Innovations Deserving
Exploratory Analysis Programs

TRANSPORTATION SAFETY

New IDEAS for Safety

Safety IDEA Program Annual Report

JANUARY 2011

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

TRANSPORTATION RESEARCH BOARD 2010 EXECUTIVE COMMITTEE*

Publications of the IDEA Programs are available on the internet at *trb.org/IDEA*.
Further information is available by contacting the IDEA Program Office by phone (202-334-3310) or fax (202-334-3471).

Transportation Research Board publications may be ordered directly from the TRB Business Office (202-334-3213), through the internet at *trb.org*, or by annual subscription through organization or individual affiliation with TRB. Affiliates and library subscribers are eligible for substantial discounts.

For further information, contact the Transportation Research Board Business Office, National Research Council
500 Fifth St., NW, Washington, DC 20001, (telephone 202-334-3214; fax 202-334-2519; or email *TRBsales@nas.edu*).

NEW IDEAS FOR SAFETY

Annual Report of the Safety IDEA Program

The Safety IDEA Program is funded by the Federal Motor Carrier Safety Administration (FMCSA) and the Federal Railroad Administration (FRA) and is managed by the Transportation Research Board.

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

January 2011

Safety IDEA Program Committee*

Chair

Robert E. Gallamore
The Gallamore Group, LLC
Rehoboth Beach, Delaware

Members

James A. Arena
Chief Technical Advisor
National Transportation Safety Board
Washington, D.C.

Robert W. Blank
Director, Research and Tests Department
Norfolk Southern Corporation
Roanoke, Virginia

Stephen A. Keppler
Executive Director
Commercial Vehicle Safety Alliance
Greenbelt, Maryland

Henry M. Lees, Jr.
Senior Engineer Track and Structure
Burlington Northern Santa Fe Railway (BNSF)
Topeka, Kansas

Tom Moore
Vice President, Education
National Private Truck Council
Arlington, Virginia

Donald A. Osterberg
Senior Vice President, Safety and Security
Schneider National, Inc.
Green Bay, Wisconsin

Stephen M. Popkin
Director, Human Factors Research and System Applications
Volpe National Transportation Systems Center
Cambridge, Massachusetts

Conrad J. Ruppert, Jr.
Assistant Deputy Chief Engineer Track
National Railroad Passenger Corporation (Amtrak)
Philadelphia, Pennsylvania

Federal Motor Carrier Safety Administration (FMCSA) Liaison

Albert Alvarez
Transportation Specialist
Office of Research and Analysis

Federal Railroad Administration (FRA) Liaison

Kevin Kesler
Chief, Equipment and Operating Practices Division
Office of Research and Development

TRB Liaison

Richard Pain
Transportation Safety Coordinator

Safety IDEA Program

Harvey Berlin
Senior Program Officer
Transportation Research Board

*As of November 2010

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Charles M. Vest is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both the Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Charles M. Vest are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is one of six major divisions of the National Research Council. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

www.national-academies.org

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Safety IDEA (Innovations Deserving Exploratory Analysis) Program supports development and testing of new and innovative concepts and methods for improving commercial truck and intercity bus safety and railroad safety. The program funds applied research and development of promising approaches that have the potential for improving intercity bus, large truck, or railroad safety and safety-related improvements.

The Safety IDEA Program is jointly funded by the Federal Motor Carrier Safety Administration (FMCSA) and the Federal Railroad Administration (FRA) and is managed by the Transportation Research Board.

This summary report describes the projects funded by the Safety IDEA program, including active and completed projects. A listing of completed Safety IDEA projects and final reports follows.

Completed Safety IDEA Projects

The following Safety IDEA projects have been completed and final reports have been prepared:

- Safety IDEA 01: *Color-Corrected Motor Vehicle Headlight, Rearview Mirror, and Windshield Glare Control*, Dr. Gordon Harris and Daniel Karpen, Principal Investigators.

- Safety IDEA 02: *Auto Radio Override Alert System for Highway/Railroad Grade Crossings,* Midland Associates, Inc., Douglas Maxwell, Principal Investigator.

- Safety IDEA 04: *Safety Effects of Operator Seat Design in Large Commercial Vehicles*, Virginia Tech, Dr. Mehdi Ahmadian, Principal Investigator.

- Safety IDEA 05: *Assessment of Driver Safety in Trucks*, Waypoint Research Inc., Dr. Michael Cantor, Principal Investigator.

- Safety IDEA 06: *System to Detect Truck Hunting on Freight Railroads*, Transportation Technology Center, Inc. (TTCI), Richard Morgan, Principal Investigator.

- Safety IDEA 07: *Driver Alertness Indication System (DAISY)*, Sphericon Ltd., Dr. Dan Omry, Principal Investigator.

- Safety IDEA 08: *Cracked Axle Detection on Moving Freight Railcars*, Transportation Technology Center, Inc. (TTCI), Richard Morgan, Principal Investigator.

- Safety IDEA 09: *Driver Feedback Device for Passive Railroad Grade Crossings*, Westat, Dr. Neil Lerner, Principal Investigator.

- Safety IDEA 10: *Monitoring Train Position to Improve Emergency Response*, Union Switch & Signal Inc., Frank Boyle and Michael Pasternak, Principal Investigators.

