Strategic Highway Research Program (SHRP) 2

Revised Safety Research Plan:
Making a Significant Improvement in Highway Safety

April 2010

The central goal of the SHRP 2 Safety Research Plan is to address the role of driver performance and behavior in traffic safety. This includes developing an understanding of how the driver interacts with and adapts to the vehicle, traffic environment, roadway characteristics, traffic control devices and the environment. It also includes assessing the changes in collision risk associated with each of these factors and interactions. This information will support the development of new and improved countermeasures with greater effectiveness.

Statement of the Problem

Highway safety improvements are not keeping up with increasing travel. Even the steady declines in the rate of collisions per vehicle-mile-traveled have diminished in the past decade. While travel continues to increase, the expansion of highway miles and lanes has slowed so that traffic volume and congestion are increasing. The demographics of the driver population are shifting, with a substantial increase in the percentage of older drivers from about 15 percent in 2010 to about 25 percent in 2030. Significant safety improvements are needed to advance safety under these changing conditions.

Future traffic safety challenges include:

- Travel growth will continue
- Changes in vehicle size and design (SUV)
- Population demographic changes (older drivers)
- New vehicle technologies (ABS, ACC)
- Changing driver behavior (aggressive driving)
- Increasing driver distraction (more vehicle-based devices)
- Increasing truck travel
- High-speed congestion

The changing traffic environment both complicates and heightens the need for fundamental traffic safety research. Each 1% improvement in safety results in 400 lives, 30,000 injuries and $2.3B annual savings. Moreover, collisions are a leading cause of nonrecurring congestion. Collision prevention has added benefits in terms of reduced delay, fuel consumption, and emissions.

Fundamental research could lead to sizeable reductions in deaths and injuries, despite the anticipated growth in travel. Such research produces an improved understanding of the factors responsible for collisions and casualties, and this information fuels the development of new or improved countermeasures. In the early days of injury prevention research, for example, expert investigators looked only at injury-producing collisions and inferred the risk factors responsible. A significant milestone occurred when the National Highway Traffic Safety Administration (NHTSA) began taking systematic samples of injury and *non-injury* collisions, providing an objective estimate of injury risk, or the probability of injury in a collision. This change allowed objective analytic methods for risk analysis that

had been used effectively in medical and other applications to be applied to traffic injury prevention. This advancement was an essential step in the development of the sophisticated occupant protection systems in today's cars.

Collision prevention is at a similar crossroad. The interrelationship of driver performance and behavior with roadway design and traffic conditions to affect the risk of collisions and casualties is largely an unknown area, despite the fact that driver behavior is widely believed to be responsible for most collisions. Accurate information on the contribution of human, vehicle, roadway and environmental factors to the risk of collisions will support improvements in existing countermeasures and the development of future countermeasures. Advanced technologies, as envisioned for intelligent transportation systems, also enable new research methods that can provide objective, exposure-based risk estimates and detailed information on driving performance–and driving errors–that could not be measured before. Future countermeasure development will require a more rigorous and detailed understanding of the relationship of multiple factors responsible for collisions and casualties.

Research Questions

The SHRP 2 safety program is intended to support a comprehensive assessment of how driver behavior and performance interact with roadway, environmental, vehicular, and human factors and the influence of these factors and their interactions on collision risk, especially lane departure and intersection collisions. Two central issues for the planned analysis are the statistical relationship of surrogate measures of collisions (conflicts, critical incidents near-collisions, or roadside encroachment) with actual collisions, and the formulation of exposure-based risk measures using these surrogate measures.

If risk is based only on actual collisions, large amounts of exposure must be combined across many drivers to get a risk estimate. The use of surrogates for collisions, such as near-collisions, critical incidents, or traffic conflicts, would greatly increase the power of the field studies since the surrogates occur much more frequently than crashes, and without harm. The concept of traffic conflicts was first introduced by Harris and Perkins at General Motors in 1968. The use of surrogates continues to develop and is currently being evaluated for traffic simulation models at FHWA (Gettman, 2003). The new data collection technologies will support continuous measurement of crash margin measures such as the time-to-lane departure, or the time-to-collision. These are examples of measures that can be used to form surrogate risk estimates for specific traffic maneuvers. The sample research questions that follow build on these two central issues.

