



# SHRP2 Advancement in Nondestructive Testing for Tunnel Linings and Concrete Bridge Decks

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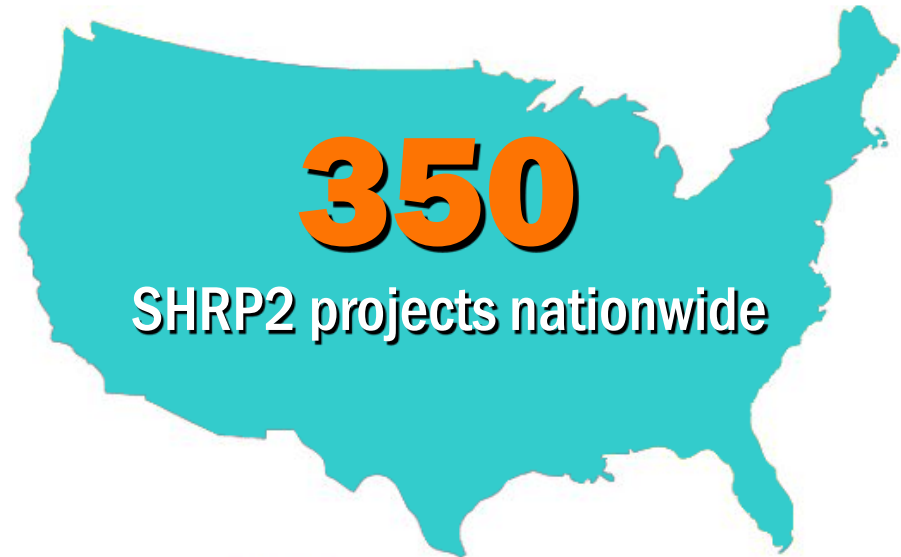
U.S. Department of Transportation  
Federal Highway Administration

AMERICAN ASSOCIATION  
OF STATE HIGHWAY AND  
TRANSPORTATION OFFICIALS

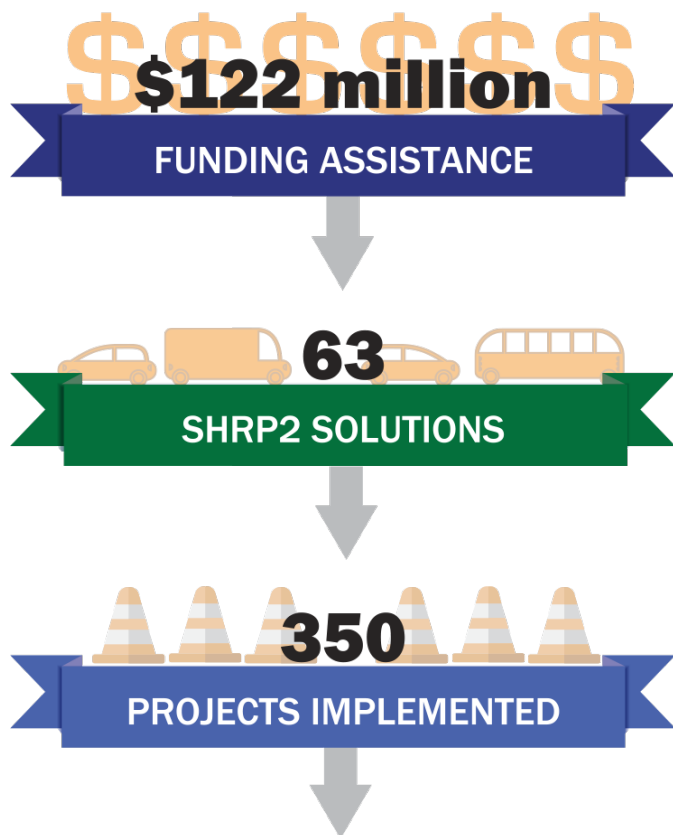
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# SHRP2 at a Glance

- **SHRP2 Solutions** – 63 products
- **Solution Development** – processes, software, testing procedures, and specifications
- **Field Testing** – refined in the field
- **Implementation** – 350 transportation projects; adopt as standard practice
- **SHRP2 Education Connection** – connecting next-generation professionals with next-generation innovations



# SHRP2 Implementation: Moving Us Forward



# Products Deployed in 9 States



-  NDT for Bridge Decks
-  NDT for Tunnel Linings

# Mapping Defects In or Behind Tunnel Linings (R06G)

Use proven high-speed and detailed NDT methods to evaluate tunnel condition as part of an integrated Asset Management program.



