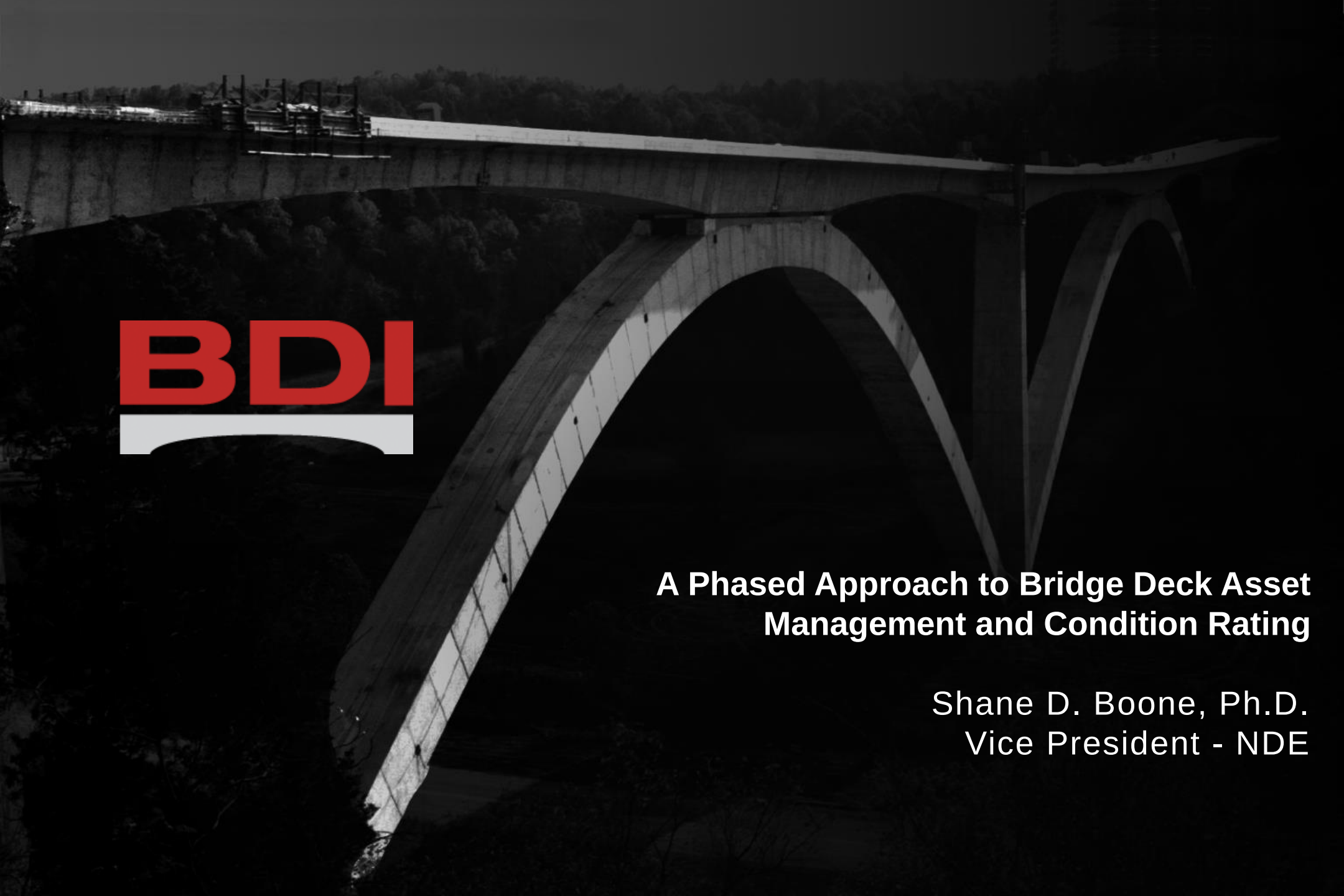

A Phased Approach to Bridge Deck Asset Management and Condition Rating

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Objectives of Presentation

1. Existing State Procedures for use of NDE
    A. Survey results
2. Existing Problems
3. Phased approach to Efficient Deck Rating
    A. Network level
        i. Preliminary screening of multiple decks
    B. Project level
        i. High resolution inspection and rating
4. Proposed Implementation
5. Questions

