2019 TRB Webinar

E-Construction: Analyzing and Utilizing Non-graphical Construction Data for Smarter Project Delivery

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Introduction

H. David Jeong, PhD.

The James C. Smith CIAC Endowed Professor

Department of Construction Science,

Texas A&M University, College Station, TX

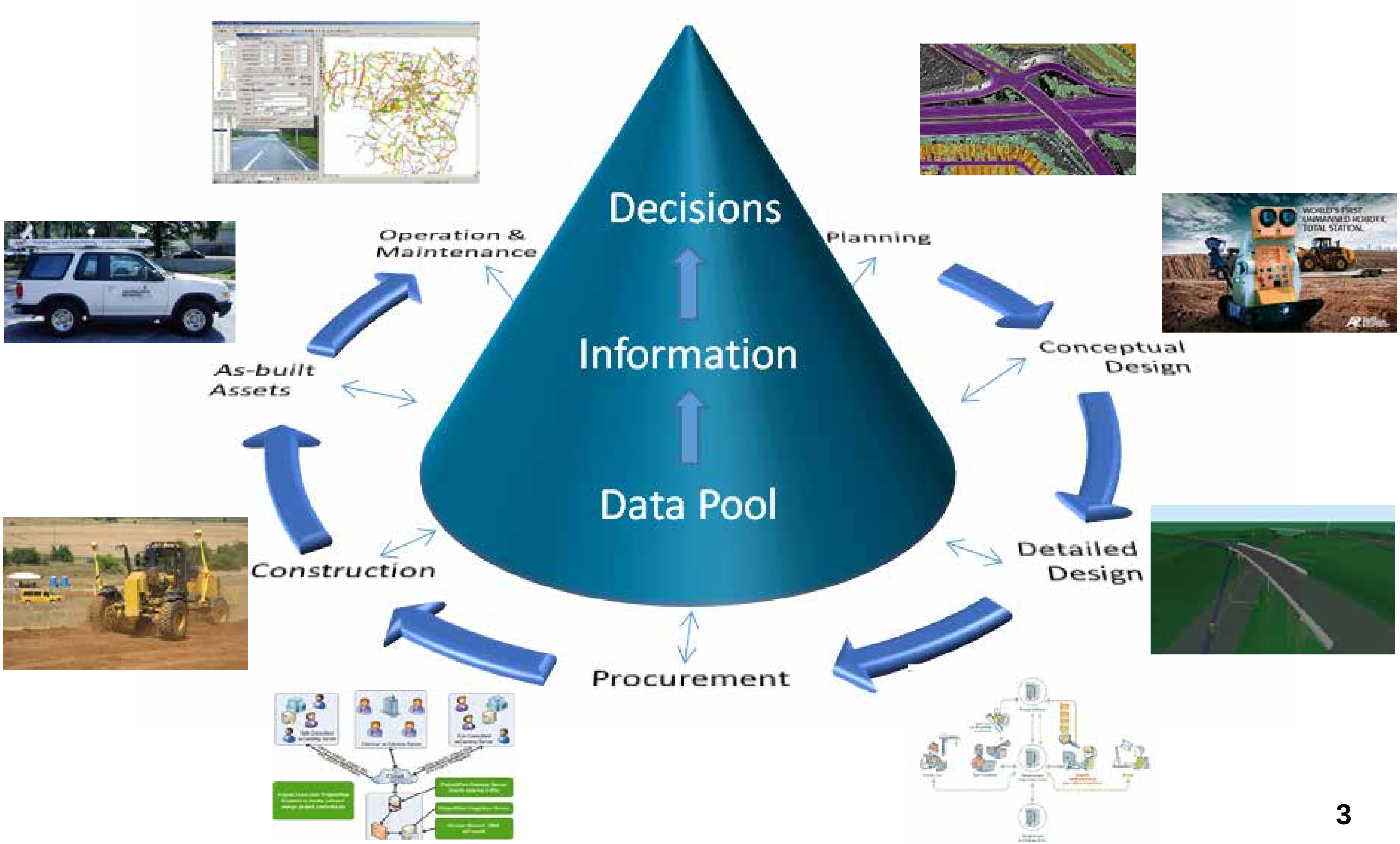
Webinar Sponsors

AFH10 - Construction Management Committee

ABJ50 - Information Systems and Technology Committee

AFH10(1) – Information Systems in Construction Management Subcommittee

Digital Project Delivery – Better, Faster, *Smarter*



Presentations

Presentation #1: FHWA’s perspectives for use of digital data in highway construction and beyond

Speakers: David Unkefer (FHWA), and Kathryn Weisner (FHWA)

Presentation #2: Analyzing and utilizing non-graphical data for smarter project delivery

Speakers: Chad Shafer (Infotech), and Janet Treadway (Ohio DOT)

Presentation #3: Construction Data – What works & what needs work

Speaker: Jayme Arlen (Kiewit)

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FHWA’s Perspectives for Use of Digital Data in Highway Construction and Beyond

FHWA Resource Center –
Kathryn Weisner, PE, NRAEMT
David Unkefer, PE

2019 TRB Webinar: ***e-Construction: Analyzing and Utilizing Non-graphical Construction Data for Smarter Project Delivery***

e-Construction Maturity

Project Delivery Process Step	State of Practice*		
	Nascent	Intermediate	Mature
Plans, Specifications, and Estimates		▲	
Electronic Bidding and Contractor Selection			▲
Construction Management Systems		▲	
Project Collaboration		▲	
Digital Signatures		▲	
Project Inspection and Testing		▲	
Project Acceptance		▲	
Project Close-Out		▲	
Data Sharing between Steps	▲		

*The state of practice is based on findings from the literature review, AASHTO survey, and detailed interviews, Source: *Addressing Challenges and ROI for Paperless Project Delivery*, FHWA-HIF-17-028, May 2017.

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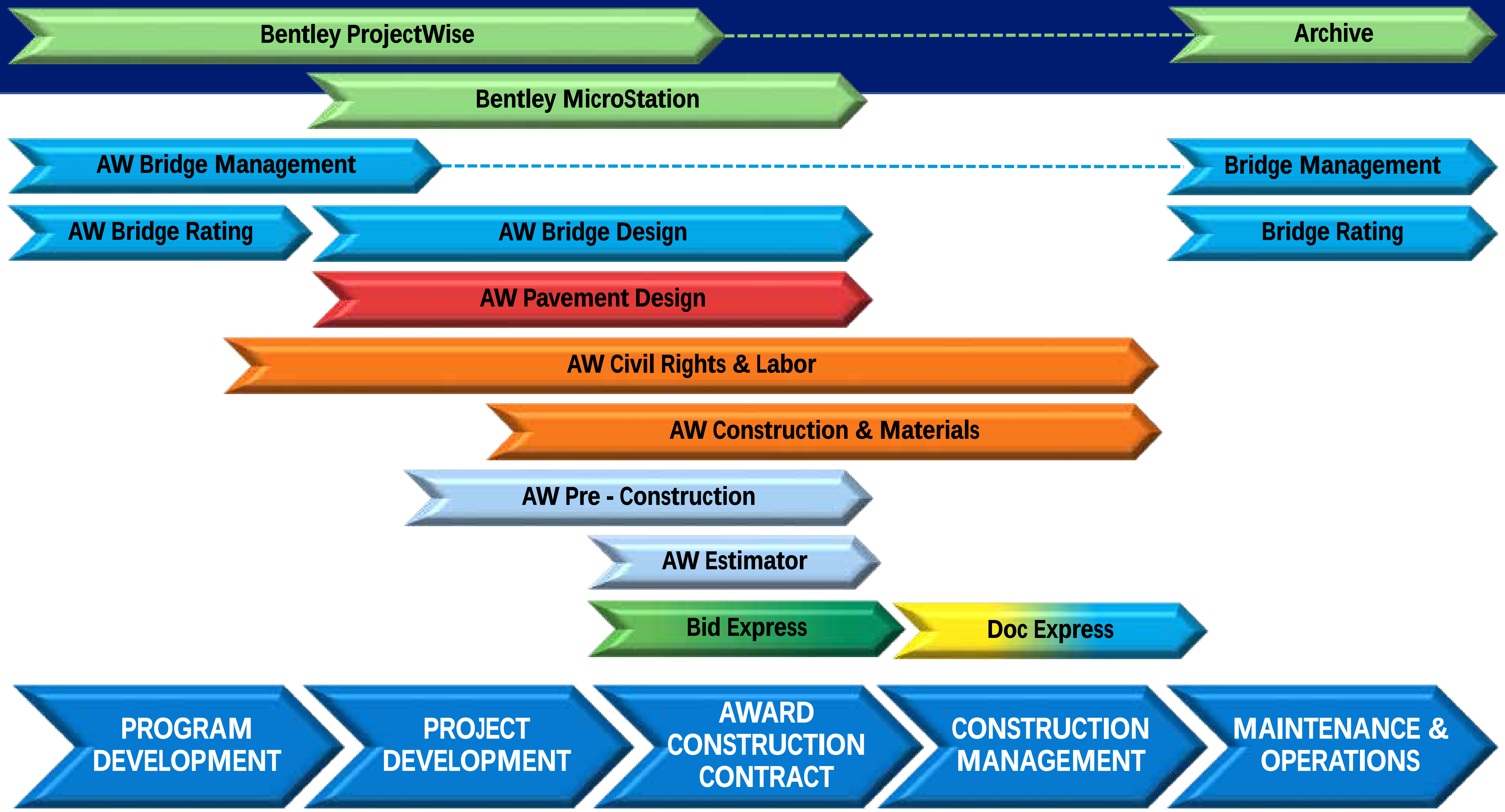
Digital Data Management Plan



Proposed Project Delivery Cycle Software Systems

Source: Oregon DOT

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Best Practices –
Single Source of Truth – Constr. Inspection

