INNOVATIVE INFRASTRUCTURE INSPECTION: USING THERMAL IMAGERY TO DETECT BRIDGE DELAMINATION

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NV5

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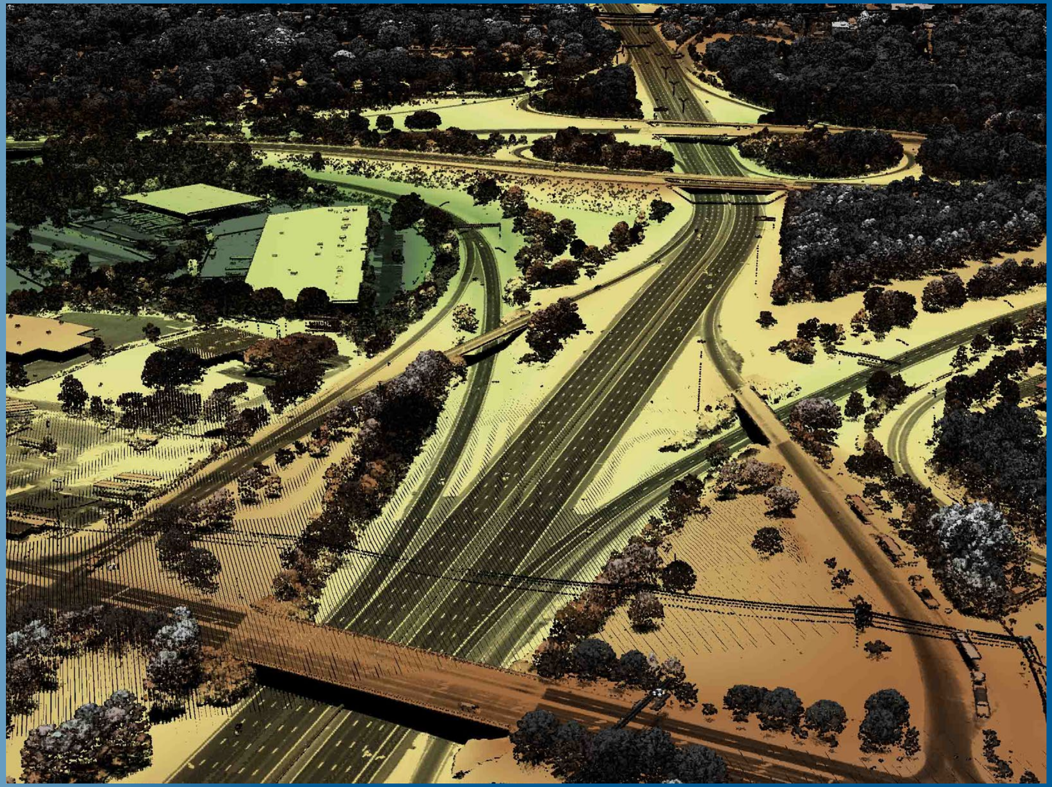
WHO IS NV5?

- Provider of technology, conformity assessment, and consulting solutions for public and private sector clients supporting infrastructure, utility, and building assets and systems
- 3,500 staff in over 100 offices worldwide
- Incorporated in 2010
- Six Business Verticals:
  – Construction Quality Assurance
  – Infrastructure Engineering
  – Utility Services
  – Environmental Health Sciences
  – Buildings & Technology
  – Geospatial

WHY NV5?

- The ability to provide a large menu of services — from geospatial, geotechnical, environmental, and pavement to survey, landscape architecture, aviation, and transportation design.
- We can offer our clients in the Pacific Northwest combined resources and expertise from our local legacy companies (GeoDesign, WHPacific, PES Environmental, and Quantum Spatial).



PACIFIC NORTHWEST CAPABILITIES

- Environmental Site Assessments & Remediation
- Geospatial
- Geotechnical Engineering
- Industrial Hygiene
- Landscape Architecture
- Pavement Engineering
- Site Development Planning & Design
- Structural Engineering (Bridges)
- Survey & Mapping
- Transportation Engineering

