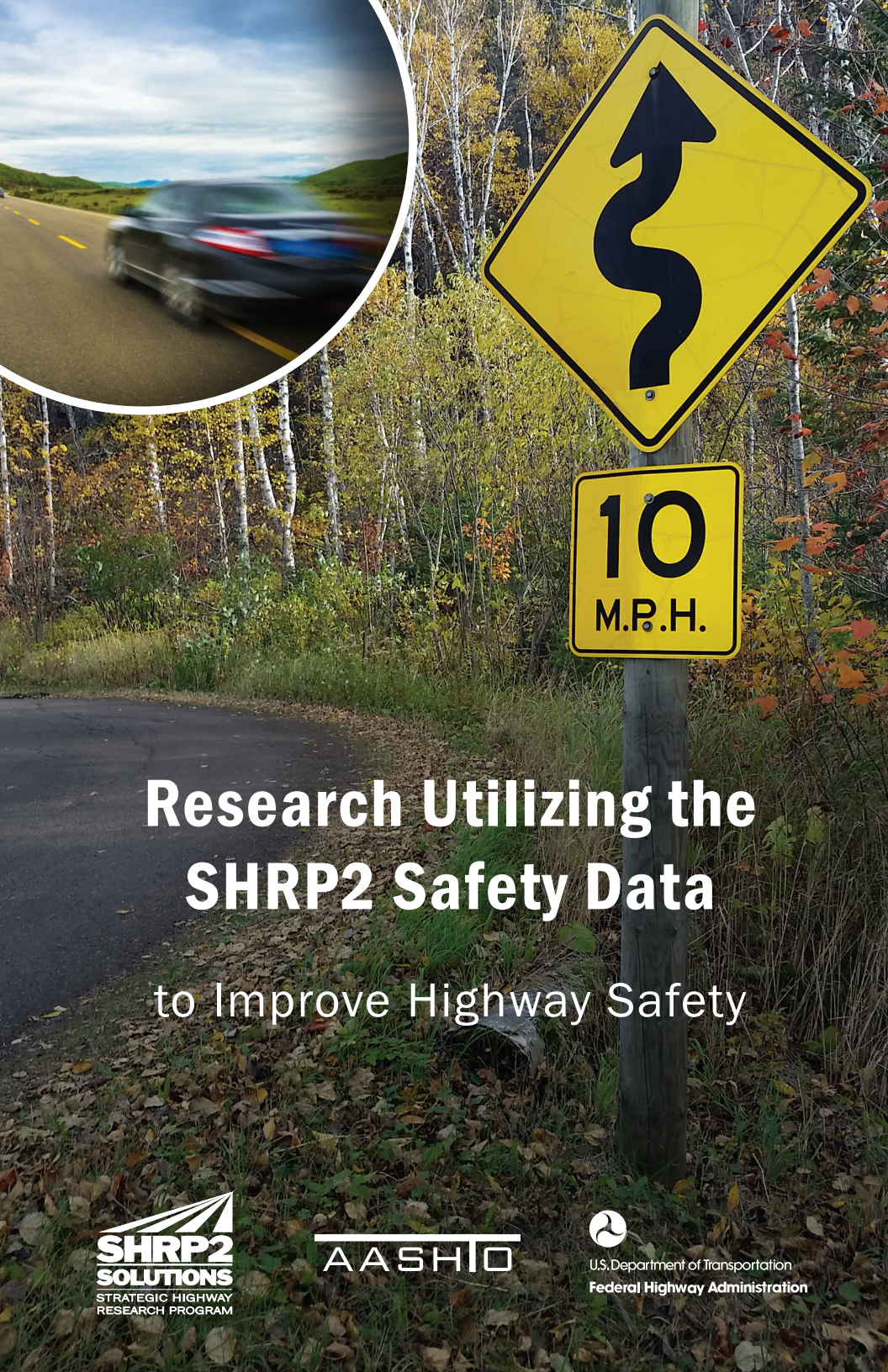


Research Utilizing the SHRP2 Safety Data

to Improve Highway Safety

SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

AASHTO

U.S. Department of Transportation
Federal Highway Administration

Using Innovative Research to Build Real-World Improvements

The Federal Highway Administration's (FHWA) Office of Safety Research and Development is dedicated to improving the safety of the nation's roadways through innovative research. In support of this goal, a project undertaken during the research phase of the second Strategic Highway Research Program (SHRP2) led to the development of the Naturalistic Driving Study (NDS), which provides objective information on driver behavior from real-world situations.

