Digital As-Built (DAB) and Workflow of Pavement Construction

2026 MTC&E ISIC Track

March 18–20, 2026 · Minneapolis, Minnesota

ISIC International Society For Intelligent Construction

Contents

Digital As-Built (DAB) and Workflow of Pavement Construction

Executive Summary

The International Society for Intelligent Construction (ISIC) North America Chapter sponsored a dedicated technical track at the 2026 Minnesota Transportation Conference and Expo (MTC&E), held March 18–20, 2026, in Minneapolis, Minnesota. The one-day ISIC Track focused on Digital As-Built (DAB) technologies and pavement construction workflows, bringing together public agencies, contractors, technology providers, and consultants to examine current practices, emerging solutions, and implementation lessons across the pavement life cycle.

The ISIC Track addressed the growing need for accurate, interoperable, and actionable construction data to support quality construction, effective contract administration, and long-term asset management. Presentations highlighted how modern construction equipment, sensing technologies, and digital delivery platforms can automatically capture as-built data during milling, paving, compaction, and material delivery operations. Emphasis was placed on integrating these data streams into agency systems to improve decision-making, documentation, and lifecycle management.

Key technical sessions explored DAB workflows derived from Material Delivery Management Systems (MDMS), 2D and 3D machine guidance for milling and paving, paver-mounted thermal profiling, intelligent compaction, and the development of "living models" that connect construction as-builts with asset and pavement management systems. Case studies demonstrated how these technologies are being applied in practice to enhance quality control and quality assurance (QC/QA), diagnose construction issues, support payment accuracy, and improve finished pavement performance.

The track also examined organizational and contractual considerations necessary for successful implementation, including digital scoping, project-specific electronic data, model requirements, data standards, and interoperability among equipment and software platforms. Agency perspectives, particularly from the Minnesota Department of Transportation (MnDOT), provided insight into current deployment strategies, implementation challenges, and planned transitions toward more comprehensive DAB requirements.

The ISIC Track concluded with an open panel discussion featuring representatives from transportation agencies, contractors, equipment manufacturers, and consultants. The discussion reinforced the importance of collaboration, standardized workflows, and workforce readiness in advancing intelligent construction practices. Panelists emphasized that Digital As-Built data are no longer optional add-ons but foundational components of modern pavement construction and management.

This report documents the ISIC Track agenda, abstracts, speaker contributions, and key discussion themes. It serves as a reference for transportation agencies, industry practitioners, and researchers seeking to better understand current DAB capabilities, implementation pathways, and opportunities to improve pavement construction quality, efficiency, and long-term asset performance through intelligent construction technologies.

Key Takeaways:

- Digital As-Built (DAB) data are foundational to modern pavement construction, enabling accurate documentation, improved QC/QA, and stronger connections between construction activities and asset management systems.
- Intelligent construction technologies—such as MDMS, 2D/3D machine guidance, intelligent compaction, and thermal profiling—are already being applied successfully to capture high-resolution as-built data during construction operations.
- Integration and interoperability are critical success factors. Effective DAB workflows require coordination among equipment, software platforms, agency systems, and data standards across the project lifecycle.
- DAB supports better decision-making beyond construction, including payment accuracy, diagnostics of construction issues, lifecycle planning, and development of “living models” for pavement and asset management.
- Agency leadership and industry collaboration are essential to advancing adoption, addressing implementation challenges, and transitioning from pilot projects to standardized practice.
- Digital delivery and workforce readiness must evolve together, ensuring that project teams have the skills, guidance, and contractual frameworks needed to fully leverage DAB technologies.

Introduction

2026 MTC&E ISIC TRACK

The International Society for Intelligent Construction (ISIC, www.IS-IC.org) North America Chapter sponsored an ISIC track during the 2026 Minnesota Transportation Conference and Expo (MTC&E) from March 18th to 20th, in Minneapolis, MN, USA. The theme of the one-day ISIC Track was "Digital As-Built (DAB) and Workflow of Pavement Construction."

MTC&E MARCH 18-20 2026 MINNESOTA TRANSPORTATION CONFERENCE & EXPO

What is ISIC?

The International Society for Intelligent Construction (ISIC) is a source of knowledge and information on intelligent construction technologies for public agencies, contractors, consultants, academia, and other relevant industries.

ISIC

ISIC provides a forum for disseminating knowledge concerning collecting, analyzing, and applying information relating to intelligent construction technologies (ICT) for infrastructure. ICT is a combination of modern science and innovative construction technologies. The mission of ISIC is to promote the application of ICT across the infrastructure life cycle: from surveying, design, construction, operation, maintenance/rehabilitation, adaptation to environmental changes, and risk minimization. Its mission aims to improve the quality of construction, reduce costs, and enhance safety.

The scope of ISIC encompasses all current and emerging intelligent construction technologies across the infrastructure life cycle. The Scope includes intelligent sensing, data analysis, decision-making, and execution. The Scope covers civil engineering, construction machinery, electronic sensor technology, survey/testing technology, information technology/computing, and other related fields.

ISIC TRACK – Learning Objectives

- Gain a comprehensive understanding of Digital As-Built (DAB) technologies and their application in pavement construction workflows.

- Explore how DAB enhances quality control and assurance in construction projects.
- Discover how DAB workflows and software technologies support updates to asset and pavement management systems.
- Engage with perspectives from agencies, industry leaders, and contractors.

ISIC TRACK – Agenda

- Date: Wednesday, March 18th, 2026
- Format: One-day track

Morning Session (Room 13,14,15)

Time	Topic	Speakers	Moderator
08:00 AM – 08:30 AM	ISIC Track 01 - Introduction and Overview	Dr. George K. Chang (Transtec-Terracon)	Dr. George K. Chang (Transtec-Terracon)
08:30 AM – 09:30 AM	ISIC Track 02 - DAB from the Material Delivery Management System (MDMS)	Rebecca Embacher (MnDOT)	Dr. George K. Chang (Transtec-Terracon)
09:30 AM – 10:15 AM	ISIC Track 03 - DAB from 2D/3D Milling	Tom Chastain (Wirtgen Group)	Dr. George K. Chang (Transtec-Terracon)
10:15 AM – 10:30 AM	Break		
10:30 AM – 11:15 AM	ISIC Track 04 – DAB from 2D/3D Paving and Thermal Profiling	Jim Preston (TOPCON) and Craig Lamarque (Wirtgen Group)	Dr. George K. Chang (Transtec-Terracon)
11:15 AM – 12:00 PM	ISIC Track 05 – DAB from Intelligent Compaction	Todd Mansell (Caterpillar)	Dr. George K. Chang (Transtec-Terracon)

12:00 PM – 01:00 PM Break (lunch)

Afternoon Session (Room 13,14,15)

Time	Topic	Speakers	Moderator
01:00 PM – 01:45 PM	ISIC Track 06 – DAB for Living Models in Asset and Pavement Management Systems	Jim Preston (TOPCON)	Dr. George K. Chang (Transtec-Terracon)
01:45 PM – 02:45 PM	ISIC Track 07 - DAB for Improving Construction QC and QA	Amanda L. Gilliland (Transtec-Terracon) and Scott Fernald (Granite Construction)	Dr. George K. Chang (Transtec-Terracon)
02:45 PM – 03:00 PM	Break		
03:00 PM – 4:00 PM	ISIC Track 08 - Complete Paving DAB Workflow Examples	Rebecca Embacher (MnDOT) and Scott Fernald (Granite Construction)	Dr. George K. Chang (Transtec-Terracon)
4:00 PM – 5:00 PM	ISIC Track 09 – Open Panel Discussion	Moderator: Curt Turgeon (MnDOT) Panels: DOTs (MnDOT), vendors (Caterpillar, Wirtgen, TOPCON), contractors (Granite), consultants (Transtec-Terracon, WSB)	Curt Turgeon (MnDOT)
5:00 PM	Adjourned		

Speakers' Biography

Dr. George K. Chang, P.E

President, International Society for Intelligent Construction (ISIC); Transtec Group, a Terracon Company

Dr. George K. Chang is an internationally recognized expert in pavement smoothness and intelligent construction technologies, with more than three decades of experience in research, practice, and implementation. He founded the International Society for Intelligent Construction (ISIC) to advance the application of intelligent construction technologies across the infrastructure life cycle. Dr. Chang has led specification development, research initiatives, and software tool development that have significantly influenced the adoption of intelligent compaction and construction practices worldwide. He is the developer of widely used platforms such as ProVAL and Veta, which support pavement smoothness analysis and intelligent construction workflows. Since 2007, he has led intelligent construction implementation efforts across the United States and internationally, including projects in Europe, China, and Australia.

Rebecca Embacher, M.S.

Advanced Materials and Technology Engineer, Minnesota Department of Transportation (MnDOT); ISIC Technical Committee Member

Rebecca Embacher is the Advanced Materials and Technology Engineer at the Minnesota Department of Transportation. She holds a master's degree in civil engineering from the University of Minnesota and has professional experience spanning academic research, consulting, and agency roles. Her background includes work in pavement engineering, materials testing, pavement design and preservation, seasonal load limits, and construction quality. Over the past two decades, she has been actively involved in implementing intelligent construction technologies, including machine guidance, intelligent compaction, paver-mounted thermal profiling, e-construction, e-ticketing, and material delivery management systems. Her work supports MnDOT's efforts to integrate construction data into digital delivery, asset management, and advanced analytics platforms.

Tom Chastain

Milling Product Manager, Wirtgen Group

Tom Chastain serves as Milling Product Manager for the Wirtgen Group, where his responsibilities include product application support, dealer training, and contractor engagement. His work focuses on equipment setup, model execution, and best practices for milling operations using 2D and 3D technologies. He delivers classroom and field-based training for dealers and contractors and supports demonstration planning in coordination with regional representatives. Mr. Chastain is also involved with national and local organizations dedicated to advancing construction practices and technology adoption.

Jim Preston

Intelligent Paving Specialist, TOPCON; Treasurer, ISIC North American Chapter

Jim Preston is an Intelligent Paving Specialist at TOPCON with nearly three decades of experience in civil engineering, construction technology, and international markets. He began his career through internships with civil engineering and consulting firms supporting roadway and bridge projects for public agencies. His professional focus shifted toward field operations and construction technology, where he has worked extensively with equipment manufacturers and contractors. Mr. Preston is active in industry technology committees, including ISIC and NRRA, and contributes to expanding the practical application of intelligent construction solutions across paving and construction workflows.

Todd Mansell, M.B.A.

Product Application Specialist, Caterpillar; Vice-Chair, ISIC North American Chapter

Todd Mansell is a Product Application Specialist with Caterpillar's Global Paving Division, where he provides training and technical consulting to customers worldwide. He holds a civil engineering degree from Lakehead University and an MBA from Santa Clara University. With more than 35 years of experience in the asphalt paving industry, his career has included roles in laboratory testing, field inspection, quality control management, training, and equipment technology development. Mr. Mansell is actively involved in national and international paving organizations and committees supporting innovation and quality improvement.

Craig Lamarque

Vice President, Head of Digital Products, Wirtgen America

Craig Lamarque leads the Digital Products organization at Wirtgen America, with responsibility for training, technical support, and application support across the Wirtgen Group's digital product portfolio. He works closely with equipment brands, dealers, contractors, and road authorities to optimize digital solutions. Prior to joining Wirtgen, Mr. Lamarque spent 24 years with John Deere Construction in training, product support, and sales roles, including more than a decade in strategic account management supporting major road-building contractors.

Amanda L. Gilliland, P.E.

Senior Engineer, Transtec Group, a Terracon Company; Communications Coordinator, ISIC North American Chapter

Amanda Gilliland is a professional engineer with extensive experience in asphalt paving quality control and intelligent construction implementation. She spent a decade in the construction industry as a paving quality control manager and led the first documented use of intelligent compaction by a contractor in Alaska. Since joining Transtec, she has contributed to national initiatives focused on improving pavement data quality and advancing intelligent construction practices. She has supported long-term intelligent construction implementation programs with state transportation agencies, including the Missouri Department of Transportation.

Scott Fernald

Construction Manager and Automation Technology Coordinator, Granite Construction; ISIC North American Chapter

Scott Fernald is a Construction Manager at Granite Construction with 26 years of experience in the construction industry, including more than two decades with Granite. His career includes roles as Project Engineer and Project Manager, leading to his current responsibility overseeing asphalt paving operations in the Utah Region. In addition to operational leadership, Mr. Fernald serves as Construction Technology Manager, where he leads efforts to integrate and advance construction automation and intelligent technologies.

Curt Turgeon

Director, Office of Materials and Road Research, Minnesota Department of Transportation (MnDOT); ISIC Steering Committee Member

Curt Turgeon is the Director of the Office of Materials and Road Research at the Minnesota Department of Transportation. He has played a leading role in advancing innovative construction technologies within MnDOT and across the transportation industry for several decades. His work has focused on materials research, construction practices, and the implementation of emerging technologies to improve project quality and performance. Mr. Turgeon serves on the ISIC Steering Committee and supports collaboration among agencies, industry partners, and technology providers.

Session Descriptions

ISIC Track 01 - Introduction and Overview

Abstracts

The opening presentation of the ISIC Track introduced ISIC and provided an overview of the Digital As-Built (DAB) and the pavement construction workflow. This ISIC track brings together experts from agencies, industry, and academia to explore the latest advancements in intelligent construction technologies and their application in pavement construction.

Speakers

Dr. George K. Chang, P.E., Transtec Group, a Terracon Company – President, ISIC

Presentation

(Cover Slide) – All slides are in Appendix A.

ISIC Track 02 - DAB from the Material Delivery Management System (MDMS)

Abstracts

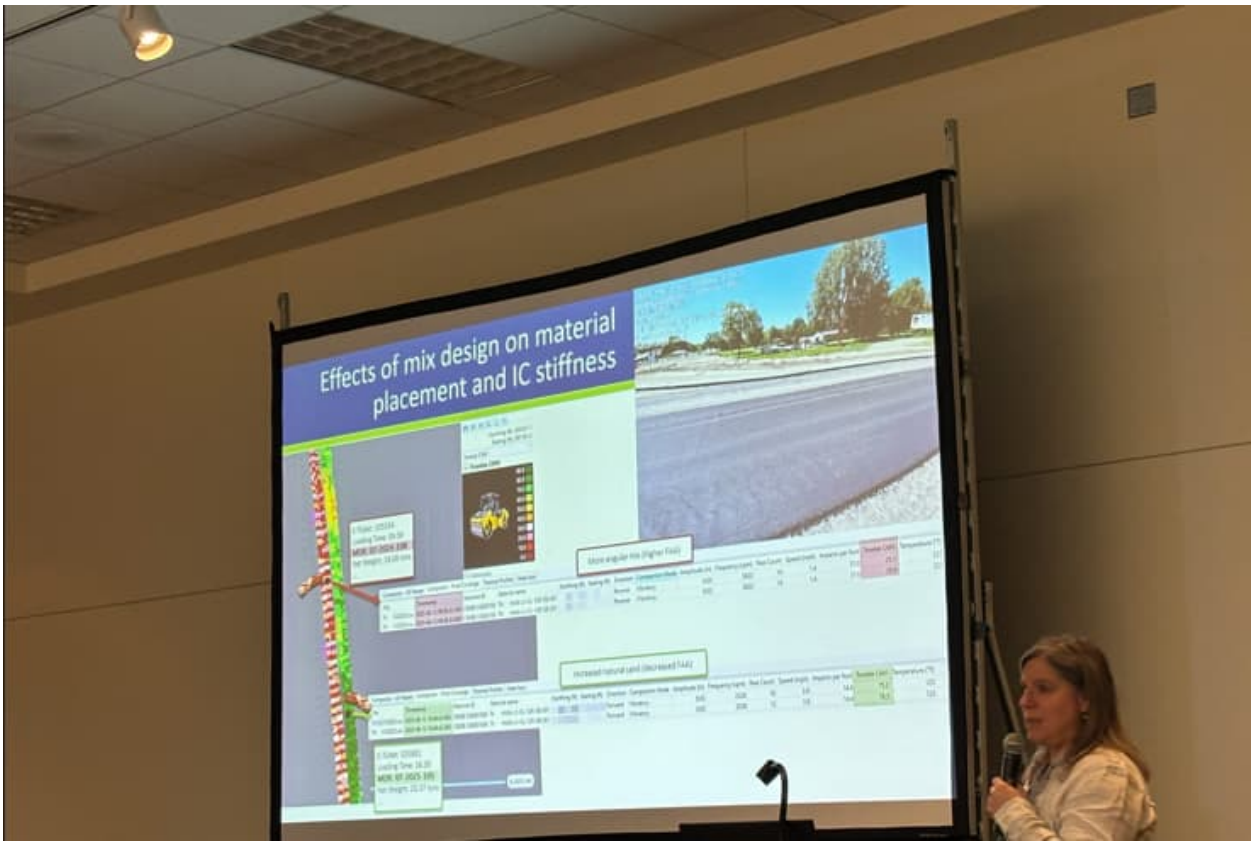
The presentation provided an overview of MnDOT's Digital As-Built (DAB) process, which uses the Material Delivery Management System (MDMS) to manage material delivery data for construction projects. It explains the types of materials currently included in MDMS, the data captured by contractors and the department, and how this information flows into MnDOT's VetaCenter platform. The system uses e-tickets, hauler data, and loading/delivery event records—often triggered through static or mobile geofences—to document material types, quantities, and placement locations. The captured data integrates with asset management, design, planning, and construction to support a connected data environment and improve accuracy, quality, and payment efficiency.

MDMS also connects lab and field test results to specific E-tickets and dump locations, enabling diagnostics such as investigating density failures or thermal segregation using technologies like IC and PMTP. The presentation shows how MDMS supports contract administration, field adjustments, pay-quantity tabulations, and compliance testing. It additionally highlights MDMS rollout schedules for bituminous mixtures and structural concrete, including exemptions for small quantities and specific placement conditions.

Finally, the roadmap details MnDOT's transition to requiring contractors and suppliers to push MDMS data directly into VetaCenter beginning in the 2025–2026 timeframe, with broader adoption planned through 2031.

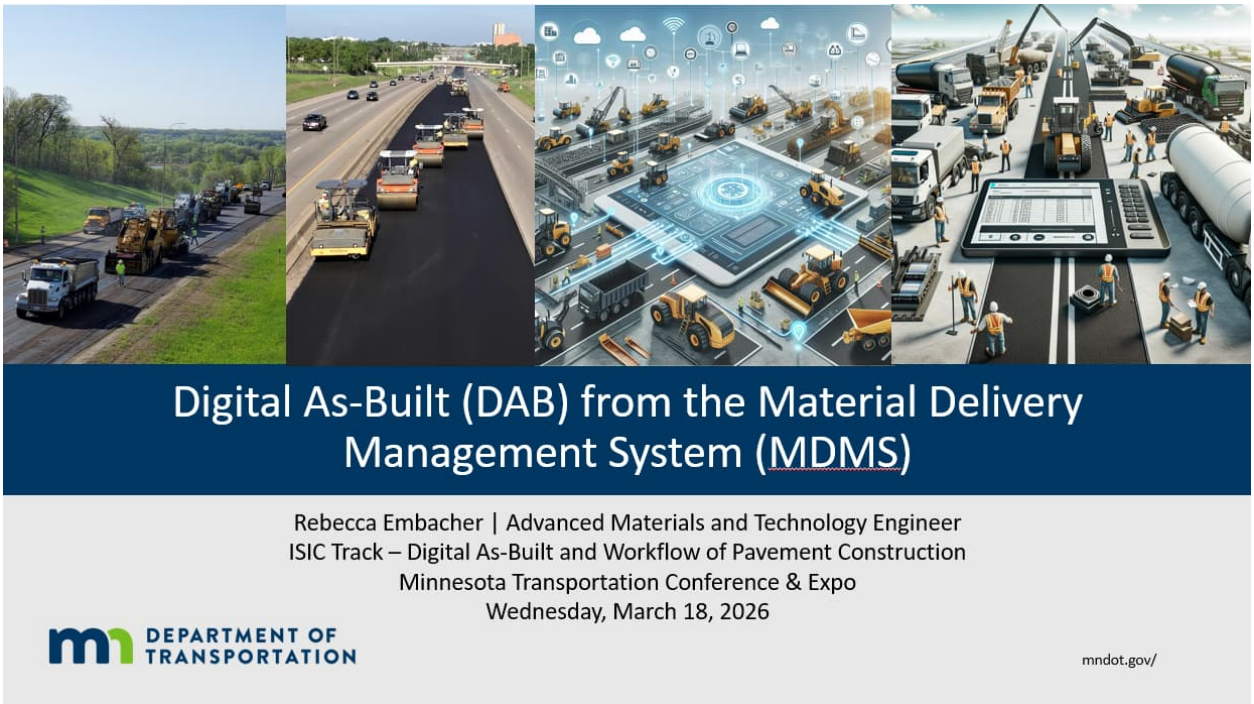
Speakers

Rebecca Embacher, Advanced Materials and Technology Engineer, MNDOT – Technical Committee of ISIC



Presentation

(Cover Slide) – All slides are in Appendix A.



ISIC Track 03 - DAB from 2D/3D Milling

Abstracts

This presentation focused on using 2D/3D models for milling, including Machine Setup Best Practices – key dos and don'ts when configuring equipment to ensure accurate model execution. Model Building - what goes into creating a constructible model, and Field Execution – what's needed to successfully use 3D models on site, including equipment, data flow, and crew coordination.

Speakers

Tom Chastain, Milling Product Manager, Wirtgen Group

Presentation

N/A

ISIC Track 04 – DAB from 2D/3D Paving and Thermal Profiling

Abstracts

This presentation focused on using 2D/3D models for paving and automatic documentation of data related to pavement thermal profiling, paving parameters, and construction as-builts. It will also cover data formats and storage, enabling data sharing across different equipment and providing operators with additional information to manage the construction process better.

Speakers

Jim Preston, TOPCON - Treasurer of ISIC North American Chapter

Craig Lamarque, V.P., Head of Digital Products, Wirtgen America

Presentation

(Cover Slide) – All slides are in Appendix A.

ISIC Track 05 – DAB from Intelligent Compaction

Abstracts

This presentation covered automatic documentation of data related to pavement compaction, intelligent compaction, and construction as-builts. It will also cover data formats and storage, enabling data sharing across different equipment and providing operators with additional information to manage the construction process better.

Speakers

Todd Mansell, Caterpillar – Vice-Chair of ISIC North American Chapter

Presentation

(Cover Slide) – All slides are in Appendix A.

ISIC Track 06 – DAB for Living Models in Asset and Pavement Management Systems

Abstracts

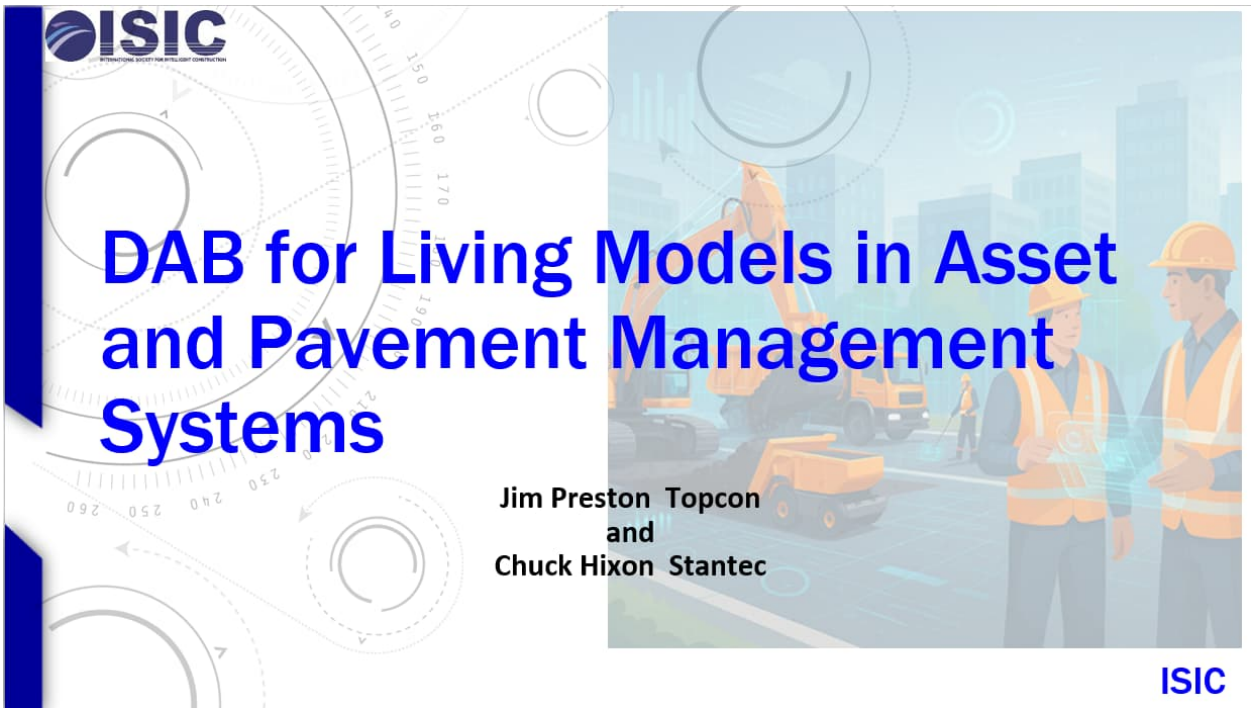
This session highlighted how technology built into modern construction equipment, such as machine control, compaction measurement, and onboard sensors, can collect valuable as-built data. This session will demonstrate how this data can be integrated into asset and pavement management systems, enabling owners to create "living models" that support informed planning, maintenance, and lifecycle management decisions. Real-world examples will illustrate the benefits and opportunities.

Speakers

Jim Preston, TOPCON - Treasurer of ISIC North American Chapter

Presentation

(Cover Slide) – All slides are in Appendix A.



ISIC Track 07 - DAB for Improving Construction QC and QA

Abstracts

This session highlights how DAB from modern construction equipment can improve construction quality control and assurance. Real-world case studies will be demonstrated to trace the causes (cool streak from PMTP, lack of roller coverage/passes from IC, evidence of low DPS values, etc.) and determine solutions for poor or failed in-place asphalt densities.

Speakers

Amanda L. Gilliland, P.E., Transtec Group, a Terracon Company – Communication Coordinator of the ISIC North American Chapter

Scott Fernald, Granite Construction - Automation Technology Coordinator of the ISIC North American Chapter

Presentation

(Cover Slide) – All slides are in Appendix A.

ISIC Track 08 - Complete Paving DAB Workflow Examples

Abstracts

The presentation outlined MnDOT's end-to-end digital workflow for pavement construction, emphasizing intelligent construction technologies, digital as-builts, and data interoperability. It highlights innovations in scoping, particularly how accurate lidar, GPR, and AMG data collection support milling, muck excavation, and pavement design. Ground Penetrating Radar is shown as essential for determining existing layer thicknesses and avoiding design errors, with examples illustrating issues when GPR data is missing or unused.

Design sections describe constraints for AMG milling models, required extensions, surface trimming, and the importance of smoothness modeling to prevent irregularities. The bid package section explains the role of Project-Specific Electronic Data, discipline models, and the precedence of digital documents in MnDOT's contract structure.

A major case study demonstrates how AMG milling with robotic total stations helped resolve severe settlement issues on an urban project, enabling precise mill depth mapping, controlled operations, and successful correction of roadway smoothness and drainage. The project example shows that even with variable depths and complex urban utilities, AMG provided accurate milling to within 0.02 ft, delivering a high-quality finished product.

Speakers

Rebecca Embacher, Advanced Materials and Technology Engineer, MNDOT – Technical Committee of ISIC

Presentation

(Cover Slide) – All slides are in Appendix A.

Complete Paving Digital As-Built Workflow
Digital Workflow from Design to Construction for Pavements

Rebecca Embacher | Advanced Materials and Technology Engineer
ISIC Track – Digital As-Built and Workflow of Pavement Construction
Minnesota Transportation Conference & Expo
Wednesday, March 18, 2026

DEPARTMENT OF TRANSPORTATION

mndot.gov/

ISIC Track 09 – Open Panel Discussion & Closing Remarks

Abstracts

The ISIC track concluded with an open panel discussion that ties its topics to perspectives from various industry sectors. The panel members will include DOTs (MnDOT, etc.), vendors (Caterpillar/Wirtgen/TOPCON, etc.), contractors (Granite, etc.), and consultants (Transtec-Terracon/WSB, etc.)

Speakers

Moderator

Curt Turgeon, Director of the Office of Materials and Road Research of MnDOT – Steering Committee Member of ISIC

Panel Members

Presentation

(Cover Slide) – All slides are in Appendix A.

Closing Remarks

The ISIC Track highlighted the increasing role of Digital As-Built (DAB) data as a foundational element of modern pavement construction and infrastructure management. Across the sessions, a consistent theme emerged: intelligent construction technologies are no longer experimental tools, but practical, deployable solutions that improve construction quality, transparency, and lifecycle decision-making when integrated into well-defined workflows.

Presentations and case studies demonstrated how DAB data captured during material delivery, milling, paving, and compaction can support construction quality control and assurance, accurate payment, and improved communication among project stakeholders. Equally important, the discussions emphasized the value of connecting construction as-built data to asset and pavement management systems, enabling agencies to develop "living models" that support long-term planning, maintenance, and performance management.

The open panel discussion reinforced that the successful adoption of DAB practices depends on collaboration among agencies, contractors, equipment manufacturers, and consultants. Standardized data practices, interoperable systems, and a prepared workforce were identified as critical factors in moving from pilot implementations toward broader, consistent use across projects and programs.

ISIC will continue to serve as a forum for sharing knowledge, experiences, and lessons learned related to intelligent construction and Digital As-Built workflows. Readers are encouraged to stay engaged with ISIC activities, technical resources, and future events to support continued collaboration and the advancement of intelligent construction practices across the transportation industry.

2026 MTCE ISIC Track Speakers, Moderators, and Panels

Appendix A – Presentation Slides

The presentation materials included in this appendix were prepared by the respective speakers and remain the intellectual property of their authors. The materials are provided for informational and reference purposes only.

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MARCH 18-20 2026
MINNESOTA TRANSPORTATION CONFERENCE & EXPO

ISIC Track
Digital As-Built (DAB) and Workflow of Pavement Construction

Wednesday, March 18th, 2026 - Room 13,14,15

By

International Society for Intelligent Construction (ISIC)

IS-IC.ORG

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ISIC Track 01
Introduction and Overview

By
Dr. George K. Chang, P.E.
Transtec Group, Inc., A Terracon Company
ISIC President

ISIC

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Learning Objectives

1. Gain a comprehensive understanding of Digital As-Built (DAB) technologies and their application in pavement construction workflows.
2. Explore how DAB enhances quality control and assurance in construction projects.
3. Discover how DAB workflows and software technologies support updates to asset and pavement management systems.
4. Engage with perspectives from agencies, industry leaders, and contractors.

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Agenda

Time	Topic	Speakers
08:00 AM – 08:30 AM	ISIC Track 01 - Introduction and Overview	Dr. George K. Chang (Transtec-Terracon)
08:30 PM – 09:30 AM	ISIC Track 02 - DAB from the Material Delivery Management System (MDMS)	Rebecca Embacher (MnDOT)
09:30 AM – 10:15 AM	ISIC Track 03 - DAB from 2D/3D Milling	Tom Chastain (Wirtgen Group)
10:15 AM – 10:30 AM	Break	
10:30 AM – 11:15 AM	ISIC Track 04 – DAB from 2D/3D Paving and Thermal Profiling	Jim Preston (TOPCON) and Craig Lamarque (Wirtgen Group)
11:15 PM – 12:00 PM	ISIC Track 05 – DAB from Intelligent Compaction	Todd Mansell (Caterpillar)

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4:00 PM – 5:00 PM	ISIC Track 09 – Open Panel Discussion	Moderator: Curt Turgeon (MnDOT) Panels: DOTs (MnDOT, NDDOT), vendors (Caterpillar, Trimble, Wirtgen, TOPCON), contractors (Granite, KnifeRiver), associations (MAPA), consultants (Transtec-Terracon)
5:00 PM	Adjourned	

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MTC&E 2026 – ISIC Track Speakers


Rebecca Embacher
MnDOT


George K. Chang
Transtec-Terracon


Jim Preston
TOPCON


Todd Mansell
Caterpillar


Tom Chastain
Wirtgen Group


Amanda Gilliland
Transtec-Terracon


Scott Fernald
Granite Construction


Craig Lamarque
Wirtgen Group


Curt Turgeon
MnDOT

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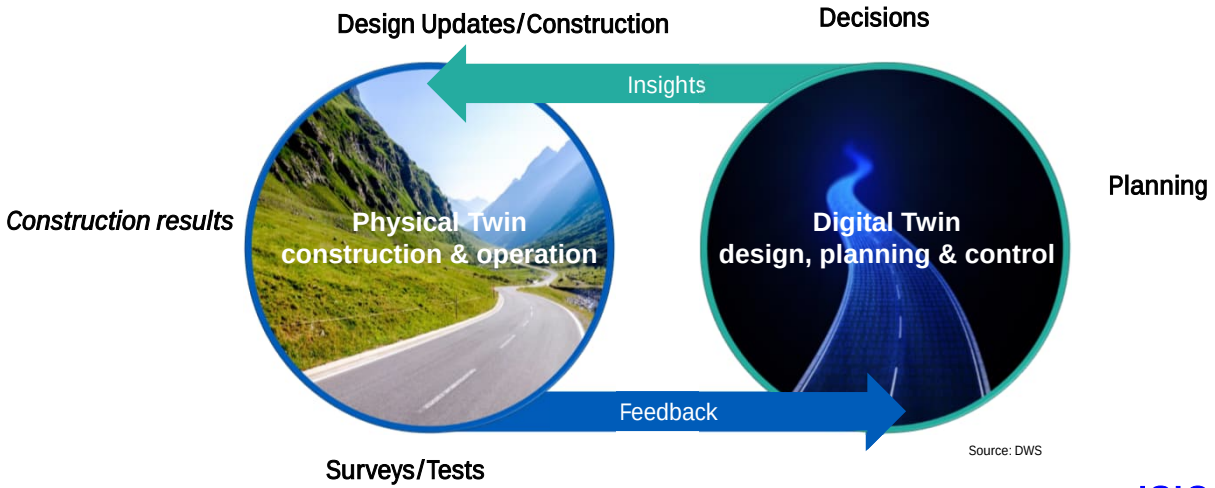
Digital Twin

A Close-Loop System



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Courtesy: CSW

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Intelligent Construction Technologies

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INTERNATIONAL SOCIETY FOR INTELLIGENT CONSTRUCTION

www.IS-IC.org

ISIC

Source: Embacher (2025)

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INTERNATIONAL SOCIETY FOR INTELLIGENT CONSTRUCTION

Subcommittee No. 8 Digital-As Build

Promote the development and implementation of Digital As-build from Intelligent Construction Technologies

Chuck Hixon
Stantec

Rebecca Embacher
MnDOT

Laikram Narsingh
Wirtgen America

Todd Mansell
Caterpillar

Jim Preston
TOPCON

Source: ISIC

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Broad Definition of Digital As-Built

- Any Construction Stages that Collect Digital As-Built (DAB) Data
- Construction Machines
- Construction Materials Quantities and Qualities
- Construction Processes
- Agency Inspections and QA

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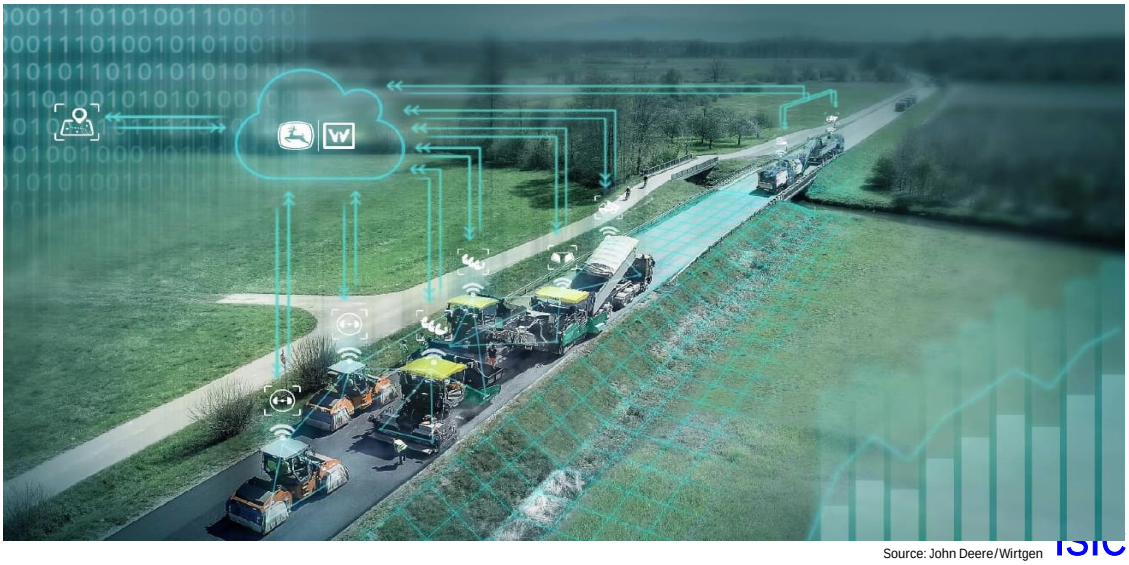
Example DAB Technologies



Source: John Deere/Wirtgen

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Machines Capture Digital As-built Data

Machines	Geometry	Quantity	Quality
Excavator (AMG)	√		
Motor Grader (AMG)	√		
Milling Machine (3D)	√	√	
Trucks (w e-Ticketing)		√	
Pavers (w PMTP)	√	√	√
Compactors (w IC)	√		√
2D GPR (DPS)			√
3D GPR	√		√

* All DABs include full-coverage geospatial information: positioning (N/E/E, L/L/E) and date-time stamps

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Manually Capture As-built Data

Measurements	Geometry	Quantity	Quality
Agency grade checks	√		
Agency material quantity Records		√	
Agency material QA data			√
....			

* All manual ABs needs to be digitized or logged digitally to combine with other DABs.

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Excavator - AMG

- Geometry
  - Excavated surface elevations
- Quantity
  - Excavated soils volume
- Quality
  - NA

Source: Caterpillar/Trimble

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Motor Grader - AMG

- Geometry
  - Finished 3D surfaces
- Quantity
  - Soils volume
- Quality
  - NA

Source: Caterpillar/Trimble

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Trucks – e-Ticketing

- Geometry
  - NA
- Quantity
  - Delivered Material weights
- Quality
  - NA

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3D Milling

- Geometry
  - Milled surface elevations
- Quantity
  - Milled Material Volumes
- Quality
  - NA

Source: John Deere/Wirtgen

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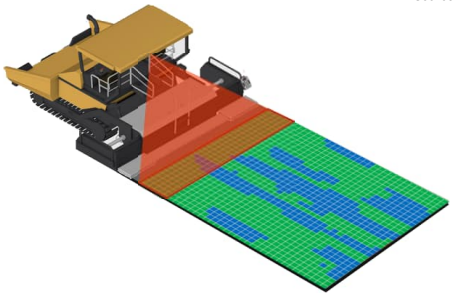
Paver with PMTP

- Geometry
  - Paved surface elevations and thicknesses
- Quantity
  - Uncompacted material volume
- Quality
  - Thermal segregation
  - Paver speeds
  - Paver stops

Source: John Deere/Wirtgen



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Compactor with IC

- Geometry
  - Compacted surface elevations
- Quantity
  - NA
- Quality
  - Roller passes/coverage
  - Compaction temperature (for asphalt)
  - Stiffness (including support condition)

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2D GPR - DPS

- Surface
  - RTK elevations
- Quantity
  - NA
- Quality
  - Dielectric constant profiles
  - Estimated asphalt densities


Source: GSSI


Source: ESS


Source: GSSI


Source: HAMM

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3D GPR

- Surface
  - Pavement Layer thicknesses
- Quantity
  - NA
- Quality
  - Dielectric constant profiles
  - Estimated asphalt densities


Source: Kontur

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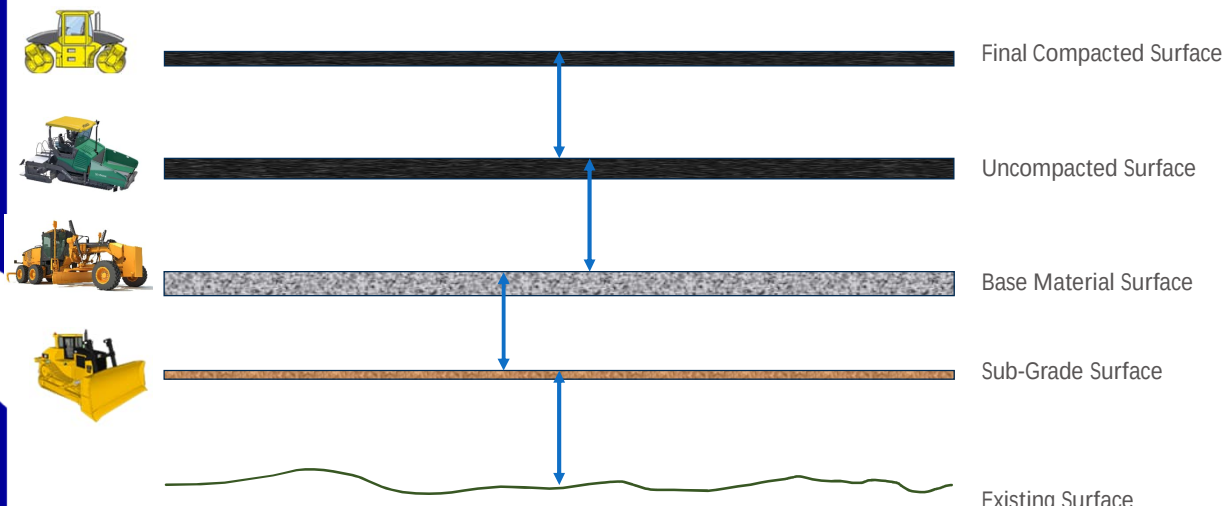
20

Machine DAB – New Construction

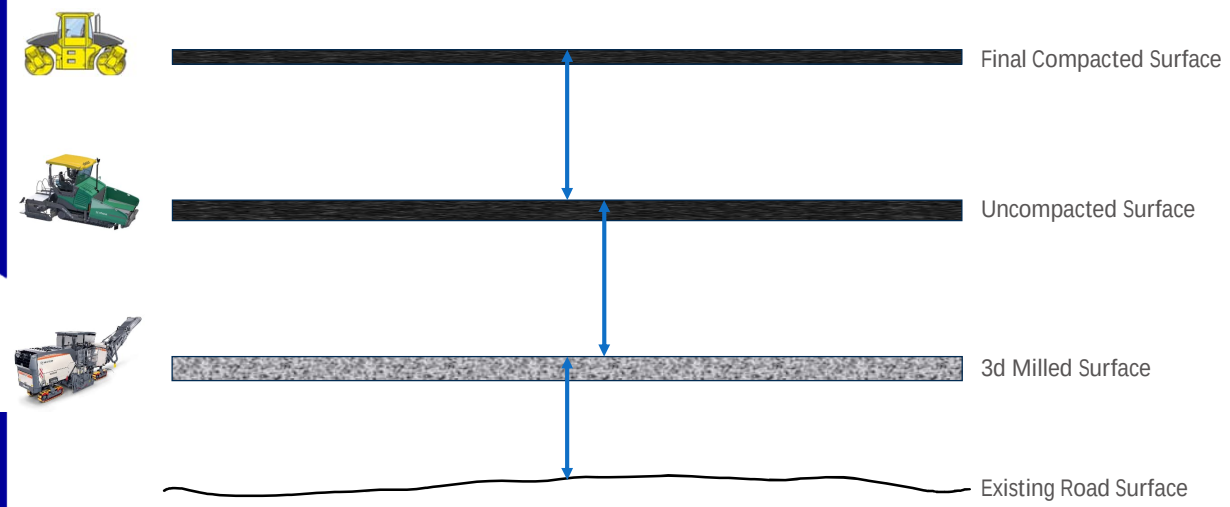


Source: Trimble

ISIC

21

Machine DAB – Rehabilitation



Source: Trimble

ISIC

22

FHWA EDC-2 to EDC-6

Stepping-Stones: Preexisting BIM Activities

EDC-6 — e-Ticketing + Digital As-Builts

EDC-4 — e-Construction: Electronic Data Capture and Automation

EDC-3 — Three-dimensional (3D) Model + Schedule (4D) + Cost (5D) + Postconstruction

EDC-2 — 3D Engineered Models for Construction
Intelligent Compaction (IC)

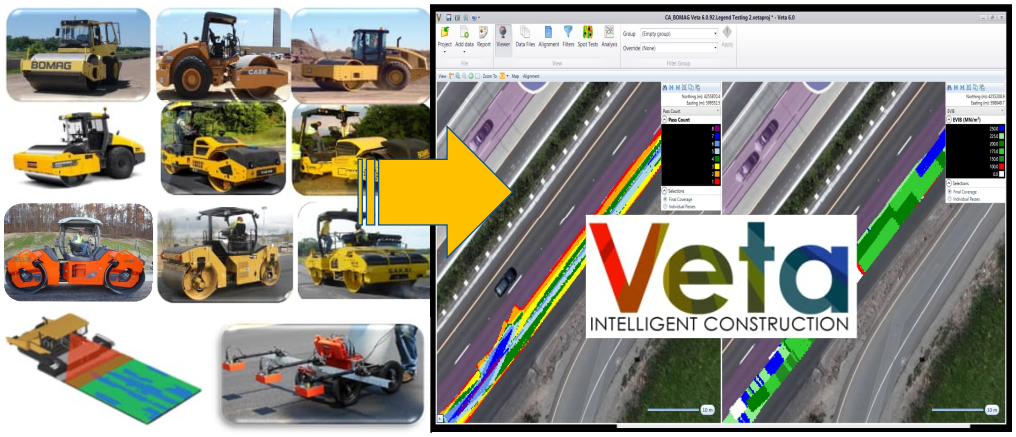
Every Day Counts
Innovation for a Nation on the Move

Source: FHWA

ISIC

23

Many Systems ONE SOFTWARE



Source: Transtec Group

ISIC

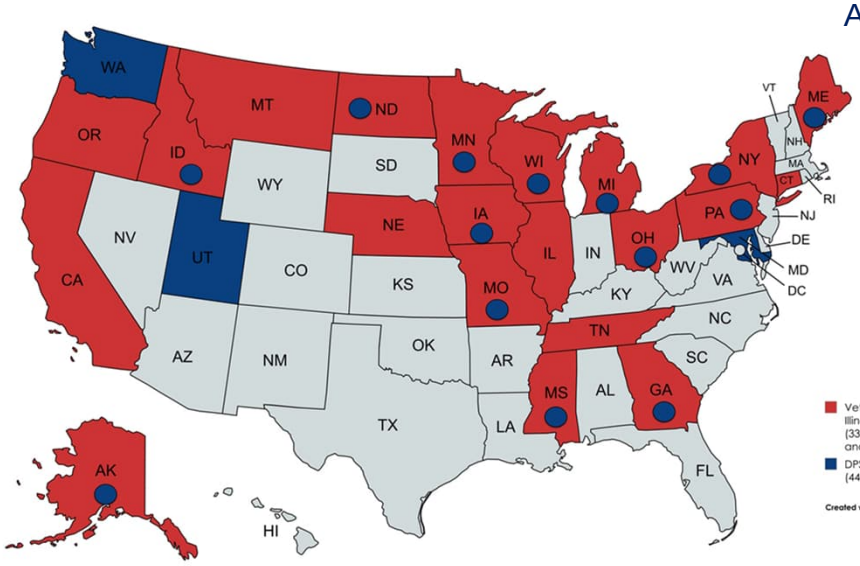
24

States Fund Veta Development

Veta INTELLIGENT CONSTRUCTION

AASHTO-Compliant

AASHTO



ISIC

Source: Embacher (MnDOT)

25

Connected Data Environment in construction

Source: ISIC

Leverages recent Rover investments and efficiencies

- Augmented reality
- Connecting construction measurements
- Quicker, more accurate payments

Source: Frontier

Source: Embacher (2025)

26

Converting Veta Software to a Web-Based Platform

Connected data environment

- Business owners receive real-time feedback for immediate adjustments:
  - Materials provided
  - Material installation
  - Equipment, staffing and staging
- Remove staff from hazardous locations
- Verification of quality of materials and work
- Help minimize potential for fraud
- Quicker payments

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2026 ISIC NA Conference – Louisville, KY

ISIC

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Rest of Today's Agenda

Room 13, 14, 15

Time	Topic	Speakers
08:00 AM – 08:30 AM	ISIC Track 01 - Introduction and Overview	Dr. George K. Chang (Transtec-Terracon)
08:30 PM – 09:30 AM	ISIC Track 02 - DAB from the Material Delivery Management System (MDMS)	Rebecca Embacher (MnDOT)
09:30 AM – 10:15 AM	ISIC Track 03 - DAB from 2D/3D Milling	Tom Chastain (Wirtgen Group)
10:15 AM – 10:30 AM	Break	
10:30 AM – 11:15 AM	ISIC Track 04 – DAB from 2D/3D Paving and Thermal Profiling	Jim Preston (TOPCON) and Craig Lamarque (Wirtgen Group)
11:15 PM – 12:00 PM	ISIC Track 05 – DAB from Intelligent Compaction	Todd Mansell (Caterpillar)
01:00 PM – 01:45 PM	ISIC Track 06 – DAB for Living Models in Asset and Pavement Management Systems	Jim Preston (TOPCON)
01:45 PM – 02:45 PM	ISIC Track 07 - DAB for Improving Construction QC and QA	Amanda L. Gilliland (Transtec-Terracon) and Scott Fernald (Granite Construction)
02:45 PM – 03:00 PM	Break	
03:00 PM – 4:00 PM	ISIC Track 08 - Complete Paving DAB Workflow Examples	Rebecca Embacher (MnDOT) and Scott Fernald (Granite Construction)
4:00 PM – 5:00 PM	ISIC Track 09 – Open Panel Discussion	Moderator: Curt Turgeon (MnDOT) Panels: DOTs (MnDOT, NDDOT), vendors (Caterpillar, Trimble, Wirtgen, TOPCON), contractors (Granite, KnifeRiver), associations (MAPA), consultants (Transtec-Terracon)
5:00 PM	Adjourned	

ISIC

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30

THANK YOU!

ISIC

INTERNATIONAL SOCIETY FOR INTELLIGENT CONSTRUCTION

ISIC

31

Digital As-Built (DAB) from the Material Delivery Management System (MDMS)

Rebecca Embacher | Advanced Materials and Technology Engineer
ISIC Track – Digital As-Built and Workflow of Pavement Construction
Minnesota Transportation Conference & Expo
Wednesday, March 18, 2026

DEPARTMENT OF TRANSPORTATION

mndot.gov/

1

DEPARTMENT OF TRANSPORTATION

What is the MDMS?

SP(2061) Material Delivery Management System (MDMS)

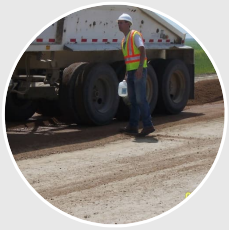
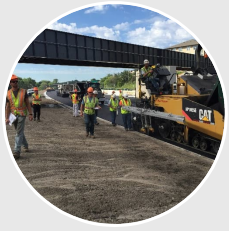
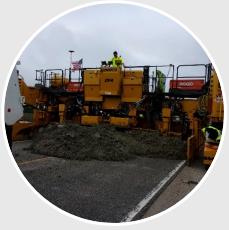
2

Definition

System that manages data associated with delivery of material to a contract.

