



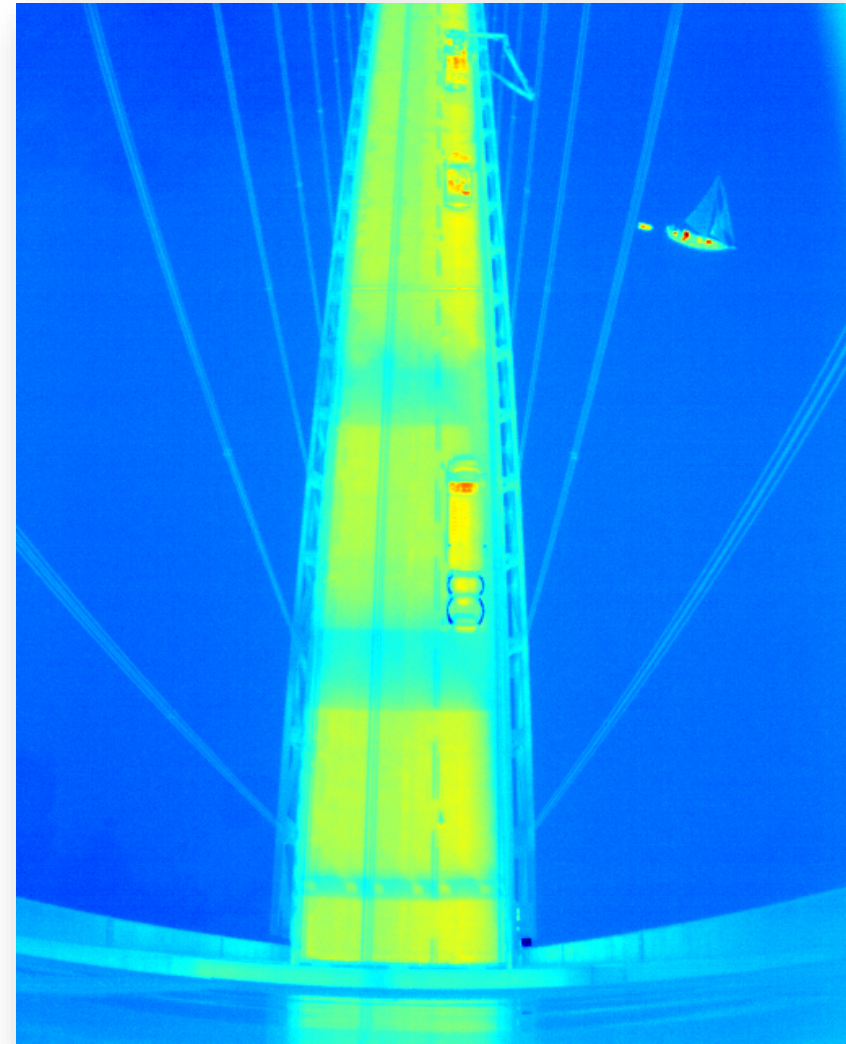
*Innovative Infrared Nondestructive Evaluation  
Technologies*



# Overview

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- Identify who we are
- Describe the IR-UTD technology
- Provide some examples, applications, and verification data
- Questions / discussion



# Who We Are

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Paul Fuchs

- FHWA NDE Center (12 years)
- Fuchs Consulting, Inc. (20+ years)



Infrared Products and Services (4<sup>th</sup> Year)



Glenn Washer

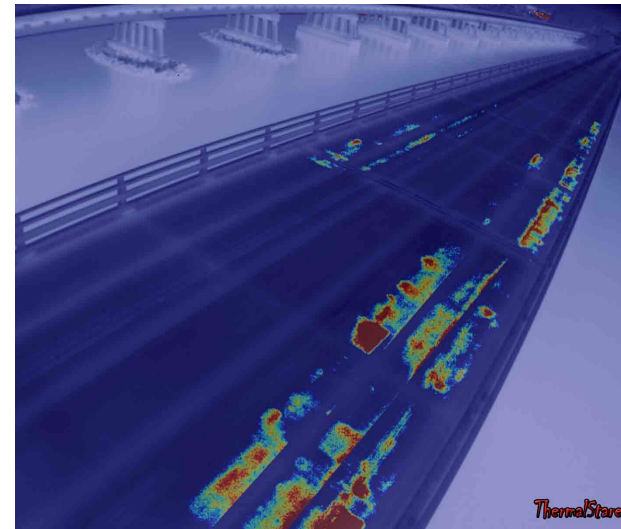
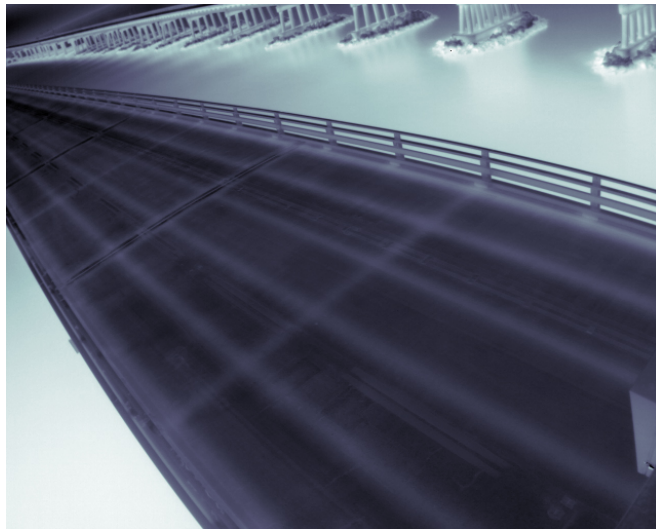
- FHWA (14 years)
  - TFHRC NDE Center Program Manager
- Professor University of Missouri (13+ years)



# What is IR-UTD?

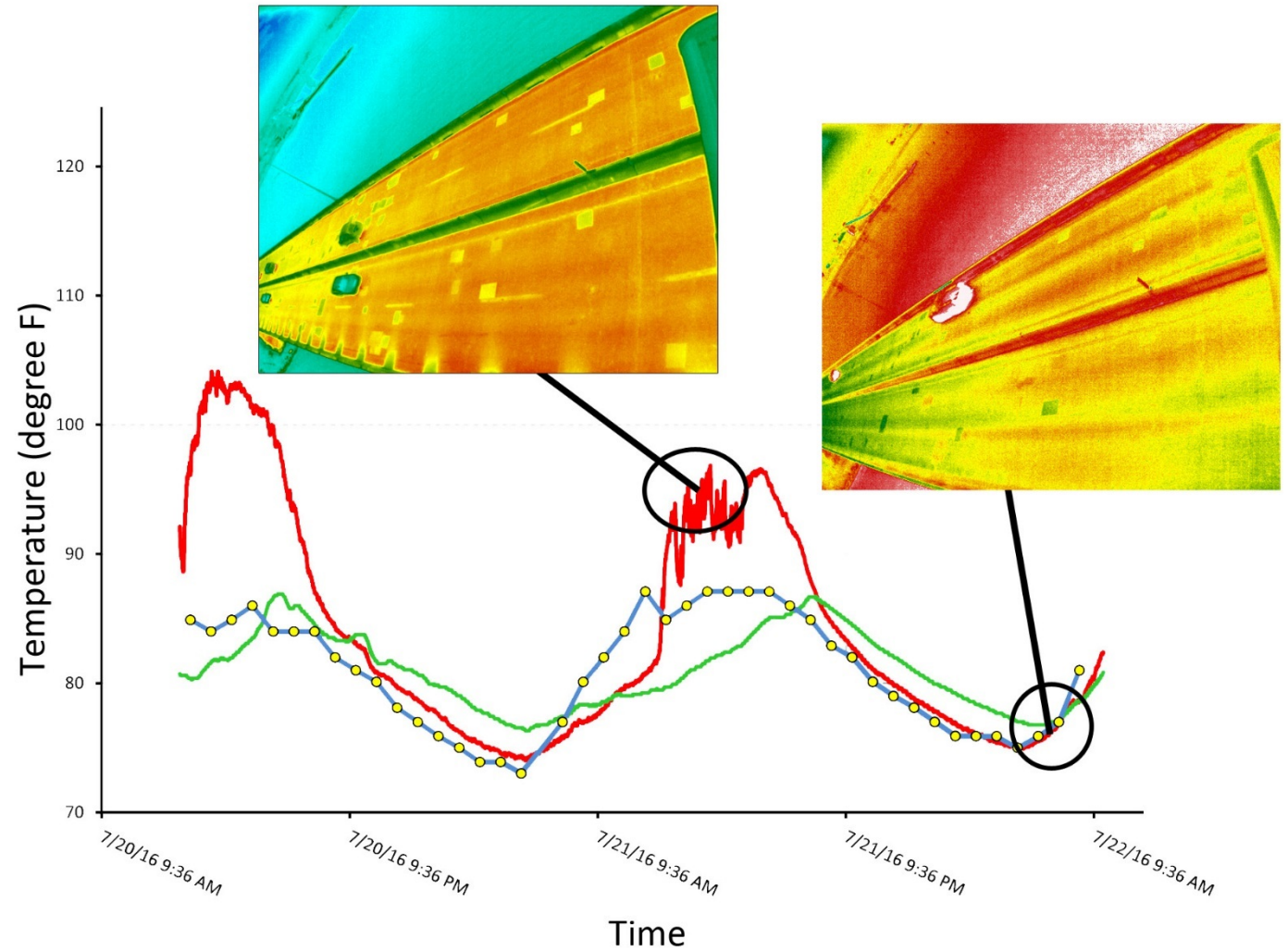
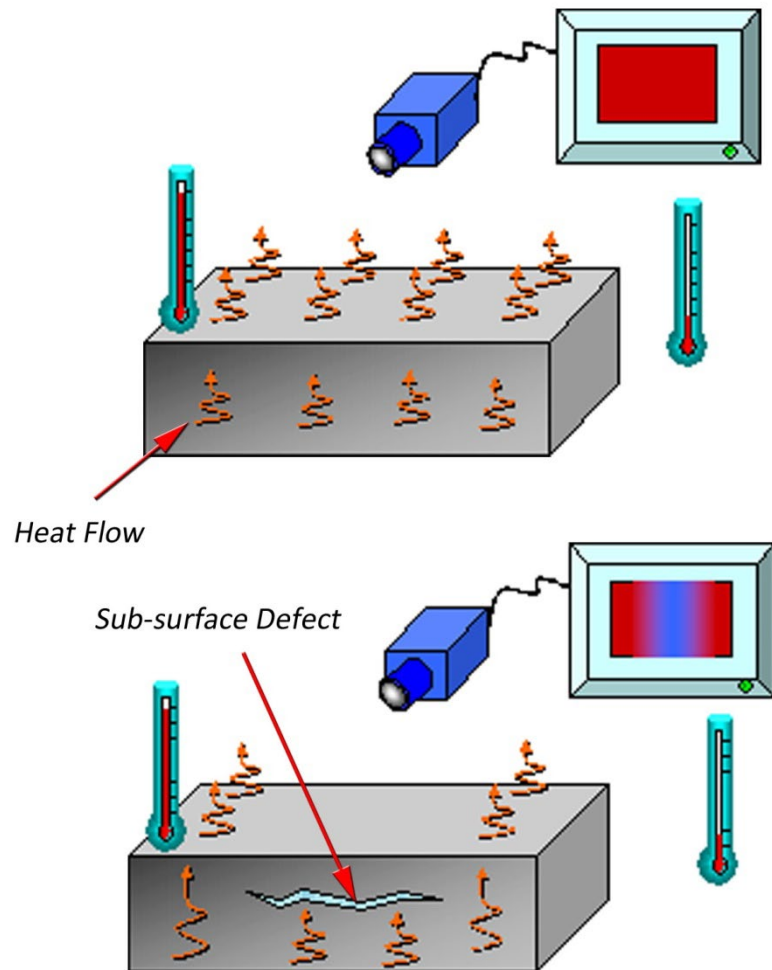
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- Infrared Ultra-Time Domain Thermography (IR-UTD)
- New technology designed to detect subsurface damage (delams) in concrete decks, superstructures, and substructures
- Transient thermography – *time-based* data collection





# Timing of Measurements



# Difference Between Conventional IR and IR-UTD

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## Conventional IR

1. *Captures a single image at a certain point in time*
2. *Thermal contrasts in image are interpreted to identify subsurface defects*
3. *Sensitive to environment and timing*
4. *Limited depth*
5. *Ineffective through overlays*

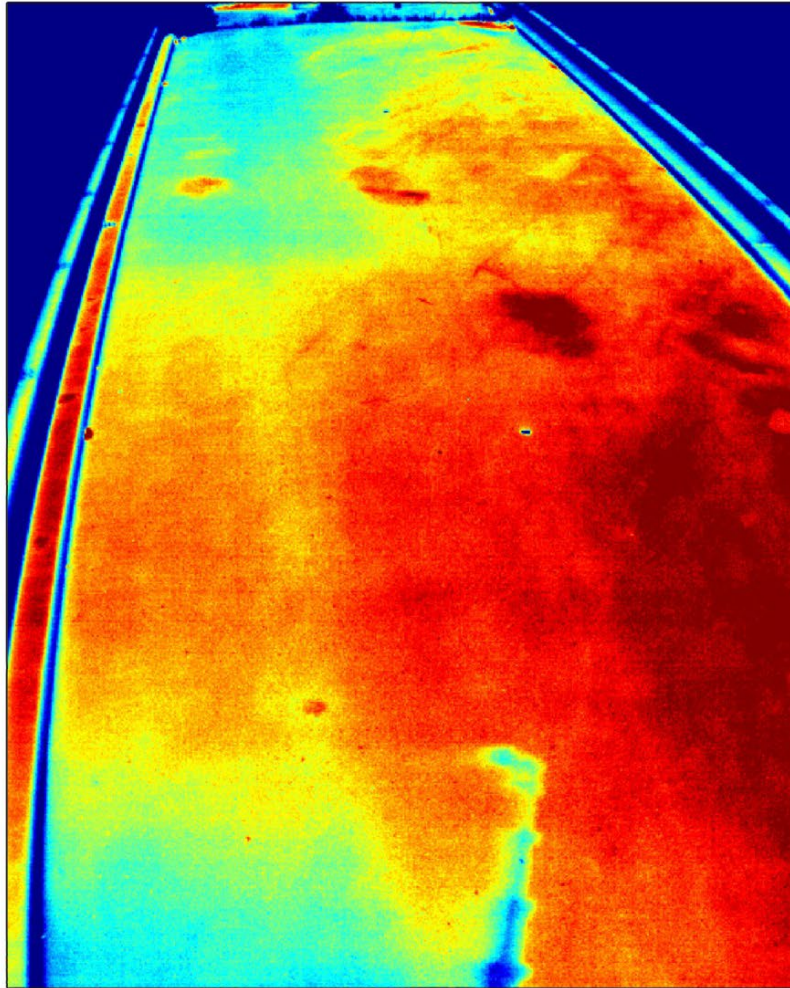
## IR- UTD

1. *Capture multiple images over a 24-48 hr time period*
2. *Data is processed using advanced algorithms; thermal inertia is interpreted to identify subsurface defects*
3. *Tolerant to environment; collects data at all times over collection interval*
4. *Increased depth of sensitivity*
5. *Improved effectiveness through overlays*

