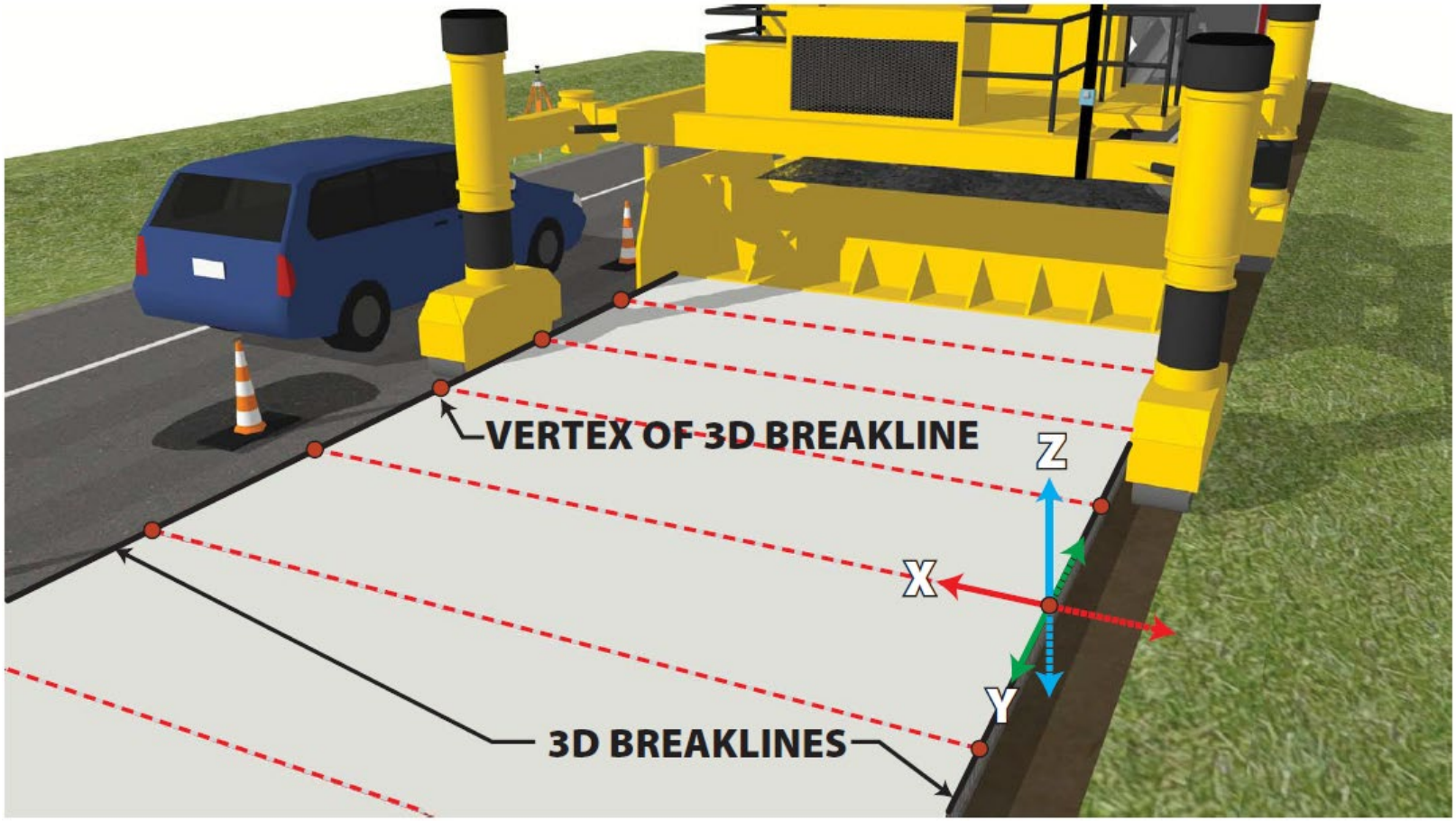
Photos Courtesy of Michigan Department of Transportation Photography and Video Services Unit



