Creating a safer transportation system:

How the new SHRP2 safety databases can take us there

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

PHASE 3

APRIL 2018

SHRP2 SOLUTIONS

TOOLS FOR THE ROAD AHEAD

Using new data and research to reduce crashes and improve highway safety

Traffic safety is a top priority of transportation agencies across America – safety for the traveling public using our roadways, safety for transportation agency employees and their contractors working to maintain our streets and highways, and safety for our incident responders. More than 2.4 million people were injured in motor vehicle crashes in 2015. Driver behavior has been cited as a primary factor in 90% of crashes, but this assessment in typically made after crashes occur; the new analyses undertaken in these studies provide a much deeper understanding of the circumstances in which the behavior occurred by using advanced technology to observe drivers and crashes in near real time.

Through a project now underway and supported by the Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO), state transportation agencies and their research partners are using new data developed through the second Strategic Highway Research Program (SHRP2) to develop improved methods for reducing crashes and improving highway safety.

"This information will ultimately enable states to develop specific measures that will help us reduce crashes and save lives. It's a great opportunity for state DOTs and our partner research agencies to turn new data into valuable tools."

—Rudy Malfabon, Chair, AASHTO's Safety Task Force, and Director, Nevada Department of Transportation

Photo courtesy FHWA

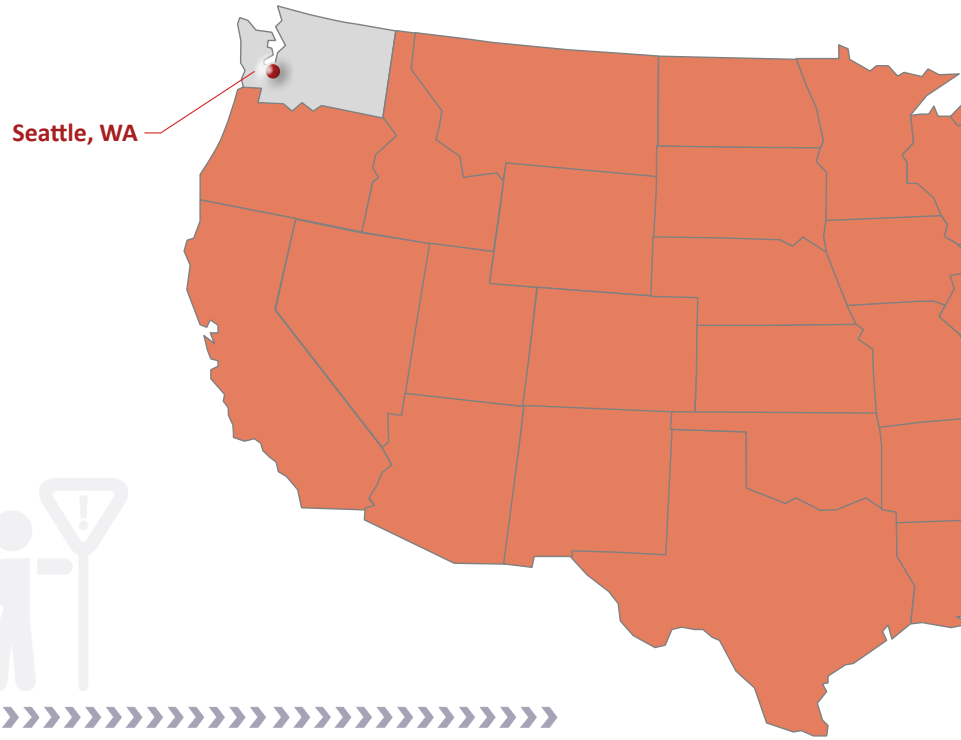
The SHRP2 safety data are comprised of two large databases: a **Naturalistic Driving Study** (NDS) database and a **Roadway Information Database** (RID). The NDS data provide a wealth of information regarding driving behavior, and the RID is a companion database measuring roadway elements and conditions. These two databases can be linked to associate driver behavior with the actual roadway characteristics and driving 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 3,100 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. These data are the first opportunity for researchers to study U.S. driving behavior that is as close to "natural" as possible for the purpose of investigating highway safety issues.

