NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

TRB Webinar: Implementation of UAS into Transportation Infrastructure Inspection

April 30, 2025

1:00PM – 2:30 PM

PDH Certification Information

1.5 Professional Development Hours (PDH) – see follow-up email

You must attend the entire webinar.

Questions? Contact Andie Pitchford at TRBwebinar@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Program. Credit earned on completion of this program will be reported to RCEP at RCEP.net. A certificate of completion will be issued to each participant. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the RCEP.

ENGINEERING RCEP REGISTERED CONTINUING EDUCATION PROGRAM

Purpose Statement

This webinar will share leading applications of UAS to help provide safe and efficient infrastructure assessment capabilities. Presenters will share three case studies: one on bridge inspection, another on airport pavement inspection, and a third on construction modeling.

Learning Objectives

At the end of this webinar, you will be able to:

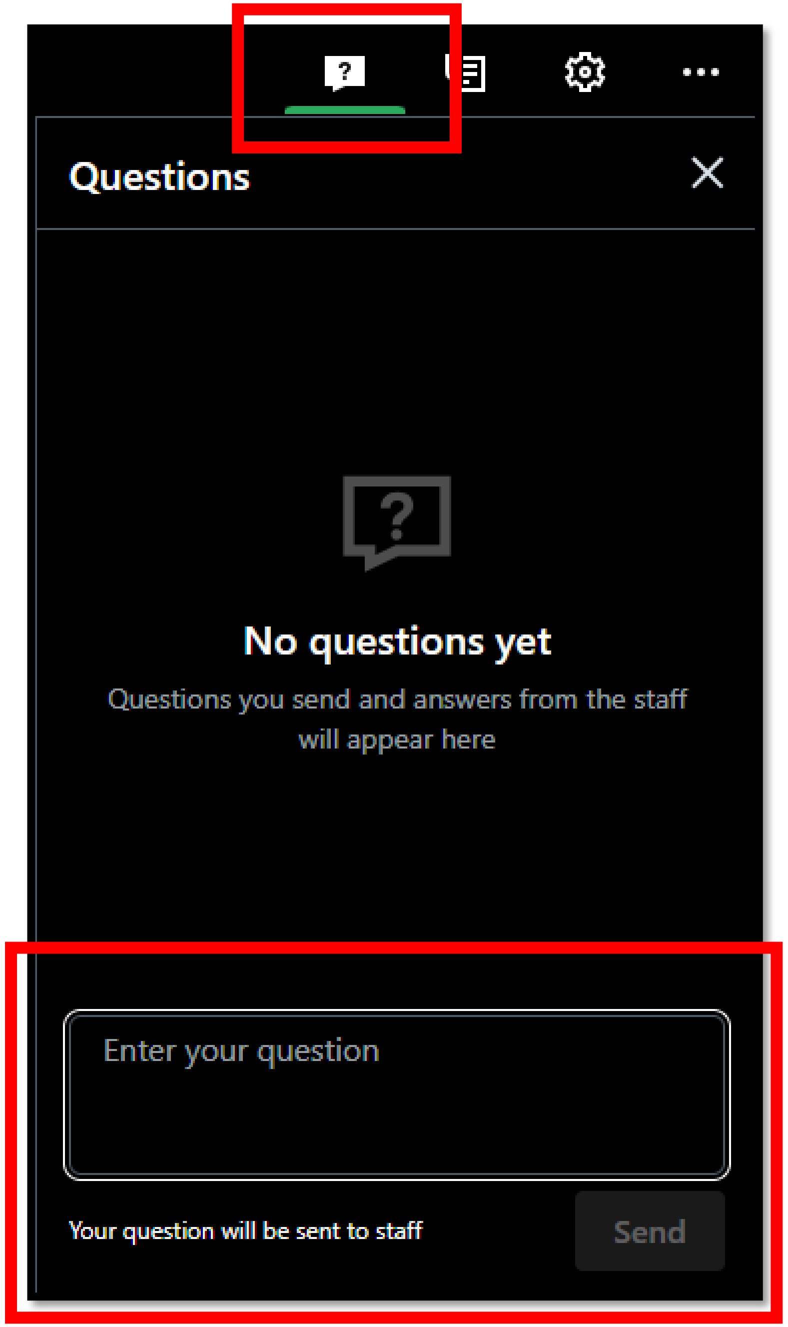
(1) Leverage UAS technology to assist infrastructure inspection

(2) Identify how UAS technology deployment can help reduce time and costs and increase safety for inspections

(3) Understand which sensors and platforms are being used for infrastructure inspection

Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



Today's presenters

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NATIONAL ACADEMIES *Sciences Engineering Medicine*

Eyes in the Sky: Unlocking Airfield Pavement Inspection with sUAS

Halil Ceylan, Ph.D., Dist.M.ASCE

Dept. of Civil, Construction and Environmental Engineering (CCEE)

ISU Site Director, FAA PEGASAS Center of Excellence on General Aviation

Program for Sustainable Pavement Engineering and Research (PROSPER)

Institute for Transportation (InTrans)
Iowa State University (ISU)

TRB Webinar

April 30, 2025

Acknowledgements

- Project sponsors on sUAS research
  - FAA and PEGASAS
- Our collaborators, including but not limited to,
  - Michigan Tech Research Institute
  - Applied Pavement Technology, Inc.
- FAA Technical Point of Contacts

About PROSPER

PROSPER

Program for Sustainable Pavement Engineering and Research

PROSPER | ABOUT PROSPER

About PROSPER

- More than 15 professional staff, post-doctoral students, and visiting scholars
- Over 70 Ph.D./M.S./M.E. graduate student researchers
- Over 70 undergraduate student researchers

https://prosper.intrans.iastate.edu/

Director Introduction:
Halil Ceylan, Ph.D., Dist.M.ASCE

- Title(s)
  - Pitt-Des Moines, Inc. Endowed Professor, Civil, Construction and Environmental Engineering (CCEE)
  - Director, Program for Sustainable Pavement Engineering and Research (PROSPER)
  - ISU Site Director, Partnership to Enhance General Aviation Safety, Accessibility and Sustainability (PEGASAS), FAA Center of Excellence on General Aviation

- Education
  - Ph.D. Civil Engineering, University of Illinois at Urbana-Champaign, 2002
  - M.S. Civil Engineering, University of Illinois at Urbana-Champaign, 1995
  - B.S. Civil Engineering, Dokuz Eylul University, Izmir, Turkey, 1989

Outline

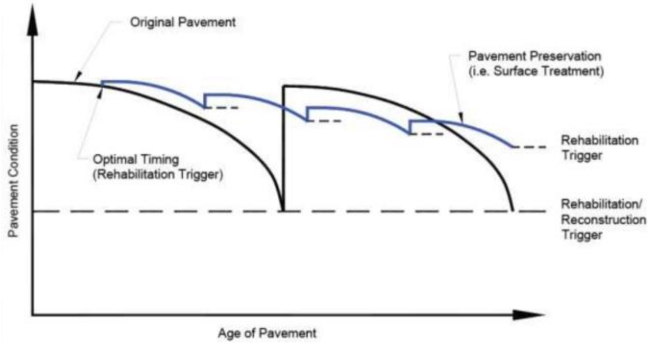
- Background
- Data Collection and Analysis
- Notable Results
- ML in Pavement Inspection
- Summary
- Questions and Answers

Background

- Airfield pavement inspections are crucial for maintaining safe and serviceable pavements
- 3.32 billion USD was allocated for airfield pavement improvement in 2019
- Early pavement damage detection is essential for timely pavement maintenan
- Airport pavements are visually inspected

Cracks

Pavement Preservation Concept



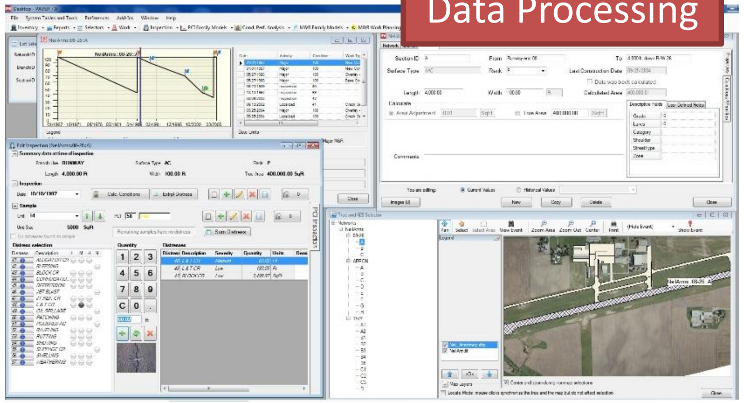
FAA AC 150/5380-7B

Background (Cont'd)

- PCI value calculated – value ranges from 0 (failed) to 100 (perfectly new)
- Small Unmanned (Uncrewed) Aircraft Systems (sUAS) became potential pavement inspection tools
- ISU-led team conducting research on the feasibility of sUAS for pavement inspection

Data Collection

Data Processing



Colorado State University

Background (Cont'd)

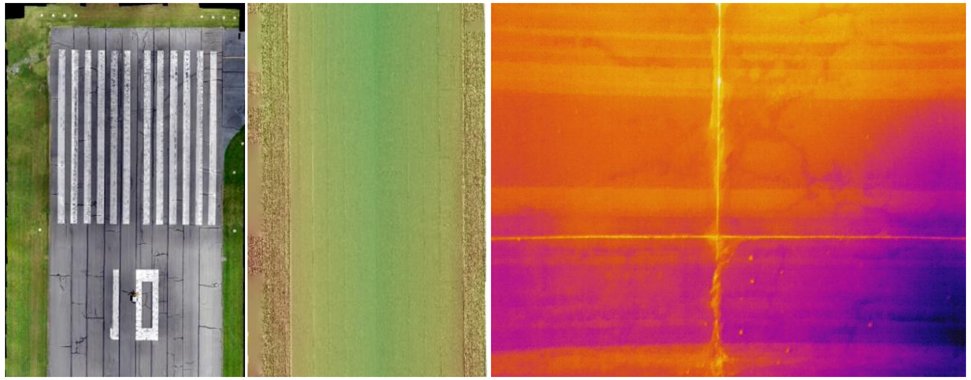
- sUAS aka drone is an unmanned aircraft weighing <55 lbs, including everything on board / attached

- Consists of
  - Unmanned Aircraft
  - Ground Control Station
  - Command & Control Link

sUAS Platform

Color Sensor

Controller



Sample Data (Color, Elevation, Thermal)

Background (Cont'd)

- Drone operations are particularly effective for missions that are dangerous or dull
  - Humans are not put at risk
  - Continuous operations are possible

- Operations with drone often cost less than using manned aircraft

Outline

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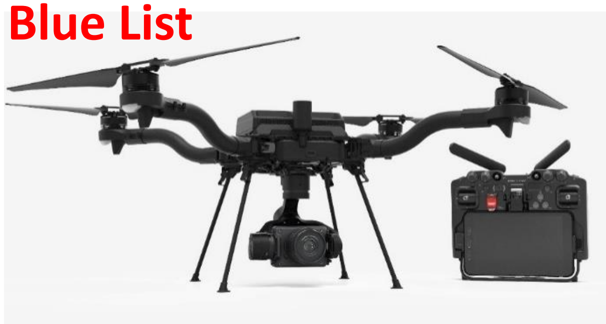
Data Collection and Analysis

- Our Notable sUAS Related Inventories

Blue List



Freefly Astro

NDAA

Aurelio x6

Mavic 2 Enterprise Advanced

Sony LR1

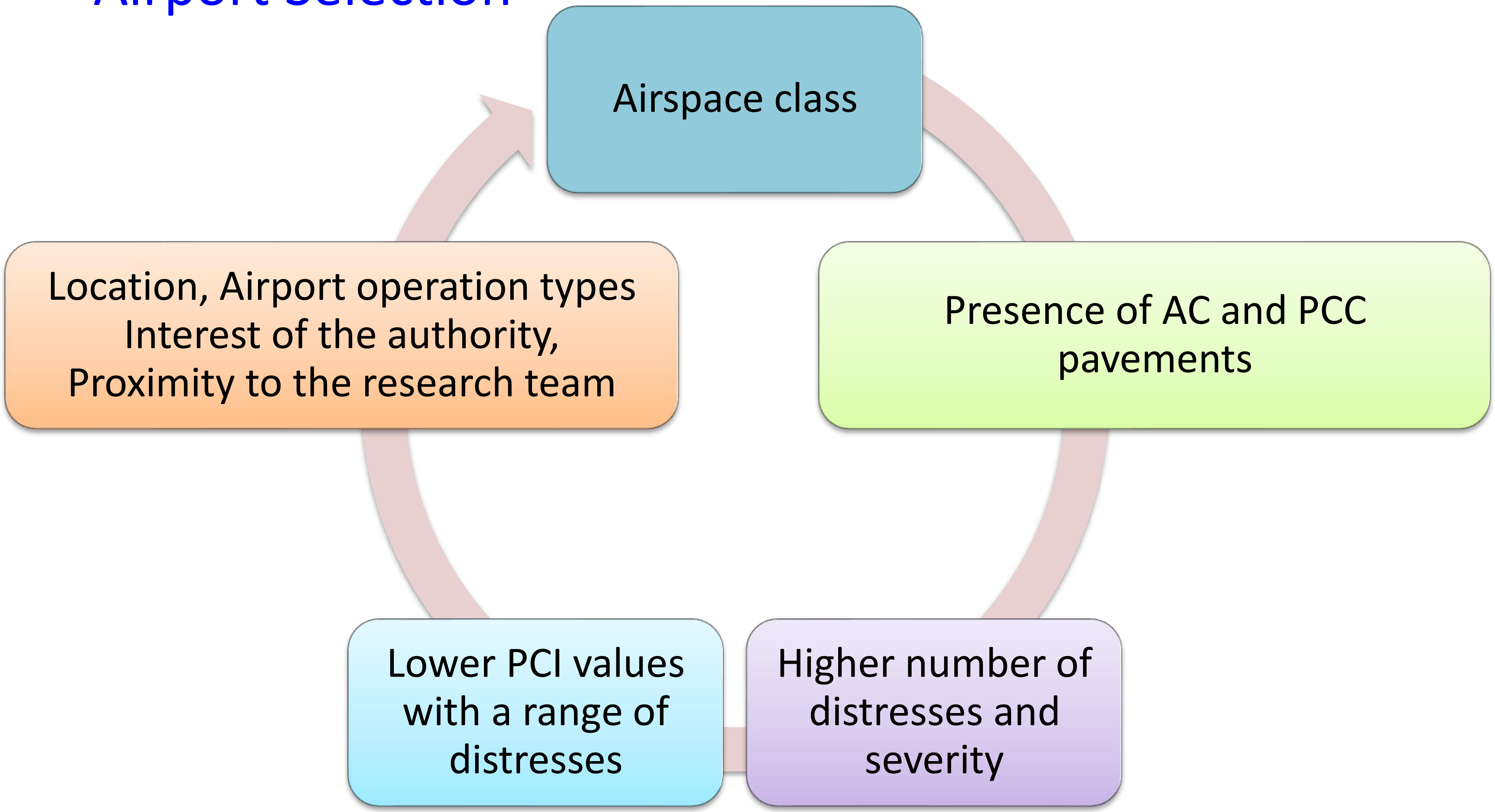
Nikon D850

Aeropoint

Image credits: Freefly, UAV International, Sony, and Nikon

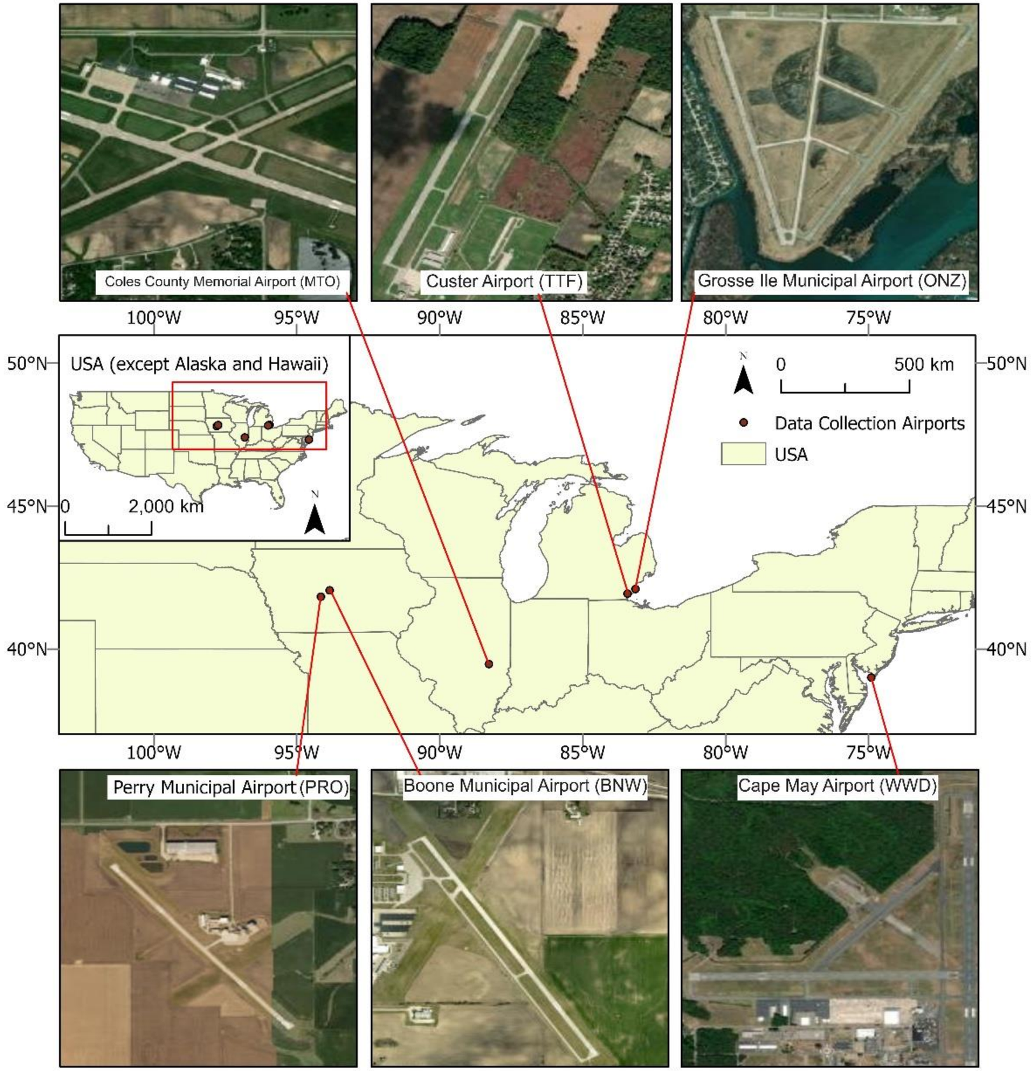
Data Collection and Analysis (Cont'd)

- Airport Selection



Data Collection and Analysis (Cont'd)

- Field Demonstration



Data Collection and Analysis (Cont’d)

- Airfield Pavement Inspection: Field Safety First

*images captured at ONZ and TTF

Data Collection and Analysis (Cont'd)

Data Processing

Import Geotagged image

Auto alignment

Image position correction with ground control point (GCP)

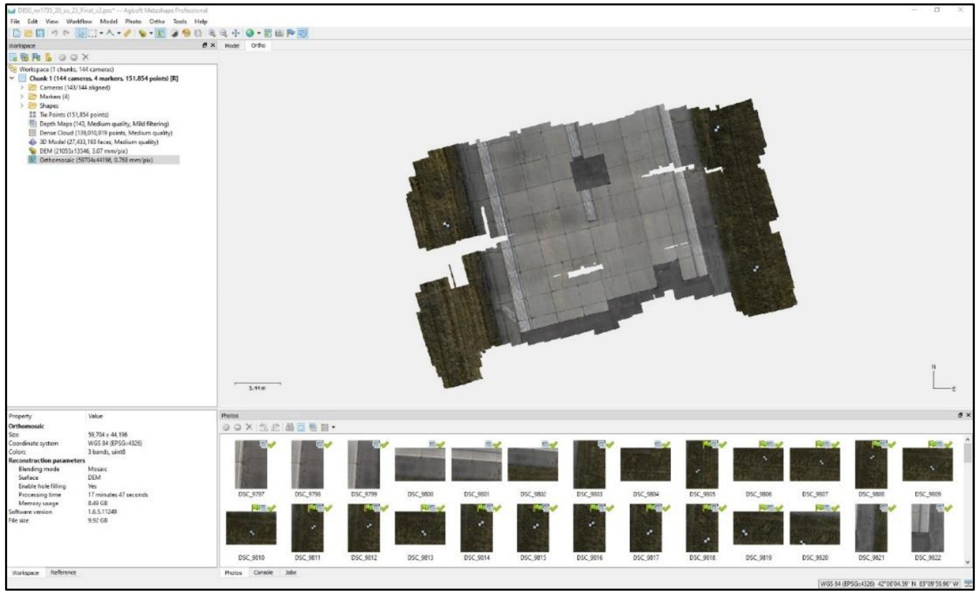
Dense cloud creation

Digital Elevation Model (DEM) generation and export

Hillshade DEM creation in ArcGIS Pro

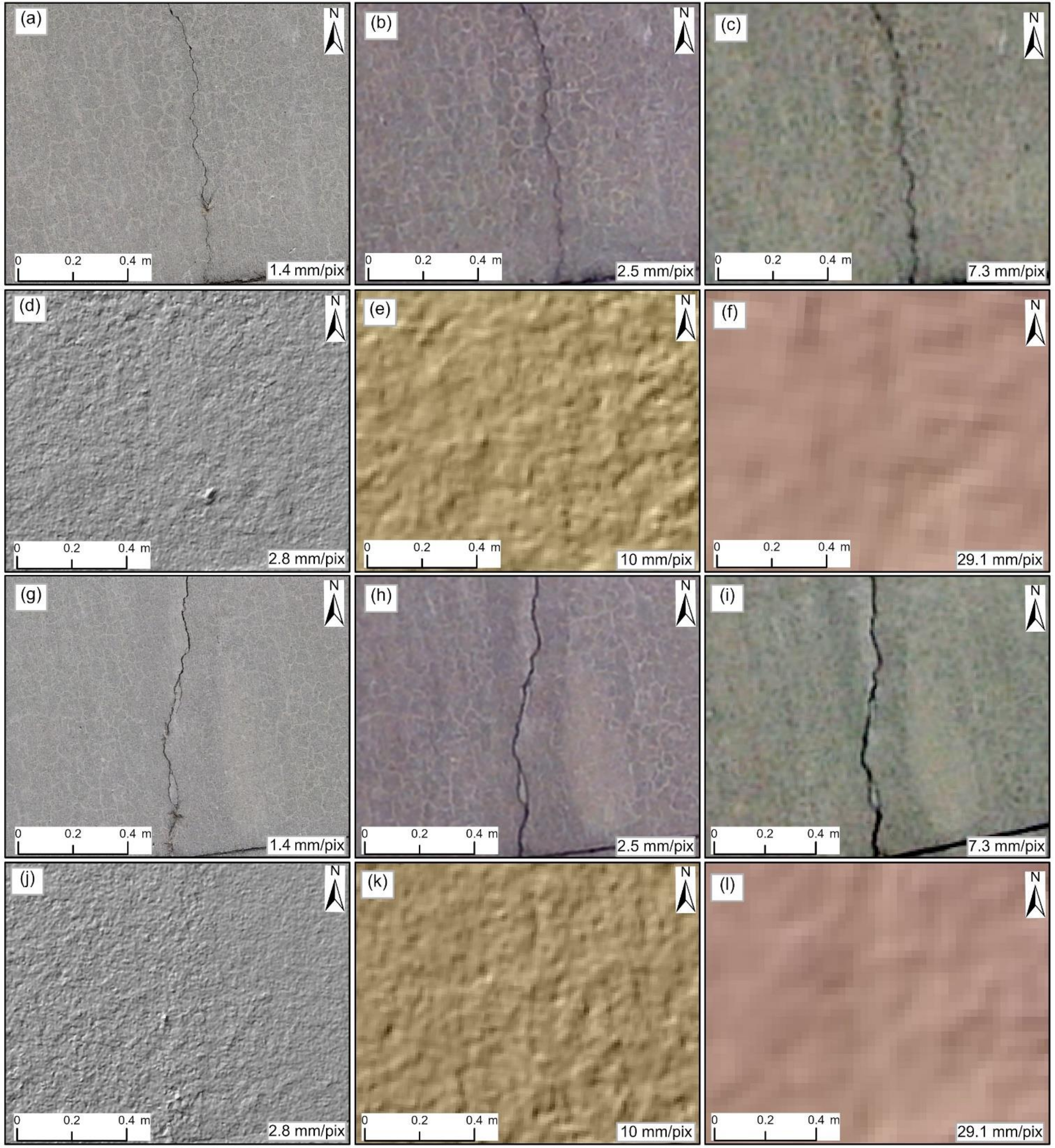
Visual analysis

Orthophoto generation and export



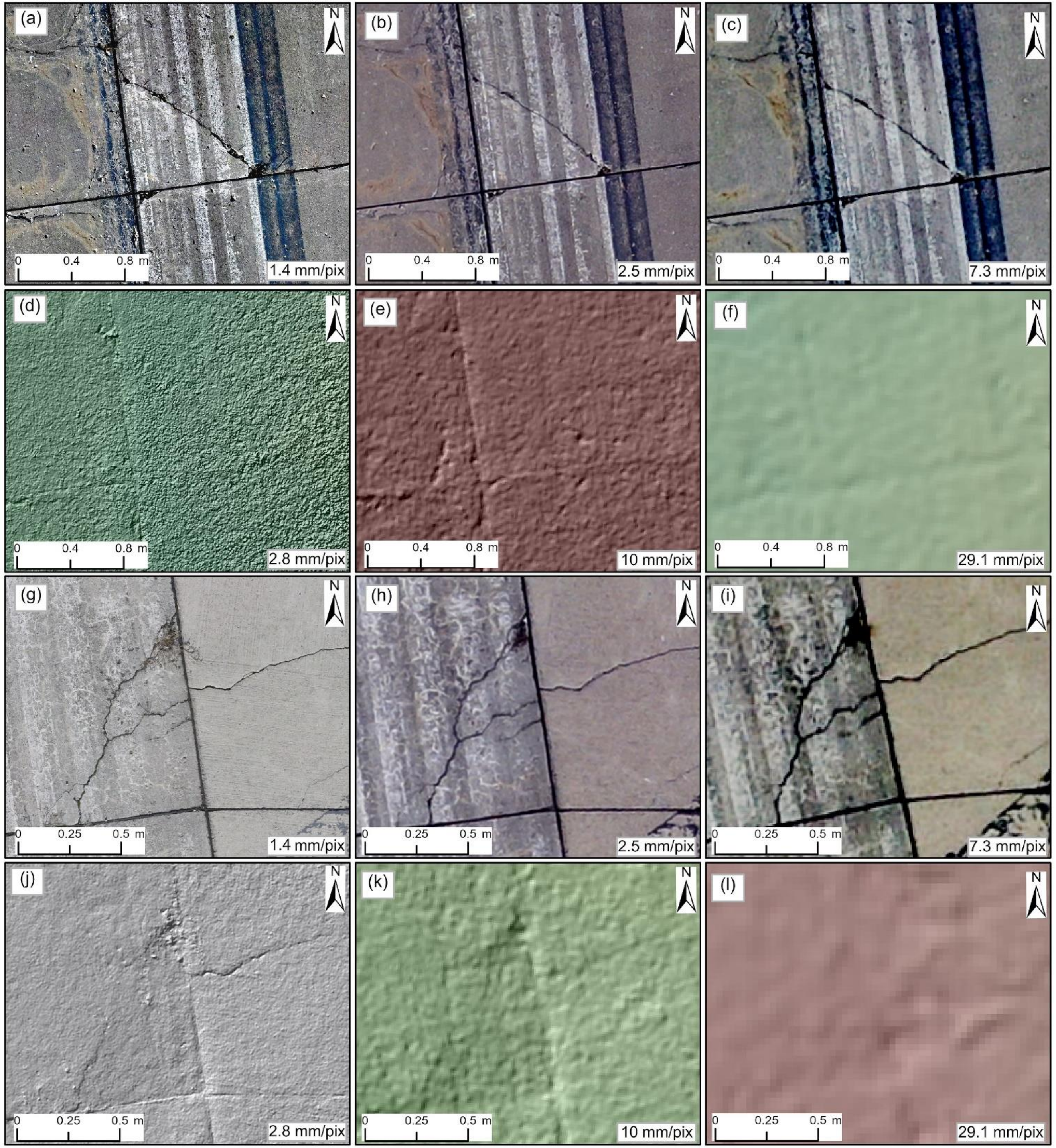
Data Collection and Analysis (Cont'd)