# Tunnels in the United States

According to the Federal Highway Administration:

- **473+** highway tunnels in the national inventory (state and federal, including Puerto Rico) spread out across the nation.
- **37 States** have at least 1 tunnel on a highway:
  - California – 64
  - NPS – 64
  - Colorado – 38



Photos courtesy of Wikipedia

# Tunnel Evaluation

- New Tunnel Inspection Requirements are now in place for all DOT tunnels across the country with the **National Tunnel Inspection Standard (NTIS)**.
- Clear inspection and reporting requirements, with new needs for high-speed inspection.



The screenshot displays the Federal Register website for a proposed rule. At the top left is the Federal Register logo and the text "FEDERAL REGISTER The Daily Journal of the United States Government". A blue bar highlights "Proposed Rule". The main title is "National Tunnel Inspection Standards", with a subtitle "A Proposed Rule by the Federal Highway Administration on 07/30/2013". Below the title, there are sections for "ACTION" (Supplemental Notice Of Proposed Rulemaking (Snprm).) and "SUMMARY" (The FHWA is proposing the National Tunnel Inspection Standards (NTIS) for highway tunnels. The FHWA previously proposed the NTIS in a notice of proposed rulemaking (NPRM) published in the Federal Register). On the right side, there are social media icons, a "LEGAL DISCLAIMER" button, and "Font Controls" with plus, minus, and text size icons.

# High-Speed Mapping of Defects In or Behind Tunnel Linings (R06G)

## Challenge

- Safely performing tunnel inspections in a high-traffic and confined work space.

## Solution

- Use proven NDT scanning technologies to evaluate tunnel linings more quickly and comprehensively.
- Results then directly coupled with an integrated asset management program.