3

Current materials included in Special Provision (2061) Material Delivery Management System

Aggregate	Asphalt Paving	Concrete Paving	Ready-Mixed Concrete
			
2118 (Aggregate Surfacing) - On Hold (Tabled) – *(1901.6.D Computerized Loader Bucket Scales (10,000 tons or less))*	2360 (Plant Mixed Asphalt Pavement) 2363 (PASSRC and PASB) 2365 (Stone Matrix Asphalt)	2301 (Concrete Pavement)	2461 (Structural Concrete)

4

Data captured by Contractor

Source
(E-Ticket)
(Contractor's MDMS)
Table SP2061-1

Hauler
(Contractor's MDMS)
Table SP2061-11
(Not required for 2461)

Loading and Delivery Event
(Contractor's MDMS)
Table SP2061-12
(Only Start/End Dump Time and Duration in Truck required for 2461)

5

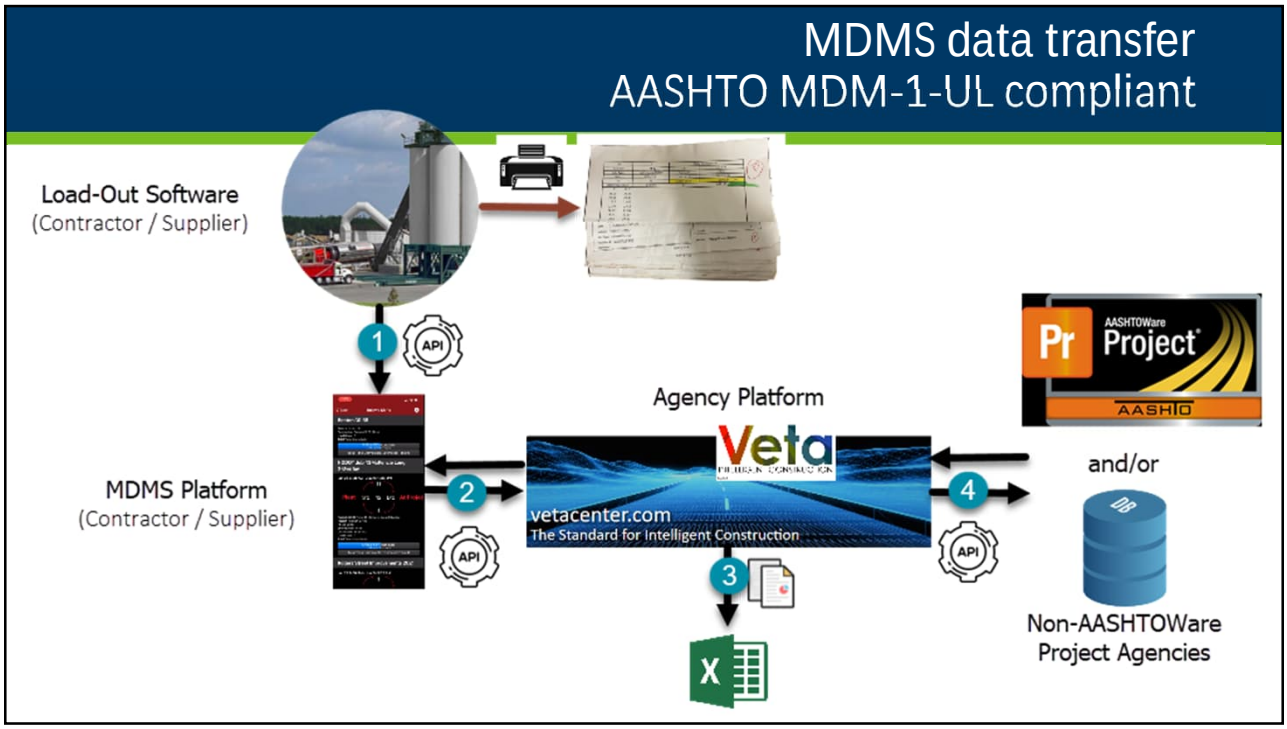
MDMS data captured by Department's platform – VetaCenter

Testing and Contract Administration
Table X3.1

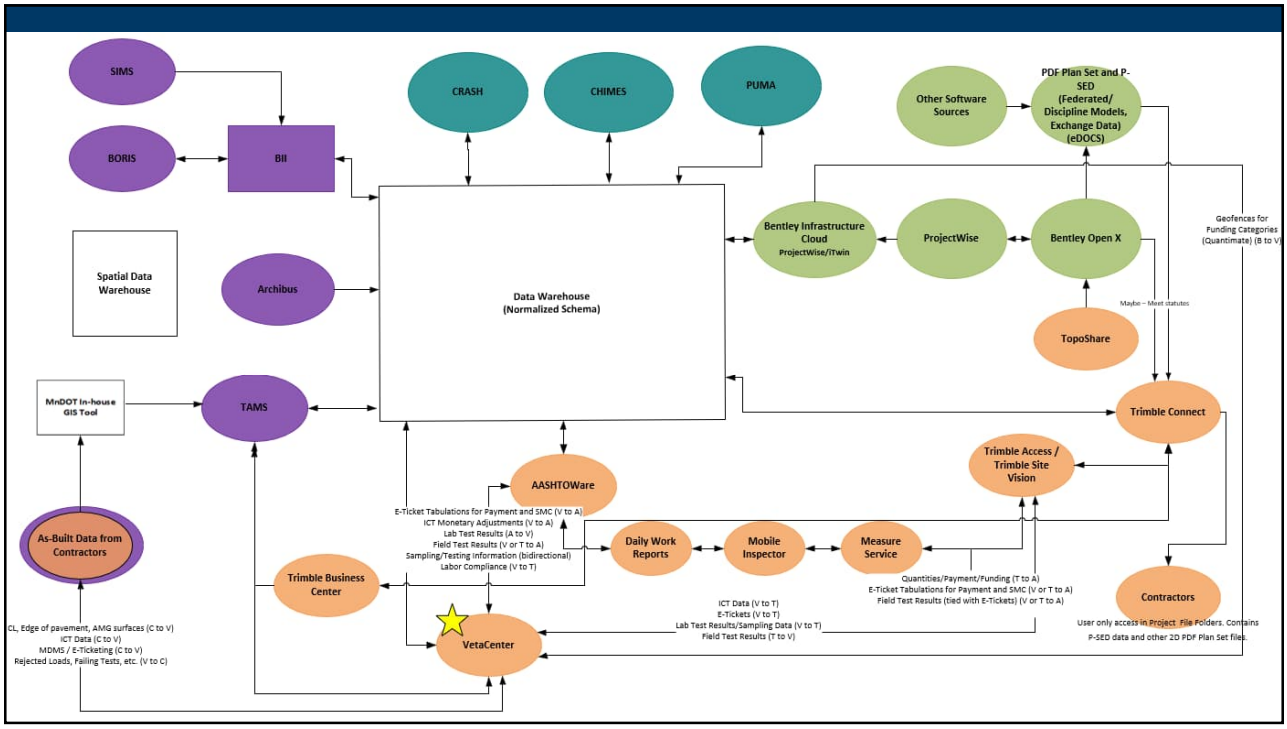
Agency Verification
Table X3.13

Environmental Product Declarations (EPD)
Future Table (TBD)
Subset of EPD data
Declaration Id, Product Category Rules (PCR), Version Id, EPD URL,
EPA designation, Global Warming Potential (A1 – A3, Total)

6


MDMS data transfer
AASHTO MDM-1-UL compliant
Load-Out Software
(Contractor / Supplier)
1
API
Agency Platform
Veta
vetacenter.com
The Standard for Intelligent Construction
AASHTOWare Project
AASHTO
MDMS Platform
(Contractor / Supplier)
2
API
4
API
and/or
3
X
Non-AASHTOWare
Project Agencies

7


SIMS
BORIS
BII
CRASH
CHIMES
PUMA
Other Software Sources
PDF Plan Set and P-SED (Federated/ Discipline Models, Exchange Data) (eDOCS)
Spatial Data Warehouse
Archibus
Data Warehouse (Normalized Schema)
Bentley Infrastructure Cloud
ProjectWise/iTwin
ProjectWise
Bentley Open X
Geofencas for Funding Categories (Quantimate) (B to V)
TopoShare
MnDOT In-house GIS Tool
TAMS
Trimble Connect
Trimble Access / Trimble Site Vision
AASHTOWare
E-Ticket Tabulations for Payment and SMC (V to A)
ICT Monetary Adjustments (V to A)
Lab Test Results (A to V)
Field Test Results (V or T to A)
Sampling/Testing information (bidirectional)
Labor Compliance (V to T)
Daily Work Reports
Mobile Inspector
Measure Service
As-Built Data from Contractors
Trimble Business Center
Quantities/Payment/Funding (T to A)
E-Ticket Tabulations for Payment and SMC (V or T to A)
Field Test Results (tied with E-Tickets) (V or T to A)
Contractors
ICT Data (V to T)
E-Tickets (V to T)
Lab Test Results/Sampling Data (V to T)
Field Test Results (T to V)
VetaCenter
CL, Edge of pavement, AMG surfaces (C to V)
ICT Data (C to V)
MDMS / E-Ticketing (C to V)
Rejected Loads, Failing Tests, etc. (V to C)
User only access in Project. File Folders. Contains P-SED data and other 2D PDF Plan Set files.

8

Connected Data Environment in construction

- Augmented reality
- Connecting construction measurements
- Quicker, more accurate payments
- Increased quality

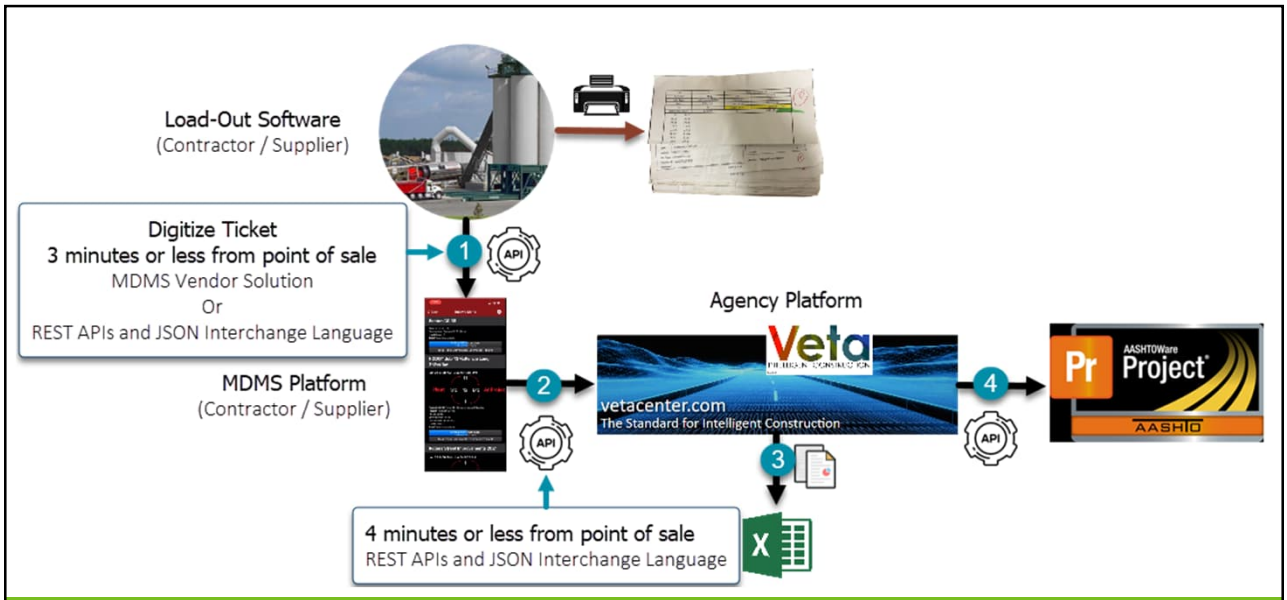
9

DEPARTMENT OF TRANSPORTATION

Documentation of Type and Quantity of Material

E-Ticket (Source Data)

10

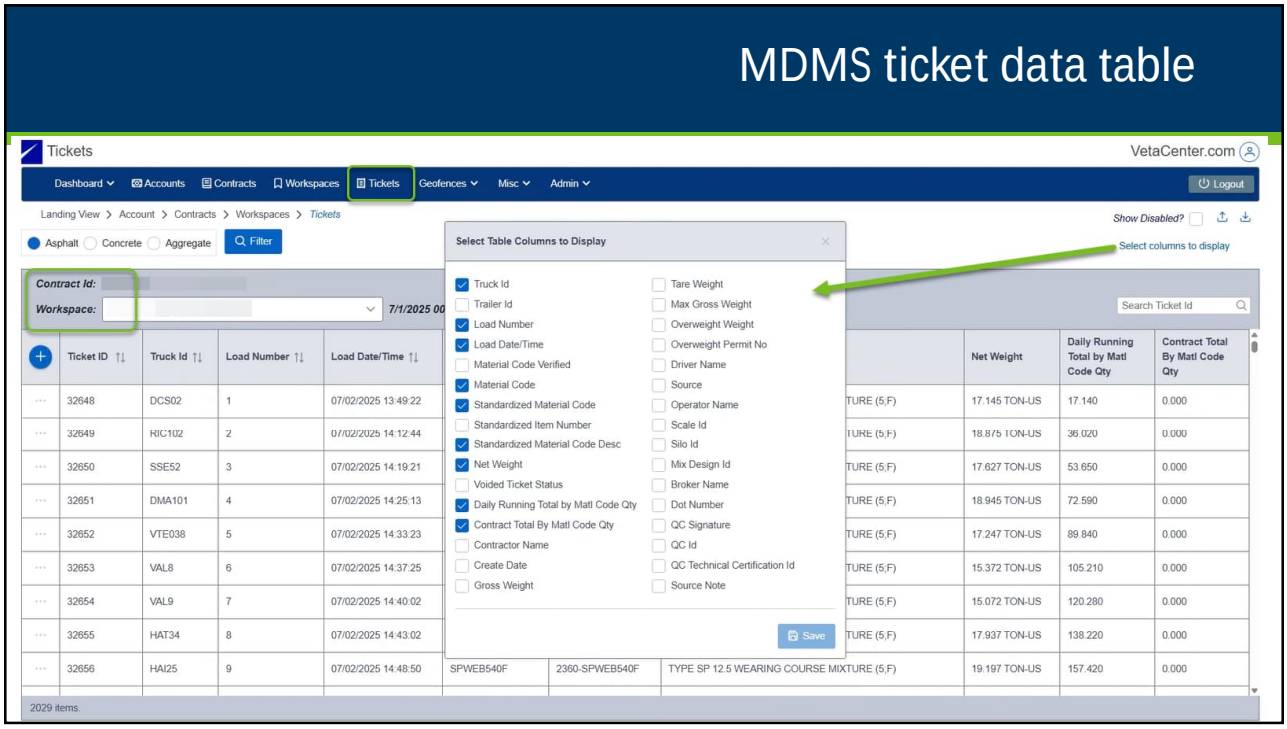


Digitize source data

S-xx.3A(8) Set up source (E-Ticket) data transmittal

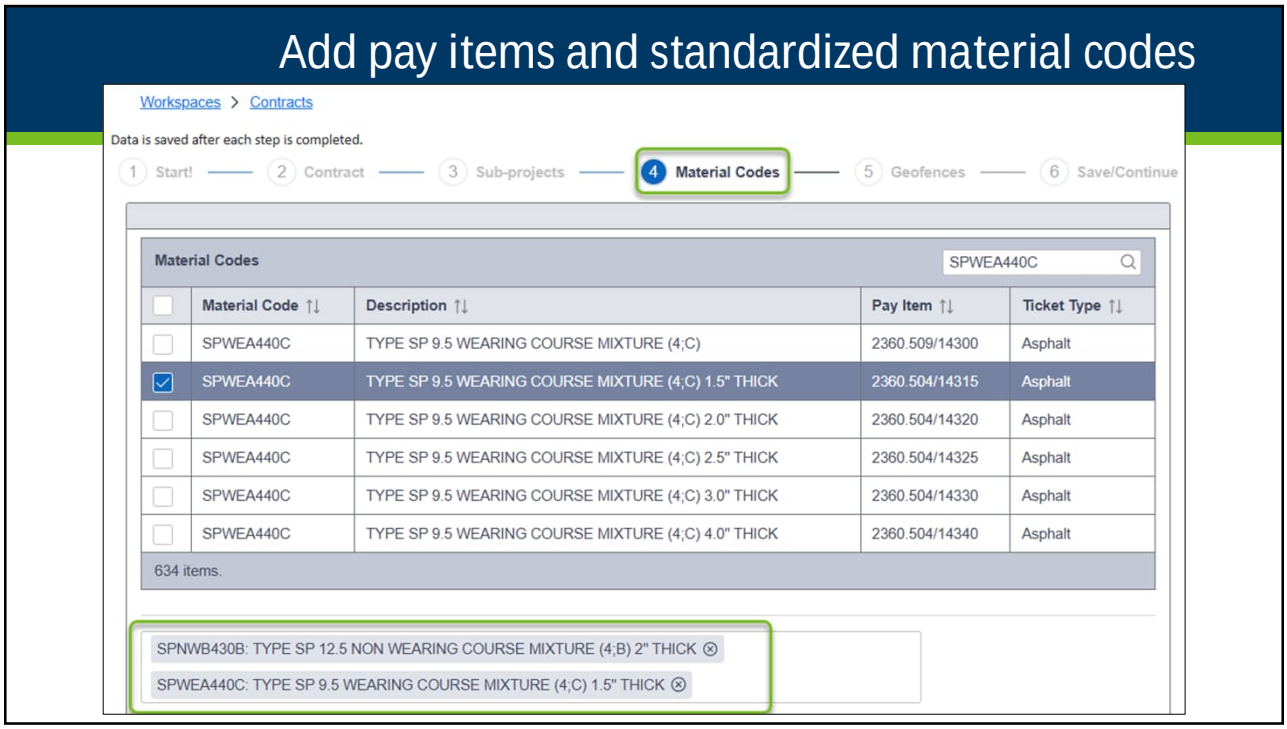
11

MDMS ticket data table



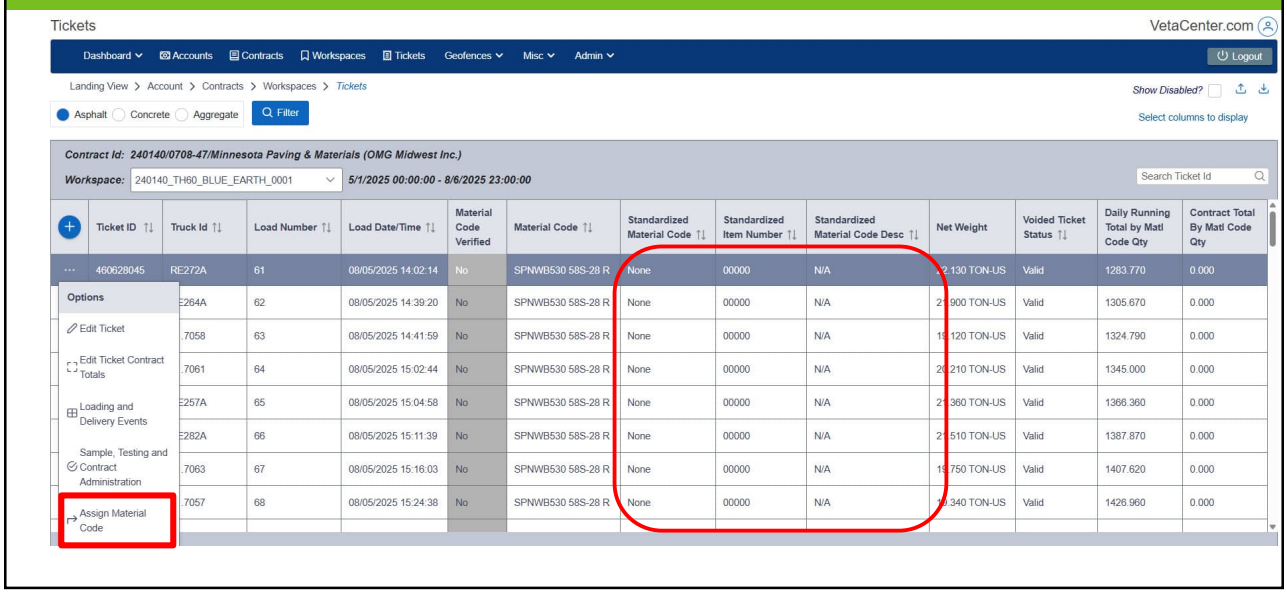
12

Add pay items and standardized material codes



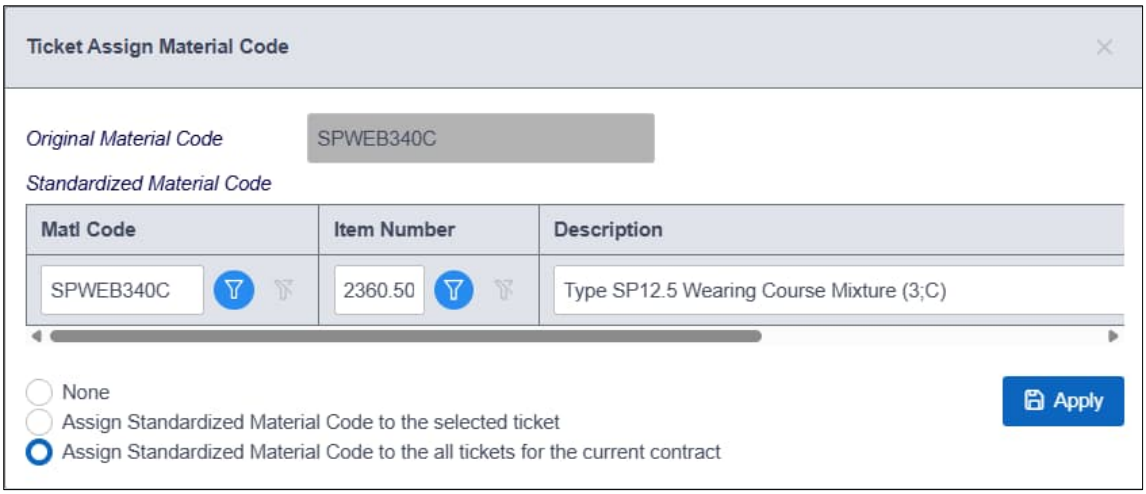
13

Assign “standardized” Material Code to E-Ticket(s)



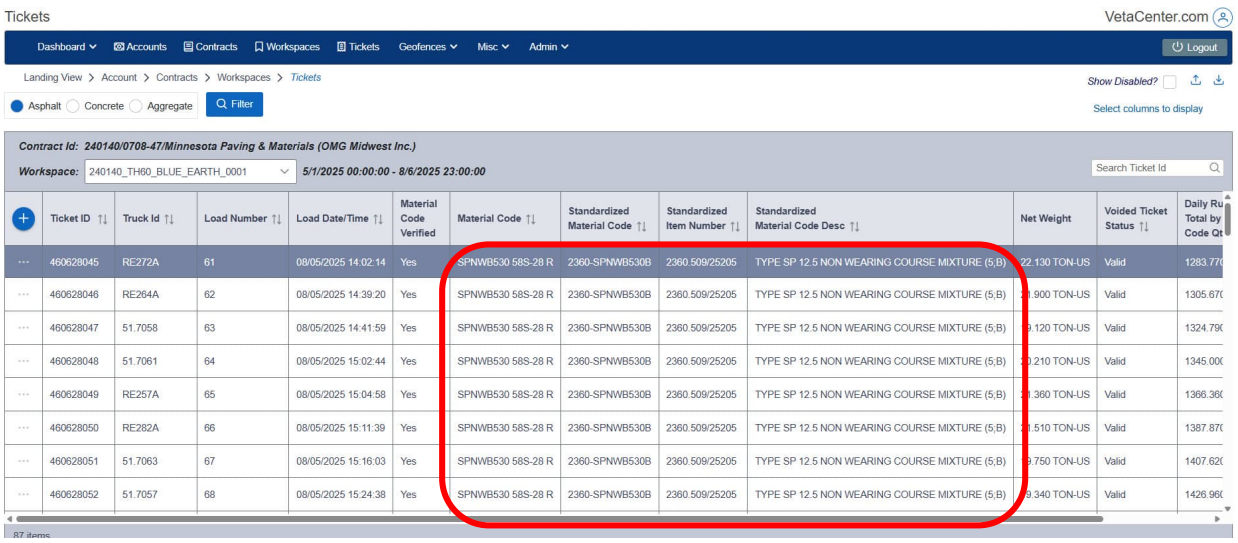
14

Assignment of standardized material code and pay item "globally" or per ticket



15

Example of global assignment of material codes and pay items



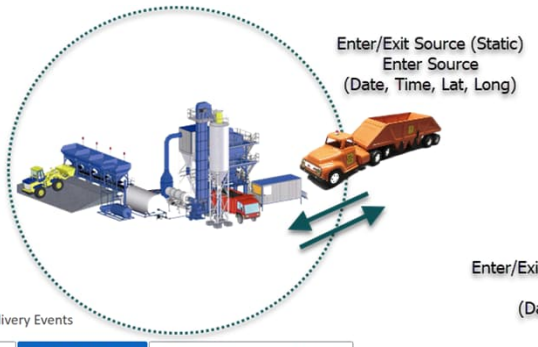
16

DEPARTMENT OF TRANSPORTATION

Location of Material Placement

Loading and Delivery Event Data

17



Ingredients | Load/Delivery Events | Sampling, Testing And Contract Admin

Workspaces > Tickets > *this ticket*

Show Disabled?

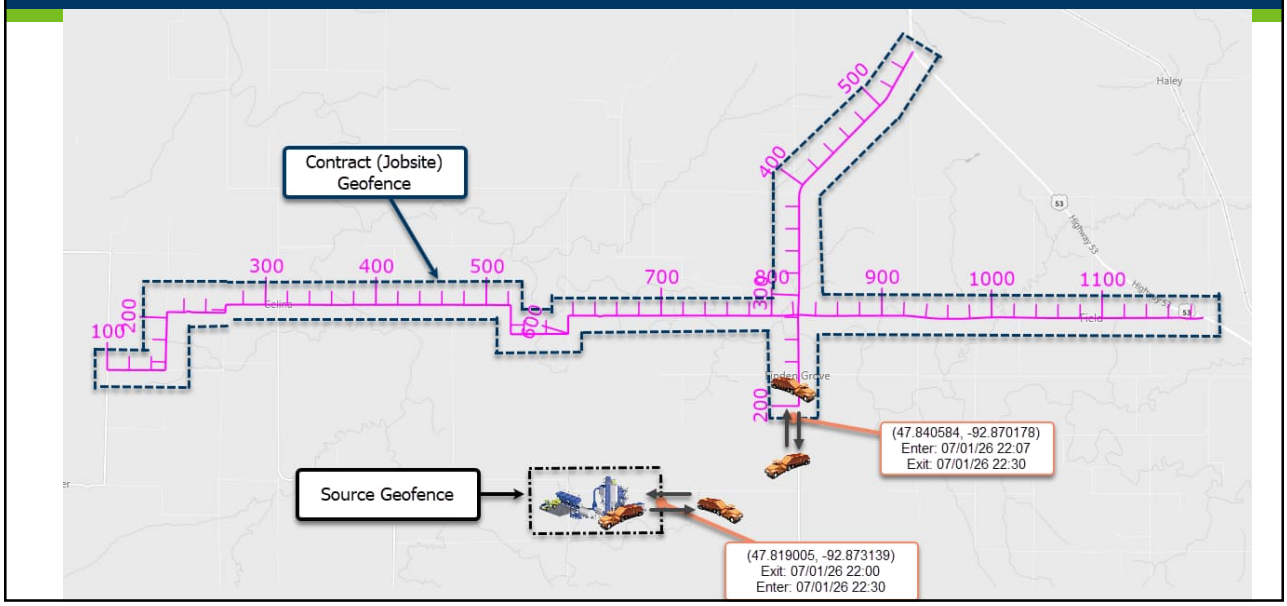
Ticket: 55181 - Asphalt

Geofence Id	Start Date/Time	End Date/Time	Duration (hh:mm:ss)	Geofence Type	Machine Id	Start Latitude	Start Longitude	End Latitude	End Longitude	Dump Latitude	Dump Longitude	Dump Date/Time
BP028_StLouis	6/28/2023 08:43:06	6/28/2023 8:50:06	00:05:00	Source		47.819005	-92.873139	47.819005	-92.873139			
SP6931-01_TH73	6/28/2023 08:54:06	6/28/2023 8:56:06	00:02:00	Contract		47.840584	-92.870178	47.863023	-92.870154			
SP6901-29_TH1	6/28/2023 08:56:06	6/28/2023 9:05:06	00:09:00	Dump	Mainline	47.865479	-93.081257	47.863023	-92.870154	47.858555	-92.962875	6/28/2023 9:00:06
SP6931-01_TH73	6/28/2023 09:05:06	6/28/2023 09:07:06	00:02:00	Contract		47.863023	-92.870154	47.840584	-92.870178			

Loading and delivery event table

18

Static geofences trigger recording of date, time, and location of trucks entering/exiting source and jobsite

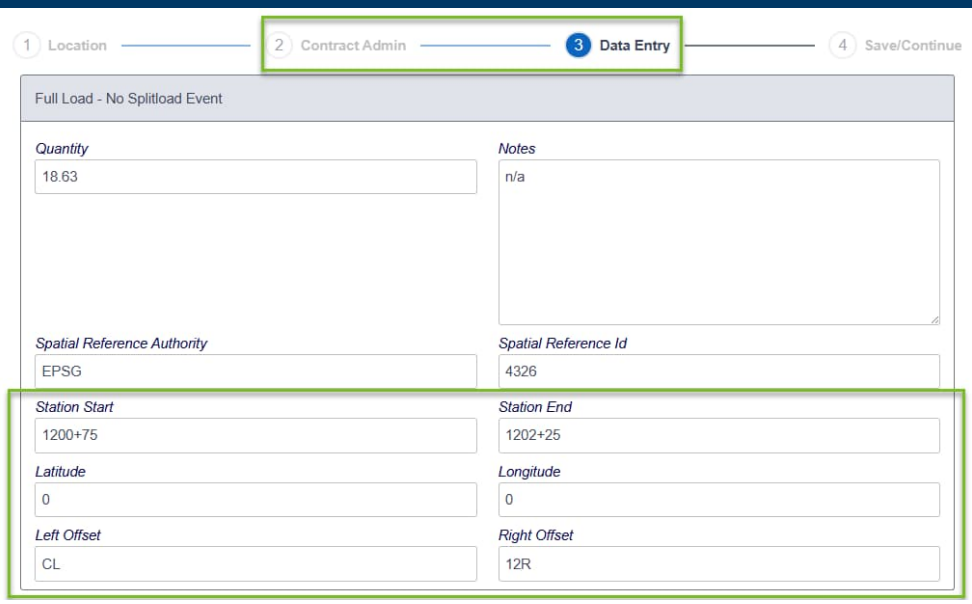


19

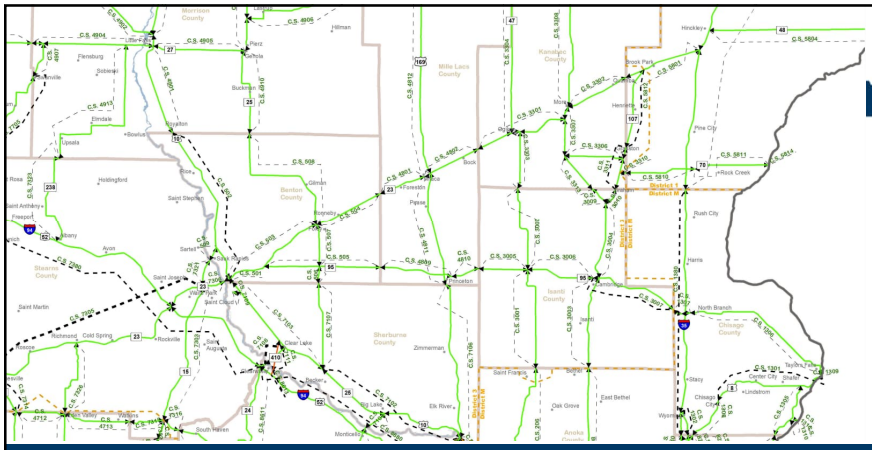
Mobile geofence triggers recording of date, time stamp and location of material delivery

20

Manual recording of dump location



21

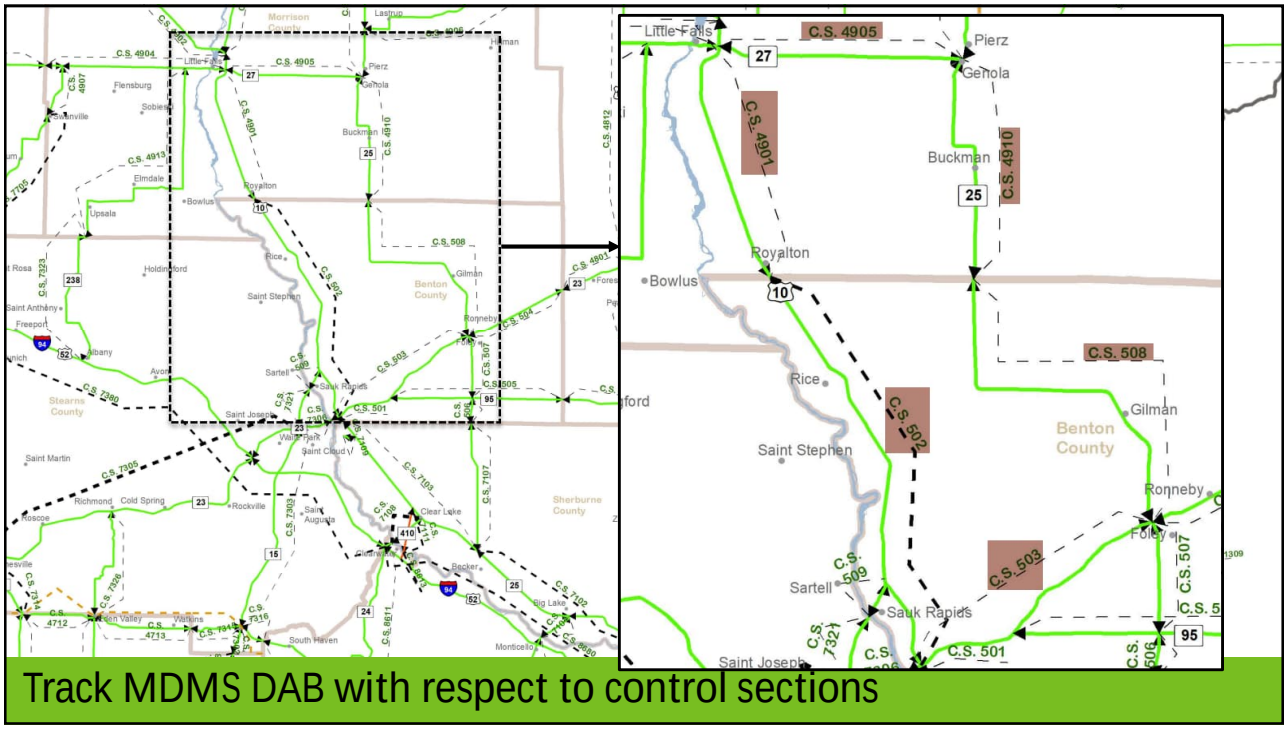


DEPARTMENT OF TRANSPORTATION

Assignment of Material, Quantities, and Costs to Roadway Control Sections

Use in Pavement Management (Life Cycle Cost Analyses, Roadway History, etc.)

22



Track MDMS DAB with respect to control sections

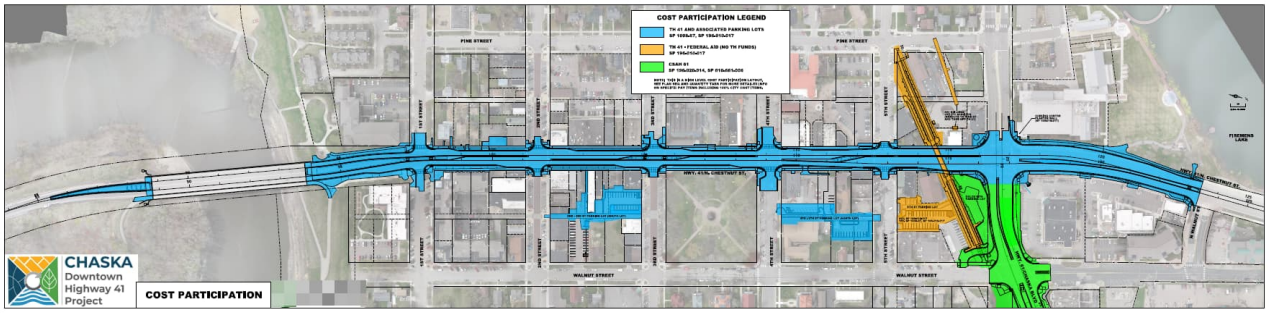
23

Add project-funding category geofences to Contract

1 Start! — 2 Contract — 3 Sub-projects — 4 Material Codes — 5 Geofences — 6 Save/Continue

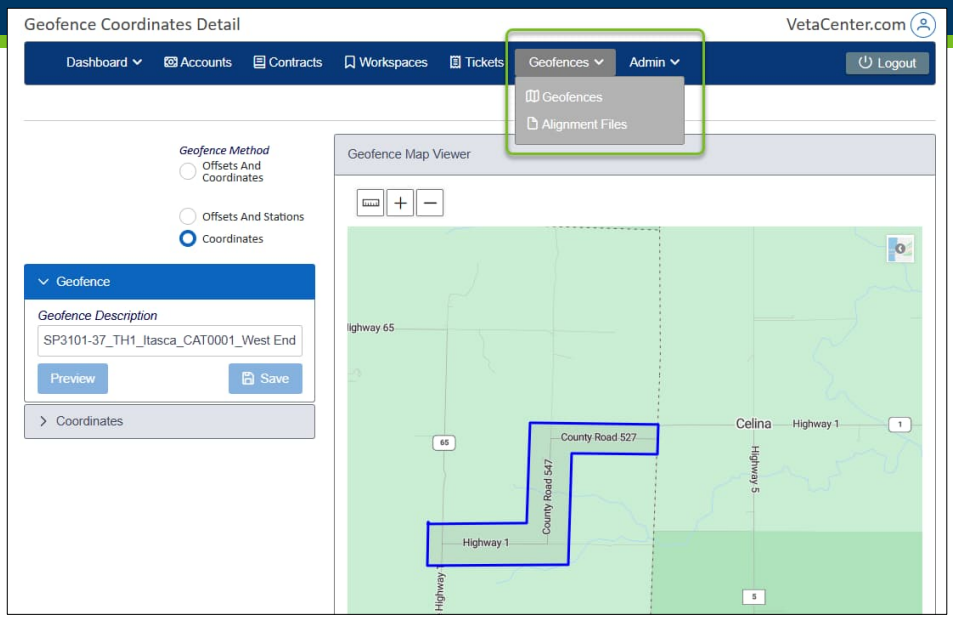
Geofences

	Geofence Description	Geofence Type	Spatial Ref Authority	Spatial Ref Id



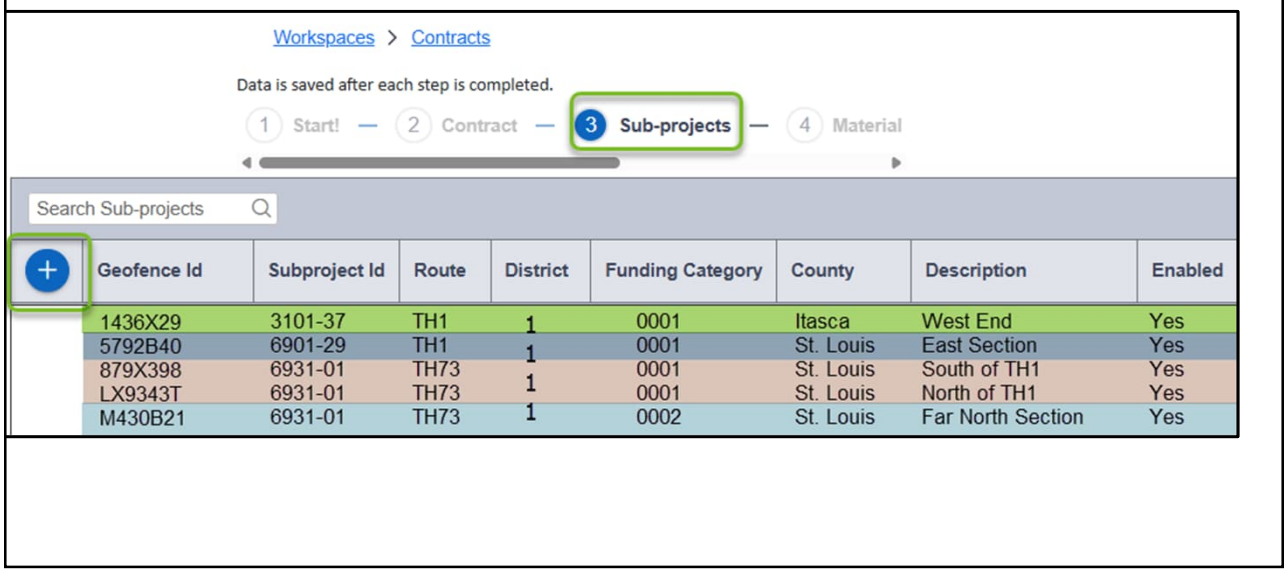
24

Creation of project-funding category static geofences



25

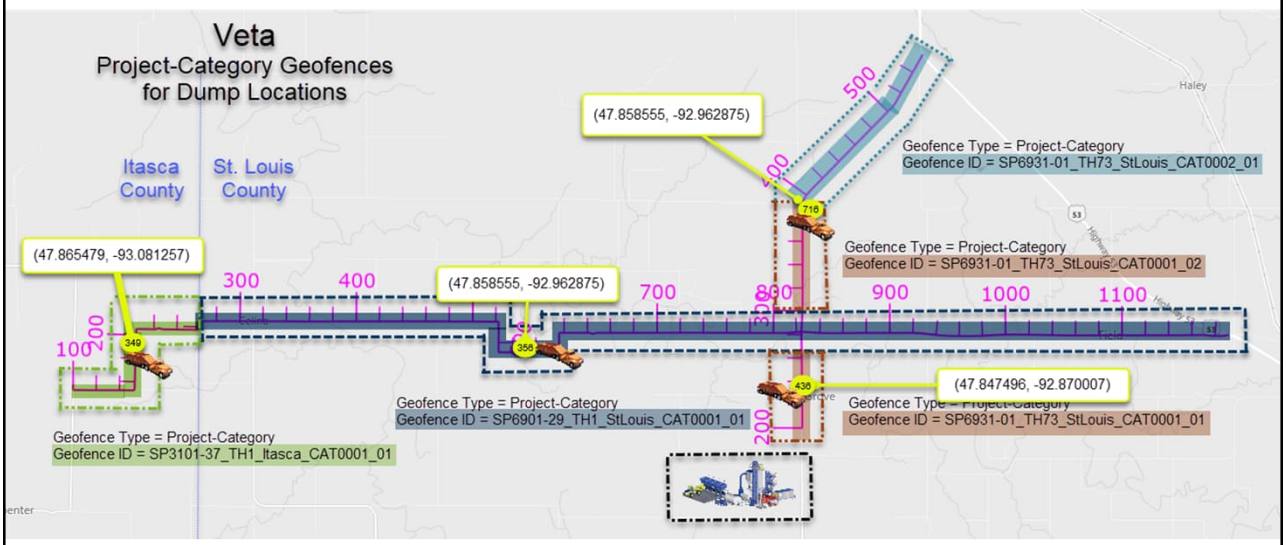
Add metadata associated with control sections and funding categories



Geofence Id	Subproject Id	Route	District	Funding Category	County	Description	Enabled
1436X29	3101-37	TH1	1	0001	Itasca	West End	Yes
5792B40	6901-29	TH1	1	0001	St. Louis	East Section	Yes
879X398	6931-01	TH73	1	0001	St. Louis	South of TH1	Yes
LX9343T	6931-01	TH73	1	0001	St. Louis	North of TH1	Yes
M430B21	6931-01	TH73	1	0002	St. Louis	Far North Section	Yes

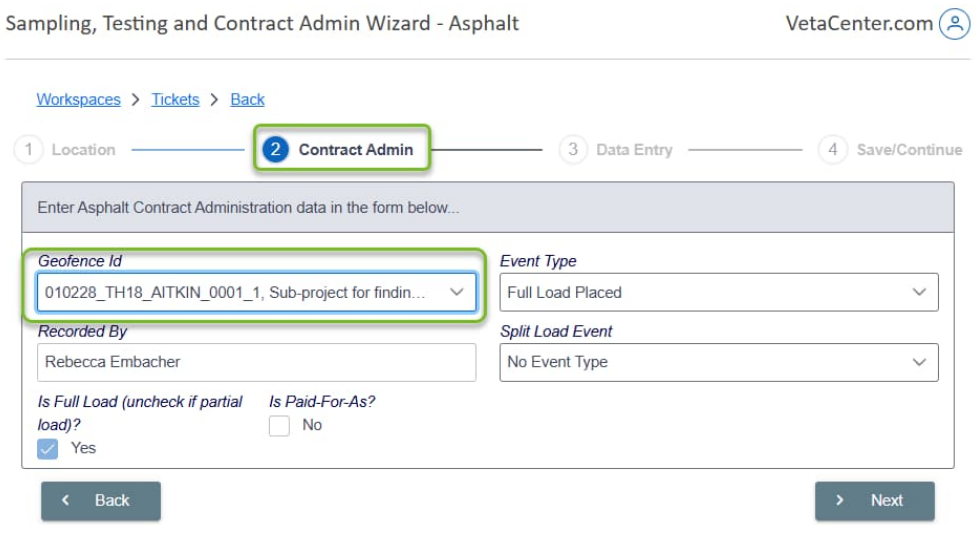
26

Auto-recording of control sections and funding categories using static geofences and dump locations



27

Manual recording of control section and funding category



28

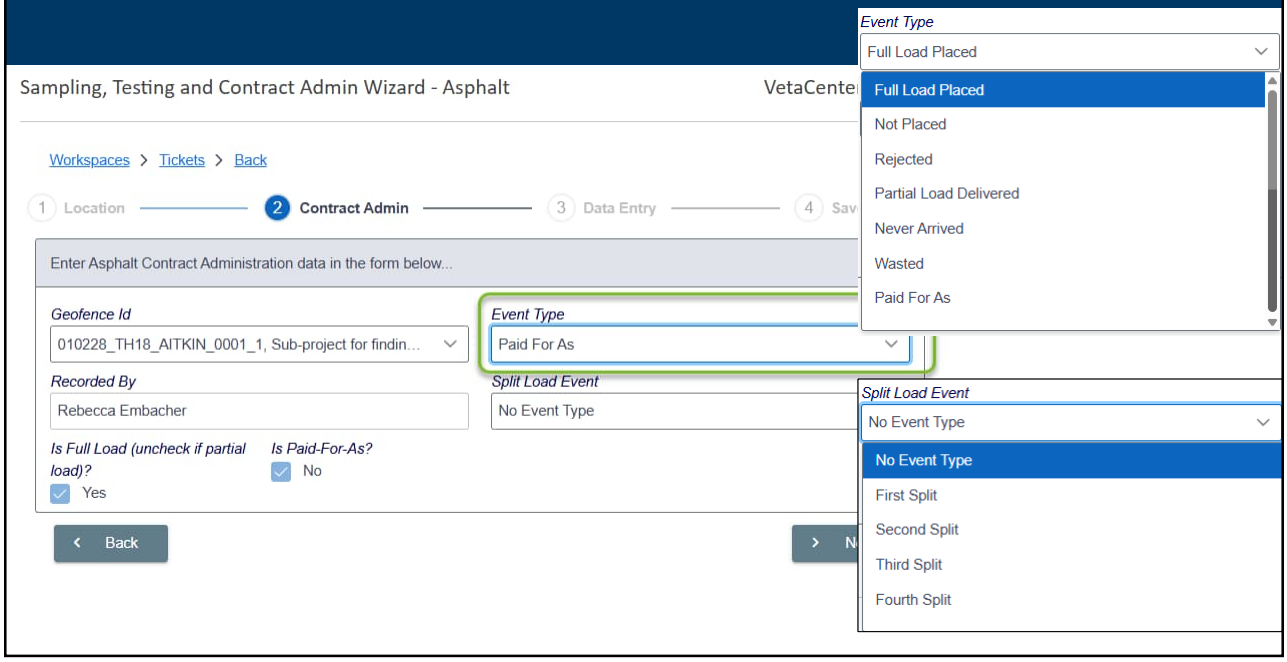
DEPARTMENT OF TRANSPORTATION

Things Happen . . . Field Adjustments

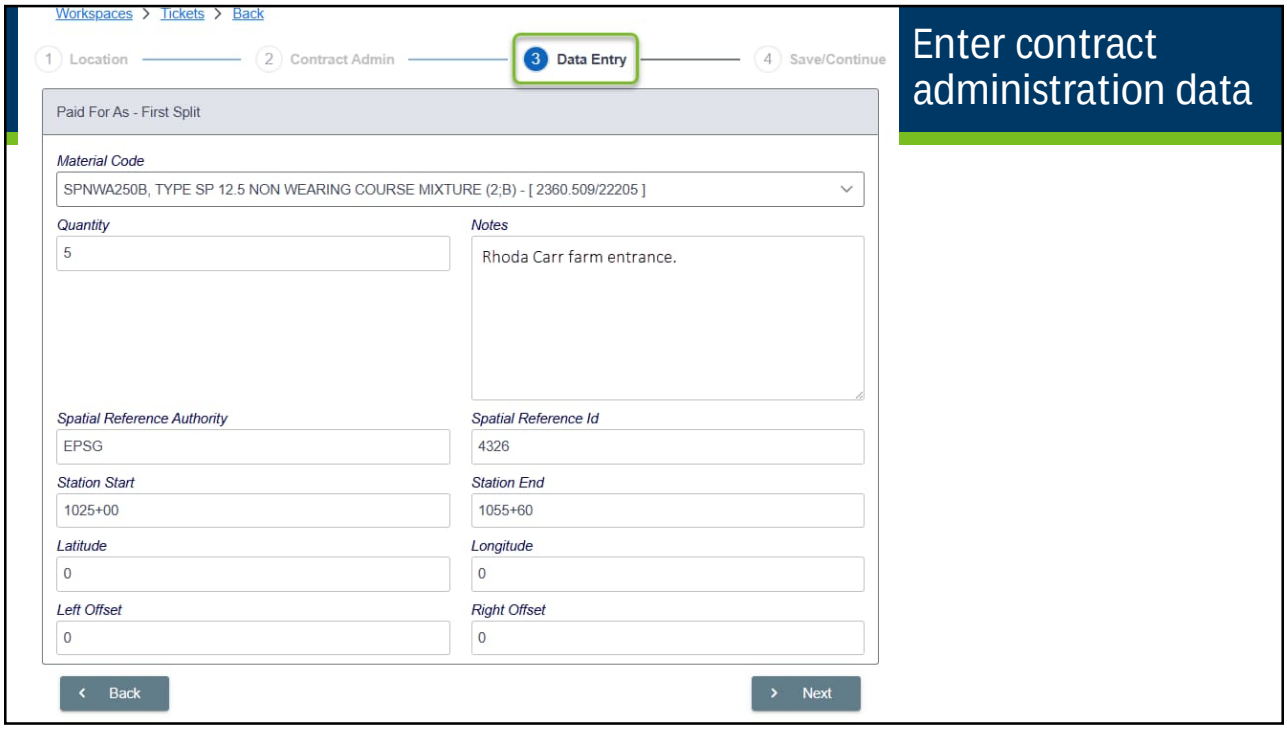
Documentation of Adjustments to Update Digital As-Built

29

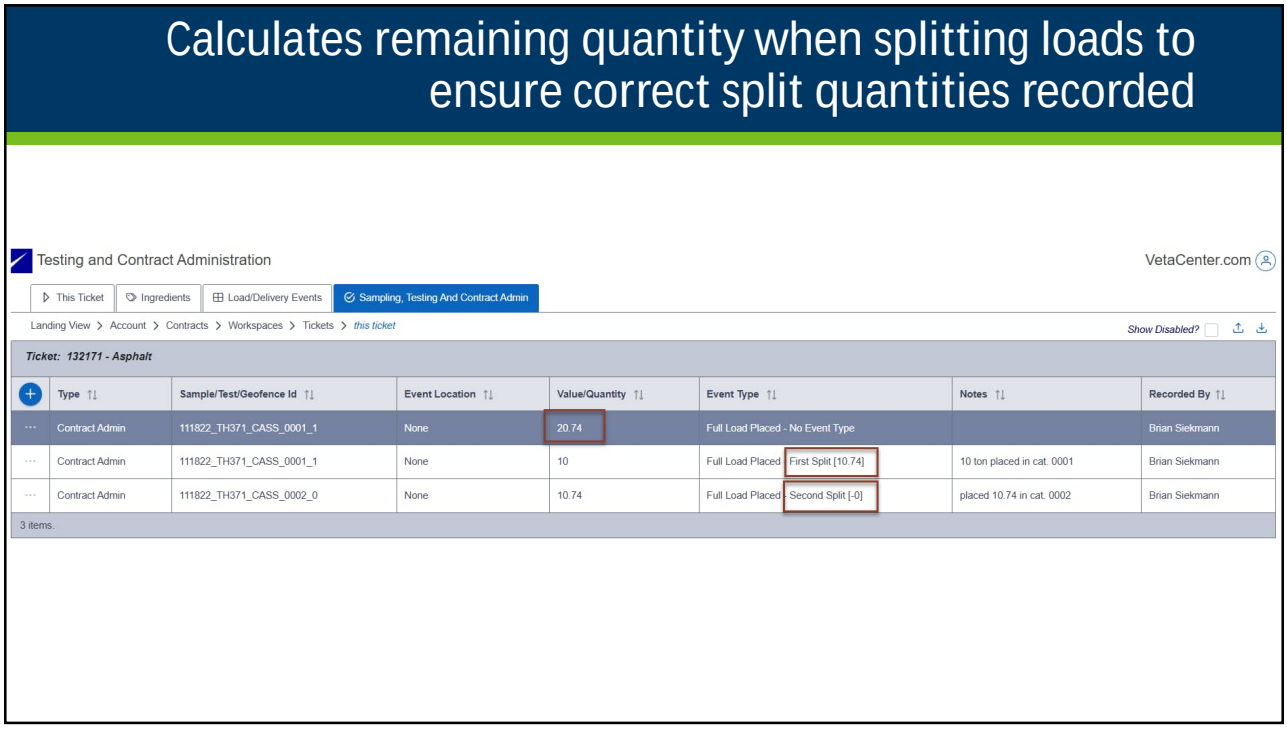
Contract administration activities



30

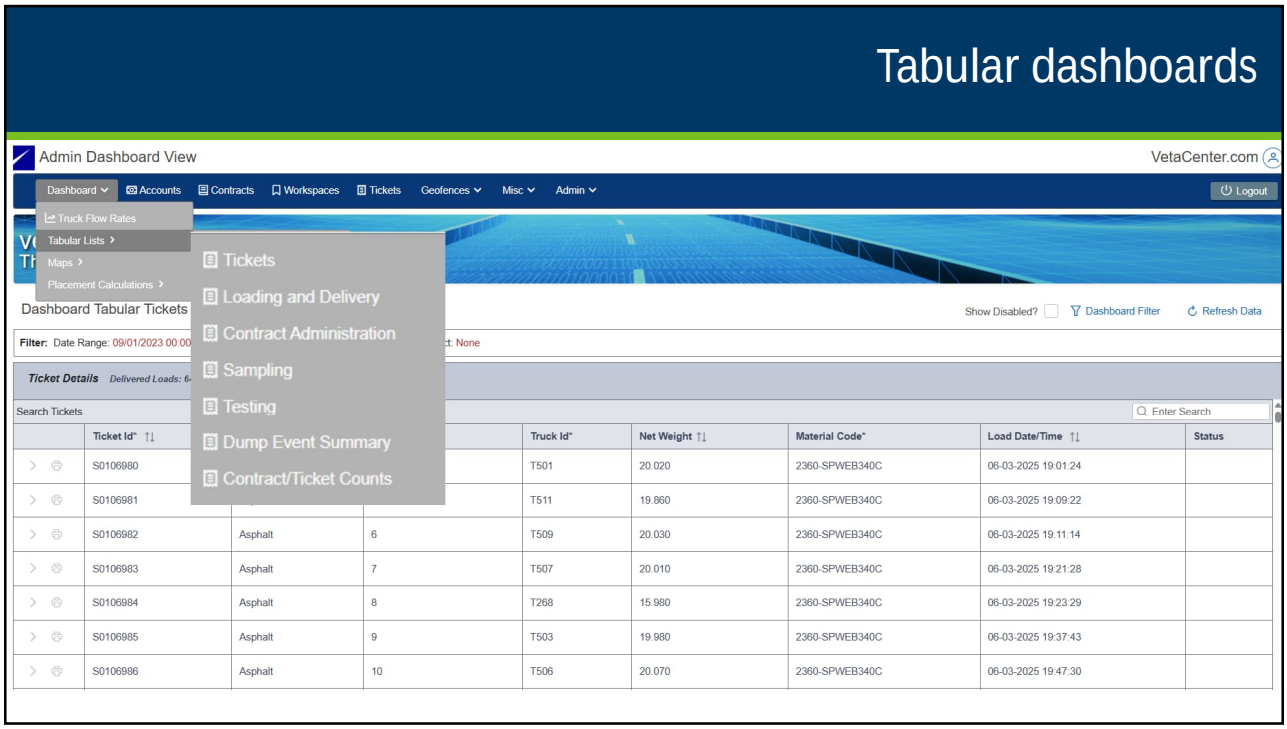

Workspaces > Tickets > Back
1 Location
2 Contract Admin
3 Data Entry
4 Save/Continue
Enter contract administration data
Paid For As - First Split
Material Code
SPNWA250B, TYPE SP 12.5 NON WEARING COURSE MIXTURE (2;B) - [2360.509/22205]
Quantity
5
Notes
Rhoda Carr farm entrance.
Spatial Reference Authority
EPSG
Spatial Reference Id
4326
Station Start
1025+00
Station End
1055+60
Latitude
0
Longitude
0
Left Offset
0
Right Offset
0
Back
Next

31


Calculates remaining quantity when splitting loads to ensure correct split quantities recorded
Testing and Contract Administration
VetaCenter.com
This Ticket
Ingredients
Load/Delivery Events
Sampling, Testing And Contract Admin
Landing View > Account > Contracts > Workspaces > Tickets > this ticket
Show Disabled?
Ticket: 132171 - Asphalt
Type
Sample/Test/Geofence Id
Event Location
Value/Quantity
Event Type
Notes
Recorded By
Contract Admin
111822_TH371_CASS_0001_1
None
20.74
Full Load Placed - No Event Type
Brian Siekmann
Contract Admin
111822_TH371_CASS_0001_1
None
10
Full Load Placed
First Split [10.74]
10 ton placed in cat. 0001
Brian Siekmann
Contract Admin
111822_TH371_CASS_0002_0
None
10.74
Full Load Placed
Second Split [-0]
placed 10.74 in cat. 0002
Brian Siekmann
3 items.