Basic questions will address how driver behavior is affected by driver, vehicle, roadway and environmental factors and how changes in driver behaviors are related to crash risk under various vehicle, roadway and environmental conditions. While the study can involve many crash types and situations, attention will be given to crashes involving lane departures and crashes at intersections. Candidate factors include, but are not limited to:

- Driver factors: age and gender, speed, driver errors, inattention, distraction, fatigue, impairment, and perhaps driving characteristics such as aggressive or nonaggressive driving styles that might be characterized from measured driving performance such as speed on curves, deceleration levels on intersection approach, or gap acceptance.
- Roadway factors: edge-marking, rumble strips, lane width, shoulder type and width, curvature, grade, signing and sight distance.
- Intersection factors: signal versus signed, intersection configuration, signal timing, traffic volumes, and sight distance.
- Environmental factors: light condition, weather, and pavement quality condition.

- Vehicle factors: vehicle type (e.g., car, SUV, van), braking characteristics, handling characteristics, available crash prevention technologies (e.g., cruise control, stability control), and visibility characteristics (e.g., blind zones, headlamp performance).

Specific research questions would address the possible relationship of the factors listed above, either independently or in combination, with exposure-based risk measures for road departure or intersection safety.

SHRP 2 Safety Projects

The SHRP 2 safety research plan includes two tracks: a large field study of driving behavior and performance using a comprehensive, state-of-the-art instrumentation package installed in the vehicles of volunteer participants; and a video system to record the movements of all vehicles at specific road sites such as an intersection. The SHRP 2 field studies are intended to support a comprehensive safety assessment of how driver behavior and performance interact with roadway, environmental, and vehicular factors and the influence of these factors and their interactions on collision risk, especially the risk of lane departure and intersection collisions. The accompanying chart lays out the main projects. The chart provides a general idea of the flow of work. The exact number, content, and timing of contracts are subject to change.

The in-vehicle driving behavior and crash risk study is shown across the top of the chart, beginning with a Study Design (S05) that leads to project, S07, to recruit volunteer drivers, install the instrumentation, and collect data in multiple sites starting in 2010. Project S05, the Study Design, includes the development of a complete data collection system, a field trial of the system, and the management plan for the full in-vehicle study. The S07 site data collection projects will be managed by an overall quality assurance and technical coordination contractor (Project S06). A separate project, S12A, has been established to select the manufacturer of the Data Acquisition System.

The Study Design is supported by Project S01 to identify analytic methods to address the research questions and Project S03 to evaluate mobile measurement systems collecting detailed and accurate roadway information in the study areas. Project S02 will integrate the findings of the S01 projects to produce an analysis plan for the full in-vehicle driver study.

Another critical need for the in-vehicle study of driving behavior is detailed roadway data with greater coverage of the roads used by the volunteer drivers. These data will support the association of driver behavior with roadway characteristics such as grade, curvature and posted speed limits. The Study Design is supported by separate projects to collect and integrate the roadway data (S03 and S04). The objective of Project S03 is to evaluate the accuracy of mobile roadway measurement systems operated at highway speeds and to qualify measurement systems for Project S04B. Project S04A will provide and manage road information to be utilized in safety analysis. Roadway data will be collected in the study areas under a separate project, S04B. It is envisioned that the desired GIS roadway database will be a combination of data merged from existing systems and data collected with state-of-the-art measurement systems for selected roads in the study areas.

