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AAR Affiliated Laboratory Project Summary

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Summary

Transportation Technology Center, Inc. runs a unique strategic research initiative for the Association of American Railroads (AAR) that is scanning for technologies that can be applied to railway engineering problems.

The AAR Affiliated Laboratory Program is one way in which the railroads maintain awareness, adopt, and assimilate new technologies. The program also provides a pool of engineers and scientists who are familiar with railroads and who are available to solve technological problems. Projects of the program help train future engineers who will build and maintain the railroads.

This *Technology Digest* provides a status report of projects funded during 2011 at each of the three laboratories: University of Illinois, Urbana, Texas Transportation Institute/Texas A&M, College Station, and Virginia Polytechnic Institute and State University, Blacksburg.

These projects are viewed as "seed money" by the universities to allow the faculty to understand a railway industry problem, explore potential technologies that may provide solutions, and demonstrate a proof of concept laboratory or field test.

Current projects for each laboratory are:

- Illinois: Improved Concrete Tie Design & Performance, Evaluating In-Service Ballast Condition from Field Imaging, Bridge Performance Assessment Using Simplified Field Monitoring, Improved Bolted Connections for Special Trackwork, and WW Hay Railroad Engineering Collection
- Texas A&M: Automated Detection of Cracked Axles, Hydraulic Hazard Forecasting, Wheel Fatigue Mitigation, Effects of Corrosion on the Fatigue Life of Steel, Bridge Pier Protection, and In-Situ Assessment of Timber Pile Capacity
- Virginia Tech: Online Wheel/Rail Defect Diagnosis Using Limited Bogie Data, Analysis and Classification of Ultrasonic Field Measurements, Active Radio Frequency Identification for Cargo Management and Real Time Health Monitoring, Real Time Train Wheel Prognosis and Health Management, and Energy Harvesters for Railroad Applications

A steering committee of railway technologists, representing AAR member railroads, the Federal Railroad Administration, and railway suppliers monitors the program. The Technology Scanning Committee is chaired by Tim Drake, Vice President Engineering, Norfolk Southern Railway.

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INTRODUCTION

The AAR Affiliated Laboratory Program is one way in which the railroads maintain awareness, adopt, and assimilate new technologies. The program also provides a pool of engineers and scientists who are familiar with railroads and who are available to solve technological problems. Projects of the program help to train future engineers who will build and maintain the railroads.

The program was started in 1981 under the leadership of William J. Harris, then head of the AAR Research and Test Department. There are currently three affiliated laboratories:

- University of Illinois, Urbana: A charter member of the program. Illinois has a long history of affiliation with railroad engineering. Chris Barkan is the lab director.
- Texas Transportation Institute (TTI)/Texas A&M, College Station: Joined the program in 1992. Gary Fry is the lab director.
- Virginia Polytechnic Institute (Virginia Tech) and State University, Blacksburg. Our newest lab, Virginia Tech joined the program in 2005. Mehdi Ahmadian is the lab director.

Status of 2011 Projects

Sixteen projects are currently funded by the AAR Affiliated Laboratory Program. Tables 1-3 list the projects, and a brief synopsis of each is provided.

University of Illinois (Table 1)

Improved Concrete Tie Design & Performance: This project is investigating the rail seat deterioration mechanism for concrete ties. Work in 2011 has been focused on developing an economic method for evaluating rail seat abrasion potential. A simplified test that still produces rail seat abrasion representative of the field has been developed. This evaluation tool is being used to evaluate concrete tie design and materials parameters. Figure 1 shows the lab test setup.

Evaluating In-Service Ballast Condition from Field Imaging: This project employs machine vision technology to assess the condition of ballast in track. Preliminary analysis suggests that a transverse or longitudinal section cut view is required to adequately assess the ballast condition. This will limit applications to places where track maintenance is being conducted. In the laboratory, image analysis is able to extract the shape and texture of the first row of visible ballast.

Figure 1. Rail Seat Abrasion Test

Bridge Performance Assessment Using Simplified Field Monitoring: This project leverages work done by Illinois on highway bridges to develop performance monitoring systems. A survey of railroad bridge engineers was conducted to determine appropriate performance measures for railroad bridges.