32

Tabular dashboards

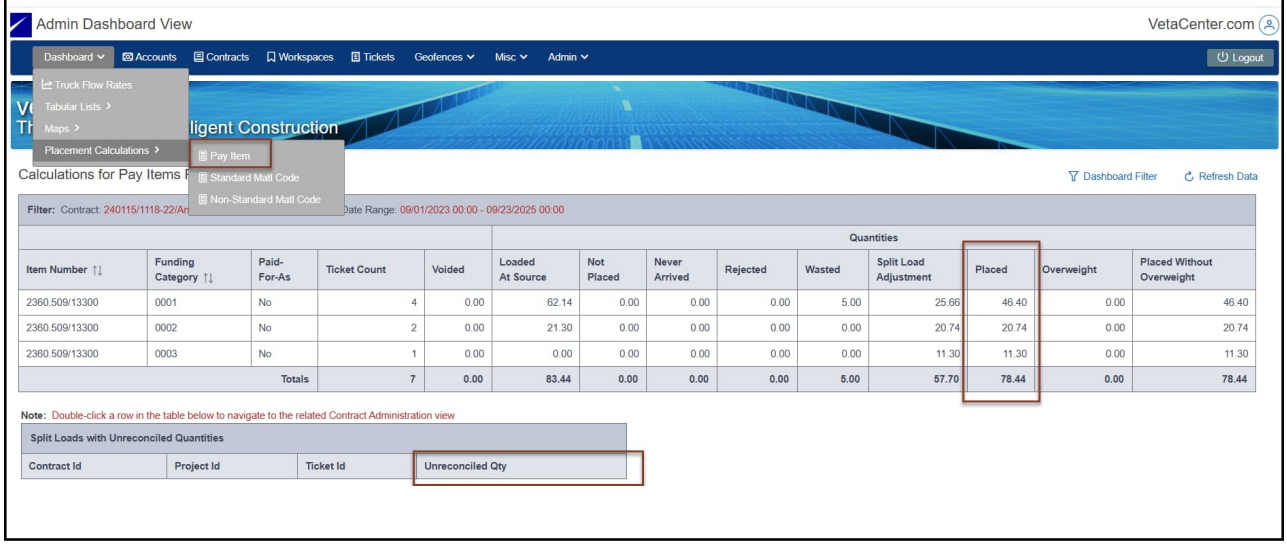


33

Contract administration dashboard

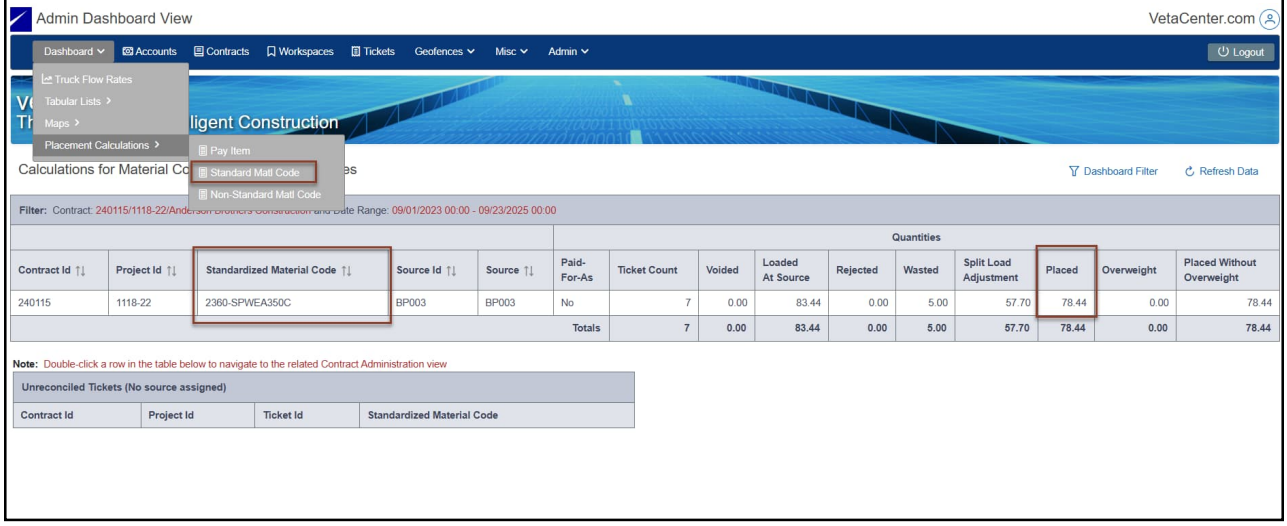
34

Tabulations of pay quantities



35

Tabulations for testing rates



36

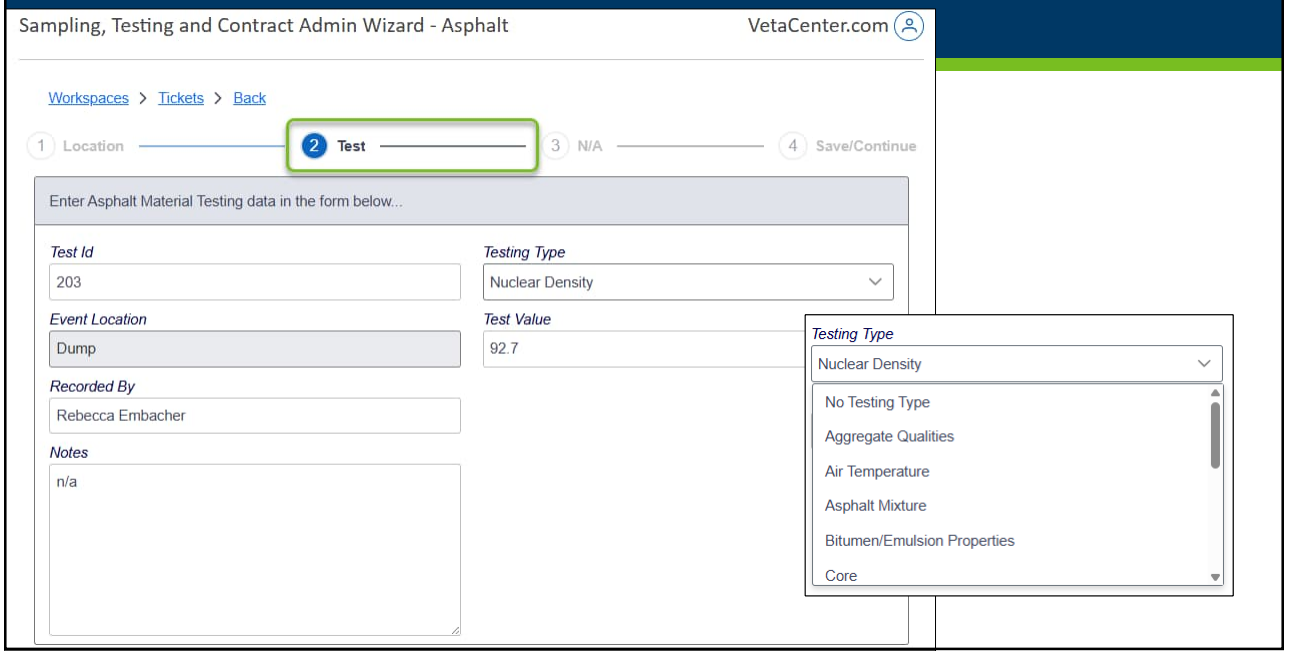
DEPARTMENT OF TRANSPORTATION

As-built Material Properties (Test Results)

Tied to E-Ticket and to Material Placement Location

37

Adding field test data to E-Ticket



38

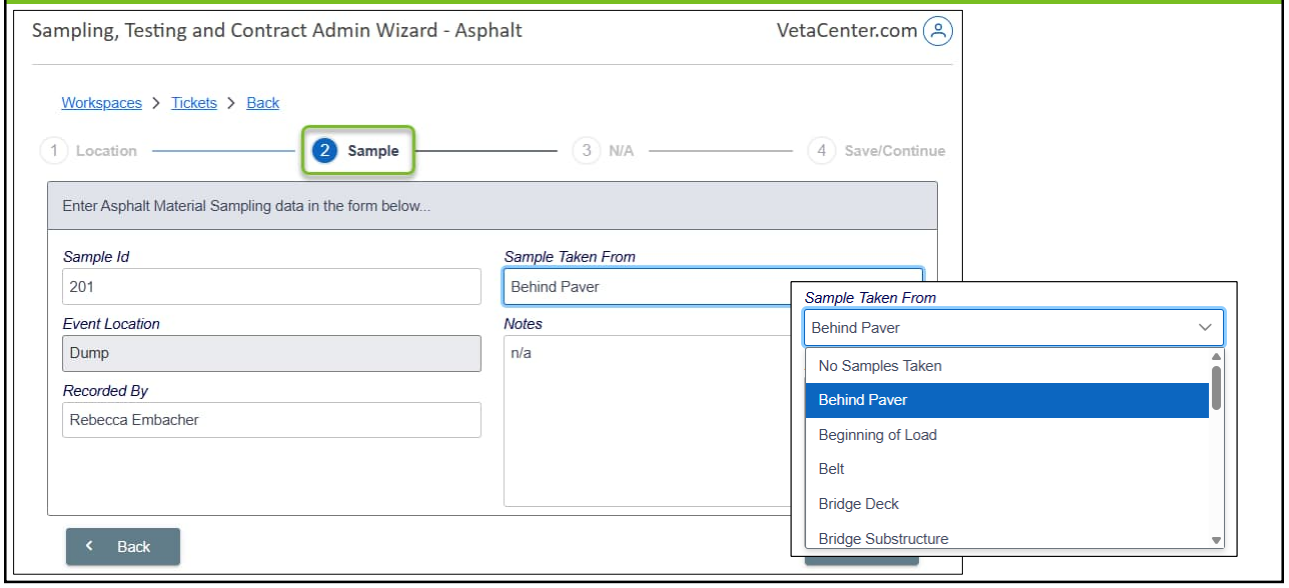
Testing and hand-batched quantities for ready-mixed concrete

Data Description
First increment of water and/or admixture additions.
Second increment of water and/or admixture additions.
Third increment of water and/or admixture additions.

Data Description
Test at source
Test when no water and/or admixture additions
Test after first increment of water and/or admixture additions
Test after second increment of water and/or admixture additions
Test after third increment of water and/or admixture additions

39

Adding lab sample ID to E-Ticket



40

Connection of lab test data to field placement using E-Ticket and Dump Location

41

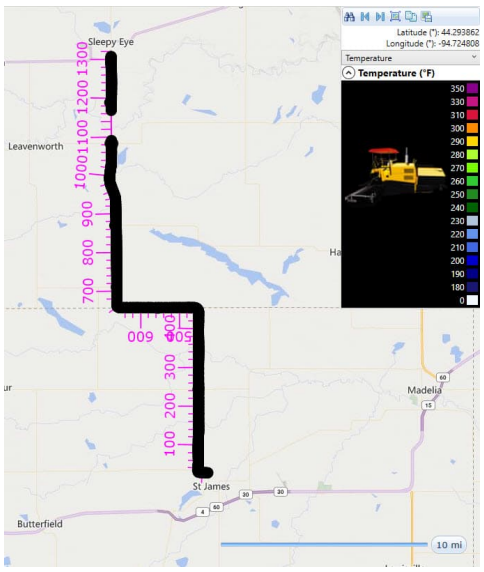
Connection of field test data to field placement using E-Ticket and Dump Location

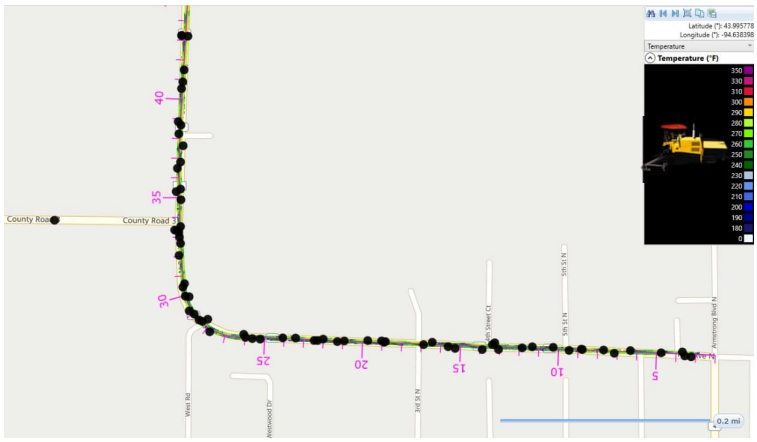
42

DEPARTMENT OF TRANSPORTATION

Connecting the Dots

43





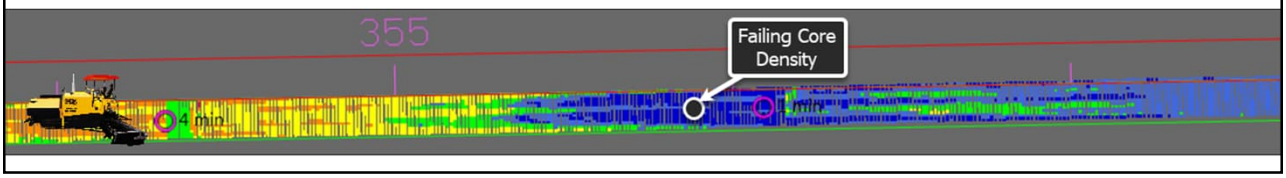
Dumping locations are used to connect E-Tickets and lab/field test data to intelligent construction technologies

44

Connecting data to troubleshoot cause of workmanship issues

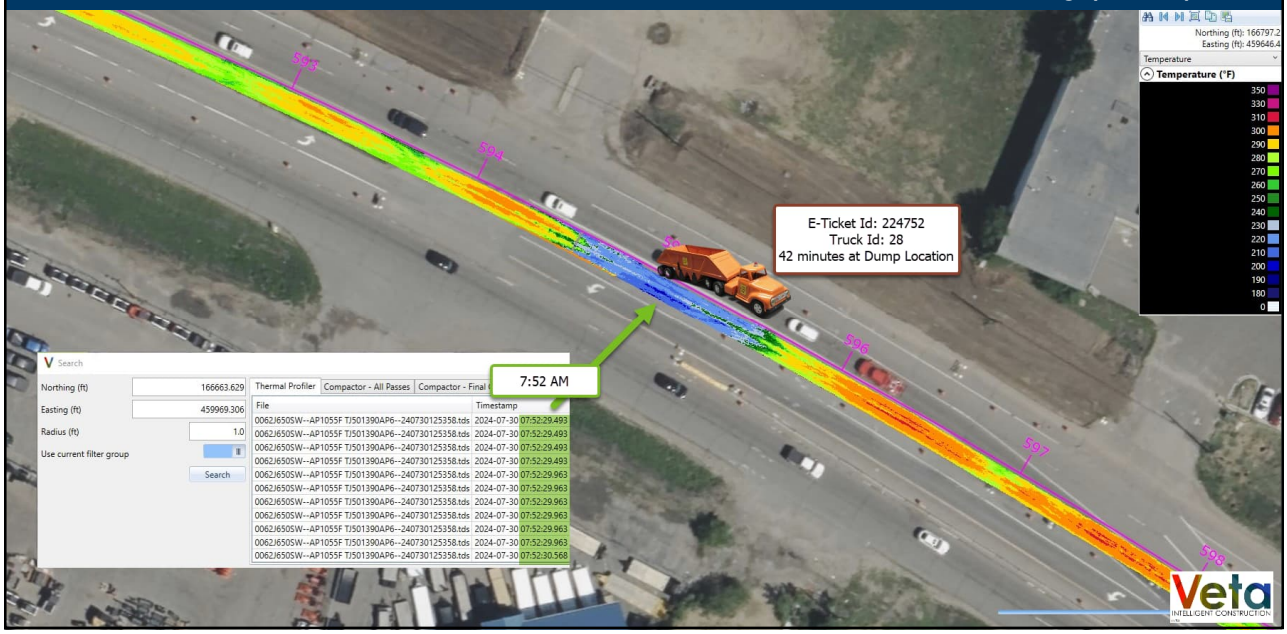
Failing Core Density

- What we know:
  - Location
  - Associated E-Ticket
  - Lab and field tests connected to E-Ticket and location
- Mix Design = No Issues
- Lab Tests = No Issues
- IC = no compaction concerns
- PMTP = cold spot at failing density
- Field Tests = Variable stockpile moisture contents



45

Cause of thermal segregation – cold region
Paver Mounted Thermal Profiling (PMTP)



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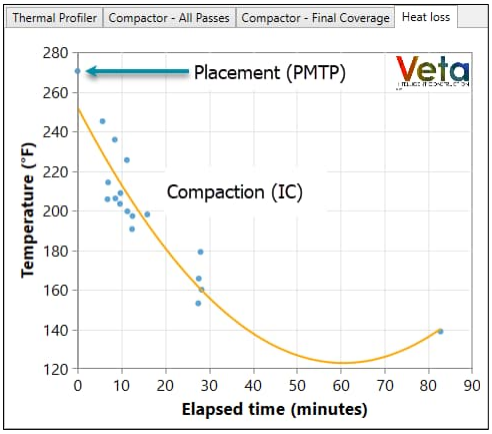
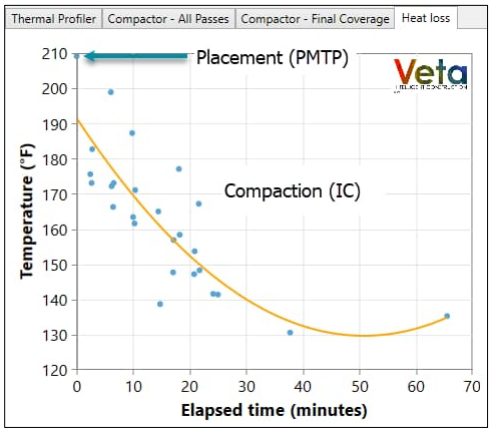
Heat loss curves

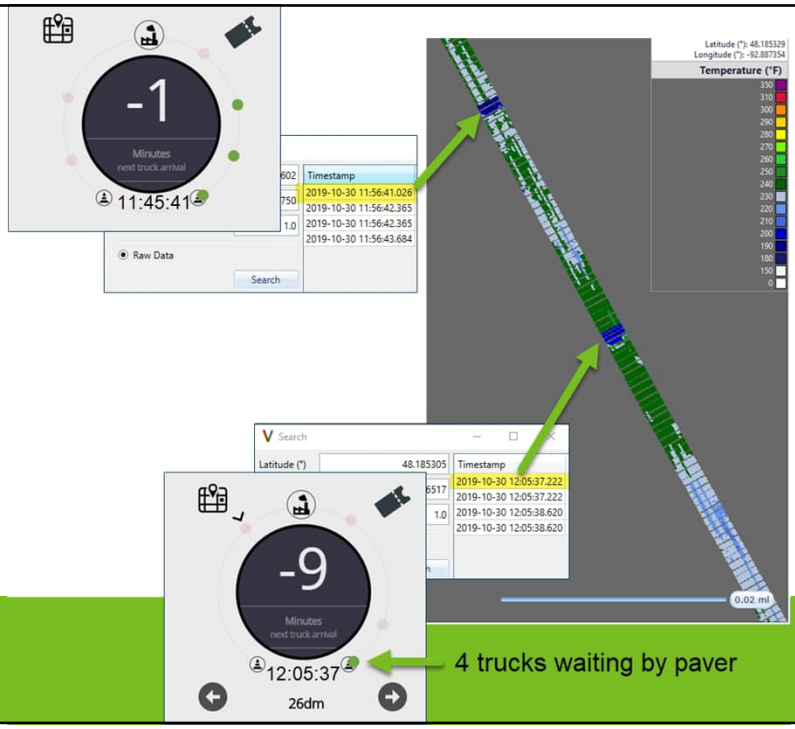
Heat loss curve prior to cold segment



Heat loss curve at cold section

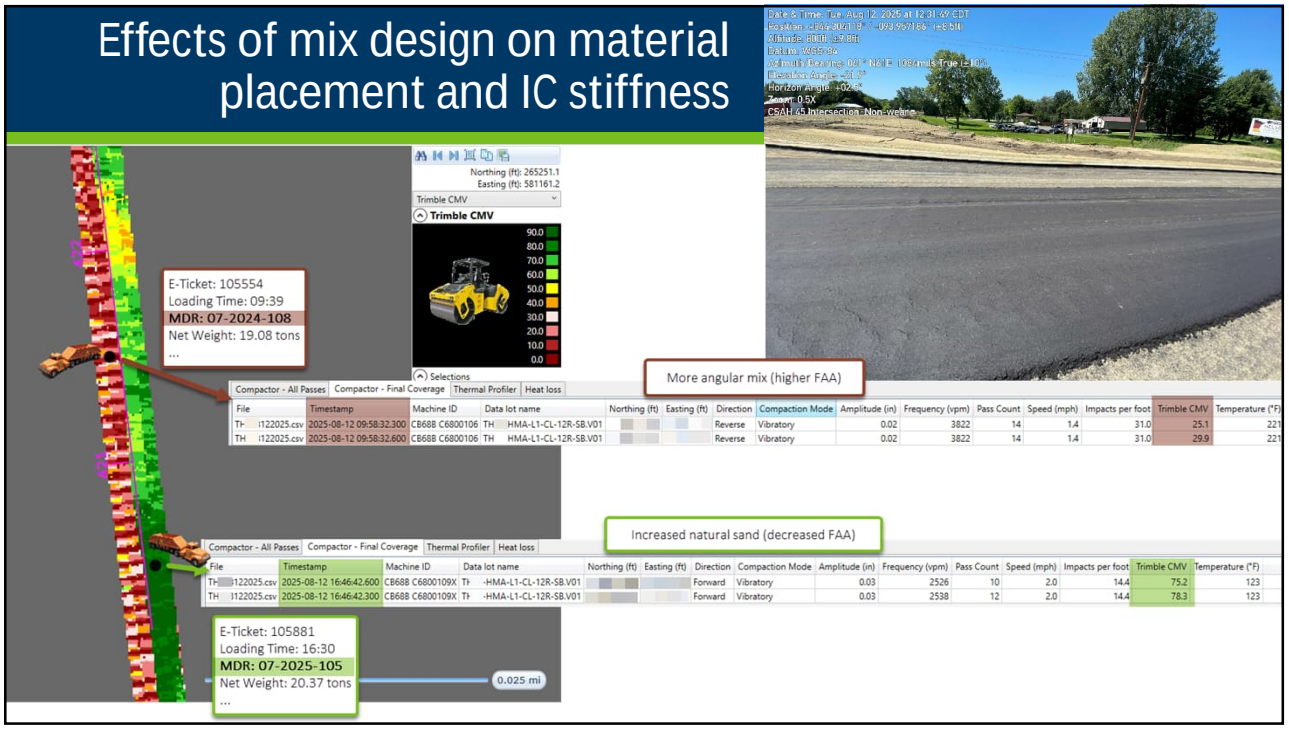


47

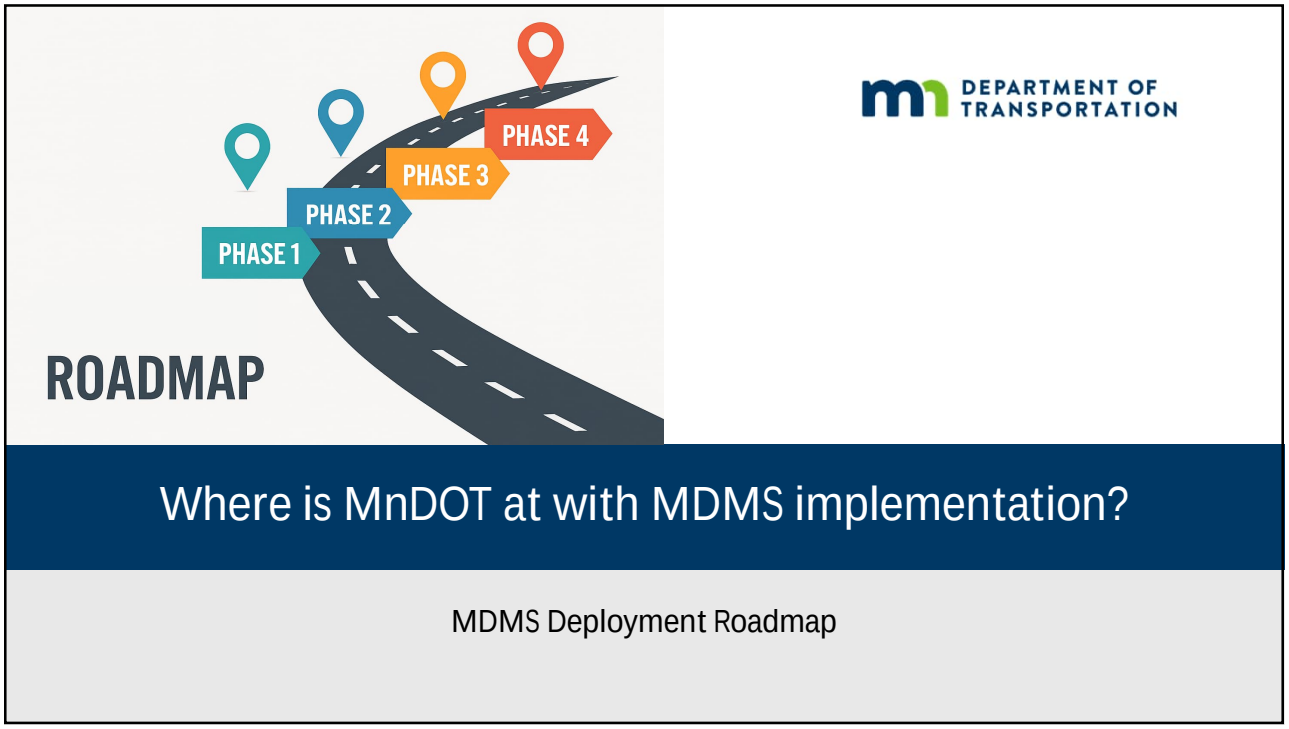


Connected data to support: fleet management, production rates, paving speeds, number of rollers/compaction efforts, and more

48


Effects of mix design on material placement and IC stiffness
E-Ticket: 105554
Loading Time: 09:39
MDR: 07-2024-108
Net Weight: 19.08 tons
More angular mix (higher FAA)
Increased natural sand (decreased FAA)
E-Ticket: 105881
Loading Time: 16:30
MDR: 07-2025-105
Net Weight: 20.37 tons
0.025 mi

49


PHASE 1
PHASE 2
PHASE 3
PHASE 4
ROADMAP
DEPARTMENT OF TRANSPORTATION
Where is MnDOT at with MDMS implementation?
MDMS Deployment Roadmap

50

Bituminous MDMS implementation
(2360 Plant Mixed Asphalt, 2363 PASSRC and PASB, 2365 Stone Matrix Asphalt)

- 2018-2019
  - Pilot Projects
- 2020-2023
  - CovID
  - Change Orders
  - Incidental
- 2024
  - Metro: 5,000 tons and greater
  - Greater MN: Discretion of Engineer
- 2025
  - Metro: 100%
  - Greater MN: 5,000 tons and greater
- 2026
  - Statewide: 100%

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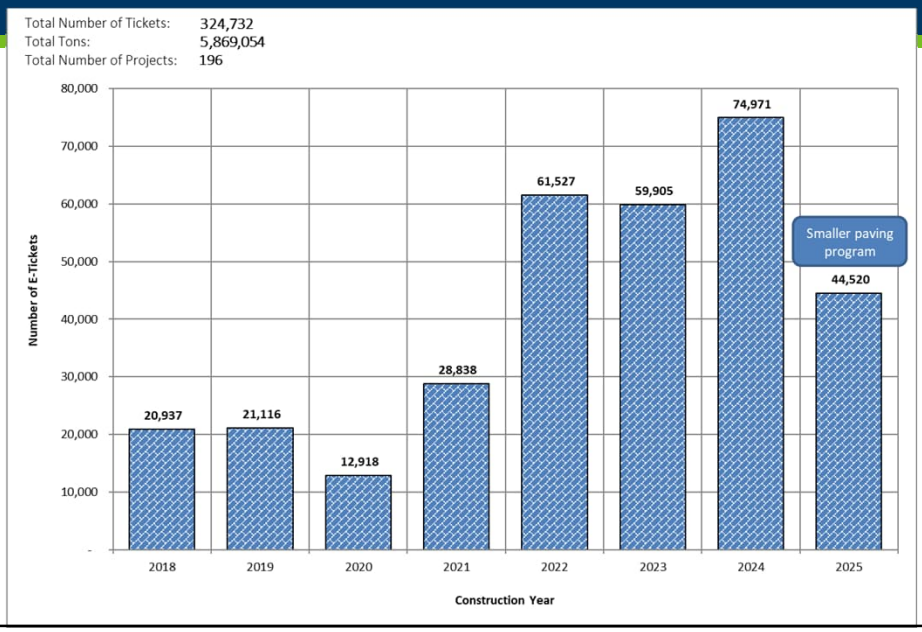
MDMS project history



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Small bituminous mixture quantities

MnDOT 2360, 2363, and 2365 bituminous mixture quantities (per mix type) that are less than or equal to 600 tons

The following MDMS data is not required:

- Tracking of truck locations
- Loading and delivery event data
- Dumping events (date, time, locations)
- Creation of Source and Contract Geofences

MDMS data still required for collection:

- Source data (E-Ticket)
- Hauler data

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Secondary bituminous mixture placement

(New Note Table 2061-12: loading and delivery event data fields)

Dump event data is not required for placement of bit mixtures used for:

- Patching
- filling areas of excavation that are less than 750 linear feet
- tight blade leveling

MDMS data still required:

- Source data (E-Ticket)
- Hauler data
- Loading and Delivery Event (asset tracker):
  - Truck Entering and Exiting Source
  - Truck Entering and Exiting Contract (jobsite)

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2461 Structural Concrete

- 2026
  - Change Orders
- 2027
  - 5 projects
  - 500 cy or greater
- 2028
  - 25-50% of projects
  - 500 cy or greater
- 2029
  - 50-75% of projects
  - 500 cy or greater
- 2030
  - 75-100% of projects
  - 250 cy or greater
- 2031
  - 100% of projects

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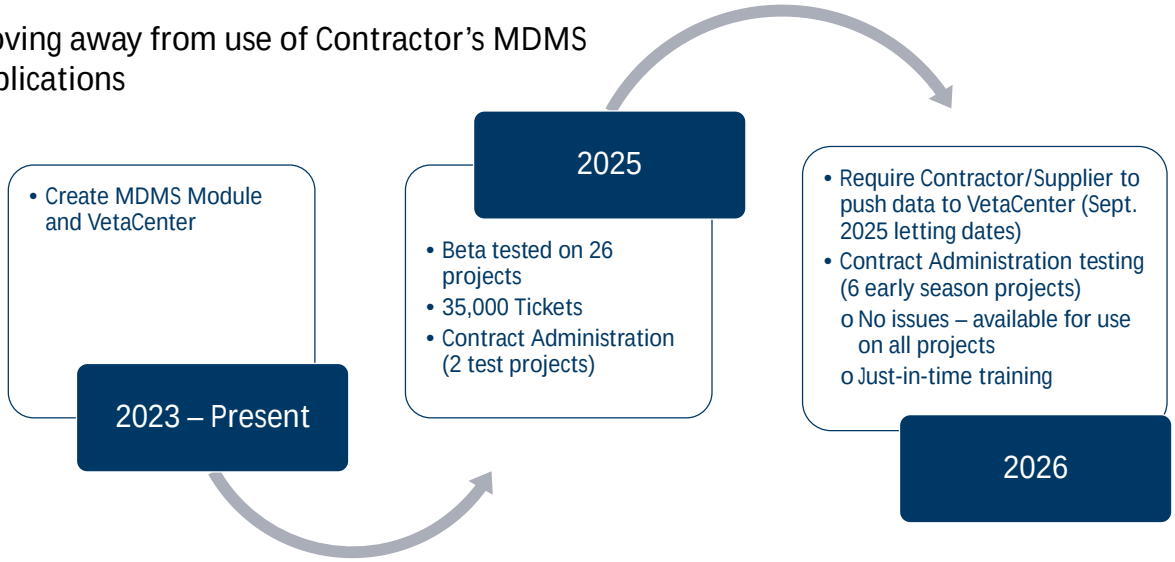
Suppliers may opt to use MDMS

Suppliers who wish to switch to SSD but are unable to meet the January 1, 2026, Certificate of Compliance requirements outlined in 2461.3F2, may opt to use MDMS as an alternative

56

VetaCenter implementation schedule Inspector's tool to view MDMS data

Moving away from use of Contractor's MDMS applications



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DEPARTMENT OF TRANSPORTATION

Thank You!

Rebecca Embacher
Rebecca.Embacher@state.mn.us
651-373-5222

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1

Agenda

Public

1. **Why Digital-as-Built (DAB)?** – Craig
2. **Jobsite Intelligence:**
    a. Surface Creation / Capture – Jim
    b. Data Viewing and Management – Jim & Craig
4. **Smart Automation:**
    a. 2D Paving Technologies & Thermal Profiling – Craig
    b. 3D Paving Technologies – Jim
    c. Performance Tracking & Reporting – Jim & Craig
5. **The Paving & Compaction connection** – Craig
6. **Closing + Q&A** - Jim

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2

Common Industry Challenges

Public

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3

Common Contractor Challenges

Public

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4

Our Solutions

Public

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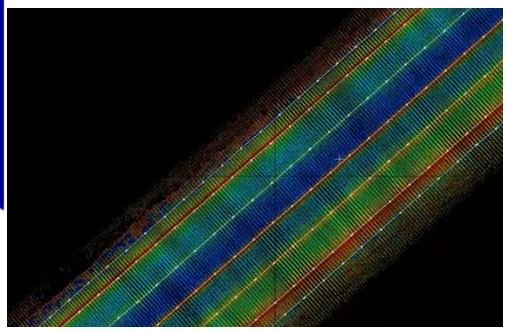
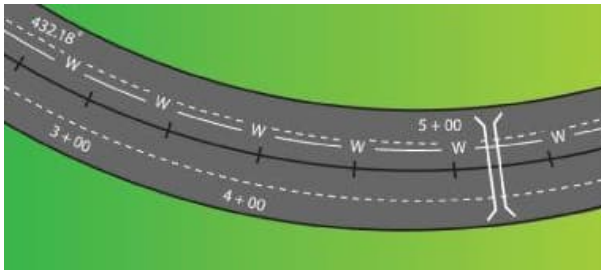
5

Topcon
Magnet Office / Resurfacing

Public

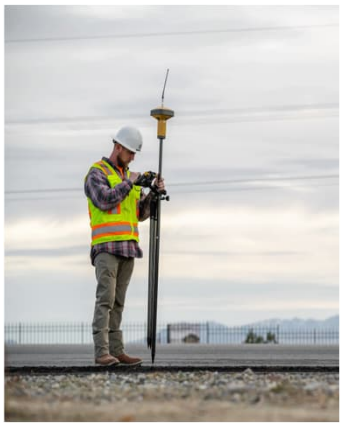




6

Public

Conventional Method



MOBILE SCANNING METHOD

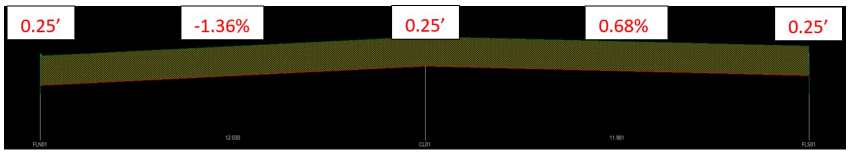
7

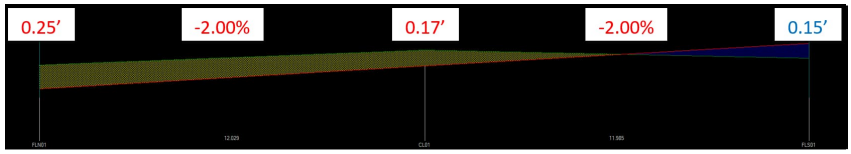
Public

Magnet Office/**Resurfacing**

Design Examples

- Make significant smoothness improvements
- Design to specific grade requirements
- Meet elevation constraints
- Identify the need for leveling courses

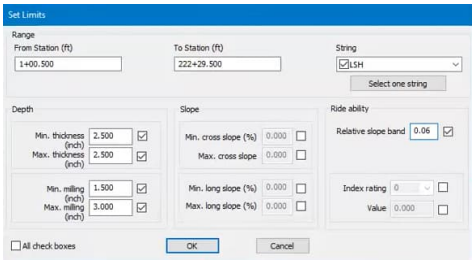


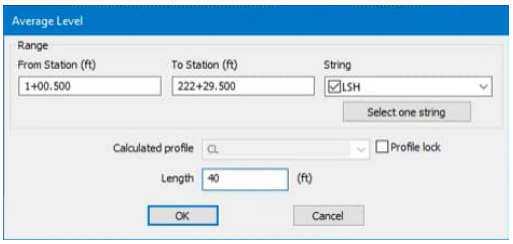


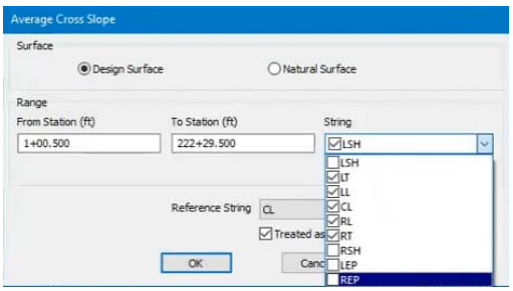
8

Public

MAGNET Office







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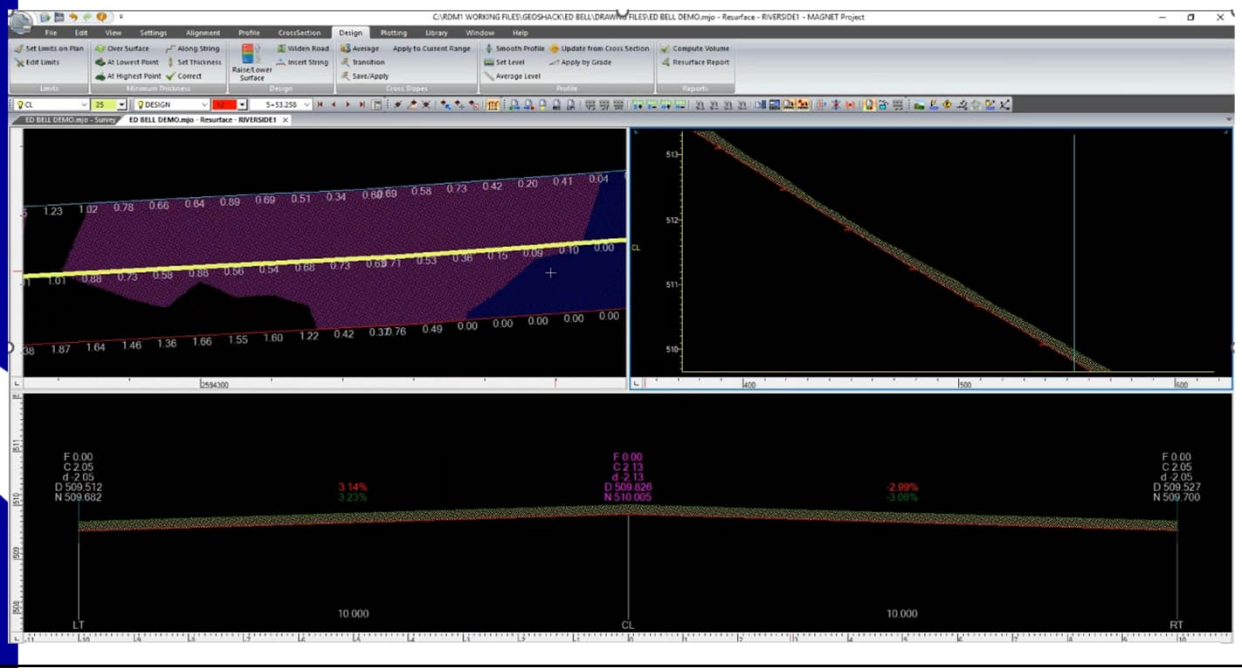
Magnet Office/Resurfacing



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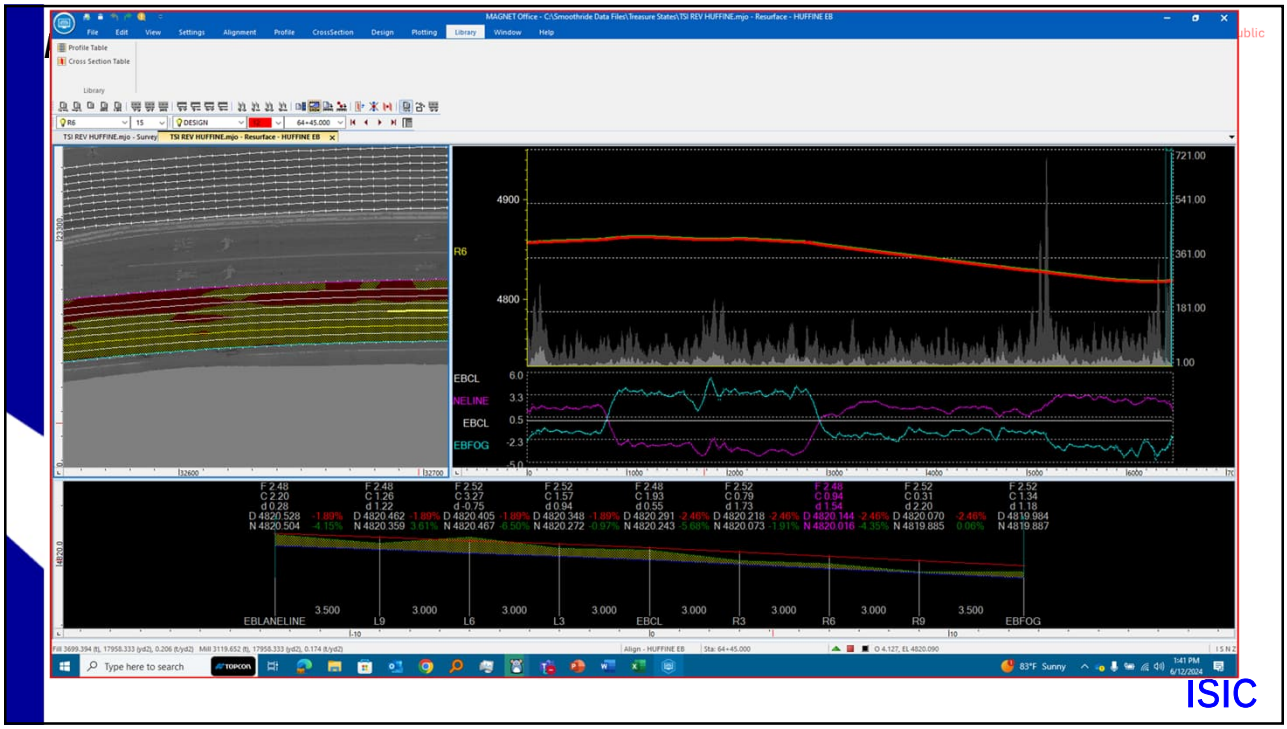

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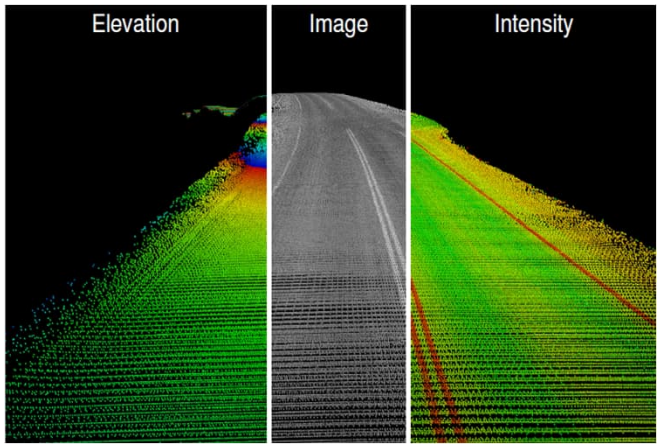
Public

Magnet Collage Data Processing

- *Fast processing*
- *Accepts both .tps files and RiNEX*
- *Create surface file*
- *Create Linework*



12

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Cross Slope

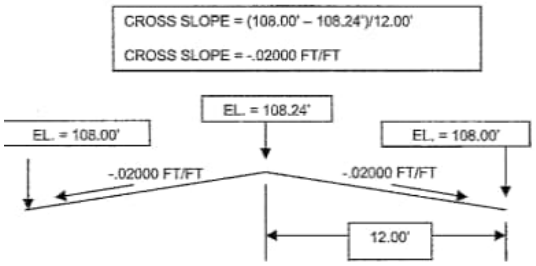

FIGURE 1
NORMAL CROWN

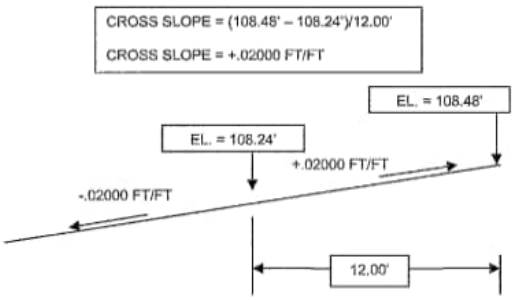

FIGURE 2
REMOVE CROWN

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Cross-Section Report

SCDOT I26 SMA AS Built Data
EastBound
BCC Job # 23196

Fast Lane					Slow Lane				
Station	Plan X Slope	Elevation Left	Elevation Right	Calculated X Slope	Station	Plan X Slope	Elevation Left	Elevation Right	Calculated X Slope
3905+00	2.0%	98.97	99.16	-1.90%	3905+00	2.0%	99.19	99.39	-2.00%
3905+50	2.0%	98.73	98.95	-2.20%	3905+50	2.0%	98.98	99.19	-2.10%
3906+00	2.0%	98.48	98.75	-2.70%	3906+00	2.0%	98.79	98.99	-2.00%
3906+50	2.0%	98.23	98.46	-2.30%	3906+50	2.0%	98.51	98.71	-2.00%
3907+00	2.0%	97.79	98.01	-2.20%	3907+00	2.0%	98.06	98.26	-2.00%
3907+50	2.0%	97.41	97.62	-2.10%	3907+50	2.0%	97.66	97.86	-2.00%
3908+00	2.0%	97.03	97.24	-2.10%	3908+00	2.0%	97.28	97.48	-2.00%
3908+50	2.0%	96.68	96.89	-2.10%	3908+50	2.0%	96.93	97.12	-1.90%
3909+00	2.0%	96.31	96.52	-2.10%	3909+00	2.0%	96.56	96.76	-2.00%
3909+50	2.0%	95.99	96.21	-2.20%	3909+50	2.0%	96.23	96.43	-2.00%
3910+00	2.0%	95.6	95.81	-2.10%	3910+00	2.0%	95.85	96.05	-2.00%
3910+50	2.0%	95.22	95.43	-2.10%	3910+50	2.0%	95.46	95.66	-2.00%
3911+00	2.0%	94.93	95.14	-2.10%	3911+00	2.0%	95.16	95.36	-2.00%
3911+50	2.0%	94.64	94.86	-2.20%	3911+50	2.0%	94.88	95.08	-2.00%
3912+00	2.0%	94.32	94.52	-2.00%	3912+00	2.0%	94.57	94.77	-2.00%
3912+50	2.0%	94.03	94.24	-2.10%	3912+50	2.0%	94.23	94.43	-2.00%
3913+00	2.0%	93.71	93.91	-2.00%	3913+00	2.0%	93.94	94.14	-2.00%
3913+50	2.0%	93.49	93.72	-2.30%	3913+50	2.0%	93.74	93.95	-2.10%
3914+00	2.0%	93.36	93.57	-2.10%	3914+00	2.0%	93.60	93.80	-2.00%
3914+50	2.0%	93.24	93.45	-2.10%	3914+50	2.0%	93.45	93.66	-2.10%
3915+00	2.0%	93.11	93.31	-2.00%	3915+00	2.0%	93.33	93.53	-2.00%
3915+50	2.0%	92.9	93.11	-2.10%	3915+50	2.0%	93.20	93.40	-2.00%
3916+00	2.0%	92.91	93.11	-2.00%	3916+00	2.0%	93.20	93.41	-2.10%
3916+50	2.0%	92.97	93.18	-2.10%	3916+50	2.0%	93.27	93.47	-2.00%
3917+00	2.0%	93.05	93.27	-2.20%	3917+00	2.0%	93.37	93.57	-2.00%
3917+50	2.0%	93.2	93.41	-2.10%	3917+50	2.0%	93.49	93.69	-2.00%
3918+00	2.0%	93.36	93.56	-2.00%	3918+00	2.0%	93.63	93.84	-2.10%
3918+50	2.0%	93.47	93.68	-2.10%	3918+50	2.0%	93.77	93.98	-2.10%
3919+00	2.0%	93.64	93.85	-2.10%	3919+00	2.0%	93.92	94.12	-2.00%
3919+50	2.0%	93.78	93.99	-2.10%	3919+50	2.0%	94.06	94.26	-2.00%
3920+00	2.0%	93.92	94.13	-2.10%	3920+00	2.0%	94.19	94.39	-2.00%
3920+50	2.0%	94.07	94.27	-2.00%	3920+50	2.0%	94.32	94.53	-2.10%

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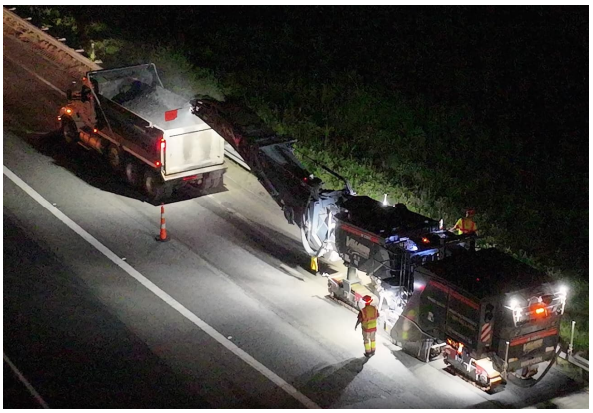
Public

Milling to design

Milled to the design accurately
Monitored slopes during the operation
Maintained production



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Why now?