- Airfield Pavement Inspection
  - 5 field data collection and 1 validation site
  - 6 platforms and 9 sensors
  - Data resolutions
    - 0.75 mm/pix to 21 mm/pix RGB orthophoto
    - 2.98 mm/pix to 84 mm/pix DEM
    - 8 mm/pix and 31 mm/pix stereo thermal



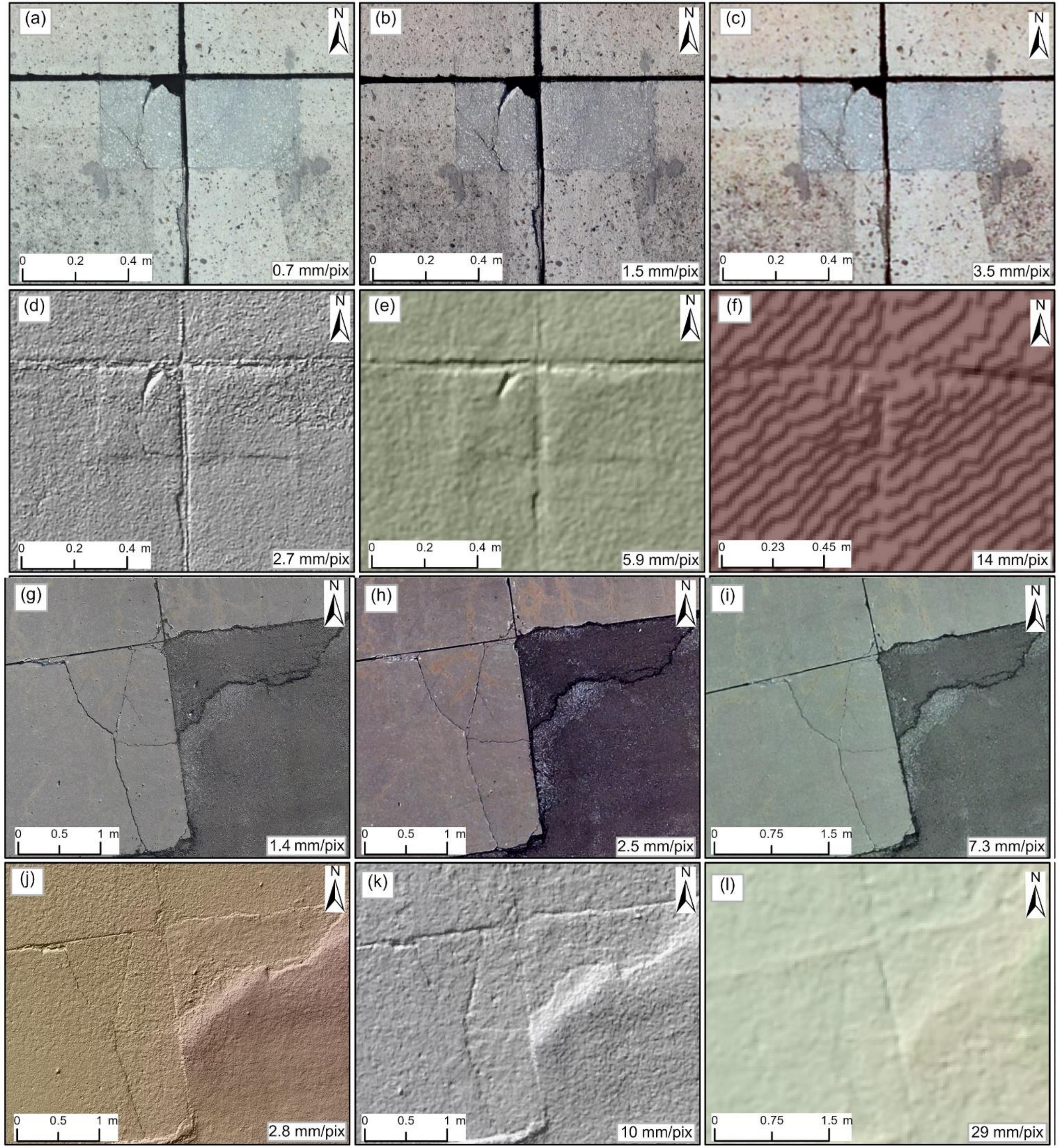
LTD Cracks (L) (a-f) on PCC Pavement

LTD Cracks (M) (g-l) on PCC Pavement



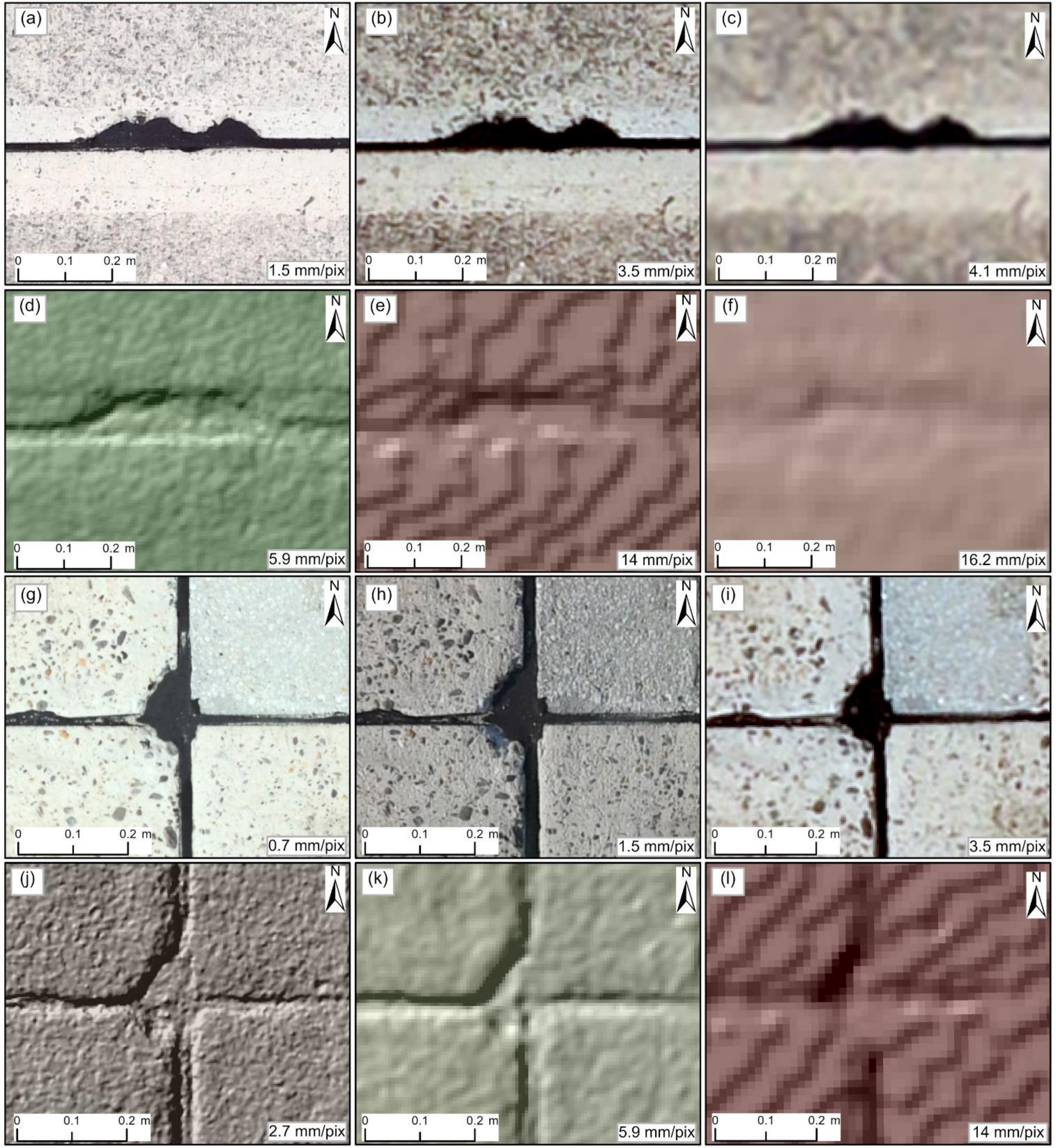
Corner Breaks (L) (a-f) on PCC Pavement

Corner Breaks (M) (g-l) on PCC Pavement



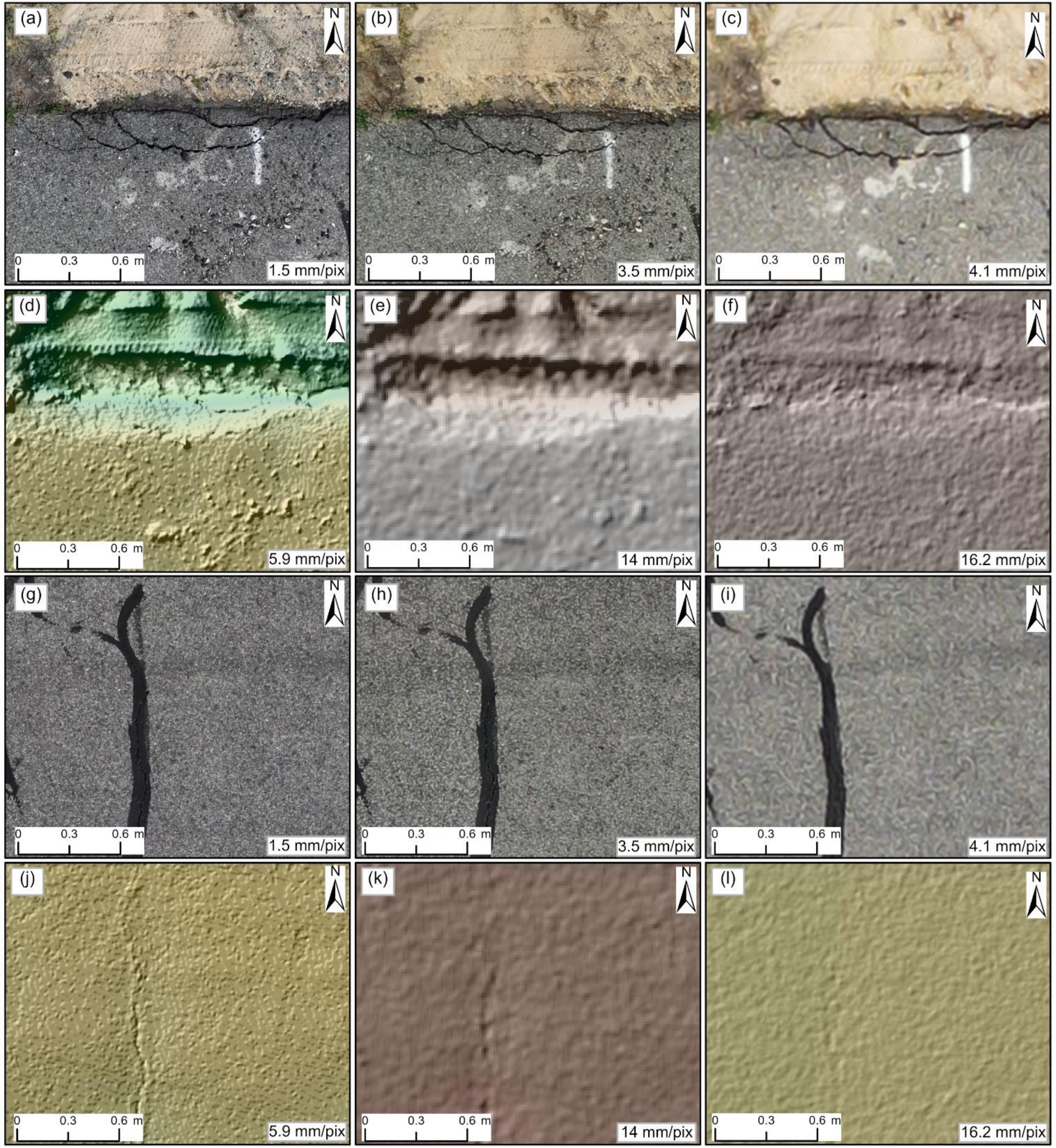
Small Patch (L, M) (a-f) on PCC Pavement

Large Patch (H) and Shattered Slabs (M) (g-l) on PCC Pavement



Joint Spalling (L) (a-f)
on PCC Pavement

Corner Spalling (M) (g-l)
on PCC Pavement



Alligator Cracks (L) (a-f)
on AC Pavement

L&T Cracks (L) (g-l)
on AC Pavement

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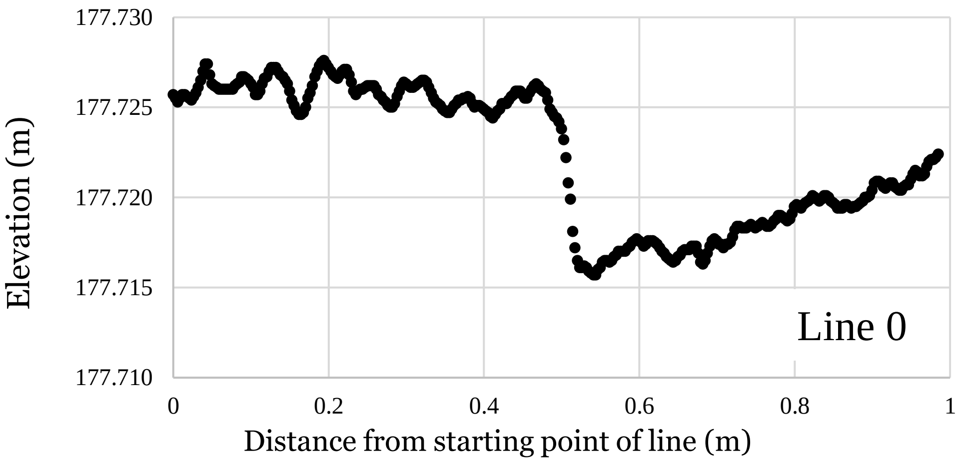
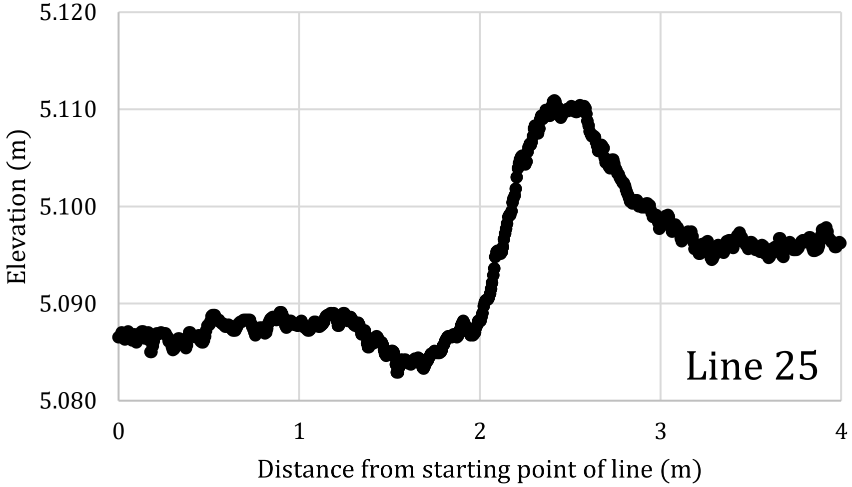
Notable Results

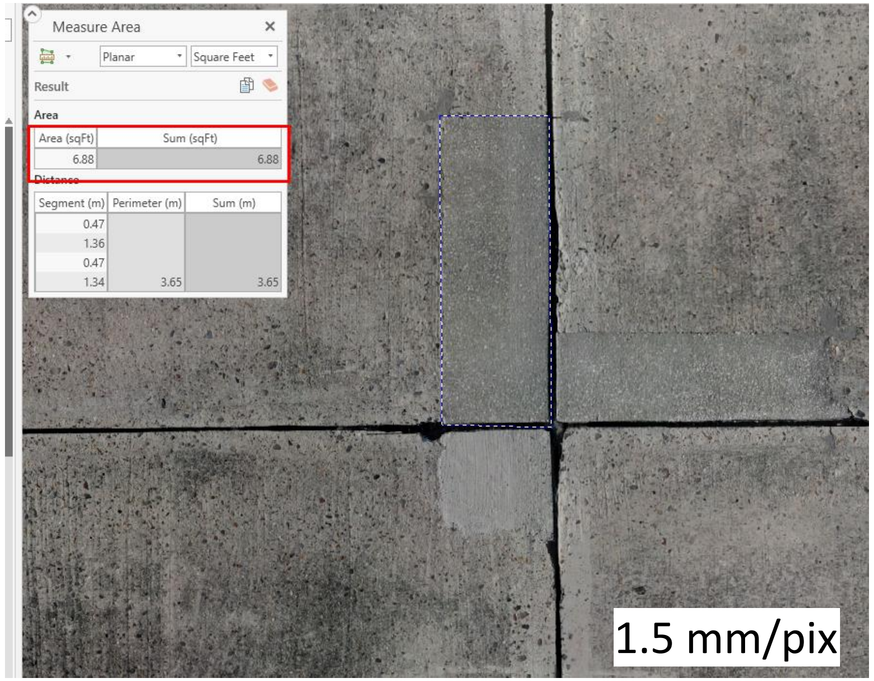




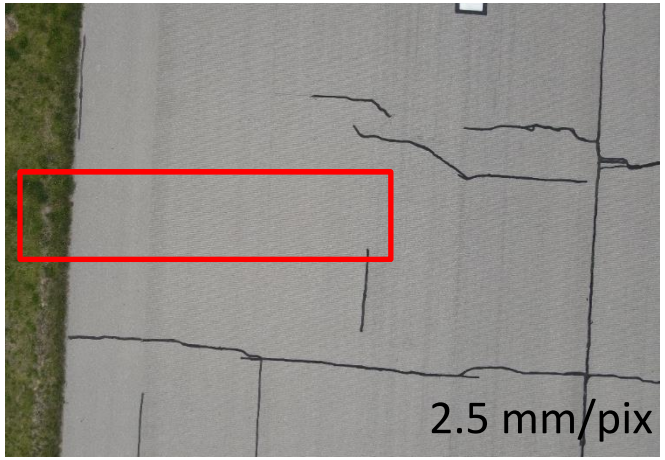
Notable Results (Cont'd)

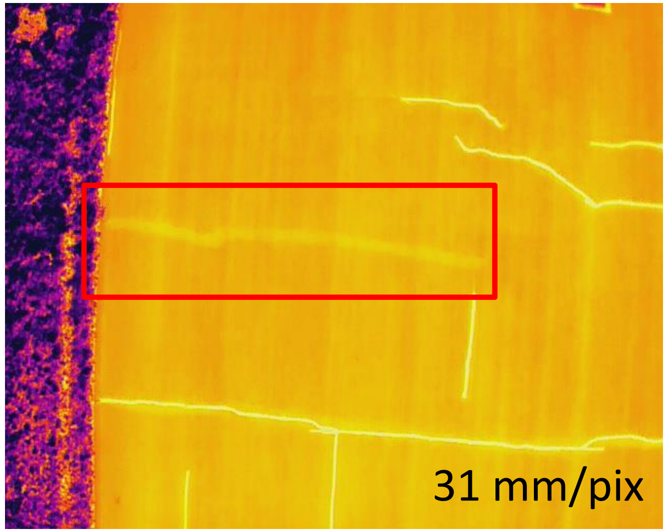
Patching and L&T cracks identification

Patching is divided into two types: small (less than 5.5 square feet) and ***large (over 5.5 square feet).***



Large patching (L) noted as *small patching (L)*



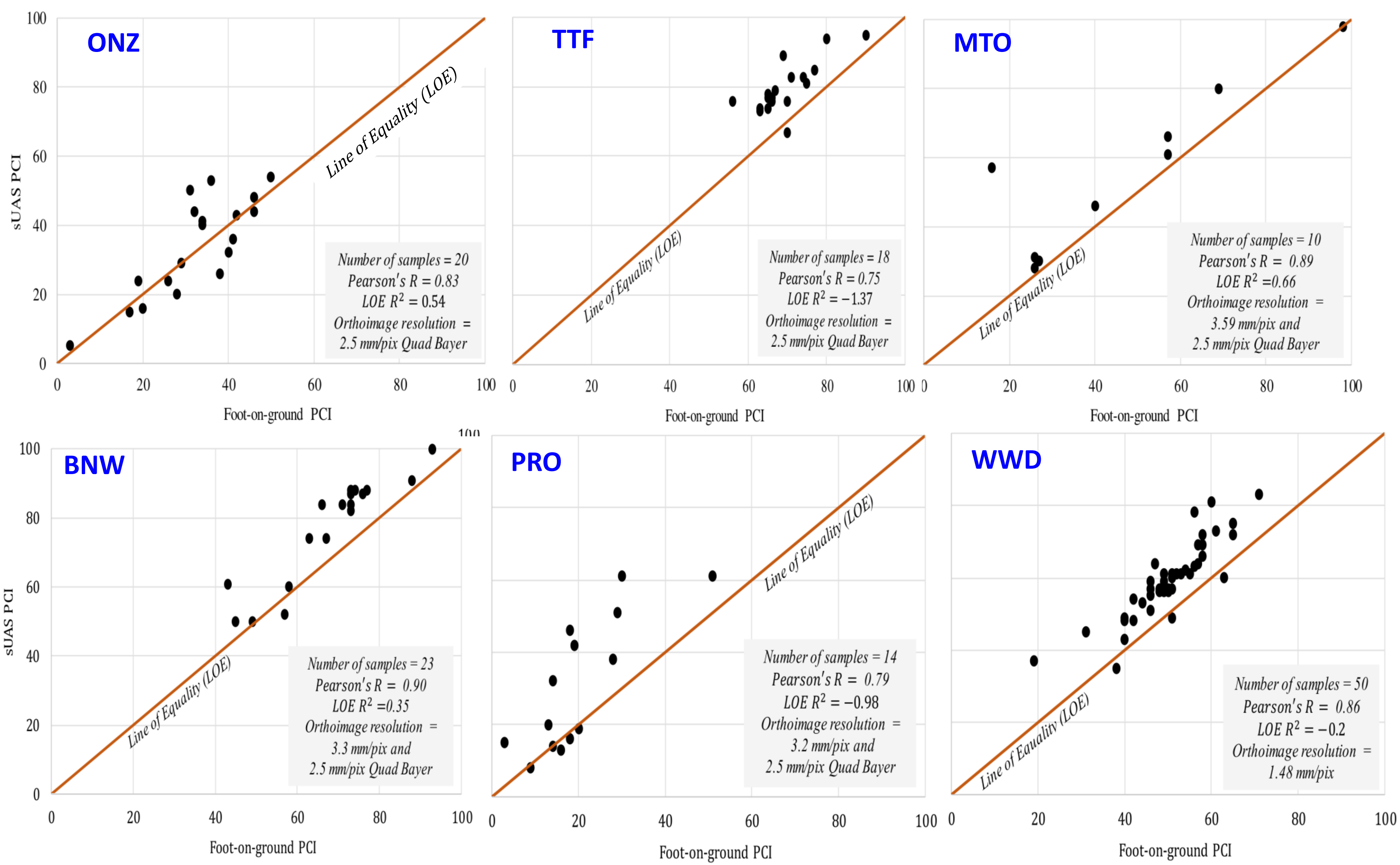


L&T cracks underneath the recent asphalt overlay show heat signature in thermal data

Notable Results (Cont'd)

- Airfield Pavement Inspection: Summary
  - RGB detect 13/14 available PCC pavement distresses and 6/9 AC pavement distresses
  - DEMs useful for faulting and shoving
  - Resolutions Recommendations
    - RGB: 1.5 mm/pix recommended
    - DEM: 6 mm/pix is highly recommended
    - Thermal: <30 mm/pix is adequate

