NCITEC Project Title: Three Integrated Projects to Enhance Non-Contact Rail Inspection Technology for Application to Substructure Health Evaluation on Both Rail and Road Bridges

PI: Elizabeth K. Ervin, Civil Engineering

Co-PIs: Chris Mullen, Civil Engineering; Vyacheslav Aranchuk, National Center for Physical Acoustics (NCPA); James P. Chambers, NCPA and Mechanical Engineering

Project Period: 8/1/2012 - 12/31/2013

Project Objective: Use non-contact techniques to advance inspection of transportation infrastructure in order to improve public safety and economic competitiveness.

Integrated Activities:

1. Experiment 1: Non-Contact Rail Inspection
   A mock railway track with substructure has been constructed outside the NCPA. The track substructure has artificial settlement defects at its center. Dynamic characteristics of both normal and defective states will be analyzed using health algorithms.
2. Experiment 2: Bridge Scale Model
   A mock reinforced-concrete bridge will be constructed in the NCPA. The design is complete, and construction planning is in progress. Different bearings will represent wear, and then destructive testing will take place. Dynamic characteristics of both normal and defective states will be analyzed using health algorithms.
3. Experiment 3: Full Scale Bridge Test
   No developed methodology can be valid without application to a full scale bridge. East Gate Bridge on University Avenue will be tested for its current state with respect to a finite element model baseline.
4. Structural Health Monitoring (SHM) Algorithm Development *(throughout project)*
   A comprehensive, in-house source code Matlab program has been completed. The program incorporates structural info, test data, modal decomposition, mode correlation, damage detection, and health visualization. Beta testing is underway.
5. Finite Element (FE) Modeling *(throughout project)*
   The bridge scale model was designed with SAP2000 for frequency estimation. This effort will continue to study the effect of model complexity versus the as-built bridge. FE modeling will examine the scalability of damage detection algorithms using data from destructive scale model testing to bridge field test. This will also aid in examining the effects of local damage on global structural response. The use of an FE baseline is especially novel.

Schedule of Experiments with Progress:

(1) Full Scale Rail – Build Fall 2012 (completed), Test Spring 2013 (in progress)

(2) Scale Model Bridge Experiments – Design Fall 2012 (completed), Build Spring 2013 (in progress), Test/Analysis Summer to Fall 2013

(3) Full Scale Bridge Experiments – Planning Fall 2012 to Spring 2013 (in progress), Test Summer 2013, Analysis Fall 2013

Benefits:

1. The development of a comprehensive structural health evaluation program is a unique selling point, providing the basis for further research in a variety of fields.
2. The new integrated inspection technique is expected to more efficient, more cost effective, and more accurate than traditional (visual) techniques.
3. More accurate estimation of remaining life could potentially prevent collapse but, at a minimum, will aid decision-making on the bridge's upkeep.

Potential Products: Part of this project is the determination of how best to transfer a new technique to field inspectors and/or maintenance workers.