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# Technology Scanning Update – Status of 2006 Virginia Polytechnic Institute and State University Affiliated Laboratory Projects

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## SUMMARY

The Association of American Railroads Affiliated Laboratory (Affiliated Lab) Program is one way in which the railroads maintain awareness of, adopt, and assimilate new technologies. The Affiliated Lab Program also provides a pool of engineers and scientists who are familiar with railroads and who are available to solve technological problems. Additionally, Affiliated Lab projects help train the young engineers who will build and maintain the railroads in the future.

There are currently three Affiliated Labs:

- Virginia Polytechnic Institute and State University (VT)
- University of Illinois Urbana-Champaign
- Texas Transportation Institute/Texas A&M University

This *Technology Digest* will provide a status report by the Transportation Technology Center Inc., of projects funded in 2006 at VT. Findings from these projects include:

- An insulated joint (IJ) has been designed to address the failure modes of the current IJs. While the design falls short of the hoped for jointless IJ, it holds promise of eliminating insulator and epoxy failures that result in short service lives for heavy axle load service IJs.
- Application of fiber-optic Doppler light detection and ranging sensors will allow automated measurement of wheel slip and wheel/rail friction. This technology offers the potential to measure many other track/vehicle parameters that may be useful for assessing component condition and train safety.
- A method to improve the clarity of locomotive cab communications has been developed as a result of the crew alertness detector project. This technology involves use of a small array of microphones to distinguish speech from noise in real time. Work is now proceeding on the alertness detector algorithms.
- An improved capability friction wedge model has been developed for truck suspension analysis and design. The model is an improved representation of the actual friction wedges than is used in currently available software.

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TTCI. Transportation Technology Center, Inc.

## INTRODUCTION

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

The program was started in 1981 under the leadership of William J. Harris, then head of the Association of American Railroads (AAR) Research and Test Department. There are currently three Affiliated Labs:

- VT – Blacksburg, Virginia. VT, our newest laboratory, joined the program in 2005. Mehdi Ahmadian (540) 231-4920 is the laboratory director.
- University of Illinois – Urbana, Illinois. A charter member of the program. Illinois has a long history of affiliation with railroad engineering. Chris Barkan is the laboratory director.
- Texas Transportation Institute/Texas A&M – College Station, Texas. Joined the program in 1992. Gary Fry is the laboratory director.

## STATUS OF 2006 PROJECTS

There are 19 projects currently funded by the Affiliated Lab Program. The following paragraphs and tables describe each of the VT projects. Table 1 lists each project and its current status.

**Table 1. Status of 2006 AAR Affiliated Laboratory Projects at VT**

| VT 2006 Tech Scan Projects | Principal Investigator | Deliverable | Status |
|---|---|---|---|
| Advanced IJs–Phase 2 | Mehdi Ahmadian | Feasibility, report | Prototype in laboratory tests |
| Doppler Sensors, Friction | Carvel Holton | POC demo | Proof-of-concept completed |
| Field-deployable System for Detect Crew Alertness | Steve Southward | Feasibility, report | Alertness algorithms in development, comms clarity a potential spin-off. |
| Advanced Modeling of Friction Wedge | Corina Sandu | Report, model | Friction wedge model built. Begin verification with field data. |
| Prototype System Automated Monitoring and Measurement of Curve Movement | John Duke | Prototype test | Field demonstration planned |

## ADVANCED IJS–PHASE 2

The purpose of this project is to develop concepts and prototypes for a jointless IJ. The railroads need an IJ that will provide reliable service under heavy axle load (HAL) traffic. The current IJs are prone to a shortened service life under HAL traffic. The typical failure mode is an electrical short after the joint has loosened from epoxy debonding. VT's mission is to develop an improved performance IJ that will function with existing signal systems and eliminate the major failure modes in HAL service.

Many concepts were examined to eliminate or improve the mechanical joint in the running surface of the rail. None proved entirely satisfactory. The use of a tapered joint will help to reduce joint-caused dynamic loads.

