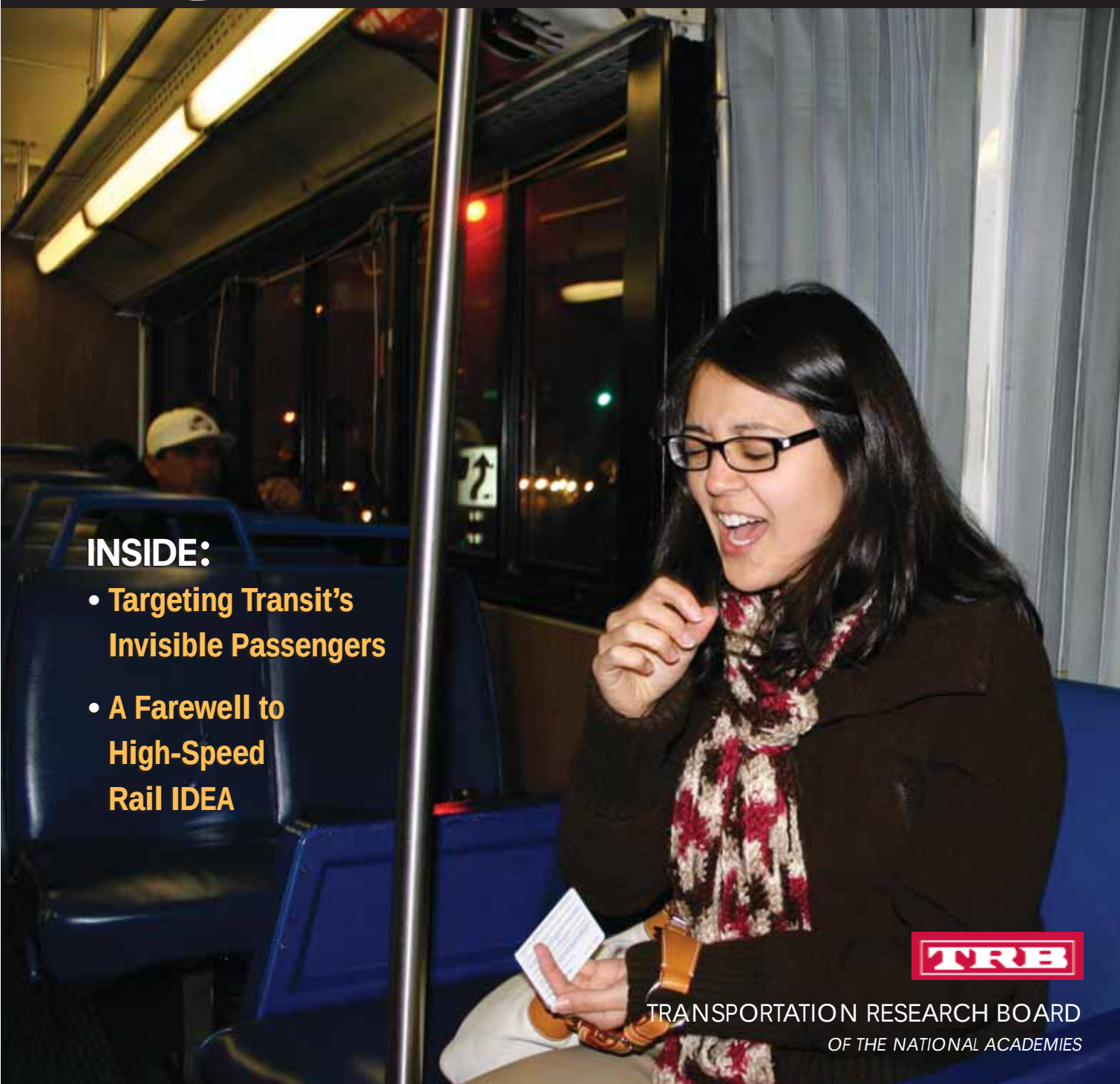
SPARKING INNOVATIVE TRANSPORTATION SOLUTIONS

Issue 14
Fall/Winter
2008

RAIL
HIGHWAY SYSTEMS
TRANSIT &
TRANSPORTATION SAFETY

Ignition

News from **TRB's IDEA** Programs



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- A Farewell to High-Speed Rail IDEA

TRB
TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Sparking Innovative Transportation Solutions

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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.