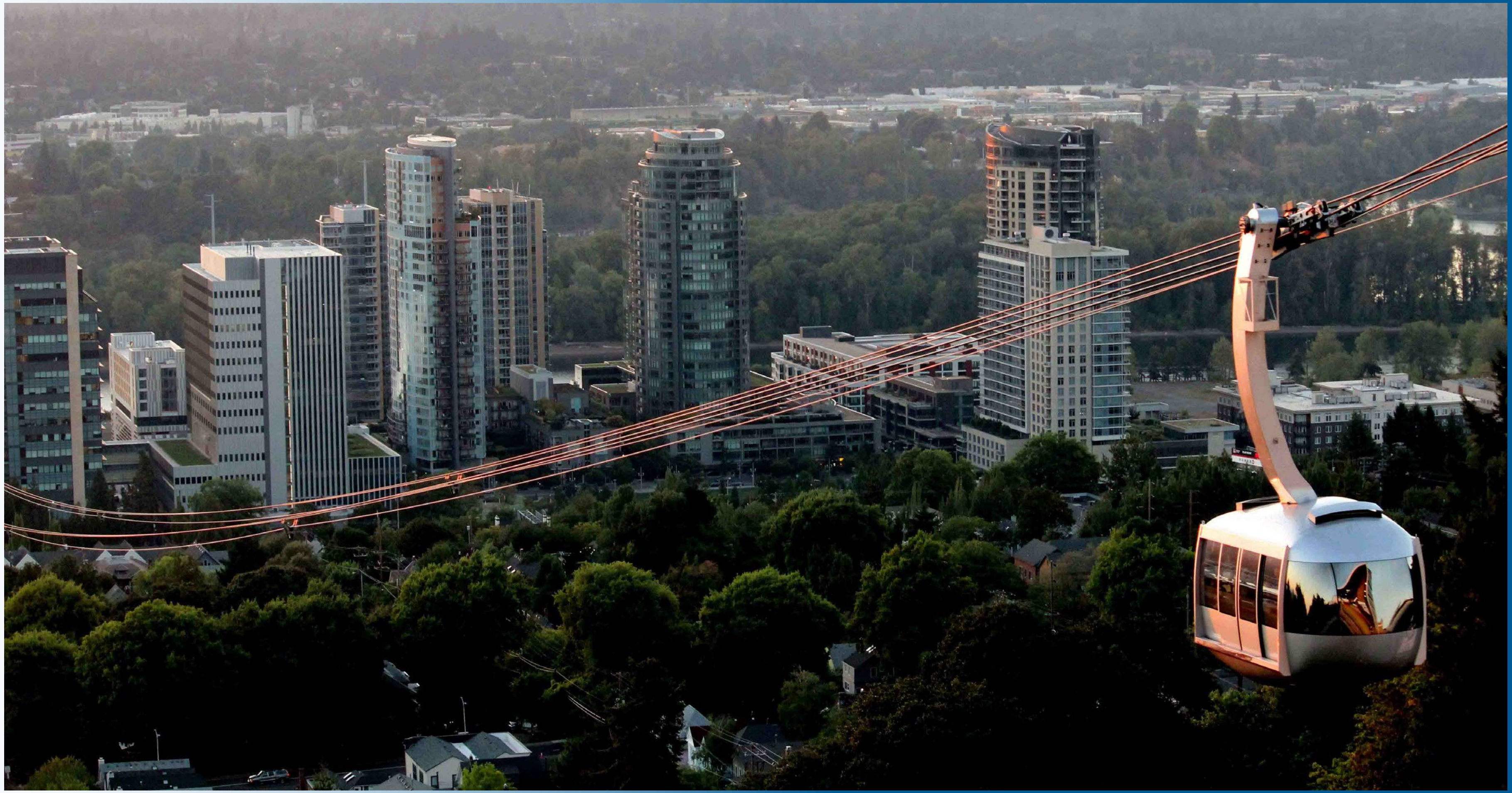
PAVEMENT ENGINEERING

Pavement engineering for roadways, airfields, industrial yards, and parking lots. Services include:

- Flexible, rigid, and composite pavement design
- Pavement evaluation
- Pavement condition assessment
- Materials characterization
- Maintenance and rehabilitation studies
- Non-destructive testing:
  - Falling Weight Deflectometer (FWD) testing
  - Ground Penetrating Radar (GPR) testing
  - Dynamic Cone Penetrometer (DCP) testing

PACIFIC NORTHWEST LOCATIONS

- **OREGON**
  - Portland
  - Wilsonville
  - Corvallis
  - Bend
- **WASHINGTON**
  - Vancouver
  - Tacoma
  - Seattle
  - Tri-Cities



NV5 GEOSPATIAL

- Fleet of Fixed Wing Aircraft
- Unmanned Aerial Solutions (UAS)
- Mobile lidar
- Terrestrial and Topobathymetric Lidar
- Multispectral Imagery
- Hyperspectral and Thermal Imagery
- Production Centers of Excellence Across the Country
- Enterprise GIS (eGIS)

TRANSPORTATION EXPERIENCE

80+ YEARS
ALL 50 STATES
25 STATES MSA COVERAGE

STAFF OF 600+ PROFESSIONALS

14 PROFESSIONAL LAND SURVEYORS
13 CERTIFIED PHOTOGRAMMETRISTS
13 PROJECT MANAGEMENT PROFESSIONALS

Problem Statement

Summary

The Wisconsin Department of Transportation approached us to plan for and test **an alternative airborne approach to ground-based infrared thermography for bridge decks.** We advised on the recent improvement of thermal sensors and were able to test options and recommend approaches that would provide high-resolution thermal imagery, is safe and has no impact on traffic.

We worked closely with our acquisition team, who recommended aerial platforms, flying heights, airspeeds, and considered weather restrictions. We had many meetings with our team and the DOT to openly discuss the challenges and opportunities with this approach.

Other nondestructive remote sensing techniques: impact echo, ultrasonic surface wave, ground penetrating radar, image-based techniques, and infrared technology. All have advantages and disadvantages.

NEXCO-West's mobile survey setup

FLIR A6701sc camera used to create infrared delamination maps

Solution

Fixed wing, low-altitude flights

- 1,000 ft above mean terrain (AMT)
- 110 knots nominal airspeed (186 fps)
- Nominal resolution TIR & RGB = 7 cm (2.5 in)