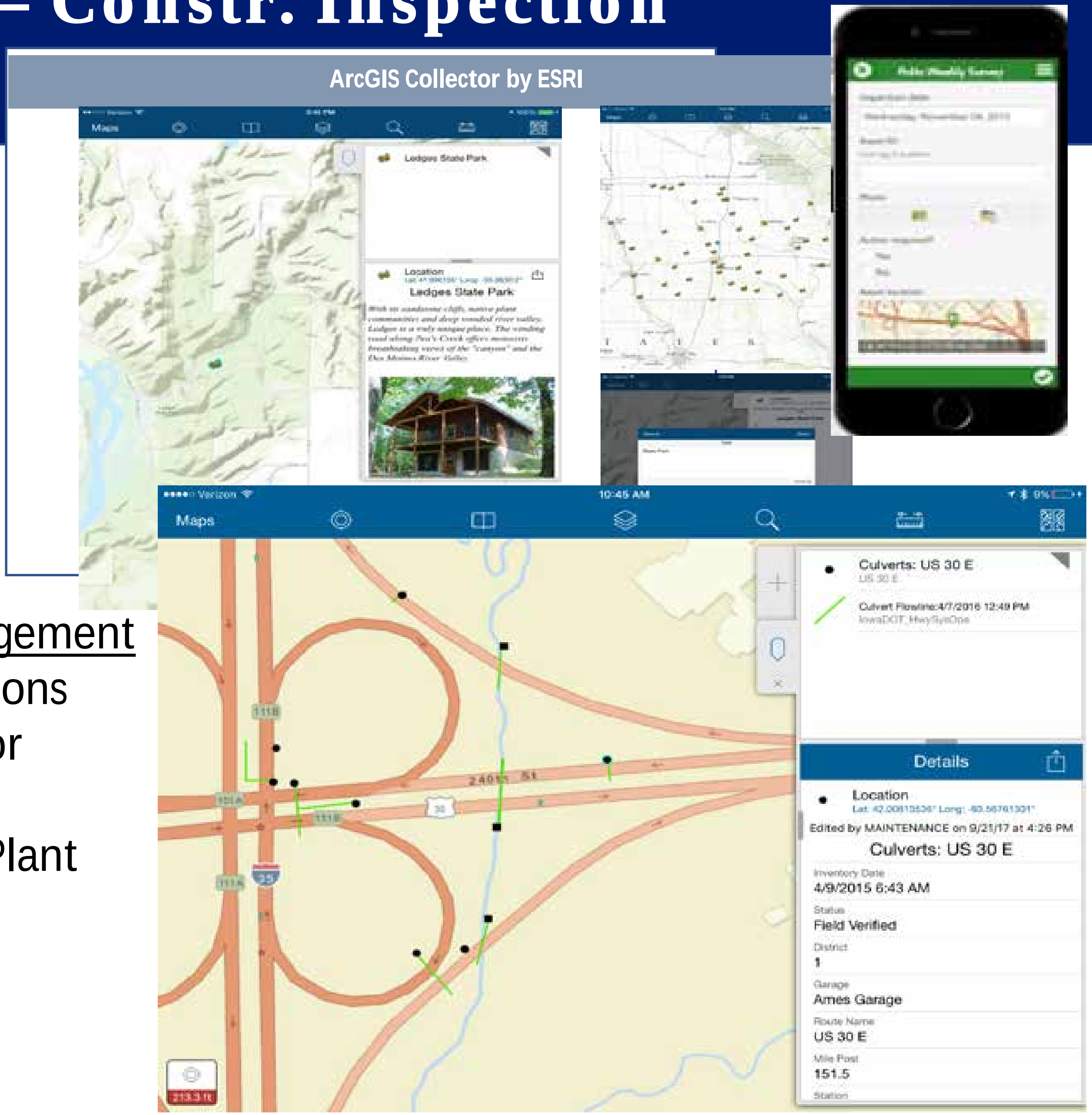
Ø Field Data Collection with

esri

Collector & Survey 123

Survey123

Collector



<u>Asset Inventory</u>

- Ø Guardrail
- Ø Culverts
- Ø Signs
- Ø Lighting

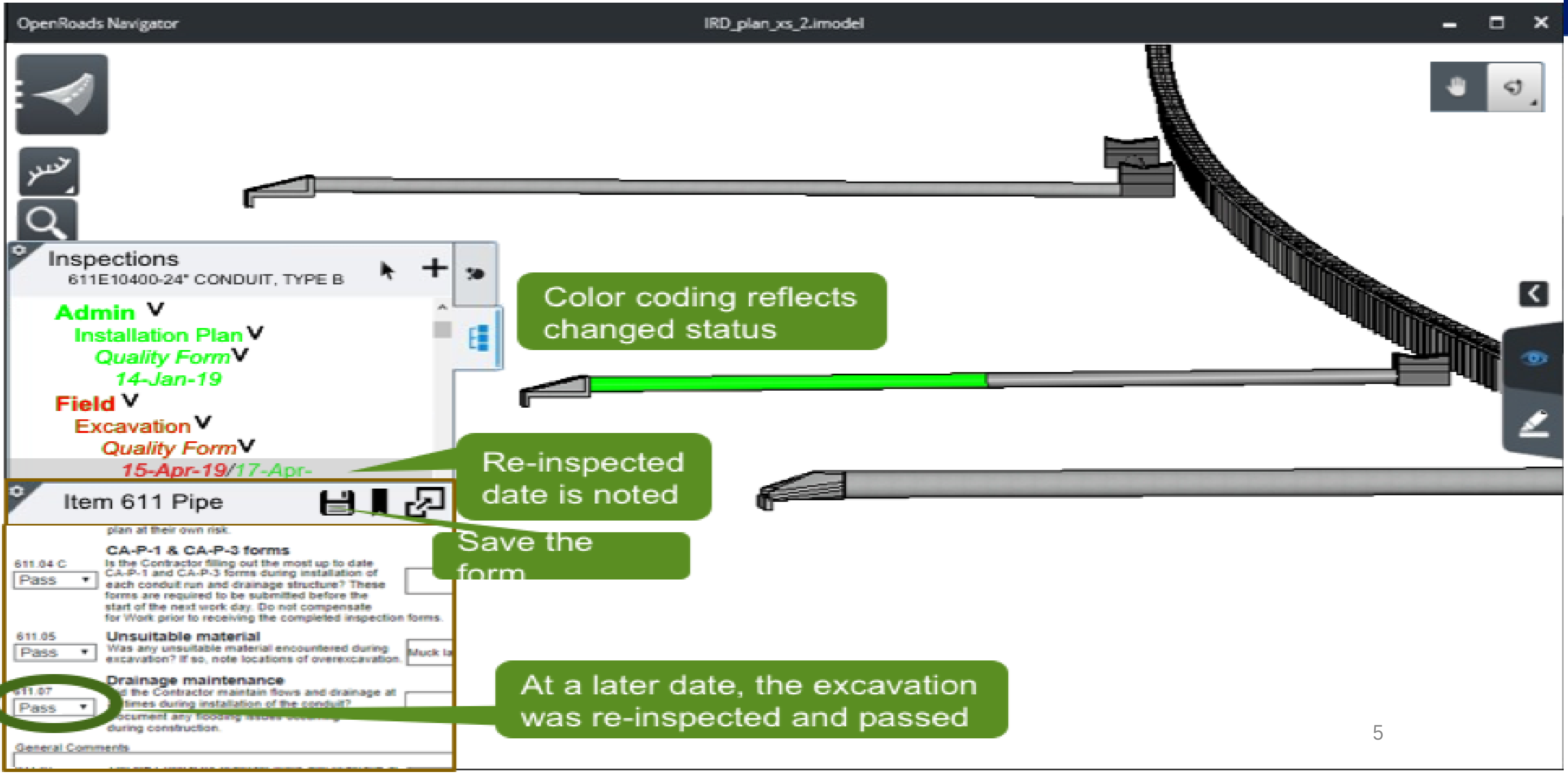
<u>Project Materials Management</u>

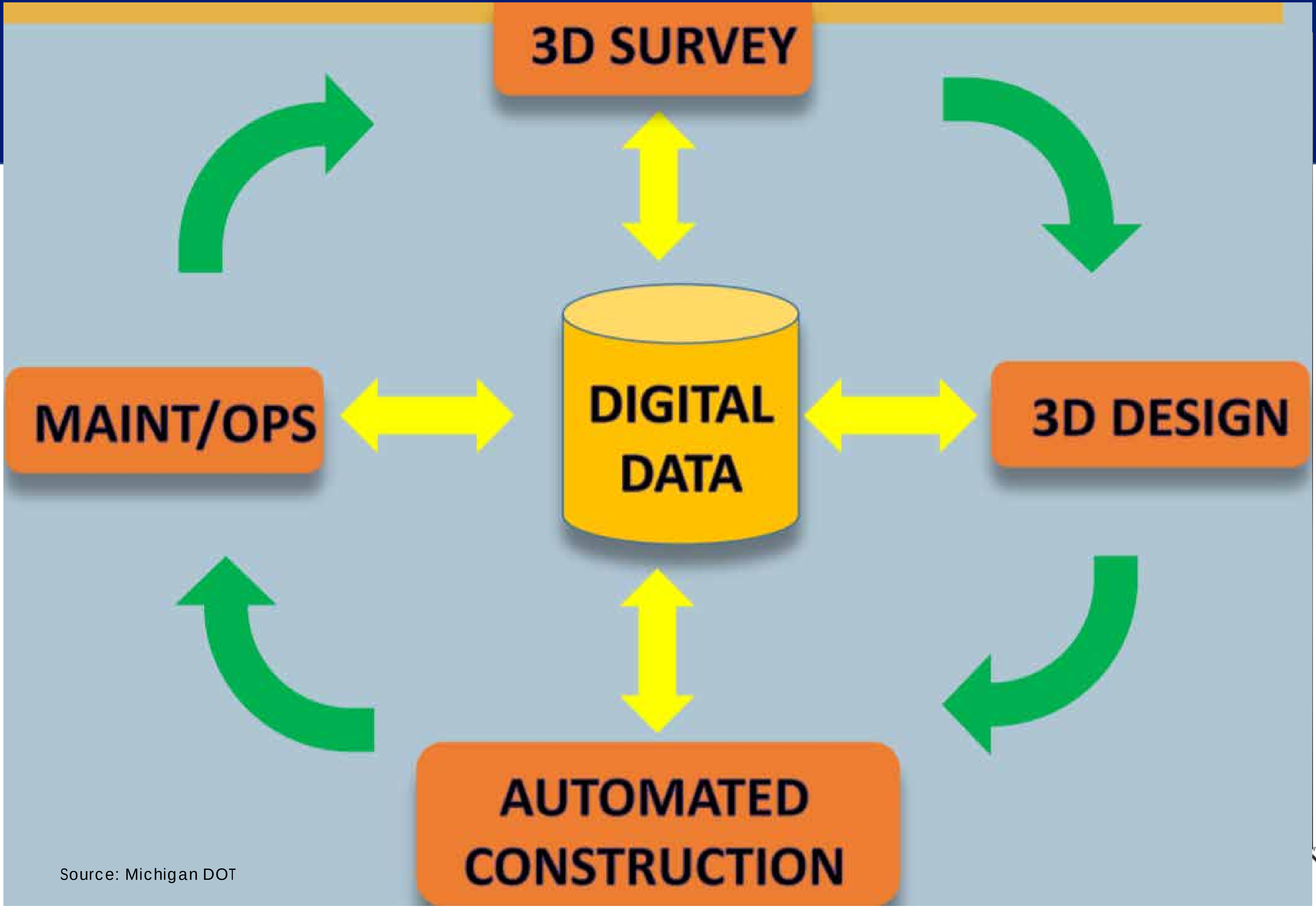
- Ø HMA Sample Locations
- Ø Field Information for Sample Testing
- Ø HMA, PCC, & Agg. Plant Calibrations and Qualifications
- Ø Design Data

Source: IOWA DOT and ARC GIS

Best Practices – Single Source of Truth – Constr. Inspection

Source: INDIANA DOT and Bentley





Source: Michigan DOT

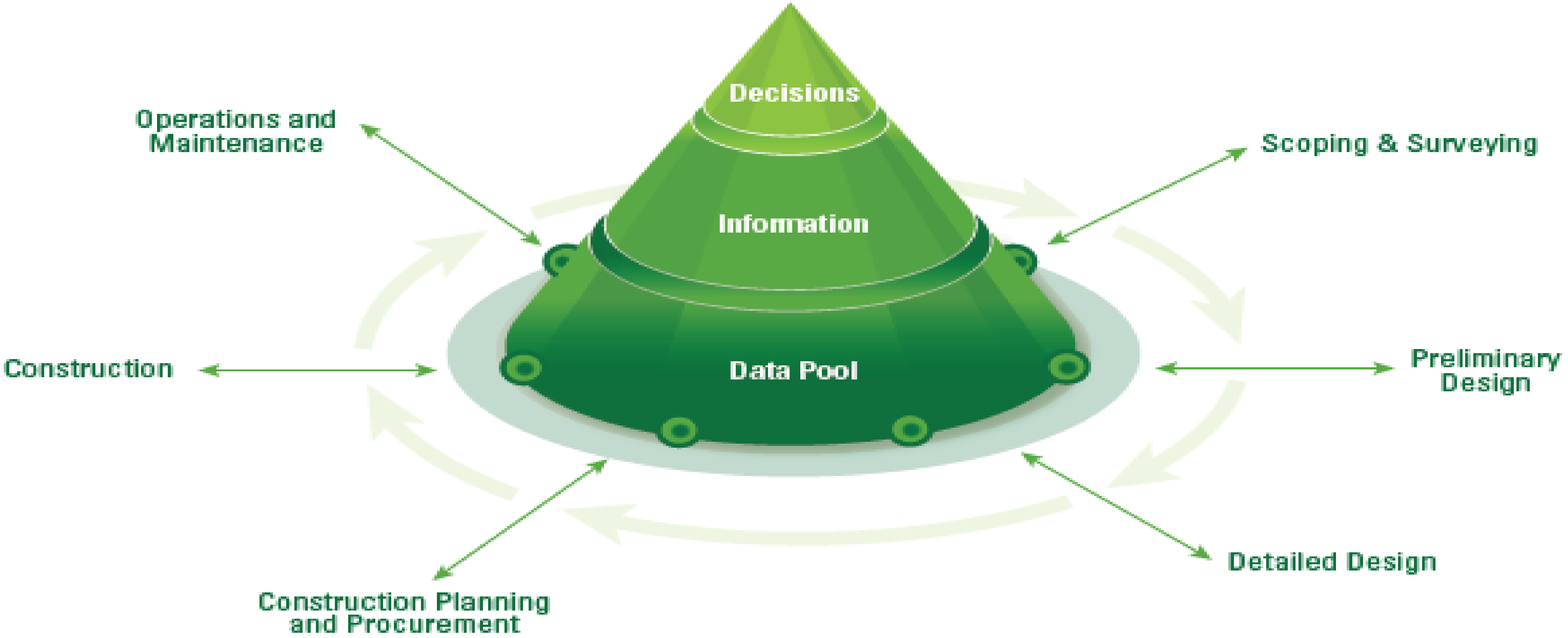
Source: https://www.channelpartnersonline.com/2019/04/11/todays-channel-the-big-picture/

BIM is a transformative approach to digital program and project delivery –

e-Everything

BIM for Infrastructure is a collaborative work method for structuring, managing, and using digital data and information about transportation assets throughout their lifecycle.

BIM for Infrastructure
- eConstruction and non-graphical data is one part, one data source



Source: Dr. David Jeong, Iowa State University,

Geospatially referenced highway asset data

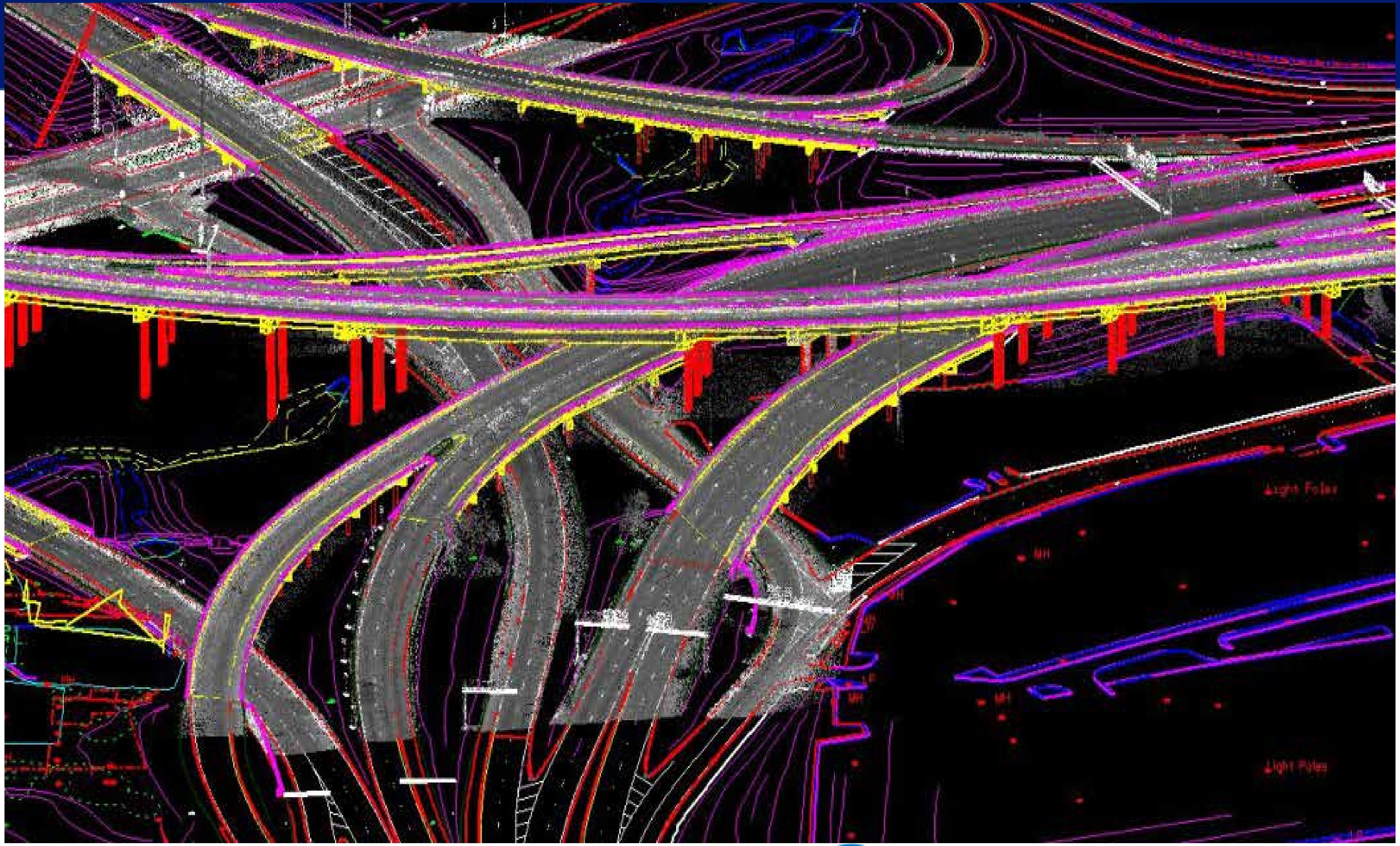


Image credit: Woolpert

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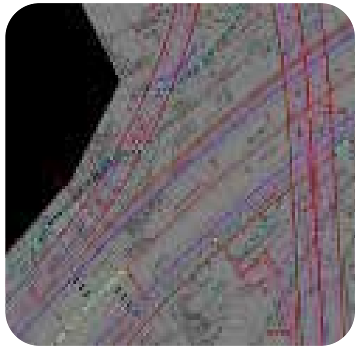
BIM/CIM Technology Clusters

2D

- 2D Plan sets in the field during construction



3D / nD

- 3D Visualization during construction (e.g. isometric drawings, physical models, etc.)
- 3D CADD 4D Modeling Analysis (3D + schedule)
- 5D/nD Modeling Analysis (model-based quantity takeoff/model-based cost estimating)
- Work Packaging Software / Advanced scheduling

Sensing

- 3D Imaging (e.g. LiDAR, photogrammetry)
- Geographical Information Systems (GIS)
- Global Positioning Systems (GPS)
- Intelligent Transportation Systems (ITS)
- Field Sensors (e.g. RFID, ground penetrating radar, ultrasonics)
- Intelligent Compaction
- Automated Machine Guidance and Control (AMG)
- Utility Engineering / Clash Detection / Coordination

Data Management

- Electronic archival and updating of plans
- Digital Asset Management
- Materials Management System (e.g. Spreadsheets and RFIDs)
- Mobile Digital Devices for onsite applications (tablets, smart phones, etc.)
- Data Connectivity Other than Cellular Towers
- Digital Signatures

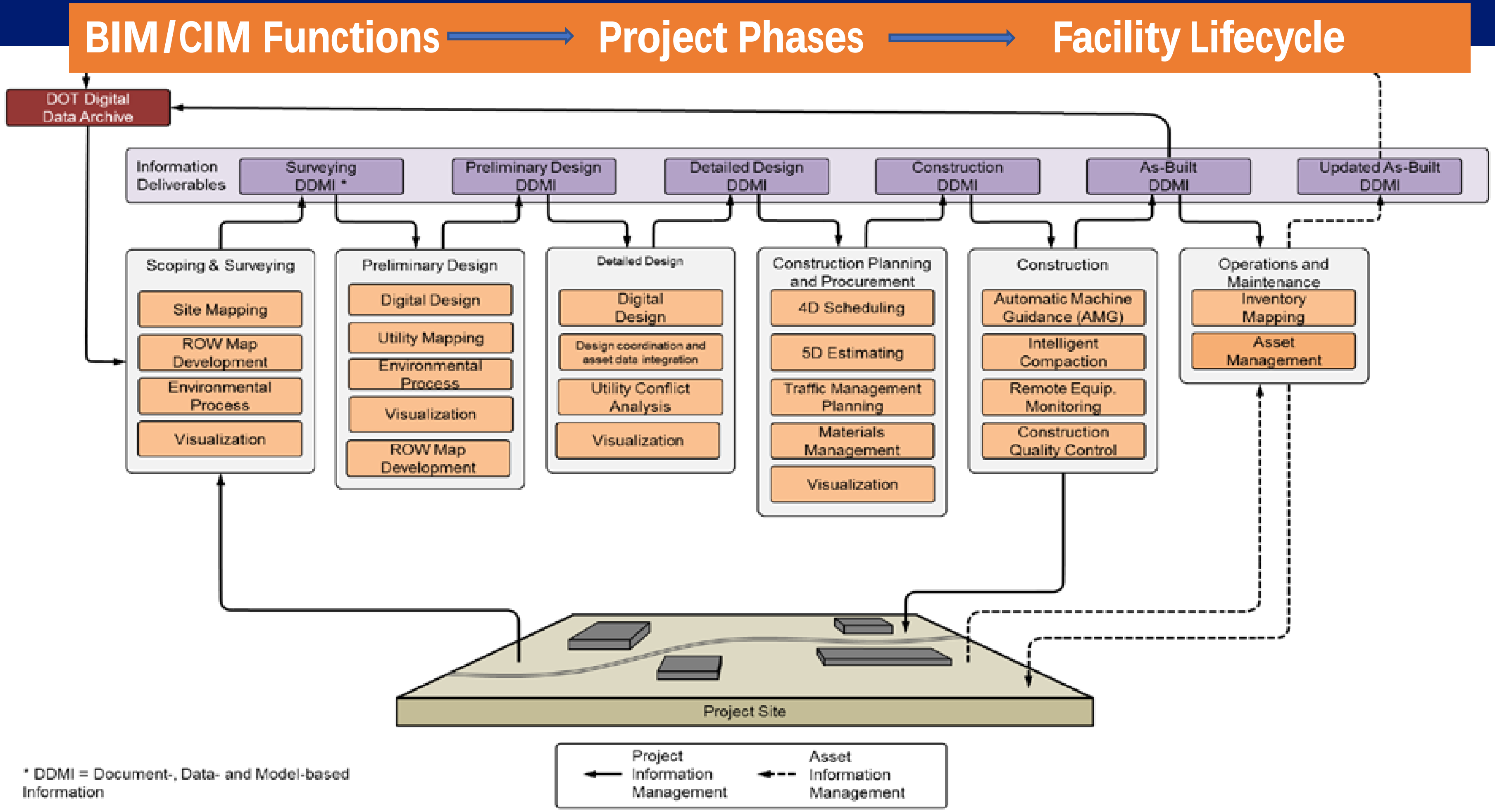
Source: NCHRP Report 831

Creating Digital As-Built Records

Construction is the most cost-effective time to capture position information

Image Source: FHWA

Impact of BIM/CIM on Project Workflow



Source: NCHRP Report 831

FHWA BIM-Related Research

- Integrating 3D Digital Models and other Building Information Management Data into Asset Management
- Construction Inspection for Digital Project Delivery
- Leveraging Augmented Reality (AR) for Highway Construction
- Identifying Data Frameworks and Governance for Establishing Future BIM for Infrastructure Standards
- Unmanned Aerial Systems (UAS): Bridge Inspection - Data Quality and Handling

Complete: Construction Inspection for Digital Project Delivery

Brief Scope : *To document effective practices and management of digital data used during construction inspection, and to develop guidance for managing, disseminating and integrating inspector's digital data*

Project Schedule: *Oct 2018 completion*

Project Status: *Final Report in progress*

Key Deliverables To Date*: Interim Report*

Source: FHWA

Ongoing: Identifying Data Frameworks and Governance for Establishing Future BIM for Infrastructure Standards