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. Inam Jawed is the TRB program officer.

Safety IDEA is jointly funded by FMCSA and FRA. The committee is chaired by Bob Gullamore, a consultant. The program focuses on innovations to improve railroad, inter city bus, and truck safety. Harvey Berlin is the TRB program officer.

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

On the Cover: A sneeze can send 2,000–5,000 bacteria-filled droplets into the air at 70 to 100mph. (Photo courtesy of Sita Shablack and Patrick Zelinski.)

TRANSPORTATION RESEARCH BOARD
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Contents

Let there be light!

The American Public Transportation Association announced that in the second quarter of 2008 Americans made about 140 million more trips by public buses and trains than during the same period last year. With more of us packed on board, we may be much closer to our fellow transit commuters—and to their cold and flu germs—than is good for our health. Unless, of course, we're riding on a bus equipped with an ultraviolet light technology for killing bacteria, viruses, and mold. Before you take your next deep breath, read about the Transit IDEA project that targets the bugs on the bus.

Three other innovations are described in the New Ideas section of this issue. One is a system for virtually constructing steel bridge girders, eliminating the need to assemble a bridge at the fabrication shop to ensure that it will fit together at the job site. Another benefit of the technology is that it creates a permanent record of each girder's as-built condition. A second project takes action to alert drivers at passive railroad crossings with a portable system that calculates a driver's speed approaching the unsignaled crossing and displays a warning message. The third highlighted project applies time domain reflectometry as the basis for testing strength in fresh and early-stage concrete. The most recent research phase tested surface-mounted strip sensors for a truly nondestructive test method.

In the Business section we mark the end of an era as the High-Speed Rail IDEA program draws to a close. Look for a few highlights of the program that for more than a decade has supported ideas to save lives, time, and money for the railroad industry. We encourage researchers to still send in those good ideas as funding options may be found in the remaining IDEA programs. And watch this space—we're hopeful that new investments in innovation will come to light before too long.

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**

Targeting Transit's Invisible Passengers

Transit ridership is increasing in many areas of the United States, but not all of those on board are paying fares. Bacteria, viruses, and mold apparently are frequent riders and their freeloading costs transit agencies plenty. Fare-paying human passengers no doubt prefer a different arrangement as well.

Fortunately, Transit IDEA investigator Lee Huston has adapted ultraviolet germicidal irradiation (UVGI) technology to the transit bus environment by incorporating it into bus air conditioning systems. Used in building and hospital air handling units for some years now, ultraviolet light is a proven method for eliminating harmful air-borne contaminants. The innovation in this project is adapting the concept to the particular demands of transit systems to make them safer for passengers and employees and to make equipment easier to maintain.

The Bugs on the Bus

Two of the three major pathogens on transit buses, bacteria and viruses, are transmitted by people. Mold, however, can grow inside the air conditioning unit, which democratically circulates whatever is in the air throughout the bus. The risk of contagion and illness comes not from the entry of a pathogen into the human body but from the reproduction of pathogens once they have gained entry. One or two mold or virus spores aren't harmful, but the consequences can be serious if they multiply. Initial tests of the UVGI system were conducted at the Houston Metropolitan Transit Authority, where 23 separate mold species were identified in the air conditioners of buses.