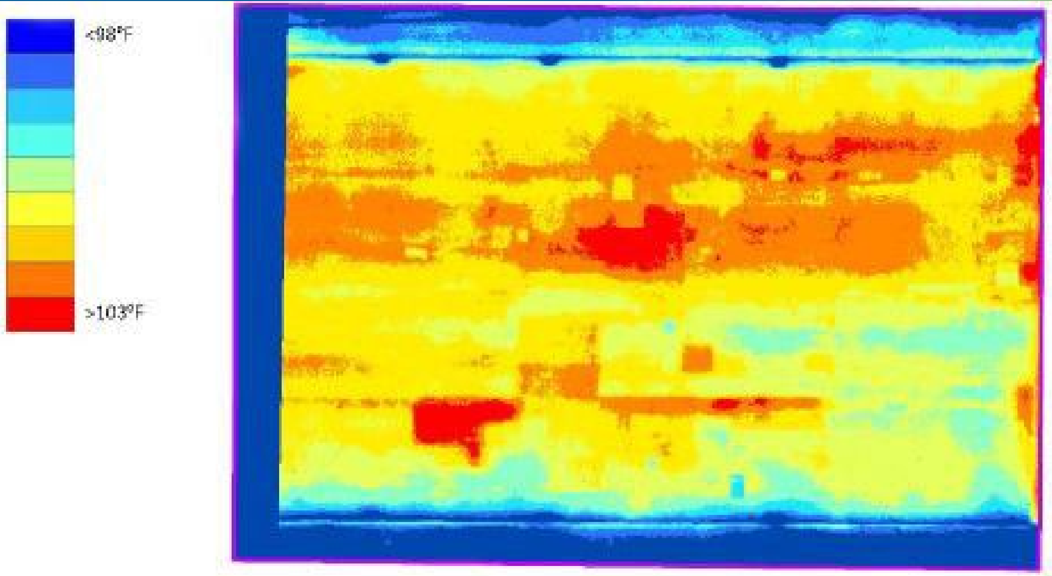
TIR Sensor footprint (FLIR X8500sc)

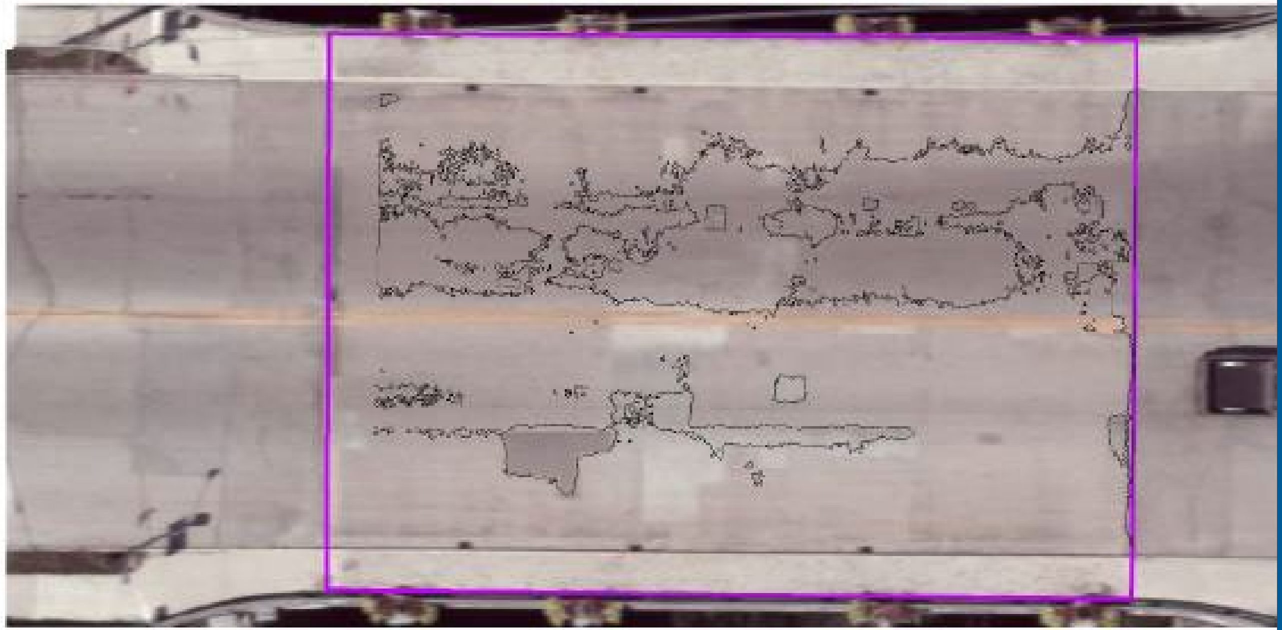
- 1280 x 1024 pixels
- 100 mm focal length (lens)
- 147 ft cross track x 118 ft along track
- Rapid frame capture > 10 Hz

True color camera (RGB)

- Similar to TIR or better resolution
- Validation

Thermal Conduction





What are we trying to find and why thermal imagery?

- Delamination is a result of the concrete deteriorating due to the rusting of the steel infrastructure within the bridge deck.

- When the efficient heat conduction is interrupted, the surface temperatures will be greater, and can be detected in high resolution thermal infrared imagery.

- The ‘hot spots’ on the surface are where delamination is occurring.