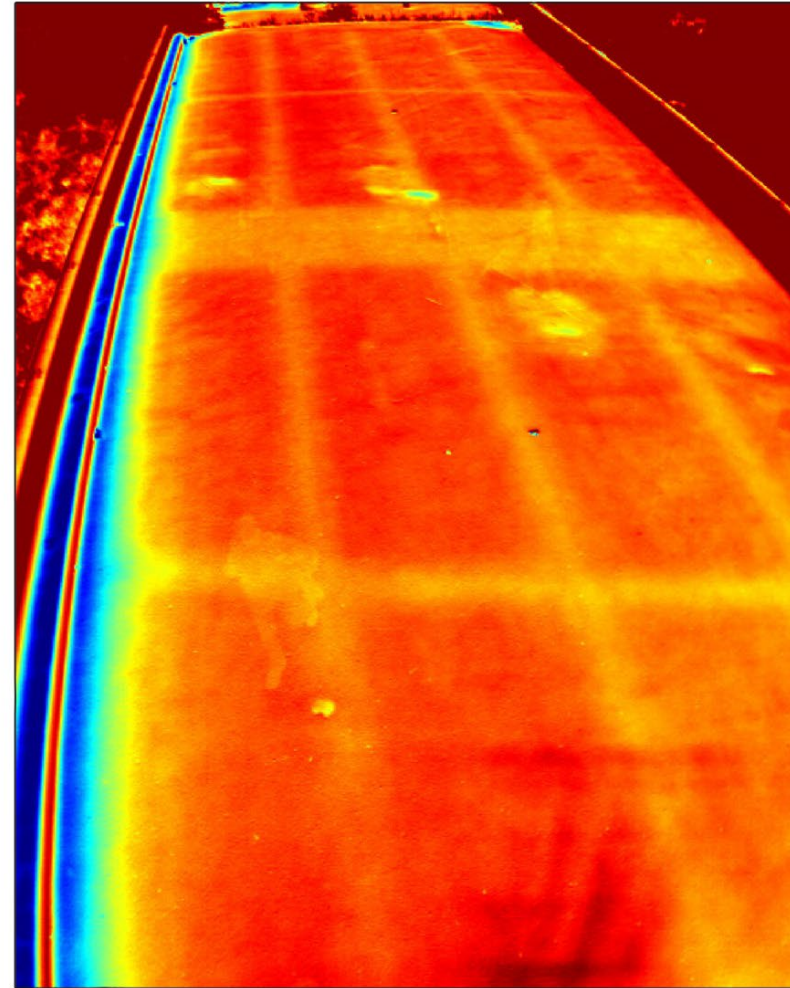


# Comparison Between Conventional IR and IR-UTD Imaging

Conventional IR (maximum contrast)



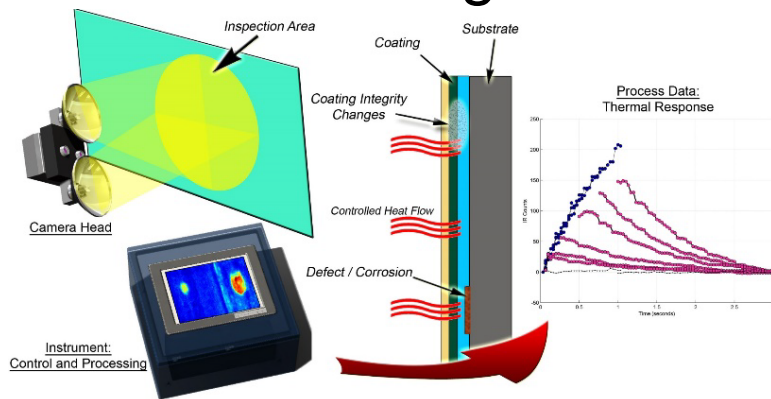
IR-UTD processed image



# How was this technology developed?

## FHWA SBIR for Coatings NDE

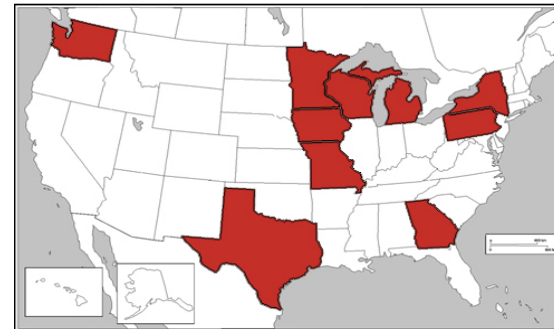
- FCI developed an IR system for detecting corrosion and other defects under coatings
- Technology uses active heating source and collects images over several seconds during cooling
- Algorithms developed to reveal subsurface damage



## Pooled Fund TPR(5)-247

- Tested a version of the technology adapted for detecting subsurface damage in concrete
- Collect data over several hours instead of several seconds
- Use advanced algorithms to detect delams in bridge decks (and other concrete structures)

[https://library.modot.mo.gov/RDT/reports/TRyy1144/cmr16-007\\_Final.pdf](https://library.modot.mo.gov/RDT/reports/TRyy1144/cmr16-007_Final.pdf)

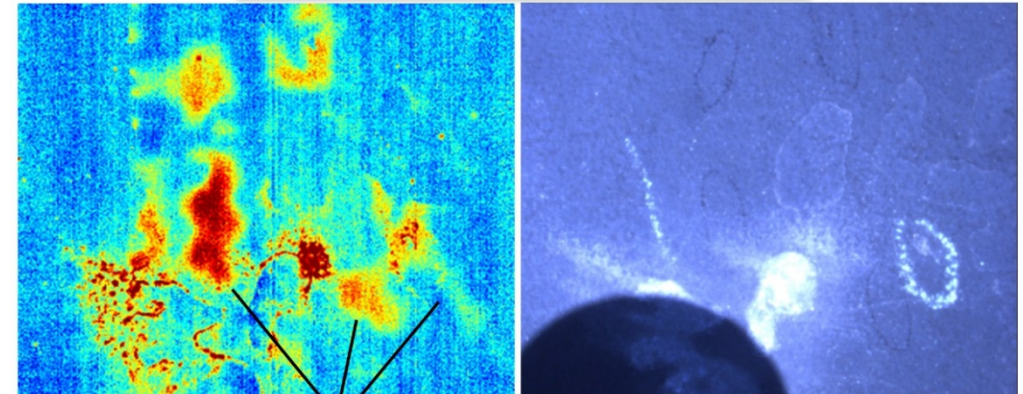




# IR-CIS Detects Defects Under Coatings



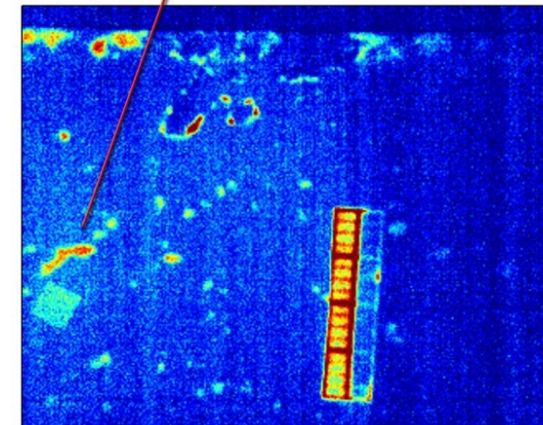
## Defects under metalizing



20170801\_12\_35\_27.4

Defect Indications (multiple; not all indicated)

*Defect of interest*



Data Set: 20140721\_16\_01\_39.7

## Defects under conventional coatings

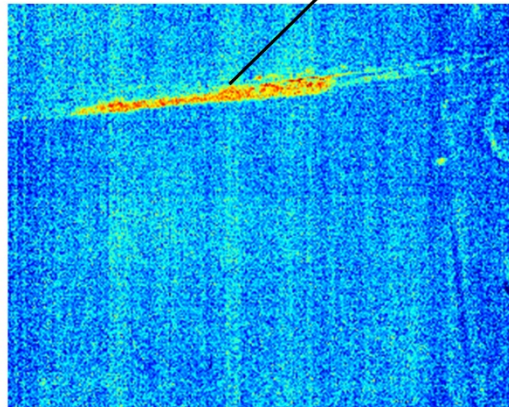


# Example Setup

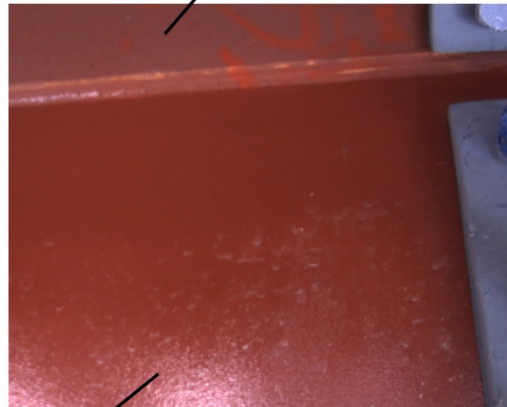


Defect indication

Top flange



20170721\_10\_18\_50.9



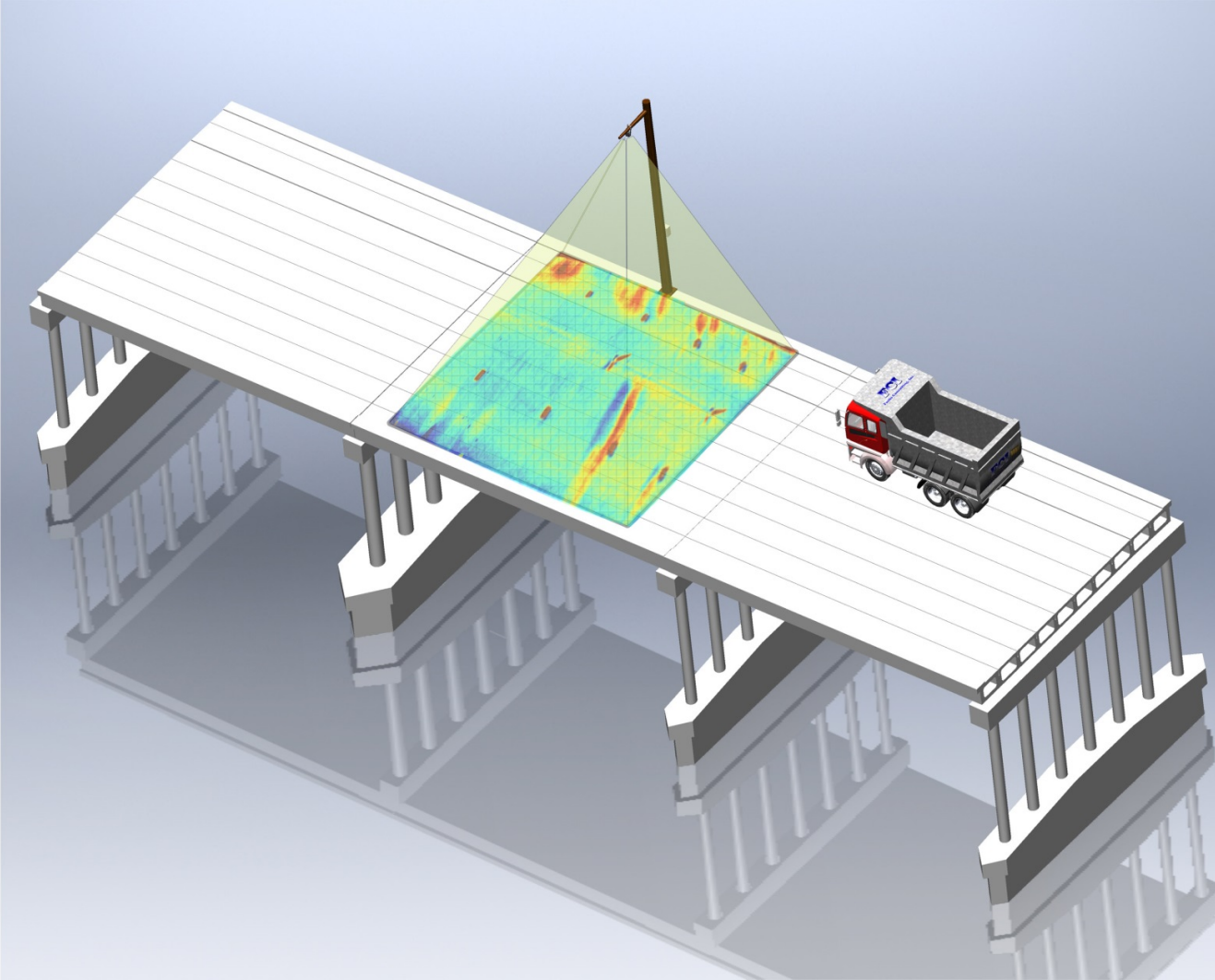
Web





# How Does the IR-UTD technology work?

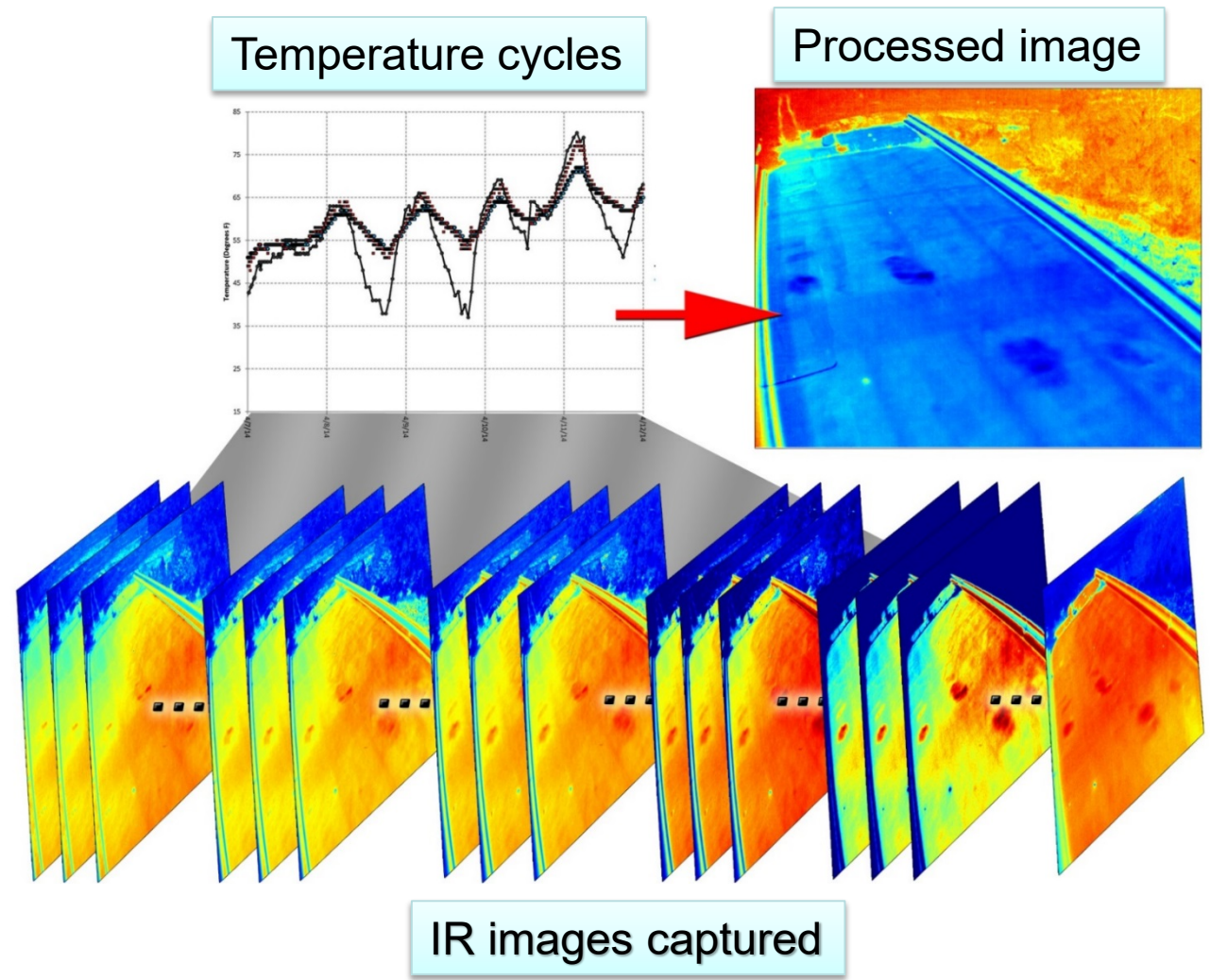
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- *Measure large area of deck*
- *Long-term measurements*
- *Collect data with all lanes open to traffic*
- *Multiple installation options*

