NRRA National Road Research Alliance

Meeting Minutes: NRRA Intelligent Construction Technologies (ICT) Team

(Agency & Associate Member Meeting)

Date: January 7, 2021
Minutes prepared by: Rebecca Embacher
Location: Microsoft Teams
NRRA Team Webpage: http://www.dot.state.mn.us/mnroad/nrra/structure-teams/intelligent-construction/index.html

Attendance

Agency Members

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Associate Members

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☐	North Dakota	Carey Schreiner	
☐	North Dakota	David Bruins	
☒	North Dakota	Nathan Haaland	

Other Attendees: Antonio Gomes Correia (University of Minho, Portugal), Jerry Bickner, Mike Hoffman

Decisions Made

- None

Action items

- Determine top 5 project priorities by March 4, 2021 meeting.

- Determine Intelligent Construction Technologies to use during MnROAD re-construction at April meeting.

Agenda

- Presentation: “Introduction to ISIC” – George Change and Tim Kowalski
- Presentation: “Progress Update: Evaluation & Application of MnDOT Road Doctor Survey System” – Eyoab Zegeye Teshale

Next Meeting

Date: February 4, 2021
Time: 10:30-11:30AM Central Time
Location: Microsoft Teams
Agenda items: NRRA Phase II Funding and Action Items

Meeting Notes

Entire duration of meeting was set aside for the following presentations:

- Presentation: “Introduction to ISIC” – George Change and Tim Kowalski
- Presentation: “Progress Update: Evaluation & Application of MnDOT Road Doctor Survey System” – Eyoab Zegeye Teshale

See slides below.

ISIC
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NRRA
National Road Research Alliance
Strategic Implementation Through Cooperative Pavement Research

Introduction to ISIC

By

George K. Chang, PH.D., P.E. (Transtec Group) &

Tim Kowalski (Wirtgen America)

THE TRANSTEC GROUP
The World's Pavement Engineering Specialists

WIRTGEN GROUP
A JOHN DEERE COMPANY

IS-IC.ORG

ISIC

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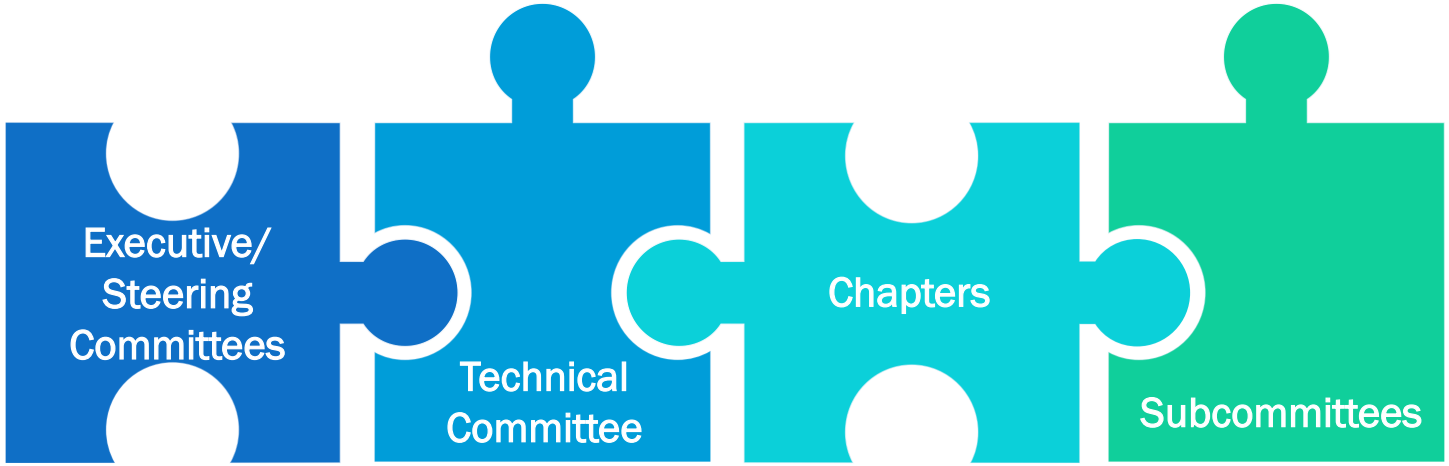
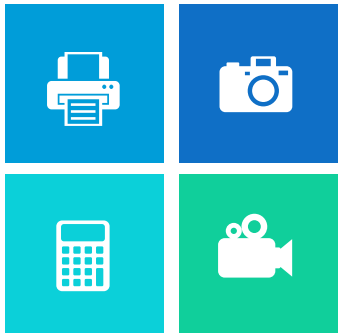
Intelligent Construction Technologies (ICT)

ISIC Structure



Executive/Steering Committees
Provide visions and directions.

Technical Committee
Provide technical expertise.



Chapters
Extend to local regions.

Subcommittees
Handle specific administrative, educational and technical functions.

ISIC

ISIC Subcommittees

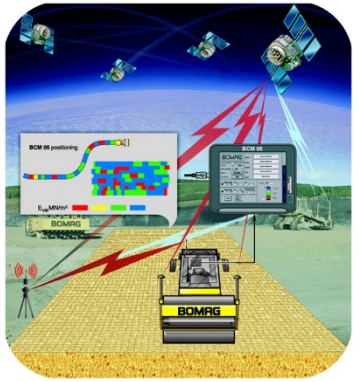
- SC1 Perception and Control
- SC2 Dana Analysis and Management
- SC3 Artificial Intelligence (AI) and Engineering
- SC4 Integration and Innovation
- SC5 Green and Safety
- SC6 Education and Training

ISIC

SC1 Perception and Control

All technologies related to data acquisition and controls, including

- sensing technologies,
- data collection technologies (e.g., GNNS, LiDAR , Unmanned Aerial Systems (UAS)),
- Internet,
- monitoring technologies (e.g., materials, paving, and intelligent compaction),
- Automated Machine Control (AMC),
- Automated Machine Guidance (AMG), and
- Autonomous Control Machinery (ACM), etc.

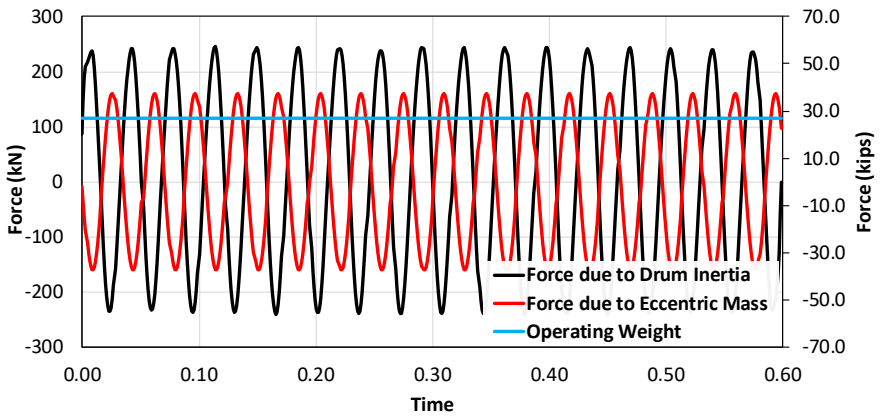


ISIC

SC2 Data Analysis and Management

All technologies related to data analysis and management, including:

- data science (e.g., Big Data, data communication protocols and standards),
- signal analysis,
- Cloud computing, and
- digital information platforms, etc.



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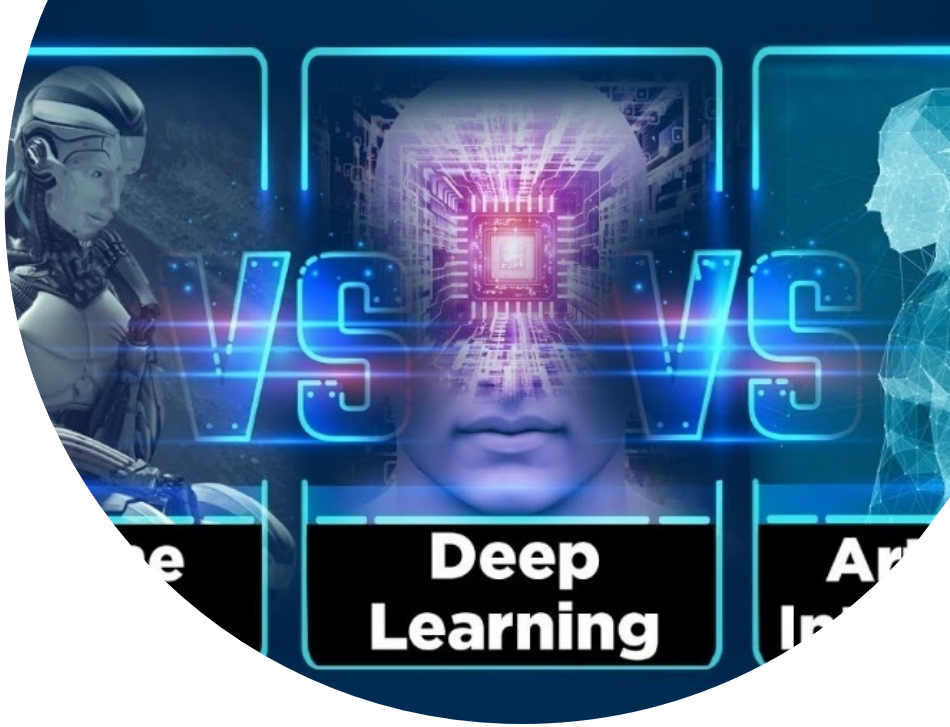
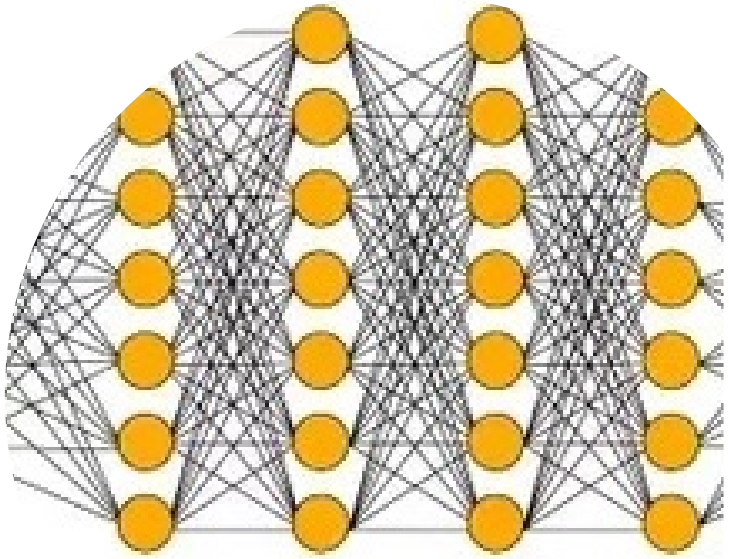
SC3 Artificial Intelligence (AI) and Engineering

