2019 TRB Webinar

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

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

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

### e-Construction Maturity

<table>
<thead>
<tr>
<th>Project Delivery Process Step</th>
<th>State of Practice*</th>
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<td>Nascent</td>
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<tr>
<td>Plans, Specifications, and Estimates</td>
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<td>Electronic Bidding and Contractor Selection</td>
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<td>Construction Management Systems</td>
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<td>Project Collaboration</td>
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<td>Digital Signatures</td>
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<td>Project Inspection and Testing</td>
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<td>Project Acceptance</td>
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<td>Project Close-Out</td>
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<tr>
<td>Data Sharing between Steps</td>
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*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.
Digital Data Management Plan

Proposed Project Delivery Cycle Software Systems

Source: Oregon DOT

- Field Data Collection with Collector & Survey 123

Asset Inventory
- Guardrail
- Culverts
- Signs
- Lighting

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

Source: IOWA DOT and ARC GIS

Source: INDIANA DOT and Bentley

Color coding reflects changed status
Re-inspected date is noted
Save the form
At a later date, the excavation was re-inspected and passed
Source: Michigan DOT
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.

Source: https://www.channelpartnersonline.com/2019/04/11/today-channels-the-big-picture/
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
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

BIM/CIM Functions → Project Phases → Facility Lifecycle

* DOMI = Document, Date- and Model-based Information

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
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

- Data Governance
  - Data Architecture
  - Data Modeling & Design
  - Data Storage & Operations
  - Data Security
- Data Governance Components
  - Data Quality
  - Metadata
  - Reference & Master Data Management
  - Data Warehousing & Business Intelligence
  - Documents & Content
  - Data Integration & Interoperability
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
What Is The CTDOT TED Initiative?

Transportation Enterprise Database (TED)

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
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

Data Management and Governance Practices

A Synthesis of Highway Practice

NCHRP
REPORT 831

Civil Integrated Management (CIM) for Departments of Transportation

Volume 2: Research Report

TRANSPORTATION RESEARCH BOARD
The National Academies of SCIENCES • ENGINEERING • MEDICINE
State of Practice – Contractor Use of Data

Source: Dodge Data and Analytics, Steve Jones
CONTACTS

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[www.fhwa.dot.gov/construction/econstruction](http://www.fhwa.dot.gov/construction/econstruction)  
[www.fhwa.dot.gov/3d](http://www.fhwa.dot.gov/3d)

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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
• **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**

![Gauge indicating 85% on time and 91% on budget.]
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

Cost Estimation
Proposal Preparation
Bid Letting, Analysis and Award
Construction Management and Inspection
Materials Management
Civil Rights and Labor

Data Analytics

Answers
Decisions
Reports
Dashboards
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
  ß 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

- Power: 22%
- Transportation: 31%
- Oil, gas & chemical: 22%
- Building: 13%
- Mining: 4%
- Water/wastewater: 8%

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
  o 14,200 units
  o $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:
  o All Construction Industries
  o Engineering Services
  o Overhead Departments
  o Construction Equipment
DESIGN QUANTITY GROWTH
DESIGN-BUILD/EPC SHARE OF CONSTRUCTION INDUSTRY REVENUE

1990: 5%

Today: 40%

$10B to $80B
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

<table>
<thead>
<tr>
<th>Description</th>
<th>90% status</th>
<th>90% status</th>
<th>Baseline cost/Uo...</th>
<th>Adjusted cost/Uo...</th>
<th>Qty delta</th>
<th>Cost delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storm Drain</td>
<td>Complete</td>
<td>9588.00</td>
<td>$16.43</td>
<td>$29.88</td>
<td>-432.00</td>
<td>$119,678.24</td>
</tr>
<tr>
<td>LAB - Remove Flankwork, Curb and Gutter</td>
<td>Quantity driver</td>
<td>$63.33</td>
<td>$63.33</td>
<td>-1,634.00</td>
<td>-103,481.22</td>
<td></td>
</tr>
<tr>
<td>UPRR and CN CS Subballast</td>
<td>Quantity driver</td>
<td>$43.77</td>
<td>$43.77</td>
<td>11,710.00</td>
<td>$512,546.70</td>
<td></td>
</tr>
<tr>
<td>Prepare Subgrade</td>
<td>Quantity driver</td>
<td>$0.50</td>
<td>$0.50</td>
<td>-0.00</td>
<td>$0.00</td>
<td></td>
</tr>
<tr>
<td>Excavation to Embank</td>
<td>Quantity driver</td>
<td>$5.73</td>
<td>$5.73</td>
<td>29,825.00</td>
<td>$170,897.25</td>
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</tr>
<tr>
<td>Excavation to Waste Ag Indus</td>
<td></td>
<td>$1.65</td>
<td>$1.65</td>
<td>53,660.00</td>
<td>$88,539.00</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The above table shows the quantity tracker details for various design elements, including their statuses, quantities, and cost variances.
Past, Current & Future - Time and People
OLD – Home Grown System
Time Cards, People, Quantities and Safety
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