The RID is a geo-database that contains detailed information about the roadway characteristics in and around the NDS study cities. 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 geo-referenced, 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 Arizona DOT



NDS Study Design

- Largest naturalistic driving study ever undertaken
  - 3,147 drivers, all age/gender groups
  - 3,958 data years; 5 million trip files; 49.7 million vehicle miles
  - 3 years of data collection
    - Most participants 1 to 2 years
  - Vehicle types: All light vehicles
    - Passenger Cars
    - Minivans
    - SUVs
    - Pickup Trucks
  - Six data collection sites
- Integrated with detailed roadway information in the RID

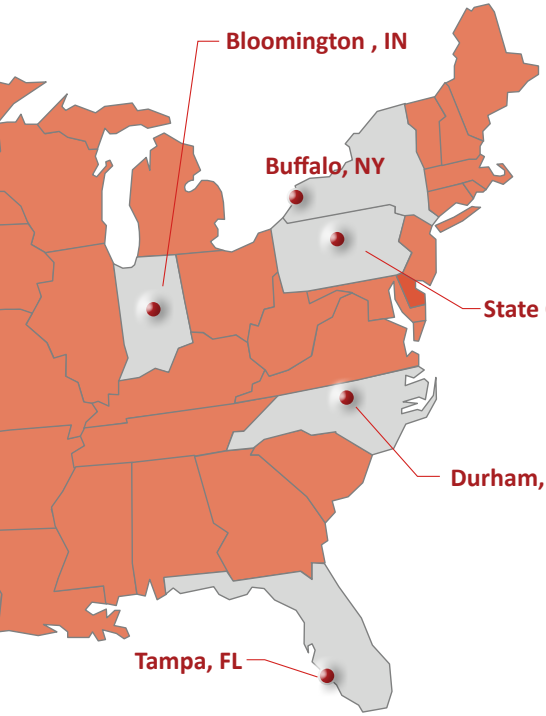


Photo courtesy Arizona DOT

Safety Task Force

In March 2014, AASHTO's Safety Task Force was formed to assist with designing a program to enable state departments of transportation (DOTs) and their researchers to access and begin using the safety data. The Safety Task Force includes representatives from each safety-related AASHTO committee and provides input and feedback to the FHWA/AASHTO Implementation Assistance Program (IAP) safety effort. The Task Force identified the three-phased approach used in the IAP solicitation process to focus state DOT efforts on the most promising strategies for using the SHRP2 safety data. The Safety Task Force has assisted AASHTO and FHWA in reviewing the research proposals submitted for the IAP solicitation as well as the research findings at the conclusion of Phase 1. It has provided support and guidance to the states and their research partners throughout the process.

I-80 – Wyoming Variable Speed System, December 2014
Photo courtesy of Dr. Mohamed M. Ahmed, PE, University of Wyoming

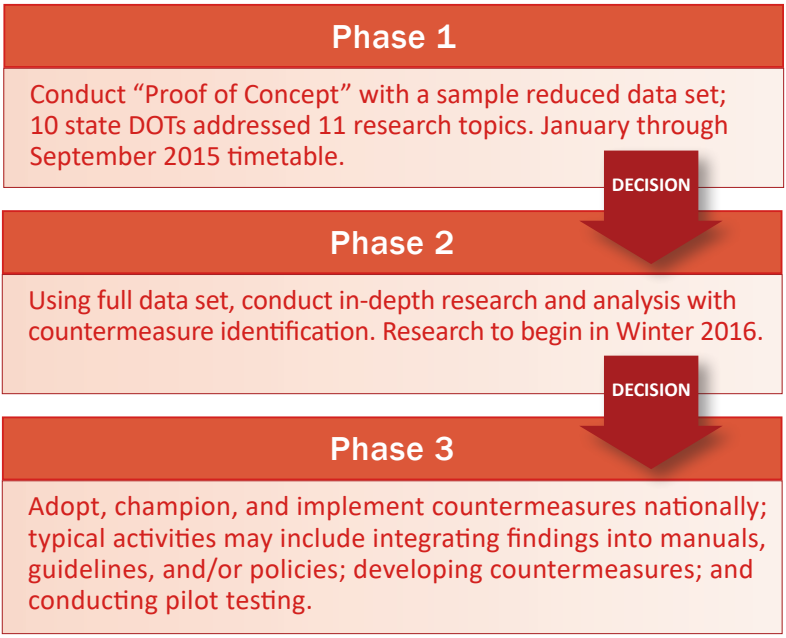
Adding safety to the Implementation Assistance Program—the *Concept to Countermeasure* Project

Through the FHWA/AASHTO Implementation Assistance Program (IAP), results from the NDS and RID databases are being made available to state DOTs interested in analyzing the data to identify crash causation factors and to develop effective countermeasures, such as road designs or public safety campaigns, which will address their common safety concerns.

