ND Condition Assessment of George Washington Memorial Parkway/Arlington Memorial Bridge

TRB 93rd Annual Meeting
LTBP Program Workshop – Program Briefing
Washington, DC – Thursday January 16, 2014

Robert Zobel, Ph.D., P.E.
Technical and Development Engineer
Federal Highway Administration

Sue Lane, P.E.
Outreach and Development Engineer
Federal Highway Administration

Hamid Ghasemi, Ph.D.
Team Leader/Program Manager
Federal Highway Administration

Tom Saad, P.E.
Structural/Bridge Engineer
Federal Highway Administration

Long-Term
Bridge Performance
Program

Objectives of AMB Assessment by LTBP

- *Assess the condition of the deck with respect to the concrete quality (degradation) and corrosive environment, and*

- *Assess the condition of the deck with respect to the extent and severity of delamination and/or overlay debonding in the deck.*

Corrosion   Delamination   Concrete Degradation

Deck Condition Assessment Vs. NDE Method
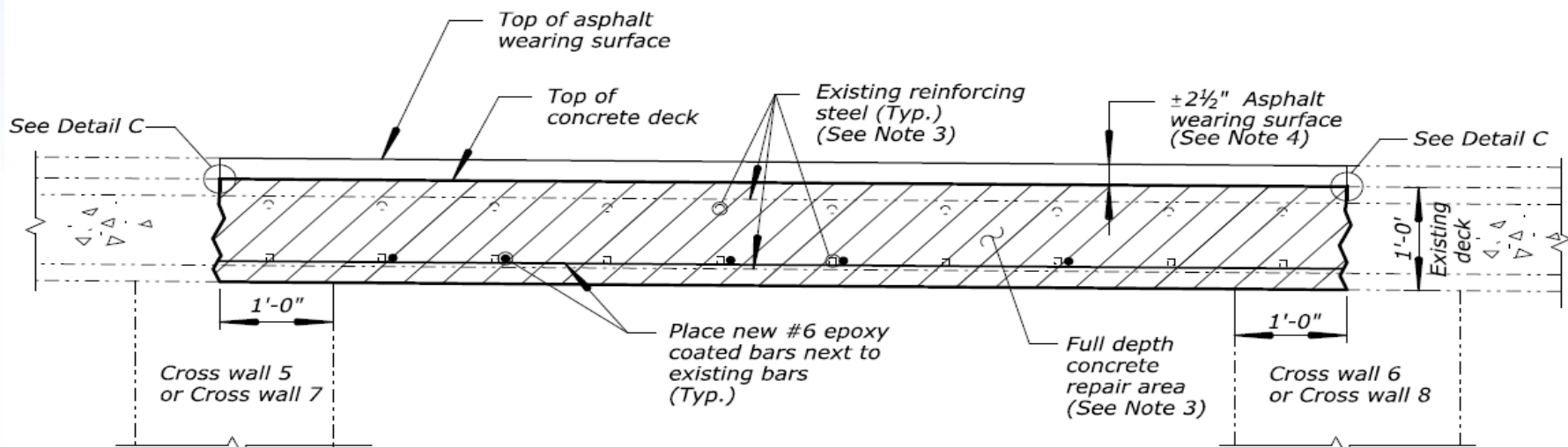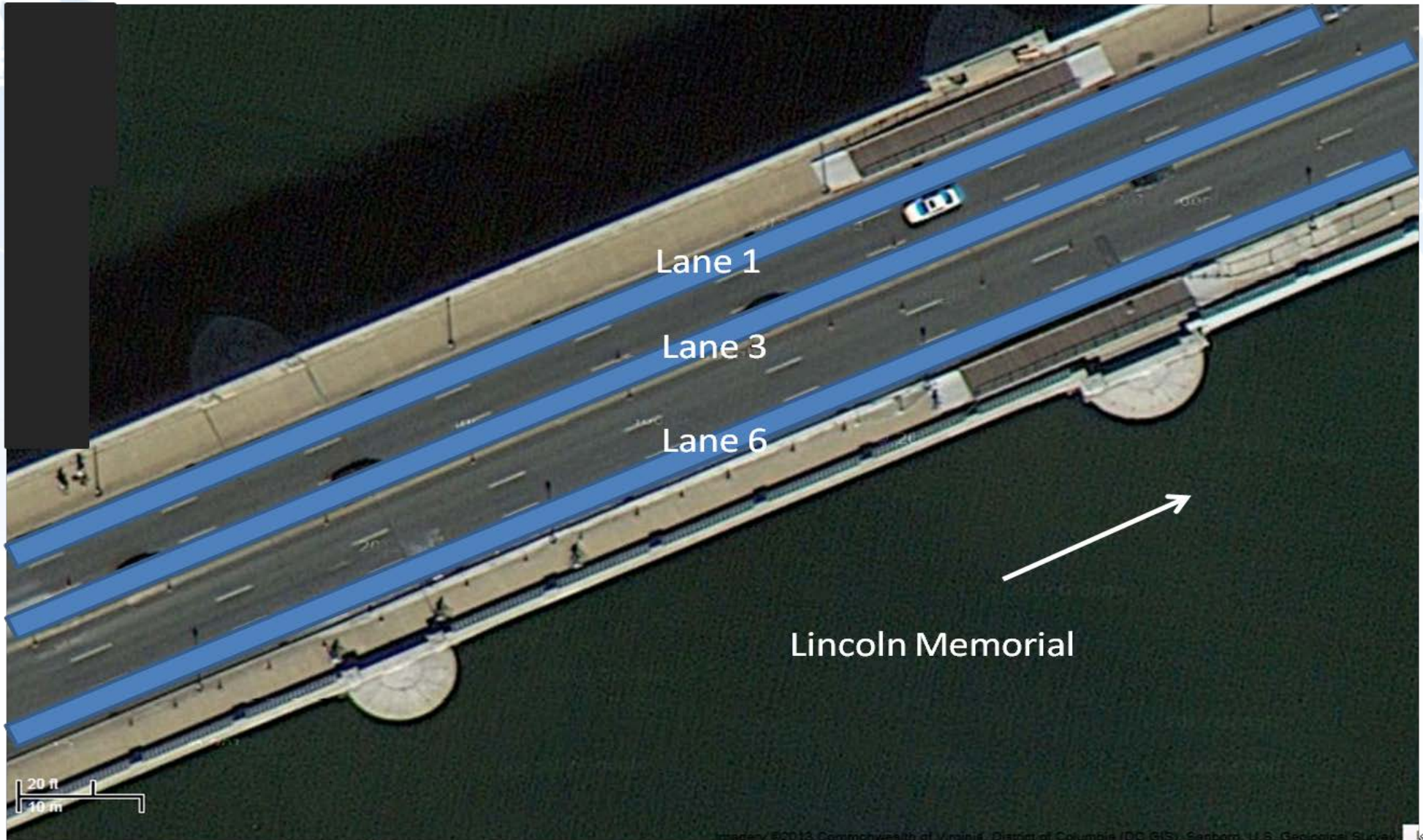
- **Corrosion Assessment**
  - Ground Penetrating Radar (GPR) – Potential for corrosive environment

- **Concrete Quality (Degradation) Assessment**
  - Ultrasonic Surface Waves (USW) – Modulus degradation
  - GPR – Likelihood of deterioration

