From Concept to Proof to Practice

TRB's IDEA Programs Turn 20

Sparking Innovation Through High-Risk, High-Payoff Research

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Gary Rayner was driving his car on a sunny day in California when half a brick lobbed from a passing car dented his hood and cracked his windshield; the consequences, of course, could have been much more serious. Rayner wished he had evidence to prosecute those responsible for the road rage and to recover the costs of the damage. An inventor, he thought of the onboard black boxes that record events leading up to airliner crashes. Perhaps he could develop a similar technology for motor vehicles—more than 30,000 people die in highway crashes each year in the United States.

Rayner started to work in his spare time toward developing a video event recorder for motor vehicles. The goal was to monitor driving activity by continuously recording a video of the roadway, audio, and directional g-forces into a digital looping memory. Activities such as hard braking, acceleration, harsh cornering, or collisions generate *g*-forces that could trigger the device to save a recording of the event.

Rayner needed more resources to develop a prototype for the DriveCam. In 1999, fellow inventors advised him to apply for financial assistance from a Transportation Research Board (TRB) program, Innovations Deserving Exploratory Analysis (IDEA). IDEA accepted Rayner's proposal and provided $100,000 to build several units to prove the viability and effectiveness of the technology; California's technology investment program supplied another $66,000 in cost sharing. According to Rayner,

> The timing of the IDEA award was of paramount importance. It was a major vote of confidence and a key catalyst in being taken seriously during our first funding round. The core of the IDEA proposal became the basis of our official business plan, which helped to get that process started in time for approaching investors. We also found that the contacts we made within the U.S. Department of Transportation (DOT), the National Highway Traffic Safety Administration, and the transportation industry because of the IDEA award were almost as valuable as the funding itself.

Today, many vendors worldwide offer enhanced versions of the DriveCam video event recorder. For fleets, the device can communicate with a central database in conjunction with a company driver training program. Fleet owners who regularly review the event recording with their drivers typically report a 40 percent to 70 percent reduction in incidents.

The Federal Motor Carrier Safety Administration recently sponsored a study by the Virginia Tech Transportation Institute on the use of video event recorders in driver training for two fleets of commercial trucks. The study found that risky driving incidents fell by 52 percent in the first fleet and by 34 percent in the second fleet during a 17-week period. For truck fleets, other benefits included reductions in insurance costs, in vehicle damage, in workers' compensation claims, and in personal injury costs.

Public transportation operators also have adopted video event recorders. Bus fleets in Washington, D.C., Los Angeles County, and San Francisco County are equipped with the recorders.

This example epitomizes the IDEA process—propelling high-risk, high-payoff innovation from concept into adopted practice for the benefit of the traveling public.

Photo: WMATA

A technician installs a DriveCam on a Washington Metropolitan Area Transit Authority bus. DriveCam was developed in 1999 with assistance from TRB's IDEA program and has come into use by bus and truck fleets across the country.

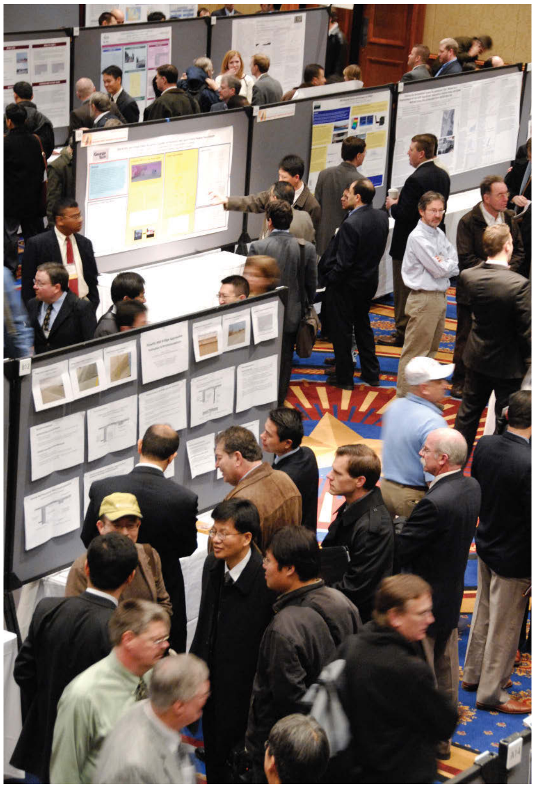


Photo: Risdon Photography

Poster sessions presenting and demonstrating IDEA projects are a regular and well-attended feature at TRB Annual Meetings.