A three-phased approach

SHRP2's three-phased approach to safety research—called *Concept to Countermeasure, Research to Deployment Using the SHRP2 Safety Databases*—is supported by $7 million in financial and technical assistance through the SHRP2 IAP. Developed through the SHRP2 Safety focus area, the NDS and RID offer more than two petabytes of driver behavior data to researchers and their DOT counterparts.

In the first phase of research conducted in 2015, 11 teams from 10 states used small sets of data to conduct preliminary analyses of eight different safety concerns. In Phase 2, which was announced in December 2015, nine teams continued their research and conducted more thorough, in-depth analyses using a larger set of data from the NDS and RID.



Phase 2 produced meaningful results that are likely to lead to an implementable countermeasure or new behavioral strategies. Because of these results, FHWA is providing additional financial and technical support for Phase 3 to six teams, which will address implementing the countermeasure.

Implementation does not include additional research; instead, implementation in Phase 3 includes engineering or other support to update national manuals or policies, or strategies to incorporate the countermeasure and endorse it for national adoption. Phase 3 may also include pilot testing a developed safety countermeasure in the field, implementing new public outreach efforts, or using other measures to improve highway safety.

Six teams from five states have continued on to the Phase 3 implementation

Phase 3 Implementation Projects	
Pedestrian Safety	Florida DOT
Speeding	Michigan DOT Washington State DOT
Work Zones	Minnesota DOT
Adverse Conditions	Wyoming DOT
Roadway Lighting	Washington State DOT

From eleven initial research projects, nine were selected to continue their research in 2016 using the two safety databases on eight important safety topics. Six projects were then ultimately chosen to continue to Phase 3 implementation.

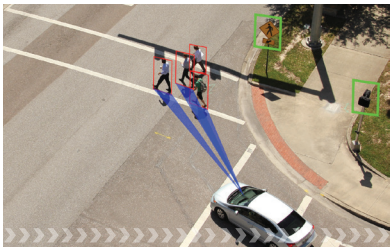
The DOTs selected for Phase 3 included Florida, Michigan, Minnesota, Washington, and Wyoming. Washington State DOT received two awards for separate research topics. The topics include pedestrian–vehicle interaction; speeding; work zones; adverse weather conditions; and roadway lighting.

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

Florida DOT

Understanding interactions between drivers and pedestrians at signalized intersections

Florida is among the five states with the highest pedestrian fatality rates in the U.S. As a result, one of the Florida DOT's highest priorities is investigating major contributing causes for pedestrian fatalities and developing effective countermeasures targeting significant improvements in pedestrian safety. In Phase 1, the DOT used limited samples of NDS and RID datasets to understand the interactions among drivers, pedestrian features (e.g., pedestrian signs, pedestrian signals, and crosswalks), and pedestrians at signalized intersections in order to demonstrate the effective and successful use of the SHRP2 NDS datasets and to provide recommendations and guidance for future studies.



Understanding the interactions between pedestrians and drivers at signalized intersections | *Photo courtesy University of South Florida, Dr. Achilleas Kourtellis and Dr. Pei-Sung Lin*

The Phase 2 research used a larger dataset to gain a more comprehensive understanding of the effectiveness of selected pedestrian features at signalized intersections; the effect of driver characteristics on their compliance with individual pedestrian features; the impact of gender and age group on driver interactions; specific interactions between drivers and pedestrians; and the impact and types of driver attention or distraction on interactions with pedestrian features and pedestrians.

Among the findings in Phase 2 were that a "No Turn on Red" sign has the highest rate of compliance (91%) with drivers, followed by "Turning Vehicles Yield to Pedestrians" (86%), "Stop Here on Red" (75%), and "Right on Red Arrow after Stop" (74%). All four features increased the likelihood of compliant behaviors compared to control groups. During Phase 2, the NDS Automatic Video Processing Tool (AVPT) and Data Reduction and Analysis Tool (DRAT) developed in Phase 1 were enhanced and used for data analysis. Based on the research findings, potential countermeasures in engineering, education and enforcement were recommended for future pilot implementation.

During Phase 3, the DOT is coordinating with the research team at the Center for Urban Transportation Research (CUTR) at the University of South Florida and other related agencies to implement selected countermeasures recommended from

Phase 2. The CUTR research team will conduct and evaluate pilot implementation in the northern, central, and southern regions of Florida to fine-tune and finalize countermeasures, and make recommendations to DOT to support future successful statewide implementation.

