NASA Workshop

Federal Highway Administration

Turner-Fairbank Highway Research Center

Fred Faridazar
July 2011

What/Who is the Federal Highway Administration (FHWA)?

The FHWA is an agency within the U.S. Department of Transportation.

Supports State and local governments in the design, construction, and maintenance of the Nation’s highway system(Federal Aid Highway Program) and various federally and tribal owned lands (Federal Lands Highway Program).

Federal, State & Local Relationship
Federal Responsibilities

- ✓ Review and approve State Projects
- ✓ Develop regulations and guidance
- ✓ Promulgate standards
- ✓ Provide technical assistance
- ✓ Distribute line of credit
- ✓ Reimburse States their eligible expenses

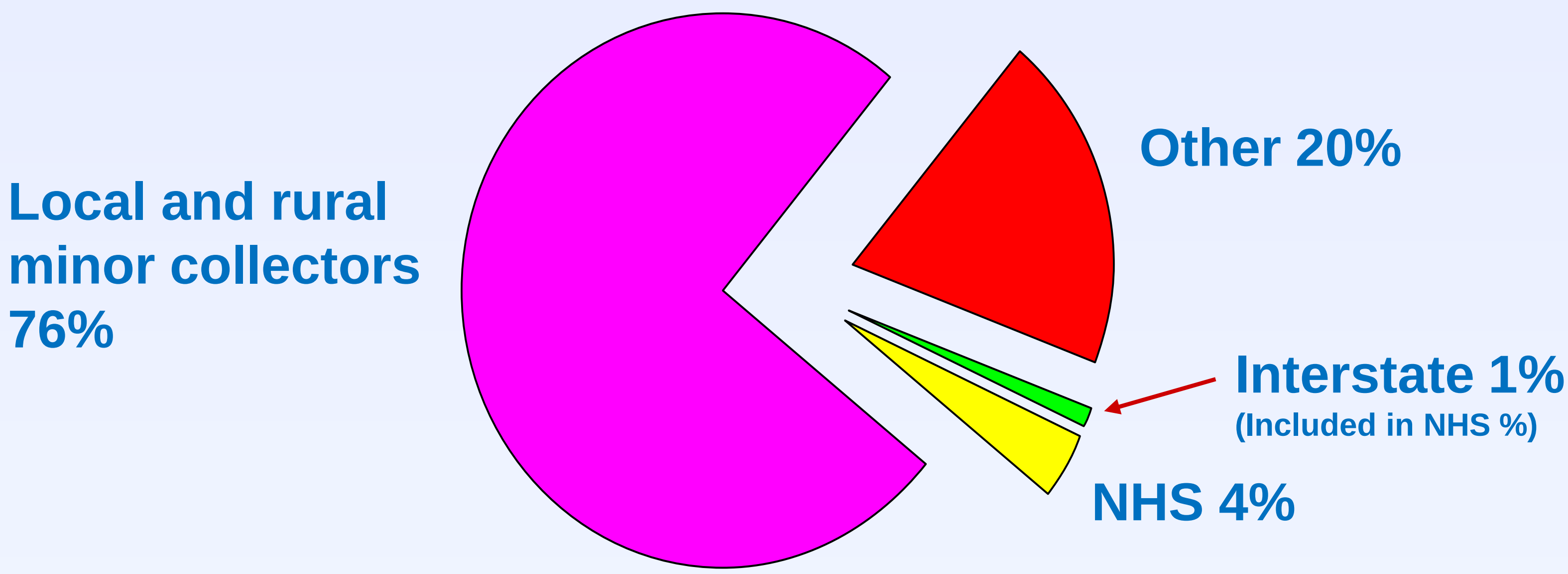
Federal, State & Local Relationship

State and Local Responsibilities

- ✓ Conceive, plan, design, initiate, and construct projects

- ✓ Maintain and operate highways

Functional Classification
Eligibility for Federal Financial Assistance



Ineligible ***Eligible***

4 million miles of public roads total

Federal Highway Administration Headquarters Offices

- Office of Administration
- Office of Chief Counsel
- Office of the Chief Financial Officer
- Office of Civil Rights
- Office of Federal Lands Highway
- Office of Infrastructure
- Office of Innovative Program Delivery
- Office of Operations
- Office of Planning, Environment, and Realty
- Office of Policy and Governmental Affairs
- Office of Professional and Corporate Development
- Office of Public Affairs
- **Office of Research, Development, and Technology**
- Office of Safety

Office of Research, Development, and Technology

http://www.fhwa.dot.gov/research/tfhrc

Federal Highway Administration Research and Technology

Coordinating, Developing, and Delivering Highway Transportation Innovations

TURNER-FAIRBANK HIGHWAY RESEARCH CENTER

About | Expertise | Laboratories | Offices | Programs | Research Projects | Contact

Research Home

TFHRC Home

Computer-Based Guidelines for Concrete Pavements: HIPERPAV III USER MANUAL

The High Performance Paving (HIPERPAV®) III software program is a comprehensive yet user friendly software package. This software program will be of interest to those involved in concrete pavement mix designs as well as the design and construction of concrete pavements. In this user manual, guidance is given on how to use the new HIPERPAV® III software program for the analysis of early age Portland cement concrete pavement (PCCP) behavior. Read More

1 2 3

News

The CMF Clearinghouse: A Handy Safety Tool

FHWA has developed an accessible Web-based, one-stop resource for information on crash modification factors. [Read more]

The Double Crossover Diamond

Introducing an innovative interchange for grade-separated crossroads that promises to speed construction, save money, and increase safety. [Read more]

Integrated Corridor Management

Analysis, modeling, and simulations of ICM strategies are going forward on three of the Nation's busiest roadways. Coming next—demonstrations. [Read more]

Periodicals

» *Focus* Newsletter

» *Public Roads* Magazine

» *R&T Transporter* Newsletter

Contacts

» Research Expertise

» Research Laboratories

» RD&T Organizational Directory Roles and Responsibilities

Presentation Outline

1. Exploratory Advanced Research
2. Pavement Sensors

   Pavement Monitoring

   - Self-powered Pavement Monitoring Sensor
   - Carbon Nanotube Based Self-sensing Concrete for

   Pavement Materials Tracking

   - Applications of RFID Technology to Asphalt Paving
3. Roadway Renewable Energy
4. Stay-in Lane
5. Additional Application Need

Exploratory Advanced Research (EAR) Program

Focus Areas

- Integrating highway system concepts
- Nanoscale research
- Human behavior and Travel Choices
- New technology and advanced policies for energy and resource conservation
- Information sciences
- Breakthrough concepts in material science
- Technology for assessing performance

Exploratory Advanced Research (EAR) Program

Program Status

- 80+ Initial stage investigations
  - Nanoscale research workshop
  - Smart Particles RFI
- Five solicitations resulting in
  - 39 projects awarded
  - $29M federal, $15M match
  - Five more projects under review

Exploratory Advanced Research (EAR) Program

Potential Breakthroughs

- New research methods
  - Driver engagement (GM)
  - Behavioral economics (UCF)
- New models
  - Driver visibility (SAIC, TTI, NIST, Virginia Tech)
- New technology
  - Scour measurements (TFHRC, ANL, NASA JPL)

Exploratory Advanced Research (EAR) Program

Topics under Investigation

- Integrated Highway System Concepts
  - International approaches: vehicle automation
- Nano-scale Research
  - Measurement of dispersion
- Human Behavior and Travel Choices
  - Dynamic ridesharing
  - Vision assisted technologies
- Energy and Resource Conservation
  - Sustainable underground structures
  - Electric vehicle commercialization

Topics continued

- Information Sciences
  - Video decoding, feature extraction
  - Probabilistic record linkage (data mining)
- Breakthroughs in Materials Science
  - “Self-healing” materials
  - Cement hydration kinetics
- Technology for Assessing Performance
  - “Smart balls” for autonomous culvert inspection
  - Pressure sensitive paints for aerodynamic testing;
  - Remote sensing for environmental processes

Exploratory Advanced Research (EAR) Program

EAR Program website

www.fhwa.dot.gov/advancedresearch

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Pavement Monitoring

- Most of existing methods either require significant personnel time or the use of costly equipment.
- Currently pavement instrumentation for condition monitoring is done on a localized and short term basis.