Need to Do More with Less

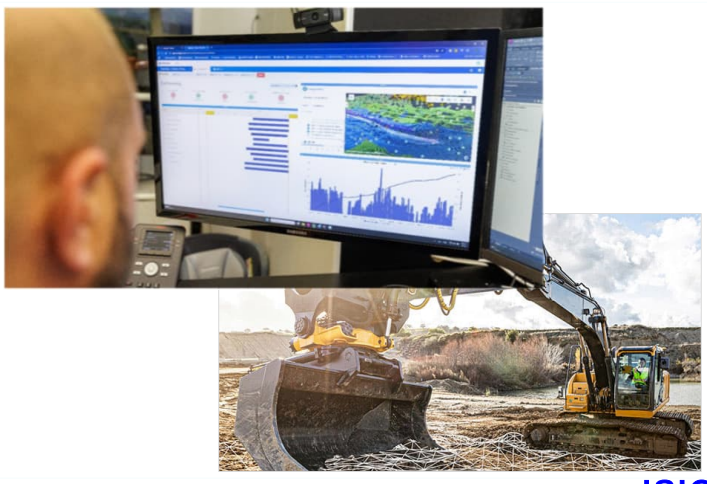
Digitalizing construction operations will reduce delays and increase production, reducing labor challenges.

Want Connected Services

Topcon's connected services integrates with their digital field tools for near-real-time project insights and automations.

Expect Continuous Value

The added value of Topcon's connected services sets Topcon apart and enables continuous value delivery.



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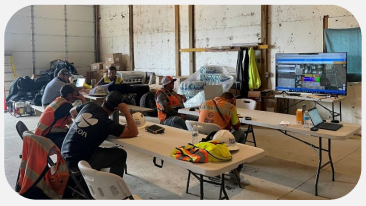
Connectivity through Integration



Telematics

Connected Machine Control

Integrations, Data Management, and Data Automations

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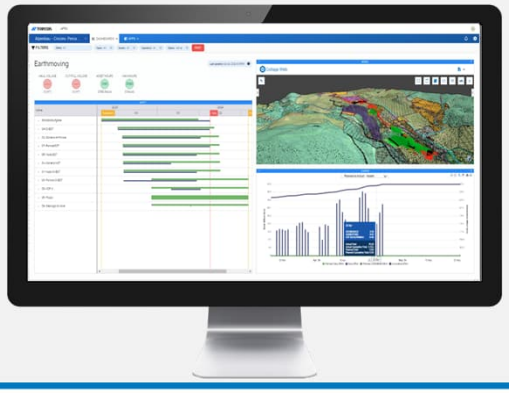
Centralized Data Management

Aptix™



Schedules

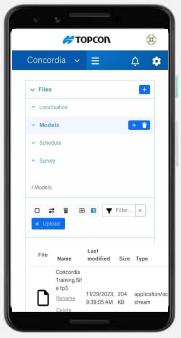
Point Clouds

Construction Models

Telematics

Designs

Asbuilts



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John Deere Operations Center

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John Deere Operations Center

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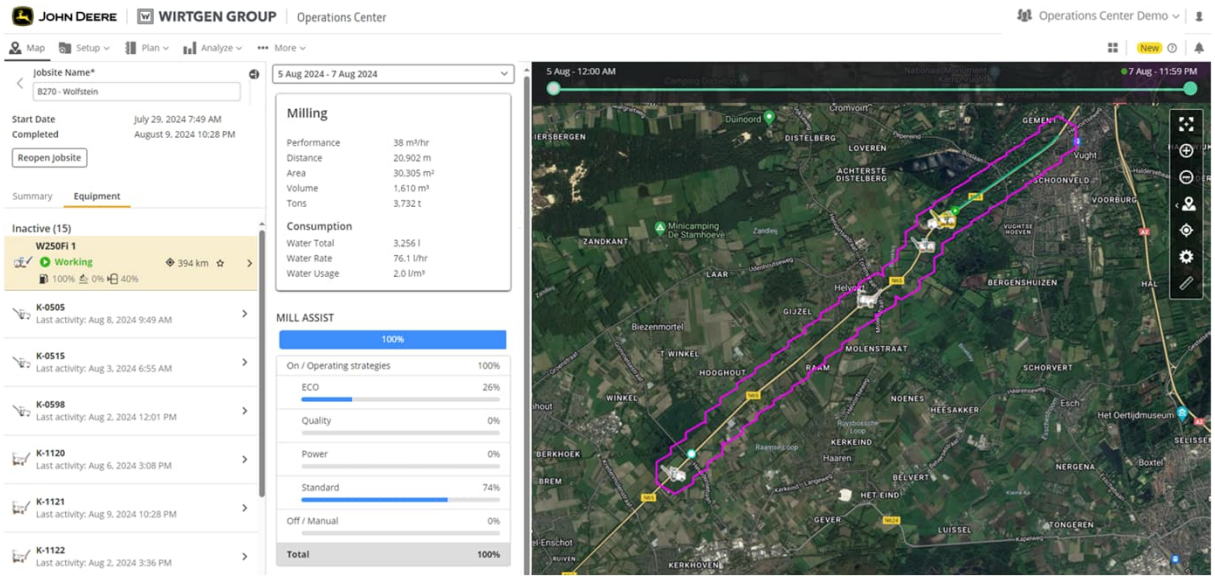

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John Deere Operations Center

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JOHN DEERE

WIRTGEN GROUP

- Jobsite Data & Information
- Performance & Productivity Data
- Work Planner
- Analytics

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21

Our Solutions

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JOBSITE INTELLIGENCE
Better decisions based on comprehensive facts

SMART AUTOMATION
Maximizing performance & productivity

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22

Vogele 2D Paving

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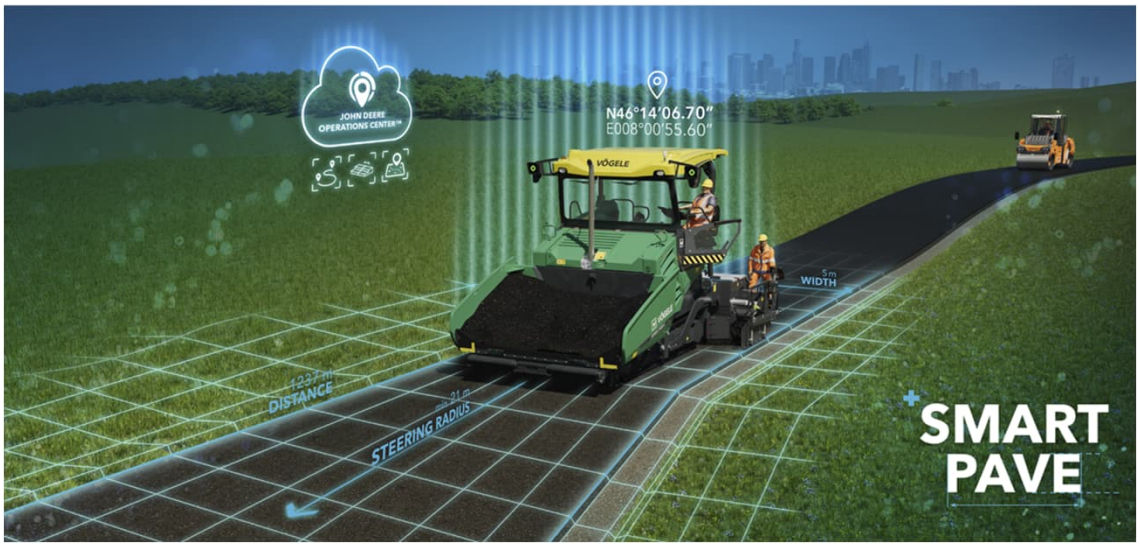

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Vogele 2D Paving

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Vogele 2D Paving

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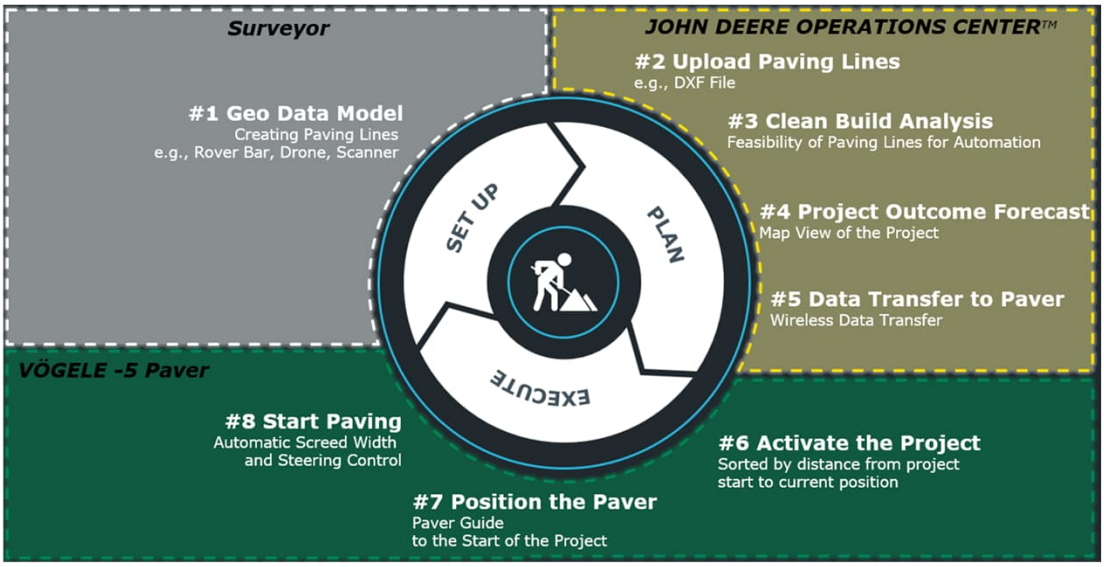

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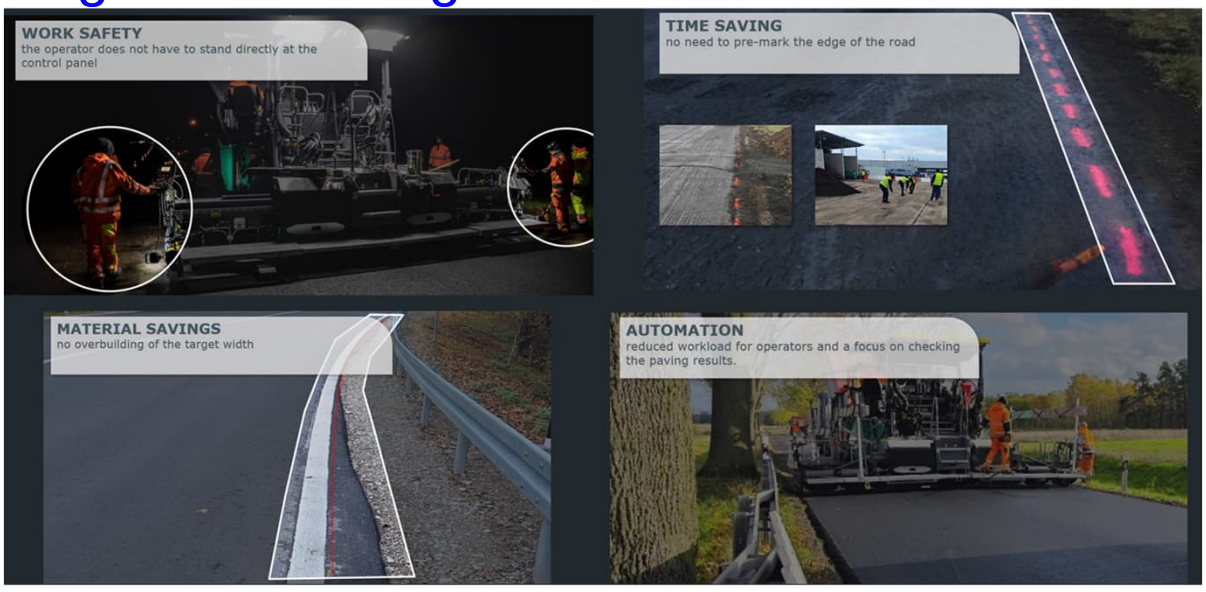
Vogele 2D Paving

Public



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Topcon 3D Paving Technologies

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3D Paving: 3D Reference (Model)

3D Model Built from Scanned Surface

- ***Topcon SmoothRide Interface with Vögele Niveltronic+ 3D (5 Pin Receptacle)***

Topcon 3D Positioning Instruments

Topcon GNSS Receiver (X & Y)

Topcon GX-60 & MC-R3 Box

Vögele Machine Control (Niveltronic Screed Control)

Vögele Sensors (Z from 3D model)

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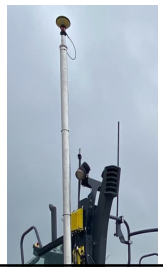
3D Paving: Positioning Instruments

2 Types of Positioning Instruments

- **Supplied by Different Group of OEM's (Subject Matter Experts)**
  - **Different from Paver OEM'S**

1. UTS – Universal Total Station

Leica UTS or GPS



2. mm GPS

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3D Paving: Positioning Instruments

3D Positioning Instruments

- **UTS – Universal Total Stations**
  - **Multiple Stations required – Minimum 3**
  - **Tracking, Transition & Checking Grade**

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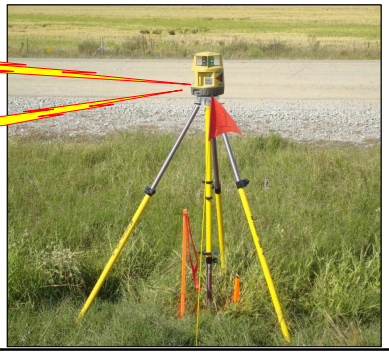
3D Paving: Positioning Instruments

3D Positioning Instruments

- mm GPS
  - Grade Controlled by Laser
  - X & Y Controlled by GPS



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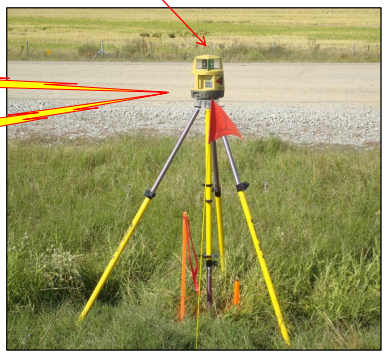
3D Paving: Positioning Instruments

3D Positioning Instruments - mmGPS



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Topcon Performance Tracking & Reporting

Public

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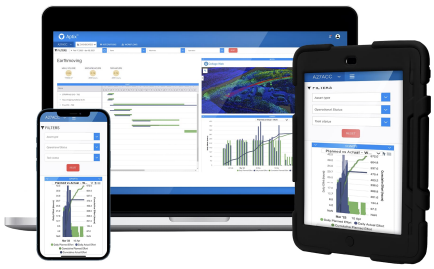
33

Public

Aptix™

Integration Platform



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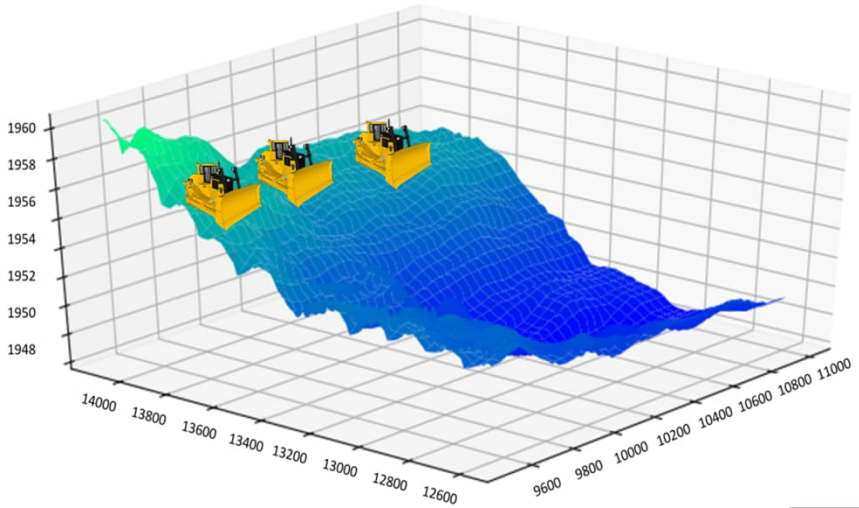
Disciplines involved

Many different roles or disciplines within the project execution are not connected digitally.

35

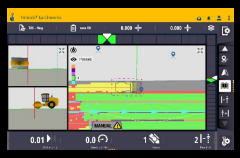
Machine Data Mapping

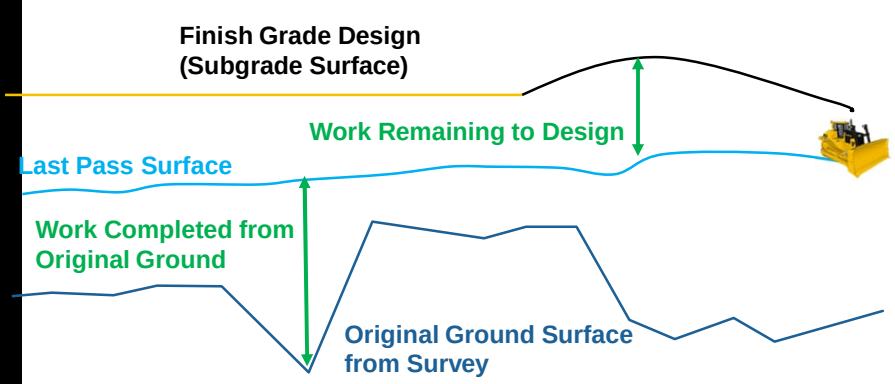
Elevation: 5,455.8 (06/07/18 03:00 PM)
N 1,205,601.015 ft - E 3,109,029.047 ft
Lat 39.896184 - Lon -105.114535



36

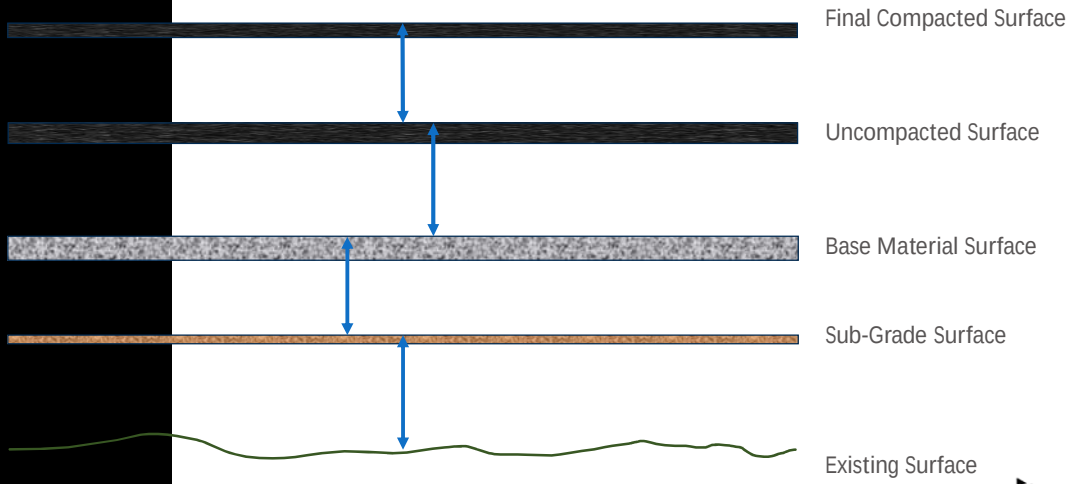
Machine Data Mapping - Scheduling



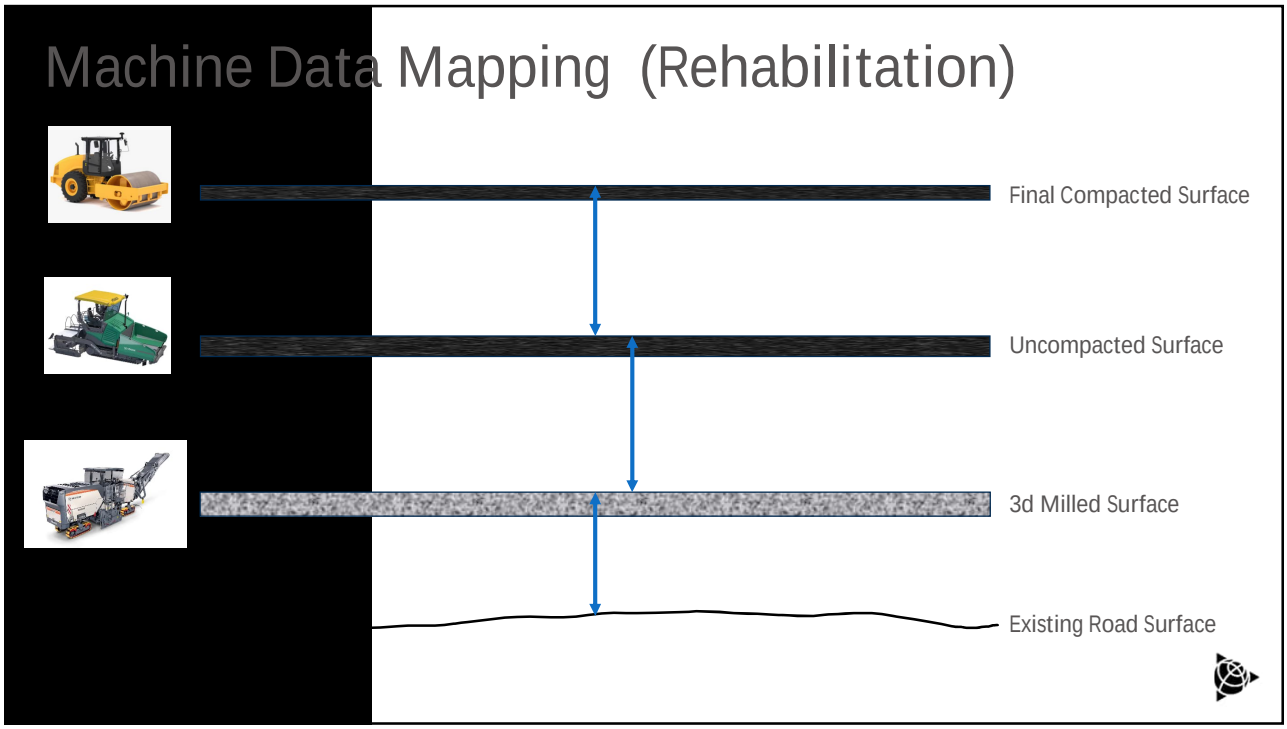


37

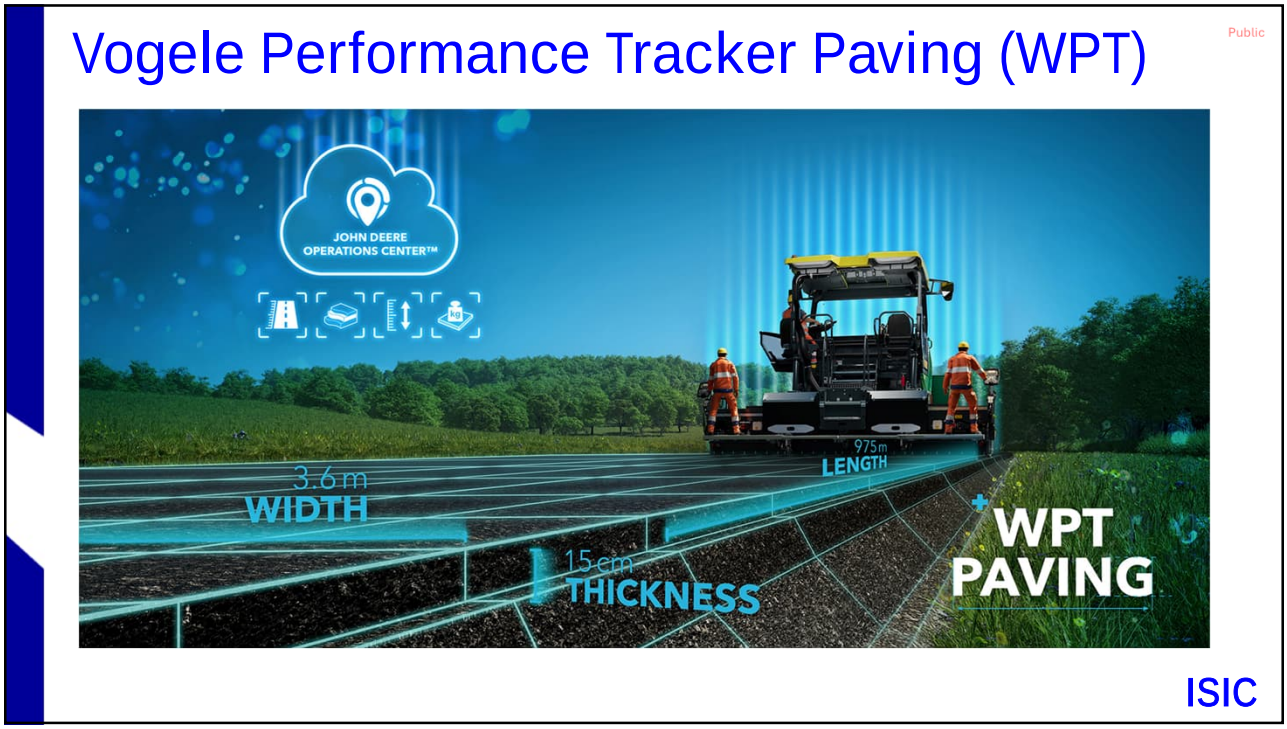
Machine Data Mapping (New Construction)



38


Machine Data Mapping (Rehabilitation)
Final Compacted Surface
Uncompacted Surface
3d Milled Surface
Existing Road Surface

39


Vogele Performance Tracker Paving (WPT)
Public
JOHN DEERE OPERATIONS CENTER™
3.6 m
WIDTH
975m
LENGTH
15 cm
THICKNESS
WPT
PAVING
ISIC

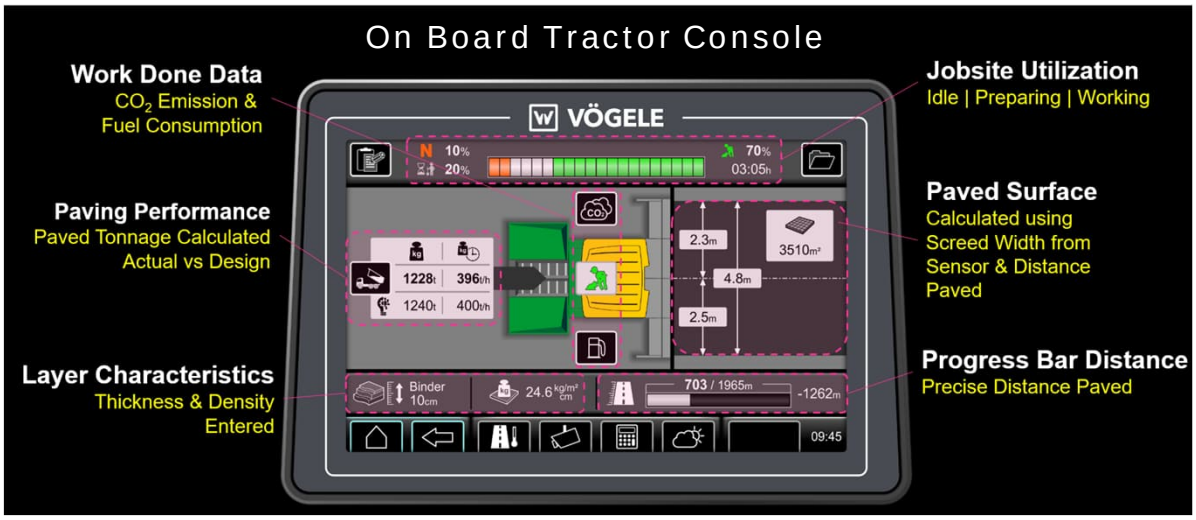
40

Vogele Performance Tracker Paving (WPT)

ISIC

41

Vogele Performance Tracker Paving (WPT)



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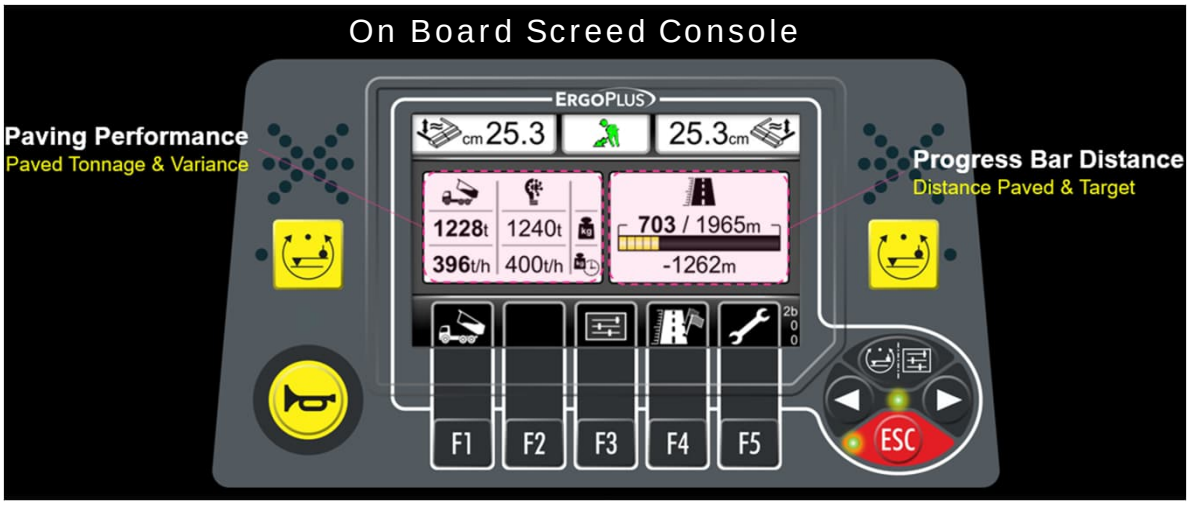
Vogele Performance Tracker Paving (WPT)

Public



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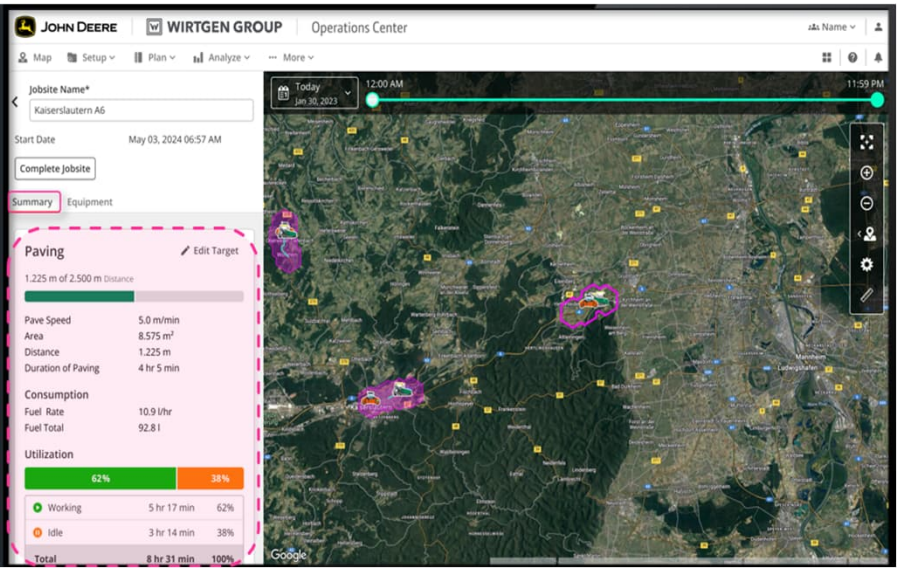
Vogele Performance Tracker Paving (WPT)

Public

Jobsite Summary Card
Ave. Paving Speed
Paved Area
Paved Distance
Paving Time
Fuel Consumption



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Vogele RoadScan Thermal Profiling

Public

> High-precision thermal camera

> Compact and low weight for easy transportation and installation

> Temperature measurement up to 42ft wide

> Measured value resolution of ~3°F

> Measuring point size 4" x 4" (AASHTO R110 – 6" to 12")

> Temperature range between 32°F and 530°F with a ± 2% tolerance

JOHN DEERE

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Vogele Performance Tracker Paving (WPT)

Public

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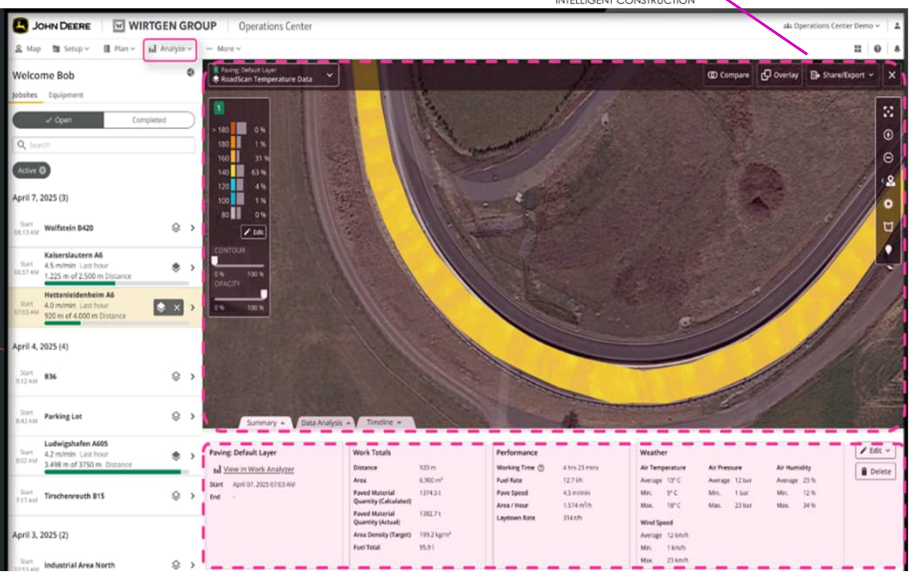
Jobsite Analyzer
Geo-referenced Documentation
Detailed Map Analyzer
Point Analysis

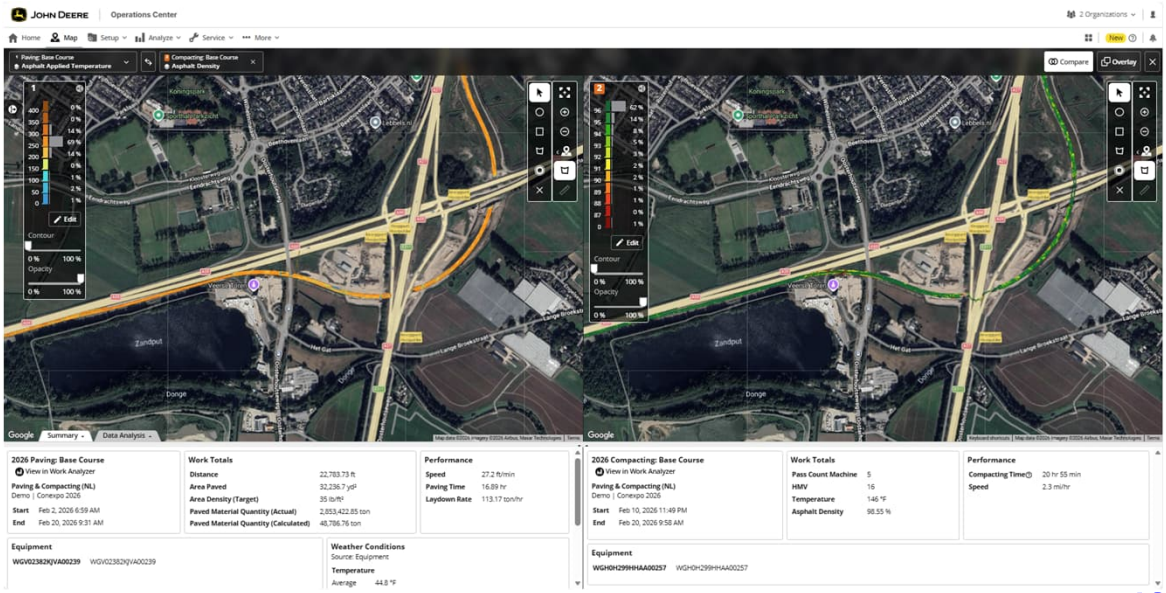
Jobsite Analyzer
Work Totals
Paving Stops
Screed Information



46

Vogele Performance Tracker Paving (WPT)

Public



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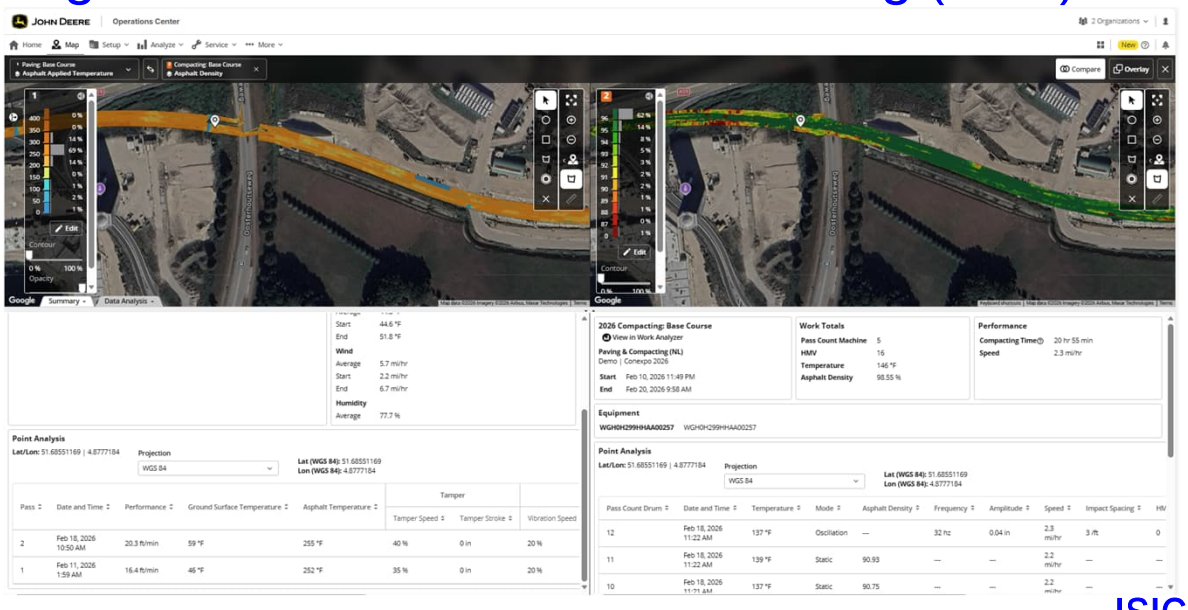
47

Vogele Performance Tracker Paving (WPT)

Public



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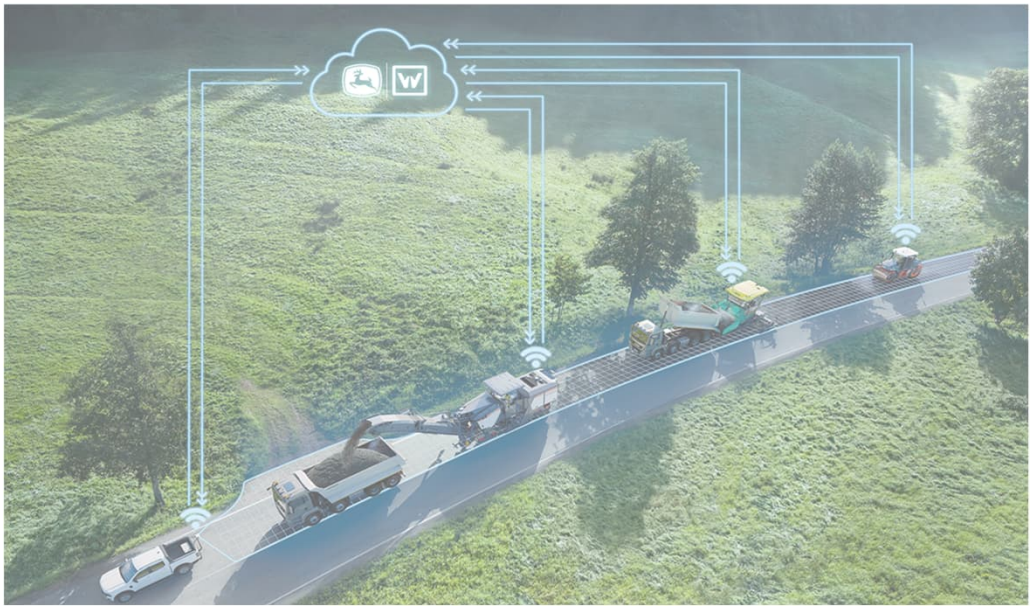
48

The Paving & Compaction Connection and DAB

Public



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The Paving and Compaction Connection and DAB

Public

Jobsite Intelligence
Better decisions through information

Jobsite Monitoring
Documentation & Reporting
Performance Analytics

Equipment Management

WPT Compacting

WPT Paving

JOHN DEERE OPERATIONS CENTER™

Connected Automation
Automation
Assistant System

Smart Compact

Track *Assist*

Smart Pave

Auto Trac

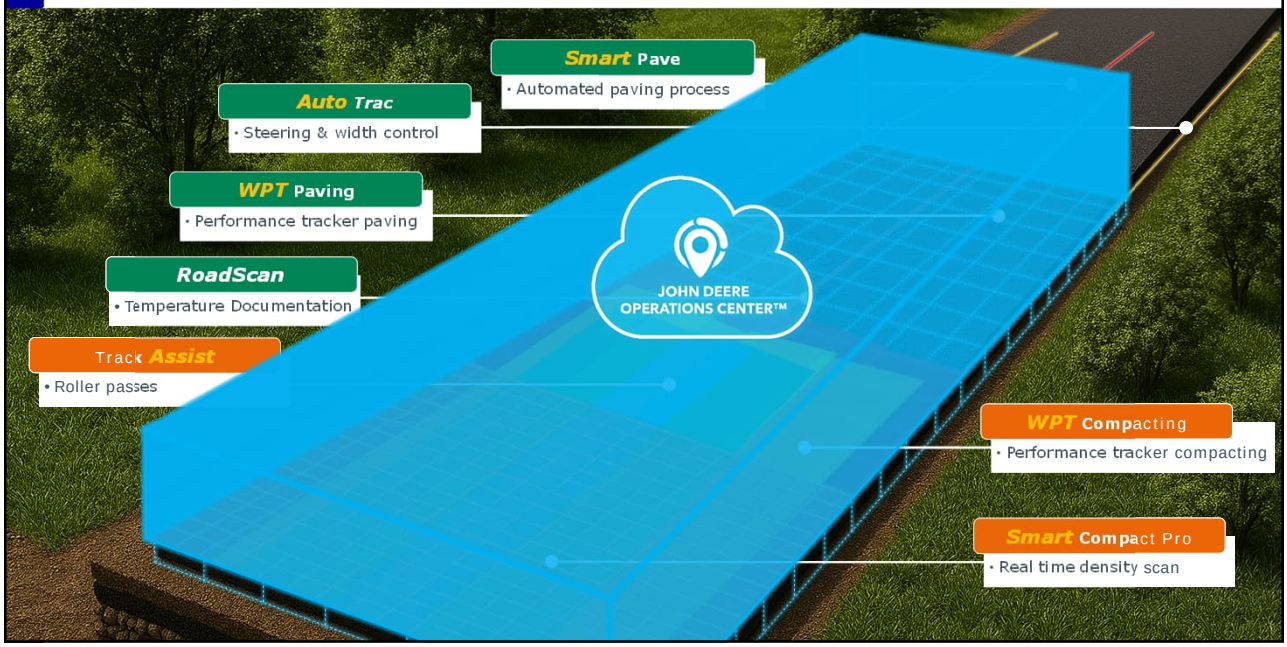
Grade *Assist*

Smart Automation
Maximizing Performance & Productivity

50

The Paving and Compaction Connection and DAB

Public



51

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2026 ISIC NA Conference – Louisville, KY

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THANK YOU!

Q&A

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MARCH 18-20 2026
MINNESOTA TRANSPORTATION CONFERENCE & EXPO

ISIC Track 05

Digital As-Builts from Intelligent Compaction

Wednesday, March 18th, 2026

Presented by: Todd Mansell, Caterpillar

IS-IC.ORG

1

Shift to Data-Driven Construction

- Infrastructure owners expect digital records
- Contractors need better risk control
  - Real-time information
- Inspectors need real-time visibility
- Intelligent compaction (IC) is well-known technology

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2

TPF Intelligent Construction Technologies (ICT)

- MDMS - Material Delivery Management System (“As-Built” is 1 of 6 Modules)
- PMTP – Paver Mounted Thermal Profiler
- IC - Intelligent Compaction
- DPS - Dielectric Profile System
- 3D Milling & Paving
- IRI – International Roughness Index
- Data Analysis done with Veta SW
- Not all States, Not all Projects

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3

What Problem(s) are we Solving ?

- Paper as-builts are incomplete and inconsistent
  - Often because they are not recorded in real-time
- Improved Quality
  - Point-based density tests are “spot checks”
- Disputes arise from lack of measured data
- Closing out projects takes too long
  - Much time is spent collating the data
- No files or “as-builts” for future maintenance
  - Conventional files are difficult, if not impossible, to locate later
  - more accurate future bidding

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4

What is an "IC" Roller ?

- Soils
- Asphalt

- Rollers equipped with GPS/GNSS
- Accelerometers measure stiffness response / MDP
- GPR (new) – measures dielectric, correlated to density
- Onboard computers log data continuously
- Produces real-time maps of compaction, temperature, stiffness, density (from dielectric)
- Data is sent to the "cloud" in near real-time

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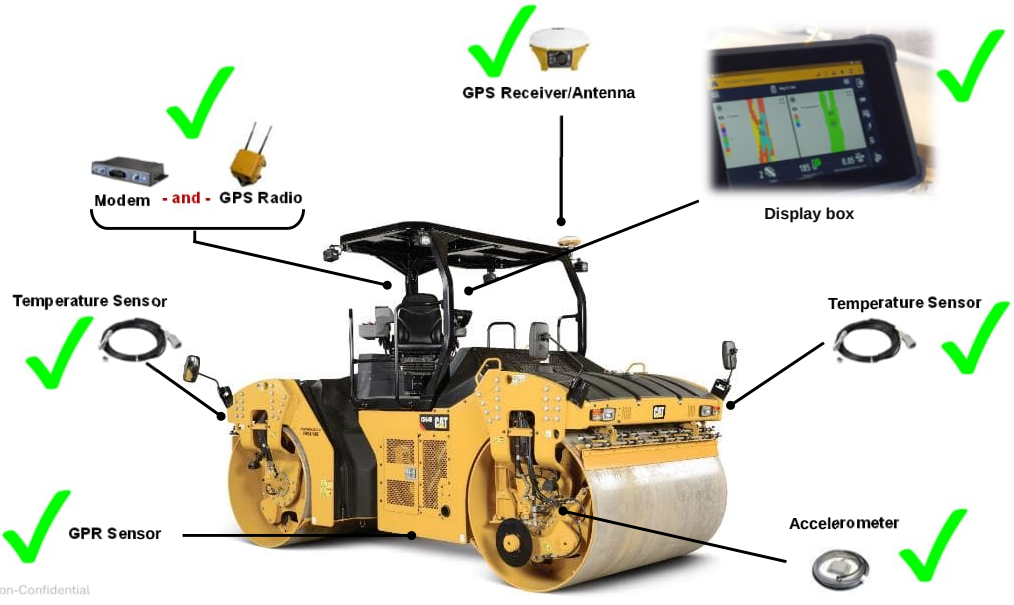
Components on an Asphalt IC roller



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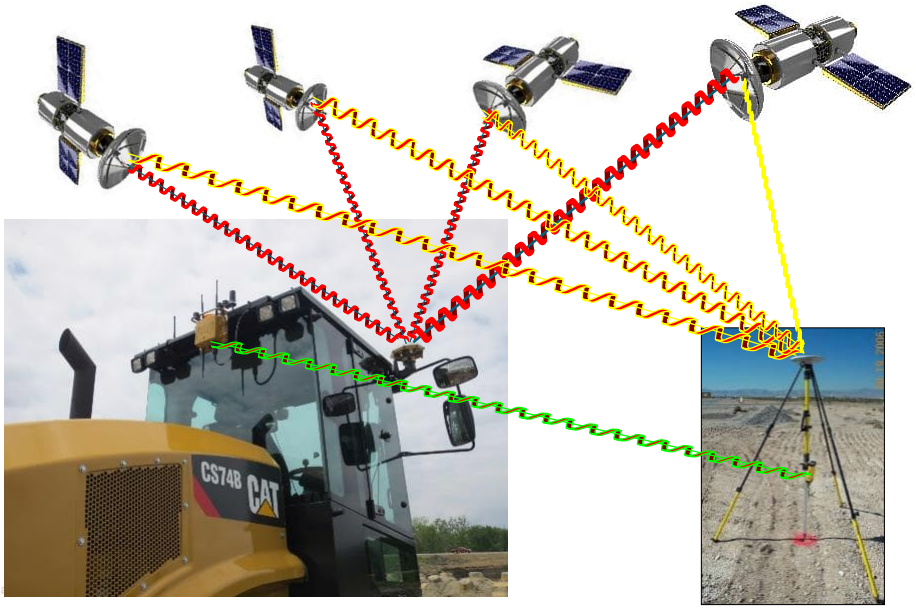
Real-Time Kinematic (RTK)



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7

What Data is Collected with IC ?