Application of AI on construction, including:

intelligent algorithms, computing and methodologies (e.g.,

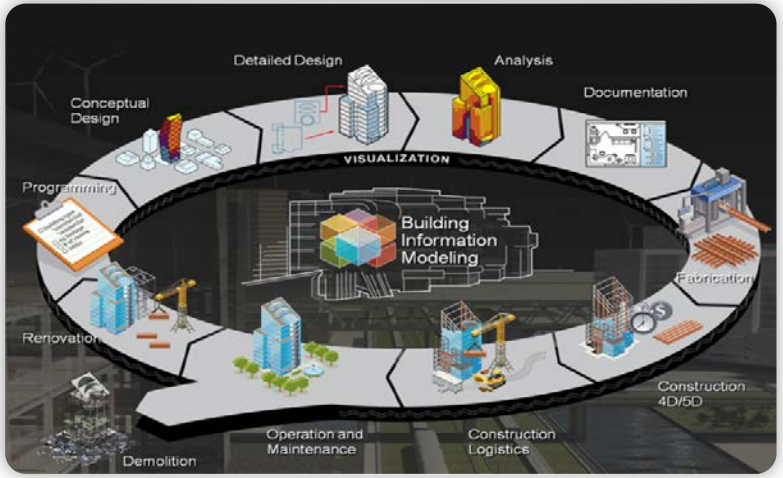
- engineering expert systems,
- neural network,
- machine learning, etc.)





ISIC

SC4 Integration and Innovation



Application with fundamental theories and integrated technologies during design, construction, and rehabilitation/maintenance stages, e.g.,

- stress analysis,
- augmented reality technologies (BIM, VR/AR, 3D visualization),
- interaction between construction machinery and constructed media,
- risks forecast/evaluation,
- management and decision-making, etc.

SC5 Green and Safety

- Conservation of natural resources, environmentally friendly technologies.
- Application of automated sensing/safety technologies on construction and operation, and
- forewarns of all kinds of disasters and recovery, etc.

SC6 Education and Training

Promote globally intelligent technologies. including textbooks, technical training and so on.

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ISIC Journal - ICT for Infrastructure

A Book Series - ICT for Transportation Infrastructures

7 Books in English (Springer) and Chinese (CRPC) in 2021

1. Introduction to Intelligent Construction Technology of Transportation Infrastructure
2. The Basis of Perception Terminals: Information Technology in Engineering
3. The Basis of Perception Methods: One-dimensional Dynamics and Applications in Engineering
4. The Basis of Machine Analysis and Decision-Making: Into Machine Learning
5. A Weapon for Engineering Quality: Perception and Data
6. Executive Assistant: Control Technology in Engineering
7. Pioneer of Intelligent Construction: Intelligent Compaction

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ISIC Webinar

BIM for Pavements

July 2020

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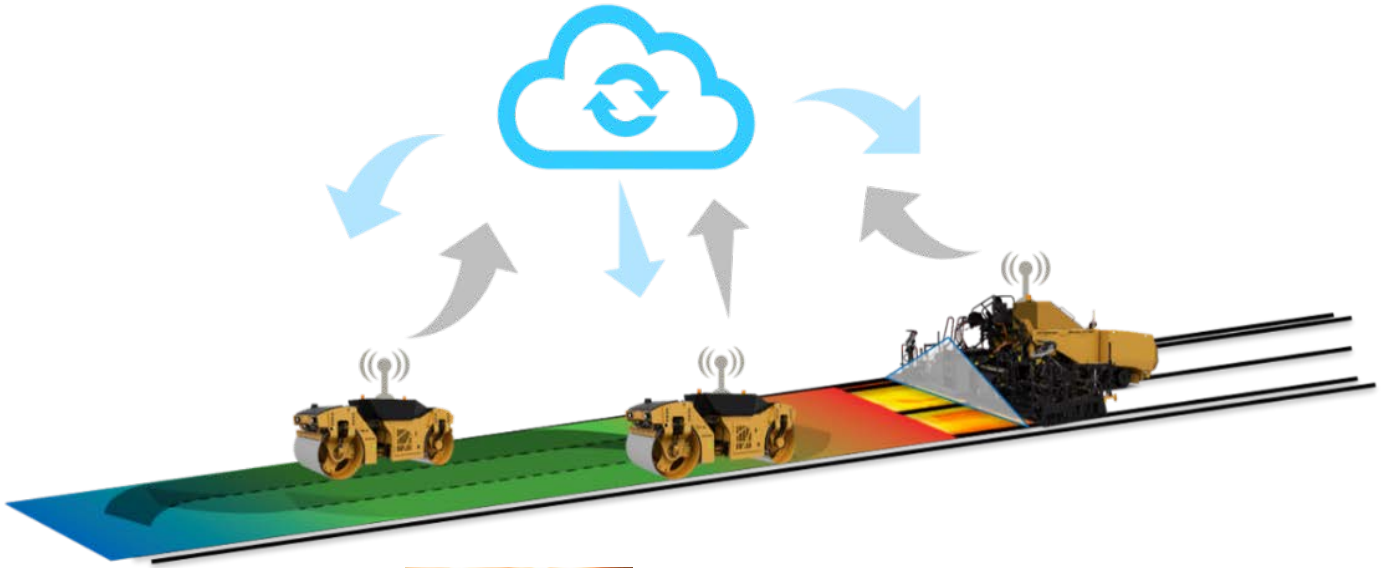
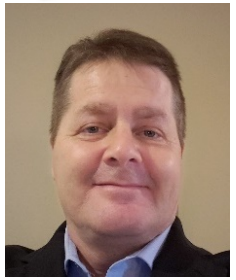
ISIC Webinar

Automation in Construction



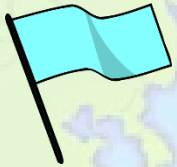



Oct. 2020

ISIC

ISIC International Conferences





- 2016 – Inaugural Meeting (ICTG Conf. Portugal)
- 2017 – Minneapolis, MN, USA
- 2019 – Beijing, China
- 2022 – Guimaraes, Portugal
- 2024 – TBA, USA

2017 Conference – MN, USA

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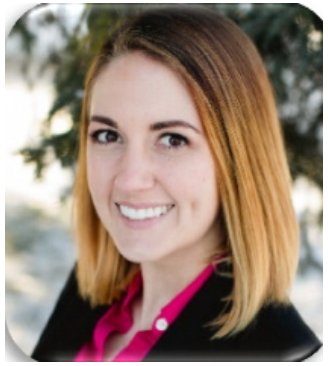
North America Chapter



ISIC North America Chapter Plan

- Regular officers web meetings
- Technical advice for NRRA/FHWA on ICT Data QA (IC, PMTP, DPM, eTicket, MDMS)
- Membership Drive
- ISIC NA Chapter Mini-Conference in Oct. 2021

