Project Briefs for

SHRP 2 Safety Research

Overview

Tools for Data Analysis

Advancing the State of the Art

November 2013

SHRP2
STRATEGIC HIGHWAY RESEARCH PROGRAM

Frequently Asked Questions about the SHRP 2 Naturalistic Driving Study

What is SHRP 2?

In 2005, the United States Congress created the second Strategic Highway Research Program (SHRP 2) to address the challenges of moving people and goods efficiently and safely on the nation's highways. SHRP 2 is administered by the Transportation Research Board of The National Academies, under a Memorandum of Understanding with the Federal Highway Administration (U.S. Department of Transportation) and the American Association of State Highway and Transportation Officials.

SHRP 2 is a targeted, short-term research program carried out through competitively awarded contracts to qualified researchers in the academic, private, and public sectors. SHRP 2 addresses four strategic focus areas: the role of human behavior in highway safety; rapid renewal of aging highway infrastructure; congestion reduction through improved travel time reliability; and transportation planning that better integrates community, economic, and environmental considerations into new highway capacity. Additional information about SHRP 2 can be found on the program's Web site at www.trb.org/shrp2.

What is a "naturalistic" driving study?

A naturalistic driving study investigates ordinary driving under real-world conditions in order to make the driving experience safer. In the SHRP 2 study, 3000 volunteer drivers will agree to have their cars fitted with cameras, radar, and other sensors to capture data as they go about their usual driving tasks.

Experience with earlier naturalistic driving studies demonstrates that drivers quickly forget the presence of cameras and sensors, which are as inconspicuous as possible. This allows researchers to study driving behavior that is as close to "natural" as possible: thus a "naturalistic driving study." This kind of study is needed because driver behavior contributes to more than 90 % of crashes and is the primary factor in more than 60 % of crashes.

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

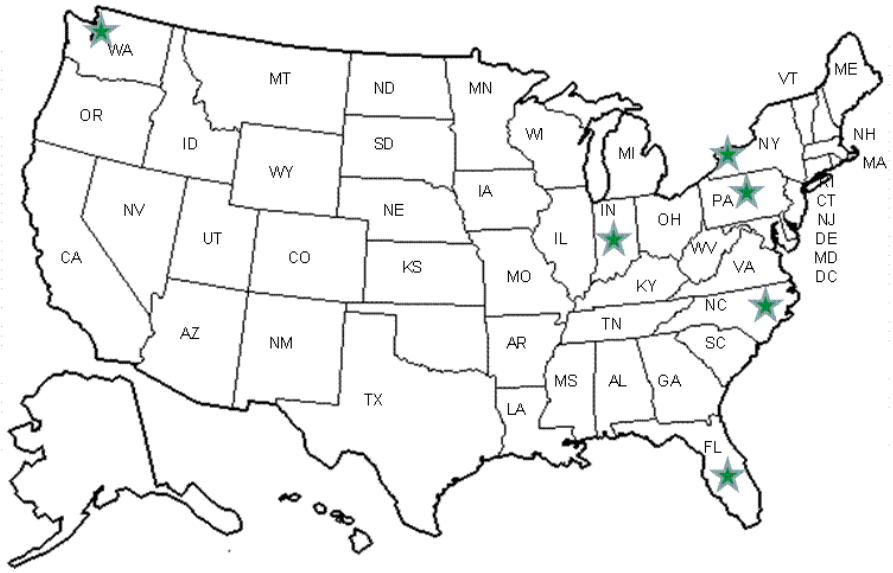
Who will be included in the study?

The drivers in the study will be men and women in various age groups, from different socioeconomic strata, and from different geographic areas across the United States, driving different types of light vehicles. Volunteer drivers will be recruited in a variety of ways, including through a national call center and local outreach efforts to attract drivers in each category.

Volunteers will be assessed for their visual perception, driving knowledge, reaction time, lower limb strength, and other factors so that these factors can be studied in relation to actual driving behavior under normal driving conditions.

Where will data be collected?

Six sites have been selected through a process that required contractors to present their qualifications and demonstrate the suitability of the site they wished to manage. The sites that were ultimately chosen from the 19 contractors who responded to the requests for qualifications are in Tampa, Florida; central Indiana; Durham, North Carolina; Erie County, New York; central Pennsylvania, and Seattle, Washington.



What types of data will be collected?

Video images of the view out the front and rear windshields, the passenger side view, the driver's face and hands, and the cabin will be recorded. Additionally, rates of acceleration, lateral and vertical motion, the presence of alcohol within the cabin, position information, turn signal actuation and other variables such as steering wheel angle, speed, seat belt use and air bag deployment will be recorded through various sensors. Radar will be used to identify objects in the front of the cars, their range, and the rates at which the range changes. An incident push button will allow participants to report critical events and emergencies. Separately, data will

also be collected on roadway elements such as road type, geometry, shoulders, safety furniture, signage, pavement markings, and more for the roads most frequently used by the volunteer drivers. Detailed investigations of selected crashes will also be conducted.