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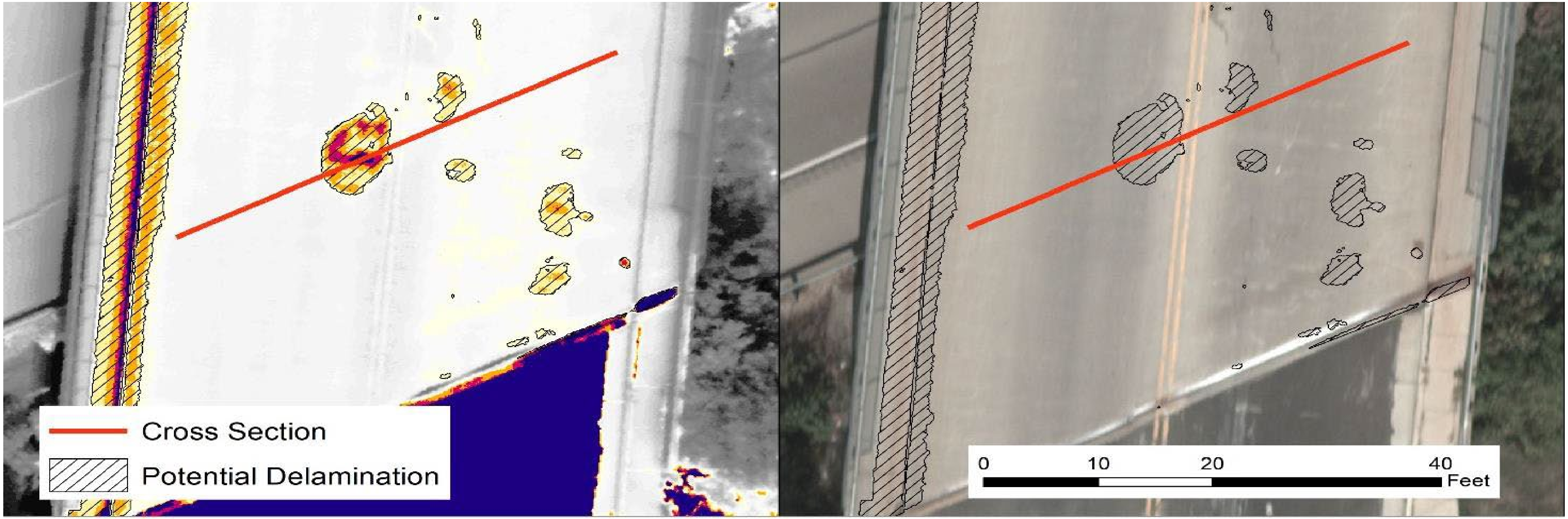
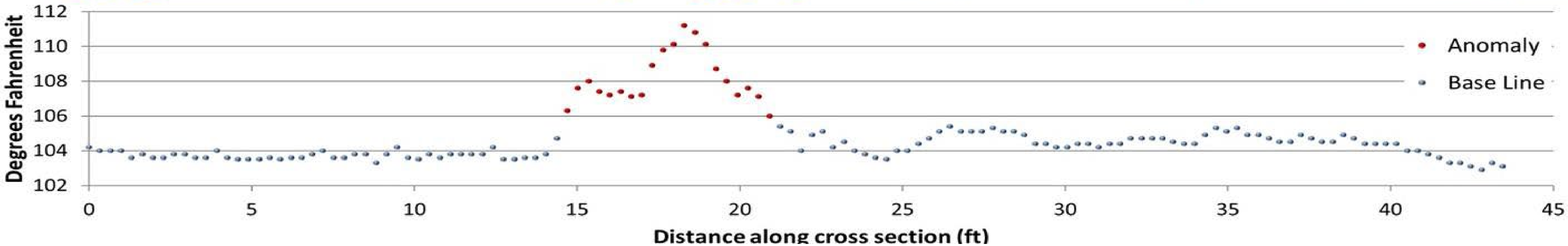
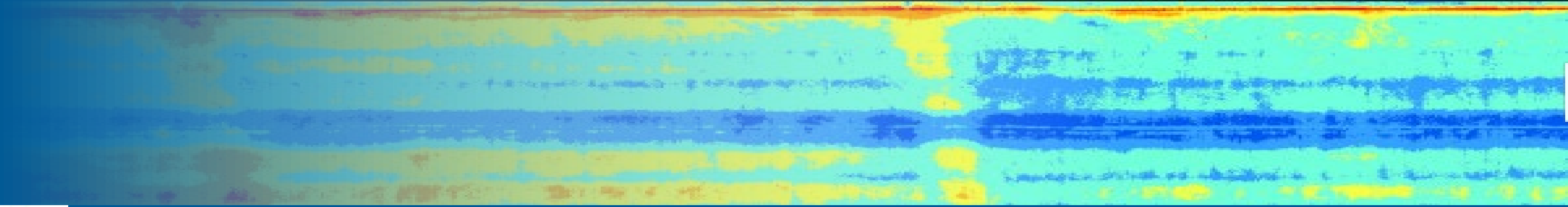
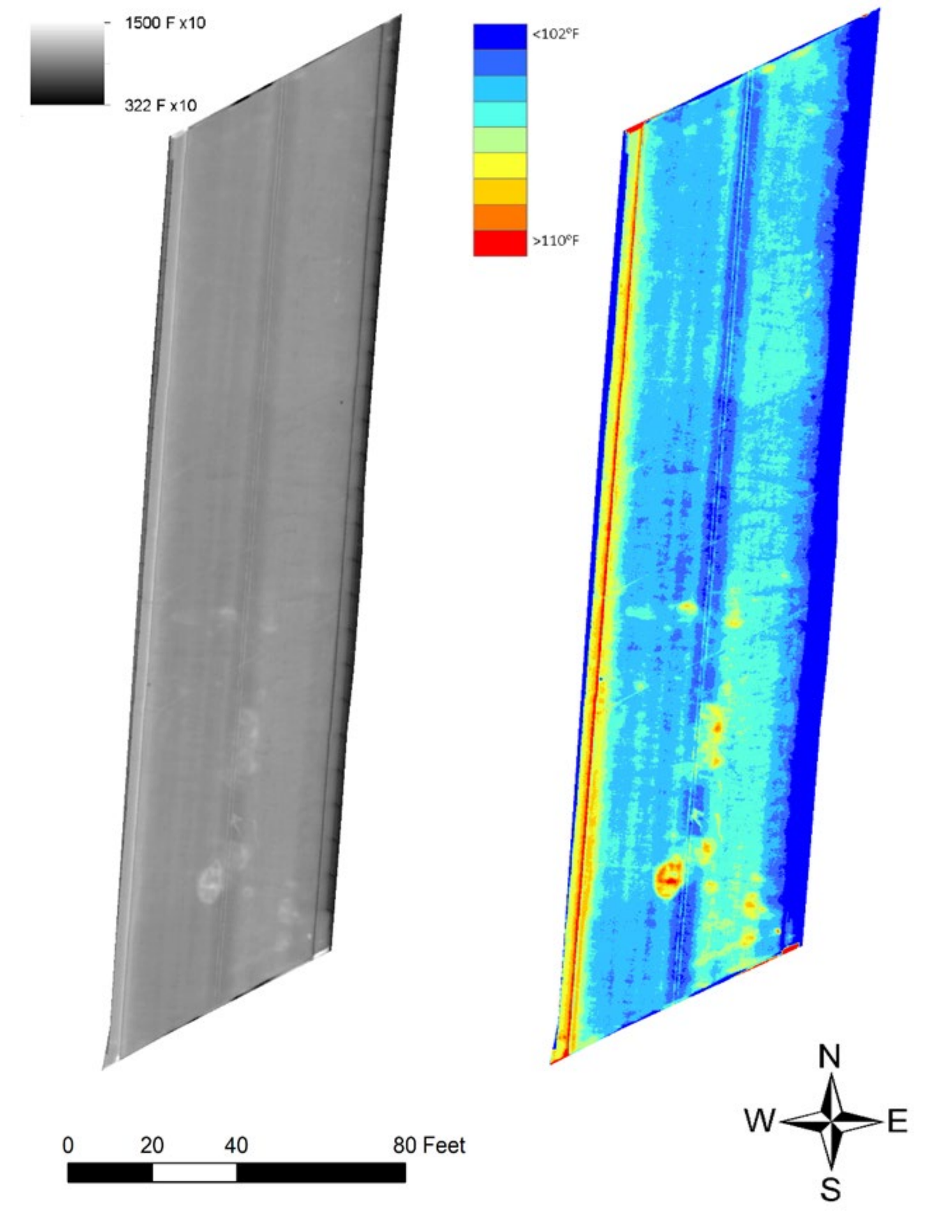
Temperatures on the Surface