AMG Paving - Inputs

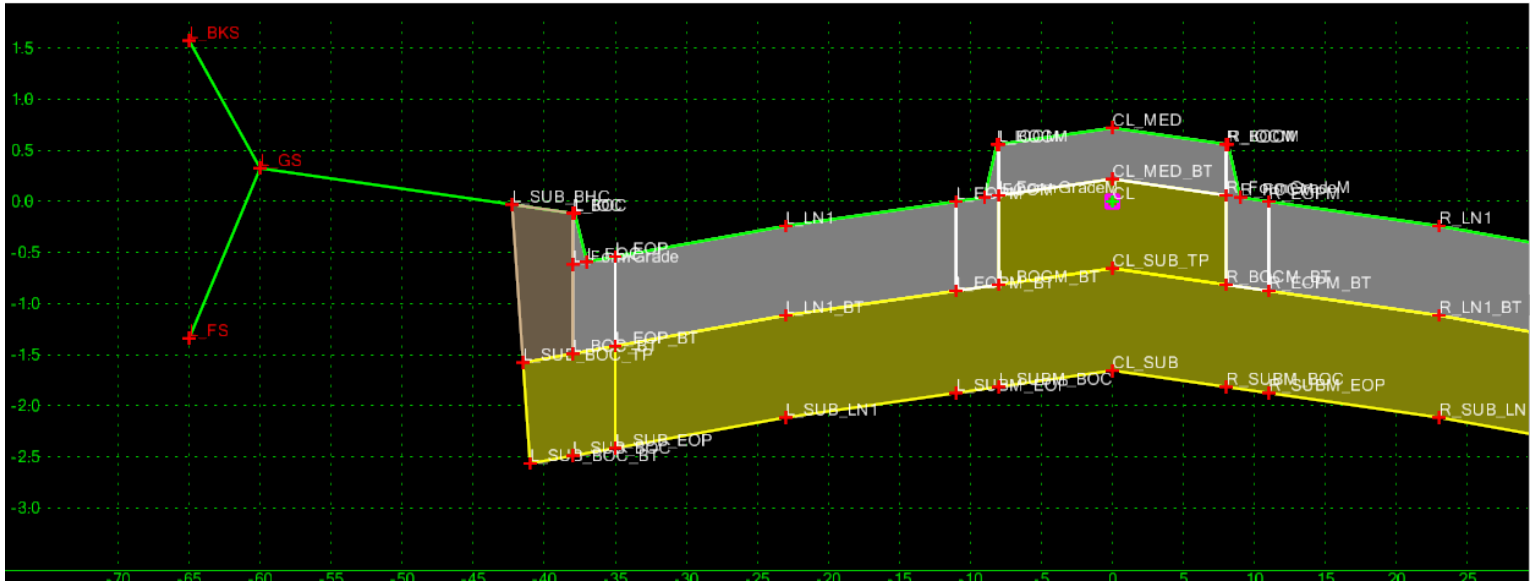


AMG Paving - Inputs



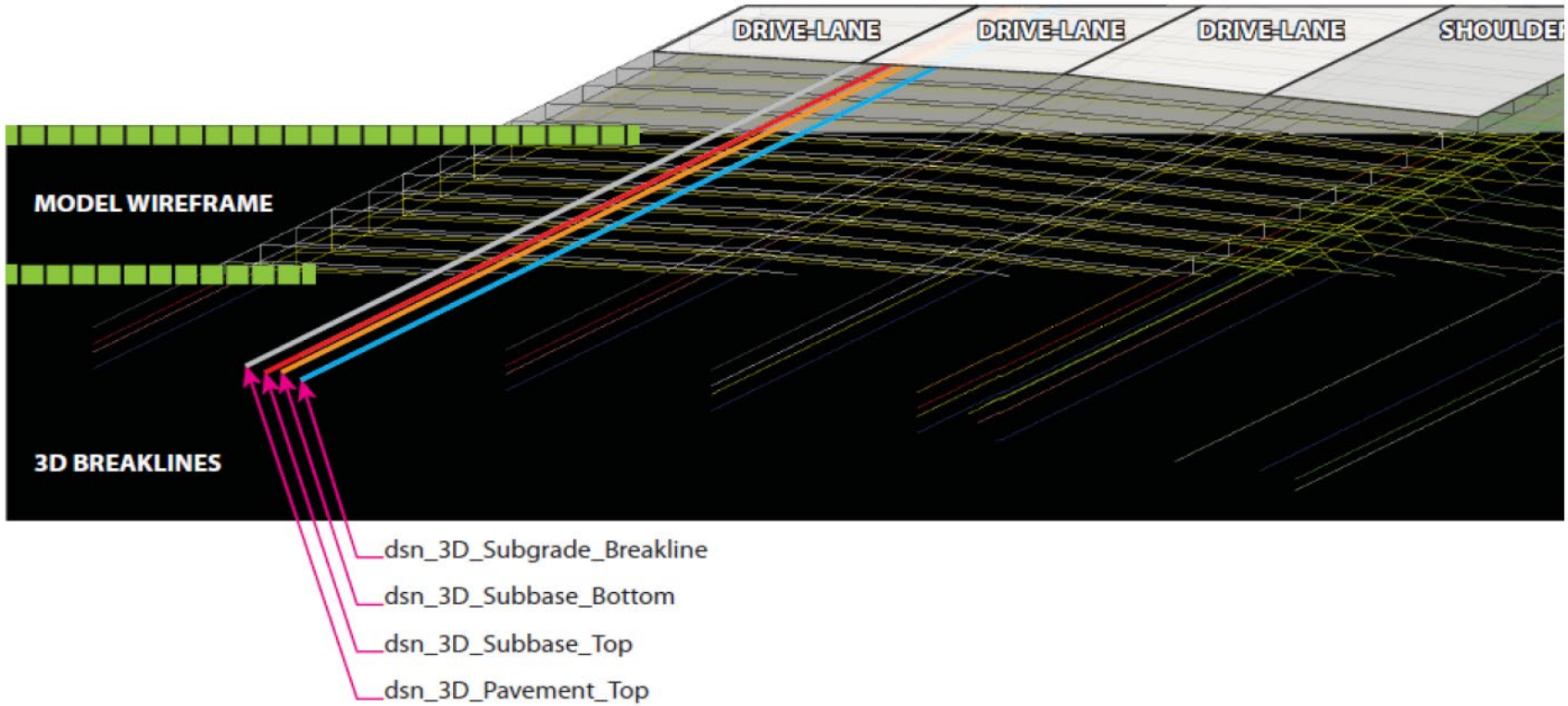
CAD Standards

- Level/Layer File names
- File Naming
- Alignments
- Templates
- Point Controls
- Makes it easier on your designers and on downstream users
- Document the files