Are there privacy protections?

All the data recorded in the study participants' cars are encrypted as they are stored on a hard drive in the vehicle. No one can access the drive until it is uploaded to an isolated and secure server. Only authorized users of the data will be permitted access and different levels of authorization are required for access to various types of data. The policies and procedures for secure data storage and access are being developed and will be overseen by one or more ethics review boards established to protect research volunteers.

How will the data be used?

The primary objective of the study is to produce a rich cache of data on driving behavior that researchers for decades to come can use as the basis for safety improvements. Nearly 500 research questions have been gathered from safety researchers and practitioners. Currently the questions are being prioritized according to their potential for improving safety and additional studies are under way to develop the best methods for analyzing the data. There will be some focus on crashes at intersections and those that involve road departure, because these crash types account for more than half of highway fatalities.

In addition to these safety questions and many more that will be raised in the future, there may be still broader applications for the data, in areas such as highway operations and planning, environmental impact of vehicles, and psychological study of drivers. The SHRP 2 study is not specifically designed for these uses, but the database may well be able to support more than highway safety research.

When will the study begin?

In May of 2010 we expect that contractors will begin to instrument vehicles, assess drivers, and start the 2-year data collection process. Several steps must be accomplished before that, such as acquiring the data collection equipment and recruiting volunteers and the target start time must accommodate these prerequisites.

Why is this worth doing?

Every 1 % improvement in highway safety through implementing SHRP 2 research (a very modest expectation) would save more than 400 lives, avoid more than 25,000 injuries, and save $2.3 billion in costs associated with injuries and deaths annually in the United States.

Where can I find more detailed information?

The complete research plan and project schedule are available on the SHRP 2 web site, as are presentations, project descriptions, and contact information for all SHRP 2 staff. As details of the study are refined, further information including how to reach people designated as contacts for the study will be announced on the website and through other channels, including the TRB e-newsletter.

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

Details and news are on the website:
www.TRB.org/SHRP2

A Foundation for Safer Driving

A Safety Brief summarizing research preliminary to the SHRP 2 Naturalistic Driving Study

APRIL 2011

Volunteer drivers in six US states are pioneering new territory for all of us as they participate in the largest study of driving behavior ever conducted. We know that driving behavior is the primary cause of most crashes. Now for the first time, technologies can be combined to gather objective, scientific information about what happens when people crash, when they experience a near-crash, and when they drive without incident. What scientists and engineers learn from the volunteers and the sensors in their cars will be the basis for significant improvements in highway safety because, finally, we will have real-world data about crashes and contributing conditions. In fact, by instrumenting more than 3000 cars over two years, we will have roughly a petabyte of data (that's the capacity of a million 1-gigabyte flash drives).

Conducted through the second Strategic Highway Research Program (SHRP 2), which is administered by the Transportation Research Board of the National Academies in conjunction with the Federal Highway Administration and the American Association of State Highway and Transportation Officials, the SHRP 2 naturalistic driving study supports the program goals of advancing solutions for highway safety, renewal, and congestion.

Carrying out this driving behavior research involves layers of complexity understood by a relatively small international community of safety data experts. But the research plan is driven by a few straightforward questions. This brief report describes how the questions are being addressed in the SHRP 2 safety research projects that set the foundation for safer roads ahead. Details about each project are available on the Safety page of the SHRP 2 website and project numbers are provided here for reference to the project database. The web address is www.TRB.org/SHRP2/Safety.

How can we significantly improve safety?

Driver behavior has been identified as the major factor in about 90% of roadway crashes. Researchers believe that if we could understand how drivers interact with and adapt to their vehicles, the traffic environment, the roadway characteristics, the traffic control devices, and the environmental conditions that together create the driving experience, then we could identify how to reduce the risk of a crash. The transportation safety and data experts who helped to craft the SHRP 2 Safety program agree that significant improvement in road safety can only be achieved by addressing driver behavior; they also know that the driver remains the most difficult part of the system to study. The only way to obtain objective data about the driving experience is to collect it in real time with equipment that the driver can quickly accept. Such naturalistic driving studies (NDS) have been conducted before on a small scale and they provide a starting point for this much larger effort. (*TRB Special Report 260: Strategic Highway Research, Saving Lives, Reducing Congestion, Improving Quality of Life,* chapter 5, documents the early development of the research plan.)

SHRP 2
STRATEGIC HIGHWAY RESEARCH PROGRAM
Accelerating solutions for highway safety, renewal, reliability, and capacity

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

What questions should we investigate and which are most important?

