

INDOT Intelligent Road Design and Construction Using 3D Models

Derek Fuller, INDOT e-Construction Specialist

Tim Haney, Parsons, PE, sUAS (drone) Pilot

Andrew Pangallo, INDOT I-69 Finish Line Construction Manager

2020 Purdue Road School

March 10, 2020

Mission Statement

- The use of intelligent 3D CAD models to support the lifecycle of transportation assets (roads and bridges) that provides predictive analysis and reporting capabilities that is data driven and allows the agency to make better operational and strategic management decisions.

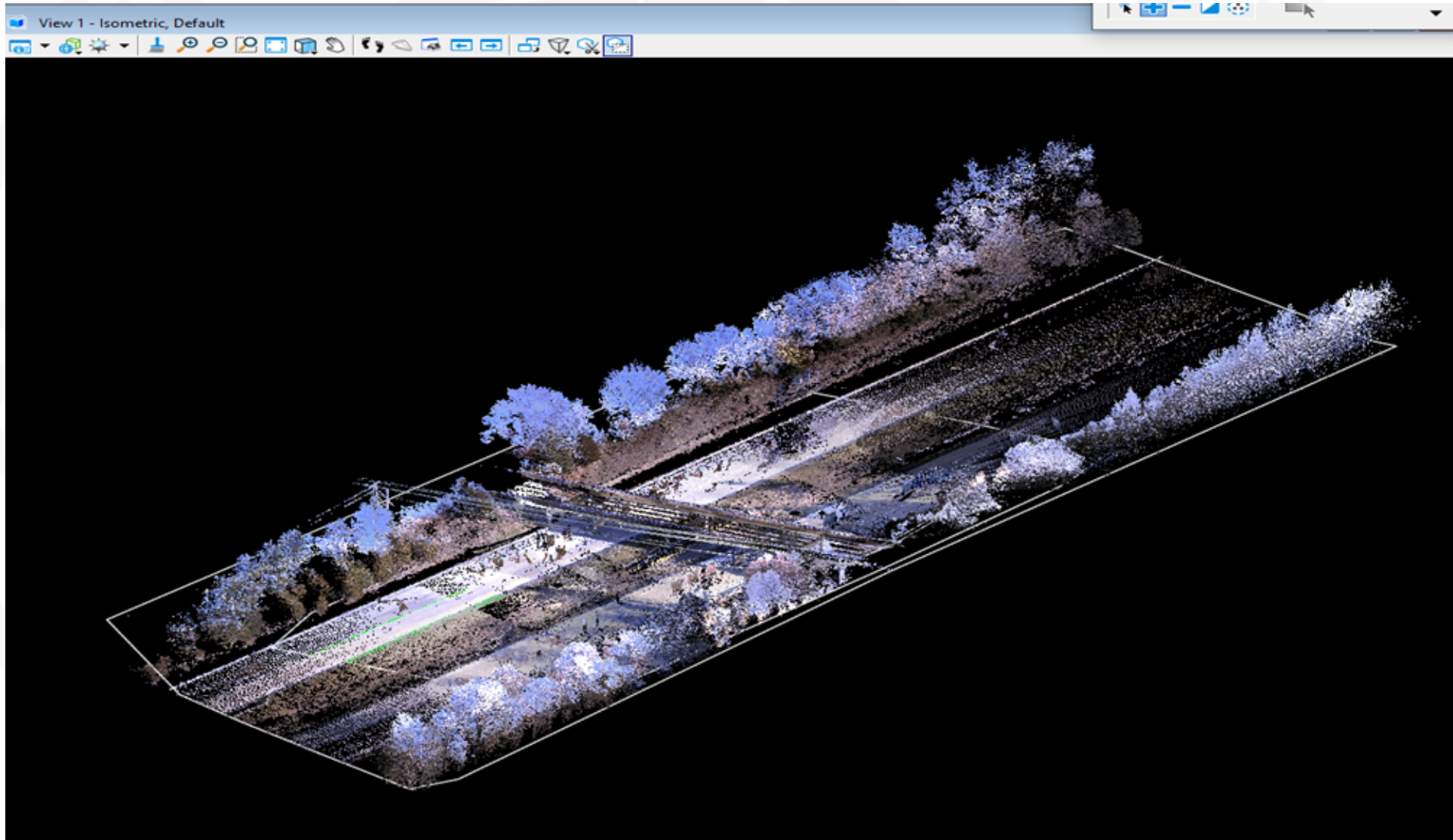
2019 e-Construction Accomplishments

- e-Ticketing for Materials Delivery
 - Demonstration HMA project on SR15, Contract RS-40919-A
 - May/June 2019
 - Phend & Brown contractor
 - Fleetwatcher system by Earthwave Technologies
 - Mainly provided INDOT personnel opportunity to get hands experience with electronic data
 - Comparison of paper tickets and digital data were the same quantities
- INDOT Hosted FHWA Digital Construction Inspection Workshop
 - July 2019
 - Utah DOT – Digital Construction efforts
 - Ohio DOT – AASHTOWare Project implementation
 - Parsons – Digital Design and 3D models

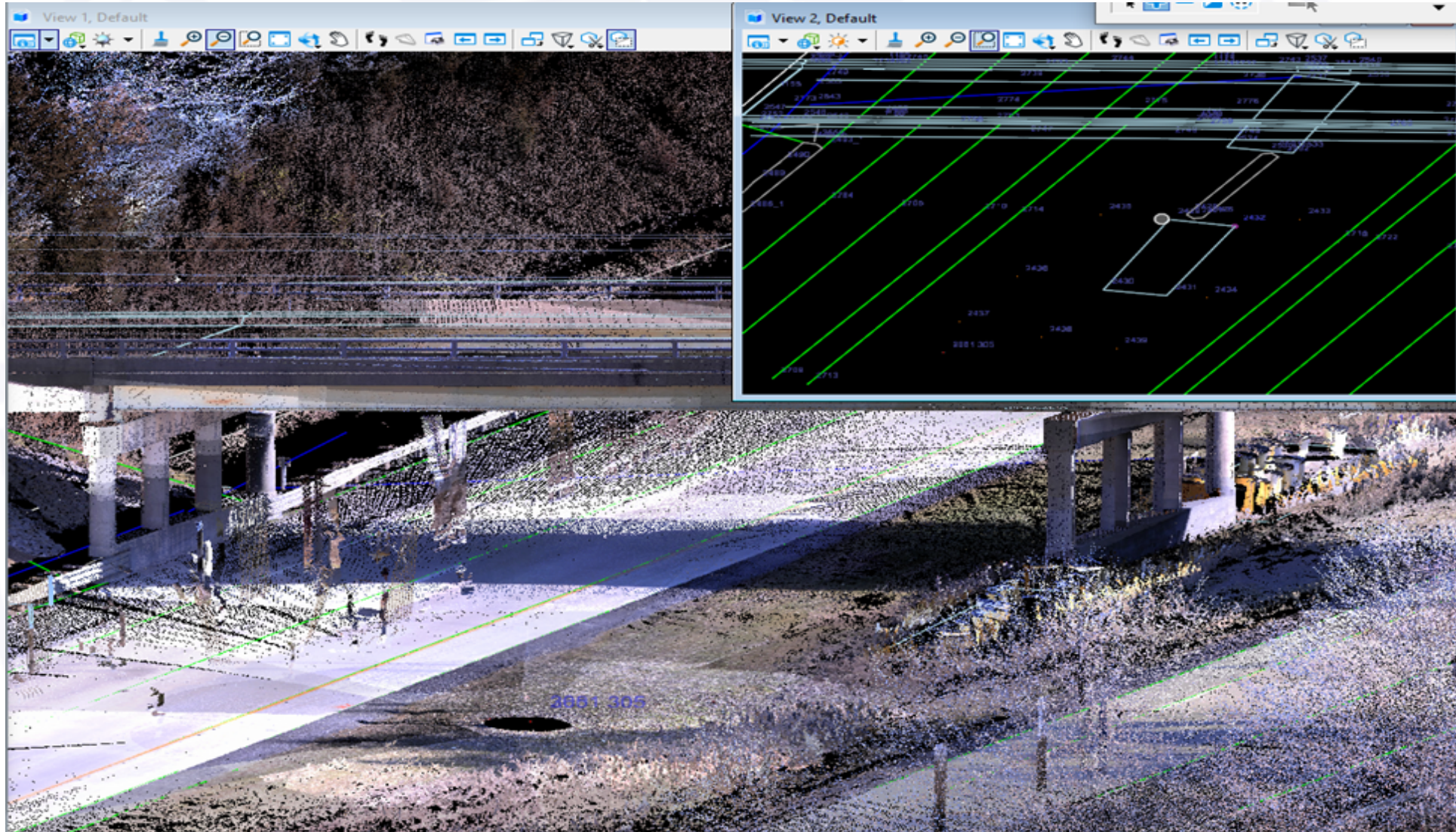
Digital Design and Construction Inspection

- Bentley OpenRoads Designer (ORD) Connect Edition Pilot Project
 - “Work In Progress” Workspace
 - Pilot for road design and survey Spring/Summer-'20
 - Determine workflow changes
 - Find any issues with tools in new software
 - Implement Item Types
 - Workflow for adding pay items attributes to design features
 - Investigate possibility of using for quantity calculations
 - Potential roll-out of ORD CONNECT internally Fall-'20

Bentley OpenRoads Designer Connect



Bentley OpenRoads Designer Connect (cont.)