When such pathogens pass UV light, they are killed or made incapable of reproducing. Ultraviolet light comprises three light spectra. The A and B spectra are used in tanning salons and in hospitals for medical purposes. It is the C spectrum of 254 nanometers that irradiates harmful bacteria, viruses, and molds and kills them. Testing by Biological Consulting Services of North Florida Inc., found that one pass through UV light reduces mold and fungi by 95–99%. During the tests, common viruses and surrogates representing dangerous human pathogens, bacteria, and bio-terror agents were reduced by 99%. There are also new drug-resistant strains of Staphylococcus aureus that can be irradiated by ultraviolet light.

An Idea Comes to Light

Huston, the investigator, said that the idea for using UVGI came to him when he was examining possible air fresheners for buses. "I started looking around for different types of air systems that would enhance the interior of a bus. By accident, I ran into ultraviolet light. It killed odors and had the added benefit of killing the bacteria and germs that are distributed by air conditioner systems."

In Transit IDEA project 53, Huston designed a new ballast, which provides the starting voltage and stabilizes the current, to suit the voltage of a transit bus, adapted the ultraviolet light (UV) bulb to handle the constant vibrations of a bus environment, and developed a new air conditioning filter.

Ballasts in buildings run on 110/220 volts of alternating current. To work with the direct current of a transit bus, JKA Company created a ballast that functions nominally at 24 volts of direct current. "I had worked with Houston Metro early on," Huston stated. "They wanted a ballast that would operate UV lamps continuously but would not run a bus battery down. A special circuit was developed for the ballast and patented. When the UV lamp and ballast sees 23.5 volts, it automatically shuts off. When the alternator kicks in, it supplies 26.5 volts. When that happens it turns the lamp back on. It took about two and a half years to develop a reliable ballast."

For UV lamps to work in the environment of a transit bus, a special mounting bracket was designed to fit into the air conditioning system. A spring clip

holds the lamp into place, and there are two sets of vibration dampeners on each side; one set is in the lamp holder and the other is where the lamp holder fastens to the bus. "In the process," said Huston, "a filament was developed that is heavier than what is used in an office or a hospital." The heavier filament withstands the high vibrations found in a transit bus. The vibration dampeners coupled with the heavy filament decrease the likelihood of a bulb failure and, according to Huston, the average bulb lasts 18 months.

The Benefits Filter In

Circulating cleaner air is clearly a benefit to both customers and employees of transit agencies, but there are additional advantages to the UVGI system. Savings have been documented in both maintenance costs and diesel fuel expenses and fewer environmental pollutants are released during bus maintenance and operation.

In conjunction with the UVGI system, the investigator also replaced the standard air conditioning filters that were used on transit buses with a newly designed reusable electrostatic air filter. The old filters were inexpensive per unit, but allowed a lot of heavy debris to pass through, clogging the filters rapidly and requiring replacement about every month. The UVGI system's reusable electrostatic air filter lasts for 5 years. It is cleaned using a high-powered pressure washer. The new filters capture 99% of particles as small as 5 microns and 70% of particles as small as 0.3 microns.

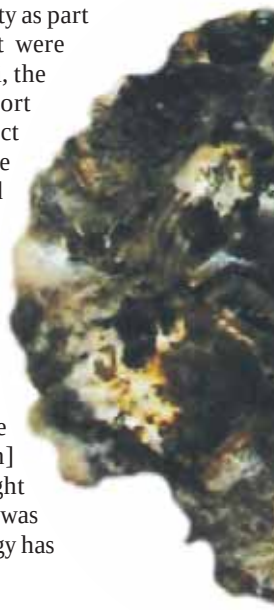
An air conditioner has three main parts: an evaporator, a compressor, and a condenser. The condenser changes the gas to a liquid, which is then pumped through the evaporator by the compressor. The UVGI system places a UV bulb at the evaporator. "What happens normally," Huston says, "is that all of the mold build-up forms on the evaporators. It can be described as a bio-film—like an oyster sticking on a rock. It coats the fins of the evaporator. It's dark, damp, and there is plenty of food. Mold can propagate itself; every six hours it doubles." In order for mold to be seen by the human eye, there need to be 40 million mold spores, but even one one-millionth of an inch of mold on the evaporators can reduce the efficiency of an air conditioner by about 15%. The UVGI system removes mold from the evaporator, making the air conditioner more efficient and requiring less diesel fuel to power it. The diesel fuel savings are approximately 0.4 gallons per day, based on 10 hours of bus operation a day with a 280-horsepower engine that gets 4 miles per gallon and a 28-horsepower air conditioner compressor. The UVGI system reduces the compressor operation by about one hour per day, which, over a fleet of 100 buses, can save nearly 40 gallons of fuel per day as well as any related greenhouse gas emissions.