Safety practitioners and researchers were consulted to determine which questions need to be answered so that effective safety strategies can be developed; more than 400 questions were put forward. With further input from participants at the annual SHRP 2 Safety Symposia, the questions were distilled into four broad categories, including: road-departure, intersection, driving performance, and driver interaction with advanced vehicle technology. Overall, the intent is to determine what risks are inherent in the relationship of a driver's performance to the roadway design and to traffic conditions.

The project to develop a study design for the SHRP 2 NDS also produced a process and criteria for selecting sites where data would be collected and a design for the sample of participants and vehicles that would provide the necessary range of data, including, for example, age, gender, and demographics *(Project S05)*.

The list of research questions is expected to expand as the full impact of the data collected and analyzed is understood.

What data do we need to answer the questions?

To answer questions about what influences the risk of being in a collision, data are needed about drivers, vehicles, and roads. We need to see what drivers see and where they are looking. We need data on speed, distance from the car ahead, acceleration, braking, seat belt use, geographic location, and vehicle characteristics and performance. Data on road type, geometry, shoulders, safety furniture, signage, and pavement markings are needed. Additionally, environmental variables such as traffic, lighting, and weather conditions will be collected to the extent possible. Six study sites were selected to provide a range of demographics, geography, weather, state laws, road types, and road usage.

Research Question Categories

Road departure • General intersection, including straight, and left- and right-turn crossing paths • Rear-end crashes, both striking and struck • Pedestrian/animal/pedalcyclist/object • Head-on • Lane-change/merge • Backing • New and near-future vehicle • General driver behavior • General multi-factor/multivariate

Subcategories

Questions related to: Traffic, roadway, and environment • Vehicles • Driver or driver error • Multifactor or multivariates • Passengers • Infotainment systems and Nomad devices • Aggressive driving • Vision, attention, and distraction • Speed and speeding • Crash countermeasures • Passing maneuvers

How do we collect the data?

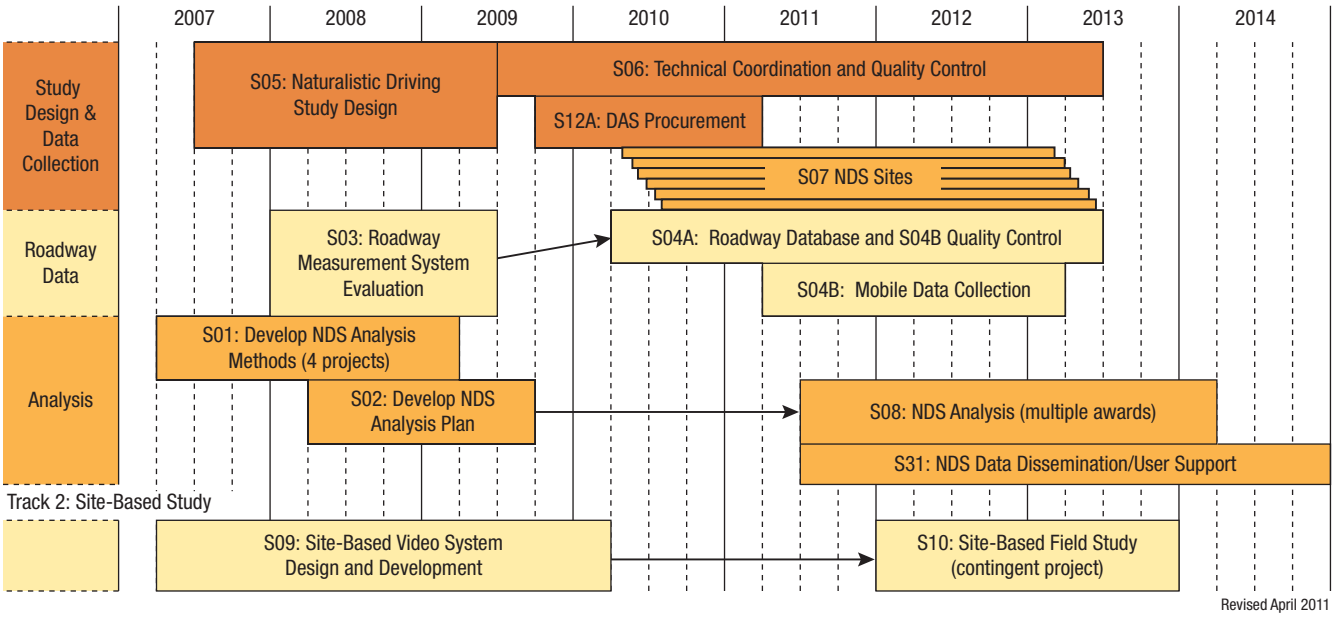
Driving and Vehicle Data

Volunteers, of course, are central to the conduct of the study. Sampling statisticians were consulted to help plan the process of recruiting participants. A subsequent pilot test determined that a combination of recruiting methods would be needed to achieve the full complement of more than 3000 drivers. A centralized call center and centralized data base are used for consistency across the six study sites.