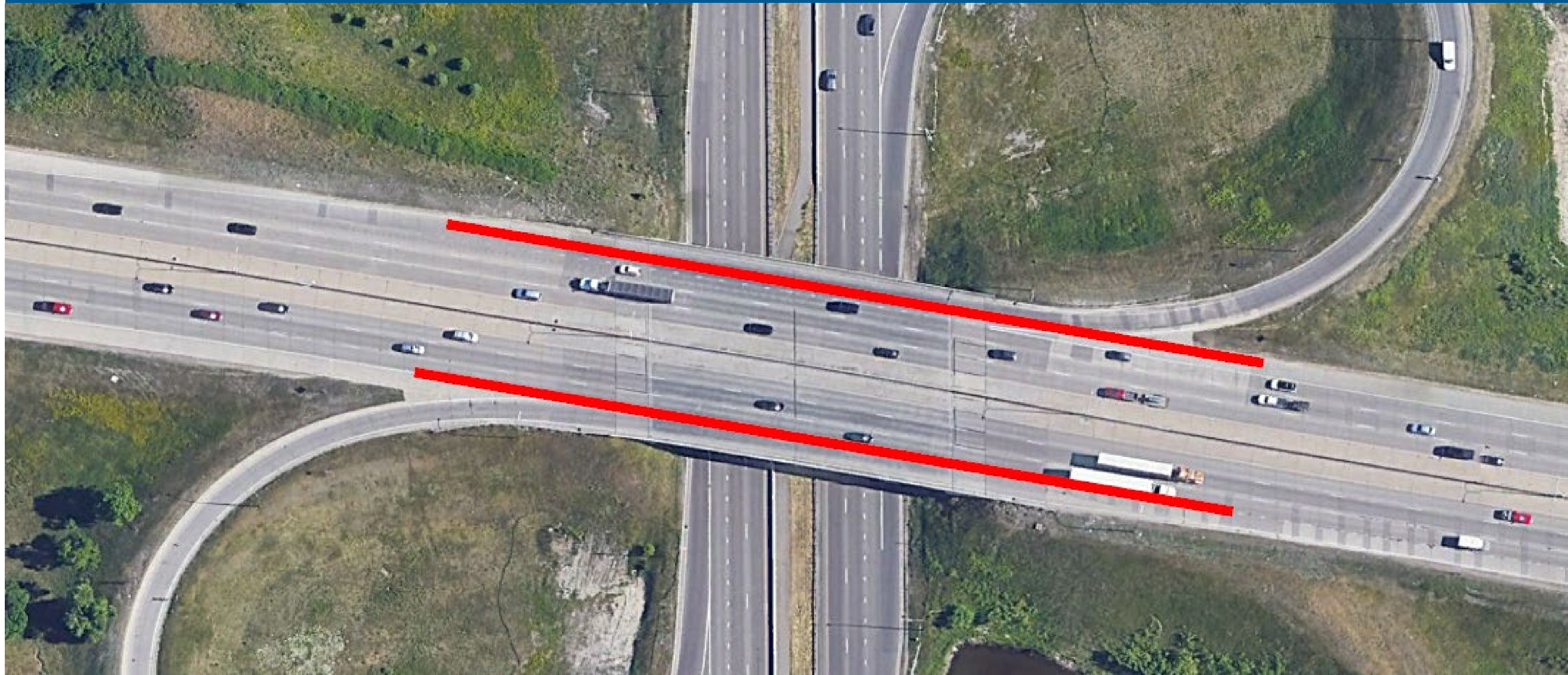


Versatility



Why put the sensor on an aircraft?