- Safety IDEA 12: *Development of an Automatic Diagnostic System for Air Brakes in Trucks*, Texas Transportation Institute, Texas A&M University, Dr. Darbha Swaroop, Principal Investigator.

- Safety IDEA 14: *On- Board Railroad Wheel Monitoring System*, L-3 Communications Coleman Aerospace, Michael McCurdy and David Jacobs, Principal Investigators.

The proposals for Safety IDEA 03 and Safety IDEA 11 were withdrawn by the proposers, for reasons discussed in the write-ups in this report.

Proposals

Safety IDEA proposals may be submitted by private companies, public agencies, universities, or individuals. Proposers are encouraged to work with industry companies in developing proposals and to get participation of railroads or trucking companies in Safety IDEA proposals.

The Safety IDEA Program is one of the four active IDEA programs managed by the Transportation Research Board. The other three active IDEA programs are the NCHRP Highway IDEA Program, the Reliability IDEA Program, and the Transit IDEA Program.

Guidelines for preparing and submitting IDEA proposals are provided in the "IDEA Program Announcement", which is available on the IDEA web site at www.trb.org/idea. If there are questions about submitting Safety IDEA proposals, they can be asked by calling the IDEA programs office at (202) 334-3310 or by e-mail to hberlin@nas.edu.

Color-Corrected Motor Vehicle Headlight, Rearview Mirror, and Windshield Glare Control
Safety IDEA Project 01

Research Agency:	Dr. Gordon Harris
Principal Investigator:	Dr. Gordon Harris and Daniel Karpen
Completed:	February 15, 2005 - - Project Completed
IDEA Contract Amount:	$90,000

The purpose of this project was to use clinical optometric research and field trials to investigate the reduction in glare and improvement in night visibility from the use of Neodymium Oxide doped headlights, rear view mirrors, and windshields.

Neodymium Oxide, as a component of glass, selectively filters out yellow light. Neodymium Oxide can be incorporated into the glass of the headlight lamp, rear view mirror, and windshield. When yellow light is filtered out of the spectrum, the color contrast of other colors is improved. Improvement in contrast can permit a motor vehicle driver to better discriminate viewed objects at night. Filtering yellow light from headlights reduces glare and should lessen eyestrain currently resulting from light emitted from conventional headlights of oncoming vehicles at night.

Neutral density filters and neodymium windshield glass were received and used in trial tests. Samples of windshield glass were received from windshield manufacturers.

Thirty subjects were tested in the offices of Dr. Gordon Harris, who is a doctor of optometry. Nine different tests were performed in the office. Field trials were conducted, in which 30 subjects carried out tests drives at night. The office test involved specific optometric tasks done in a clinical optometric setting, and the field trials involved road testing of standard headlights and Neodymium Oxide doped headlights.

The Draft Final Report was reviewed by members of the Expert Review Panel for this project and by the Safety IDEA committee. The revised Final Report for this project, addressing comments from these committee members' reviews, was submitted in February 2005. This project is completed.

The project investigators presented a Society of Automotive Engineers (SAE) paper on this project at the 2005 SAE World Congress in Detroit in April 2005.

Auto Radio Override Alert System for Highway/Railroad Grade Crossings
Safety IDEA Project 02

Research Agency:	Midland Associates, Inc.
Principal Investigator:	Douglas Maxwell
Completed:	November 22, 2005 - - Project Completed
IDEA Contract Amount:	$79,000 (Additional $46,300 in cost sharing)

The purpose of this project was to test the proposed Auto Radio Override Alert System, which was designed to enable a train to override active AM and FM radios in motor vehicles in the immediate area of a highway/railroad grade crossing, to warn the motor vehicle drivers of the approach of the train. No modification or new device in the motor vehicle would be needed.

The concept of overriding the broadcast program was validated in earlier tests with the transmitter located on an emergency vehicle and transmitting only on certain FM frequencies. The objective of this investigation was to validate the design and application, with the transmitter located on a locomotive or at a highway/railroad grade crossing in a rural area, and transmitting the emergency message across the AM and FM broadcast bands.

The field tests, which would have been part of Stage 3 of this three-stage project, continued to be delayed as Midland Associates waited to get an experimental test license approved by the Federal Communications Commission (FCC). Since Midland Associates did not get a license from the FCC to allow them to do the field tests, following continued efforts by Midland Associates, this project was ended, as recommended by the Midland Associates' Principal Investigator.

The Principal Investigator prepared a project Final Report on the part of this project that was carried out, including what was learned in this effort. Lessons learned from this effort should be useful if there is any future consideration of a similar device. The Principal Investigator submitted the Final Report in November 2005. This project is completed.

Integration of LED Technology with Highway High Mast Illumination Equipment
Safety IDEA Project 03

Research Agency:	Focus Illumination Limited
Principal Investigator:	Phillip DeSantis

This proposal was withdrawn by the proposer. The proposer found technical difficulties involving the power supplies, which they felt would make the project unfeasible at this time. The Principal Investigator became ill also. This project would have been considered for joint funding by the NCHRP IDEA program and the Safety IDEA program if it had not been withdrawn.