Improved Bolted Connections for Special Trackwork: A literature review of bolted rail connections showed several performance issues. Analytical models of rail joints and crossing diamond frog joints were developed and exercised. Results were compared to recent industry results. The study suggests that stresses in joint bars near bolt holes are high, and that measures to reduce or accommodate these stresses would be useful.

WW Hay Railroad Engineering Collection: The University has an extensive library system that houses a railroad engineering collection named for Professor W.W. Hay. The engineering library is funded to maintain and build the collection. The library also provides search and retrieval services for railroad engineering personnel.

Table 1. 2011 Affiliated Lab Projects at Illinois

Illinois 2011 Tech Scan Projects	Principal Investigator	Deliverables	Status
Improved Concrete Tie Design & Performance	David Lange, Riley Edwards	Rail seat abrasion evaluation tests, report	Lab tests under way
Evaluating In-Service Ballast Condition from Field Imaging	Erol Tutumluer	Feasibility study, report	Determined that a vertical cut (e.g., cross section image) is needed
Bridge Performance Assessment Using Simplified Field Monitoring	James LaFave	Prototype sensor development, report	Surveyed bridge monitoring needs. Developed a candidate list of problems, technologies, and test sites.
Improved Bolted Connections for Special Trackwork	Larry Fahnestock	Transverse defect, finite element analysis results of frogs, report	Developing recommendations for reducing stresses at bolted rail fastenings.
WW Hay RR Eng Collection	William Mischo	Information retrieval services, user's manual	Provides the industry with a center for railroad engineering reference materials

Texas Transportation Institute and Texas A&M (Table 2)

Automated Detection of Cracked Axles: A feasibility study of noncontacting ultrasonic inspection of axle journals was conducted. The study showed inspection was possible. A prototype inspection system has been designed and built. Proof of concept testing is planned.

Hydraulic Hazard Forecasting: A demonstration project is planned for a location in a western watershed. Using sensors in the field and analysis tools, the system will provide advance warning of potentially damaging flood events in remote watersheds.

Wheel Fatigue Mitigation: Nonlinear plastic strain modeling of wheel/rail contact will be used to determine fatigue lives of wheels. Recommendations for improving fatigue life will be made from parametric analysis of wheel stresses.

Effects of Corrosion on the Fatigue Life of Steel: A study of the effects of various corrosion and load application rates is being conducted.

Bridge Pier Protection: A prototype design for a bridge pier protection system for waterways has been developed. The system consists of inverted anchored barges. The inverted barge has the proper shape and sufficient mass to deflect barges away from the bridge pier. Figure 2 shows the inverted barge deflector design.

In-Situ Assessment of Timber Pile Capacity: A method of assessing timber bridge pile capacity in place has been developed. The method requires the railway to measure individual pile loads and deflections in place using load cells and very accurate displacement transducers. Figure 2 shows the field measurement set up and the transducers.

Figure 2. Timber Bridge Pile Capacity Field Assessment

Table 2. 2011 Affiliated Lab Projects at Texas A&M

TTI/Texas A&M 2011 Tech Scan Projects	Principal Investigator	Objective	Status
Automated Detection of Cracked Axles	Stefan Hurlebaus	Report, feasibility study	Theoretical feasibility study complete. Lab testing with defective axle begun.
Hydraulic Hazard Forecasting	Tony Cahill & Kelly Brumbelow	Demonstration project using western watershed	Demonstration site selection proceeding with western railways.
Wheel Fatigue Mitigation	Gary Fry	Report, strategies to improve fatigue performance	Wheel and rail models from previous study being modified for this project. Parametric studies under way.
Effects of Corrosion on the Fatigue Life of Steel	Peter Keating	Report	Testing continues. Corrosion and fatigue are competing degradation modes. At certain rates, corrosion removes fatigue cracking.
Bridge Pier Protection	Akram Abu-Odeh	Report, demo design	Prototype designs developed for waterways. Searching for potential demonstration sites.
In-Situ Assessment of Timber Pile Capacity	Gary Fry	Report	Obtained easier to use displacement measurement devices. Strength testing of piles removed from bridge in process

Virginia Polytechnic Institute (Table 3)

Online Wheel/Rail Defect/Irregularity Diagnosis Using Limited Bogie Data: Using truck side frame acceleration data, a method to detect broken rails and rail flaws that affect the surface of the rail has been developed. This system has been developed using data from the Facility for Accelerated Service Testing at Transportation Technology Center, Pueblo, Colo. and in revenue service. It is potentially more accurate than vehicle–track interaction analysis currently being used by railways.

