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Bridge Inspection And Evaluation: Current Status And Where We Are Heading?

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Learning Objectives and Outline

- Get an idea of current highway bridge population in the United States and history of bridge inspections
- Learn how highway bridges are visually inspected at present following federal standards
- Understand changes to current expectations from bridge inspection process to accommodate bridge management perspective
- Identify upcoming changes to federal inspection standards
- Comprehend how NDE and structural monitoring is being used to augment visual inspections

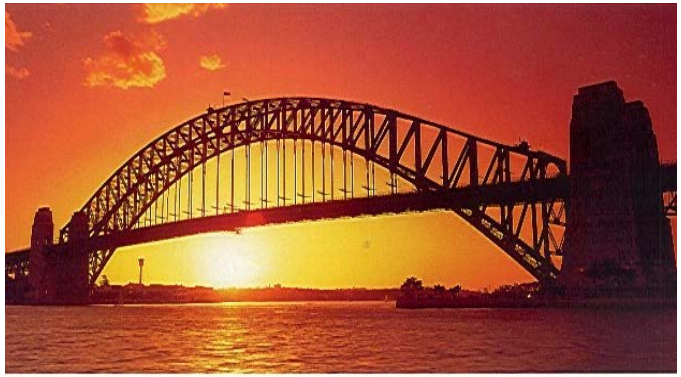
Pay Attention to Green Highlighted Items

What is a bridge?

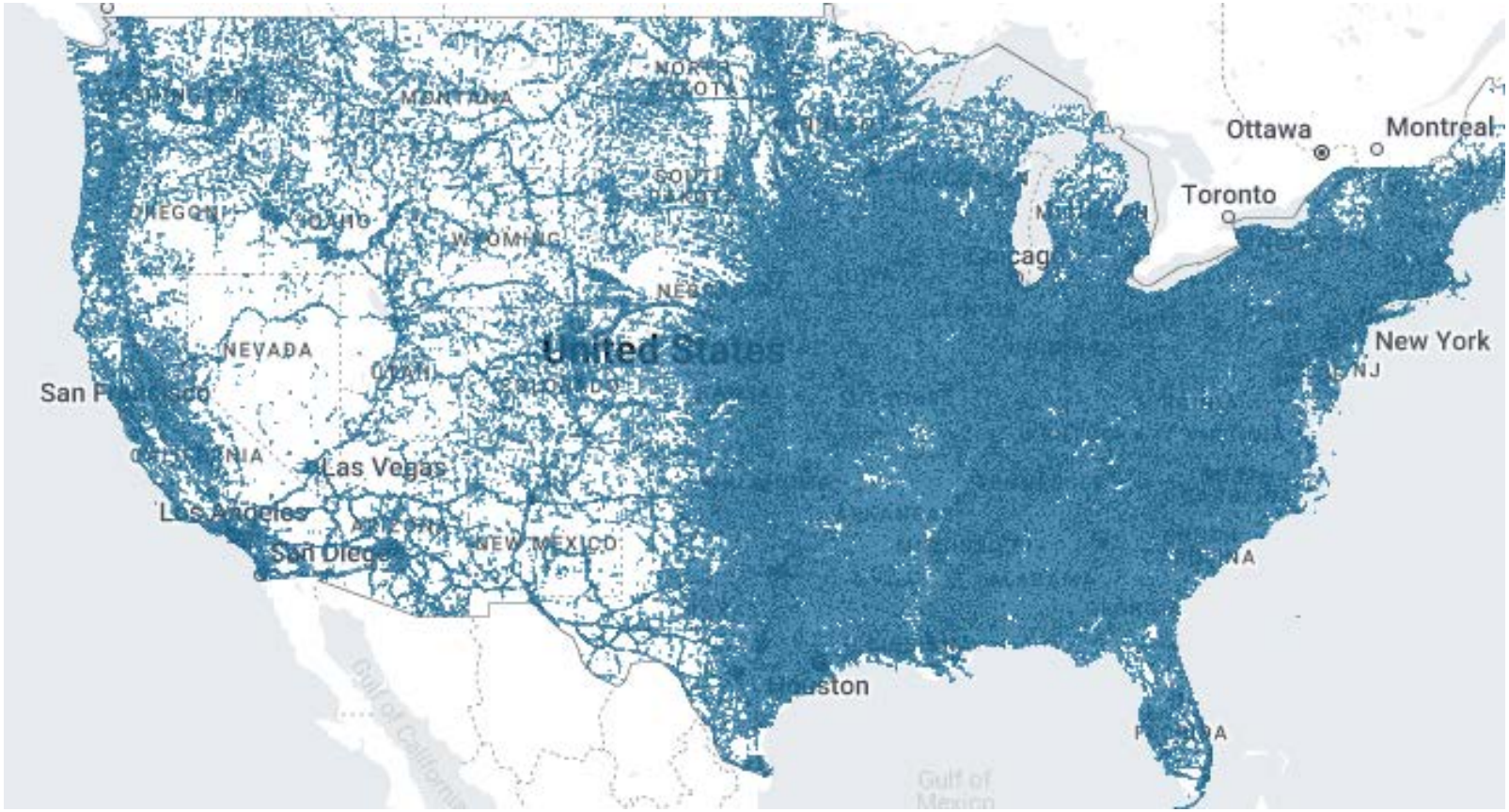
- It must be over a depression or an obstruction, such as water or a highway