- **Delamination Assessment**
  - Impact Echo (IE)
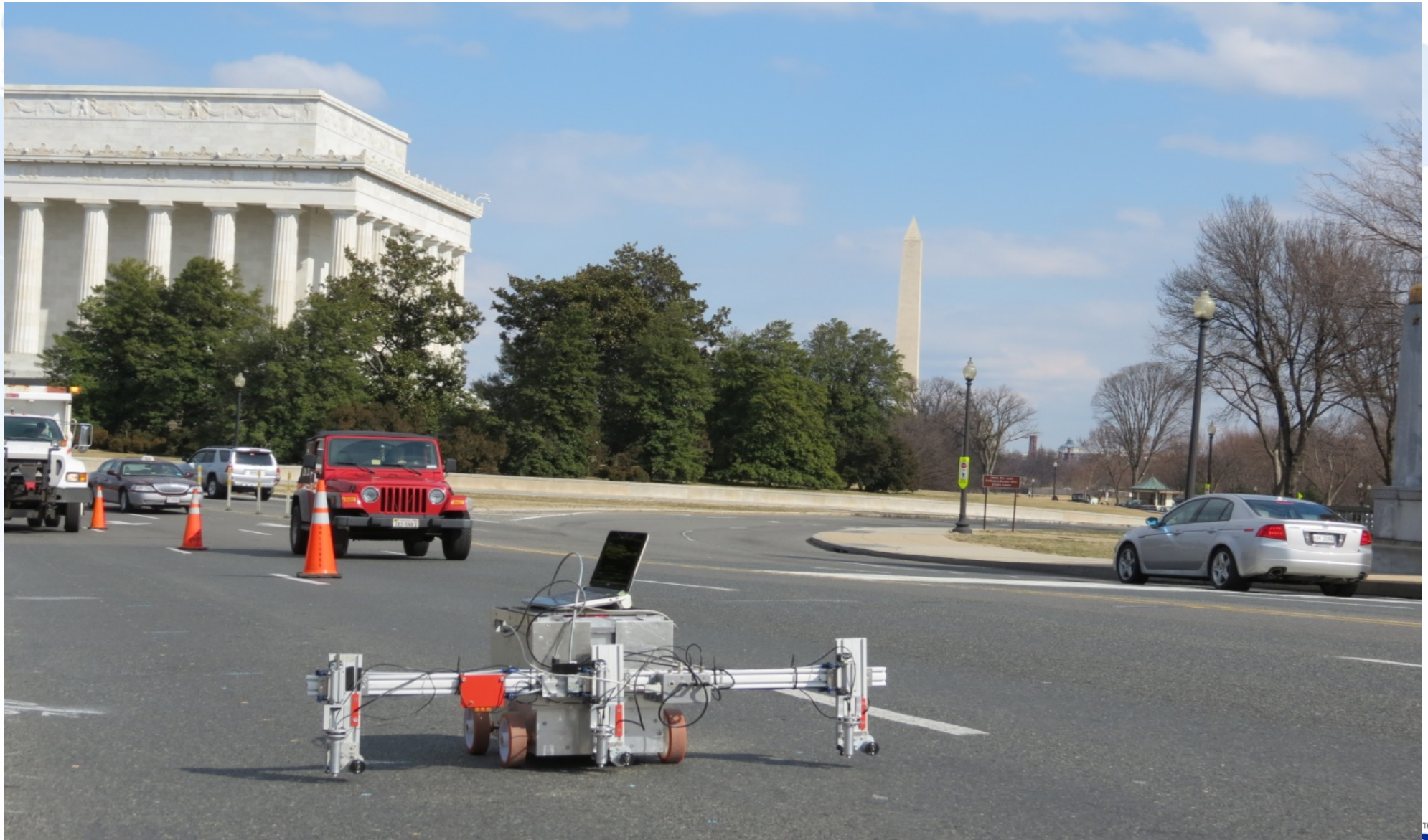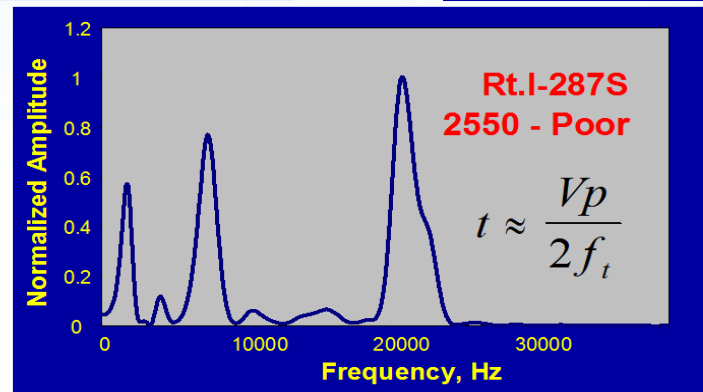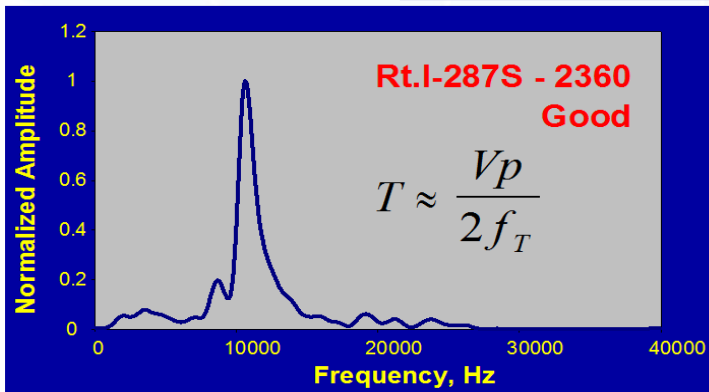 - GPR – Likelihood of delamination

Typical Deck Cross-Section
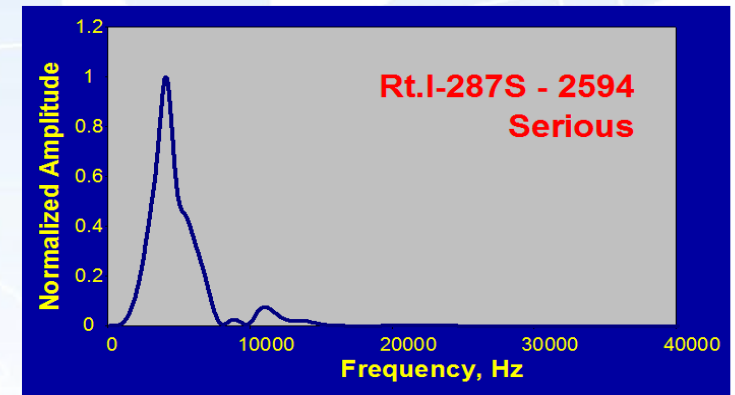
Long-Term
Bridge Performance
Program

Lane 1

Lane 3

Lane 6

Lincoln Memorial

20 ft
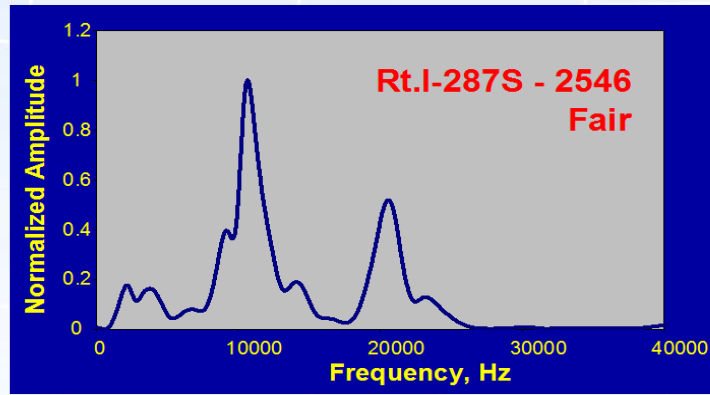10 m

Long-Term
Bridge Performance
Program

Delamination Assessment Using Impact Echo (IE)