Once an onerous and often ineffectual process, cleaning evaporators appears to be much simpler with the UVGI system. "There was never any way to keep the evaporator clean," Huston explains, "[Some agencies] used a high-potency acid to burn off the bio-film. That caused toxic stuff to go down the drain. They tried organically approved cleaner, but it didn't really work that well. Then they tried spraying with water. All that did was enhance the mold growth . . . If the evaporators are clogged, the heat exchange does not occur and reduces the life of the compressors. The fan motors related to the air conditioner do not last as long." Furthermore, these inefficient means of cleaning can take from a half hour to an hour. Because the UVGI system removes mold from the evaporator, the cleaning time is reduced to approximately 10 minutes. "You take a little hand vacuum and run it over the intake side," Huston asserted, "There is five minutes of cleaning the filter and it takes five minutes to vacuum the inside of the evaporator. It's a major saving to the transit agency and environmentally much safer."

> "Mold can propagate itself; every six hours it doubles."

What's Next

Initial tests of the system at Houston Metropolitan Transit Authority as part of this Transit IDEA project were successful; Andrew Skabowski, the director of maintenance support functions, wrote that the project "clearly showed an effective way to enhance health and safety of our transit ridership and the employees who provided the service with transit buses." Since then, the product has been incorporated into buses in Fort Worth, Texas, and Tampa, Jacksonville, and West Palm Beach, Florida. Jon Kavalonis, the maintenance manager at Palm Tran in West Palm Beach, attested to the validity of the UVGI system in transit buses, "We have installed it on the buses, and [the UVGI system] did clean up any dirt or bacteria. After the light had been on for a while, [the air conditioner] was almost new looking." Interest in this technology has spread as far as Spain.



The UVGI system is also expected to expand into other areas of use. Huston has just completed development of a 37.5-volt direct current adaptation necessary to accommodate passenger rail systems, which are the next likely area of implementation. Other possible applications include gas masks for the military and first responders.

The technology also demonstrated a serendipitous effect during the early odor-testing by Houston Metro staff. In what must have been a potent test of odor removal effectiveness, catfish parts and deer estrogen were placed in the air conditioner trays of two buses—one equipped with the UVGI system and one without it. At the end of the test, the bus without the UVGI system had what was reported to be "a strong odor" and the tray was full of cockroaches. The bus with the UVGI system not only had no odor—it had no cockroaches either.

The investigator can be contacted by email at: th@gte.net

A Shocking Way to Test Concrete Strength

Predicting the development of concrete strength is important for construction decisions such as removing forms, saw cutting, and opening pavement to traffic, but techniques for measuring concrete properties may not be accurate for all of these decision points. Concrete decks that have been accepted on similar strength criteria can show distinctively different performance over the years.

In NCHRP IDEA project 126, principal investigator Xiong (Bill) Yu of Case Western Reserve University explored the application of time domain reflectometry (TDR) to measure a variety of properties related to the performance of fresh and early-stage concrete. A nondestructive test (NDT) technology that uses electromagnetic wave principles, this technique can measure various properties at once. Probes roughly the size of a ballpoint pen are placed into concrete to measure the free water content, degree of hydration, time of setting, strength, and other such properties by detecting the average electrical conductivity in the concrete.