- It must carry traffic and have an opening (span) of more than ***20 feet***

Typical Bridges



US Highway Bridge Population

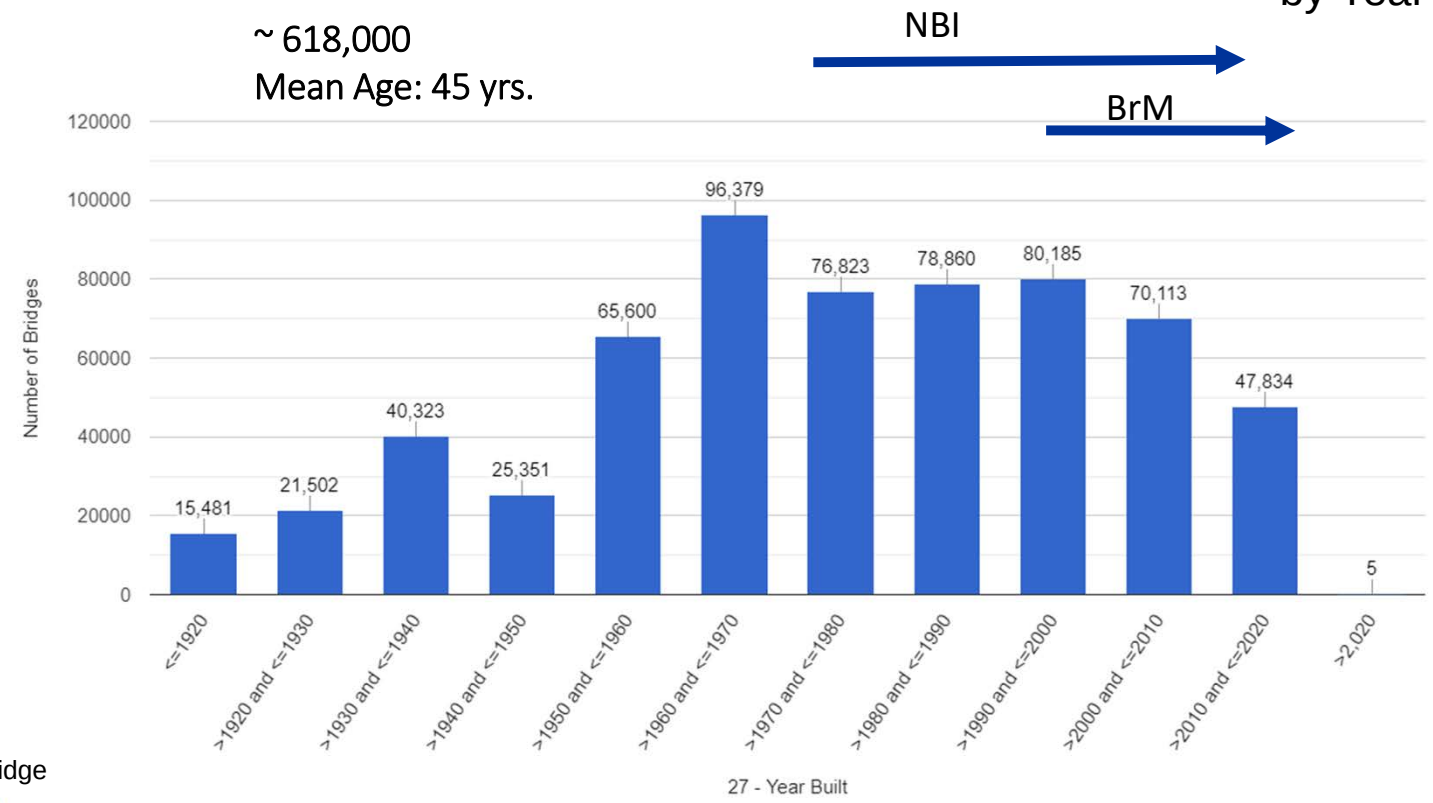


Source: FHWA InfoBridge

US Highway Bridge Population

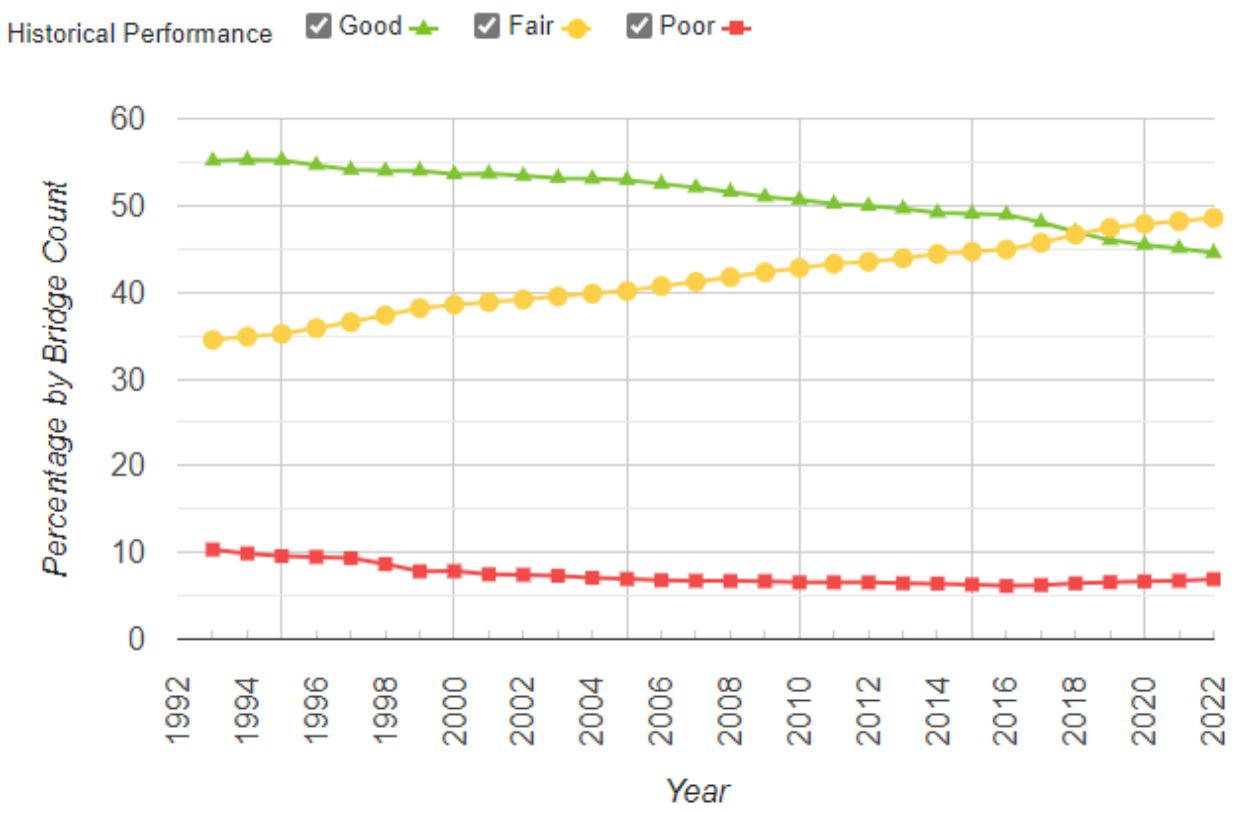
Highway Bridges
by Year Built

~ 618,000
Mean Age: 45 yrs.