These unprecedented data provide a significant opportunity to investigate not only the role of driver behavior in traffic safety, but also highway operations and planning. The NDS documents the interaction of the driver with the vehicle, roadway, and the environment in detail. The data can be used in combination with the Roadway Information Database (RID) to match behaviors with specific roadway environments.

In order to put this important resource into the hands of researchers and state departments of transportation (DOTs), in 2016 the Office posted a Broad Agency Announcement (BAA) soliciting proposals that could lead to traffic safety improvements for our roads.

Research entities partnered with state DOTs

The BAA-sponsored effort consists of two phases: Phase 1 served as a 'proof of concept' and determined if specific topics could be successfully researched using the NDS data and complementary RID to determine if meaningful conclusions or countermeasures could be achieved. Eight research groups-- teamed with 12 different DOT partners-- were funded based on specific criteria. These DOTs included Alabama, California, Iowa, Maryland, Michigan, Minnesota, Missouri, New York, Ohio, Virginia, Washington, and Wisconsin.

Following the results of Phase 1, six projects were approved for Phase 2, enabling researchers to conduct more in-depth analyses, leading to specific highway safety improvements. Eight state DOTs – some teaming together – are actively engaged with their six research partners in Phase 2.

Projects being funded in Phase 2 will explore speed and safety relationships, high-visibility enforcement, rural intersection safety, work zones, and vulnerable road users. Work began in early 2017 and is expected to continue through the next three years.

> *Through the Safety Training & Analysis Center (STAC) and in partnership with state DOTs, academia, and other institutions, FHWA is using the SHRP2 safety data to conduct research that will increase our understanding of behavioral, environmental, operational, and other types of factors contributing to crashes.*
>
> *These studies are designed to produce effective safety countermeasures that can be used across the U.S. to reduce fatalities and serious injuries on our nation's roadways."*
>
> **— Monique Evans,** Office of Safety Research and Development, TFHRC, FHWA

> *This BAA is yet another vehicle in which we can advance the use and application of the SHRP2 NDS data. It is our hope that the wider research community will take advantage of this rich resource now and in the future."*
>
> **— Aladdin Barkawi,** FHWA SHRP2 Safety Implementation Coordinator

Photo courtesy Caltrans (top left), CH2M (bottom right)

What are the NDS and RID databases?

The SHRP2 safety data are comprised of two large databases: NDS data provide a wealth of information regarding driving behavior, and the RID is a companion database measuring and cataloging roadway elements and conditions.

The NDS provides objective information on what preceded crash and near-crash events, and identifies what drivers actually are doing during real-world driving conditions. In the SHRP2 study that developed the data, more than 3,500 volunteer drivers in six locations had their cars outfitted with miniature cameras, radar, and other sensors to capture data as they went about their usual driving tasks.

The RID is a geo-database that contains detailed information about the roadway characteristics in and around the NDS study sites (see related map). New roadway data were collected using a mobile van on 12,500 centerline miles across the six NDS sites. Existing roadway and other relevant information were obtained from government, public, and private sources, and includes crash histories, traffic, weather, work zones, and safety campaigns.

The NDS and RID data sets have been linked to provide researchers with a uniquely powerful data source. Both data sets are georeferenced, allowing for driver behavior to be matched with the roadway environment, as well as to temporal elements of the driving environment, such as work zones and weather.

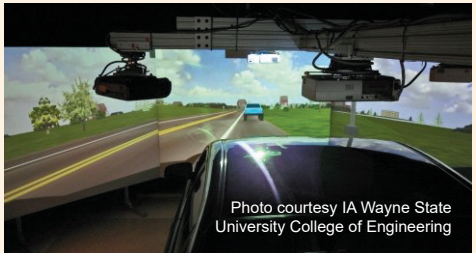


Photo courtesy IA Wayne State University College of Engineering

Six research entities teamed with eight states to address critical roadway safety concerns

Topic	Research Organization	Partner States
MRI Global	Speed	MO, OH, UT
TransAnalytics, Inc.	Vulnerable Road Users	FL, IA
University of Missouri	Work Zones	MO, VA
Iowa State University	Rural Intersection Safety	IA
UMTRI	Work Zones	MI
CUBRC	Enforcement	NY

Battelle partnered with Alabama, Ohio, California, and Washington. VTTI partnered with Virginia and were part of the Phase 1 study.