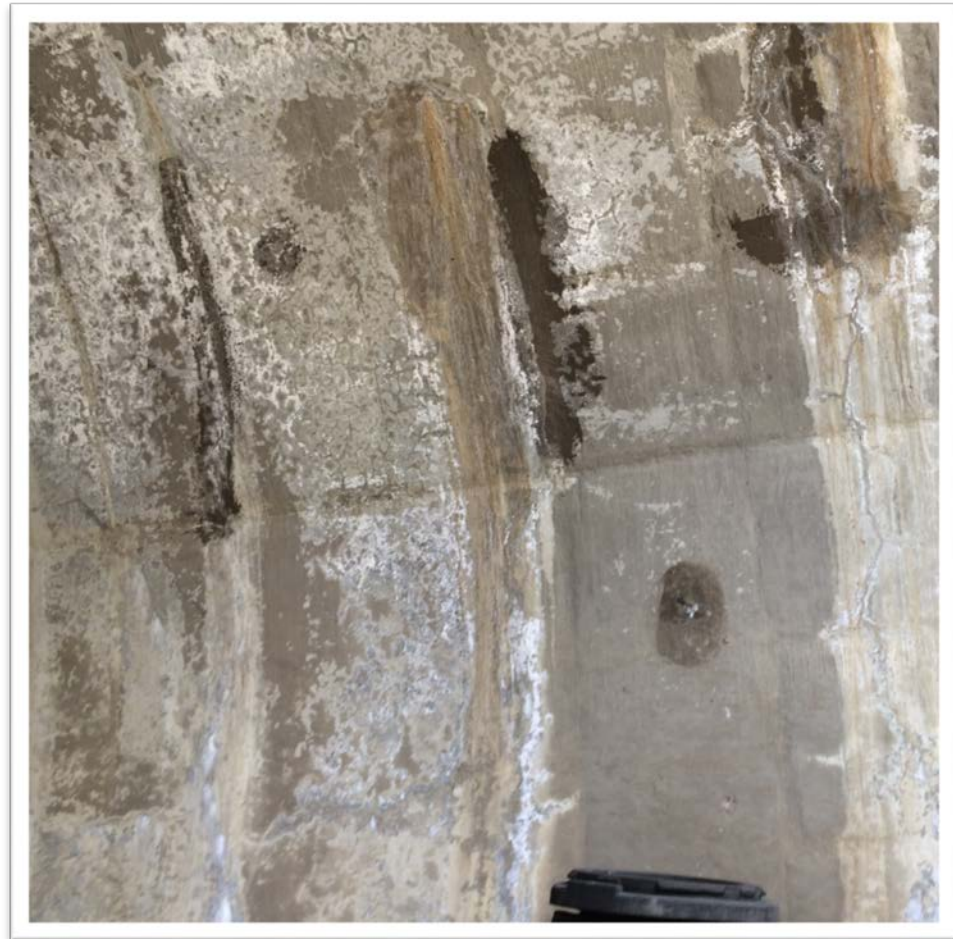


# Tunnel Deterioration Overview

Tunnel deterioration is a major maintenance problem for highway departments.

## Issues for Tunnel Liners:

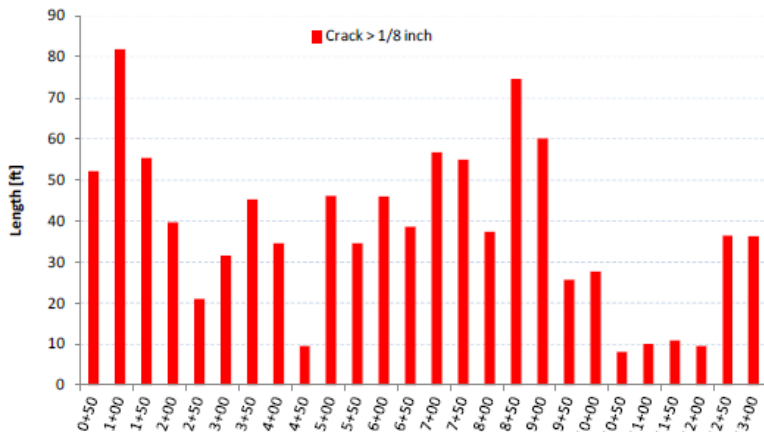
- Corrosion of reinforcing steel
- Moisture intrusion
- Debonding/delamination of shotcrete and tile
- Drainage system failure
- Cracking of concrete
- Deformations and bulges



# Current SHRP2 Implementation: Pennsylvania and Colorado DOT



Penetrator GPR of PennDOT Tunnel



Distribution of Cracks Greater Than 1/8"  
Armstrong Tunnel

- Initial training on NDT methods completed.
- Field testing of two PennDOT tunnels completed using various scanning methods.
- Testing reports due shortly for review.
- Tunnel-specific asset management programs created – and available for sharing with other states.

# Previously Evaluated and Proven NDT Technologies

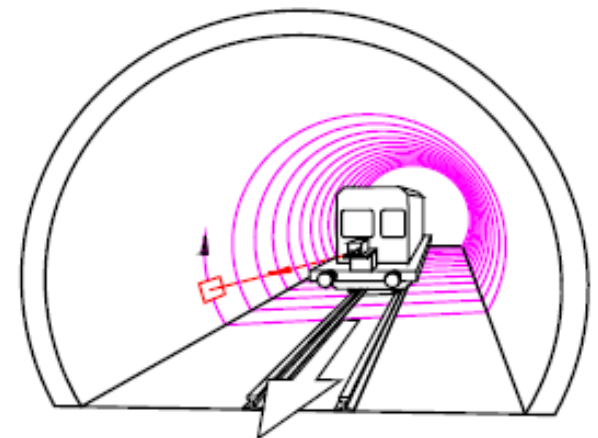
## Techniques Used:

- Air-coupled ground-penetrating radar (GPR)
- Thermography (handheld or vehicle mounted thermal camera)
- LiDAR scanning
- Photogrammetry
- Ground-coupled GPR
- Ultrasonic echo
- Ultrasonic surface waves and impact echo