Each volunteer in the study takes a series of assessments of driving-related skills and attributes, such as visual perception, visual-cognitive ability, psychomotor ability, physical ability, health and medication status, psychological factors, driving knowledge, and driver history. These assessments were developed with input and oversight from a panel of highly regarded experts. All protections required for the rights and safety of participants in human subject research are in place, and each step of the study design has been approved by the institutional review boards of the National Academy of Sciences and other contracting agencies.

An on-board data acquisition system (DAS) has been designed and manufactured and technicians have received training in how to install the automotive-grade equipment in the volunteer's vehicle in such a way that it can be removed at the end of the study without damage to the vehicle. The DAS will continuously record driver behavior and vehicle kinematics. It includes four video cameras, velocity and acceleration sensors, a global positioning system, forward radar, an incident button, a light sensor, and a passive alcohol sensor. Machine vision tools to track lane fidelity and an eyes-forward monitor are included. The data collected are encrypted and stored in an onboard computer for up to six months before being downloaded to a central data repository. Crash investigations will be conducted after certain crashes (for example, those in which air bags deployed) to gather more detailed data *(Projects S05, S06, and S07)*.

SHRP 2 Safety Research Program



As of spring 2011, the nationwide driving study is operational at all six sites, including (from west to east) Seattle, Washington; Central Indiana; Erie County, New York; Central Pennsylvania; Tampa, Florida; and Durham, North Carolina. Contractors selected to establish and operate the field data collection sites are responsible for equipment installation and driver assessments, collecting and transmitting data, addressing problems, investigating crashes, and for periodic reports documenting the field study activities. Another team provides technical oversight, coordination and quality control, including training, communications, logistics, and data management. The combined goal is to collect about 3,900 vehicle-years of data in a 28-month period *(Projects S06 and S07A-F)*.

Roadway Data

Determining the relationship of roadway characteristics to crash risk and driver behavior requires detailed data about road grade, curvature, cross slope, posted speed limits, and other characteristics. These types of data are being collected, with an emphasis on the roadways likely to be traveled by drivers participating in the study. Roadway inventory data may also be supplied by state, county, and municipal transportation organizations. A database will be developed and linked to the driving behavior database by a research contractor who will identify the data and analysis requirements of those who will eventually be using the data to improve safety *(Projects S04A and B)*.

What's the best way to analyze the data?

To begin to answer this question, four research teams independently identified and developed different ways to analyze this type of data and applied their analysis methods to data collected during smaller field studies of crashes involving cars running off the road (road departures) and intersection safety issues *(Project S01)*. A different research team in a later project reviewed the results and integrated various components of the plans. They developed a list of essential elements and sample work plans to illustrate the type of information that is relevant to analyzing data

Site-Based Data

A second track of data collection focuses not on individual drivers but on all traffic that passes through specific road segments. A video system is being deployed to record the movements of all vehicles at a site, such as an intersection. Cameras placed above the selected site will record details about the motion and relative positions of the traffic, while the steering, braking, and throttle control reflect the driving behavior through the segment. Eventual application of this technology will support more direct and systematic comparison of roadway design and driving behavior *(Project S09)*.

related to a research question and the methodological issues specific to that question. These plans illustrate some of the fundamental challenges that researchers must address in using naturalistic driving study data to answer driving safety research questions *(Project S02)*.

> ***Every 1 percent reduction in crashes will prevent 330 deaths and about $2 billion annually in medical expenses and other losses from these crashes. Crashes are also a leading cause of traffic congestion, which increases delay, fuel consumption, and emissions.***

As data become available from the six sites, researchers will begin to use the data and analytical methods to address some of the high-priority questions identified earlier in the program. The first analysis projects will begin in mid-2011. Early results from these activities will help refine data access and analysis methods in addition to providing the way toward improved safety countermeasures *(Project S08)*.

What Happens Next?

As volunteer recruitment and data collection continue, questions of how to house and maintain the enormous NDS database will continue to be addressed. Allowing qualified researchers to access and use the data is crucial to developing the knowledge from which a new generation of safety improvements can develop. Yet the access must be balanced with rigorous restrictions necessary to protect the confidentiality and safeguards promised to participating drivers. Establishing protocols and crafting the kinds of living documents needed for the coming years will be a focus of efforts as the study gains momentum.