Safety Effects of Operator Seat Design in Large Commercial Vehicles
Safety IDEA Project 04

Research Agency:	Virginia Tech
Principal Investigator:	Dr. Mehdi Ahmadian
Completed:	June 1, 2005 - - Project Completed
IDEA Contract Amount:	$89,650 (Additional $99,400 in cost sharing)

This project investigated the effect of seat cushion design in large commercial trucks on driver fatigue and vehicle safety. The project included field tests and evaluations, and development of guidelines for improving truck seat design to address driver fatigue.

This effort was motivated by the findings by the U.S. Department of Transportation and others that fatigue is a major factor in commercial vehicle accidents. The issues related to human fatigue (the long-term physical effect) are quite different and far more complex than those related to comfort (the short-term effect on human body) that have been studied extensively in the past.

The project validated the findings of Virginia Tech's laboratory studies, by investigators conducting a series of field tests and evaluations using class 8 trucks. This included the tests on a semi-truck (i.e., a Volvo VN Series class 8 truck) at the Advanced Vehicle Dynamics Laboratory of Virginia Tech. The tests, which included both subjective and objective evaluations, were aimed at better understanding the relationship between seat design and driver fatigue and vehicle safety, in terms of driver alertness and attentiveness, reduced rates of accidents, frequency of near misses, and ability to perform the tasks that are commonly required during driving.

The Draft Final Report was reviewed by the Expert Review Panel for this project and by the Safety IDEA committee. The revised Final Report for this project, addressing comments from committee members' reviews, was submitted in June 2005. This project is completed.

Assessment of Driver Safety in Trucks
Safety IDEA Project 05

Research Agency:	Waypoint Research Inc.
Principal Investigator:	Dr. Michael Cantor
Completed:	October 5, 2006 - - Project Completed
IDEA Contract Amount:	$89,260 (Additional $47,000 in cost sharing)

This project tested "WayPoint," a web-based, non-verbal cognitive assessment tool, which has been shown to identify people who are at risk to drive various kinds of commercial motor vehicles. Waypoint Research Inc. (WRI) developed norms for drivers of long haul and local trucks. Test data was compared with the following criterion measures: preventable crashes, crash severity, and performance on a driver training range. WRI also replicated previous research showing a relationship between sleepiness and "WayPoint" score.

The test assessed the match between a driver's channel capacity (speed of information processing) and his or her "situational awareness" (how aware the person is of the visual field). Potential applications for trucking companies that operate fleets of heavy trucks include driver selection, identification of drivers who would benefit most from training, a diagnostic for the kind of training that would be most effective and for feedback to the driver.

More than 1,200 truck drivers from seven different truck fleet operators took the "WayPoint" test on the web in this project. The research was done in cooperation with seven trucking companies.

The Draft Final Report was reviewed by the Safety IDEA committee and also by expert reviewers for this project. The revised Final Report for this project, addressing comments from committee members' reviews, was submitted in October 2006. This project is completed.

System to Detect Truck Hunting on Freight Railroads
Safety IDEA Project 06

Research Agency:	Transportation Technology Center, Inc. (TTCI)
Principal Investigator:	Richard Morgan
Completed:	February 28, 2006 - - Project Completed
IDEA Contract Amount:	$80,000 (Additional $56,000 in cost sharing)

This project investigated the viability of using an array of non-contact, displacement measurement sensors (DMS) to detect railroad car truck hunting. The system is intended to provide information for monitoring the dynamic lateral stability performance of railroad car trucks passing a wayside installation. (See Figure 1.)