Surveys

- Nondestructive Evaluation of Existing Steel Structures
  - Multiple choice
  - 17 questions, 27 state responses
  - Multiple responses included relevant information for decks

- Nondestructive Evaluation of Bridge Decks
  - Open ended questions
  - 5 questions, 20 state responses

Deck Inspection Questions

1. What is your state's existing procedure for performing an in-depth deck inspection (i.e. chain drag, coring, chlorides, etc.)?

2. What is your state's existing procedure for determining which bridge decks should receive an in-depth inspection and when they should be programmed for such an inspection?

3. What NDE methods does your state currently use, on a regular basis, for deck inspection (if any – just say none if not applicable)?

4. If your state does not currently use NDE on a regular basis, what hesitancies, bad experiences, horror stories, etc. have kept you from implementation?

Relevant Survey Results

1. Chain drag and sounding are the most commonly used inspection techniques for in-depth deck inspection.

2. Most states do not have an in-place procedure for determining when in-depth inspections should be performed.
    1. Most consistently based on age or poor visual inspection ratings.
    2. 90% - used after the discovery “probable anomaly during biennial safety inspections or arm's length visual inspection.”

3. Ground penetrating radar and Infrared Thermography were the most common, if used.
    1. 45% do not use
    2. Impact echo mentioned sparsely

4. Perception of high costs were the most prevalent reason for not using NDE
    1. Lack of correlation between results and chaining
    2. Lack of experience

Common NDE for Decks

1. Most states chain drag

2. In-depth inspections are performed based on age or visual inspection results

3. GPR or IR

4. Perception of high costs and poor correlation in the past.

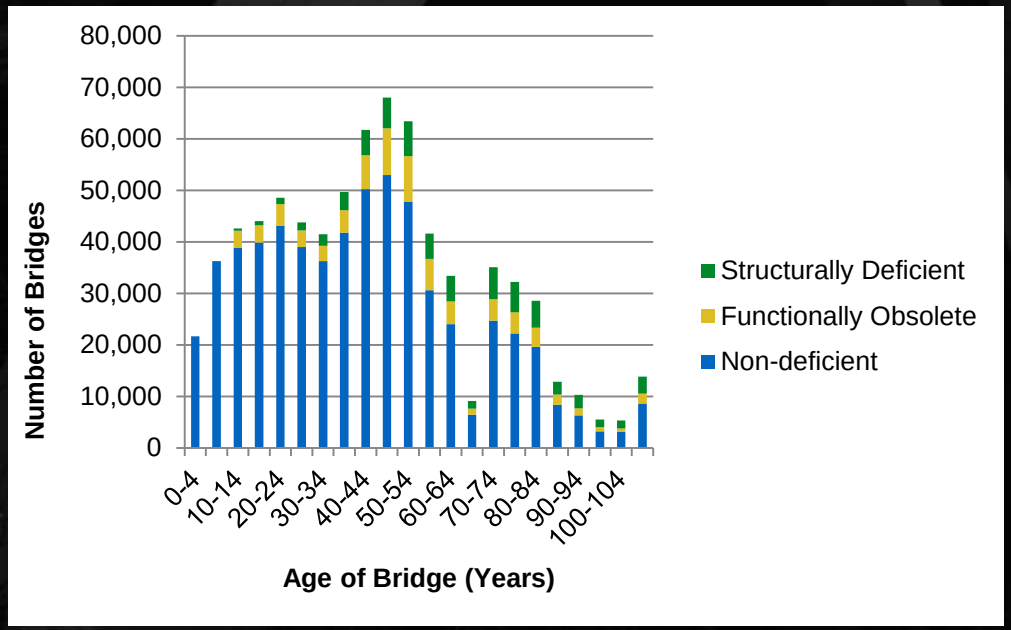
Technology vs. Need

"It seems like, recently, research is performed to advance technology without ever asking what the real problem is, or how states want / need to address it."

