Remote Structural Monitoring and Corrosion Degradation Modeling of Bridges

2008 Army Corrosion Summit

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Outline

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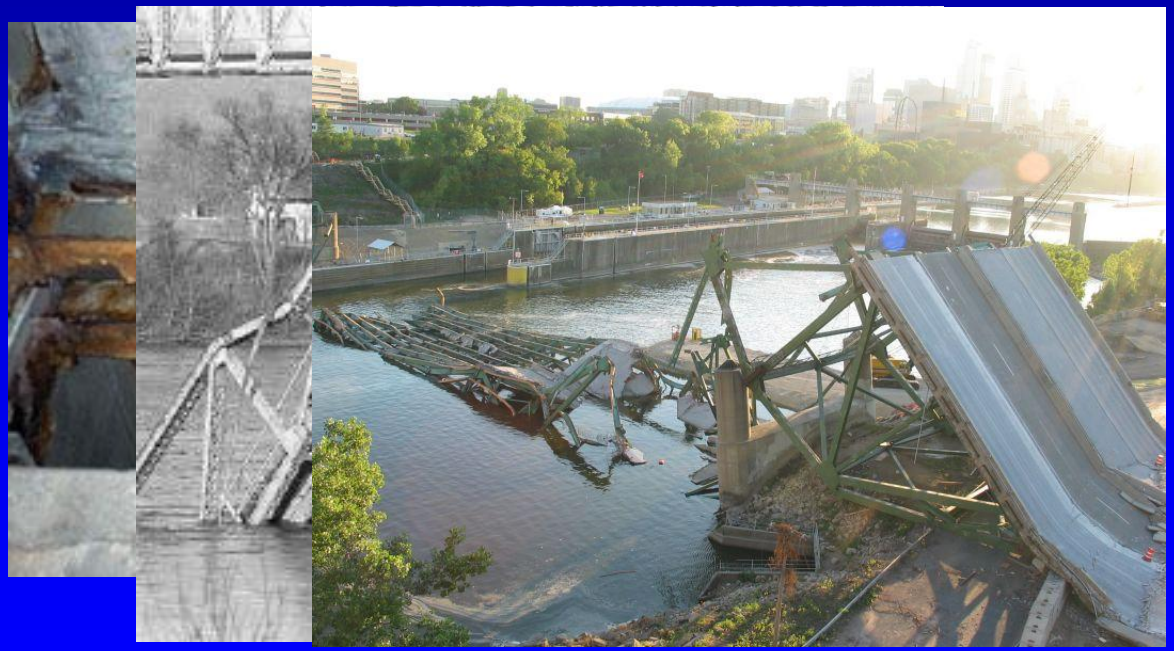
Background

- Bridges are essential infrastructure
- Many Army and DoD bridges in need of repair & replacement due to corrosion / material degradation
- Over 11-year period, 503 U.S. bridges failed, 100 of these due to corrosion
- Routine inspection may not detect hidden cracks
- Avoid catastrophic failure

Definitions

- Fracture Critical Design – Bridges: where failure of a single component could cause the bridge to collapse
- Corrosion a major concern with these fracture critical structures



