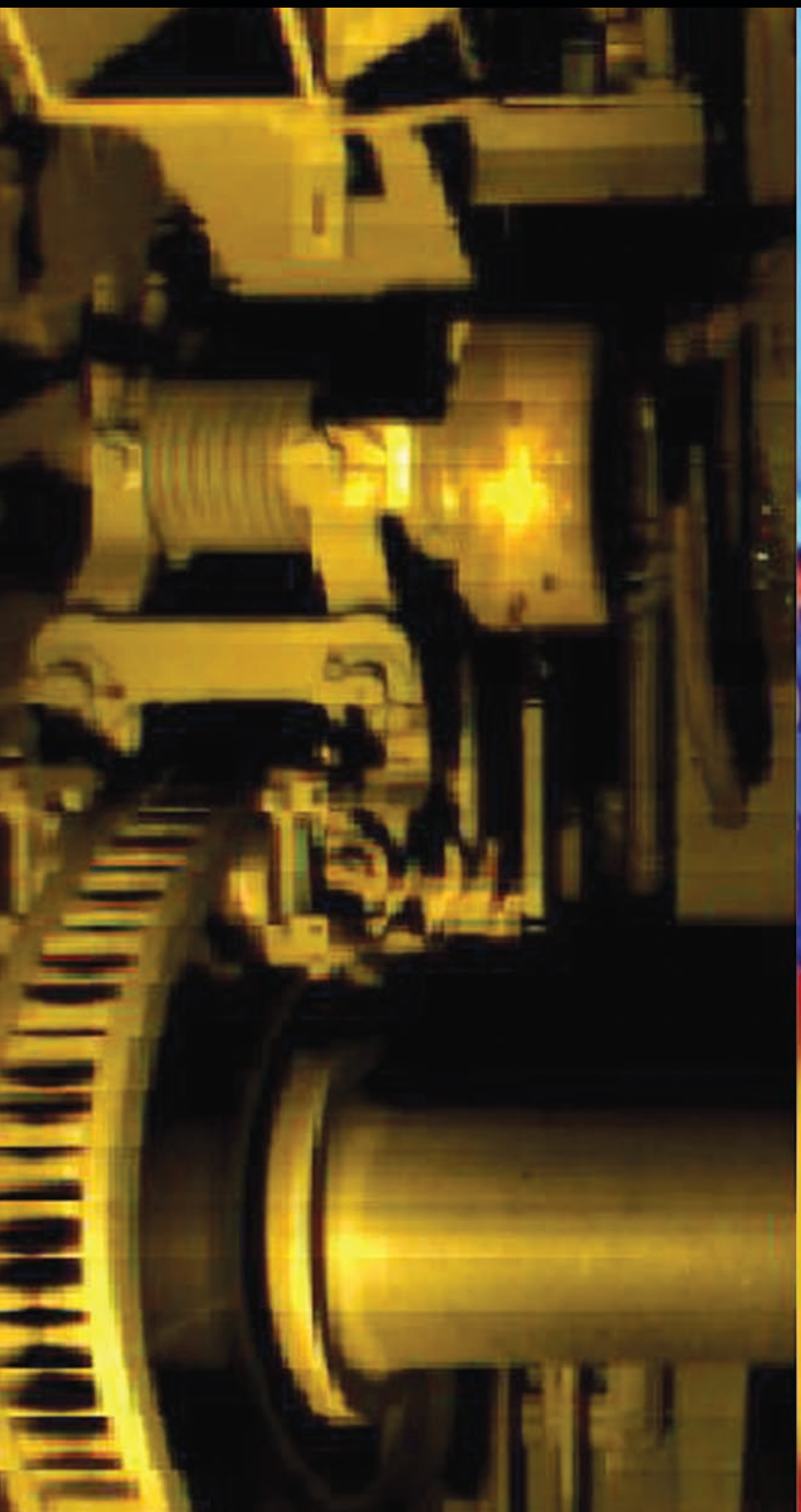
SPARKING INNOVATIVE TRANSPORTATION SOLUTIONS

Issue 13
Spring/Fall
2008

RAIL
HIGHWAY SYSTEMS
TRANSIT &
TRANSPORTATION SAFETY

Ignition

News from **TRB's IDEA** Programs



INSIDE:

Undercarriage inspection in a whole new light

TRB
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OF THE NATIONAL ACADEMIES

THE IDEA PROGRAMS

Innovations Deserving Exploratory Analysis

IDEA programs provide start-up funding for promising but unproven innovations in surface transportation systems. The programs' goal is to foster ingenious solutions that are unlikely to be funded through traditional programs.