Principle of Impact Echo and Resulting Condition Grades

Rt.I-287S - 2546 Fair

Rt.I-287S - 2594 Serious

Rt.I-287S - 2360 Good

$$T \approx \frac{Vp}{2f_T}$$

Rt.I-287S 2550 - Poor

$$t \approx \frac{Vp}{2f_t}$$

Long-Term
Bridge Performance
Program
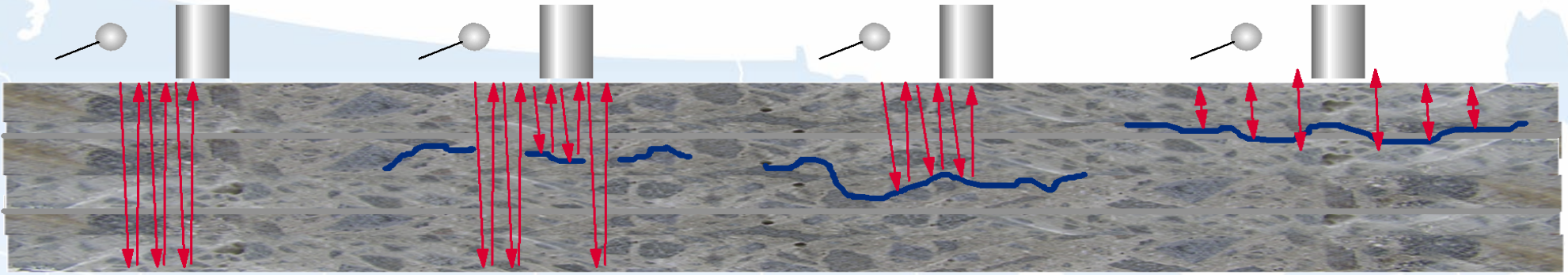
Typical Delamination Assessment and Impact Echo Validation with Cores

Impact-Echo (IE) Grading

Distance from west abutment, ft

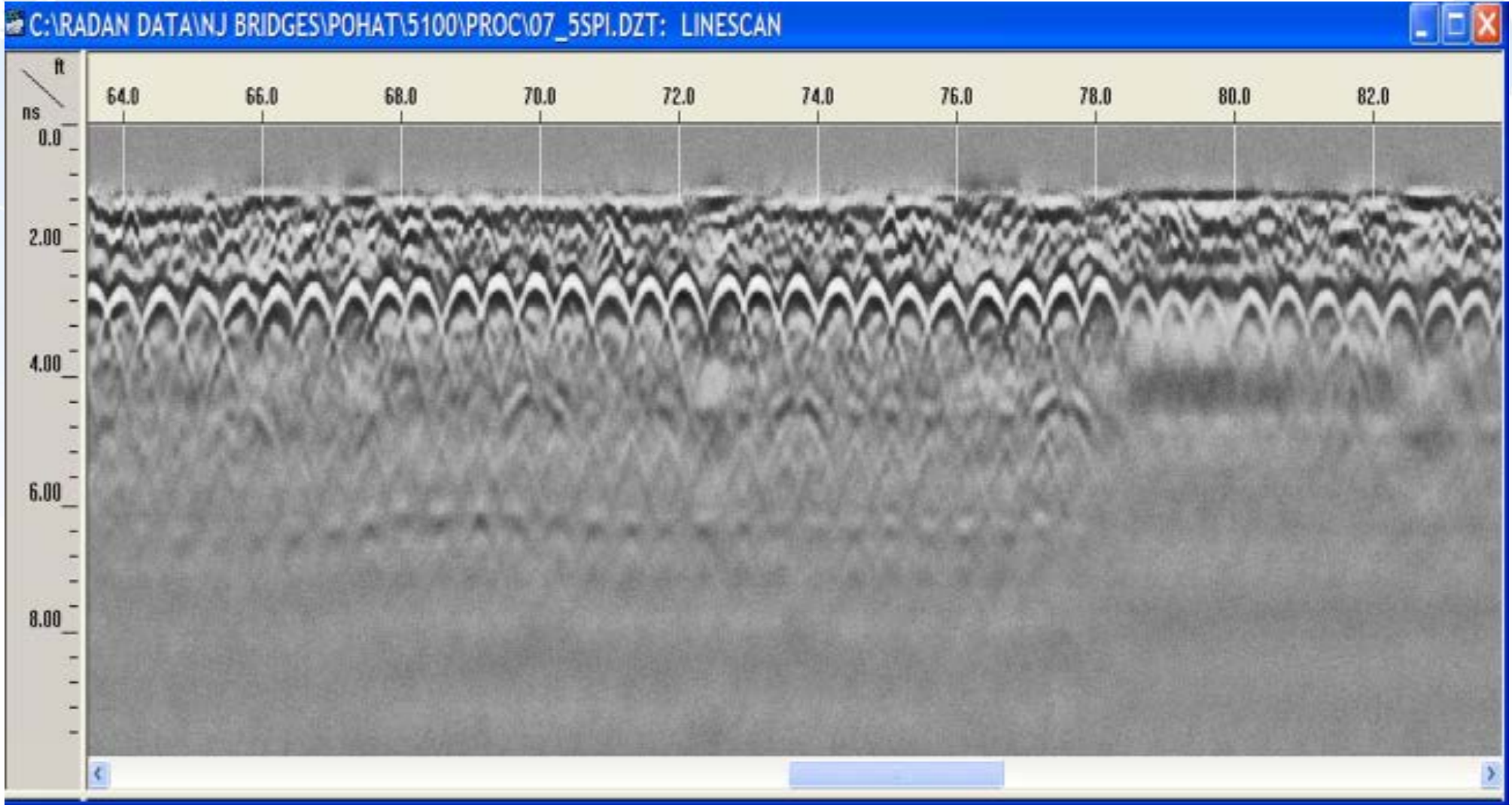Long-Term
Bridge Performance
Program
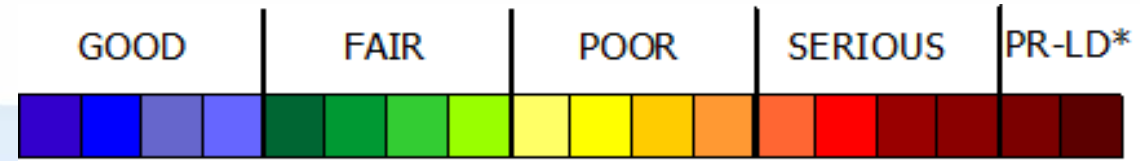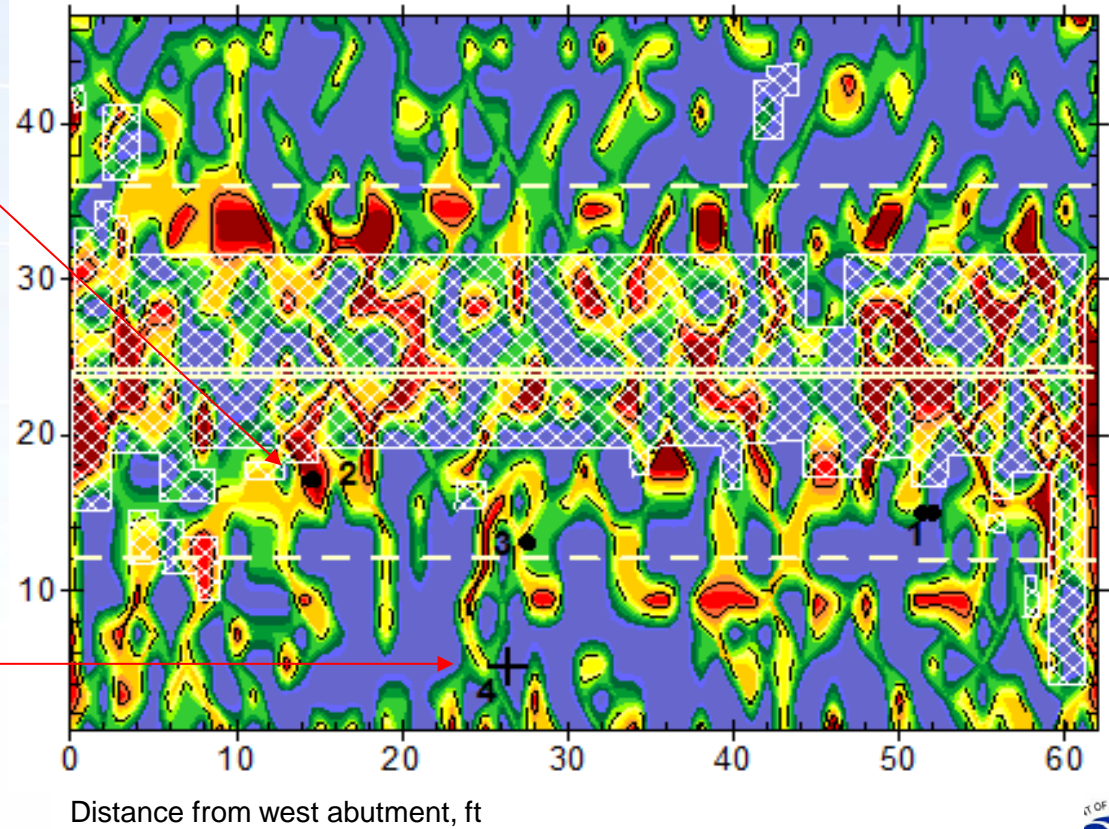
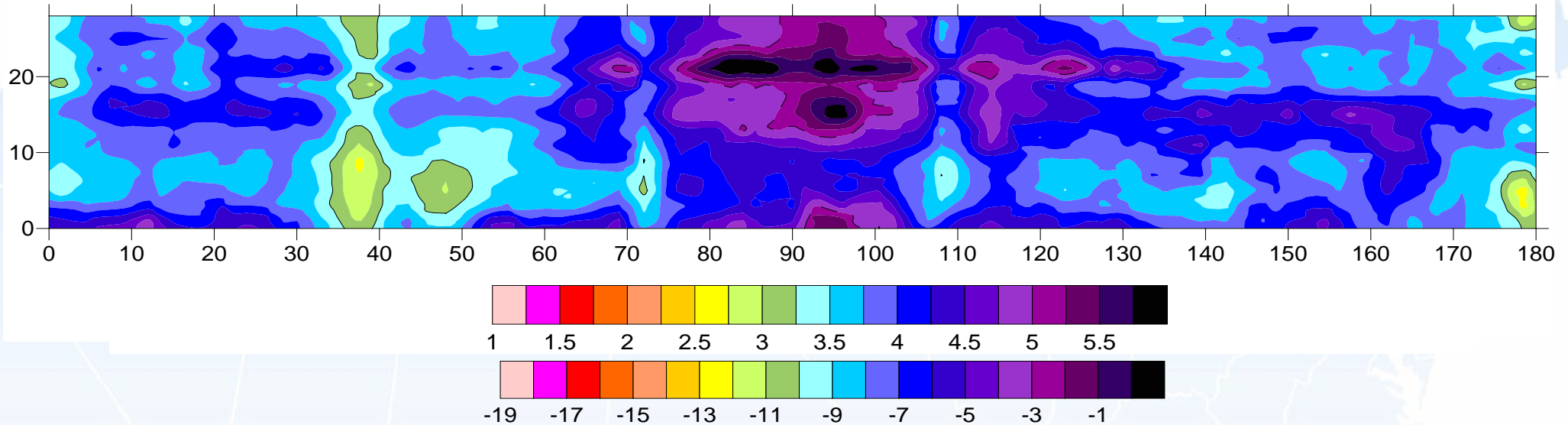## Deck Condition Assessment Using Ground Penetrating Radar (GPR)