Source: FHWA InfoBridge

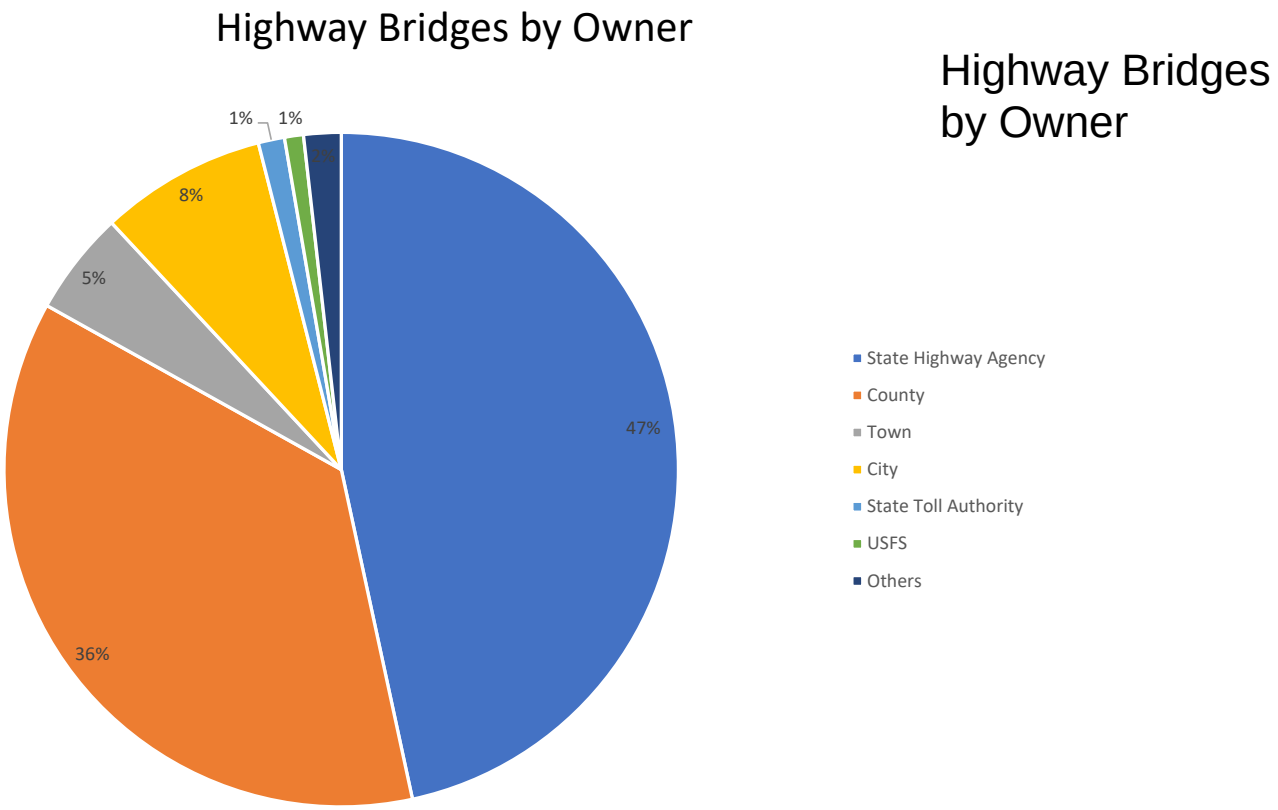
US Highway Bridge Population



Highway Bridges by Condition

Source: FHWA InfoBridge

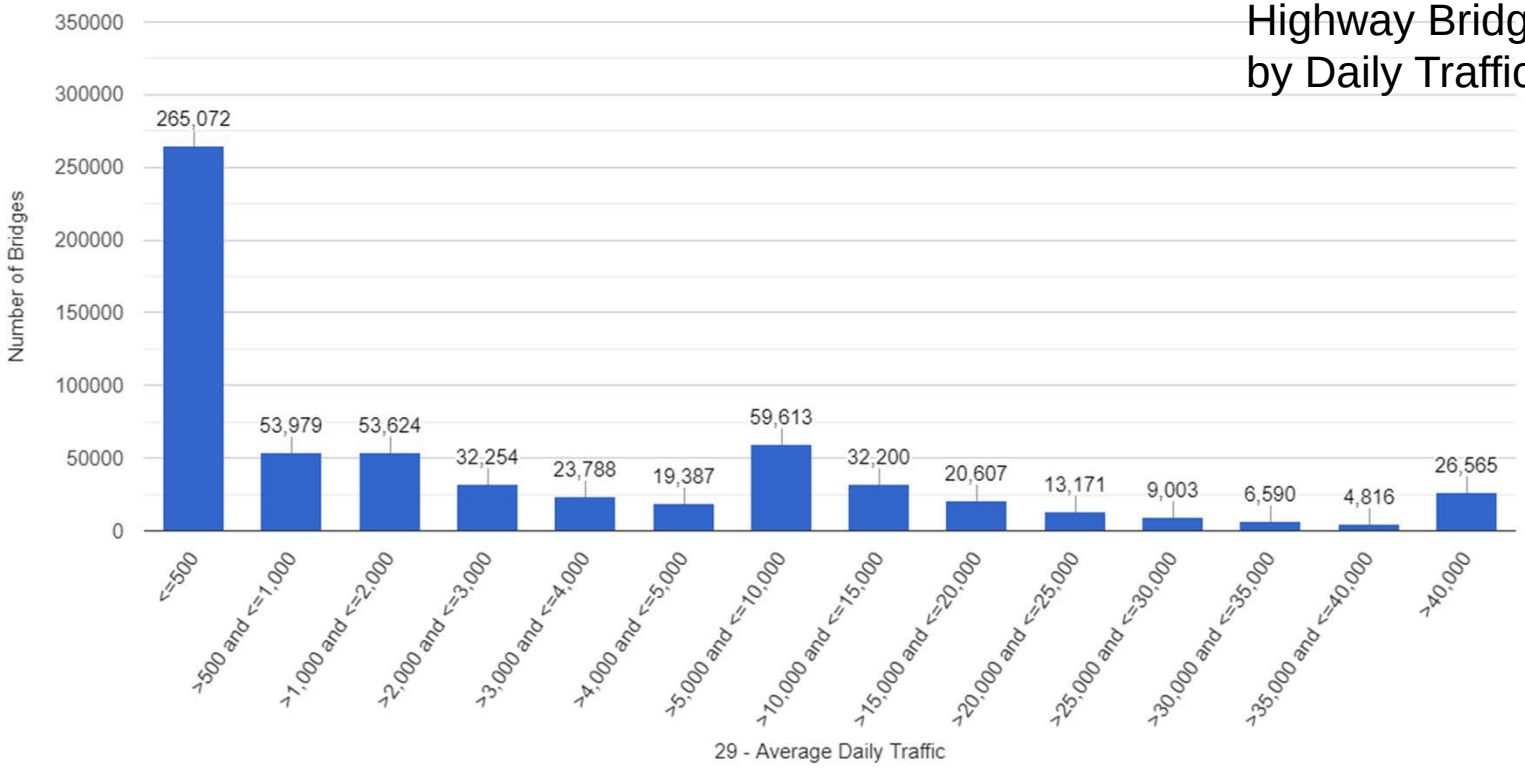
US Highway Bridge Population



Source: FHWA InfoBridge

US Highway Bridge Population

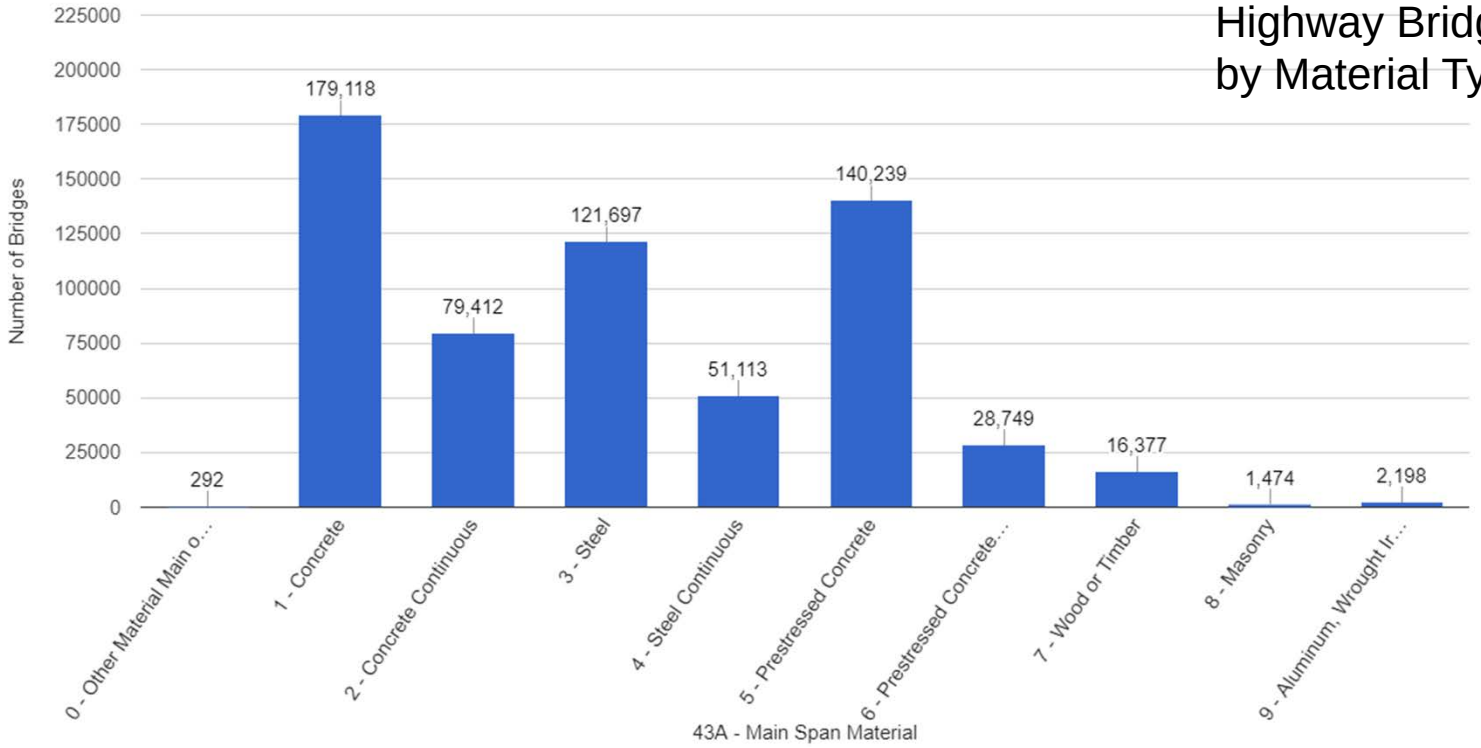
Highway Bridges
by Daily Traffic



Source: FHWA InfoBridge

US Highway Bridge Population

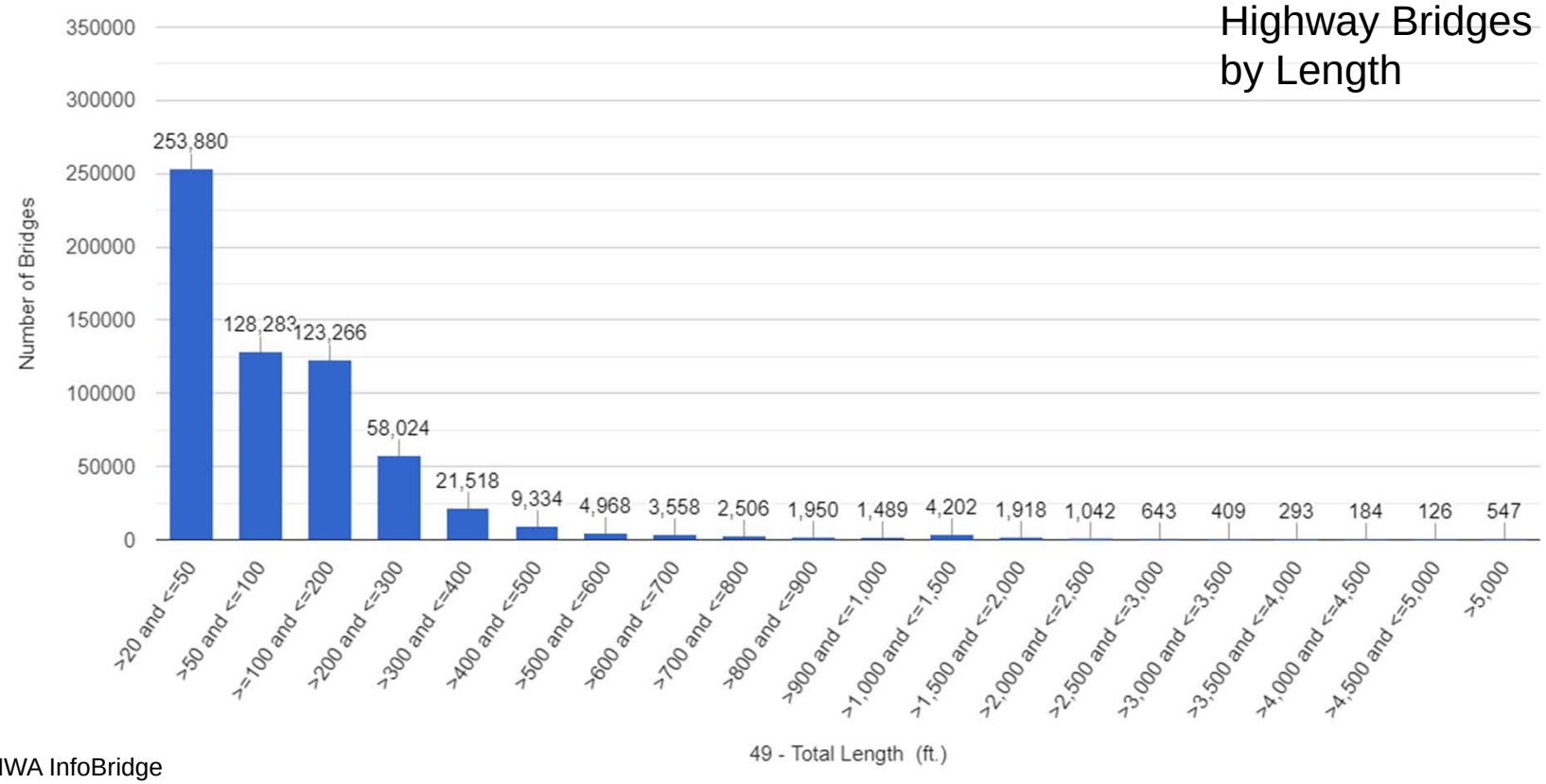
Highway Bridges
by Material Type



Source: FHWA InfoBridge

US Highway Bridge Population

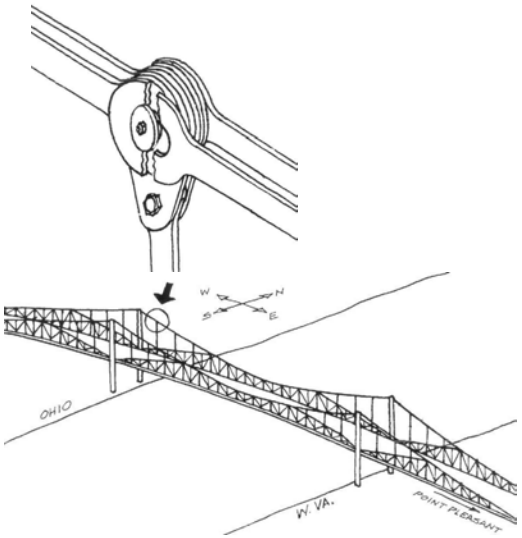
Highway Bridges by Length



Source: FHWA InfoBridge

Bridge Inspection History

- 1916 Act: Federal Aid to Highways
  - Inspections of highway structures was part of maintenance work by states and others
  - More detailed program under Public Roads Administration during 1930-40s
- Inspection guidelines vary from state to state, and owner to owner
- Personnel experience and consistency varied significantly
- 1967: Ohio River (Silver) Bridge Collapse
  - President Johnson formed a task force charged to determine procedures available to preclude future disasters and implement changes, if needed