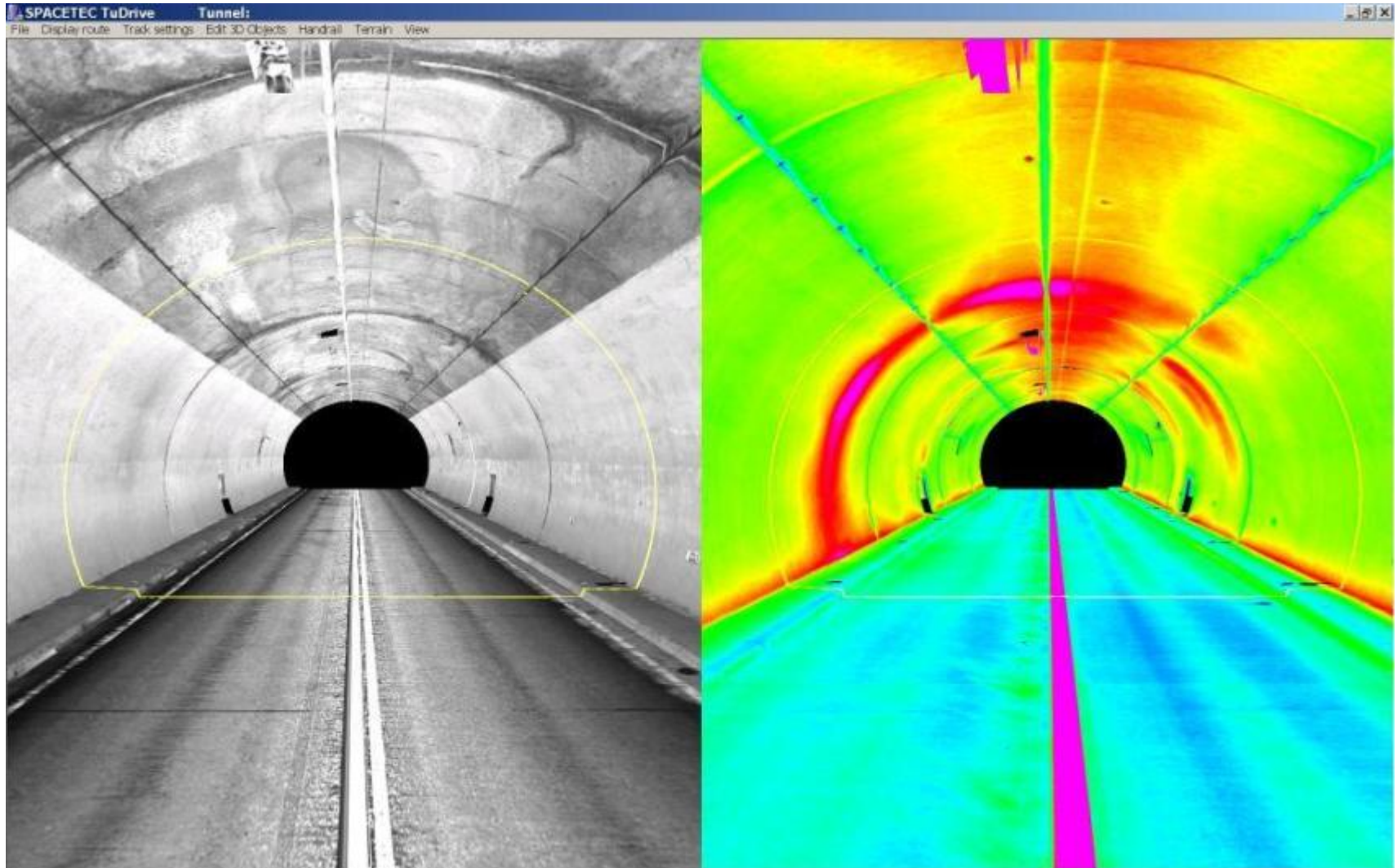


# Benefits of NDT Technologies

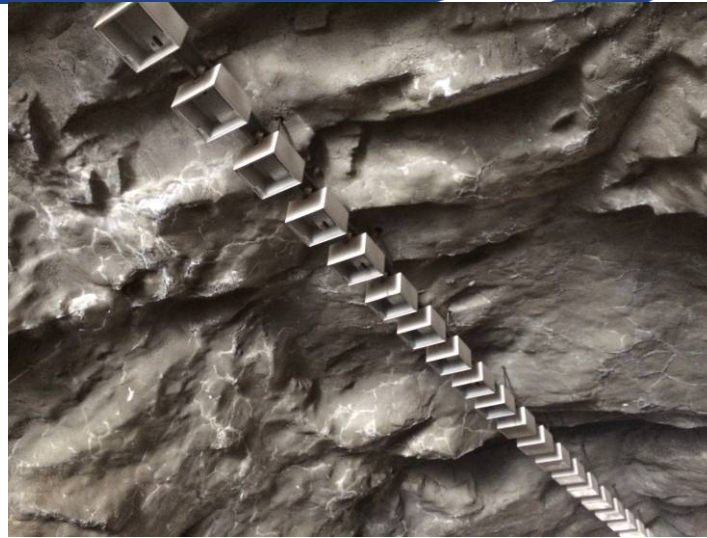
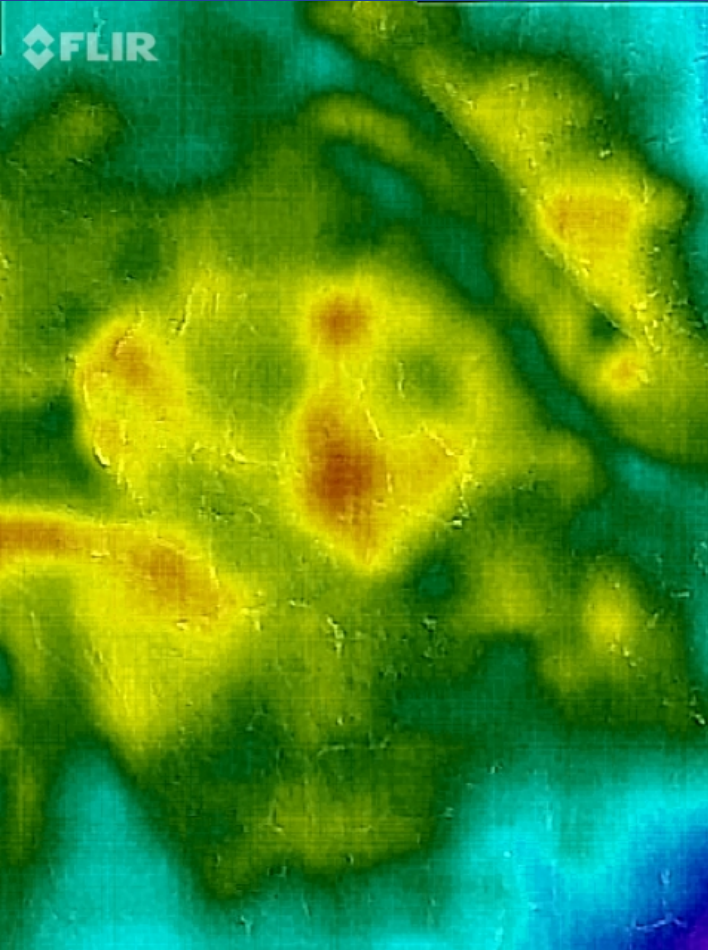
- Shorter and possibly fewer tunnel shutdowns during inspections, resulting in fewer detours.
- Safer for inspectors.
- Scanning tests provide 100% coverage.