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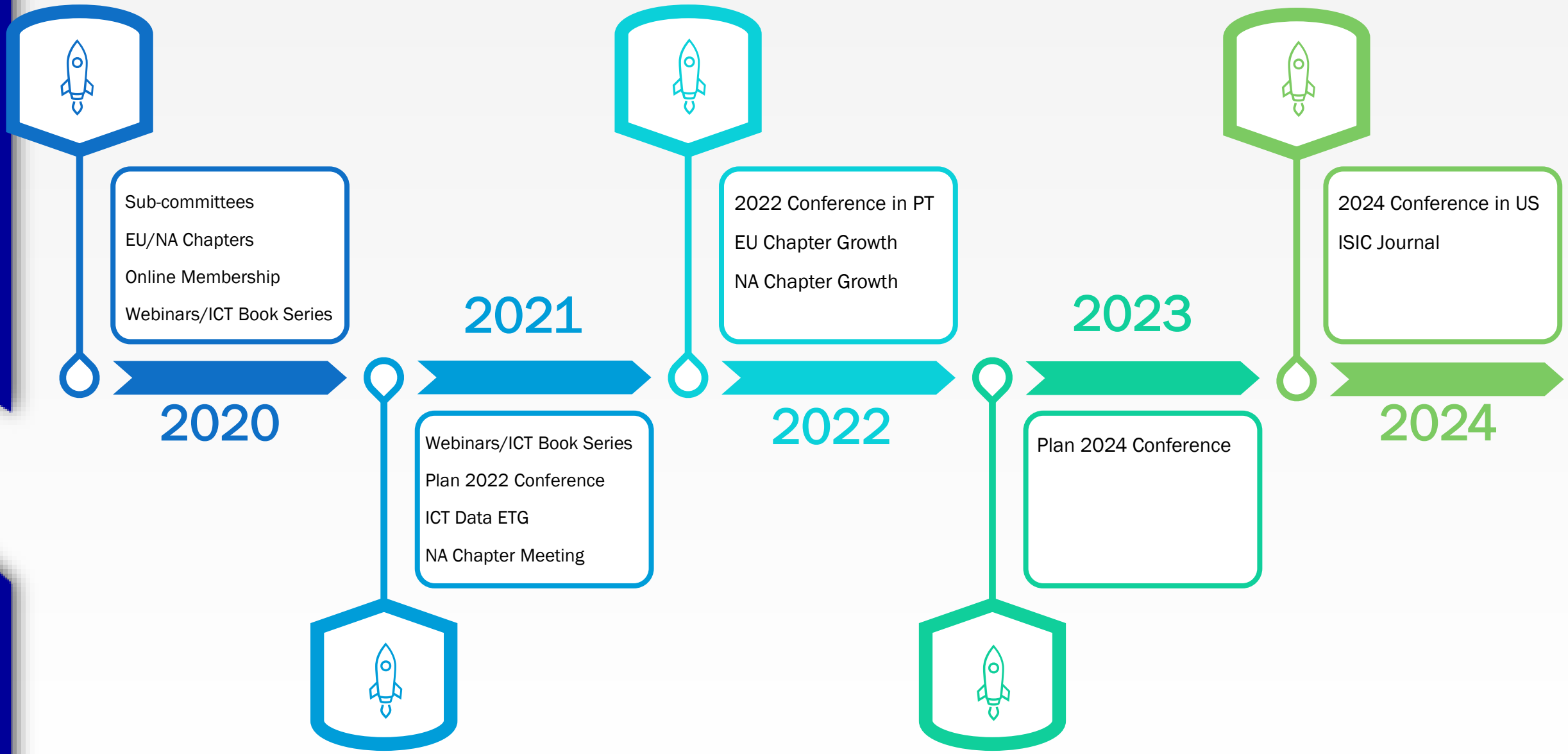
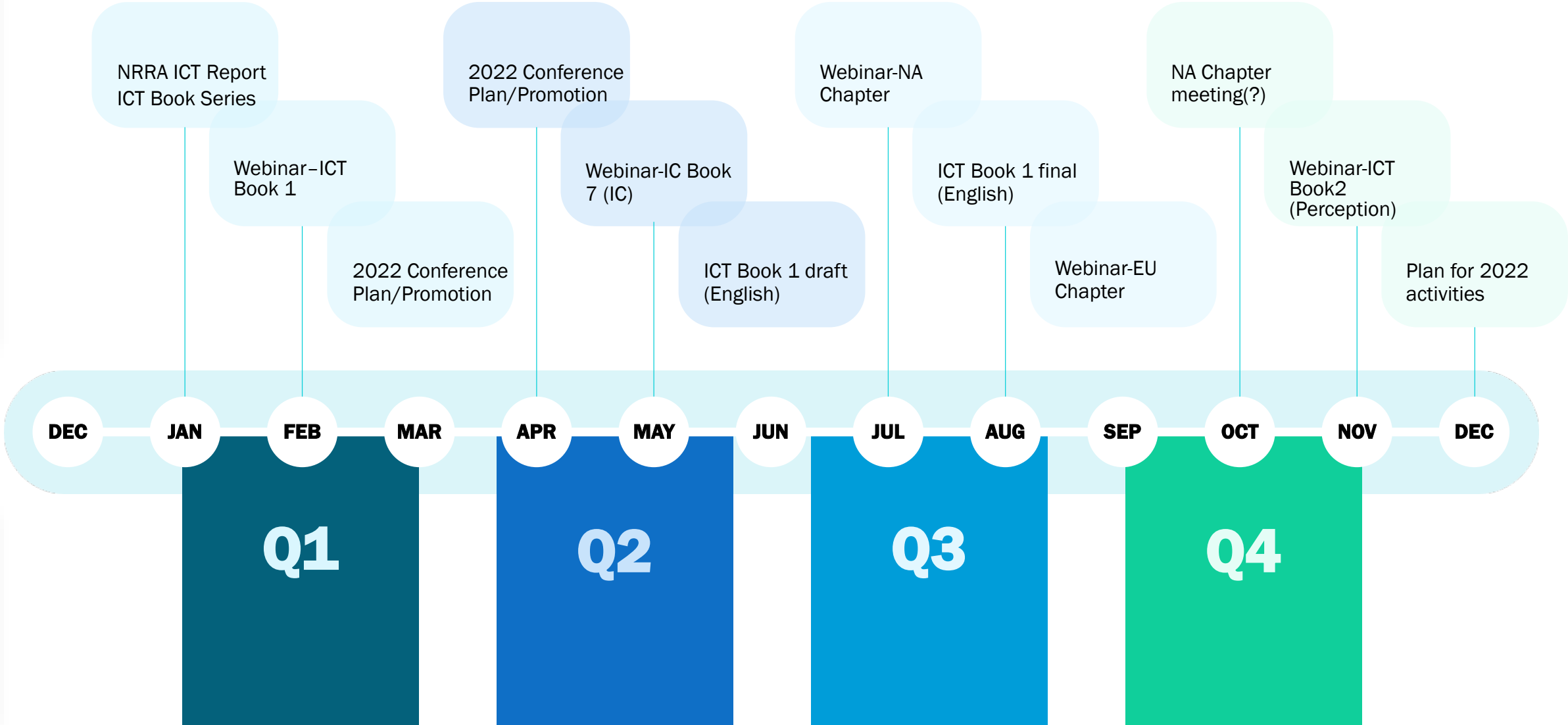
Future Growth & Development

- Growth Plan for ISIC
- Subcommittees in Specialized Fields
- Local Chapters
- ICT Standards
- ICT Journal
- Workshops/Webinars

ISIC 5-Year Plan Goals



ISIC 2021 Calendar



ISIC Membership

- Free and Open to Public
- Privilege to access member-only contents
- Apply on IS-IC.org

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www.IS-IC.org

Progress Update:
Evaluation & Application of MnDOT Road Doctor Survey System



MnDOT Office of Materials & Road Research

Eyoab Zegeye Teshale, Ph.D., P.E. (Presenter)

Thomas Calhoon

Dai Shongtao Ph.D., P.E

NRRA ICT monthly meeting

January 01, 2021

DEPARTMENT OF TRANSPORTATION

MnDOT Road Doctor Survey Van (RDSV)

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RDSV Applications

What does it measure?

- Surface measurements
  - HD Video cameras
    - Digital video images
  - Lidar Laser
    - Point cloud data (X,Y,Z coordinates)
    - Reflection intensity
  - Thermal camera
    - Surface temperature
  - Accelerometer + LIDAR + IMU
    - Surface profile
    - Vehicle accelerations
- Subsurface
  - Horn and ground coupled GPR antennas
    - 1D amplitude reflections
  - 3D GPR
    - 2D amplitude reflections
- Positioning and navigation system
  - Local and global coordinates

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Interpretation/Translation

The real challenge is in translating these measurements to engineering dimensions and parameters (IRI, layer thicknesses, surface and subsurface conditions, material properties and uniformity, detection of interfaces or buried targets, laser surface reconstructions, moisture/frost etc.,)

There is critical work that needs to be done before and after the testing

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Progress Update

Summary of Major activities

- Building the RDSV system (2018-2019)
  - Purchase of hardware and software application from Road scanners
  - Installation of sensors and wiring
  - System verification and training with Road scanners
- Operating the system
  - Proper use of sensors and data collection software
  - Equipment maintenance
- Logistics of data collection activities
  - Safety (i.e., traffic control needs)
  - Data storage and proper data collection frequencies
  - Required resources for testing and data processing(i.e., staffing, time)
- Data collection
  - Supporting research activities
  - Responding to district investigation requests
  - Exploring other application
- Data processing and interpretation
  - Road Doctor Software
  - Examiner
  - In-house codes and algorithms (Python, VBA, etc.)
- Reporting
  - Report templates (macros)
  - Exploring ways for sharing meaningful results

Pre & Post Reconstruction Evaluations

Road 70th St NE Otsego, MN

MnDOT/NCAT Research Study

- Study aimed at evaluating the effectiveness of cold recycling treatments

7001W 1" Thin lay 4" Existing	**7002W** 1" Thin lay 4" Existing	**7003W** 1" Thin lay 4" Existing	**7004W** 1" Thin lay 4" Existing	**7005W** 1" Thin lay 4" Existing	**7006W** 1" Thin lay 2" Overlay 2" Existing	**7007W** 1" Thin lay 3" CCPR 2" Existing	**7008W** 1" Thin lay 4" Existing
7001E 1" Thin lay 7" SFDR	**7002E** 1" Thin lay 7" SFDR	**7003E** 1" Thin lay 3" CIR 1" Existing	**7004E** 1" Thin lay 3" CIR 1" Existing	**7005E** 1" Thin lay 3" CCPR 1" Existing	**7006E** 1" Thin lay 3" Overlay 1" Existing	**7007E** 1" Thin lay 3" CCPR 1" Existing	**7008E** 1" Thin lay 7" Existing

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Pre & Post Reconstruction Evaluations

Road 70th St NE Otsego, MN

Video cameras for visual inspections of road conditions

- EB road in worst conditions
- Fatigue, thermal, rutting and base related distresses
- Geotagged images provide exact location of distressed sections
- Comparisons of pre and prost reconstruction pavement conditions

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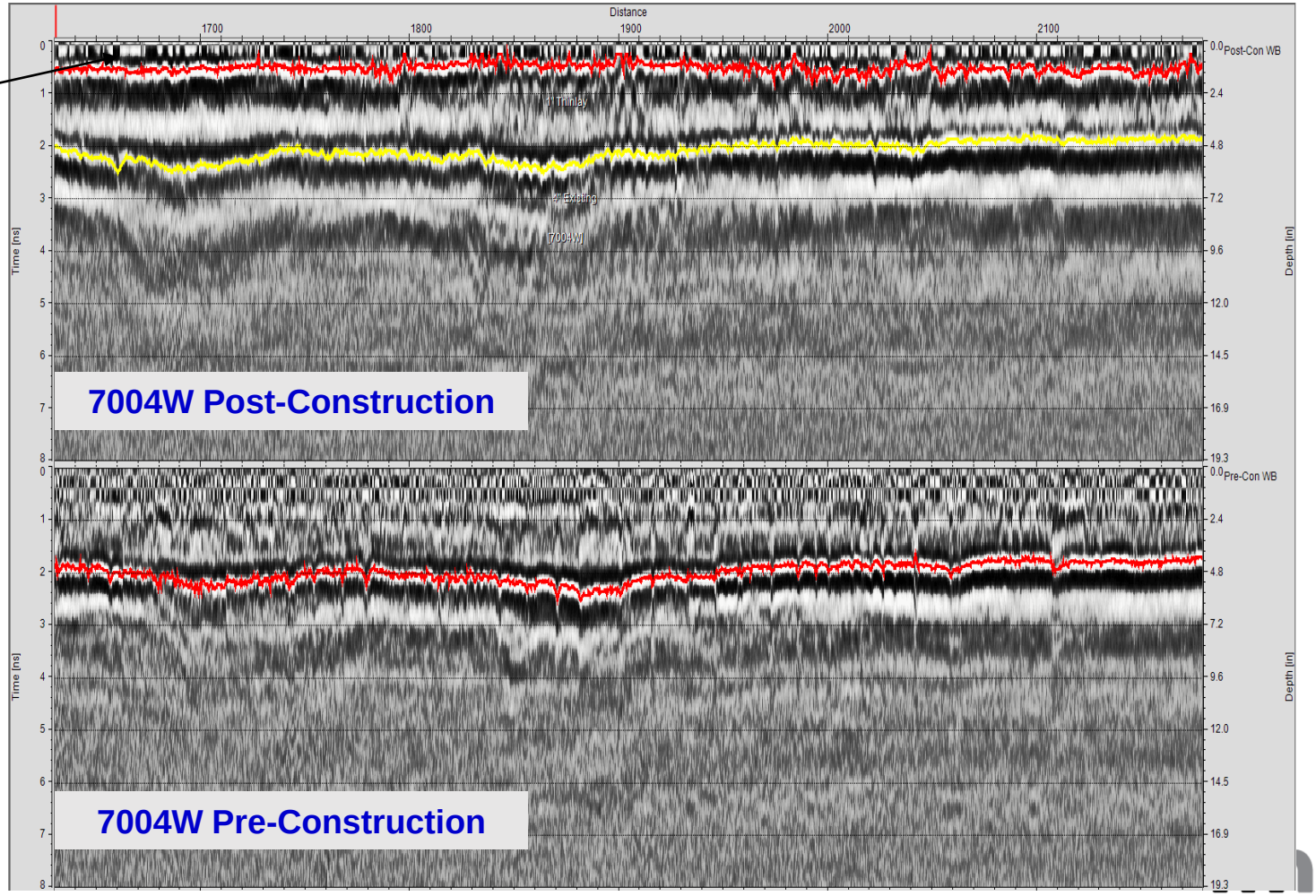
Pre & Post Reconstruction Evaluations