SHRP2 Implementation Assistance Program also using NDS and RID

To maximize the use of the NDS data, FHWA and AASHTO are also sponsoring the SHRP2 Implementation Assistance Program (IAP). From initial work conducted by 11 states in Phase 1, the final, third phase has narrowed the focus to five states that have begun developing countermeasures in the areas of pedestrian safety, speeding, work zones, adverse weather conditions, and roadway lighting. Guided by FHWA and the AASHTO Safety Task Force, the countermeasures will be available for use by local, state, and federal transportation agencies in the future. More information on the IAP projects at: http://shrp2.transportation.org/Pages/Safety.aspx

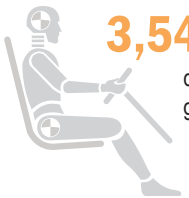
NDS Study Design

- Largest naturalistic driving study ever undertaken
- Integrated with detailed roadway information in the RID

6 data collection sites

3 years of data collection; most participated one-to-two years

Almost 2,000 crashes (ranging from severe to very minor) were identified

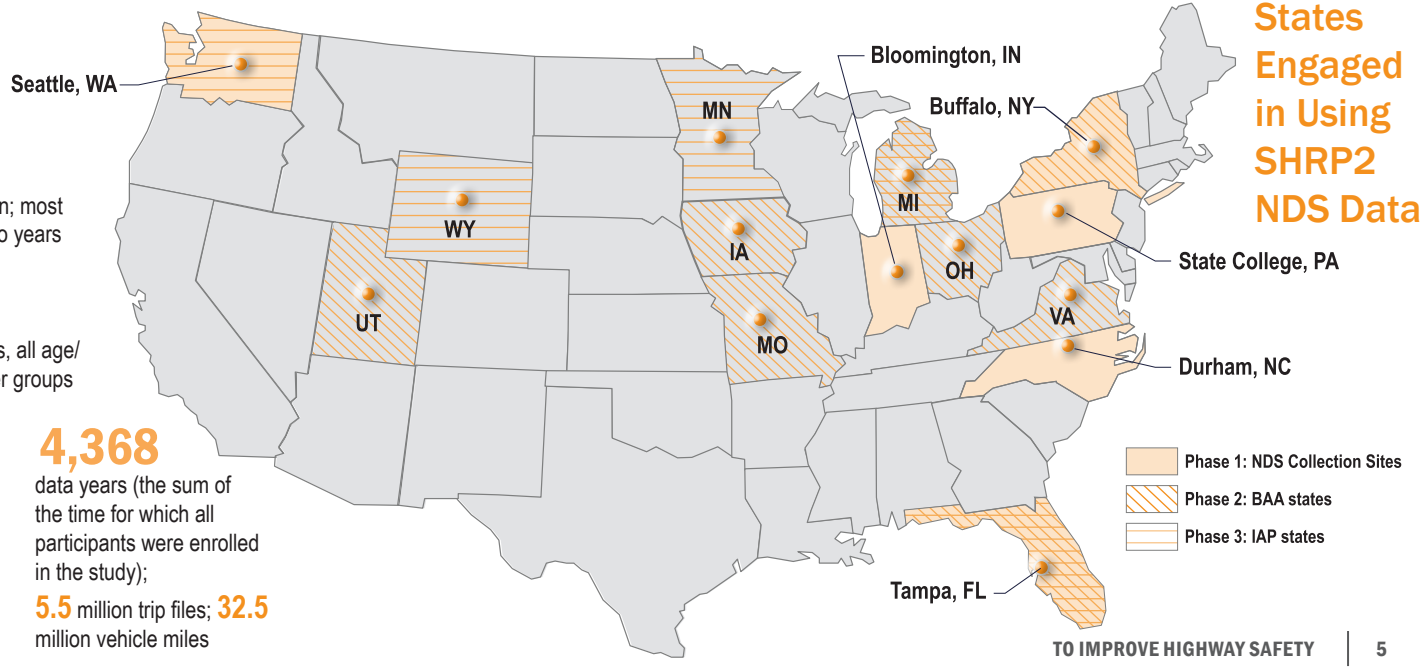


3,542 drivers, all age/ gender groups

Vehicle types: Vehicle types: all light vehicles; passenger cars; minivans; SUVs; pickup trucks

4,368 data years (the sum of the time for which all participants were enrolled in the study);

5.5 million trip files; **32.5** million vehicle miles



States Engaged in Using SHRP2 NDS Data

MRI Global; Partner States: Missouri, Ohio, Utah

Identifying Speed-Safety Relationships

The goal of this study is to develop relationships between operating speed and crash frequency on urban and suburban arterials for use in the Highway Safety Manual (HSM) and in other safety management tools such as Safety Analyst and usRAP models. The project is using continuous speed data recorded from NDS vehicles along several roadway segments included in the RID and comparing several years of historical crash data (from state crash databases) on those segments to drivers' speeds on those segments, taking into account various roadway characteristics that might impact speed or safety.


