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Final Report

Advanced Non-Destructive Bridge Deck Condition Assessment

Iowa Department of Transportation
State Planning & Research Project: 20-SPR0-007

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16. Abstract: Iowa Department of Transportation expressed an interest in commissioning Infratek Solutions Inc. to provide its next-generation bridge deck assessment and analysis services (insight) to Iowa's selected bridge inventory. To meet this objective, Iowa has initiated a research study with the goal of exploring and refining how advanced NDE assessment technologies may be deployed to best serve asset management goals. For this reason, Infratek Solutions Inc. deployed its High Speed and High Definition bridge deck evaluation systems, conducted automated data collection and processing on all the bridges, and analyzed the data to identify deterioration mechanisms, repair quantities, and intervention recommendations. All data, final results, and actionable insights were made accessible to Iowa DOT through Infratek's online asset management portal, where multiple statistics, data analysis, and manipulation tools are available for users. The results were also packaged in comprehensive PDF reports that can be easily downloaded from the portal.

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Executive Summary

Infratek Solutions Inc. specializes in delivering practical and effective performance-based asset management systems fueled by cutting-edge advanced technological platforms for critical infrastructure sector.

Established in 2014, Infratek has enjoyed working with Federal Highway Administration, various State Transportation Agencies, Bridge Authorities to bring practical technological advancements to tackle their infrastructure asset evaluation and management problems. Capitalizing on the experience gained through the development and field deployment of the commercial edition of the Robotic Assisted Bridge Inspection Tool (RABIT-CE), Infratek is scaling up and enhancing its offering to be more responsive to the day to day asset management needs of bridge owners. Based on numerous interactions with owners, such needs primarily include (a) accurate and quantitative assessment of current condition, (b) estimates of remaining service life and deterioration mechanisms, and (c) recommendations for interventions and their influence on remaining service life.

Iowa Department of Transportation expressed an interest in commissioning Infratek to provide its next-generation bridge deck assessment and analysis services to their selected bridge inventory. To meet this objective, Iowa initiated a research study with the goal of exploring and refining how advanced assessment technologies may be deployed to best serve asset management goals.

We are excited to be engaged in this mutually beneficial partnership and are committed to develop, maintain, and customize the systems and underlying processing and analysis engines to match the needs of Iowa DOT. We do not view this opportunity as simply another service contract, but rather as a partnership that will allow us to refine our offerings based on the insights and experiences of Iowa DOT engineers and staff to better serve the state's needs. We are pleased to submit this final report and accompanying data sets for Iowa Department of Transportation's review.

Methodology

To provide maximum efficiency, the Infratek offering integrates both High Speed and High Definition sensing technologies (although these technologies may be used independently of one another depending on the owner's requirements). The standard, envisioned operation requires bridges to be initially scanned at highway speed by the best in class available NDE technologies. The acquired data is then processed in an automated manner and used to plan the deployment of high-resolution sensing technologies in two ways. First, the data is examined to identify bridges that may benefit from the high definition scanning. In general, such bridges are those for which interventions appear to be appropriate.

Second, and perhaps more importantly, the high-speed scanning can be used to direct the high definition scanning to the portions of the deck for which such information is most valuable. For example, if the high-speed scanning indicates that 60% of a deck is in very good shape, this portion of the deck would not be subjected to high definition scanning, which will drastically reduce the time-on-bridge, cost, and disruption to the traveling public. Although it may be possible to use visual inspection results to perform this initial screening, given its limitations related to finding sub-surface deterioration, difficulty in providing precise spatial information about the identified defects, and qualitative nature, it is probably best suited to simply identify candidate bridges (as opposed to regions of decks that should be scanned with the high definition system). As a result, the cost and time required to deploy the high-definition system if driven by visual inspection (as opposed to the high-speed system) would likely be far greater as it would then be used to screen entire bridge decks as opposed to selected portions.

This strategy has the potential to substantially decrease the time on the bridge, leading to higher efficiency, lower traffic control cost, and ultimately enabling more bridges to be scanned.