"Why would you apply an overlay when you don't know what's going on beneath the surface – you could be covering up completely deteriorated material."

The Real Problem

1. ASCE 2013 –
    1. 30% over 50 year design life
    2. 121 billion investment backlog
    3. Need an extra $8 billion annually
2. Not enough money for inspections, maintenance, and construction.



Insufficient Funds

1. In 1971:
    A. Sufficient funds for inspection, repair, maintenance, and replacement:
        i. Higher relative amounts of funding,
        ii. Infrastructure wasn't as old

2. Now:
    A. Insufficient funds:
        i. Less funding (much less)
        ii. Infrastructure is degraded

A Proposed Solution

1. Perform screening techniques to:
    1. Identify which bridges need in-depth inspection,
    2. Collect quantitative data,
    3. Create a risk based inspection, asset management program
2. Perform project level inspections, maintenance, and repair as needed

Multiple Options for Screening

1. All based on the use of advanced technologies
    1. Drones,
    2. Video based systems,
    3. Sensors (structural monitoring),
    4. Scanning
    5. Others

Phased Approach to Deck Inspection

Phased Approach to Deck Inspection

Phased Approach to Network Level Bridge Deck Inspection

1. *Simple Theory*
    1. *Use high speed deck scanning to quickly evaluate and screen bridge decks in a safe, efficient manner,*
    2. *Use the quantitative data to determine which decks need to be programmed for project level work.*
    3. *Accumulate this data to create network level life cycle models for bridge deck deterioration, repair, and replacement.*

Phased Approach to Deck Inspection

Phase I Approach: High speed deck scanning to provide condition assessment using GPR, IR, and HD Video

Phase I Deliverables: Draft condition assessment reports and mapping of Concrete Deterioration, Delamination, Patching, Spalling, and Concrete/Overlay Cover.

Phase II Approach: Project level inspection for NDE validation, high resolution inspection (chlorides, IE, etc.), and element level condition rating.

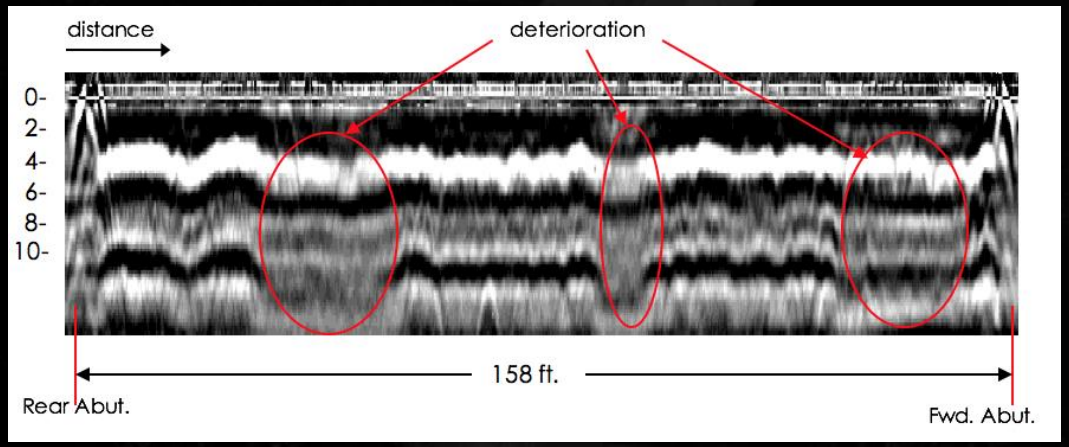
Phase II Deliverables: Data verification, high resolution mapping, and condition assessment and life cycle analysis.

