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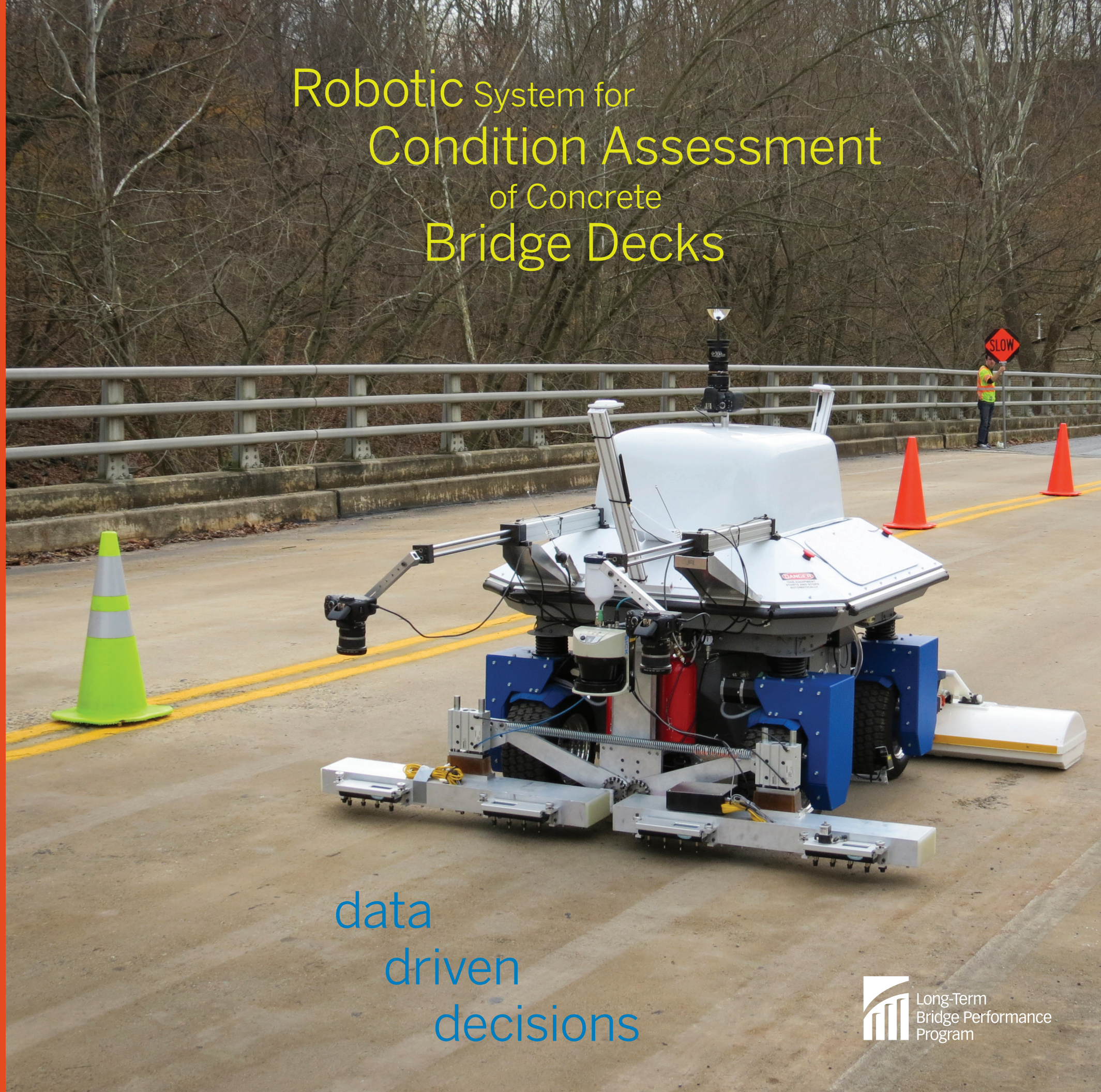
**Federal Highway Administration**