A website for the Naturalistic Driving Study hosted by the research team is at http://www.shrp2nds.us/

Details on the entire SHRP 2 Safety research program are on the SHRP 2 website at www.TRB.org/SHRP2/safety

A SHRP 2 Safety Project Brief

Analyzing Driver Behavior Using Data from the SHRP 2 Naturalistic Driving Study

MAY 2013

Studies have long shown that the most significant factor in crashes is the driver. To date, however, the driver and the driver's interaction with the road, vehicle, and environment have been difficult to study in an objective way. A new method—naturalistic driving studies (NDS)—provides objective data, which transportation agencies can use to derive improved countermeasures and more effective uses of existing countermeasures to reduce crashes and improve roadway safety.

The second Strategic Highway Research Program (SHRP 2) is conducting the largest and most comprehensive NDS ever undertaken. The study has recruited more than 3,100 volunteer drivers, ages 16–80, at sites in six states: Florida, Indiana, North Carolina, New York, Pennsylvania, and Washington. All their trips are recorded for up to two years. Data include vehicle speed, acceleration, and braking; vehicle controls; lane position; forward radar; and video views to the front and rear of the vehicle and on the driver's face and hands. When complete in early 2014, the NDS data set will contain in excess of 33,000,000 travel miles from some 3,800 vehicle-years of driving—more than 4 petabytes of data.

In parallel, the Roadway Information Database (RID) will contain detailed roadway data on about 12,000 centerline miles of highways in and around the study sites, in addition to information on roadway features, crash histories, traffic and weather conditions, work zones, and active safety campaigns in the study areas from state data sources. The NDS and RID data can be linked to associate driving behavior with the roadway environment.

This project brief describes how NDS data can be searched. It also provides an overview of three SHRP 2 projects that are analyzing NDS and RID data to develop real-world safety countermeasures.

Trip Files

NDS data are stored in trip files, one for each of the study's 5 million trips. These files record each variable every time it is sampled: every 1/10 second for most variables, every 1/15 for video, every second for GPS, and so forth—a time history record of each trip from the time the vehicle starts until it is turned off. For example, a 10-minute trip would have on the order of 10 min × 60 sec/min × 10 samples/sec, or 6,000 records, with each record having about 100 different measures or data points. These trip files are very large and it would be time-consuming and expensive to search all the files to identify trips with specific characteristics.

To accelerate data searches and provide summary information, SHRP 2 developed a trip summary file. This file makes trips easier to find by capturing summary information in a

SHRP 2
STRATEGIC HIGHWAY RESEARCH PROGRAM
Accelerating solutions for highway safety, renewal, reliability, and capacity

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Source: wikihow.com

single record for each trip. Some variables don't change during a trip, such as driver age and gender, vehicle type, and other descriptive information. Other variables can be replaced by summary measures computed over the whole trip, such as average speed, total distance traveled, time or distance traveled with speeds over 70 mph, or number of accelerations over some threshold. The file will include flags to indicate the presence of a crash or near-crash on the trip. The trip summary is a single file with one record per trip—5 million records for the whole dataset. This file can be searched relatively quickly to find trips with specified characteristics. The trip summary file will not contain personally identifying data, lends itself to a user-friendly web interface, and can be downloaded into common packages, such as Access. The file will include a trip ID so that full trip files can be located easily for further analysis.

Crash, Near-Crash, and Baseline Files

The NDS will include more than 700 crashes of various severities, ranging from those that produced major injuries or death to those when a vehicle struck a curb and continued driving. It will include about 7,000 near-crashes—incidents in which a crash would have occurred if the driver had not braked or steered abruptly at the last moment. Many studies will analyze these crashes and near-crashes to investigate what caused the crashes, what might have prevented them, what led to a near-crash situation, and how drivers in near-crashes avoided a crash.

SHRP 2 is producing crash and near-crash data files to assist these studies. These files will contain a record for each crash or near-crash and will be available to qualified researchers. The record, called an epoch, contains all relevant data for about 20 seconds before and 10 seconds after the crash or near-crash. In addition, SHRP 2 is producing baseline files of event-free driving with which to compare the crashes and near-crashes. The baseline files will contain similar 30-second epochs either selected at random from all NDS trips or records matched to crashes and near-crashes. For example, for a specific crash, epochs could be selected from the same driver's trips at the same time of day and day of week on the same or similar roads.

Data Analysis

In February 2012, four analysis contracts were awarded under SHRP 2 project S08 to study specific research questions using the early NDS and RID data. In the proof-of-concept Phase 1 of these projects, each contractor obtained small initial data sets from the NDS and RID, tested and refined their research plan, and developed detailed plans for their full analyses. Three contractors were selected for Phase 2, in which they will obtain and analyze a much richer data set; these studies will conclude by July 2014. Summaries of these three contractors' Phase 1 results follow. The results from these studies should lead to real-world countermeasures. These projects also provide examples of the types of analyses that can be conducted with SHRP 2 NDS and RID data.