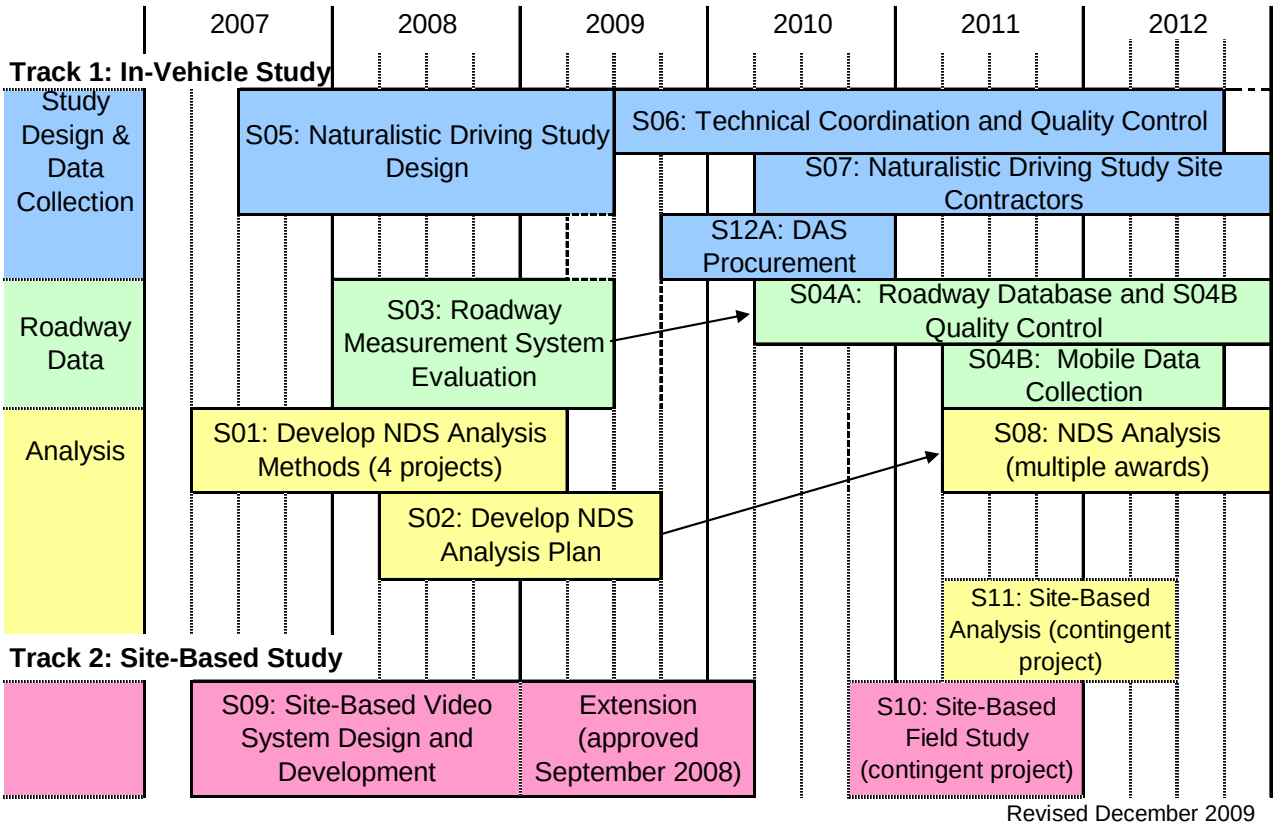

Figure 1: SHRP 2 Safety Projects Timeline

The large field studies envisioned in SHRP 2 will produce very large datasets. While data collection technology has made rapid advances in the past few years, analytic methods have not kept pace. The field data collection projects are also supported by a series of projects to develop analytic methods. The analysis work begins with multiple projects under S01 to develop analytic approaches and demonstrate them with existing data. Key aspects of the analyses include the application of crash surrogate approaches (traffic conflicts, critical incidents, near-collisions, and other surrogate measures), development of exposure-based collision risk measures, and the formulation of analytic methods to quantify the relationship of human factors, driver behavior, vehicle, roadway and environmental factors to collision risk. The results of the S01 projects are integrated in Project S02 to develop an analysis plan for the field study data collected in S07 and S04. Multiple analysis projects (S08) are planned to address a wide range of research questions using the data collected.