<table>
<thead>
<tr>
<th>Property or Characteristic</th>
<th>Spec</th>
<th>Process (RQC/PC)</th>
<th>Frequency</th>
<th>UoM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate Moisture</td>
<td></td>
<td>RQC</td>
<td>200 CY</td>
<td></td>
</tr>
<tr>
<td>Air Content</td>
<td></td>
<td>RQC</td>
<td>1,000 CY</td>
<td></td>
</tr>
<tr>
<td>Air Voids</td>
<td></td>
<td>PC</td>
<td>1,000 Ton</td>
<td></td>
</tr>
<tr>
<td>Asphalt Content</td>
<td></td>
<td>RQC</td>
<td>* Ton</td>
<td></td>
</tr>
<tr>
<td>Atterberg Limits</td>
<td></td>
<td>RQC</td>
<td>2,500 LF</td>
<td></td>
</tr>
<tr>
<td>Compressive Strength</td>
<td></td>
<td>RQC</td>
<td>2,000 QA</td>
<td></td>
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<tr>
<td>Gradation</td>
<td></td>
<td>RQC</td>
<td>1,000 QA</td>
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<tr>
<td>Hveem Stability</td>
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<td>RQC</td>
<td>1,000 QA</td>
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<td>Hydrated Lime</td>
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<td>RQC</td>
<td>1,000 QA</td>
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<td>In Place Density when within 100' of Bridge Approach</td>
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<tr>
<td>In Place Density</td>
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<td>RQC</td>
<td>1,000 QA</td>
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<td>Lett lmm</td>
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<td>RQC</td>
<td>1,000 QA</td>
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<td>Material Compliance</td>
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<td>RQC</td>
<td>1,000 QA</td>
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<tr>
<td>Micro Void</td>
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<td>RQC</td>
<td>1,000 QA</td>
<td></td>
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<tr>
<td>pH (**)</td>
<td></td>
<td>RQC</td>
<td>1,000 QA</td>
<td></td>
</tr>
<tr>
<td>Resistivity (**)</td>
<td></td>
<td>RQC</td>
<td>1,000 QA</td>
<td></td>
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<tr>
<td>RESISTIVITY &lt;&gt;&lt;&gt;</td>
<td></td>
<td>RQC</td>
<td>1,000 QA</td>
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<tr>
<td>Slump</td>
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<td>RQC</td>
<td>1,000 QA</td>
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<tr>
<td>Soil Survey (Classification, R Value)</td>
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<tr>
<td>Sulfate, pH, Chlorides &amp; Resistivity</td>
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<tr>
<td>Theoretical Max. Specific Gravity</td>
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<tr>
<td>Voids in Mineral Aggregate</td>
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<td>RQC</td>
<td>1,000 QA</td>
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<tr>
<td>Water-Soluble Chloride ion (**)</td>
<td></td>
<td>RQC</td>
<td>1,000 QA</td>
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<tr>
<td>Water-Soluble Sulfate ion (**)</td>
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<td>1,000 QA</td>
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<tr>
<td>Water-Soluble Chloride Ion (**)</td>
<td></td>
<td>RQC</td>
<td>1,000 QA</td>
<td></td>
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</tbody>
</table>
Past, Current & Future - Earthwork Quantities
Models - Design vs Construction Quantities
Earthwork - Mass Haul and Material Flow
Better Mapping capabilities
Drones vs Traditional Survey

- 4 hrs
  - 560 acres
  - 2,000 images
  - 10,000,000 pts

- 3 hrs
  - 420 acres
  - 1,500 images
  - 7,500,000 pts

- 2 hrs
  - 280 acres
  - 1,000 images
  - 5,000,000 pts

- 1 hr
  - 140 acres
  - 500 images
  - 2,500,000 pts

350X survey resolution
50X survey speed
Accuracy and Frequency
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