The full Phase 1 report for this project (*Initial Analyses from the SHRP 2 Naturalistic Driving Study: Addressing Driver Performance and Behavior in Traffic Safety*) is available at http://www.trb.org/Main/Blurbs/168727.aspx or by searching the report's title at www.TRB.org.

Lane Departures on Rural Two-Lane Curves

Center for Transportation Research and Education, Iowa State University; Public Policy Center, University of Iowa

Rural two-lane curves pose a significant safety problem, and the interaction between the driver and the roadway environment in rural curves is not well understood. To learn more, this research is assessing the relationships between driver behavior and the roadway and environmental factors on rural two-lane curves and how these relationships affect the likelihood of lane departures.

Most highway agencies have implemented a range of countermeasures to reduce lane departures on rural two-lane curves. However, agencies have only limited information about the effectiveness of these countermeasures and even less information about why they are or are not effective.

In Phase 1, SHRP 2 NDS and RID data were used to develop initial models that explore how drivers interact with the roadway environment and what conditions are present when a driver does not successfully negotiate a

curve compared to the when successful negotiation occurs. The full project will gain insight into where a driver's attention is focused during curve negotiation and what roadway cues—such as signs, chevrons, and pavement markings—are most effective in keeping drivers within their lane. The research has implications for roadway design, selecting and locating curve warning signs, and providing adequate sight distance.

The results of this research will help transportation agencies make better decisions about countermeasure selection. They will be useful to safety researchers; the American Association of State Highway and Transportation Officials (AASHTO); the Federal Highway Administration (FHWA); and state, county, and city transportation agencies.

Evaluation of Offset Left-Turn Lanes

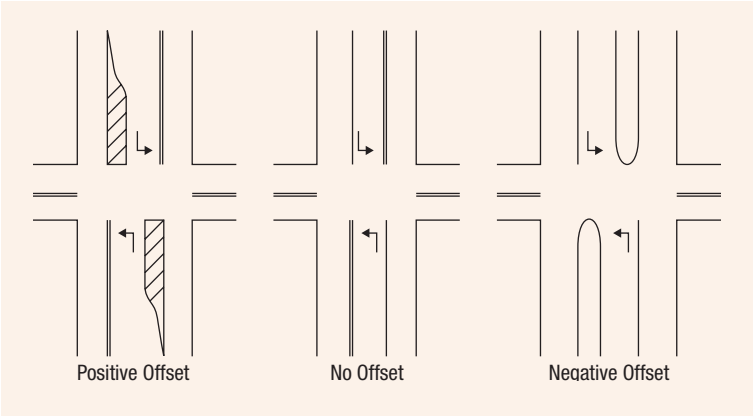
MRIGlobal

Left-turn lanes are used at intersections to provide a safe location for storing left-turning vehicles, out of through-traffic lanes, while their drivers wait for a suitable gap in opposing traffic to turn left. The provision of a left-turn lane minimizes the potential for rear-end collisions with through vehicles approaching from behind the left-turning vehicle and reduces the pressure on left-turning drivers to leave an exposed position and accept an inappropriate gap in opposing through traffic. However, vehicles in opposing left-turn lanes can block each other's view of oncoming traffic (see Figure 1, center diagram).

A geometric design solution for these sight obstructions is to offset the left-turn lanes (that is, to move the left-turn lane laterally within the median so that the opposing left-turn vehicles no longer block the sight lines of their drivers). The drawings in Figure 1 illustrate intersections with positive offset, zero offset, and negative offset for opposing left-turn lanes.

While the principle of offset left-turn lanes is accepted based on anecdotal evidence, there is no conclusive quantitative evidence of their effects on driver behavior or crash reduction or of how these effects vary with the width of the offset. This research project will determine if offset left-turn lanes affect gap acceptance behavior and improve safety for left-turning vehicles, as well as whether the presence of a vehicle in the opposing left-turn lane has an impact on the effect. Based on the small sample in Phase 1 that included just a few months of NDS trip data, it is estimated that the full Phase 2 study, which will include at least three times as many NDS driver trips, may yield on the order of 8,000 rejected gaps and 1,000 accepted gaps. With this dataset, the team will be able to determine if offset left-turn lanes affect driver gap acceptance behavior, as well as whether the presence of a vehicle in the opposing left-turn lane has an impact on the effect.

Figure 1. Illustration of positive, zero, and negative offset left-turn lanes (Persaud et al., 2009)



The results from this research could be used to establish a minimum desirable offset for opposing left-turn lanes and to determine how that information can best be presented as design guidance for application by intersection designers. This guidance could be included in the AASHTO *Green Book* and state highway agency design manuals. These applications could have a direct impact on fatal and injury crashes that involve left-turn maneuvers, as well as on many less severe crashes.