Digital Design and Construction Inspection - 2

- Bentley Construction Inspection App (SYNCHRO)
 - Field Testing April 2019
 - Form based app
 - Commercial release with issue/notification tracking October-'19
 - Commercial release/update to add Field Inspection February-'20
 - Adding 3D Model design to SYNCHRO under development
 - Potential Proof of Concept on I-69 in Martinsville
 - Design > Inspection Workflow
 - Design consultant provided CAD files
 - Pick a few asset types
 - Add Item Types for pay items
 - Test workflow of using pay items as key for passing data to SYNCHRO

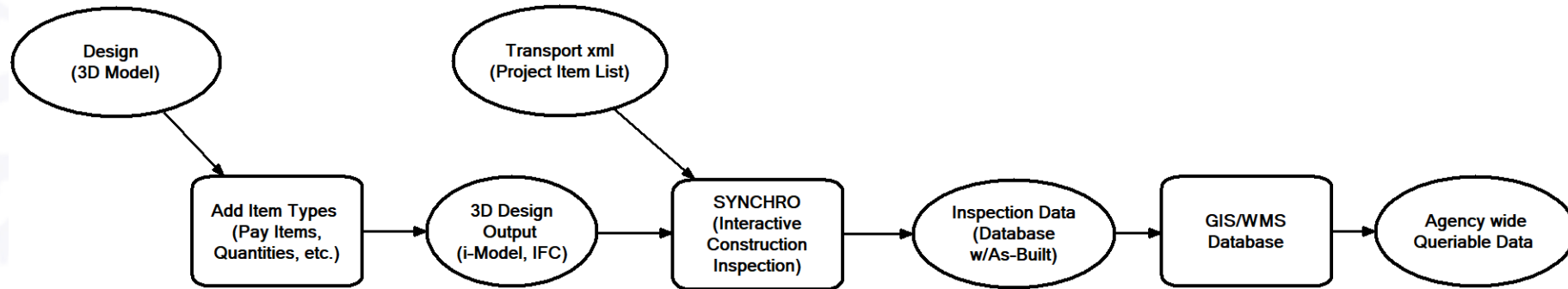
Bentley SYNCHRO (pg.2)

- Form Based Workflow (non-3D model)



Bentley SYNCHRO (pg. 3)

- 3D CAD Model Based Workflow



Bentley SYNCHRO (pg. 4)

8:46 AM Tue Mar 3 65%

001 - Field Inspections Test Project

Updated 3/3, 8:46 AM

TUESDAY, MAR 3 30°F 52° 25° Sunny

WED 61° 34° Sunny

THU 57° 34° Sunny

FRI 64° 39° Partly Cloudy

SAT 66° 43° Mostly Sunny

SUN 61° 37° PM Show

Create

- Issue
- Observation
- Daily log
- Inspection
- RFI

View

- Documents
- Offline Documents

My tasks [View all >](#)

No tasks

8:53 AM Tue Mar 3 64%

Create New Inspection Inspect

Back

Inspection name *
HMA Approach

Pay item *
610-07487

Form type *
Quality

Bentley SYNCHRO (pg. 5)

8:52 AM Tue Mar 3 64%

< Back Select Pay Item Confirm

- 200 Earthwork
 - 211 B Borrow and Structure Backfill
- 400 Asphalt Pavements
 - 406 Tack Coat
- 500 Concrete Pavement
 - 502 Portland Cement Concrete Pavement, PCCP
 - 502-06329 PCCP, 12 in.
 - 502-12153 PCCP, Precast, Removable
- 600 Incidental Construction
 - 610 Approaches and Crossovers
 - 610-07487 HMA for Approaches, Type B
 - 610-07488 HMA for Approaches, Type C
 - 610-07788 HMA for Approaches, Type D
- 700 Structures
 - 715 Pipe Culverts, And Storm And Sanitary
 - 720 Manholes, Inlets, And Catch Basins
 - 720-44000 Casting, Adjust To Grade
 - 720-45005 Inlet, A2
 - 720-45069 Inlet, P12
 - 720-45410 Manhole, C4
 - 720-98174 Inlet, B15
 - 720-98555 Inlet, C15

8:53 AM Tue Mar 3 64%

< Back Create New Inspection Save

HMA Approach

Pay item: 610-07487

Form type: Quality

Approaches and Crossovers

- > Proofrolling
- > Quality Control
- > Design Mix Formula
- > General
- > Weather Limitations
- > Spreading and Finishing
- > Joints
- > Compaction
- > Low Temperature Compaction Requirements

Bentley SYNCHRO (pg. 6)

8:55 AM Tue Mar 3 64%

< Back Create New Inspection Save

HMA Approach

Pay item: 610-07487

Form type: Quality

Approaches and Crossovers

- > Proofrolling
- Quality Control
 - Was HMA transported and placed according to a Quality Control Plan, QCP? Yes
 - When a safety edge is required for a project, the QCP shall identify the device or devices in accordance with 409.03(c) to be used for constructing the safety edge.
- Design Mix Formula
 - Was the correct approved design mix formula, DMF, listed on the pay tickets? Yes
- > General

8:55 AM Tue Mar 3 64%

< Back Create New Inspection Save

HMA Approach

Pay item: 610-07487

Form type: Quality

Approaches and Crossovers

- > Proofrolling
- > Quality Control
- > Design Mix Formula
- > General
- > Weather Limitations
- > Spreading and Finishing
- > Joints
- > Compaction
- > Low Temperature Compaction Requirements

Bentley SYNCHRO (pg. 7)

8:56 AM Tue Mar 3 64%

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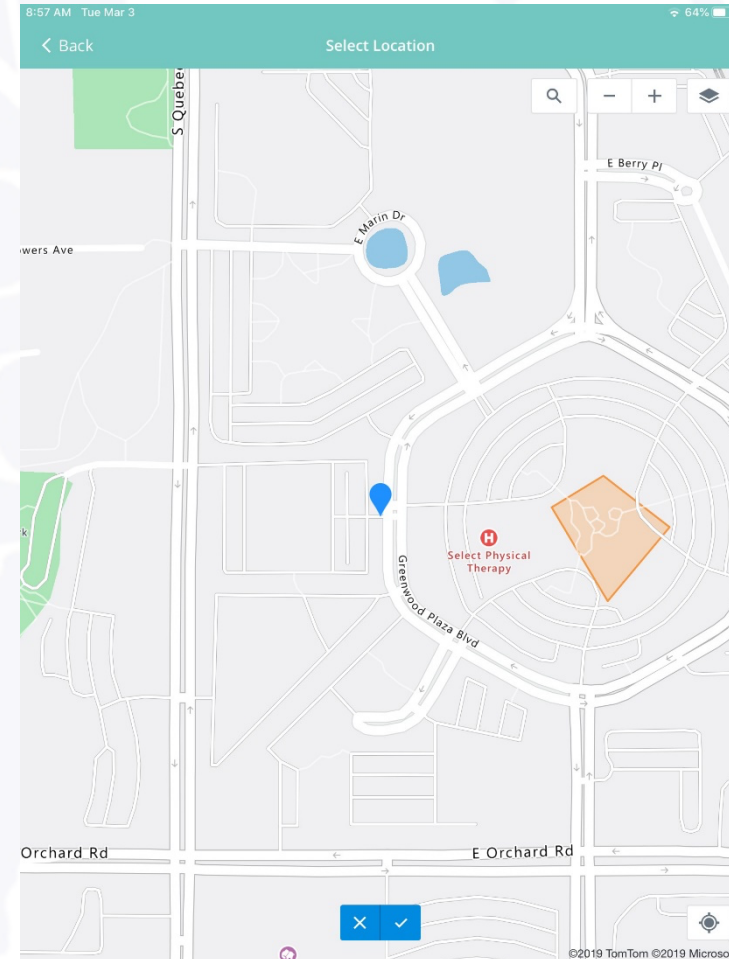
- > Low Temperature Compaction Requirements
- > Mixing Plant
- > HMA Laydown Operations - Distributor
- > HMA Laydown Operations - Hauling Equipment
- > HMA Laydown Operations - Laydown Equipment
- > HMA Laydown Operations - Compaction Equipment
- > HMA Laydown Operations - Miscellaneous Equipment
- > Inspection Comments