Managed by the Transportation Research Board, IDEA programs are supported by the member state departments of transportation of the American Association of State Highway and Transportation Officials (AASHTO), the Federal Transit Administration (FTA), the Federal Railroad Administration (FRA), and the Federal Motor Carrier Safety Administration (FMCSA).

The Transit IDEA program, which receives funding from FTA as part of the Transit Cooperative Research Program, is guided by a panel chaired by Fred Gilliam, President/CEO, Capital Metropolitan Transportation Authority in Austin, Texas. Harvey Berlin is the TRB program officer.

High-Speed Rail IDEA is funded by the FRA as part of its next-generation high-speed rail research. A committee chaired by Mike Franke, National Railroad Passenger Corporation, has oversight. Charles Taylor is the TRB program officer.

The High-Speed Rail IDEA Program is not currently accepting new proposals. Discussions with the FRA are under way regarding the establishment of a new Rail IDEA Program designed to foster innovations in railroad technology, both passenger and freight.

The NCHRP Highway IDEA program is supported by the member state departments of transportation of AASHTO through the National Cooperative Highway Research Program (NCHRP). It is guided by a panel chaired by Sandra Q Larson, Director of Research, Iowa State DOT.

Safety IDEA is jointly funded by FMCSA and FRA. The committee is chaired by Ray Pethtel, Virginia Tech Transportation Institute. Harvey Berlin is TRB program officer.

Visit the IDEA web site:
www.TRB.org/IDEA

On the Cover: Images from a machine vision technology to automate rail car inspection. See page 6.

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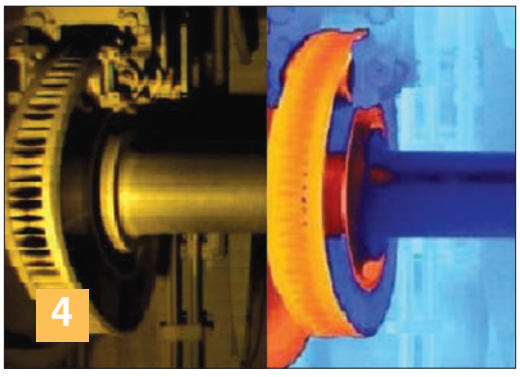
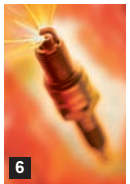
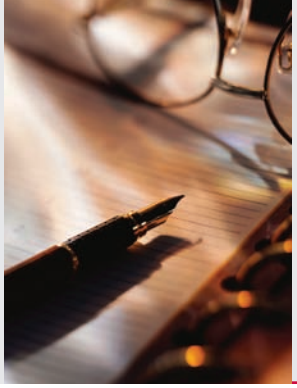






A High Priority becomes More Urgent

Nearly 140,000 miles of track serve the rail industry in the United States and someone has to inspect, repair, and maintain it all. It is work done on lonely stretches of countryside, in dark tunnels, crowded rail yards, and busy urban stations, on bridges and through mountain passes. In any one of these settings, track work can be dangerous.

In this issue of Ignition, we highlight six IDEA projects that aim to enhance safety on and around the tracks. The feature article, Research Improves the Odds at the Tracks, cites some surprising statistics that underscore the urgency of making waysides and grade crossings safer and describes three projects with promising approaches to doing just that.

In the New Ideas section, three other rail-related projects cover very different ground. Read about a technology that stitches together images—in both visible and infrared spectra—of passenger car undercarriages so that a machine-vision system can find problems by comparing the images with templates of components in good condition. Another project overlays train location information on the street-level maps used by emergency dispatch centers so that responders won't be routed where trains are crossing. The last of these six rail projects adapted for use in the United States an automated system for delivering sand to the railhead when loss of adhesion is an issue, which is common during the fall season.

There is good news in the Business Section. Two IDEA projects have been selected for further funding by federal research programs, which boosts the likelihood that these innovations will be able to cross the chasm between invention and implementation. That's another high priority.

Linda Mason
Communications Officer
Transportation Research Board
of the National Academies

Your comments are welcome and may be sent to the editor at: **lmason@nas.edu**

Research Improves the Odds at the Tracks

This article describes three IDEA projects with potential to improve safety when people and railroad tracks cross paths.