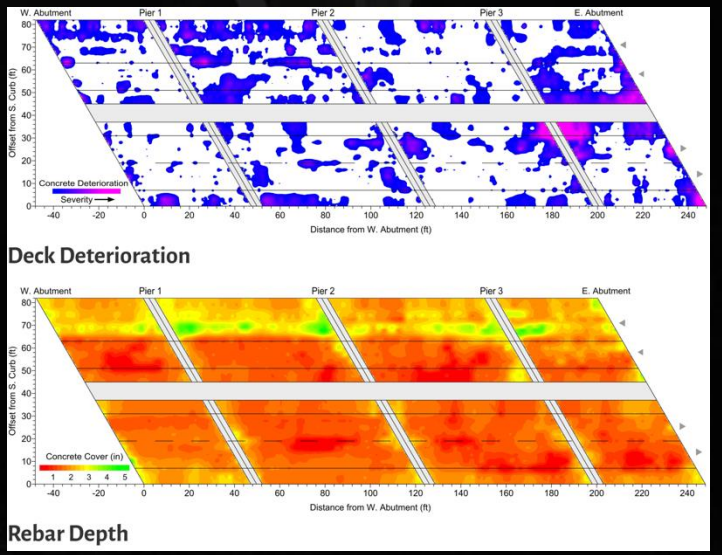
Phased I

- High Speed
  - Single or step frequency OR impulse GPR
  - Mobile Infrared Thermography, and
  - Up to 4K HD Video
- Combined approach to ensure both deep and shallow deterioration can be mapped
- <u>Doesn’t replace NBIS Visual Inspection - Supplements it, and makes it safer</u>

Phased I - GPR

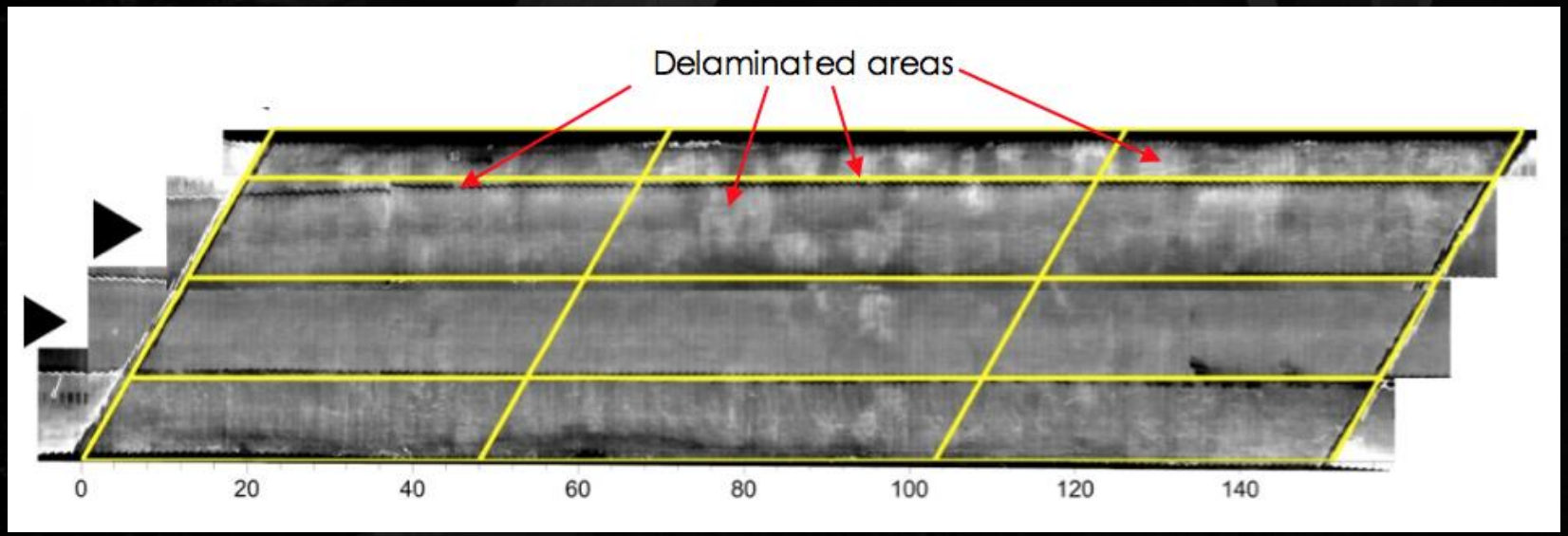
- Analyzed to determine extent of concrete deterioration
  - 4 lines of data per lane, each representing a cross section of the deck
  - Specialized software use for geospatial analysis, feature extraction, and deterioration analysis.
  - Data combined to create plan area of deterioration