Brief Scope: *To investigate the best approach for establishing policies and standards related to digital data, and to create a road map for future efforts towards implementing BIM*

Project Schedule: *Dec 2018 completion*

Project Status: *Lit review/Desk Scan in progress*

Key Engagement Opportunities: *Agency participation in upcoming interviews*

Key Deliverables To Date*: None*

Source: Connecticut DOT and WSP

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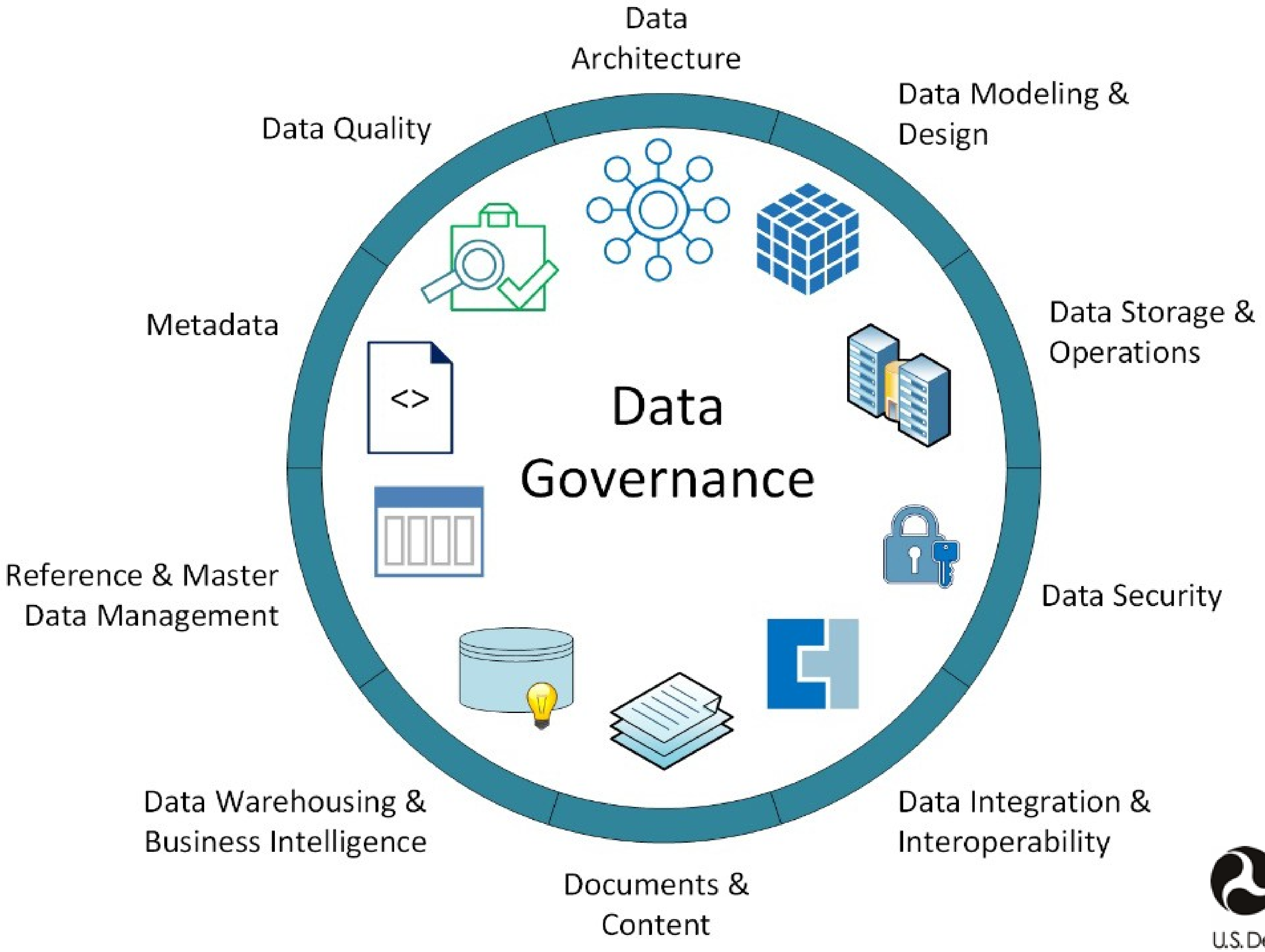
Interoperability - Data Governance & Data Exchange

- Durability and accessibility of data
- Facilitate exchange between software
- LandXML is current solution, but not enough for future data exchanges
- IFC - BIM/Structures likely to adopt, plan for roadways

FHWA Research on BIM Data Frameworks and Governance
KEY TASK: Review Data Governance & Standards in Each Area



wsp

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Ongoing: Integrating 3D Digital Models and other Building Information Management Data into Asset Management

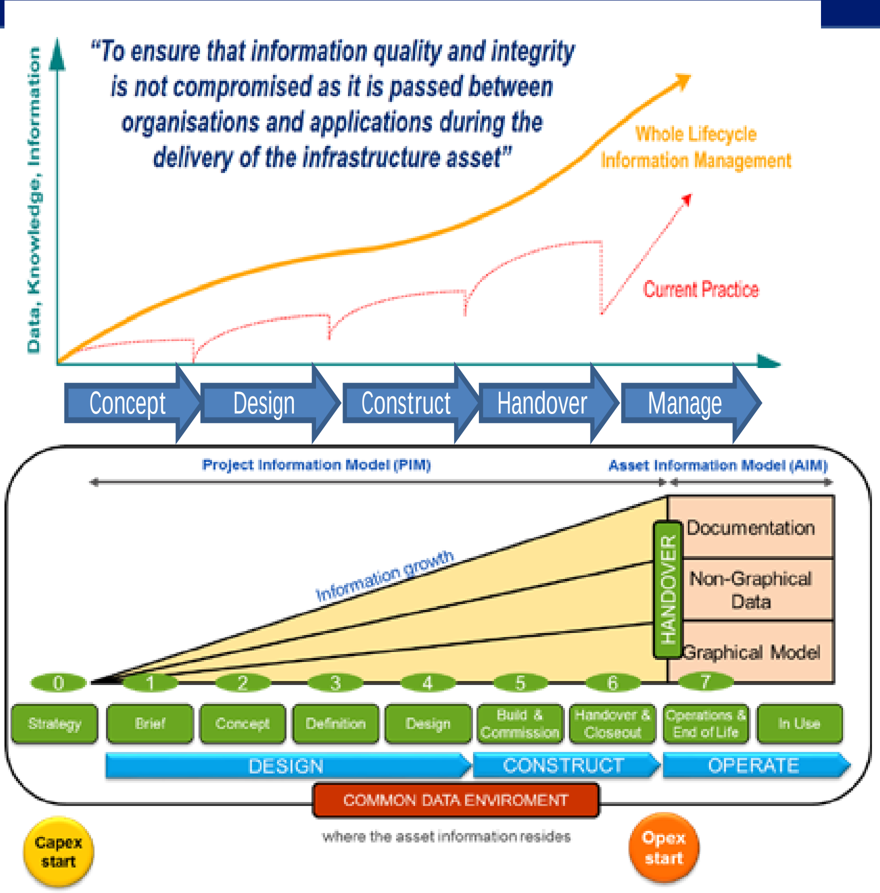
Brief Scope: *Develop best practice guidance to enable the integration of BIM data into highway agency practices, standards and specifications for better asset management outcomes*

Project Final Deliverable Schedule: *May 2018*

Project Status: *Finalizing project report. Completed technical review of national and international efforts with regard to standards, data exchange and use*

Key Engagement Opportunities: *Webinar in June 2018.*

Key Deliverables To Date: *Interim Report of Findings*



Source: FHWA

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What Is The CTDOT TED Initiative?

Transportation Enterprise Database (TED)

Transportation
Enterprise
Data
Warehouse

A collaborative Agency-wide effort to manage data as a shared enterprise asset

Assembles data from a variety of authoritative sources within the Agency

Promotes intra-Agency collaboration, communication, and consensus building

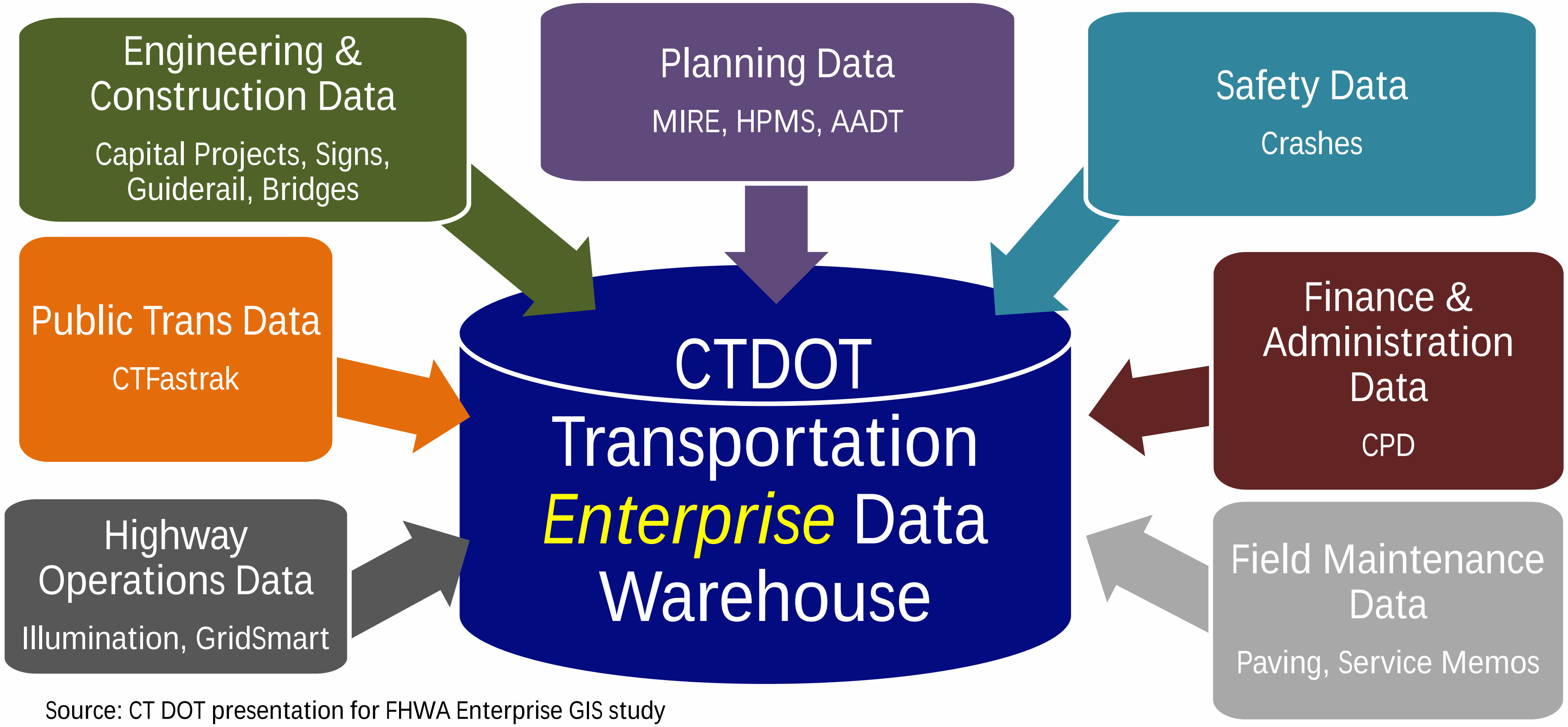
Highlights need for proper asset data maintenance strategy

Requires strong executive support to execute data governance

Source: CT DOT presentation for FHWA Enterprise GIS study

TED - A Change in Mindset Regarding Data

"The most important thing we are doing here is collapsing the silos,"
-Eash Sundaram, EVP of innovation and CIO of ***JetBlue***



Source: CT DOT presentation for FHWA Enterprise GIS study

FDOT's CIM - Maximizing the value for Stakeholders!

Core building blocks are 3D models and **Data (geospatial)** that brings organizational value when integrated.

Source: April Blackburn/John Krause presentation for FDOT's 2017 Design Training Expo

2017 Design Training Expo

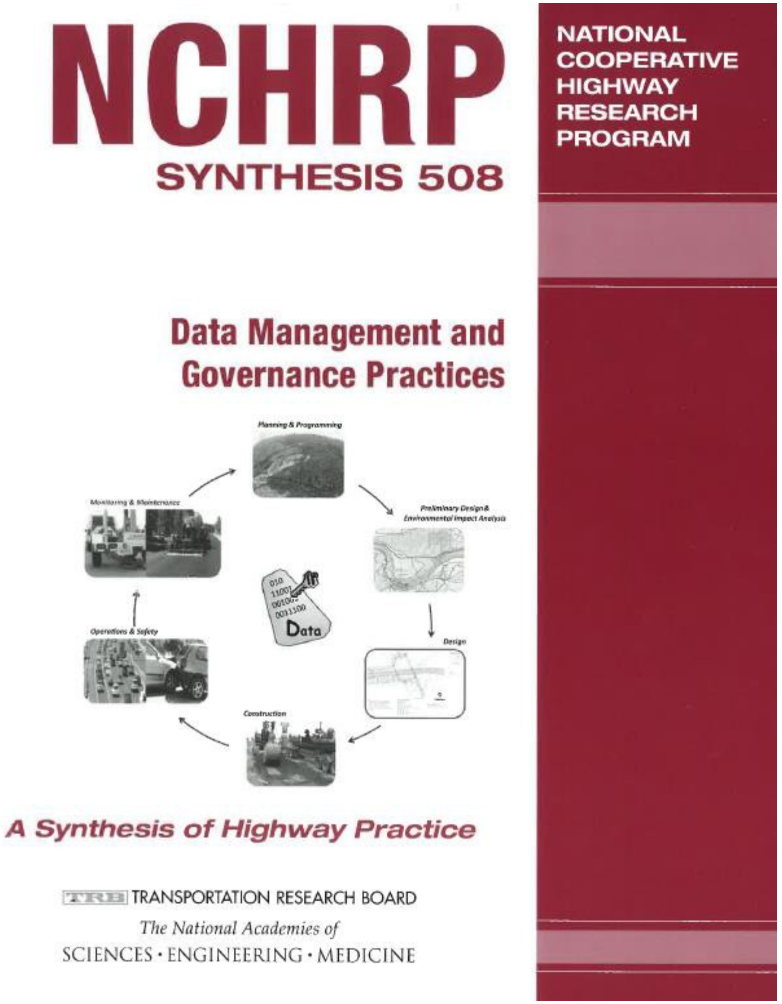
Why do we need ROADS ?

- **Our problem is we lacked organizational data governance.**
- We went from our own file cabinets and have added digital media with no enterprise plan.

ROADS = Data Governance = Processes

- Data governance is business processes that ensure that important data assets are formally managed.
- Data governance ensures that data can be trusted and used with confidence by stakeholders.

Source: April Blackburn/John Krause presentation for FDOT's 2017 Design Training Expo


NCHRP
SYNTHESIS 508
NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
Data Management and Governance Practices
Planning & Programming
Preliminary Design & Environmental Impact Analysis
Design
Construction
Operations & Safety
Monitoring & Maintenance
Data
A Synthesis of Highway Practice
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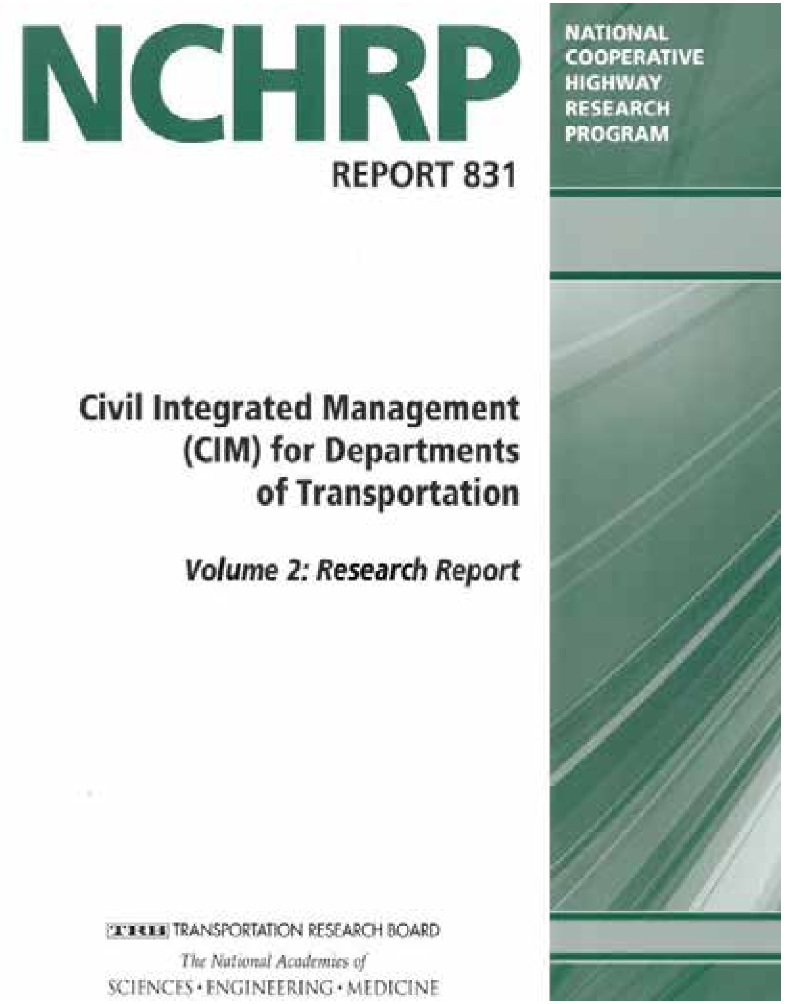
NCHRP
REPORT 831
NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
Civil Integrated Management (CIM) for Departments of Transportation
Volume 2: Research Report
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State of Practice – Contractor Use of Data

Source: Dodge Data and Analytics, Steve Jones

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CONTACTs

e-Construction
Kat Weisner, kathryn.weisner@dot.gov

BIM for Infrastructure
Connie Yew, connie.yew@dot.gov
Katherine Petros, Katherine.petros@dot.gov
David Unkefer, david.unkefer@dot.gov

www.fhwa.dot.gov/construction/econstruction

www.fhwa.dot.gov/3d

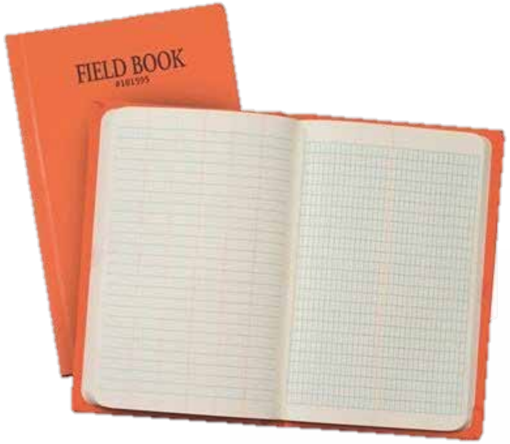
infotech

Ohio Department of Transportation

Analyzing and Utilizing Non-Graphical Data for Smarter Project Delivery

Chad Schafer | Infotech, Inc.