Typical GPR B-Scan of Bridge Deck

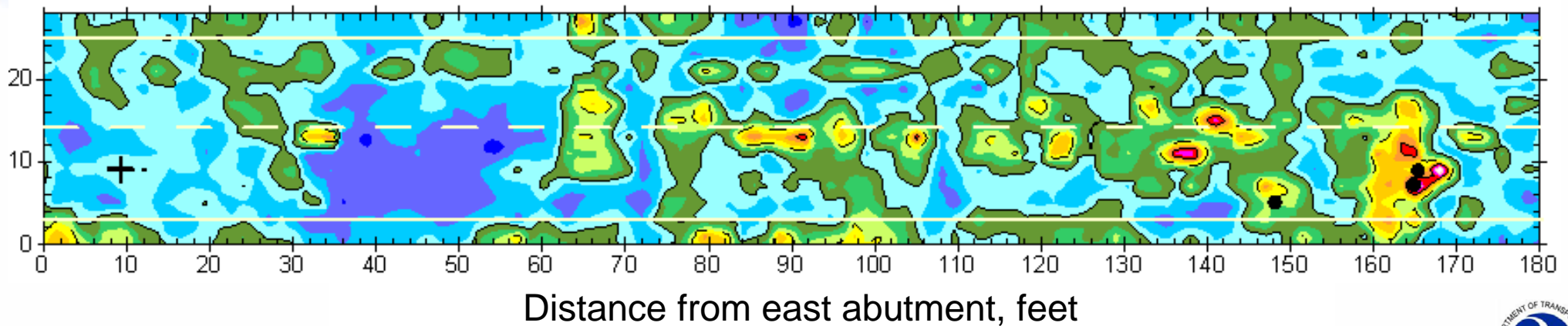# *Typical Concrete Cover and Condition Maps from GPR Survey*

Concrete Cover (inches)

Top Rebar Amplitude (Normalized dB) - Depth Corrected

Distance from east abutment, feet

Long-Term
Bridge Performance
Program

Concrete Quality Assessment Using Ultrasonic Surface Waves (USW)
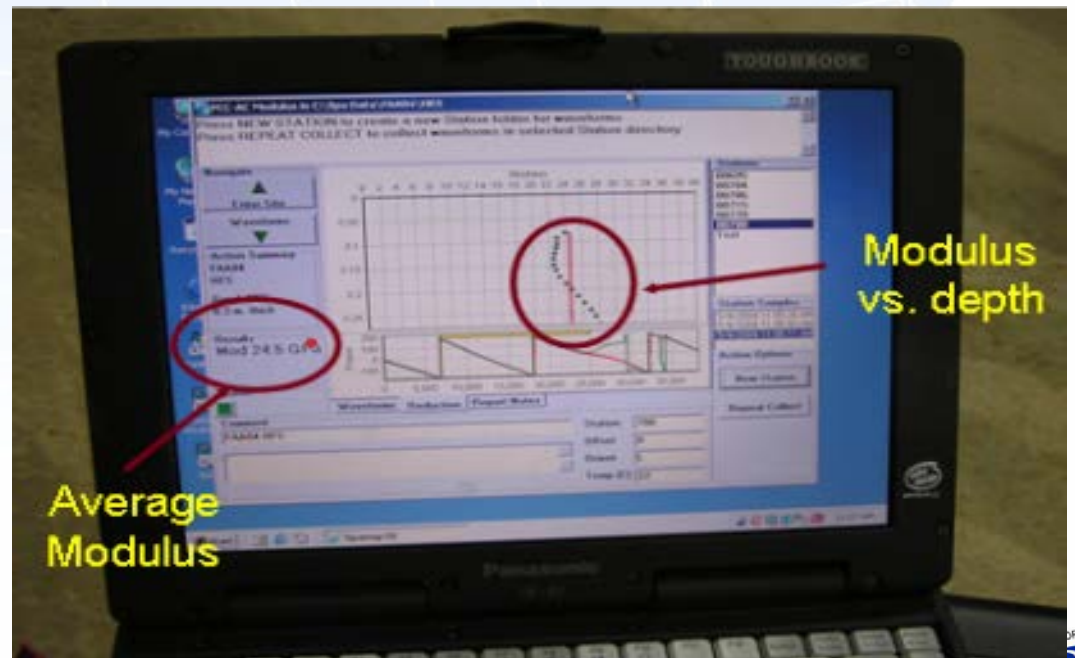
Typical Concrete Quality Assessment Using Concrete Modulus from USW Test