Multiple sensor technologies are deployed at each data collection site, allowing the bridge owners to assess the condition of the bridge decks from different NDE aspects, each highlighting different characteristics of the concrete deck. The addition or subtraction of a certain technology has no influence on the cost of the project as each group of NDE technologies are deployed together to reach maximum productivity on the bridge:

- **High Speed Technologies:**
  - Air Coupled GPR
  - Infra-Red Thermography
  - High Resolution Surface Imaging and Crack Mapping
  - Bridge Deck Profiler
  - 360° High Resolution Imaging
  - Light Detection and Ranging (LiDAR)

- **High Resolution Technologies:**
  - Ground Coupled GPR
  - Ground Coupled Impact Echo
  - Ultrasonic Surface Waves
  - Electrical Resistivity

Tasks

This project was executed in multiple phases with each phase having its own tasks and deliverables as described below:

Task 1. Design and Develop Visualization and Reporting Procedures

The goal of this task was to refine and customize the data visualization and report formats for the condition assessment deliverable. During this task, Infratek's visualization and reporting procedures were customized to produce reports, diagrams, and maps that match the perceived needs of state engineers and decision makers.

Task 2. Design and Develop Data Analysis and Intervention Algorithms

The goal of this task was to develop specific definitions for end-of-service-life (of bridge decks) as well as state-specific intervention options and a preliminary set of thresholds that will trigger the recommendation for each type of intervention. To accomplish this task, the Infratek team provided Iowa DOT with a summary of (1) the available deterioration-specific condition metrics that may be obtained with both the high speed and high definition systems, (2) example thresholds to define end-of-service-life and different condition states, and (3) example thresholds that may be used to trigger different intervention recommendations. Following the review by Iowa DOT, the Infratek team incorporated the feedback received into its procedures to produce the final data analysis reports accordingly.

Task 3. Develop Recommendations for Interface and Integration Procedures with 3rd Party Asset/Bridge Management Systems

The goal of this task was to develop recommendations and guidelines to interface and to integrate the data, performance metrics, and intervention recommendations with Iowa's existing in-house or 3rd party bridge/asset management systems.

To accomplish this, Infratek provided a data dictionary and interface guidelines on how to access, read and parse various raw and processed data sets that were submitted to Iowa DOT as a result of this project.

Task 4. Field Data Collection

Under this task, Infratek performed the field data collection for the bridges identified by Iowa DOT. In addition to identifying the bridges, Iowa DOT also defined the type of data collection to be performed on each one of the bridges as high-definition scanning. Infratek also conducted High Speed data collection on all of the bridges as part of its own investment into this valued collaboration between the two entities.

Sites were identified based on a number of assumptions for data collection that are highlighted below:

- The selected bridges are no more than 45 minutes of drive apart (on average)
- The average size of the bridges is 10,000 square feet or lower. At some cases, the identified bridges could be larger.
- None of the bridges selected for data collection will have asphalt overlays
- All necessary traffic control will be scheduled and planned for by Iowa DOT

- All high-speed data collection activities are Infratek investments and are considered optional. They will occur during the day with no need for traffic control.

Figure 1 - HS System Collecting Data on a Bridge in Iowa

Figure 2 - HD System Collecting Data on a Bridge in Iowa

Task 5. Data Processing and Analysis

The goal of this task was to further process and analyze the data to estimate effective interventions, estimate repair quantities and identify deterioration mechanisms. For each bridge from which data was collected, Infratek employed the models and processes defined under Task 2 to develop a report consistent with the Condition Forecasting and Recommended Intervention deliverable described above. Each of the reports generated was reviewed by NDE experts, published to Infratek's “insight” asset management portal and shared with Iowa DOT.

Task 6. Outcome Review, Refinement, and Phase 2 Planning

As part of this task which was ongoing during the past two tasks, results and the feedbacks received from Iowa DOT during field data collection, data processing and analysis were incorporated into the ongoing procedures and the data analysis thresholds and recommendations were refined accordingly before producing the final results.

Results

This project provided individualized Data Analysis and Algorithm Reports for each of the fifteen pre-selected bridges for this project. The resulting data was first presented through a series of maps that reflect various levels and types of deterioration together with their spatial variation. Included with each map was a brief narrative describing the type of data presented and any key characteristics observed. Secondly, the data was summarized through a series of metrics. Finally, a narrative describing the overall condition, repair quantity estimates, mechanisms for the observed deterioration, and recommendations was presented. The results were also published to Infratek’s “insight” Asset Management Portal, where the users can use several statistical and data analysis tools.