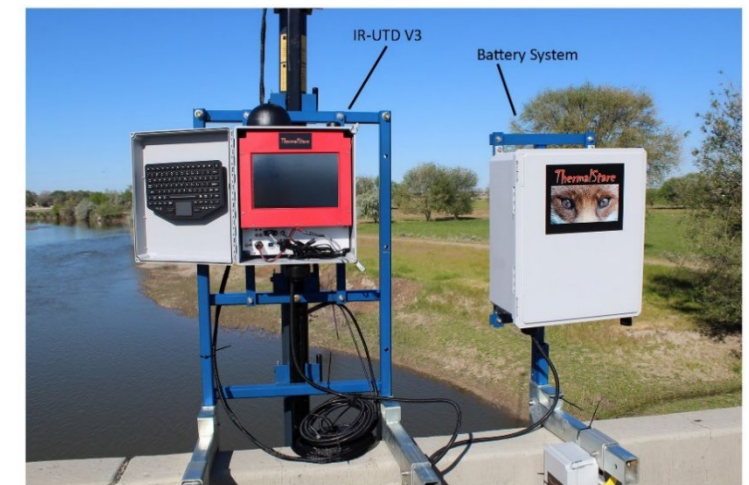
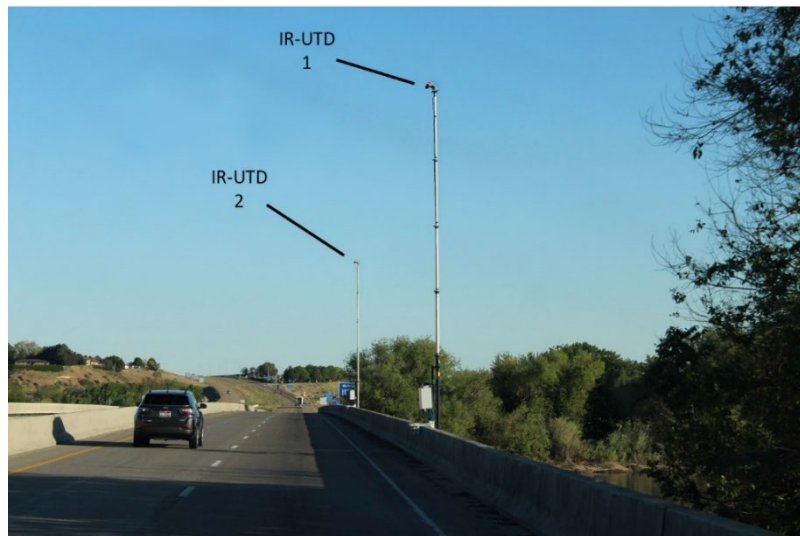
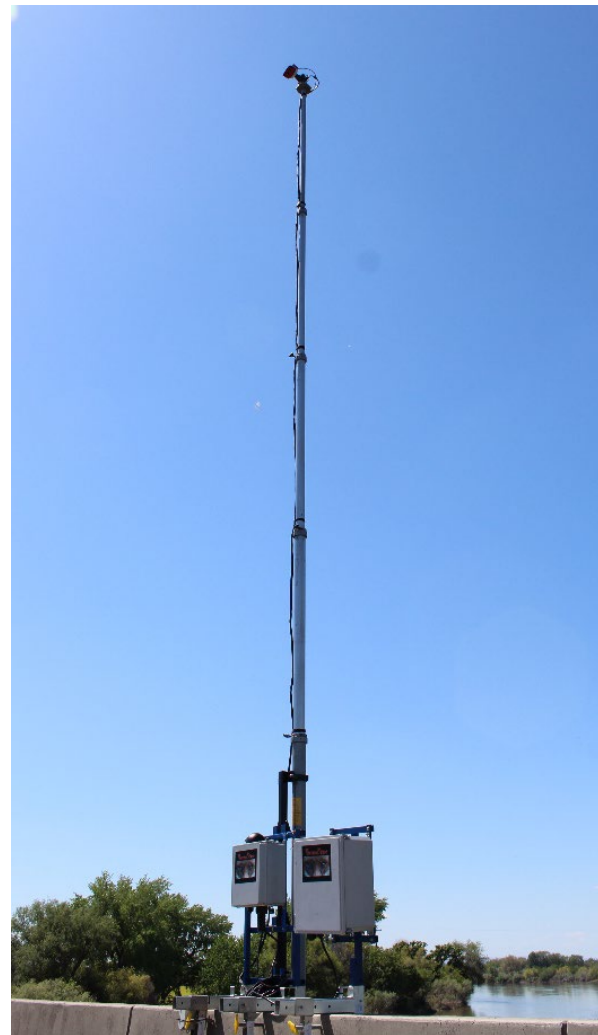
# Data Collection Procedure

- Data collected over 24-48 hours
- Open to traffic during collection
- Data processed to produced image
- Large areas of deck captured in a single image
- High resolution IR imaging





# How is the technology deployed? IR-UTD: Parapet Mount



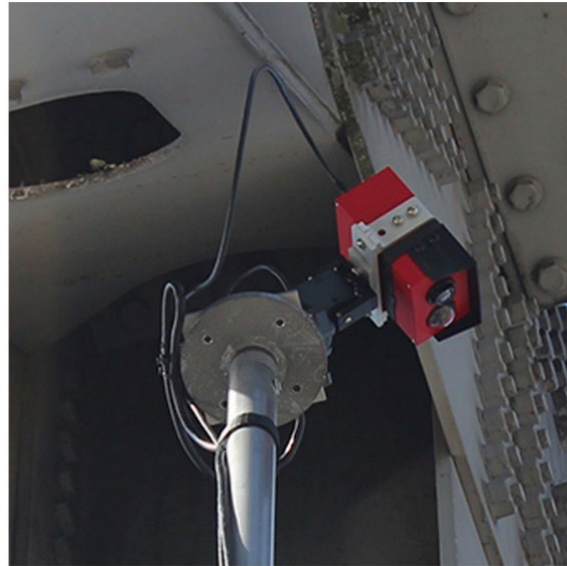


# How is the technology deployed?

Light poles, ITS equipment, traffic cam poles, etc.



Francis Scott Key Bridge, Baltimore, MD



Chesapeake Bay Bridge, Annapolis, MD



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# ***IR-UTD: Examples***

# IR-UTD – Damage detection in concrete

- *Collects data with all lanes open to traffic*
  - Vehicles removed from images through advance signal processing

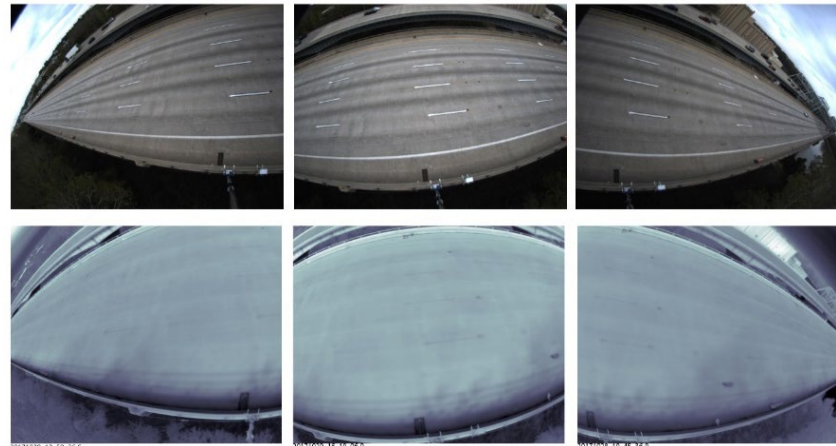


Field of view from mast



Measures with traffic

IR-UTD images

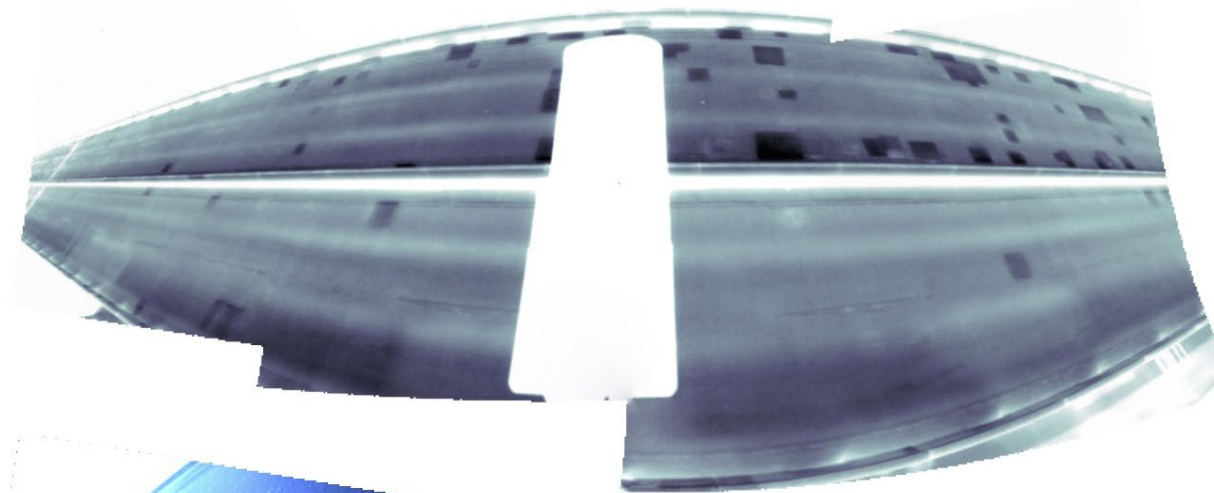




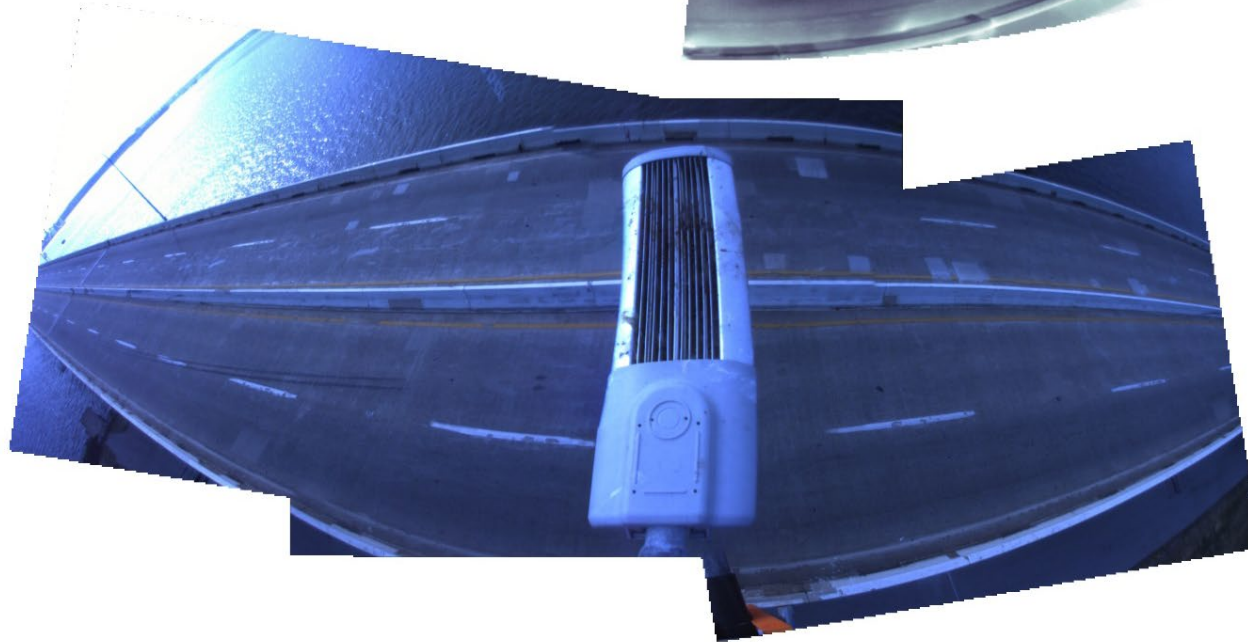
# IR-UTD IR & Visual Data Collection

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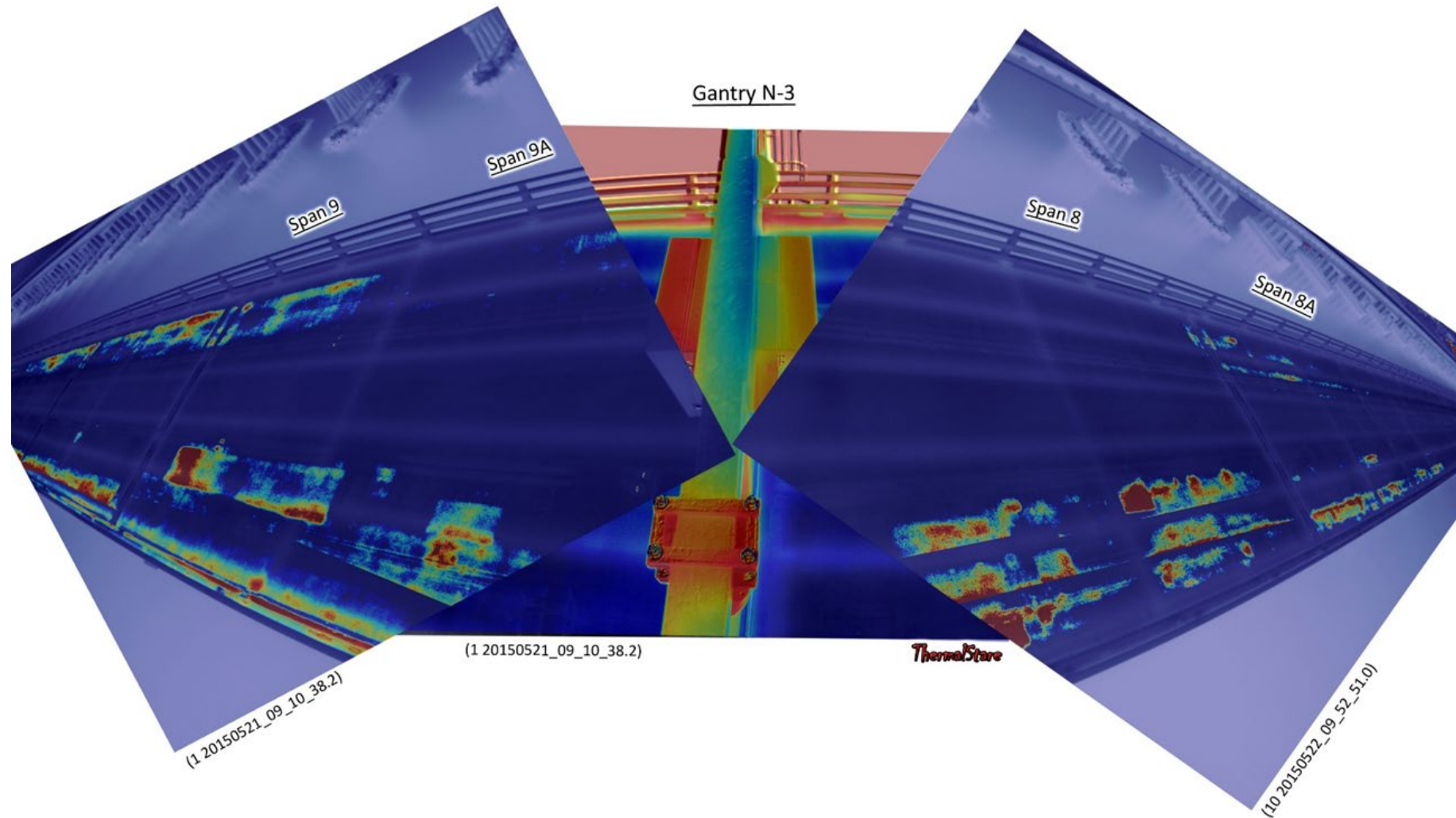
IR-UTD  
(B&W palette)