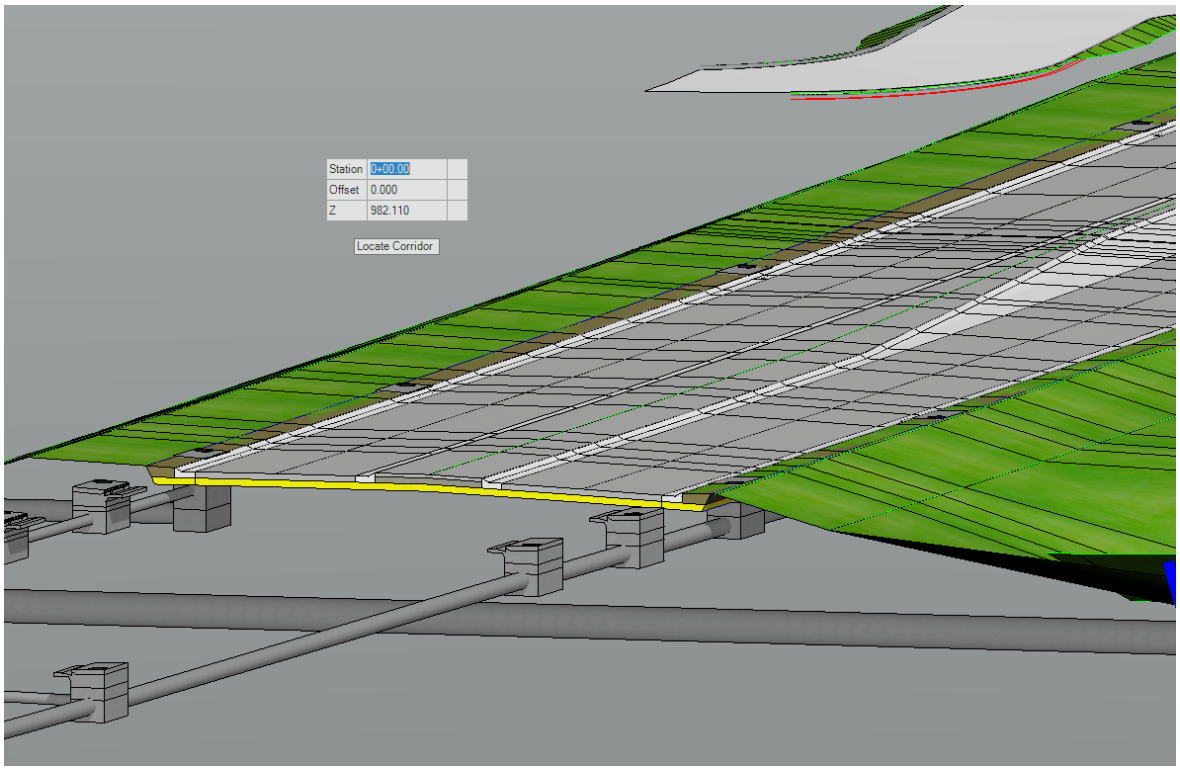
CAD Standards

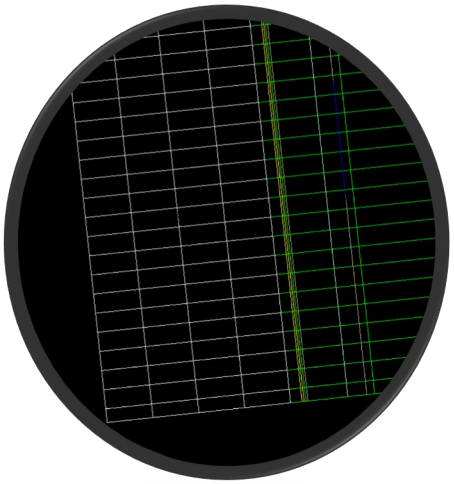
Figure 5H-1.02: 3D Break Lines Contained within the 3D Engineered Model



Level of Detail – AMG Deliverables

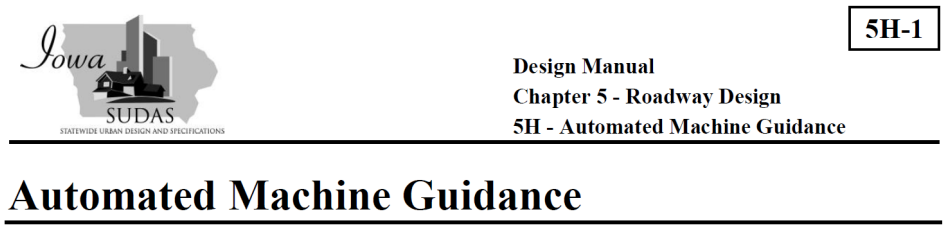
- Depends on Ultimate Use
- Grading – 10’- 25’ is fine
- Paving 1’-5’ is better





Data Transfer

- Universal Data Types are key!
  - Proprietary data types are only good when both parties are using the same software – typically not the case
- CADD files = DXF
  - 2D linework (i.e. Boundary/ROW)
  - 3D linework (i.e. Roadway section breaklines, terrain breaklines)
  - 3D modeled solids (i.e. Bridge abutments, piers, piles, girders, etc.)
- Alignments and Surfaces = XML
  - Horizontal Alignments and Profiles
  - Digital Terrain Models (DTMs), Triangulated Irregular Networks (TINs), etc)
- LiDAR Data = E57
  - Aerial LiDAR
  - Terrestrial LiDAR
  - Mobile LiDAR



Common Issues

- Tight Horizontal and Vertical Control
- Tie-Ins must be surveyed
- Transitions must be modeled
- Crossing breaklines
- Files too large
- Contractors would prefer breaklines extend beyond end of paving

Other Considerations

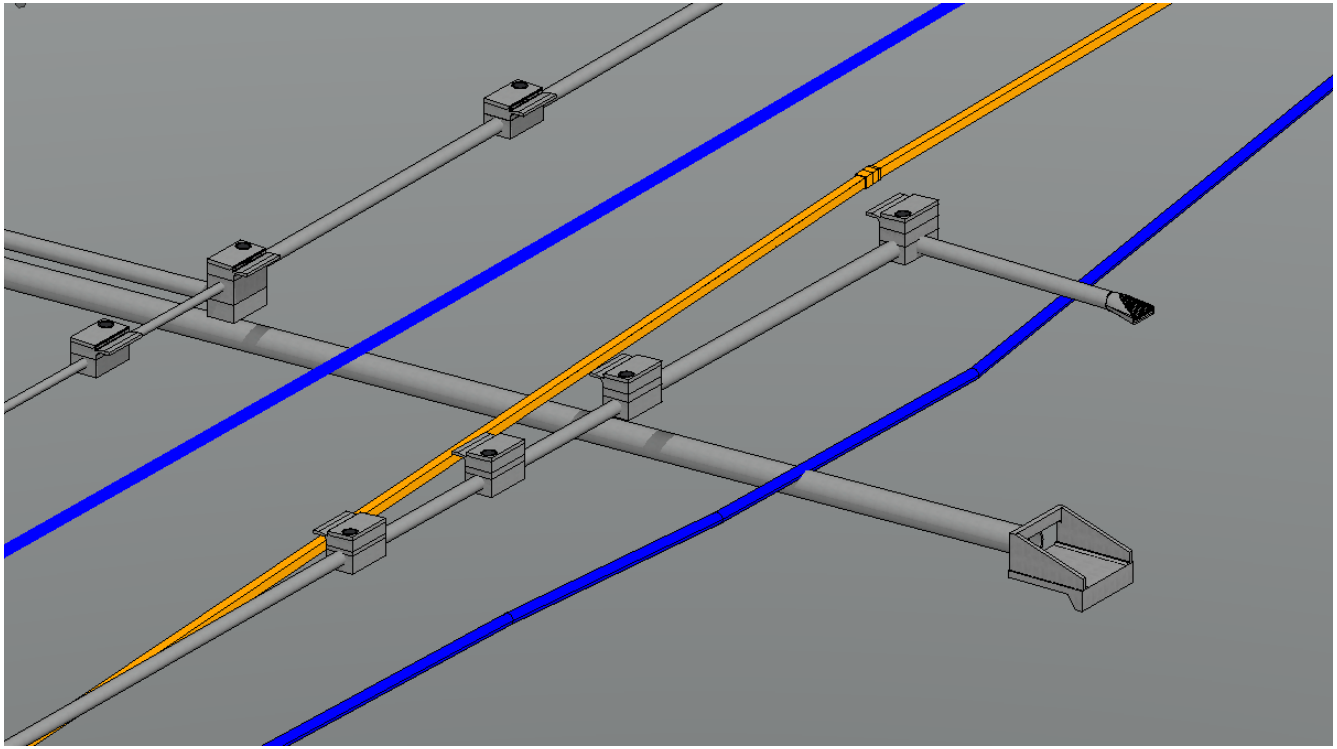
- Delivery of Data to Contractor
  - Pre-letting or Post-Letting