Notable Results (Cont'd)



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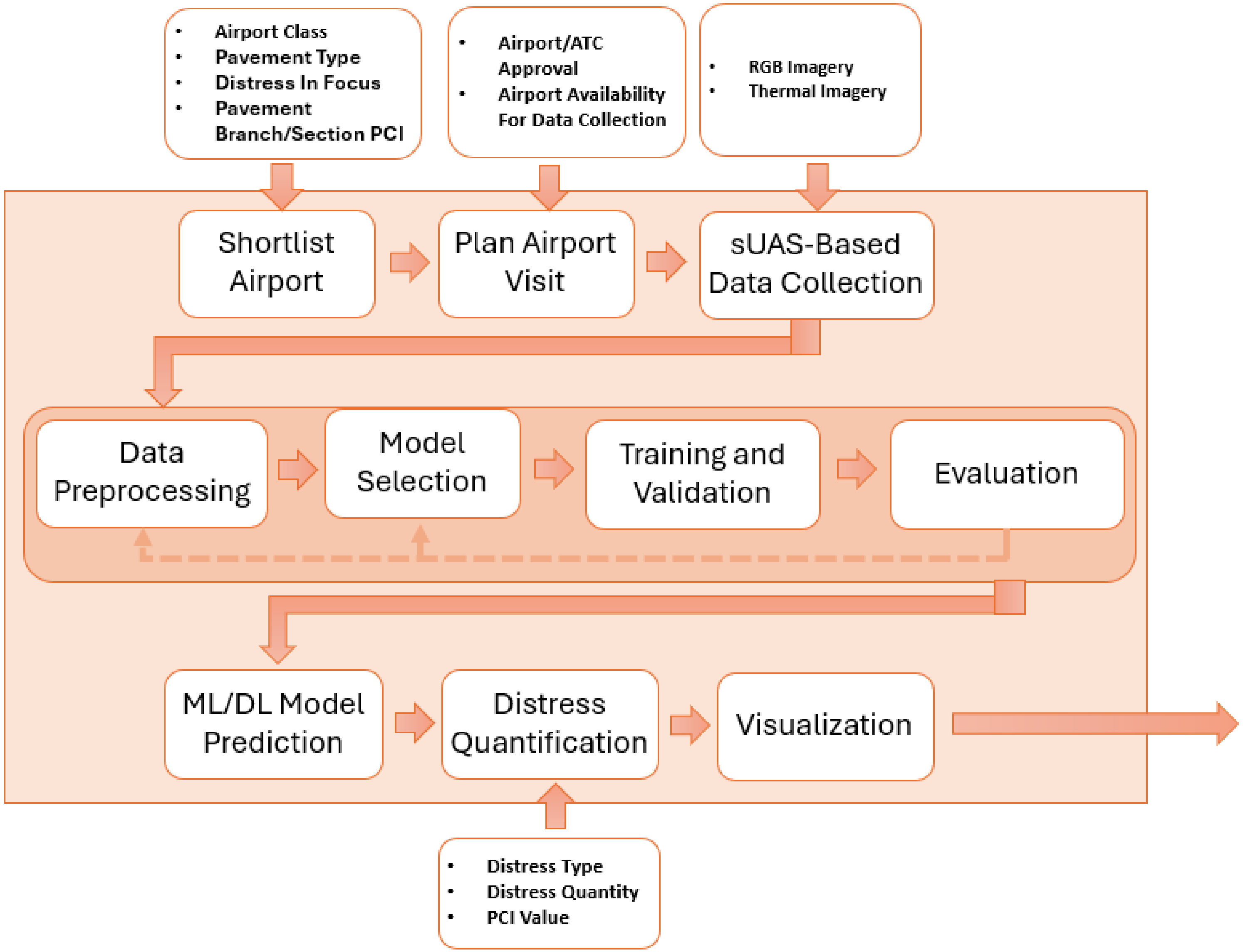
- Ongoing FAA-funded project
  - Evaluate ML models for distress detection in sUAS Data
  - Benefits:
    - Cost-effective
    - Survey large pavement in a shorter time
    - Scalability and adaptability
    - Potential to complement traditional inspection
    - Real-time analysis potential

ML in Pavement Inspection (Cont'd)

- Workflow

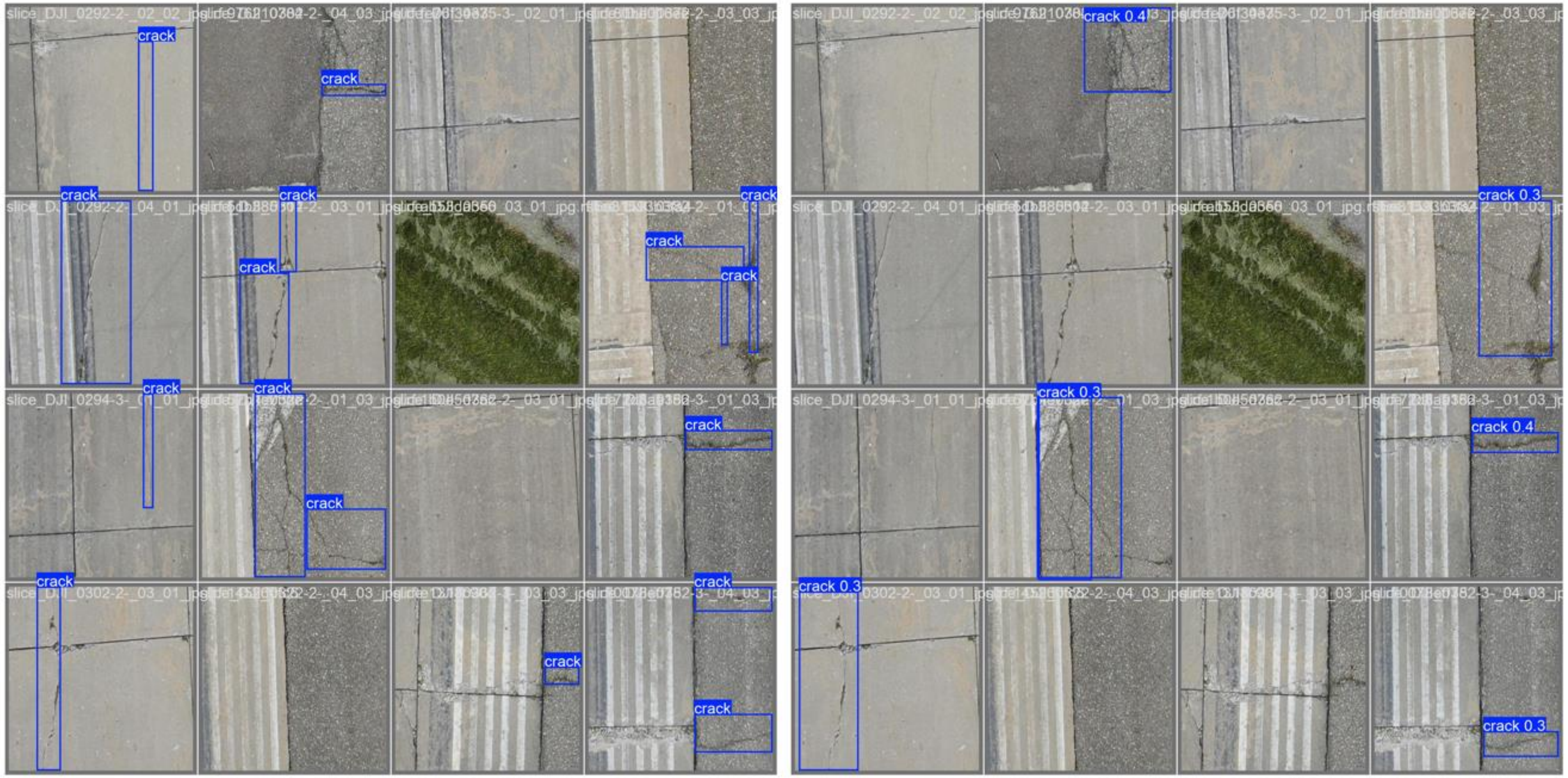


ML in Pavement Inspection (Cont'd)

- Different DL Models

Architecture	Probable Models	Functionality
VGG	VGG-16/VGG-19	Image Classification
ResNet	ResNet-152v2	Image Classification
Inception	Inception-v4/ Inception-ResNet-v2	Image Classification
R-CNN	Faster R-CNN/Mask R-CNN	Object Detection
YOLO	YOLOv8/v9/v10/v11/v12 (N/S/M/B/L/X)	Object Detection, Image Classification, Instance Segmentation
U-Net	U-Net/U-Net++	Semantic Segmentation
Transformer-Based	ViT/RT-DETER/Segformer	Object Detection, Image Classification, Semantic Segmentation
GANs	Vanilla GAN, DCGAN	Image Generation & Augmentation

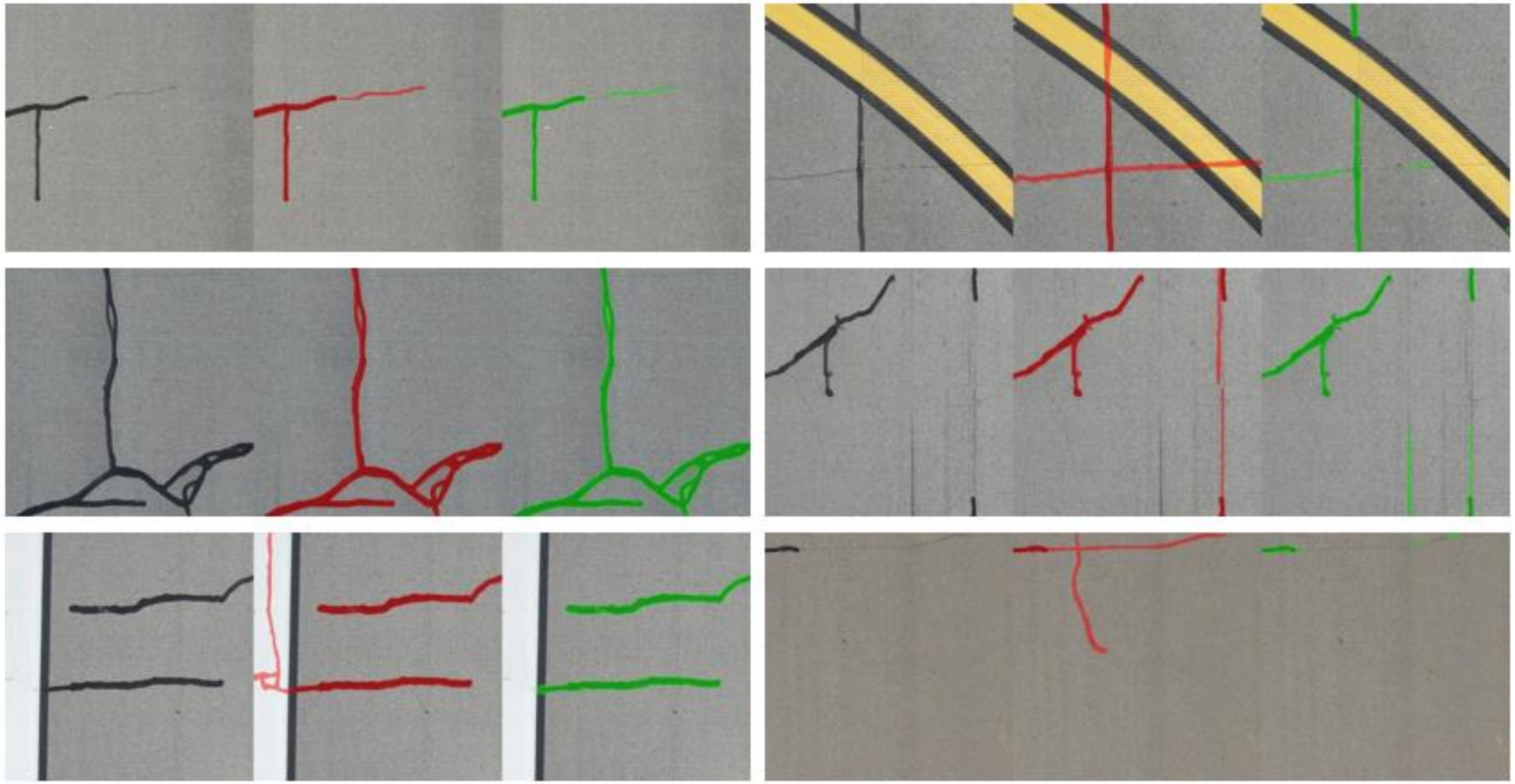
- Sample of DL-Based Crack Detection



Annotated Label Predicted Results

Cracks detected by the YOLOv11s model

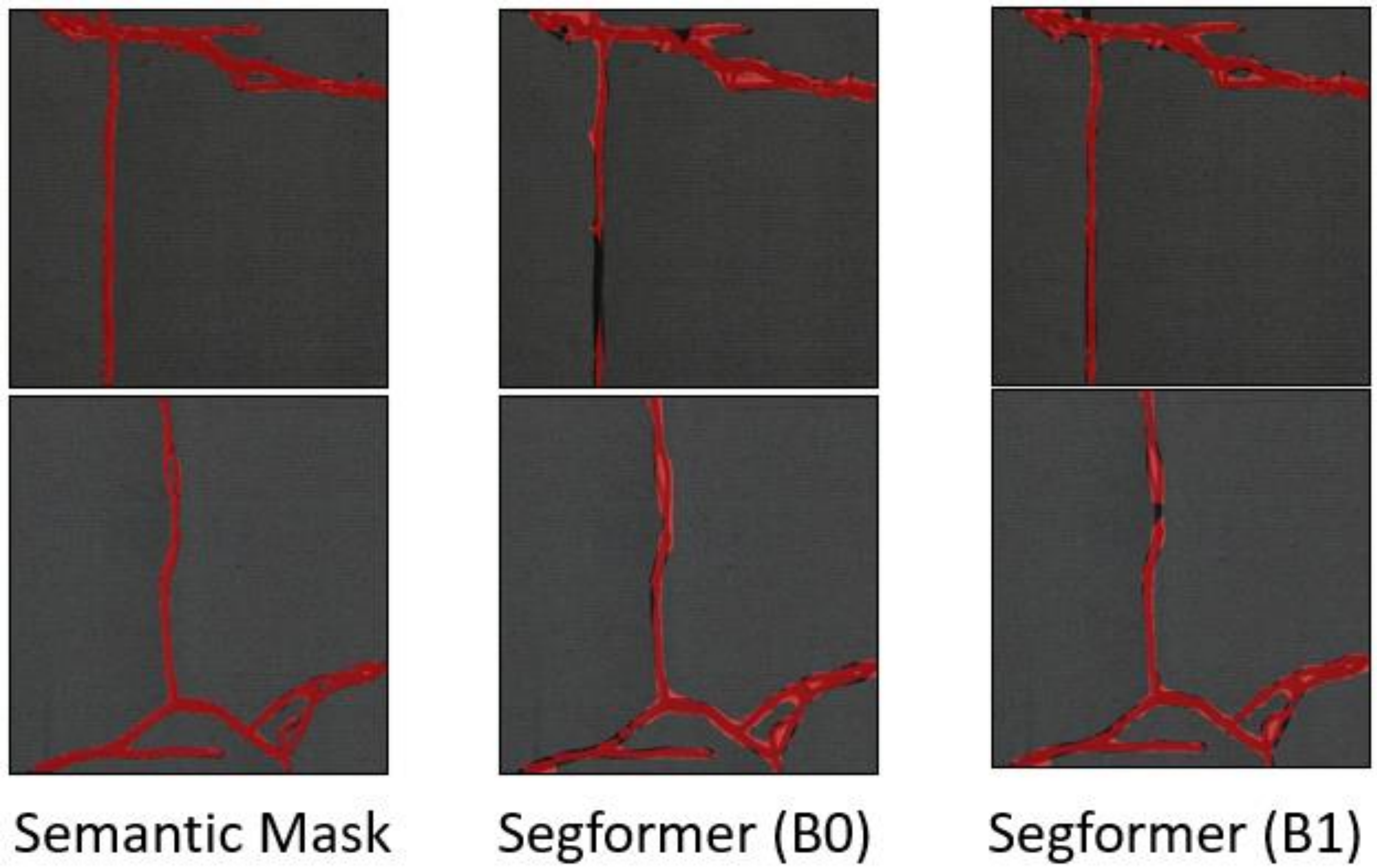
- Sample of DL-Based Crack Detection



Sealed Cracks detected by the UNET model

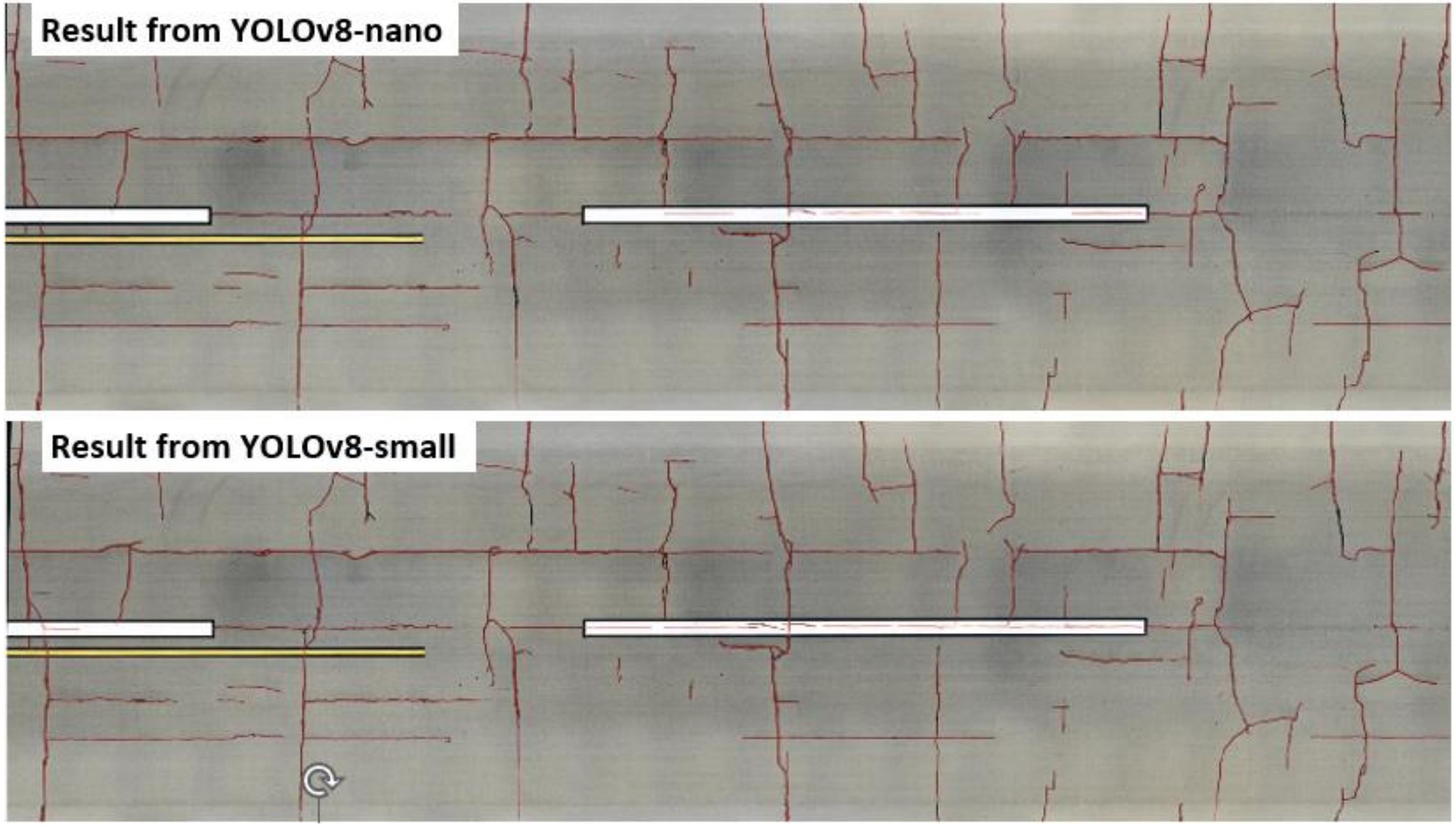
Red: Annotated Mask; Green: Predicted Mask

- Sample of DL-Based Crack Detection



Sealed Cracks detected by the Segformer models

- Large Scale Crack Detection
  - Pavement section dimensions: 91 m x 25.5 m



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Summary

- sUAS could successfully be used for airfield pavement distress detection
- Majority of the distresses are detected in RGB and DEM data
- Thermal data can add additional value
- Correlation between manual PCI and sUAS-based PCI is high
- ML models are fast and accurate for crack detection

Summary (Cont'd)

- The following learning objectives are met
  - Leverage sUAS to assist in infrastructure inspection
  - Understand which sensors and platforms are being used for infrastructure inspection (*partially*)

Contact Information

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Pitt-Des Moines, Inc. Endowed Professor in Civil, Construction and Environmental Engineering

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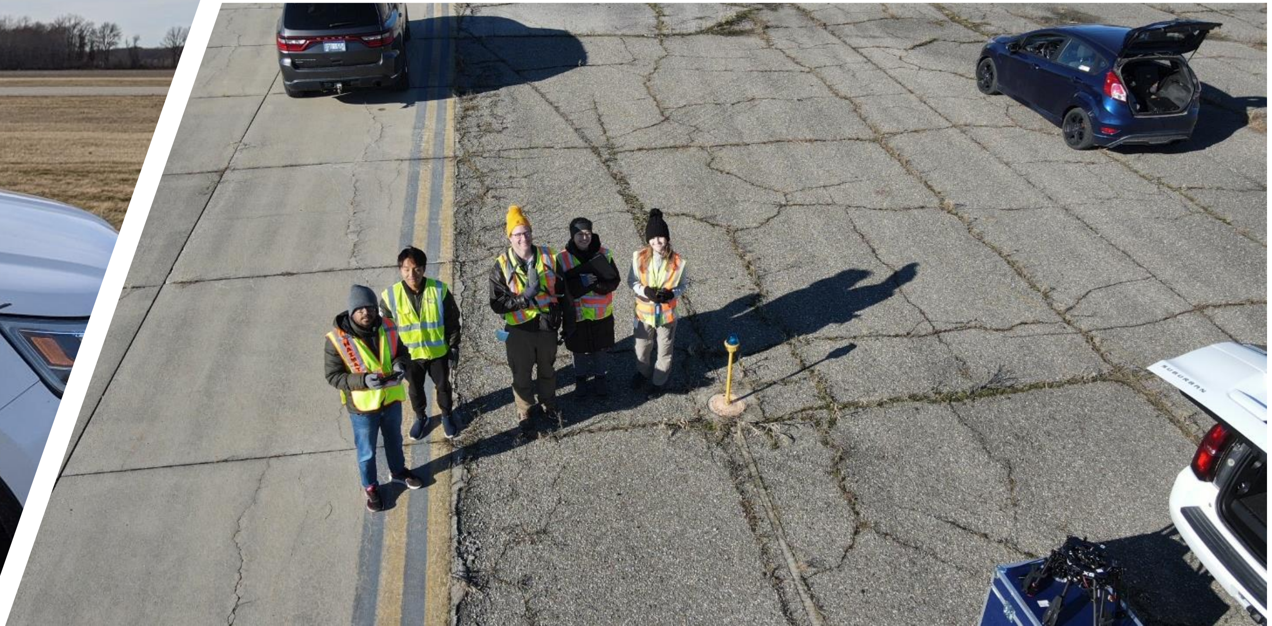
Questions

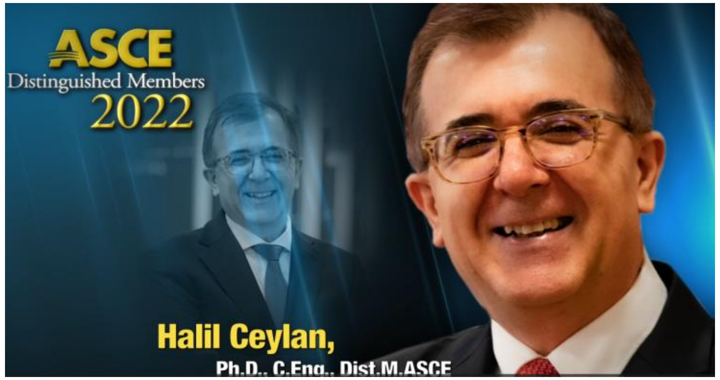


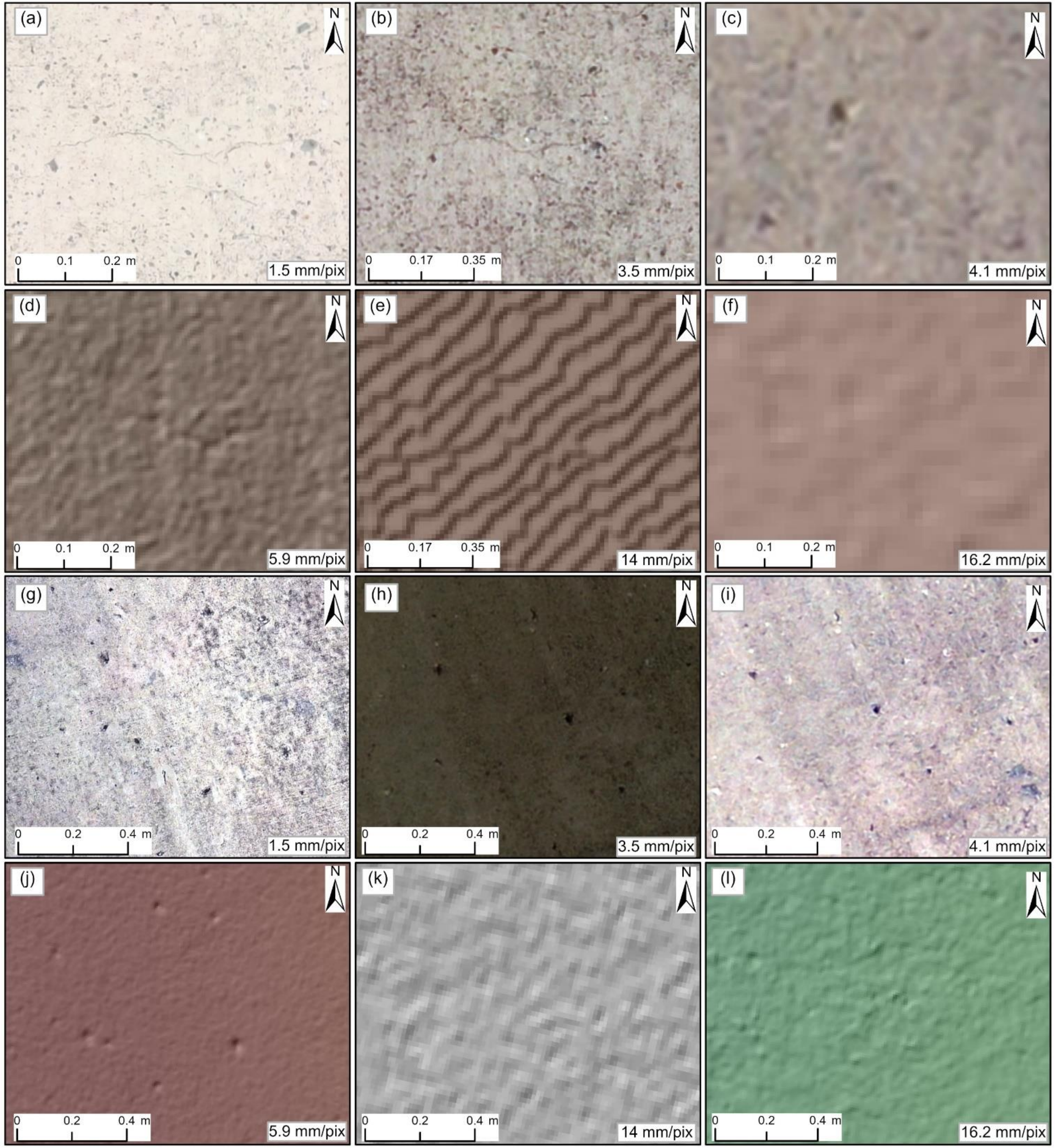
Extra Slides

Director Introduction:
Halil Ceylan, Ph.D., Dist.M.ASCE (Cont'd)

