Issue 1
Fall 2002

Ignition

News from TRB's IDEA Programs

HIGH-SPEED RAIL
HIGHWAY SYSTEMS
TRANSIT &
TRANSPORTATION SAFETY

INSIDE:

- Can Metal Foam Technology Improve Rail Car Safety?
- We Talk to the Investigator

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

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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 Eva Lerner-Lam, Palisades Consulting Group. 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 William J. Harris, Consultant, has oversight. Charles Taylor is the TRB program officer.

The NCHRP Highway IDEA program is supported by AASHTO through the National Cooperative Highway Research Program (NCHRP). It is guided by a panel chaired by Carol A. Murray, Commissioner, New Hampshire DOT; Inam Jawed is TRB program officer.

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

Visit the IDEA web site:
www.nationalacademies.org/trb/idea

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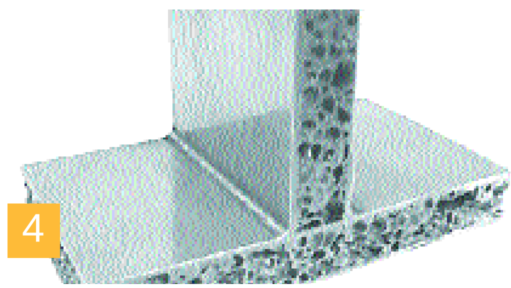
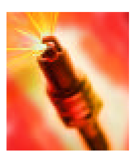




From the Director's Desk

Welcome

My trusty red pick-up truck has reliably hauled grass seed and lumber, Christmas trees and firewood for 15 years now. But after so many seasons, there is a moment of doubt when I turn the key. Will it start this time? Will the right mix of fire, fuel, and air combine at the right time to enable forward motion? Will we have ignition?

Ignition—that moment when progress becomes possible—is what the IDEA programs are about. A curious mind asks a question, a new possibility is raised, the discipline of science is applied, and a potential innovation is identified. But what then? Lacking the necessary spark, good ideas and engines are both nonstarters. IDEA programs provide the spark of early funding and support that can put ideas in motion, and that's why Ignition seemed to fit as a title for this publication.

Welcome to the first edition of Ignition. Three times a year, we will bring you news of ideas being investigated and products with promise. We will interview investigators about their experiences with the IDEA programs and transportation leaders about their vision of challenges ahead that will require new ideas. The business section will share successes and opportunities.

We encourage your comments, which can be emailed to the editor at lmason@nas.edu, and hope to be sharing useful information. Most of all, we're happy to be starting up.

Neil F. Hawks
Director, Special Programs
Transportation Research Board

T. Dennis Claar, Ph.D.

This *Theory* is full of holes

Apparently that's why it works. Dr. Dennis Claar, Executive Director of the Fraunhofer USA Center for Manufacturing and Advanced Materials in Newark, Delaware, is the principal investigator for a High-Speed Rail IDEA project based on metal foam technology. To understand how metal that is about 80% air could one day protect train and automobile passengers during a crash, we talked with Dr. Claar about a technology of interest to people who design everything from convertibles to aircraft carriers.

We asked about the development curve for metal foam technology, about its potential applications in transportation, and about the Center's experience with the IDEA programs in developing new materials. Along the way we learned that introducing new materials to the marketplace can be quite an endurance test, especially for a product that looks a lot like Rice Krispy treats made from aluminum foil.

Would you introduce us to the Center?

Our Center is one of seven U.S. affiliates of Fraunhofer Gesellschaft, a German nonprofit R&D organization. We're somewhat analogous to the system of federal labs that includes Los Alamos, Sandia, and Argonne. We partner with Delaware's main academic institutions and with business development efforts here in Delaware. Of course we also have partners in specific research contracts. On the IDEA project we are partnering with Talgo, a rail car manufacturer based in Spain.

So often we hear that inventions actually started as serendipitous mistakes in the lab. Do you know any creation myths about this material?