- Pre-letting allows the contractor to factor in the quality of the data they are getting

- Does not give any contractor a competitive advantage

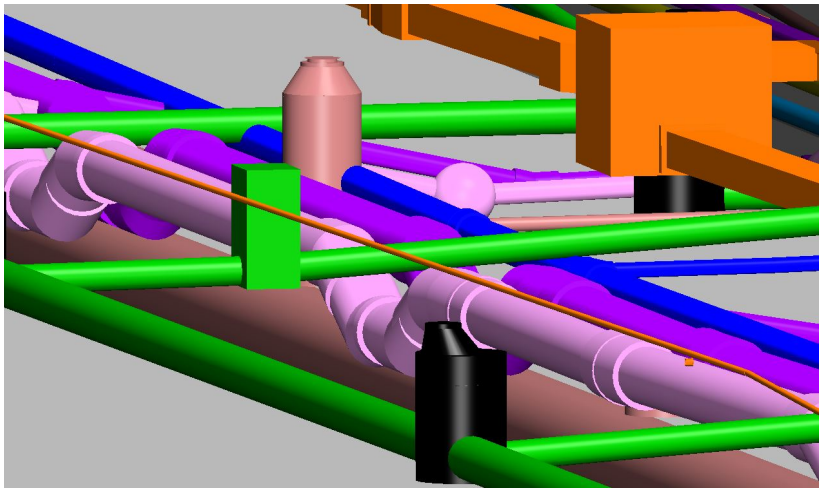
Enhanced Quality Assurance in Design

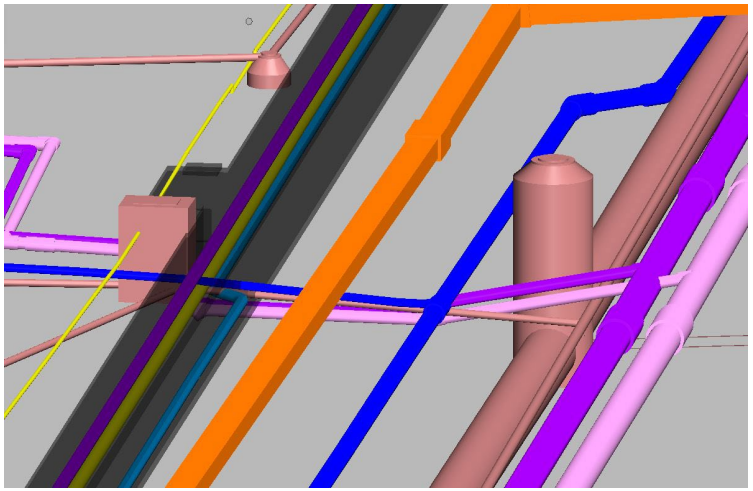
- 3D and Drivethrough views
- Clash Detection
- Clearance Measurements