Mark this form as completed without performing an actual inspection

File Upload

Location

+ Description



Bentley SYNCHRO (pg. 8)

8:57 AM Tue Mar 3 63%

< Back Create New Inspection Save

> HMA Laydown Operations - Laydown Equipment

> HMA Laydown Operations - Compaction Equipment


> HMA Laydown Operations - Miscellaneous Equipment

> Inspection Comments

Mark this form as completed without performing an actual inspection

File Upload

Location

 hma approach

Latitude 39.612626 / Longitude -104.901781

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8:59 AM Tue Mar 3 63%

< Back Inspections + 🔍 Select

00033	610-07487	HMA Approach	Quality	🕒 Pending	Mar 3, 2020 Created by: Derek Fuller
00032	211-0926x	Tyty	Quality	📅 Not Started	Feb 27, 2020 Created by: Mark Hattersley
00031	502-06329	Concrete Pave...	Quality	🕒 Pending	Feb 25, 2020 Created by: Beth Buerger
00030	720-45410	Manhole 25	Quality	🕒 Pending	Feb 20, 2020 Created by: Corey Johnson
00020	720-45410	Manhole 5437	Quality	📄 Overridden	Feb 18, 2020 Created by: Beth Buerger
00014	720-45410	Manhole 22	Quality	📄 Overridden	Feb 17, 2020 Created by: Corey Johnson
00012	720-98174	Manhole002	Quality	✅ Passed	Feb 14, 2020 Created by: Beth Buerger
00011	720-45005	Manhole 65543	Quality	🕒 Pending	Feb 14, 2020 Created by: Beth Buerger
00003	502-12153	Concrete Pave...	Quality	✅ Passed	Feb 14, 2020 Created by: Beth Buerger
00002	502-06329	Concrete pave...	Quality	📄 Overridden	Feb 14, 2020 Created by: Beth Buerger
00001	211-0926x	Backfill 001	Quality	✅ Passed	Feb 14, 2020 Created by: Beth Buerger

Bentley SYNCHRO (pg. 9)

SYNCHRO Control x + construction.bentley.com/5844c07e-727d-48d2-ad7c-46536ff7eeef/inspections

SYNCHRO Control 001 - Field Inspections Test 001 - Field Inspections Test Project DF

Pay Items

Select All

- 200 Earthwork
 - 211 B Borrow and Structure Backfill
 - 211-0926x Structure Backfill, Type 1/2/3/5
- 400 Asphalt Pavements
 - 406 Tack Coat
 - 406-05520 Asphalt For Tack Coat
 - 406-05521 Asphalt For Tack Coat
 - 406-12347 Asphalt Emulsion For Tack Coat
- 500 Concrete Pavement
 - 502 Portland Cement Concrete Pavement, PCCP
 - 502-06329 PCCP, 12 in.
 - 502-12153 PCCP, Precast, Removable
- 600 Incidental Construction
 - 610 Approaches and Crossovers
 - 610-07487 HMA for Approaches, Type B
 - 610-07488 HMA for Approaches, Type C
 - 610-07788 HMA for Approaches, Type D
- 700 Structures
 - 715 Pipe Culverts, And Storm And Sanitary Sewers
 - 715-04611 Safety Metal End Section 4:1 Dia 12 In
 - 715-05053 Pipe, Tvoe 1. Circular. 12 in.

Inspections

<input type="checkbox"/>	Pay item	Inspection name	Form type	Date	Inspected By	Status	
<input type="checkbox"/>	211-0926x	Backfill 001	Quality	Feb 14, 2020	Beth Buerger	Passed	...
<input type="checkbox"/>	211-0926x	Tyty	Quality	Feb 27, 2020	Mark Hattersley	Not Started	...
<input type="checkbox"/>	502-06329	Concrete pavement - ...	Quality	Feb 14, 2020	Beth Buerger	Overridden	...
<input type="checkbox"/>	502-06329	Concrete Pavement M...	Quality	Feb 25, 2020	Beth Buerger	Pending	...
<input type="checkbox"/>	502-12153	Concrete Pavement - ...	Quality	Feb 14, 2020	Beth Buerger	Passed	...
<input type="checkbox"/>	610-07487	HMA Approach	Quality	Mar 3, 2020	Derek Fuller	Pending	...
<input type="checkbox"/>	720-45005	Manhole 65543	Quality	Feb 14, 2020	Beth Buerger	Pending	...
<input type="checkbox"/>	720-45410	Manhole 22	Quality	Feb 18, 2020	Corey Johnson	Overridden	...
<input type="checkbox"/>	720-45410	Manhole 5437	Quality	Feb 18, 2020	Beth Buerger	Overridden	...
<input type="checkbox"/>	720-45410	Manhole 25	Quality	Feb 20, 2020	Corey Johnson	Pending	...
<input type="checkbox"/>	720-98174	Manhole002	Quality	Feb 14, 2020	Beth Buerger	Passed	...

Administration

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Bentley SYNCHRO (pg. 10)

SYNCHRO Control 001 - Field Inspections Test 001 - Field Inspections Test Project DF


Dashboard

Category: Construction Of...

Property: Assigned To



Property: Status



Quick Stats

Filled out Forms	Assigned to Me	Due this week
17	1	2
Open	Avg. Open	Open > 30 days
8	6 days	0
Closed	Closed this week	Closed today
0	0	0

Construction Office

Filled out Forms Export view to Excel

ID	Subject	State	Status	Created by	Assigned to	Due date	Priority	Description	Type	Category
00004	Pavement 001	Open	Assigned	Beth Buerger	Corey Johnson	Feb 18, 2020 6 days Over...	High	Review thickness	Progress	Issue
00008	Review for slope	Open	Review	Beth Buerger	Chase Wells	Feb 14, 2020 10 days Over...	Critical		Design	RFI
00009	HMA 001 - Rutt...	Open	Review	Beth Buerger	Beth Buerger	Feb 17, 2020 7 days Over...	Critical	Please inspect...	Progress	Issue
00010	Manhole 4475...	Open	Review	Beth Buerger	Beth Buerger	Feb 18, 2020 6 days Over...	Medium	Please review	Design	RFI
00013	Test issue	Draft	Draft	Derek Fuller	Derek Fuller	Feb 18, 2020 6 days Over...	Medium	just testing the...	Design	Issue
00015	North Arrow in...	Draft	Draft	Corey Johnson	Beth Buerger	Feb 20, 2020 4 days Over...	High	This is not the...	Design	Issue