Rail transit provides more than 3 billion passenger trips each year and is responsible for only a tiny fraction of transportation fatalities. In 2004, the figure was 0.1 percent, according to the National Transportation Safety Board's(NTSB) Safety Report for that year. Even as ridership trends rise—and in recent months they have risen sharply in response to the economic downturn in the United States—safety incidents are decreasing in number. The rail transit industry has a strong safety record. [1]

Tragically though, the Federal Transit Agency also reports that between October of 2005 and April of 2007 the number of rail transit worker fatalities tripled and the number of injuries increased significantly. During those 18 months, 11 track workers died and more than a dozen were seriously injured.[2] After the NTSB investigated events that lead to the death of an experienced track worker on the Red Line of the Washington Metropolitan Area Transit Authority (WMATA) Metro system in May of 2007, it recommended actions to improve the odds for people who maintain and inspect track.

Among those actions was a recommendation to promptly implement technology to warn track workers of a train's approach and a corresponding system to alert train operators when they approach a work zone. The NTSB's statement on the investigation says in part, "The Board determined that technology can provide additional protection for wayside workers, especially in a work environment in which a lapse of attention can quickly result in serious injury or death. There is technology that can provide alerts to both the train operator and the wayside workers." (*3*)

Track worker safety has long been a high priority in the industry and both the Transit IDEA and High-Speed Rail IDEA programs have funded several investigations over the years seeking technologies to reliably warn people of approaching trains. Results of one of these Transit IDEA investigations to improve track worker safety hold promise as feasibility testing has been successfully conducted at a number of transit systems.

In Transit IDEA project 55, principal investigator Peter Bartek developed a four-part warning system that can be operated along with an agency's current safety procedures to protect wayside workers. The system includes an ultrasonic transducer installed in the operator's cab, a wireless light and horn warning unit set in the work zone(a), portable protected radio frequency-controlled activators placed in the track bed(b), and armband alarms that are worn by track workers. It was this system that the NTSB demonstrated during the public board meeting in January 2008 at which its findings and recommendations in the WMATA case were announced.

Tests of the system had been conducted at the Greater Cleveland Regional Transit Authority, New York City Transit, the Massachusetts Bay Transportation Authority, the Southeastern Pennsylvania Transportation Authority, and the Port Authority Transit Corporation.

a

These collaborations between researchers and transportation agencies that provide real-world conditions in which to test innovations are an important—and mutually beneficial—aspect of the IDEA programs. In this case, the warning device for rail rapid transit personnel was tested in tunnels, on S- and

double S-curves, 90-degree curves with building obstructions, and fly-over curves to determine whether its signals would be reliably detected at distances that allow trackside personnel to find safe positions as trains pass.

The prototype device worked effectively in the field tests and independent laboratory testing results indicate secure data connections, uncorrupted transmissions, and durable materials. WMATA has since purchased four of the track worker warning systems to conduct further pilot testing and evaluation on their rail transit facilities. The systems have also been purchased by the Maryland Transit Administration for use on its rail rapid transit line in Baltimore and pilot tests will be conducted in Boston by the Massachusetts Bay Transportation Authority.

b

Technology can't solve every problem, but it can provide information to inform our actions.

Improving the Odds at Grade Crossings

Effective warning systems are also a high priority at the more than 200,000 intersections in the United States where roadways and railroad tracks cross at the same grade level. A great deal of attention has been paid to improving safety at these grade crossings and thousands of them have been closed in recent years. Still, according to the Federal Railroad Administration Office of Safety Analysis Website, 2,700 incidents occurred at grade crossings in 2007, resulting in 339 fatalities. The DOT Office of Inspector General reports that about half of grade crossing incidents occur at intersections that are equipped with active warning devices and that most of the incidents are caused by risky driver behavior. These data suggest two areas of concern: the 76,000 public grade crossings that are not equipped with active warning devices and improving the effectiveness of warnings to deter risky driver behavior.

Technology can't solve every problem, but it can provide information to inform our actions. Reliable train arrival information is one element of any effective track warning system. Two projects in the High-Speed Rail IDEA program are investigating technologies to predict train arrival times, information needed to activate warning devices at grade crossings and in other potentially risky situations.