- Can be done on any size bridge regardless of length or number of lanes
- Image resolution uniformity across the dataset
- Potential to survey 15-20 bridges per hour



Alternate Airborne Approach

Fixed wing, low-altitude flights

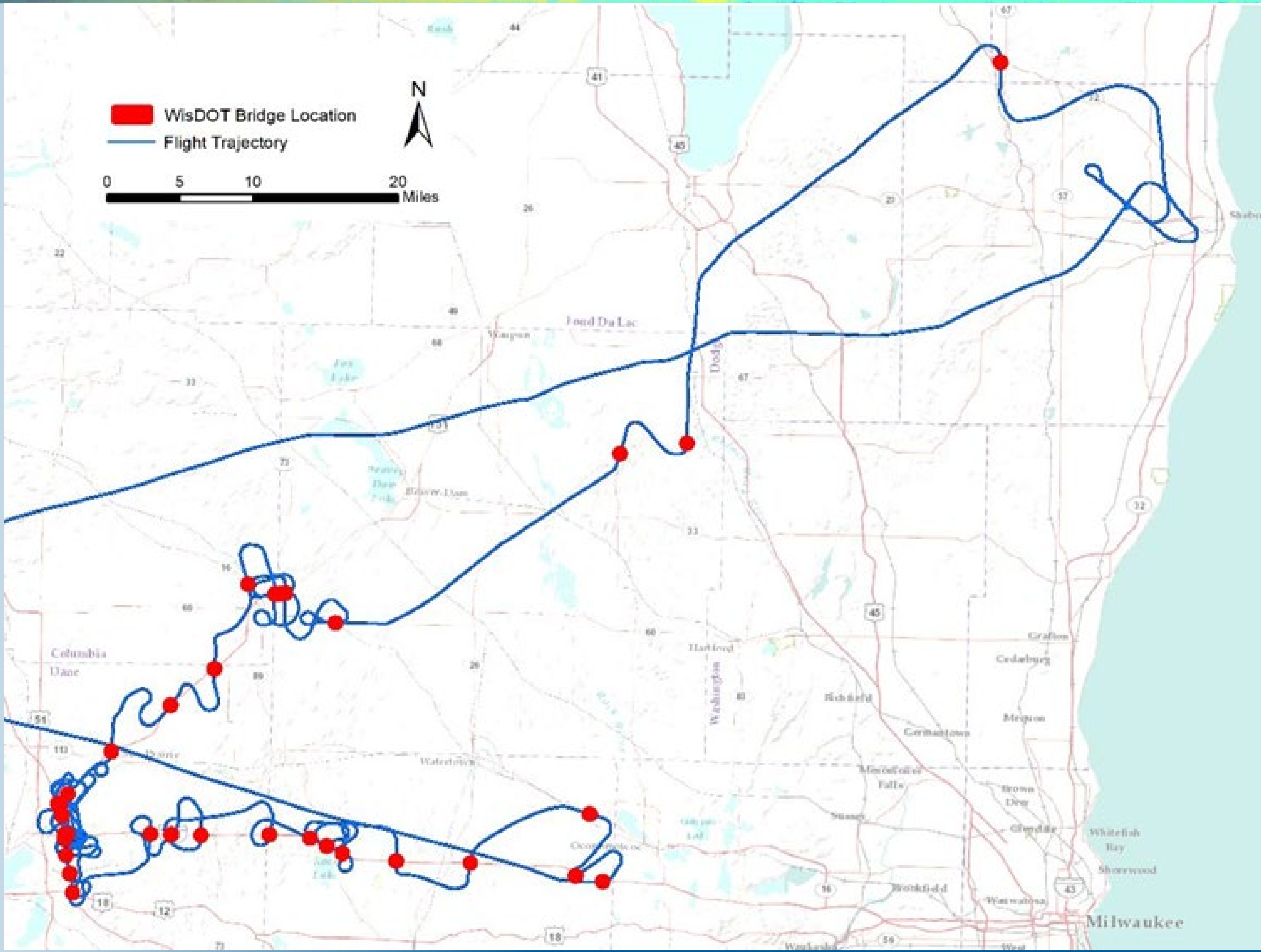
- 1,000' above ground level (AGL)
- 110 knots nominal airspeed (186 fps)
- Pixel resolution TIR & True Color (RGB) = 7 cm (2.5 in)