Visual Images

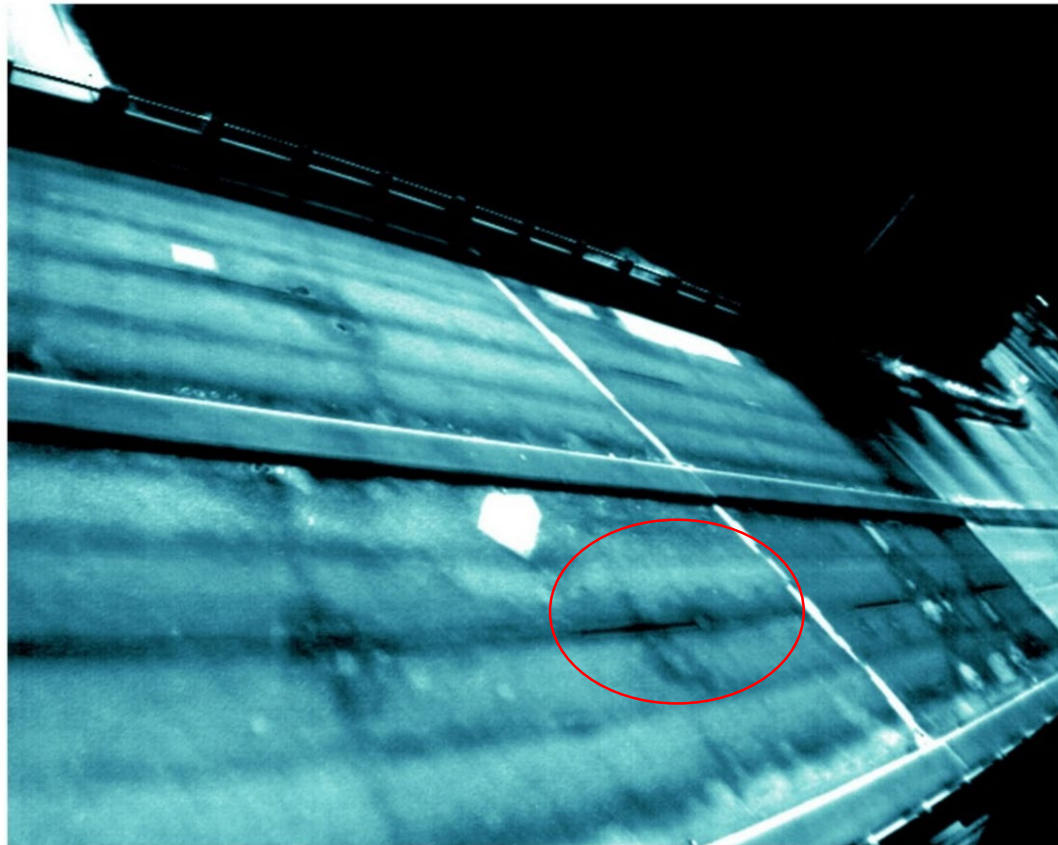


# IR-UTD: Chesapeake Bay Bridge



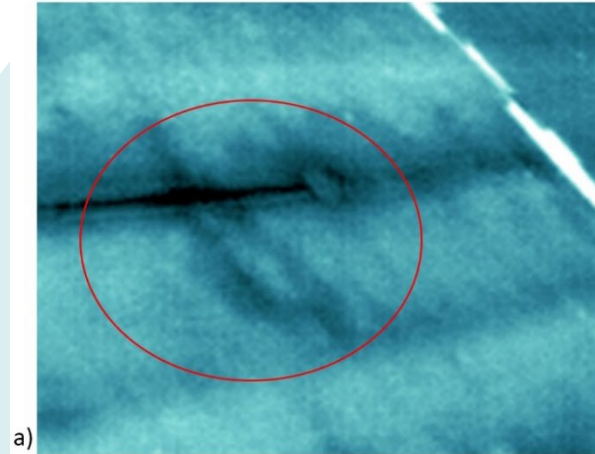


# IR-UTD Data

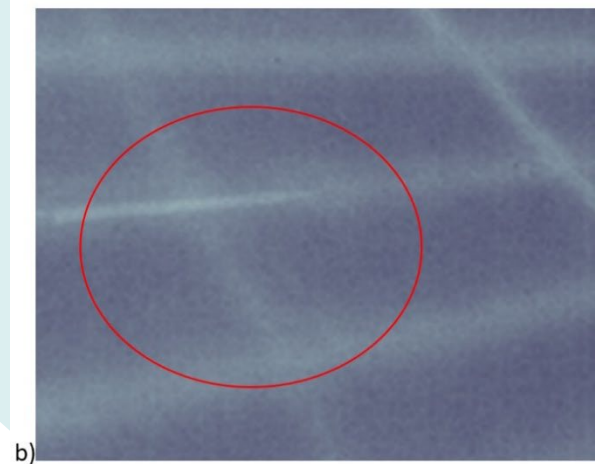
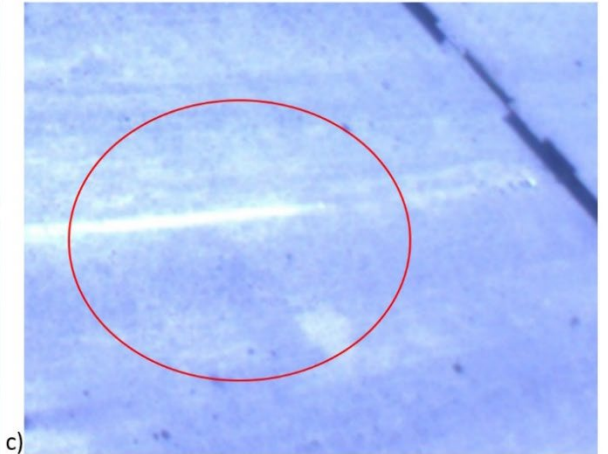


IR-UTD Image

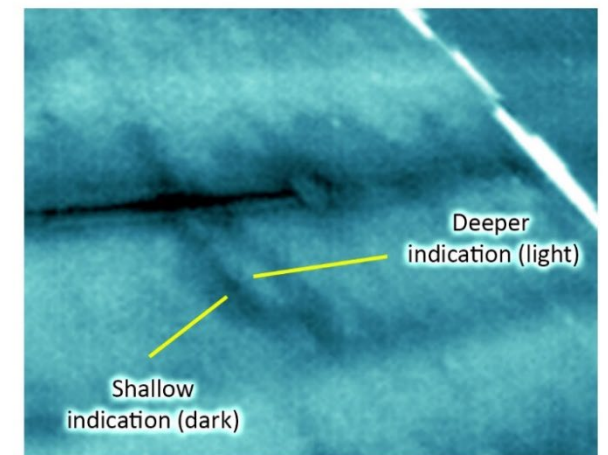
IR-UTD Image



Visual Image

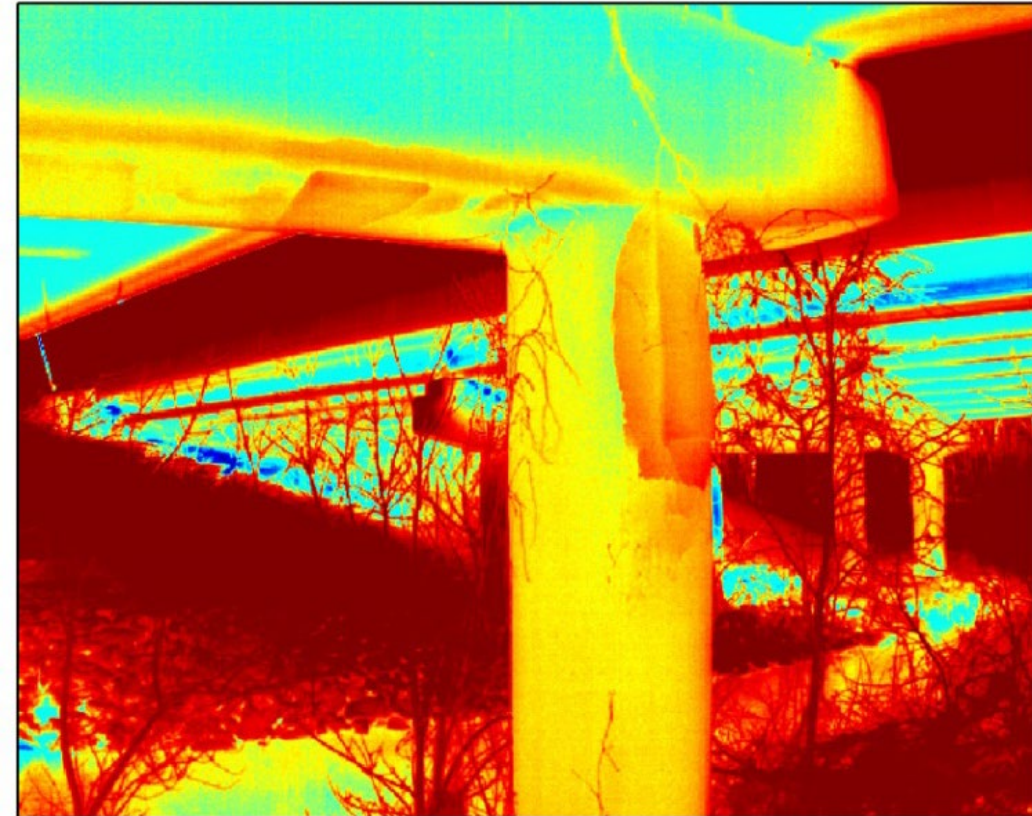
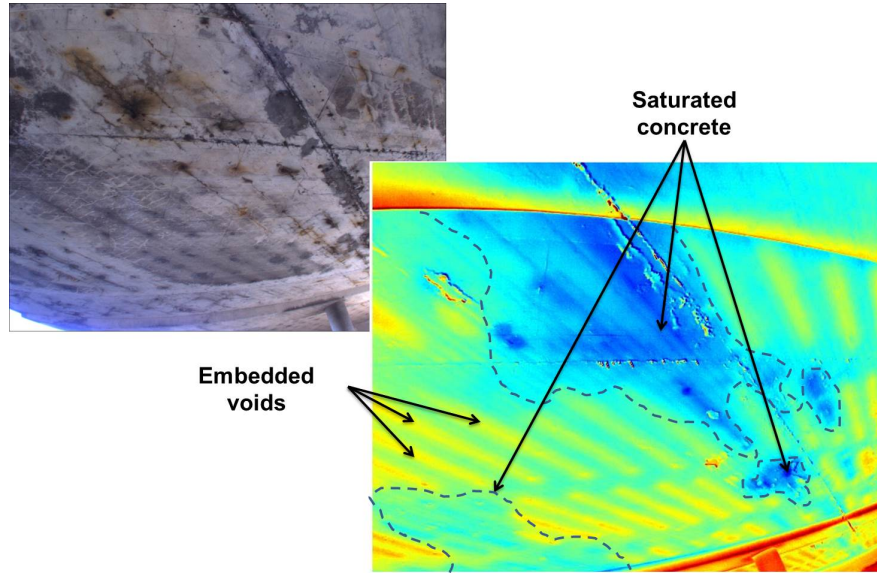