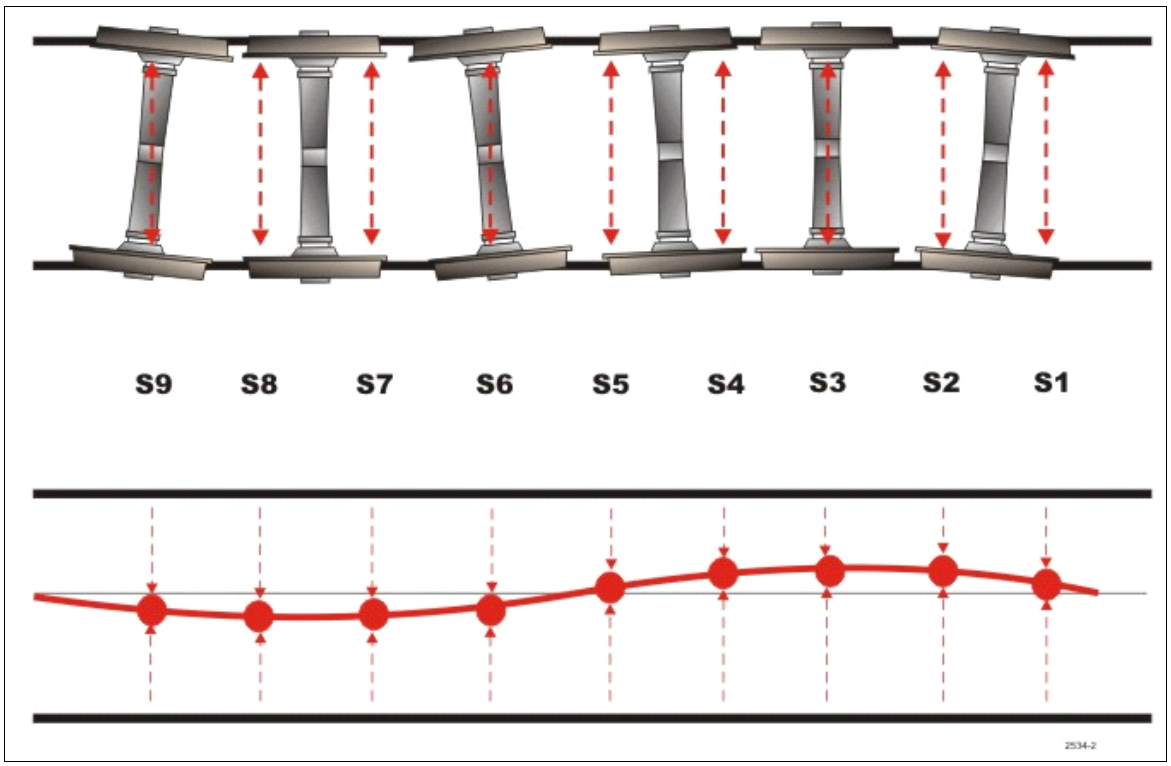

Figure 1: A wheelset's path captured by a multiple sensor array

The system was developed using two stages: a laboratory stage (Stage 1) and on-track testing (Stage 2). During Stage 1, fiber optic DMS were selected and tested for the performance characteristics necessary for truck hunting detection; however, test results indicated that the selected sensors were unable to perform well in this application. The expert review panel recommended that an alternative DMS-based truck hunting detection prototype be evaluated in Stage 2 of the project. This prototype, developed by an Australian company known as Lynxrail, uses an array of paired inductive proximity DMS instead of fiber optic DMS.

At the time of the completion of Stage 1, there was an opportunity for an evaluation at a

revenue service site for Stage 2. In July of 2004, the Norfolk Southern Corporation (NS), in conjunction with the Federal Railroad Administration (FRA), conducted a comparative test of truck hunting detection systems as part of their separate ongoing cooperative agreement for wayside component inspection demonstrations. TTCI was allowed to participate in the evaluation using the Lynxrail prototype in Flat Rock, Kentucky. (See Figure 2.)

Figure 2: Norfolk Southern test site for wayside detectors in Flat Rock, Kentucky

The Stage 2 test results indicated that the Lynxrail prototype provided estimates of speed and Root-Mean-Square (RMS) of carbody end lateral accelerations that were highly positively correlated with those measured by onboard instrumentation. These results validated the concept of truck hunting detection via an array of paired DMS; however, variability was observed in the Lynxrail prototype estimates of RMS lateral accelerations, especially at higher vehicle operating speeds.

Changes in wheel/rail interaction and in truck performance make truck hunting a very dangerous event with the potential for derailment as a possible outcome. It is important to identify rail cars in service that exceed acceptable levels of truck hunting. Fulfilling this need through proper utilization of wayside, DMS-based truck hunting detection technology offers the obvious opportunity to curtail hunting related derailments, but it also provides possibilities to mitigate: (i) accelerated degradation of car suspension systems and wheel profiles, (ii) track damage, (iii) as well as damage to the payload of

the car. Additional benefits may result from fact that the system is designed to be modular and transportable.

The prototype arrays of paired inductive proximity DMS performed adequately when compared with onboard data, and thus final development of the system should be encouraged. Several prototype enhancements needed to better support the operations of the North American railroad industry include: (i) incorporation of Automatic Equipment Identification (AEI) interface capabilities, (ii) ruggedization of track-mounted system components, (iii) protection of the system so it can successfully function in all North American climates, and (iv) possible improvements to the algorithms used to estimate RMS of carbody end lateral accelerations.

The Draft Final Report was reviewed by the Safety IDEA committee and also by the Expert Review Panel for this project. The revised Final Report for this project, addressing comments from committee members' reviews, was submitted in February 2006. This project is completed

Driver Alertness Indication System (DAISY)
Safety IDEA Project 07

Research Agency: Sphericon Ltd.
Principal Investigator: Dr. Dan Omry
Completed: December 4, 2006 - - Project Completed
IDEA Contract Amount: $78,000 (Additional $118,150 in cost sharing)

This project tested the innovative concept for detecting driver inattentiveness that was developed by Sphericon. This concept is based on steering system dynamics: the separation of driver actions from the effects of the external world on the vehicle's lateral motion and using that relationship to evaluate driver alertness. When driver action is weighed against the effect of disturbances (bumps and road imperfections, wind gusts, etc.) on the lateral motion of the vehicle, a good measure as to the alertness or attentiveness of the driver can be obtained.

This project included the development and construction of a hybrid (hardware-in-the-loop) simulator which integrated a real steering system with a computerized simulator and with an elaborate set of sensors and data acquisition system. The use of such a simulator allowed experiments with inattentive drivers in the safe environment of the laboratory.

The last stage of the project included the enhancement of the DAISY algorithms. This involved conducting driving tests in the hybrid simulator with drivers at different stages of alertness and analysis.

Twenty-four tests were conducted of which eight were discarded due to various issues with the use of the new simulator system or with the test subjects. Analyses of the data were performed and the algorithms were enhanced to conform to the selected measurement approach. The results obtained from the tests were translated into an alertness indicator which was then compared with an index produced by subjective judgment: two investigators observed independently the recorded video of the test subjects and graded their level of alertness.