Construction Office

3D Modeling

SPR 4421 Life
Cycle
Integration of
Infrastructure
Information
Modeling

3D Modeling
with Bentley
SYNCHRO App
Demonstration

3D Modeling
Deliverable
Pilot

UAS

Primavera
P6/Synchro

SPR 4421 Infrastructure Information Modeling

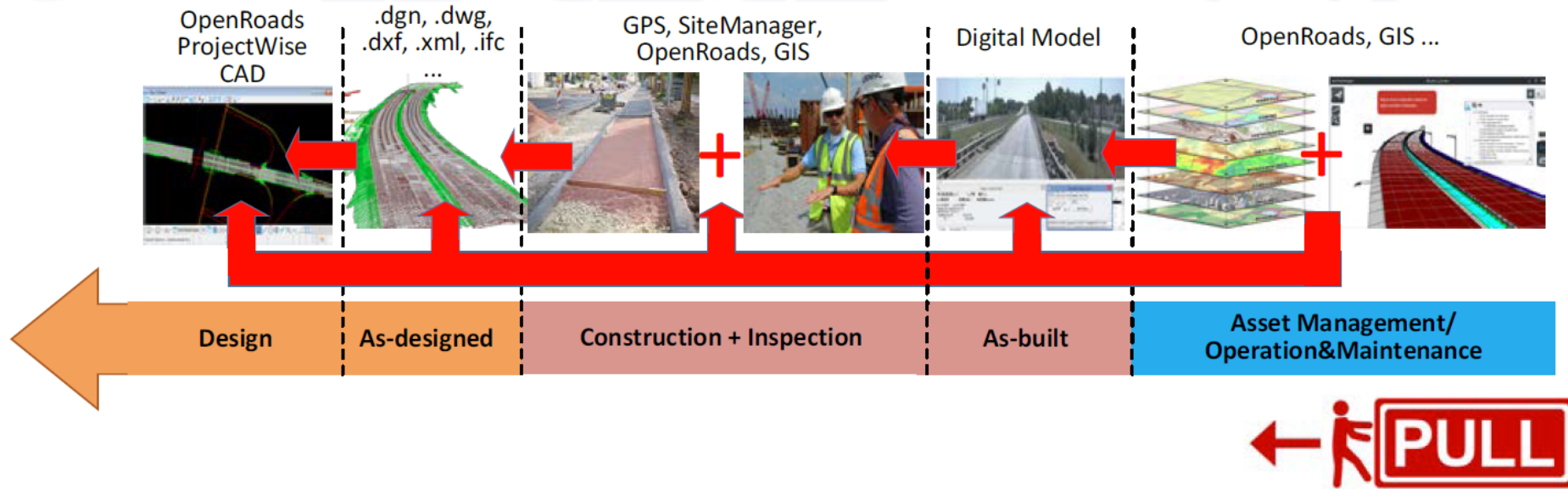


Figure 2. Recommended Pull-Type Data Flow for INDOT (Cai et al., 2015; Fuller, 2018)

Ideal Technology	Ideal Process
Compatibility of project software and apps	Sharing of files (e.g., 3D models) among designers, contractors, and INDOT
	Clear definition of business process and workflow
	Accurate infrastructure asset information

SPR 4421 Infrastructure Information Modeling - 2

Integration of BIM and GIS for facility management

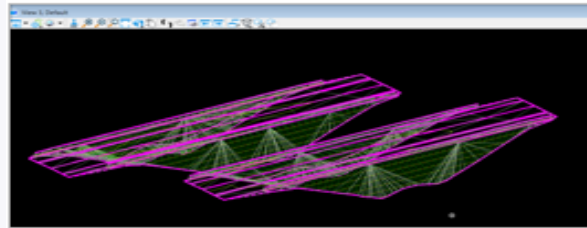


Figure 1. Bridge decks in .DGN



Figure 2. Bridge decks in .STP

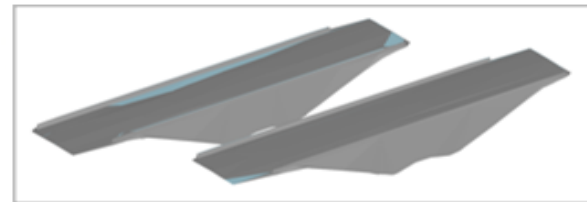


Figure 3. Bridge decks in .IFC

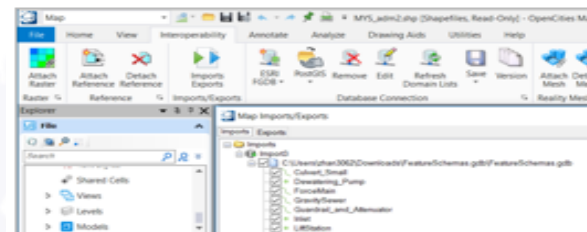


Figure 4. GIS data

The .DGN data can be exported to .STP file.

The .STP file can be exported to .IFC file.

The .IFC file can be integrated with GIS file.

SPR 4421 Infrastructure Information Modeling - 3

Required Files

- Models and documents that are required to be delivered to the contractor and INDOT but are not part of the documents or files defined as the legal document.
File types to be filled by INDOT
(Example) Roadway design layout file - DGN, DXF

Legal Document

- Models and documents that are required to be delivered to the contractor and INDOT which the engineer of record (EOR) certifies as a correct and accurate representation of the design intent. Legal Document and required format(s) to be delivered are as follows:

For Information Only

- Additional helpful files, some required and some not required, to be delivered to the contractor and INDOT. For Information Only files and required format(s) to be delivered are as follows:

SPR 4421 Infrastructure Information Modeling - 4

EN-Environmental Areas						
Erosion Control-P	DWG/DGN	0.50'+/-	2D	N/A	N/A	N/A
Wetlands Surveyed-E	DWG/DGN	0.50'+/-	2D	N/A	N/A	N/A
Hazmat-E	DWG/DGN	0.50'+/-	2D	N/A	N/A	N/A
EW-Earthworks/Non-roadway Surfaces						
Surfaces-E	DWG/DGN/XML	varies*	3D	3D	3D	3D
Grading/Non-Road Surfaces-P	DWG/DGN/XML	0.06'+/-	3D	3D	3D	3D
Cut/Fill Areas Isopachs-P	DWG/DGN	0.06'+/-	2D	N/A	N/A	N/A
Longitudinal Breaklines/Points-E	DWG/DGN/XML	varies*	3D	3D	3D	3D
Longitudinal Breaklines/Points-P	DWG/DGN/XML	0.06'+/-	3D	3D	3D	3D
Slope Intercepts-P	DWG/DGN	0.06'+/-	2D	N/A	N/A	N/A
Surface Limits-E	DWG/DGN	0.06'+/-	2D	N/A	N/A	N/A
Surface Limits-P	DWG/DGN	0.06'+/-	2D	N/A	N/A	N/A
RD-Roadways/Surfaces-Proposed						
Road Pavement-Top Surfaces-P	DWG/DGN/XML	0.02'+/-	3D	3D	3D	3D
Road Pavement-Base Course Surfs-P	DWG/DGN/XML	0.06'+/-	3D	3D	3D	3D
Road Pavement-Subgrade Surfs-P	DWG/DGN/XML	0.06'+/-	3D	3D	3D	3D
Road Curb & Gutter-P	DWG/DGN/XML	0.02'+/-	3D	3D	3D	3D
Road Barriers-P	DWG/DGN/XML	0.06'+/-	3D	3D	3D	3D

SPR 4421 Infrastructure Information Modeling - 5

- **Panel Discussion:** We wish to get feedback and insight from experts (**designers, consultants, contractors, and INDOT staff**) about the current process, organization structure, information formats, and technologies in design, construction, and O&M.
- **Survey:** We wish to survey current information users at **INDOT O&M** about their evaluation of current processes and technologies in documentations of design and construction.
- The time we expected to conduct activity will be between **April and September 2020**.

CONTACT US TO JOIN THIS STUDY



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(AutoIC) Lab

LIFE CYCLE INTEGRATION OF INFRASTRUCTURE INFORMATION MODELING

INTRODUCTION

A successful implementation of IIM requires an integration from all aspects of a business, including technology, process, and information. Current practices reflect issues such as: isolation of project phases, incompatibility of project software and apps, unclear definition of business process and workflow, and inaccurate infrastructure asset information.

To solve the problem, this research will answer following questions:

- (1) What data are needed for the assets that INDOT have?
- (2) What is the best time and methodology to collect asset data?
- (3) Who is responsible to collect, check, update, and maintain asset data in what format?
- (4) How to convert data needs during O&M to construction & design requirement or documentations?

JOIN US

(1) Panel Discussion: We wish to get feedback and insight from experts (designers, consultants, contractors, and INDOT staff) about the current process, organization structure, information formats, and technologies in design, construction, and O&M.