Photo courtesy MoDOT

The data is being evaluated separately for factors such as light versus dark, peak versus off-peak, and following versus not following to determine how operating speeds differ under various conditions. This may provide insight about how and when speed management strategies should be implemented.


Photo courtesy ODOT

Expected Outcomes

- New safety performance functions or crash modification factors that include a speed measure for use in Chapter 12 of the Highway Safety Manual
- Guidance on the impact of speed policies and posted speed limits on safety
- Guidance on the implementation of speed-management countermeasures

Contacts: Jessica Hutton, MRIGlobal, jhutton@mriglobal.org; John P. Miller, Missouri DOT, john.miller@modot.mo.gov; Derek Troyer, Ohio DOT, derek.troyer@dot.ohio.gov; Scott Jones, Utah DOT, wsjones@utah.gov.


Photo courtesy MoDOT


Photo courtesy FHWA

Understanding the relationship between operating speed and crash frequency and severity will enable practitioners to estimate the potential safety impact of speed limit policies and speed management countermeasures. The study will quantify the effects that operational speed has on crash type, frequency, and severity on two-lane undivided and four-lane divided urban and suburban arterials. The results are expected to provide new safety performance functions (SPFs) and/or new crash modification factors (CMFs) for inclusion in a future edition of the Highway Safety Manual (Chapter 12).

CUBRC and State University of New York at Buffalo; Partner State: New York

Improving high-visibility highway safety enforcement programs through better understanding of driver behaviors

High-Visibility Enforcement and Education (HVE) programs typically include vigorous targeted law enforcement coupled with media campaigns to educate drivers and alert them to the enforcement activities. HVEs have been shown to be effective in improving driver behaviors in several areas, such as reducing distracted driving, and increasing seat belt use and compliance with pedestrian rights-of-way; however, their long-term effectiveness in reducing speeding and aggressive driving is less clear.

The goal of this project is to produce information and strategies that can help states and others improve their HVE programs, particularly as these programs relate to the reduction of aggressive driving behaviors. In Phase 1, using the SHRP2 NDS data to examine driver behaviors, five aggressive driving behavior observables (speeding, tailgating, failure to obey traffic control devices, failure to yield right-of-way, and failure to signal when changing lanes) were analyzed before, during, and after the implementing of HVE programs at two New York sites.

Expected Outcomes

- Evaluations of effectiveness of High-Visibility Enforcement and Education (HVE) programs based on driver profiles
- Recommendations for the design and conduct of more effective HVE programs

Improved enforcement campaigns could lead to better-informed drivers and, potentially, fewer crashes.

Contacts: Alan Blatt, CUBRC, blatt@cubrc.org; Robert Limoges, New York State DOT, robert.limoges@dot.ny.gov.

Unique metrics were developed using SHRP2 NDS data to quantify tailgating and speeding, and statistical modeling techniques were demonstrated on a limited set of Phase 1 data. During Phase 2, a more robust set of SHRP2 data is being employed to produce statistically significant results on the effectiveness of HVE programs aimed at changing driver behaviors.

Photo courtesy NYS Police (all)

Iowa State University; Partner State: Iowa

Assessing driver behavior at rural intersections

Thirty percent of crashes and six percent of all fatal crashes occur at intersections in rural areas, representing a significant but poorly understood safety problem. The objective of this study is to use the data from SHRP2 NDS and RID to capture the dynamic interaction between driver behaviors and rural intersection geometry at high-speed rural intersections.

In Phase 1, researchers observed driver behavior firsthand using video, vehicle kinematics, and roadway data to determine how roadway, driver, environmental, and vehicle factors interact to affect driver safety at rural intersections. The research team conducted different analyses to examine the behaviors of drivers and the effect of these behaviors on safety. Both safety-critical events and surrogate measures were used in the different analyses.

Phase 2 is building on the first phase and will result in a better understanding of how drivers negotiate rural high-speed intersections -- where drivers are focusing their attention, the role of distraction, the effectiveness of current countermeasures, roadway factors leading to driver errors (e.g., sight distance issues), and the impact of environmental factors (e.g., nighttime conditions) on driver error. Results will lead to better intersection design, more informed selection of traffic control devices, effective countermeasures, and targeted information to inform policy decisions.