The comparative analyses conducted resulted in promising results. Although the analysis was qualitative in nature, the similarity of the pattern of the alertness index generated by DAISY to that produced by the subjective judgment method indicated the validity of the principles that govern the operation of DAISY.

The Draft Final Report was reviewed by the Safety IDEA committee and by the Expert Review Panel for this project. The revised Final Report for this project, addressing comments from these committee members' reviews, was submitted in December 2006. This project is completed.

Cracked Axle Detection on Moving Railcars
Safety IDEA Project 08

Research Agency:	Transportation Technology Center, Inc. (TTCI)
Principal Investigator:	Richard Morgan
Completed:	August 31, 2006 - - Project Completed
IDEA Contract Amount:	$50,000 (Additional $157,650 in cost sharing)

This project examined a method for remotely detecting cracks in moving railroad car axles. The objective of this project was to determine if Laser Air-coupled Hybrid Ultrasonic Technique (LAHUT) inspection methodologies developed for detecting flaws and defects in rail and railroad car wheels could be applied to wayside detection of cracks in freight car axles. Figure 1 shows a broken railroad axle that occurred in the FAST Track at TTCI.

Figure 1: Broken railroad axle

The efforts focused on adapting LAHUT inspection methodologies for remotely detecting cracks in axles of test railcar wheelsets. This project includes developing procedures required to apply the LAHUT to detect axle cracks, followed by designing and conducting a proof-of-concept (POC) demonstration. Potential benefits include improved safety of railroad operations by removing cracked railcar axles from service prior to failure.

The developmental approach and testing of the cracked axle detection system included two stages. Stage 1 involved completing an extensive literature review of laser-based ultrasonic inspection methods. Stage 2 involved the planning and conducting of a POC demonstration in a dynamic environment.

Stage 1 activities included laboratory experiments using a high-energy pulsed laser to introduce ultrasonic wave modes into the axle body and an air-coupled transducer to monitor the ultrasonic waves. Figure 2 is a diagram of the lab set up used during Stage 1 testing. Data analysis techniques used during this stage of development monitored the ultrasonic signals for the arrival of both expected and unexpected waveforms.

Stage 2 activities focused on determining if the laboratory results could be used to construct a system for dynamic detection of surface breaking fatigue cracks in the axle body.

Figure 3 displays the components and Stage 2 test set-up used during the POC demonstration.

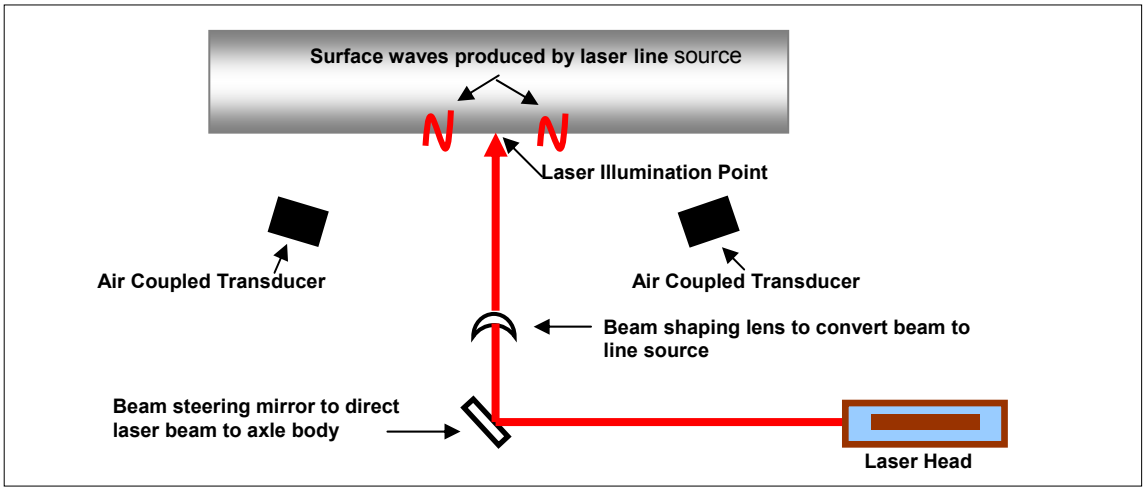

Figure 2: Axle inspection laboratory setup

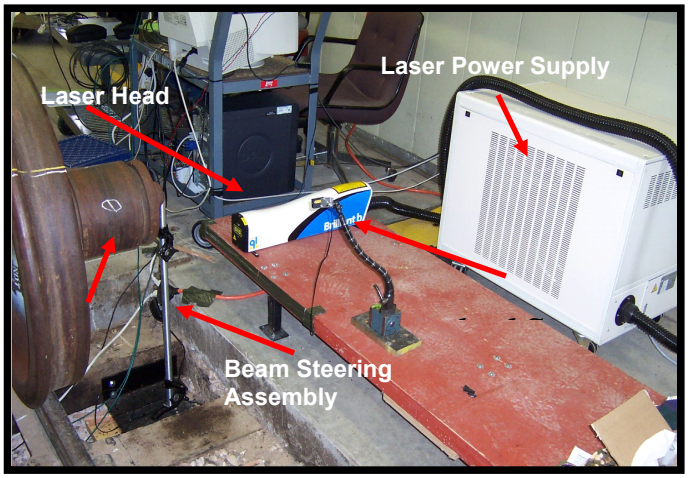

Figure 3: Proof of concept demonstration test setup

A single laser pulse was output by the high-energy laser. Some 206 axle passes were completed with six test axles containing defects. Forty-one passes were completed with axles containing no defects. At the conclusion of the POC demonstration, 88 percent of the defects were detected with only one false positive in 41 opportunities.