- Recent Awards
  - 2025 American Society of Civil Engineers (ASCE) Francis C. Turner Award
  - 2024 Transportation Research Board (TRB) Roy W. Crum Award
  - 2023 American Society of Civil Engineers (ASCE) Robert Horonjeff Award
  - Dist.M.ASCE, American Society of Civil Engineers (ASCE)
  - Fellow, American Society of Civil Engineers (ASCE)
  - 2022 University of Illinois Alumni Achievement Award
  - 2021 American Society of Civil Engineers (ASCE) James Laurie Prize
  - 2021 University of Illinois at Urbana-Champaign (UIUC) Civil and Environmental Engineering Alumni Association (CEEAA) Distinguished Alumnus Award
  - 2019 FAA PEGASAS Jimenez Faculty/Researcher Award
  - 2018 Award for Mid-Career Achievement in Research
  - 2018 Margaret Ellen White Graduate Faculty Award
  - And 15 other awards

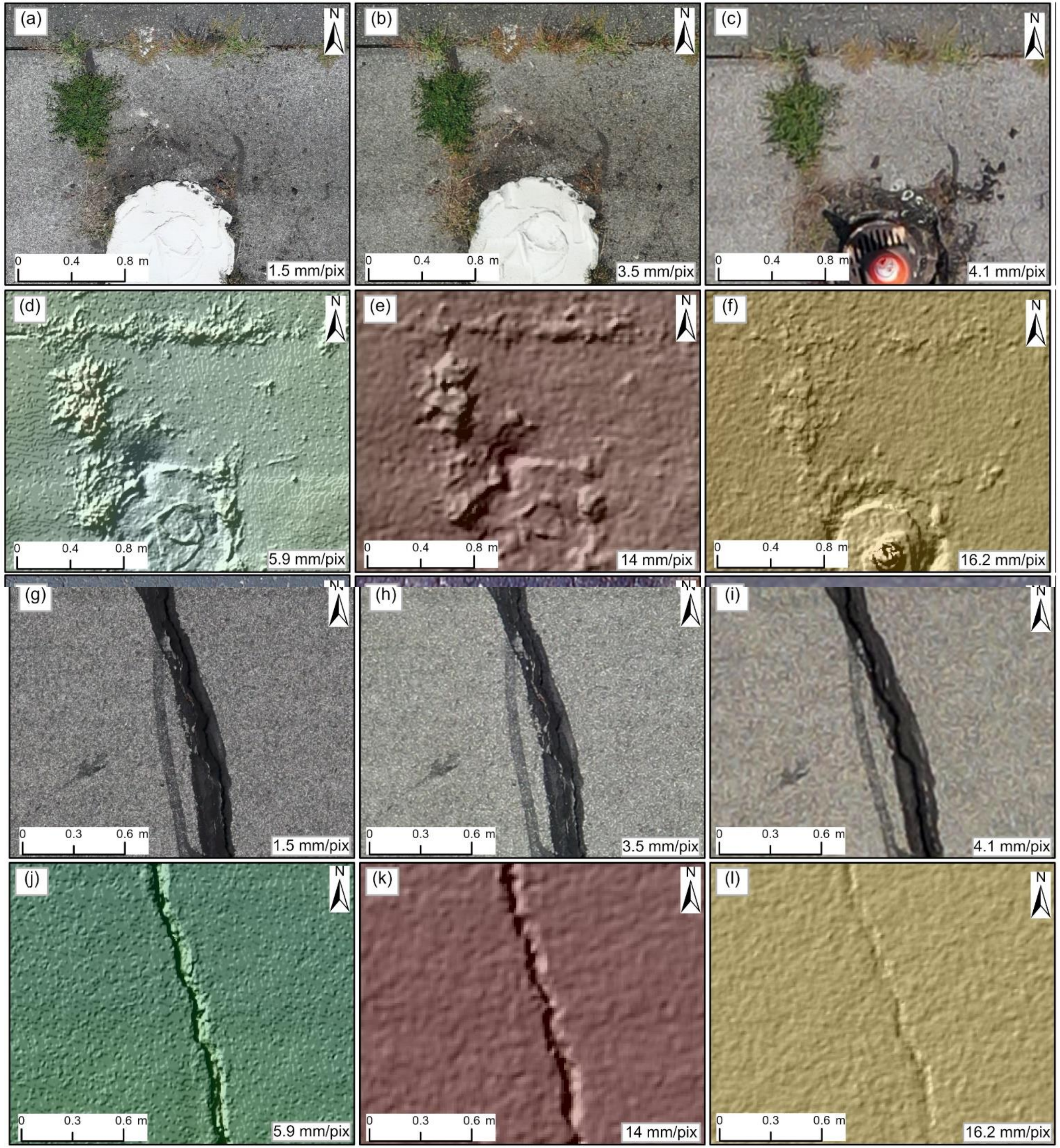
- Teaching
  - CE583/CE483 Pavement Analysis and Design; CE382 Design of Concretes; CE 360 - Geotechnical Engineering





Shrinkage Cracks (a-f)
on PCC Pavement

Pops-up (g-l)
on PCC Pavement



Patching (H)
Depression (M) (a-f)
on AC Pavement

L&T Cracks (H) (g-l)
on AC Pavement

Notable Results

PCC Pavement Distress Detection Capabilities

ASTM Distress (PAVER™ Distress #)	Severity	Detection		Minimum Res (mm/pix)	
		RGB	DEM	RGB	DEM
Blowup (61)					
Corner break (62)	L	Yes	No	2.5	ND
	M, H	Yes	No	21	ND
LTD cracks (63)	L	Yes	No	7.26	ND
	M	Yes	No	21	ND
	H*	Yes	NA	21	NA
Durability cracking (64)	L	Yes	No	7.26	ND
	M	Yes	Yes	21	10
	H	Yes	Yes	21	29.1
Joint seal damage (65)	L	No	No	ND	ND
	M	Yes	No	2.5	ND
	H	Yes	Yes	7.26	5.96
Small patching (66)	L	Yes	No	3.3	ND
	M/H*	Yes	Yes	4.5	5.96
Large patching (67)	L	Yes	No	21	ND
	M/H	Yes	No/Yes	21	29
Popouts (68)	NA	Yes	Yes	3.3	5.96

L = Low, M = Medium, H = High, RGB = Red Green Blue, DEM = Digital Elevation Model
mm/pix = millimeter/pixel, NA = Not Applicable, ND = Not Detected
* = Based on detection of lower severity
Color cells = Distress not available

Notable Results (Cont'd)

PCC Pavement Distress Detection Capabilities

ASTM Distress (PAVER™ Distress #)	Severity	Detection		Minimum Res (mm/pix)	
		RGB	DEM	RGB	DEM
Pumping (69)	NA				
Scaling (70)	L				
	M/H*	Yes	Yes	21	10
Settlement or faulting (71)	L	No	No	ND	ND
	M/H*	No	Yes	ND	2.98
Shattered slab (72)	L	No	No	ND	ND
	M, H	Yes	Yes	21	10
Shrinkage cracks (73)**	NA	Yes	No	2.5	ND
Joints spalling (74)	L	Yes	No	2.5	ND
	M	Yes	Yes	2.5	5.96
	H	Yes	Yes	2.5	5.96
Corner spalling (75)	L	Yes**	No	ND	ND
	M	Yes	No	3.3	ND
	H	Yes	Yes	3.3	10
Alkali Silica Reaction (ASR) (76)	L	Yes**	No	7.26	ND
	M	Yes**	Yes	7.26	5.96***
	H	Yes	Yes	7.26	5.96***

L = Low, M = Medium, H = High, RGB = Red Green Blue, DEM = Digital Elevation Model
mm/pix = millimeter/pixel, NA = Not Applicable, ND = Not Detected
* = Based on detection of lower severity, **Detection not always possible, ***Based on observation
Color cells = Distress not available

Notable Results (Cont'd)

AC Pavement Distress Detection Capabilities

ASTM Distress (PAVER™ Distress #)	Severity	Detection		Minimum Res (mm/pix)	
		RGB	DEM	RGB	DEM
Alligator cracking (41)	L	Yes	Yes	3.5	5.94
Bleeding (42)	NA				
Block cracking (43)	L	Yes	Yes	7.26	9.2
	M	Yes	Yes	7.26	19.6
	H	Yes	Yes	7.26	19.6
Corrugation (44)	NA				
Depression (45)	L	No	No	ND	ND
	M	No	Yes	ND	5.96
	H	Yes	Yes	4.06	16.02
Jet blast erosion (46)	NA				
Joint reflection cracking (47)	NA				
L&T cracking (48)	L	Yes	Yes	7.26	9.2
	M	Yes	Yes	7.26	19.6
	H	Yes	Yes	7.26	19.6
Oil spillage (49)	NA				

L = Low, M = Medium, H = High, RGB = Red Green Blue, DEM = Digital Elevation Model
mm/pix = millimeter/pixel, NA = Not Applicable, ND = Not Detected
* = Based on detection of lower severity, **Detection not always possible, ***Based on observation
Color cells = Distress not available

Notable Results (Cont'd)

AC Pavement Distress Detection Capabilities

ASTM Distress (PAVER™ Distress #)	Severity	Detection		Minimum Res (mm/pix)	
		RGB	DEM	RGB	DEM
Patching (50)	H	Yes	Yes	4.06	16.02
Polish aggregate (51)					
Raveling (52)	L	Yes	No	1.48	ND
	M	Yes	No	1.48	ND
	H*	Yes	No	1.48	ND
Rutting (53)	NA				
Shoving (54)	L	No	Yes	ND	5.94
	M	Yes	Yes	2.5	10
	H	Yes	Yes	2.5	10
Slippage cracking (55)					
Swell (56)	L	No	No	ND	ND
	M	No	No	ND	ND
	H				
Weathering (57)	L	No	No	ND	ND
	M	No	No	ND	ND
	H	No	No	ND	ND

L = Low, M = Medium, H = High, RGB = Red Green Blue, DEM = Digital Elevation Model
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Notable Results (Cont'd)

AC Pavement Distress Detection Capabilities

ASTM Distress (PAVER™ Distress #)	Severity	Detection		Minimum Res (mm/pix)	
		RGB	DEM	RGB	DEM
Patching (50)	H	Yes	Yes	4.06	16.02
Polish aggregate (51)					
Raveling (52)	L	Yes	No	1.48	ND
	M	Yes	No	1.48	ND
	H*	Yes	No	1.48	ND
Rutting (53)	NA				
Shoving (54)	L	No	Yes	ND	5.94
	M	Yes	Yes	2.5	10
	H	Yes	Yes	2.5	10
Slippage cracking (55)					
Swell (56)	L	No	No	ND	ND
	M	No	No	ND	ND
	H				
Weathering (57)	L	No	No	ND	ND
	M	No	No	ND	ND
	H	No	No	ND	ND

L = Low, M = Medium, H = High, RGB = Red Green Blue, DEM = Digital Elevation Model
mm/pix = millimeter/pixel, NA = Not Applicable, ND = Not Detected
* = Based on detection of lower severity, **Detection not always possible, ***Based on observation
Color cells = Distress not available

Publications and Presentations on sUAS Research

Publications

1. Sourav, M. A. A., Ceylan, H., Brooks, C., Dobson, R., Kim, S., Peshkin, D., & Brynick, M. (2024). Use of small unmanned aircraft systems in airfield pavement inspection: implementation and potential. *International Journal of Pavement Engineering*, *25*(1), 2401630. https://doi.org/10.1080/10298436.2024.2401630
2. Sourav, M. A. A., Mahedi, M., Ceylan, H., Kim, S., Brooks, C., Peshkin, D., Dobson, R., & Brynick, M. (2022). Evaluation of Small Uncrewed Aircraft Systems Data in Airfield Pavement Crack Detection and Rating. *Transportation Research Record*, 0(0). https://doi.org/10.1177/03611981221101030
3. Vidyadharan, A., Carter, T., Ceylan, H., Bloebaum, C., Gopalakrishnan, K., & Kim, S. (2017). Civil infrastructure health monitoring and management using unmanned aerial systems. In Airfield and Highway Pavements 2017 (pp. 207-216).
4. Sourav, M. A. A., Ceylan, H., Kim, S., & Brynick, M. (2024). Integration of Small Unmanned Aircraft Systems and Deep Learning for Efficient Airfield Pavement Crack Detection and Assessment. In International Conference on Transportation and Development 2024 (pp. 884-893).
5. Sourav, M. A. A., Ceylan, H., Kim, S., Brooks, C., Peshkin, D., Dobson, R., & Brynick, M. (2023). Use of Digital Elevation Model for Detecting Airfield Pavement Distress. In *Airfield and Highway Pavements 2023* (pp. 254-265).

Publications

6. Sourav, M. A. A., Mahedi, M., Ceylan, H., Kim, S., Brooks, C., Peshkin, D., Dobson, R., Brynick, M., & DiPilato, M. (2022). Small Uncrewed Aircraft Systems-Based Orthophoto and Digital Elevation Model Creation and Accuracy Evaluation for Airfield Portland Cement Concrete Pavement Distress Detection and Rating. In *International Conference on Transportation and Development 2022* (pp. 168-180). https://doi.org/10.1061/9780784484371.016
7. Sourav, M. A. A., Ceylan, H., Brooks, C., Peshkin, D., Kim, S., Dobson, R., Cook, C., Mahedi, M., & Jenkins, A. (2023). *Small Unmanned Aircraft System for Pavement Inspection.* (No. *DOT/FAA/TC-23/50*). United States. DOT. FAA. William J. Hughes Technical Center.
8. Sourav, M. A. A., Ceylan, H., Brooks, C., Peshkin, D., Kim, S., Dobson, R., Cook, C., & Brouillette, O. (2022). *Small Unmanned Aircraft System for Pavement Inspection: Task 4—Execute the Field Demonstration Plan and Analyze the Collected Data* (No. DOT/FAA/TC-22/35). United States. DOT. FAA. William J. Hughes Technical Center
9. Sourav, M. A. A., Ceylan, H., Brooks, C., Peshkin, D., Kim, S., Dobson, R., Cook, C., & Brouillette, O. (2022). *Practical Lessons Learned from Planning, Collecting, Processing, and Analyzing Small Unmanned Aircraft System Data for Airfield Pavement Inspection.* (No. *DOT/FAA/TC-22/48*). United States. DOT. FAA. William J. Hughes Technical Center.

Publications and Presentations on sUAS Research (Cont'd)

Presentations

1. Sourav, M. A. A., Ceylan, H. (2022). *Use of sUAS in Airfield Pavement Inspection.* Oral Presentation. ASCE T&DI Uncrewed Aircraft Systems Committee. 4th Quarter Virtual Meeting. December 12, 2022. Virtual.
2. Sourav, M. A. A., Ceylan, H., Kim, S., Brooks, C., & Peshkin, D. (2022). *Use of Drone in Airfield Pavement Distress Detection - A Possibility and A Future.* Poster Presentation. Mid-Continent Transportation Research Symposium. September 14–15. Ames, Iowa.
3. Sourav, M. A. A., Mahedi, M., Ceylan, H., Kim, S., Brooks, C., Peshkin, D., Dobson, R., Brynick, M., & DiPilato, M. (2022). *Small Uncrewed Aircraft Systems-based Orthophoto and Digital Elevation Model Creation and Accuracy Evaluation for Airfield Portland Cement Concrete Pavement Distress Detection and Rating.* Oral Presentation. ASCE International Conference on Transportation & Development 2022. May 31– June 3, 2022. Seattle, WA
4. Sourav, M. A. A., Mahedi, M., Ceylan, H., Kim, S., Brooks, C., Peshkin, D., Dobson, R., & Brynick, M. (2022). *Evaluation of Small Uncrewed Aircraft Systems Data in Airfield Pavement Crack Detection and Rating.* Poster Presentation. The Transportation Research Board (TRB) 100th Annual Meeting. January 8–12, 2023 in Washington, D.C.

UAS for Construction Inspection and Building Information Modeling (BIM)

Dr. Reihaneh (Rei) Samsami (P.E., CAPM)
Tagliatela Family Assistant Professor and MSCM Program Director
Department of Civil and Environmental Engineering
University of New Haven

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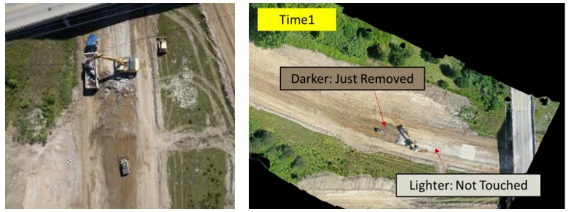
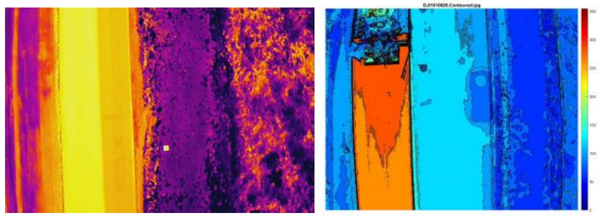
1. Automated Progress Monitoring

- UAS Data Collection Protocols
- UAS Visual Data Analysis
- Progress Metrics
- Fitting Metrics in The Workflow



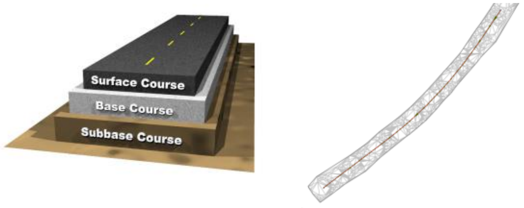
2. Automated Quality Inspection

- UAS Data Collection Protocols
- UAS Thermal Data Analysis
- Quality Control Metrics
- Fitting Metrics in The Workflow



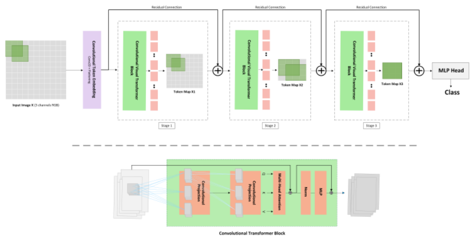
3. Automated As-Built BIM Development

- UAS BIM Parameters
- Information Analysis Techniques
- Supporting The Decision-making Workflows Using BIM



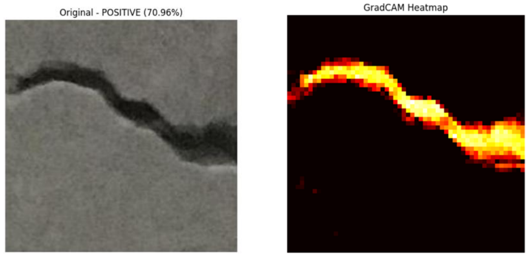
4. Automated Bridge Inspection

- Automated Data Collection
- UAS Visual Data Analysis
- Crack Detection And Location
- Comparison between algorithms



5. Explainable AI

- Explainable AI for Better Transparency



A BRIEF LOOK AT RECENT RESEARCH AT

SAMSAMI LAB

Dr. Rei Samsami

Dr. Colin Brooks

Dr. Amlan Mukherjee

Dr. Mo Nassar

Dr. Saida Elmi

COLLABORATIVE EXCELLENCE: OUR TEAM IN ACTION

Michigan Tech Research Institute

MDOT Michigan Department of Transportation

www.mtri.org

Integration of Unmanned Aerial Systems Data Collection into Day-to-Day Usage for Transportation Infrastructure – A Phase III Project

Final Report, No. SPR-1713

Prepared by:
C. Brooks[1], C.Cook[1], R. Dobson[1], T. Oommen[2], K. Zhang[2], A. Mukherjee[2], R.Samsami[2], A.Semenchuk[3], B.Lovelace[4], V.Hung[2], Y.Tan[2], Y.Yang[2], A.Jenkins[1], J.Graham[1], V.C. Lekha[2], M.Billmire[1], V.Barber[1]

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[3] Surveying Solutions Inc. (SSI), Standish, MI
[4] Collins Engineers Inc., St. Paul, MN

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Research Manager:
André Clover, P.E.
Michigan Department of Transportation
8885 Ricks Road
Lansing, MI 48917

Revised version of June 11, 2022

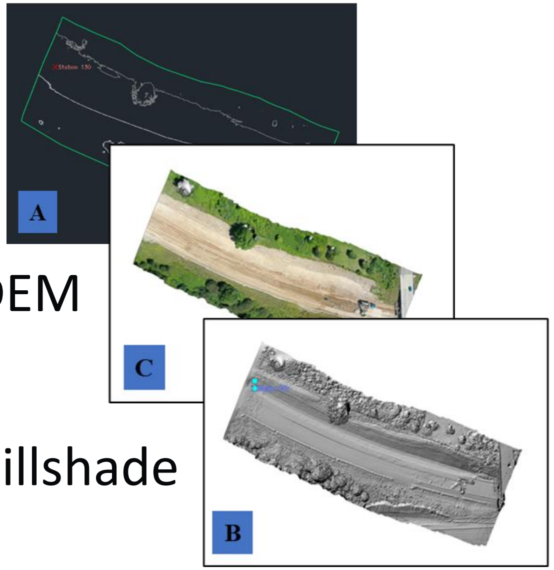
PROGRESS MONITORING

Development of a comprehensive methodology that integrates data collection, processing, analysis, and the derivation of progress estimation metrics for informed decision-making in construction projects.

I-496: Reconstruction Project (Lansing, MI)

PROGRESS MONITORING

DJI Mavic 2 Pro mdMapper 1000

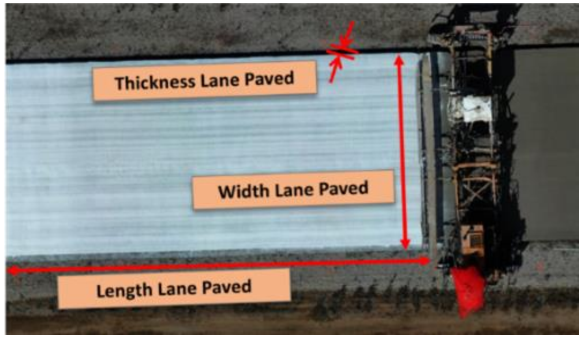


DEM

Hillshade

Geo-TIFF

Agisoft Photoscan



MDOT Standard Specifications for Construction

Construction Activity
602.Concrete Pavement(SY)

Image Processing
Image Labeling

Pavement Removal Pay Item: SY	
Length (ft)	690.51
Width (ft)	22.80

$$Estimated\ Production\ Rate = \frac{Quantity\ Observed}{Duration} = \frac{690.51 \times 22.80}{4.133} = 428.42\ \left(\frac{SY}{Hr}\right)$$

Earned Value Analysis

Project managers : Engineer's Opinion of Cost.
Contractors: Future Biddings.

Take corrective actions to bring the project's performance back.

Detect the reasons for lower productivity rates and address them (weather conditions, site conditions, unplanned errors, and waiting time).

DATA ANALYSIS & INFO RETRIEVAL

Image Processing

Divide an image into “meaningful” regions; based on color, texture, etc.