Janet Treadway | Ohio DOT



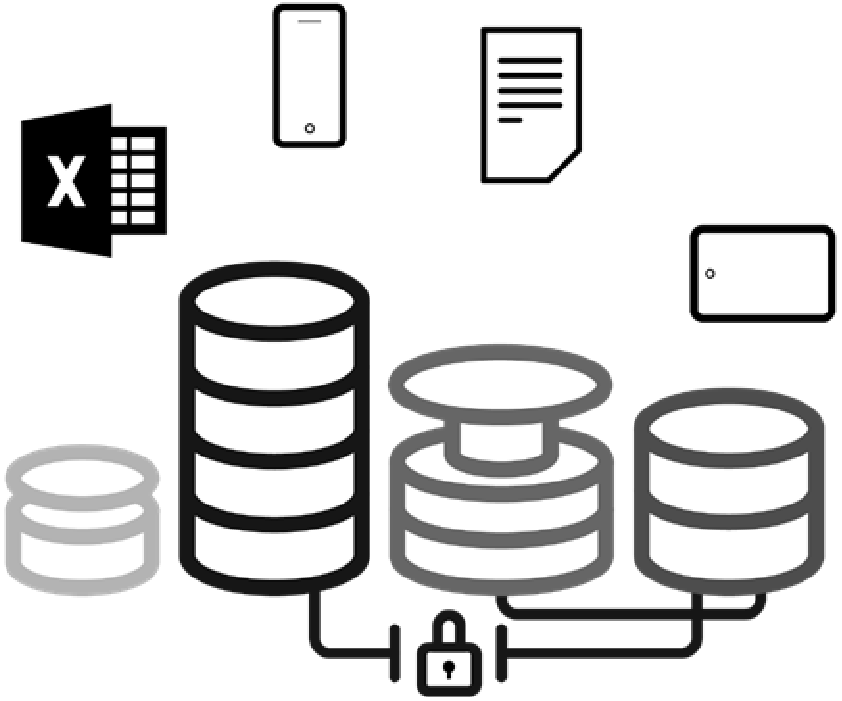



The Times They Are A Changin

Efficiency through Technology & Collaboration

every day counts

An Innovation Partnership with States



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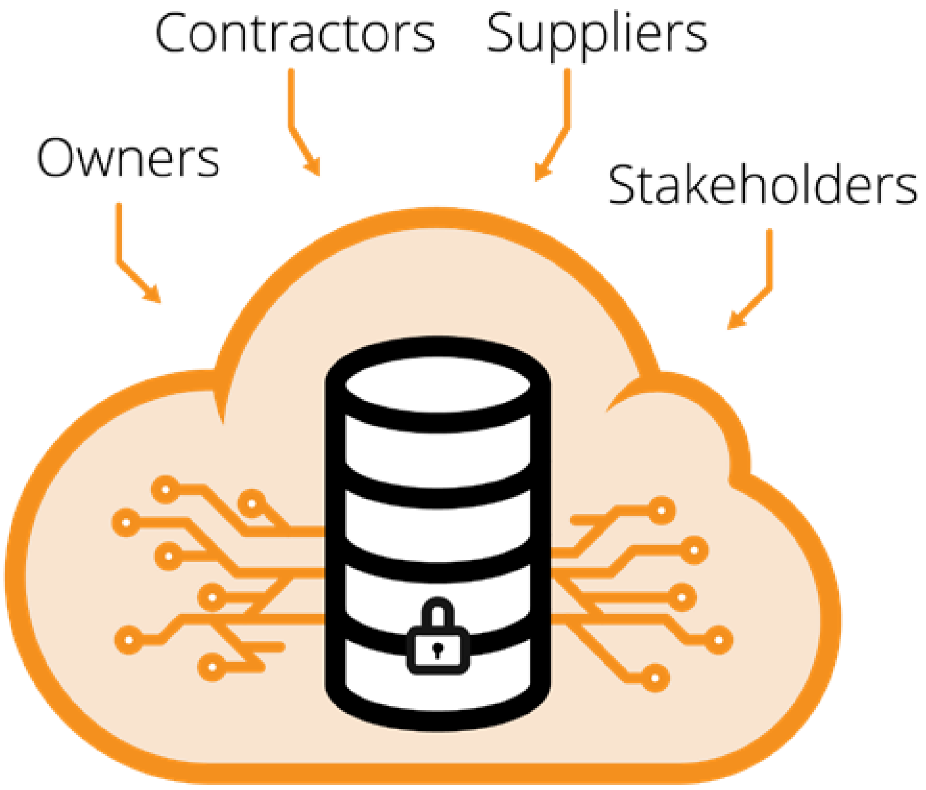


Multiple Data Sources

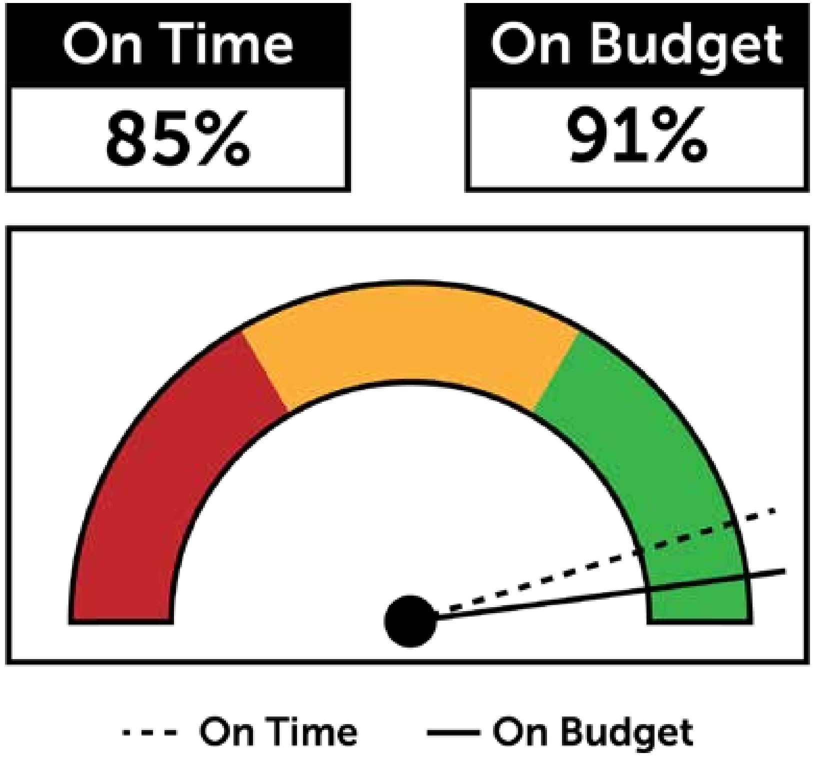
Unified Data Source

Data Terms and Meaning

- **Data Science**: Preparation, cleansing, analysis and presentation
- **Big Data:** High volume, requires innovative ways of analysis
- **Data Analytics:** Conclusions about the information

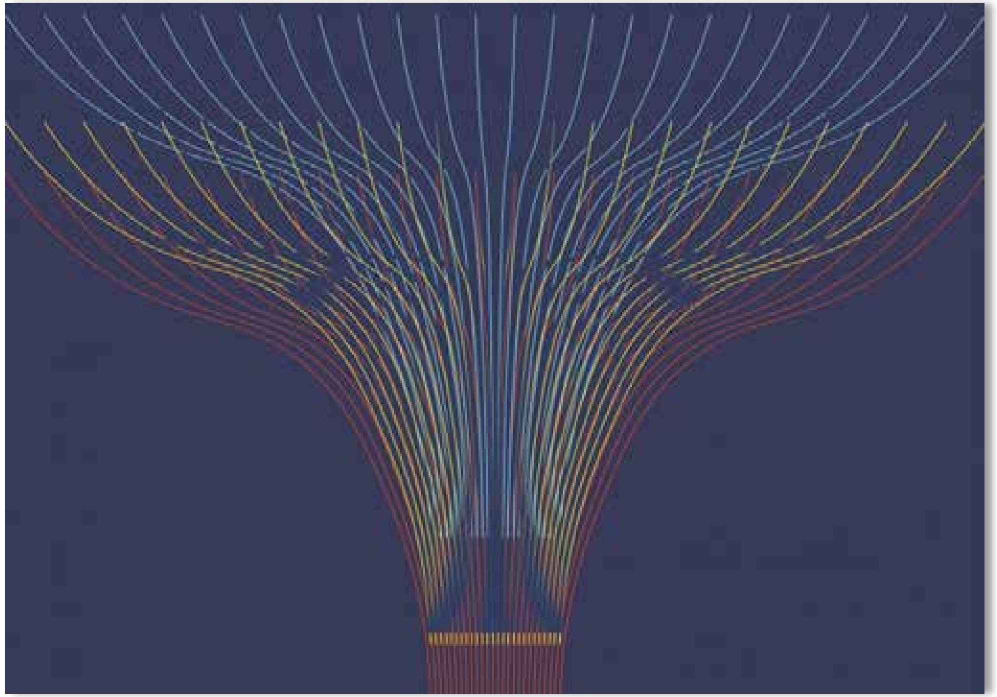
Graphical vs. Non-Graphical Data
Value in both

- **Graphical**
  - 3D models
- **Non-graphical**
  - Charts, dashboards
  - Results of analysis
- **Construction data**
  - Item progress
  - Material tests
  - Change orders
  - Payments
- **Document workflow**

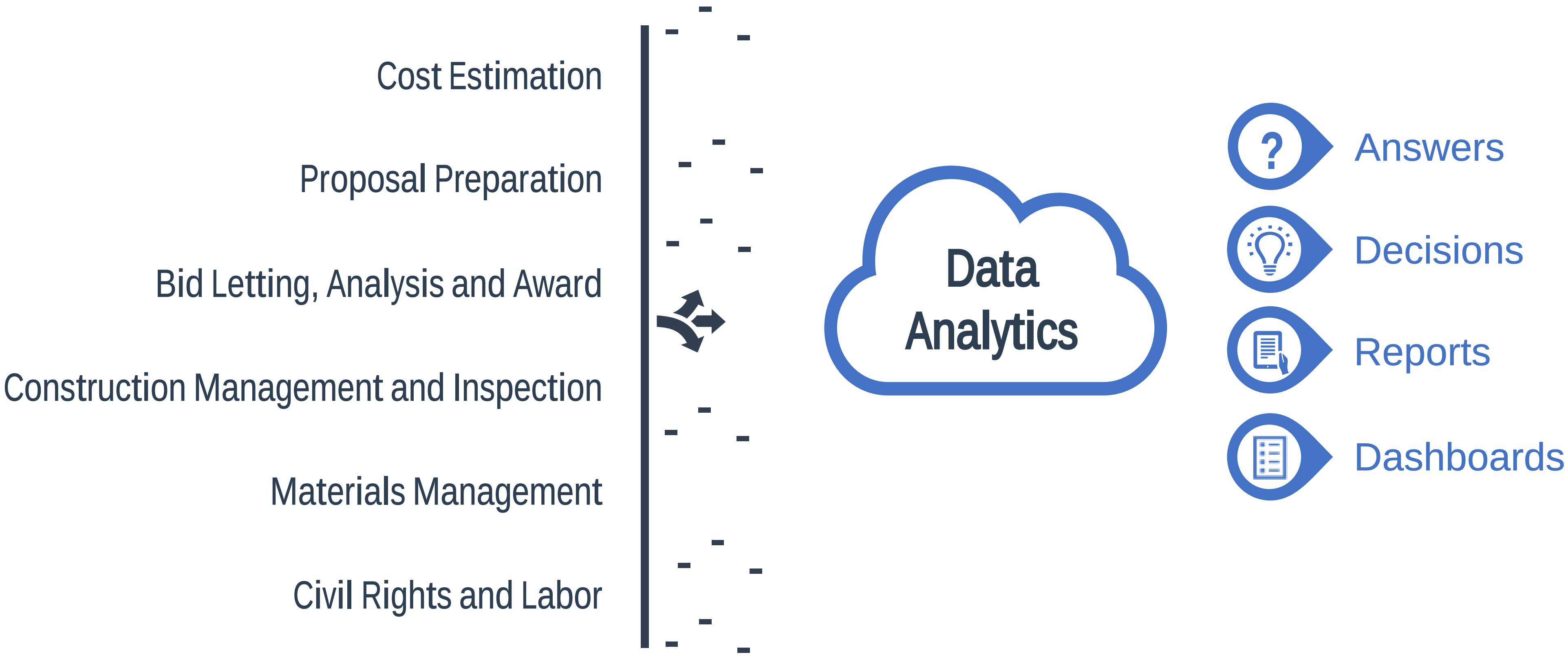


Data Unification

- **What do you do with all this data?**
  - Merging data from multiple sources
- **Challenges**
  - Standardized
  - Many data sources
- **Enter date once, use it many times**
- **Focus on business areas**
  - Ease of use
  - Filters
- **Electronic, standardized and secure**