What Is IDEA?

From 1987 to 1992, the National Research Council conducted the first Strategic Highway Research Program (SHRP) on behalf of state transportation agencies. In guiding the program's planned research, the SHRP Executive Committee identified a need to spur innovation. They recognized that innovation, like inspiration, cannot be programmed in a structured research plan with specific projects and tasks.

The SHRP Executive Committee therefore allocated 2 percent of all SHRP funds to innovative, high-risk, high-payoff research. The first IDEA program proved viable and successful; Dean Carlson, then Executive Director of the Federal Highway Administration (FHWA), and Frank Francois, then Executive Director of the American Association of State Highway and Transportation Officials (AASHTO), among others, strongly advocated for the continuation of IDEA after the conclusion of SHRP in 1992. At the recommendation of the Executive Committee, the SHRP IDEA program moved to TRB as the National Cooperative Highway Research Program (NCHRP) IDEA.

At first, FHWA and AASHTO jointly funded the NCHRP IDEA program. FHWA gradually had to reduce its contribution, but the AASHTO leadership, recognizing the value of the program, decided to pick up the deficit. In 1999, when FHWA was unable to continue its support, AASHTO assumed the funding responsibility through NCHRP.

Three new programs soon were added, following the NCHRP IDEA model: Transit Cooperative Research Program (TCRP) IDEA, funded by the Federal Transit Administration; High-Speed Rail IDEA, which is no longer active; and railroad Safety IDEA, funded by the Federal Railroad Administration.

How Does IDEA Work?

IDEA offers early-stage funding for promising but unproven innovations for highways, transit, and railroad safety and performance. The program is independent of the immediate mission concerns of public agencies and of the short-term financial imperatives of the private sector. Government research programs can refer any innovative, high-risk, unsolicited proposals that otherwise might not be funded to the IDEA programs for consideration.

Although the IDEA programs announce general areas of research interest, the projects are investigator driven. The goal is to promote innovations that can progress to next-generation technologies and methods.

Three IDEA programs currently solicit proposals: NCHRP IDEA for highways, TCRP IDEA for transit, and Safety IDEA for railroads. Each IDEA program follows a similar administrative model, adapted for sponsorship arrangements and target

Photo: Risdon Photography

At the 2006 TRB Annual Meeting, Jean-Louis Briaud (*right*) demonstrates the Briaud Compaction Device—developed under the NCHRP IDEA program—to measure soil modulus at the surface of a compacted layer.

Performance of IDEA Programs

	NCHRP 1993–2012	TCRP 1993–2012	Safety 2002–2012
Proposals received	1580	540	225
Awards	171 (11%)	70 (13%)	22 (10)%
Projects completed	147	60	19
Products being used in practice	15%	20%	12%
Great promise for practice	15%	15%	24%

audiences. Each program operates through a committee or panel of volunteer transportation experts who solicit, review, and select proposals that merit research contracts.

Anyone can apply for IDEA funds. The focus is on early-stage projects, not on proven technologies. Two types of projects are eligible:

◆ **Proof-of-concept projects**, which investigate the feasibility of a concept and its potential for application to transportation; and

◆ **Prototype projects**, which develop concepts that show particular promise.

Cost sharing is a recommended approach, demonstrating to the oversight panels that others believe in the technology enough to commit funds.

Rarely does a product emerge ready-to-go from an IDEA project. Usually further development, evaluation, commercialization, marketing, and deployment must occur before an innovation is implemented. The trek from concept to application can take years and can be costly.

John Hillman (*left*), inventor of the hybrid composite beam (HCB), describes the innovative technology to a TRB Annual Meeting attendee in 2004.