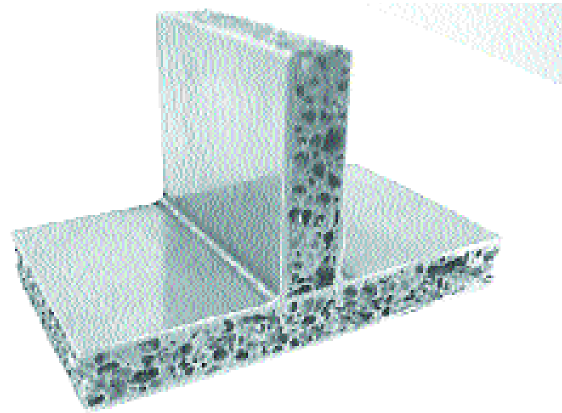
Actually, metal foams as a concept go back probably 50 years, in terms of introducing air into beakers full of material to see what would happen. Well, the story is that the inventor went into the Fraunhofer lab in Bremen, Germany, on a Saturday in the early 1990s, started with aluminum powder, added yeast, baking soda—the things that you would use to make bread rise. He pressed it into a pellet and put it into the furnace to heat up, hoping that it would foam up and turn into aluminum bread, so to speak. It didn't, because the temperatures needed to process aluminum basically turn the ingredients for bread into char. But he realized then that he needed to find ingredients that would create gas bubbles at the temperatures at which aluminum begins to melt. Eventually he tried titanium hydride, just a pinch, which formed bubbles at the right temperature and caused the metal to expand.

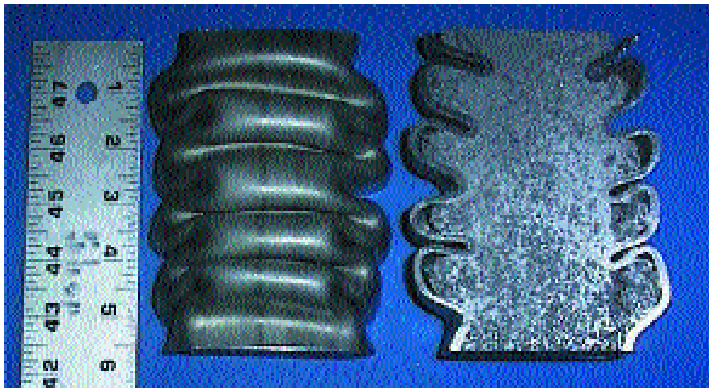
Your IDEA project involves filling structural members of rail cars with metal foam. I'm holding a 1-inch cube of aluminum foam that weighs about as much as a pencil. Let's say I'm a passenger in one of those rail cars. How does this protect me?

When you crush the foam, it absorbs a lot of energy. If you look at split sections of structural steel injected with aluminum foam that have been crushed vertically from 12 inches to about 5 inches, you find foam that was originally 80% porous now has a porosity of about 10%. So we're absorbing between 35% and 40% greater energy per pound than the same tube without aluminum foam.

Another way is to make it harder to bend the supporting members of the rail car. You can get about 40% to 50% increase in bending strength by using the foam inside the structural member. This will keep the stanchion and partitions from collapsing in on the passenger compartment. Another possibility is to fill the buffer zones at the ends of rail cars with foam to absorb crash energy there.

Photo by Steven Brown, courtesy of Talgo America





Energy absorbing aluminum foam in compressed steel sections

What other applications for the metal foam technology seem likely?

Aluminum foam sandwich panels, made of 1 cm of foam between thin sheets of dense aluminum, are very promising. Our labs in Germany are working with a car body manufacturer to replace a stamped steel firewall with a sandwich panel that is eight times stiffer and about 50% lighter. Another application is replacing steel panels with metal foam sandwich panels on ships, where lightweight materials could make a huge difference in power usage.

Commercialization is often the most difficult part of the process for IDEA projects, but this technology seems to have found several paths to the marketplace. Does that surprise you?

Commercialization is part of the Fraunhofer model, which is to team with universities to do research and with industry for implementation. Commercial success can have a lot to do with whether you're pushing your technology, which can be like pushing a wet noodle, or if you're providing a solution to a problem, such as the need for lightweight materials.

You hold more than a few patents yourself; have there been ideas that just never got out of the box? And if so, were you able to identify why that happened?

With about 60 patents to my name, there certainly are some ideas that never made it to commercialization. Sometimes the reason is not being able to focus on each stage of product development at the right time. But, advanced materials are the most difficult things to implement. Designers are reluctant to change materials. There's a famous curve that shows that the incubation time for getting a new material into the marketplace is 15 years. And there are many examples that fit into that model.

So introducing something new to the marketplace really requires a long view—especially if that material is full of holes! We've had to reverse the thinking that a hole is a flaw and learn that controlled porosity can be good! We're trying to get more and more porosity; we make some parts that have as high as 95% porosity.