The focus of the project turned to ways to provide insulation while reducing the failures associated with the epoxy and insulator between rail and joint bars. An insulator module was developed to provide this function without use of conventional insulator cloth and epoxy. Figure 1 shows the insulator module and proposed IJ concept. A ceramic coating provides the insulation. The shape of the module and location of the ceramic coating ensure that the stresses in the insulator will be compressive and relatively low compared to its strength.

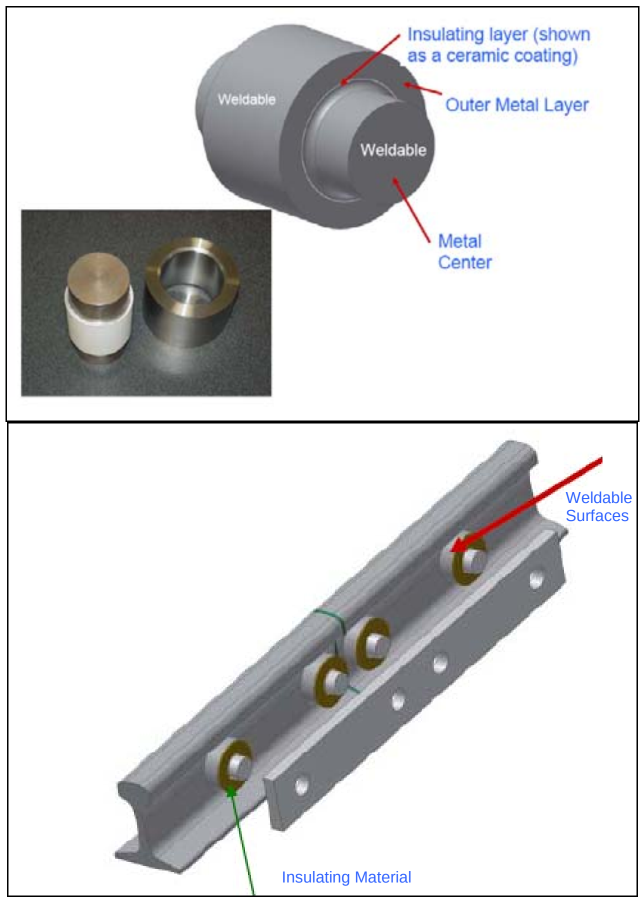


**Figure 1. Insulator Module and Proposed IJ**

## SIMPLE FIBER-OPTIC DOPPLER SENSORS FOR MEASUREMENTS OF RAIL FRICTION AND OTHER VELOCITY-BASED PARAMETERS

Automated measurement of rail running surface friction is the goal of this project. The VT approach is to measure wheel slip using fiber-optic Doppler light detection and ranging techniques. A comparison of wheel and car velocities is made to determine the amount of wheel slip. From this value, plus assumptions about wheel/rail contact configuration, an estimate of the wheel/rail friction can be made.

The system can be either vehicle mounted (for determining rail friction) or wayside mounted (for determining wheel/brake conditions). Additional information can be obtained with a vehicle mounted system, such as track gage, vehicle velocity, and rail surface condition.

Both driven (locomotive) and rolling wheels can be measured with this system. Figure 2 shows the prototype system setup for friction measurement on Norfolk Southern (NS). Figure 3 shows the results of a run made on NS near Roanoke, Virginia.

Results to date look promising, but more field testing and independent verification is needed before a production prototype system can be developed.