Bridge Inspection History

- 1968 Act: Required establishment of NBIS
  - Limited to Federal-aid Highway System
  - Inspection Frequencies
  - Inspector Qualifications
- 1970
  - AASHTO Manual for Maintenance Inspection of Bridges
  - FHWA Bridge Inspectors Training Manual
  - 1970 Act: Establishment of NATIONAL Bridge Inspection Standards (NBIS) in 1971
    - A licensed engineer to manage the program in each organization
    - 2-Year inspection cycle
    - Reporting requirements and ratings including Sufficiency Rating
    - Various inspection types
- Late 1970s
  - Dedicated bridge funding to address unsafe bridges and inspection of non-federal aid system bridges

Bridge Inspection History

- NBIS revised several times attributed to major failures
  - Mianus River Bridge Collapse ➔ Fracture critical inspections with max 2-year cycle
  - Schoharie Creek Bridge Collapse ➔ Underwater Inspections
- Major Revisions in 2004
  - Critical findings
  - QC/QA
  - Refresher Training
- Minnesota Bridge Collapse in 2007
  - FHWA recommended use of NDE to assess gusset plate condition

Current Inspections

- Mostly visual
- Every state DOT should have a Program Manager with a PE license
- All bridges must be inspected at least every 24 months – not to exceed 48 months
- Under water inspections every 60 months – not to exceed 72 months
- Critical findings and follow-up actions
- Complex bridges need bridge specific inspection guidelines
- QC/QA
- Comprehensive Bridge Inspection Training for all team leaders and divers
- Refresher Training
- Load Rating following Bridge Inspection

Current Inspections

Wearing surface/Deck

Primary members

Pedestals and bearings

Columns

Wing walls

Paint

Current Inspections

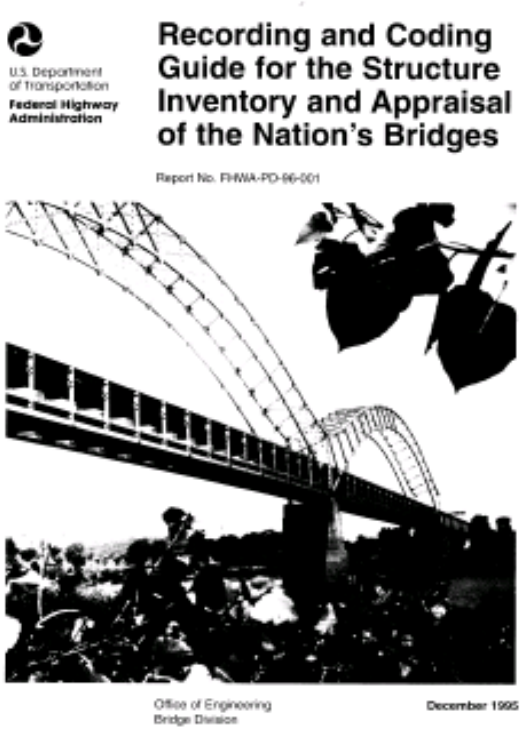
- What do inspectors do?
  - Sight
  - Sound
  - Touch
- Evaluate entire structure to as-built condition
- Note structural deficiencies
- Note safety related issues
- Rate five components, indicative of entire structure, not for localized deterioration
- Collect data to estimate structure capacity to safely carry loads the bridge carries
- Collect or verify bridge inventory

Current Inspections

- Deck
- Super structure
- Substructure
- Culvert
- Channel and channel protection

