# Exploration of Ultrasound for the Evaluation and Preservation of Structures

tech transfer summary

**MIRA, an advanced nondestructive testing device, has the potential to improve the accuracy and coverage of structural inspections.**


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**RESEARCH PROJECT TITLE**
Exploration of Ultrasound for the Evaluation and Preservation of Structures

**SPONSORS**
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The Bridge Engineering Center (BEC) is part of the Institute for Transportation (InTrans) at Iowa State University. The mission of the BEC is to conduct research on bridge technologies to help bridge designers/owners design, build, and maintain long-lasting bridges.



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## Goal and Objectives

The goal of this project was to explore the ability of a nondestructive testing (NDT) device called MIRA to assess the condition of a bridge's superstructure. Specific objectives were to evaluate the device's ability to detect internal cracking and the location and relative size of reinforcement in the deck underneath an overlay and to identify voids in post-tensioning ducts.

## Background

Bridge inspection and preservation efforts have included NDT methods for decades. The most commonly used are chain dragging and hammer sounding, though these methods are imprecise and often subjective.

More advanced methods, such as impact echo, ultrasonic pulse velocity, and ground penetrating radar (GPR), have not been widely implemented due to their sensitivity to moisture conditions, the need for extensive access to the structure, shallow penetration depths, and other critical limitations.

MIRA, an ultrasonic linear array device that employs dry point contact transducers, has the potential to improve the accuracy and coverage of structural inspections. The technology promises a high penetration depth, high accuracy due to overlapping measurements, the ability to collect data regardless of moisture conditions, and the ability to obtain data when access to the structure is limited.

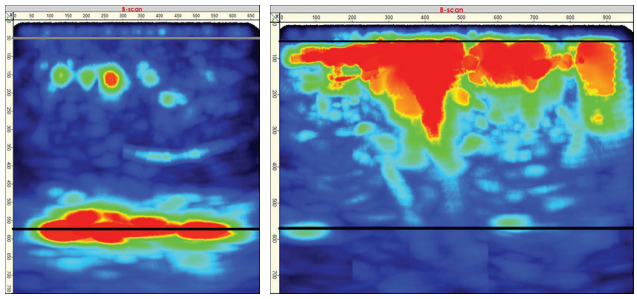

*MIRA device being used in the field*

## Research Description

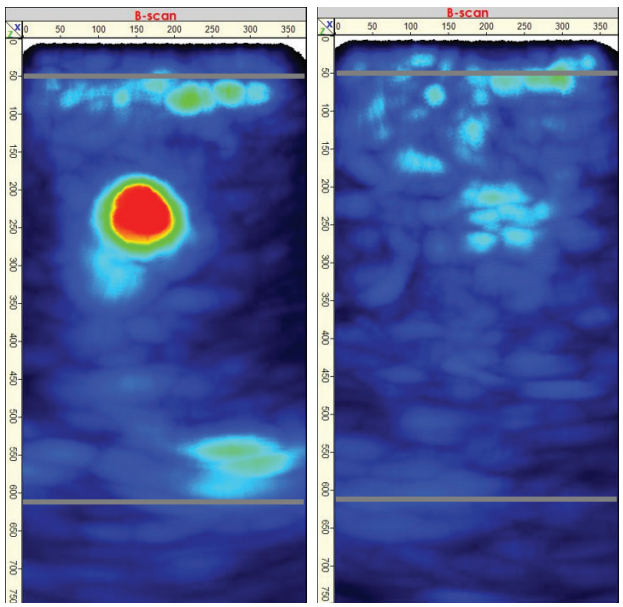
MIRA was deployed at two bridges in Iowa: the Mingo Bridge and the Highway 2 Bridge over the Missouri River.

At the Mingo Bridge, the objective was for MIRA to detect internal cracking and the relative size and location of reinforcement in the bridge deck underneath an existing overlay. The Mingo Bridge was chosen because it had an aging overlay in place that was slated to be replaced soon and because many cracks had been observed on the top surface of the deck. However, the overlay was replaced only after this project ended.

At the Highway 2 Bridge connecting Iowa and Nebraska over the Missouri River, the objective was for MIRA to assess the condition of post-tensioning ducts in areas where voids had previously been found using different NDT methods. Three post-tensioning tendons in the web were examined.



*Cross-sectional MIRA scans of different areas of the Mingo Bridge deck: (left) a localized red area indicating a possible defect and a large red area indicating the bottom of the deck; (right) an extensive red area indicating defects in the deck substrate below the overlay*




*Cross-sectional MIRA scan over the locations of different post-tensioning tendons in the Highway 2 Bridge: (left) a red area showing a void in the tendon duct; (right) a scan indicating that no void is present*

The results of the MIRA scans on both bridges were validated against field inspection results, and, in the case of the Highway 2 Bridge, a report from an earlier NDT inspection.

## Key Findings

- When the overlay on the concrete deck was in good condition, MIRA could effectively detect the location and relative size of the top layer reinforcement.
- MIRA scans could not clearly distinguish between the bottom surface of the deck and the bottom layer reinforcement at about 575 mm below the surface.
- When cracks were present in the overlay, MIRA was able to detect these defects. However, since the substrate deck condition on the Mingo Bridge could not be examined during this project, this type of damage seen in the MIRA scans could not be field verified.
- MIRA performed well in detecting voids in post-tensioning ducts.

## Conclusions and Recommendations

MIRA demonstrated promising capabilities, but some limitations were observed. For example, when severe cracking is present in an overlay, MIRA scans show a large area of damage from the top reinforcement to the mid-depth of the deck. It is difficult to determine the precise location of the distress based on this output, and extent of the detected damage could not be verified in this project.

This project hoped to capture the actual condition of the Mingo Bridge's substrate via field evaluation during overlay placement. Unfortunately, because the letting of that work was delayed, the actual condition could not be captured within the timeframe of this project. Future research is recommended on an experimental basis to quantitatively evaluate MIRA's performance and thereby validate the condition of the substrate.

## Implementation Readiness and Benefits

NDT technology that allows for both visual and quantitative evaluation below the surface of the bridge deck would be advantageous for inspection programs and preservation planning.

While some limitations to MIRA's capabilities were identified, with additional study the technology has the potential to improve the accuracy and coverage of structural inspections.