How does your IDEA project fit into that model?

The first IDEA project helped us perform tests so the material's crush energy absorption could be evaluated for potential applications in train locomotives and passenger cars. And now we're at a stage where we need to test applications to find out what the improvements are. This is where you can go from technology push to technology pull. We knew it would be valuable to have a partner from the industry to pull us along in the right direction. The IDEA program has a technical advisory committee that was helpful in providing information and guidance and putting us in touch with Talgo, who partnered with us for the second-phase IDEA project. Talgo is testing and evaluating materials to help identify rail car components that could be replaced with metal foam-filled parts.

So the TRB technical review panel was a real benefit, and not all agencies have that as part of their program. There is another review by the High-Speed Rail IDEA Program Committee, which was helpful as well because these were people from other parts of the transportation arena, who had different perspectives and were good contacts. My experience with TRB and IDEA has all been positive.

* * * * *

Hoping that we wouldn't be pushing our luck, we contacted Jean-Pierre Ruiz, Executive Vice President and CEO of Talgo America, to ask about the industry side of this partnership. Talgo, a manufacturer of lightweight railcars, is headquartered in Madrid, Spain, and has operations worldwide. Its U.S. base is in Seattle, which is home for Ruiz.

Talgo's interest in the IDEA project, Ruiz explained, is to explore a product that could reduce operating costs by increasing fuel economy for trains and improve their crashworthiness as well. He characterizes the collaboration of two innovative companies on two separate continents as "challenging," and only partly because Talgo's Spanish-speaking design engineers are in a time zone 9 hours ahead of Fraunhofer's English-only staff in Delaware. Further complications arise in coordinating investigators, who Ruiz says "are mostly curious and interested by the science" and a private company, "which takes the opposite view, that an idea may be original and sophisticated but is of no use if it doesn't offer a positive financial impact."

It is exactly this balancing act that the IDEA programs support by encouraging partnerships between investigators and industry. The inherent potential to address real-world constraints that might not be apparent in the lab works to everyone's advantage. This support, says Ruiz, is one reason why IDEA programs are important to innovation. ❖

Tracking Trains

The railroad industry is investigating a variety of communications-based train control systems. These systems use computers on locomotives and at control centers, combined with train location and navigation systems and digital data communications, to control train operations. They have the potential to dramatically improve safety, service reliability, and the use of railroad track and equipment.

Train navigation is a key component of such systems. Precise location information is essential to determine whether a train is in compliance with its movement instructions. This can be particularly challenging when trains operate in multiple track territory where the distance between adjacent tracks is small. Conventional Global Positioning Satellite (GPS) technology cannot provide the accuracy required. Rate gyros or laser fiber optic gyros can do the job, but they are very expensive.

The High-Speed Rail IDEA Program is funding two projects to develop low-cost alternatives to conventional gyro navigation systems for such applications. Ensco, Incorporated is investigating the use of an array of inexpensive microelectromechanical systems (MEMS) accelerometers. Data from these accelerometers are integrated with GPS or digital GPS data using Kalman filtering techniques to provide accurate location information, including which track the train is on.

Seagull Technologies is investigating a three-receiver, three-antenna GPS heading reference system that incorporates a parallel track resolution algorithm. For robustness, the system is augmented with a low-cost heading gyro and the odometer output from the locomotive. Output from both the Ensco and Seagull systems is compared with a rail data base that identifies where such features as turnouts (switches) are located. Concept exploration contracts for both systems were successfully completed and extensive field testing is underway. ❖

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Accessible Transit Fare Machines

Transit fare vending machines can be difficult for people with impaired vision to use. Many complicated fare structures are well beyond what can be represented by raised letters and Braille instructions. An effective solution to this problem would make rail transit systems accessible to more riders.

KRW Incorporated, partnering with the Tri-County Commuter Rail Authority (Tri-Rail) in south Florida and the National Federation of the Blind, was awarded a Transit IDEA contract by the Transportation Research Board to develop and demonstrate a practical and cost-effective device to make fare vending machines fully usable by persons with vision impairments. This will be done through an audio instruction system and a complimentary system of raised letter, Braille, and tactile pathway instructions on the face of the fare machine. This device will be useful to vision-impaired and sighted transit riders alike.

The end product, expected by December of 2002, will include a User's Guide with instructions on how to install, program, and test the device in fare vending machines.