1. **Quality**
   - Pass count & coverage
   - Compaction measurement value (ICMV/DPS/MDP)
   - Surface temperatures
2. **Quantity** – tons n/a
3. **Geometry** – surface elevation

All data has time stamps and location (Geo-spatial)

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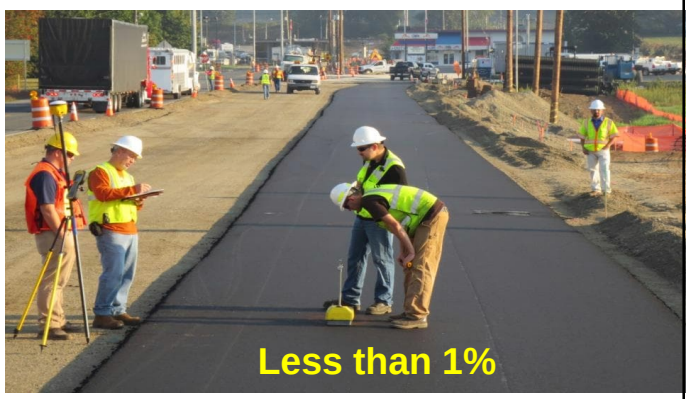
Operator's view – soil project

9

Why IC Data is Valuable

- Continuous, 100% coverage
- Geospatially accurate
- Machine-generated and objective
- Immediate, actionable feedback reduces rework, improves quality



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10

What are Digital As-Builts ?

"Living records updated during construction to support *effective life cycle asset* and *performance* management"

- Georeferenced, structured construction records
- Layer-by-layer documentation
- Machine-readable and GIS-ready
- Permanent asset history

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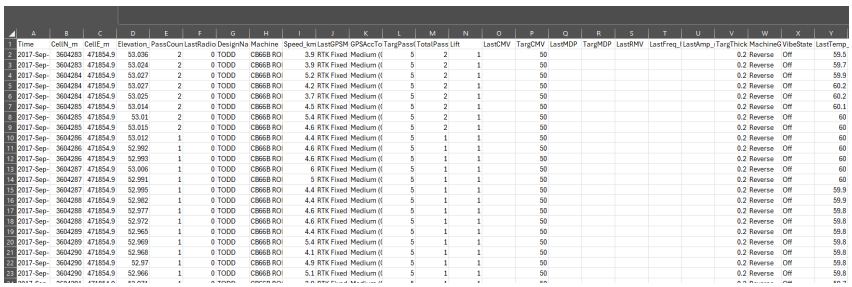
How Does IC Fit into Digital As-Builts ?

- IC already captures location, time, and performance
- Data aligns naturally with lift boundaries
- Provides continuous measurement and feedback
- Reduces manual testing and documentation burden



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	Time	CellN_m	CellE_m	Elevation_	PassCoun	LastRadio	DesignNa	Machine	Speed_km	LastGPSM	GPSAccTo	TargPassC	TotalPass	Lift_	LastCMV	TargCMV	LastMDP	TargMDP	LastRMV	LastFreq_I	LastAmp_I	TargThick	MachineG	VibeState	LastTemp_
2	2017-Sep-	3604283	471854.9	53.036	2	0	TODD	CB66B ROI	3.9	RTK Fixed	Medium ((	5	2	1		50						0.2	Reverse	Off	59.5
3	2017-Sep-	3604283	471854.9	53.024	2	0	TODD	CB66B ROI	3.9	RTK Fixed	Medium ((	5	2	1		50						0.2	Reverse	Off	59.7
4	2017-Sep-	3604284	471854.9	53.027	2	0	TODD	CB66B ROI	5.2	RTK Fixed	Medium ((	5	2	1		50						0.2	Reverse	Off	59.9
5	2017-Sep-	3604284	471854.9	53.027	2	0	TODD	CB66B ROI	4.2	RTK Fixed	Medium ((	5	2	1		50						0.2	Reverse	Off	60.2
6	2017-Sep-	3604284	471854.9	53.025	2	0	TODD	CB66B ROI	3.7	RTK Fixed	Medium ((	5	2	1		50						0.2	Reverse	Off	60.2
7	2017-Sep-	3604285	471854.9	53.014	2	0	TODD	CB66B ROI	4.5	RTK Fixed	Medium ((	5	2	1		50						0.2	Reverse	Off	60.1
8	2017-Sep-	3604285	471854.9	53.01	2	0	TODD	CB66B ROI	5.4	RTK Fixed	Medium ((	5	2	1		50						0.2	Reverse	Off	60
9	2017-Sep-	3604285	471854.9	53.015	2	0	TODD	CB66B ROI	4.6	RTK Fixed	Medium ((	5	2	1		50						0.2	Reverse	Off	60
10	2017-Sep-	3604286	471854.9	53.012	1	0	TODD	CB66B ROI	4.4	RTK Fixed	Medium ((	5	1	1		50						0.2	Reverse	Off	60
11	2017-Sep-	3604286	471854.9	52.992	1	0	TODD	CB66B ROI	4.6	RTK Fixed	Medium ((	5	1	1		50						0.2	Reverse	Off	60
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13	2017-Sep-	3604287	471854.9	53.006	1	0	TODD	CB66B ROI	6	RTK Fixed	Medium ((	5	1	1		50						0.2	Reverse	Off	60
14	2017-Sep-	3604287	471854.9	52.991	1	0	TODD	CB66B ROI	5	RTK Fixed	Medium ((	5	1	1		50						0.2	Reverse	Off	60
15	2017-Sep-	3604287	471854.9	52.995	1	0	TODD	CB66B ROI	4.4	RTK Fixed	Medium ((	5	1	1		50						0.2	Reverse	Off	59.9
16	2017-Sep-	3604288	471854.9	52.982	1	0	TODD	CB66B ROI	4.4	RTK Fixed	Medium ((	5	1	1		50						0.2	Reverse	Off	59.9
17	2017-Sep-	3604288	471854.9	52.977	1	0	TODD	CB66B ROI	4.6	RTK Fixed	Medium ((	5	1	1		50						0.2	Reverse	Off	59.8
18	2017-Sep-	3604288	471854.9	52.972	1	0	TODD	CB66B ROI	4.6	RTK Fixed	Medium ((	5	1	1		50						0.2	Reverse	Off	59.8
19	2017-Sep-	3604289	471854.9	52.965	1	0	TODD	CB66B ROI	4.4	RTK Fixed	Medium ((	5	1	1		50						0.2	Reverse	Off	59.8
20	2017-Sep-	3604289	471854.9	52.969	1	0	TODD	CB66B ROI	5.4	RTK Fixed	Medium ((	5	1	1		50						0.2	Reverse	Off	59.8
21	2017-Sep-	3604290	471854.9	52.968	1	0	TODD	CB66B ROI	4.1	RTK Fixed	Medium ((	5	1	1		50						0.2	Reverse	Off	59.8
22	2017-Sep-	3604290	471854.9	52.97	1	0	TODD	CB66B ROI	4.9	RTK Fixed	Medium ((	5	1	1		50						0.2	Reverse	Off	59.8
23	2017-Sep-	3604290	471854.9	52.966	1	0	TODD	CB66B ROI	5.1	RTK Fixed	Medium ((	5	1	1		50						0.2	Reverse	Off	59.8

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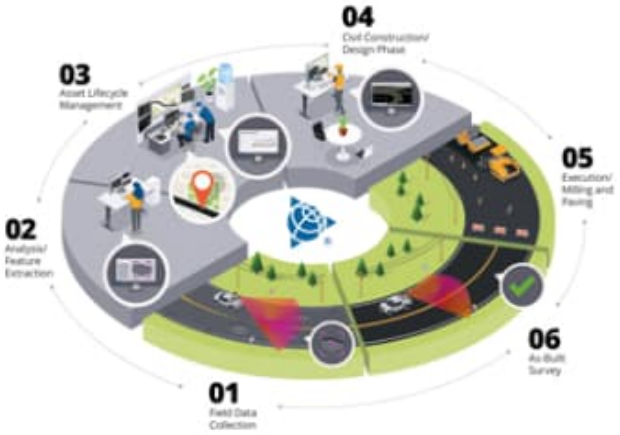
Intelligent Compaction to As-Built Workflow

1. Collect data
2. Validate data
3. Process and merge
4. Integrate with other project data
5. Export final digital as-built package



Courtesy: Trimble

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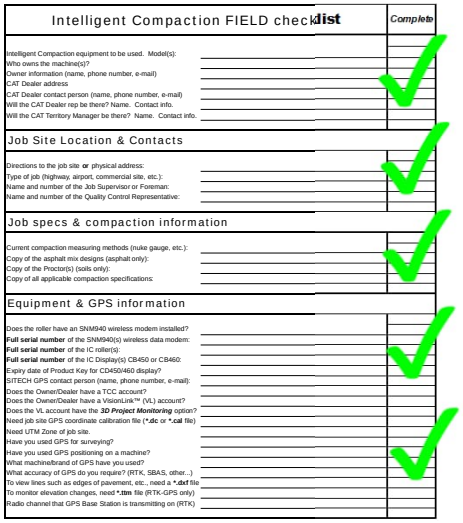
13

Step 1: Data Collection

- Daily roller logs
- GNSS accuracy checks
- Machine setup verification
- Standardized file formats (e.g., VETA)
  - File-naming convention **AASHTO MP 39-19**
  - Data file format **AASHTO PP 114-21**



Intelligent Compaction FIELD checklist — Complete

Intelligent Compaction equipment to be used. Model(s):
Who owns the machine(s)?
Owner information (name, phone number, e-mail)
CAT Dealer address
CAT Dealer contact person (name, phone number, e-mail)
Will the CAT Dealer rep be there? Name. Contact info.
Will the CAT Territory Manager be there? Name. Contact info.

Job Site Location & Contacts

Directions to the job site **or** physical address:
Type of job (highway, airport, commercial site, etc.):
Name and number of the Job Supervisor or Foreman:
Name and number of the Quality Control Representative:

Job specs & compaction information

Current compaction measuring methods (nuke gauge, etc.):
Copy of the asphalt mix designs (asphalt only):
Copy of the Proctor(s) (soils only):
Copy of all applicable compaction specifications:

Equipment & GPS information

Does the roller have an SNM940 wireless modem installed?
Full serial number of the SNM940(s) wireless data modem:
Full serial number of the IC roller(s):
Full serial number of the IC Display(s) CB450 or CB460:
Expiry date of Product Key for CD450/460 display?
SITECH GPS contact person (name, phone number, e-mail):
Does the Owner/Dealer have a TCC account?
Does the Owner/Dealer have a VisionLink™ (VL) account?
Does the VL account have the **3D *Project Monitoring*** option?
Need job site GPS coordinate calibration file (***.dc** or ***.cal** file)
Need UTM Zone of job site.
Have you used GPS for surveying?
Have you used GPS positioning on a machine?
What machine/brand of GPS have you used?
What accuracy of GPS do you require? (RTK, SBAS, other...)
To view lines such as edges of pavement, etc., need a ***.dxf** file
To monitor elevation changes, need ***.tin** file (RTK-GPS only)
Radio channel that GPS Base Station is transmitting on (RTK)

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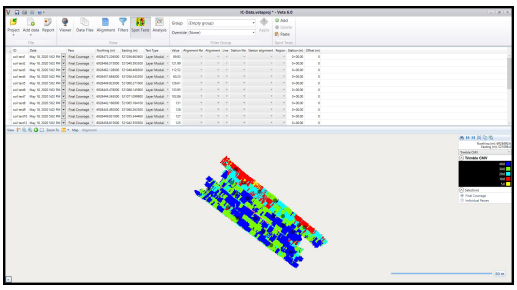
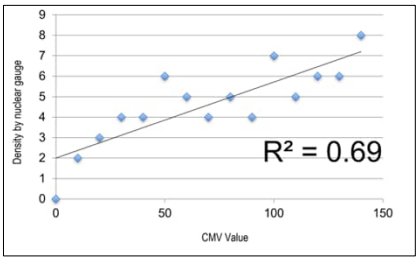
Step 2: Data Validation

- Remove bad GPS segments
- Identify coverage gaps
- Confirm vibration mode
- Temperature verification
- Compare IC values to spot tests
- CFR 637.203 ??





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15

Step 3: Data Processing

Veta INTELLIGENT CONSTRUCTION

- Merge multiple rollers of different manufacturers, positions in the rolling train (asphalt), etc.
  - "overlay" map
- Segment by lift and station
  - Importance of good file-naming convention!
- Generate maps and summaries
- OEMs have their own software – but <u>not standardized</u>

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Step 4: Integration with other Data

- Material tickets
- Conventional density spot tests
- Inspection reports
- Drone surveys (optional)
- BIM/GIS systems
- Paver thermal data
- *Digital as-builts are most powerful when IC data is combined with other project information!*

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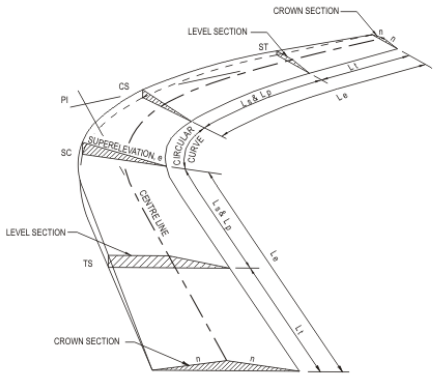
Step 5: Final Digital As-Built Package

- Pass Count/Coverage maps
  - Roller pass sequence
- Temperature maps
- ICMV maps
  - QA/QC spot-test correlations
- Surface and individual layer elevations



Guide Policy for Geometric Design of Freeways and Expressways - NAASRA 1976

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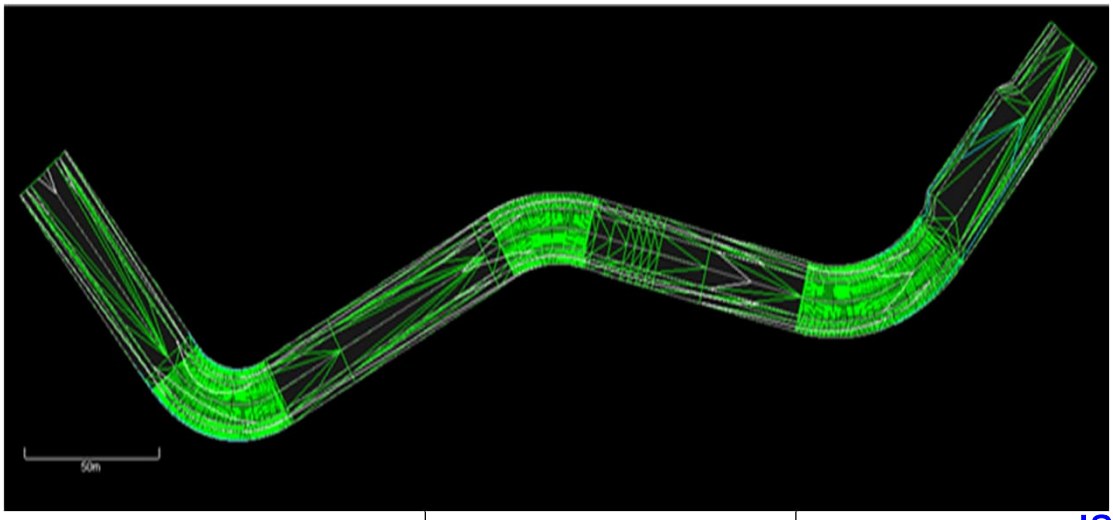
Final Compaction Digital As-Built



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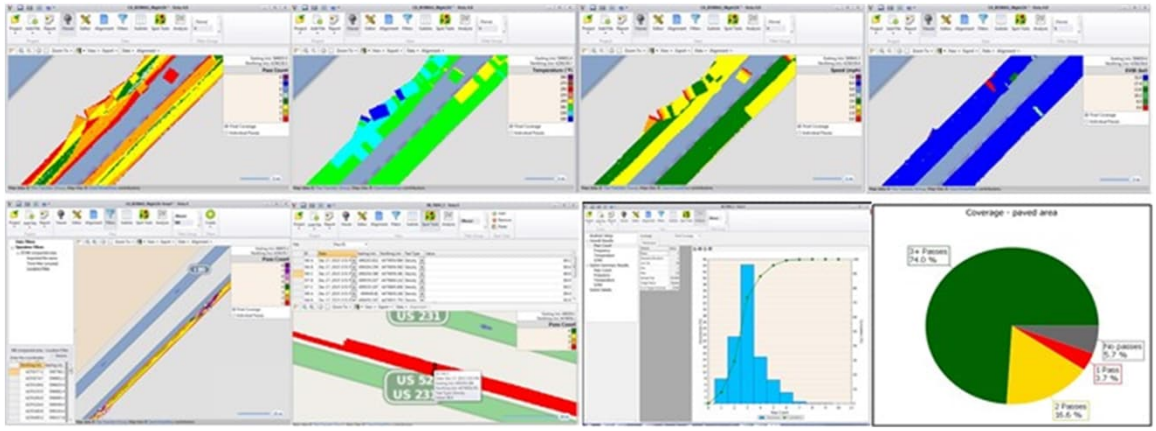
19

Where Do We View, Analyze & Merge Data?

- **Jobsite** – Bluetooth from machine to Inspector, QC
- **Jobsite or Office** through Veta software

Veta
INTELLIGENT CONSTRUCTION



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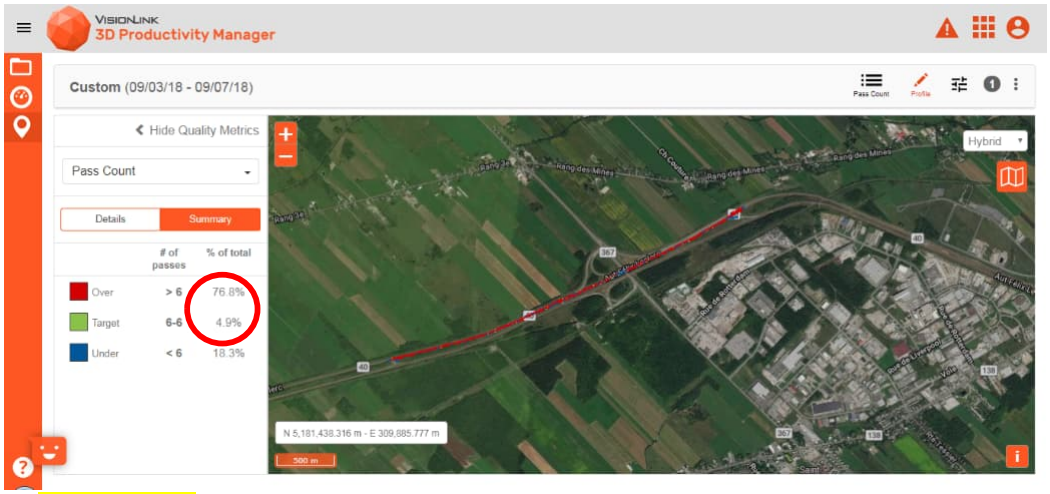
Pass Count: Not Using Mapping



- All rollers 83% > target pass (6)

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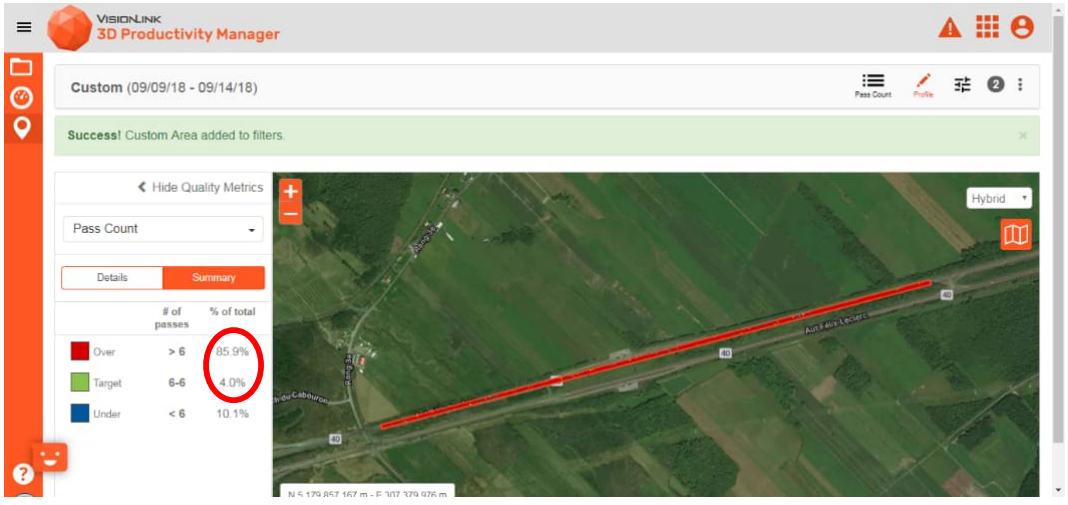
Pass Count: Using Mapping



- All rollers 90% > target pass (6)

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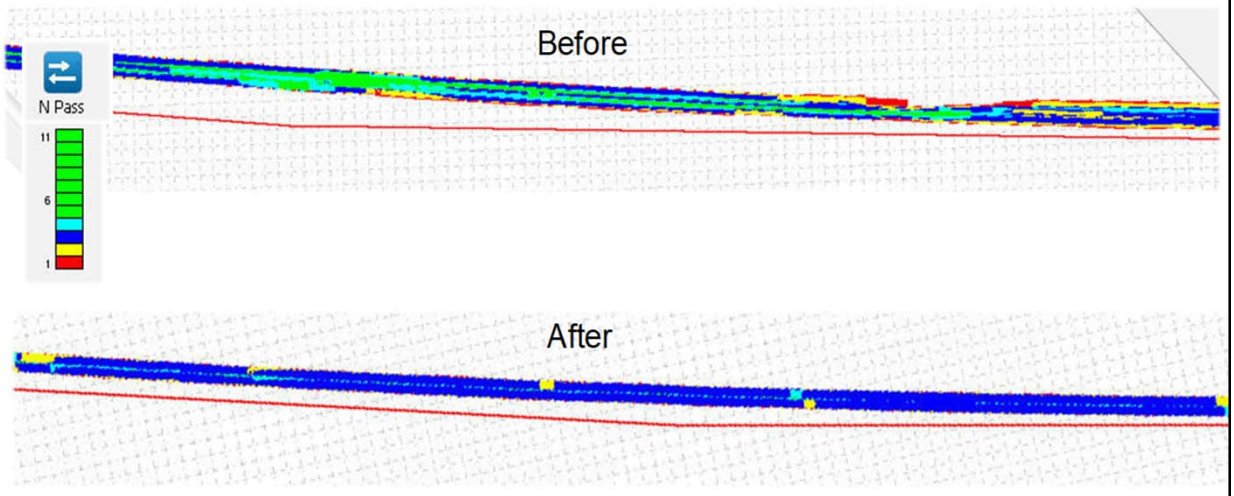
Before & After IC - Consistency!!



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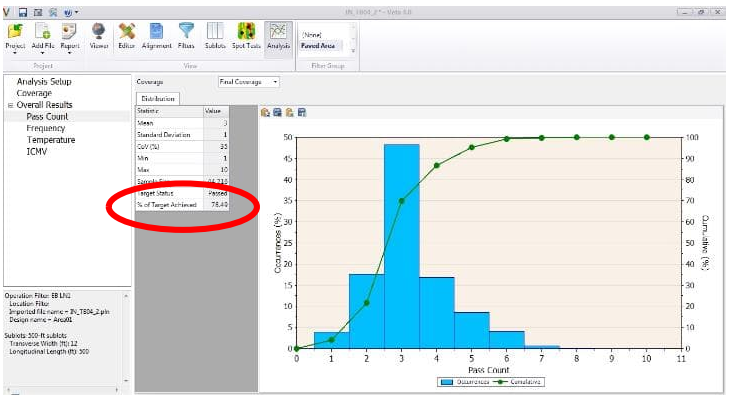
Determining % Coverage in VETA



- % Coverage can be determined by:
  1. Creating Filters in VETA
  2. Manually trimming data in VL before exporting
  3. Having roller operator manually turn mapping “on” or “off” when he/she leaves the ‘IC Area’

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Uniform Pass Count

- Meet required number of passes per test strip or method spec
- Uniformity of Compaction - PWL specifications
- Roller Speed
  - Is the roller able to keep up with paver and get 10 - 14 ipf ?
  - Do I need another roller? Change frequency? Amplitude?
  - Does paver need to slow down?
- Training tool for operators to see their pattern

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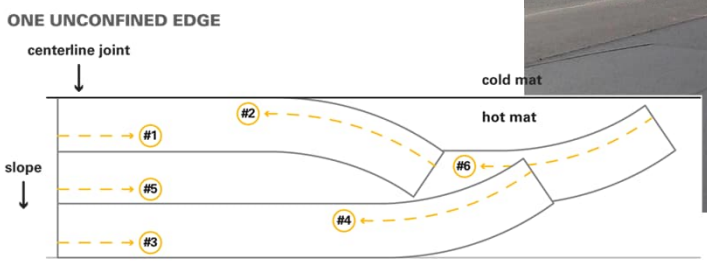
Rolling Pattern Training Tool

- Turning out at end of pass
- Direct correlation to smoothness (IRI)



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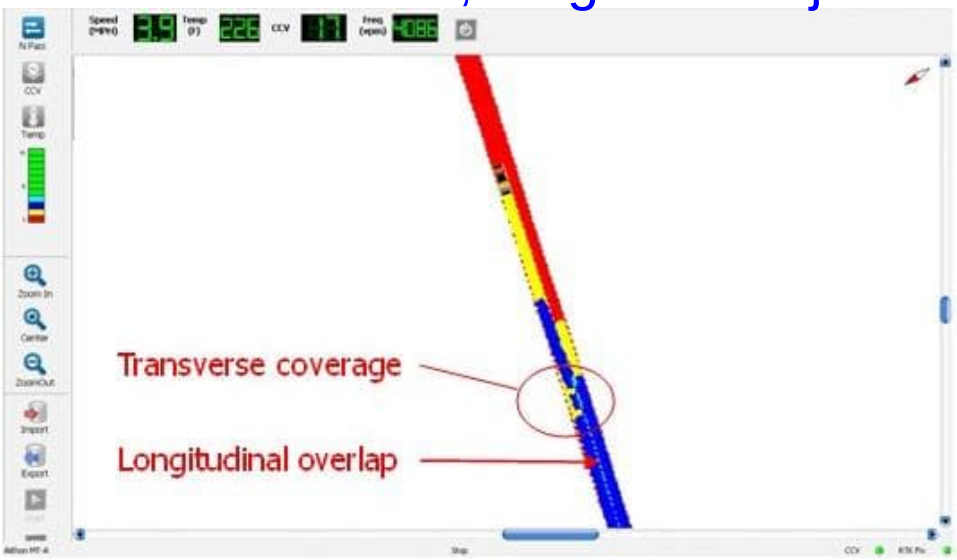
Transition zones, longitudinal joints



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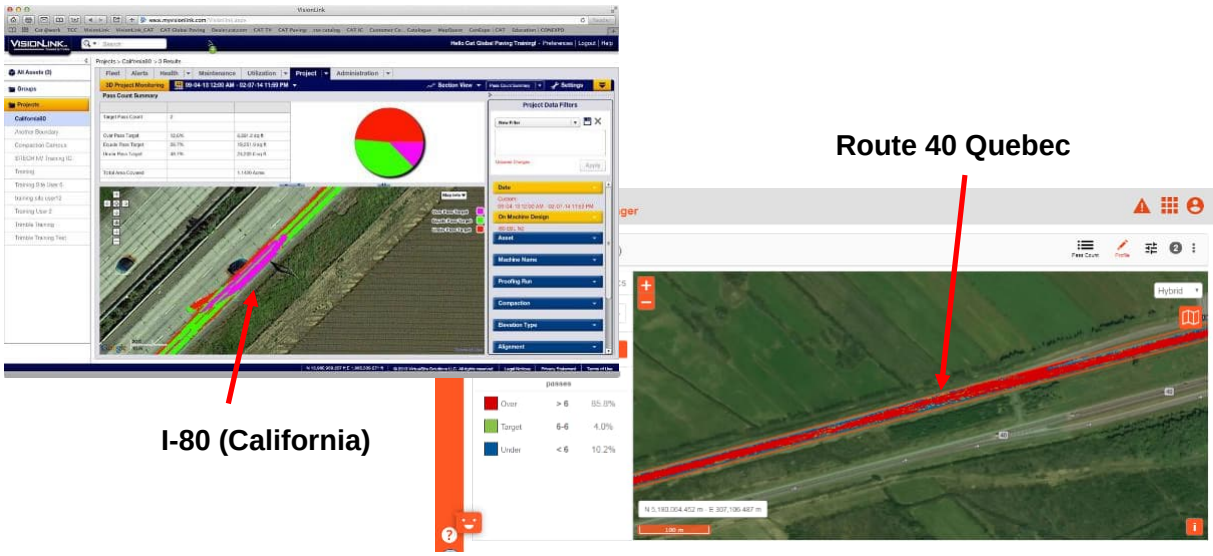
Transition Zones



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Night vision - “the back pass”

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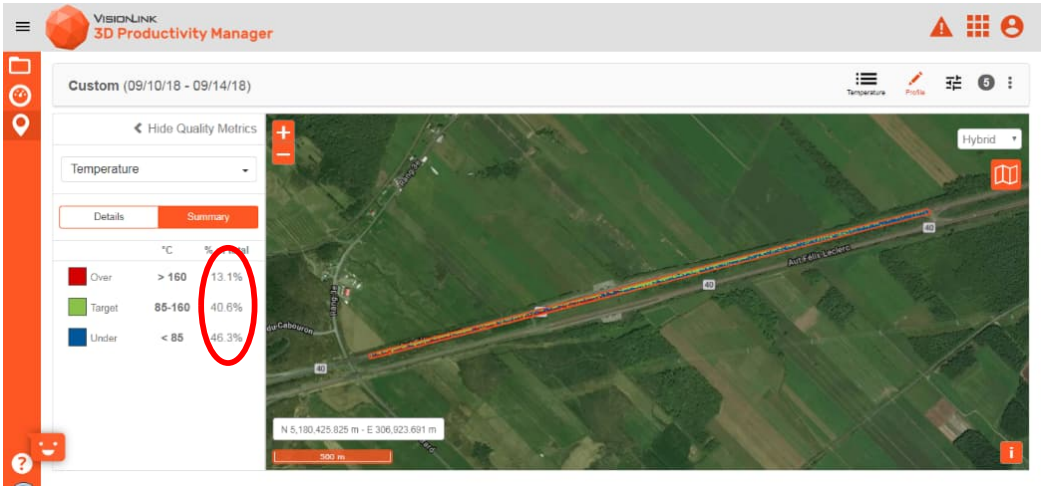
Temp: 1st pass breakdown



- Data indicates long breakdown passes
- Difficult to know without being on site and without plan file

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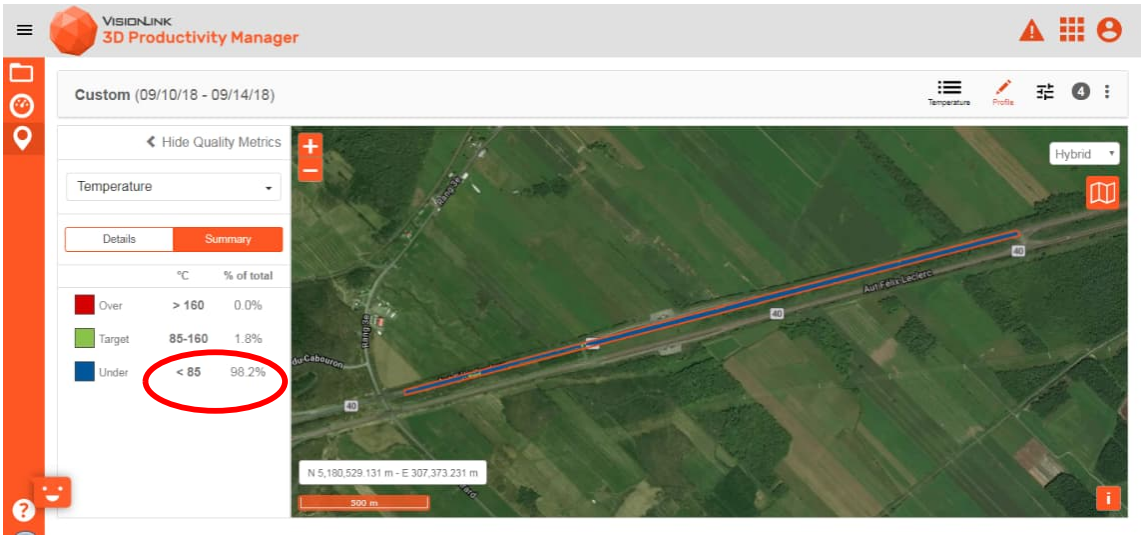
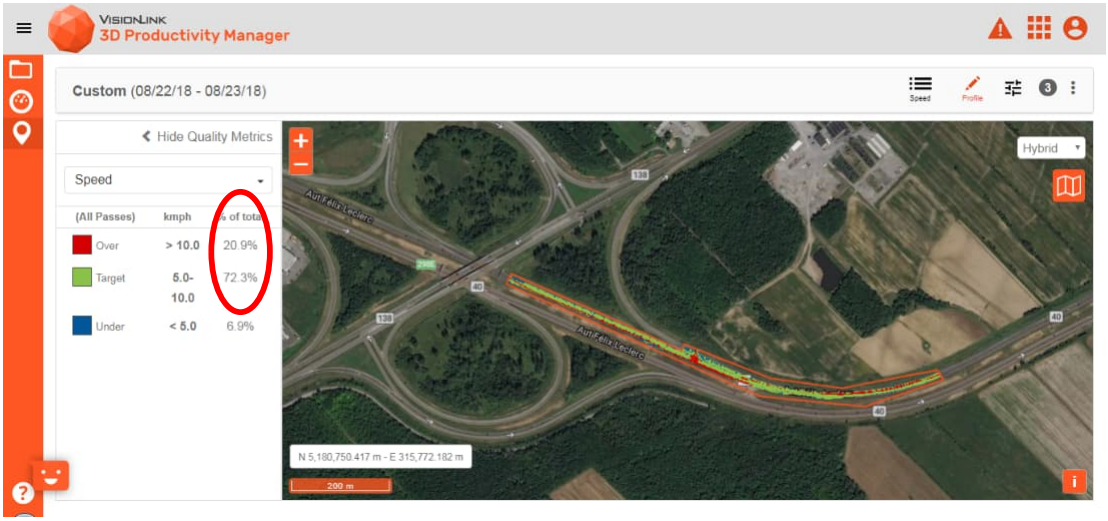
Temperature: last pass finish



31

Speed: Smoothness & Density



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Roller Speed should be 10 - 14 ipf

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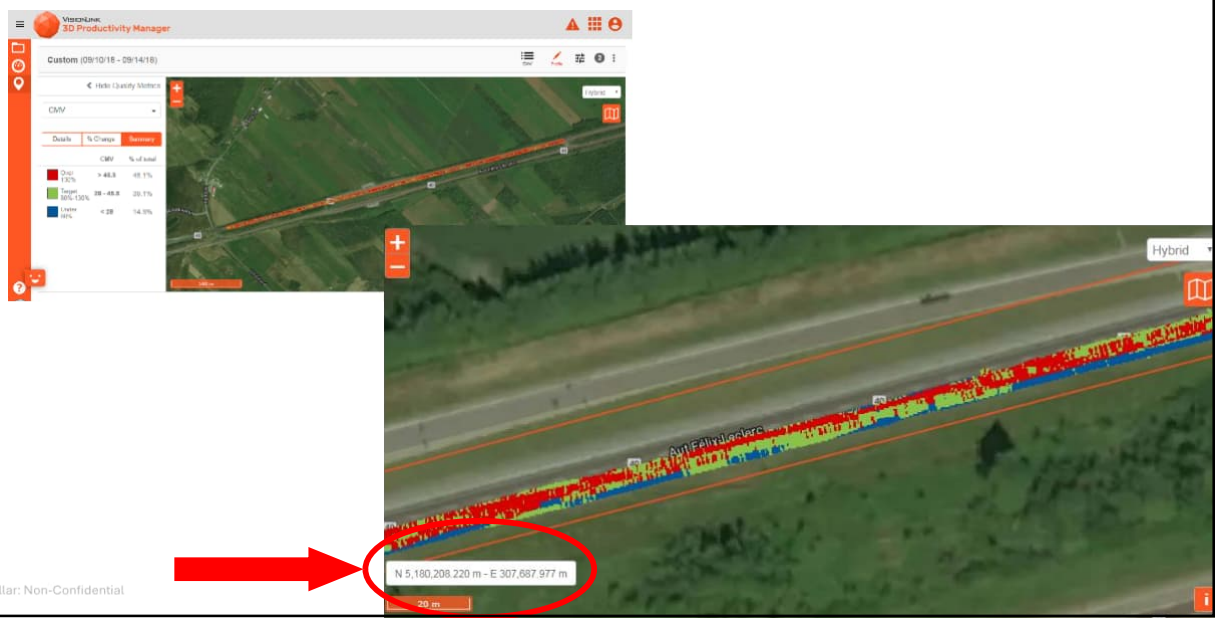
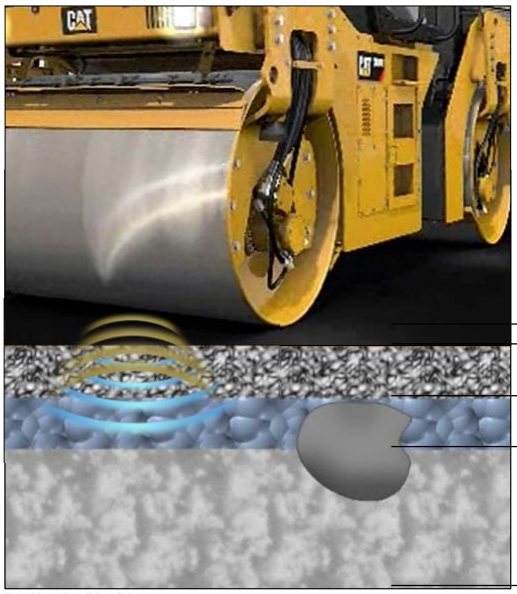
ICMV (accelerometer value)



34

Remember...ICMV measures deep...



- CMV value is a *composite* measurement
- Affected by amplitude, speed, direction, etc.

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Correlation of ICMV with existing test methods

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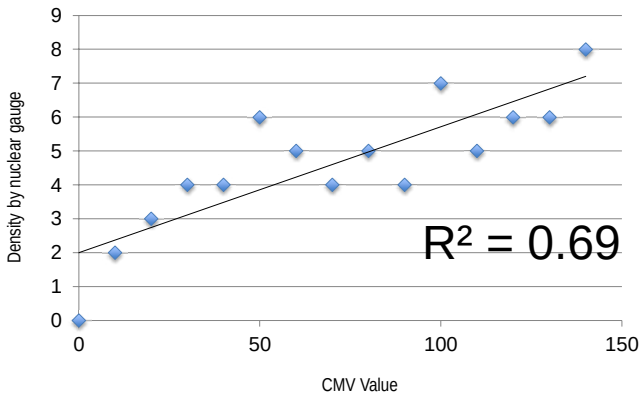
Correlating ICMV with existing test methods



- Plot a linear regression analysis of the conventional test data and the CMV data to establish an R^2 value
- R^2 is an indication of how well CMV represents the density or stiffness data measured using conventional methods
- Repeatable correlations between ICMV and density have not been proven

R^2 = 1.00 = perfect correlation

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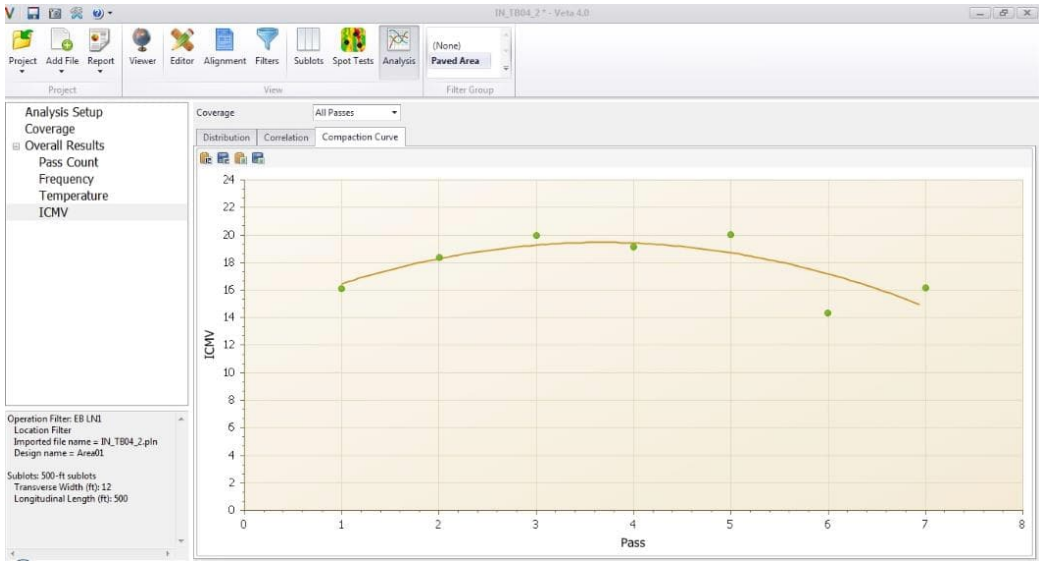
Compaction Curve in VETA



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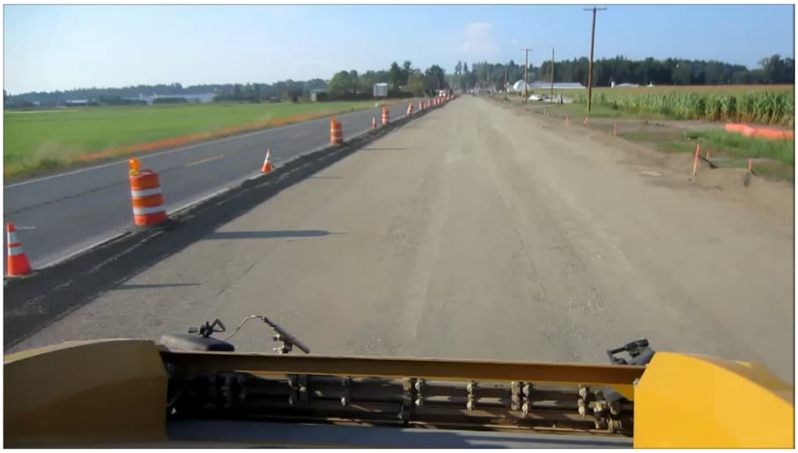
Pre-mapping to find soft areas



- Can be done in one pass
- ICMVs obtained to identify relative weak areas prior to paving
- Depth and extent of “soft spot” is difficult to identify

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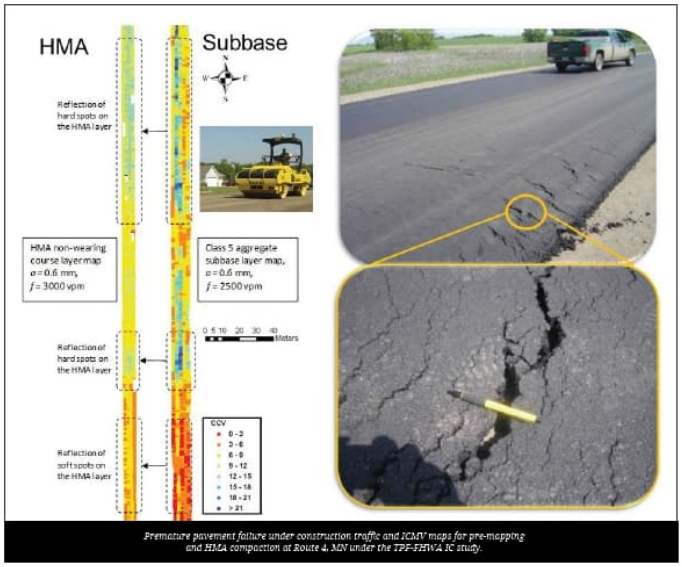
Pre-Mapping in Minnesota



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Roller-mounted GPR (DPS) – TPF-5 (443)

https://www.dot.state.mn.us/materials/dps/index.html

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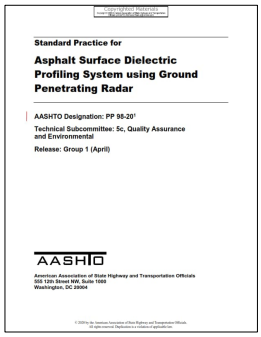
Roller-Mounted GPR

https://www.dot.state.mn.us/materials/dps/index.html

- Density read-out “on-the-fly” in real-time!
- Can be an indicator of segregated of mix
- Must be calibrated to mix type and lift thickness
  - Relatively easy process
- Becoming more understood!



Standard Practice for

Asphalt Surface Dielectric Profiling System using Ground Penetrating Radar

AASHTO Designation: PP 98-20[1]

Technical Subcommittee: 5c, Quality Assurance and Environmental

Release: Group 1 (April)

AASHTO

American Association of State Highway and Transportation Officials
555 12th Street NW, Suite 1000
Washington, DC 20004

Image: Trimble

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DAB Information Could Eliminate Coring

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Machine to Machine Data Sharing

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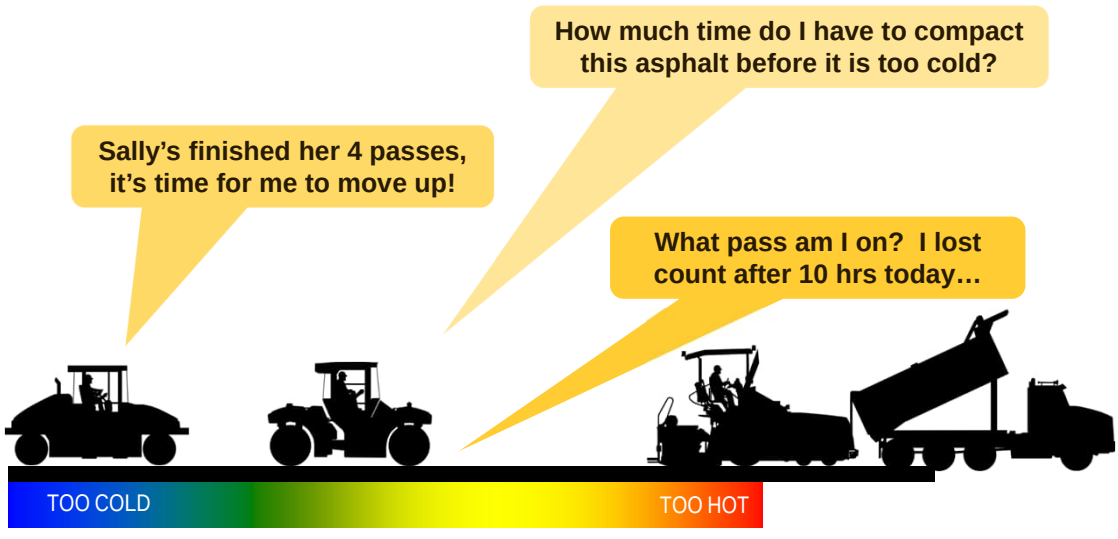
Real-time IC information I can work with!!



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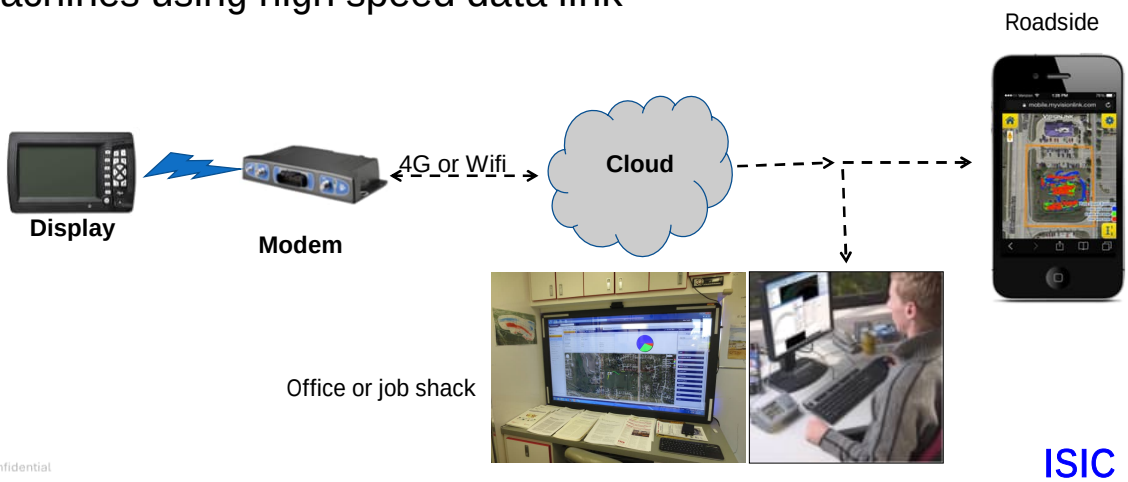
IC High Speed Data Sync

Much faster wireless sync to/from office and machines using high speed data link



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The Power of Combining Data !

DPS Dielectric Values

PMTP Thermal Profile

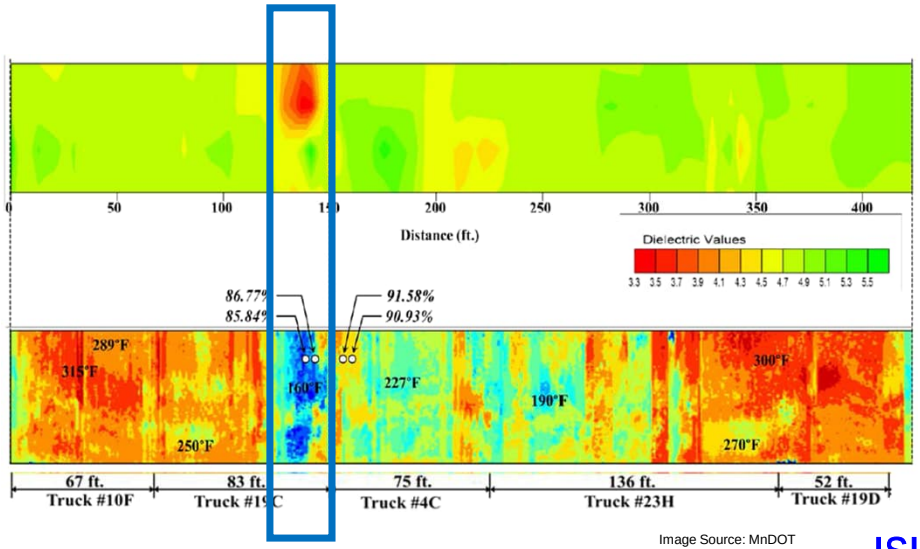

Image Source: MnDOT

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Summary: What IC can and cannot do...

- Can record coverage (passes)
- Can record surface temperature
- Can identify relative “soft spots” at depth unknown
- Can record accurate locations
- Cannot measure density using accelerometer
- Can measure density using GPR ??...or can it ??.....

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Summarizing the benefits of IC

- Information that is “actionable” in real-time on the job
- Operator – self-training and self-monitoring tool
- Uniform coverage = better density & smoothness = bonus pay
- Transition zones
- Statistical pay factor specs PWL - consistency!
- Night work
- Temperature monitoring
- Longitudinal joint overlap/joint density
- Identifying relative soft spots in base
- Reduced field testing – safety/cost
- Documentation of 100% of compaction
- Density using GPR ??