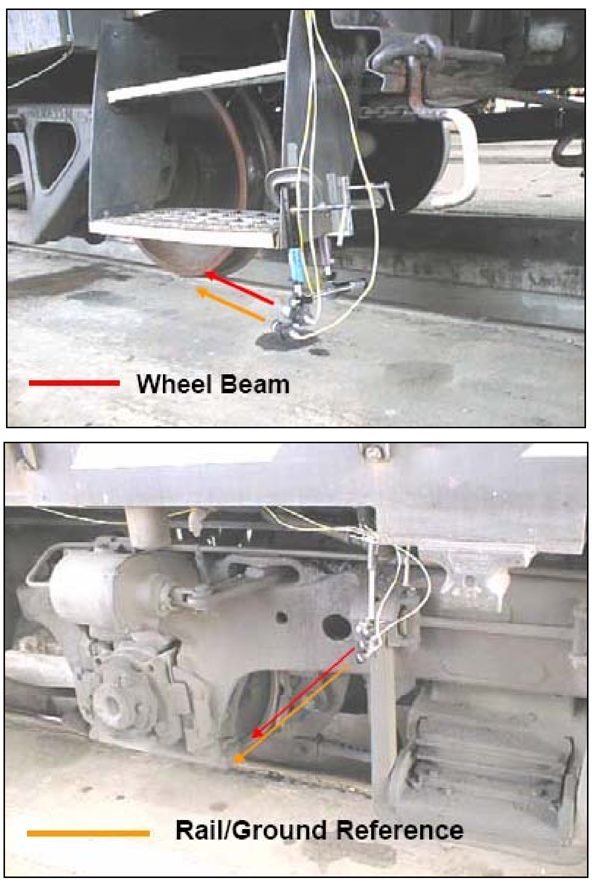


**Figure 2. Prototype Wheel/Rail Friction Measurement System on NS**

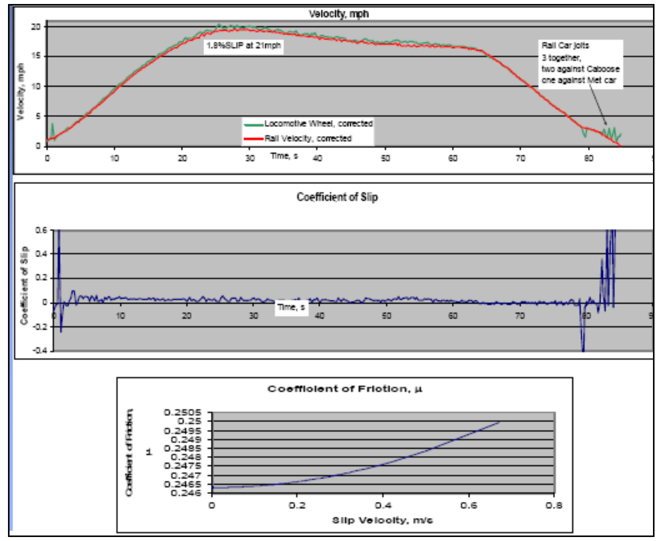


**Figure 3. Results of Friction Measurement Made on NS with Prototype System**

## FIELD-DEPLOYABLE SYSTEM FOR DETECTING CREW ALERTNESS

Crew or employee alertness is a concern of all industries with 24/7 and variable shift operations. As with other transportation modes, train engineers risk becoming inattentive before they actually fall asleep. It is possible for crew members to respond to or reset a vigilance device in a fashion similar to the snooze button on an alarm, without being fully alert.

VT has been working on a system that can detect subtle changes in crew speech that are reliable indicators of loss of alertness. It is important to note that the alertness detector does not process the speech for content. Rather, it uses variations in speech rhythm, energy, and pitch from baseline conditions to determine the loss of alertness.

Prior to developing the alertness detection algorithms, a clear speech signal is needed. VT has developed a means of improving the clarity of crew communications by using an array of microphones. This technology allows one to improve communications in noisy environments, such as locomotive cabs, without requiring headsets. This technology can improve the speech signal to noise ratio dramatically in real time. This will make crew alertness detection possible in noisy railroad environments without requiring crews to wear headsets.

## ADVANCED MODELING OF FRICTION WEDGE

The friction wedge is the main damping component in freight car truck suspensions. Two wedges are placed between the truck bolster and each side frame. Figure 4 shows a friction wedge in a typical truck. This simple component is responsible for many of the nonlinearities in 3-piece truck performance. Its stick-slip behavior is difficult to model and predict in the field. However, better modeling of this component will help in developing improved performance designs.