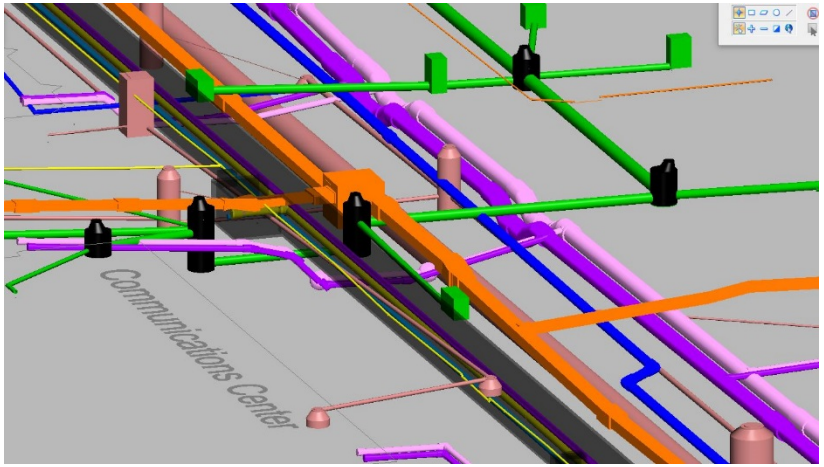


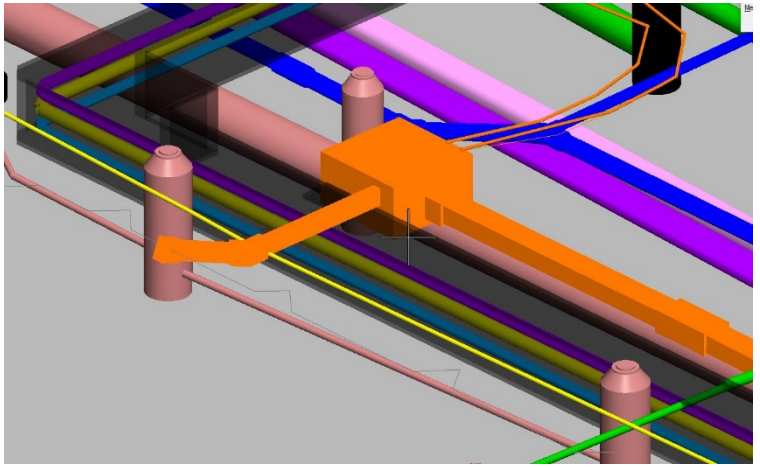
SNYDER & ASSOCIATES

Enhanced Quality Assurance in Design





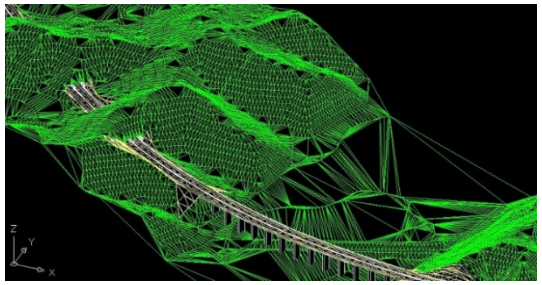


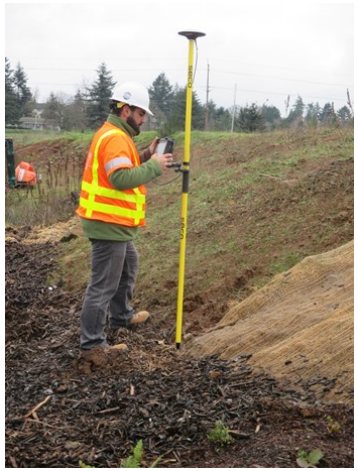


SNYDER & ASSOCIATES

Digital Construction Inspection

- Beyond e-Construction
- Inspectors using Digital Design Data





SNYDER & ASSOCIATES

Digital Construction Inspection

- Designer's role should continue into construction
- Designer reviewing contractor's model
- Who is creating the model of record?
- Handling Changes in Construction
- How much of a surveyor will our construction inspectors have to become?

How Much Survey in Construction?

- Field Calibration of Model and Survey Data Collection
- Selecting the Right Tool
- Hardware and Software Skills
- Greater Integration of Workflows with Design

GNSS Rovers

- FHWA vision – Every Inspector has one of these

SNYDER & ASSOCIATES

Contractor Work Plan

SUDAS Standard Specifications

Division 1 - General Provisions and Covenants
Section 1050 - Control of Work

1.15 ADDITIONAL CONTRACTOR RESPONSIBILITIES

If a form of automated machine guidance (AMG) is used for grading or paving operations, the following is required:

A. At least one week prior to the preconstruction meeting, submit to the Engineer for review a written AMG work plan which indicates the following:
   - Equipment type
   - Control software manufacturer and version
   - Proposed location of GPS base station for broadcasting differential correction data to rover units
   - Proposed locations where AMG will be utilized

B. Provide Engineer with up to 8 hours of formal training on Contractor's AMG systems.

C. For grading contracts, provide a rover for use by the Engineer.

D. Check and recalibrate, if necessary, the AMG system at the beginning of each work day.

E. Contractor will bear all costs associated with use of the AMG system, including but not limited to reconstruction of work that may be incurred due to errors in application of the AMG system. Correction of grade elevation errors and any associated quantity adjustments resulting from the Contractor's activities are to be done at no cost to the Contracting Authority.

Uses

- Check Station/Offset Positioning
- Checking Grade (subgrade)
- Measuring Quantities (linear, area, volume)
- Locating Compaction Tests
- Site Mapping
- Utility Locates/Conflict Documentation
- Utility Asbuilts

Our GNSS Enabled Tablet

DT Research

DT301T/RTK Rugged Tablet

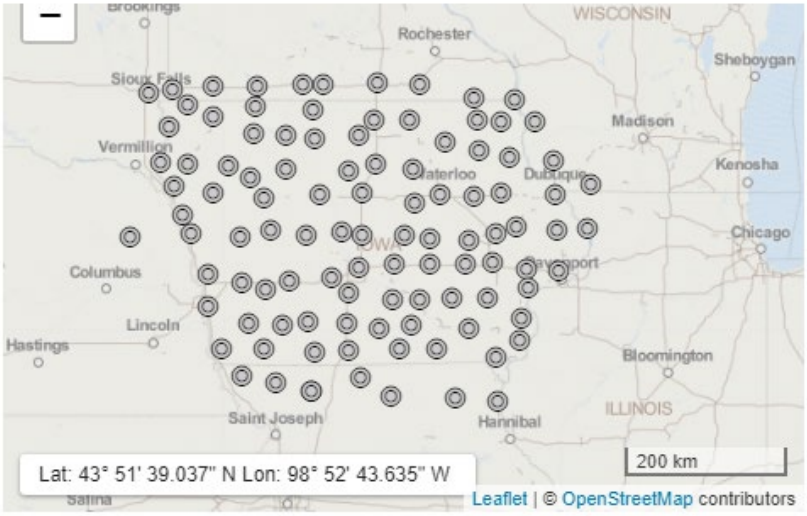
Slim, Lightweight with Integrated High-Accuracy GNSS