Pavement Monitoring

Two approaches are typically taken to monitor the condition of pavements:

- Manual distress surveys
- Automated condition surveys
  Imaging technology for distress survey
  Transverse profiling for the wheel path rutting

- Other testing approaches
  e.g., deflection testing

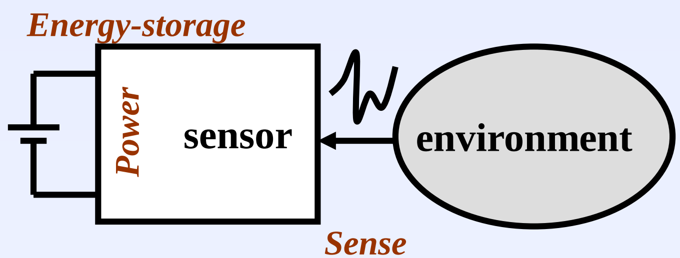
Significant personnel time or the use of costly equipment

Can only be used cost-effectively on a periodic and/or localized basis

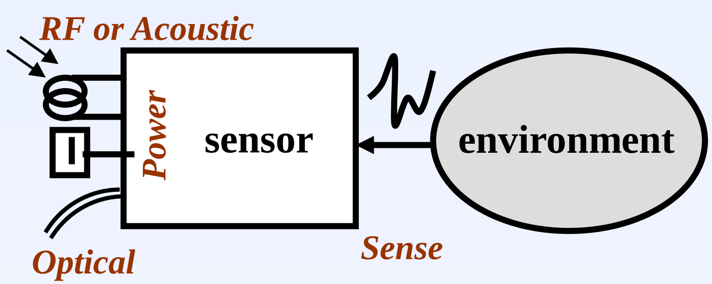
Self-Sustained Smart Sensing Systems

An ongoing FHWA project with Michigan State University

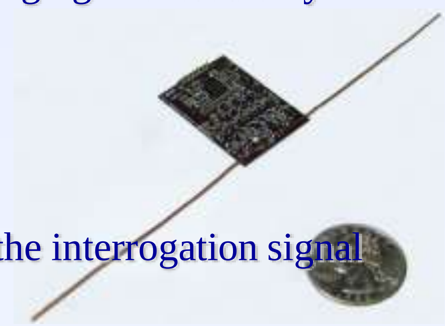
Sensors which operate by scavenging energy for sensing, computation, storage and transmission from the ambient environment.



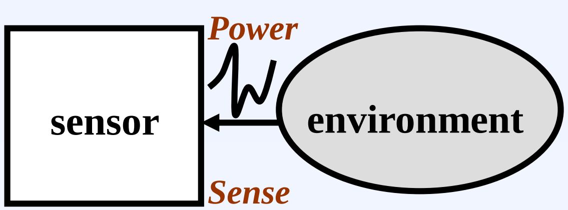
- **Rechargeable Sensors**
  - Energy stored by trickle-charging and used only powering conditions met.



- **Passive Sensors**
  - Sensor is active only when the interrogation signal present.



Intel WISP, Source: IEEE



- **Self-powered Sensors**
  - Harvest energy for operation from the signal being sensed.

Carbon Nanotube (CNTs) Based Self-Sensing Concrete

Ongoing FHWA project with the University of Minnesota

Carbon Nanortubes (CNTs)

Carbon nanotubes (CNTs) are seamless tubular structures.

(10^{-9}m), length 0.2 ~ 5 micrron, Dia 1-20 micron

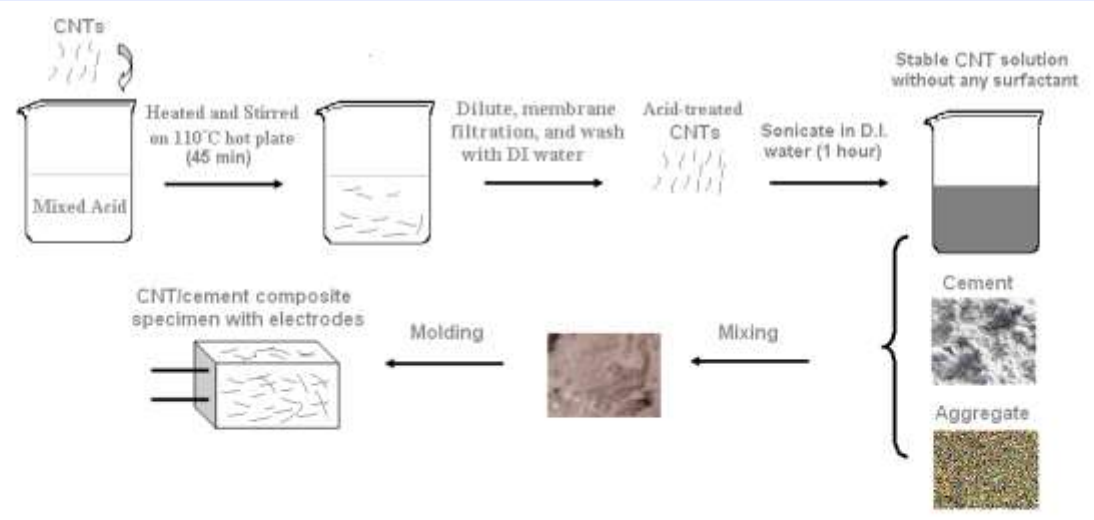
One shell of carbons (singlewalled carbon nanotubes (SWNTs)), or

Tens of concentric shells of carbons (multiwalled carbon nanotubes (MWNTs)).

Carbon Nanotube (CNTs) Based Self-Sensing Concrete

Experiments

Method #1: surface modification with acid treatment

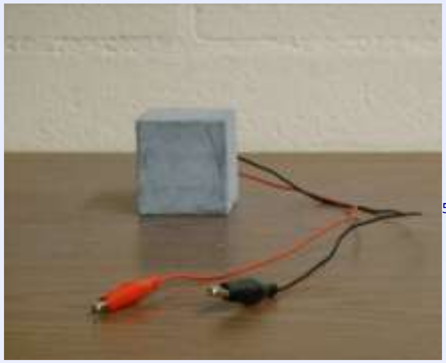


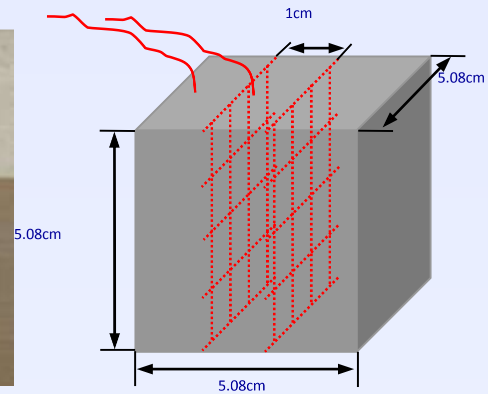
Method #2: surface modification with surfactant

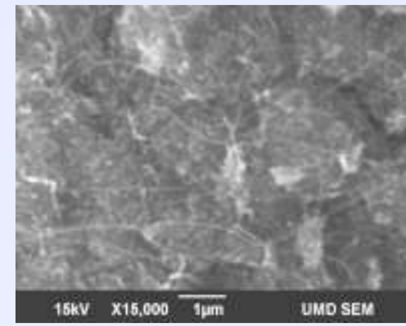
Surfactants, such as sodium dodecyl sulfate (SDS) and dodecylbenzene sulfonate (NaDDBS), can be wrapped around the nanotubes, which in turn can render CNTs to be dispersed in water and mixable with cement