The instrumented vehicle approach in the first track uses video to record the driver's face, forward view, and instrument panel. This type of video data is the best source of information on driver factors such as inattention, distraction, and fatigue. However, the use of volunteer drivers effectively limits the roadway and environmental factors to those associated with the driver's choice, rather than a researcher-chosen array of factors. The use of in-vehicle instrumentation prevents the researcher from comparing the experience of many vehicles operating on the same road segment because only the study vehicles have the instrumentation package. Consequently, the information on surrounding traffic is also limited.

The site-based risk study complements the in-vehicle study by looking at all of the traffic passing through a given road segment. This approach lends itself to a more direct and systematic comparison of roadway

design and operational variables. The site-based data collection approach uses multiple video cameras that can be placed overhead at selected sites to record detailed information on the motion and relative position of traffic moving through the selected road segment or intersection. Multiple cameras can be linked to cover an entire intersection or longer road segment. At this time, only the first project of this track, Project S09, Site-Based Video System Design and Development, is programmed. The purpose of this initial project is to improve the capabilities of existing systems. The Safety Research Plan continues this track with site-based field data collection under Project S10. The field study (S10) is intended to support a comprehensive assessment of the individual and interactive collision risk of all vehicles within the field of the video cameras. Driver behavior is reflected in the steering, braking, and throttle control that produce the path of the vehicle. The analysis of the field data is carried out in Project S11. Execution of this track beyond Project S09 will depend on available funding and on the outcome of Project S09 to improve the capabilities of existing site-based video systems.

The safety projects and current budget allocation are listed in Table 1. Project start dates and contractors are shown for work already under way and estimated RFP dates are shown for future projects. The SHRP 2 safety work is at the half-way point. Contracts have been awarded, as shown in Table 1, for Projects S01, S02, S03, S05, and S09. Final reports are either under review or awaiting publication, except for Project S09 which is due in early 2010.

SHRP 2 is about to embark on a major field data collection effort, which encompasses Projects S04A, S04B, S06, S07 and S12A. The SHRP 2 Naturalistic Driving Study will involve installation of a Data Acquisition system (DAS) in the vehicles of approximately 3,000 volunteer drivers over a 2-year period (2010-2012). The DAS includes: forward radar; 4 video cameras, including one forward-facing, color, wide-angle view; accelerometers, some vehicle network information; GPS; on-board computer vision lane tracking, as well as other computer vision algorithms; and data storage capability. Data from the DAS will be recorded continuously while the participant's vehicle is operating; this continuous recording allows for an exposure-based approach and is central to the SHRP 2 Safety Research Program. The Naturalistic Driving Study will be carried out in the six sites listed below and shown in Figure 2. Each site will host 150-450 participant vehicles.

- Seattle, Washington
- Erie County, New York
- Tampa Bay, Florida
- Central Indiana
- Central Pennsylvania
- Durham, North Carolina

Contractors have been selected for the six S07 project sites and for the S04A Roadway Database project and the contracting process are underway. The Study Design contractor, Virginia Tech Transportation Institute (VTTI), has been awarded Project S06 for Technical Coordination and Quality Control. The RFP to manufacturer the Data Acquisition System was released in October 2009 and awards are anticipated to 3 manufacturers to produce prototype units for evaluation. The RFP for the Mobile Roadway Data Collection Project, S04B, will be released later in 2010.