SNYDER & ASSOCIATES

Our GNSS Enabled Tablet

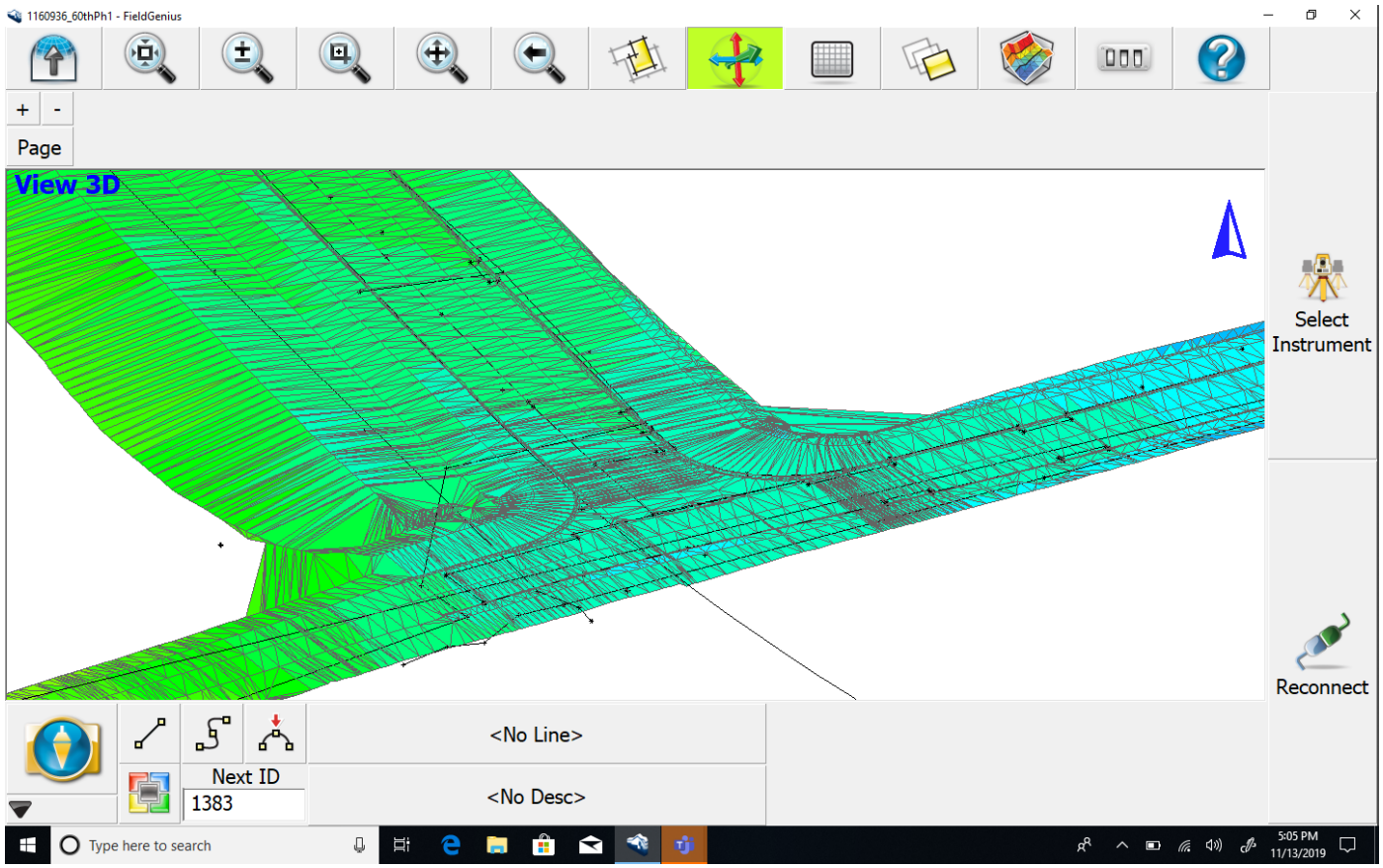
- Connects to the Iowa RTN
- Utilizes FieldGenius software by MicroSurvey
- Utilizes same digital information given to contractors
- Accuracy:
  - +/- ½” Horizontally
  - +/- 0.10’ Vertically