The original project plan called for four audio instruction devices to be installed and tested at four Tri-Rail stations. Results of this Transit IDEA project thus far have been so encouraging that Tri-Rail, with assistance from the National Federation for the Blind, has already purchased six more devices which will be installed at three additional commuter rail stations. Tri-Rail has also requested funding assistance from the Florida Department of Transportation for installation of another 20 devices so that all of their commuter rail stations can be equipped to provide accessible fare vending equipment to its patrons. ❖

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Picture This

Analyzing cracks in a highway surface can yield as much information to a pavement engineer as X-rays or fingerprints to the trained eye. But collecting the pavement crack data has been hazardous, slow, expensive, and the results often too variable to be useful.

Dr. Kelvin Wang and a research team at the University of Arkansas developed a method of collecting and analyzing pavement condition data in real time at 60 miles an hour. In a current NCHRP Highway IDEA project, the team is investigating a way to develop 3-dimensional imagery to identify and measure cracking, rutting, potholes, and patching, all at highway speeds. The process uses a vehicle equipped with computers and multiple digital cameras to acquire pavement images. Algorithms are being developed to convert the data to a 3-D geometric model with image resolution to 1 mm.

A system that efficiently provides precise information while decreasing both risk and cost will be welcome in the highway industry. Managers will have reliable data on which to base decisions that affect design, construction, and maintenance of highways and highway users could have a smoother ride. Wang hopes the system will gain nationwide acceptance, and has formed a company, WayLink Systems Corp., to market the technology. ❖

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Innovative Railroad Bridges

Many railroad bridges in the United States were built in the early 1900s or before. Time and tonnage have taken their toll on these structures, and many must be replaced or upgraded.

A High-Speed Rail IDEA project has developed a cost-competitive alternative to conventional steel or reinforced concrete bridge beams that would be stronger, lighter, and more resistant to corrosion. The concept of a composite structural beam system using both plastic and concrete components was developed by John Hillman of Teng & Associates.

The hybrid-composite beam system consists of an arch of concrete connected at its footings with steel or carbon fibers, all encased in a plastic beam shell. The concrete arch provides compression reinforcement, and the steel or carbon fibers provide the tension reinforcement. Shipping the plastic beam shell to the construction site before it is reinforced simplifies installation and saves transportation costs.

A prototype hybrid-composite beam system was subjected to 100,000 cycles of fatigue loading before being loaded to failure. Failure occurred at more than 3.5 times the required design service load.

Planning is now under way to install and test a prototype beam system in a bridge on a high-tonnage rail line. ❖