IR-UTD processed to show structure



IR-UTD Image with labels

# IR-UTD: Substructure Evaluation

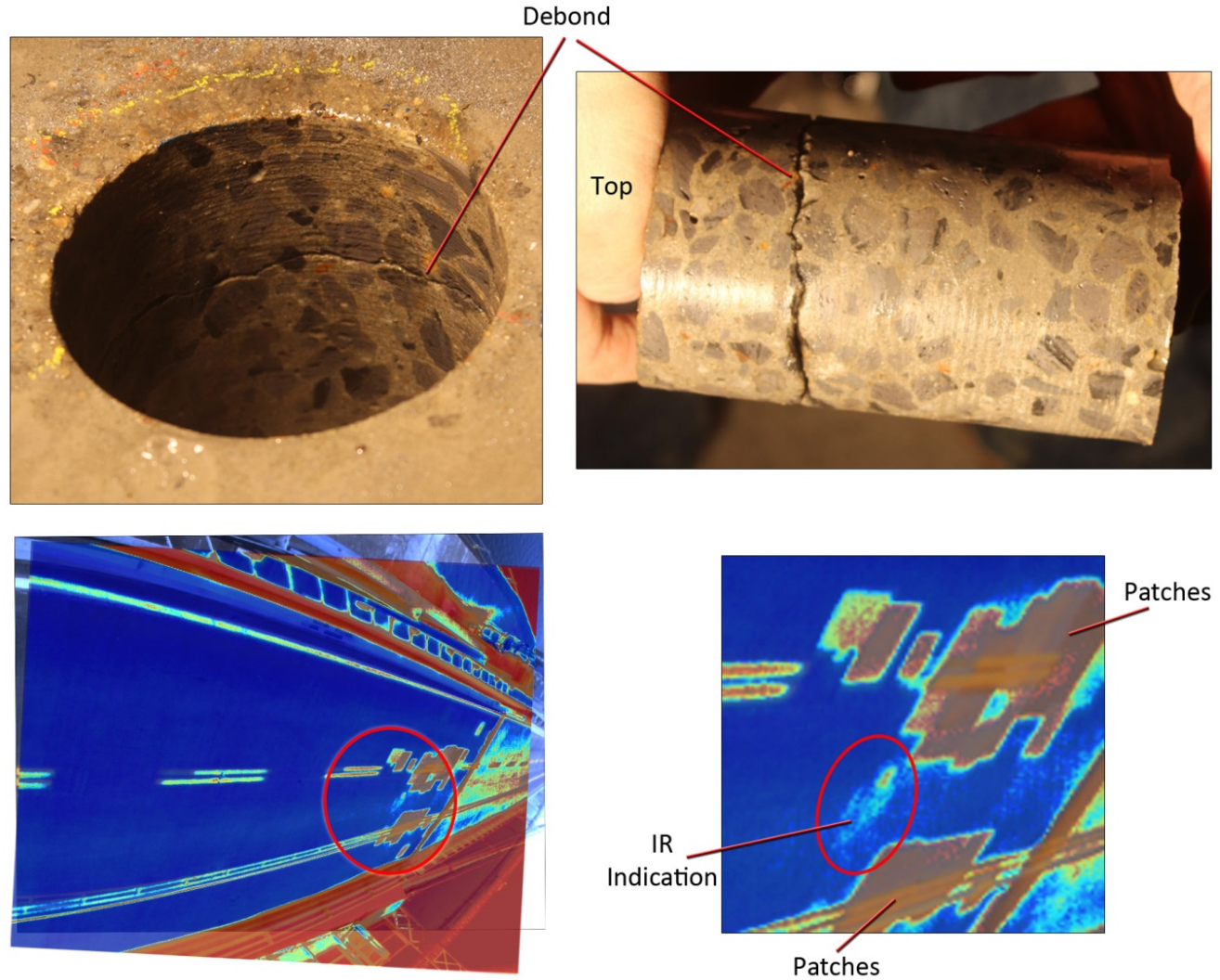




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# ***IR-UTD: Overlays***

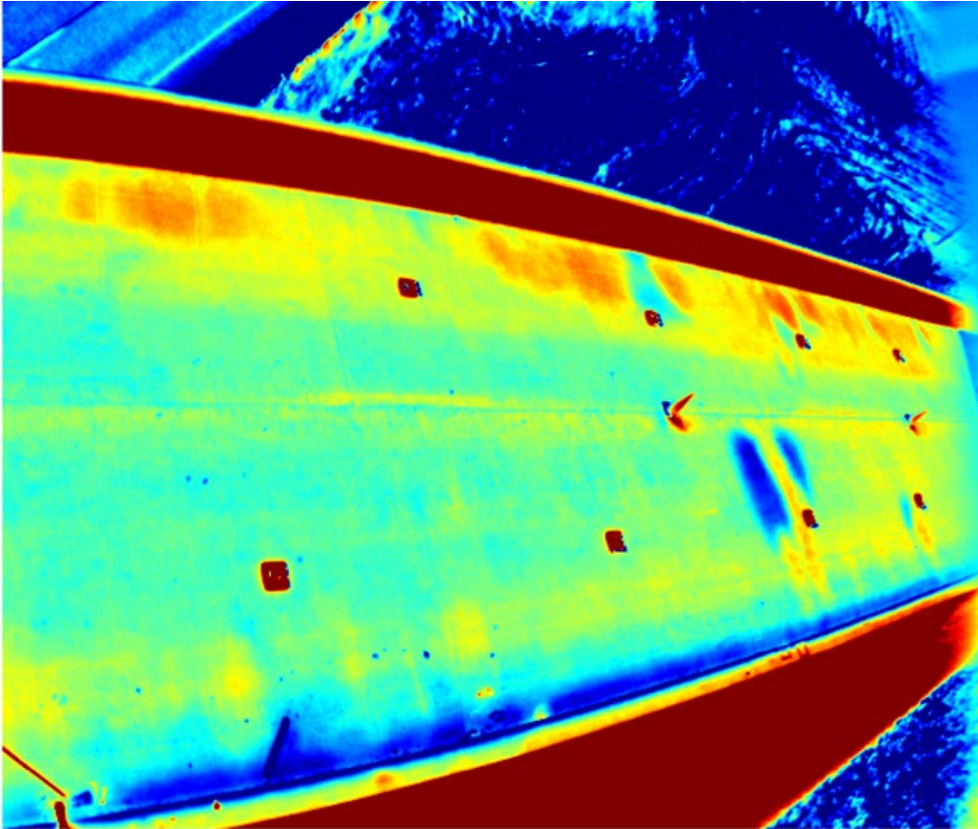
# Chesapeake Bay Bridge, MD





# Bridge Deck - Iowa

IR-UTD Image

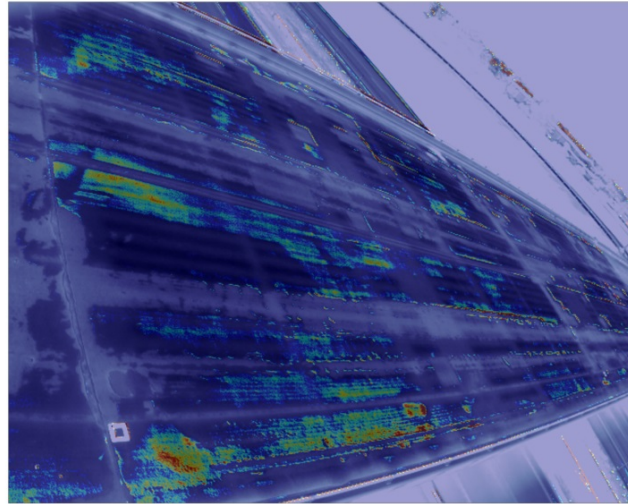


IADOT Sounding Marks



# Grindstone Road Bridge, MO

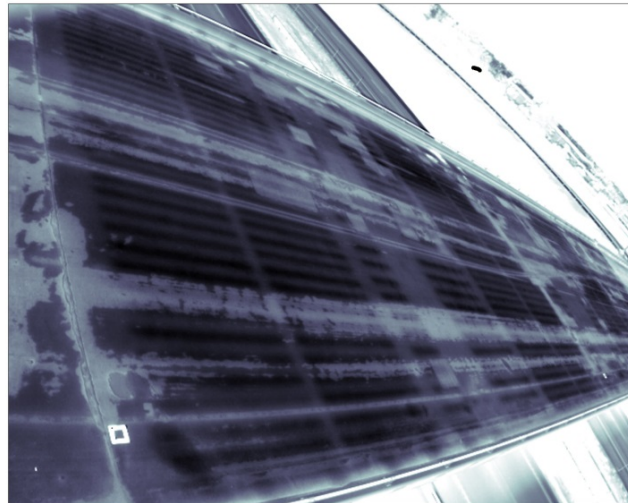
IR-UTD:  
Overlay of defects  
and structure



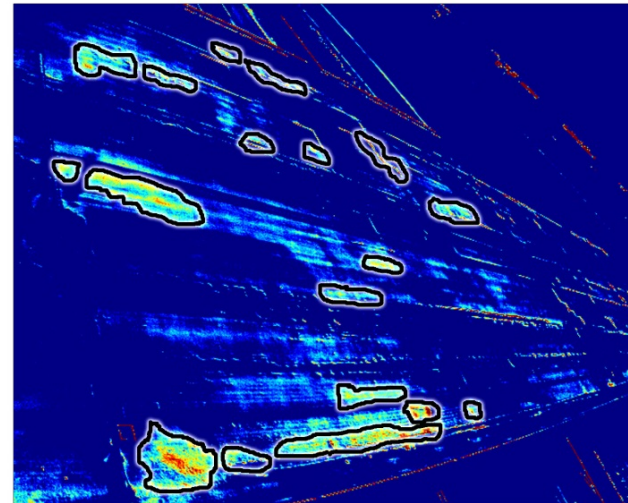
Visual image



IR-UTD:  
Internal features



IR-UTD:  
Delaminations



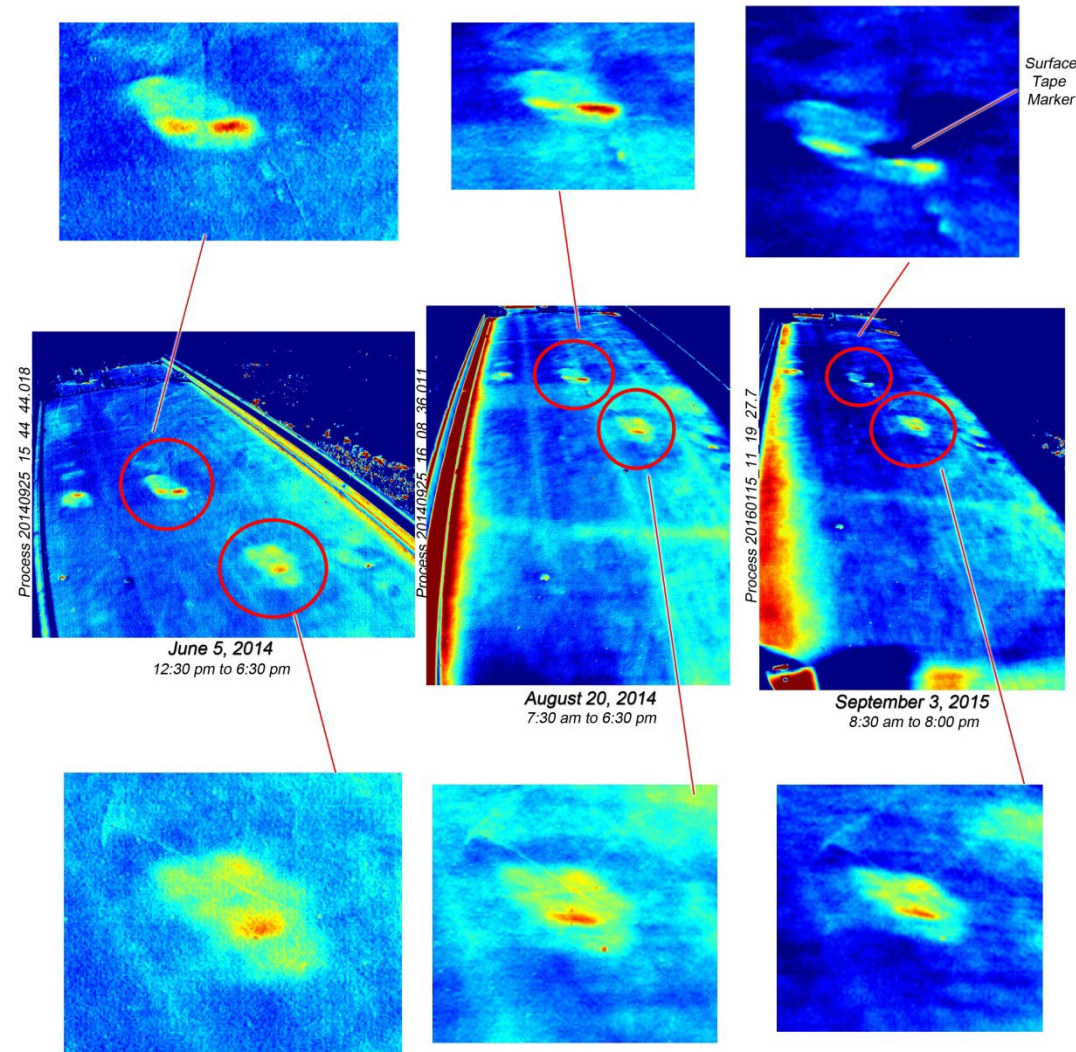


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# ***IR-UTD: Verification***

# IR-UTD: Repeatability

- *Repeatable images from*
  - June 2014
  - August 2014
  - September 2015
- *Show same defects with same characteristics*
  - Different positions of mast
  - Different weather conditions
  - Different data collection times

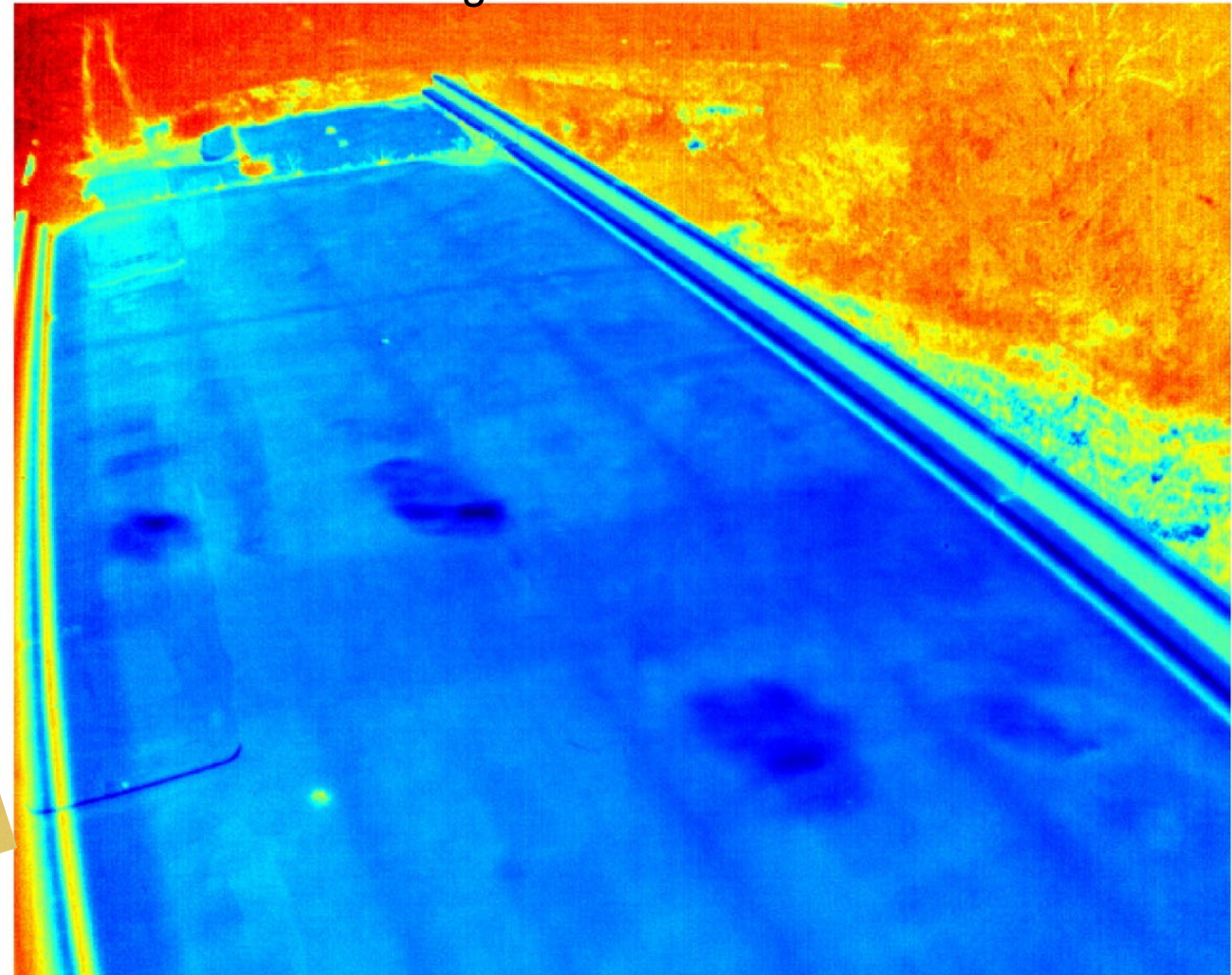
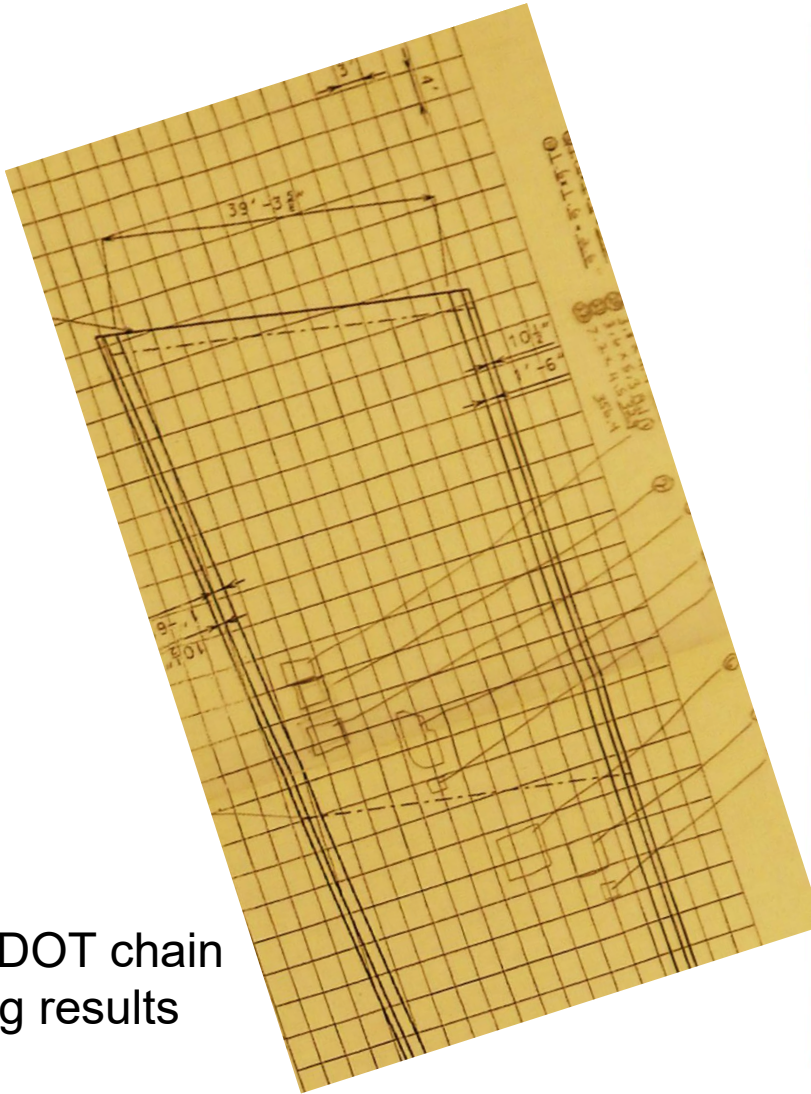