  - LiDAR and Photogrammetry
  - Air Coupled GPR
  - Scanning Infrared
- Handheld devices to test areas in depth.



# LiDAR and Infrared Scanning Examples



# Hand-Held IR Example



Shotcrete Lined Tunnel



FLIR 1 IR  
Camera

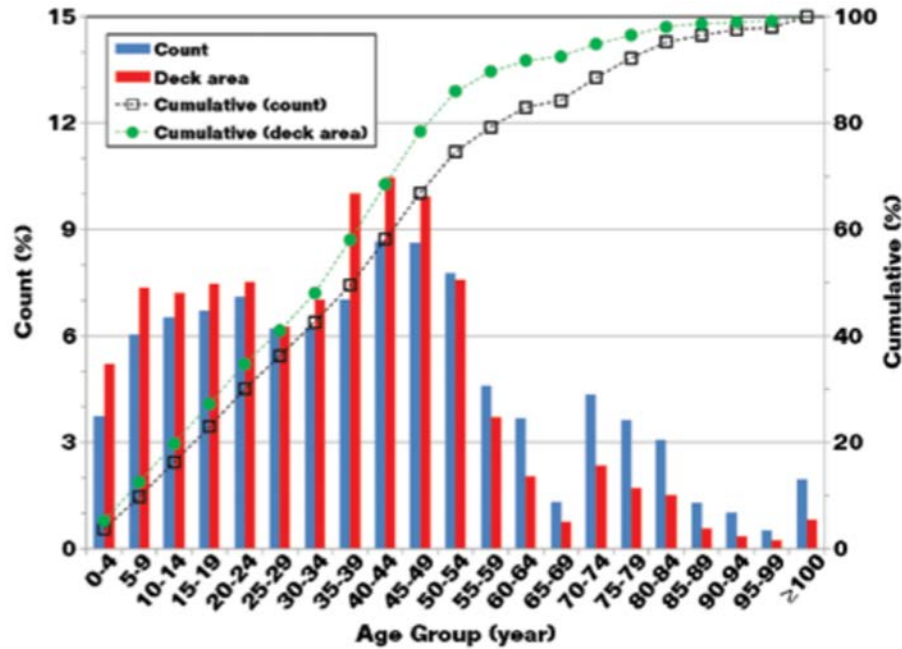
IR Image of Debonded Shotcrete (debonds in red)