While other NDT technologies may only be able to measure one or two properties, Yu's technique simultaneously performs several measurements that would otherwise require multiple NDT technologies. Yu stated, "Due to the fact that TDR is based [on] the established electromagnetic wave principles, it was able to probe microstructural responses due to physico-chemical reactions in hydrating concrete . . . the technology measures similar properties as other NDT technologies and achieves similar or better accuracy." Free water content can be estimated within an accuracy of ± 0.01%, and the density can be measured within ± 3%. The new method has the potential to be used by construction workers who pour concrete, as well as by transportation agencies and contractors for the QA/QC process.

The technology has completed the proof-of-concept stage. A patent has been awarded for the method and apparatus for measuring properties of concrete, and a provisional patent application related to nonintrusive testing design has been filed. Equipment developers and manufacturers have expressed interest in this method and the research team has partnered with a company to explore the development of a commercial prototype. They are also developing a truly nondestructive test by using surface-mounted strip sensors that would gather information from the curing concrete without intrusion. Extensive testing to accumulate the database and experience is being performed. A more user-friendly interface and a low-cost pulse source for TDR signals are also being developed. TDR offers great potential; as Yu stated, "Fundamental research on electromagnetic wave interactions with heterogeneous materials is the driving force to uncover the potential of this technology."

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Virtual Assembly of Steel Bridge Girders

To ensure that a steel bridge will fit together at a job site, most state departments of transportation require the steel bridge fabricator to assemble some or all of the parts of the bridge before it leaves the shop. By some estimates, shop assembly composes 10–20% of the total cost of a steel bridge. Quality control measurements typically are performed manually, using string lines and rulers, to verify the condition of the girders. This process can be time consuming and is susceptible to latent errors that are not noticed until the bridge is erected on site.

A system for virtually constructing the bridge components is being developed by Paul Fuchs of Fuchs Consulting Inc., in NCHRP IDEA Project 127, to eliminate the need for shop assembly, saving time and money. The system has two main functions: to electronically measure the manufactured product and to provide a complete permanent record of the as-built condition of each girder. This documentation includes the size, dimensions, and location of holes, which can save steps in the manufacturing process.

The laser metrology system that performs the scan is an extremely accurate, large-volume three-dimensional coordinate mapping device. It can measure objects that have a volume as large as 80–200 feet or as small as 5–10 feet, to the accuracy of

0.007 inches out of a total range of 100 feet. The laser system does not need targets or contact with the girder, and it can work with existing 2D or 3D CAD systems. Once girders have been input into a CAD system, they can be virtually tested and fit together.

The product is currently on its way to commercialization. The proof-of-concept stage has been completed, but further development will be required to complete the system. Fuchs Consulting Inc. is currently looking for partners and people interested in collaborating to fully develop a commercial product. The ability to automate the measurement process is one of the features in development. Manually, the device is able to take the measurements in approximately 90 minutes. That time will be significantly shortened once the device is automated, with time variations dependent on the girder involved and the site. Although the device is specifically designed for bridge fabrication, the technology has the possibility of being used in other fields that require measuring large objects, such as ship construction and aerospace engineering.

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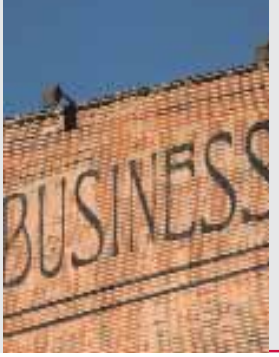
Portable Alerts for Drivers at Passive Railroad Grade Crossings

There are no gates, barriers, or lights at many railroad crossings in the United States where traffic and train volumes are not high enough to warrant the installation and maintenance of permanent, active warning devices. In the absence of such barriers, drivers often disregard the danger of approaching trains and travel through railroad grade crossings too fast to stop if they need to. Although there is infrequent train activity in these areas, reckless driver behavior still results in crashes and fatalities.