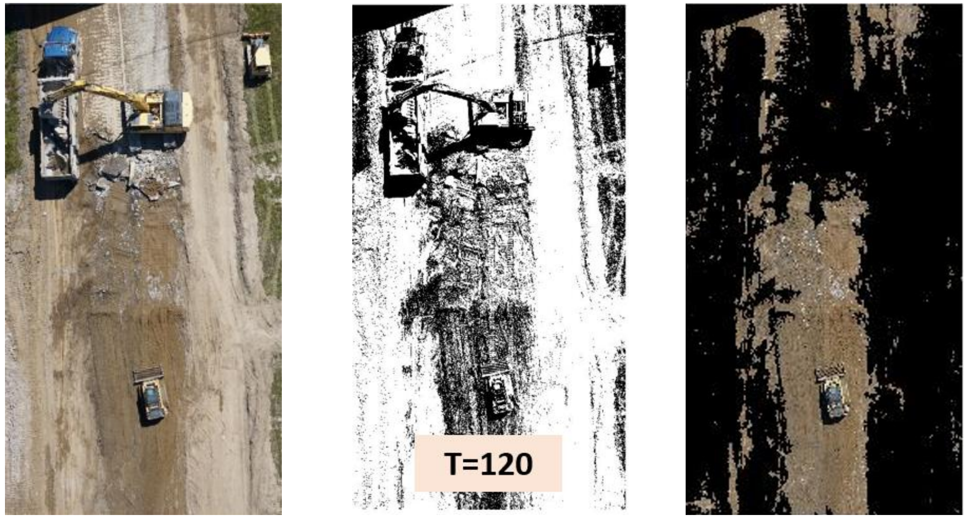
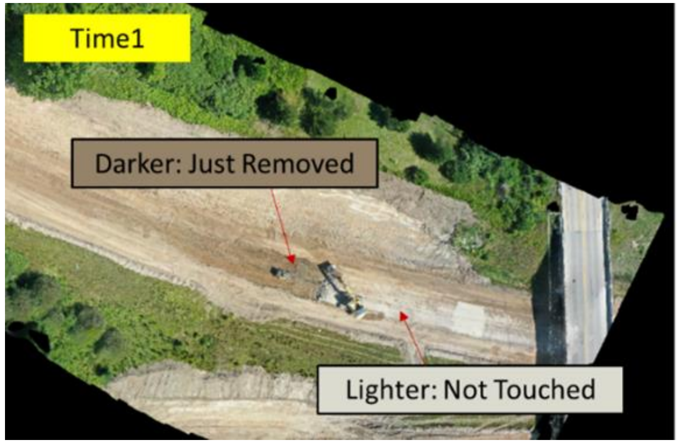


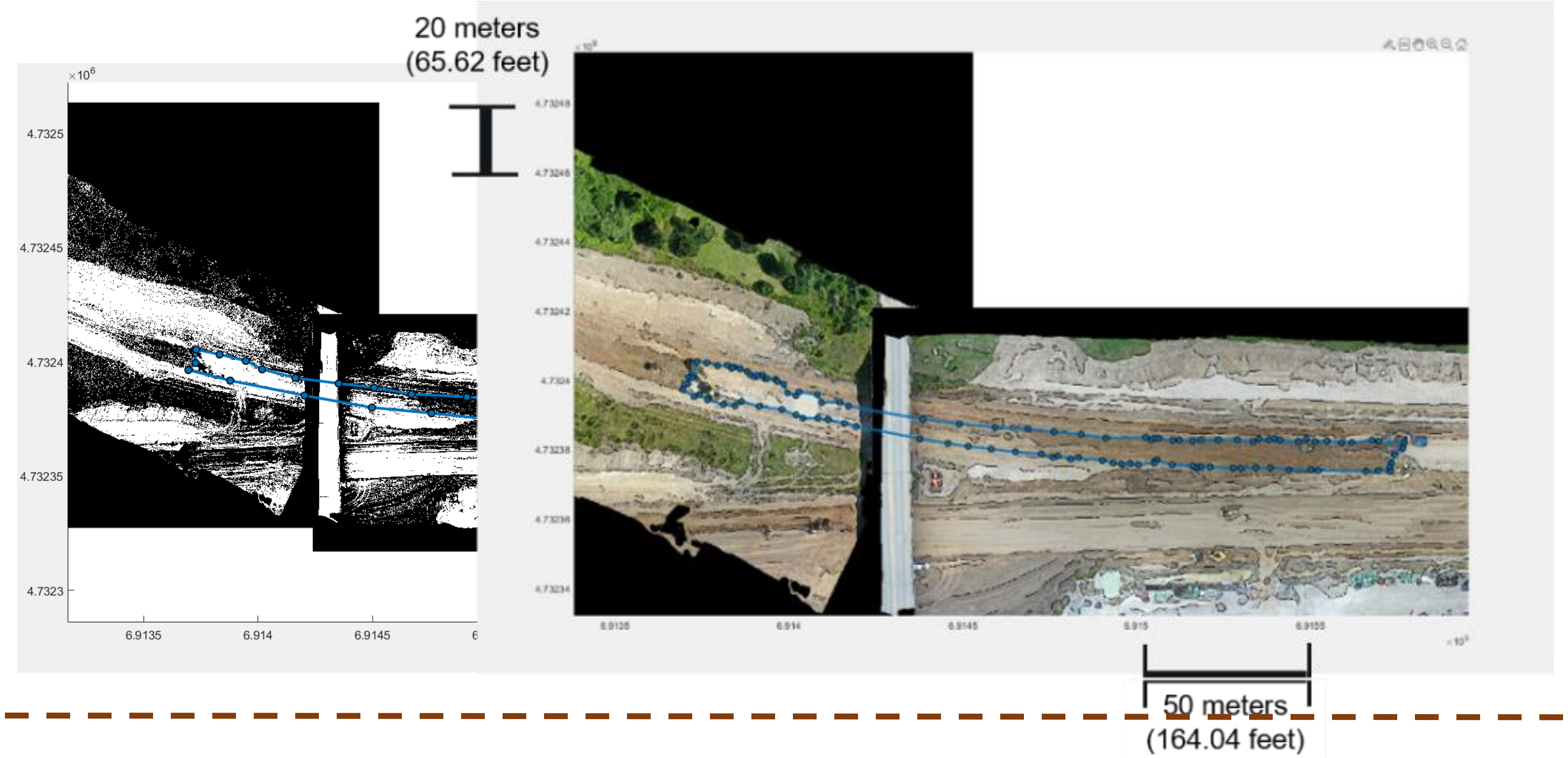
Image Labeling

Detect objects of certain class (heavy equipment) using computer vision.

Detect activities, Parameters, Equipment, Work quantities.

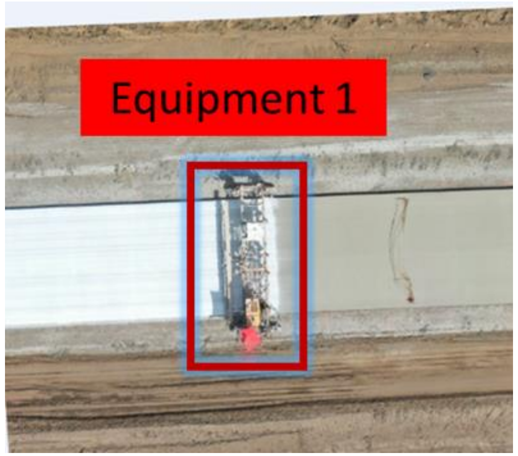
DATA ANALYSIS & INFO RETRIEVAL





Activity	Unit	Parameter	Measure	Parameter	Measure
Pavement Removal	SY	Length (ft)	690.51	Width (ft)	22.80

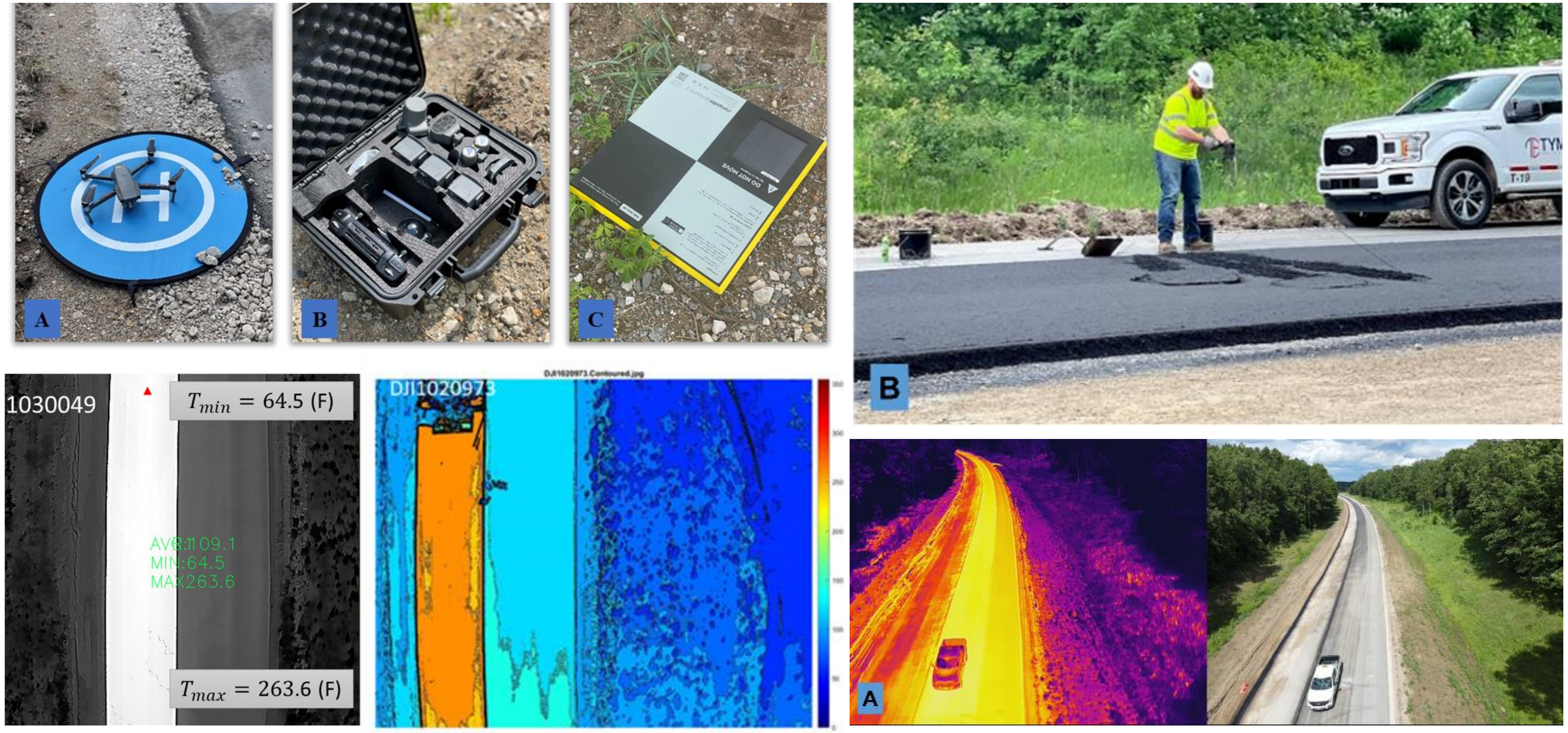
DATA ANALYSIS & INFO RETRIEVAL



Activity	Unit	Parameter	Measure	Parameter	Measure
Concrete Pavement	SY	Length (ft)	973.52	Width (ft)	26.87

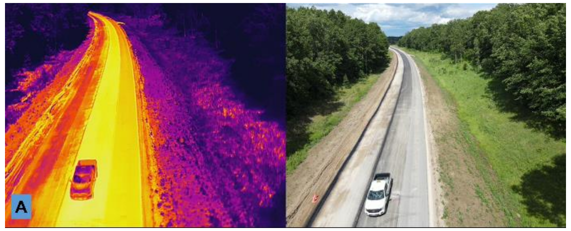
HMA THERMAL SEGREGATION

Creation of data collection protocols and the application of thermal image analysis to improve HMA pavement inspections.

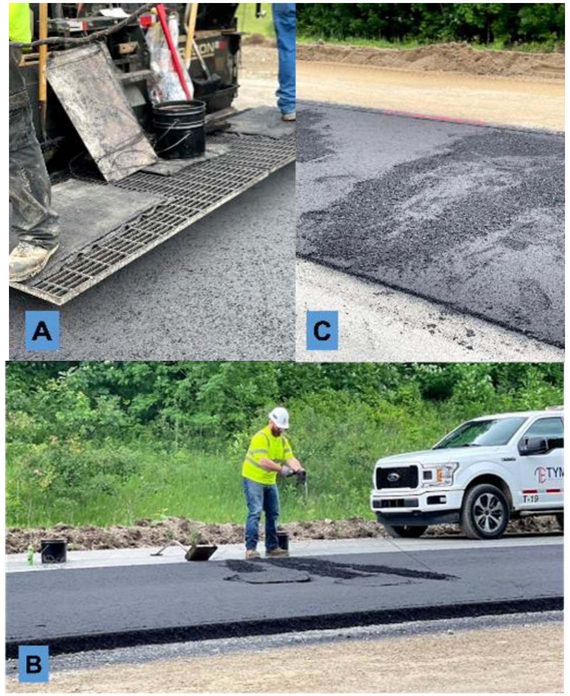


I-69: HMA reconstruction project (Lansing, MI)

HMA THERMAL SEGREGATION

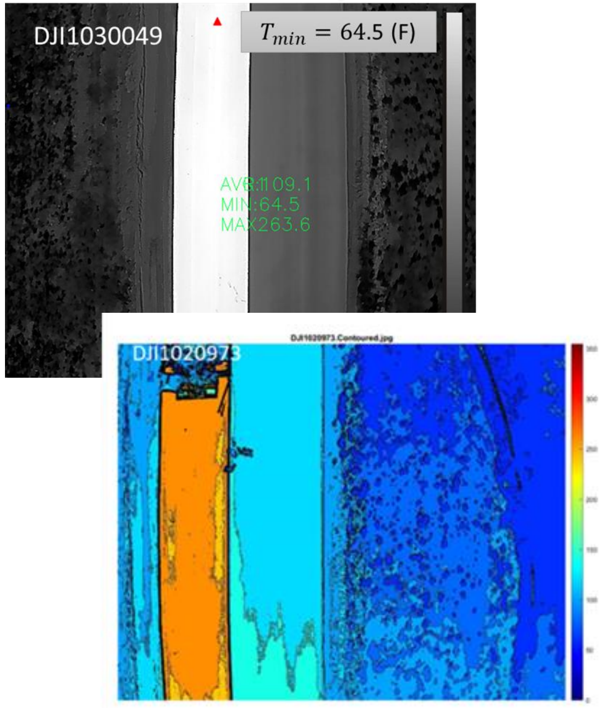


RJPG Geo-TIFF



MDOT MTM 324-07

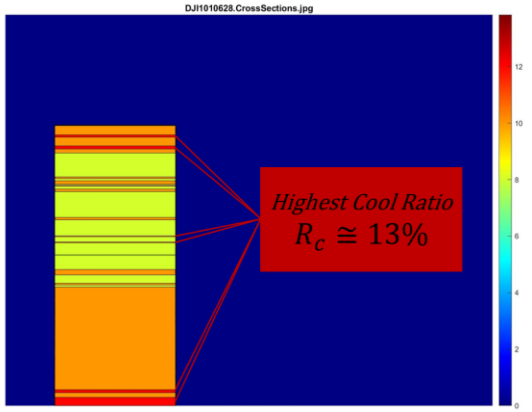
Mavic2 thermal images individually scaled.



Contouring

$\%R_c$: Cool Areas
$\%R_{ps}$: Potentially Segregated
$\%R_{hs}$: Highly Segregated

Image	$\%R_c$	$\%R_{ps}$	$\%R_{hs}$
DJI1010628	**5.3**	0.4	0.8
DJI1020973	1.7	0.4	0.8
DJI1030040	0.2	0.2	0.5
DJI1040849	1.4	**1.8**	**2**
DJI1050081	1.1	1.5	1.3
DJI1060783	0.7	1.2	1
DJI1070237	0.4	0.7	1.1
DJI1070435	0.7	0.4	1.6



Project managers & Inspectors

Fix the segregated areas or prevent future segregation.

Real-time results

DATA ANALYSIS & INFO. RETRIEVAL

Intensity –Temperature relationship is defined for each single image.

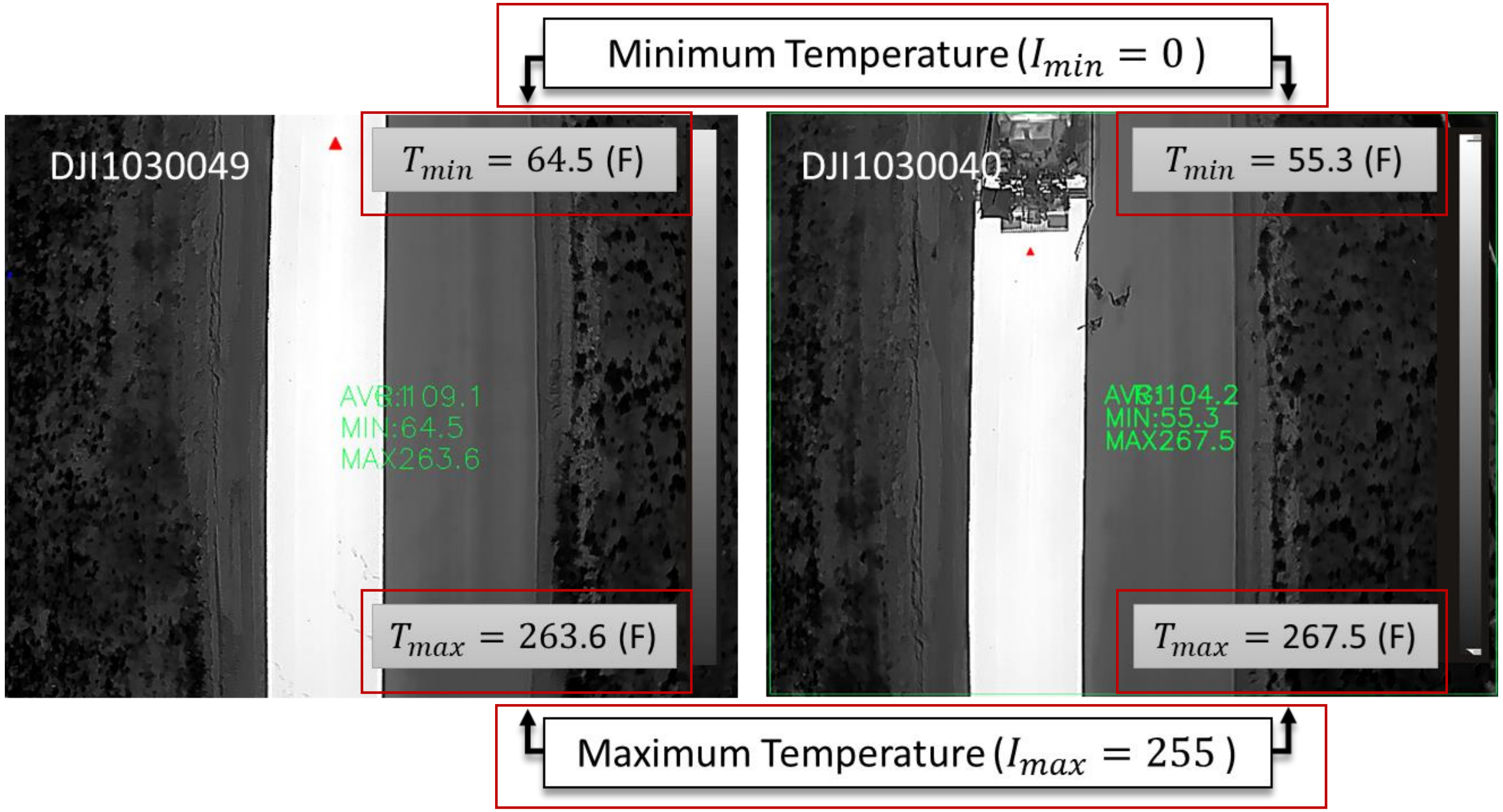
↓

Images are universally scaled.

↓

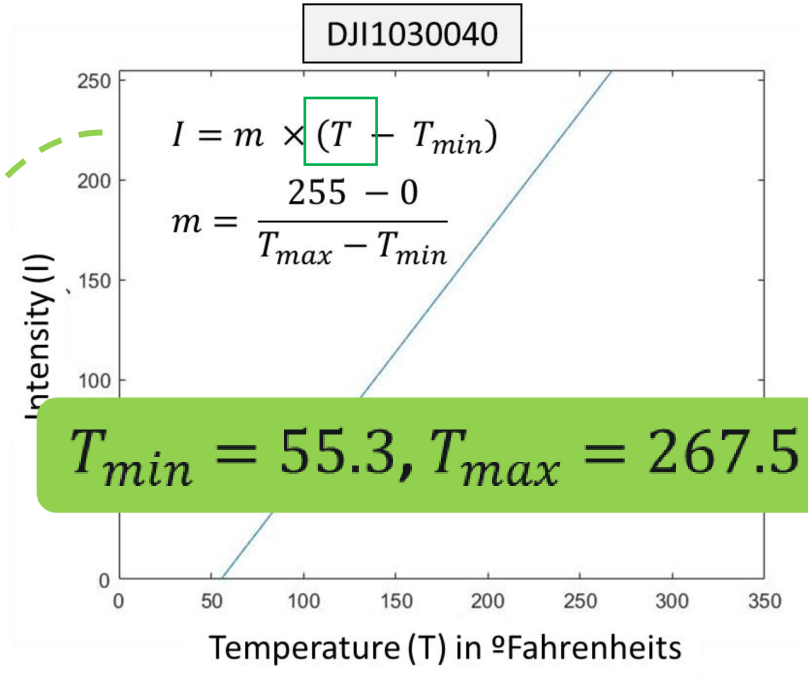
Cool Spots are visualized on each image.

Mavic 2 thermal images are each individually scaled.

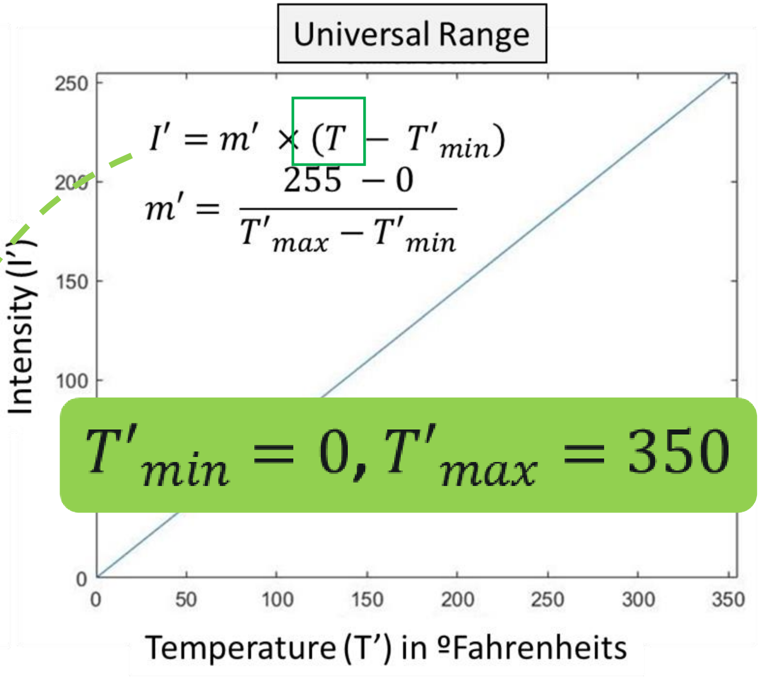


DATA ANALYSIS & INFO. RETRIEVAL

Scaling



$$T_{min} = 55.3, T_{max} = 267.5$$



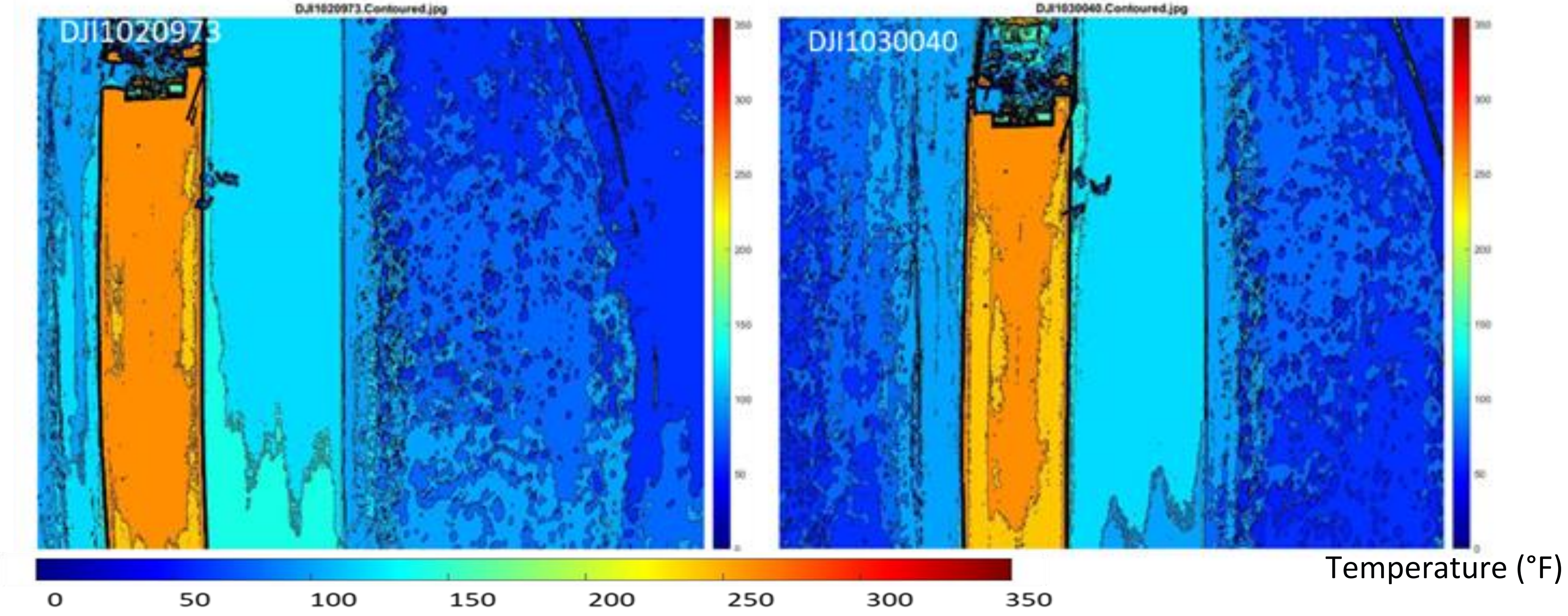
$$T'_{min} = 0, T'_{max} = 350$$

$$T = \frac{I}{m} + T_{min}$$

$$\mathrm{I}' = \mathrm{m}' \times \left(\frac{I}{m} + T_{min} - T'_{min}\right)$$

DATA ANALYSIS & INFO. RETRIEVAL

Contouring



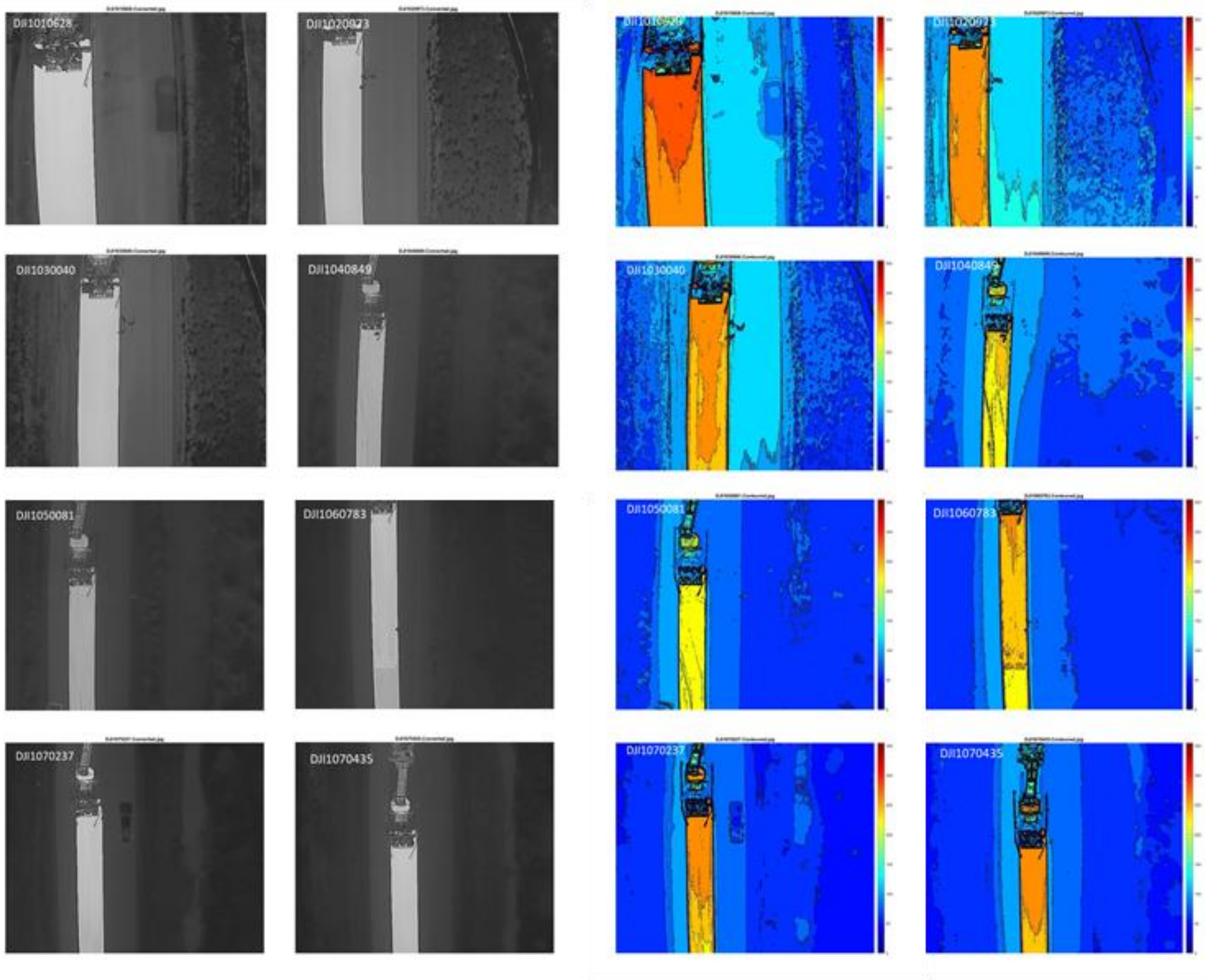
THERMAL SEGREGATION ESTIMATION

Thermal segregation metrics are defined.