The results of the POC demonstration performed by TTCI clearly support the feasibility of using laser-based ultrasonic inspection to detect flaws in the axle body, both statically and dynamically. These results strongly suggest that this inspection technique could form the basis of a wayside system to detect cracks in the axle body. Further, it may be

possible to extend the technique to find flaws in other axle segments (wheel seat and journal bearing area).

The Draft Final Report was reviewed by the Safety IDEA committee and also by the Expert Review Panel for this project. The revised Final Report for this project, addressing comments from committee members' reviews, was submitted in August 2006. This project is completed.

TTCI has continued development on an in-track system that will detect defects in both the axle body and wheel seat areas. Plans by TTCI after completion of this Safety IDEA project include system installation and testing at TTCI.

Driver Feedback Device for Passive Railroad Grade Crossings
Safety IDEA Project 09

Research Agency:	Westat
Principal Investigator:	Dr. Neil Lerner
Completed:	December 21, 2006 - - Project Completed
IDEA Contract Amount:	$85,000 (Additional $15,000 in cost sharing)

This project developed a low-cost, portable device to provide drivers with explicit feedback about the safety of their behavior at passive highway-railroad grade crossings. Passive grade crossings have no gates, barriers, or lights and are typically located in rural areas with relatively low traffic volumes and relatively low train volumes. At passive grade crossings, drivers are responsible for slowing sufficiently and searching for trains so that they can stop in time if a train is approaching.

Past research has indicated that many drivers do not behave properly at passive crossings. Any countermeasures to improve the situation at passive crossings should be low-cost. The concept in this project is to design an intelligent device that can determine whether drivers are exceeding safe approach speeds, given the sight distance, local train speeds, site geometry, and vehicle characteristics. Because the device would be portable, it could be used at multiple sites, in the same way speed trailers are used, thus making the cost per site low. It could be used for periodic or spot application at multiple passive grade crossings in a region or corridor.

Driver behavior research suggests that one reason for poor crossing behavior for some drivers is "benign feedback." Drivers may approach crossings too fast to allow effective visual search and safe stopping, however because the actual arrival of a train at about the same time is a relatively rare event, the experience is "benign" (no consequence) despite their errors. Thus they essentially think that what they did was OK. The driver feedback device under development here is designed to provide realistic, individualized feedback to inform drivers of unsafe behavior at grade crossings and teach them what is more appropriate. This driver feedback system is not intended to be a traffic control device that controls drivers' actions on their approach to a crossing. Rather it is an instructive system that informs the driver about what they did. It is meant to influence drivers in a given area even after the portable system has been removed for use elsewhere.

Figure 1 shows a conceptual example of the type of feedback provided to motorists after they encounter the crossing. This illustration is "conceptual" in that the message shown is idealized, but not really practical, given the on-road requirements for legibility distance, sign reading time, display size, and the capabilities of conventional portable changeable message signs. One of the tasks of the project was to devise an effective message and format that is both practical and well-understood.

Stage 1 of this two-stage project accomplished the following:

- Review of literature and technologies regarding state-of-the-art in traffic feedback systems
- Evaluation of road user requirements for message perception, comprehension, and acceptance (based on driver focus groups as well as literature and analyses)

Figure 1: Conceptual example of a driver feedback display for passive grade crossings

- Determination of formal functional requirements and performance specifications.

The functional specifications developed in Stage 1 provide the basis for the engineering design in Stage 2 of this project. Functional specifications were derived for vehicle sensing, train sensing, environmental sensing, driver displays, user interface, rail crossing traffic data recording and storage, and other general device requirements.

In Stage 2, the project investigators designed and constructed a prototype system meeting the functional requirements. The system was then evaluated under systematic conditions in a test-bed setting.

There are close to 90,000 public passive highway-rail grade crossings in the U.S. The low vehicular and/or train traffic levels at passive grade crossings, or other factors, make it impractical to install and maintain upgraded levels of protection (e.g. gates or grade separation) at all of those crossings. The portable nature of the proposed device could provide a practical way to address safety at such locations. Feedback at any one location should also generalize in terms of improved driver behavior at other grade crossings. Thus there would be potential for widespread application and reduction of crashes.

The effectiveness of the device (measured in terms of improved driver behavior, during device operation and subsequent to device removal) would need to be verified and quantified through field evaluation at representative sites after this project.

The Draft Final Report was reviewed by the Safety IDEA committee and also by the Expert Review Panel for this project. The revised Final Report for this project, addressing comments from committee members' reviews, was submitted in December 2006. This project is completed.