Photo: Risdon Photography

Benefits for Inventors and the Public

IDEA awards up to $150,000 for NCHRP IDEA projects, and up to $100,000 for Transit IDEA and Safety IDEA projects. The benefits for inventors are more than monetary, however, and include the following:

◆ Introduction to potential public agency users who can test the innovation;

◆ Assistance and peer review by an expert committee and review panel;

◆ Exposure through TRB's website, publications, and poster sessions at TRB's Annual Meeting; and

◆ Assistance from TRB staff.

Other programs that can help in later development for commercialization also review IDEA projects for possible candidates. Examples include FHWA's Highways for Life and Every Day Counts initiatives, the Exploratory Advanced Research Program, the Small Business Innovation Research, and AASHTO's Technology Implementation Group.

By nurturing innovation, the programs also benefit the public. In addition to demonstrating valuable products, the programs attract cost-sharing arrangements that boost the value of the public investment. When cost-sharing arrangements augment IDEA funds, the amount of research that the IDEA programs can support is nearly doubled.

John Hillman, inventor of the hybrid composite beam (HCB), summarized his experience with IDEA:

> The IDEA program has been an invaluable asset. The funding is no doubt critical, in that there just aren't many avenues for an independent inventor or small company to gain access to that kind of seed money to pursue the initial stages of research and development. However, beyond the funding, the IDEA program provides a level of credibility that helps gain access to individuals who can help make or break the success of the project. Whether it is potential customers, investors, or panel members who can provide valuable input, the reputation of the IDEA program is highly regarded in the transportation industry and needs no introduction.

Following are several notable success stories from the IDEA programs, starting with Hillman's HCB.

Hybrid Composite Beam for Bridges

Developed under NCHRP IDEA Project 60, the HCB is a high-strength, lightweight, corrosion-resistant beam for bridge construction. The HCB comprises three main subcomponents: a shell, compression reinforcement, and tension reinforcement.

The shell is a fiber-reinforced plastic (FRP) box beam. The compression reinforcement consists of concrete, pumped into a profiled conduit—generally an arch—within the beam shell. The tension reinforcement consists of carbon, glass, or steel fibers anchored at the ends of the compression reinforcement. The HCB combines the strength and stiffness of conventional concrete and steel with the light weight and corrosion resistance of advanced composite materials.

The HCB improves the speed of construction and is well suited to accelerated bridge construction projects. Its service life is estimated at more than 100 years.

An HCB weighs approximately one-tenth of a typical precast concrete beam of the same span length. The lighter weight reduces shipping and erection costs—for example, six HCBs can be shipped on a truck that would carry one beam of precast concrete. HCBs require a 30-ton crane instead of the large 150- to 200-ton cranes for precast concrete beams.

The first cost of construction with HCBs—which includes transportation, installation, preparation for service, and other initial capital expenditures—is competitive with that for conventional methods using prestressed concrete beams. Costs will decrease, however, as demand for HCBs increases, creating economies of scale. With its longer service life, HCB is superior in terms of life-cycle costs. AASHTO's Technology Implementation Group selected the HCB as a focus technology for implementation in 2011.

Examples of structures with HCBs include the Lockport Township High Road Bridge over Long Run Creek in Illinois, the Route 23 Bridge over Peckman's Brook in Cedar Grove, New Jersey—both constructed in 2009—and the Knickerbocker Bridge built in 2011 over Back River in Boothbay, Maine.

Photo: Dale Peabody, Maine DOT

Several transportation agencies are using HCBs in construction and replacement of bridges, as in the replacement of Knickerbocker Bridge in Boothbay, Maine.

The HCB undergoes testing under a project funded by NCHRP IDEA and High-Speed Rail IDEA.

The U.S. Army Corps of Engineers recently used HCBs in Bridge No. 4 at Fort Knox, Kentucky. Virginia DOT is installing HCBs to replace Tide Mill Bridge in Fredericksburg. Missouri's "Safe and Sound Project" is building three HCB bridges with a grant from FHWA Highways for LIFE.

Burlington Northern and Santa Fe (BNSF) is conducting live load tests of a full-scale HCB rail bridge at the Transportation Technology Center, Inc., near Pueblo, Colorado. If the tests prove successful, BNSF may install the span on a structure in revenue service.