Thermal segregation metrics are estimated using the scaled images.

No	Metric	Title	Category	Criterion
1	R_c	**Ratio of Cool Areas**	Temperature Range	Is laying temperature within the temperature window of **185°F-293°F** (85-145 °C) considered?
2	R_{ps}	**Ratio of Potentially Segregated Areas**	Temperature Differentials 1	Are temperature differentials larger than **19°F** (10 °C) causing Potentially Segregated spots?
3	R_{hs}	**Ratio of Highly Segregated Areas**	Temperature Differentials 2	Are temperature differentials larger than **36°F** (20 °C) causing Highly Segregated spots?

THERMAL SEGREGATION ESTIMATION



%Rc : Cool Areas
$\%R_{ps}$: Potentially Segregated Areas
$\%R_{hs}$: Highly Segregated Areas

Image	%Rc	$\%R_{ps}$	$\%R_{hs}$
DJI1010628	**5.3**	0.4	0.8
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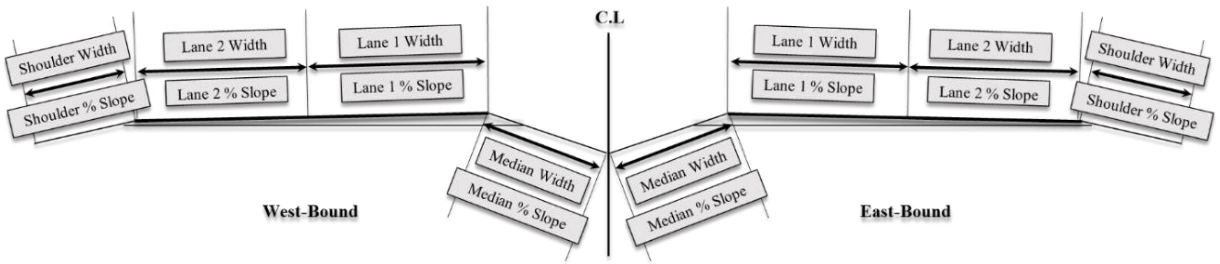
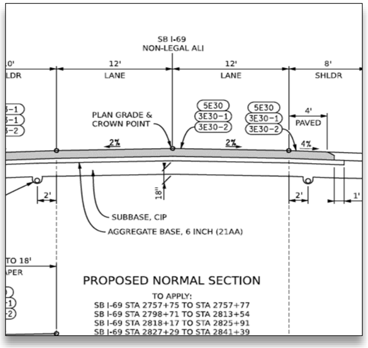
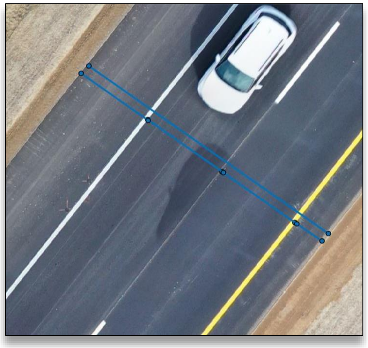
DJI1070237	0.4	0.7	1.1
DJI1070435	0.7	0.4	1.6

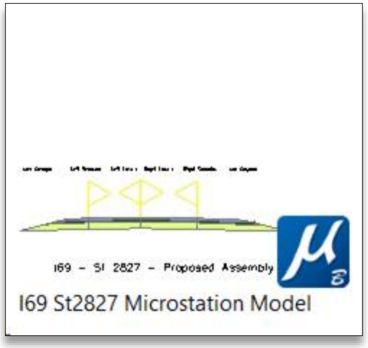
AS-BUILT BIM MODELING

Integration of UAS data within BIM for as-built visualization of the project.





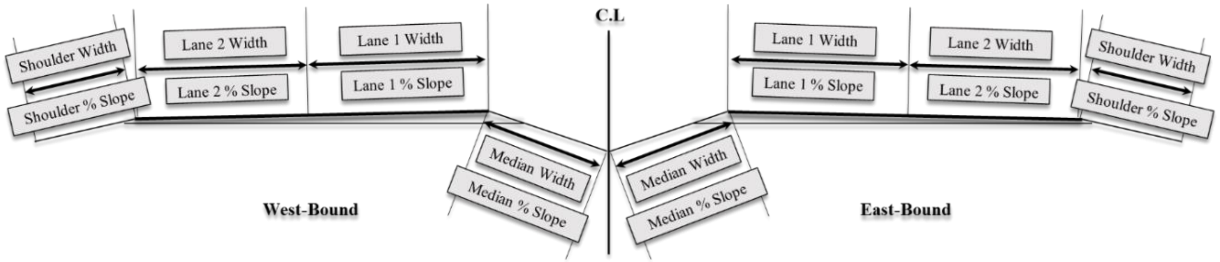


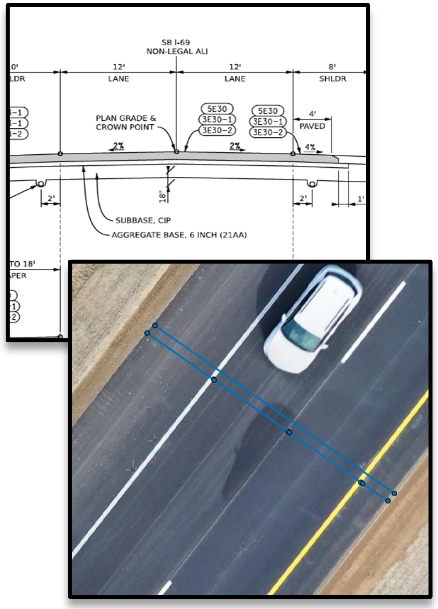


I-69 and I-496 Projects (Lansing, MI)

AS-BUILT BIM MODELING

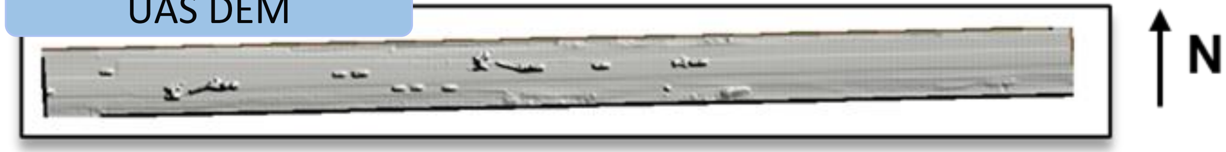
Surface Parameters



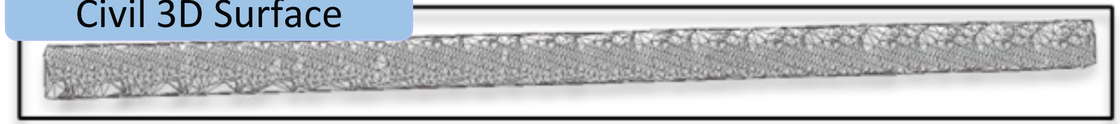


Lane1	Width	4.26 m
	Length	482 m
	% Slope	2%
Lane2	Width	3.69 m
	Length	482 m
	% Slope	2%
Shoulder1	Width	2.67 m
	Length	482 m
	% Slope	4%
Daylight1	Width	0.85 m
	Length	482 m
	% Slope	1:4

UAS DEM

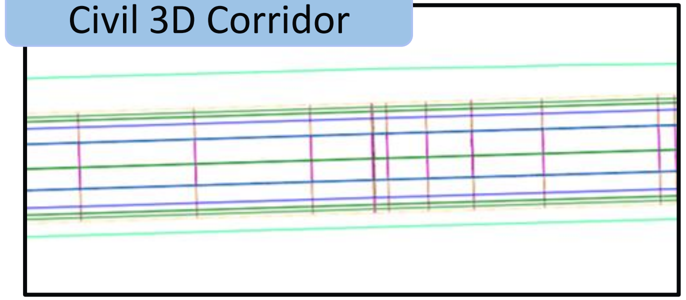


Civil 3D Surface

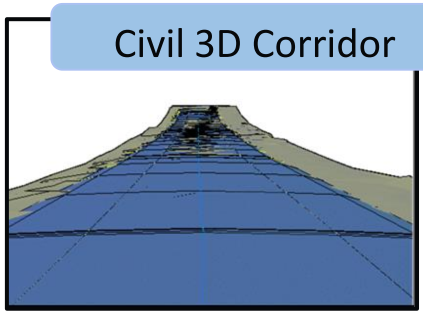


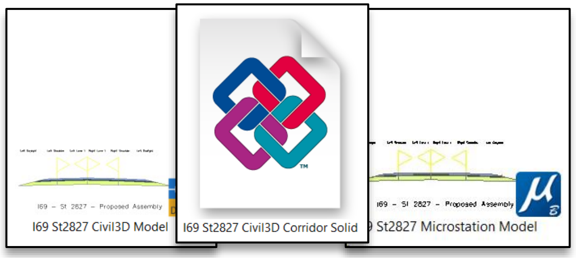
Alignment

Civil 3D Corridor



Civil 3D Corridor





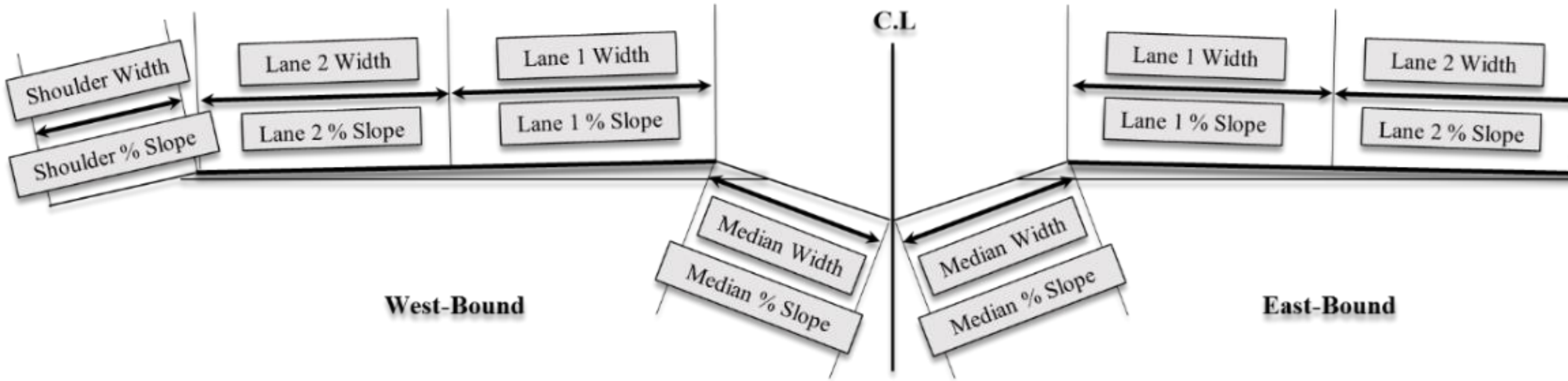
CIVIL 3D BIM
CORRIDOR SOLID
MICROSTATION BIM

PARAMETER DEFINITION & MAPPING

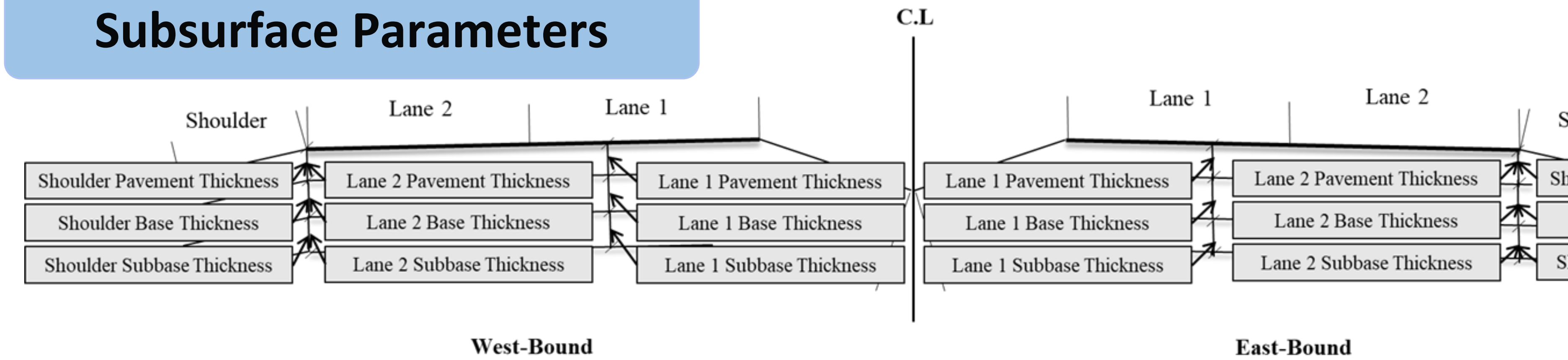
BIM parameters and their geometric constraints are defined.

UAS Geometry Parameters are mapped onto the BIM Parameters.

Surface Parameters

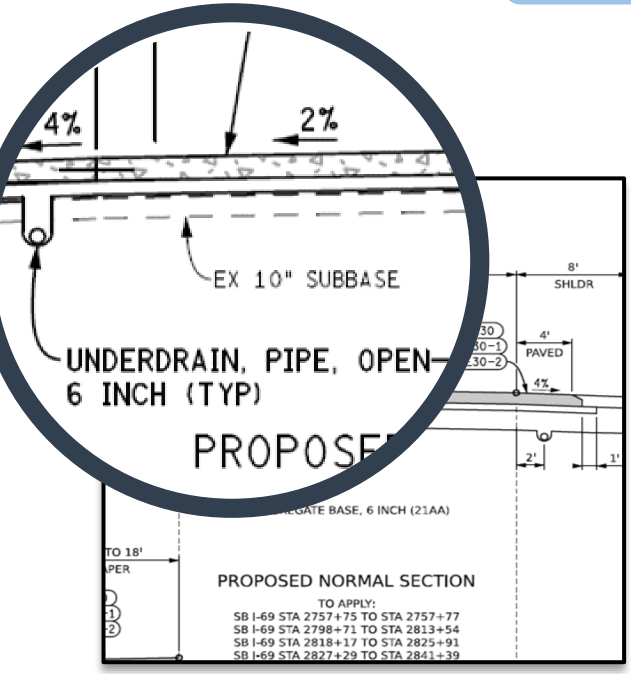


Subsurface Parameters

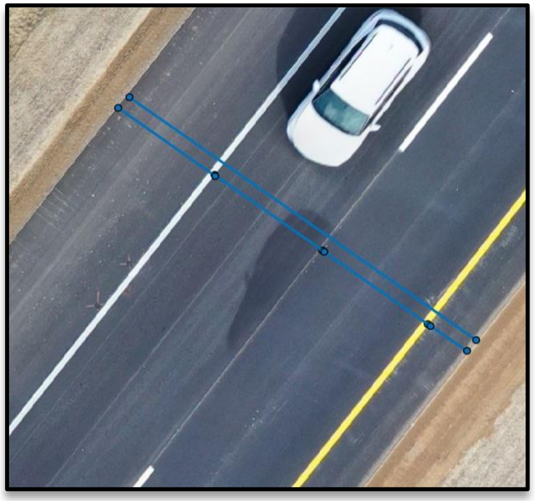


PARAMETER DEFINITION & MAPPING

INPUT



Project Plans



UAS Images

OUTPUT

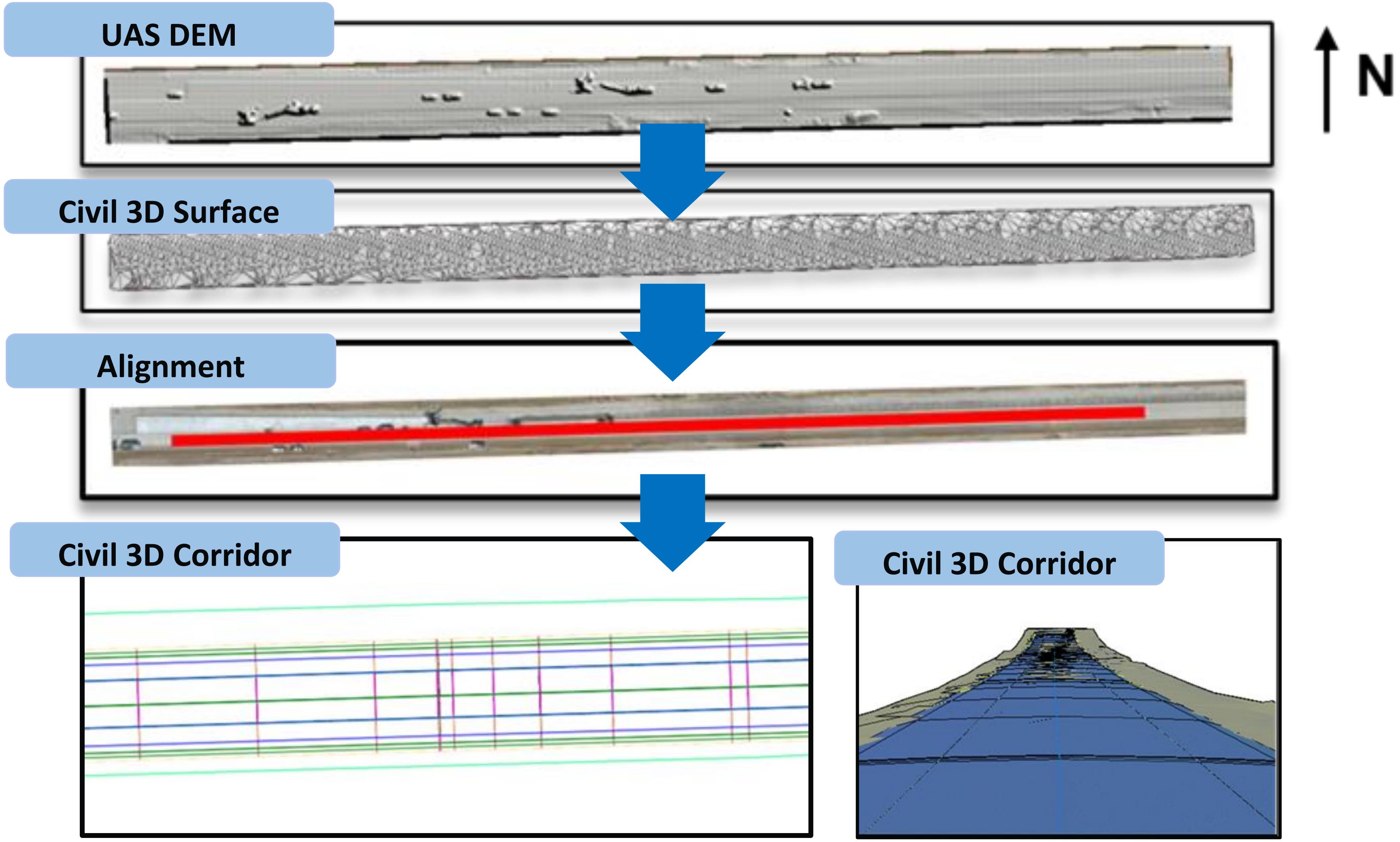
BIM PARAMETERS (MDOT I-496)	Surface	Lane 1	Width	4.26 m
			Length	482 m
			% Slope	2%
		Lane 2	Width	3.69 m
			Length	482 m
			% Slope	2%
		Shoulder 1	Width	2.67 m
			Length	482 m
			% Slope	4%
			Width	3.05 m
	Subsurface	Lane 1	Pavement Thickness	0.25 m
			Base Thickness	0.15 m
			Subbase Thickness	0.25 m
		Lane 2	Pavement Thickness	0.25 m
			Base Thickness	0.15 m
			Subbase Thickness	0.25 m
		Shoulder	Pavement Thickness	0.25 m
			Base Thickness	0.15 m
			Subbase Thickness	0.25 m

AS-BUILT BIM DEVELOPMENT

Point data is extracted from DEM data and used to create surface.

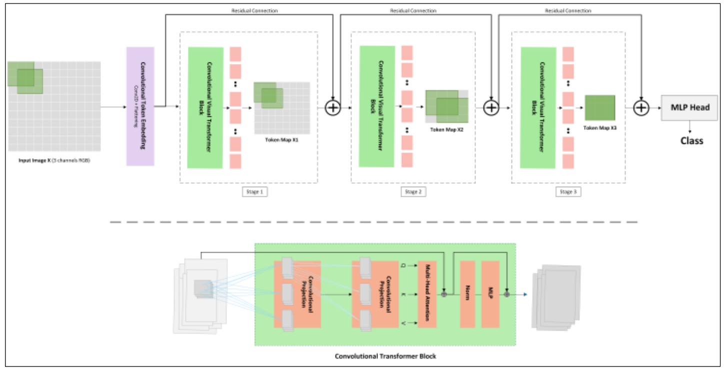
Hillshade image is used to extract the road alignment and create it on the surface.

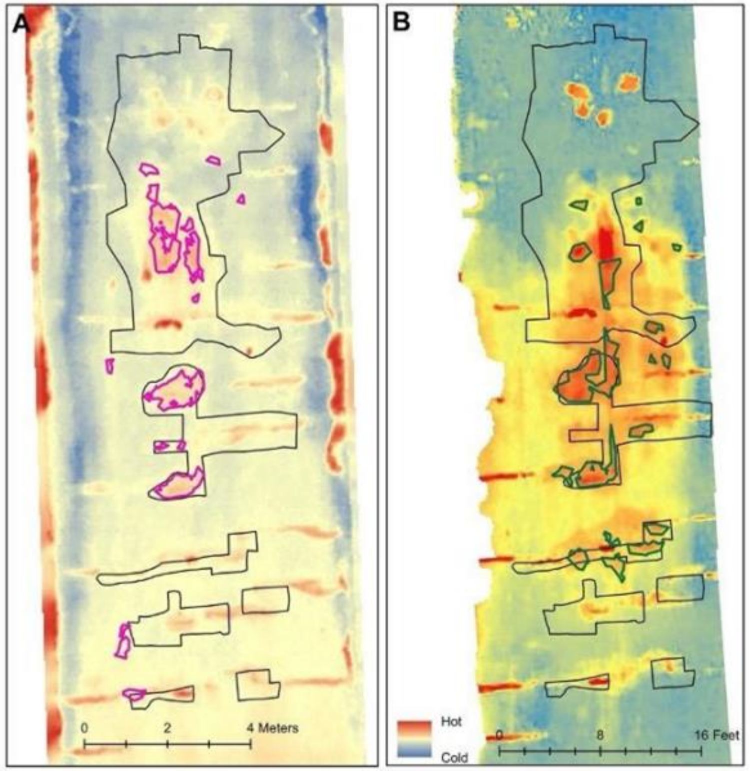
BIM parameters are used to create an assembly and the corridor.