Distance from west abutment (ft)

Young's Modulus (ksi)

Bridge Deck Condition

Rebar Corrosion   Delamination   Spalling

Electrical Resistivity

Half-Cell Potential

GPR

Impact Echo   Ultrasonic Echo

Chain Drag/Hammer Sounding   IR Thermography

Visual Inspection

Time

RABIT™
(Robotic Assisted Bridge Inspection Tool)
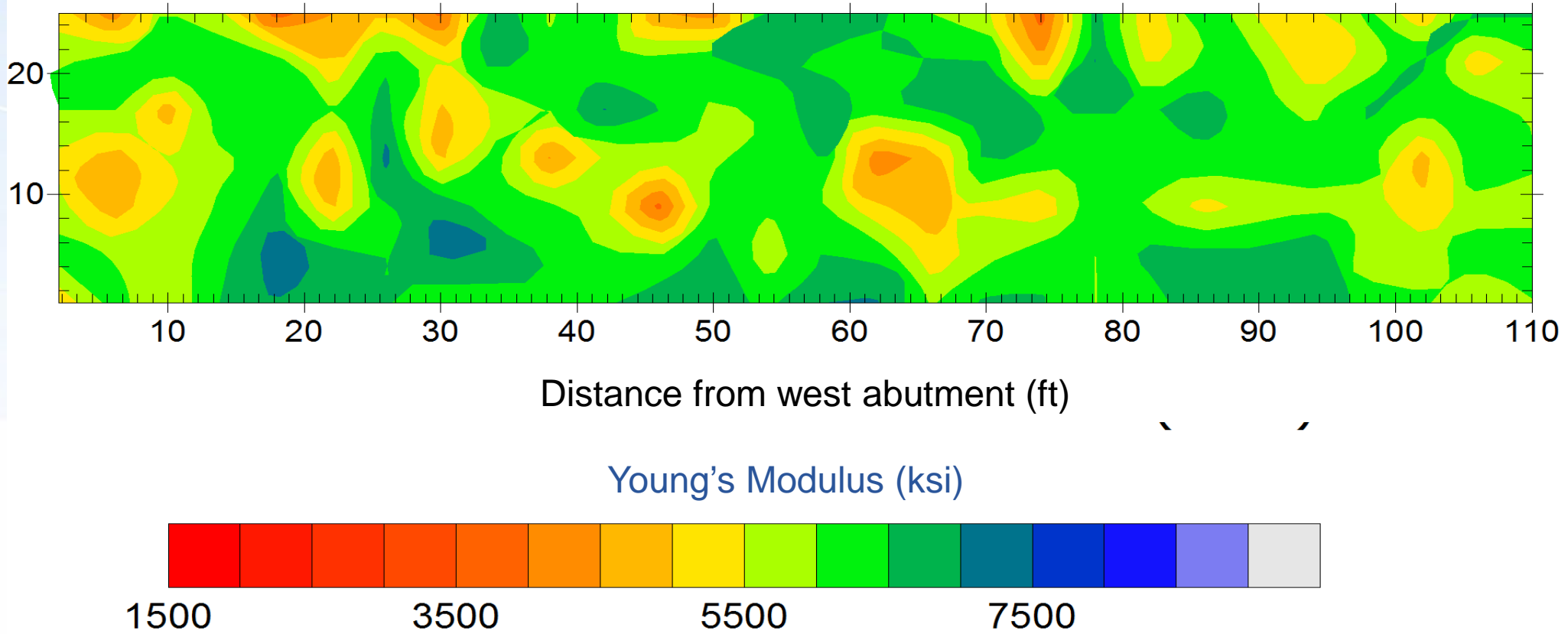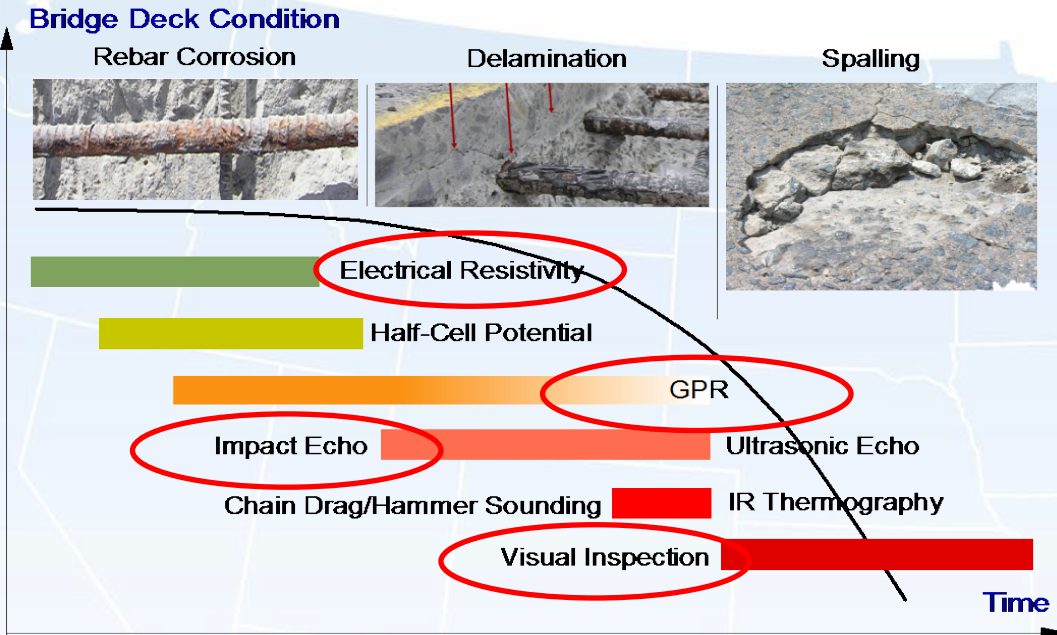
Automation of Data Collection and Analysis & Data Visualization

Long-Term
Bridge Performance
Program

Multi-NDE Technology Assessment Using RABIT™ -- Individual Components Shown Below