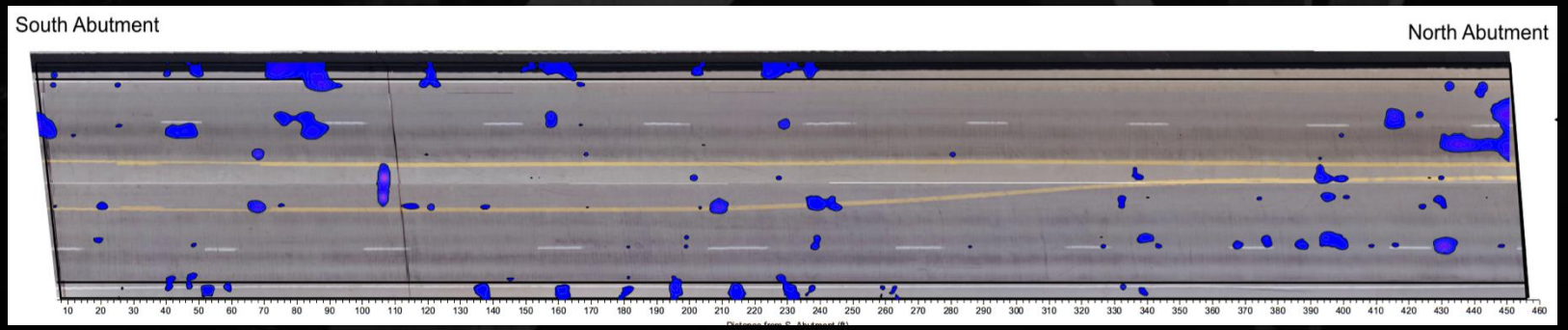


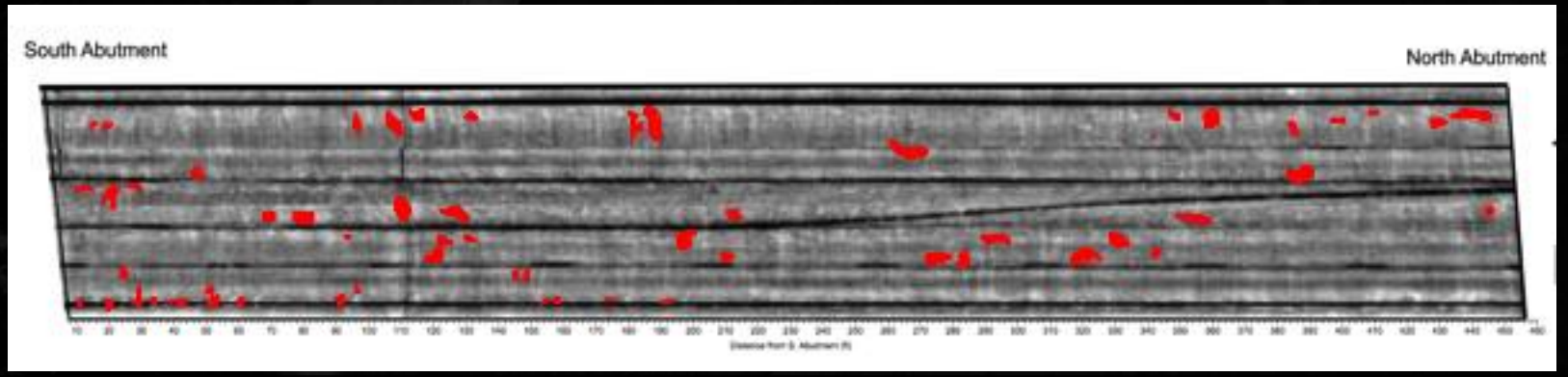
Phased I - Infrared

- Analyzed to identify debonding and shallow delaminations
  - High precision electronic encoder to allow for geospatial analysis
  - Synchronous HD and IR video
    - Differentiation of flaws and surface features