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Faster Project Close-out

- Digital data allows for some automated checks, summaries, reducing or eliminating hand calculations
- Easier to keep up with daily progress
- Less paperwork at the end of a project
- Faster hand-off to the Owner
- Get paid faster

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Common Challenges

- GNSS accuracy issues
- Inconsistent data file naming – Use **AASHTO MP39-19**
- Data format (for VETA) – Use **AASHTO PP114-21**
- Lack of training on both data collection and workflow
- Clarity of existing specs in conjunction with new technology(s)
- Understanding the limitations and advantages of GPR
  - *Continuous Asphalt Mixture Compaction Assessment Using Density Profiling System (DPS) [TPF-5(443)]*

https://www.dot.state.mn.us/materials/dps/index.html

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How to Manage Challenges

- Pre-construction coordination meeting
- Standardized workflows
- Clear roles and responsibilities and reporting frequency
- Early coordination with the Owner
- Specification updates with technology – alignment!
  - Specs pay based on cores, but monitor/measure 100% coverage
  - Clarity on how the Contractor will get paid

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The Future of IC Digital As-Builts

- IC digital as-builts will become standard
- DAB integration with digital twins will continue to expand
- IC DAB data will be in Pavement Management System(s)
- IC DAB data helps mitigate risk for both Owner & Contractor
- Goes “hand-in-hand” on the Roadmap to Autonomy

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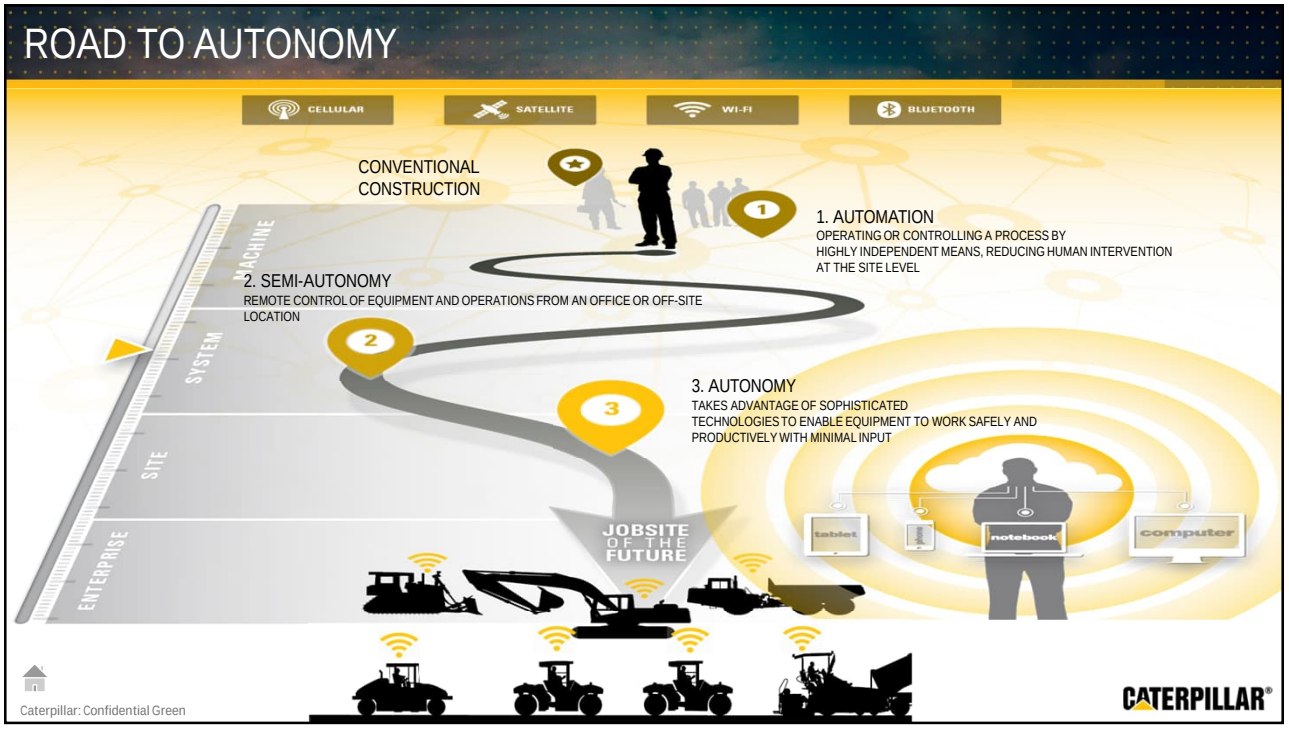

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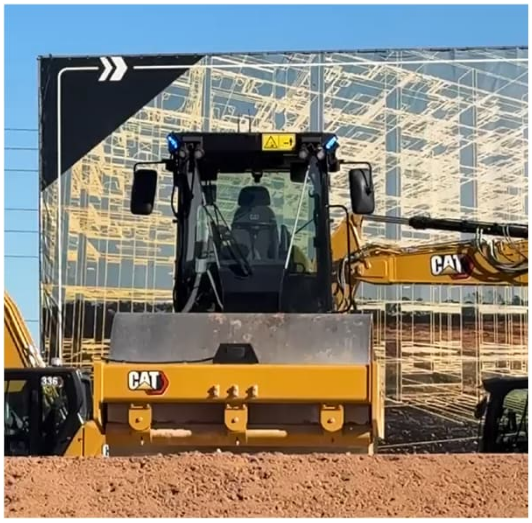
Autonomous Everything !?!?!?

Starting to combine automated measuring with autonomous operation and wireless, real-time data collection!!



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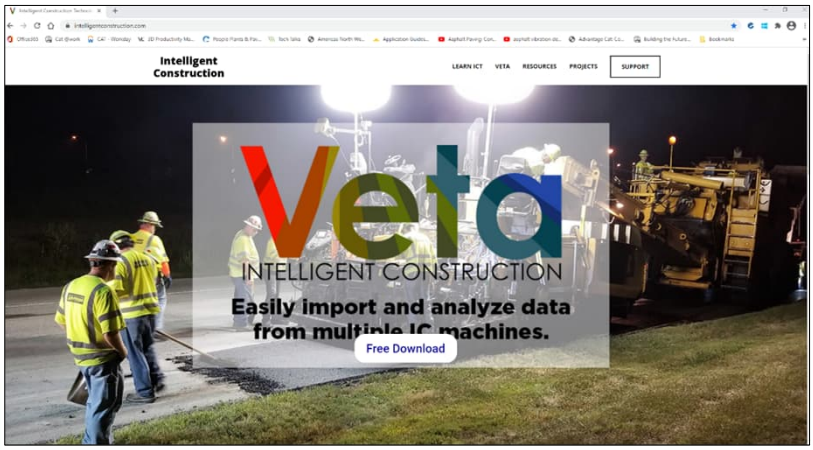
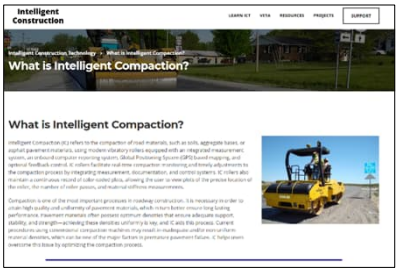
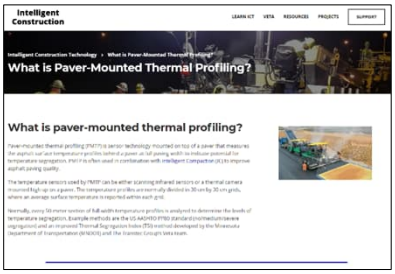
Where to go for IC & Veta software

www.intelligentconstruction.com







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Key Takeaways

- IC provides 100% coverage, objective data
- Integration is achievable with today's tools (VETA)
- The industry is moving toward full digital delivery and IC is one part of that journey
- Digital as-builts improve quality and reduce risk

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THANK YOU!

SCAN HERE

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DAB for Living Models in Asset and Pavement Management Systems

Jim Preston Topcon
and
Chuck Hixon Stantec

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1

Solving your challenges with today's technology

What do we do with all this data.....

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2

Digital Twin

- multiple definitions & perceptions
- multiple uses
- think beyond the initial task
- reverse engineer

A digital representation of a physical asset, process or system, in the built or natural environment, that connects and communicates with its physical counterpart to drive optimum value throughout the lifecycle

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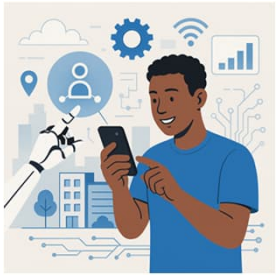

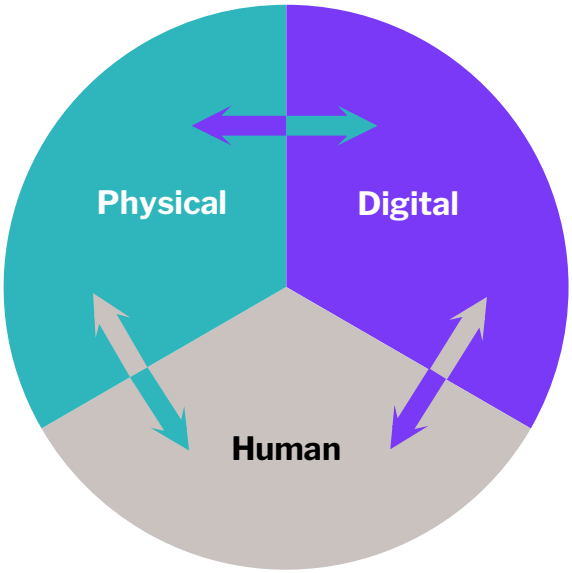

The key: essential that the enterprise and the people within it, are structured, organized and incentivized in a way that maximizes its' use.

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The twin starts with the existing system and evolves

What do you want to achieve? What data do you have?

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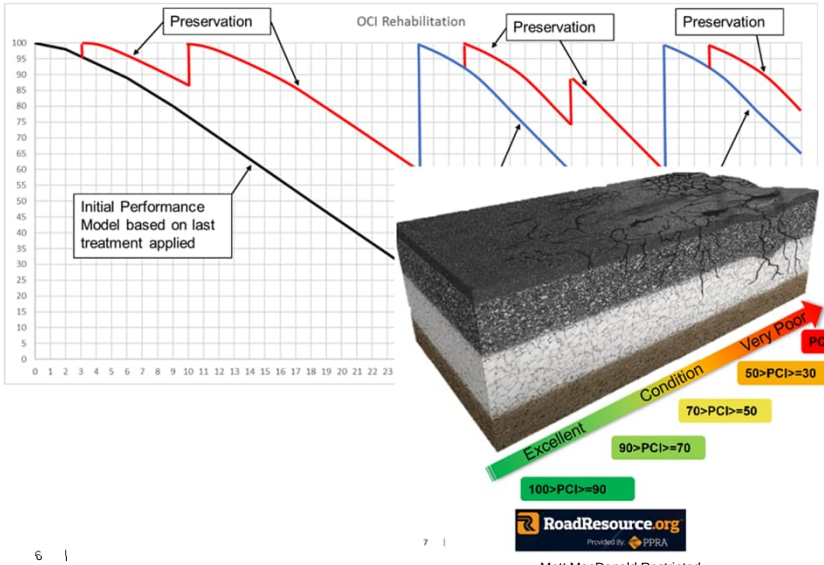
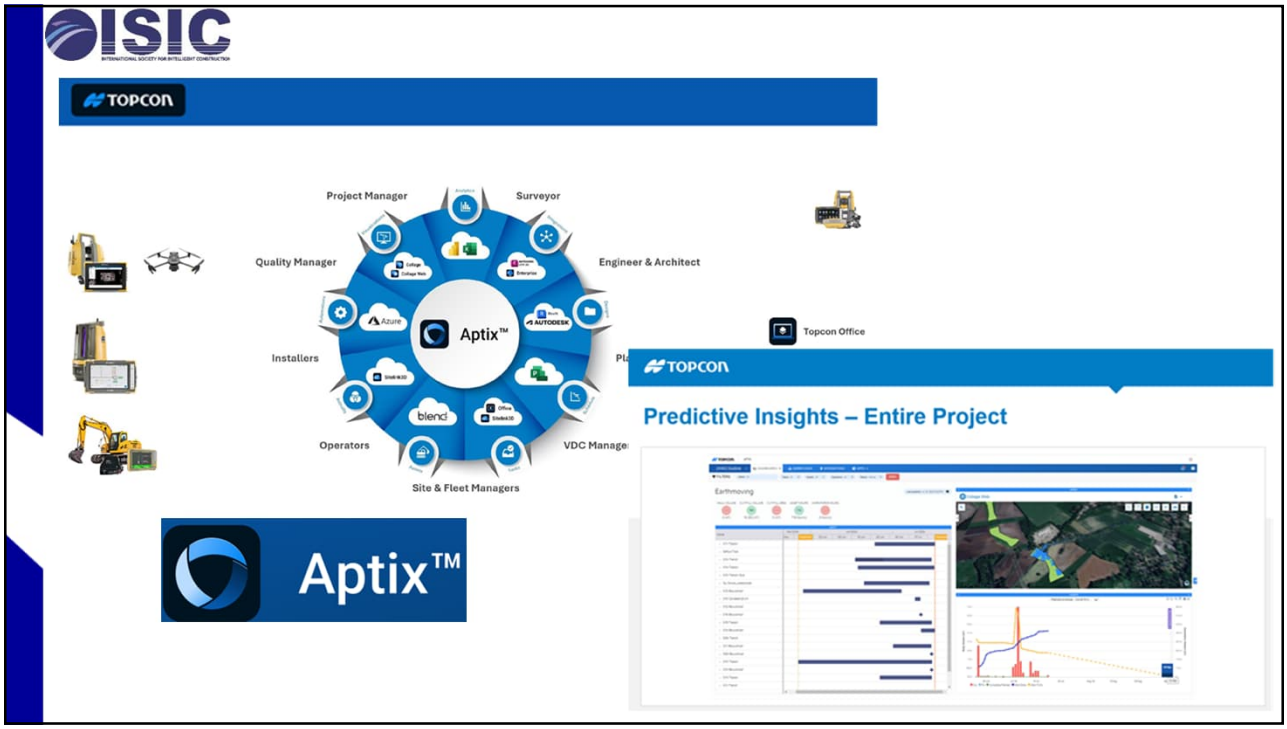
Pavement Management Concept

Your Goal – your data to achieve it



Mott MacDonald Restricted

6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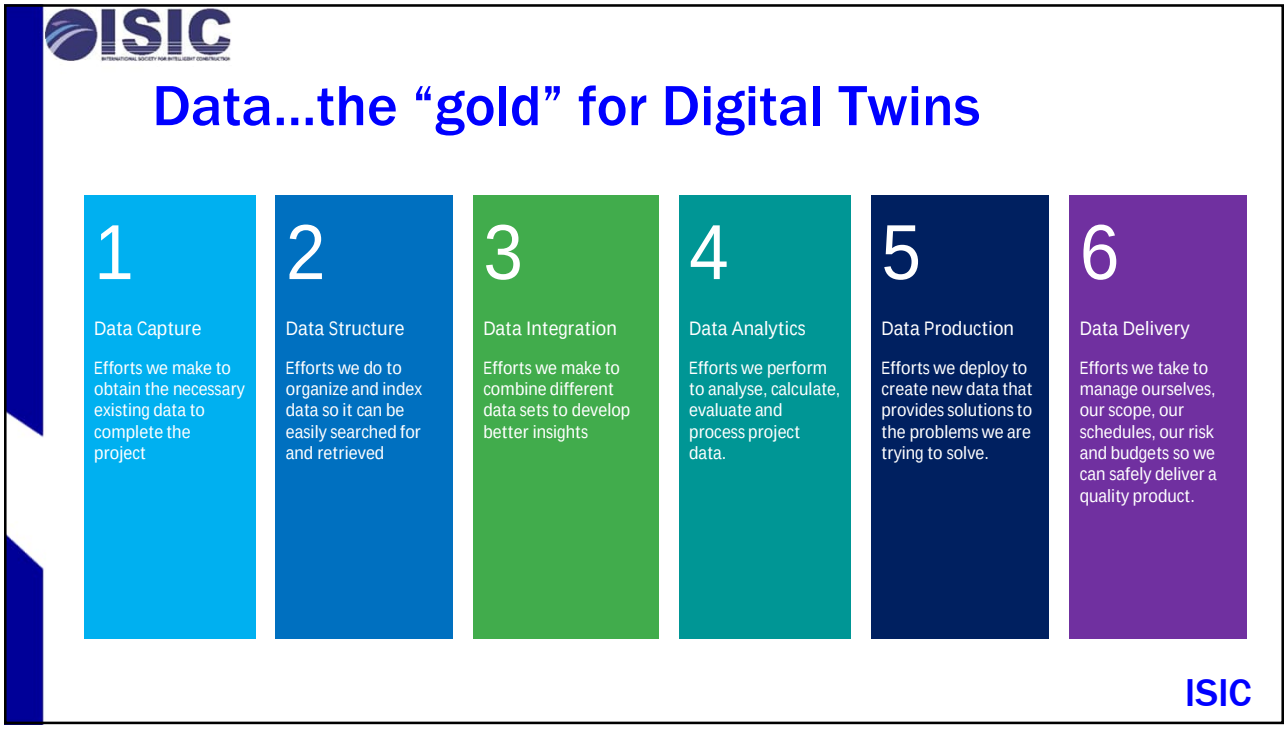
TOPCON
Project Manager
Surveyor
Quality Manager
Engineer & Architect
Aptix™
Installers
Operators
VDC Manager
Site & Fleet Managers
Topcon Office
TOPCON
Predictive Insights – Entire Project
Aptix™

7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Data...the "gold" for Digital Twins
1
Data Capture
Efforts we make to obtain the necessary existing data to complete the project
2
Data Structure
Efforts we do to organize and index data so it can be easily searched for and retrieved
3
Data Integration
Efforts we make to combine different data sets to develop better insights
4
Data Analytics
Efforts we perform to analyse, calculate, evaluate and process project data.
5
Data Production
Efforts we deploy to create new data that provides solutions to the problems we are trying to solve.
6
Data Delivery
Efforts we take to manage ourselves, our scope, our schedules, our risk and budgets so we can safely deliver a quality product.
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Data…the digital footprint

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9

Mining your data “gold” to build impactful digital twins

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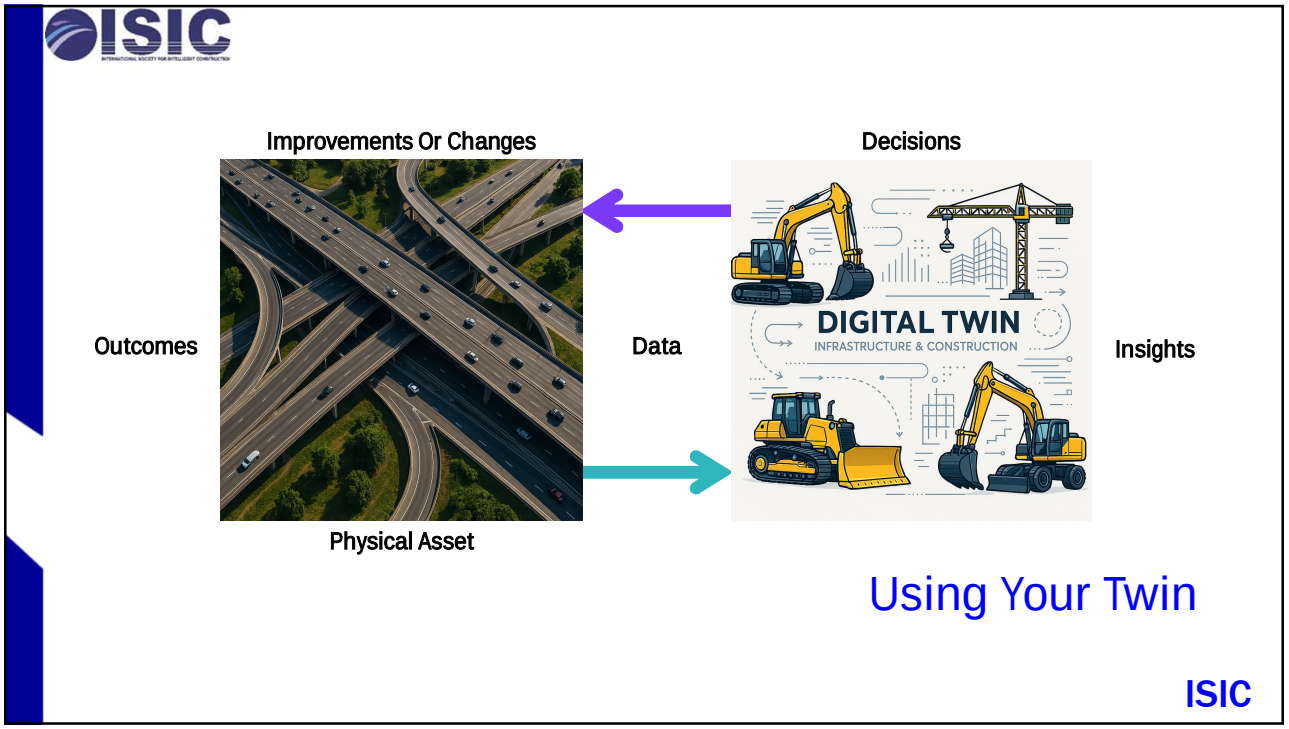
Improvements Or Changes
Decisions
Outcomes
Data
Insights
DIGITAL TWIN
INFRASTRUCTURE & CONSTRUCTION
Physical Asset
Using Your Twin
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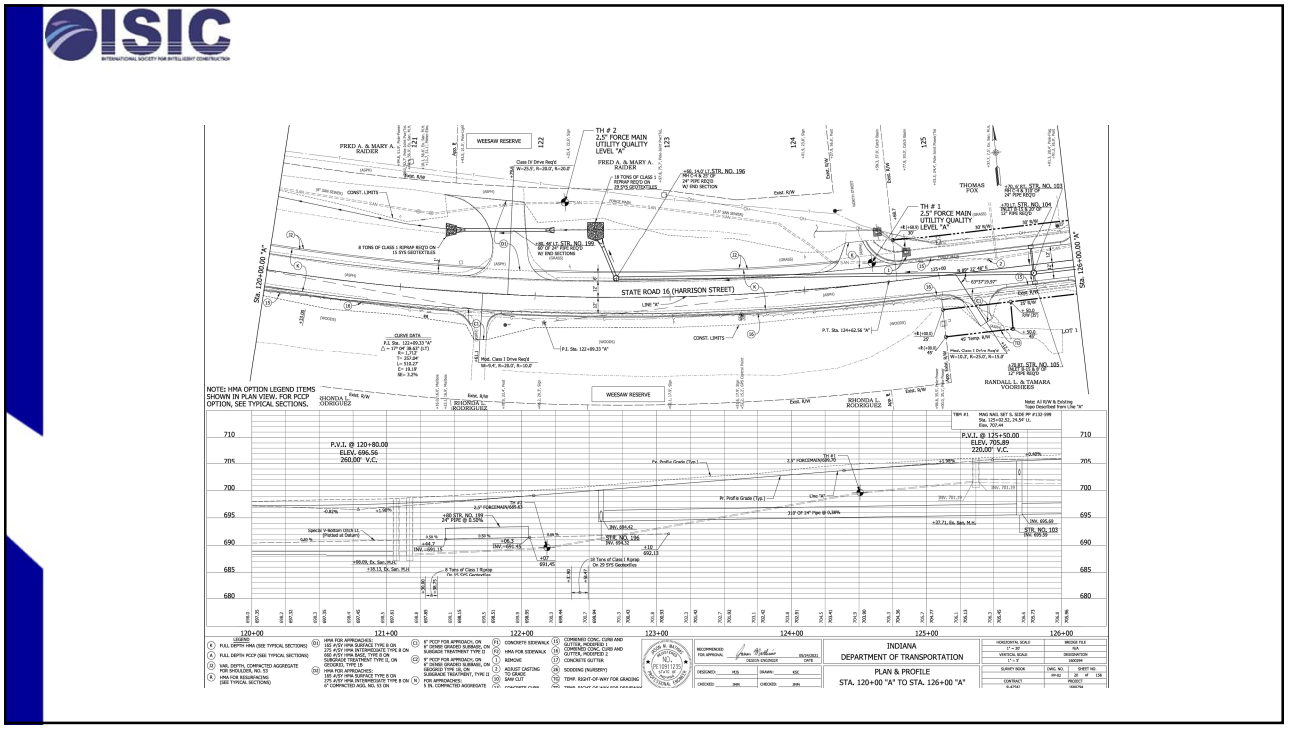
11


STATE ROAD 16 (HARRISON STREET)
INDIANA
DEPARTMENT OF TRANSPORTATION
PLAN & PROFILE
STA. 120+00 "A" TO STA. 126+00 "A"

12

Earthwork Subgrade

- Earthwork begins once the project has staked
- The site will be balanced which moves material from cut areas to fill areas.
- Additional material may be need to be added or removed to accommodate the vertical profile
- Rough grading will further outline the shape of the proposed roadway
- Cross slopes will be added to rough grading to assist drainage and reduce other material usage

13

Grade Check

- Grades will be check and verified for the entire project
- Checking grades is an important process to verify
  - Proper elevation are met
  - Proper material usage
  - Tie ins and matching fixtures
  - QC/QA

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Subbase

- A subbase layer will be placed on the subgrade layer and also have a membrane barrier place over the subgrade
- This provide stabilization, drainage and will be fine graded for pre-leveling
- It critical that the subbase layer is as smooth and accurate as possible to reduce additional layer material usage.
- Continuous grade checks are strongly recommended.

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Paving

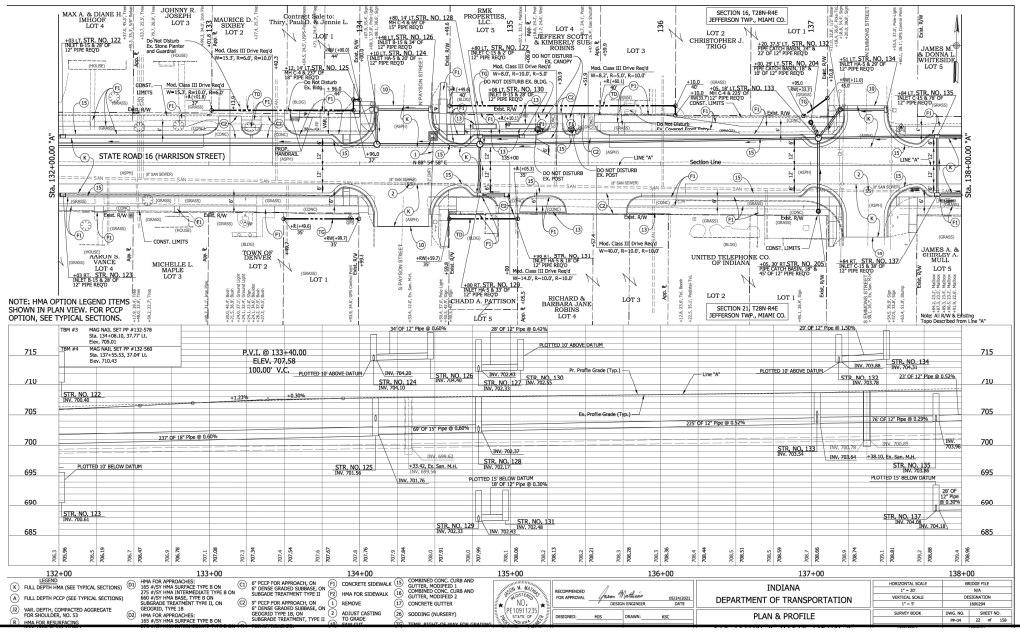
- Asphalt pavers are designed with a self leveling screed and will create the smoothest surface possible
- Concrete pavers have fixed screed that place material to a specific depth regardless of the subbase or base course
- Asphalt and/or concrete can be used for either base or wearing course
- Grade and slope verification needs to be constantly monitored

16

Inspection

- Grades will be check and verified for the entire project
- Checking grades is an important process to verify
  - Proper elevation are met
  - Proper material usage
  - Tie ins and matching fixtures
  - QC/QA

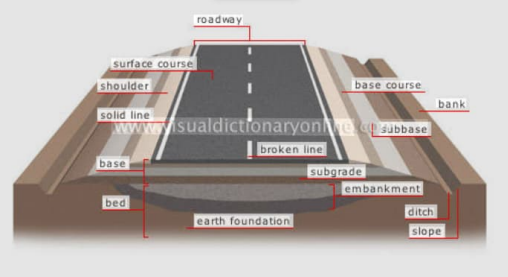
17

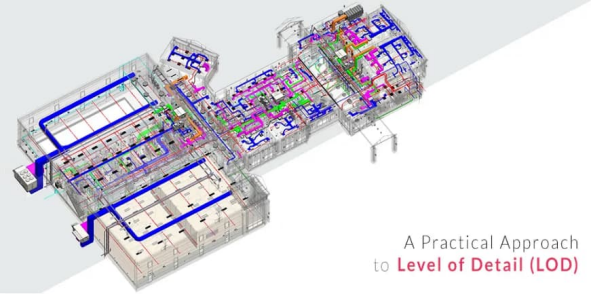


18

Level of Detail

What LOD is adequate and what data collection equipment should be used?





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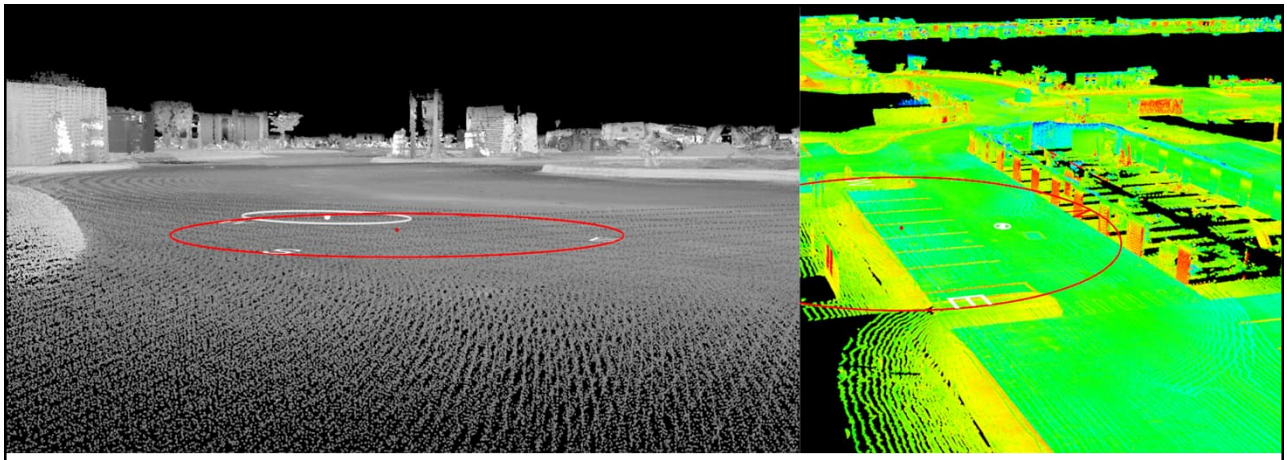
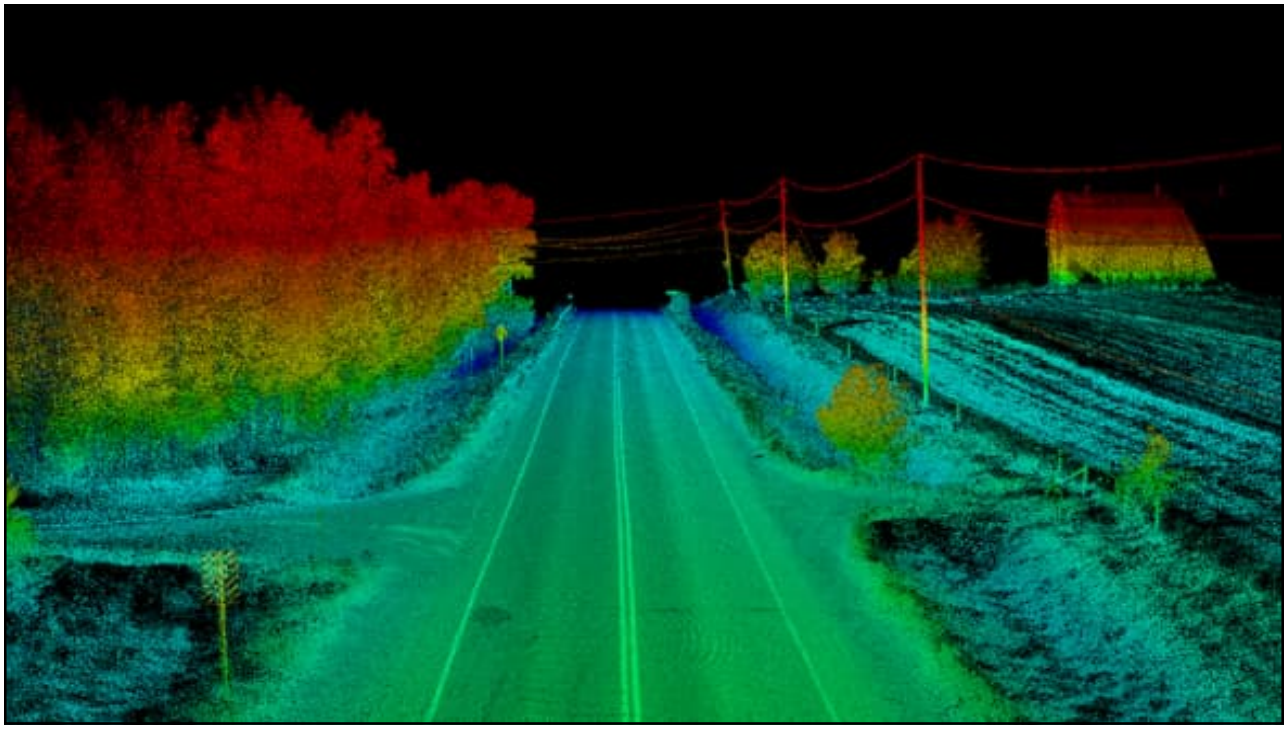


Data Processing and Management

20



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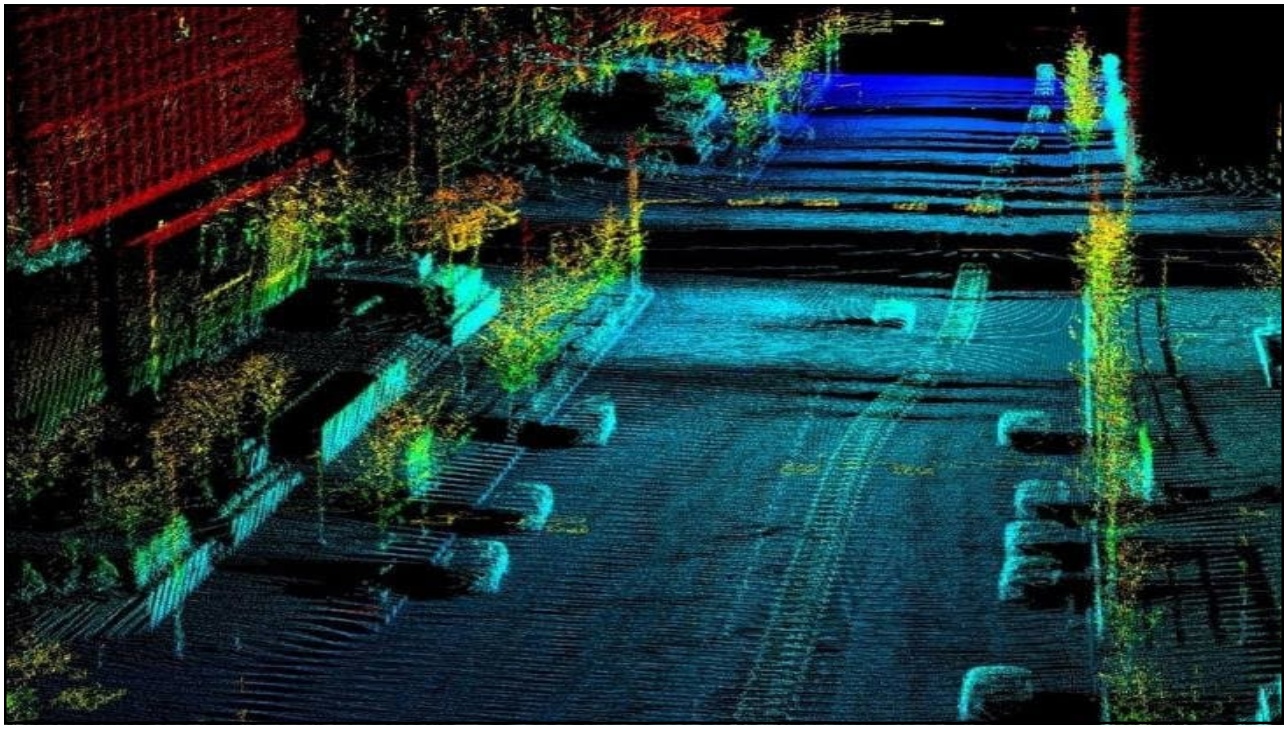

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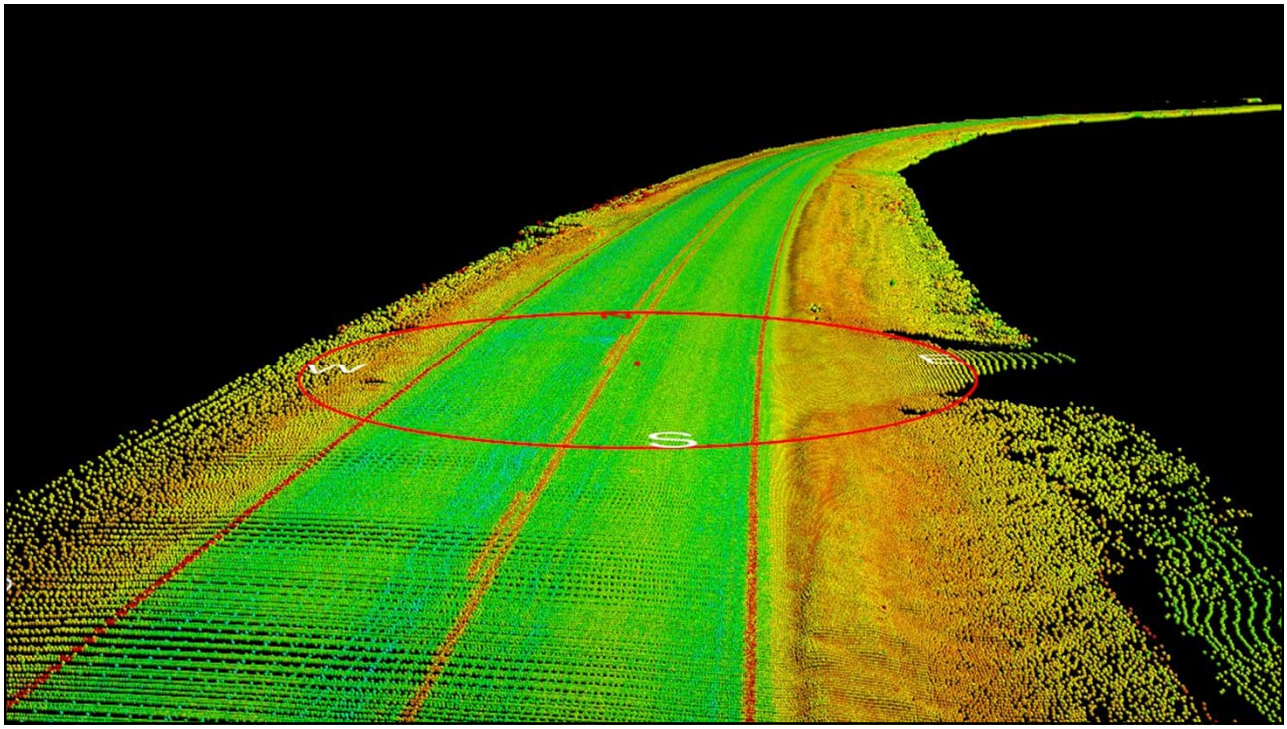

23

Thank you

Questions?

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MARCH 18-20 2026
MINNESOTA TRANSPORTATION CONFERENCE & EXPO

ISIC Track
Digital As-Built (DAB) and Workflow of Pavement Construction

Wednesday, March 18th, 2026 - Room 13,14,15

By

International Society for Intelligent Construction (ISIC)

IS-IC.ORG

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ISIC Track 07
DAB for Improving Construction QC and QA

By

Amanda Gilliland (Transtec-Terracon) and Scott Fernald (Granite Construction)

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Speakers Introduction

Amanda Gilliland
Transtec-Terracon

Scott Fernald
Granite Construction

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Learning Objectives

- Recognize how DAB supports construction QC/QA
- Understand key DAB data sources (PMTP, IC, DPS)
- Use DAB data to trace issues back to construction operations
- Review real-world QC/QA case studies
- Learn from contractor experience using DAB in the field

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Outline

- Recap on DAB/ICT Data Sources
- Construction QC/QA Case Studies
- Contractor's Experiences
- Q&A

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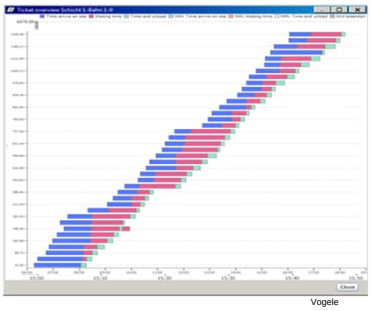
Background on Data Sources

6

MDMS (Expanded E-Ticketing)

Material Delivery Management System

E-ticketing +



Vogele

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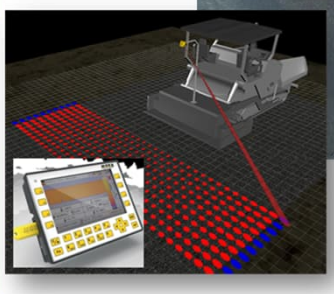
PMTP

Paver-Mounted Thermal Profiler



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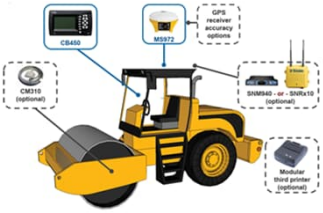
IC

Intelligent **C**ompaction

Source: MOBA



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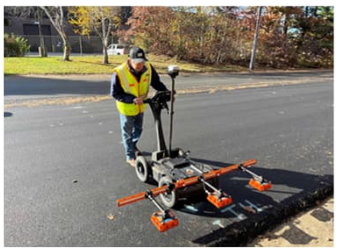
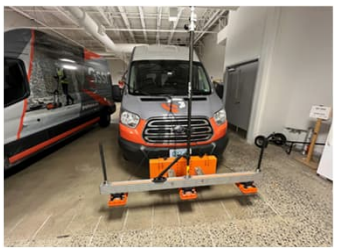
DPS

Dielectric **P**rofiling **S**ystem





Dielectric

to

Asphalt Densities

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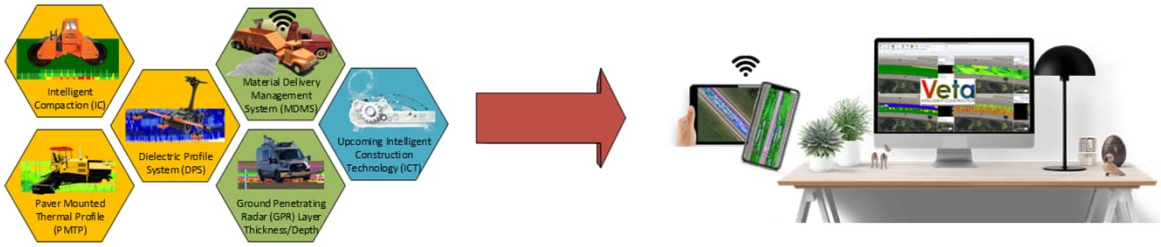
Leverage with Veta ICT Software

Veta
INTELLIGENT CONSTRUCTION

AASHTO-Compliant



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Outline

- Recap on DAB/ICT Data Sources
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- Q&A

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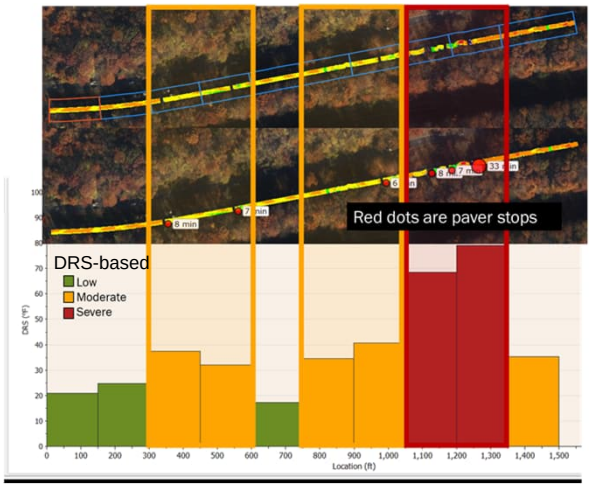
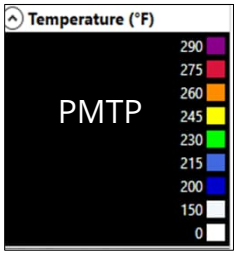
Paver Stops and Thermal Segregation





Source: Transtec Group

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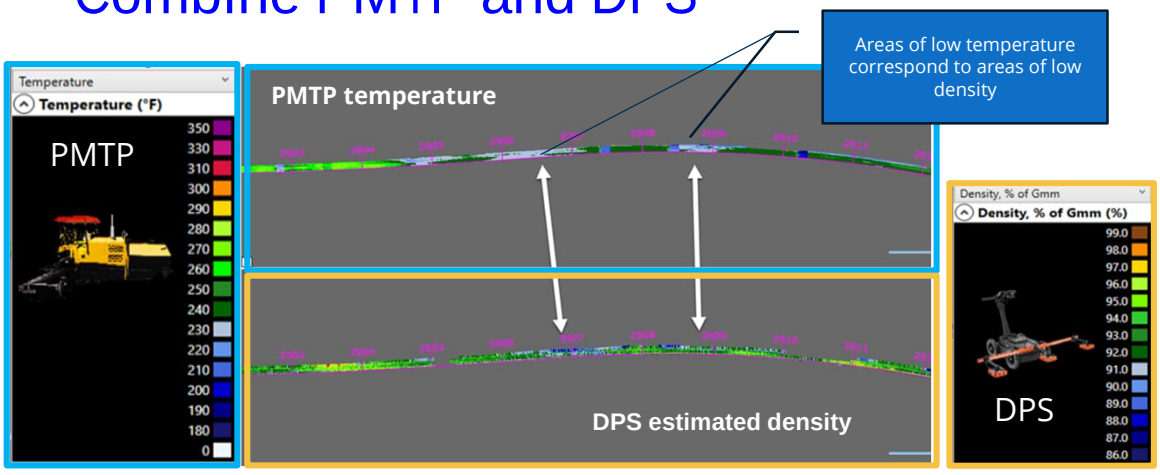
Combine PMTP and DPS



Source: ISIC

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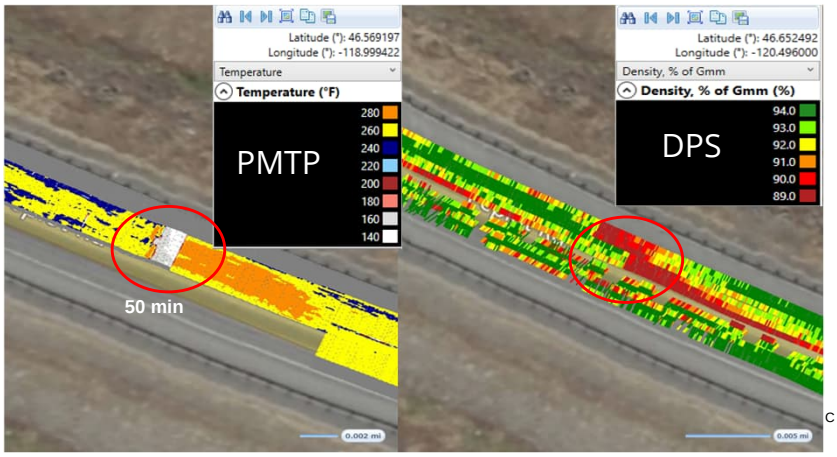
Combine PMTP and DPS (Cont'd)



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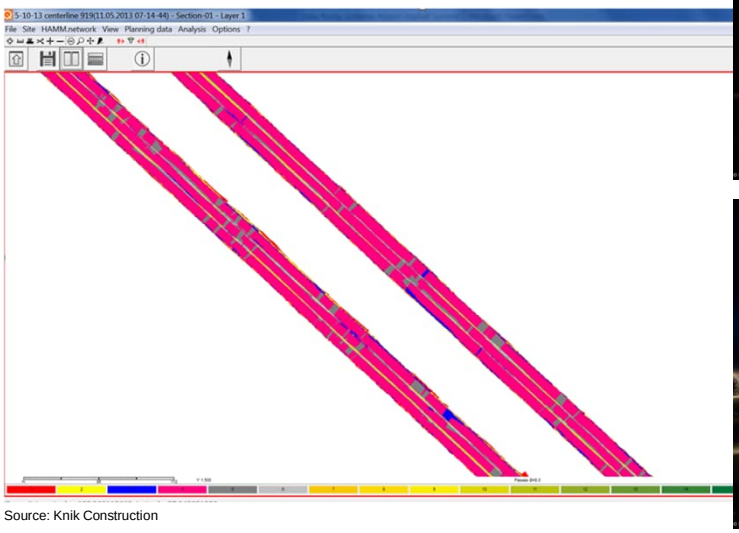
IC – Nighttime Paving



Source: Knik Construction

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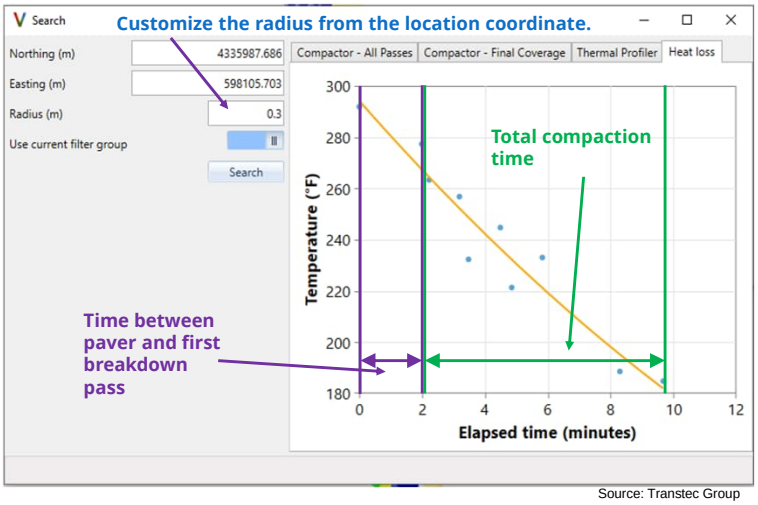
Combine PMTP and IC



Source: Transtec Group

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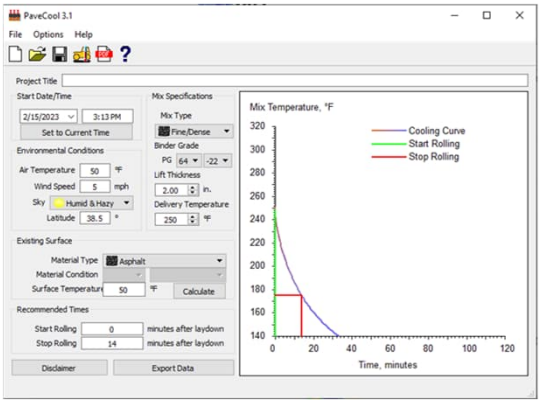
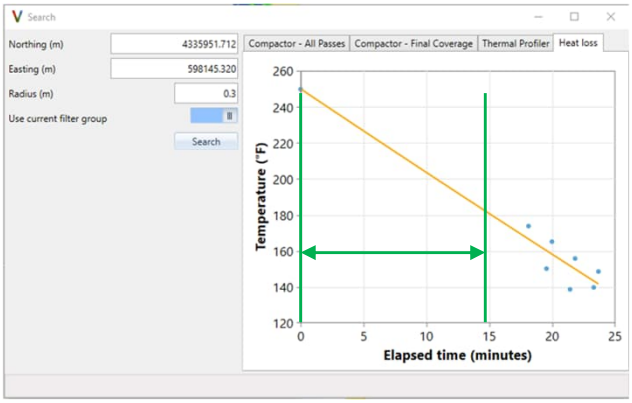
Target Compaction Time Window

Low core density in isolated locations on project – what is the cause?



Source: MnDOT



Source: Transtec Group

Compaction occurs outside the recommended window.