GPS Antenna

Digital Camera

GPR Array

Acoustic Array

ER Wenner Probes

Long-Term
Bridge Performance
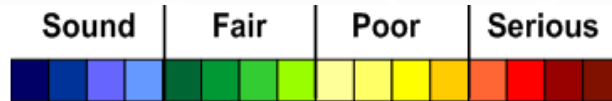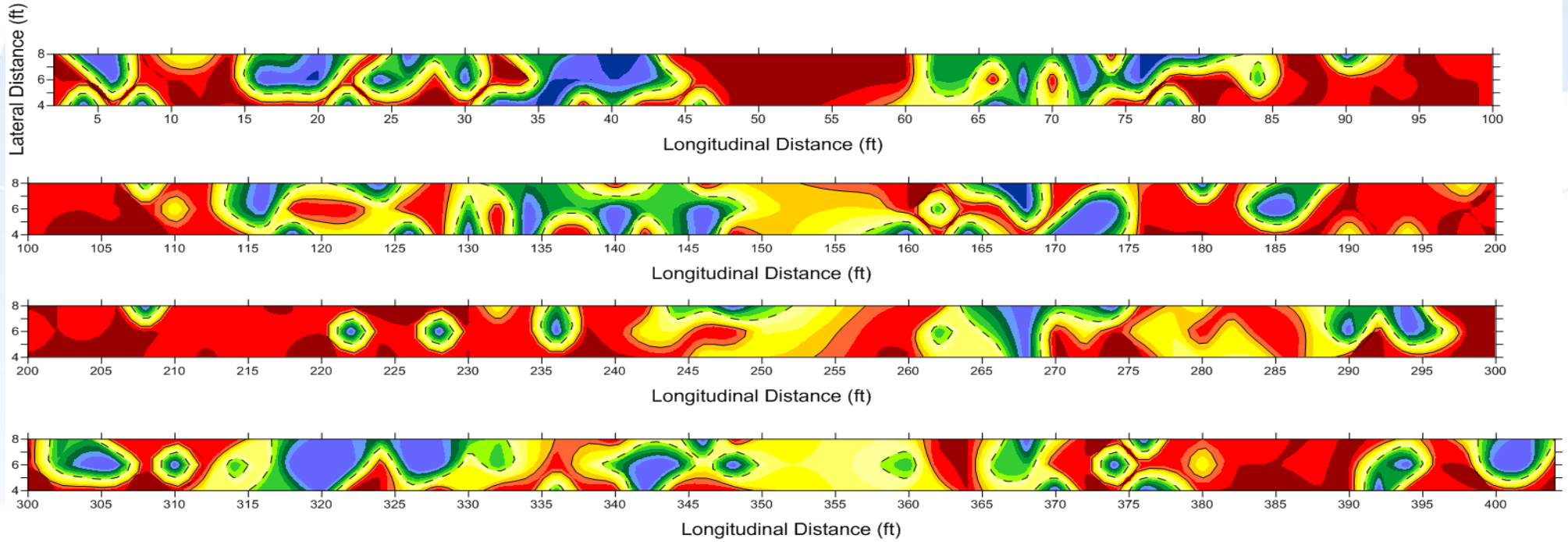Program
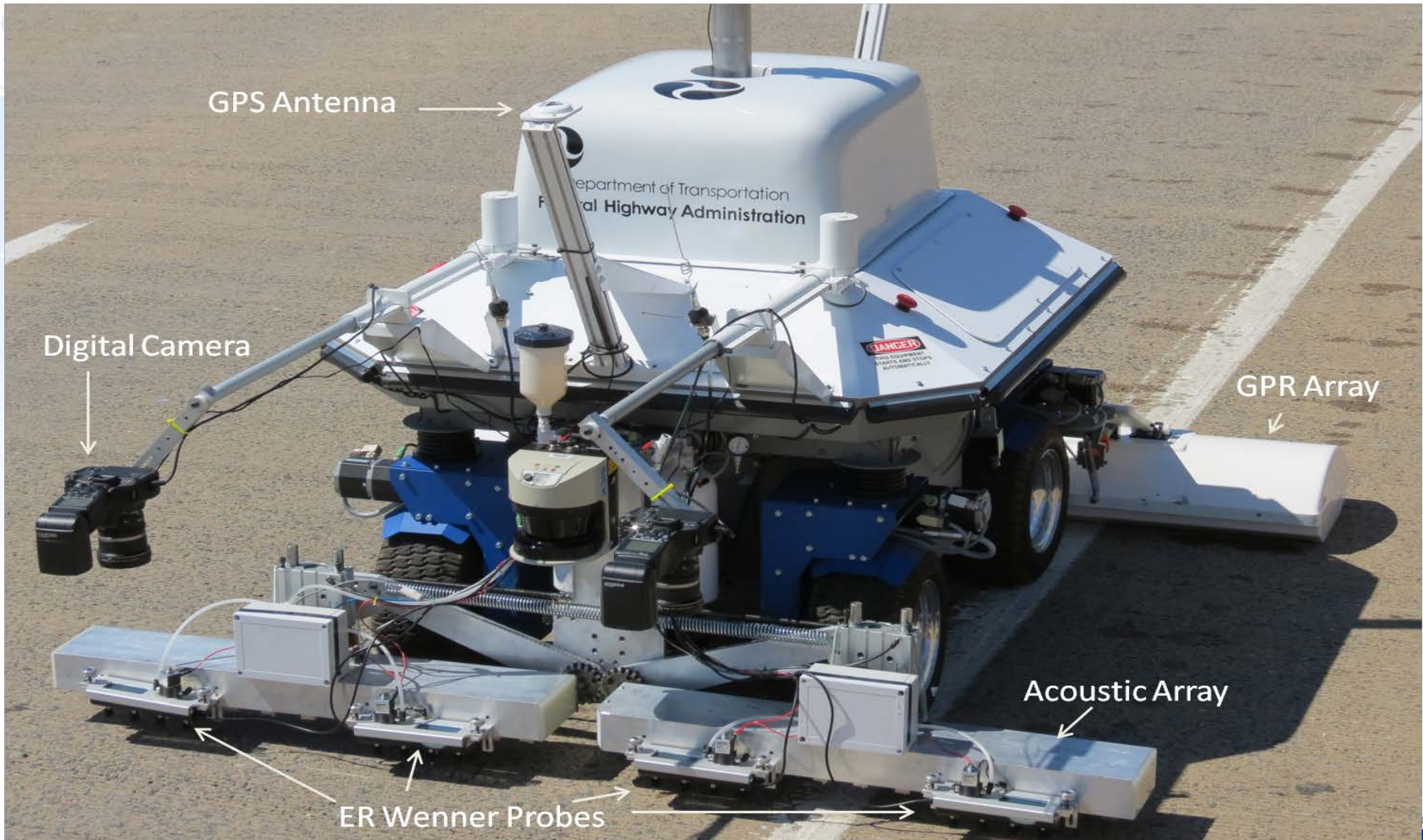
Multi-NDE Technology Assessment Using the RABIT™

Delamination Assessment – Lane 1 (Lincoln Memorial Side)

Delamination Assessment

Because of the asphalt overlay, some detection is a result of asphalt debonding, or disintegration of near surface concrete.

Grading

Good   - No delamination/debonding detected

Fair/Poor   - Incipient delamination

Serious   - Fully delaminated or debonded

		Lane 1		Lane 3		Lane 6	
		Arlington	Lincoln	Arlington	Lincoln	Arlington	Lincoln
Impact Echo	Good	9%	18%	15%	19%	21%	19%
	Fair/Poor	19%	23.50%	23.50%	29%	52%	47%
	Serious	72%	58.50%	61.50%	52%	27%	34%

Concrete Quality Assessment

Composite modulus

Grading

Good   -   > 3000 ksi

Fair/Poor   -   2000-3000 ksi

Serious   -   < 2000 ksi

|		Lane 1		Lane 3		Lane 6	
		Arlington	Lincoln	Arlington	Lincoln	Arlington	Lincoln
USW	Good	35%		7%		4%	
	Fair/Poor	34%		59%		17%	
	Serious	31%		34%		79%	

GPR Condition Assessment

*Qualitative assessment based on the attenuation of electromagnetic waves on the top rebar level.*

		Lane 1		Lane 3		Lane 6	
		Arlington	Lincoln	Arlington	Lincoln	Arlington	Lincoln
GPR	Good		8%		11%		11%
	Fair/Poor		67%		62%		72%
	Serious		25%		27%		17%