IOWA REAL-TIME NETWORK



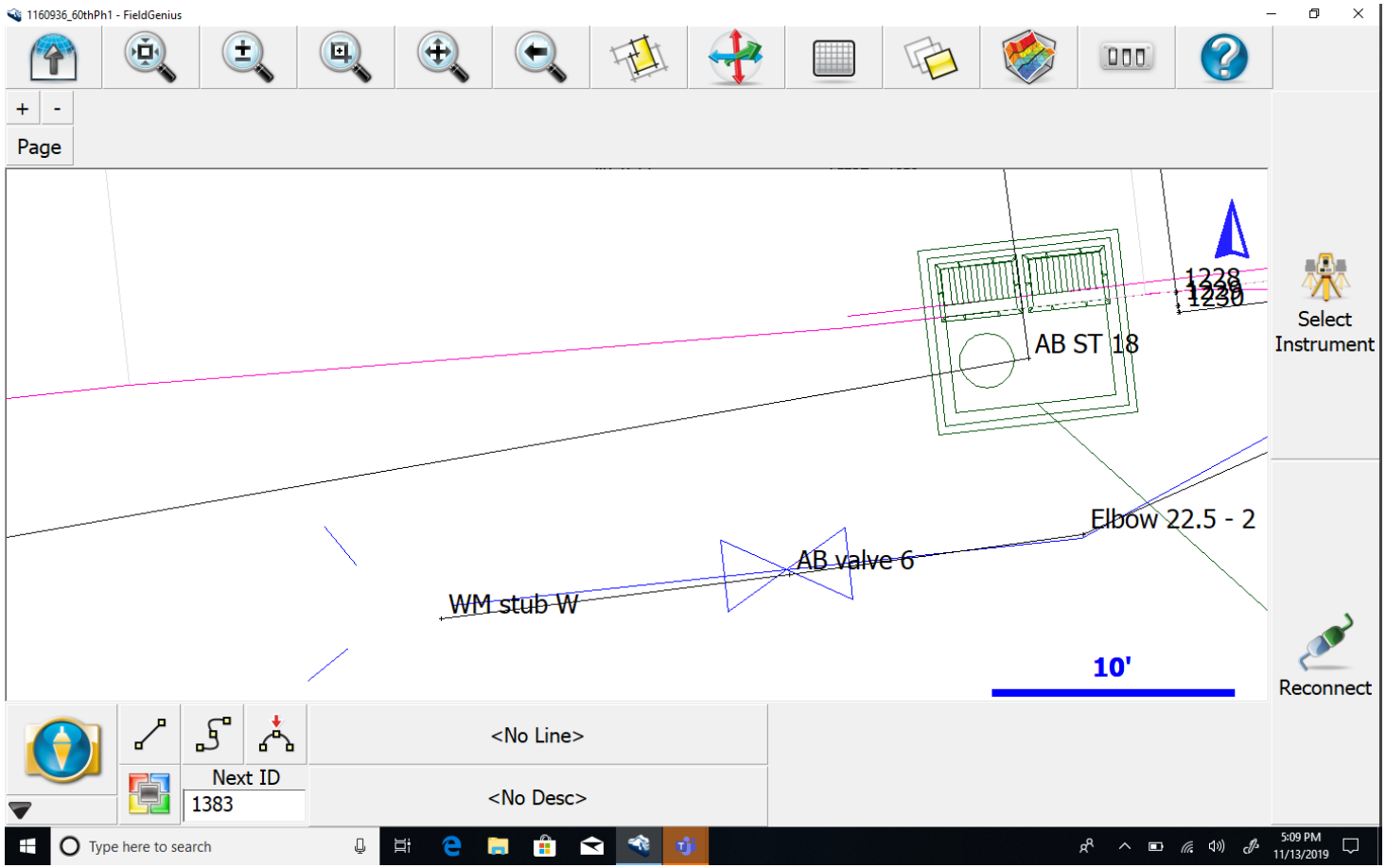
FieldGenius

- Utilizes same information given to contractor



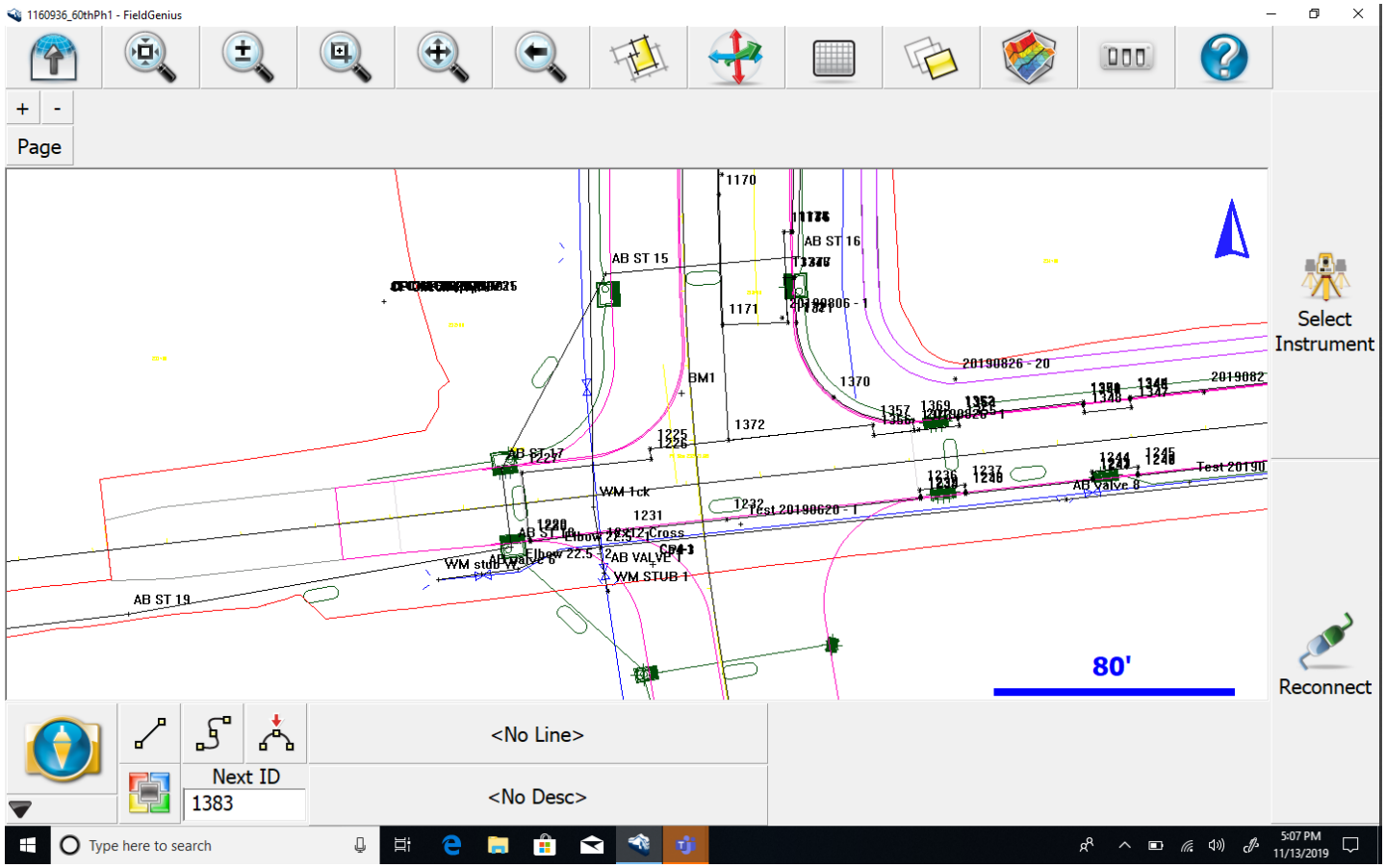
FieldGenius

- Collect Asbuilt Locations



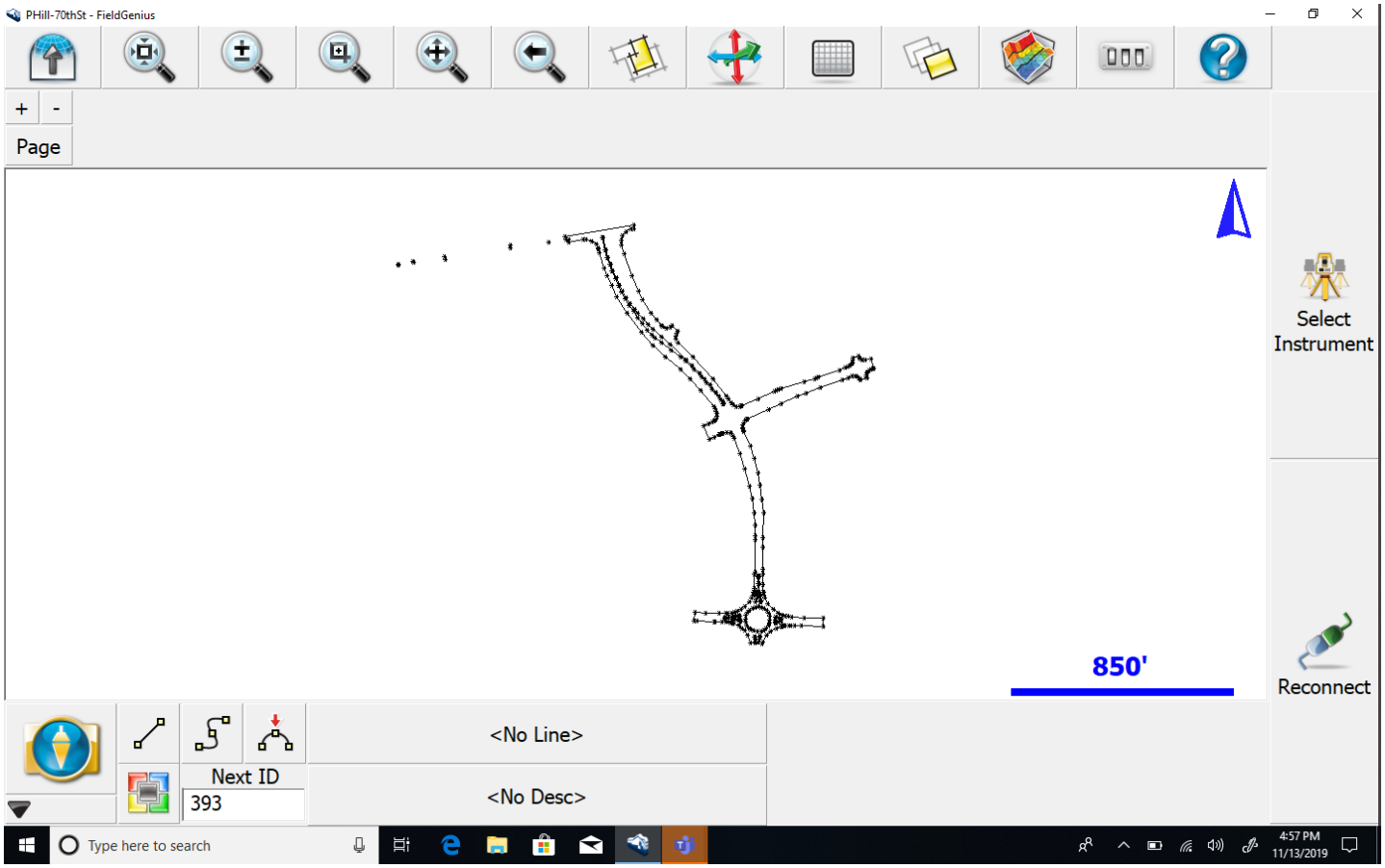
FieldGenius

- Check Layout/Stakeout Points



FieldGenius

- Measure Quantities

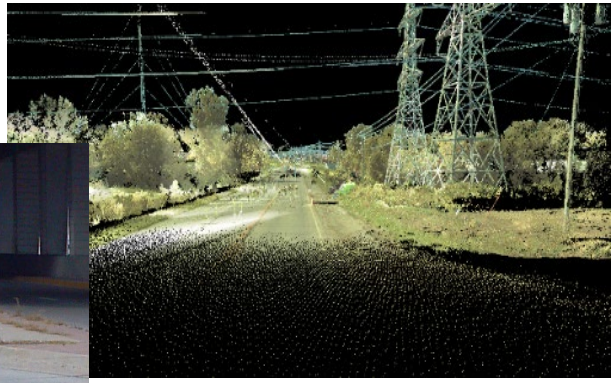


All tools are not created equal

Method	Network Accuracy (RMS)
Fixed Wing Aerial LiDAR/Photogrammetry	3" – 6"
Low Altitude Helicopter LiDAR/Photogrammetry	1" – 2"
Mobile LiDAR	½" – 1"