(2) Survey: We wish to survey experts (designers, consultants, contractors, and INDOT staff) about their evaluation of current processes and technologies in design, construction, and O&M.

WHEN

Apr. to Sep. 2020

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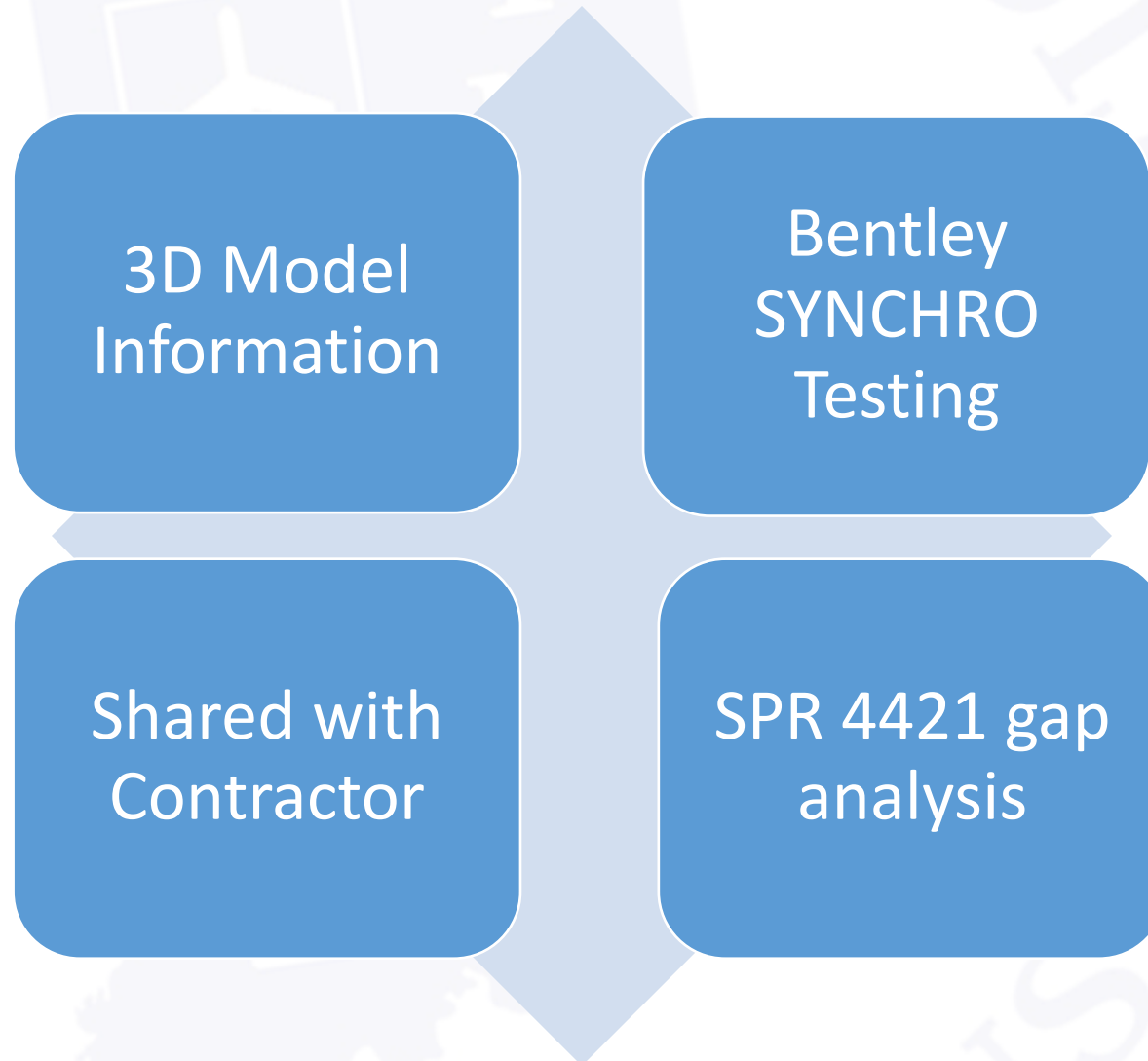


CHI

tian154@purdue.edu
6293, HAMP Hall, Purdue Uni.