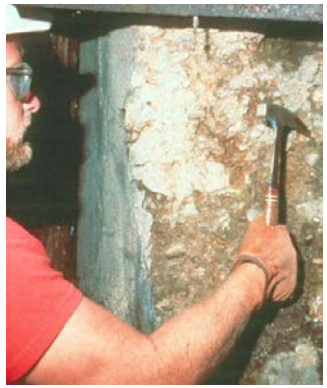
FEDERAL RATING SCALE

9 - EXCELLENT CONDITION
8 - VERY GOOD CONDITION
7 - GOOD CONDITION
6 - SATISFACTORY CONDITION
5 - FAIR CONDITION
4 - POOR CONDITION
3 - SERIOUS CONDITION
2 - CRITICAL CONDITION
1 - "IMMINENT" FAILURE CONDITION
0 - FAILED CONDITION



Current Inspections

- Inspection Types
  - Initial Inspection
  - Routine Inspection
  - In-Depth Inspection
  - Special Inspection
  - Damage Inspection
- Tools
  - Cleaning Tools
  - Inspection Tools
  - Visual Aid Tools
  - Measuring Tools
  - Documentation Tools
  - Access Tools
- NDE
  - Magnetic Particle
  - Liquid Penetrating Test
  - D-Meter
- Special Investigation
  - Ultrasonic Testing
  - Impact Echo
  - …..



Uses of Bridge Inspection Data

- Assuring Safety of Traveling Public and Structure
  - Critical Findings (Structural and Safety related)
  - Emergency Repairs
  - Postings and Closings
- Maintaining Current Bridge Data
- Bridge Management
  - Planning future projects
  - Permitting operations
  - Post-event assessment

Bridge Management Philosophy

- Bridge Management THEN
  - Safety
  - Security

- Bridge Management NOW
  - Mobility
  - Reliability
  - Economic Competitiveness
  - Environmental Consciousness
  - Life-cycle Costs

Reactive to Proactive

- Requires
  - Proactive approach to detect damage
  - Preservation focus
  - Less or no traffic interruptions
  - Quantitative data driven decision making

Changes to NBIS

- Moving reactive to proactive asset management requires more data.

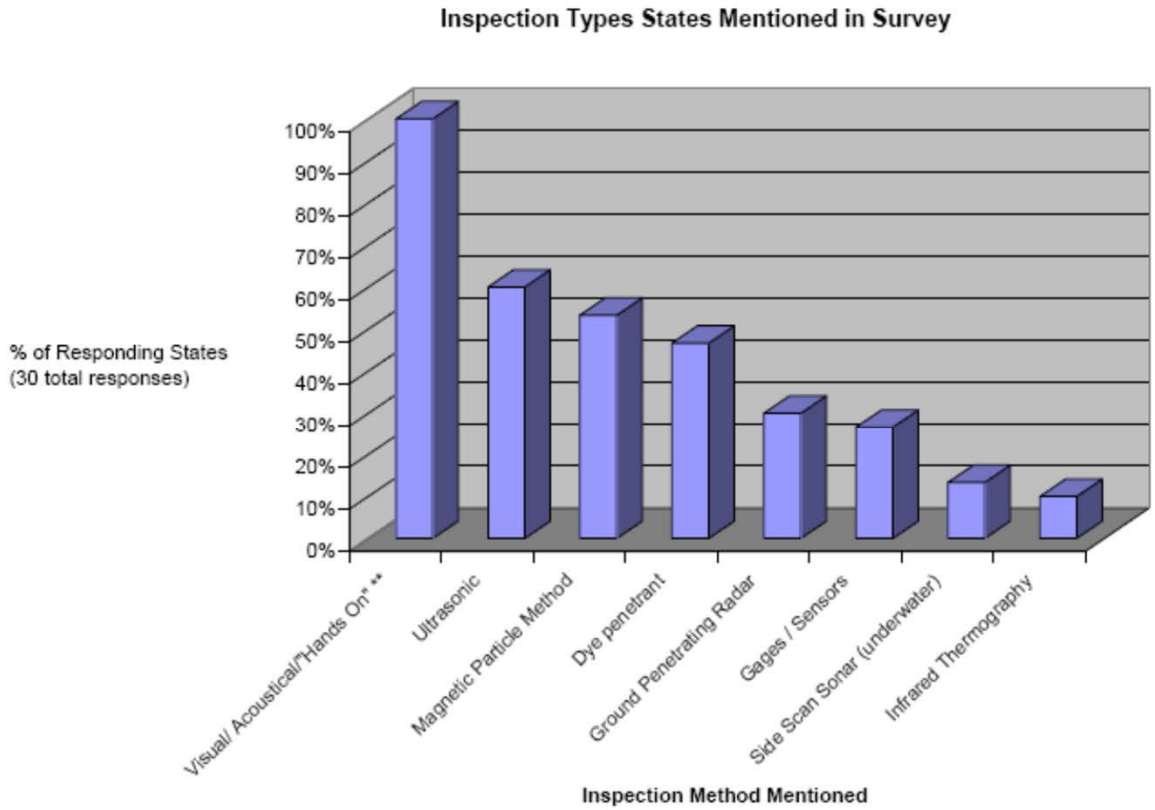
- NBIS 2014 Changes
  - Element level data collection (since 2014)
  - Four condition states
  - Element quantity in each condition rating
  - Data to accommodate planning needs

Condition State	1 (Good)	2 (Fair)	3 (Poor)	4 (Severe)
RC Deck (sq. ft.)	6000 (60%)	1500 (15%)	2000 (20%)	500 (5%)
Pot Bearings (each)	9 (45%)	5 (25%)	4 (20%)	2 (10%)
Steel Girder (ft.)	500 (50%)	100 (10%)	300 (30%)	200 (20%)

Changes to NBIS

- NBIS 2022 Changes
  - Specifications for National Bridge Inventory
  - Expansion of component level ratings
  - Risk-based, data driven, performance management program
  - Risk-based management
  - NDE Data

What Methods are Bridge Engineers using Now?