Carbon Nanotube (CNTs) Based Self-Sensing Concrete

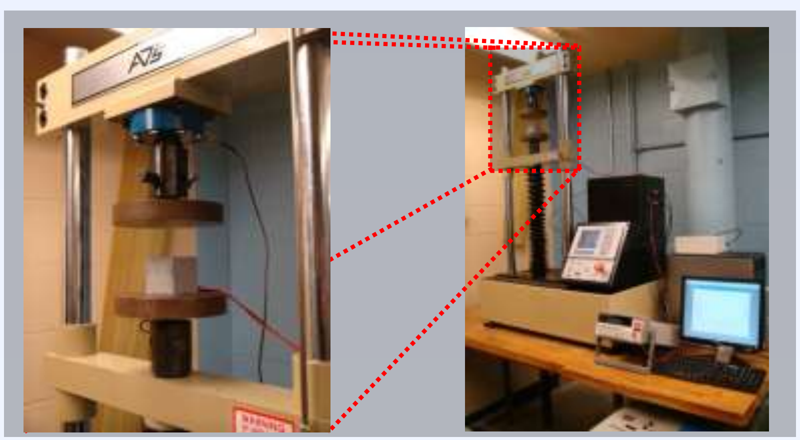
Experiments -measurement

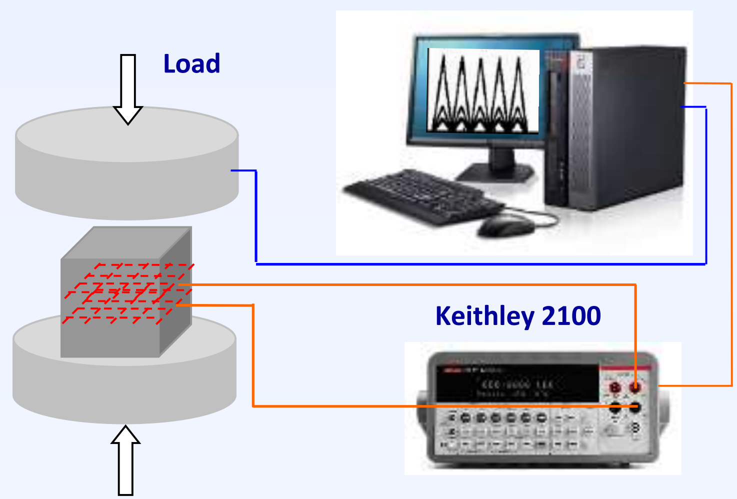






- Experimental setup for piezoreisitive tests

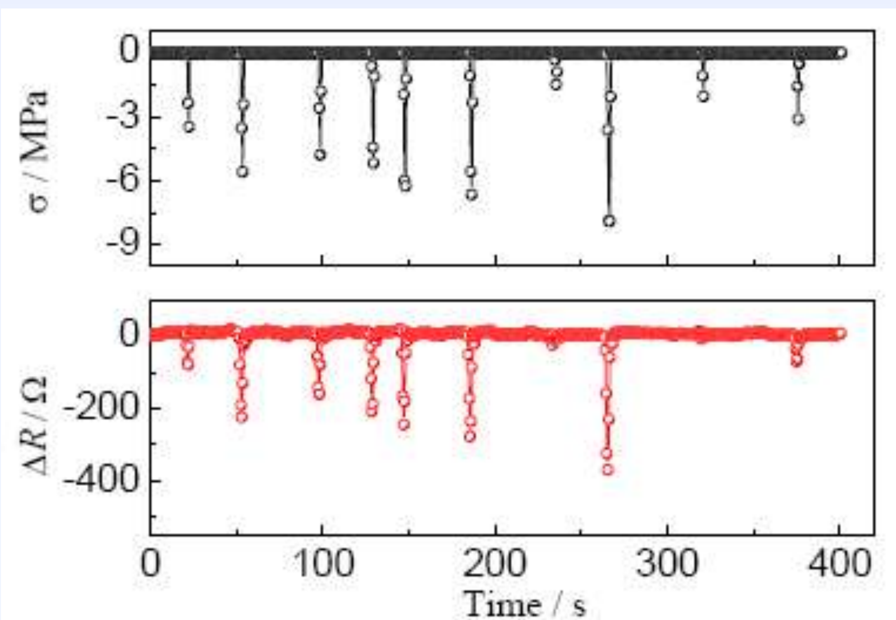


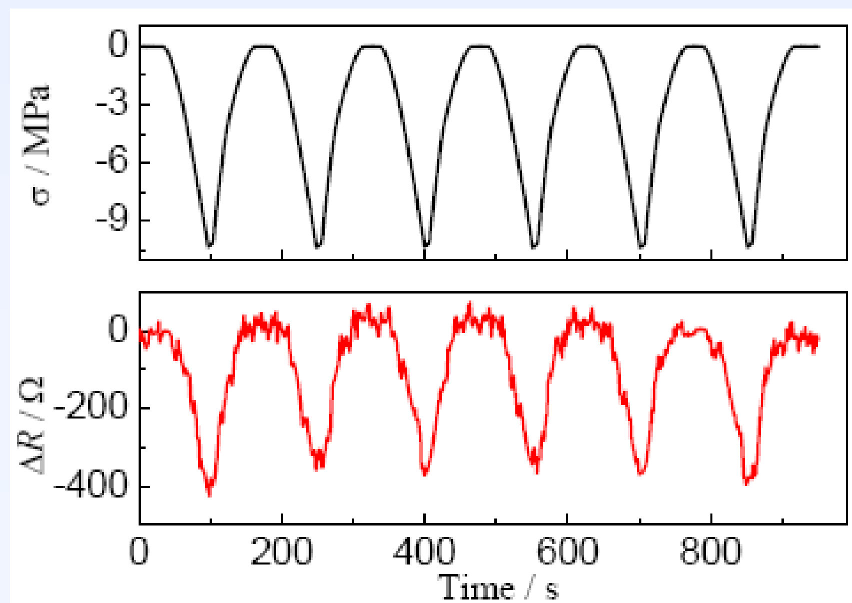


Piezoresistive response of the CNT/cement composite (CNT: 0.2 wt %)

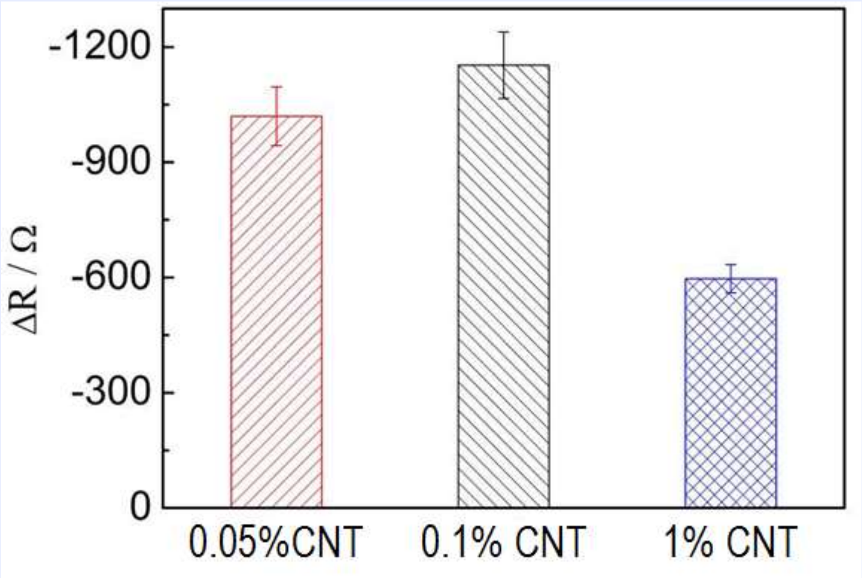
Impulsive loading also cause regular changes in the electrical resistance of self-sensing CNT/Cement composite.