In HSR IDEA project 50, investigator Steven Turner is testing the concept of introducing coded, differential radio frequency pulses into the rail at grade crossings and using time domain reflectometry to determine the distance at which approaching trains reflect these pulses. Measuring how the train-distance information changes over time will predict train arrival time, which can then be used to activate grade crossing warning systems. Preliminary design on the prototype system has been completed, including detailed specifications of the design requirements and other system characteristics. Arrangements are in place to bench test the prototype at the laboratories of two manufacturers of conventional grade crossing warning systems to confirm compatibility with existing track circuit controllers, and to conduct field testing on tracks at the Transportation Technology Center at Pueblo, Colorado.

In HSR project 53, Tysen Mueller tested the feasibility of detecting location and speed of trains and vehicles by a sensor technology with an unwieldy name—anisotropic magnetoresistive magnetometers. The sensors consist of a thin nickel-iron film on a silicon wafer. When exposed to a magnetic field such as the Earth's magnetic field, the electrical resistance of the film changes with changes in the field that would be caused by the nearby movement of a large ferrous metal mass, such as a locomotive or a car. In field tests, the sensor system reliably detected highway vehicles at distances up to 100 feet and trains at distances up to 180 feet. Train speeds measured using two sensors were accurate within 5% as compared with a radar speed gun. With these test results, the expert panel for this project concluded that the concept merits further development. The proposed applications for this technology include detecting train location and speed to activate grade crossing warning systems, detecting highway vehicles and other obstructions at grade crossings, detecting track maintenance equipment on or adjacent to the track, and right-of-way incursions.

While not every new concept will prove effective, research that improves the odds of working safely at trackside remains a worthwhile investment, not a risky bet. Each concept tested and every technology skillfully evaluated advances our understanding and brings us closer to safety improvements we can live with.

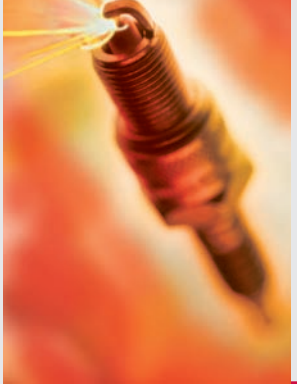
Contact information for these projects:

Transit project 55: peter.bartek@protran1.com.

High-Speed Rail Project 50: analogic@prairieweb.com

High-Speed Rail Project 53: ctaylor@nas.edu

1. **Testimony before Congressional Subcomittee on Highways, Transit and Pipelines hearing on State Safety Oversight Program. July 19, 2006 www.fta.dot.gov/news/testimony/news_events_5230.html**
2. **Http://transit-safety.volpe.dot.gov/safety/sso/DearColleague/2007-05-08/HTML/default.asp**
3. **Statement of the National Transportation Safety Board, SB-08-05 http://www.ntsb.gov/Pressrel/2008/080123.html**
4. **Federal Railroad Administration, Office of Safety Website: http://safety-data.fra.dot.gov/OfficeofSafety/default.aspx**
5. **Office of the Inspector General, US DOT. http://www.oig.dot.gov/StreamFile?file=/data/pdfdocs/Final_Signed_508_Grade_Crossing_Report_05-03-07.pdf**