# IR-UTD: Chain Drag Comparison

Bridge Deck - Missouri

MoDOT chain  
drag results

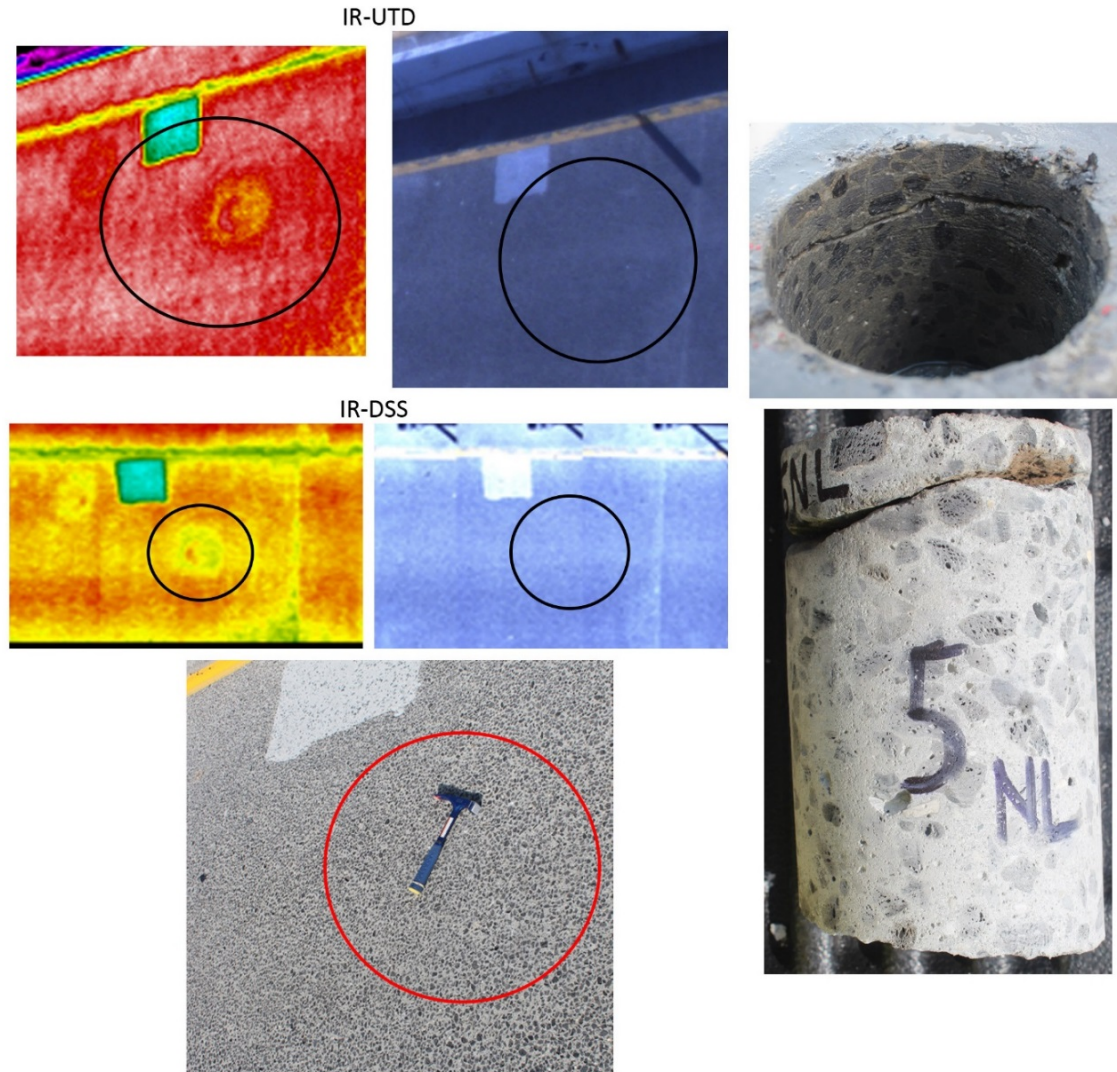


IR-UTD processed image



# IR-UTD: Coring

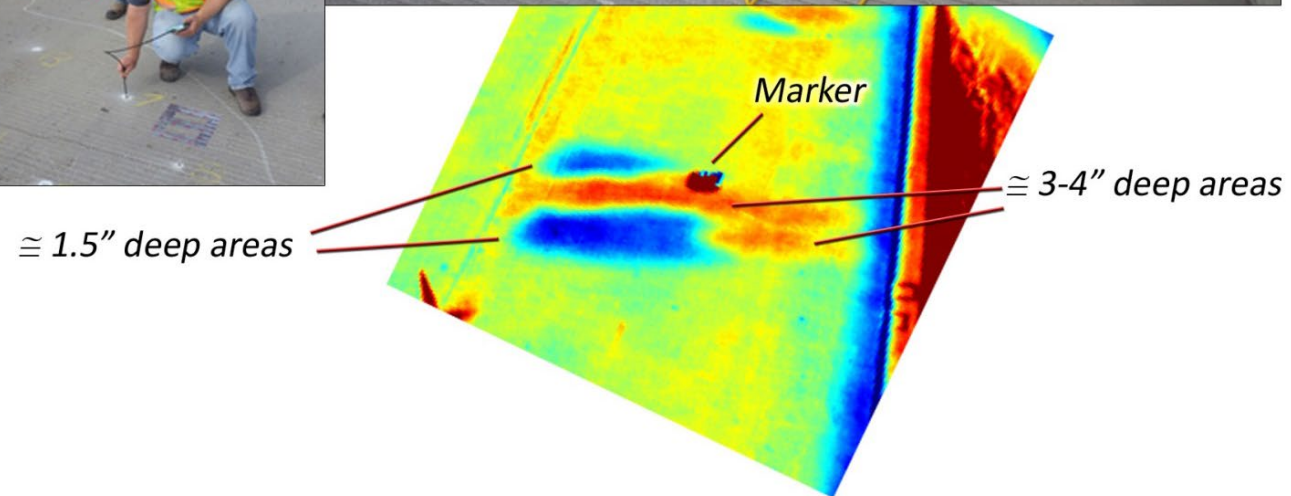
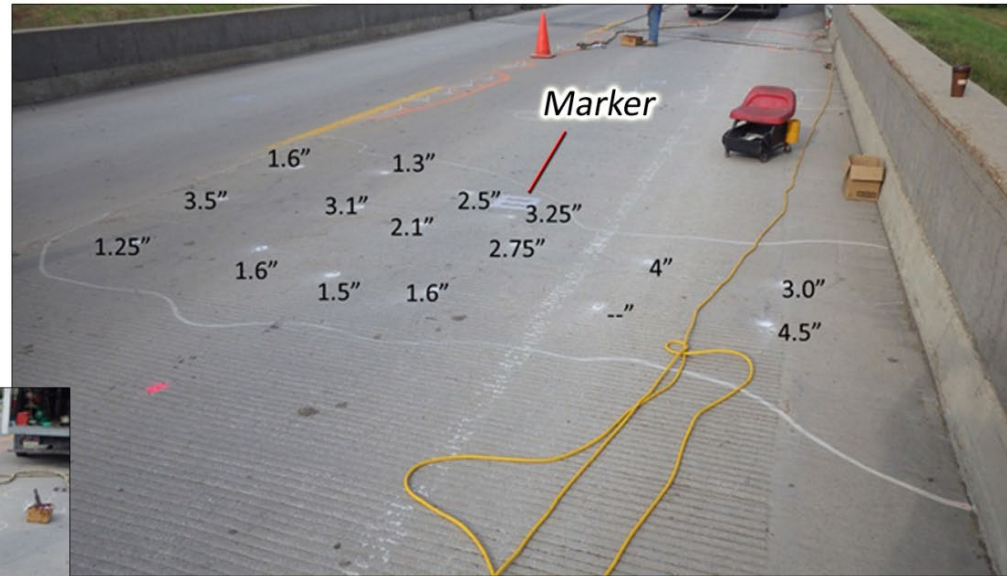
- *Frances Scott Key*
  - 19/19 correct
  - 19 pre-selected cores
  - Intact and defect cores
- *Chesapeake Bay Bridge*
  - 11/12 correct
  - 12 pre-selected cores
  - Intact and defect cores





# IR-UTD: Defect Depth Verification

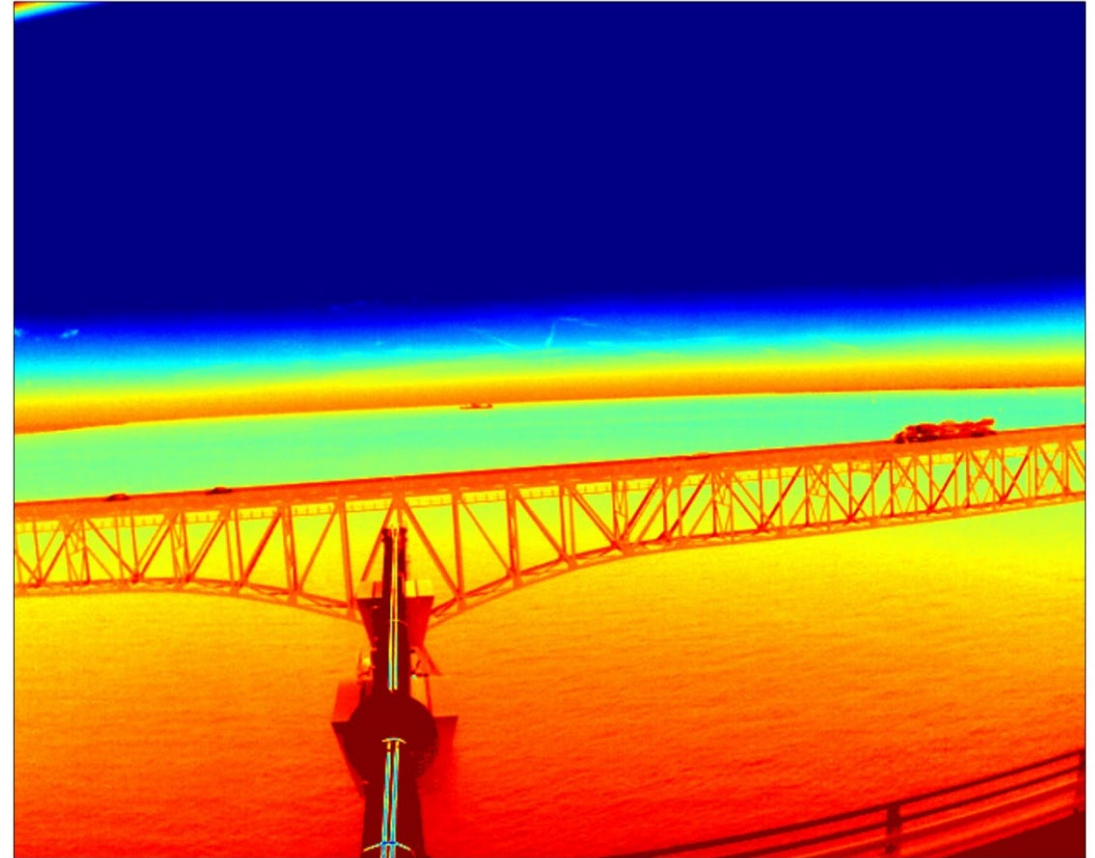
Depth measurement  
with borescope



# Applications

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- Bridge decks
  - Decks with overlays
- Bridge soffits
- Substructure elements
- Large concrete structures
  - Dams, walls, tanks, tunnels
- Buildings
- Military





# *Thank You*

*www.ThermalStare.com*

**FCI**

**Fuchs Consulting, Inc.**

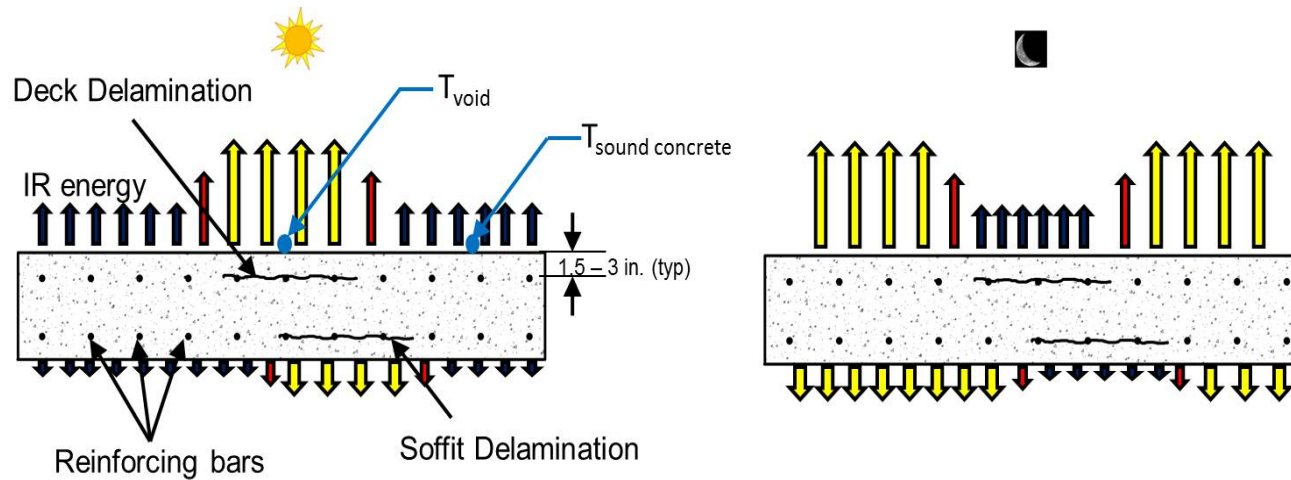


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# Backup slides

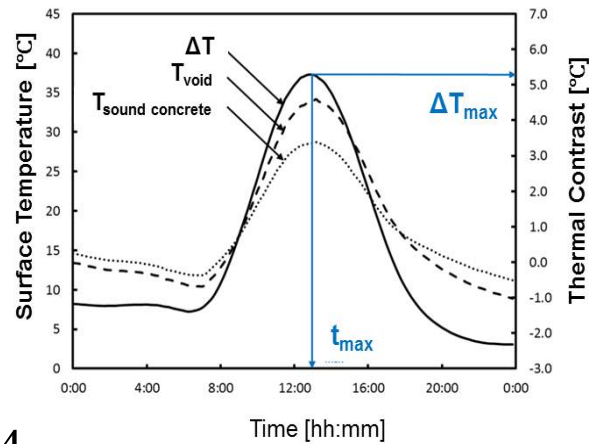


# Background – Conventional IR Thermography

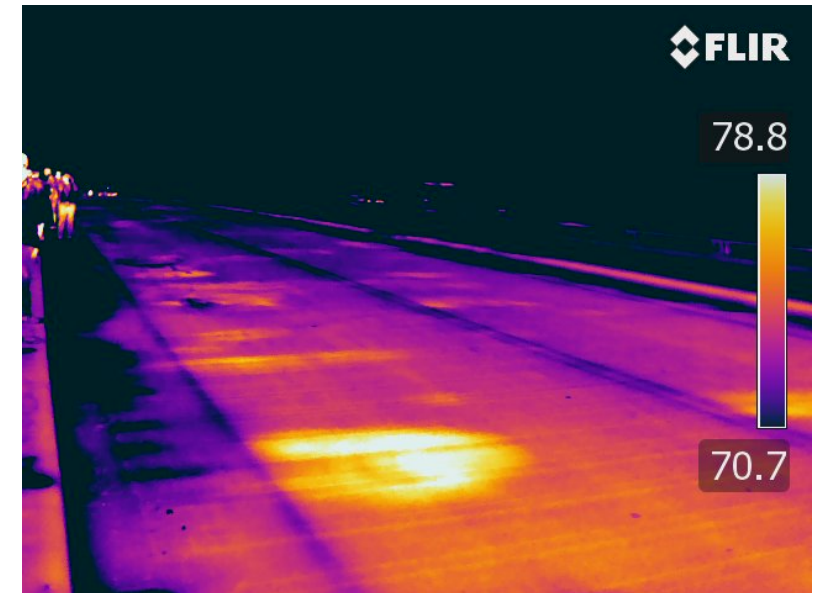


(A)