Electrical resistance decreases upon loading and increases upon unloading under constant comp of 6MPa

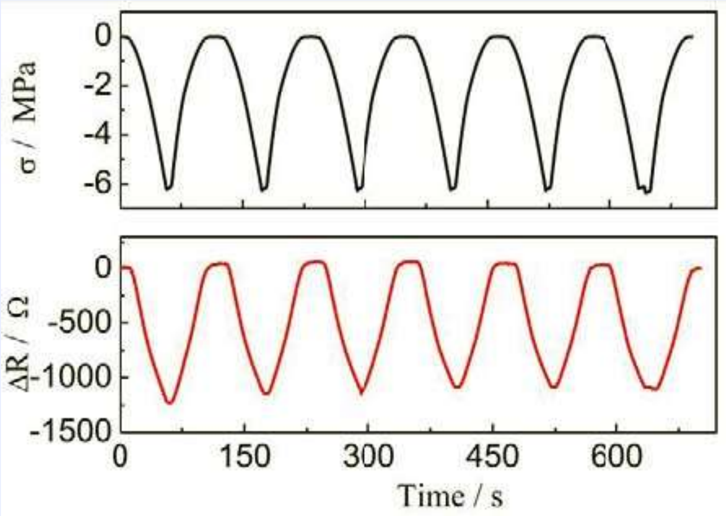




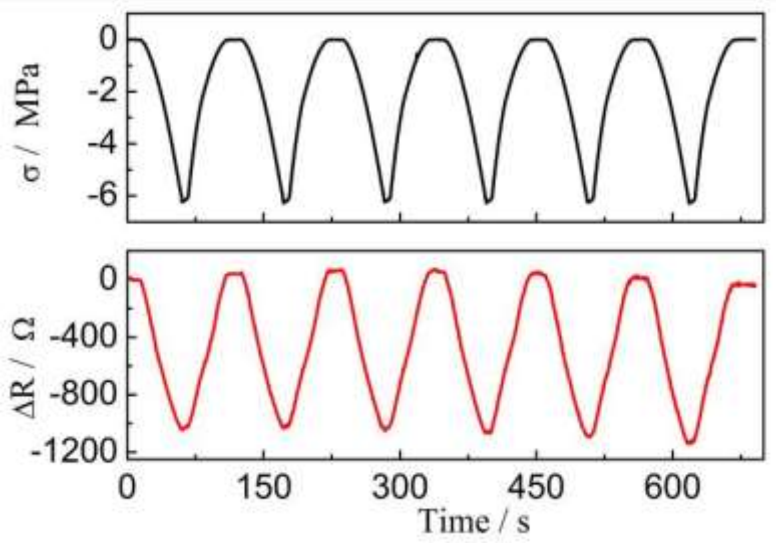
Carbon Nanotube (CNTs) Based Self-Sensing Concrete



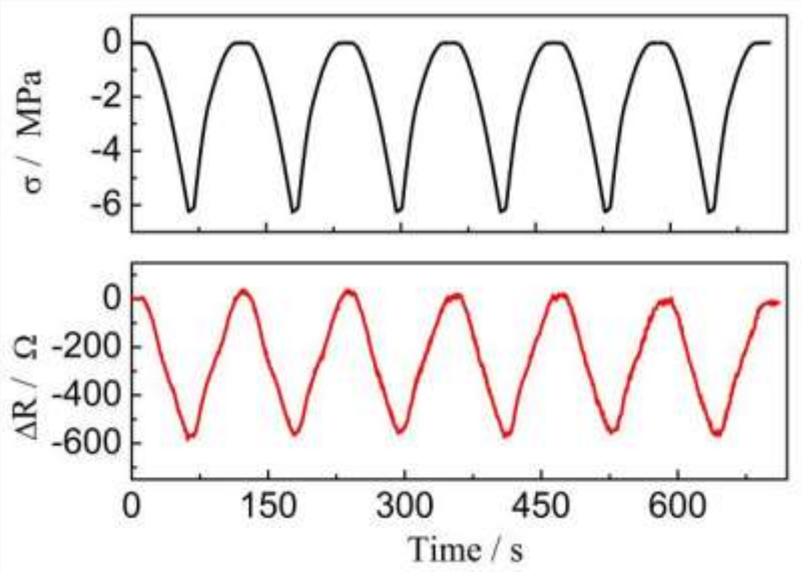
a) With 0.05 wt.% of MWNT



b) With 0.1 wt.% of MWNT



c) With 1 wt.% of MWNT



Carbon Nanotube (CNTs) Based Self-Sensing Concrete

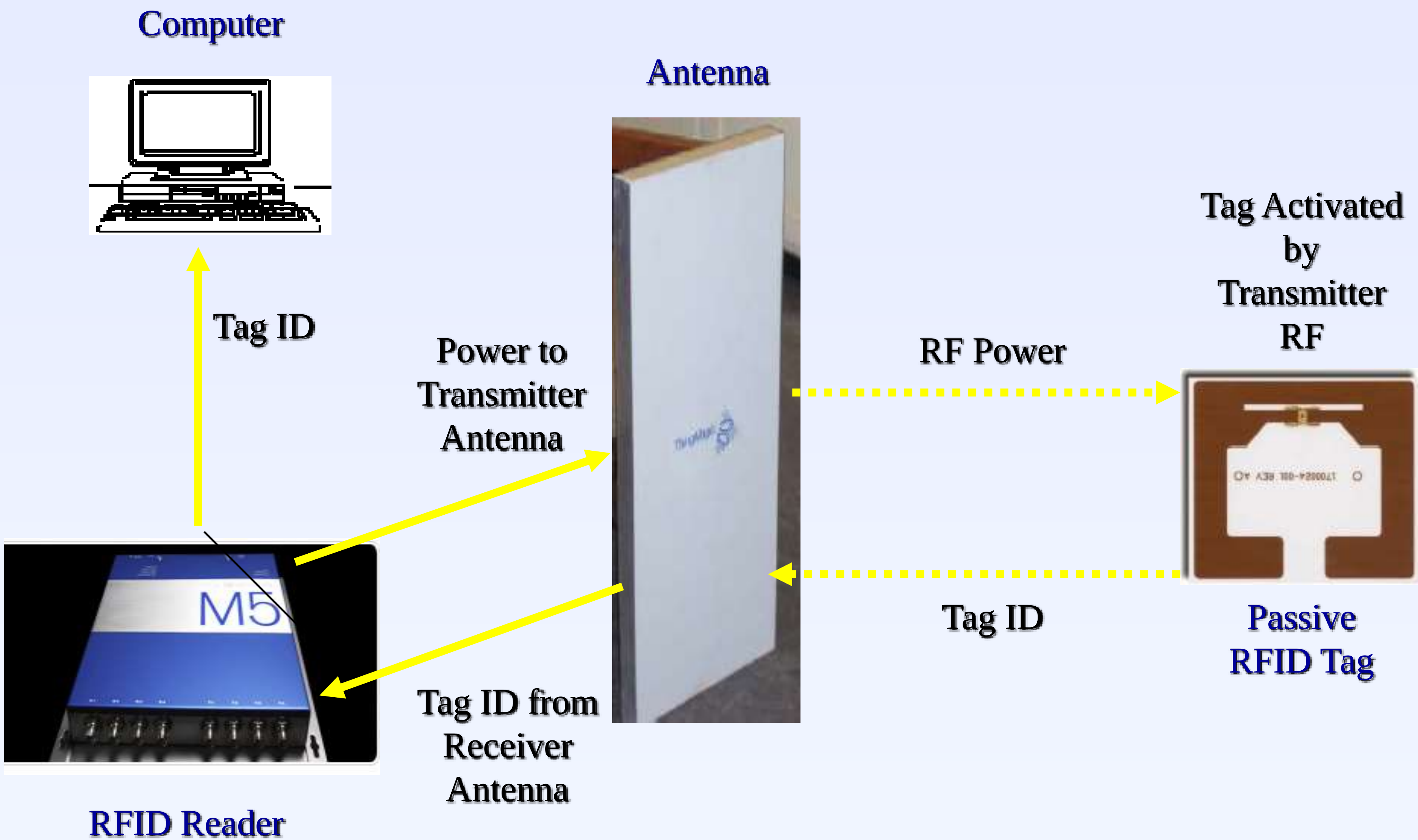
Preliminary Road Test Results

CNT composite fabricated with *method #2 (NaDDBS surfactant)* ***(CNT: 0.1 wt %)***

