# 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*

JANUARY 2016

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 2.3 million people were injured in motor vehicle crashes in 2014. While driver behavior is cited as the primary factor in more than 90 percent of these crashes, little is known about what role this behavior plays in causing or preventing these crashes.

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*

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.

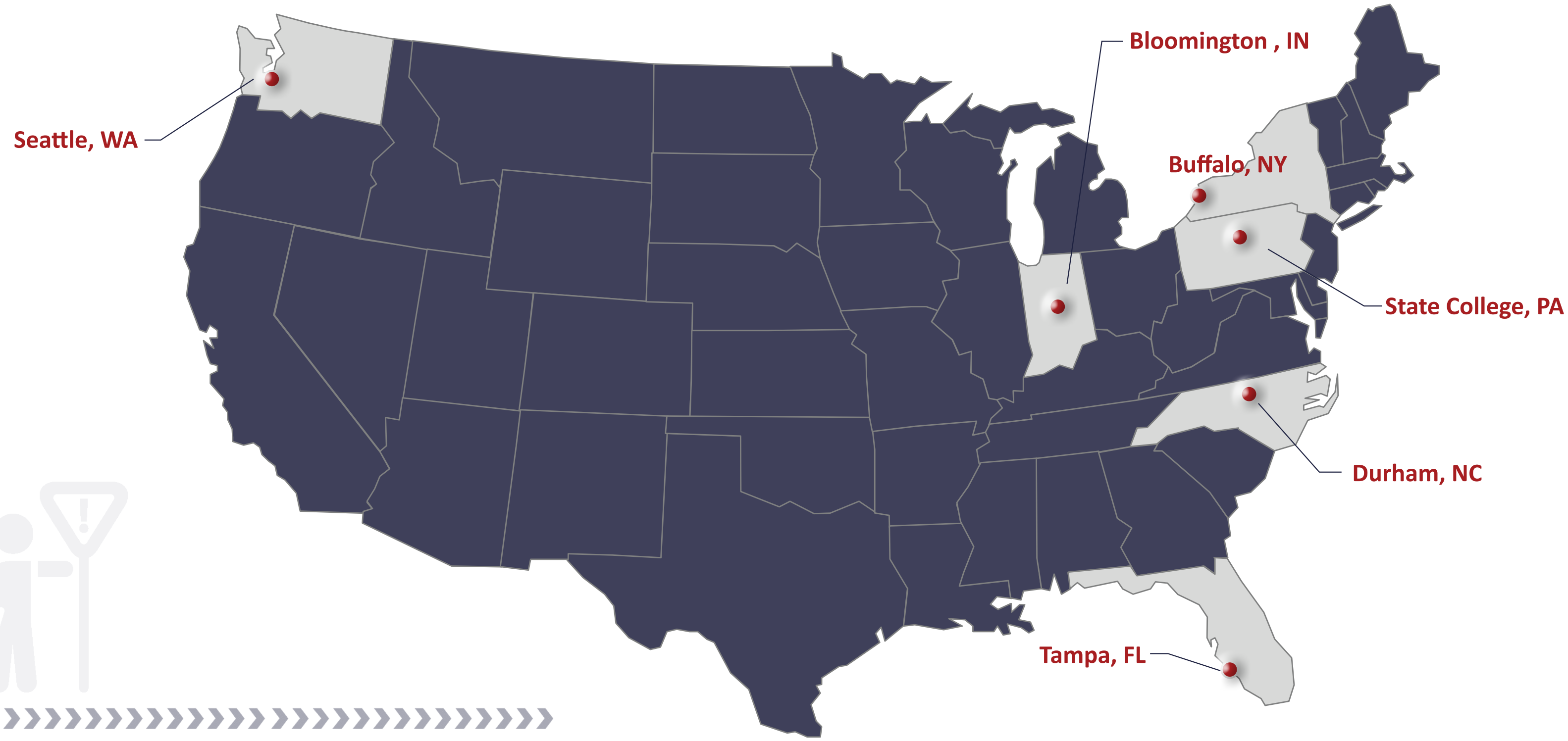

*Photo courtesy FHWA*

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.

*Photo courtesy University of Wyoming Technology Transfer Center*

## 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 will continue their research and conduct more thorough, in-depth analyses using a larger set of data from the NDS and RID.

**Phase 1**

Conduct "Proof of Concept" with a sample reduced data set; 10 state DOTs addressed 11 research topics. January through September 2015 timetable.

DECISION

**Phase 2**

Using full data set, conduct in-depth research and analysis with countermeasure identification. Research to begin in Winter 2016.