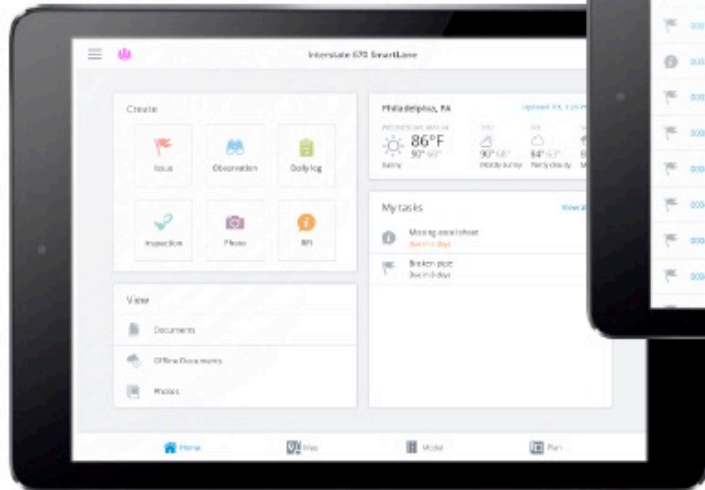
3D Modeling Demonstration



3D Modeling Demonstration - 2

Mobile - Field UX
One Experience, Multiple views,
Easy to use

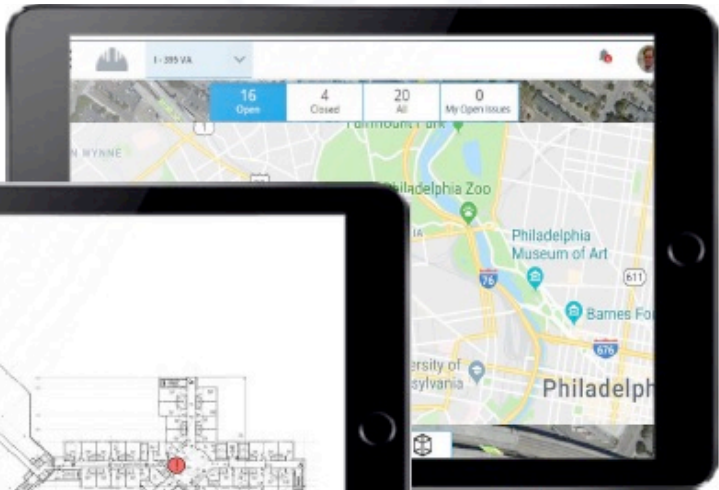
Task view



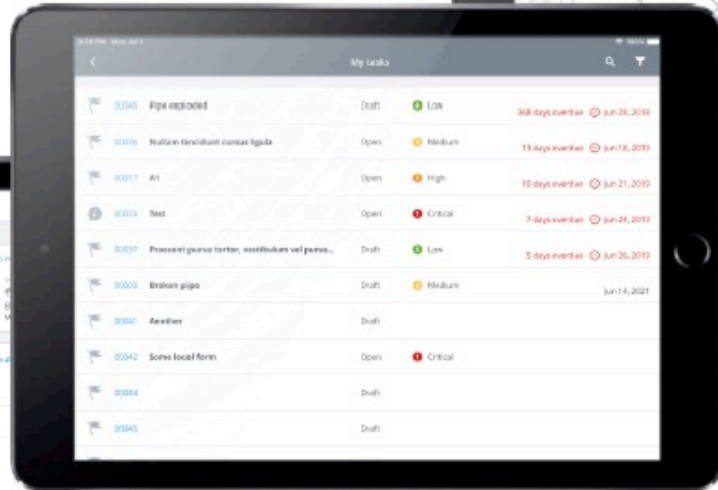
2D plan view



Map view



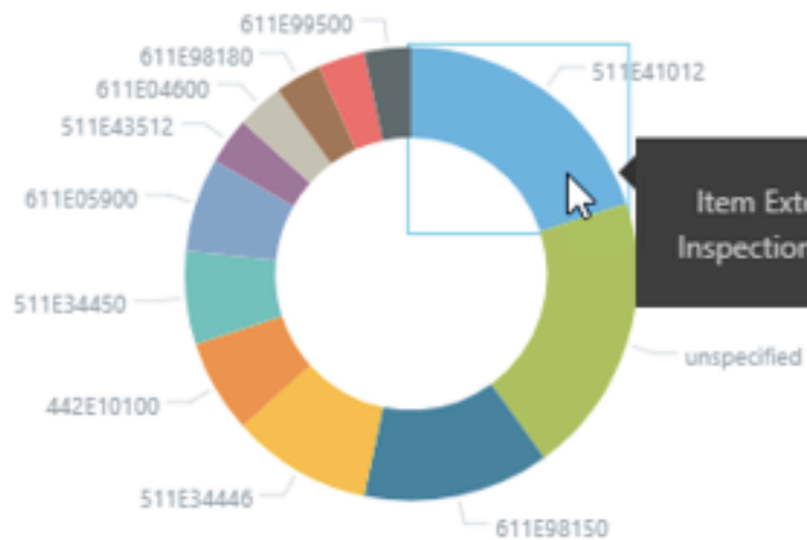
Report view



Model view



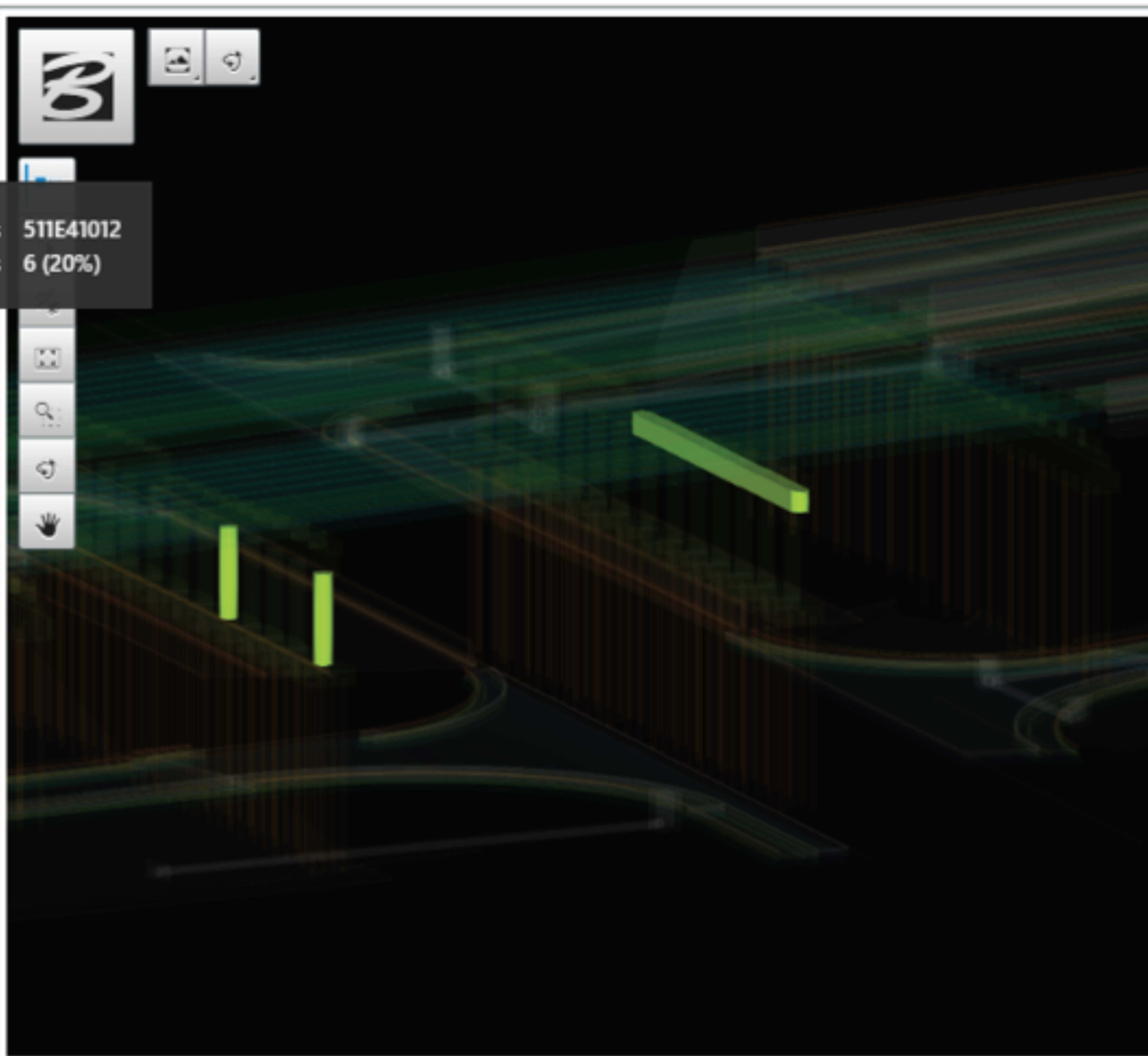
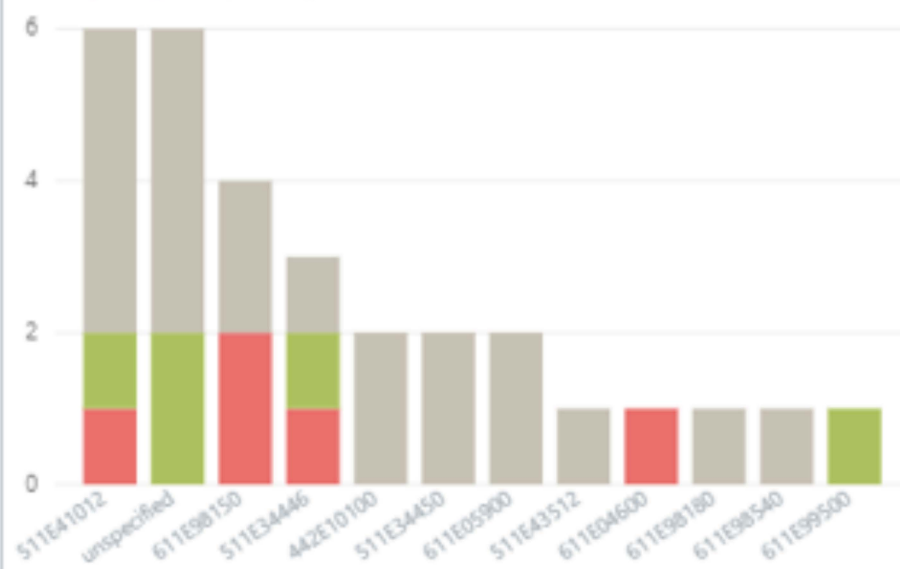
Inspections by Item Extensions



Item Extensions
Inspection Status
511E41012
6 (20%)

Inspection Status by Item Extensions

Status ● Fail ● Pass ● Pending



3D Modeling Demonstration - 3

Job Selection

- Major projects complexity

Overall Risk\$\$\$

- Setting a standard
- Expectations

Collaboration

- Design, Contractors, INDOT

Monitoring

- Real time to help decision making

Reporting



3D Deliverable Pilot

Design-Build Contractor shall capture the as-built coordinates of all new assets listed in Table 2-1 (As-Built Data List), including those new assets placed within existing conduits.

...shall collect coordinates of existing assets if they are modified or connected to any new assets (e.g., storm sewers, traffic barriers, or other features).

All x, y coordinates shall be sub-foot accurate. All z coordinates shall be 0.1-foot accurate. Coordinates and data shall be collected using the coordinate system (format to be provided)

Design-Build Contractor shall submit the data in (format to be provided) using the template provided at (to be provided).

Prior to backfilling any trenches, Design-Build Contractor shall obtain x, y, and z location of underground facilities.

3D Deliverable Pilot - 2

Table : As-Built Data List

Data No.