State Contact: Joe Santos, *Joseph.Santos@dot.state.fl.us*;
FHWA Contact: Ann Do, *Ann.Do@dot.gov*

Michigan DOT

Identifying the interrelationships among speed limits, geometry, and driver behavior

Existing research literature has consistently shown that the number of fatalities increases as speed limits increase. Using the NDS and RID data in Phase 1, the Michigan DOT and its research partners found that drivers adapted their speeds based upon changes in the roadway environment. As the average speed increased, the probability of a crash or near-crash event also increased.

Differences in crash risk were observed with respect to traffic congestion, geometric characteristics, and driver age. The research results demonstrated that inherent differences occur in speed selection among drivers and that some were more or less likely to be involved in crashes than others.

The Phase 2 research involved a more detailed examination of driver behavior data to investigate how crash potential and driver speed selection are related to posted speed limits while controlling for the effects of other important driver, traffic, and roadway characteristics. Phase 2 continued the exploration of freeway facilities and, in addition, expanded the scope to consider how these relationships vary across a broader range of high-speed roadways, including two-lane

Driving Simulator, Automotive Safety Group | Photo courtesy IA Wayne State University College of Engineering

and multilane highways. Phase 2 early findings show speeds are primarily affected by the level of traffic congestion. Also, Michigan DOT found that factors of relevance to transportation agencies include posted speed limit, junctions, weather conditions, and work zones.

In Phase 3, Michigan DOT is evaluating near-term impacts of speed limit increases, contrasting methods for identifying candidate locations for speed limit increases, and improving driver speed selection in work zone environments, under adverse weather conditions, and on horizontal curves.

State Contact: Dean Kanitz, *KanitzD@michigan.gov*;
FHWA Contact: Abdul Zineddin, *abdul.zineddin@dot.gov*

Minnesota DOT

Evaluating Work Zone Safety

More than 1,000 fatalities and 40,000 injuries occur annually in work zones in the U.S. The most common way to evaluate these types of safety issues is through analyzing crash data, which only includes reports that are often open to interpretation. Using the SHRP2 safety data, the Minnesota DOT researchers have observed actual driver behavior, helping to determine how drivers negotiate work zones and the factors present when critical situations arise.

In Phase 1, the research team analyzed the impact of driver speed and distraction on work zone safety from several different perspectives in order to offset the small sample size of work zone crashes and near-misses found in the data. The team developed methods for modeling crash risks in work zones, identified work zone reaction points, and developed a speed prediction model in order to demonstrate proof of concept. Some initial findings suggested that speed appears to be the most reliable indicator of reaction distance. The presence of a curve in a work zone tends to reduce driver speedswhen compared to speeds of drivers on a tangent in a work zone. Additionally, drivers appear to further reduce speed when more lanes within the work zone were closed.

In Phase 2, Minnesota DOT expanded to assess work zone safety from a different perspective. Using 511 data, the NDS/RID data was reduced to 1,680 trips out of more than 2 million potential work zone trips. Data

analyses showed that 44.8% of drivers decreased speed within 200 meters of a dynamic speed feedback sign (one indicating their own vehicle speed), while 5.5% decreased speed with a standard dynamic message sign commonly found in work zones.

In Phase 3, Minnesota DOT is developing a toolbox of recommended changes to traffic control manuals to inform agencies which traffic control devices are most effective in reducing vehicle speeds and improving safety, develop recommended policies for restriction of cell phones in work areas, and how to implement and evaluate recommended work zone countermeasures effectively.

Speeding in work zones will be studied. | Photo courtesy WSDOT

State Contact: Brad Estochen, *bradley.estochen@dot.state.mn.us*;
FHWA Contact: Greg Davis, *gregory.davis@dot.gov*

Washington State DOT

Examining the influence of roadway design features on episodic speeding

Speeding continues to be a primary factor in fatal and serious crashes. The number of speeding fatalities has remained basically unchanged in the past 10 years. Since the typical focus on behavioral interventions is limited in its effectiveness in addressing the driver's decision to speed, this research presents an opportunity to identify new infrastructure countermeasures and designs that can provide a more roadway-specific approach to reduce speeding in locations that have excessive speed-related crashes.