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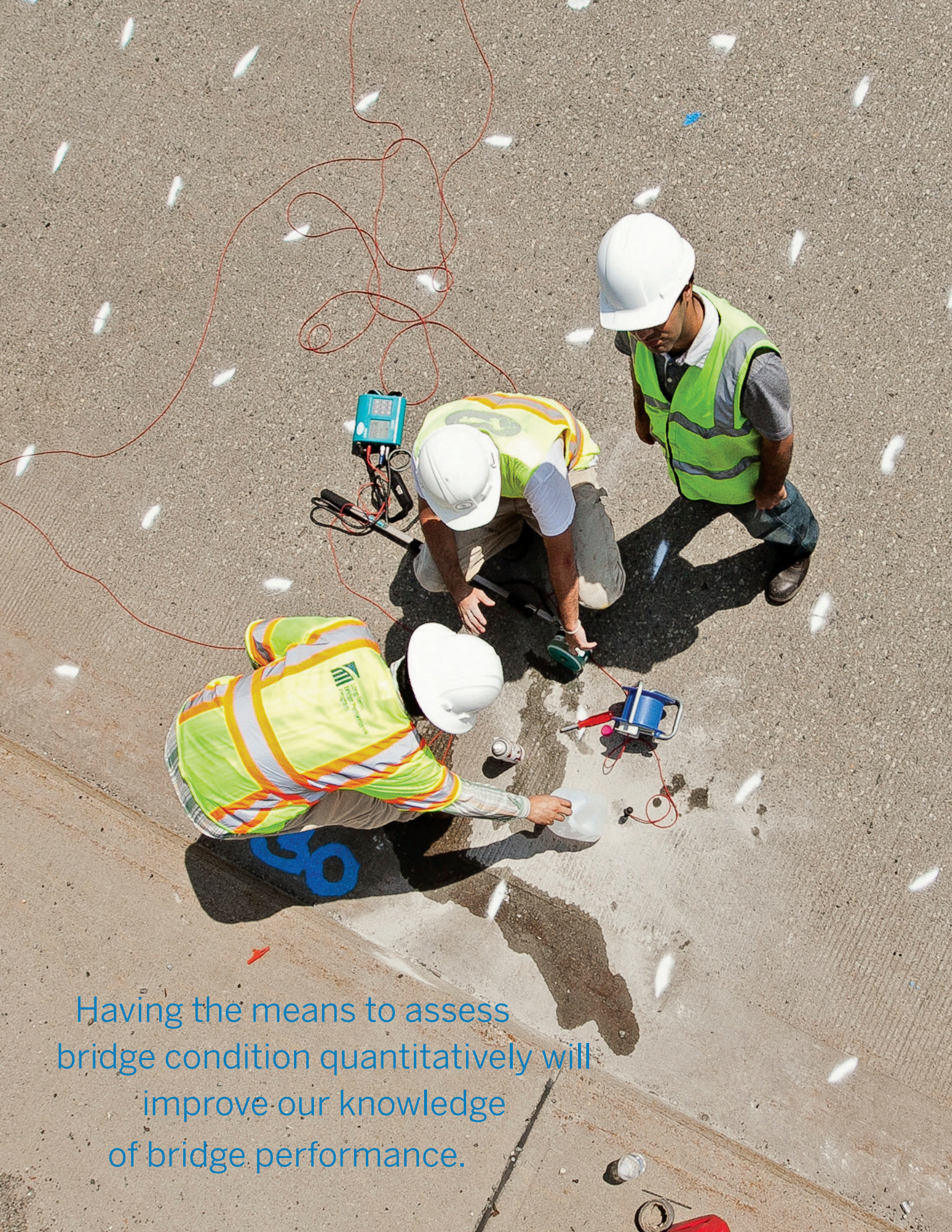
# Robotic System for Condition Assessment of Concrete Bridge Decks



data  
driven  
decisions







Having the means to assess bridge condition quantitatively will improve our knowledge of bridge performance.

# caring for our nation's bridges

In the United States, the stewardship and management of approximately 599,000 bridges present ongoing planning, operational, maintenance, and economic challenges for Federal, State, and local transportation agencies.

To help overcome these challenges and foster the next generation of bridges and bridge management systems, in April 2008, the Federal Highway Administration (FHWA) launched the Long-Term Bridge Performance (LTBP) Program, a major new strategic initiative designated as a flagship research program.

The LTBP Program is intended to be a long-term research effort with the objective of collecting scientific quality data from a large number of our Nation's highway bridges—those representing the most common bridges in the National Bridge Inventory—to provide a more detailed and timely picture of bridge health and bridge performance.