Asset

- 1 Drainage/Stormwater
- 2 Traffic Management Systems
- 3 Lighting
- 4 Signing
- 5 Traffic Signals
- 6 Traffic Barrier
- 7 Retaining Walls
- 8 Sound Barriers
- 9 Hazardous Material Management

UAS Pilot

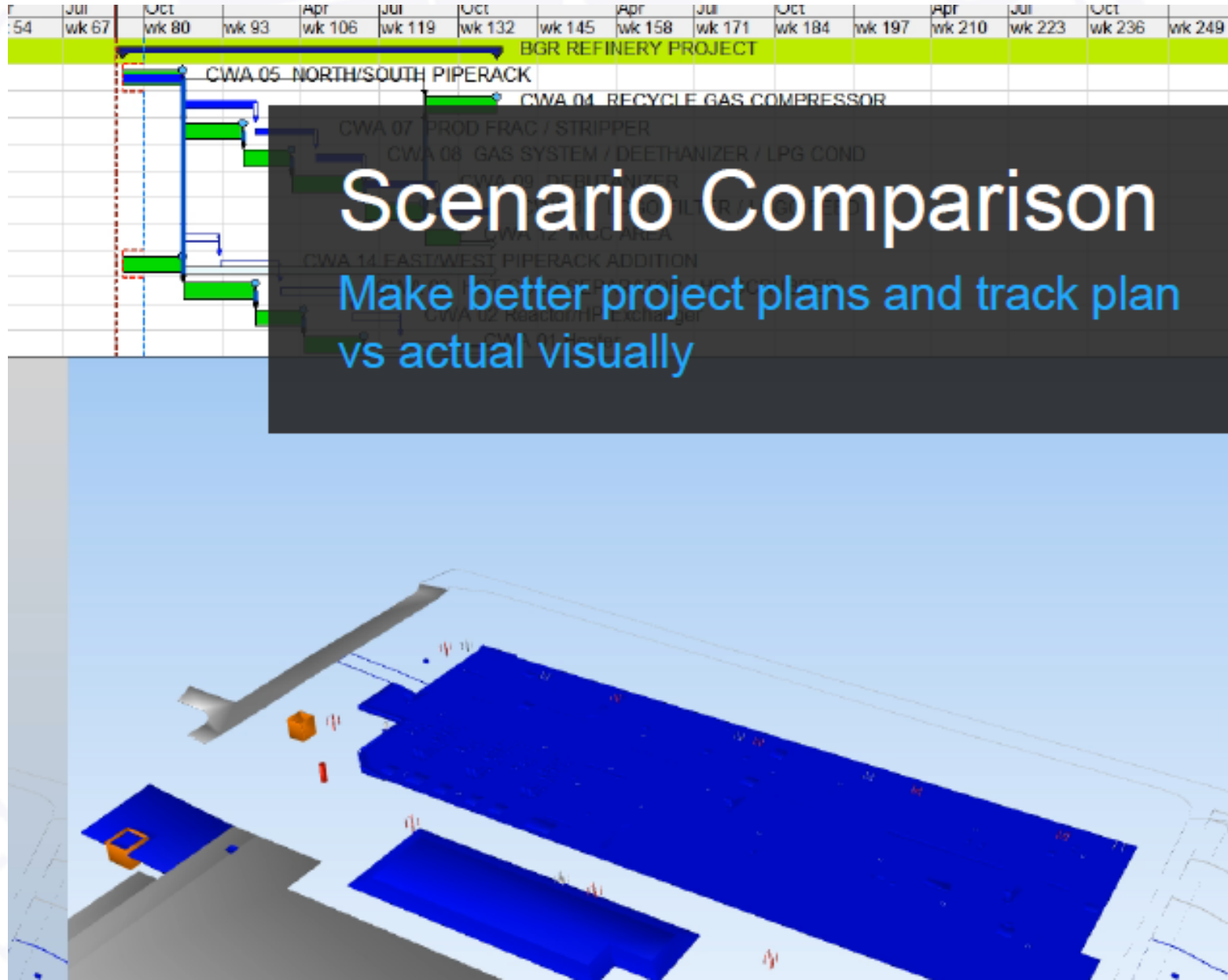
UAS Implementation Plan

- a. Supporting communications and public involvement coordination efforts;
- b. Documenting construction progress;
- c. Estimating quantities;
- d. Monitoring the location of construction workers and equipment;
- e. Evaluating and reviewing MOT within the Work zone; and,
- f. Assisting in Change Requests, Change Orders, and Dispute Resolution

UAS Pilot - 2

- a. Develop existing asset condition documentation prior to commencement of Construction Work, including LiDAR level 3D imagery and models
- b. Document existing pavement conditions on official detour routes
- c. Develop as-built asset condition documentation for post-Project retention, including LiDAR level 3D imagery and models.