> *"Fatal crashes occur too often in the rural heartland. By using the NDS data, we can better understand how a driver reacts at high-speed rural intersections, leading potentially to better intersection design and traffic control devices."*
>
> **—Shauna L. Hallmark, Director, Institute for Transportation at Iowa State University**

Expected Outcomes

- Better understanding of how drivers negotiate rural high-speed intersections and how they interact with roadway features that result in safety-compromising situations
- Quantified impacts of various countermeasures that can be used by agencies to select resources to address a particular problem

Contacts: Shauna Hallmark, Iowa State University, shallmar@iastate.edu; Jan Laaser-Webb, Iowa DOT, jan.laaser-webb@dot.iowa.gov.

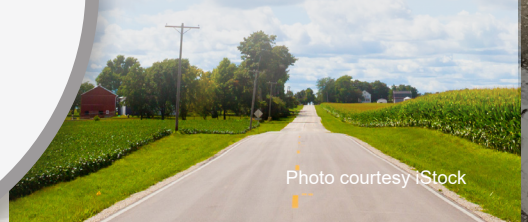


Photo courtesy iStock

Photo courtesy Center for Transportation Research and Education at Iowa State University's Institute for Transportation (top and bottom)

University of Michigan; Partner State: Michigan

Understanding normal and abnormal driving behavior in work zones

The focus of this research is to use the SHRP2 NDS to better understand driver behaviors in work zones. In 2012, 609 deaths occurred in work zones in the U.S. The complexity of driving through work zones can be challenging for drivers. Documents such as the Manual for Traffic Control Devices (MUTCD) provide guidance to states in setting up work zones, but further insight into driver behavior in these particular road configurations is necessary to develop both work-zone and vehicle-based systems to improve safety and increase traffic capacity.

In this study, the use of the SHRP2 data will help quantify the role of traffic management, work-zone activities, and traffic conditions on driver behavior (e.g., speed, merging behavior), and will help identify specific work-zone traffic-management strategies. It is also expected to dynamically identify appropriate speeds and what traffic information (such as gap distance, traffic-control features, or vehicle kinematics) could be used for real-time control of traffic.

These results have applications to existing state and MUTCD guidelines and the real-time control of work zones through digital traffic devices such as variable message signs, as well as for future applications in vehicle-to-infrastructure communication and for autonomous vehicles.

Photo courtesy MNDOT

Expected Outcomes

- Guidance for selecting specific work-zone treatments
- Scenarios to change work zone speed-limit timing scenarios to maximize throughput while maintaining safety

Contacts: Carol Flannagan, University of Michigan Transportation Research Institute, cacf@umich.edu; Joseph Gorman, Michigan DOT, gormanj4@michigan.gov.

Photo courtesy FHWA

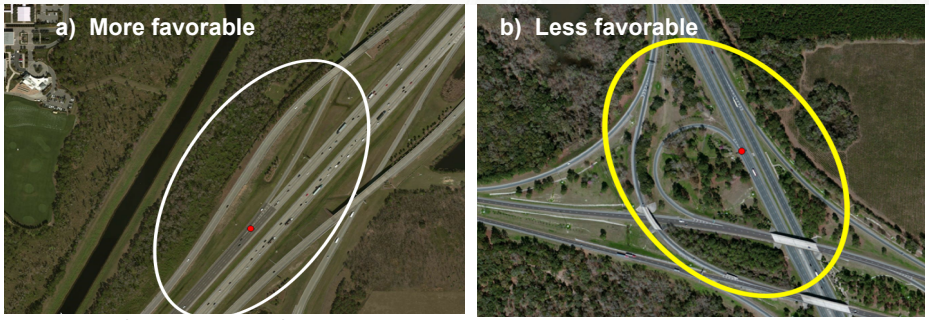
Photo courtesy WSDOT (top and bottom)

TransAnalytics, Inc.; Partner States: Florida, Iowa

Using NDS data to examine how roadway design features affect the performance of vulnerable road users

The purpose of this exploratory project was two-fold: 1) to identify variables associated with crash and near-crash events involving vulnerable road users (VRUs), including pedestrians and cyclists; and 2) to determine if more favorable roadway design features could improve the performance of elderly drivers with and without medical conditions that are more prevalent with advancing age, and that could affect performance and safety.