Monitoring Freight Train Position to Improve Emergency Response
Safety IDEA Project 10

Research Agency:	Union Switch & Signal Inc.
Principal Investigator:	Frank Boyle and Michael Pasternak
Completed:	May 5, 2008 - - Project Completed
IDEA Contract Amount:	$71,000 (Additional $48,350 in cost sharing)

The purpose of this project was to determine train location so that local authorities can respond more rapidly and effectively to emergencies. Web-based communication/information technologies were applied to the interaction and interfacing of local emergency response systems and freight trains. The application utilized GPS information to accurately display the positions of trains in real or near real time. A Geographical Information System (GIS) monitor for displaying train position is an improvement over existing displays, which present straight-line track diagrams.

This project included the technical development required to adapt the web-based information technology to handle railroad GIS data and concomitant displays. The project included testing the resulting “Civil Overviews” prototype display system. This project used CSX railroad track infrastructure data for analysis.

The Draft Final Report was reviewed by the Safety IDEA committee and also by expert reviewers for this project. The revised Final Report for this project, addressing comments from reviews, was submitted in May 2008. This project is completed.

Analyzing Near-Misses to Minimize Collisions at Railroad Crossings
Safety IDEA Project 11

Research Agency: University of California, Berkeley
Principal Investigator: Dr. Theodore E. Cohn

This contract was cancelled at the request of the investigators. This was because they felt that it would be impossible to perform the work due to a number of technical issues, and because of the death of the Principal Investigator before the project could start.

Development of an Automatic Diagnostic System for Air Brakes in Trucks
Safety IDEA Project 12

Research Agency:	Texas Transportation Institute Texas A&M University
Principal Investigator:	Dr. Darbha Swaroop
Completed:	December 31, 2008 - - Project Completed
IDEA Contract Amount:	$80,000 (Additional $67,000 in cost sharing)

This project developed a prototype system to automatically detect leaks in air brakes in trucks. This was an on-board diagnostic system. It estimated the push rod stroke, in real-time, from measurements of pressure in the brake chambers and supply reservoirs.

A leak in the air brake system is detected by making ``full'' brake applications (i.e. a brake application where the steady state pressure in the brake chamber is nearly equal to the supply pressure) and comparing the steady state pressure measurements in the brake chambers with the supply pressure. The presence of a leak in the air brake system and the push rod stroke being greater than the re-adjustment limit, increases the lag in the response of the system to a pedal input by the driver, thus making the brake system response more ``sluggish''. These factors will also lead to a decrease in the torque available for braking. A leak also increases the work load on the compressor and related components, thus leading to faster wear if undetected.

A diagnostic system was developed in this project that could be used by truck fleet owners to perform regular maintenance inspections and by road-side inspection teams as a fast and reliable tool in their enforcement inspections.

The Draft Final Report was reviewed by the Safety IDEA committee and also by expert reviewers for this project. The revised Final Report for this project, addressing comments from reviews, was submitted in December 2008. This project is completed.

Sensor Integration for Crash Avoidance for Trucks
Safety IDEA Project 13

Research Agency:	California Polytechnic State University (Cal Poly)
Principal Investigator:	Dr. Charles Birdsong and Dr. Peter Schuster
IDEA Contract Amount:	$75,000 (Additional $62,300 in cost sharing)

This project developed and tested a low-cost crash avoidance sensing system for over-the-road class 8 trucks, by testing and integrating several different sensor technologies.

A good way to improve accident avoidance is through systems capable of detecting objects around the vehicle and detecting accident risk before it occurs (through improved situational awareness) and either warning the driver or preventing dangerous actions. This technology can enable commercial trucks to respond to potential risks and improve the driver's awareness of surrounding vehicles and situations.

This project investigated a system that combines several different low-cost sensors with an integration algorithm to achieve more information than the sum of the parts. This system was designed to balance weaknesses of one type of sensor with the strengths of others. The investigators worked with an over-the-road class 8 trucking company to test and evaluate the system.

Onboard Railroad Wheel Monitoring System
Safety IDEA Project 14

Research Agency:	L-3 Communications Coleman Aerospace
Principal Investigator:	David Jacobs and Michael McCurdy
Completed:	February 2010 – Project Completed
IDEA Contract Amount:	$70,000 (Additional $35,000 in cost sharing)

The purpose of this project was to develop an economical onboard wheel monitoring system for railroad applications. Early detection of rail car wheel/bearing deterioration can help to minimize derailments and reduce damage to track. Advances in low power miniaturized sensors, processors and wireless communication systems could enable onboard wheel monitoring systems to be feasible.

The systems investigated in this project included a miniature device on the wheel axle assembly without any modification to existing equipment on the railcar; a wireless communication system forming a “discriminatory” mesh network, limited to the railcars on the train of interest, which communicates to a central monitoring station; and continuous monitoring of bearing temperature, vibration and acoustics, and wheel impact, allowing continuous data analysis.

The Draft Final Report was reviewed by the Expert Review Panel for this project and by members of the Safety IDEA Committee. The revised Final Report for this project, addressing comments from reviews, was submitted in February 2010. This project is completed.

Determination of the Longitudinal Stress in Rails
Safety IDEA Project 15

Research Agency:	Texas Transportation Institute
Principal Investigator:	Dr. Stefan Hurlebaus
IDEA Contract Amount:	$75,000 (Additional $25,000 in cost sharing)

The objective of this project was to determine the longitudinal stress in rails, in order to reduce rail buckling due to temperature-induced stresses.

