Development of a Self-sustained Wireless Integrated Structural Health Monitoring System (ISHM) for Highway Bridges

KICK-OFF MEETING MINUTES – August 5, 2011

Date & Time: Friday, August 5, 2011, 10:00AM – 3:30PM
Place: CEE Main Conference Room, 1179 Glenn Martin Hall, University of Maryland
Subject: Project Kick-off and Technical Advisory Committee (TAC) Meeting
Attendee: TAC: Jeff Robert (MSHA), Abey Tamrat (MdTA), Mrinmay Bismas (NCDOT), Paul Sprouse (NCDOT), Xiaohua "Hannah" Cheng (NJDOT), Caesar Singh (USDOT/RITA)
University of Maryland (UMD): PI - C.C. Fu (PI), Dr. Y. Zhang (co-PI), Linjia Bai, Zhen Li, Tim Saad, Gengwen Zhao, Changjiang Zhou
North Carolina State University (NCSU): Dr. F. G. Yuan (co-PI), Lei Liu
URS: Dr. Y.E. Zhou (co-PI)

Project overview presentation (RITA_ProjectSummary.pdf)

Morning Discussion Session

CRS&SI program

- Mr. Singh mentioned it is part of SAFETEA-LU program. The purpose is a development of an applied program, not a basic research.

Commercial and Remote Sensing Technologies

- Very broad program, but the real emphasis should be on *applied programs* and should be involved with*applied research.*

Background on Sensors

- Sensors are sensitive and give responses to all types of stimulations; including stimulations that come from the environment
- Dr. Zhang is implementing a 3rd generation acoustic emission sensor
    - Piezo Paint AE sensor with reconfigurable sensing dots (RPPS-dots)
- When field experiment in China, every time a train passes on a bridge, the acoustic emission sensor (on the crack) gives a response

Self-sustainable power source

- Dr. Yuan adopted Miniature Wind Turbine System for this project
- In some areas of bridge, wind may be more prevalent than solar energy
- However, wind energy is more complementary to solar because it doesn't store energy as well

Wireless Sensor System @ NCSU

- WISP – wireless sensor platform with hybrid architecture
- Top Layer – Communications layer (interfacing bond to accommodate different sensors)
- Middle – Processing layers

Financials of the Project

- Funding stops @ the prototype stages
    - It is provided on a case by case basis
    - It is possible more funding is available at the end of the project
- The rights of product are to the University but the government/DOT does have access to information
- University has the rights to patent the project
- Because the project is a funded by a public funding source, it should be available to the public

Challenges of Outreach process

- Selling the whole package to the user community may be difficult
    - Community will have to learn how to use the monitoring system
- If it brings benefit to bridge owner it will sell itself

AE Sensor for Bridge Monitoring

- Dr. Zhang mentioned Caltrans contracted PAC for a $3.4M value project to deploy 640 AE on San Francisco Bay Bridge to remotely monitor 384 critical eyebars for early detection of fatigue defects.

Project Execution

- From beginning we will start assessing the bridges
    - Dr. Fu proposed that one prospective bridge is on route 1 with a creek and pathway underneath
    - Will coordinate with Mr. Robert of MDSHA

- URS is involved w/ all bridges in MD that have fatigue cracks. Ed Zhou will help us pick one bridge from his knowledge of bridges
- A bridge should also be picked with appropriate access

Crack Monitoring/Sensor Placement

- We can detect internal defects if they propagate
- We use FEM to find "hotspot"
- Read inspection reports to learn more about the selected bridges
- Mr. Tamrat mentioned the Tidings Bridge may be a bridge of choice due to availability of access
    - Be careful to choose a bridge and not choose one just because of its convenience

Afternoon Discussion Session

Prospective Bridges for Monitoring

- Bascule Bridge (Route 27 in city 2.5 hours from Raleigh, NC) proposed by Mr. Sprouse of NCDOT
    - Type of draw bridge w/ fatigue at the end toward counterweights
- Rest Area Truss Bridge proposed by Dr. Biswas of NCDOT
    - Currently unused, but can put maintenance trucks on it

Implementation of Sensors on other Material Bridges

- AE sensors can be used for termite detection on timber structures
- Surface differences between concrete and steel
    - Smoother surface on steel structures

Identifying Existing Crack Location

- Try to find out propagation
- Paint based system
- Acoustic based system

Post Processing

- Analyze the signal from sensor(s) to determine Remaining Useful Life
    - To what point do small cracks become important
- First test for signs of potential damage, and use these signs to show the cause

Sensor Placement Strategy

- More sensors used are better
- Come up with heuristic guideline for critical placement

Goals of Project

- Configure a way extrapolate data from one sensor location and apply to other locations on the bridge
- Before we see the crack, we can detect the crack
    - Our goal is to detect *crack initiation*

Sensors Behavior

- Sensor can only tell if energy is released, means active
    - It's not the size of crack that sensor detects

Developing sensor vs. sensors already on the Market

- This prospective system will be autonomous and real time
- Project gives boost to further development to make cost effective

Commercialization

- When various companies package a product, who owns the package
    - Not coming up with a *ground up* development of remote based system
    - Intellectual property concerns
- The purpose of commercialization is not for financial profit, but to make more available to public

- Although the system will be commercially available the creative application of the system is eventually Intellectual Property

Conclusions/Emphasis of Project

- Monitor propagation of existing crack(s)
- Detect crack(s) for crack initiation
    - This will happen in the lab, because if we could do this in the field then the project wouldn't be necessary
    - After crack detection we have to qualify what type of crack it is
    - Sensors will detect existence of active crack, but will not detect inactive crack (such as cracks created during product manufacturing)
- Both crack initiation detection and existing crack propagation monitoring are important