2” X 2” X 2” sample

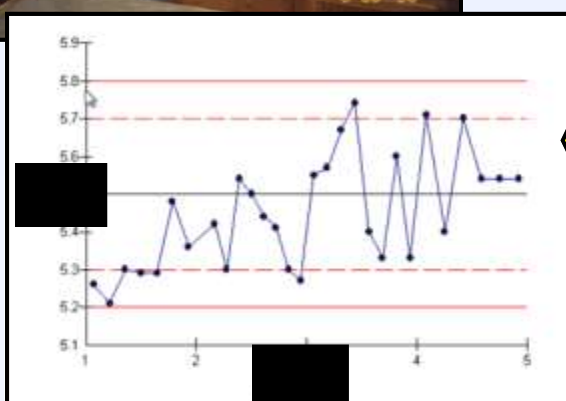
Radio Frequency Identification (RFID)

Ongoing FHWA project with the University of Maryland

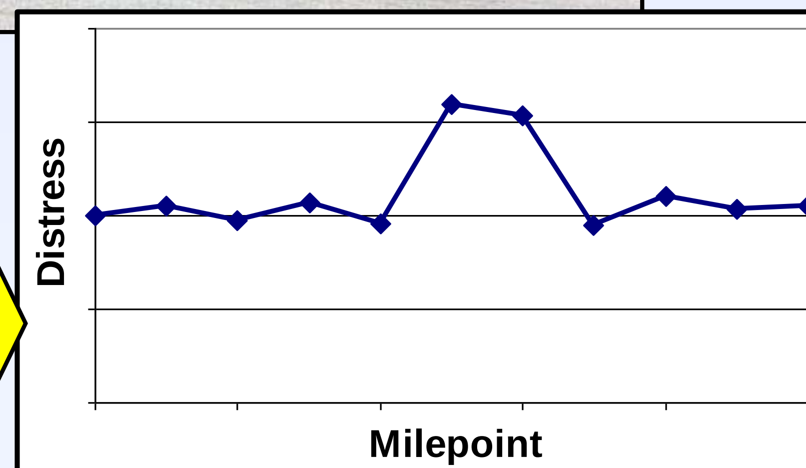


Radio Frequency Identification (RFID)

Tracking: The Problem



[redacted]



Link??

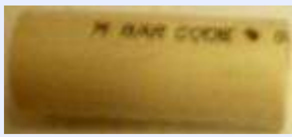
Pavement Construction

Pavement Management

Radio Frequency Identification (RFID)

The Solution?

HMA from Plant



Encapsulated RFID Tag

Haul Truck

Paver

Compaction

Identifying where loads of material end up in the pavement

Finished Pavement

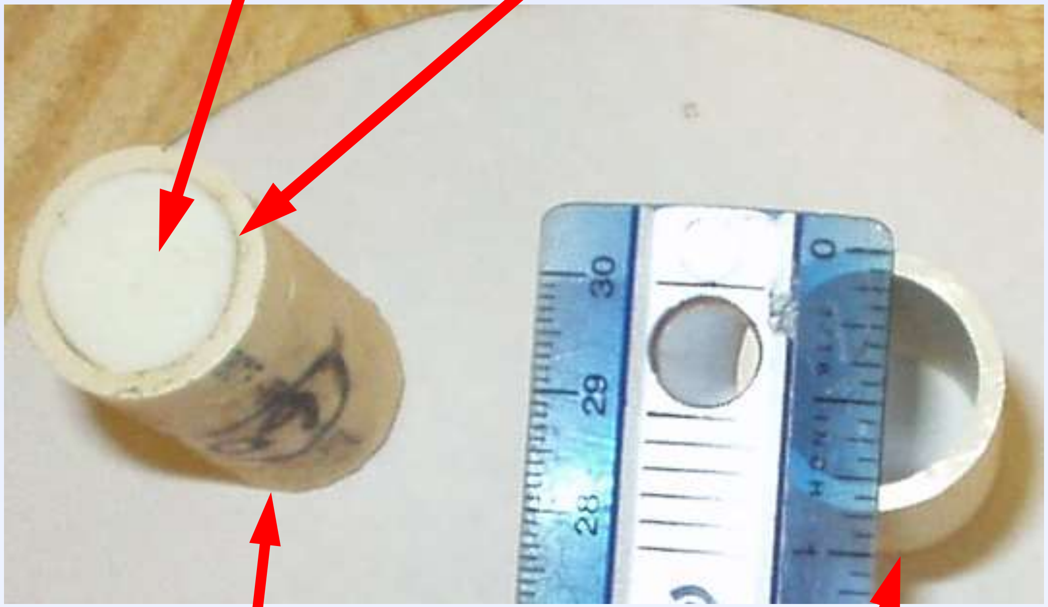
Tags scanned when convenient after construction

Radio Frequency Identification (RFID)

Tag Encapsulation

- CPVC pipes (11/16" internal diameter)
- Tags placed along inside of pipe wall
- Pipe filled with high-temperature epoxy
- Cost ~$1 each

2"x2" Passive UHF (900 MHz) RFID Tag



Radio Frequency Identification (RFID)

Field Trials: UMD Lot EE

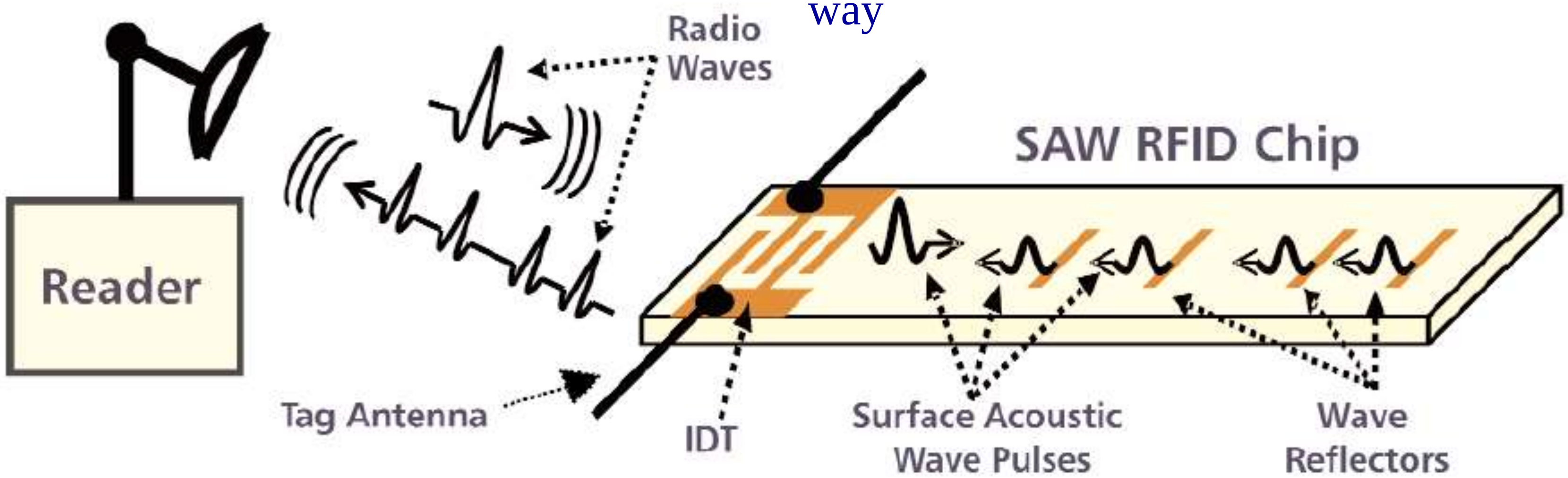
12.5 mm HMA surface, 50 mm thick
19 mm HMA base, 100 mm thick