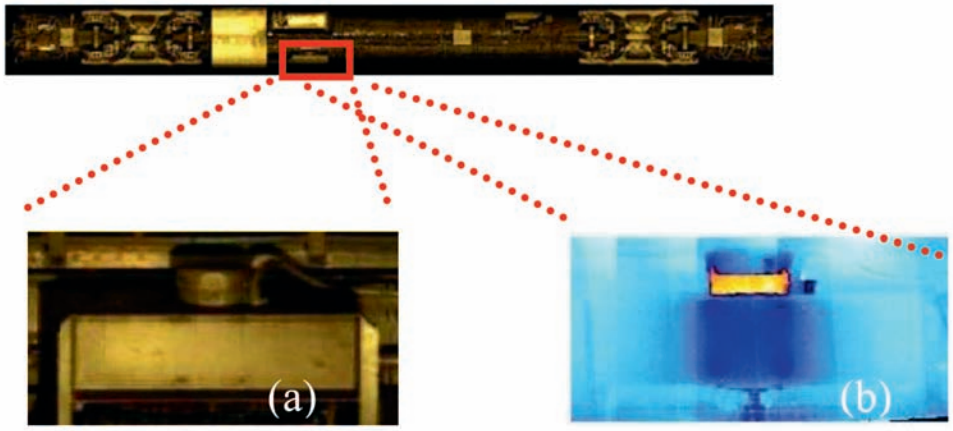
Look What's Under There

A new approach to inspecting the undercarriage of rail passenger equipment is being advanced in a current project of the High-Speed Rail IDEA program. The Association of American Railroads is funding a complementary effort by the investigator to automate inspection of the sides and ends of freight cars. Automating inspections would reduce the time that rail cars are out of service for inspection, improve consistency in detecting defects, and detect problems that can't be seen in the visible light range. A further benefit of such a technology is the ability to record and organize information for later comparison, referencing, and trend analysis.

HSR IDEA project 49 is funding further development of the concept of using multispectral imaging to detect defective or missing components and foreign objects. The project's three-module approach includes a digital video acquisition system using both infrared and visible range cameras, a system for generating panoramic images from individual video frames, and a system for identifying anomalies in the various components of the undercarriage. The components selected for study included traction motors, disc brakes, air conditioning units, and bearings. Image-based templates of entire railcars in good condition and more detailed templates of specific components were generated by machine vision techniques as a basis for comparison with cars being inspected. Combining images from both spectra gives inspectors a clear and unobstructed visible spectrum assessment of the undercarriage and of thermal outliers that may indicate developing problems.

A prototype of the machine vision inspection system has been developed and tested at a passenger car service and inspection facility.

Contact:
Principal Investigator Narendra Ahuja can be reached by email at narendra@vision2.ai.uiuc.edu.



A portion of the motor for the air conditioning unit is obscured in the visible domain (a) but becomes apparent in the thermal domain (b) because the motor is hotter than its surroundings. The infrared camera captures thermal properties of some occluded objects, not just the temperature of the closest object. The full extent to which the infrared camera can overcome occlusion has yet to be tested.

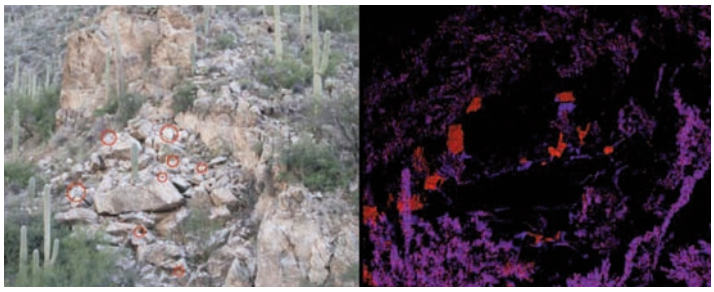
Safely Identifying the Hazards

Rockfall along highways is a major safety hazard that can cause extensive damage to the infrastructure and risk to motorists and nearby residents. A new technique for identifying, evaluating, and managing highway slopes that are prone to rockfall was tested in NCHRP IDEA project 119. A system of 3D laser scanners and high-resolution digital imaging was designed and field tested at sites in Arizona, Colorado, and Utah to predict unstable areas so that rockfall prevention measures can be taken and to assess the source locations and volume of rockfall that does occur. Safety hazards associated with current techniques for rating the risk of rockfall are eliminated in this new approach because a ground-based laser scan is conducted at a distance from the slope and uses survey points in front of the rock face.

The output from a laser scanner survey is a "point cloud" that consists of millions of reflection points that represent the 3D surface that was scanned. After some cleaning, many subsequent calculations and visualizations can be rendered from the point cloud data. Investigators have recently developed software to extract geotechnical information from point cloud data, which provides much of the information needed for rock mass characterization that is quick and partially automated, produces orders of magnitude more data, and avoids human bias issues.

A transportation pooled-fund project was approved by the Federal Highway Administration to begin in the spring of 2008. The project will investigate geotechnical uses of ground-based 3D laser scanners and the software, named Split-FX, in eight states. A deliverable of the project will be a draft recommended practice document for review by relevant committees of AASHTO.

Contact:
Principal Investigator John Kemeny can be reached by email at: jkemeny@spliteng.com



At the field site for testing the change-detection algorithm, boulders marked with red circles in the left image were moved. Removal of boulders as small as 15 cm was detected from the difference point cloud (right image). Red indicates missing material, blue indicates new.

More Information, Better Response?