Phased I – Combined Results





Phased II

- Based on Phase I Results
    - Hopefully, reduce the amount of project level inspections
- Confirmation and validation of Phase I results
- High resolution inspection for calibration of network level vs. project level results
    - Time Lapsed IR – UTD
    - Chloride measurements (RCT, HCP)
    - Impact Echo and/or chain drag
    - Coring
- Modeling parameters for life cycle analysis, element level condition rating, and improved asset management

A Proposed Implementation

1. Perform screening on a high population of network bridges,
2. Identify thresholds for performing project level inspection,
3. Determine modeling parameters that correlate screening data to high resolution inspection,
4. With correlation parameters are set, use network level inspection and high speed inspection to determine element level condition ratings.

What Would This Look Like?

1. AASHTO Bridge Element Inspection Manual
    1. Element #12/38 – Reinforced Concrete Deck Slab

Condition State Definitions

Defect	Condition State 1	Condition State 2	Condition State 3	Condition State 4
Cracking	None to hairline	Narrow size and/or density	Medium size and/or density	The condition is beyond the limits established in condition state three (3) and/or warrants a structural review to determine the ser th
Spalls / Delaminations/ Patched Areas	None	Moderate spall or patch areas that are sound	Severe spall or patched area showing distress	
Efflorescence	None	Moderate without rust	Severe with rust staining	
Load Capacity	No reduction	No reduction	No reduction	

Element Definitions

Defect	Hairline - Minor	Narrow-Moderate	Medium-Severe
Cracking	< 0.0625 inches (1.6 mm)	0.0625 – 0.125 inches	>0.125 inches (3.2 mm)
Spalls/ Delaminations	N/A	Spall less than 1 inch (25 mm) deep or less than 6 inches in diameter. No exposed rebar.	Spall greater than 1 inch (25 mm) deep or greater than 6 inches in diameter or exposed rebar
Cracking Density	Spacing Greater than 3.0 feet (0.33 m)	Spacing of 1.0 - 3.0 feet (0.33 – 1.0 m)	foot (0.33 m)
Efflorescence	NA	Surface white without build-up or leaching	Heavy build-up with rust staining

Current State of Practice

1. Where we are:
    A. Perform high speed deck screening
    B. Perform high resolution deck inspection
    C. Compare value to establish correlation factors and modeling parameters
2. Where we can go:
    A. Automate crack detection with HD video
    B. Automate delamination mapping with GPR/IR and other methods (high speed acoustics)
    C. Directly correlate quantitative measurements with element condition states.

Conclusions

1. Most states are using chain drage/sounding to perform in-depth inspection of decks

2. Hesitancy to use NDE is lack of experience, perception of high cost, and poor results in the past.

3. Primary problem that state's face is a lack of funding to do the work they need to.

Conclusions

1. Screening technologies can assist states in implementing risk based inspection protocols and improved asset management.

2. High speed deck inspection can be used to perform network level screening to better identify decks requiring project level inspection.

3. Data can be used to determine and eventually automate element level condition rating for bridge decks.

Acknowledgements

1. Ted Hopwood, Kentucky Transportation Center for survey results.
2. State DOT, SHA, DOR for survey participation.
3. Infrasense, Inc. for bridge deck NDE results and pictures.
4. Dr. Glenn Washer, University of Missouri – UTD Information

Questions

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BDI STRUCTURAL TESTING & MONITORING
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