For his invention of the HCB, Hillman has received the *Engineering News Record* 2010 Award of Excellence and recently was named recipient of the 2013 Charles Pankow Award for innovation from the American Society of Civil Engineers. Other recognitions include the American Council of Engineering Companies' 2009 Grand Award for the Lockport Township High Road Bridge and the 2010 NOVA Award from the Construction Innovation Forum.

Admixture for Improved Corrosion Resistance of Concrete

The corrosion of reinforcing steel undermines the durability of concrete structures exposed to deicing chemicals or to the marine environment. Through NCHRP IDEA Project 13, inventors–investigators Jack Stephens and James Mahoney, working at the University of Connecticut in collaboration with Connecticut DOT, developed an additive that inhibits the corrosion of reinforcing steel in concrete. The additive is based on highly hydrophobic dipolar alkenyl dicarboxylic acid diammonium salts.

An additive that inhibits the corrosion of reinforcing steel in concrete, developed through an NCHRP IDEA project, now is marketed as Hycrete and has been approved for construction projects in at least two states.

The New England Transportation Consortium evaluated the IDEA product and has established the additive's performance and its effect on concrete properties. The product is now being marketed as Hycrete, a corrosion inhibitor, by Hycrete Technologies, Inc., of Carlstadt, New Jersey. The IDEA product forms the basis of a suite of trademarked Hycrete products for inhibiting corrosion and for waterproofing.

The admixture reduces the permeability of concrete to water and chloride, as well as the corrosion of reinforcing steel bars in cracked concrete. The hydrophobic quality of the admixture makes the concrete waterproof and eliminates the need—and the associated costs—of adding a waterproofing membrane.

Hycrete increases the cost per cubic yard of concrete by approximately 25 to 30 percent. Nonetheless, the advantages outweigh the increase in material costs: superior corrosion resistance, reduced maintenance, and longer service life. A life-cycle cost analysis by Virginia DOT for the 2007 construction season estimated that Hycrete would save $1.5 million each year in net costs and would increase service life by 10 percent.[1]

New Jersey, New York, Ohio, Virginia, Kansas, the six New England states, and the U.S. Army Corps of Engineers have experimented with Hycrete for the past several years, focusing on long-term performance. Virginia DOT and Ohio DOT already have approved Hycrete for construction projects. Despite the slow rate of acceptance by state DOTs, the private sector increasingly is using Hycrete for projects such as parking garages and buildings.

In 2009, President Barack Obama invited the CEO of Hycrete, Inc., to the White House for a roundtable of eight CEOs of clean technology–focused companies to share insights on the economic impact of environmentally friendly technologies.

Corrosion-Resistant Steel for Concrete Reinforcement

Gareth Thomas, inventor and investigator on NCHRP IDEA Project 28, developed an improved, dual-phase ferritic martensitic (DFM) reinforcing steel that has superior mechanical properties and corrosion resistance.

The high-strength DFM steel is a low-alloy, low-carbon metal produced by quenching the alloy from the two-phase ferrite–austenite field, yielding a mixture of ferrite and martensite. The IDEA researcher continued to work with DFM, developing MMFX steel, which has approximately five times the corrosion resistance and twice the strength of conventional steel. MMFX Steel Corporation of America was founded in 1998 in San Diego, California, to commercialize and market the new product.

MMFX steel has superior mechanical properties but is more expensive than regular steel. The manufacturers note, however, that the yield strength of MMFX steel is 100 to 120 ksi higher than that of conventional Grade 60 steel; construction projects therefore can be completed with 20 percent to 50 percent less steel and at labor costs for placement and fabrication that are up to 60 percent lower.

In addition, the superior corrosion resistance adds years to the service life of the structure. In 2007, Michigan DOT projected a higher service life for a bridge with MMFX steel instead of with epoxy-coated steel and concluded that MMFX steel reinforcement was worth the investment of approximately $12 more per square yard.[2]

Several state DOTs and FHWA have evaluated the mechanical performance and corrosion resistance of MMFX steel, validating the superior corrosion resistance. MMFX rebar qualifies as ASTM A615 Grade 75; ASTM A1035-04 low-carbon, chromium steel

MMFX steel was used in the construction of a bridge deck in Gundy County, Iowa. The developer of the corrosion-resistant and high-strength material began experimenting with dual-phase ferritic martensitic reinforcing steel under an NCHRP IDEA project.