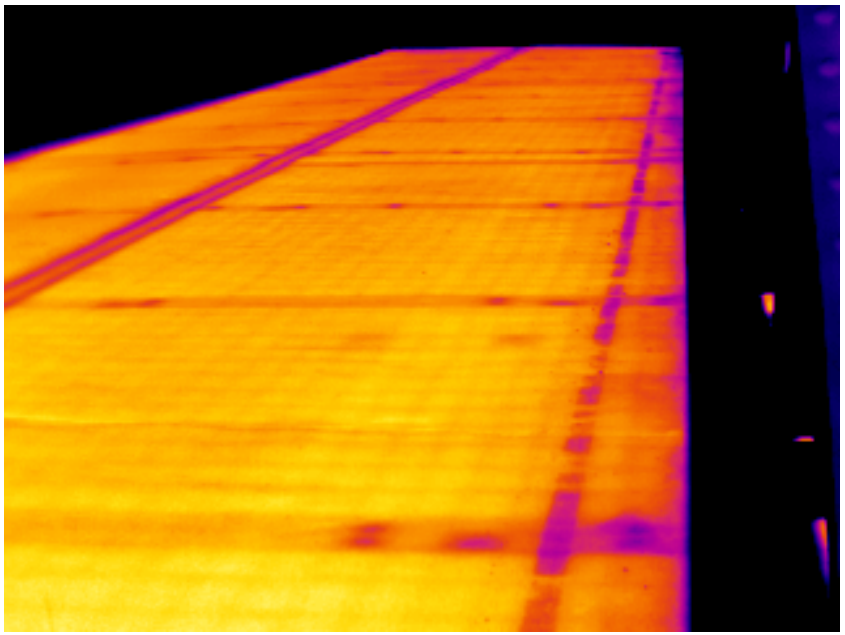


Courtesy: Kelley Rehm

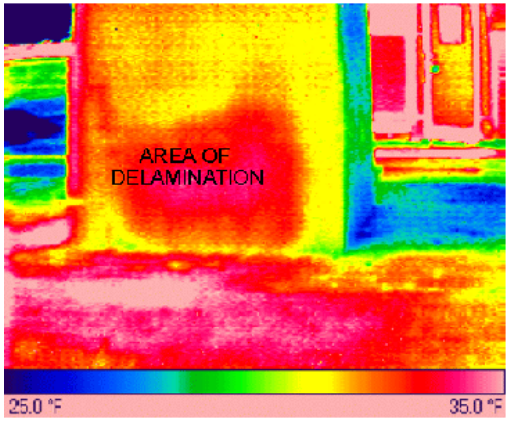
** -acoustical includes chain drag and hammer sounding
-"hands on" includes the use of snooper trucks, measurement calipers, digital cameras, etc.

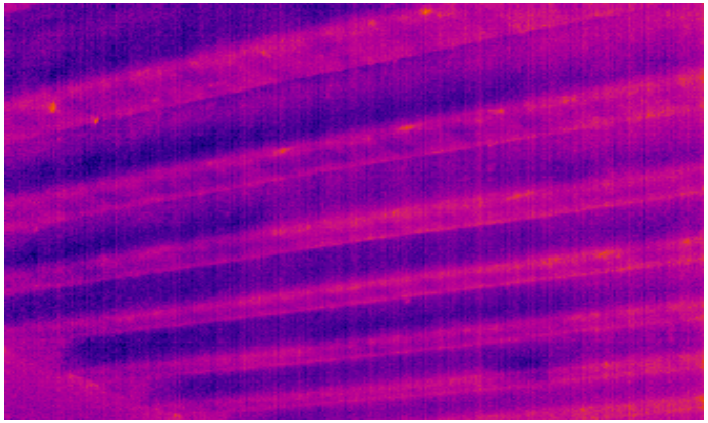
How Can NDE HELP?

- QC/QA and baseline data during initial inspection
  - Material/Construction quality
  - Defect free components
- Preventive Maintenance
  - Get data before VT can detect damage
  - Deck delamination
  - Chloride ingress causing corrosion
- Long-Term Planning
  - Rehabilitation/Replacement Prioritization
  - Research on New Materials and Details Durability



How Can NDE HELP?





How Can NDE HELP?

SGS Eddy Current based Crack Monitoring Sensor and LVDT

A Truss Bridge in Forest Port, NY

Where are we heading?

Ground Penetrating Radar

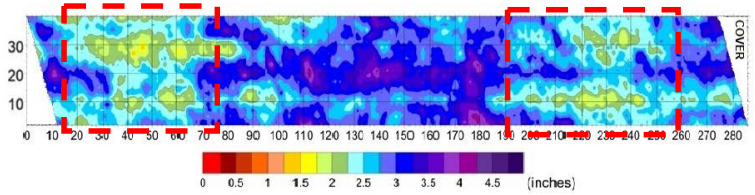
Courtesy: Stantec

Impact Echo

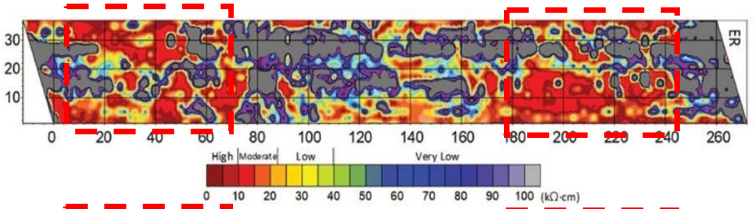
Courtesy: Infrasense

Where are we heading?