# data collection

## for improved understanding

The wealth of scientific quality data collected from a large number of our Nation's highway bridges by the robotic system for condition assessment of concrete bridge decks—and the subsequent data analysis along with the analysis of the bridge legacy data—will lead to:

- Improved knowledge of bridge performance.
- Advances in deterioration and predictive models.
- Deterioration models, which can simulate interactions between pavement, bridges, and traffic.
- Effective use of life-cycle cost analysis.
- Support for development of improved design methods and bridge maintenance/preservation practices.
- Quantification of the effectiveness of various maintenance, repair, and rehabilitation strategies.
- Improvement of the operational performance of bridges with the potential to reduce congestion and delays.
- Fostering of the next generation of bridges and bridge management systems.
- Contributions for setting national policy.

Ultimately, improved understanding of bridge health and bridge performance will promote the safety, mobility, longevity, and reliability of the Nation's highway transportation assets.



# breakthrough

## in bridge technology integration

In a single pass, this robotic system developed in a collaboration between Federal Highway Administration and Rutgers, The State University of New Jersey, can gather a wide range of data—high-resolution photographic, electromagnetic, seismic, and electrical—for external and internal deck conditions.

The robot automates data collection and deploys multiple nondestructive evaluation (NDE) technologies, simultaneously, which greatly increase the speed and comprehensiveness of the information gathered.

Perhaps the most revolutionary aspect of this robotic system is its enhanced data interpretation and visualization capabilities. Thanks to data integration, fusion, and three-dimensional rendering, the robot, can provide a three-dimensional image of the deck by combining data sets, producing an almost instantaneous snapshot of bridge deck condition that is easy to interpret.

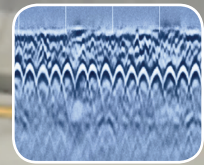
This novel method of using technology integration to gather quality data on deck conditions will improve our knowledge of bridge deck performance.



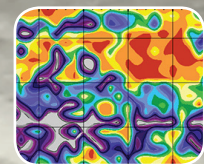


# multiple tools

for thorough diagnosis



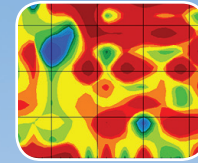
**Ground Penetrating Radar** is used to detect suspected or apparent deterioration.



**Electrical Resistivity** diagnoses the corrosive environment within the concrete deck by detecting level of moisture and flaws.



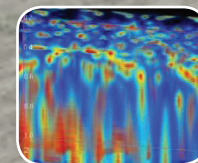
**Global Positioning System** records and tags data with exact position coordinates.



**Ultrasonic Surface Waves** assess the quality, modulus of elasticity, and hence, strength of the concrete deck.



**High-Definition Imaging** captures high-resolution images of the deck surface and 360-degree images of bridge features.



**Impact Echo** detects and characterizes delamination (horizontal cracking) with respect to depth, spread, and severity.

## NDE technologies on the robotic system

### Global Positioning System

Global Positioning System precisely tags condition data with exact location using global coordinates.

### Ground Penetrating Radar

Ground penetrating radar (GPR) provides a qualitative condition assessment of bridge decks. It can be used as a diagnostic tool for detecting apparent or suspected deterioration (such as delamination or corrosion) in an existing deck, or as a quality assurance tool for new construction or rehabilitation. The GPR system on the robot uses a dense array of ground-coupled antennas, which enable assessment with high spatial resolution.

### Impact Echo

Impact echo (IE) is a seismic or stress-wave technology used to find defects and anomalies in concrete. IE is primarily used to detect and characterize delamination (horizontal cracking), including depth, spread, and severity. Other applications for IE include detection of debonding on decks with overlays. The robot is equipped with more than a dozen IE devices.

### Electrical Resistivity

Electrical resistivity measures the resistance to the flow of electricity in a particular environment. A corrosive environment contains more water, chlorides, and/or salts or other contaminants, making it more conducive to electricity flow. Therefore, the higher the resistance measure, the lower the corrosion. The electrical resistivity of the concrete is inversely related to its potential for corrosion. This same relationship can be seen with many cases of reinforcing steel, as well.

### Ultrasonic Surface Waves

Ultrasonic surface wave (USW) testing is used to assess the quality and modulus of elasticity, and hence, strength of the concrete deck. The robot uses multiple sensor combinations to simultaneously evaluate concrete modulus across eight deck locations.

### High-Resolution Imaging

The robot uses three high-resolution cameras to capture images of the deck. Two cameras mounted on the front capture high-resolution images of the deck surface that are automatically stitched to provide a holistic deck-surface image; deck cracks are read from these images, and the lengths and widths of the cracks are mapped. The third camera is mounted on a tall mast and provides 360-degree images with visual information on the presence and condition of barriers, poles, curbs, and so forth.