Analysis and Classification of Ultrasonic Field Measurements: A method of determining the health of rotating components, such as traction motors, engine bearings, and wheels, has been developed using ultrasonic microphones and wavelet analysis techniques. The system was demonstrated in the laboratory and is able to identify defective axle bearings.

Active Radio Frequency Identification for Cargo Management: This project is exploring potential applications for smart tags. A potential application is to record car or track performance data, such as impacts at turnout frogs. The data could be used to schedule track maintenance.

Real-time Train Wheel Prognosis and Health Management: A feasibility study of image analysis to determine strain on loaded components is being conducted. The system uses a matrix of paint dots on the surface of a component, such as a wheelset, to determine the strains of the component under load. The tests will determine if the system is capable of replacing strain gages for railway applications.

Vibration-based Electromechanical Energy Harvesting Devices for Railroad Applications – Phase III: Improved prototype energy harvesters, which will reside. Figure 3 shows the prototype that will fit in a freight car spring.

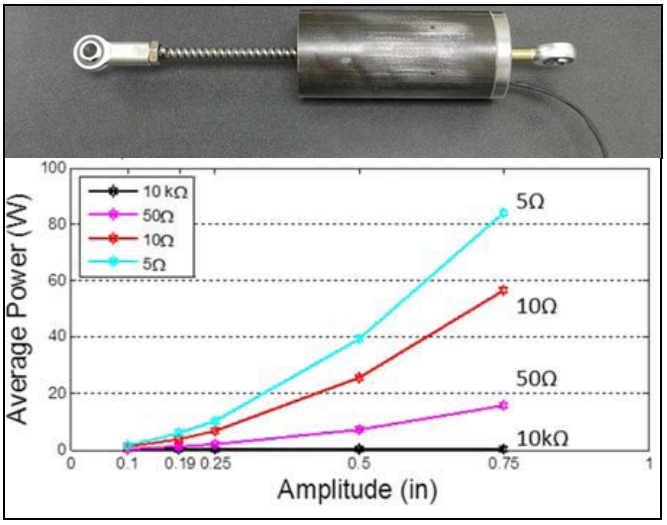

Figure 3. Prototype Onboard Energy Harvester

Future Work

Several of the current projects have progressed to the point of proof of concept. Soon, decisions will be made about whether industry funding to develop field hardened prototypes is warranted.

In the past, projects under the Technology Scanning Program have "graduated" to funding under the AAR Strategic Research Initiatives Program, FRA Office of Research and Development, and funding from individual railroads and railroad suppliers. Projects ready to graduate in 2011 include analysis and classification of ultrasonic field measurements and bridge pier protection.

Table 3. 2011 Affiliated Lab Projects at Virginia Tech

Virginia Tech 2011Tech Scan Projects	Principal Investigator	Deliverable	Status
Online Wheel/Rail Defect/Irregularity Diagnosis using Limited Bogie Data	Saied Taheri	Prototype sensors and analysis system	Tests with data from FAST show that broken rails can be detected. Imminent breaks were also found.
Analysis and Classification of Ultrasonic Field Measurements	Steve Southward	Feasibility study	Lab tests show defective bearings could be identified.
Active RFID for Cargo Management	Majid Manteghi	Demonstration	Evaluated potential applications
Real-time Train Wheel Prognosis and Health Management	Tomonari Furukawa	Feasibility study, prototype, report	Feasibility studies were begun to determine the density of paint dots needed.
Vibration-based Electromechanical Energy Harvesting Devices for Railroad Applications – Phase III	Mehdi Ahmadian	TD, prototype design, prototype	Improved prototypes built and proof tested in laboratory for 2-million cycles.

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