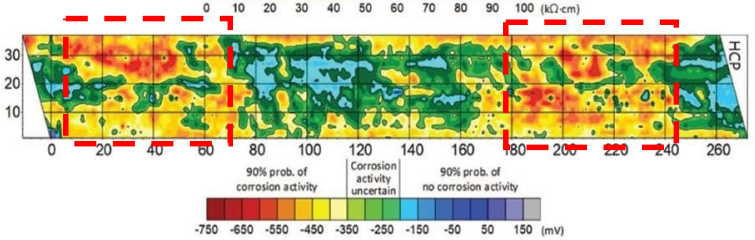
GPR Cover



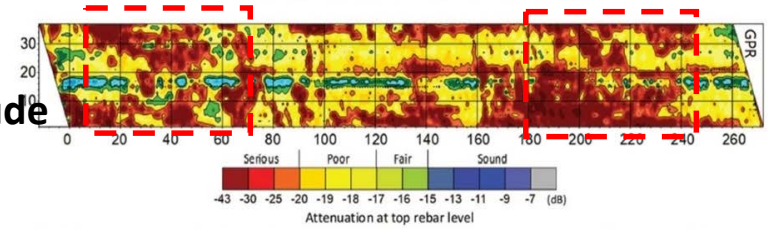
Electrical Resistivity

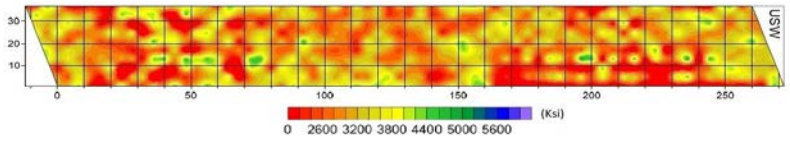


Half Cell Potential

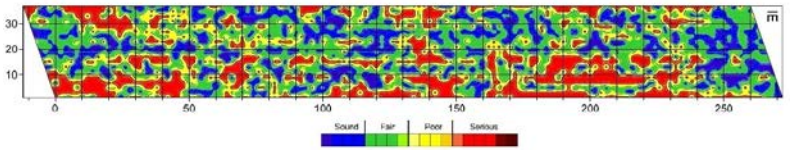


GPR Amplitude





USW



Impact Echo

Courtesy: Dr. Gucunski, Rutgers University

NDT and Visualization

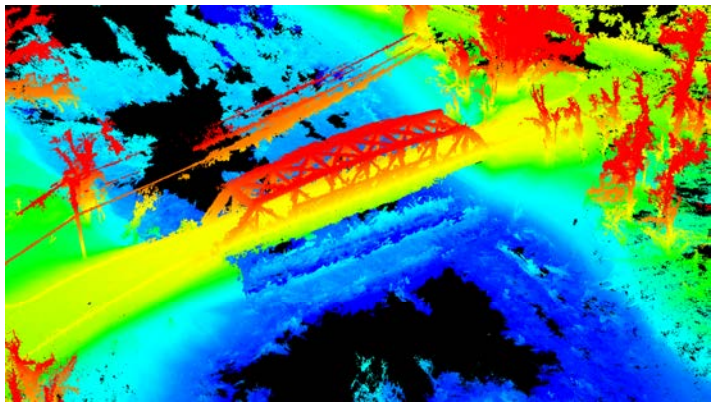
Courtesy: Dr. Hamid Ghasemi

Where are we heading?

Satellite Based Technologies

20,708 distinct radar scatters Radar sat processed historical data detected no settlement;
Merrimac Memorial Bridge Tunnel, Courtesy of Edward Hoppe, VADOT

Where are we heading?



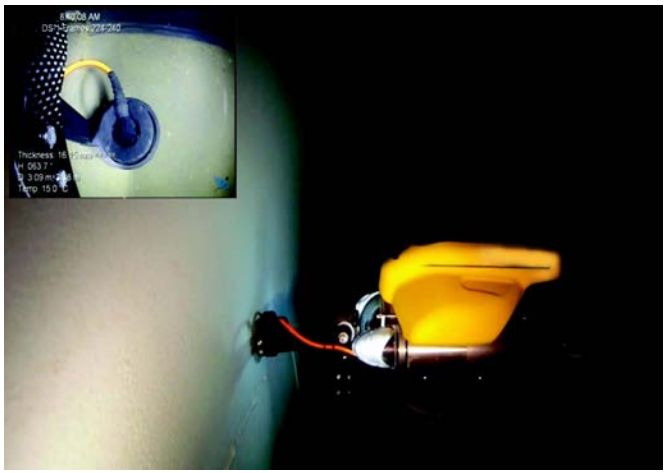
Courtesy: Jarlath O'Neil-Dunne, Spatial Analysis Lab, University of Vermont

UAV Based Technologies

Courtesy: Stantec

Where are we heading?

Sonar for Underwater Inspection

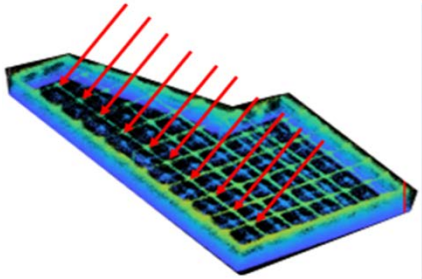


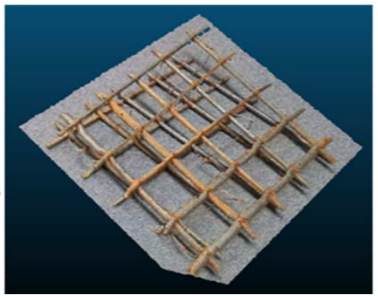
Underwater UT Inspection

Water Based Unmanned Vehicles

Courtesy: Stantec

Where are we heading?





Construction Inspection using
RGB-D Camera
(Red Green Blue – Depth)

Courtesy: Dr. Moreu, UNM

Where are we heading?

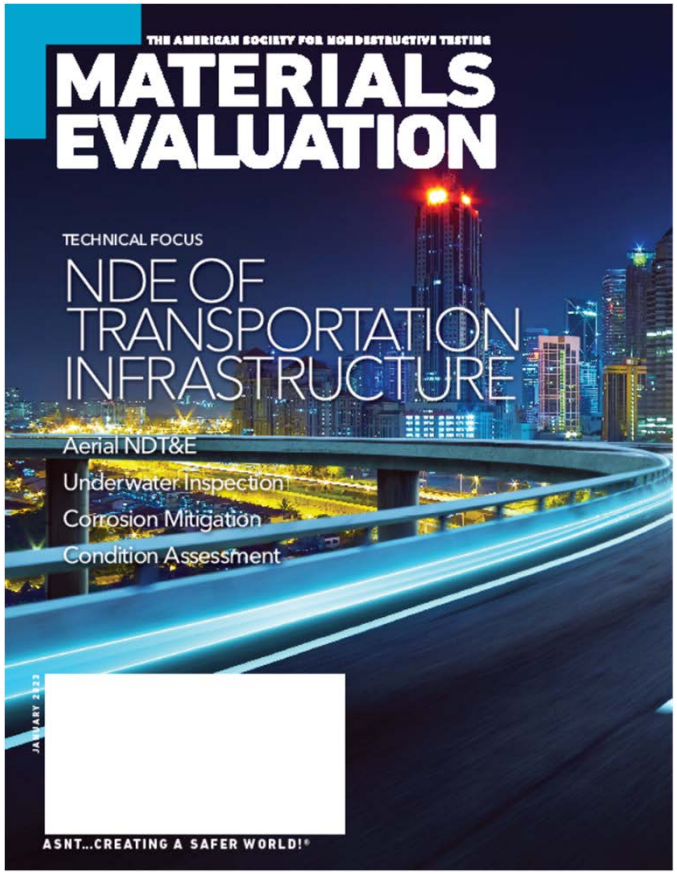
Robotic Technology

Courtesy: Dr. Chen, INSPIRE UTC

Courtesy: Dr. Xiao, CCNY/INNOVOBOT

ME January Focus Issue

- Focus on NDE of Transportation Infrastructure
  - Progression of Inspections for Corrosion Mitigation and Preservation
  - Recent Trends and Technologies in Underwater Inspection
  - Construction Quality Inspection
  - Condition Assessment of Reinforced Concrete Bridge Elements
  - Aerial NDT and NDE



Contact Information

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