BRIDGE INSPECTION

Developing new Deep Learning Models to detect and locate damages on a concrete bridge with high accuracy.

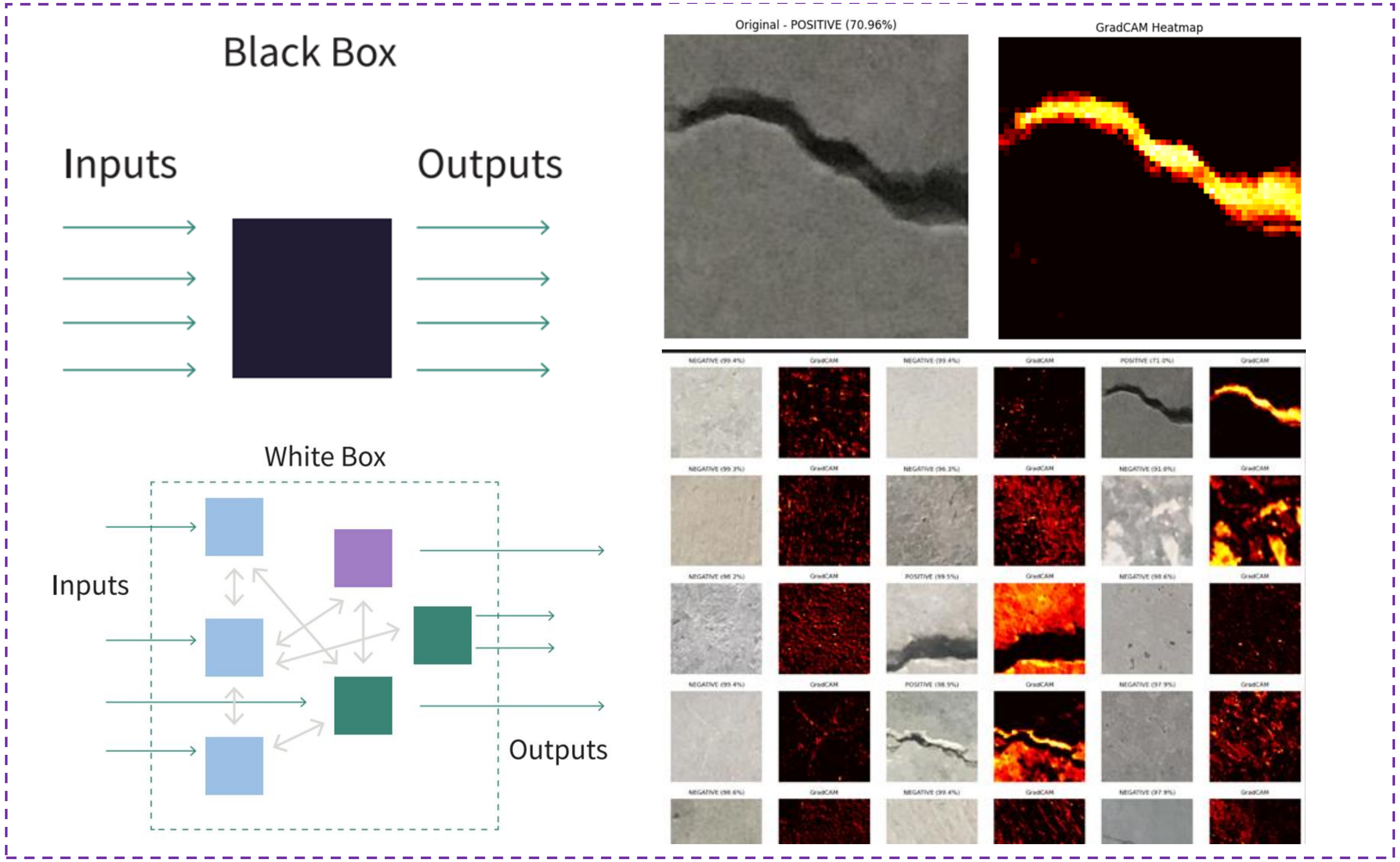




Beyer Road bridge, Saginaw, MI, Concrete Deck

EXPLAINABLE AI

Identifying critical features influencing AI decisions, by offering explainability metrics.



CHALLENGES

Environmental & Site Conditions

- Weather dependency (wind, rain, lighting)
- Obstructions affecting line-of-sight and flight stability
- Variability in ground features complicating automated recognition

Regulatory & Safety Constraints

- Airspace restrictions and FAA compliance
- Safety risks in active construction zones
- Need for certified pilots and trained personnel

Data A

- Inconsistent i
- Difficulties ali with CAD/BIM
- Noise in poin

solution
S data

Integration with BIM Workflows

- Limited interoperability with Civil 3D, MicroStation, or Revit
- Challenges mapping UAS data to as-designed parameters
- Time-consuming manual steps in creating usable BIM inputs

Operational Limitations

- Battery life and flight duration constraints
- Need for frequent calibration and maintenance
- Difficulty scaling for large or complex job sites

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CONCLUSION

- UAS technologies provide efficient, high-resolution data for construction inspection, quality control, and progress monitoring.
- Integration with BIM platforms enables as-built visualization and supports data-driven decision-making throughout the project lifecycle.
- Applications such as thermal segregation detection, automated bridge inspection, and explainable AI showcase the potential of intelligent inspection workflows.
- Challenges remain in areas like data accuracy, regulatory compliance, system integration, and workforce readiness, but ongoing research and field validation continue to bridge the gap.
- The future lies in scalable, explainable, and integrated AI-BIM solutions that enhance safety, productivity, and sustainability in civil infrastructure projects.

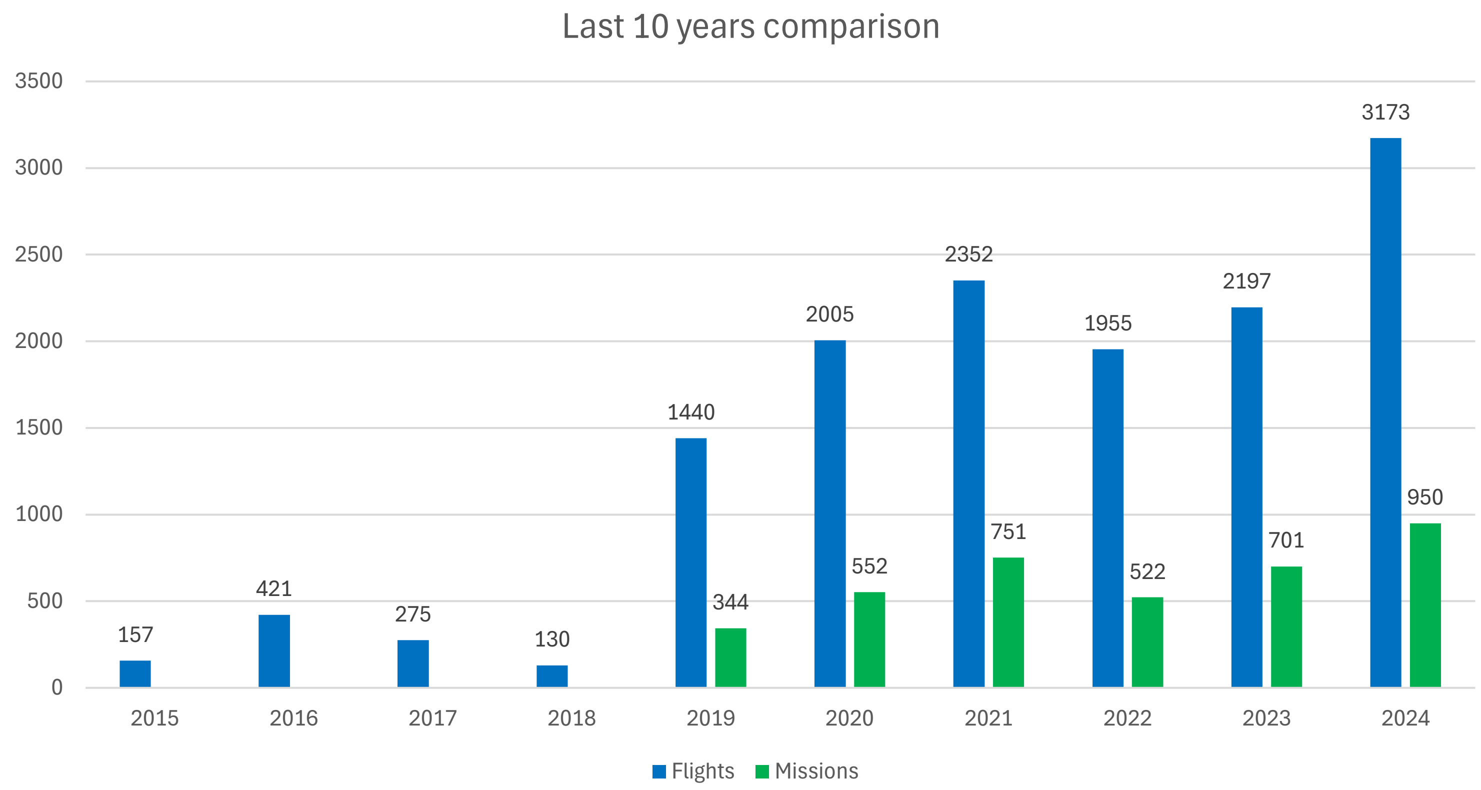
UAS Have Changed Ohio DOT Bridge Inspection

Ohio DriveOhio
UAS Center

Ohio UAS Center Report

Total Flights and Missions since 2015

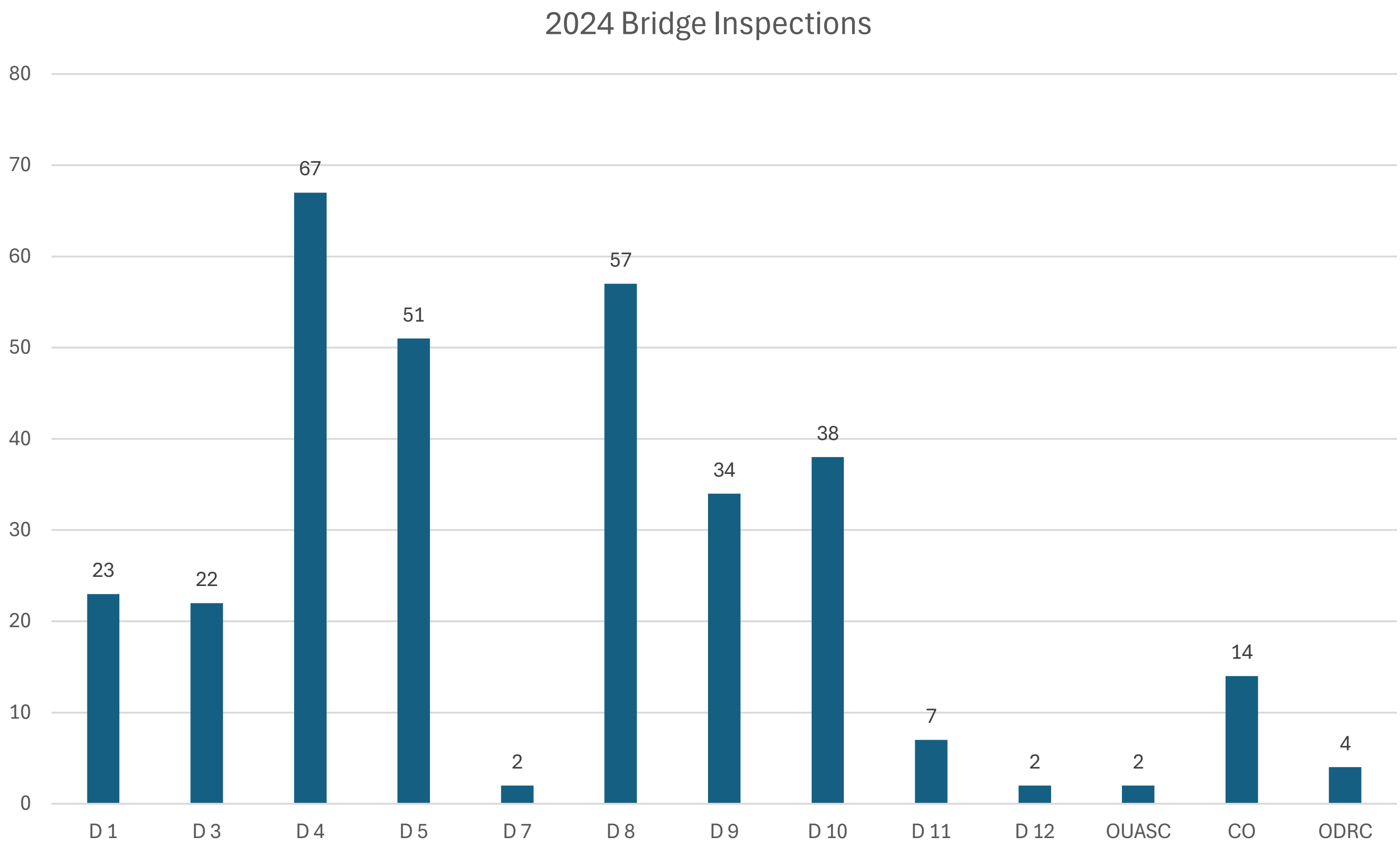
44 Pilots in 2024



#	Year	Flights	Missions
1	2015	157	
2	2016	421	
3	2017	275	
4	2018	130	
5	2019	1440	344
6	2020	2005	552
7	2021	2352	751
8	2022	1955	522
9	2023	2197	701
10	2024	3173	950
Total		**14105**	**3820**

UAS Center Report

Bridge Inspection Flights by Districts - 2024



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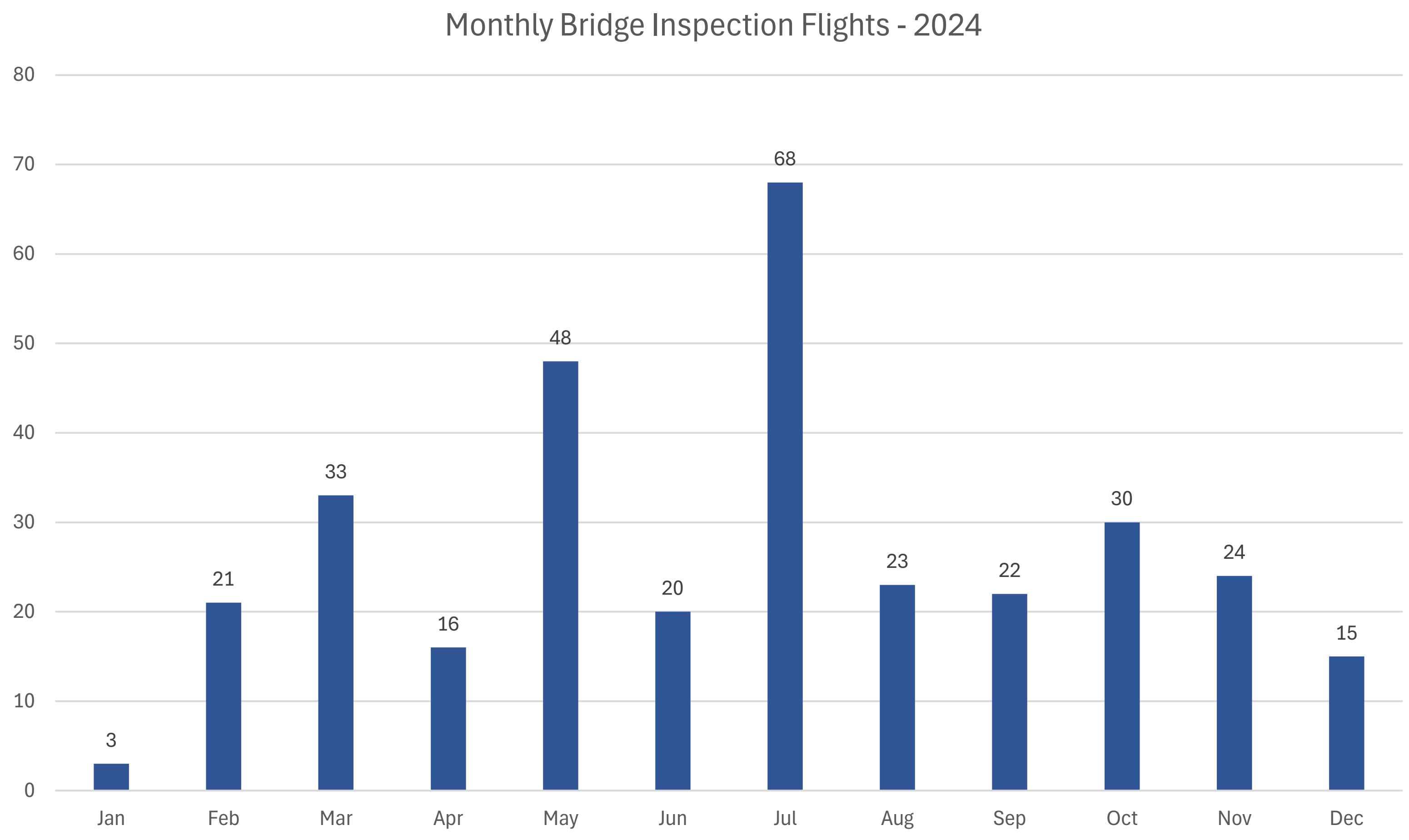
DriveOhio
UAS Center

Bridge Inspection Flights by Month - 2024



UAS Center Report

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UAS Center

Bridge Inspectors - 2024

	Pilot	# Flight	Total Miles
1	Adam Spong	40	21.02
2	Jeremy Patterson	39	11.00
3	Kevin Kennedy	38	11.94
4	Jenn Donley	36	17.24
5	Matt Stefanik	33	18.20
6	David Krazl	32	19.68
7	Jason Guth	21	15.37
8	Mike Butler	19	9.11
9	Stephanie Lentz	17	7.79
10	Andrew Hart	15	14.19
11	Craig Penix	7	1.50
12	Daniel Breda	7	3.57
13	Eric Debolt	7	1.93
14	Joshua Reel	5	2.73
15	Jamie Davis	4	1.94
16	Scott Mcclure	2	0.86
17	Brian Meade	1	2.10
	Grand Total	323	160.17

UAS Center Report

UASC Dashboard link - Microsoft Power BI

DriveOhio
UAS Center

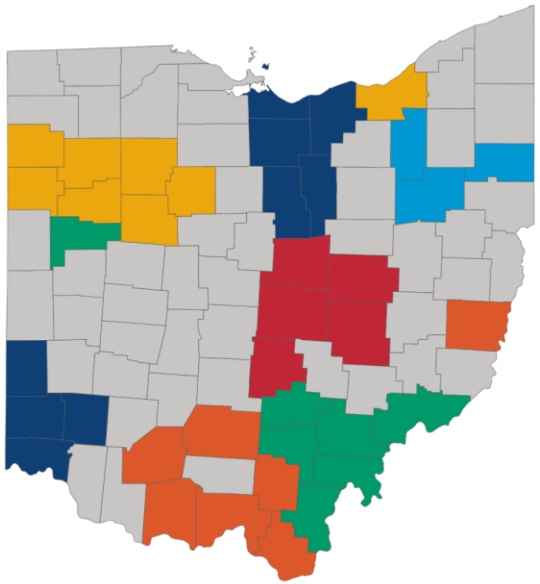
CURRENT FLIGHTS

HISTORICAL FLIGHTS

Current Flights - 2024

Number of Flights by ODOT District

District Name
- ODOT District 1
- ODOT District 2
- ODOT District 3
- ODOT District 4
- ODOT District 5
- ODOT District 6
- ODOT District 7
- ODOT District 8
- ODOT District 9
- ODOT District 10
- ODOT District 11
- ODOT District 12



Flight Type	# of Flights	% of Flights
Construction	485	15.0%
Bridge Inspection	323	10.0%
Public Information	408	12.7%
Training	929	28.8%
Survey Projects	171	5.3%
Testing	246	7.6%
Other	661	20.5%
Total	**3223**	**100.0%**

Aircraft Type	# of Flights	% of Flights
DJI	7	2.2%
Skydio	316	97.8%
Total	**323**	**100.0%**

Customer	# of Flights
ODOT District 1	24
ODOT District 2	
ODOT District 3	22
ODOT District 4	67
ODOT District 5	51
ODOT District 6	
ODOT District 7	2
ODOT District 8	53
ODOT District 9	38
ODOT District 10	39
ODOT District 11	7
ODOT District 12	2
Central Office	16
Ohio UAS Center	2
Total	**323**

160 mi
Total Distance

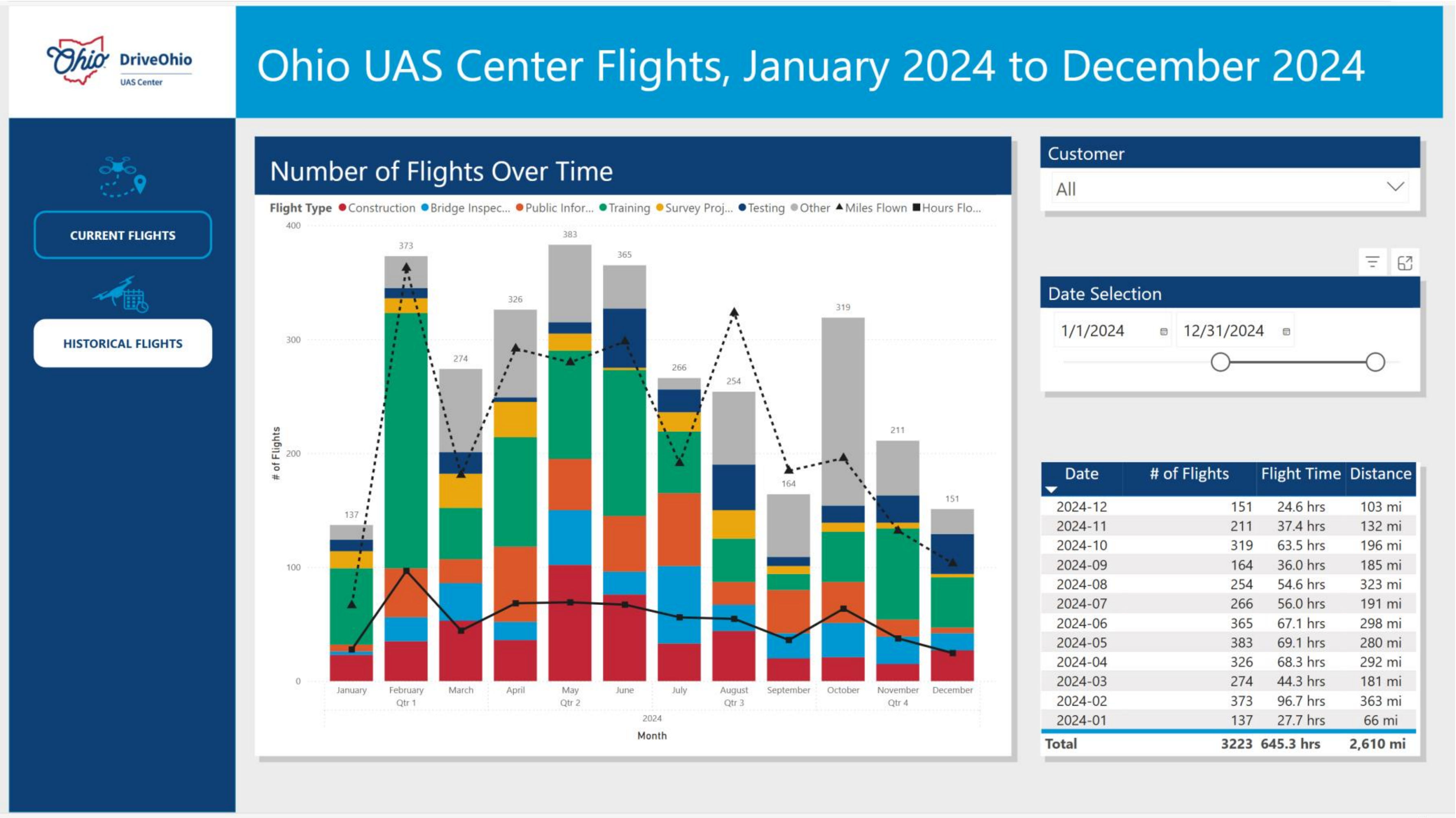
71.3 hrs
Total Time

Date Selection
- 2023
- 2024
- 2025

UAS Center Report

DriveOhio
UAS Center

UASC Dashboard link - [Microsoft Power BI]



Bridge Inspections - ROI Calculations

Snooper Inspections

LABOR

6 Employees

48 Total Labor Hours

$2,018 Total Payroll

EQUIPMENT

$625 for Snooper

$500 for Other

$1,125 for Total Cost

$3,143

($4,182 nights/weekends)

Drone Inspections

LABOR

2 Employees

8 Total Labor Hours

$427 Total Payroll

EQUIPMENT

$45 for Drone

$50 for Pickup

$95 for Total Cost

$522

($735 nights/weekends)