Color & TIR Sensor footprint – similar

- 147' cross track x 118' along track
- Width allows single line capture

Rapid frame capture

- Allows removal of most traffic



Reporting - Summary Table

Table 5: Summary of delamination inspection

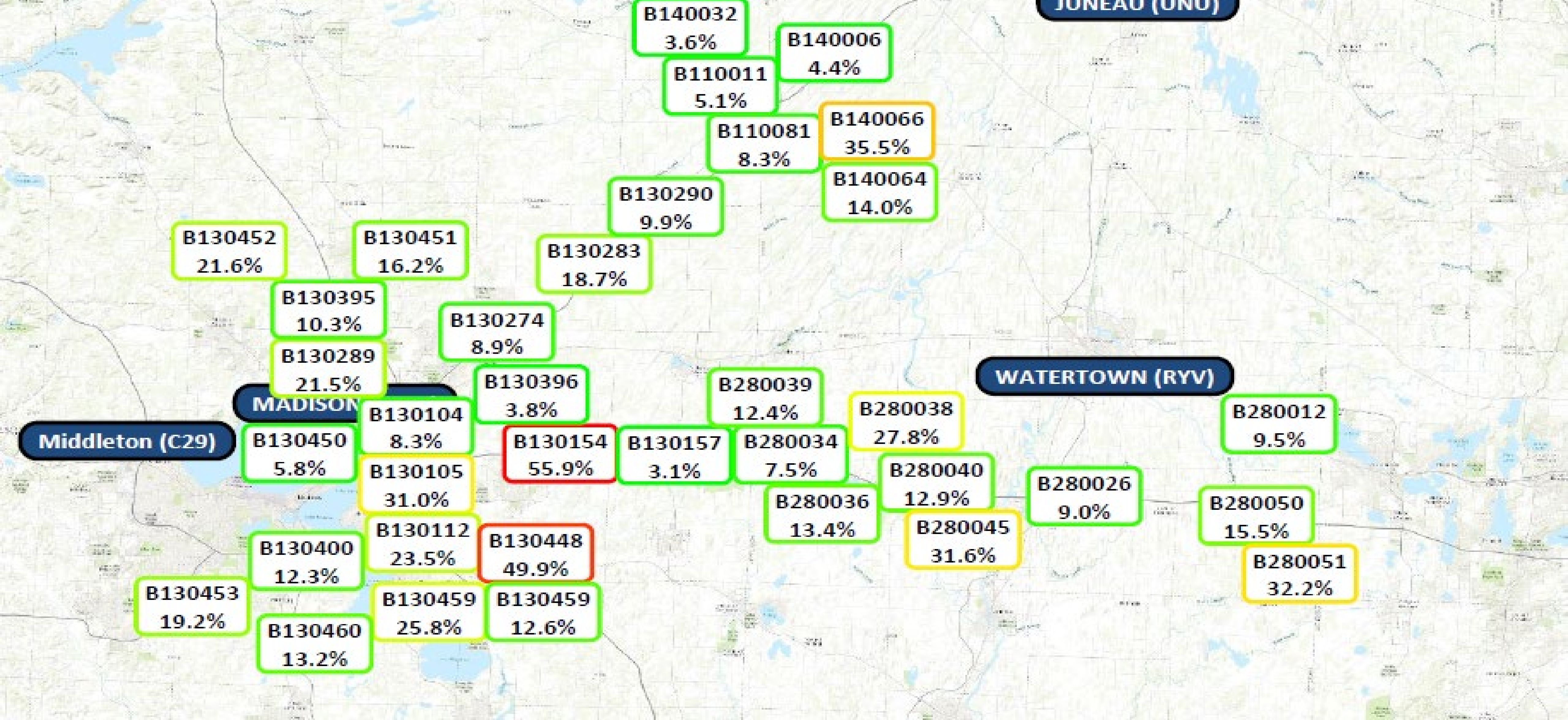
Bridge Name	Bridge Deck Area (sq ft)	Delamination Area (sq ft)	Delamination Ratio (%)
B110011	1918.0	98.5	5.1
B110081	9112.1	754.5	8.3
B130104	10371.4	857.3	8.3
B130105	9754.8	3022.9	31.0
B130112	8520.8	2003.3	23.5
B130154	1101.8	615.7	55.9
B130156	6386.8	621.3	9.7
B130157	5476.2	171.7	3.1
B130274	11253.7	999.4	8.9
B130283	8455.4	1579.5	18.7
B130289	14989.1	3218.8	21.5

Unique Benefits:

- Delamination area is calculated at any specified threshold and in relation to bridge deck total area
- Identified delamination areas are spatially referenced
- Measure change over time

High-Level View and Prioritization

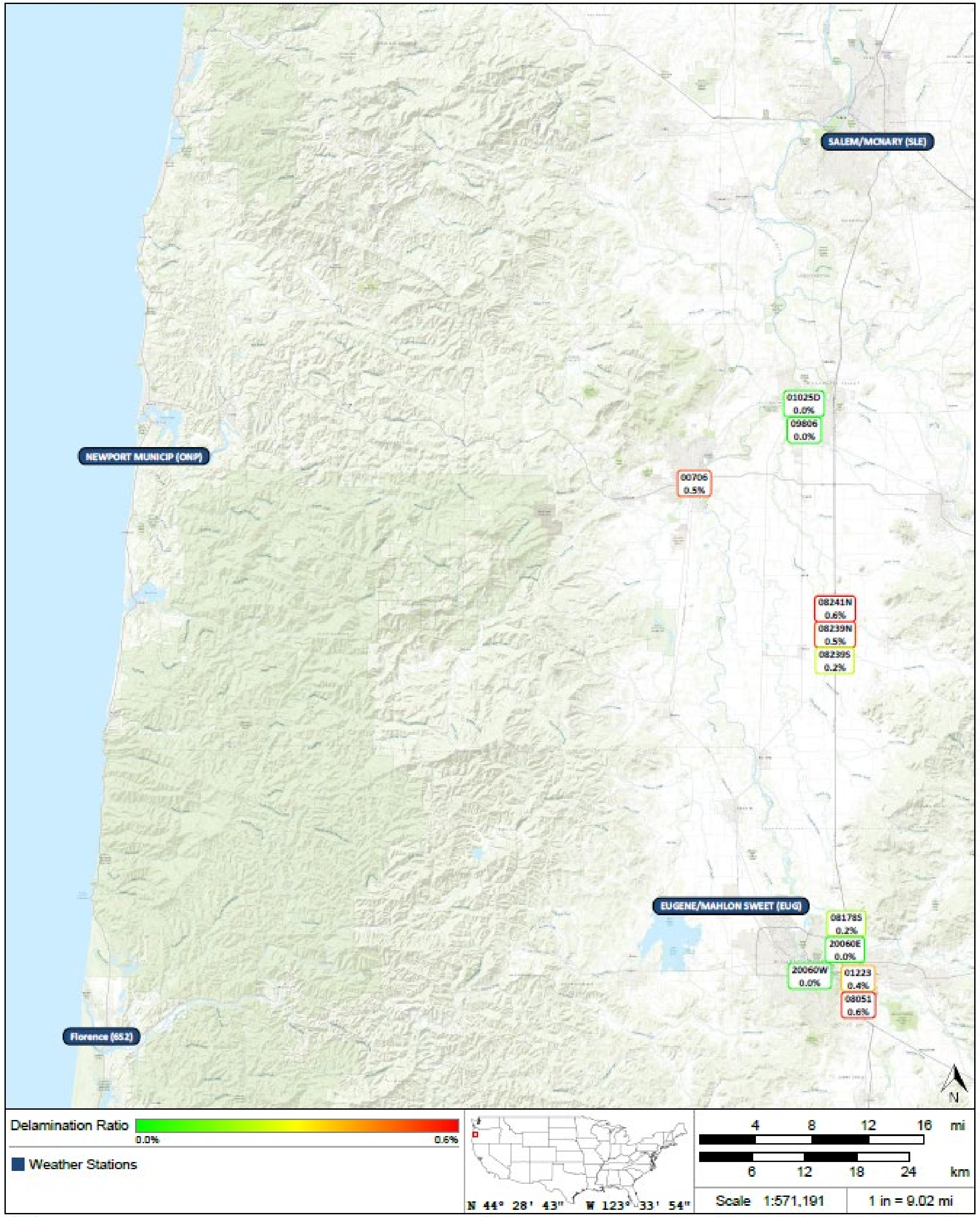
As part of a larger program this has proven to be a low-cost solution to identifying and prioritizing bridge deck maintenance.