Road 70th St NE Otsego, MN

2 GHz GPR scans for pre & post construction pavement thicknesses

- Verify actual milling depths and layer thicknesses



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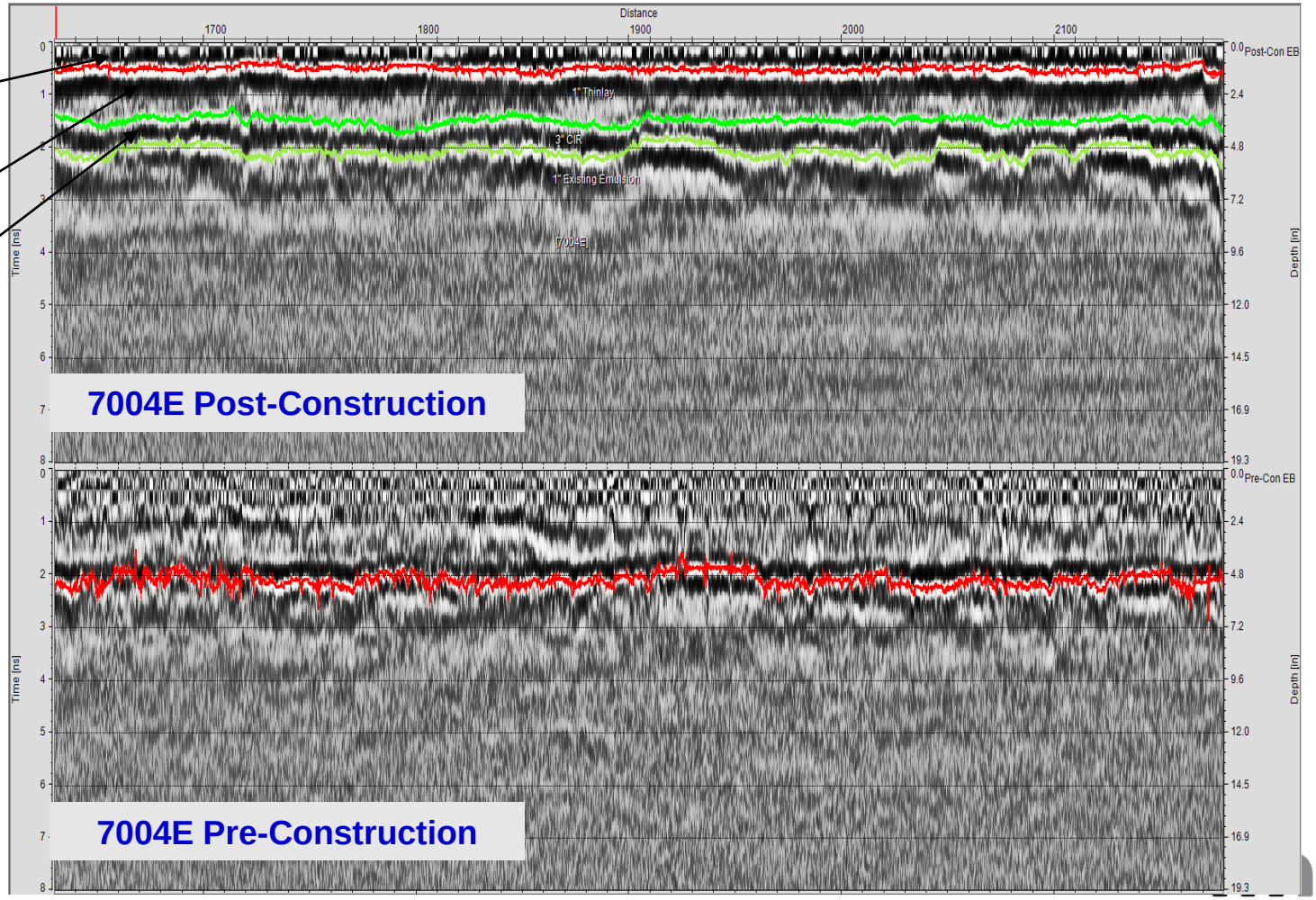
Pre & Post Reconstruction Evaluations

Road 70th St NE Otsego, MN

2 GHz GPR scans for pre & post construction pavement thicknesses

- Verify actual milling depths and layer thicknesses
- Residual thickness



Pre & Post Reconstruction Evaluations

Road 70th St NE Otsego, MN

LiDAR Laser & accelerometer for surface rutting depth and roughness depth

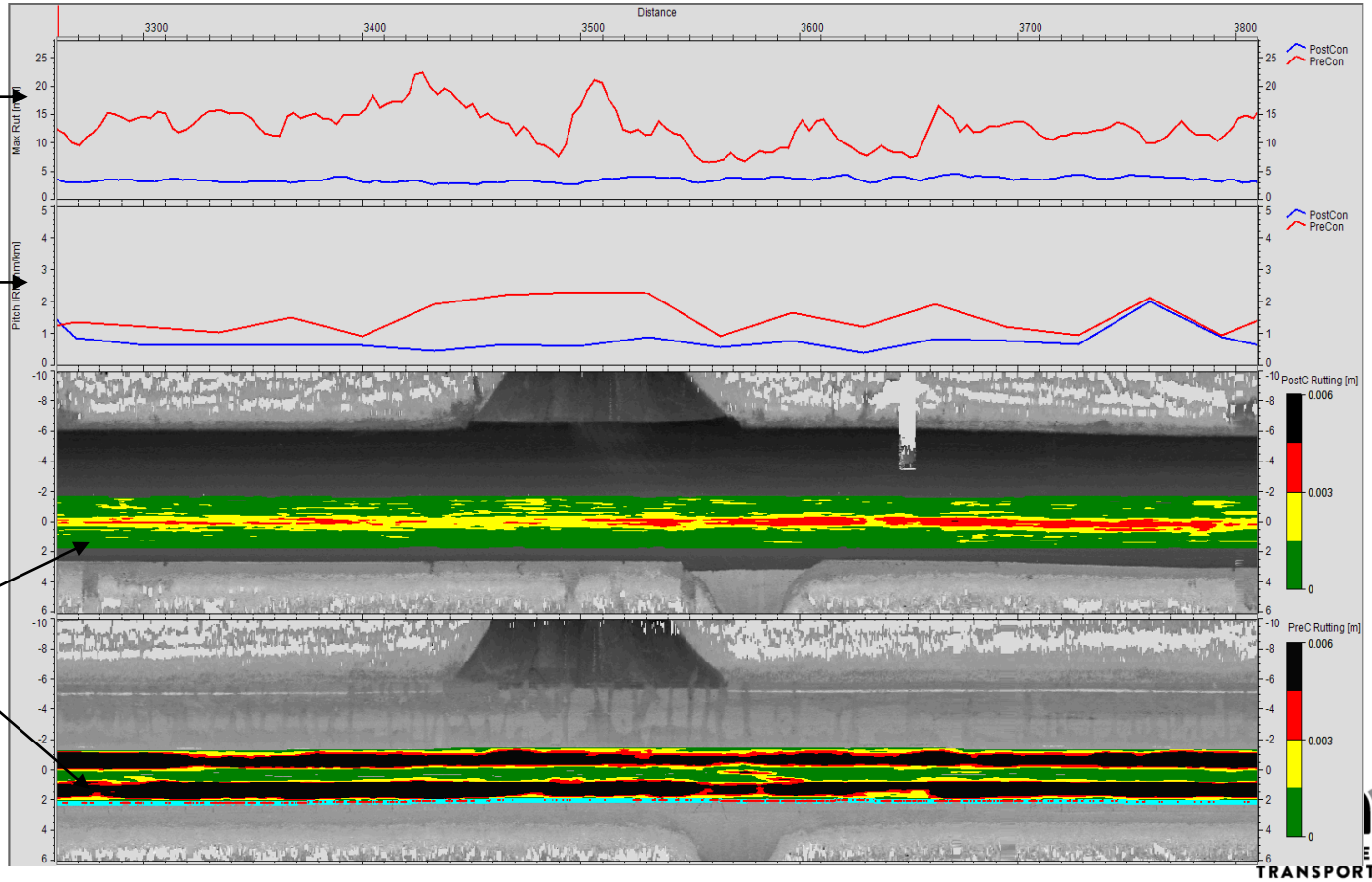
- The immediate rut and ride quality of the pavement improved significantly
- Some treatments performed better than others
- Rutting occurred mainly along the wheel-path

7007E Pre & Post Construction

Max Rut (mm)

IRI (mm/m)