4D Model P6/SYNCHRO



Pilot/Demonstration GIS

GIS
Initiative

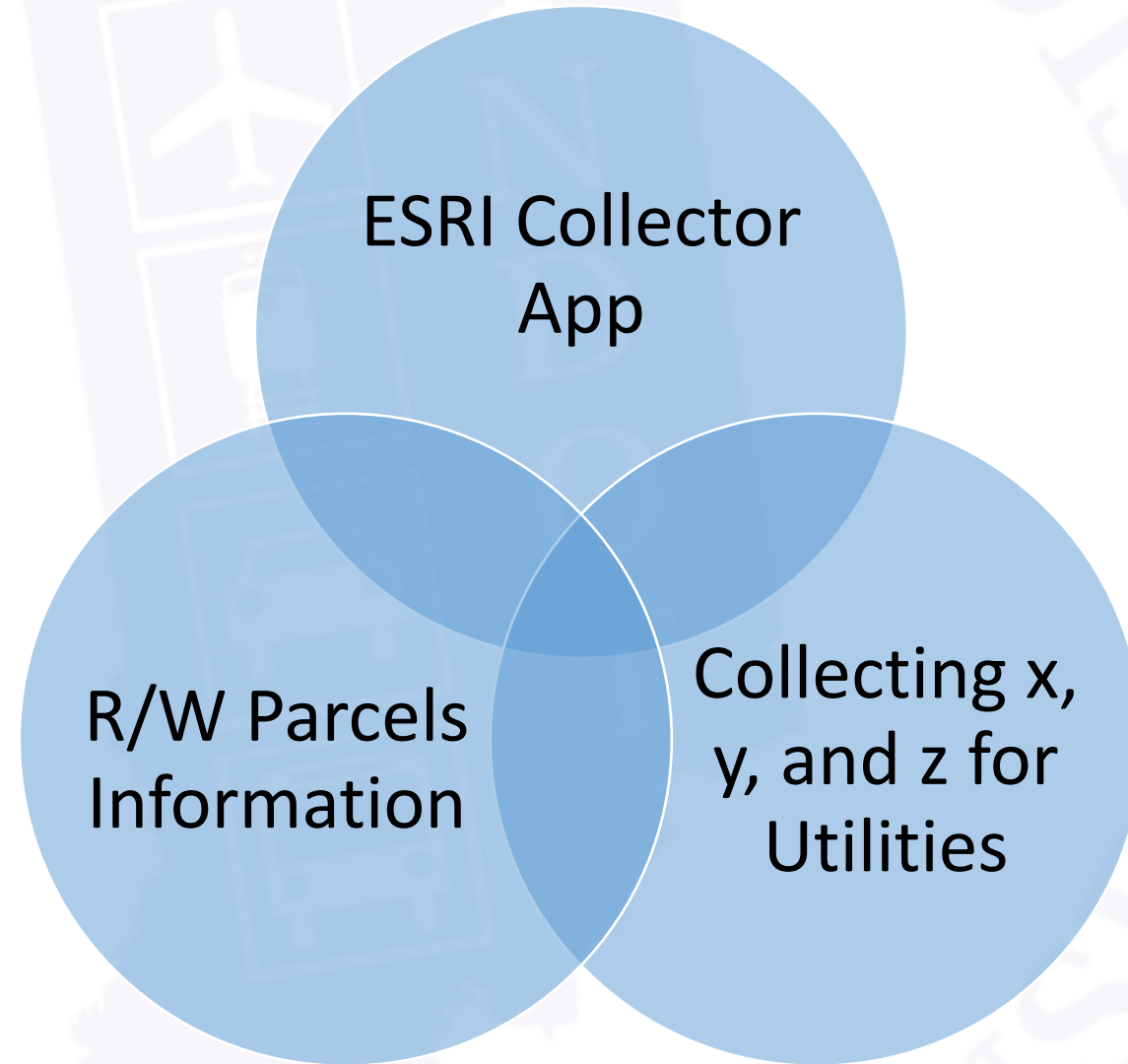
GPS
Rover

Collector
App

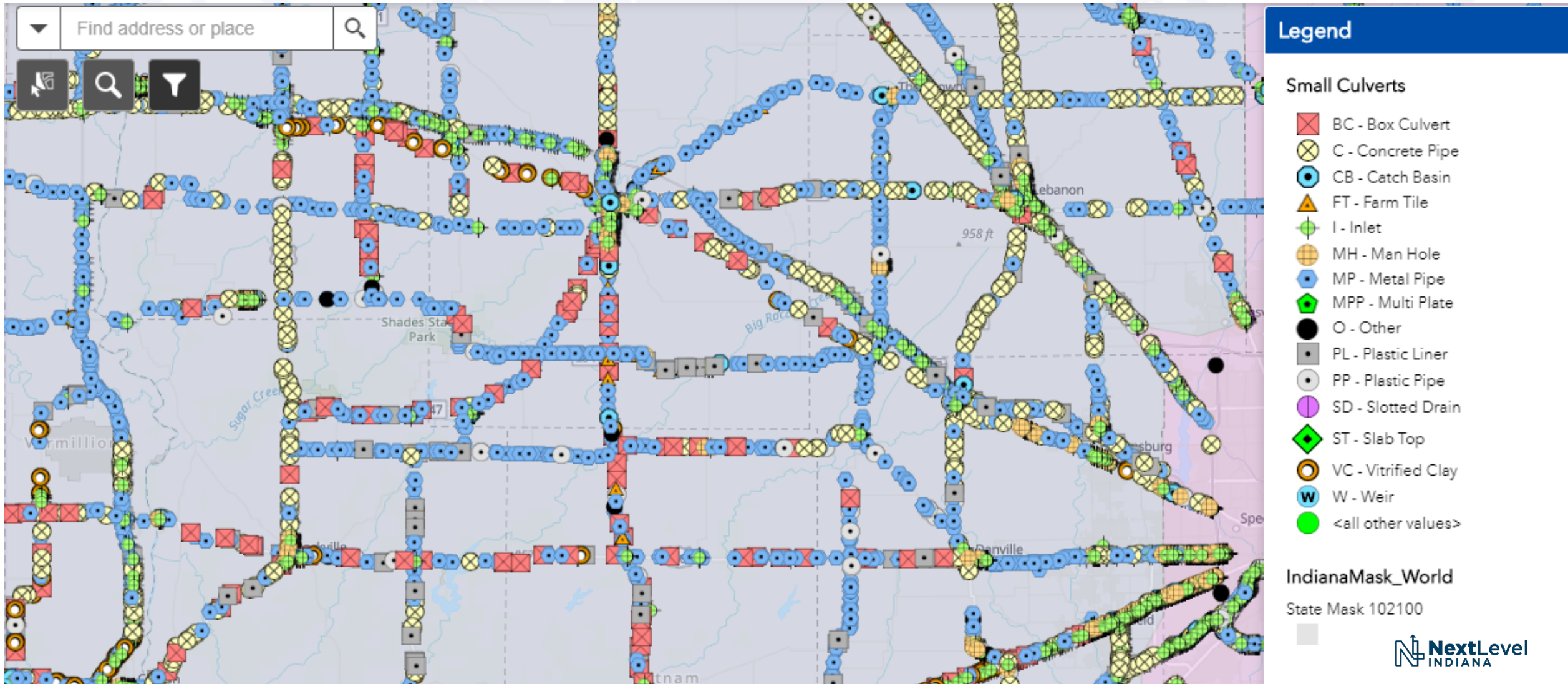
Intelligent
FCR

eTicketing

GIS Initiative

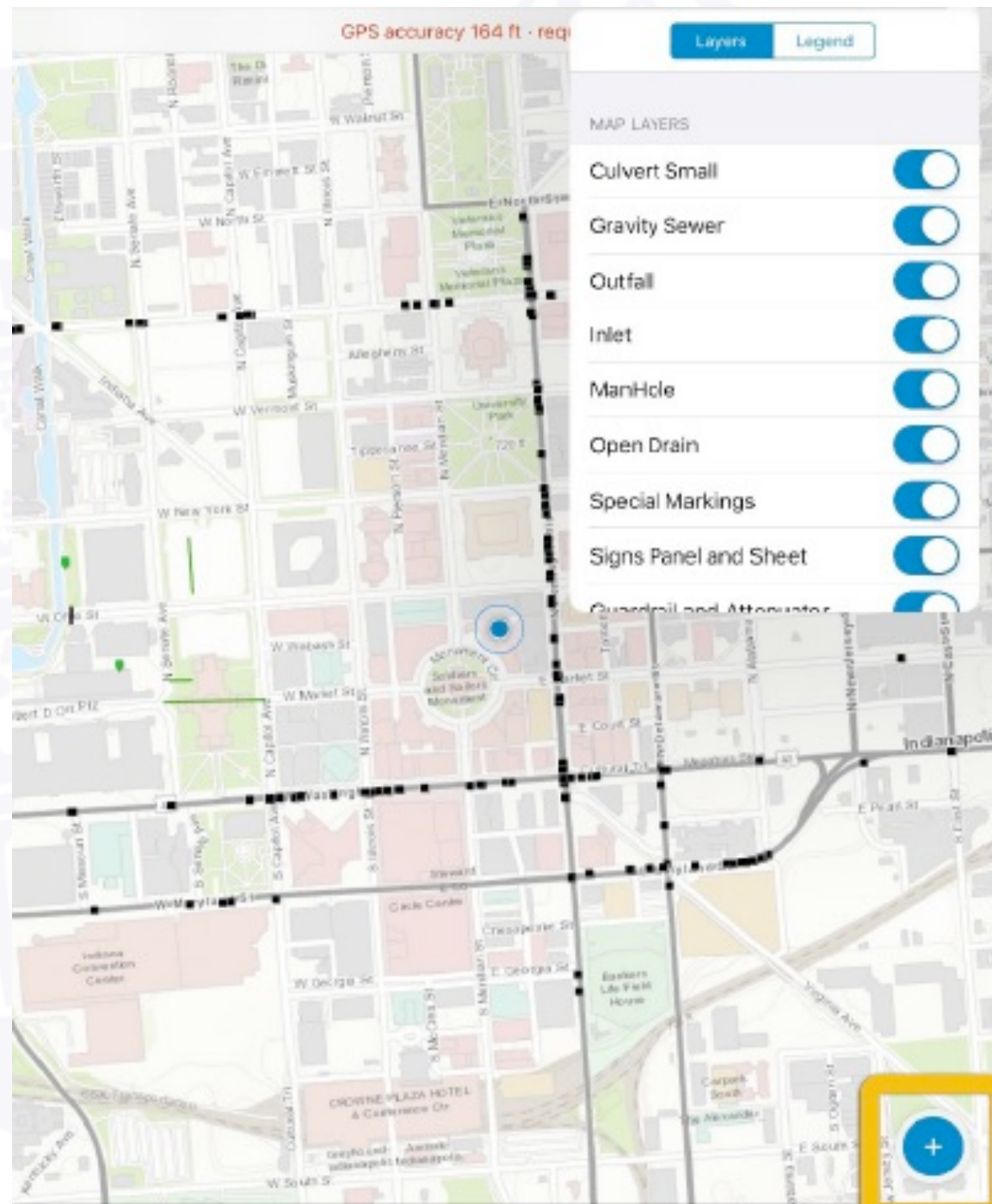


GIS Initiative - 2



ESRI Collector App

GPS Rover or other device
to boost accuracy



iFCR and other Apps

- Under Development



Field Assistant

Construction Reporting Module

Manual

Site Link



Lab Testing

Materials Management Module

Manual

Site Link



DMF Entry

HMA Mix Design Solution

DTE | P/S

App Link



HMA Pay Wizard

HMA Quality Assurance Solution

Open P/S Beta Dec 2019

Coming March 2020



CPMS

Contractor Payroll Management Solution

PE/S | Contractor

App Link



SWIM

Storm Water Inspection Management Solution

Tentative: Late 2020

CFA (current) Site Link

Questions?

- Contact Information:

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- Tim Haney: Timothy.Haney@parsons.com
- Andrew Pangallo: APangallo@indot.IN.gov