This research first accessed the SHRP2 datasets and Maryland crash data extractions from the Study Center at the University of Maryland. Analyses showed that drivers are not yielding to pedestrians in marked crosswalks at both midblock and intersection locations, and pedestrians are failing to use or obey the safety measures such as marked crosswalks, sidewalks, and traffic signals already in place.



Examples of more and less favorable designs for freeway merging maneuvers.

Source: Google Earth

Photos courtesy TransAnalytics

Expected Outcomes

Photo courtesy FHWA

- Potential updates to FHWA's *Handbook for Designing Roadways for an Aging Population*
- State design guides (FL, IA)
- Requirements for traffic-control devices
- Maintenance requirements
- Driver qualifications for re-licensing
- Policies for medical review for licensing

The second goal was met by examining kinematic data (speed/acceleration; headways; and braking events) for merging maneuvers on freeway ramps by drivers age 65+ in the Florida SHRP2 data sample. A relationship to ramp design was found, but not a relationship to either the presence or absence of medical conditions in drivers. In Phase 2, the work will re-focus on age-related deficits in key functional abilities to investigate how improved highway design can aid performance by older drivers.

Contacts: Dr. Loren Staplin, TransAnalytics, lstaplin@transanalytics.com; Gail Holley, Florida DOT, gail.holley@dot.state.fl.us; Deb Carney, Iowa DOT, debra.carney@iowadot.us.

Photo courtesy IDOT

University of Missouri-Columbia; Partner States: Missouri, Virginia

Developing analytical tools to better use SHRP2 safety data

This project is designed to develop new algorithms, methods, and visualization techniques to better analyze SHRP2 safety data in assessing work-zone crashes that can also be used in other crash analyses.

Specifically, this project used statistical analysis; artificial intelligence; exploratory data analysis (EDA); and visualization methods. The results will enable practitioners to predict safety-critical events using the classification methods. For instance, the random forest algorithm can classify work-zone events into crash, near-crash, and baseline with 92.6 percent accuracy.

In addition, a 3-D crash visualization procedure was developed that can assist in interactive training simulations and the reconstruction of crashes from multiple perspective, such as the perspective of the driver, the perspective of another vehicle involved in the crash, a bird's-eye perspective, the perspective of a construction worker, and other aspects.

These methods developed for work-zone events can be generalized and applied to studying other problem areas such as older and younger drivers, intersections, weather events, and rural intersections. The ultimate goal is to develop countermeasures based on the knowledge gained from these models.

"By developing visual and analytical tools that both our state and others can use, we can build better training programs, public awareness campaigns, and smarter roadways for the future."

— John P. Miller, Traffic Liaison Engineer, Missouri Department of Transportation