In its Phase 1 research, the Washington State DOT used the NDS and RID data to identify and assess the effects of specific roadway design elements (e.g., geometries, grades, lane and shoulder widths, roadside parking, or visual cues) and traffic engineering features (signs, curves,

lighting,) on driver's speeding choices and speed-relevant behaviors. The analysis found three factors to be significant: weather, speed limit, and traffic conditions. Among these, weather and traffic have the highest effect on speed behavior.

Examining "episodic speeding" project for SR 99 in Washington State. | *Photo courtesy Ida van Schalkwyk at WSDOT*

The Phase 2 research used a larger dataset to aid in identifying new countermeasures that target underlying driver behaviors or perceptions of the roadway. Phase 2 early findings found a new relationship between speed and other factors, such as the presence of medians and visual confinement, that can potentially be used to develop new countermeasures for speed control. The research team then developed an approach for measuring natural influences of roadway characteristics on speed that are minimally affected by individual driver differences.

For Phase 3 implementation, Washington State DOT is developing a reference guide and Diagnostic Assessment tool to assist engineers in mitigating speeding at individual locations, design and hold a one-day training course to help engineers apply the guide and tool to help with design problems, and conduct an optional implementation study to provide further validation of the Phase 2 results using spot-speed studies that capture data from a broader range of drivers.

State Contact: John Milton, *miltonj@wsdot.wa.gov*;
FHWA Contacts: Abdul Zineddin, *abdul.zineddin@dot.gov*;
Guan Xu, *guan.xu@dot.gov*

Washington State DOT

Assessing the impacts of roadway lighting on nighttime crashes

Half of the fatal crashes in the United States occur in dark lighting conditions, although nighttime traffic represents only 25% of the total

traffic volume on the system. Roadway lighting has long been considered a countermeasure to improve safety and reduce crashes.

Black Lake Adaptive LED Lighting System on State Highways project | *Photo courtesy WSDOT*

The results of the Phase 1 research showed promise for improving our understanding of the effects of lighting on driver behavior. The findings were more evident for entrance ramps than for exit ramps. They also showed some relationships to higher right-lane illuminance and uniformity, speeding, and lane changing behaviors. The research also shows promise in terms of lighting effects on driver behavior for different driver ages and roadway segments with complex geometries.

Using a larger dataset with greater variance in roadway, driver, and ramp configurations, the Phase 2 research verify the preliminary results and further identified critical lighting values, warrant-factor thresholds, and design-area specifications. Such results will be valuable for state transportation agencies in the development of performance-based and optimized lighting designs. Research was conducted to understand how roadway lighting metrics can be correlated with driver behavior variables relevant to safety. This additional research found that for freeway mainline on-or-off-ramp locations, there were few significant correlations between lighting variables and visual behavior.

In Phase 3, Washington State DOT is recommending modifications to existing lighting design guides and standards, developing tools to support and facilitate state roadway lighting design, develop guidelines for potential roadway lighting Crash Modification Factors, disseminate results and develop training materials, conduct pilot training, implement standards and guidelines in pilot lighting design projects, and assess cost-benefits of new lighting design standards.

State Contact: Ida van Schalkwyk, *VanSchI@wsdot.wa.gov*;
FHWA Contact: Michelle Arnold, *michelle.arnold@dot.gov*

Wyoming DOT

Investigating driver performance and behavior in adverse weather conditions

According to the Federal Highway Administration, weather contributed to more than 24 percent of total crashes between 1995 and 2008, based on National Highway Traffic Safety Administration (NHTSA) data. Because selecting the right speed for the right conditions is considered one of the most important driving tasks on high-speed facilities, and because the interaction between the driver and weather condition is not well understood, the objective of this research is to assess the relationship between driver behavior (i.e., speed and headway choice), roadway factors, and environmental factors. In Phase 1, the Wyoming DOT research found significant behavioral and performance differences between driving in heavy rain and in clear weather conditions under free-flow and heavy traffic conditions.

Roadway conditions captured in the SHRP2 data will be used to understand driver reactions. | *Photo courtesy University of Wyoming, WYT2/LTAP Center*