Based on the IE survey, almost eighty percent of the deck is delaminated or debonded. A high percentage of the deck, varying from about 30 percent on the Lane 6 side to more than 60 percent on the Lane 1 side, is already in a serious or severe condition. The delamination is more prevalent and more severe on the Lane 1 side and the delamination conditions are slightly less severe going towards Lane 6..
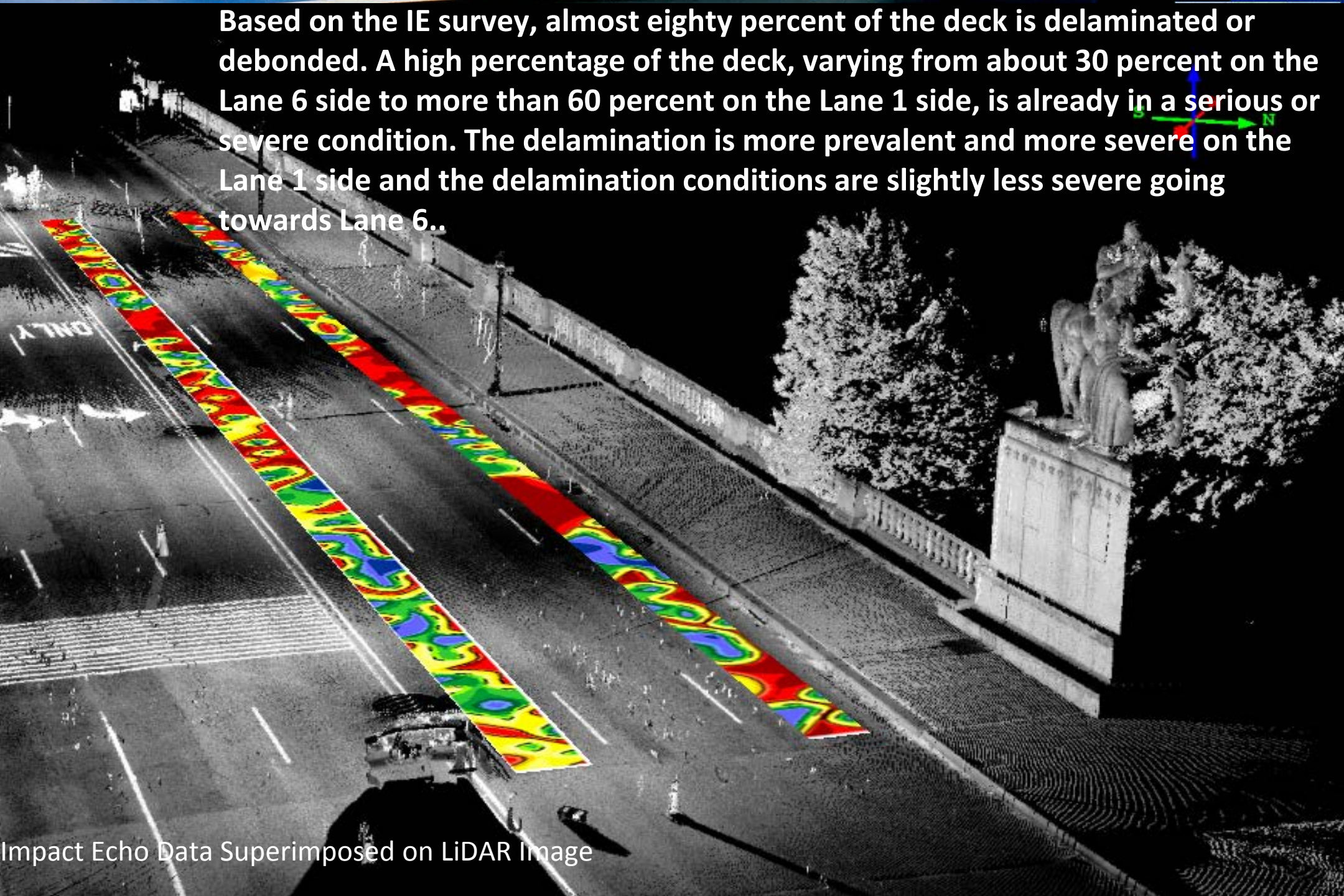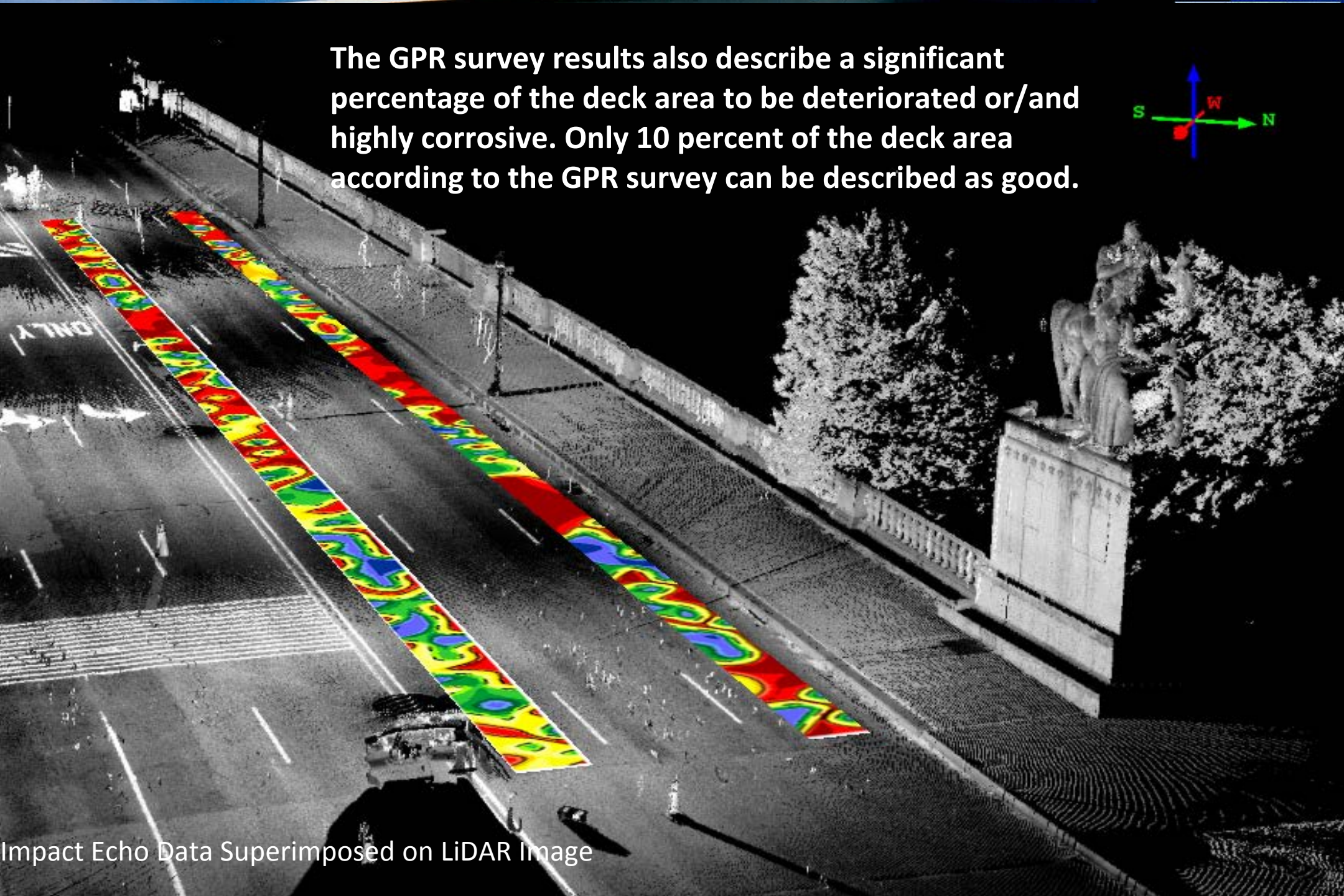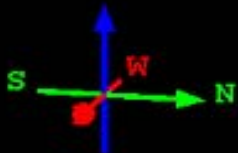
Impact Echo Data Superimposed on LiDAR Image