Rut colormap

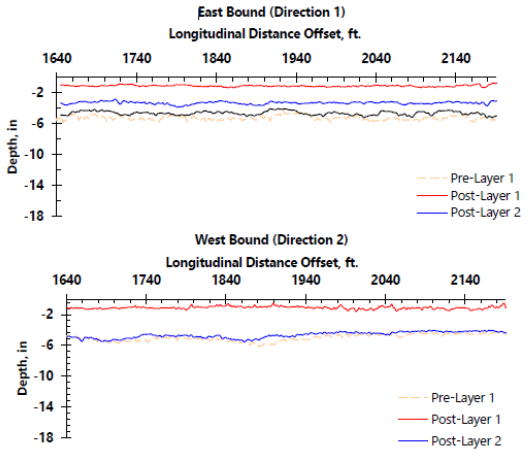


Pre & Post Reconstruction Evaluations

Road 70th St NE Otsego, MN

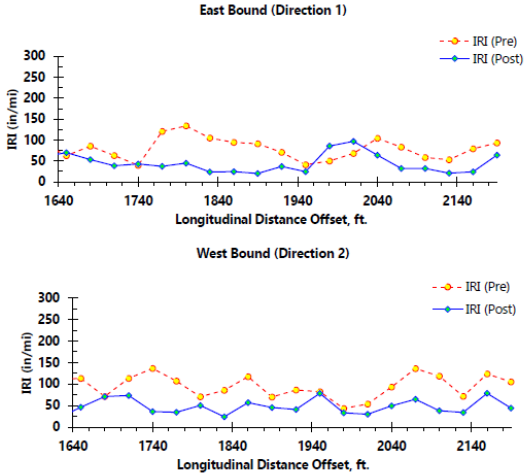
GPR THICKNESSES

Layer	Dir1 - Layer Thickness (in)				Dir2 - Layer Thickness (in)			
	Pre	CV,%	Post	CV,%	Pre	CV,%	Post	CV,%
1	5.3	5.7	1.1	9.1	5	8	1.1	18.2
2			2.2	9.1			3.5	14.3
3			1.3	15.4				27.3



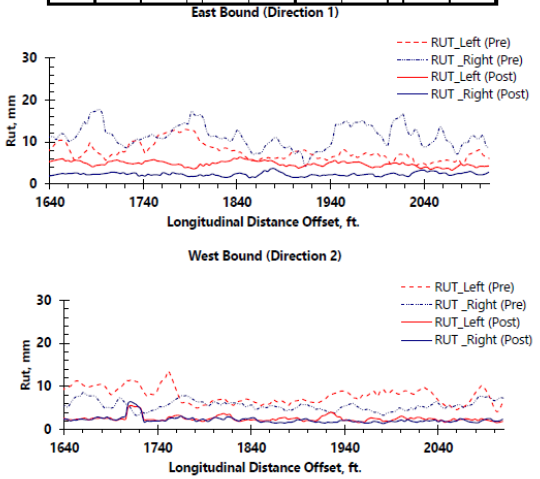
ROUGHNESS MEAUREMENTS (30 FT. INTERVAL)

Layer	Dir 1 - Ave. of Max Rut (mm)				Dir 2 - Ave. of Max Rut (mm)			
	Pre	CV,%	Post	CV,%	Pre	CV,%	Post	CV,%
1	79.4	32.4	44.8	49.6	95.3	27.9	47.4	37.6



RUTTING MEAUREMENTS

Path	Dir 1 - Rut (mm)				Dir 2 - Rut (mm)			
	Pre	CV,%	Post	CV,%	Pre	CV,%	Post	CV,%
LW	7.6	28	4.8	15	7.9	24	2.5	28
RW	11.4	23.7	2.3	17	5.6	20	2.2	32



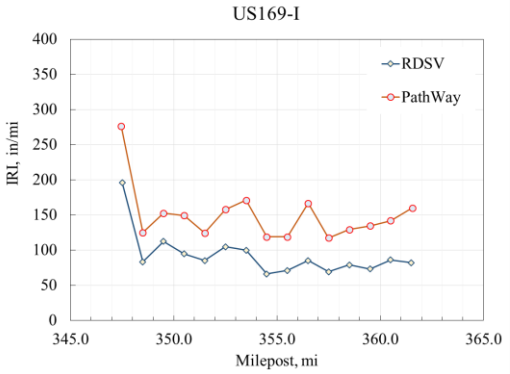
DEPARTMENT OF TRANSPORTATION

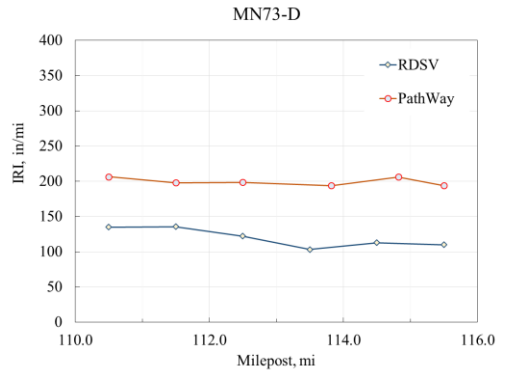
Evaluation of Roads Affected by Tenting

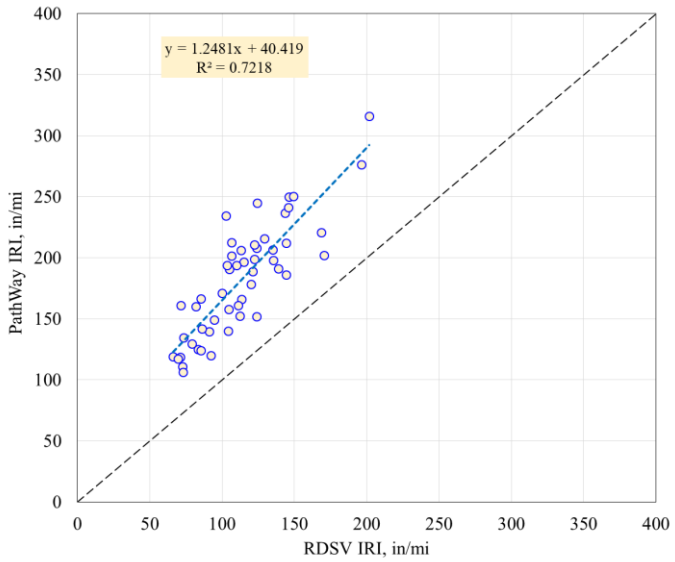
District 1 (~ 100 miles of road sections)

Comparison of ride quality: Road Doctor vs. Pathway Van Laser Profiler

- The two systems have different IRI measurement mechanisms
- Pathway: line profiles according to state and national specifications
- Road Doctor: A black box. Determined from LIDAR and Accelerometer measurements
- However, IRI from the two systems show high correlation and similar trends







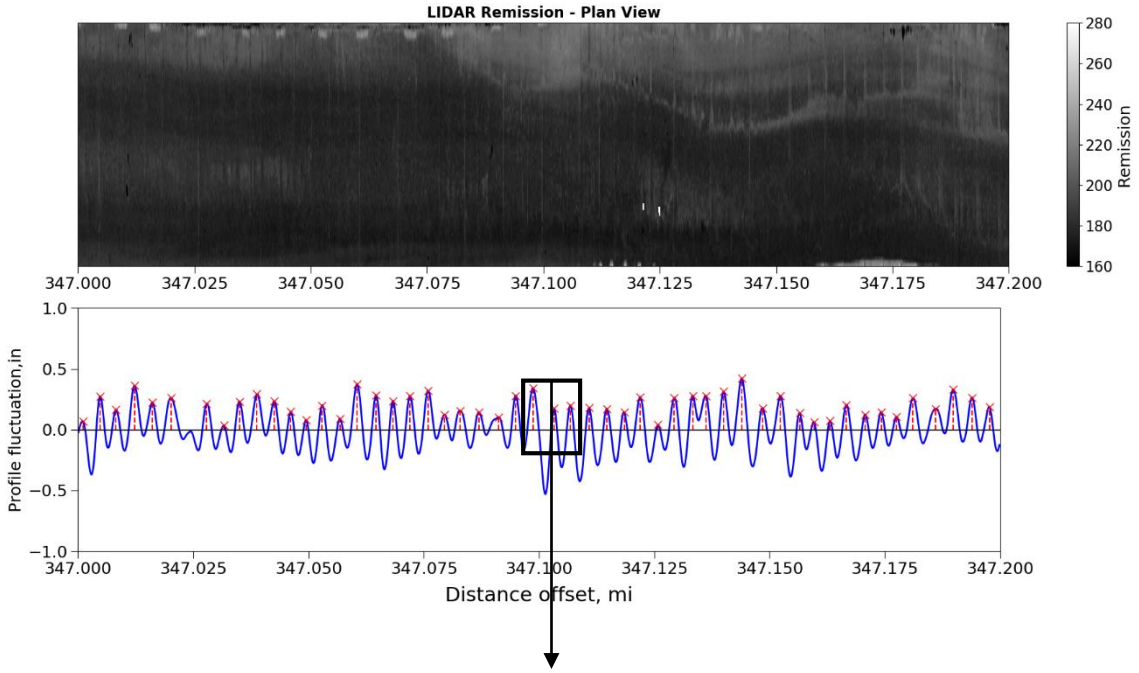
DEPARTMENT OF TRANSPORTATION

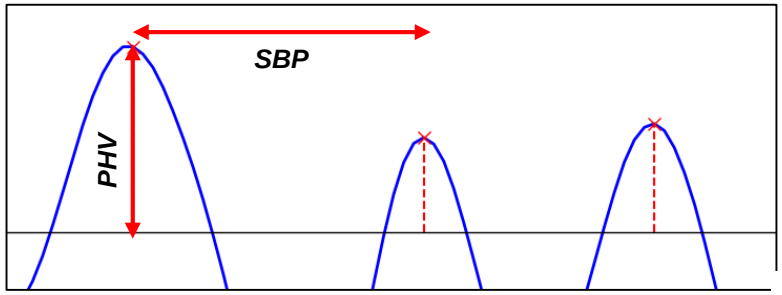
Evaluation of Roads Affected by Tenting

District 1 (~ 100 miles of road sections)

LiDAR, Thermal, GPR, and Surface Profile for evaluation of tented-cracks

- Developed a testing and analysis procedure to locate, quantify and characterize tenting
- A special algorithm to automatically detect the tented cracks and measure height and spacing
- Paper accepted for publication for more details (2021)