Radio Frequency Identification (RFID)

- Antenna height: 3” and 12”
- Other variables:
  - Vehicle speed
  - Antenna height
  - Antenna configuration

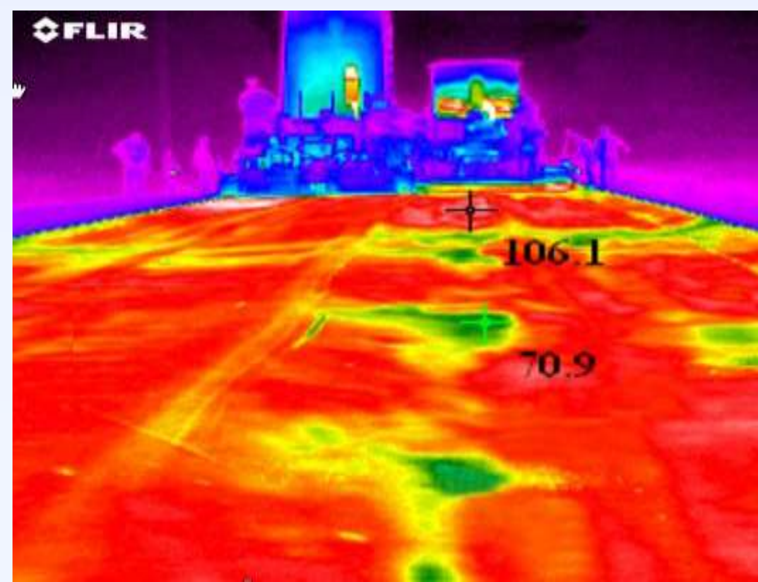
Surface Acoustic Wave (SAW) RFID

Thermal expansion of the ceramic wave guide alters the interference pattern in a recognizable way



http://www.rfsaw.com/animation/index.html

Interdigital transducer

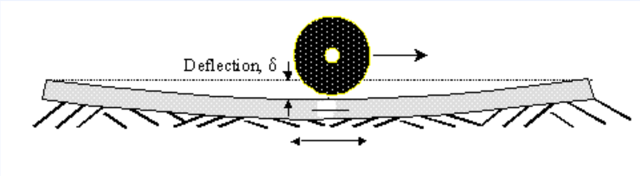


Kinetic to Electric Energy Conversion (KEEC)

Ongoing FHWA project with Virginia Polytechnic Institute and State University

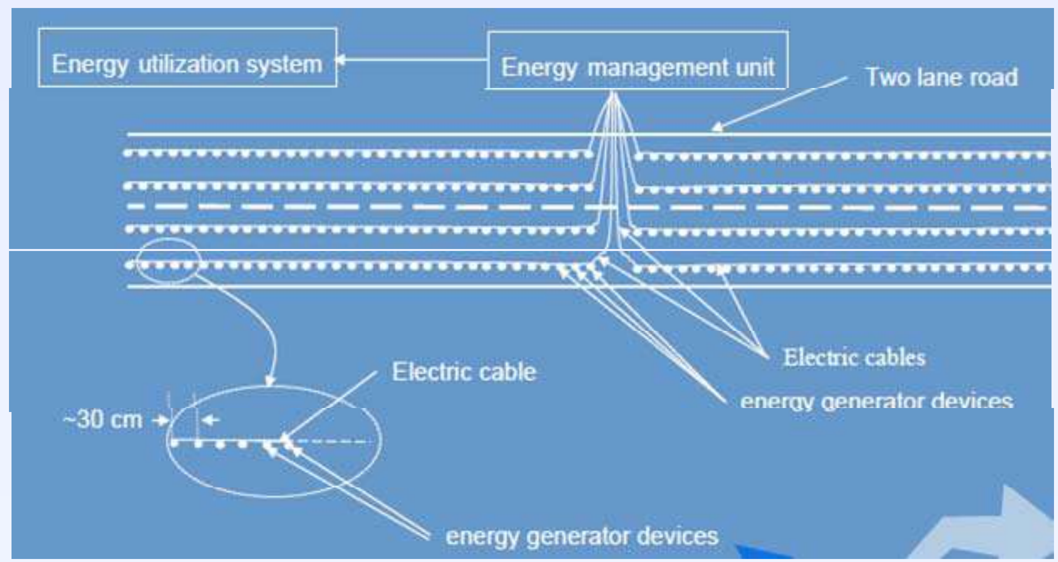
General Concept:
Harvest kinetic Enery

Kinetic to Electric Energy Conversion (KEEC)



Kinetic to Electric Energy Conversion (KEEC)

Evaluate the productivity and overall cost-effectiveness of the proposed KEEC by stochastic finite element modeling approaches



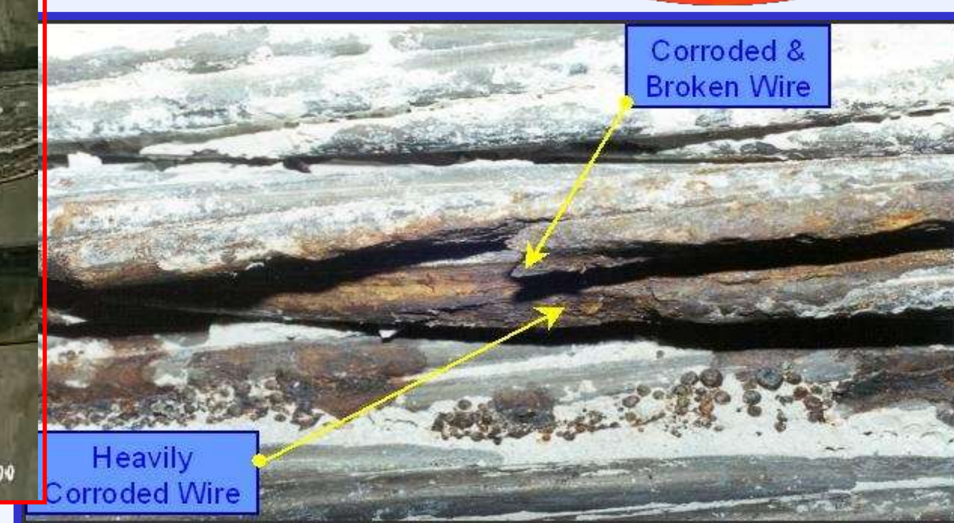
Full-Scale Field Evaluation

Federal Highway Administration
Turner-Fairbank Highway Research Center

Additional Application Need

Corrosion of Post-Tensioned Tendons

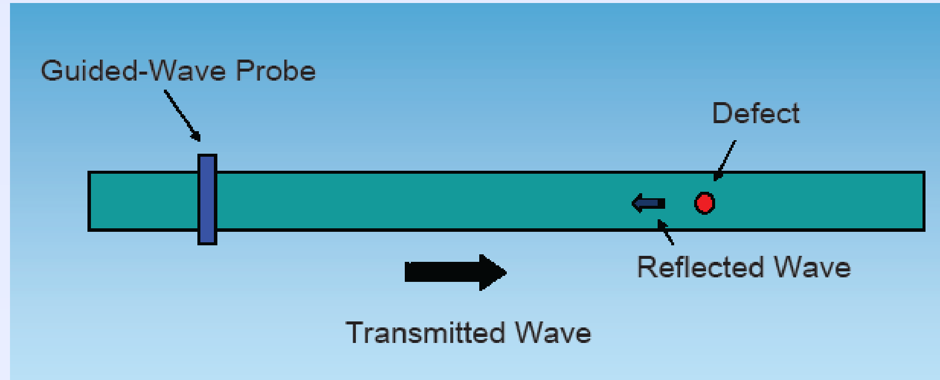
After 6 years, Mid-Bay Bridge, Destin, FL (2000)