Objectives

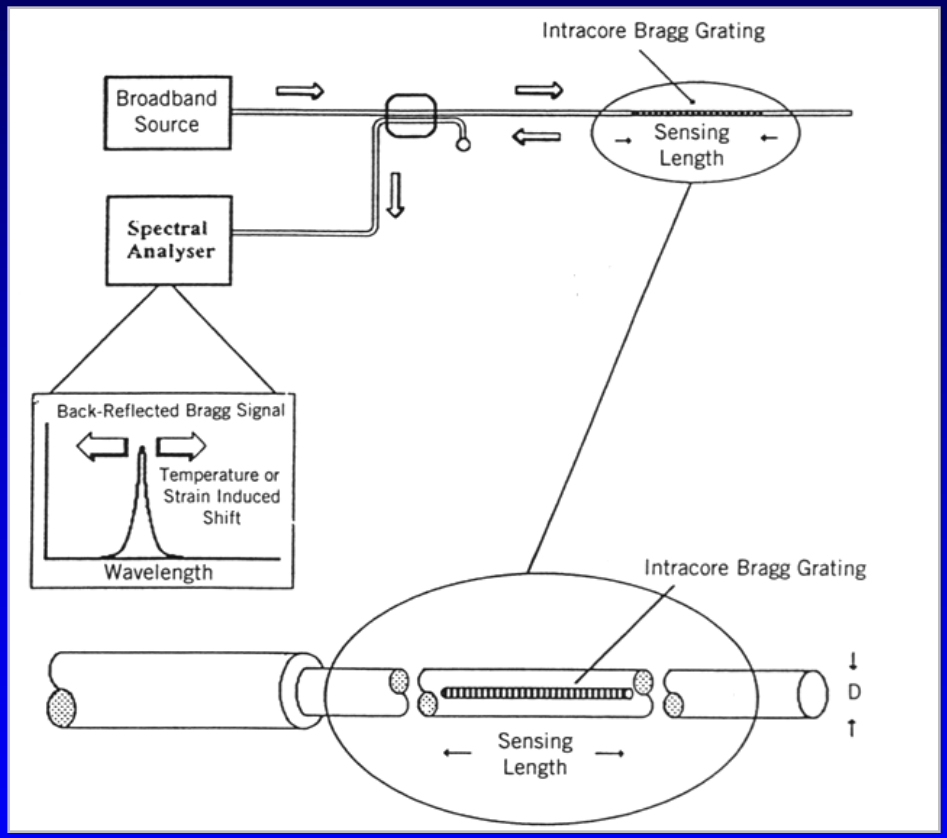
Demonstrate capabilities and validate benefits of remote structural health monitoring and corrosion degradation modeling to greatly reduce the risk of catastrophic bridge failures.

Approach

Develop and demonstrate an integrated "smart" monitoring system using both strain-based and acoustic-emission sensors, coupled with accelerometers, corrosion-rate sensors, and other possible sensors, and complete with wireless remote communications capabilities.

Candidate Technologies
Strain-Based Systems

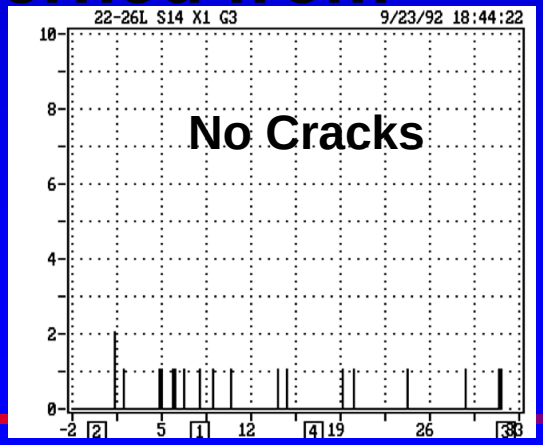
- Use optical strain gages manufactured directly inside fiber core
- Can multiplex over long distances
- Strains are calculated from shifts in wavelength
- Does not need periodic recalibration

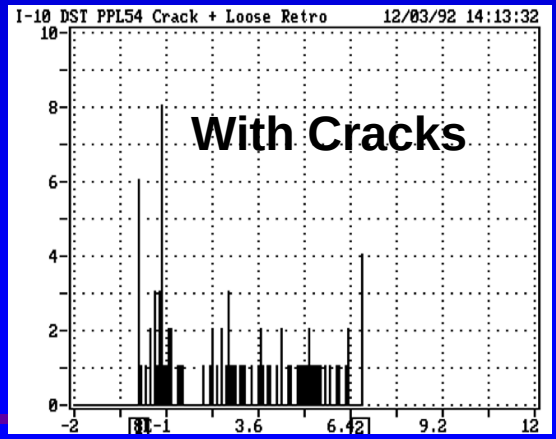


Candidate Technologies
Acoustic Emission-Based Monitoring

- Growing cracks and corrosion release ultrasonic signals
- Travel great distances
- Signals of interest easily discerned from noise