In Safety IDEA Project 09, Neil Lerner and Rick Huey of Westat developed a portable device that gives drivers feedback at crossings where there is not a permanent fixture. This portable intelligent device can be moved from crossing to crossing in a region. Because the device will not stay in one location, it has to be able to influence the behavior of drivers after it is gone. To achieve this, a static sign is placed in the approach to the tracks that informs drivers that their speed will be measured. A video camera uses image processing technology to detect the size, speed, and deceleration of approaching vehicles, as well as the presence of trains and the weather conditions. Using the information, together with information about sight distance and train speeds at the particular crossing, the system calculates the appropriate vehicle speed at the crossing and compares that to the actual vehicle speed. After crossing the tracks, drivers encounter a changeable message sign that displays the vehicle speed, "SPD NEAR TRACKS WAS XX," then one of two follow-up messages: "CANT STOP FOR TRAINS" if the driver traveled at an excessive speed or "ALWAYS LOOK FOR TRAINS" if the speed was appropriate. The device would be moved periodically in order to target different populations in need of similar feedback. A user interface is available for the technician that includes input devices (keyboard and joystick) and displays (the system status indications and video monitor). The device contains its own power source and can record and store railroad crossing train and traffic data.

A prototype has been provided to the Volpe Center in Cambridge, Massachusetts, along with the source code for image processing, feedback algorithms, and the system hardware. As a follow-on to the Safety IDEA project, the Federal Railroad Administration and Volpe want to use the device to continue research and development of railroad crossing issues. Volpe is currently addressing issues to improve false alarm resistance, especially in adverse weather situations, and to improve its ability to handle extended deployments. The image processing technology is also being expanded to other uses: Westat is currently using the technology in parking occupancy and traffic stream dynamics measurement studies.

Contact: Rick Huey, RickHuey@westat.com; Neil Lerner, neillerner@westat.com



Farewell to the High-Speed Rail IDEA Program (1997–2008)

For more than a decade the Federal Railroad Administration's support for innovation in rail transportation made the High-Speed Rail (HSR) IDEA program possible. Its sponsorship provided funding for dozens of innovators to investigate promising concepts generated outside of programmed research that had potential to improve railroad performance and safety. As those goals evolved, the activities of HSR are no longer a focus of the FRA, and so the HSR IDEA Program has drawn to a close. The Transportation Research Board looks forward to the possibility of a new rail IDEA program in the future and notes with appreciation a few of the program's highlights.

•A long-awaited alternative to thermite and flash-butt methods for field welding rail was designed by Electroslag Systems, has already generated a great deal of interest in the community's and a commercial product will be available soon.

•The hybrid-composite beam (HCB) designed by John Hillman of Teng & Associates may be the world's first hybrid composite structural member for railroad bridges and it is already in use as a highway bridge. Five major railroads demonstrated their interest in the HCB by forming a consortium to fund the successful field testing and soon a second highway bridge will be constructed.

32 HSR-IDEA PROJECTS COMPLETED TO DATE

- 26% (11) of these were awarded follow-on IDEA contracts for product development;
- 75% (24) are continuing R&D by contractor;
- 28% (9) resulted in a commercial product;
- 13% (4) have sold products; and
- 30% (10) are used in derivative products.

•A machine vision system may automate the inspection process for rail cars and locomotives, reducing the out-of-service time and detecting defects that might otherwise be missed. Developed by Narendra Ahuja of the University of Illinois, the system examines the visible and thermal spectra of the undercarriage with cameras, generates panoramic images, and identifies anomalies.

Another benefit of the HSR IDEA program has been the astute guidance and enthusiastic participation of the members of the committee that reviewed proposals, advised investigators, and provided valuable access to the railroad community. Their service is gratefully acknowledged.

Proposals for innovations in rail transportation may be of interest to the Transit IDEA or Safety IDEA programs; please call the IDEA Programs office at 202-334-3310 for information.

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