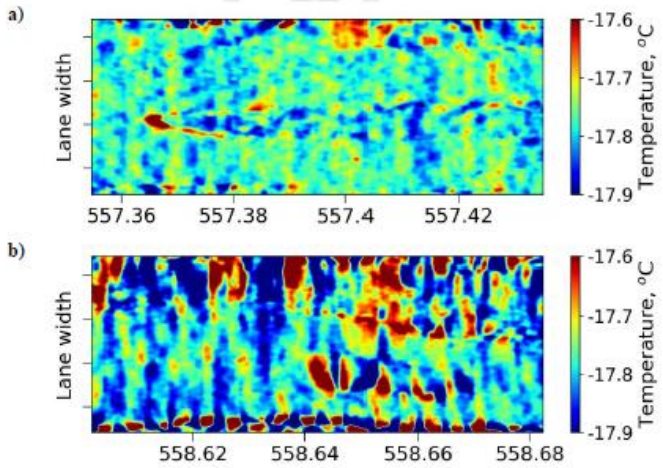
DEPARTMENT OF TRANSPORTATION

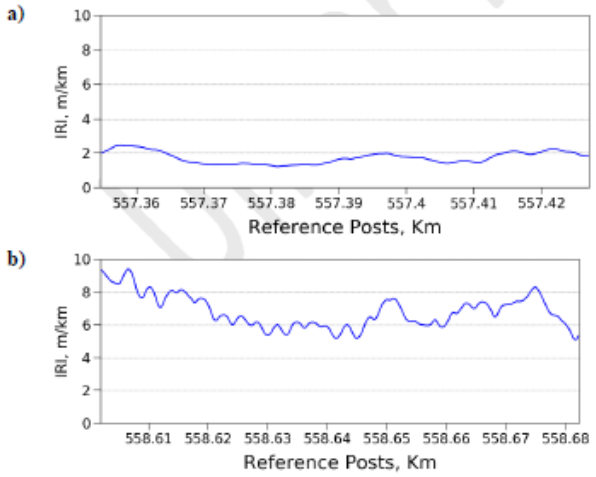
Evaluation of Roads Affected by Tenting

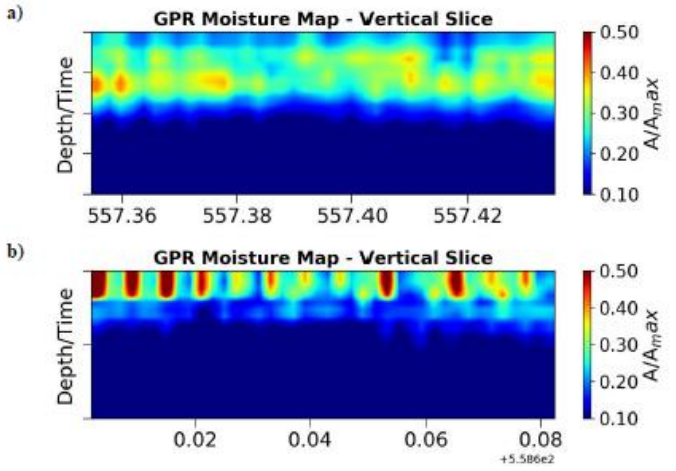
District 1 (~ 100 miles of road sections)

LiDAR, Thermal, GPR, and Surface Profile for evaluation of tented-cracks

- Explore the relationship between surface and subsurface conditions of roads affected by tenting
- Comparisons between severely and moderately affected sections







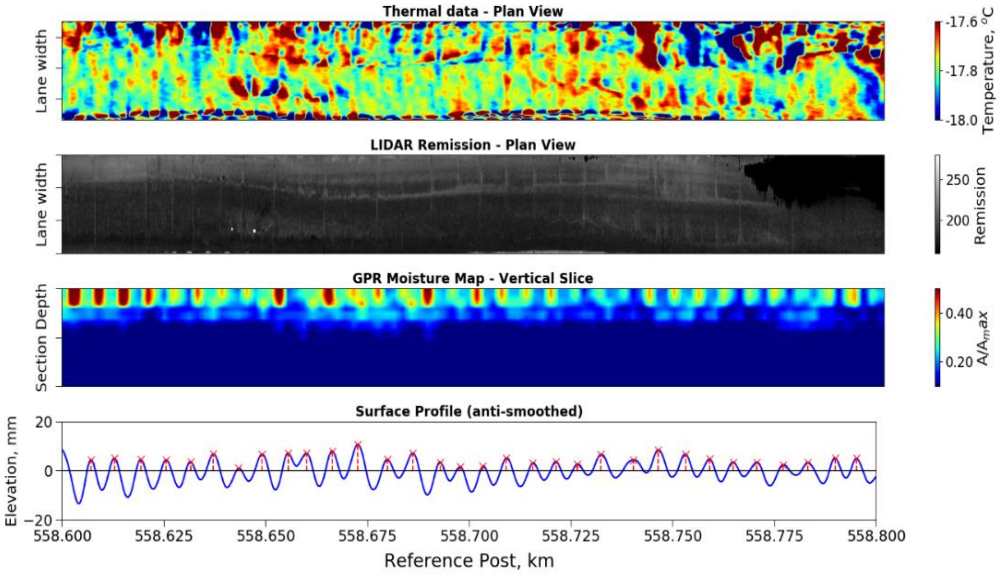
DEPARTMENT OF TRANSPORTATION

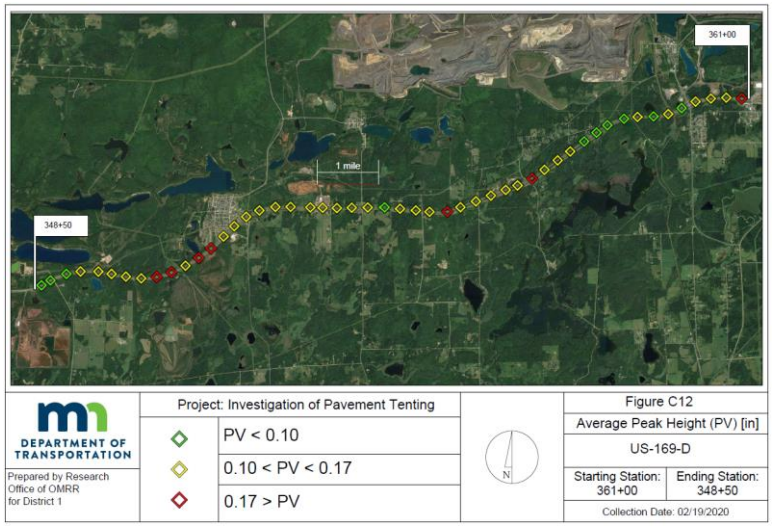
Evaluation of Roads Affected by Tenting

District 1 (~ 100 miles of road sections)

LIDAR, Thermal, GPR, and Surface Profile for evaluation of tented-cracks

- Compare the proposed tenting parameters with video, lidar, thermal and GPR data
- Provide rating maps to determine the extent and location of critically affected segments





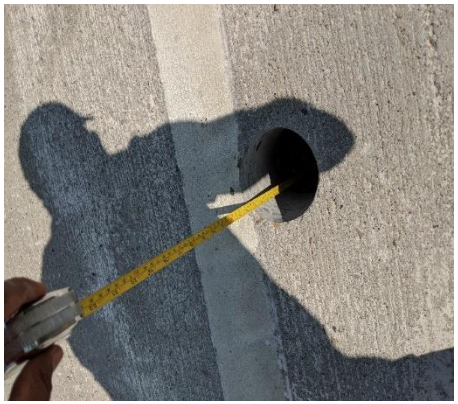
DEPARTMENT OF TRANSPORTATION

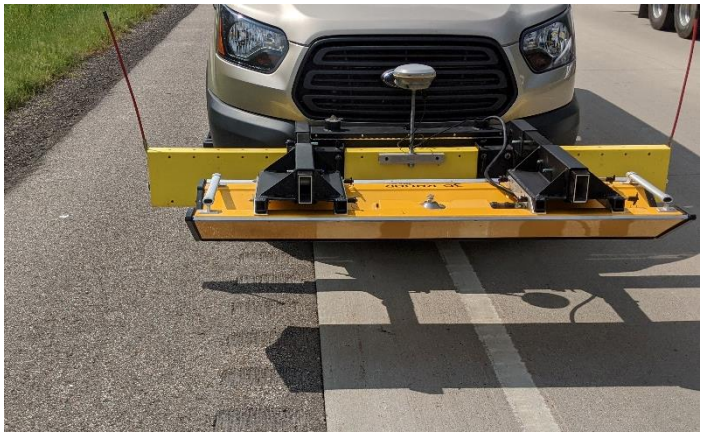
Investigation of Slope Failure Related Pavement Failure

District 7 - TH169 near St Peter Fan Drains Location

3D GPR and LiDAR

- Slope failure caused severe damages to the adjacent concrete roadway
- Evaluate if the effectiveness of the 3D GPR to locate and measure the extents of voids beneath the concrete slabs





DEPARTMENT OF TRANSPORTATION

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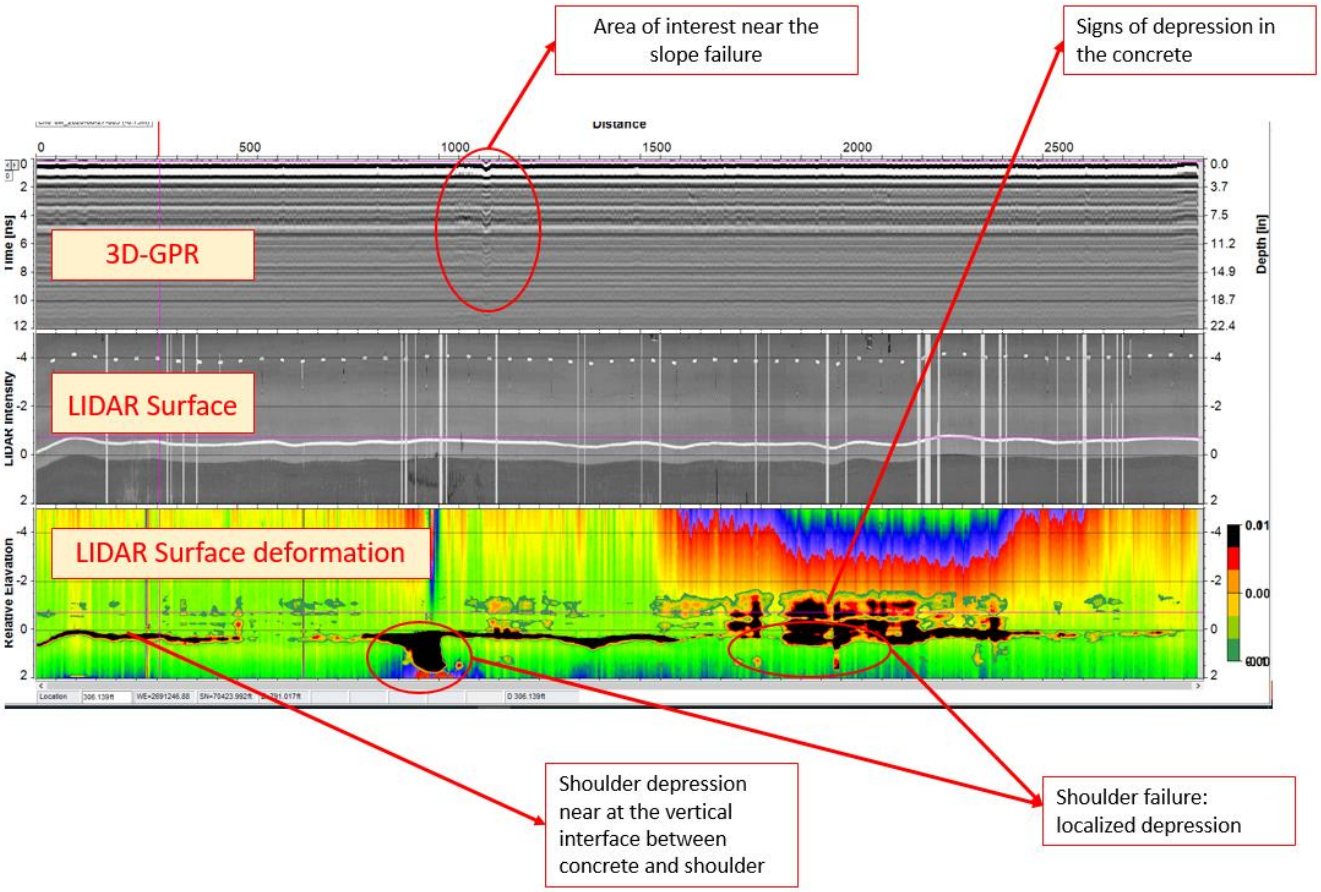