[1] Virginia Transportation Research Council Final Report 07-R30; www.virginia.dot.org/vtrc/main/online_reports/pdf/07-r30.pdf.

[2] Michigan Department of Transportation Research Report R-1499; www.michigan.gov/documents/mdot/MDOT_Research_Report_R1499_209781_7.pdf.

bars for concrete reinforcement at 100,000 psi; and AASHTO M31 Grade 75.

MMFX steel is now in use across North America on bridges, highways, parking structures, and residential and commercial buildings. Applications include bridge decks in Connecticut, Delaware, Florida, Kentucky, New Mexico, Pennsylvania, Vermont, Texas, Puerto Rico, and Manitoba, Canada. Washington State DOT has used MMFX steel dowel bars on several pavement projects.

In 2011, a Pennsylvania DOT survey found an increasing use of MMFX steels by state DOTS; 10 states had used MMFX steel on a total of 27 bridges, with Maine's 8 bridge projects and New Mexico's 7 leading the way. No state has reported major issues, although the oldest bridge using MMFX steel is about 9 years old and the newest a little more than 1 year old.

Virginia DOT allows the use of MMFX steel rebars as an alternative to stainless steel or stainless steel–clad rebars. The U.S. Army Corps of Engineers used MMFX steel throughout the structure of the Lake Tenkiller Spillway Channel Bridge in Sequoya County, Oklahoma, and the U.S. Navy has used it in hybrid modular piers in San Diego.

Thomas was named 2002 winner of the ASCE Charles Pankow Award for innovation in design and construction and 2004 winner of the NOVA Award from the Construction Innovation Forum, an international nonprofit, for innovations that improve construction quality and reduce costs. The World of Concrete Exposition recognized MMFX steel with the 2004 Experts' Choice Award.

Automated Rail Wheel Inspection System

Transit IDEA Project 17 assisted inventor Zack Mian in the development of a system for the automated inspection of rail wheel flanges to improve rail track safety. The New York State Energy Research and Development Authority provided additional funding for development of the system.

A series of 3-D laser scanners and cameras is mounted at trackside with a series of ultrasonic sensors to scan an entire cross section of a wheel. The output is a digitized profile of the wheel that is processed through geometric algorithm software. The algorithm incorporates standard wheel measurement data with additional computations to check critical characteristics, such as wheel cracks, flange angle, and wheel diameter.

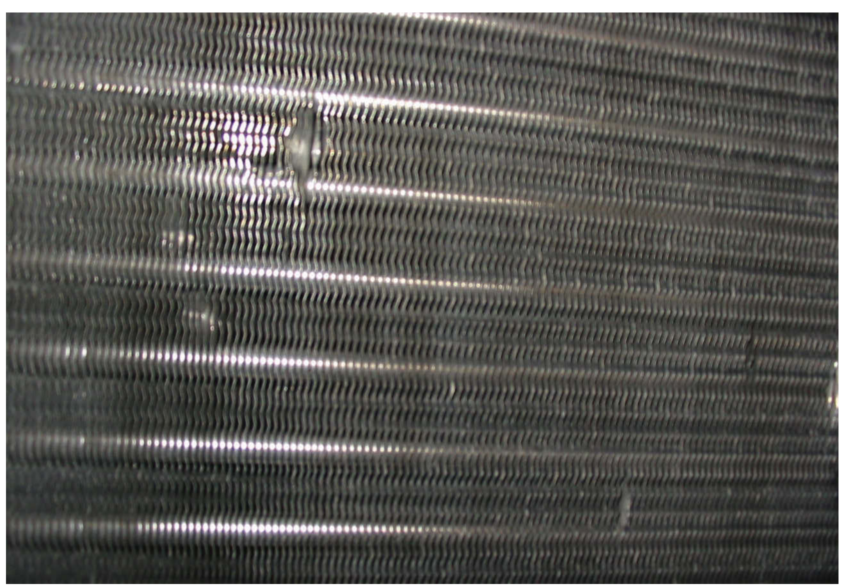
The product generates a complete profile of a rail wheel and evaluates the wheel and flange for wear. The inspection system improves track performance and safety with a faster and more accurate inspection of wheels, enabling more efficient maintenance.