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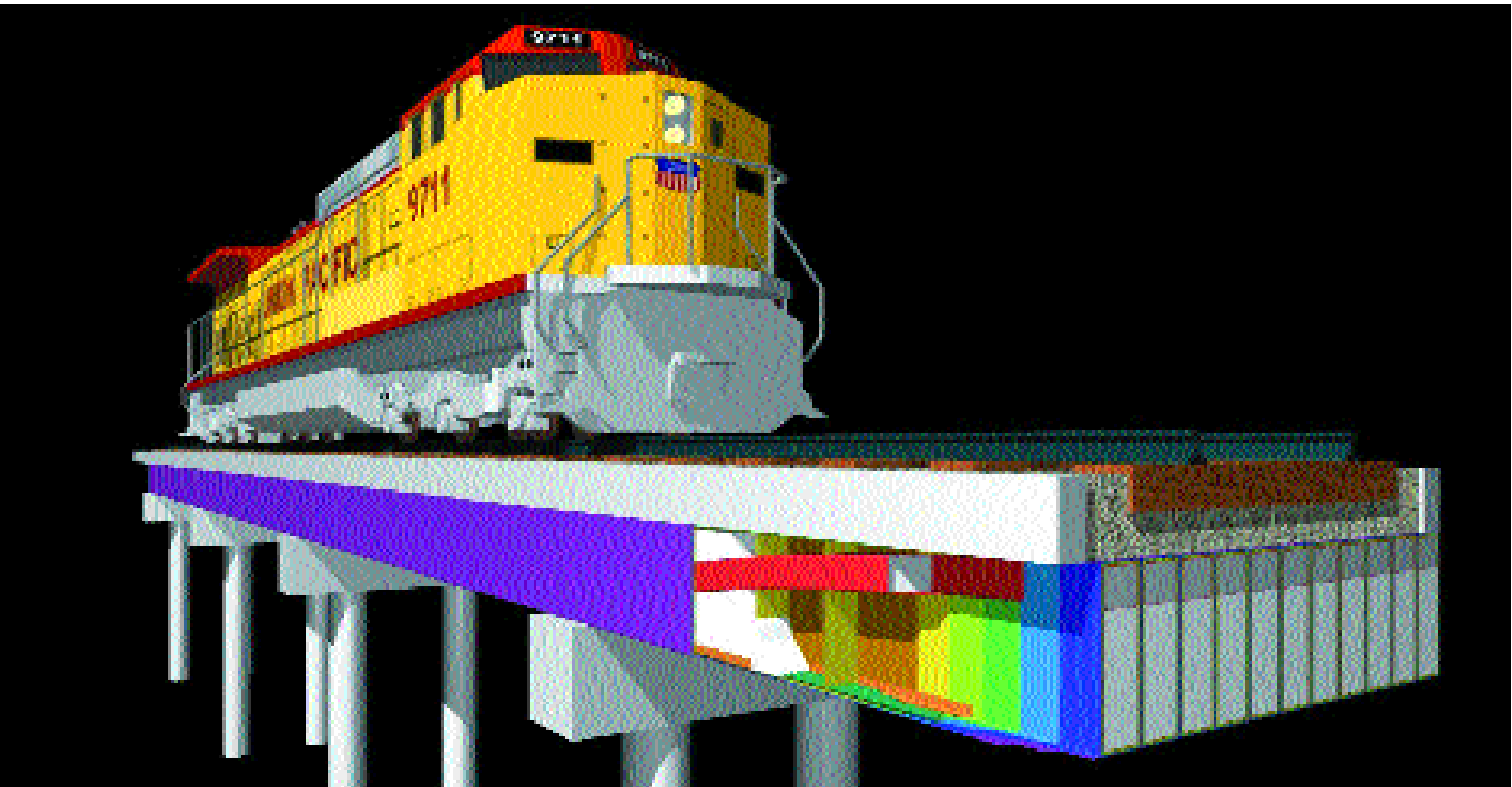
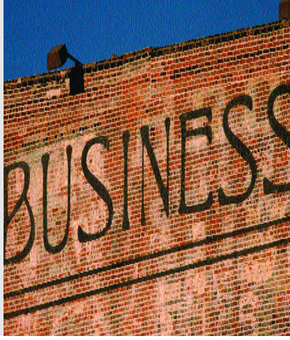
Cut-away view of hybrid composite beam system





Secure Systems, Safe Riders: Two New Transit IDEA Initiatives

The Transit IDEA program has added two initiatives that support goals to which the Federal Transit Administration (FTA) has given high priority:

- Reduce the vulnerability of transit systems to the consequences of intentional harm and
- Accommodate the safe and speedy transport of all passengers, including those with disabilities.

All four IDEA programs—High-Speed Rail, NCHRP Highway, Safety, and Transit—foster innovation in transportation practice by funding the exploration of promising but unproven concepts. The two Transit IDEA initiatives encourage investigators to seek funding for concepts that advance these goals.

Transit Security

Infrastructure security measures have long been elements of transit system development, but never before has there been such heightened awareness of their importance. Technology applications that monitor, detect, warn, or inform may be valuable in improving transit security levels.

The panel of transit experts who review proposals to the Transit IDEA program will assign priority to funding investigations that address these issues.

Bus Rapid Transit

The term 'rapid transit' typically refers to rail systems, but the FTA's new initiative seeks to integrate rapid transit features in bus-transport systems. The more advanced bus rapid transit (BRT) concepts include a number of customer-friendly features, such as

- Exclusive bus lanes and intersection priority to shorten travel times
- Less time at station stops
- Easy access for all customers through level boarding and wider vehicle doors
- Prepaid fare collection
- Real-time displays of next bus arrival times.

The Transit IDEA panel has identified research needs in two areas that affect the station dwell time. Precision docking, aligning the bus floor with the station platform, allows easy transfer for all passengers. Optical and electromagnetic technologies developed for vehicle guidance hold promise for precision docking and level boarding. New ways to accommodate wheelchair users and new methods for securing wheelchairs on buses are also needed to improve service and shorten dwell times.

The Transit IDEA program welcomes proposals in both these areas. Proposal forms and other information on submitting proposals are on the IDEA website at www.nationalacademies.org/trb/idea.

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