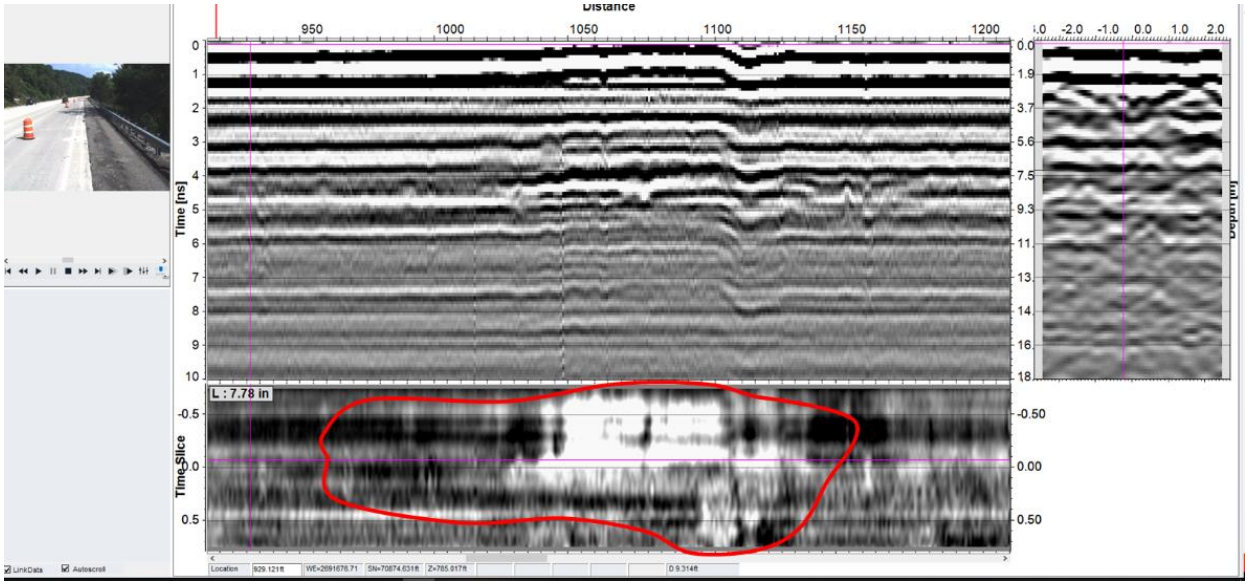
DEPARTMENT OF TRANSPORTATION

Investigation of Slope Failure Related Pavement Failure

District 7 - TH169 near St Peter Fan Drains Location

3D GPR and LIDAR

- A strong anomaly found at the interface between the concrete and base confirmed the void suspicion based on few cores
- According to this signals, the void extended for 200 ft (longitudinally) and covered ¾ of the passing lane

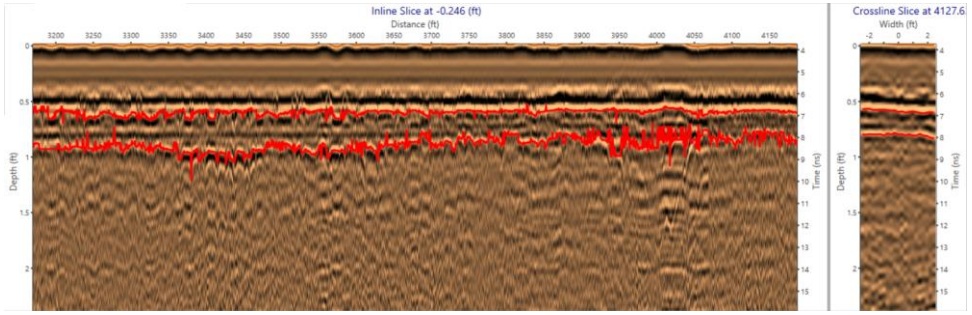


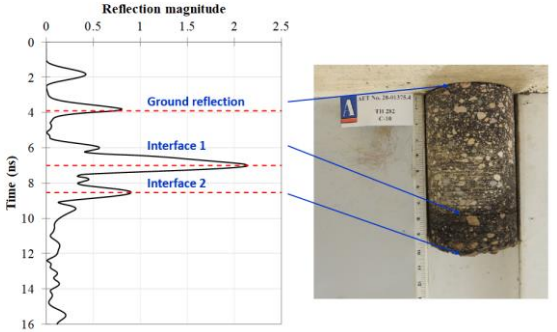
Data for Building 3D Model of Milled Surface

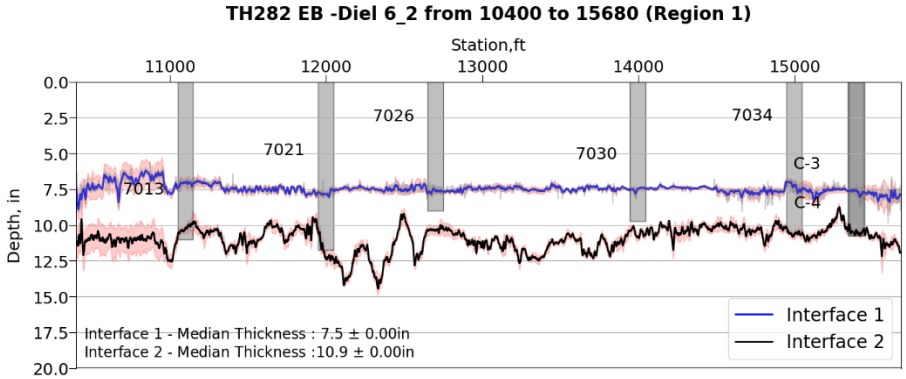
Metro - TH282 from Mill St in Jordan to MN13 in Spring Lake Township

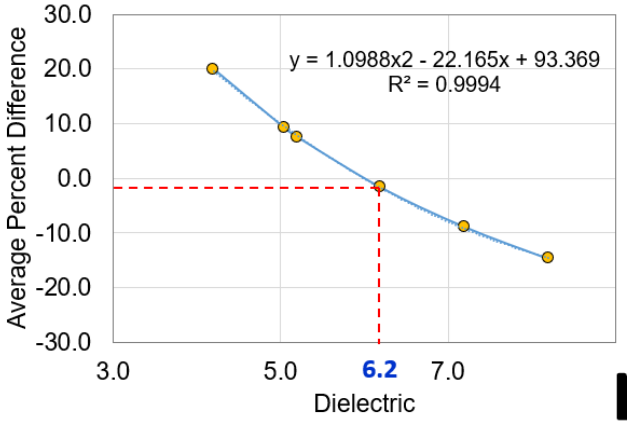
3D GPR

- Survey conducted using 21 pairs (Tx and Rx) of GPR antenna
- Layer predictions performed manually
- The road was first constructed in the ‘50 and has since been subjected to numerous reconstruction (rehabs) and maintenance treatments
- Coring and boring data indicates about 9 inches of AC layer but the variation was significant