Continuous welded rails (CWR) are typically long members which are susceptible to failure caused by significant temperature changes. Such rail temperature changes can cause rail buckling, which can cause considerable disruption to railroad operations and, in the worst case, cause freight or passenger train derailment.

An important parameter in analysis of temperature induced stresses is the rail neutral temperature (RNT), defined as that rail temperature at which the net longitudinal force in the rail is zero. The objective of this project was to determine the longitudinal stress in rails using the polarization of Rayleigh surface waves, in order to reduce buckling and fracture.

Investigators at the Texas Transportation Institute, which is an Association of American Railroads (AAR) Affiliated Laboratory, worked together to develop a methodology to determine the RNT in a nondestructive and non-contact manner. This could give the railroads the opportunity to check their rail system and to adjust the installation of the rails by installing the track system at the RNT. The potential safety benefits of this method are that it could reduce rail buckling due to temperature-induced stresses, which could decrease the number of train derailments.

Rail Vehicle Bearing Defect Detection
Safety IDEA Project 16

Research Agency:	ENSCO, Inc.
Principal Investigator:	Dr. Yu-Jiang Zhang
IDEA Contract Amount:	$80,000 (Additional $14,000 in cost sharing)

The investigators in this project conducted field testing to investigate the feasibility of detecting defective rail vehicle bearings using rail-mounted accelerometers.

The objective of this project was to test the technology under normal operating conditions to determine if the bearing signal detected by the accelerometers on the rail has sufficient signal to noise ratio to allow for reliable detection of bearing defects.

The project investigators worked with Norfolk Southern (NS) to conduct the field test on a continuously-welded-rail (CWR) railroad track that allows the test vehicle to travel at speeds up to 50 mph.

The project included test planning and design, equipment preparation, field testing, data collection, data analysis, and documentation.

Non-Contact Driver Drowsiness Detection System
Safety IDEA Project 17

Research Agency:	Case Western Reserve University
Principal Investigator:	Dr. Xiong (Bill) Yu
IDEA Contract Amount:	$100,000 (Additional $20,600 in cost sharing)

The objective of this project is to develop and test the effectiveness of an innovative real time drowsiness detection sensor to minimize traffic crashes due to driver drowsiness. The sensor will non-invasively monitor the physiological signs of drivers and determine the onset and extent of drowsiness. The project investigators will further develop and refine the non-contact electrocardiography (ECG) and electroencephalography (EEG) sensing platform.

This project will evaluate the system performance by installation on a laboratory high fidelity driving simulator and on a commercial truck. It will also evaluate the effectiveness of different countermeasures. The investigators will work with a trucking company to test and evaluate this device on their long haul trucks in field testing as part of this project.

DRIVE-SMART Driver Monitoring and Crash Risk Mitigation System
Safety IDEA Project 18

Research Agency:	Virginia Tech Transportation Institute (VTTI)
Principal Investigator:	Dr. Thomas Dingus
IDEA Contract Amount:	$98,000 (Additional $30,000 in cost sharing)

The purpose of this project is to develop a driver monitoring and crash risk mitigation system. This will include development of the electronic hardware and software components, integration, and testing.

The system will use two small cameras, machine vision technology, on-board sensors, and data from the vehicle network to monitor driver distraction, drowsiness, speeding/aggressive behavior, alcohol impairment, and non-seat belt use. These are five major factors that can contribute to crash and injury risk. With the exception of seat belt use, redundant measures will be used to reliably calculate individual and combined risk levels for presentation of a real-time warning of elevated risk to the driver, and/or delayed notification to authority figures.

The relatively inexpensive system will be wholly enclosed within a small and unobtrusive housing mounted to the windshield or dash to provide camera views of the driver's face and the forward roadway. Integrated, high-speed electronic components such as digital signal processors (DSPs) will be used to ensure that warnings occur with sufficient speed to mitigate crash occurrence and/or severity while avoiding false alarms. A single connection will provide power and data access via the vehicle network's diagnostic connector.

Increasing Driver's Traffic Awareness around the Truck: Use of 3D Sounds
Safety IDEA Project 19

Research Agency:	Volvo Technology of America
Principal Investigator:	Dr. Dominic Paul Piamonte
IDEA Contract Amount:	$100,000 (Additional $50,000 in cost sharing)

The purpose of this project is to develop and test a system using 3D sounds as a technique for augmenting the truck driver's traffic awareness around the truck. This is intended to contribute to increased safety of road users near and around the truck.

Preliminary work showed the potential of spatial or 3D auditory icons for accurately informing and warning the truck driver of vulnerable road users (pedestrians, cyclists, small vehicle motorists, etc.) near and around the truck, with high acceptance and satisfaction of use among truck drivers.

Most modern large truck cabs have a lot of sound insulation, since too much noise inside a truck is known to affect the driver's concentration and stress level. However, sound insulation of the truck cab, along with the inherent limited view around parts of the truck from inside the truck cab, contribute to the reduction in the driver's traffic awareness around the truck. The system to be developed in this project is designed to improve the truck driver's traffic awareness around the truck.

THE NATIONAL ACADEMIES™

Advisers to the Nation on Science, Engineering, and Medicine

The nation turns to the National Academies—National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council—for independent, objective advice on issues that affect people's lives worldwide.

www.national-academies.org