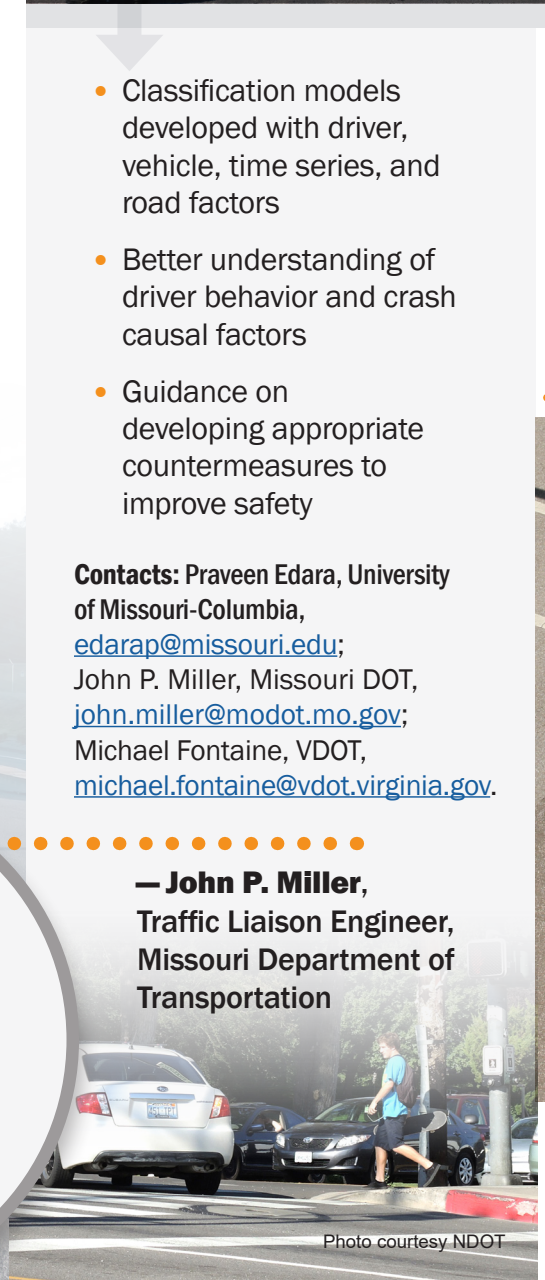


Photo courtesy NDOT

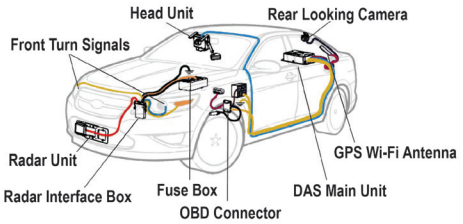
Expected Outcomes

Photo courtesy AZDOT

- Classification models developed with driver, vehicle, time series, and road factors
- Better understanding of driver behavior and crash causal factors
- Guidance on developing appropriate countermeasures to improve safety

Contacts: Praveen Edara, University of Missouri-Columbia, edarap@missouri.edu; John P. Miller, Missouri DOT, john.miller@modot.mo.gov; Michael Fontaine, VDOT, michael.fontaine@vdot.virginia.gov.

Data Acquisition System



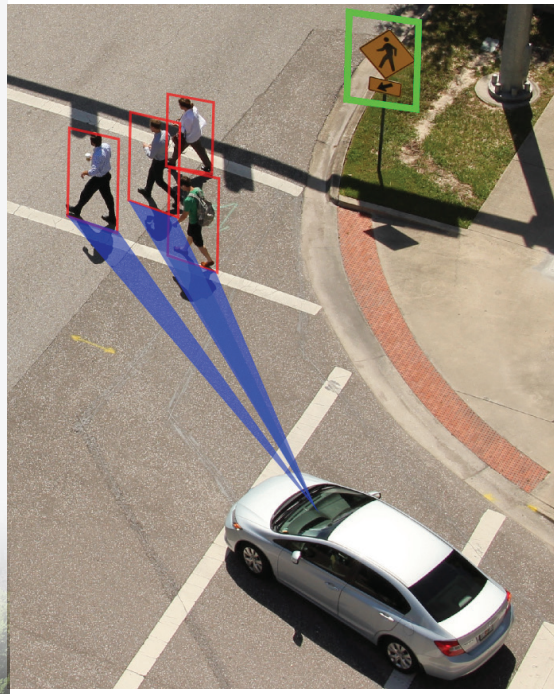


Photo courtesy University of South Florida; Dr. Achilleas Kourtellis and Dr. Pei-Sung Lin

FHWA's Safety Training and Analysis Center focuses on promoting research with the SHRP2 NDS and RID

FHWA has established the Safety Training and Analysis Center (STAC) at Turner-Fairbank Highway Research Center (TFHRC) to assist the research community and state DOTs when using the SHRP2 NDS data and RID.

The STAC serves as an incubator of new ideas throughout the research community by providing sponsored opportunities for graduate and postdoctoral students, fellows, and other researchers to gain experience working with the data. It also provides technical assistance to state DOTs and USDOT with the SHRP2 NDS and RID, and has developed tools, training, and webinars to enable decision makers and researchers to more easily use and understand the available data. Recordings of the webinars can be found at: https://www.fhwa.dot.gov/research/resources/stac/index.cfm.

Although the STAC's primary focus is to support research on the safety of the roadway environment, the uniqueness of the SHRP2 NDS data offers opportunities for research on driver behavior as it impacts highway operations and planning. In addition to the work included in this brochure and the FHWA/AASHTO IAP initiative, the STAC is sponsoring and managing the NDS Study Pooled Fund (see sidebar), which focuses research in three major areas: safety, operations, and planning.

STAC - Goals and Supporting Actions

Expand understanding of the NDS and RID

Provide training and technical assistance

Expand access to these data, including Personally Identifiable Information (PII)

Provide secure data access at STAC enclave

Expand usability of these data

Create data analysis tools and reduced data sets

Expand user base

Offer research opportunities such as fellowships or sabbaticals

STAC SAFETY TRAINING AND ANALYSIS CENTER

TURNER-FAIRBANK HIGHWAY RESEARCH CENTER

On December 20, 2016, then-FHWA Administrator Greg Nadeau and Deputy Administrator David Kim attended the ribbon cutting at Turner-Fairbank Highway Research Center to formally open the STAC's secure data enclave.