Table 1
SHRP 2 Safety Projects

Project Number	Project Title	Budget	Start
S01	Development of Analysis Methods using Recent Data; 4 contracts: A) University of Minnesota Center for Transportation Studies B) Pennsylvania Transportation Institute C) University of Michigan Transportation Research Institute (UMTRI) with Virginia Tech Transportation Institute (VTTI) E) Iowa State University CTRE with the University of Iowa	$1,500,000	March 2007
S02	Integration of Analysis Methods and Development of Analysis Plan; University of Iowa with Iowa State University CTRE, University of Minnesota, and Montana State University	$500,000	April 2008
S03	Roadway Measurement System Evaluation; Applied Research Associates (ARA) with Cambridge Systematics and KCI	$500,000	January 2008
S04	A) Roadway Information Database Developer and Mobile Data Collection (Project S04B) Technical Coordination and Quality Assurance B)Mobile Data Collection	$1,000,000 $3,500,000	April 2010 S04B RFP Aug. 2010
S05	Design of the In-Vehicle Driving Behavior and Crash Risk Study; Virginia Tech Transportation Institute (VTTI) with The University of Michigan Transportation Research Institute (UMTRI) and Battelle	$3,000,000	June 2007
S06	Technical Coordination and Independent Quality Assurance for Field Study; Virginia Tech Transportation Institute, VTTI	$6,200,000	June 2009
S07	In-Vehicle Driving Behavior Field Study (six site selected)	$16,500,000	May 2010
S08	Analysis of Driving Behavior Field Study Data and Countermeasure Implications (multiple awards)	$5,000,000	RFP late 2010
S09	Site-Based Video System Design and Development; University of Michigan Transportation Research Institute (UMTRI) with Virginia Tech Transportation Institute (VTTI), Soar Technology and University of California, Berkeley (PATH)	$1,000,000	March 2007
S10	Design and Conduct the Site-Based Field Study	--	--
S11	Analysis of Site-Based Field Study Data and Countermeasure Implications	--	--
S12A	Data Acquisition System (DAS): Equipment and Vendor Services	$10,000,000	Oct. 2009
	TOTAL	$48,700,000	

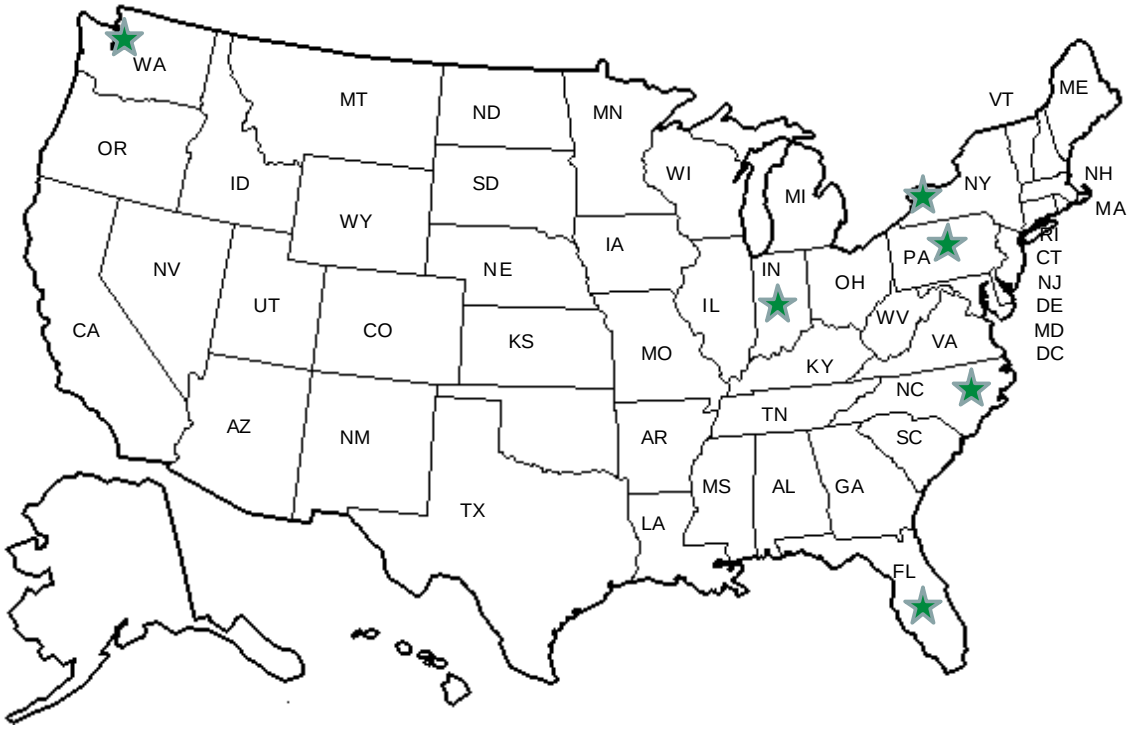

Figure 2: Sites for SHRP 2 Naturalistic Driving Study