(B)



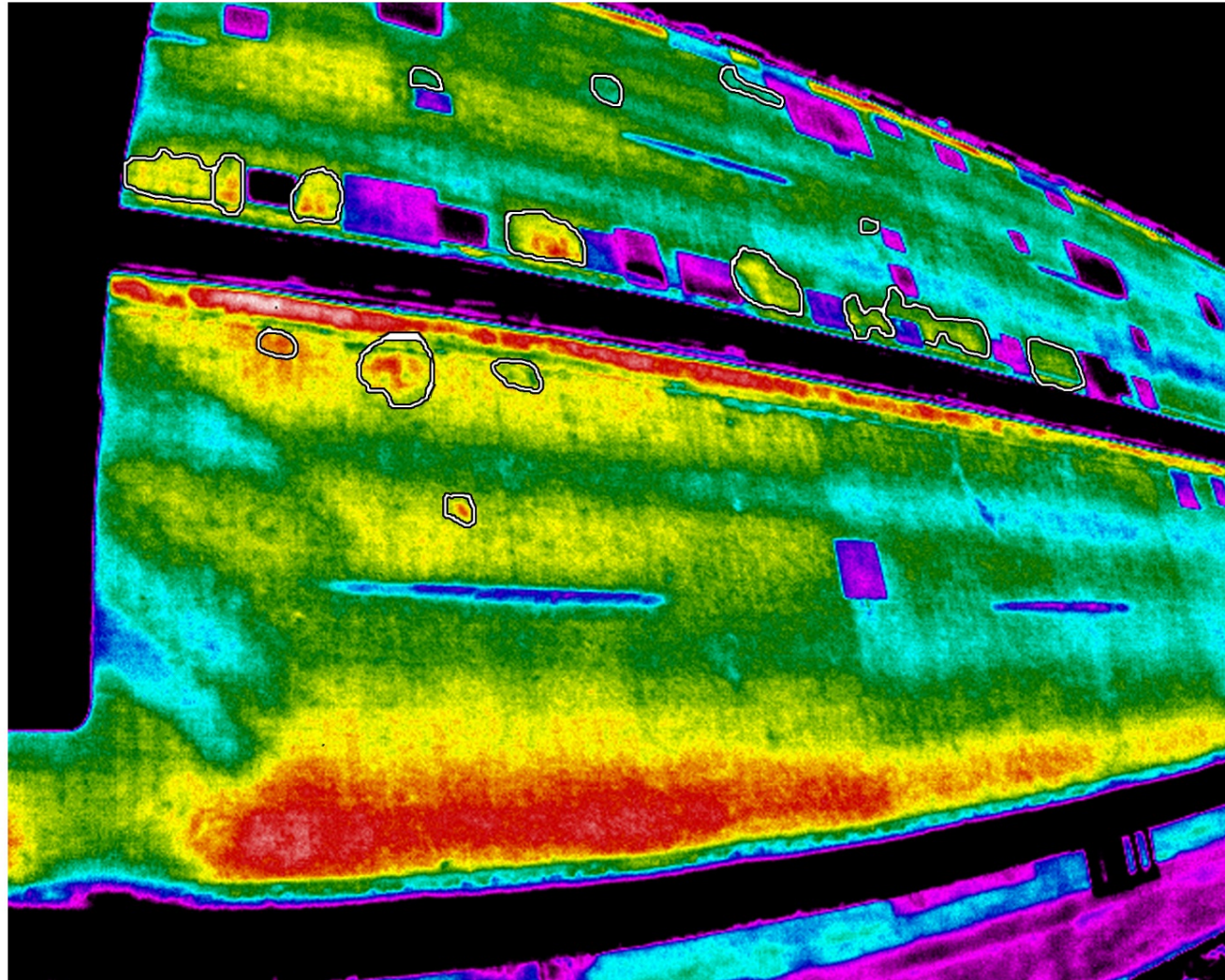
(C)



$$E = \varepsilon \sigma T^4$$

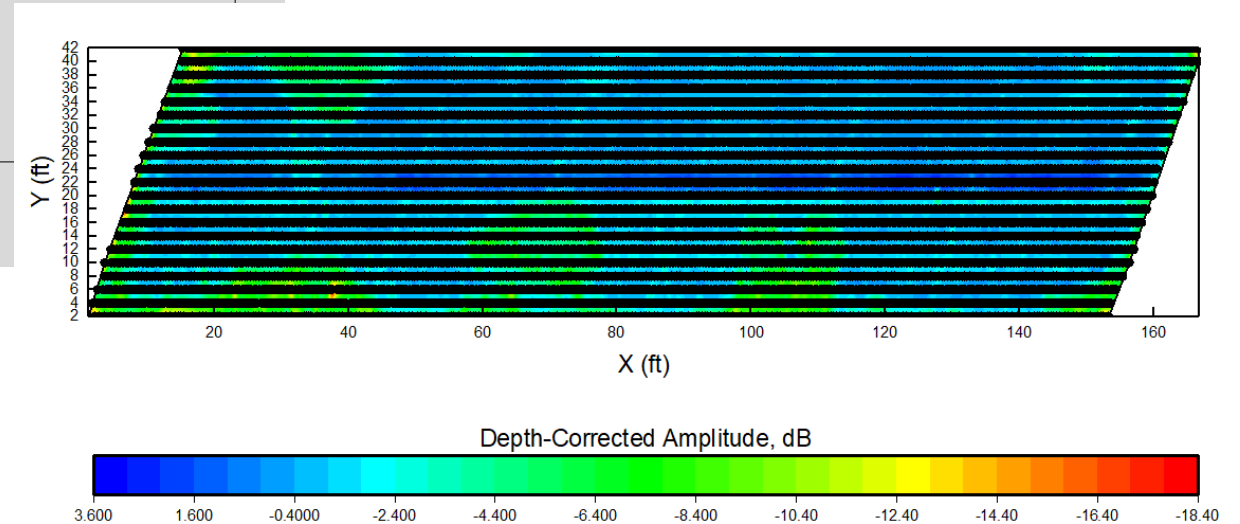
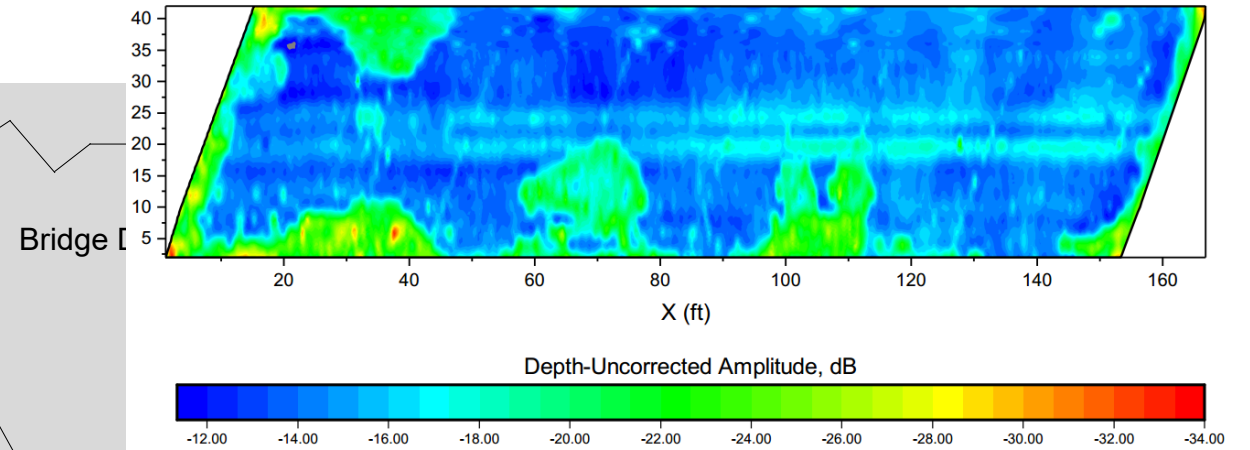
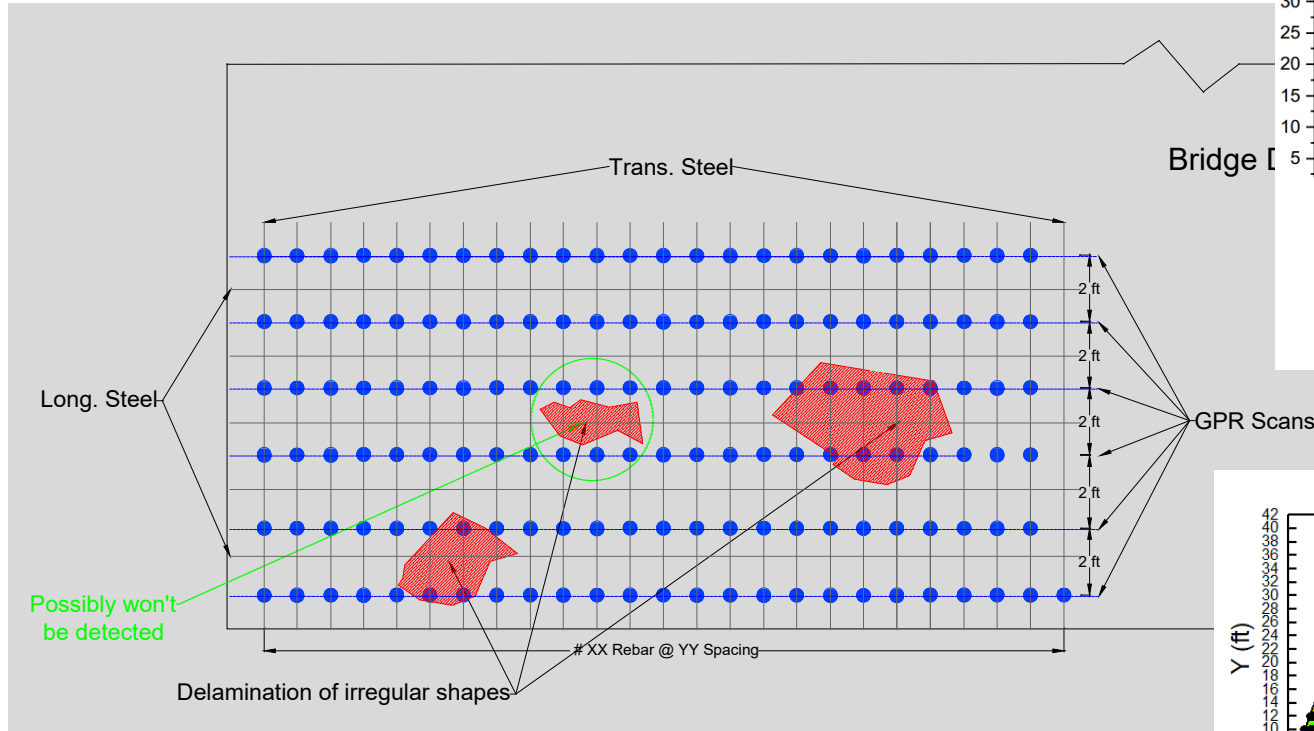
# IR-UTD: FSK Bridge, Baltimore, MD

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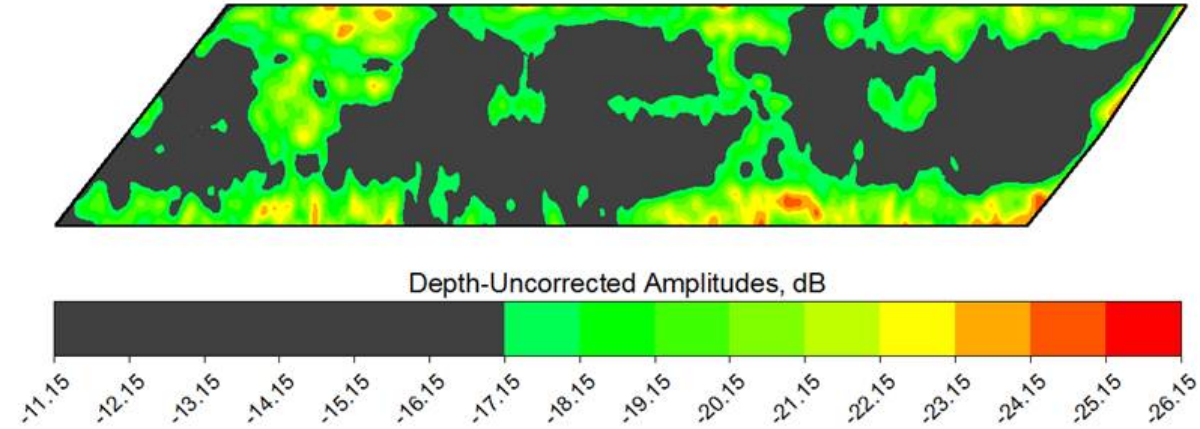


# Test points for GPR



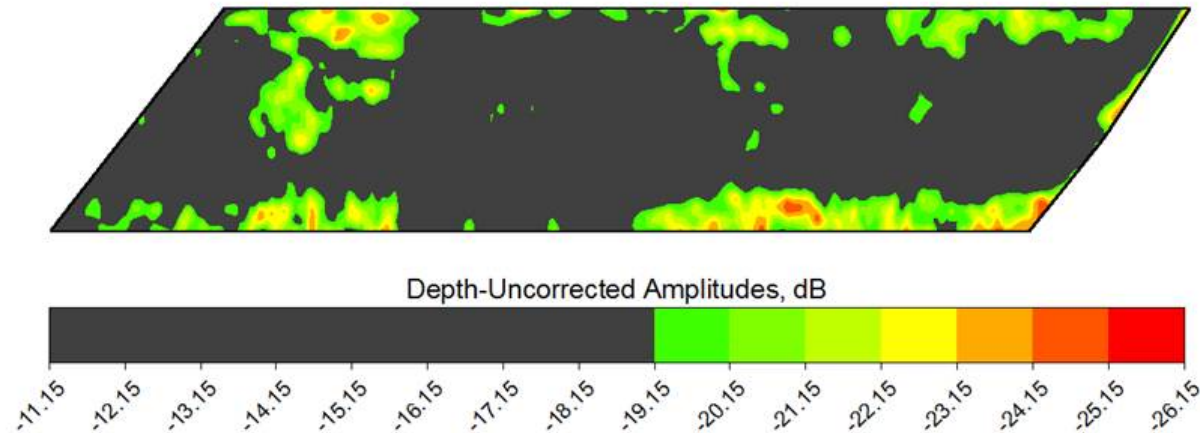
# Effect of Threshold Setting GPR Data Bridge A2111