Safer Glances, Driver Inattention, and Crash Risk

SAFER Vehicle and Traffic Safety Centre at Chalmers

Driver inattention has been the focus of significant national attention recently—in legislation, regulation, design guidelines, and information campaigns (see www.distraction.gov). The vehicle and electronics industries are moving rapidly to enable the use of electronic devices in a safe manner and to develop and implement systems to monitor driver inattention. In the past few years, two main developments have increased the priority of driver inattention: (1) There is a growing concern over the driving-compatibility of the ever-increasing availability and use of electronic devices such as smart phones and intelligent vehicle systems; and (2) research has shown a much clearer association between driver inattention and crash risk.

Unfortunately, the specific mechanisms and indicators of the risk of inattention are not well quantified. The most sensitive measures of risk are those which most precisely quantify an off-road glance that overlaps a change in the state of the driving environment or an action that began the sequence leading to a crash or

near-crash, called the precipitating event (for example, a lead vehicle that begins braking). The longer the driver looks away from the road at this specific time, the greater the risk.

This research is developing a statistically validated set of inattention-risk functions (or relationships) describing how increased inattention in lead-vehicle pre-crash scenarios leads to increased risk. In particular, the relationships between inattention and risk can be used to show more precisely which glance behaviors are safer than others. For example, this research can be used to show how much the risk of a serious injury when tuning a radio or setting a vehicle control can be reduced by reducing the length of single glances, and it can relate this net benefit to the potential cost of increasing the number of glances needed to tune the radio. By studying these relationships, researchers can determine how this risk varies in different contexts (for example, stop-and-go versus free-flowing traffic), can determine the point in time where the eyes are needed most to control braking, and can be used to differentiate the type of glance behavior that leads to crashes from the type that leads to near crashes.

The results from this research can improve the scientific knowledge supporting driver distraction guidelines for in-vehicle electronic devices, which could have several applications. Results could be used to support evidence-based distraction policy and regulations, and to teach safe glance behaviors. The most dangerous glances could be pinpointed and associated with improvements to appropriate countermeasures, such as active safety system technology. This research also could lead to improved intelligent-vehicle safety systems, such as the forward collision warning systems. Making these systems inattention-adaptive could reduce nuisance warnings and deliver more precise warnings when the risk is greatest.

References

Persaud, B., C. Lyon, K. Eccles, N. Lefler, and F. Gross (2009). *Safety Evaluation of Offset Improvements for Left-Turn Lanes*, Report No. FHWA-HRT-09-035, Federal Highway Administration, Washington, D.C.

Naturalistic Driving Study website is at www.shrp2nds.us

Discussion Forum for the NDS is at http://forums.shrp2nds.us

SHRP 2
STRATEGIC HIGHWAY RESEARCH PROGRAM
Accelerating solutions for highway safety, renewal, reliability, and capacity

SAFETY PROJECT BRIEF

PROJECT BRIEF S05 OCTOBER 2010

Design of the In-Vehicle Driving Behavior and Crash Risk Study: The SHRP 2 Naturalistic Driving Study

The SHRP 2 Safety effort will, for the first time ever, allow us to record and study the driving behaviors of a large sample of drivers in their personal vehicles—a naturalistic study. . . . It will also produce an incredible database for even more advanced analyses for at least a decade after the current study ends.

Forrest Council
Senior Research Scientist, Highway Safety Research Center, University of North Carolina
Chair, SHRP 2 Safety Technical Coordinating Committee

This document is drawn from the final report prepared by researchers for project S05. The objective of this project was to design the in-vehicle driving behavior and crash risk study, also known as the SHRP 2 naturalistic driving study (NDS), which will collect real-world driving behavior for a two-year period beginning in 2010. Projects comprising the NDS include S06: Technical Coordination and Independent Quality Assurance for Field Study, S07: In-Vehicle Driving Behavior Field Study (six sites), S04A: Roadway Information Database Development and Technical Coordination and Quality Assurance of the Mobile Roadway Data Collection, and S04B: Mobile Roadway Data Collection. The final report includes a summary of the key areas of the planning study for the SHRP 2 NDS. The report will be available early 2011 in print and electronic format. The Responsible Staff Officer for this project is Dr. Kenneth Campbell, who can be contacted at kcampbell@nas.edu.

Fundamental safety research could lead to significant improvements in roadway safety. It is estimated that each 1% improvement in safety results in 340 saved lives, 30,000 fewer injuries, and $2.3B in annual cost savings(*1*).

The SHRP 2 NDS represents a large-scale effort to collect data to better understand how drivers interact with and adapt to an extensive array of factors (e.g., the vehicle, traffic environment, roadway characteristics, traffic control devices, and the natural environment), and assess the differences in collision risk associated with each of these factors and interactions. By understanding how risk factors influence safety on our roadways, innovative countermeasures can be employed to improve our ability to design and build safer roadways and vehicles, navigate difficult environmental conditions, and teach future generations how to engage in safer driving practices.