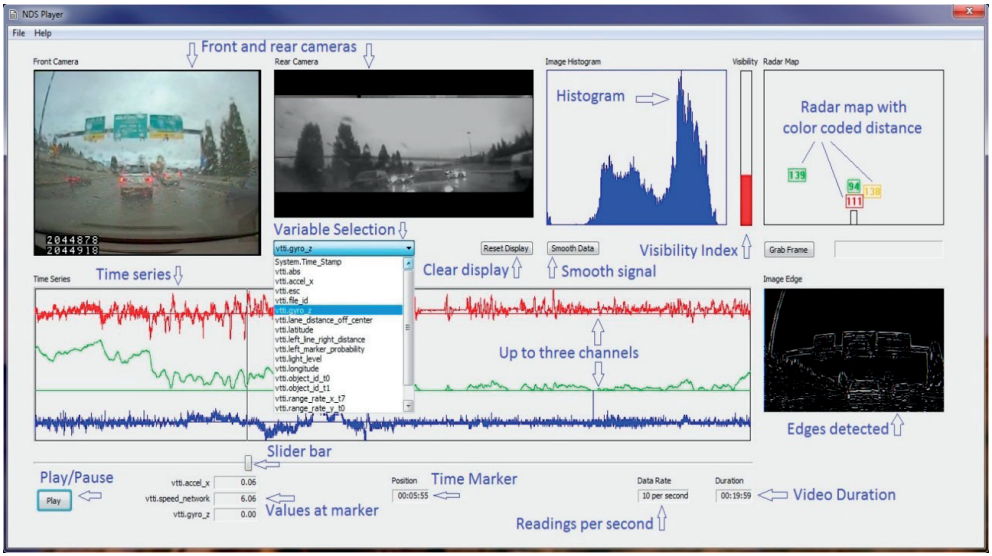
In Phase 2, the analysis was expanded to include more data from sites in various weather conditions (e.g., heavy rain, fog, and snow). The results will help in identifying cues that are the most effective in providing drivers with a more realistic Variable Speed Limit (VSL) system. VSLs are being considered as a potential solution for growing U.S. freeway congestion and safety problems. Early Phase 2 results show that NDS data are very useful in understanding driving behavior in light and heavy rain, snow, and fog compared to clear weather driving. Additionally, Wyoming DOT learned more about what drivers are doing during adverse weather and road conditions.

For Phase 3, Wyoming DOT plans to integrate human factors within the VSL to improve system effectiveness and help in achieving Vision Zero--experiencing no fatalities or serious injuries on the roadways. Wyoming was selected as one of three sites for the USDOT's Connected Vehicle Pilot

Deployment, which will be conducted on Interstate 80 VSL corridors. Phase 3 will aid in supporting connected vehicle technology in this deployment pilot.

Wyoming DOT plans to formulate a road segment-based system that could be used to communicate adverse weather condition information to the Wyoming traffic management center and then disseminate that information to drivers in real-time to mitigate the increased risk. Lastly, Wyoming DOT plans to develop practice-ready guidelines for the establishment and use of VSLs, particularly as they might be related to adverse road and weather conditions. These practice-ready guidelines will be available for states all across the country to use.

State Contact: Tim McDowell, *tim.mcdowell@wyo.gov*;
FHWA Contacts: Abdul Zineddin, *abdul.zineddin@dot.gov*;
Guan Xu, *guan.xu@dot.gov*



University of Wyoming Naturalistic Driving Study Visualization and Reduction Tool. Photo courtesy of WYDOT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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

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.

in this brochure and the FHWA/AASHTO IAP initiative, the STAC is sponsoring and managing the NDS Study Pooled Fund, 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*

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: Alabama, Connecticut, Iowa, Illinois, Nevada, and Washington State. Other states have been 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 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 on this can be found at *http://www.pooledfund.org/Details/Study/613*.

More information

For information on the FHWA/AASHTO IAP or on the safety program:

Pam Hutton, AASHTO's SHRP2 Implementation Manager, at *phutton@aashto.org*; Kelly Hardy, AASHTO's Program Manager for Safety, at *khardy@aashto.org*; or Aladdin Barkawi, FHWA Safety Implementation Lead, at *aladdin.barkawi@dot.gov*.

A wealth of information is available at:

- AASHTO Safety website: *http://shrp2.transportation.org*
- FHWA GoSHRP2 Safety website: *http://www.fhwa.dot.gov/goshrp2/Solutions/Safety/NDS/Concept_to_Countermeasure__Research_to_Deployment_Using_the_SHRP2_Safety_Data*
- Safety Training and Analysis Center (STAC) website: *http://www.fhwa.dot.gov/research/resources/stac/index.cfm*

Resources include:

- SHRP2 Naturalistic Driving Study Fact Sheet
- *NDS available data*

Photo courtesy FHWA (left), WSDOT (right)

For more information go to:
www.fhwa.dot.gov/GoSHRP2 and
http://SHRP2.transportation.org

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