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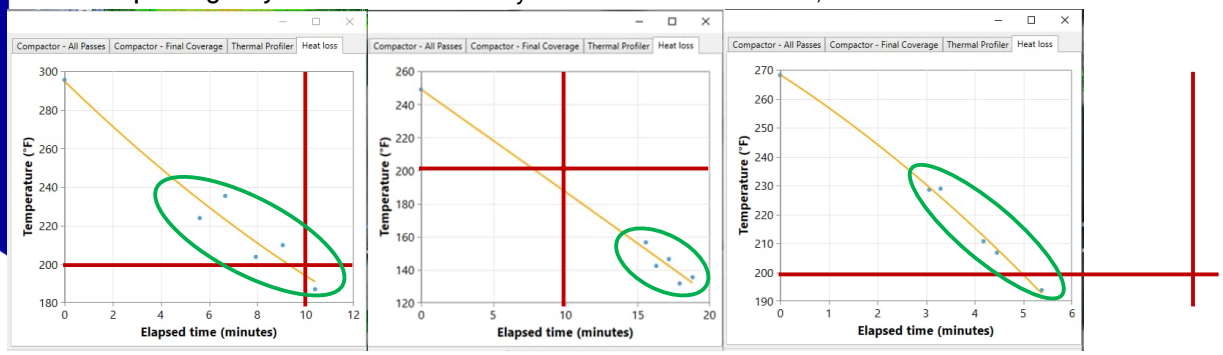
Balanced Rolling Patterns

Same paving day

Axes vary - reference bars at 200ºF, 10 minutes



~300ºF at the paver
Start rolling at:
- ~5 minutes after paver
- ~230ºF

~250ºF at the paver
Start rolling at:
- ~15 minutes after paver
- ~160ºF

~270ºF at the paver
Start rolling at:
- ~3 minutes after paver
- ~230ºF

Source: Transtec Group

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Balanced Paving - Accountability

Production | Trucking | Paving | Compaction

Balancing the Paving Operation

Source: Asphalt Institute

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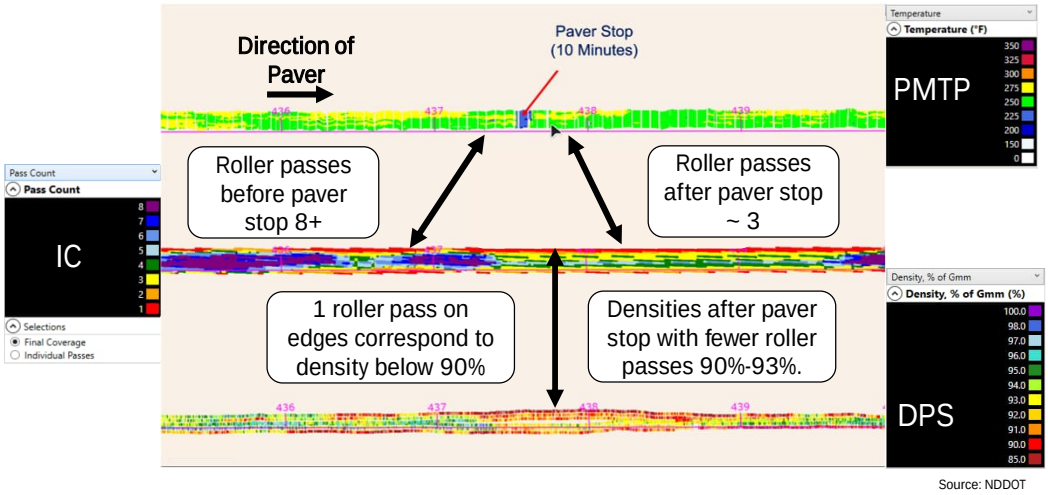
Combining PMTP, IC, and DPS



Source: NDDOT

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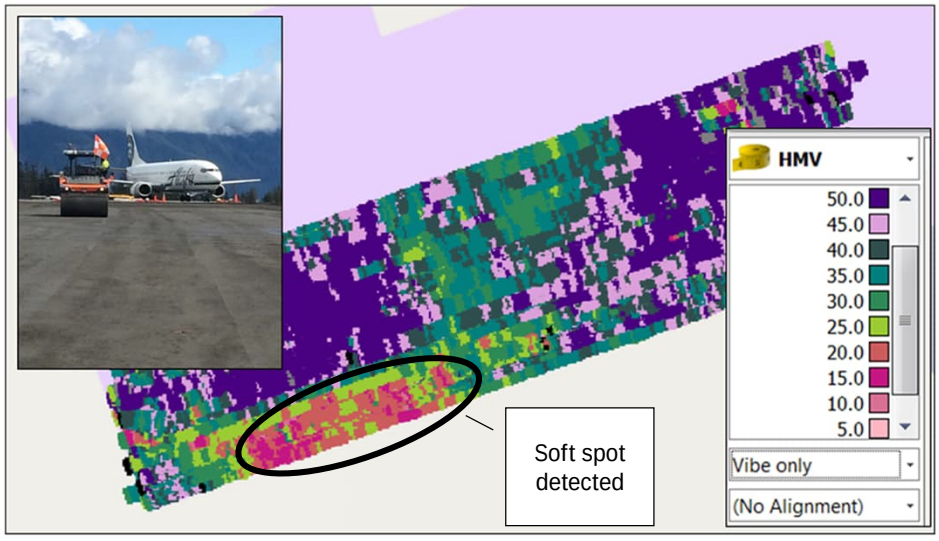
IC - Pre-Mapping



Source: Knik Construction

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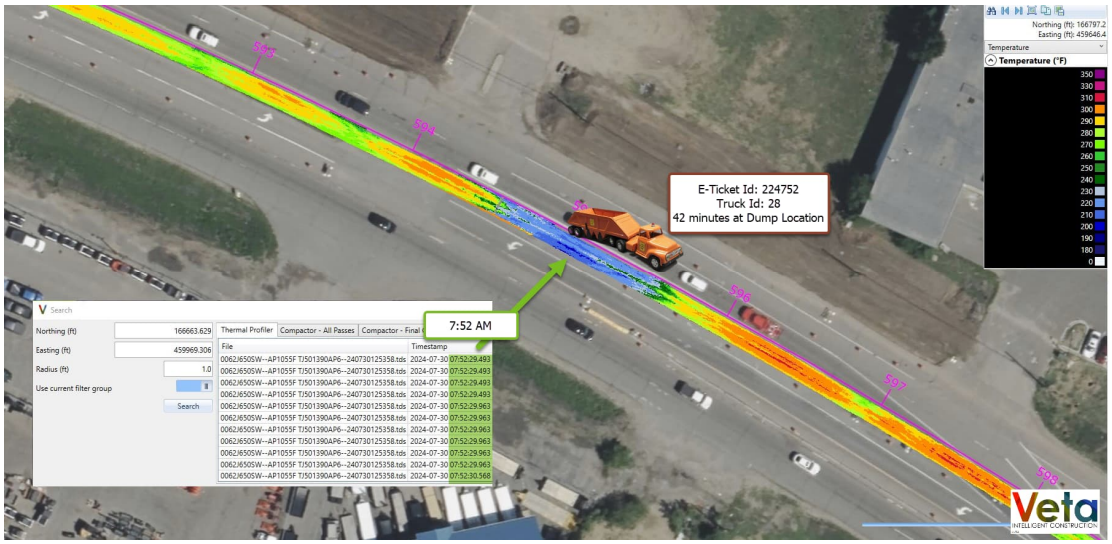
MDMS



Source: MnDOT

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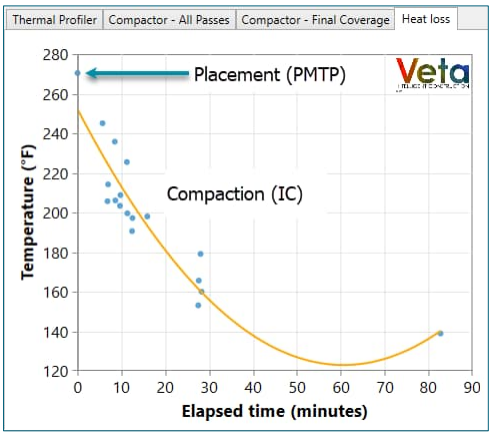
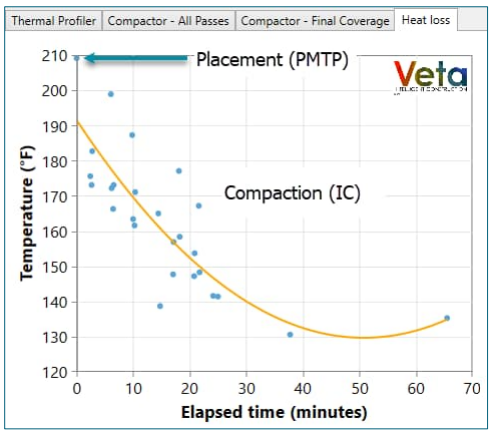
Heat loss curves

Heat loss curve prior to cold segment



Heat loss curve at cold section



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FHWA Equipment Loan Program

U.S. Department of Transportation
Federal Highway Administration

MATC
MOBILE ASPHALT TECHNOLOGY CENTER

EQUIPMENT LOAN PROGRAM

In order to increase the likelihood of adoption of new technologies, the FHWA's Mobile Asphalt Technology Center (MATC) provides loan of several pieces of equipment to agencies and contractors.

The idea is for the agency and contractor personnel to borrow equipment for various lengths of time to evaluate and determine if it meets their needs. Based on the MATC's past experience, this significantly increases the likelihood of adoption, because the agency or contractor doesn't have to buy an expensive piece of equipment only to find that it may not meet their needs. The equipment loan can last from a duration of few weeks to several months.

- Paver-mounted infrared (Pave-IR) device
- Circular Track Meter (CTM)
- NDT Pavement Thickness (MIT Scan T3)
- Dielectric Profiling System (DPS) for mat and joint density
- Aggregate Imaging System (AIMS) for aggregate properties
- X-Ray Fluorescence (XRF) device for binder composition
- Jig set for fatigue testing (I-Fit, TxOT) in AMPT device
- CoreLok for bulk specific gravity of cores
- Warm mix asphalt (WMA) foaming device

Forrest Hierholzer, QC Engineer (Granite Construction)
Forrest.Hierholzer@gcinc.com

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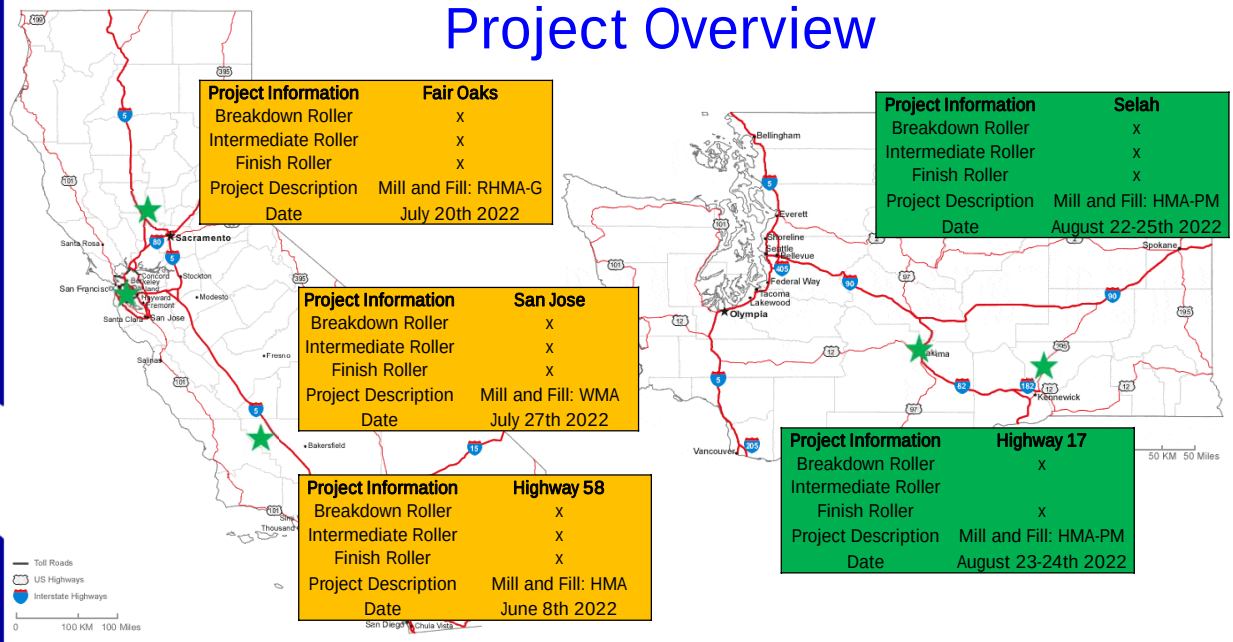
Project Overview



Project Information	Fair Oaks
Breakdown Roller	x
Intermediate Roller	x
Finish Roller	x
Project Description	Mill and Fill: RHMA-G
Date	July 20th 2022

Project Information	Selah
Breakdown Roller	x
Intermediate Roller	x
Finish Roller	x
Project Description	Mill and Fill: HMA-PM
Date	August 22-25th 2022

Project Information	San Jose
Breakdown Roller	x
Intermediate Roller	x
Finish Roller	x
Project Description	Mill and Fill: WMA
Date	July 27th 2022

Project Information	Highway 17
Breakdown Roller	x
Intermediate Roller	
Finish Roller	x
Project Description	Mill and Fill: HMA-PM
Date	August 23-24th 2022

Project Information	Highway 58
Breakdown Roller	x
Intermediate Roller	x
Finish Roller	x
Project Description	Mill and Fill: HMA
Date	June 8th 2022

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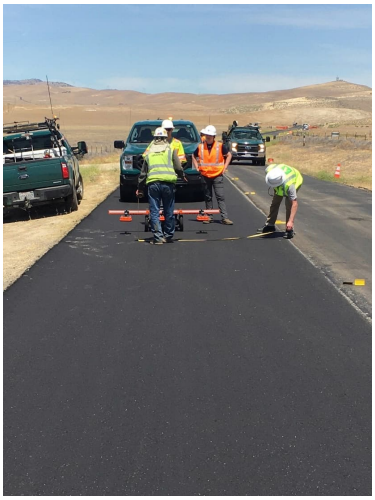
Highway 58



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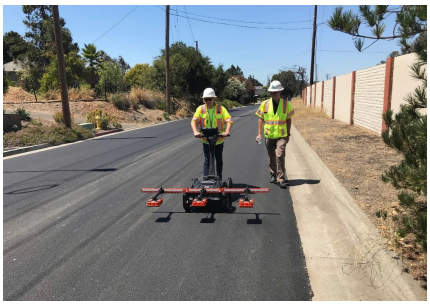
San Jose



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I-84 Yakima

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SR-16 Mesa

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Density (DPS) and IC Pass Count & Temperature

Veta
INTELLIGENT CONSTRUCTION

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Latitude (°): 46.652492
Longitude (°): -120.496000
Density, % of Gmm
Density, % of Gmm (%)
94.0
93.0
92.0
91.0
90.0
89.0
Latitude (°): 46.652407
Longitude (°): -120.496029
Pass Count
Pass Count
20
16
12
8
4
3
2
1
Selections
Final Coverage
Individual Passes
Elton Rd
97
82
0.01 mi
0.005 mi

33


Latitude (°): 46.652492
Longitude (°): -120.496000
Density, % of Gmm
Density, % of Gmm (%)
94.0
93.0
92.0
91.0
90.0
89.0
Latitude (°): 46.652407
Longitude (°): -120.496029
Pass Count
Pass Count
20
16
12
8
4
3
2
1
Selections
Final Coverage
Individual Passes
97
82
0.01 mi
0.005 mi

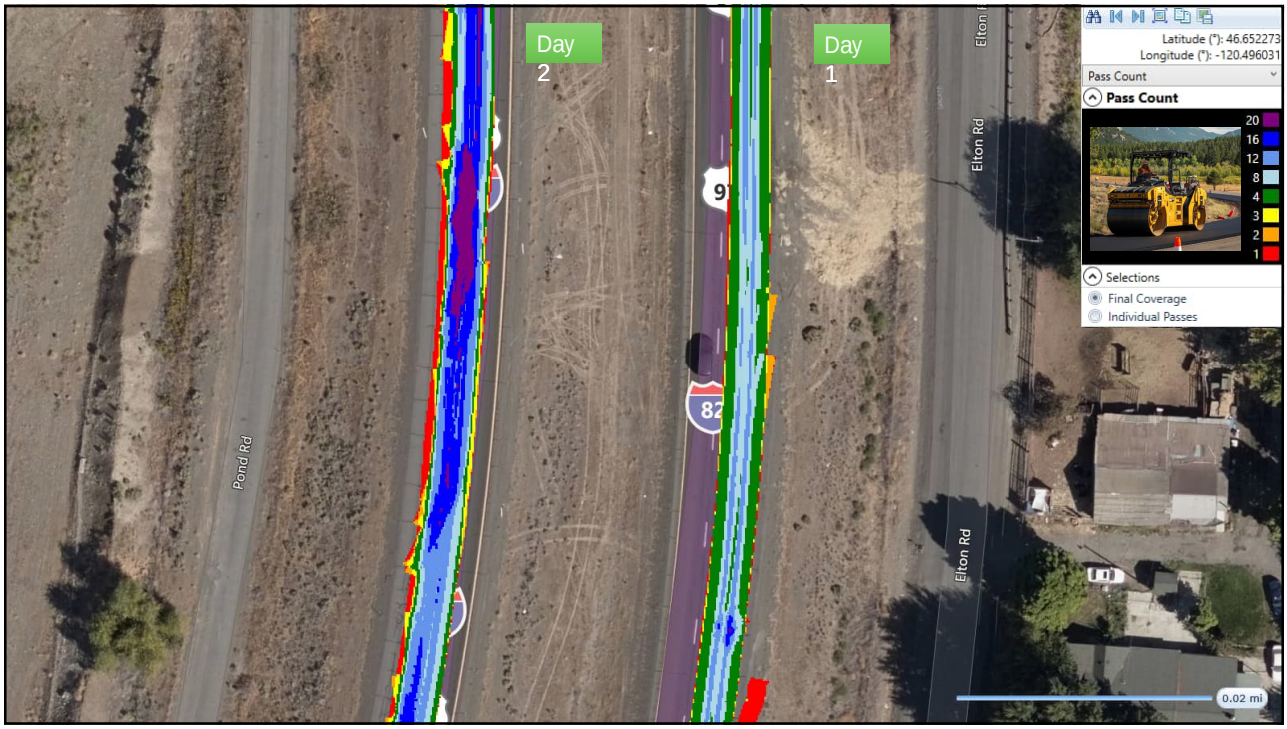
34


Latitude (°): 46.652492
Longitude (°): -120.496000
Density, % of Gmm
Density, % of Gmm (%)
94.0
93.0
92.0
91.0
90.0
89.0
Elton Rd
0.01 mi
Latitude (°): 46.652407
Longitude (°): -120.496029
Pass Count
Pass Count
20
16
12
8
4
3
2
1
Selections
Final Coverage
Individual Passes
Data Filtered: Temperature > 210 F
0.005 mi

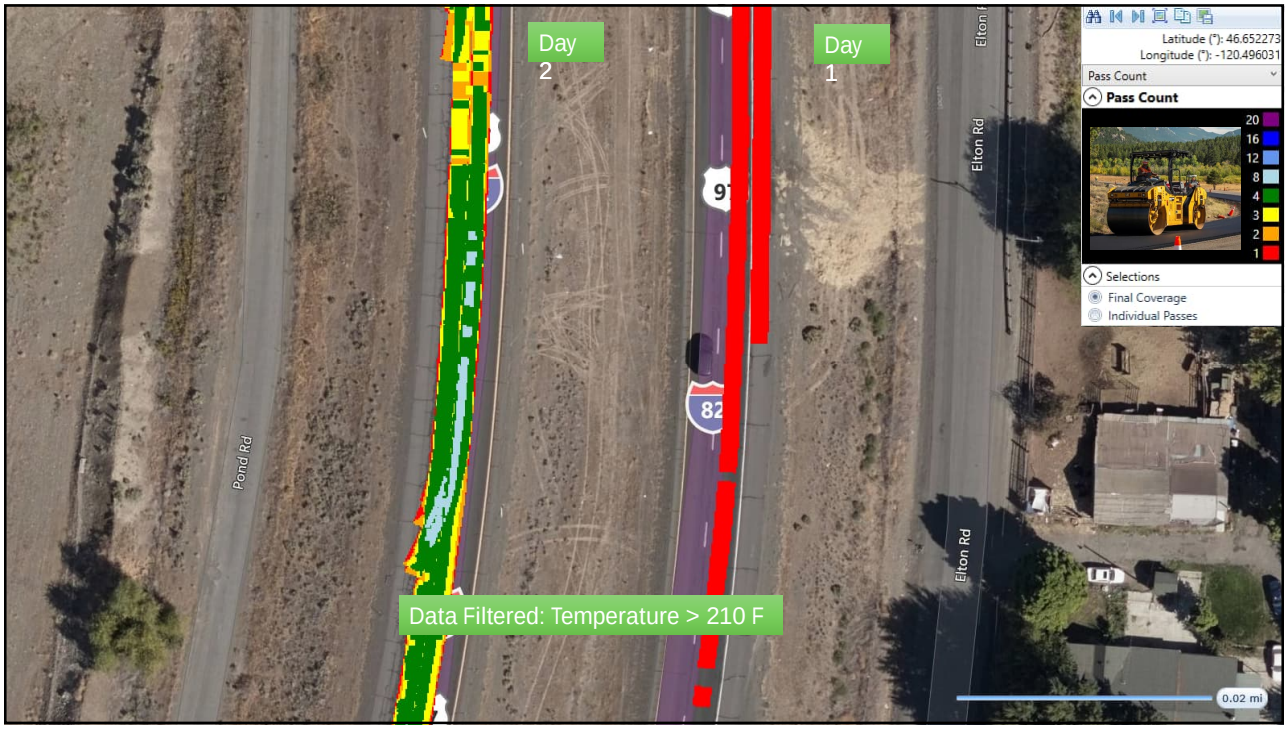
35


Latitude (°): 46.652492
Longitude (°): -120.496000
Density, % of Gmm
Density, % of Gmm (%)
94.0
93.0
92.0
91.0
90.0
89.0
0.01 mi
Latitude (°): 46.652407
Longitude (°): -120.496029
Pass Count
Pass Count
20
16
12
8
4
3
2
1
Selections
Final Coverage
Individual Passes
Data Filtered: Temperature > 210 F
0.005 mi

36


Day 2
Day 1
Pond Rd
Elton Rd
Latitude (°): 46.652273
Longitude (°): -120.496031
Pass Count
Pass Count
20
16
12
8
4
3
2
1
Selections
Final Coverage
Individual Passes
0.02 mi

37


Day 2
Day 1
Pond Rd
Elton Rd
Latitude (°): 46.652273
Longitude (°): -120.496031
Pass Count
Pass Count
20
16
12
8
4
3
2
1
Selections
Final Coverage
Individual Passes
Data Filtered: Temperature > 210 F
0.02 mi

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PWL Analysis

Veta
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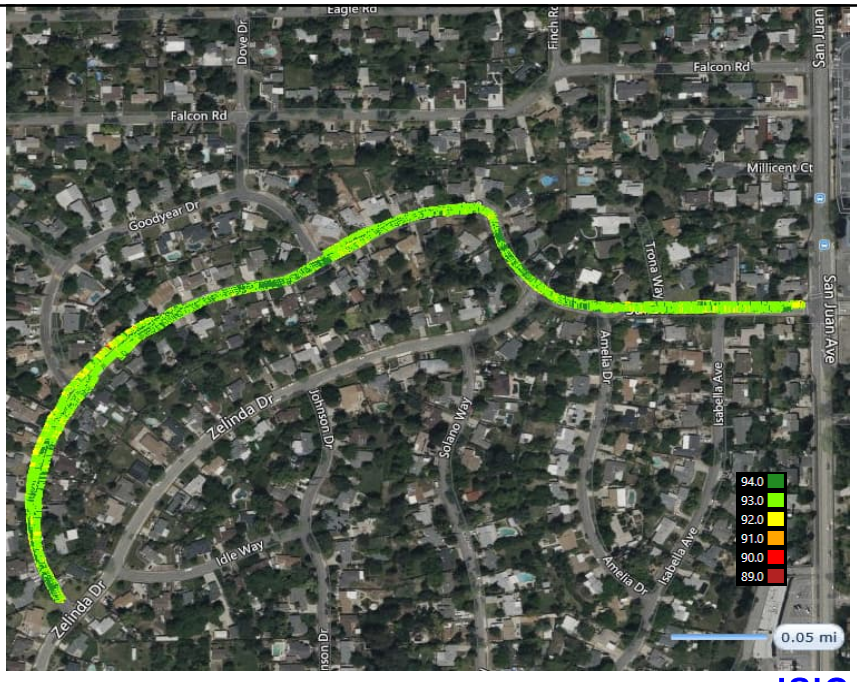
DPS vs. Core

DPS Data	
Mean Density (%)	93.6
Standard Deviation (%)	0.50
Sample Size	67,782
PWL (91-96%)	100

Core Data	
Mean Density (%)	93.9
Standard Deviation (%)	0.74
Sample Size	6
PWL (91-96%)	100



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Cart Setup (June 2022)

Limitations

Slow Data Collection

Requires someone to operate

Heavy Equipment

Multiple Cords and Connections

GPS not included

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Truck Setup (July 2023)

Limitations

Requires two people to operate

Hard to maneuver

Heavy Equipment

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Roller Setup (November 2024)

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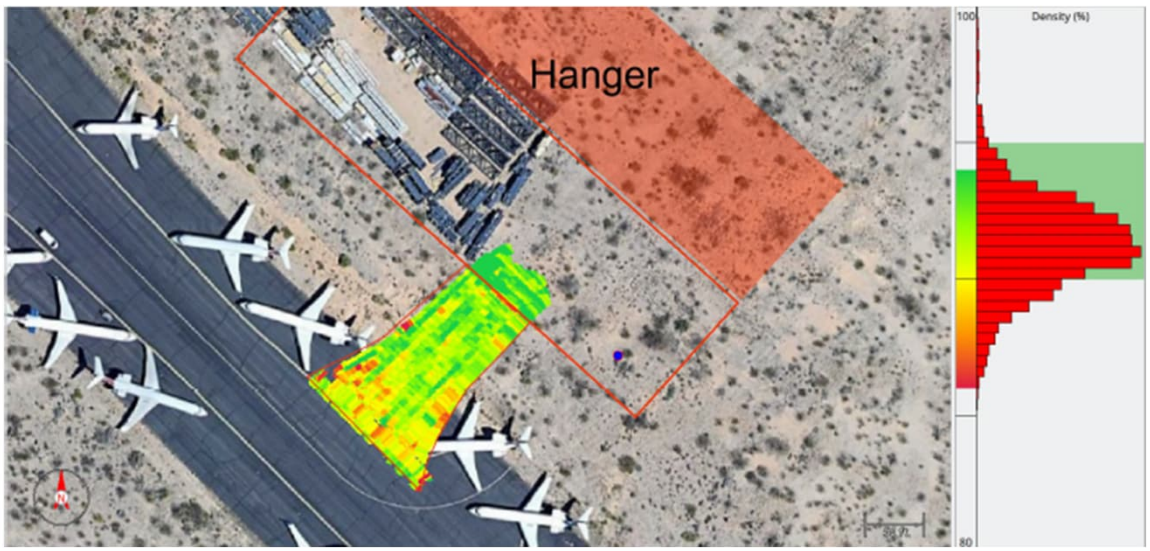
Finish Roller Data (Density)



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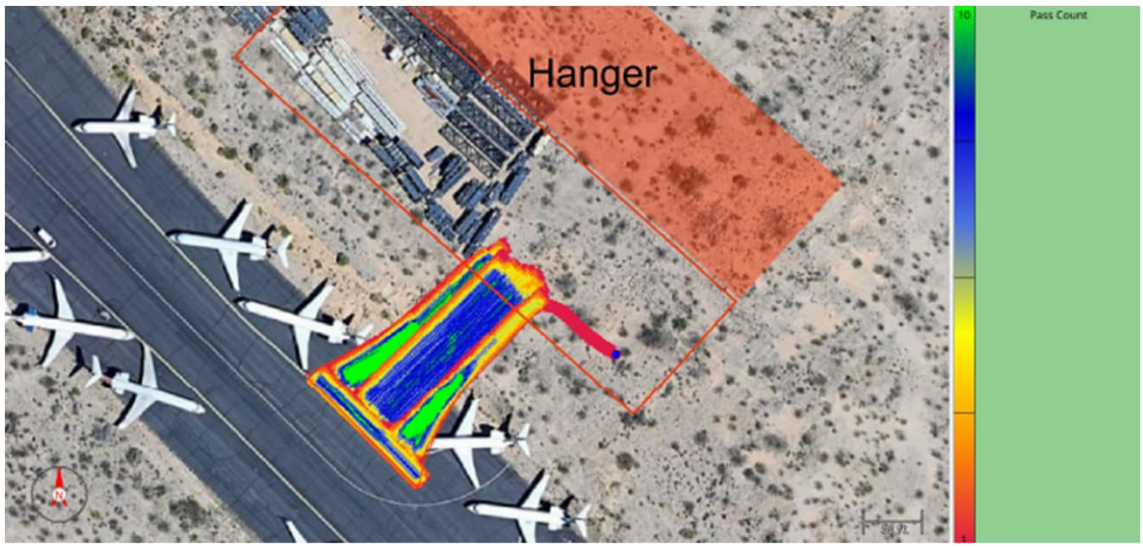
Finish Roller Data (Pass Count)



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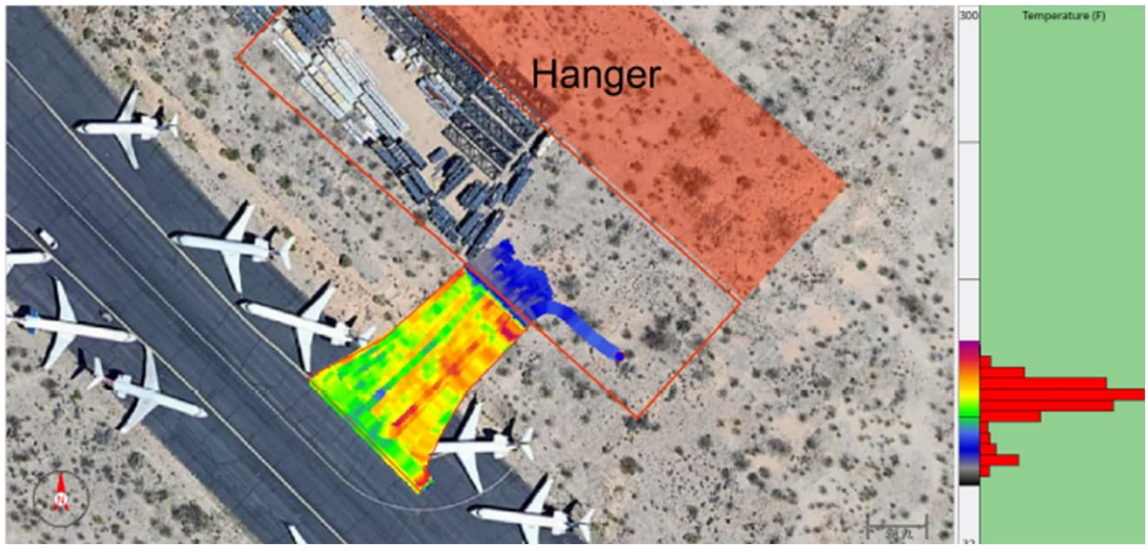
Finish Roller Data (Temperature)



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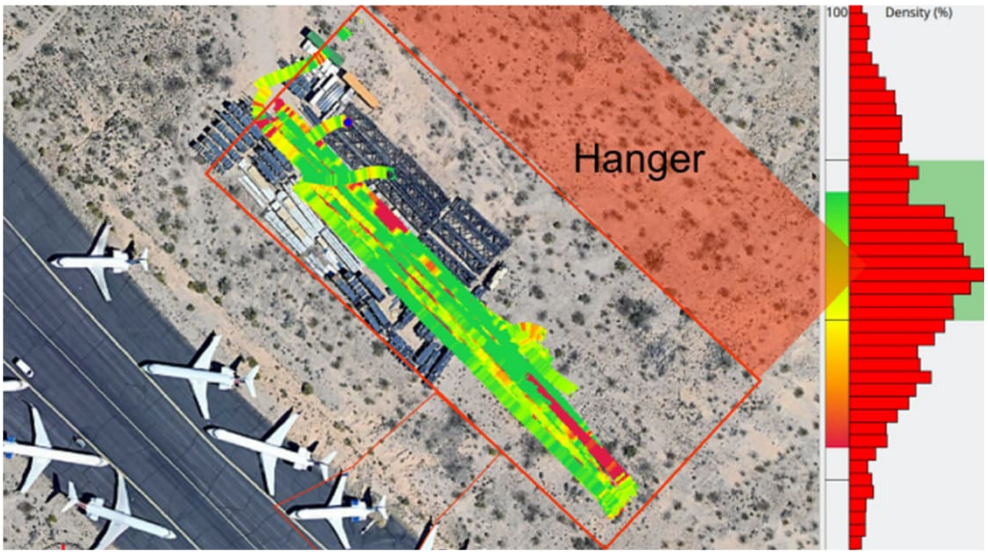
Breakdown Roller Data (Density)



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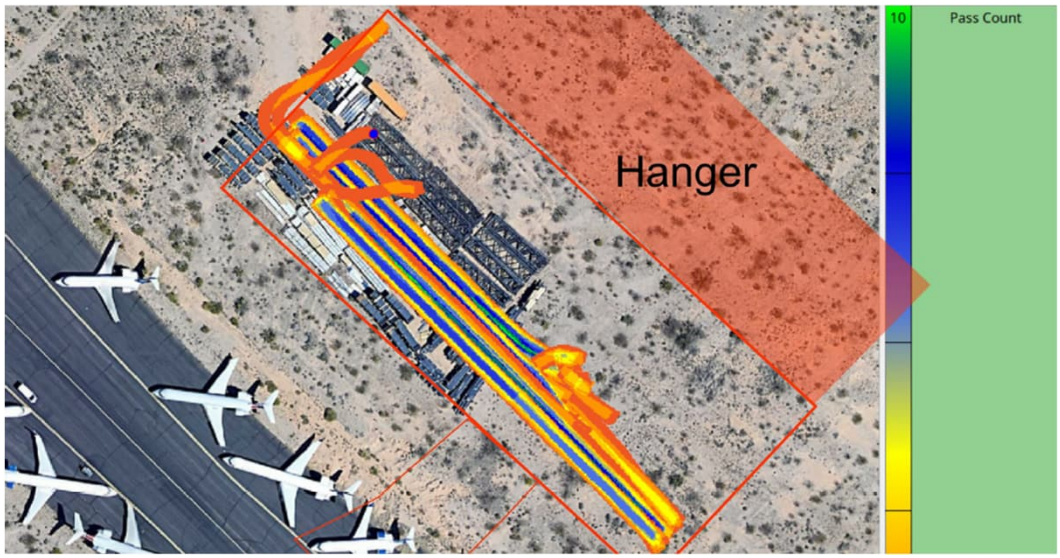
Breakdown Roller Data (Pass Count)



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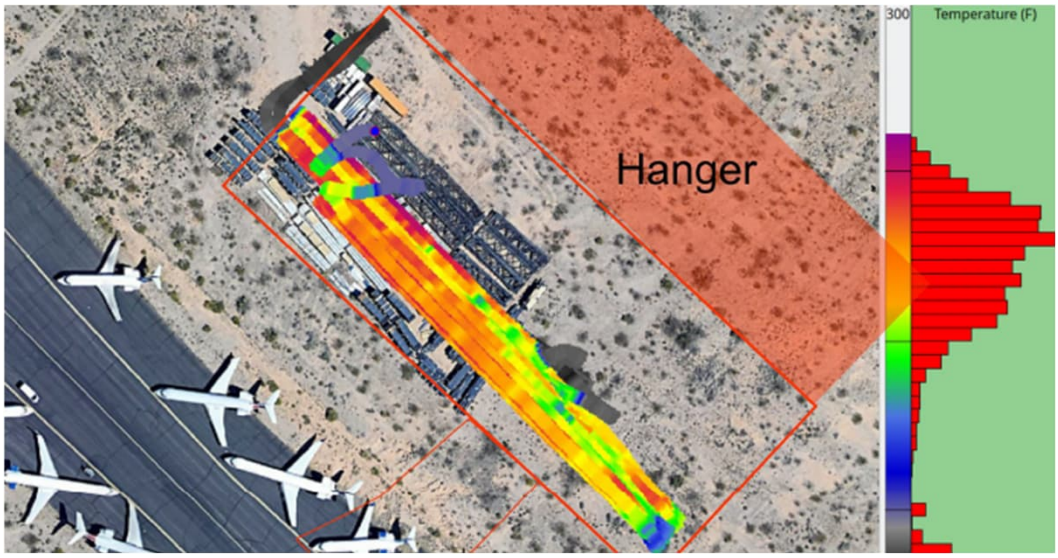
Breakdown Roller Data (Temperature)



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Roller Setup

Improvements

Does not require additional operator

Duals as Intelligent Compaction

Future Improvements

Hardwire equipment to roller battery

Improved user interface

Mobile app

Limitations

Increased roller footprint

Potential for overheating electronics

Water

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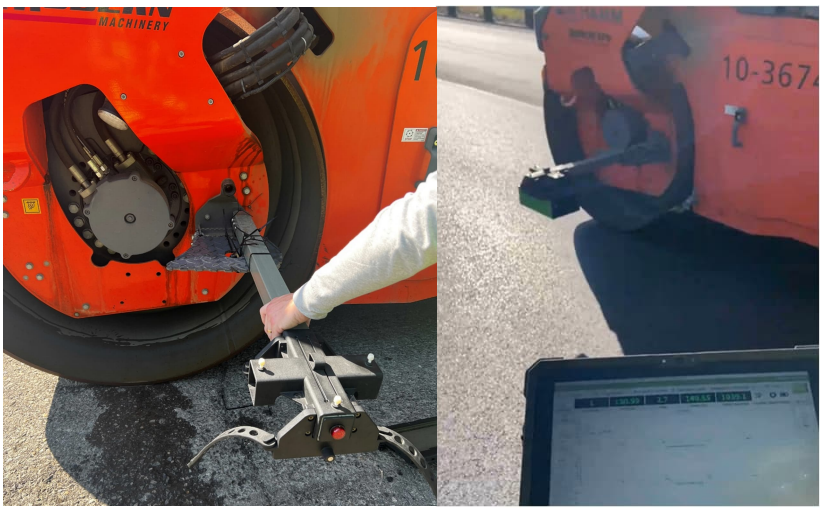
Roller Mounted DPS



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Paver
ECM
Display
Radio
Wiring
GPS Receiver
Cell Modem
Thermal Camera

Roller
ECM
Display
Radio
Wiring
GPS Receiver
Cell Modem

Base Station

Equipment Setup

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Outline

- Recap on DAB/ICT Data Sources
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Q&A

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2026 ISIC NA Conference – Louisville, KY

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THANK YOU!

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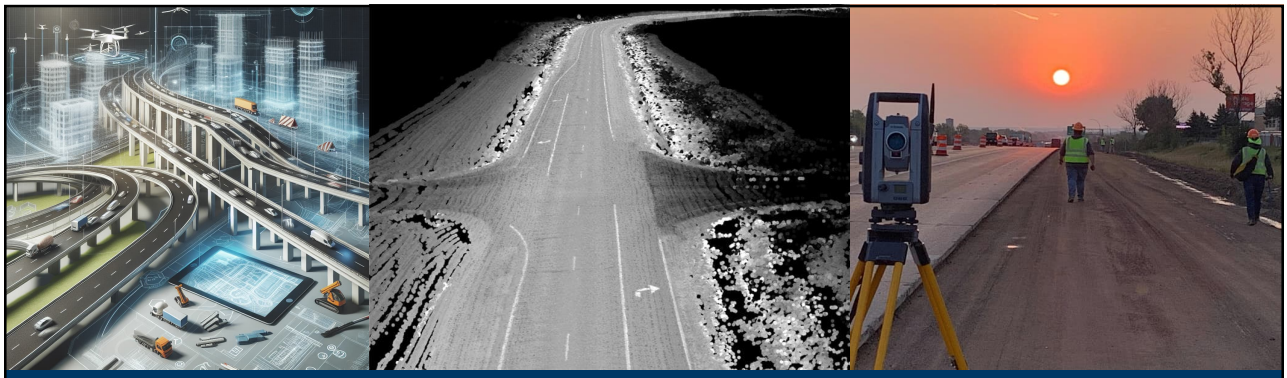


Complete Paving Digital As-Built Workflow
Digital Workflow from Design to Construction for Pavements

Rebecca Embacher | Advanced Materials and Technology Engineer
ISIC Track – Digital As-Built and Workflow of Pavement Construction
Minnesota Transportation Conference & Expo
Wednesday, March 18, 2026

DEPARTMENT OF TRANSPORTATION

mndot.gov/

1

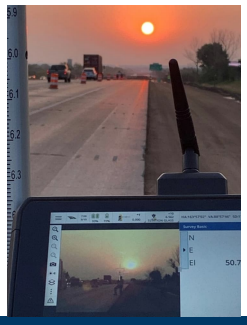
Goals (and alignment with One Minnesota Plan)

MnDOT's 2023-2027 Strategic Plan has five key goal areas:

- Promoting a culture of safety
- Equitable and inclusive procurements
- Maximizing stewardship of resources
  - Fiscal accountability
  - Customer experience/service
  - *Innovation
  - Data Interoperability
- Fostering a thriving workforce

2

DEPARTMENT OF TRANSPORTATION



Innovations in Scoping

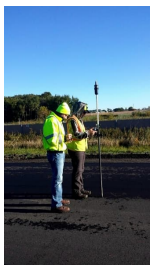
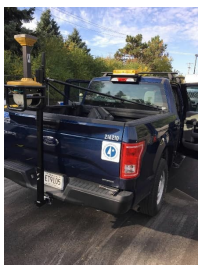
Understanding Information Required for use by Intelligent Construction Technologies and Required Accuracies

3

Collection of As-Builts

(What equipment to use? Accuracy and frequency/density of measurements needed)




4

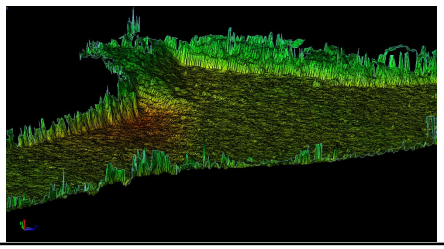
Existing pavement surface for AMG milling

- Extend collection a minimum of 1-2 ft beyond width requiring AMG milling
- Include tie-in points
- AMG Milling using Relative Surface
  - Lidar measurements only!
- AMG Milling using Robotic Total Stations
  - Lidar measurements and/or
  - DTM
    - 50-ft or less in tangents
    - 25-ft or less in super elevations, vertical curves, or sections with significant elevation changes

5

Existing surface for AMG muck excavation

- Extend existing surface about 50 feet beyond muck excavation limits
- Includes entire project
- Calculation of quantities
  - Surface to surface comparison
    - Inplace AMG Muck Excavation Surface (LandXML)
    - Bottom of AMG Muck Excavation Surface (LandXML)



6

Horizontal alignment files
Intelligent Compaction / Paver-Mounted Thermal Profiling

- LandXML format
  - Veta / VetaCenter
  - Contractor Vendor's Software
- Equipment horizontal accuracy
  - Plus or minus 2 inches

7

Horizontal alignment files
Data Acquisition Systems | Intelligent Compaction / Paver-Mounted Thermal Profiling

Use on data acquisition systems during execution of the Work

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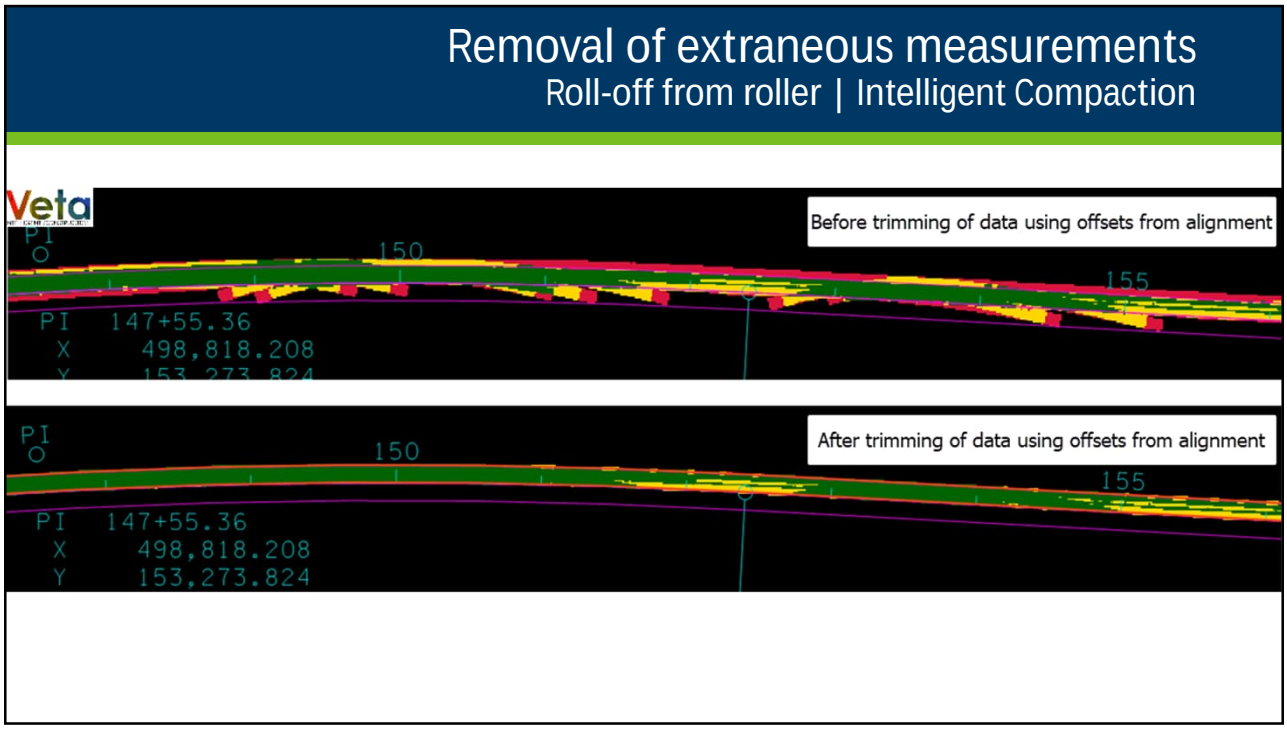
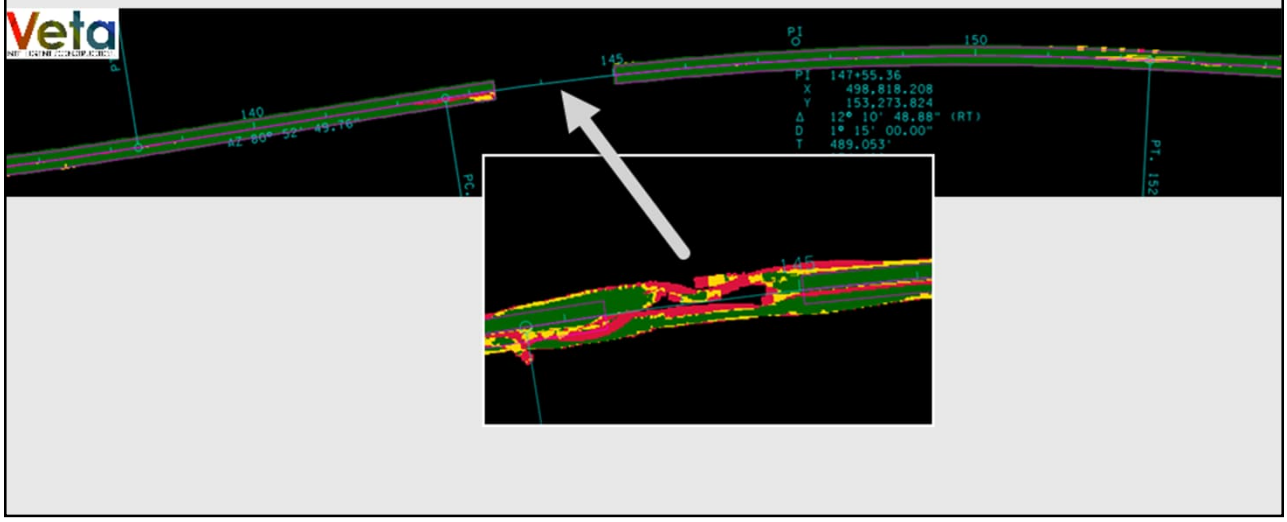
Removal of extraneous measurements
Roll-off from roller | Intelligent Compaction



9

Removal of extraneous measurements
Exception areas | Intelligent Compaction / Paver-Mounted Thermal Profiling



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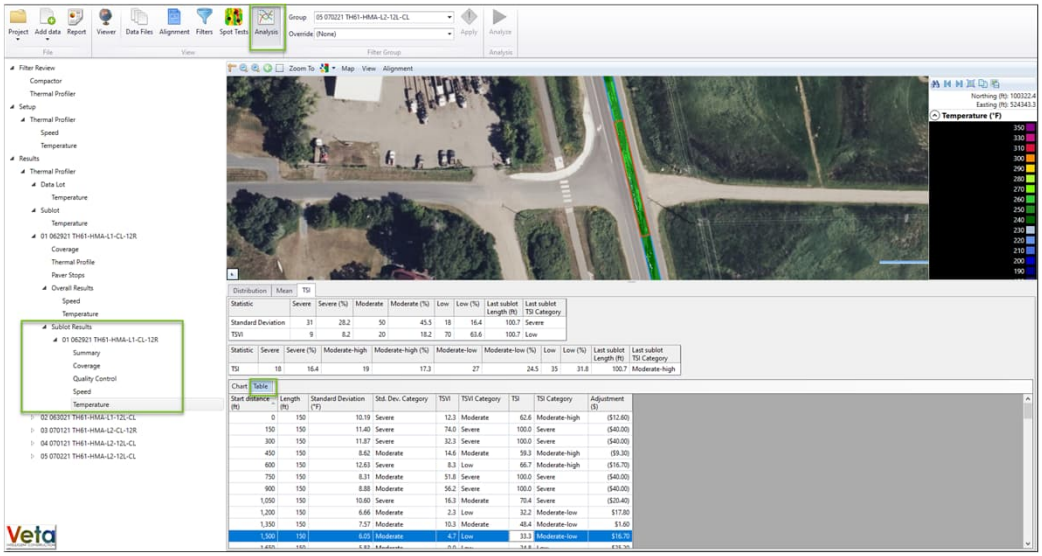
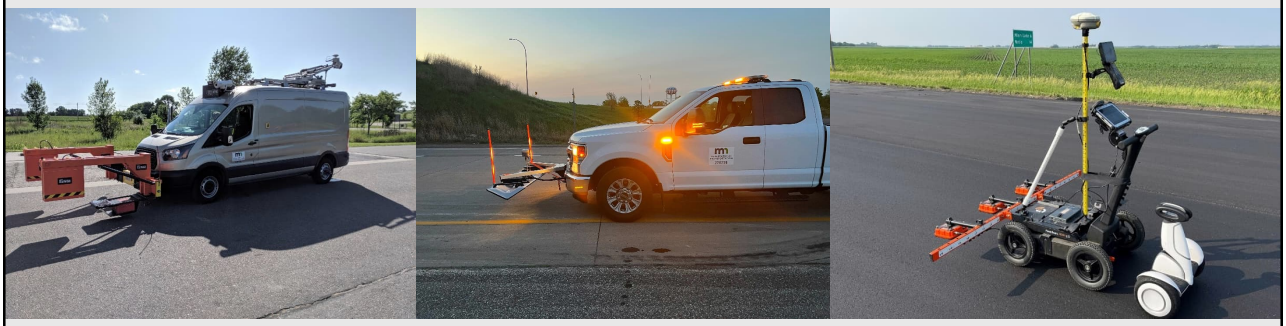
Horizontal alignment files

Data analyses for basis of payment and monetary adjustments



11

Ground Penetrating Radar (GPR)



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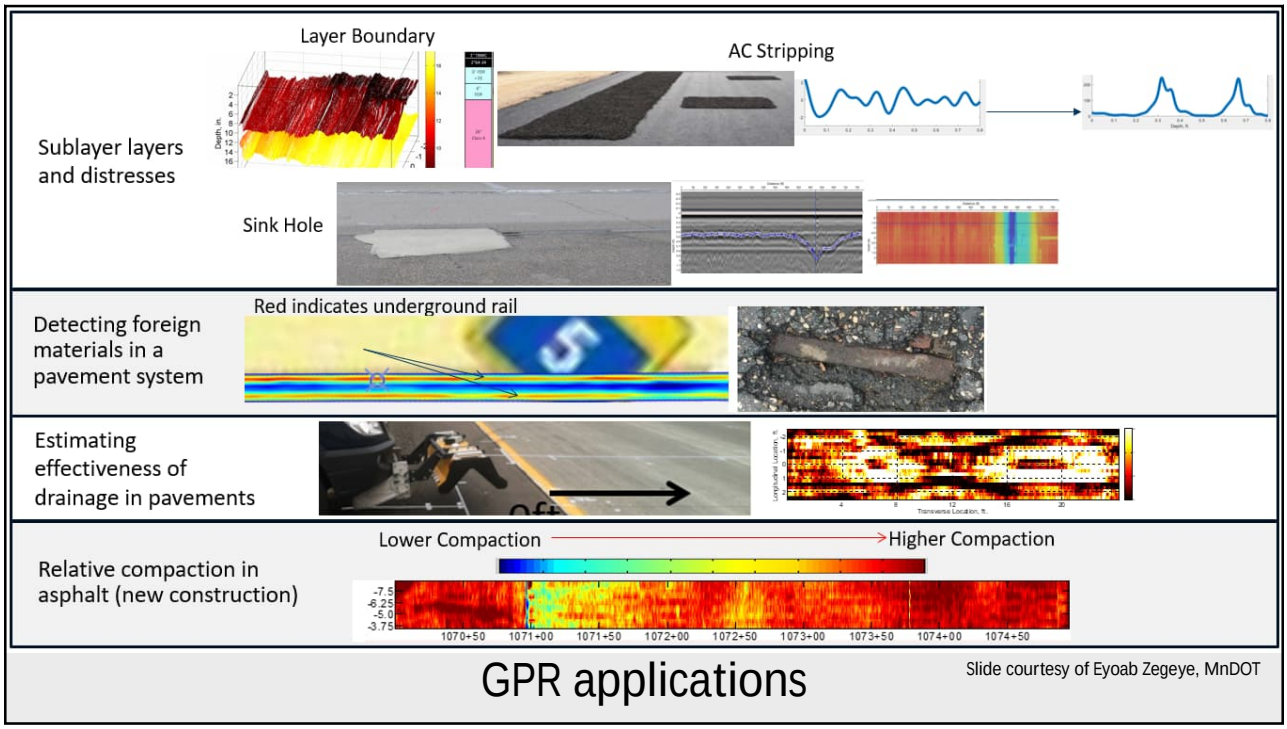