Example A-E Sensor





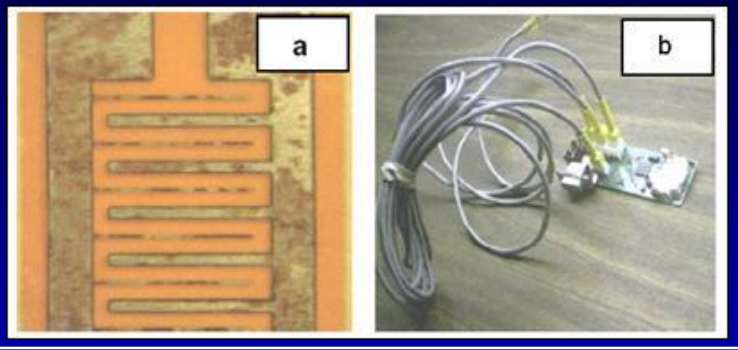
Candidate Technologies
Accelerometers – Modal Analysis

- Measurement of vibration and inclination
- Change of natural frequency an indication of change and possible damage to the structure

Example accelerometer / inclinometer

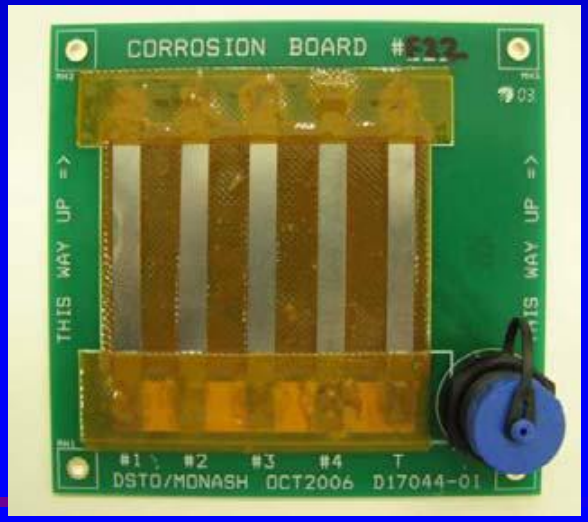
Candidate Technologies
Corrosion Rate Sensors

- Use established linear polarization resistor (LPR) technology



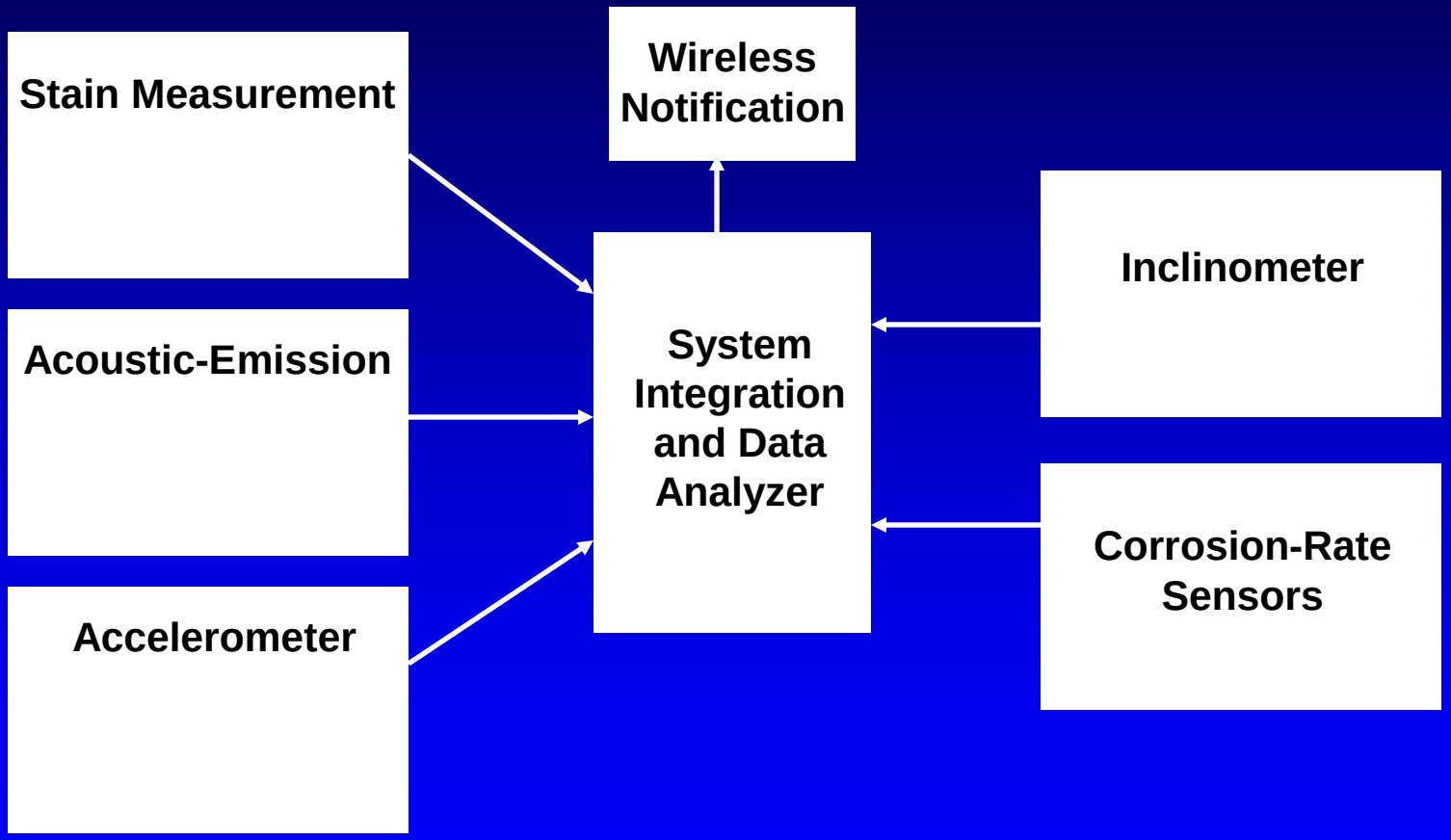
Stamp Size Linear Polarization Resistance (LPR) corrosion rate sensor system: (a) Magnified view of sensor (b) sensor node with electronics (8 sensors per node)