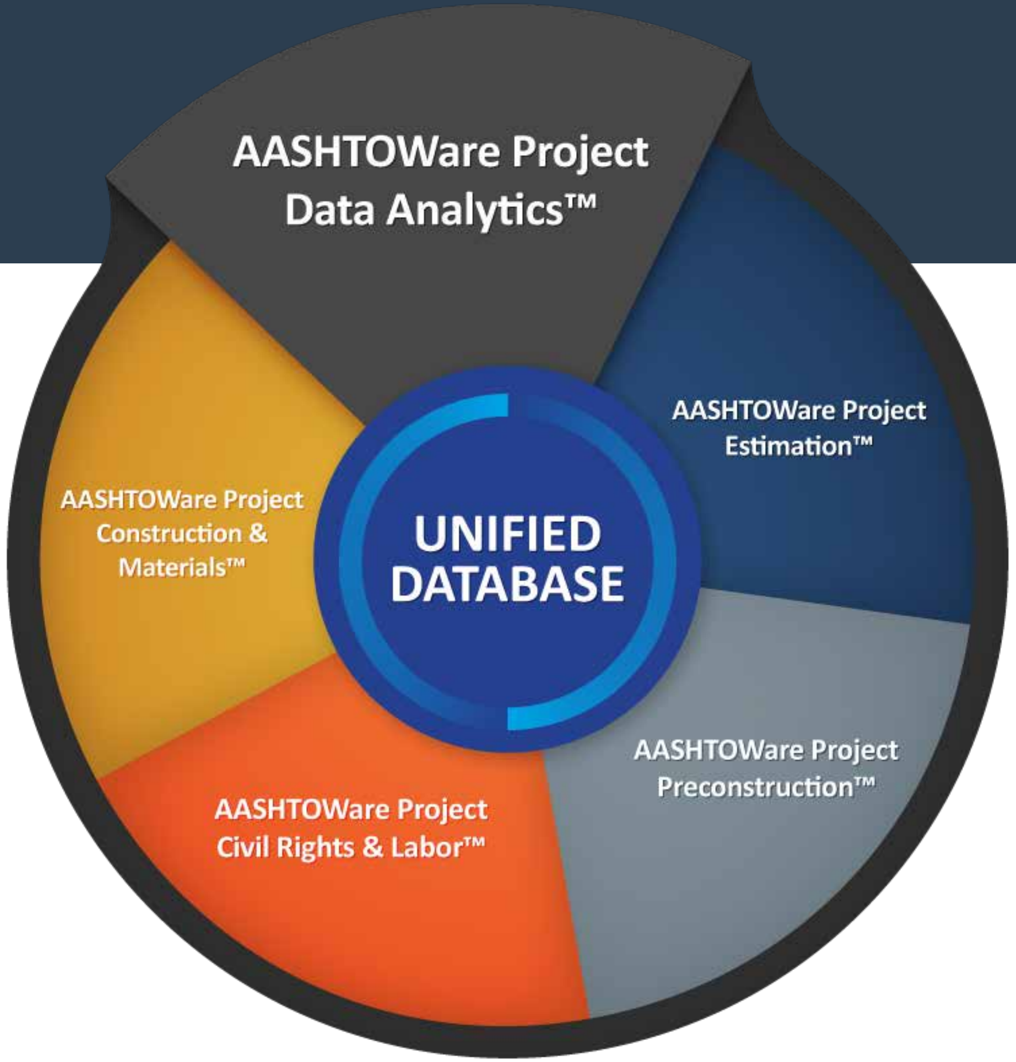


Visualize your construction data



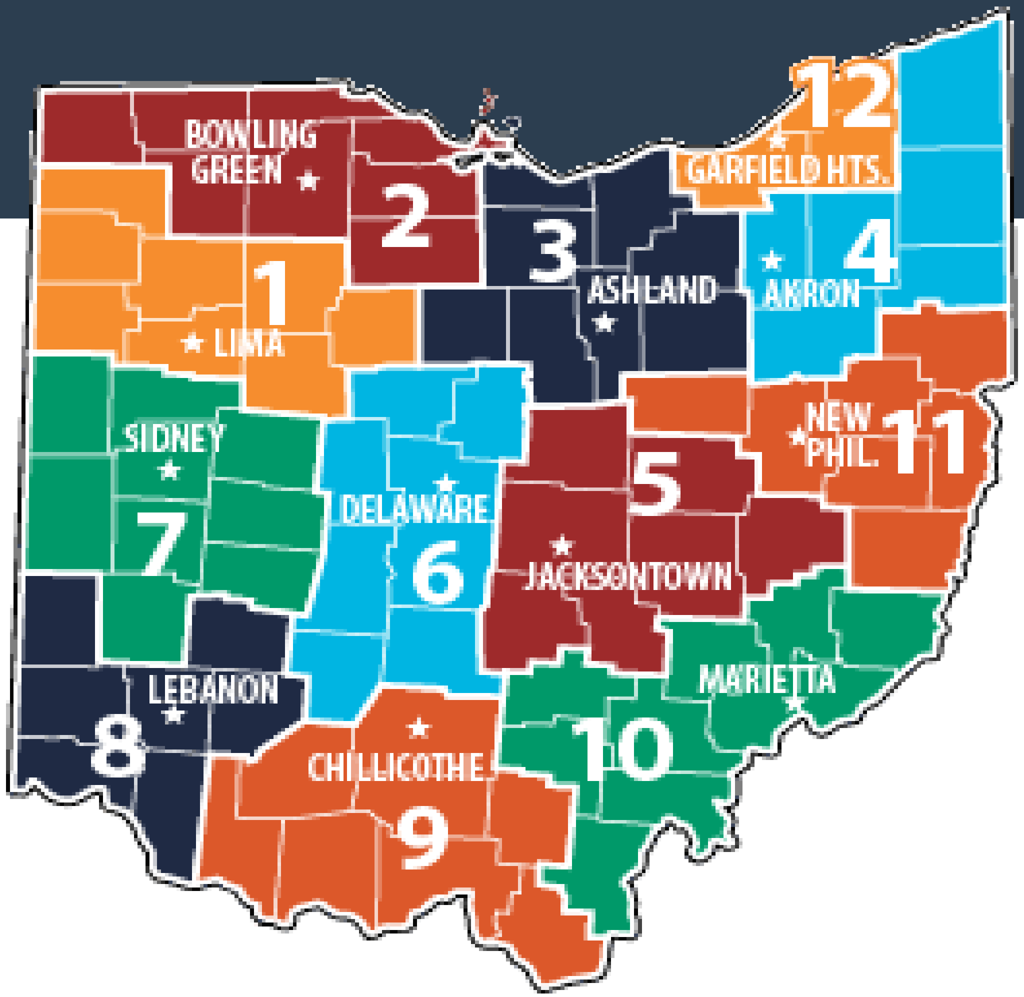
AASHTOWare Project™: A Single Source of Truth

- Data stored in single location
- Single standard security modal
- Captures information at the source
- Easy reporting of information from the various modules



Ohio DOTs Experience

- 2014 -2019
- 3,747 projects awarded
- 747 average per year
- $8,438,750,613 Awarded
    - Average $ 2,252,135 per year
- 32,917 Contract modifications executed



Data Integration and Access

- Needs to be good
- Share- utilize data across systems
- More in-depth analysis
- Device agnostic
- Where
- When
- What
  - Ease of use and comprehension
  - Surface what data is needed to make decisions

Considerations

- What and how much?
- Data = Information
- Access and users
- Security
- Auditability
- Technology is available

Construction Data – What works & what needs work

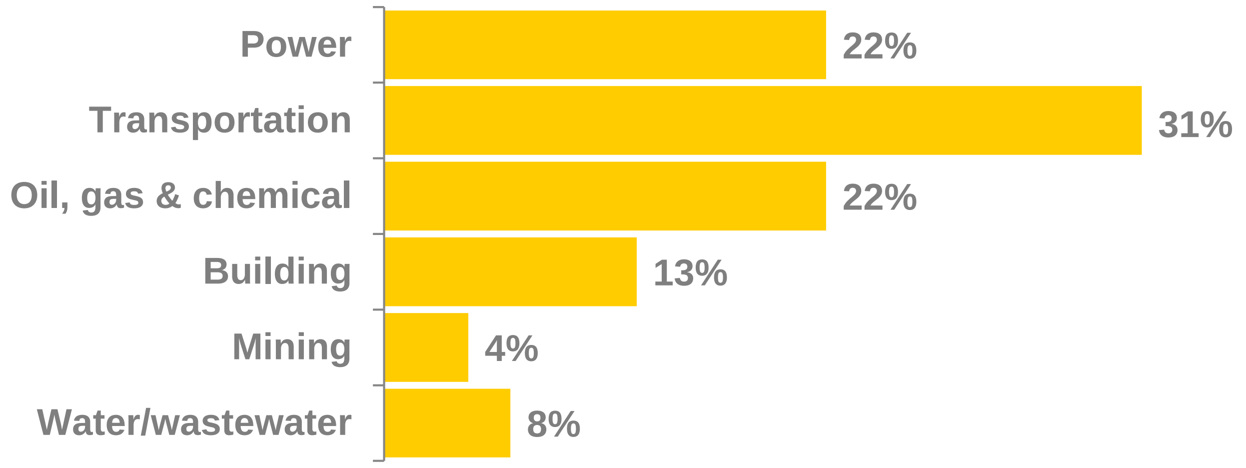
Jayme Arlen and Matt Callahan

KIEWIT CORPORATION

THE KIEWIT DIFFERENCE

- Safety is Kiewit’s top priority. No excuses. No shortcuts. Nobody Gets Hurt.
- Quality work is delivered right the first time; we stake our reputation on it.
- The environment is everyone’s responsibility. At Kiewit, we are committed to being the best possible stewards of the environment.

MARKET DIVERSITY



ABOUT KIEWIT

- More than 130 years of construction excellence
- Operations throughout North America and beyond
- $8.7 billion in 2017 revenue
- Privately held – owned by active employees
- One of the largest privately-owned equipment fleets in North America
  - 14,200 units
  - $2.3 billion replacement value

Kiewit is consistently ranked among ENR’s TOP 10 contractors.

WHY CHANGE?

- Bigger
- More Complex
- Data Driven

CHALLENGES REMAINED

REAL-WORLD PROBLEMS

- Leveraging Cost Data Across All Projects and Industries
  - Focus on People and Time Management
  - Logistics, Tracking, Trending and Forecasting of Materials or Project Progress
- Reducing Quantity Growth Risk on Design-Build and EPC Projects
  - Improve communication around non-graphical data
  - Easier ways to visualize that data

TYING COST & PRODUCTIVITY DATA TOGETHER

STANDARD COST CODING

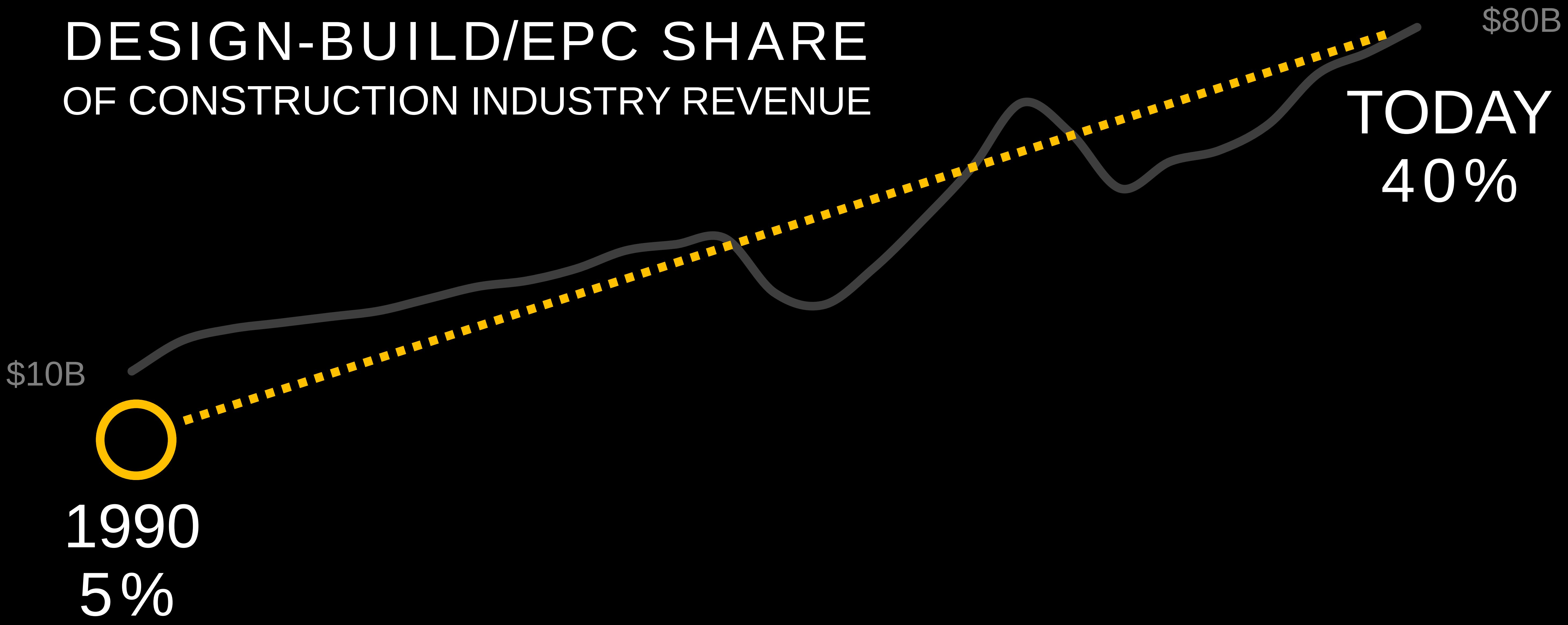
- What's Covered:
  - All Construction Industries
  - Engineering Services
  - Overhead Departments
  - Construction Equipment

DESIGN QUANTITY GROWTH

CONSTRUCTION-DRIVEN
ENGINEERING

DESIGN-BUILD/EPC SHARE

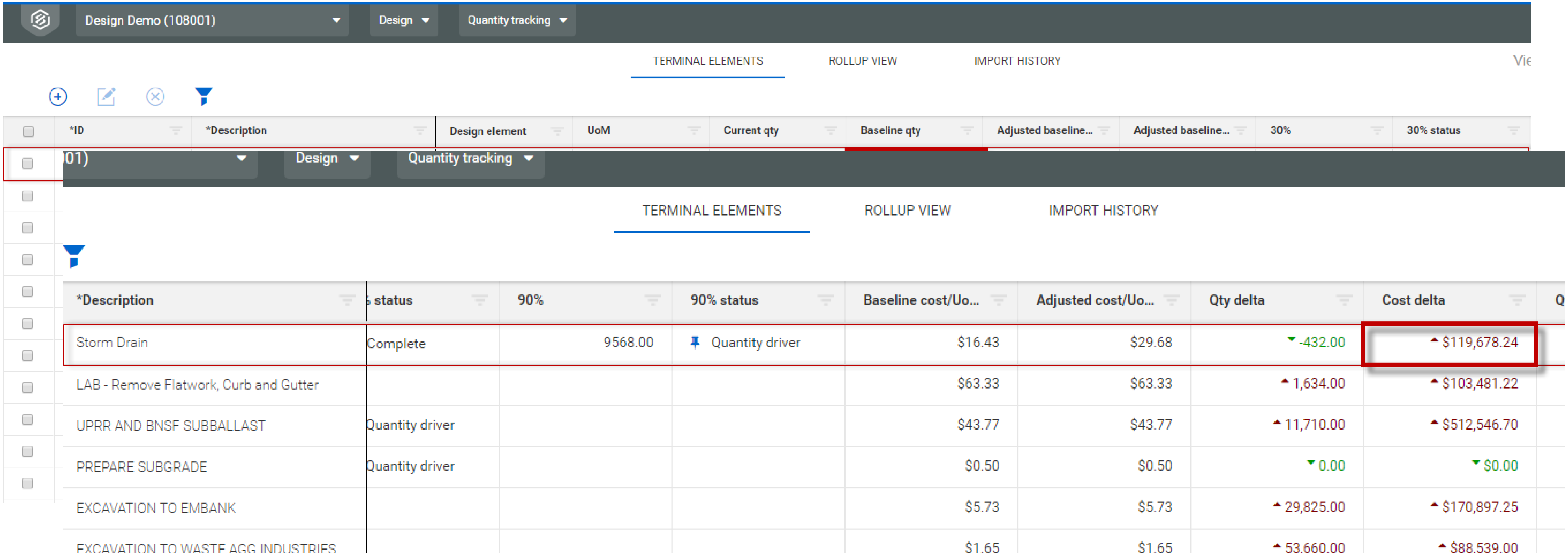
OF CONSTRUCTION INDUSTRY REVENUE



DESIGN DATA

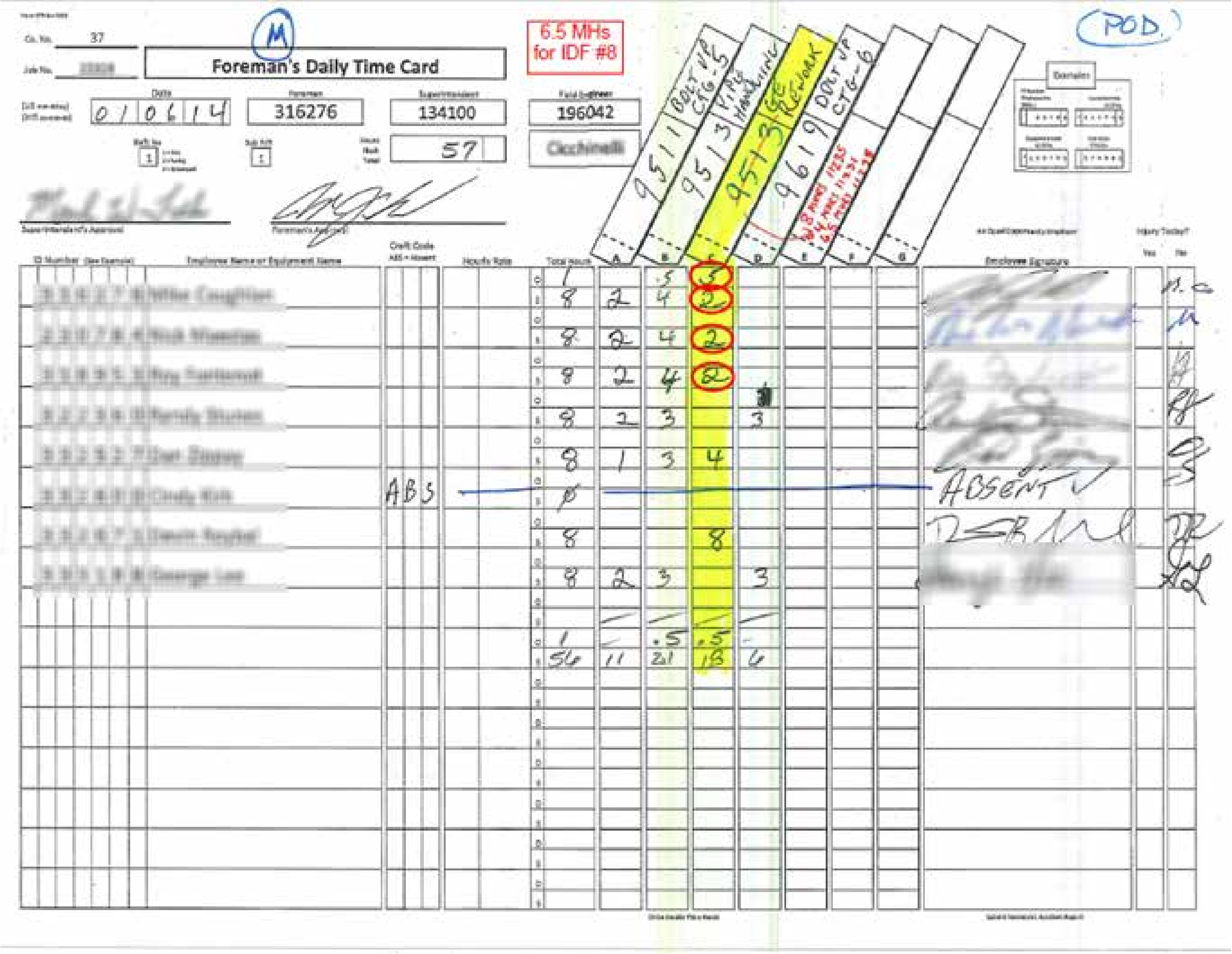
- What We Knew
  - Quantities Time of Estimate
  - How Quantities Change During Design
- Additional Data Needed
  - Standard Design Elements
  - Classify Why Quantities were Changing