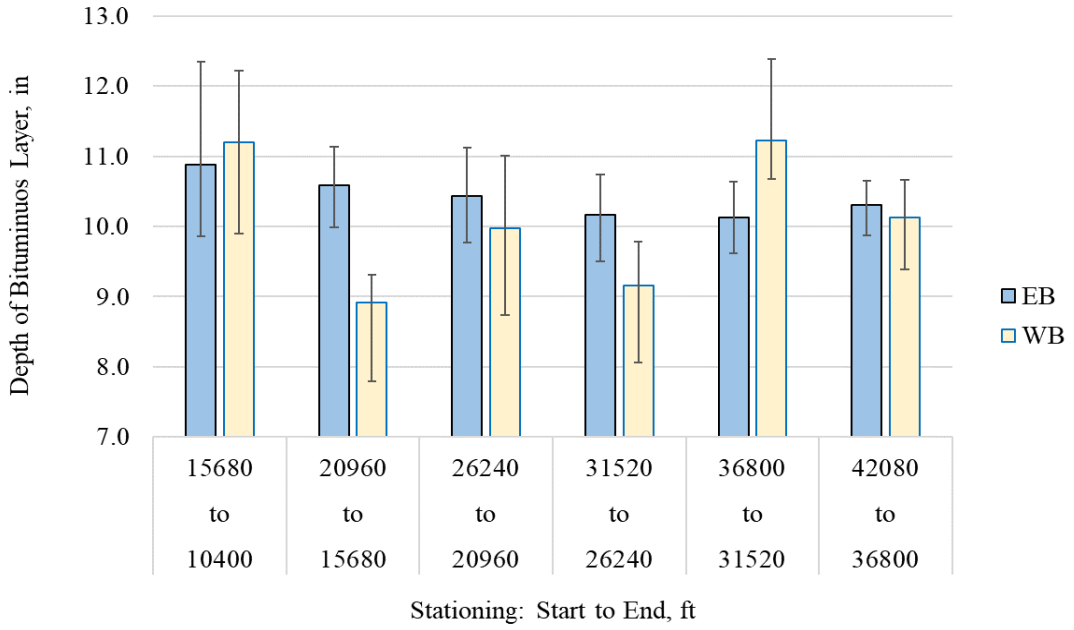
DEPARTMENT OF TRANSPORTATION

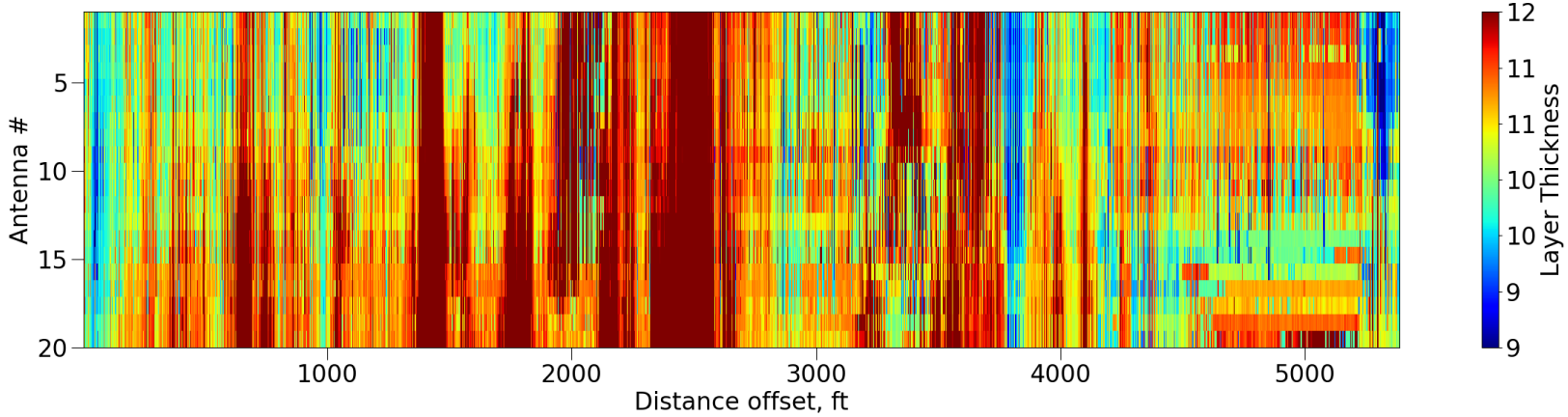
Data for Building 3D Model of Milled Surface

Metro - TH282 from Mill St in Jordan to MN13 in Spring Lake Township

3D GPR

- Provided cloud point data from 21 antenna and their GPS coordinates that can be used to construct surface model for the 3D milling machines
- Identified areas that could be critical to the milling operations due to the less than the expected AC thickness





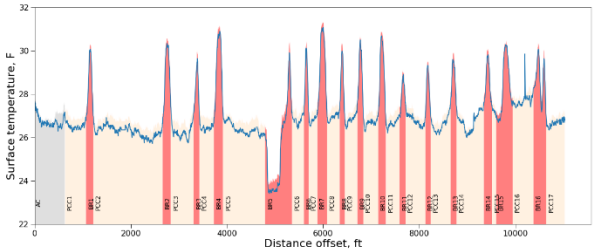
DEPARTMENT OF TRANSPORTATION

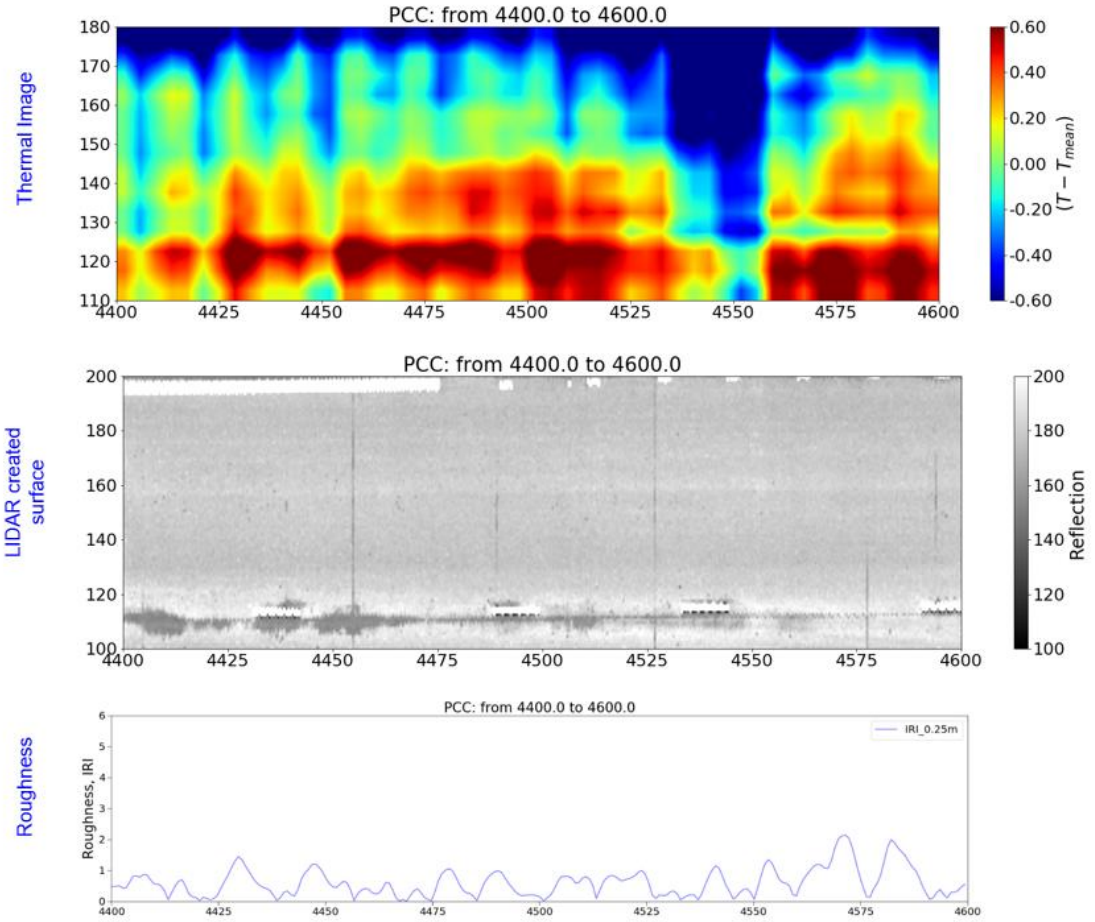
Investigation Joint Delamination of Concrete Slabs

I-94 St Paul MN (Down Town Area)

Thermal, LIDAR and 3D GPR

- So far, we were not able to link the surface temperatures to known delaminated joints
- Multiple factors affecting the surface temperature of long inhomogeneous sections



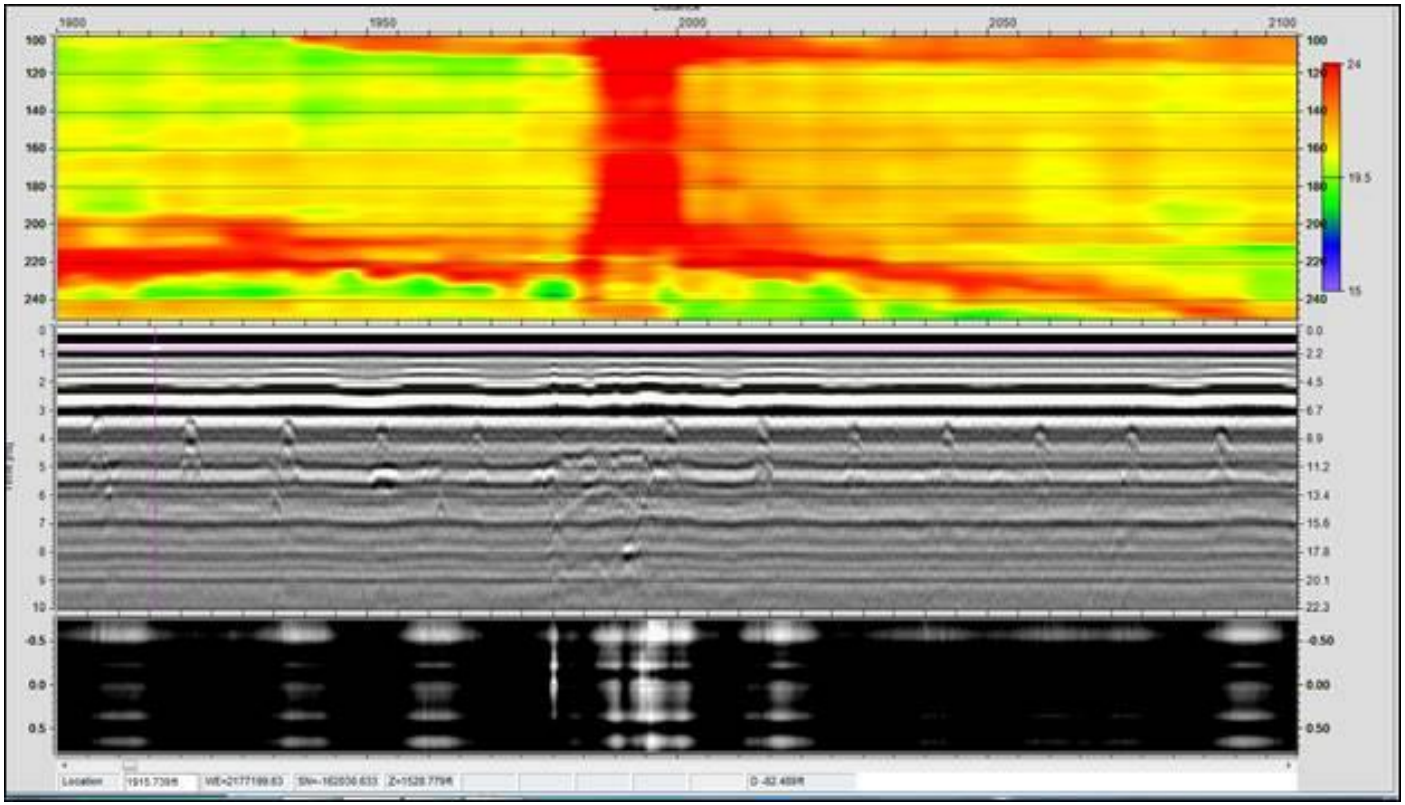


DEPARTMENT OF TRANSPORTATION

Investigation Joint Delamination of Concrete Slabs

I-90 Adrian MN

- 3D GPR provided good information on the conditions of the joints
- Link thermal and GPR data in progress



DEPARTMENT OF TRANSPORTATION

Questions

Contact info

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347-591-8186