- Also, electrical resistance-type to measure atmospheric corrosion



Example of electrical resistance-based corrosion sensor board.

Smart Structural Health Monitoring System



Candidate Bridges

- Government Bridge at Rock Island Arsenal, IL
  - Current bridge build in 1896
  - Mission critical
  - Steel truss through deck
  - Vehicles lower deck, ~10,300 per day
  - Railroad upper deck, ~5 trains per day

Candidate Bridges

- I-20 Bridge at Vicksburg, MS
  - Opened February 1973
  - Steel truss through deck
  - Part of National Defense Transportation System
  - ~23,000 vehicles per day
  - Active fault running along the river near the east bank

Candidate Bridges

- Fort Sill
  - Steel truss through deck
  - Currently closed, slated for replacement
  - Opportunity to instrument a full-sized structure, induce defects, and load as desired, including up to failure

Candidate Bridges

- Thermoplastic Composite Bridge at Fort Bragg, NC
  - Innovative thermoplastic I-beam design, being constructed as part of a separate Program
  - Designed for crossing M -1 tank
  - Model degradation of thermoplastic composite materials

Deliverables / Expected Benefits

- Provide Army and DoD with validated tools for remote structural-health monitoring and corrosion rate modeling of bridges
- Will develop engineering guidance for design and use of remote structural-health monitoring systems for bridges
- Useful by other Federal, State and local government agencies responsible for bridge inspection, safety, and maintenance & repair

Project Team

- U.S. Army Engineer Research & Development Center
  - ERDC Bridge Inspection Team
- Mississippi Department of Transportation
- Louisiana Department of Transportation
- Rock Island Arsenal Directorate of Public Works
- Fort Bragg Directorate of Public Works
- U.S. Army Engineer School
- Office of the Secretary of Defense Corrosion Control and Oversight Office
- (Army) Assistant Chief of Staff for Installation Management
- (Army) Installation Management Command
- Army Materiel Command
- Federal Highway Administration

Structural Health Monitoring and Corrosion Modeling Workshop

- Objectives: Define an appropriate system or approach for "smart" structural health monitoring (SHM) for application today on a steel truss bridge.
  - Establish the state of the art for sensors and for structural health monitoring technologies for of bridges
  - Lessons learned from past SHM applications
  - Define the critical aspects of bridges to be monitored, independently or in combination, to evaluate structural health
  - Understand the current limitations which impede SHM of bridges
- Location / Date: OSD Offices in Rosslyn, VA / Target date end-of-March/early April 2008, exact date TBD

Questions ???