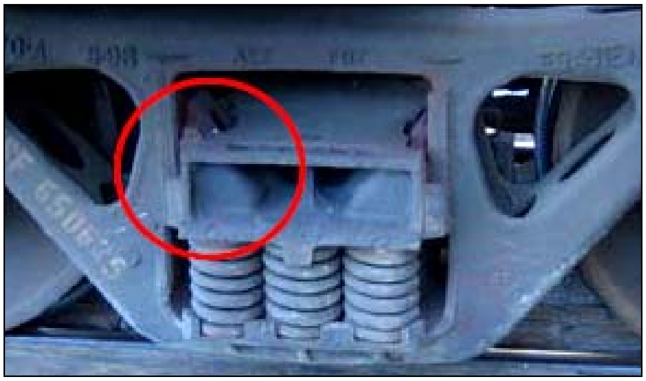

**Figure 4. Typical Freight Car Truck Friction Wedge**

The new model is a stand-alone, bolster-friction, wedge-side frame model. It can be used in this format or applied to vehicle dynamic simulation software. After proof testing, Transportation Technology Center, Inc. will implement the new model as part of NUCARS®.

Key improvements that this model offers over existing software include:

- More degrees of freedom for the wedge; allowing out of plane rotation about the vertical axis
- Allows surface contact between the wedge and the bolster and between the wedge and side frame
- Allows moments to be transmitted to the bolster and side frame from the wedge
- More accurate modeling of friction between the bolster and side frames

Figure 5 shows the degrees of freedom for the friction wedge. It depicts the yaw (top left), pitch (top right), vertical translation (bottom left), and longitudinal translation (bottom right) degrees of freedom.

## PROTOTYPE SYSTEM DEVELOPMENT FOR THE AUTOMATED MONITORING AND MEASUREMENT OF CURVE MOVEMENT

A prototype system is under development that will measure the position of railroad rail with respect to reference points on the ground. The system is intended to be an automated curve measurement system that will allow surveying of a curve from a moving vehicle, such as a hi-rail or a track geometry car. Additionally, the system may provide the data needed to recognize and predict the occurrences of incipient track buckles. Further research and development will be needed for this functionality.

The curve measurement system is intended to support railroads in meeting the requirements of Federal Railroad Administration Track Safety Standards for monitoring curve movement. The system will operate by using a scanning laser distance sensor to measure track locations with respect to fixed points on the railroad right of way. These reflectors must be installed to maximize line of sight to the curves of interest.

## ACKNOWLEDGEMENTS

The authors gratefully acknowledge the guidance of the AAR Technology Scanning Committee in steering the Affiliated Lab projects. The committee is chaired by Mike Iden, Director Locomotives, Union Pacific. Hayden Newell, Manager Innovative Research, NS, provided invaluable assistance in supporting field tests of prototypes.

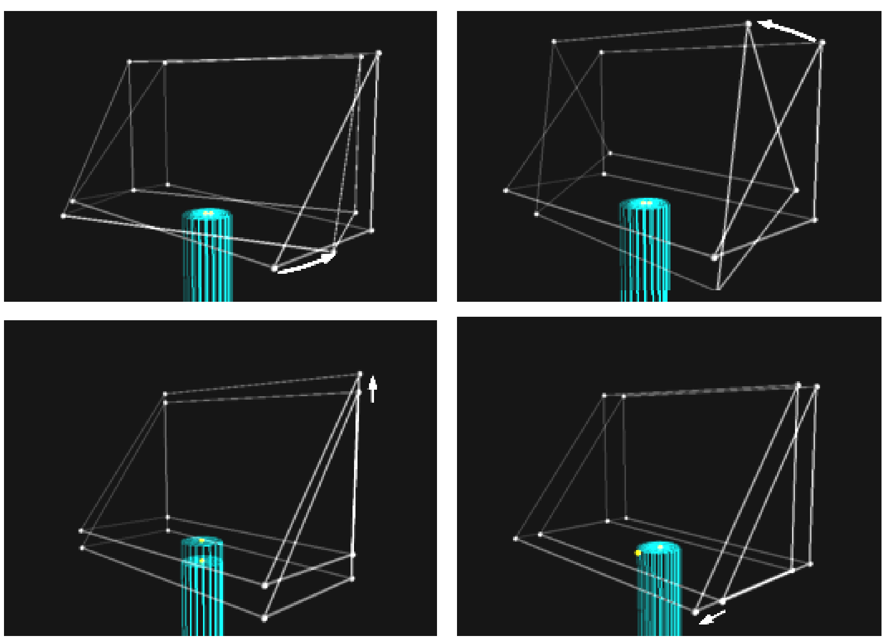

**Figure 5. Friction Wedge Model Degrees of Freedom**

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