DECISION

**Phase 3**

Adopt, champion, and implement countermeasures nationally; typical activities may include integrating findings into manuals, guidelines, and/or policies; developing countermeasures; and conducting pilot testing.

If Phase 2 produces meaningful results that are likely to lead to an implementable countermeasure or a new behavioral strategy, then FHWA could provide additional financial or technical support for Phase 3, which would address implementing the countermeasure.

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

## Nine teams from eight states will continue to research important safety concerns

| Phase 2 In-Depth Research and Analysis Projects | |
|---|---|
| Pedestrian Safety | Florida DOT |
| Roadway Departures | Iowa DOT |
| Speeding | Michigan DOT<br>Washington State DOT |
| Work Zones | Minnesota DOT |
| Horizontal and Vertical Curves | North Carolina DOT |
| Interchange Ramps | Utah DOT |
| Adverse Conditions | Wyoming DOT |
| Roadway Lighting | Washington State DOT |

From eleven initial research projects, nine have been selected to continue their research in 2016 using the two safety databases on eight important safety topics.

The DOTs selected for Phase 2 included Florida, Iowa, Michigan, Minnesota, North Carolina, Utah, Washington, and Wyoming. Washington State DOT received two awards for separate research topics. The topics include pedestrian–vehicle interaction; roadway departures; speeding; work zones; horizontal and vertical roadway curves; interchange ramps; adverse weather conditions; and roadway lighting.

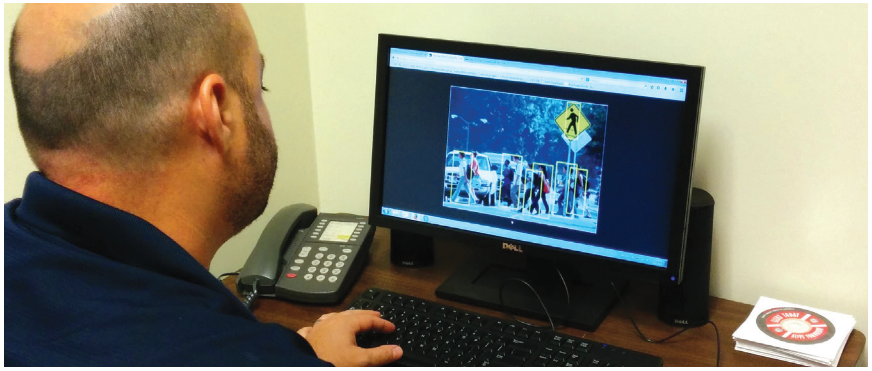
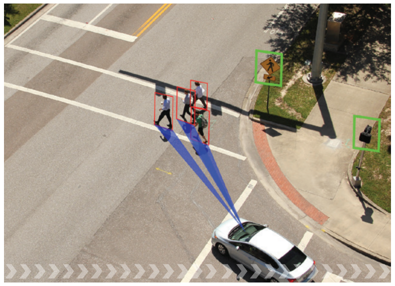


*Photo courtesy University of South Florida, Dr. Achilleas Kourtellis and Dr. Pei-Sung Lin*

## 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 the NDS and RID datasets to better understand the interactions among drivers, pedestrian features (e.g., pedestrian signs, pedestrian signals, and crosswalks), and pedestrians at signalized intersections in order to develop more effective engineering, education, and enforcement countermeasures in Phase 2 that will improve pedestrian safety.



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

Among the initial findings were that a "No Turn on Red" sign has the highest rate of compliance (70%) with drivers, followed by "Right on Red Arrow after Stop" (67%), "Turning Vehicles Yield to Pedestrians" (67%), and "Stop Here on Red" (55%). Three features—"Stop Here on Red," "No Turn on Red," and "Right on Red Arrow after Stop"—increased the likelihood that drivers would comply with these actions compared to control groups, especially when pedestrians were present.

The Phase 2 research will use a larger dataset to gain a fuller 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.

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## Iowa DOT

### *Evaluating the causes of roadway departures*

Road departures account for approximately 58 percent of all highway fatalities and can occur on any type of roadway. The Iowa DOT's research is focusing on driver speed and distraction, roadway geometry, and how roadway design countermeasures may affect road departures.

*Researching distracted driving.*
*| Photo courtesy iStockphoto*

Phase 1 looked at roadway departure risk from three different perspectives. First, roadway departure risk factors were developed using crashes or near-crashes on any type of roadway. Since only a limited number of roadway departure crashes or near-crashes were available for study in Phase 1, the researchers also used lateral position as a crash surrogate. Driver speed choice was also modeled as a function of driver and roadway characteristics. Each provided different information about the risks of roadway departures.