Emergency dispatch centers use street level mapping to help ambulance, fire, police, and other emergency responders take the best route to the scene of an incident. A project of the Safety IDEA program could make it possible to add real-time train location information to the picture. A train monitoring system known as Civil Overviews was developed in Safety IDEA project 10 as a tool for towns and cities where emergency responders may have to cross train tracks. The computer-based system clearly shows tracks, trains, and crossings in the vicinity as an overlay to the street level map. It indicates the position of trains, the tracks over which they currently have authority to move, the direction of travel, and the locations of grade crossings. As trains move, the sections of track they occupy turn red and track sections that trains have been authorized to move across are highlighted in green. These green sections inform emergency response personnel of near-term train movements.

The system is simple and inexpensive, using available Web-based technologies and a central Web application server that encrypts and protects the data that are provided in a standard format by railroads. In the investigation, CSX Railroad provided data from its central traffic control system, including track occupancy data and GPS coordinates where they were available. The system is ready for field testing and discussions are being held with railroads to identify appropriate sites.

Contact:
Principal Investigator Frank Boyle can be reached by email at: cfboyle@switch.com.

'Tis the Season—for Train Delays

Dew, frost, and leaf oil on commuter train tracks are the source of both safety hazards and performance and cost inefficiencies during the crisp and shortening days of fall. These seasonal conditions cause a loss of adhesion between train wheels and tracks, which makes it more difficult to stop a train within the expected distance. Damage to both wheels and rails can result from emergency braking situations, and damage results in repair costs and lost service. In the United Kingdom, studies conducted each autumn from 2000 through 2003 showed about 750,000 minutes (12,500 hours) lost to delay in each of the four fall seasons.

The rail industry uses sanding systems to improve adhesion under these conditions, and Transit IDEA project 49 demonstrated that a technology developed in the UK, where financial penalties are associated with schedule delays, could be adapted for commuter rail service in the United States.

SmartSander technology automatically delivers a variable quantity of sand to the railhead whenever wheel slip is detected. Because too much sand can interfere with track circuitry, adjusting sand delivery to the required braking conditions can be a significant benefit. The project involved design, manufacture, and optimization of a pilot installation kit and an evaluation of the demonstration project. The adapted system was tested on the Metro-North Railroad of the Metropolitan Transportation Authority of New York State in the fall of 2006. The trials demonstrated that the technology could be successfully adapted to US commuter rail cars. Further validation trials were conducted on the Long Island Railroad in 2007, including tests of a new design that fits on one corner of the vehicle but delivers sand to both wheels.

Contact:
Principal Investigator Graham Curtis can be reached by email at: graham.curtis@deltarail.com.

Follow-on Funding for Two IDEA Projects

For the first time ever, the Federal Highway Administration has awarded grants directly to companies that have developed innovative products for improving roads and bridges—and a product first tested in the IDEA programs is among the recipients. The FHWA's Highways for Life initiative works through its Technology Partnerships Program to help companies refine and further develop technologies in partnership with state and local transportation agencies. The program awarded five grants (selected from 55 proposals) in 2007 to help move innovations to the market—where they can improve safety and performance rather than languishing in the often uncrossable chasm that separates innovation from implementation.

The Asphalt Binder Cracking Device, developed by Sangsoo Kim with funding from the NCHRP IDEA program, received a grant of $239,386. The way asphalt responds to low temperatures is critical to its performance. The Asphalt Binder Cracking Device provides a simple and reliable method to test the cracking potential at different temperatures of the binders used in asphalt, helping to predict and therefore prevent asphalt failure due to cracking at low temperatures. The grant will be used to refine the process, possibly reducing total preparation and test time from the current 4 hours to 2 hours or less by increasing the cooling rate and upgrading to a lighter and quieter test chamber.

More information about the device is available from EZ Asphalt Technology, LLC; contact kim@ohio.edu.

A project of the Transit IDEA program has also been selected for follow-on funding. The U.S. DOT Small Business Innovative Research (SBIR) Program has awarded a contract to further develop an automatic cleaning device for electrified third rail insulators. The device was developed by Arun Vohra, who received proof-of-concept funding in Transit IDEA project 36 and funding for prototype testing in project 47. The innovative device was featured in Ignition issue 9, which is available on the TRB Website at: http://onlinepubs.trb.org/Onlinepubs/ignition/ignition_9.pdf. **The investigator can be reached by email at aruninsulator@gmail.com.**

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