DESIGN QUANTITY TRACKER

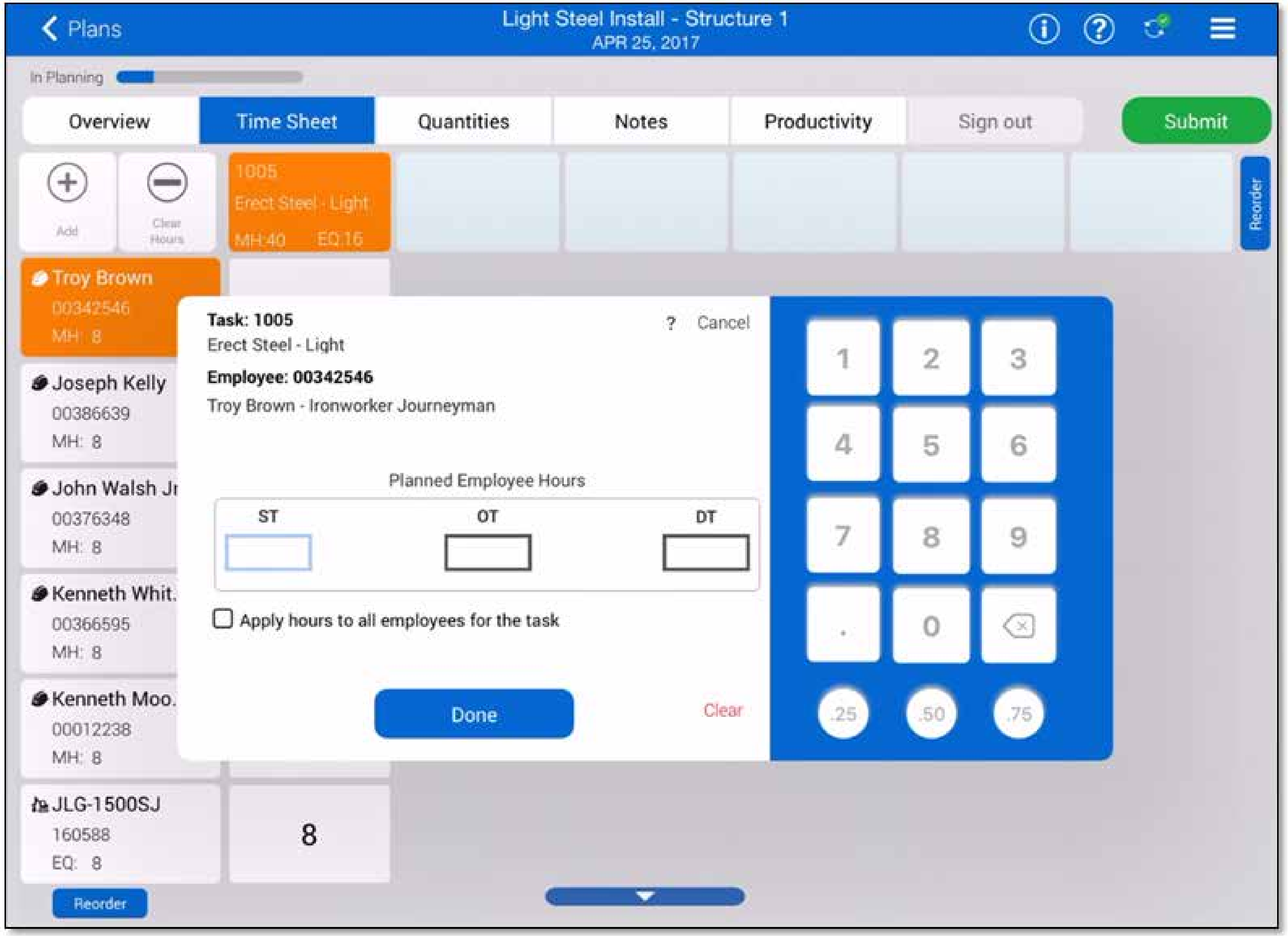


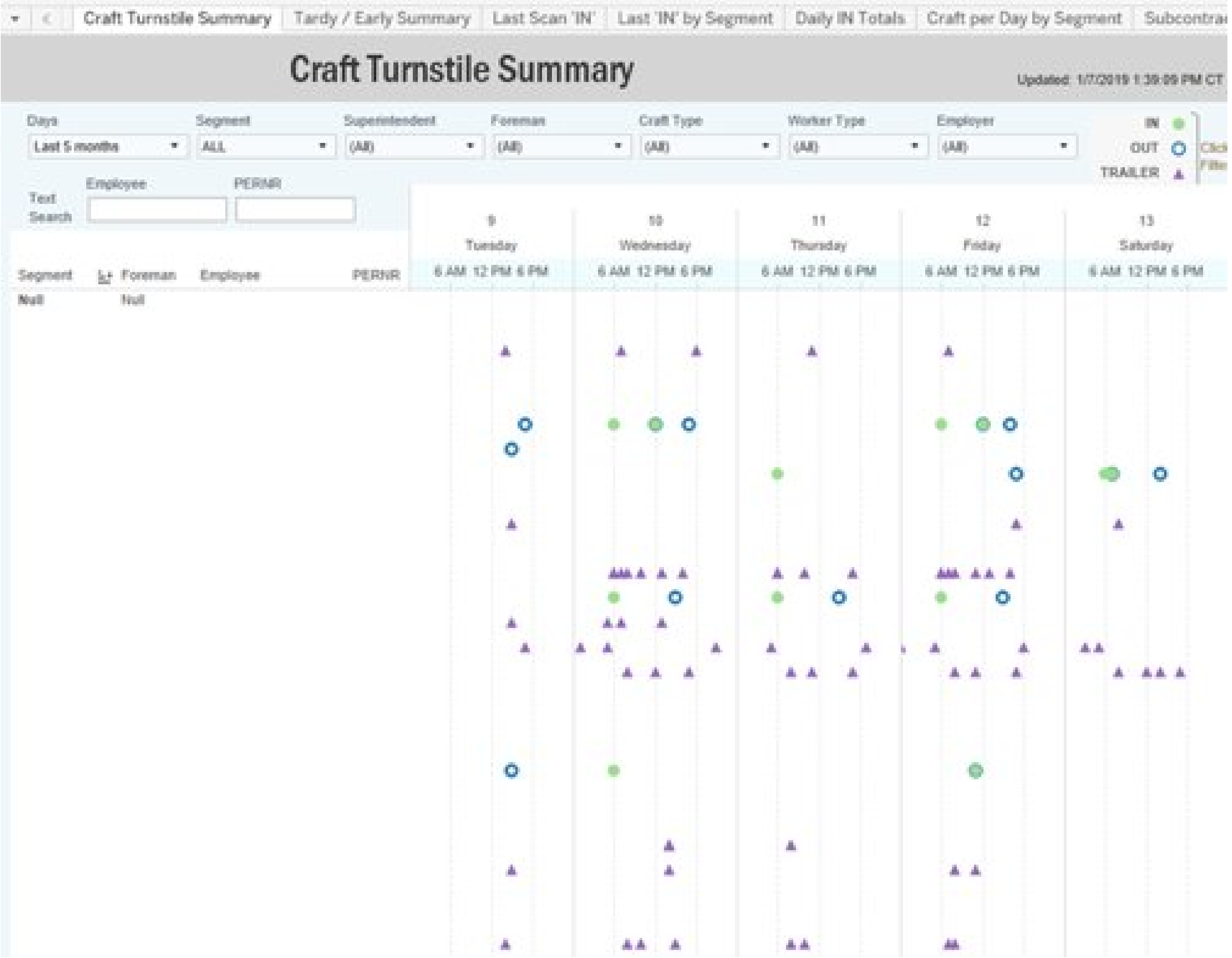
Past, Current & Future - Time and People

OLD – Home Grown System



Time Cards, People, Quantities and Safety




Craft Turnstile Summary
Tardy / Early Summary
Last Scan 'IN'
Last 'IN' by Segment
Daily IN Totals
Craft per Day by Segment
Craft Turnstile Summary
Days
Last 5 months
Segment
ALL
Superintendent
Foreman
Craft Type
Worker Type
Employer
IN
OUT
TRAILER
Text Search
Employee
PERNR
Segment
Foreman
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9
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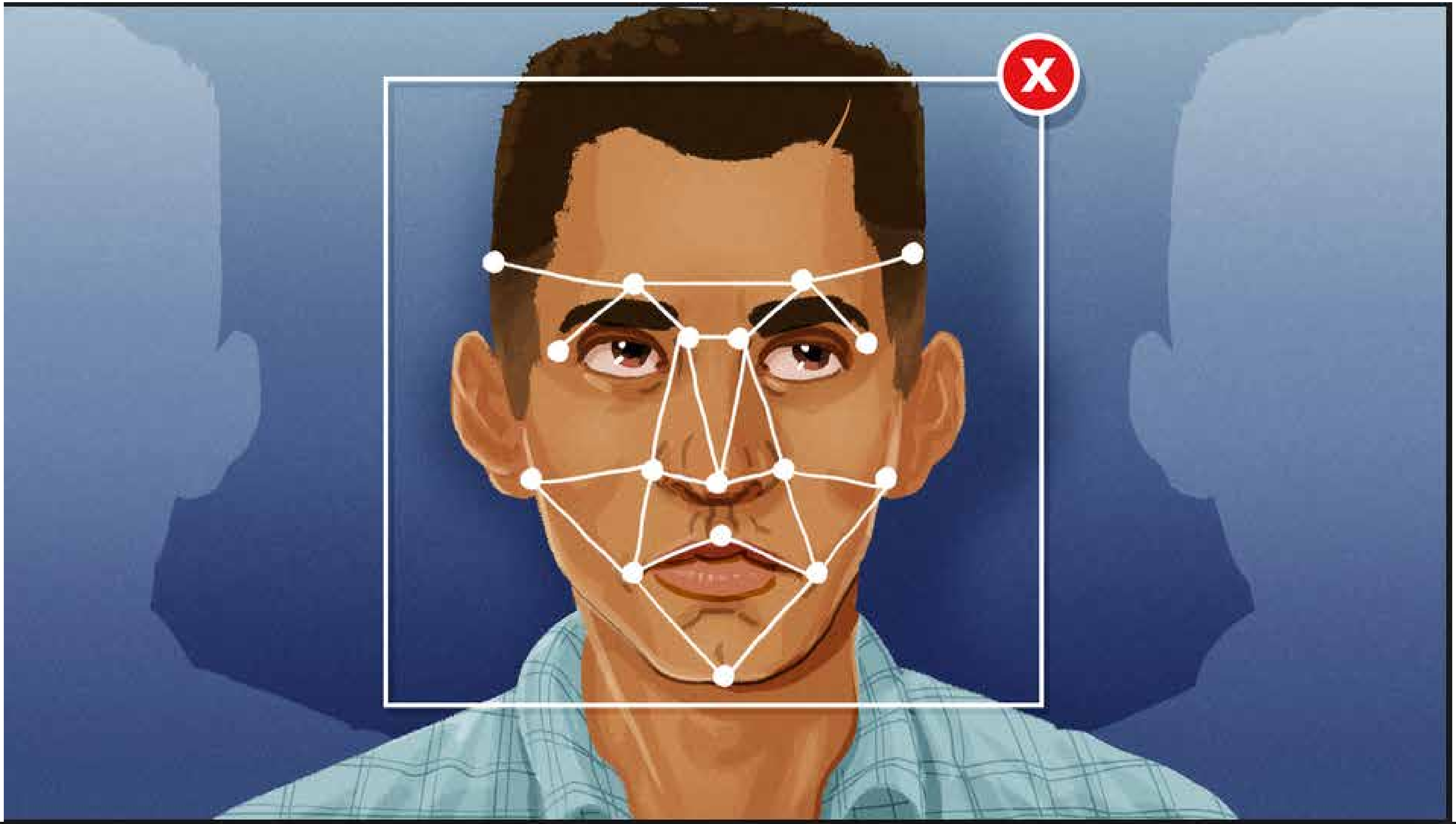
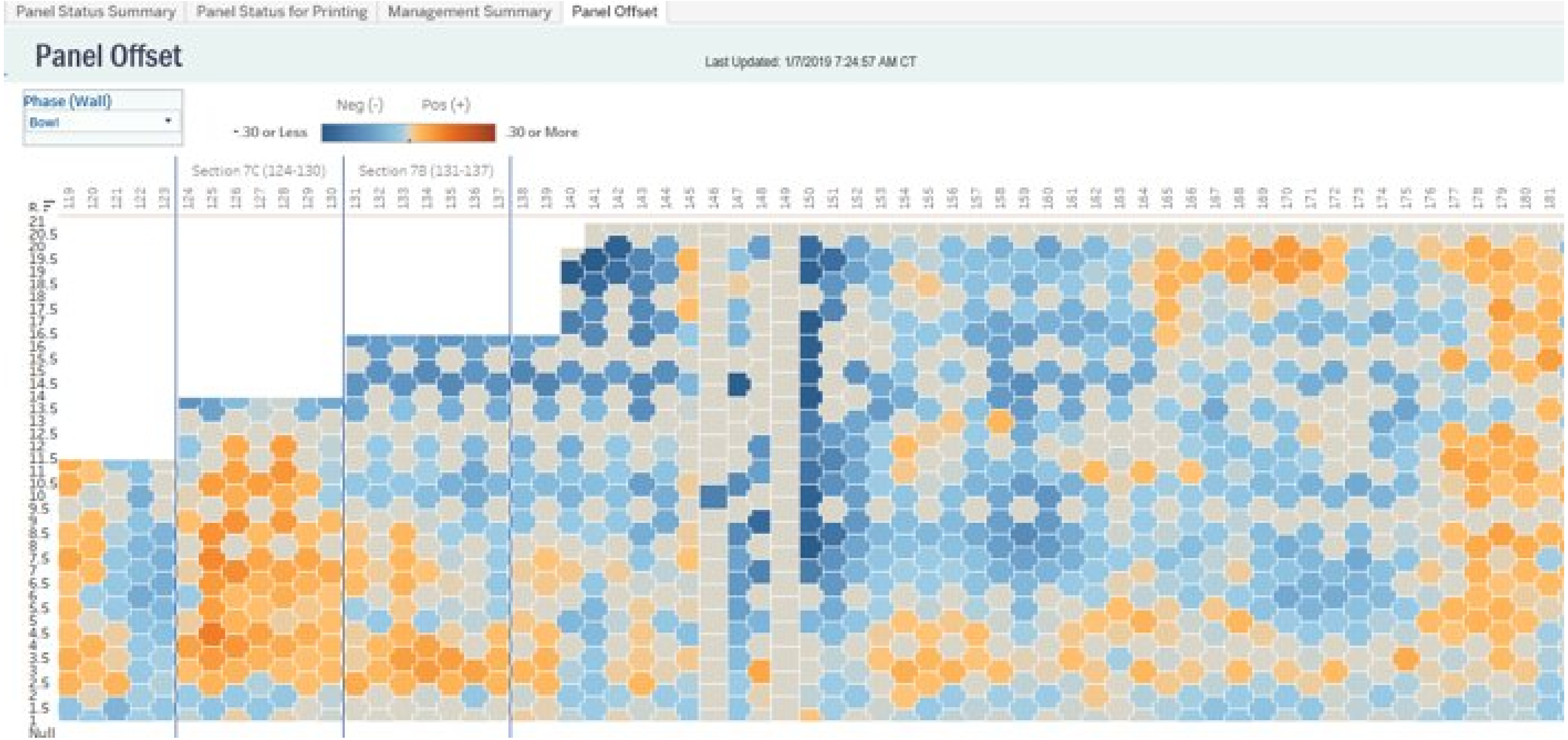
13
Saturday
6 AM 12 PM 6 PM