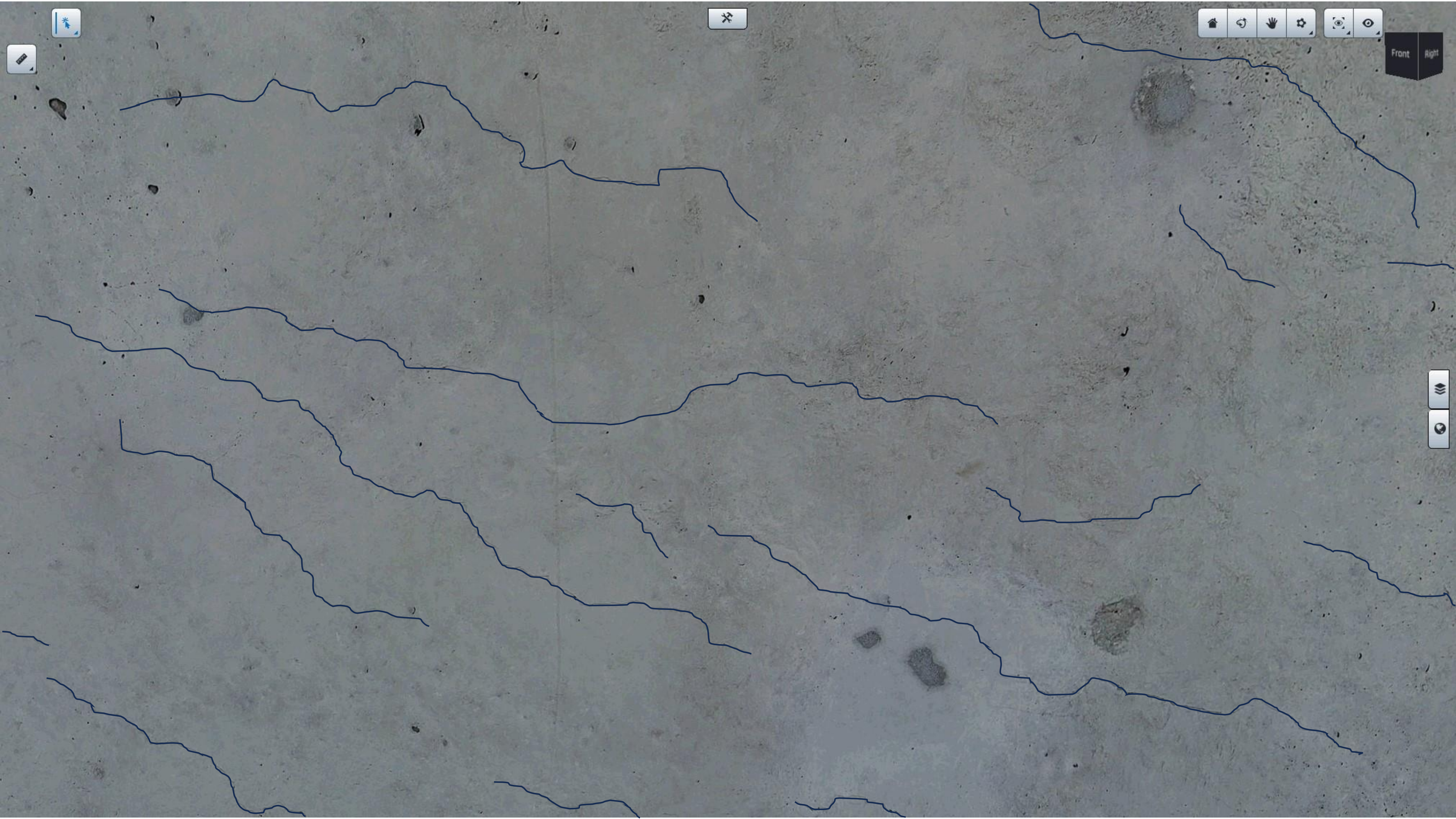
$2,621 in Savings

($3,417 nights/weekends)

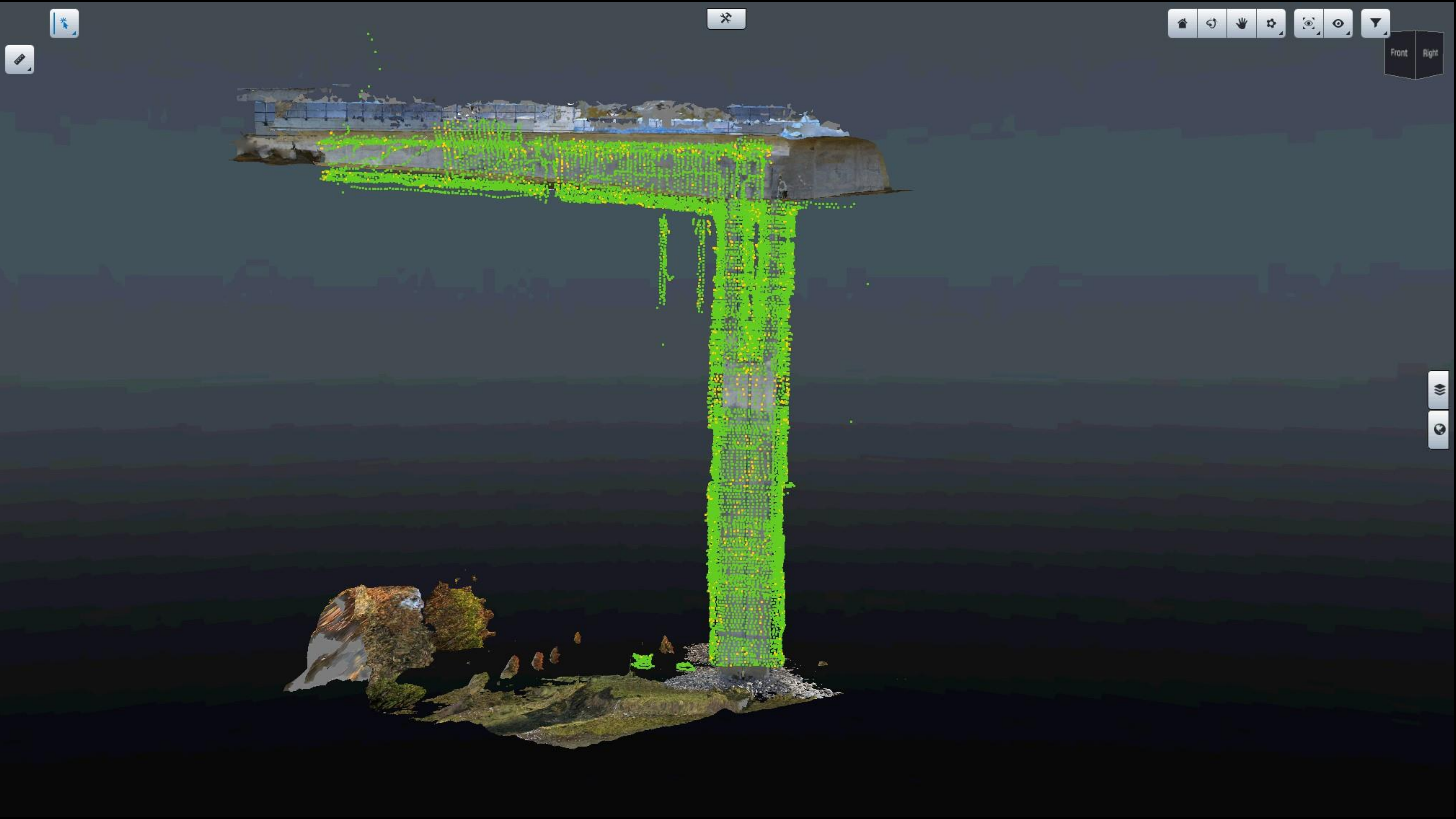
UAS
OHIO UNMANNED AIRCRAFT SYSTEMS
CENTER

The JMB Problem

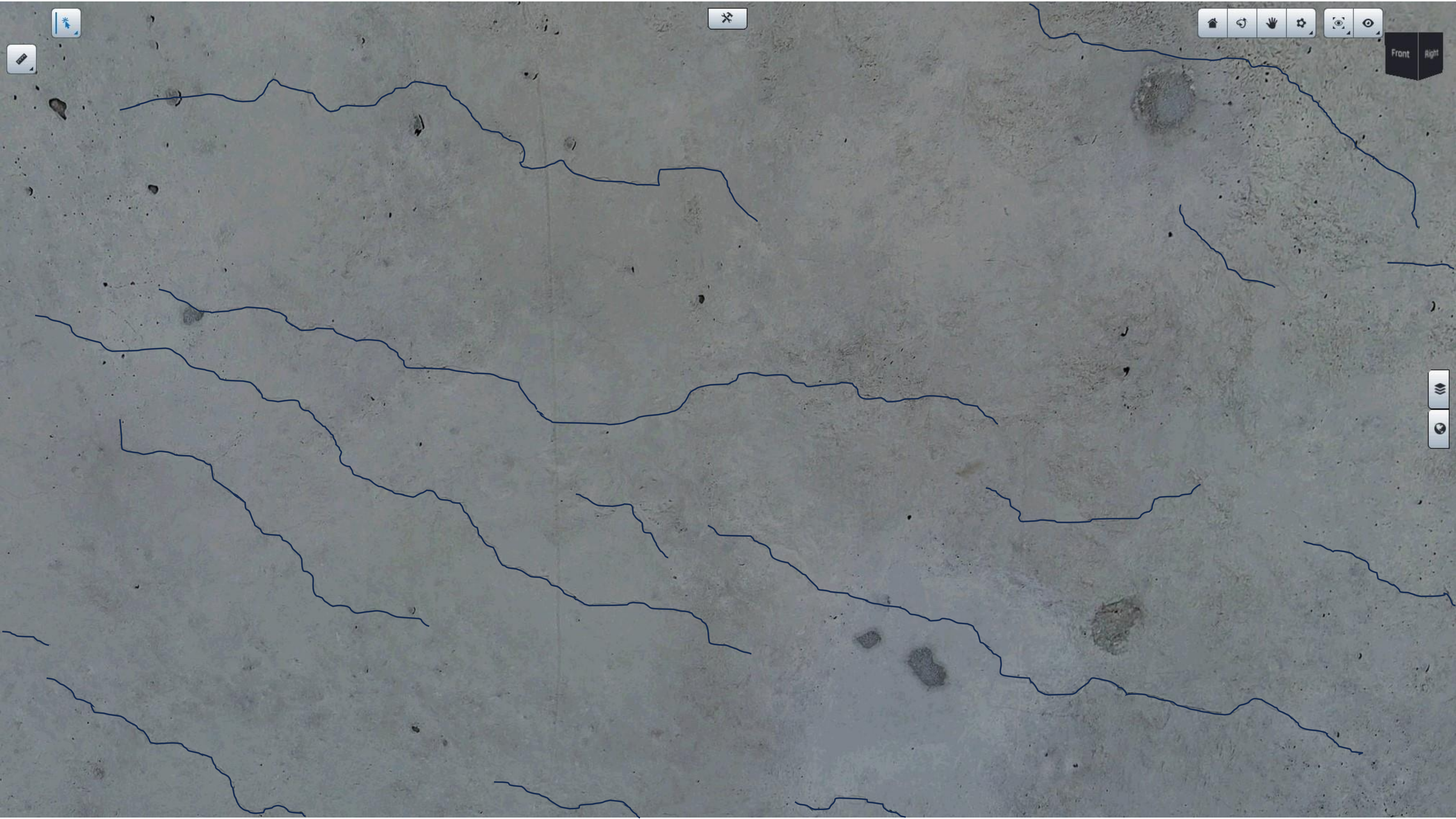

2,252 ft
239 ft
2016
Altitude: 348m


Front
Right

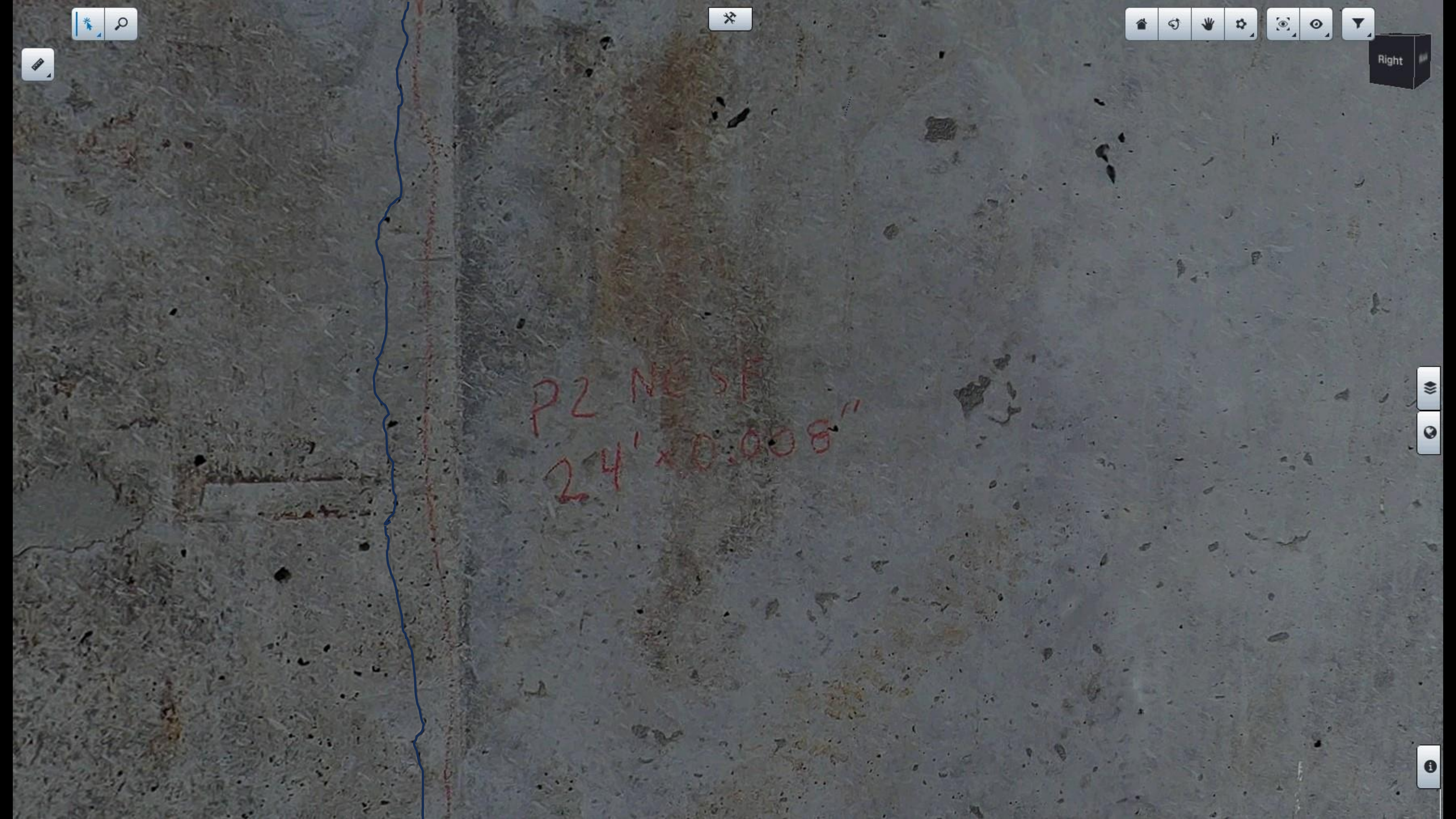
Front
0.015"W


Front
Right

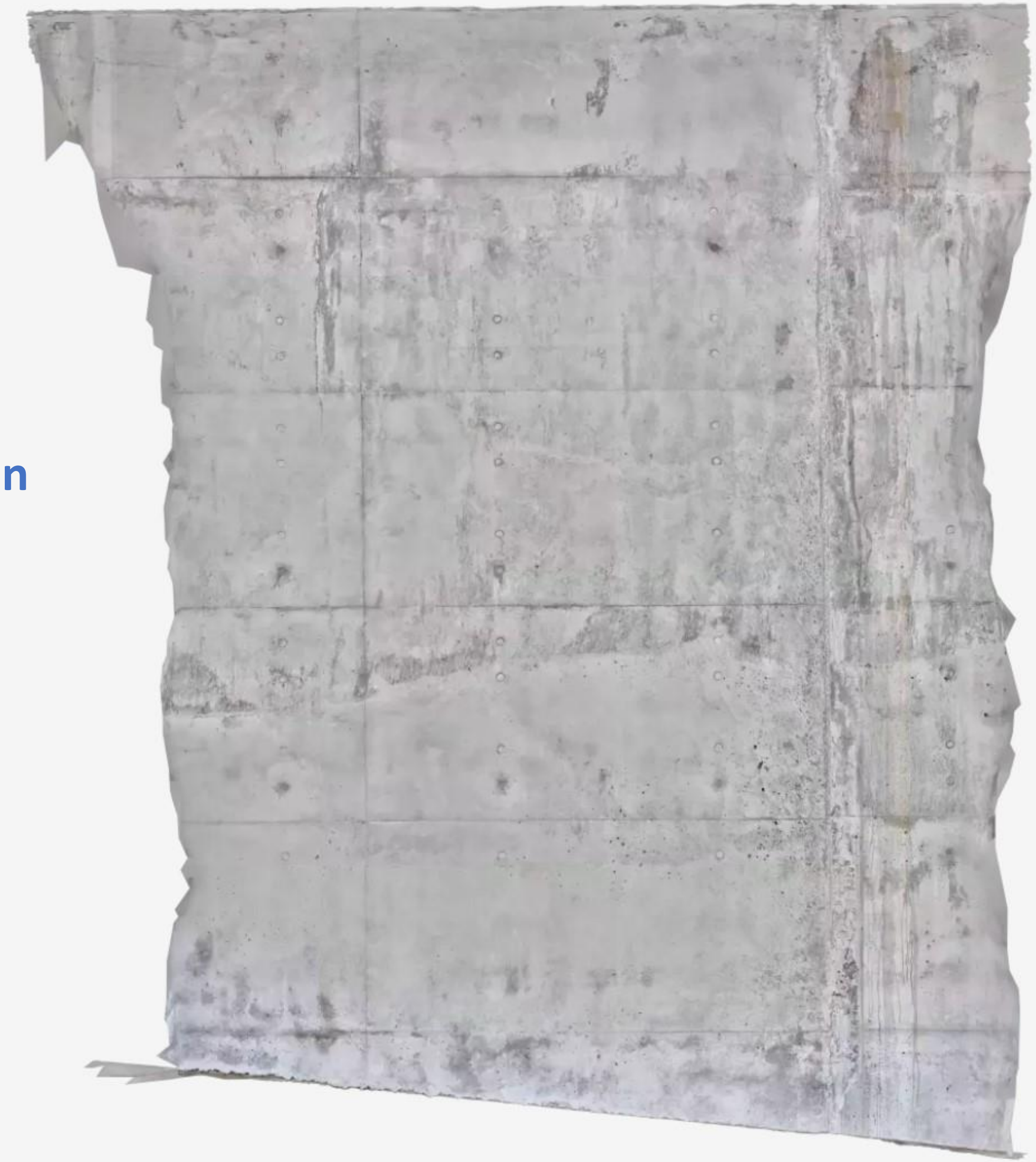

Front
Right


Front
Right


X
0.015" W


Right
P2 NE SF
24' x 0.008"

gNext
AI Crack Detection
Demo



gNext
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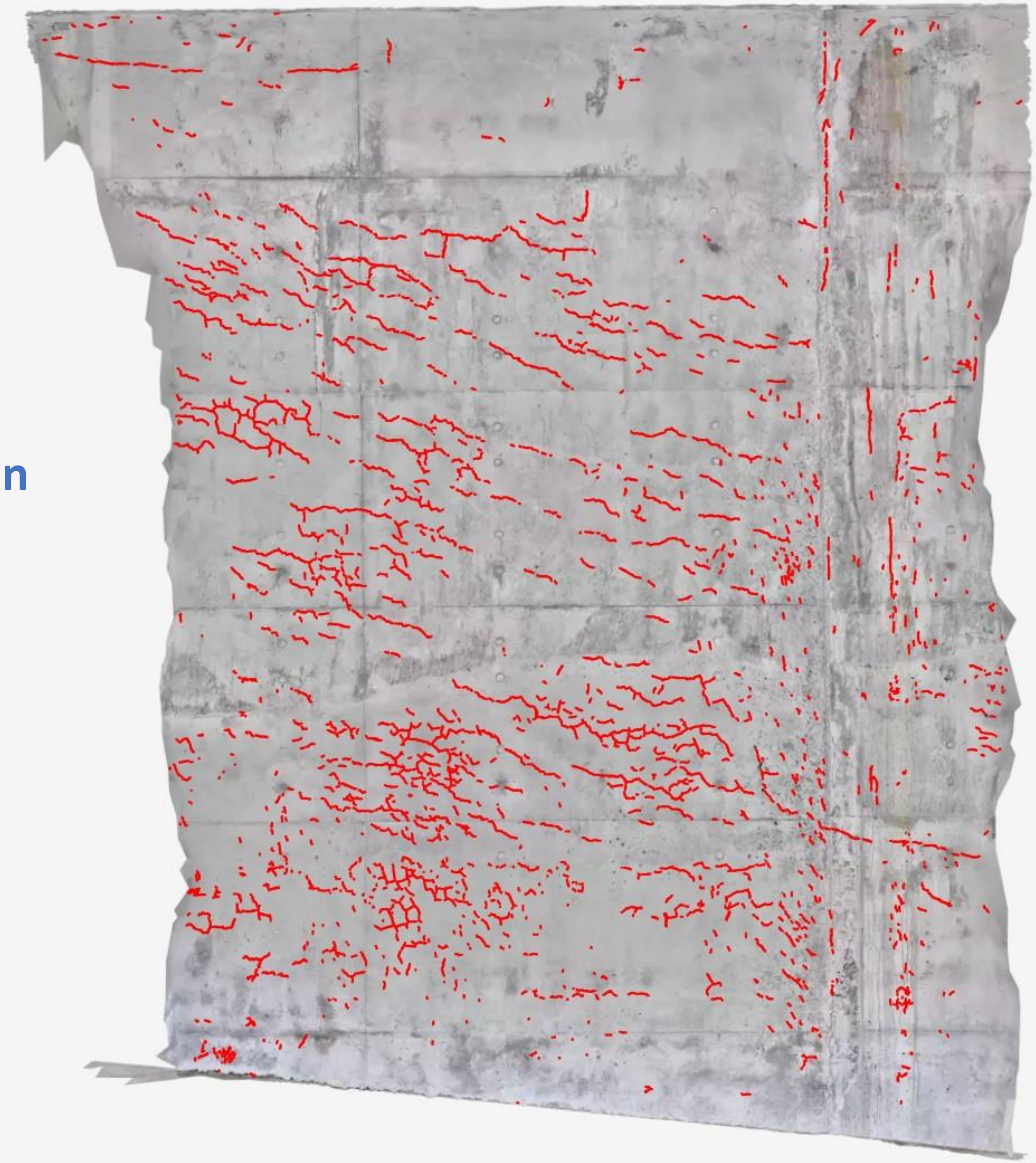

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Thank You

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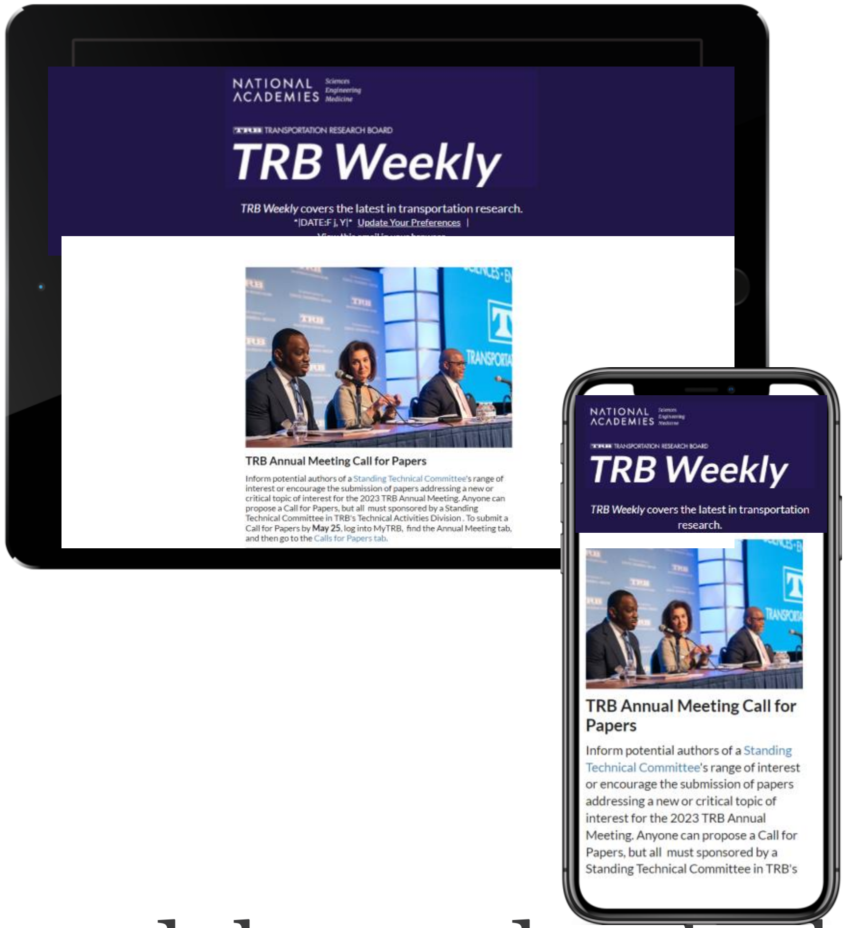

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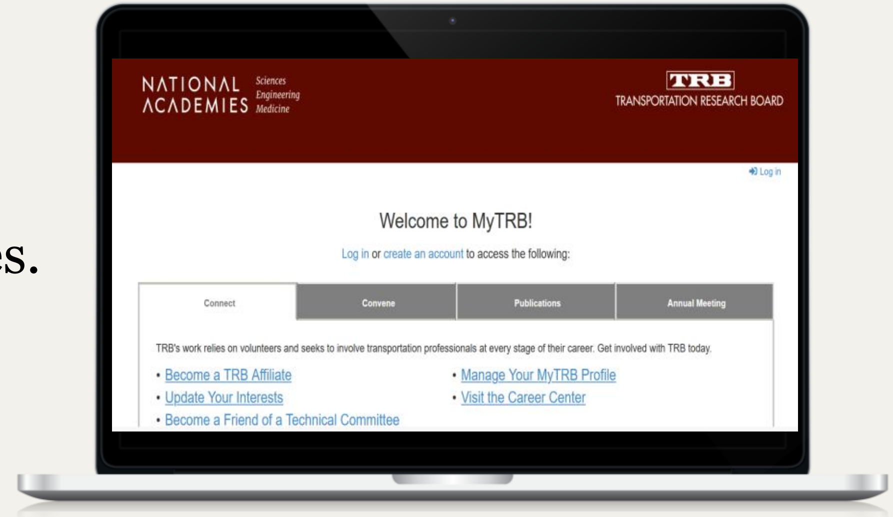

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