13

Collection of layer thickness data
Example for AMG milling

Collect 2D or 3D GPR with coordinates

- 2D GPR
  - Inner and Outer wheel Path
  - Extract pavement depths at 1 foot or less
  - If available, collect GPS coordinates with dielectric measurements
  - Does not work well for roadways with delamination and/or older road-mix base courses (use 3D)
- 3D GPR
  - Minimum of 1 pass per lane (capture inner and outer wheel paths)
  - Recommended: 2 passes in each lane (1 on left side of lane, 1 on right side of lane)

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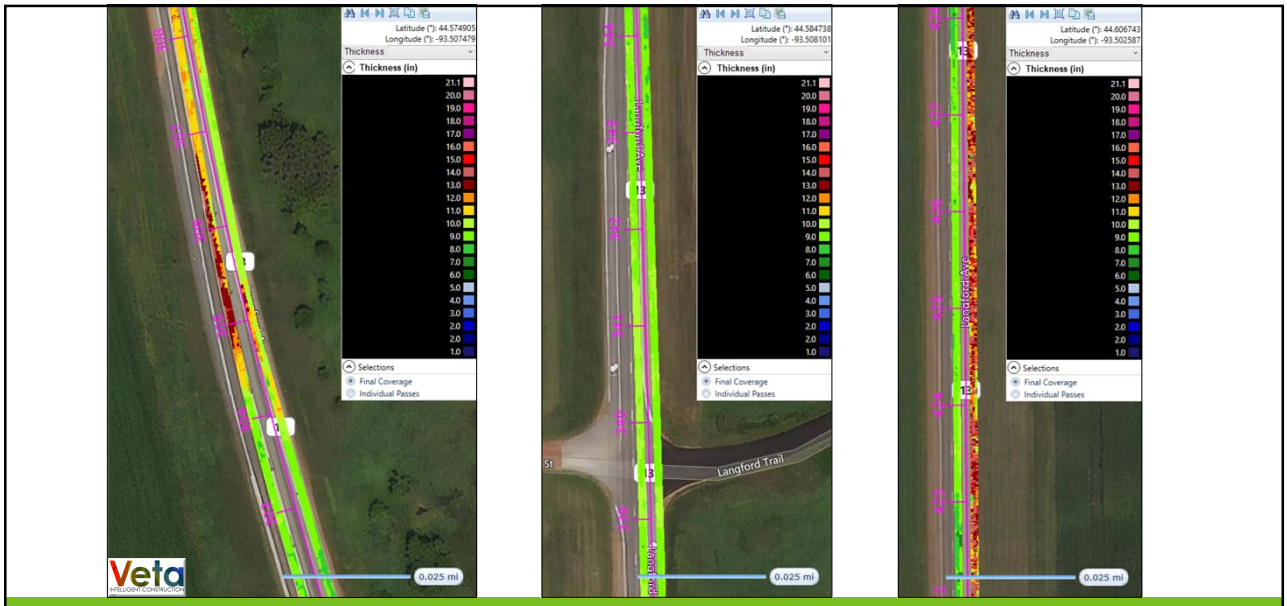

Example of bituminous layer thickness data as mapped in Veta

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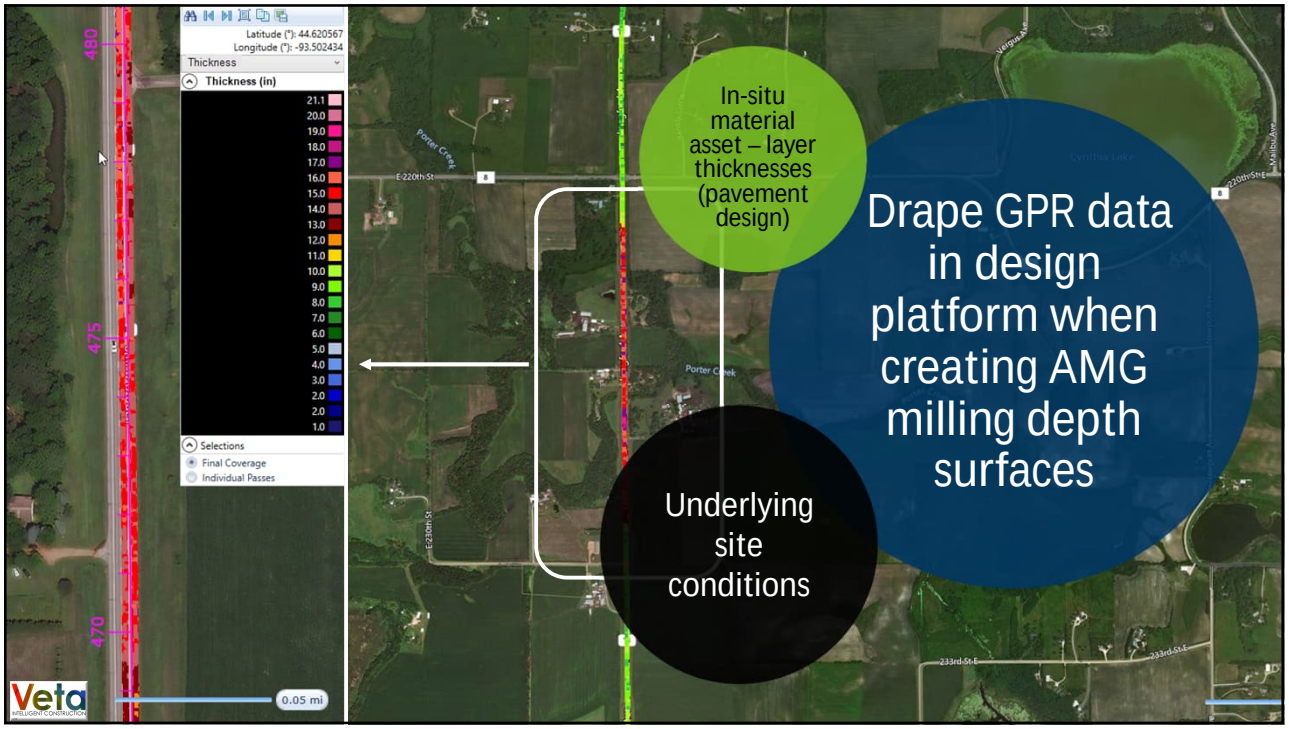

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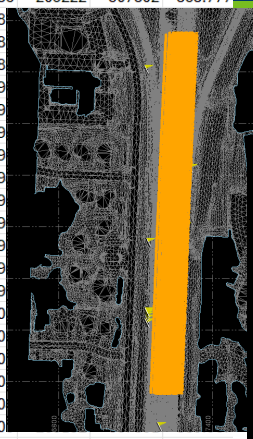
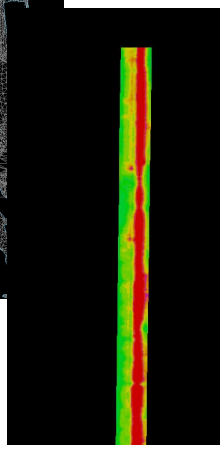
Point ID	Northing	Easting	Elevation
3282	209228	507302	868.522
3283	209227	507302	868.578
3284	209225	507302	868.644
3285	209224	507302	868.697
3286	209222	507302	868.777
3306	209190	507300	870.018
3307	209189	507300	870.078
3308	209187	507300	870.136
3309	209186	507300	870.194
3310	209184	507300	870.272
3311	209182	507300	870.33





Provide GPR layer thickness data to Design

- Traditionally raw data not provided, but only summary statistics!
  - Workflows requiring updating to accommodate for technology needs.
- Provide in consumable format for design platform
- Include X-Y coordinates and layer thicknesses
- Raw 3D GPR spacing too dense for most design platforms (21 sensors, 6 inch spacing!)
  - Export average results (e.g., 25-ft increment)

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No GPR data collected
(Milling punched into base)

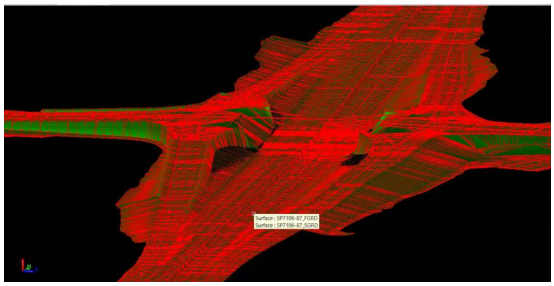
18


Cross-slope corrections / 2D GPR only at inner wheel path
(Milling scraped concrete surface)

19

GPR data not used in design process
(Surface designed touching concrete surface in areas and/or in proximity to delamination interface)

20



DEPARTMENT OF TRANSPORTATION

Design

Additional design constraints and reviews may be needed for use with intelligent construction technologies

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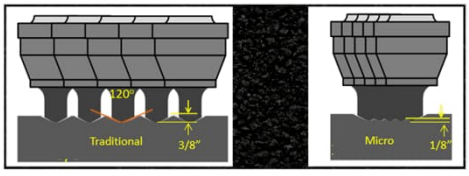
Example of design constraints for AMG milled surface models

Standard milling teeth

- Maximum and minimum milling depths
- Cross-slope corrections
- Critical project constraints
  - No shoulder PI impact
  - Minimal profile change
  - Flood planes, etc.

Microbit milling teeth (micromilling)

- Minimum mill depth = 1/8”
  - scratched surface
- Maximum mill depth = 3/4"
- Up to 1” allowed to support profile and smoothness, however, should be limited due to increase in teeth wear and reduction in production rates



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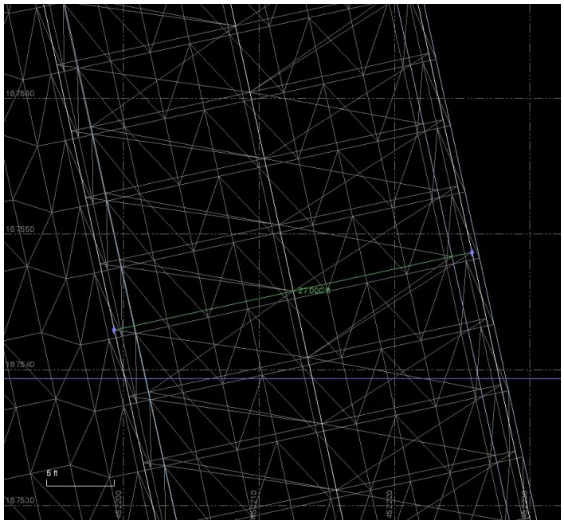
AMG model width extents
Understanding construction equipment and technology

AMG Milling

- Extend surface 1-2 ft beyond AMG milling
  - AMG Milling Depth Surface and
  - Existing Pavement Surface (required with AMG relative milling)
- Model extension reflective of existing slope in AMG milling region should breakline exist in extended surface

Grade Control

- Extend surfaces to limits of activity



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Model extended only to edge of traffic lanes

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Model extended into shoulders
(1.5 ft beyond traffic lane edge)

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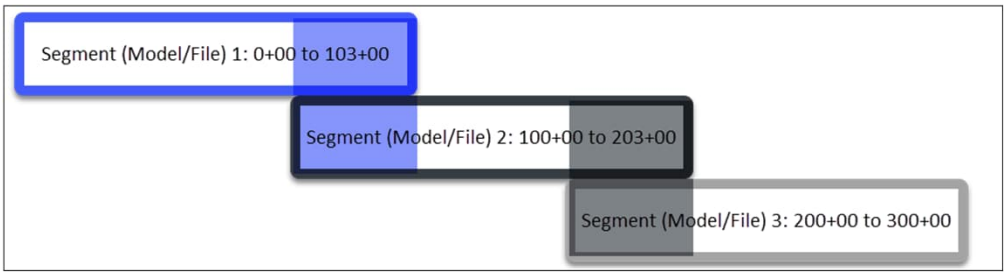
File overlaps
Certain operations are not paused at an exact longitudinal location

- Model extents overlap by 300 feet
- Elevations / mill depths must match on overlaps!
- Models match any tie-ins



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Removal of extraneous data from surfaces

- Linework
  - Do not include 3D linework that is not part of Work
    - 2D linework is used for horizontal guidance
  - Do not include duplicate and overlapping linework
- Trim existing surfaces to a manageable size to only include areas requiring the Work plus a “buffer” (e.g., 1- to 2-ft buffer for AMG milling)
- Grade control / AMG muck excavation have larger triangulation allowing import of larger surfaces that do not require trimming

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Knowing what is needed for model review and construction

Example AMG milling | AMG Milling Report

AMG Milling Report (XLSX)

- Cross-slopes (existing and design)
- Mill depths
- Recycled asphalt pavement (RAP) quantities

Used By

- Engineering estimates
  - Department and Contractor
- Model review
- Construction

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Knowing what is needed for model review and construction
Example AMG milling | Cut/Fill Maps

- Cut/Fill Map – AMG Milling Depth (LandXML and DGN)
  - Generated using surface-to-surface comparison and Thematic Heights
  - "Existing Pavement Surface" to "AMG Milling Depth Surface"
- Cut/Fill Map – Remaining Bituminous Thickness (LandXML and DGN)
  - Generated using surface-to-surface comparison and Thematic Heights
  - "Bottom of Existing Bituminous Surface" to "AMG Milling Depth Surface"
  - Data to generate "Bottom of Existing Bituminous Surface" is provided by Materials – from 2D/3D Ground Penetrating Radar (GPR) data

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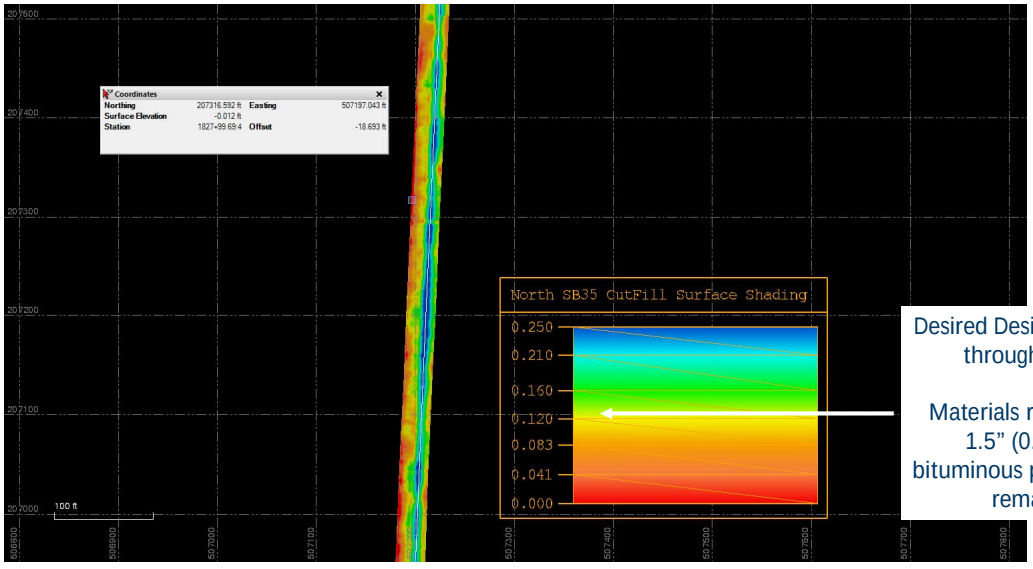
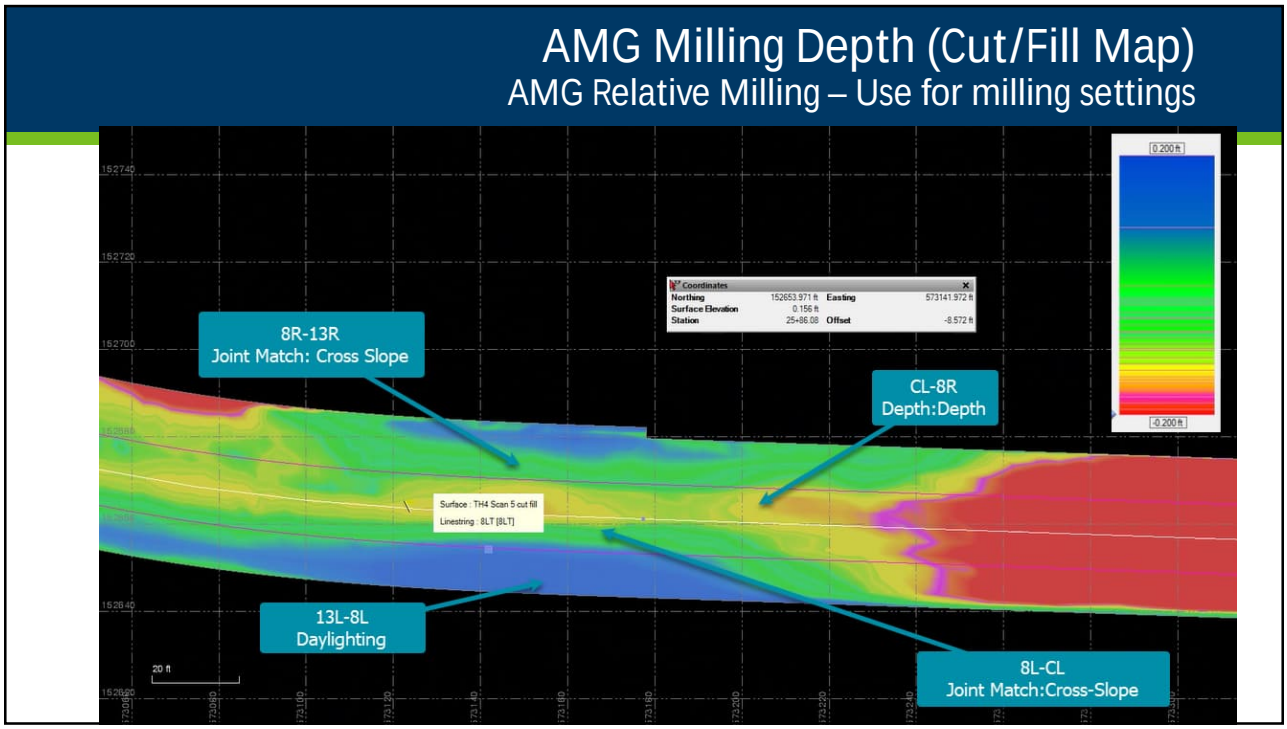
Cut/Fill Map: Remaining bituminous thickness (platform)
"Bottom of Existing Bituminous Surface" to "AMG Milling Depth Surface"



Desired Design = green through blue

Materials requested 1.5" (0.125') bituminous platform to remain

30


AMG Milling Depth (Cut/Fill Map)
AMG Relative Milling – Use for milling settings
8R-13R
Joint Match: Cross Slope
CL-8R
Depth:Depth
13L-8L
Daylighting
8L-CL
Joint Match:Cross-Slope

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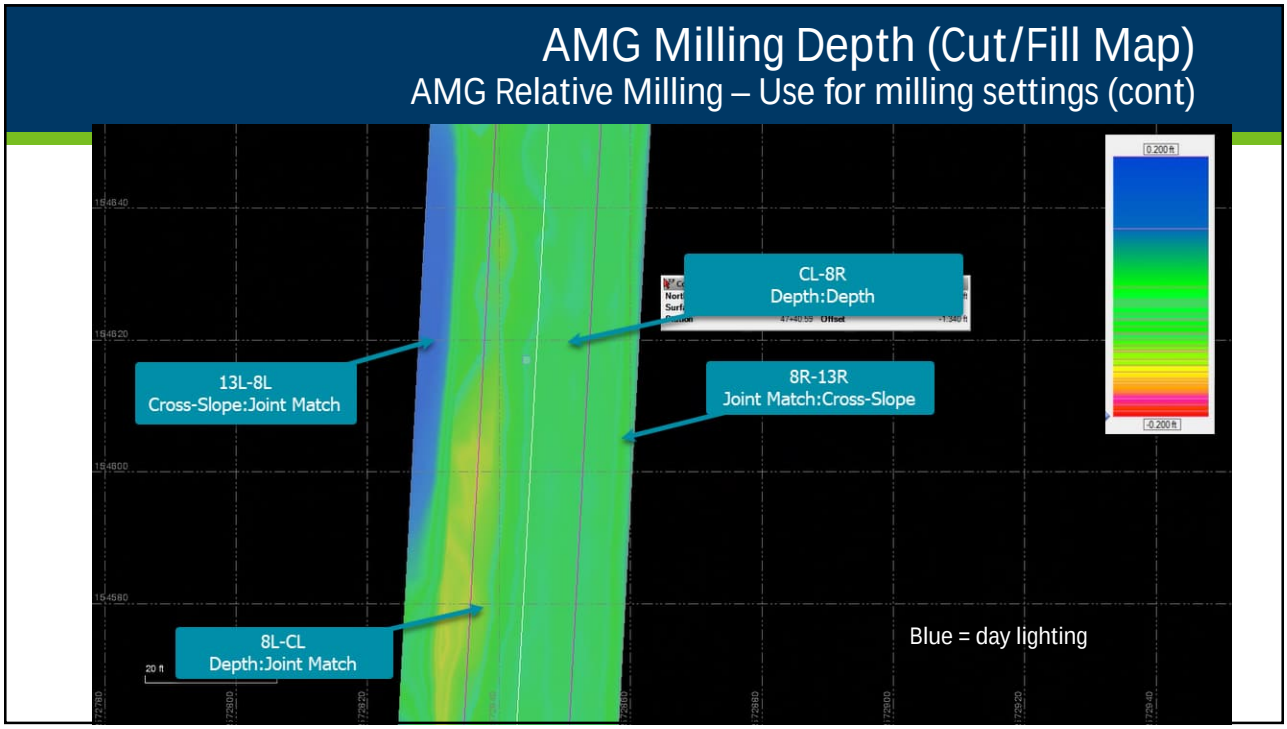
AMG Milling Depth (Cut/Fill Map)
AMG Relative Milling – Use for milling settings (cont)
CL-8R
Depth:Depth
13L-8L
Cross-Slope:Joint Match
8R-13R
Joint Match:Cross-Slope
8L-CL
Depth:Joint Match
Blue = day lighting

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Understand tolerance / performance specification requirements

Table 2399.5-1
Smoothness Incentive/Disincentive and Corrective Work for Bituminous Pavements

Equation	Smoothness inches/mile	Incentive/Disincentive $/0.1 mile
HMA-A (3 lifts or more)	< 25.0	400.00
	25.0 – 75.0	800.00 – 16.000 × Smoothness
	> 75.0	Corrective Work to ≤ 50.0 inches per mile
HMA-B (2 lifts)	< 30.0	270.00
	30.0 – 80.0	594.00 – 10.800 × Smoothness
	> 80.0	Corrective Work to ≤ 55.0 inches per mile
HMA-C (1 lifts)	< 35.0	180.00
	35.0 – 95.0	390.00 – 6.000 x Smoothness
	> 95.0	Corrective Work to ≤ 65.0 inches per mile

- Milling machine follows model!
- Irregularities can cause roughness/chatter
- Error in construction
  - Teeth wear
  - LiDAR Scan
  - AMG equipment
  - …

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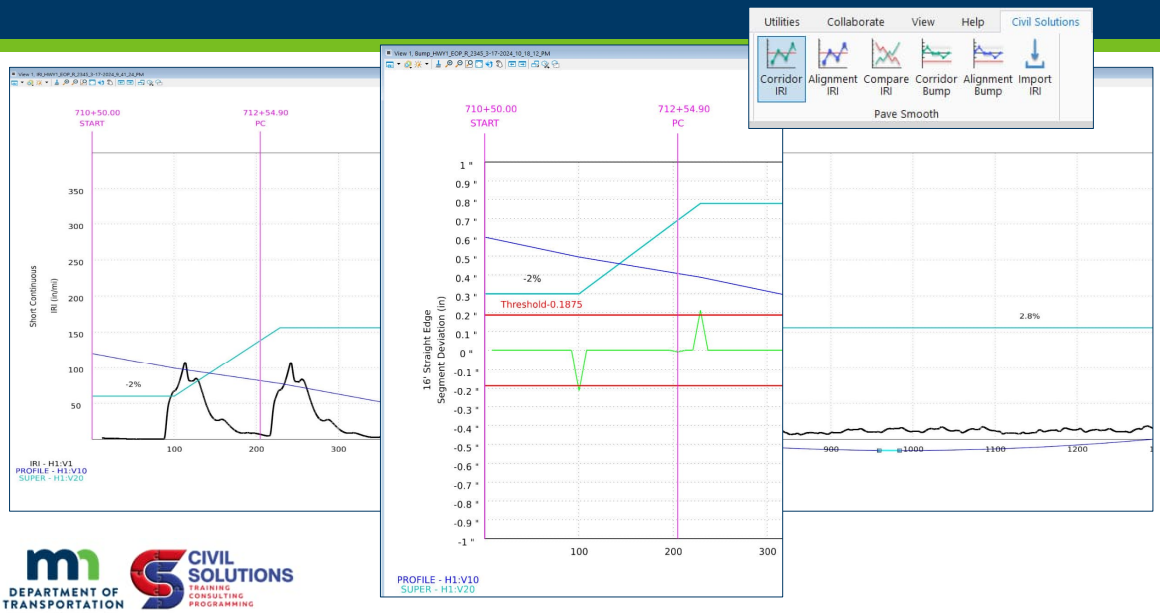
Model IRI smoothness and bump testing (PaveSmooth)



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Examples of how to improve smoothness

- If designing with vertical point of intersections (VPIs)
  - Use 25ft tangents and
  - Ensure difference in slope between tangents is less than 0.20 percent
- Use of vertical curves significantly improves smoothness
- Using parabolic / spline-based curves at start/end of super elevations
- Other irregularities may be caused by:
  - Template drops
  - Station equations

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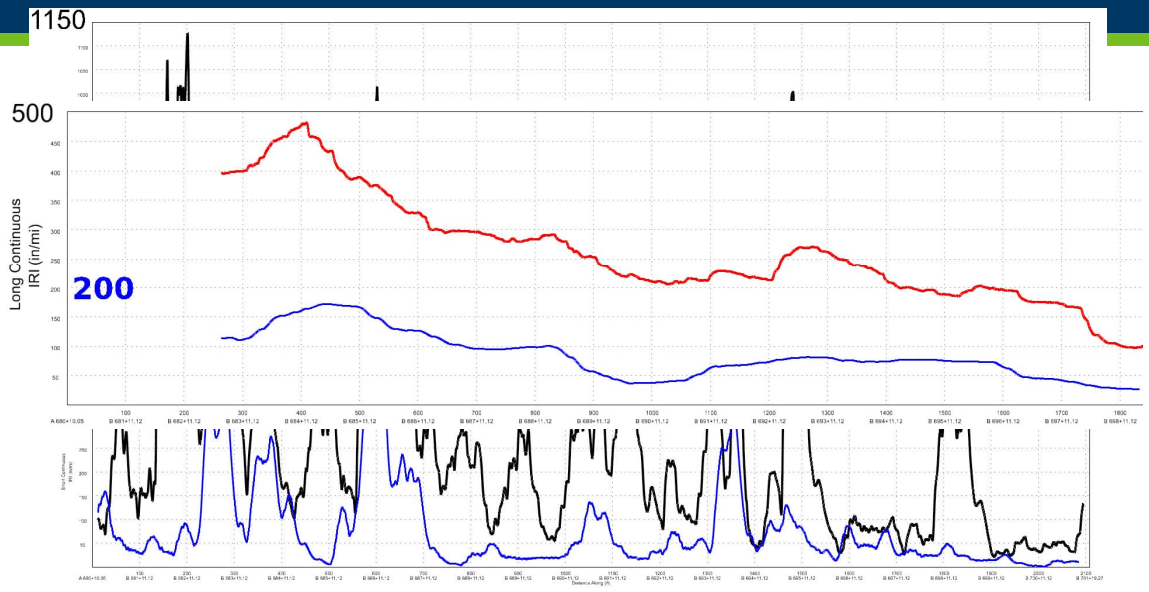
Understanding “what is good enough” – project by project basis



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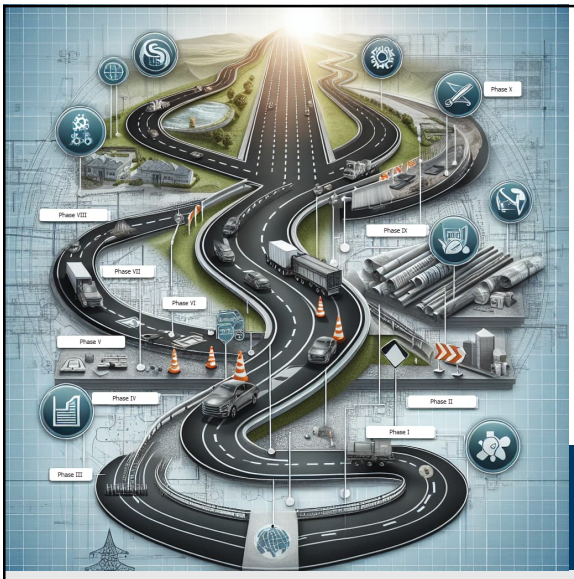

DEPARTMENT OF TRANSPORTATION

Bid Package

Proposal and Plans

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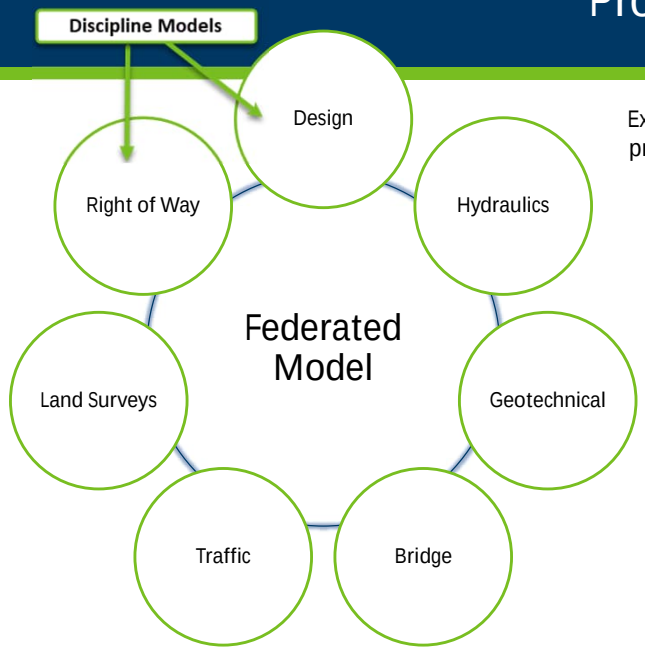
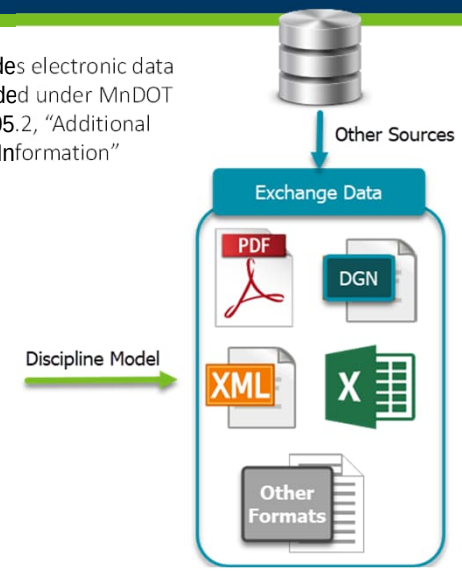
Project-Specific Electronic Data



Excludes electronic data provided under MnDOT 1205.2, "Additional Information"



Discipline Model

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SP 1103 Definitions (P-SED)

Plans

The Plans, profiles, typical cross-sections, ~~and~~ Standard Plans and Project-Specific Electronic Data that show the locations, character, dimensions, and details of the Work.

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SP 1504 Coordination of Contract Documents (P-SED)

A requirement appearing in one of the Contract documents is as binding as though the requirement appears in all. If discrepancies exist between the Contract documents, the following order of precedence applies:

(1) Addenda

(2) Special Provisions

(3) Discipline Models

(4) Exchange Data

(5) Federated Model

(6) Project-Specific Plans Sheets

(7) Supplemental Specifications

(8) Standard Plans and Standard Plates

(9) Standard Specifications

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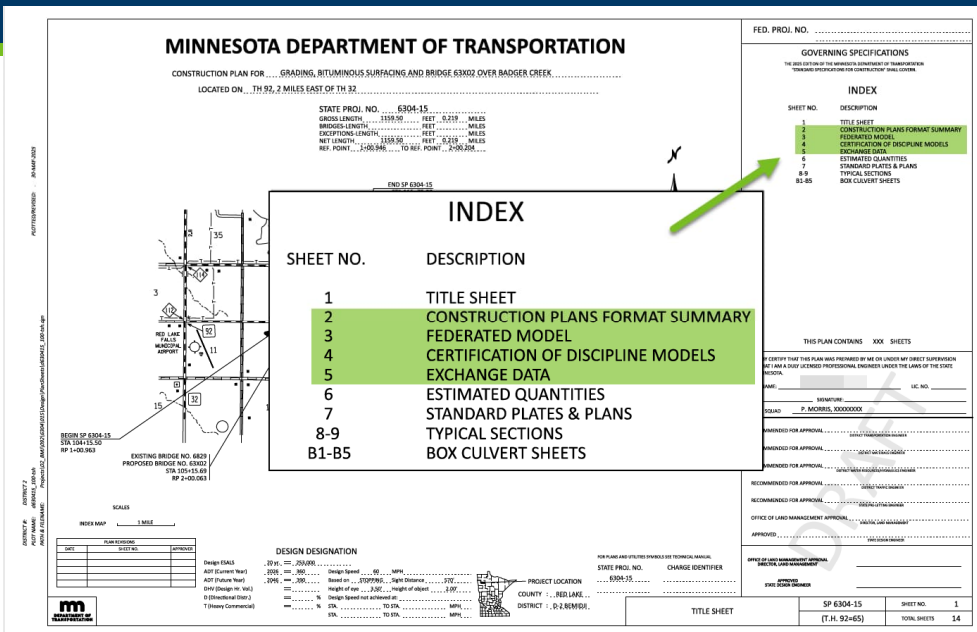
Index Table



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Construction Plans Format Summary

CONSTRUCTION PLANS FORMAT SUMMARY (1)	
HISTORICAL PAPER PLAN SECTIONS	PLAN FORMAT LOCATION
TITLE SHEET	PDF
GENERAL LAYOUT	P-SED
ESTIMATED QUANTITIES	PDF
STANDARD PLANS AND PLATES	PDF
TABULATIONS	P-SED
UTILITY PLAN	P-SED
TYPICAL SECTIONS	PDF
DESIGN DETAILS	P-SED
STANDARD PLANS	PDF
ALIGNMENT PLANS	P-SED
REMOVAL PLANS	P-SED
CONSTRUCTION PLANS FORMAT SUMMARY	P-SED
DRAINAGE PLANS	P-SED
DRAINAGE PROFILES AND TABULATIONS	P-SED
HYDRAULIC DETAILS	P-SED
ENVIRONMENTAL MANAGEMENT PLANS	PDF
SWPP PLANS AND WATER RESOURCES NOTES	PDF
EROSION CONTROL AND TURF ESTABLISHMENT PLANS	P-SED
TRAFFIC CONTROL PLANS	P-SED
PERMANENT PAVEMENT MARKING PLANS	P-SED
CROSS SECTIONS	P-SED
BOX CULVERT PLANS	PDF

(1) SEE FEDERATED MODEL, CERTIFICATION OF DISCIPLINE MODELS, AND/OR EXCHANGE DATA PLAN SHEETS FOR P-SED PLAN FORMAT LOCATION.

- PDF (traditional format), or
- P-SED (digitally delivered)

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Federated Model

If two or more Discipline Models digitally delivered

FEDERATED MODEL (1)		
FEDERATED MODEL NAME	DESCRIPTION	SHA256 FILE HASH VALIDATION CODE
123456_FEDERATED.dgn	COMBINED DISCIPLINE MODELS	b5790dc16165d5e918ad96831614db4f6e09bc85f89ac2bb8e21865618422c20

(1) SEE DIVISION S SPECIAL PROVISION (1203) ACCESS TO PROPOSAL PACKAGE (PROJECT-SPECIFIC ELECTRONIC DATA [P-SED]) FOR LINK TO FEDERATED MODEL. INFORMATION WILL BE TRANSFERRED TO AN ALTERNATE PLATFORM AFTER CONTRACT APPROVAL. CONTACT ENGINEER FOR PLATFORM TO BE USED DURING THE WORK.

FEDERATED MODEL	SP 1234-56	SHEET NO.
	(TH 78)	TOTAL SHEETS

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Certification of Discipline Models

If two or more Discipline Models digitally delivered

CERTIFICATION OF DISCIPLINE MODELS (1)			
DISCIPLINE MODEL NAME	DESCRIPTION	SHA256 FILE HASH VALIDATION CODE	LICENSED PROFESSIONAL NAME
123456_Design.dgn	DESIGN MODEL	1c83e3467e5d6a6cef39a80b4fd703c8f22e27ca7e5547e93b461057a38f593c	DARRYL B. MORETICOME
123456_Hydraulics.dgn	HYDRAULICS MODEL	f92c20e5556599fa8cbfbd8e61f12fb5596e6a86780b42198e9e0c15d72e4b50	CRYSTAL BALL
123456_Traffic.dgn	TRAFFIC MODEL	bc065969485247d140227c2f8ba0d437b49e14ea490d72d7fce2aee2307aedbe	ANNE TEAK
123456_Surveys.dgn	SURVEYS MODEL	112f18d7cec787ffd489323fd74b7917e01a9b4582ca52c09baf281celbad98f	ELLA FANT

(1) SEE DIVISION S SPECIAL PROVISION (1203) ACCESS TO PROPOSAL PACKAGE (PROJECT-SPECIFIC ELECTRONIC DATA [P-SED]) FOR LINKS TO DISCIPLINE MODELS. INFORMATION WILL BE TRANSFERRED TO AN ALTERNATE PLATFORM AFTER CONTRACT APPROVAL. CONTACT ENGINEER FOR PLATFORM TO BE USED DURING THE WORK.

I HEREBY CERTIFY THAT THE DISCIPLINE MODEL(S) INDICATED ON THIS SHEET WERE PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

PRINTED NAME:
SIGNATURE:
LIC. NO.:
DATE:

I HEREBY CERTIFY THAT THE DISCIPLINE MODEL(S) INDICATED ON THIS SHEET WERE PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

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PRINTED NAME:
SIGNATURE:
LIC. NO.:
DATE:

I HEREBY CERTIFY THAT THE DISCIPLINE MODEL(S) INDICATED ON THIS SHEET WERE PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED LAND SURVEYOR UNDER THE LAWS OF THE STATE OF MINNESOTA.

PRINTED NAME:
SIGNATURE:
LIC. NO.:
DATE:

CERTIFICATION OF DISCIPLINE MODELS	SP 1234-56	SHEET NO.
	(TH 78)	TOTAL SHEETS

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Exchange Data

EXCHANGE DATA (1)		
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123456_Removals.dgn	REMOVAL ITEMS	b5790dc16165d5e918ad96831614db4f6e09bc85f89ac2bb8e21865618422c20
123456_Proposed_Finish_Grade.xml	PROPOSED FINISHED GRADE SURFACE	c83e3467e5d6a6cef39a80b4fd703c8f22e27ca7e5547e93b461057a38f593c
123456_Grading_Grade.xml	GRADING GRADE OR BOTTOM OF AGGREGATE SURFACE	bc065969485247d140227c2f8ba0d437b49e14ea490d72d7fce2aee2307aedbe
123456_Bottom_of_Select.xml	SUBGRADE OR BOTTOM OF SELECT	db8bb7b4f752ale53715540ab83d92b677c322e8b51b2c47f393cd8f715dfe5b
123456_Proposed.dgn	PROPOSED ITEMS	794f973bb7a64ea9950d0bbed3fd4a2dc7acfc2ff2ee35ba4111485bc988cd54
123456_Pipe_Culvert.dgn	PIPE CULVERT	67e5d6dbba2404bb9543b452528443933968 7f7d3109867f2a03b4efe9bblc60
123456_Erosion_Control.dgn	EROSION CONTROL	e929144c894303ddf866ed9889306bfdld2e2bc80b40823dbe8325fd09bfdc43
123456_Turf_Establishment.dgn	TURF ESTABLISHMENT	b1cfa20a9c61aef558c9c94978383152c36c0ee91df8c8cb0a3d48fa740218f6
123456_Pavement_Markings.dgn	PAVEMENT MARKINGS	be951dac3d3534068fff3498e93cde25686817b69f8d4667c9856e26fe2dc950
123456_Traffic_Control.dgn	TRAFFIC CONTROL MARKINGS	9b74d27218269alcld24e824dc56a0de6b9e4cd474e06ae08da73a309c09e2eb
123456_INPTH78_Profile.xml	CENTERLINE HORIZONTAL ALIGNMENT AND VERTICAL PROFILE GRADE	10kl4d27218269alcld24e824dc56a0de6b9e4cd474e06ae08da73a309c09x4w0
123456_INPTH78.xml	CENTERLINE HORIZONTAL CONSTRUCTION ALIGNMENT	ld56944e453b741065223acd2fddbbc86a259a9ale37c06fbf9f7bdf7f6bced4
123456_PayItemRawDataReport.xlsx	REPORT OF PAY ITEMS AND LOCATIONS	bb8ee585d88e5a89fc8ea73b660d1fb40aaa3bba9943d32565d8fef3b454f0b1
123456_Staking_Report.xlsx	CONSTRUCTION SURVEYING STAKING REPORT	5bdb41f36006db635ccd35d35f92ed311e4876a8801c32922dc42073a05ff3c4

(1) SEE DIVISION S SPECIAL PROVISION (1203) ACCESS TO PROPOSAL PACKAGE (PROJECT-SPECIFIC ELECTRONIC DATA [P-SED]) FOR LINKS TO EXCHANGE DATA. INFORMATION WILL BE TRANSFERRED TO AN ALTERNATE PLATFORM AFTER CONTRACT APPROVAL. CONTACT ENGINEER FOR PLATFORM TO BE USED DURING THE WORK.

EXCHANGE DATA	SP 1234-56	SHEET NO.
	(TH78)	TOTAL SHEETS

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Example of innovation saving the parade!

AMG Milling using Robotic Total Stations

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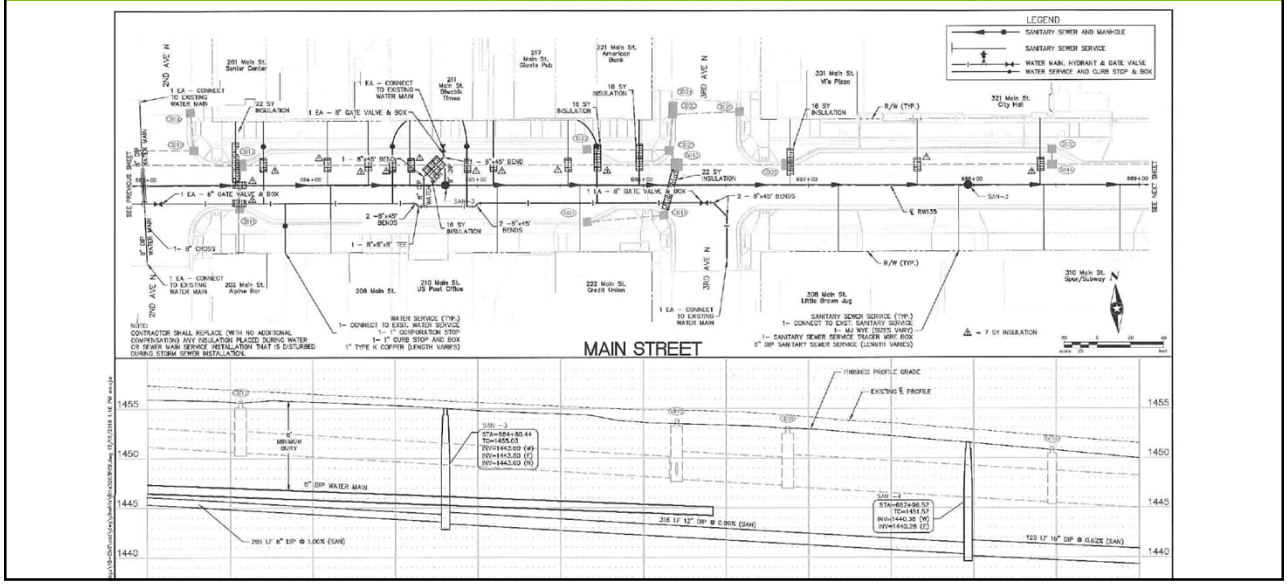
Utility Plan Sheet



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Urban Project Components

- Watermain replacements
- Repair/replace drainage structures
- Replace trunk storm sewer line
- Sanitary sewer replacements
- Reconstruct pavement and subgrade
- ADA improvements
- New sidewalk and curb and gutter

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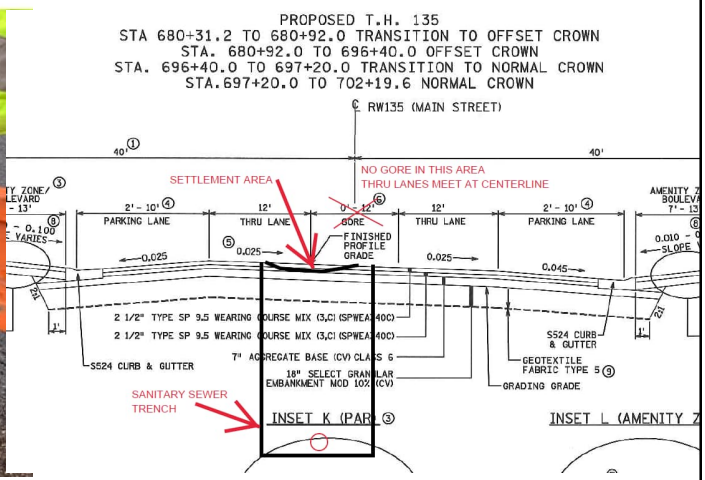
Settlement measurement after first spring thaw



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Video of settlements after first spring thaw

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Design criteria

- Match in-place curb
- Maximum mill depth
  - Minimum of 5 inches of existing material to be left in-place
- Maximum cross slope
- Drainage and Ponding

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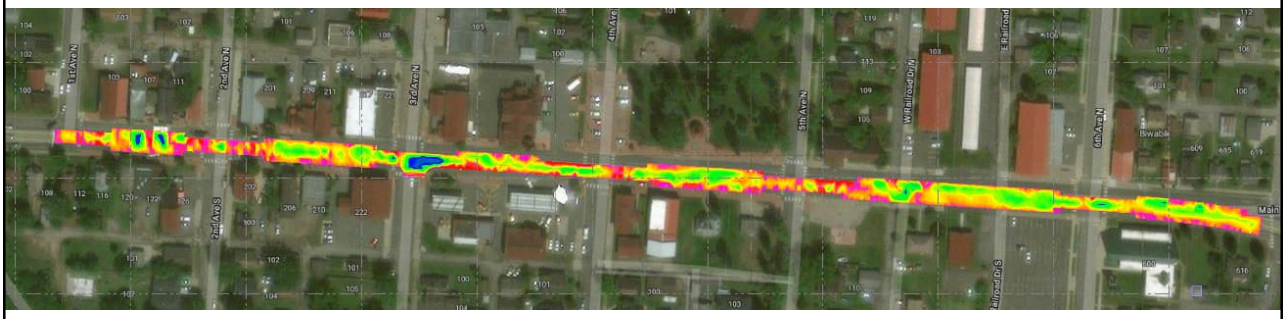
Created AMG Milling Depth Cut/Fill Map

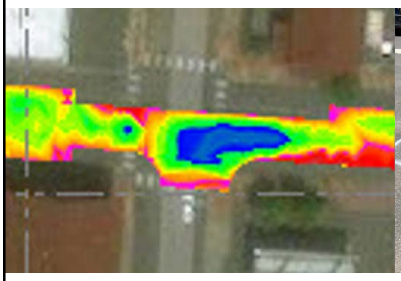
Quick view – Construction staff (mill depths – daylighting)



52

Fill areas

Marked areas to be pre-filled with leveling course to prevent daylighting of mill head



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AMG equipment setup

- RTS control milling on side of road
- 1-mast receiver with prism running control off
- Wavey and varying thicknesses


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Milling operation

- 8-ft mill
- Driving lanes – AMG milling
  - Both passes 3D
  - First pass (8-ft): depth – depth
  - Second pass (4-ft): joint match - depth
- Parking lanes
  - Conventional milling
  - Joint match (driving lane surface) – joint match (curb)

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Parking lane
joint match – joint match to 2 inches below toe of curb

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Only DTM every 10-ft, low area was in between collection points
Verified with paving contractor that averaging ski will span location to allow for fill with paver

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Example of variable depths

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Variable depth

Bumps and dips were successfully removed using AMG milling

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Finished product

Mill was within tolerance of 0.02 ft the entire time

Roadway profile, smoothness, and drainage corrections successfully corrected!

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Thank You!

Rebecca Embacher
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651-373-5222

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MARCH 18-20 2026

MINNESOTA TRANSPORTATION CONFERENCE & EXPO

ISIC Track
Digital As-Built (DAB) and Workflow of Pavement Construction

Wednesday, March 18th, 2026 - Room 13,14,15

By

International Society for Intelligent Construction (ISIC)

IS-IC.ORG

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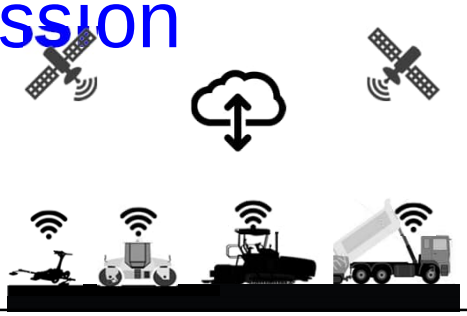
ISIC Track 09
Open Panel Discussion

Moderated By
Mr. Curt Turgeon, P.E.
MnDOT
Steering Committee, ISIC



ISIC

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Agenda

Time	Topic	Speakers
08:00 AM – 08:30 AM	ISIC Track 01 - Introduction and Overview	Dr. George K. Chang (Transtec-Terracon)
08:30 PM – 09:30 AM	ISIC Track 02 - DAB from the Material Delivery Management System (MDMS)	Rebecca Embacher (MnDOT)
09:30 AM – 10:15 AM	ISIC Track 03 - DAB from 2D/3D Milling	Tom Chastain (Wirtgen Group)
10:15 AM – 10:30 AM	Break	
10:30 AM – 11:15 AM	ISIC Track 04 – DAB from 2D/3D Paving and Thermal Profiling	Jim Preston (TOPCON) and Craig Lamarque (Wirtgen Group)
11:15 PM – 12:00 PM	ISIC Track 05 – DAB from Intelligent Compaction	Todd Mansell (Caterpillar)
01:00 PM – 01:45 PM	ISIC Track 06 – DAB for Living Models in Asset and Pavement Management Systems	Jim Preston (TOPCON)
01:45 PM – 02:45 PM	ISIC Track 07 - DAB for Improving Construction QC and QA	Amanda L. Gilliland (Transtec-Terracon) and Scott Fernald (Granite Construction)
02:45 PM – 03:00 PM	Break	
03:00 PM – 4:00 PM	ISIC Track 08 - Complete Paving DAB Workflow Examples	Rebecca Embacher (MnDOT) and Scott Fernald (Granite Construction)
4:00 PM – 5:00 PM	ISIC Track 09 – Open Panel Discussion	Moderator: Curt Turgeon (MnDOT) Panels: DOTs (MnDOT, NDDOT), vendors (Caterpillar, Trimble, Wirtgen, TOPCON), contractors (Granite, KnifeRiver), associations (MAPA), consultants (Transtec-Terracon)
5:00 PM	Adjourned	

ISIC

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Learning Objectives

1. Gain a comprehensive understanding of Digital As-Built (DAB) technologies and their application in pavement construction workflows.
2. Explore how DAB enhances quality control and assurance in construction projects.
3. Discover how DAB workflows and software technologies support updates to asset and pavement management systems.
4. Engage with perspectives from agencies, industry leaders, and contractors.

ISIC

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Panel Members

Moderator

MnDOT

Agency

MnDOT

Vendors

Wirtgen

TOPCON

Caterpillar

Wirtgen

Contractor

Granite Construction

Consultants

Transtec-Terracon

WSB

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SCAN the QR Code

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