In Phase 2, speed prediction models will be developed to assess the relationship between speed and driver and roadway characteristics, since speed plays a significant role in roadway departure crashes. Output from the speed prediction model will estimate the change in speed due to roadway, driver, or environmental characteristics. This information can be used by agencies to assess the impact of different countermeasures or policies that will cause drivers to reduce speeds.

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## 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.

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

The Phase 2 research will involve 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 will continue the exploration of freeway facilities and, in addition, the scope will be expanded to consider how these relationships vary across a broader range of high-speed roadways, including two-lane and multilane highways. Ultimately, the results of these analyses will lead to the identification of potential countermeasures, policies, and programs with the greatest potential to reduce traffic crashes and injuries on high-speed roadways.

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## 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 can observe 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-crashes 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 speeds, and drivers appear to reduce speed when more lanes within the work zone were closed.

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

Based on the experiences and findings of the Phase 1 research, the research plan for Phase 2 will be expanded to assess work zone safety from a different perspective. In the first of three analyses, specific factors will be identified that are associated with increased or decreased odds of a safety-critical event given relevant roadway, driver, or environmental characteristics. The second analysis will identify a driver reaction point that can be used when drivers react (or do not react) to upstream signing, presence of a queue, and beginning of a work zone. The third analysis will develop a model to predict driver speed. The Minnesota DOT expects to identify safety impacts for driver, work zone, and road characteristics. Recommendations based on the analysis and evaluations are expected to include changes to work zone standards.

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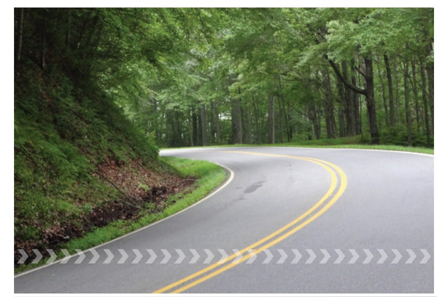
## North Carolina DOT

### *Evaluating the interaction of traffic on rural, two-lane roads*

Preventing lane departures is a high priority for many states and studies have shown that horizontal and vertical curves and grades on rural roads are associated with more crashes when compared with tangent-level sections. In Phase 1, the North Carolina DOT studied the effects of different road alignments on road departure crashes and researched how speed, driver-controlled variables, time of day, curves, and grades may also affect near-crashes. The results showed that alignments that include a horizontal curve have the worst performance in terms of the lane-deviation measures and that sharper horizontal curves are associated with higher levels of lane deviation from the center line.



*North Carolina's research focuses on rural road crashes.* | *Photo courtesy NCDOT*

Based on the results from the Phase 1 analysis, NCDOT will examine  the relationships between performance measures and crash propensity; which combinations of horizontal and vertical alignments are associated with inferior driving performance and potentially higher risk of crashes; and the potential effectiveness of countermeasures in affecting driver performance and behavior such as types of advance warnings, in-lane rumble strips, and improved roadway surface.

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## Utah DOT

### *Assessing driver behavior near closely spaced interchange ramps*

Transportation agency concerns regarding new or modified freeway access include ramp spacing on the mainline and the impact of spacing on freeway operations and safety. The Utah DOT's Phase 1 research explored driver behavior in the vicinity of closely spaced interchange ramps using the SHRP2 NDS data. It focused primarily on driver behavior between freeway entrance and exit ramps. The results included the development of a method to aid in the determination of lane changes, an algorithm that estimates lane-change duration, and a procedure for identifying various types of cell phone distraction.

*Assessing driver behavior near closely spaced interchange ramps.* | *Photo courtesy University of Utah*

In Phase 2, the Utah DOT will seek a more thorough understanding of statistical associations that show how operational and safety performance varies with changes in ramp spacing and auxiliary-lane presence. This research will examine the sequences of events that lead to crashes and near crashes in areas with closely spaced interchange ramps, and attempt to identify a set of driver behavior measures that are associated with roadway attributes (e.g., ramp spacing, auxiliary-lane presence) and with expected crash frequency. The primary goal is to use what is learned about driver behavior to recommend a set of countermeasures to improve safety performance at locations with closely spaced interchange ramps. The use of NDS and RID data will allow the team to capture the complexity of speed selection, gap searching, gap acceptance, merging, diverging, and other lane-changing and lane-keeping activities that occur on freeway segments with an entrance ramp followed by a downstream exit ramp.

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## 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.

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

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.