Study Design

The study design elements are defined from a variety of perspectives and are intended to facilitate researchers' ability to address as many of a comprehensive set of categorized research questions as feasible. The research questions were collected early in the process and synthesized into categories such as road departure, general intersection, head-on crashes, and general driver behavior. The report discusses each of the elements and the process for participant recruitment.

There are two broad aspects to the NDS design: (1) contractor-site selection and (2) participant-vehicle sample design. Contractors were selected at six sites: Erie Country, New York; Seattle, Washington; Central Pennsylvania; Central Indiana; Tampa Bay, Florida; and Durham, North Carolina. Volunteer drivers will be selected by age, gender, and vehicle type and will participate for either one or two years. Table 1 shows the participant categories by age and gender. Passenger cars and light trucks will be the focus of the study.

Data Collection

Several categories of data will be collected including driver assessments, time series data and video from the onboard data acquisition system (DAS), participant demographics, vehicle inventory, and crash investigations. Primary participants will be assessed on a variety of driving-related skills and attributes including: visual perception, visual-cognitive ability, cognitive ability, psychomotor ability, physical ability, health and medication status, psychological factors, driving-knowledge, and driver history. The DAS, which will continuously record driver behavior and vehicle kinematics, will include a wide variety of sensors such as: four video cameras, velocity and acceleration sensors, location from a global positioning system (GPS), forward radar, and a passive alcohol sensor. Machine vision tools will also be incorporated into the DAS, including a lane tracker and an eyes-forward monitor. Crash and crash site investigations will be conducted after certain crashes to gather more detailed data surrounding particular events of interest. Further details on the data being collected—including specific driver assessment tests, DAS details, and criteria and procedures for crash investigations—will be available in the final report.

Participant Protection and Data Management

Institutional review board (IRB) approval of human-subject research is a critical task that the project team undertook promptly after the project began. Of paramount concern in this effort was the need for this task to maintain close coordination

Table 1: Participant Gender and Age

Gender and Age Range	Age Range Description	One-Year Participants	Two-Year Participants	DAS units	Primary Participants	Data Years
M 16-17	Minor Teen	72	28	100	172	200
M 18-20	Adult Teen	72	28	100	172	200
M 21-25	Young Adult	72	28	100	172	200
M 26-35	Adult	72	28	100	172	200
M 36-50	Middle Adult	72	28	100	172	200
M 51-65	Mature Adult	72	28	100	172	200
M 66-75	Younger Older Driver	72	28	100	172	200
M 76+	Older Older Driver	72	28	100	172	200
F 16-17	Minor Teen	72	28	100	172	200
F 18-20	Adult Teen	72	28	100	172	200
F 21-25	Young Adult	72	28	100	172	200
F 26-35	Adult	72	28	100	172	200
F 36-50	Middle Adult	72	28	100	172	200
F 51-65	Mature Adult	72	28	100	172	200
F 66-75	Younger Older Driver	72	28	100	172	200
F 76+	Older Older Driver	72	28	100	172	200
Any	Advanced Vehicle Technology	0	350	350	350	700
	Totals:	**1,152**	**798**	**1,950**	**3,102**	**3,900**

with nearly all other project tasks. Key issues include protection of participant confidentiality, protection of passengers who did not consent, protection of GPS location data, and continued protection of participant confidentiality once the data are stored in a database for post hoc analysis. Details of the IRB process and methods to ensure confidentiality are in the final report. The report also describes: how data will be transferred from vehicles to servers, including data encryption methods, data upload, processing, and backups; the data magnitude, which is expected to total approximately 1 petabyte; and methods for ensuring quality control, such as remote data health checks and contractor inspections.

Data Access

Data access policies address several concerns. The primary objective is to make the data as widely available as possible while maintaining the privacy assurances guaranteed in the consent form. The researchers plan to provide scalable user access control to the combined data sets. They expect that most external access to the data will be through a website or web service, but provisions will be in place to provide qualified users secure access to sensitive data. Data from the NDS will also be integrated with data from the roadway information database that will be developed in project S04A. Details regarding data access are in the final report.

This research was produced by the Virginia Tech Transportation Institute (VTTI) with the support of the University of Michigan Transportation Research Institute and the Battelle Memorial Institute. The Principal Investigator was Dr. Thomas Dingus of VTTI. The other authors of the report are Jon Antin, Suzanne Lee, and Jonathan Hankey of VTTI.

Reference

1. *Special Report 260: Strategic Highway Research, Saving Lives, Reducing Congestion, Improving Quality of Life.* TRB, National Research Council, Washington, D.C., 20001. http://onlinepubs.trb.org/Onlinepubs/sr/sr260.pdf

www.TRB.org/SHRP2/Safety

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