# Nondestructive Testing of Concrete Bridge Decks

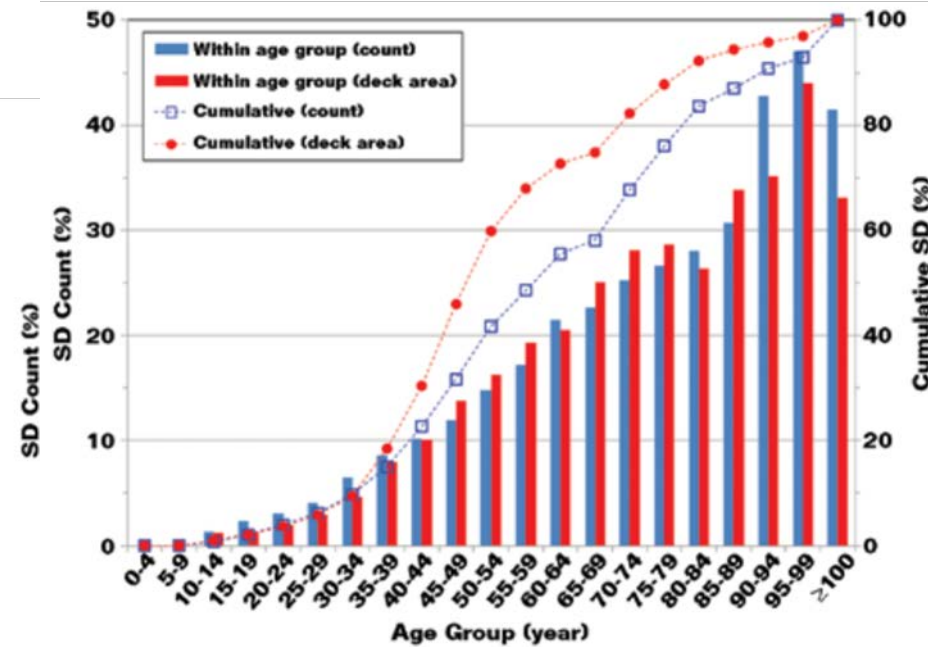


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# Problems



Distribution of the total bridges by age (2010 NBI data)