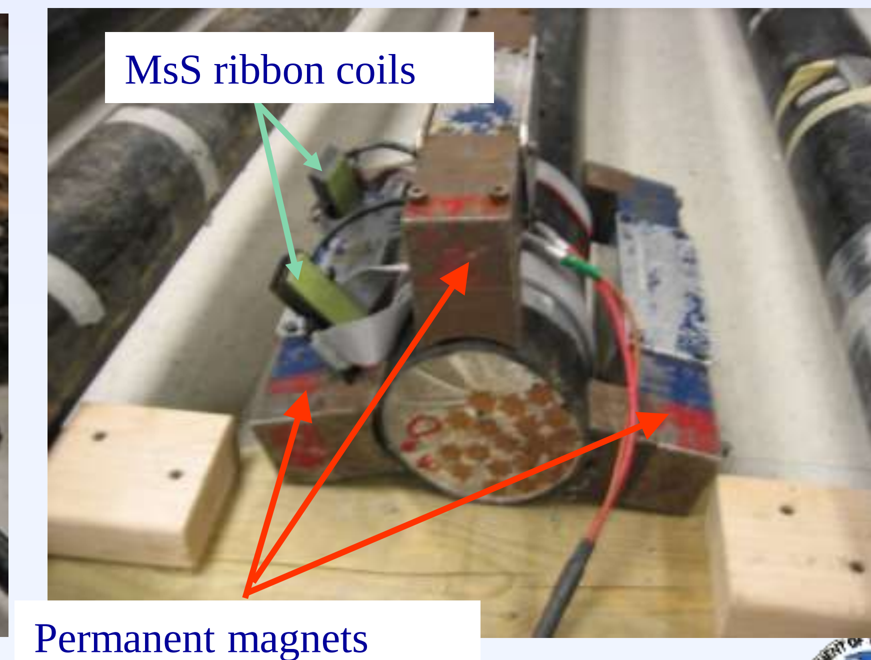


Corrosion of Post-Tensioned Tendons

Ultrasonic Measurement

Magnetostrictive Sensor (MsS) Guided-Wave Test Method





Long-Term Bridge Performance Program (LTBP Program)

NDE Technologies & Condition Assessment

Corrosion

GPR

Resistivity

Half-Cell

Delamination

GPR

Impact Echo

Concrete Degradation

GPR

Ultrasonic Surface Wave

Secure Wireless Sensor Network for Infrastructure

IAI is developing an innovative suite of wireless sensor technologies for monitoring the condition of bridges, pipelines, and industrial systems.

Wireless Sensor Nodes

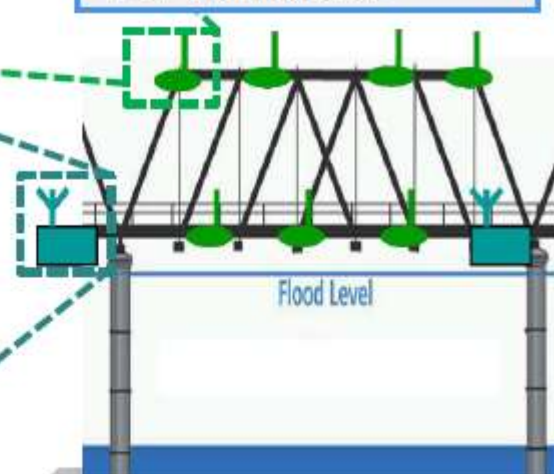
- Ultrasonic guided wave
- Acoustic Emission
- Strain
- Corrosion
    - Time of Wetness
    - Temperature
    - Humidity

Sensor Gateway Node

- Secured network
- Provides GPS & range to sensor nodes
- WiFi/GSM communications
- Energy harvesting

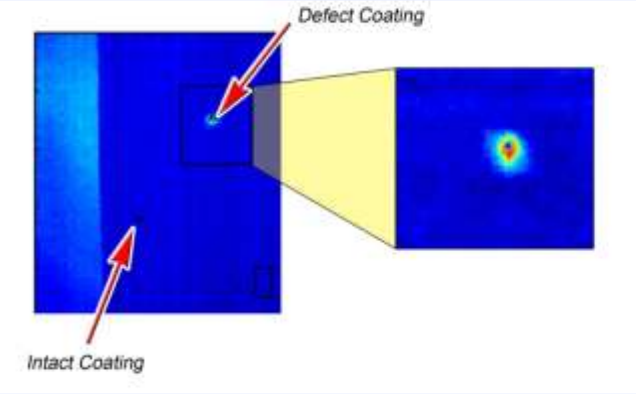
Benefits

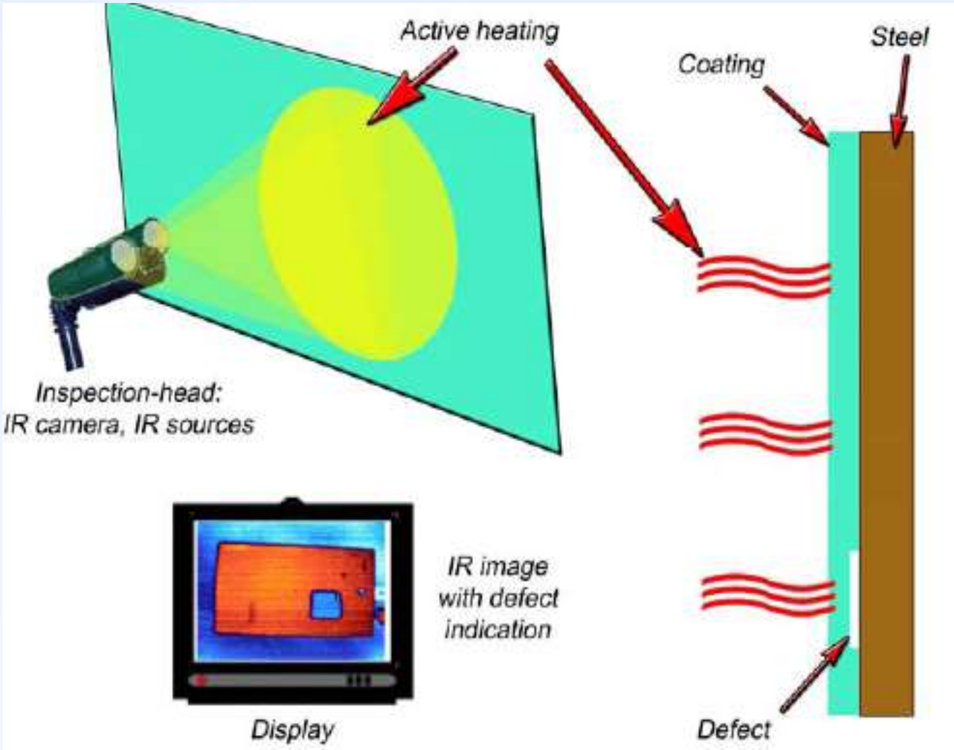
- Real-time multi-parameter measurements
- Low power
- Wireless
- Robust
- High accuracy
- Low maintenance