The Phase 2 research will use a larger dataset to aid in identifying new countermeasures that target underlying driver behaviors or perceptions of the roadway. Sites with certain countermeasures such as dynamic speed signs or speed calming measures will be compared to similar sites with no measures. The resulting information may provide roadway engineers and designers with additional methods for influencing speed by selecting design parameters (e.g., lane widths, roadway furniture) that are consistent with operating speed goals.

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

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.

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

Using a larger dataset with greater variance in roadway, driver, and ramp configurations, the Phase 2 research will verify the preliminary results and further identify 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. Additionally, they offer improvements to current state and national lighting design guidelines, and add to our understanding of the effects of lighting on older drivers.

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## Wyoming DOT

### *Investigating driver performance and behavior in adverse weather conditions*

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

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.

In Phase 2, the analysis will be expanded to include more data from six sites in various weather conditions (e.g., heavy rain, fog, snow, and ice). The study will gain insights into how drivers adjust their behaviors to compensate for increased risk due to reductions in visibility. 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. The research will also provide valuable information about how drivers interact with the roadway and weather and the impact on the effectiveness of countermeasures.

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. The Phase 2 study will aid in supporting connected vehicle technology in this deployment pilot.

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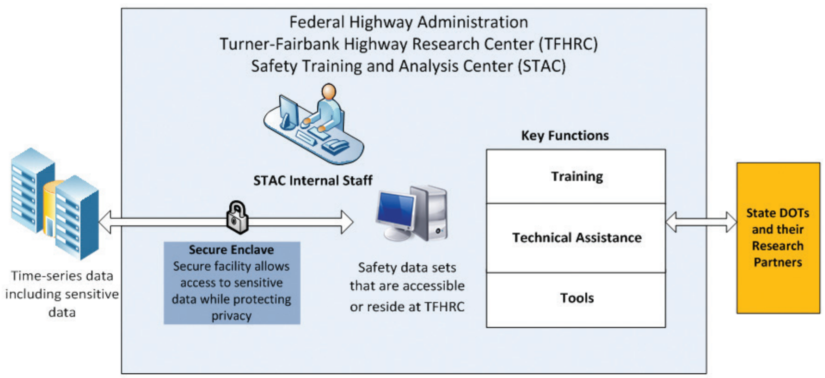
## Safety Training and Analysis Center increases access and expands services

The Safety Training and Analysis Center (STAC) at the FHWA Turner-Fairbank Highway Research Center was established to assist the research community and state departments of transportation (DOTs) in implementing the SHRP2 safety data. The STAC is developing hands-on training and analytic tools, producing reduced datasets, and pilot testing its new secure data enclave to remotely access the SHRP2 NDS data.

Some of those tools and projects include:

- Automated video decoding/data extraction
- Automated extraction of facial features from video
- Automated masking of the identity of participants




*http://www.fhwa.dot.gov/research/resources/stac/index.cfm*

In cooperation with the National Highway Institute (NHI), the STAC is also developing a training course to provide an introduction to the SHRP2 safety data. The course will promote the data available to researchers, explain the data access requirements, and assist in identifying concepts for potential uses of the data by DOTs.

FHWA received a large number of proposals from across the country in response to a recent Broad Agency Announcement (BAA) for research proposals that leverage the SHRP2 safety data. FHWA awarded six contracts and two cooperative agreements, funding a total of eight diverse research proposals.

FHWA is currently completing the final details of an Intergovernmental Personnel Act (IPA) agreement with the University of Connecticut to conduct additional research at the STAC using the NDS data on speeding and crash risk. Additional fellowship and sabbatical opportunities at the STAC should be expected in the future.

FHWA has also allocated $25 million through a five-year assistance agreement with the National Academy of Sciences and Transportation Research Board for continued work with the SHRP2 safety data to facilitate and improve future implementation efforts. This work is being guided by a Safety Oversight Committee established by TRB. The committee is developing policy requirements and will set the standards on how to share the data so they can be widely used.

Visit *http://www.fhwa.dot.gov/research/resources/stac/index.cfm* for more information on the STAC.

**Additional NDS/RID Research Supported by the STAC**

| Partner State(s) | Research Topics |
|---|---|
| Alabama<br>Ohio<br>California<br>Washington | Intersections |
| Iowa<br>Minnesota<br>Wisconsin<br>Michigan | Rural Intersection Safety |
| Maryland | Vulnerable Road Users |
| Michigan | Work Zones |
| Missouri | Speed |
| New York | Enforcement |
| Virginia | Crash Surrogates |

*Turner-Fairbank Highway Research Center (TFHRC), Safety Training and Analysis Center (STAC) | Photo courtesy FHWA*

# More information

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

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### *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)*