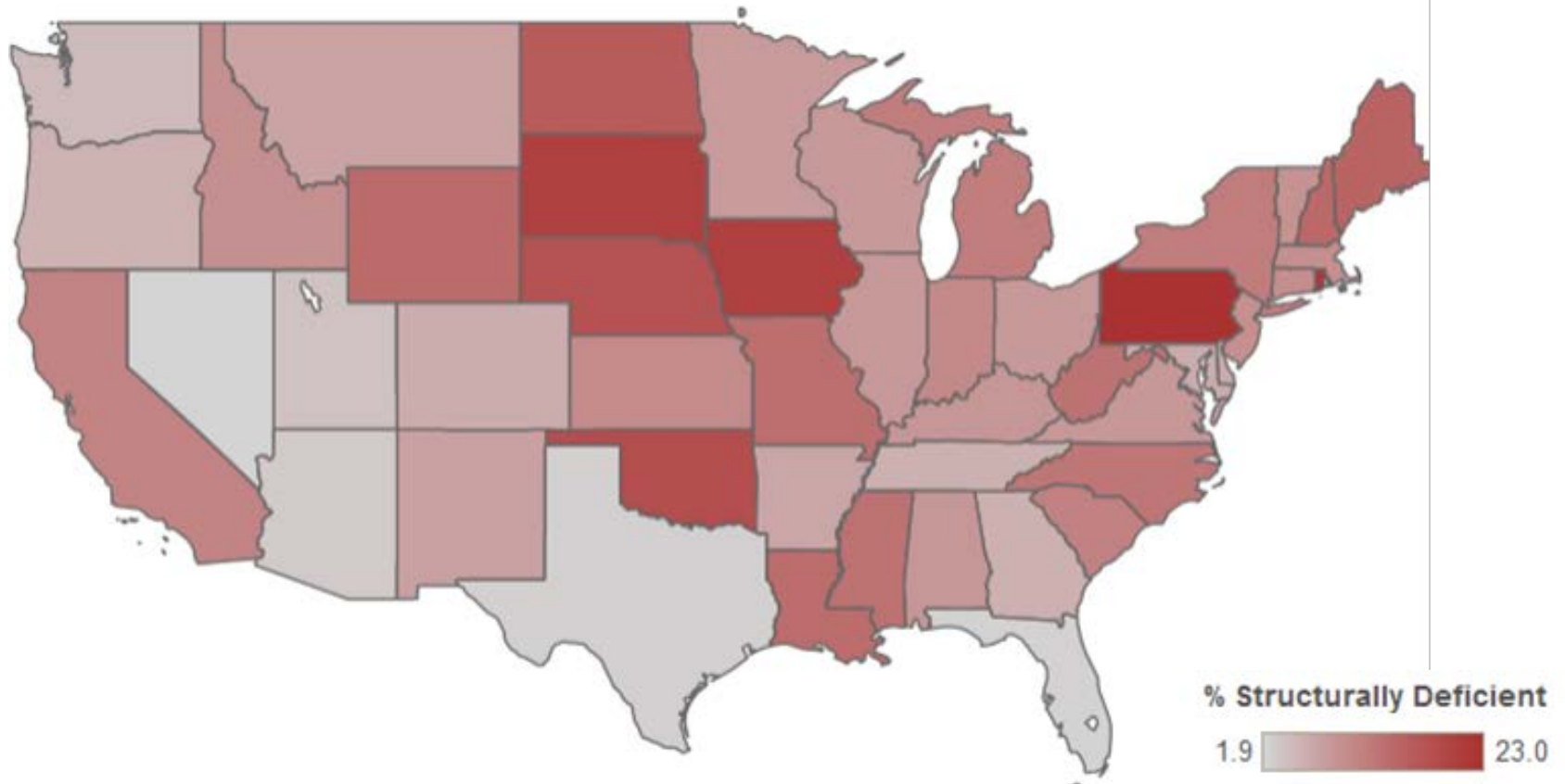


Structural deficient bridges by age (2010 NBI data)