Future– Artificial Intelligence Data Capture and Analysis

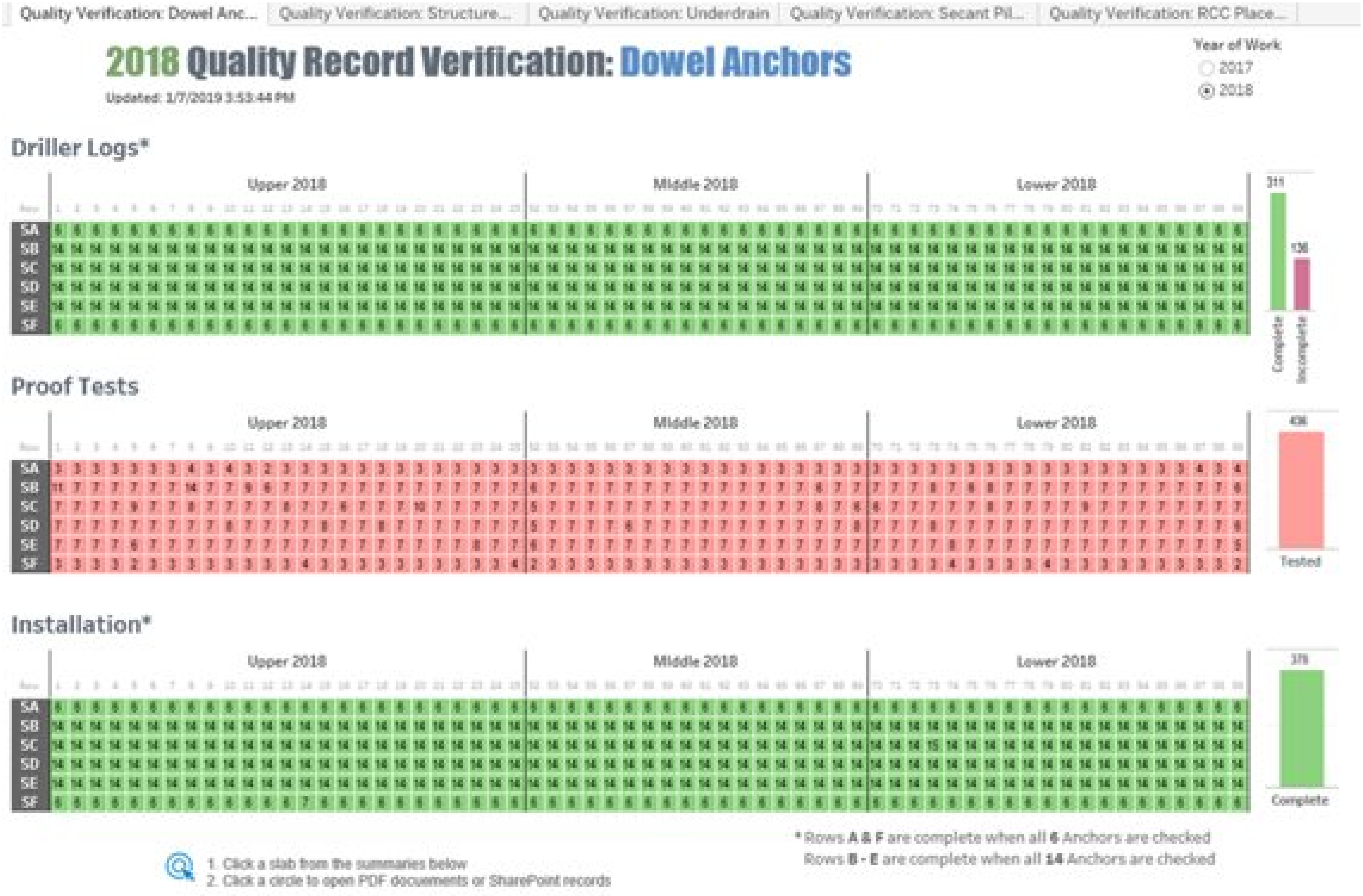


Past, Current & Future - Non Graphical Data

Logistics to Compliance

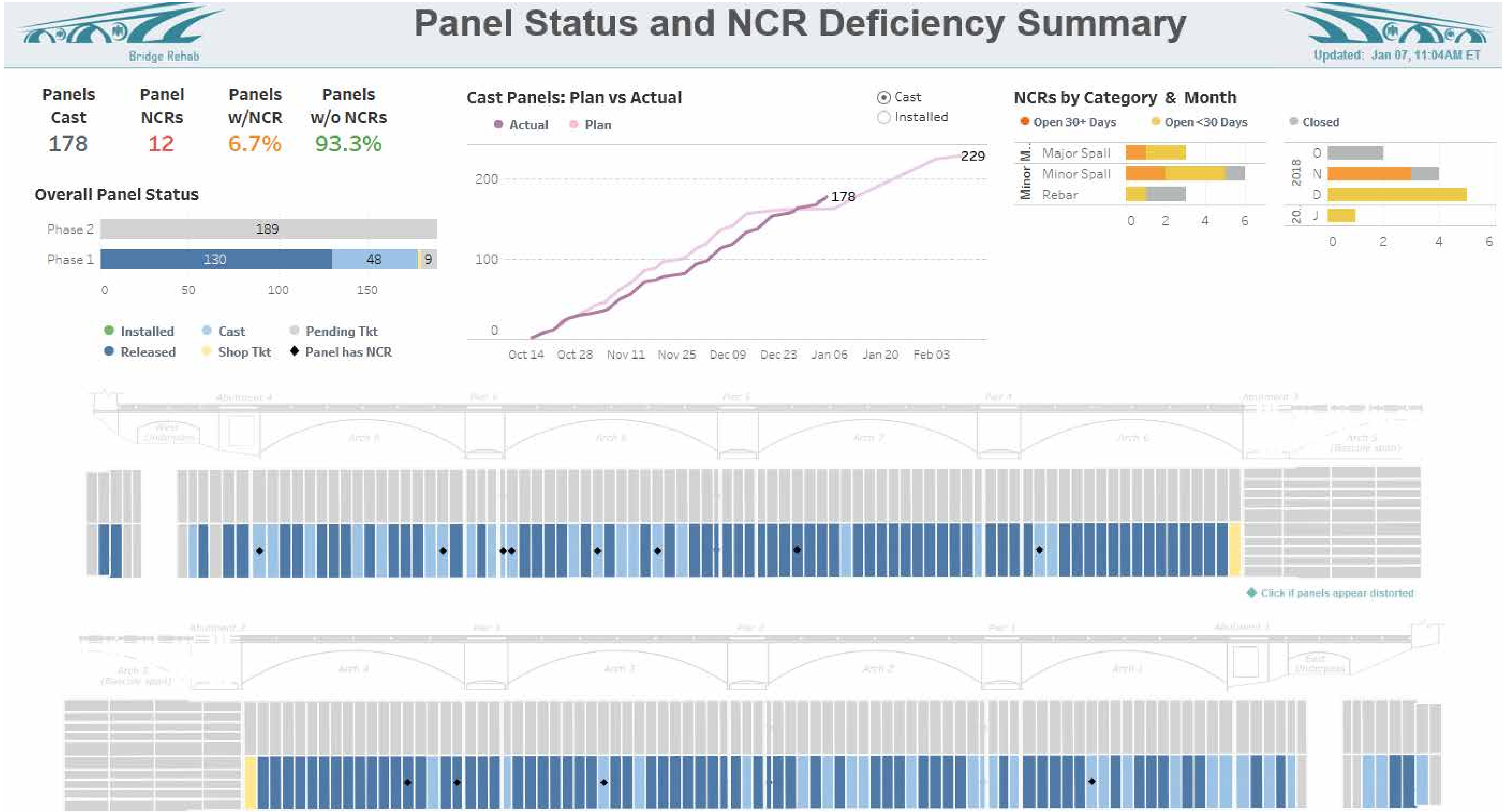


Inspection Turnover



Progress and Material tracking

Quality Tracking



Project Wide - Quality Inspections and planning

Block Inspection Summary | PC/IQC Testing Summary | Drilled Shaft Summary | Wall Inspections | PC/Inspection Tests | BMP Inspections | Daily Reports (IQC) | IQC Testing | Material Receiving Report | MOT Inspections | Drainage Ins

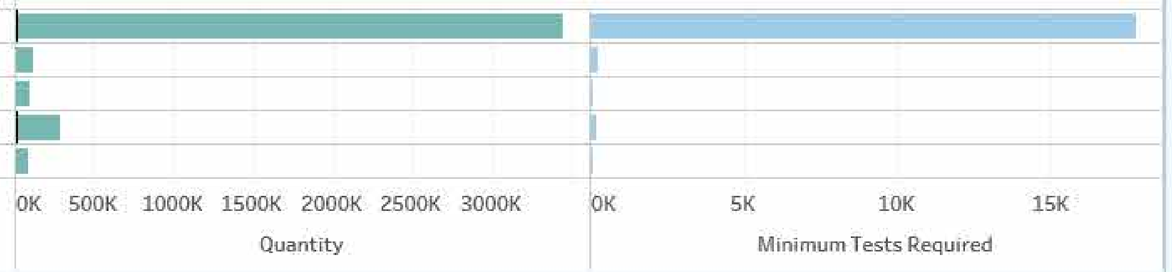
Quality: Inspection Summary by Block

Updated: Jan 07, 10:59AM MT

Select a Test

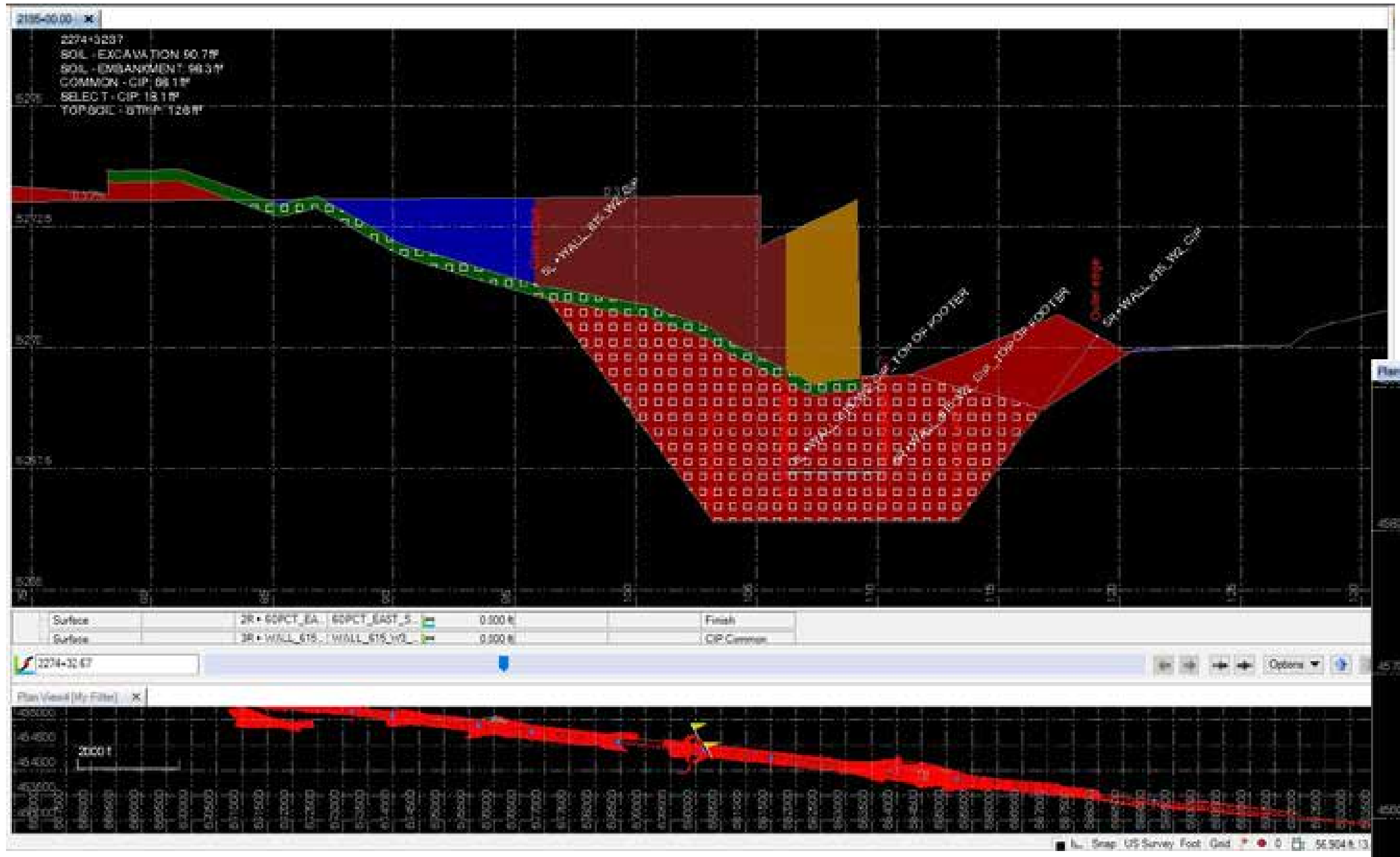
- Aggregate Moisture
- Air Content
- Air Voids
- Asphalt Content
- Atterberg Limits
- Compressive Strength
- Gradation
- Hveem Stability
- Hydrated Lime
- In Place Density when within 100' of Bridge Approac..
- In-Place Density
- Lottman
- Material Compliance
- Micro Deval
- pH**
- Resistivity**
- RESISTIVITY**
- Slump
- Soil-Survey (Classification, R-Value)
- Sulfate, pH, Chlorides & Resistivity
- Theoretical Max. Specific Gravity
- Voids in Mineral Aggregate
- Water-Soluable Chloride Ion **
- Water-Soluable Sulfate Ion */**
- WATER-SOLUBLE CHLORIDE ION **
- Water-Soluble Sulfate Ion */**

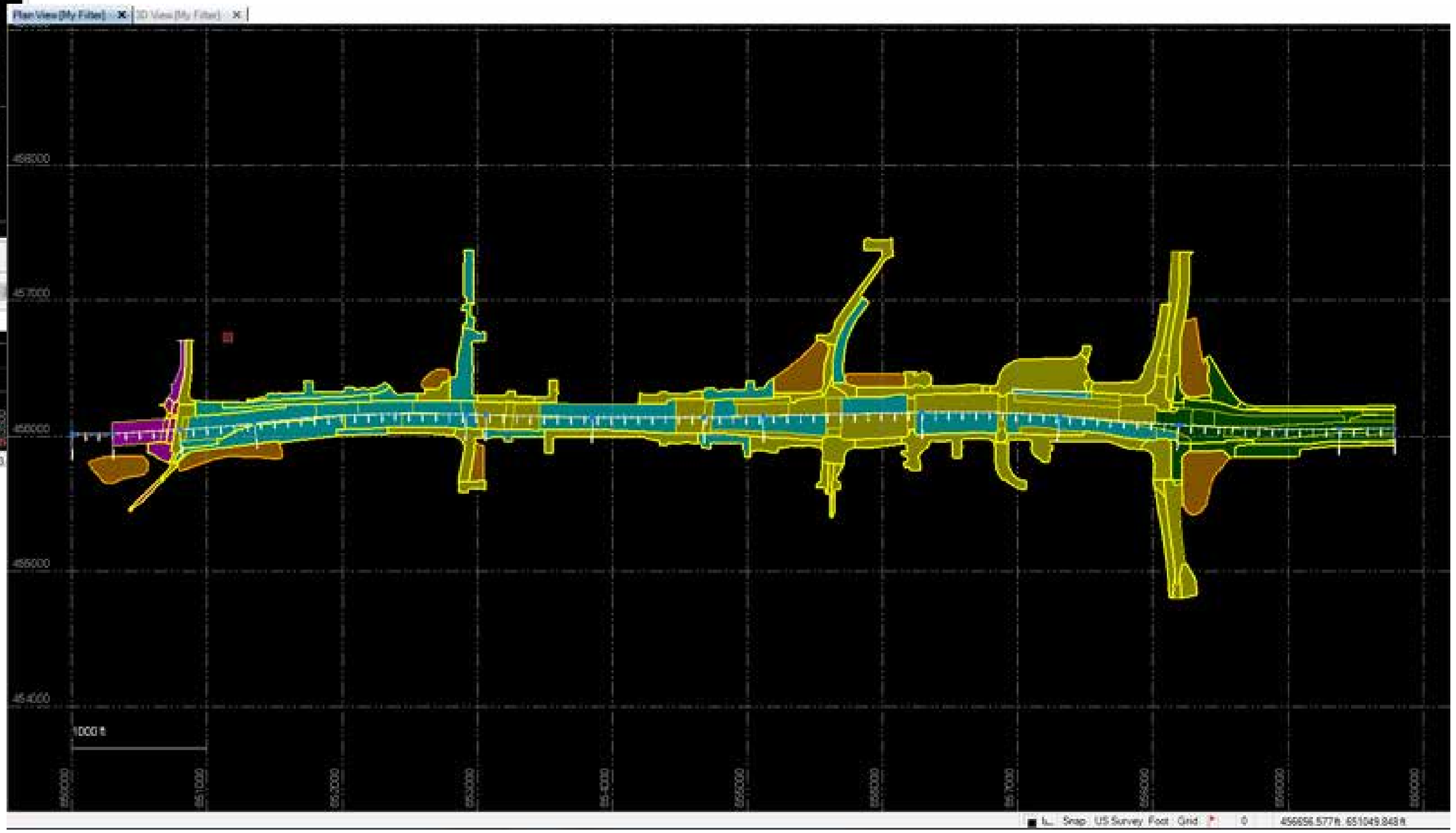
PROPERTY OR CHARACTERISTIC	Spec	Process (IQC / PC)	Frequency	UoM
Gradation	206	IQC	200	CY
	304	IQC	1,000	CY
	401	PC	1,000	Ton
	403	IQC	*	Ton
	609	IQC	2,500	LF



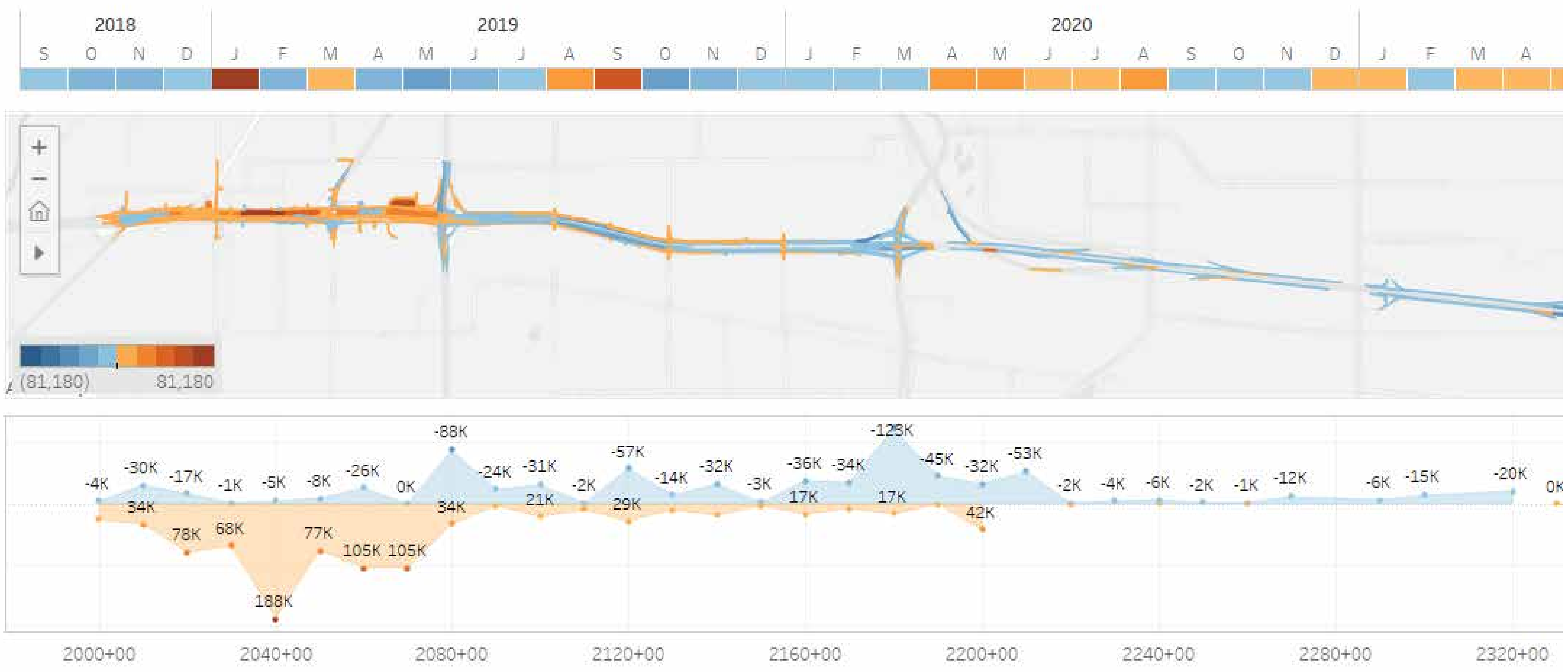
Past, Current & Future - Earthwork Quantities