Tripod-Mounted Static LiDAR	¼" – ½"
Terrestrial Surveying: RTK GNSS/GPS (AMG too)	½" – 1"
Terrestrial Surveying: Total Station/Digital Level	<¼" – ½"

Other Tools

- Total Stations
- LiDAR
- HyDrone
- UAS

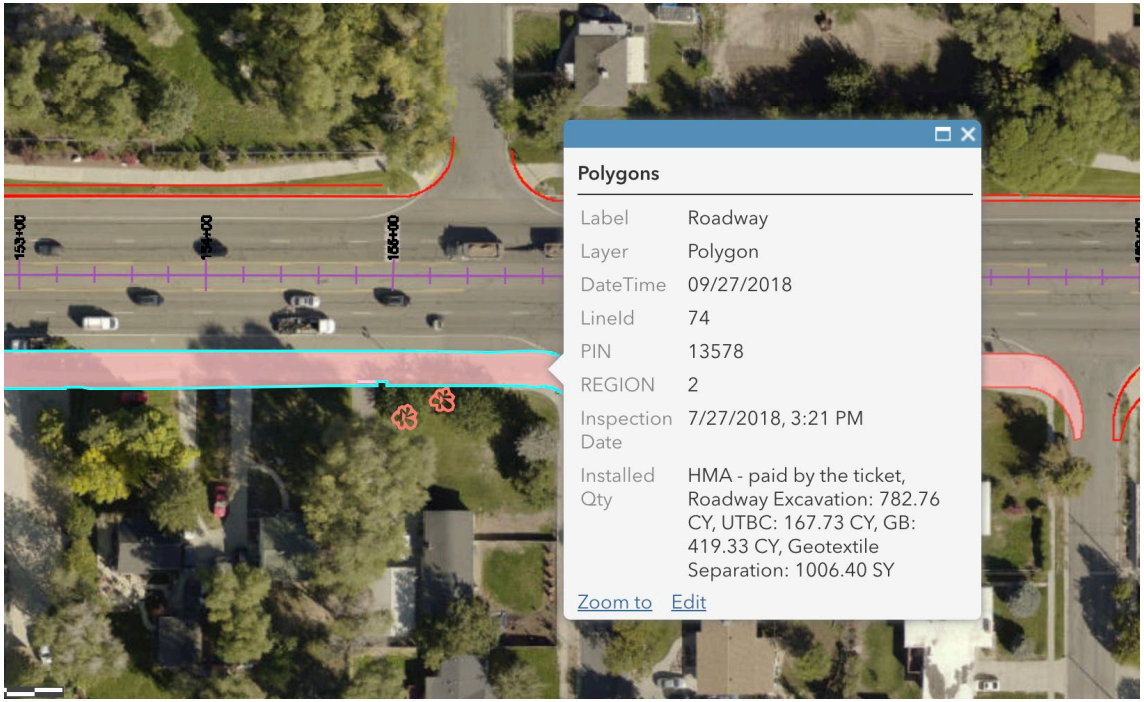


Other Tools

- Before and After Drone Photos

Future Developments

- Design Models will continue to have more data
- Utah DOT has been using 2D data in GIS
- Indiana/Ohio Construction App



SNYDER & ASSOCIATES

Contact Information

Gabriel Nelson, P.E.

Civil Engineer

gnelson@snyder-associates.com