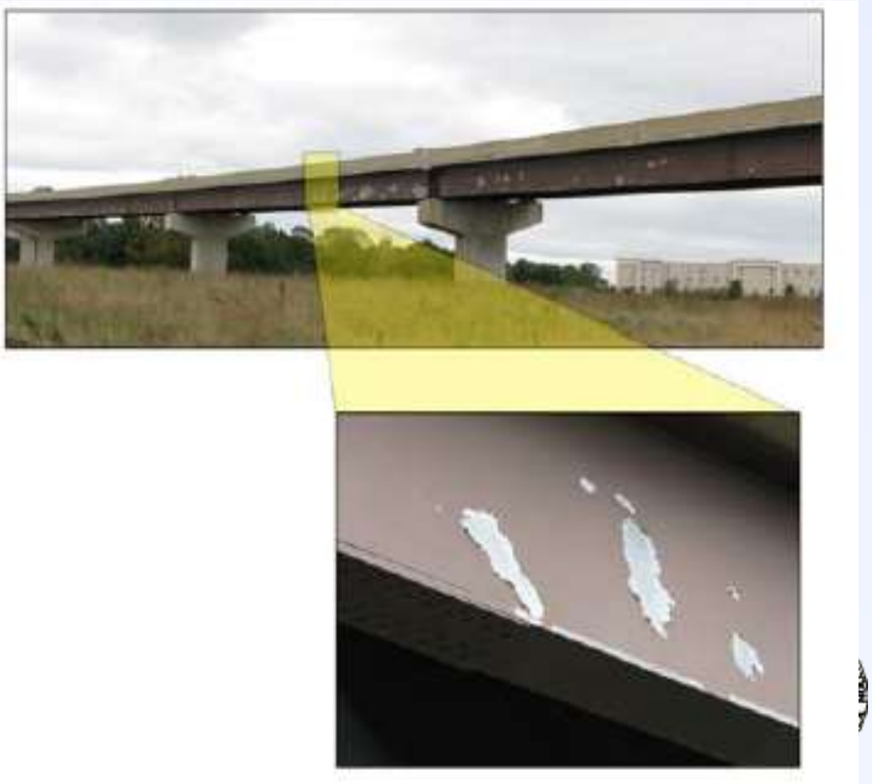


Thermographic Coating Inspection

Infrared inspection technique will use infrared thermography with active heating and embedded infrared camera to quickly image defect areas in coating system.

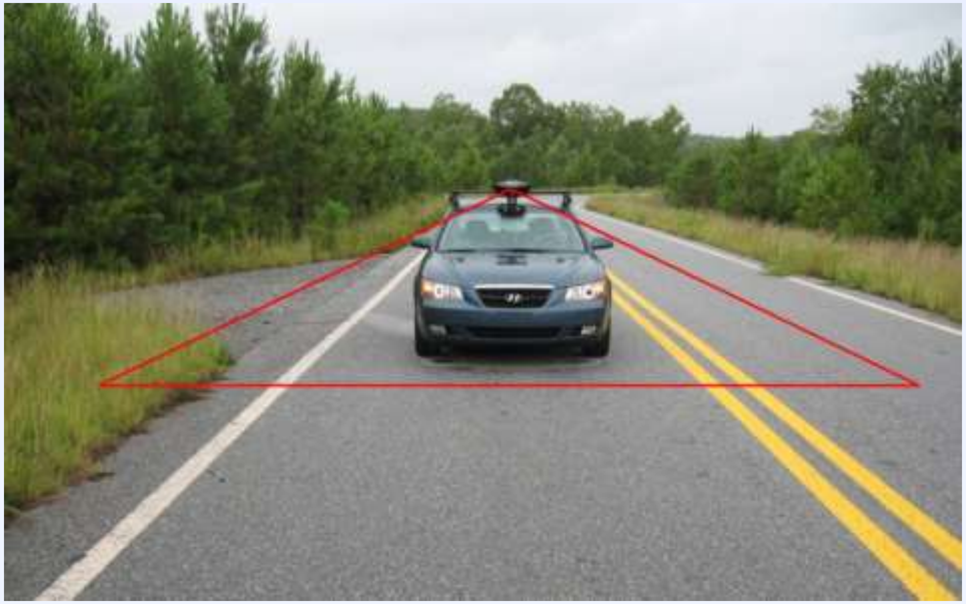






Staying in Lane
Intelligent Fusion of Vehicle Sensor Data

Lane keeping system is a mechanism designed to warn a driver when the vehicle begins to move out of its lane.



Staying in Lane
Intelligent Fusion of Vehicle Sensor Data

Variety of onboard equipment

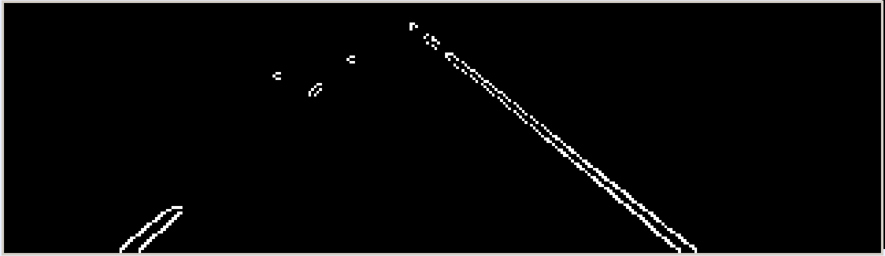
Camera

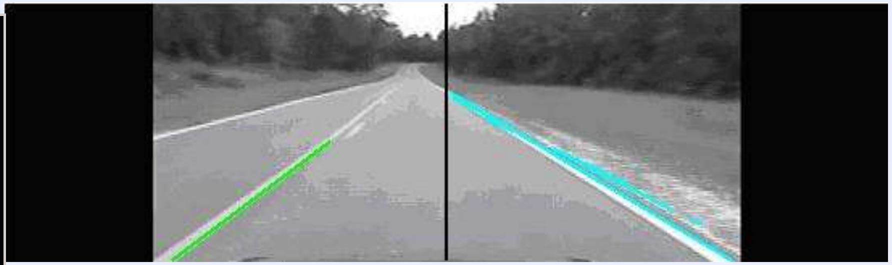
Accelerometers
Wheel speed sensors
Rate gyroscopes

GPS (Accuracy down to 10 cm (3.9 in.))

Advanced light detection and ranging (LiDAR) systems (Adaptive cruise control and collision avoidance)

Staying in Lane
Intelligent Fusion of Vehicle Sensor Data





Staying in Lane
Intelligent Fusion of Vehicle Sensor Data

The goal of this study is to focus the data from a range of sensors to compensate for the deficiencies of each-creating an accurate reliable system for navigation control.

Estimated U.S. Roadway Lane-Miles by Functional System

	2005	2006	2007	2008	2009
TOTAL lane-miles	**8,371,718**	**8,420,589**	**8,457,353**	**8,483,969**	**8,542,163**
Urban, total	**2,263,360**	**2,308,602**	**2,343,858**	**2,392,026**	**2,442,735**
Interstate	85,986	87,944	89,270	90,763	90,949
Other arterial[b]	523,838	532,933	540,189	552,377	568,591
Collector[c]	225,548	231,853	233,853	242,715	252,483
Local	1,427,988	1,455,872	1,480,546	1,506,171	1,530,712
Rural, total	**6,108,358**	**6,111,987**	**6,113,495**	**6,091,943**	**6,099,428**
Interstate	125,564	124,380	123,512	122,825	121,878
Other arterial[b]	529,555	530,121	530,476	530,606	537,392
Collector[c]	1,373,348	1,368,471	1,369,500	1,366,079	1,378,933
Local	4,079,891	4,089,015	4,090,007	4,072,433	4,061,225

1996-2009: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics* (Washington, DC: Annual Issues), table HM-60, available at http://www.fhwa.dot.gov/policy/ohpi/hss/hsspubs.cfm as of Mar. 11, 2011.

Why Self-powered Wireless Passive Sensor for Monitoring of Pavement is Needed?

Long term monitoring

- reduce maintenance cost
- improve longevity
- enhance safety, and
- advance research in pavement design and construction operation.

- The data will help facilitate a more effective pavement maintenance and rehabilitation/preservation schedule.

Thank You

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