The concrete modulus for most of the deck, about 80 percent, is less than 3000 ksi. The modulus is on the low side of typical values of concrete modulus in bridge decks, which in most cases is measured between 4000 and 6000 ksi.
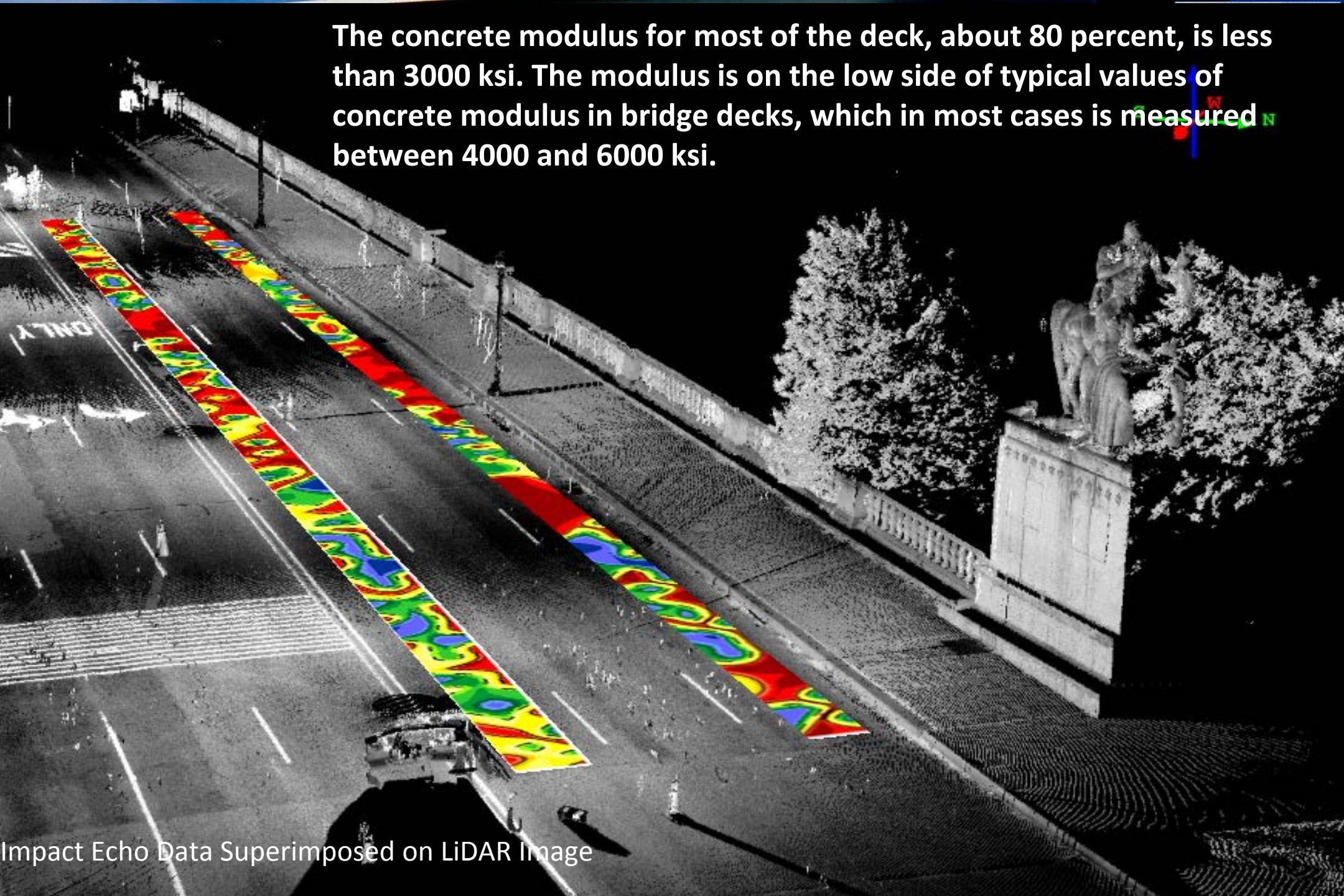
Impact Echo Data Superimposed on LiDAR Image

The GPR survey results also describe a significant percentage of the deck area to be deteriorated or/and highly corrosive. Only 10 percent of the deck area according to the GPR survey can be described as good.
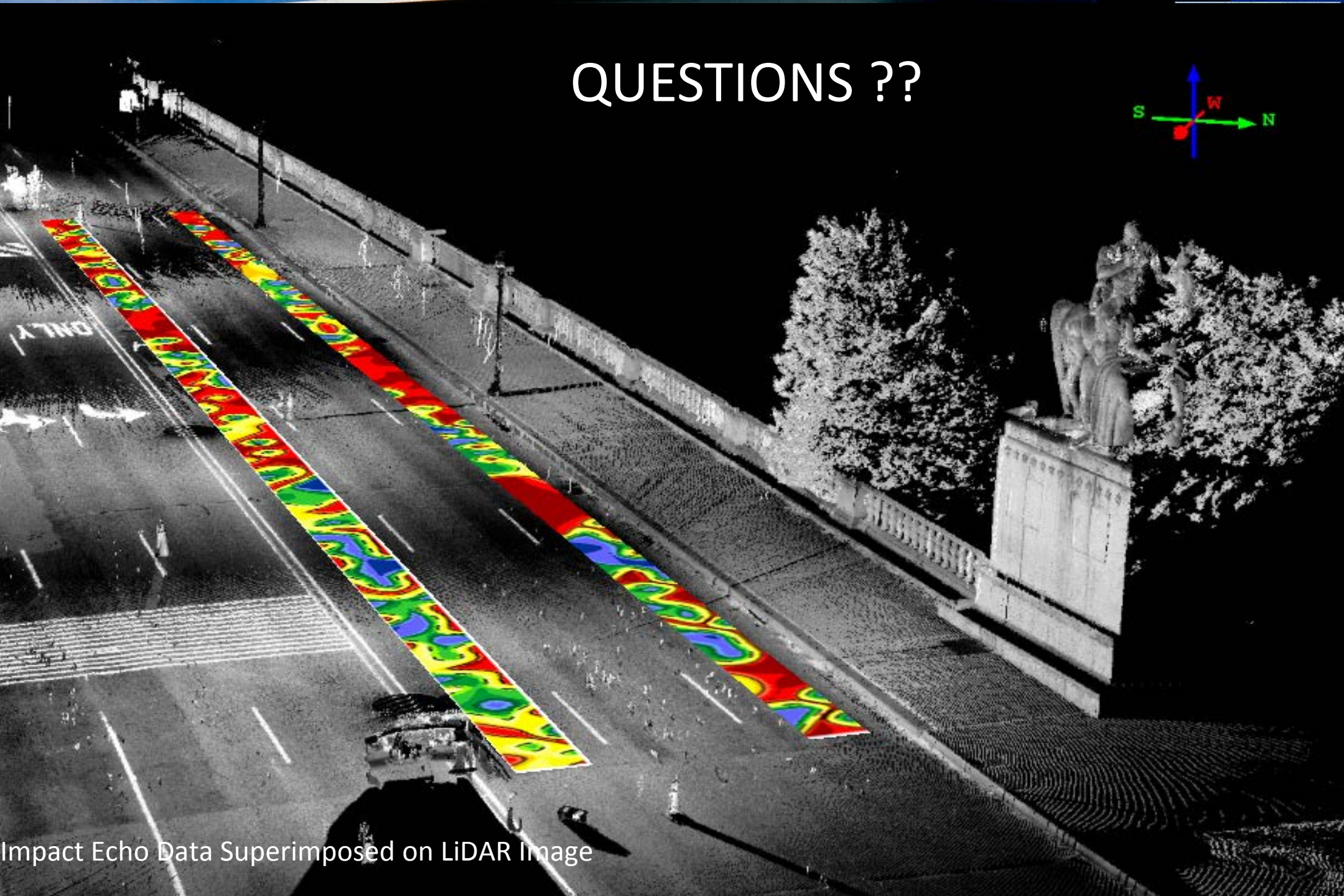
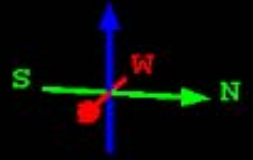Impact Echo Data Superimposed on LiDAR Image

AMB Assessment by LTBP

- *With the support of the LTBP Program and the RABIT™ were able to successfully characterize extent of deterioration of bridge deck in very short time (3 days)*

- *LTBP has been asked to help with further ND assessment of the historic structure*

- *LTBP Program Support provided EFL with valuable information to aid in developing a rehabilitation plan*

QUESTIONS ??

Impact Echo Data Superimposed on LiDAR Image