43% damage



- 6 dB

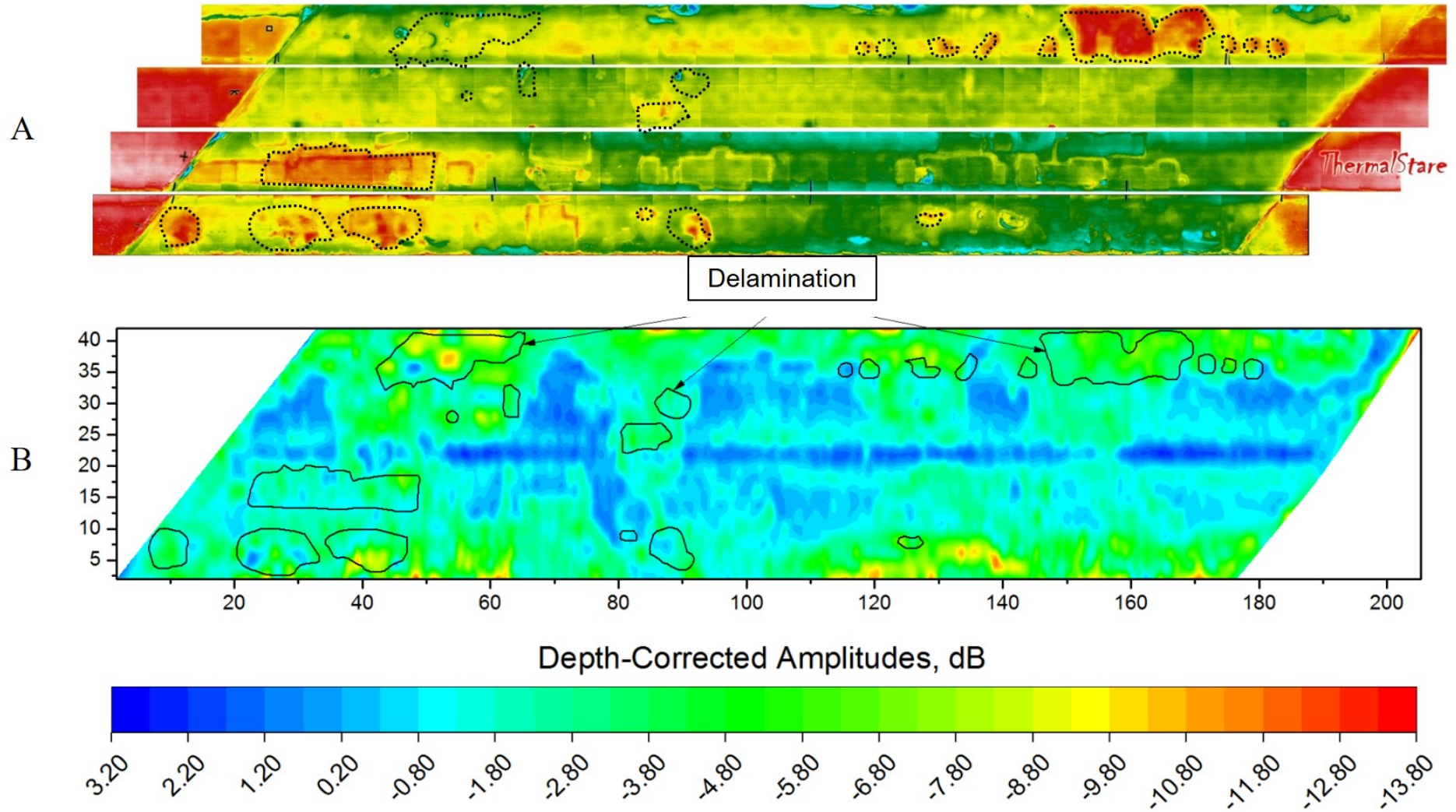
22% damage



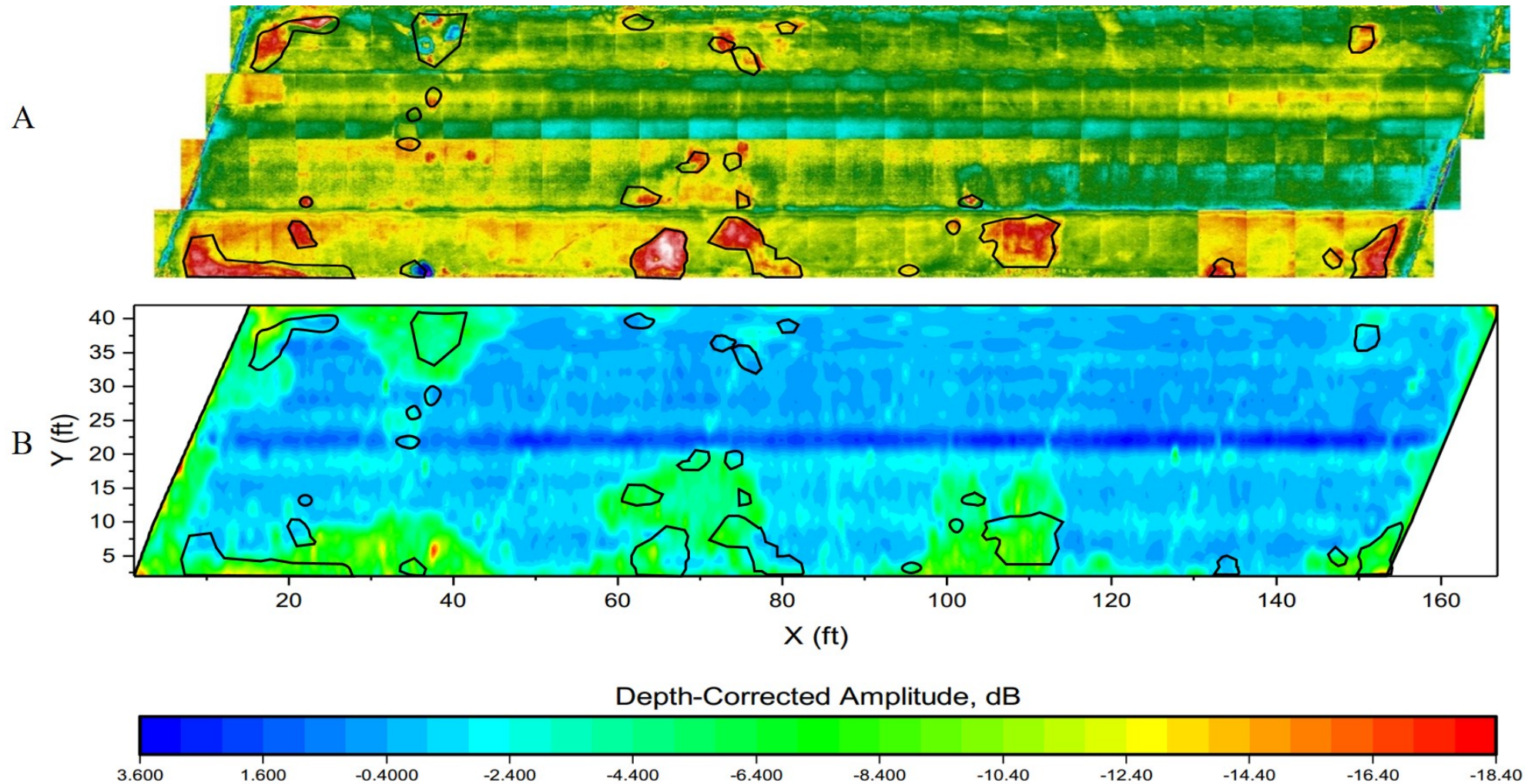
- 8 dB



# Bridge A2111



# Bridge A2112

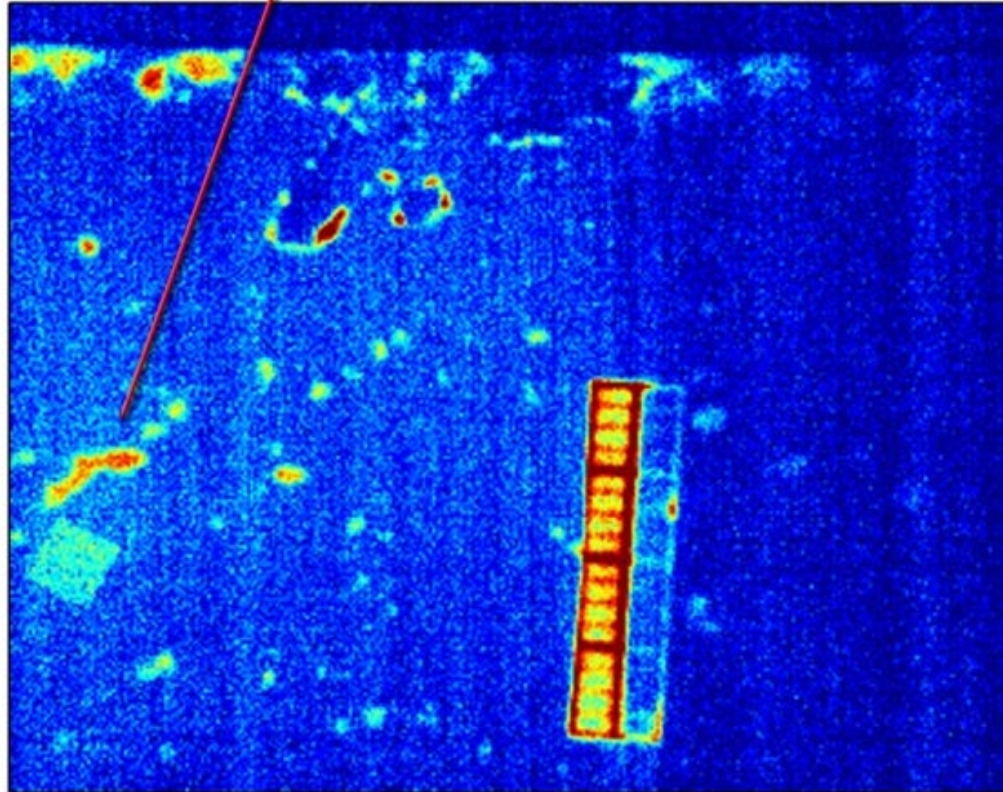




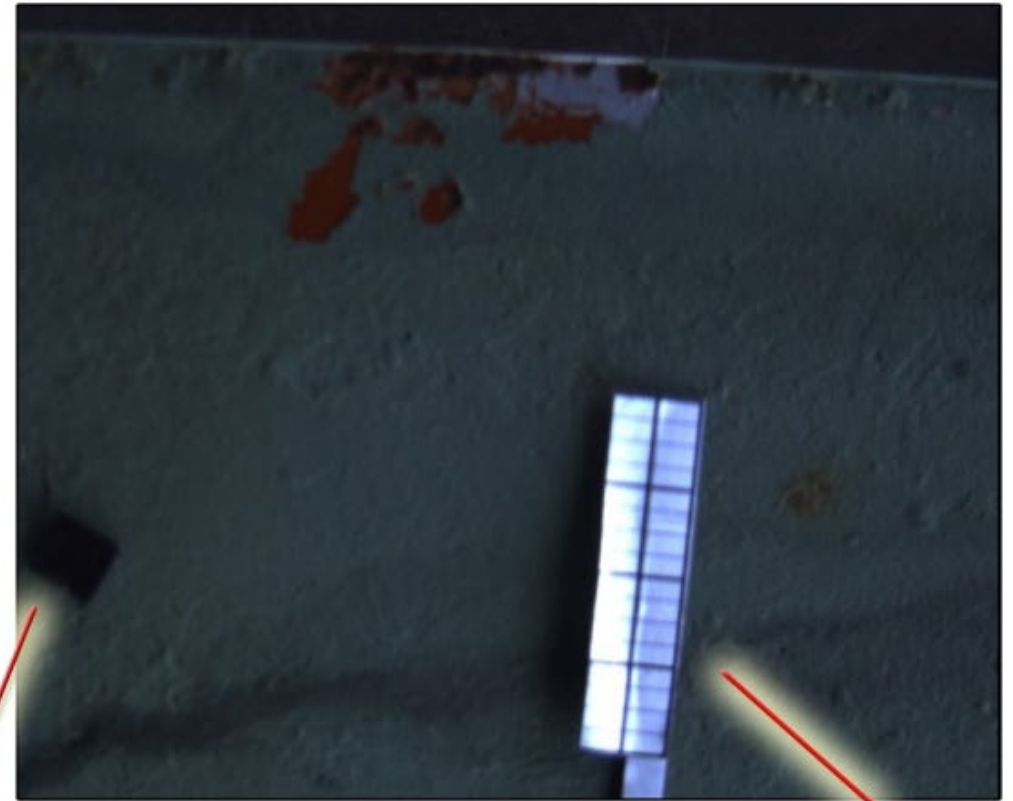
# IR-CIS Over-coating Defects

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*Defect of interest*



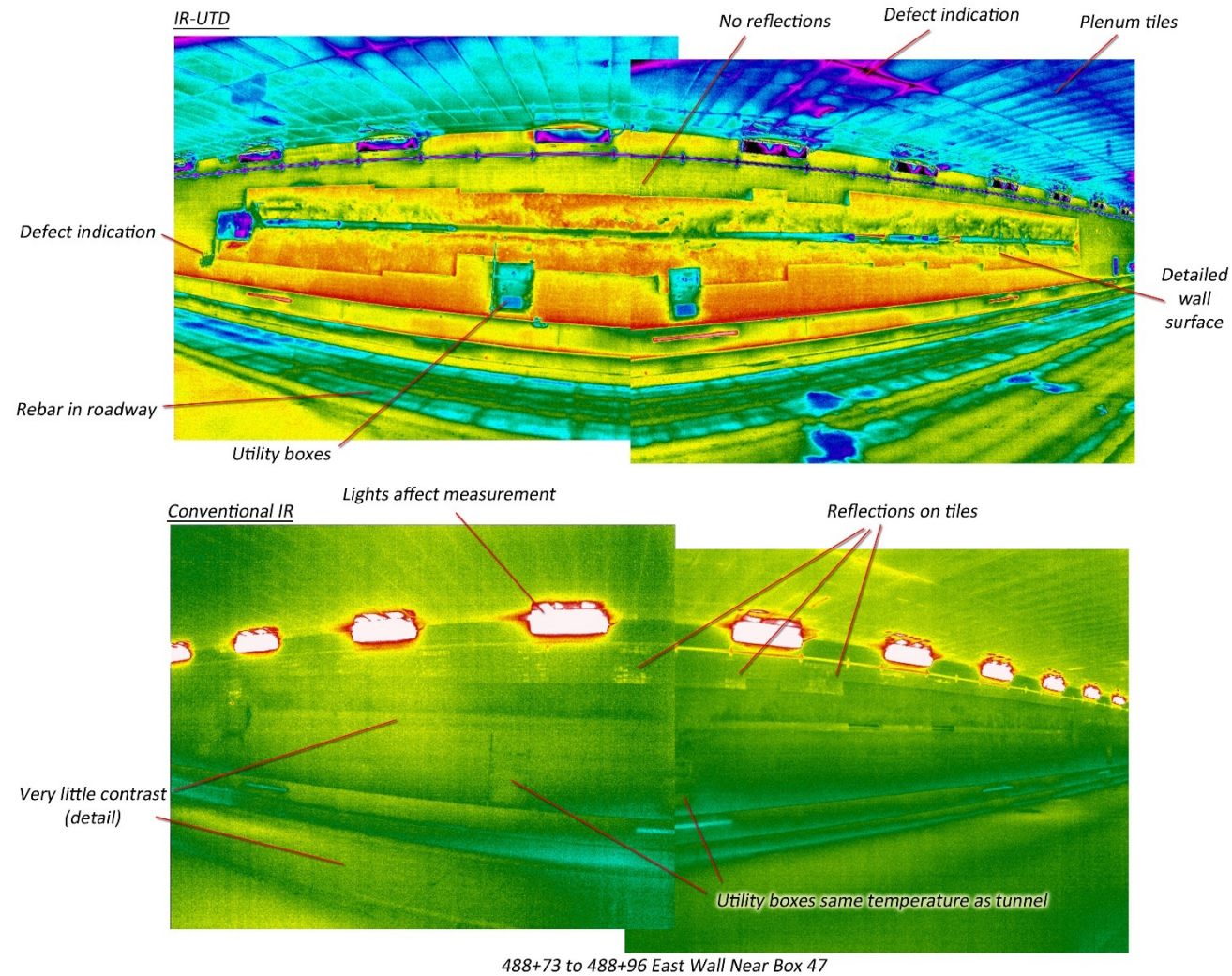
Data Set: 20140721\_16\_01\_39.7



Marker

Marker

# IR-UTD: Baltimore Harbor Tunnel





# IR-TSA

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# *Working with ThermalStare*

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- *Exclusive instrumentation / techniques*
  - *Time-lapse IR measurement of large-scale structures (IR-UTD)*
  - *Coating inspection*
  - *Stress measurement of weld details*
- *ThermalStare can offer*
  - *Services*
  - *Equipment*
  - *Training*
- Direct service provider
- Subcontract service for engineering consultants