From left: James Pol, Aladdin Barkawi, Monique Evans, David Kim, Greg Nadeau, Michael Trentacoste, Carol Tan, Charles Fay and Yusuf Mohamedshah, all from FHWA.

SHRP2 Naturalistic Driving Study Pooled Fund Expands Focus to Operations, Planning, and Safety

In March 2017, FHWA announced it is leading a pooled-fund study that will continue to advance research using the NDS and RID. Six states have joined the study including Alabama, Connecticut, Iowa, Illinois, Nevada, and Washington State, and other states are invited to participate.

The goal of the study is to advance the development of implementable solutions for state and local transportation agencies with an emphasis on the broad areas of safety, operations, and planning. It will also enable highway practitioners to share information and collaborate on research that advances individual disciplines as well as to address cross-cutting areas, such as the advancement of a connected-automated highway system.

A Technical Advisory Committee (TAC) will direct the pooled-fund activities, determine yearly funding allocations, define the research needs for the pooled fund, select the projects to be conducted, approve research teams, and oversee the work to ensure the objectives are met. More information at: http://www.pooledfund.org/Details/Study/613.

Photo courtesy FHWA (top and bottom)

More Information

For information on the FHWA BAA project, Research Studies that Leverage the SHRP2 Data:

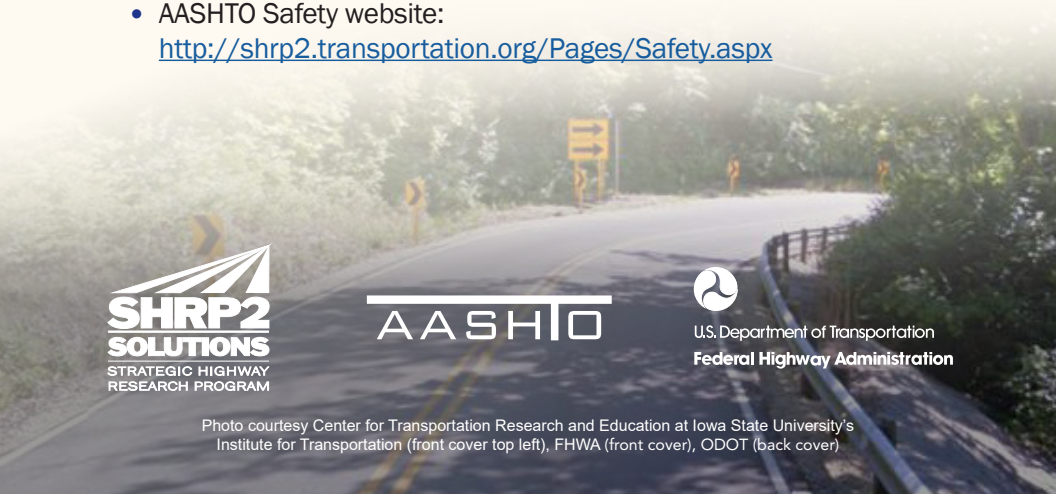
- Charles R. Fay, SHRP2 Research Manager, Safety Training & Analysis Center (STAC), charles.fay@dot.gov or 202-493-3336
- Yusuf Mohamedshah, SHRP2 Research Analyst, Office of Safety Research and Development, Yusuf.Mohamedshah@dot.gov or 202-493-3464

For information on SHRP2 Safety-Related Programs:

- At FHWA: Aladdin Barkawi, FHWA SHRP2 Safety Implementation Coordinator, Aladdin.barkawi@dot.gov or 202-493-3312
- At AASHTO: Pam Hutton, SHRP2 Implementation Manager, phutton@aashto.org or 303-263-1212; Kelly Hardy, Program Manager for Safety, khardy@aashto.org or 202-624-5868

Important websites:

- Safety Training and Analysis Center (STAC) website: https://www.fhwa.dot.gov/research/resources/stac/index.cfm
- SHRP2 NDS Data Access website: https://insight.shrp2nds.us/
- SHRP2 Roadway Information Database: http://www.ctre.iastate.edu/shrp2-rid/
- AASHTO Safety website: http://shrp2.transportation.org/Pages/Safety.aspx



SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

AASHTO

U.S. Department of Transportation
Federal Highway Administration

Photo courtesy Center for Transportation Research and Education at Iowa State University's Institute for Transportation (front cover top left), FHWA (front cover), ODOT (back cover)