# Bridge Deterioration

2013 State Bridge Condition Ratings



# R06A Challenge: State of Practice



# Challenge: Evaluating the Full Range of Deterioration Types



## Deterioration of Interest

- Delamination
- Corrosion
- Vertical cracking
- Degradation

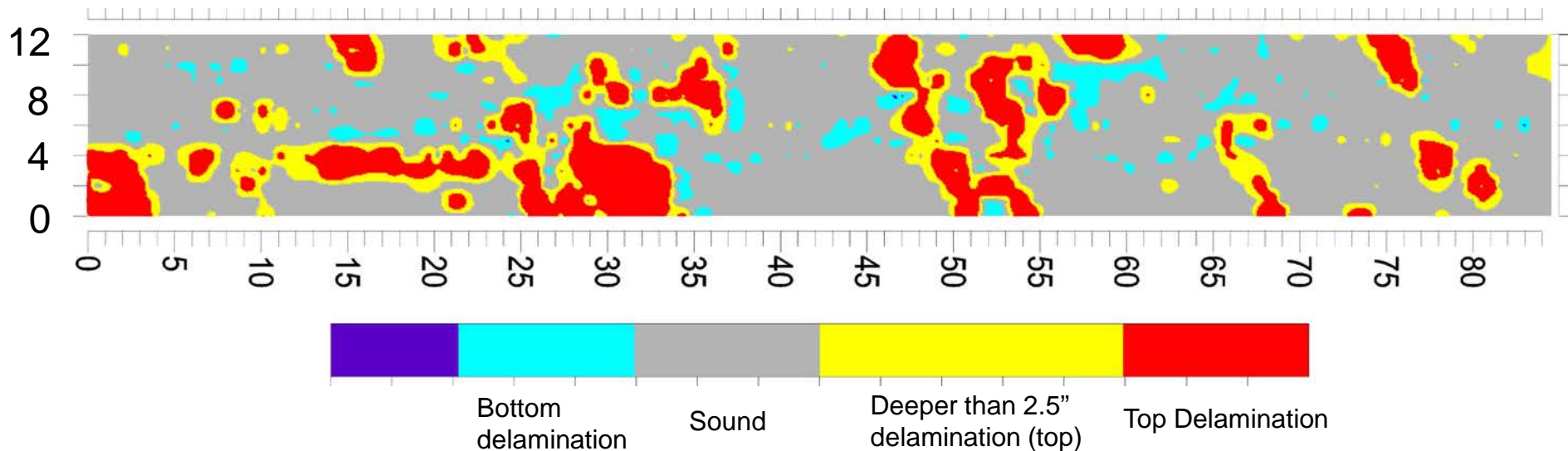
# NDT Technologies

NDT Technique	Mode of Deterioration Detected	System	Resolution	Lane Closure
IE	1) Deeper cracks - top and bottom rebar mat 2) Shallow delamination 3) Concrete degradation - ASR/DEF - Freeze thaw	1) Scanning	High	Yes
		2) Point by Point	Grid size	Yes
GPR	1) Corrosion 2) Cracks (if filled with deicing salt) 3) Concrete degradation	1) Air coupled	Lower	No
		2) Ground coupled	High	Yes
IR	Shallow delamination - Top and bottom	1) Truck mounted	High	No
		2) Handheld	High	Yes
Resistivity	Corrosion	Point by Point	Grid size	Yes
Half Cell/GP	Corrosion	Point by Point	Grid size	Yes
Slab IR	Cracks	Point by Point	Grid size	Yes
SASW	1) Vertical cracks 2) Concrete degradation	1) Scanning	High	Yes
		2) Point by point	Grid size	Yes

**Vs.**

Sounding	Only shallow delamination	Manual		Yes
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# Example Deliverable from NDT



Areas with Probable Top Delaminations = 14%

Areas with Probable Incipient (Deeper) Top Delaminations = 13%

Areas with Probable Bottom Delaminations (or Thin Section) = 5.7%

# Classroom Training and Field Demonstration



# State Directions



State DOT	Technologies Interested	Direction	Status
Indiana	GPR/IR	Hire Consultants	Completed the selection process. AECComm and Resource International, Inc. won the on call project. Issued the P.O to Resource International and ready to start the field test anytime now.
Virginia	GPR	Hire Consultants	Developing the RFP.
Louisiana	GPR	Hire Consultants	Developing the RFP.
Oregon	GPR/IE/IR	Hire Consultants	Developing the RFP.
Iowa	IE	Purchase Equipment	Developing the specifications.
Pennsylvania	GPR/IR	Purchase Equipment	Purchased 2 cellphone IR camera (Seek Thermal and Flir). Evaluating both cameras. Planning to deploy 2 units for each of 11 districts. Looking for quotes for a GPR system.
Florida	IR	Purchase Equipment	Purchased IR cameras (Flir). Completed the training for the personnel. Ready for the field test.
Missouri	Resistivity	In house resources	Developing field program

# Assistance Opportunities

Round 7 IAP April 1 <sup>st</sup> to 29 <sup>th</sup>	User Incentive
Nondestructive Testing for Concrete Bridge Decks (R06A)	8 available Up to \$30,000 each
Nondestructive Testing for Tunnel Linings (R06G)	8 available Up to \$30,000 each

**Who can apply:** State DOTs, MPOs, local and tribal agencies. Local agencies must coordinate application submittals with their state DOTs.



# For More Information

## Product Leads:

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## Additional Resources:

**SHRP2**

**Websites:**

[fhwa.dot.gov/GoSHRP2](http://fhwa.dot.gov/GoSHRP2)

<http://shrp2.transportation.org>

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