Models - Design vs Construction Quantities



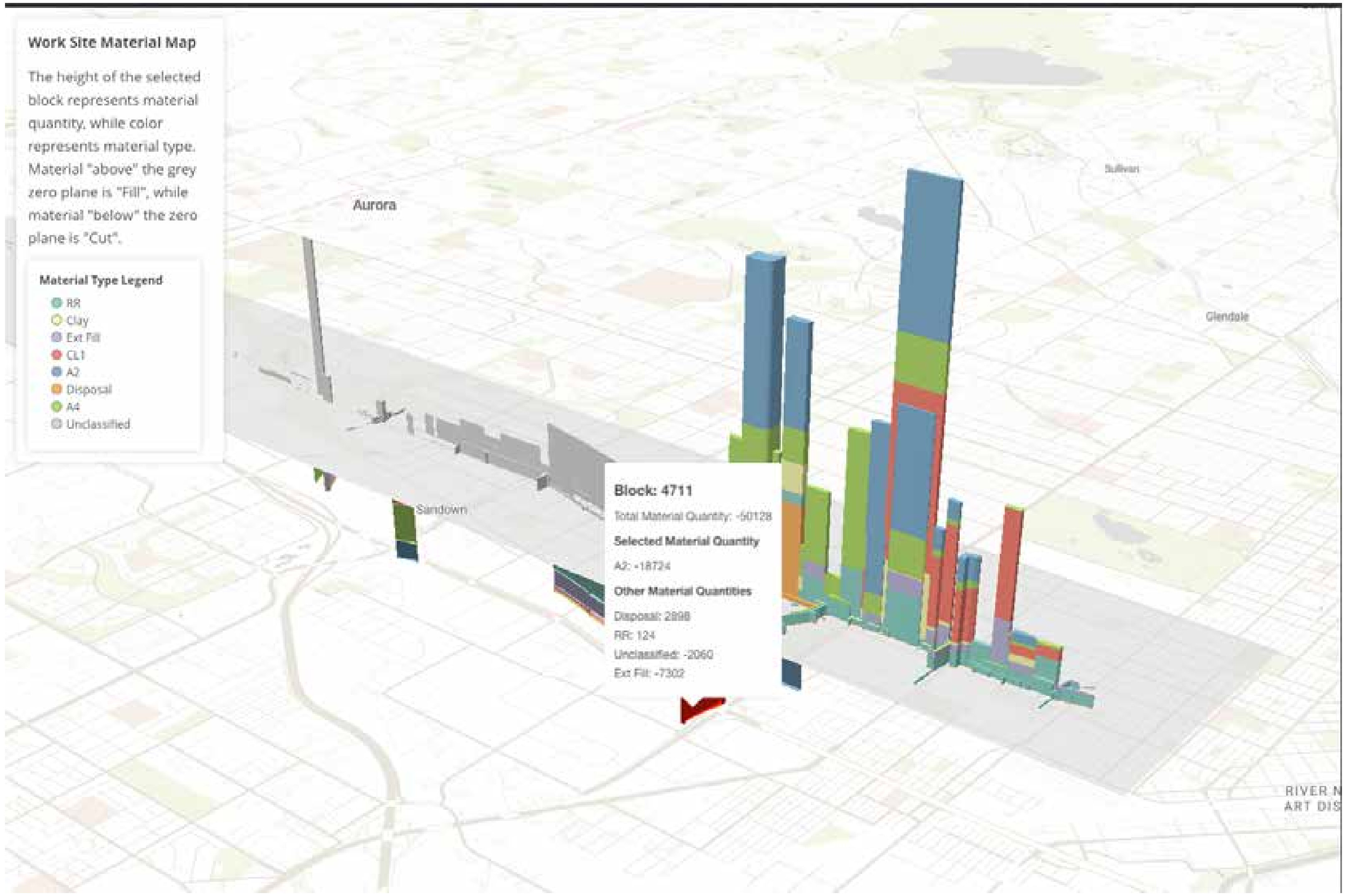


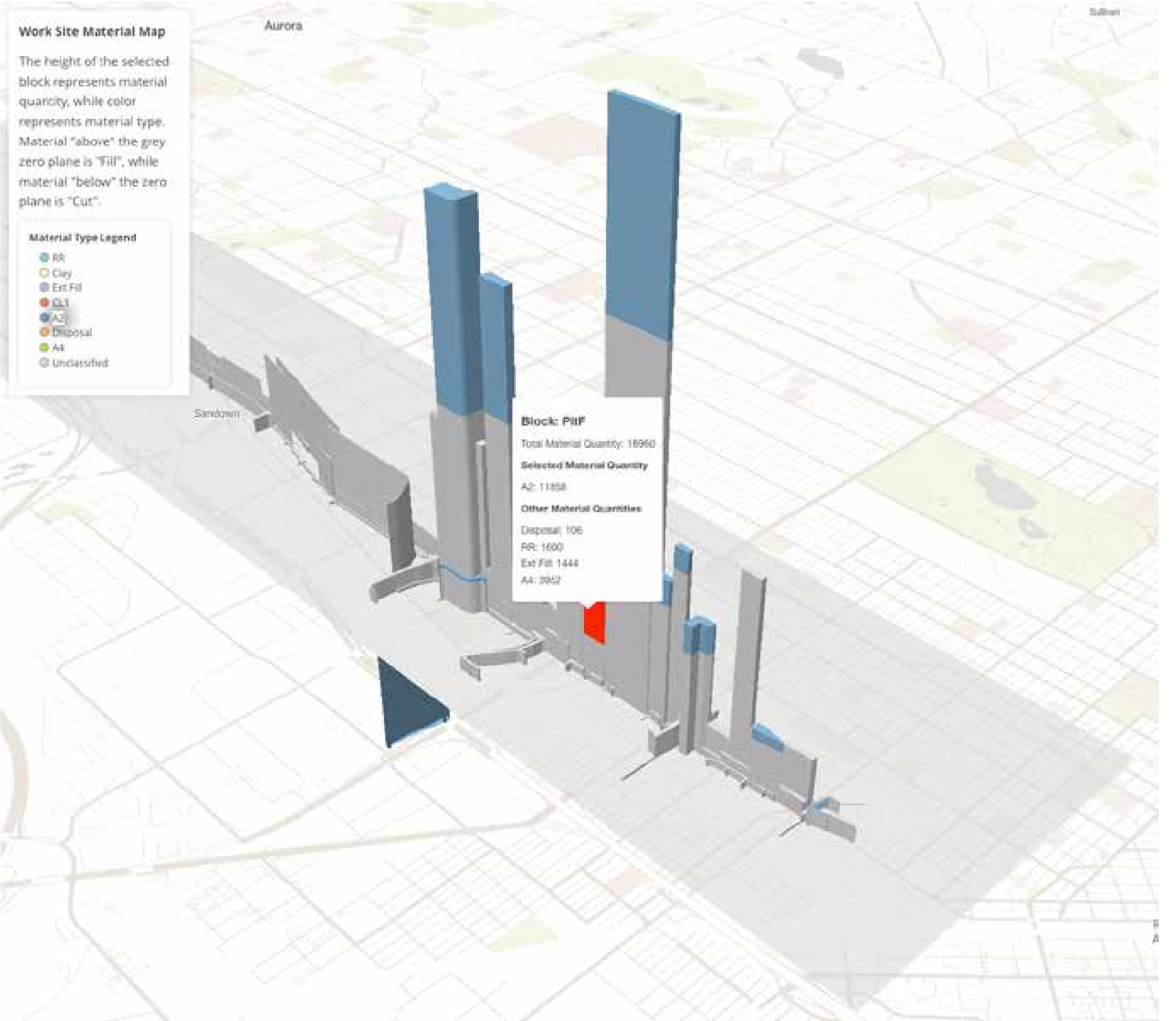
Earthwork - Mass Haul and Material Flow



Block	Station	ActivityID	Start	Finish	Duration	Activity Description	Loads	Common A2	Common A4	Common Clay	Common Ext
Total								(40,000)	(40,000)	0	(1,
1002	2060+00	C.MOT.3.2155	01/05/21	01/08/21	3	Construct Temporary Detour - Block 1002	196		(2,392)		
1003	2078+00	C.MOT.4.2195	10/19/20	11/09/20	21	Construct Temporary Detour - Block 1003	201		(2,449)		
2001	2023+95	C.DRT.2.2010	11/03/20	11/06/20	3	Excavate - Block 2001	59				
2002	2000+40	C.DRT.2.2020	02/01/19	03/01/19	28	Excavate - Block 2002	1,550	5,323	1,768	840	1
2003	2008+54	C.DRT.2.2030	06/30/21	08/05/21	36	Excavate - Block 2003	232				
2102	2013+80	C.DRT.2.4605	05/26/20	07/01/20	36	Embank - Block 2102	200		80		

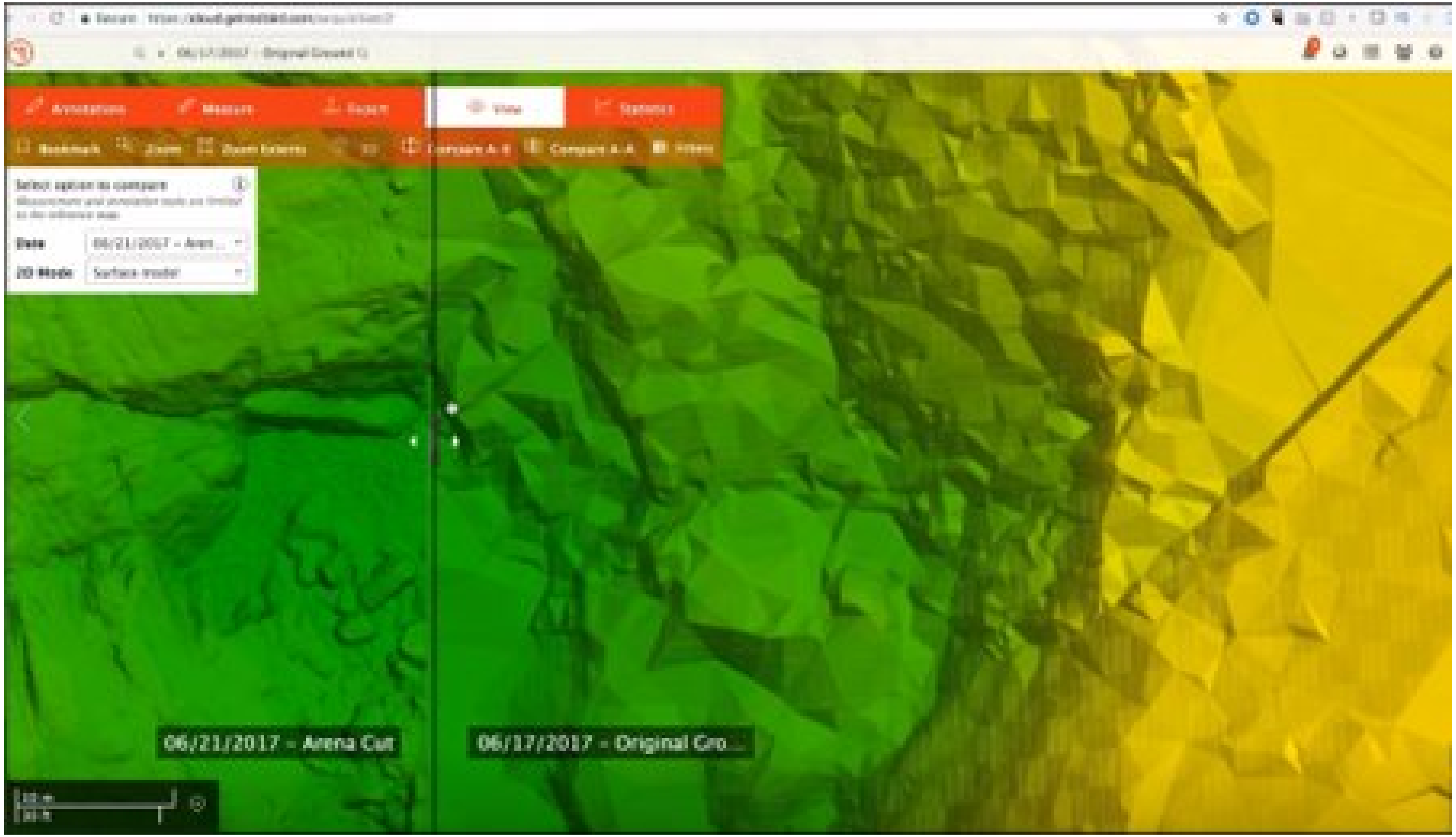
Better Mapping capabilities

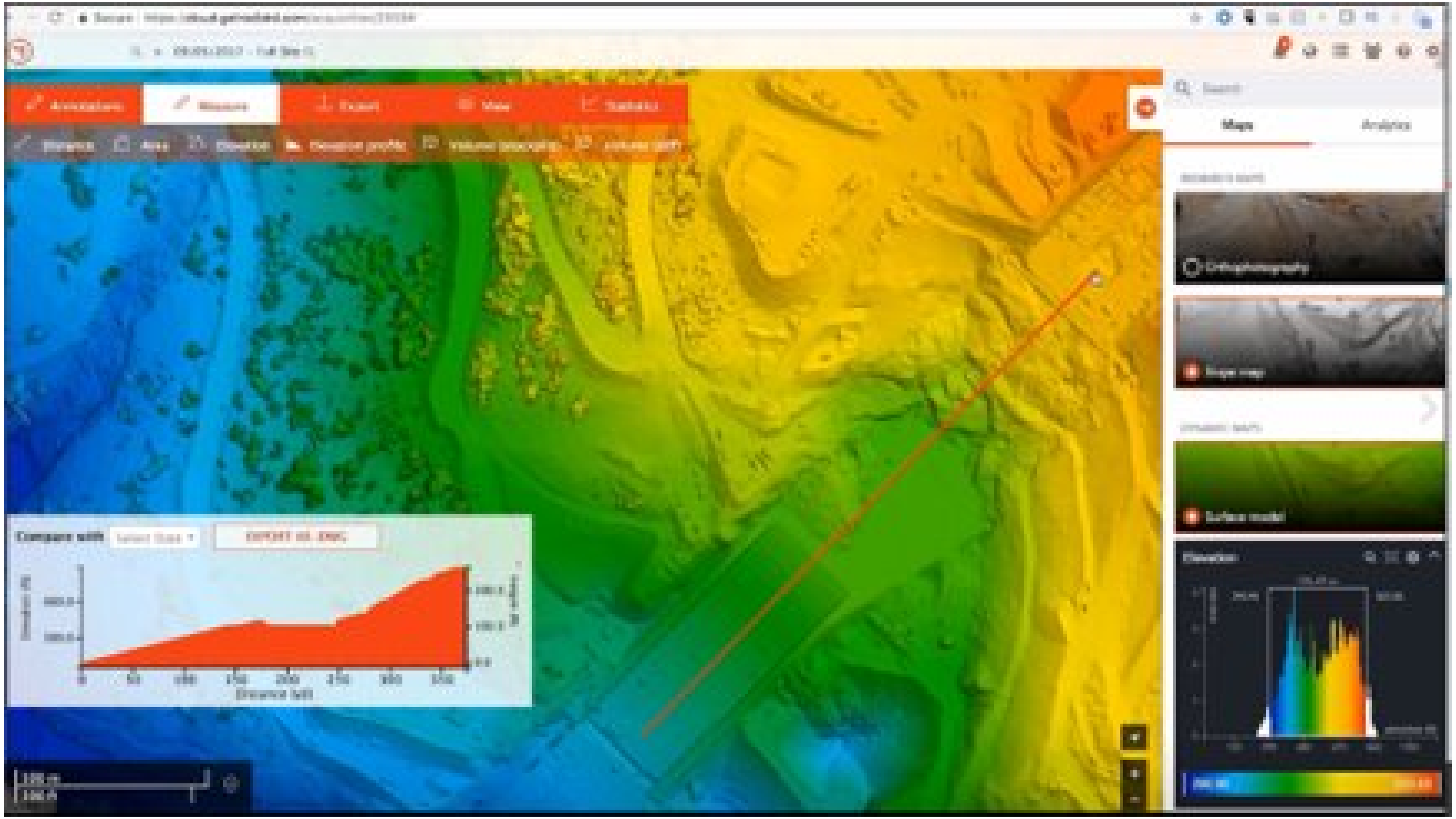




Drones vs Traditional Survey

Accuracy and Frequency




Annotations
Measure
Export
View
Statistics
Distance
Area
Elevation
Compare with
Maps
Analytics
Orthophotography
Surface model
Elevation

What's needed?

- Connected Systems and Data
- Standard Cost Coding
- A Culture of Collaboration to Tie it All Together
- Technology needs to continue to improve

THANK YOU