A Transit IDEA project assisted in the development of a system for automated inspection of rail wheel flanges. The system is now in use in several CSX rail yards and also has been purchased by New Jersey Transit.

CSX has purchased and installed five in-ground wheel inspection systems for CSX yards. New Jersey Transit has purchased the system to inspect wheels on rail transit vehicles. The automated rail wheel inspection system has created jobs for U.S. workers—the U.S. company that developed the system from the Transit IDEA project has sent U.S. employees to build and install the system in Sydney, Australia, and Izmir, Turkey.

Ultraviolet Germicidal Irradiation for Transit Buses

Houston Metro field-tested ultraviolet germicidal irradiation (UVGI) in transit bus air conditioning systems and found significant reductions of mold, bacteria, fungi, and harmful viruses in the vehicles, providing health-related benefits to bus passengers, drivers, and employees. Developed under Transit IDEA Project 53 by inventor Lee Huston, the UVGI



Ultraviolet germicidal irradiation reduces the buildup of mold, bacteria, fungi, and viruses on transit bus air conditioning systems. The Transit IDEA product also increases fuel efficiency and can extend the service life of the system's evaporator.

Peter Bartek demonstrates the rail warning system he invented for increased track worker safety with support of the Transit IDEA program.

PHOTO: RISDON PHOTOGRAPHY

also protects against bioterrorist contaminants; increases air flows, contributing to more efficient cooling and lower maintenance costs; and reduces fuel costs for transit buses.

Yet another benefit emerged when the UVGI system was used in conjunction with the newly designed, reusable electrostatic air filter. The system was found to improve particle size capture without reducing the air flow to the evaporator; the reduced cleaning time for the evaporator extended the component's service life.

Transit agencies in Fort Worth, Texas, and in West Palm Beach, Fort Lauderdale, Tampa, and Jacksonville, Florida, have purchased and installed UVGI systems in transit bus air conditioning systems. The Chicago Transit Authority has included the UVGI system in specifications for purchasing new articulated buses. Dallas Area Rapid Transit also has written the UVGI system into its purchasing specifications; 400 buses equipped with the system are scheduled for delivery.

Warning Rail Transit Personnel of Approaching Trains

Peter Bartek invented a system to warn rail transit personnel that trains are approaching and developed the product through Transit IDEA Project 55. When it detects an approaching train, the warning system immediately sends a protected signal that turns on a set of wireless safety lights and horns in the work zone and triggers personal arm band devices worn by track workers, flaggers, and trackwalkers. In addition, a device installed in the train cab warns the operator that transit track workers are ahead.

Staff of the National Transportation Safety Board (NTSB) demonstrated the technology at a public meeting in January 2008 and recommended the adoption of alert technology to prevent track-worker fatalities on rail transit systems (NTSB Report R-08-04). This Transit IDEA–developed product also has created jobs in the United States for the manufacture and installation of the component devices for the U.S. and export markets.

Rail transit operators implementing the technology include the Chicago Transit Authority; the Los Angeles County Metropolitan Transportation Authority; Southeastern Pennsylvania Transportation Authority; Santa Clara Valley Transit Authority in California; the Greater Cleveland Regional Transit Authority in Ohio; Sound Transit serving the Seattle, Washington, area; the Massachusetts Bay Transportation Authority serving Boston; and the Maryland Transit Administration serving Baltimore. The Metropolitan Atlanta Rapid Transit Authority in Georgia and the Charlotte Area Transit System in North Carolina have purchased the devices for installation on their rail transit systems. Queensland Rail of Australia and Russian railways also have purchased the U.S.-manufactured devices.

Opportunities for Inventors

The TRB IDEA programs accept proposals from inventors year round. Oversight committees for each program select innovations for awards twice a year for the highway and the transit IDEA, and annually for the railroad safety IDEA. Information on submitting proposals is posted on the TRB website at www.trb.org/IDEAProgram/IDEASubmitProposal.aspx, or call 202-334-3310 or e-mail dewilliams@nas.edu.

Since 2002, *Ignition*, the magazine of TRB's IDEA programs, has explored initiatives and products.