Oregon Pilot

- 11 Bridges
- Eugene, Corvallis, Albany, Salem
- One hour of flight time
- Coordination with FAA & National Parks
- Thermal Imagery team based in Corvallis, OR
- Bridge Design & Construction based in Wilsonville, OR

ODOT 2022 Pilot Bridge Deck Condition Evaluation Overview Map



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Reporting - Summary Table

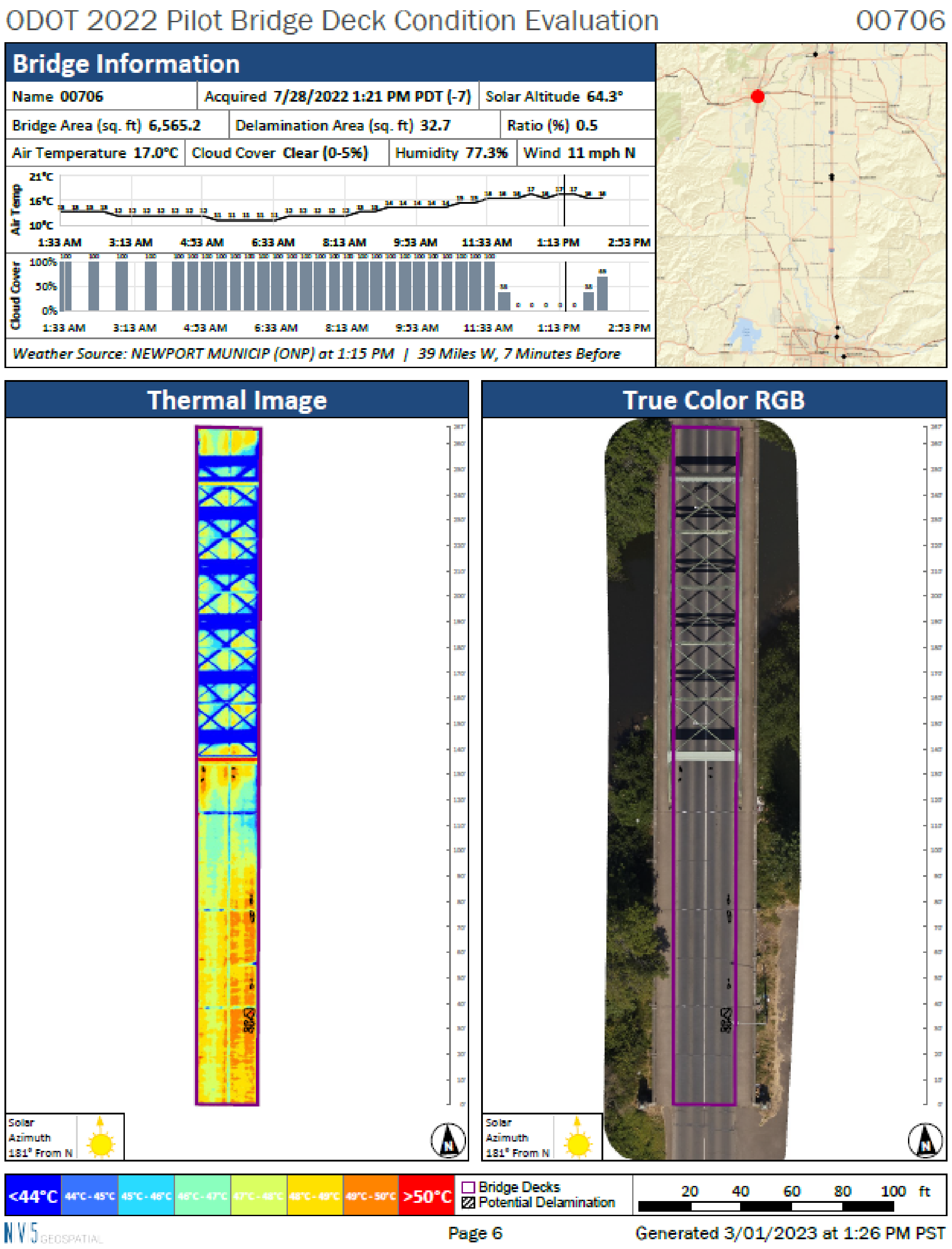
Lessons learned from ODOT pilot of 11 bridges:

(1) Oregon bridges are sparse and scattered all over the state.

(2) Test was successful. Thermal data agreed with current maintenance reports.

(3) Fixed wing approach best for bridges with no occlusion.

(4) Sensor can get higher resolution even in mountainous areas.



THANK YOU!

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