SHRP2 Safety, *Concept to Countermeasure* Phase 2 Early Research Findings

Safety Implementation Assistance Program

Summary of the SHRP2 Safety Task Force Endorsements for SHRP2 Phase 3

May 2017

Summary of Phase 2 Early Research Findings

Purpose

In 2014, 11 states were selected to participate in *Concept to Countermeasure, Research to Deployment Using the SHRP2 Safety Databases*, conducted through the second Strategic Highway Research Program's (SHRP2) Implementation Assistance Program. The state departments of transportation (DOTs) and their research partners were tasked with conducting targeted research using the Naturalistic Driving Study (NDS) (also developed through SHRP2) and the Roadway Information Database (RID). The three-phased project sought to ultimately identify possible countermeasures that would improve safety on the nation's highways.

Following Phase 1, nine projects were selected to move into Phase 2. The intent of this memo is to:

1. Provide an update on the early research findings of the nine SHRP2 safety data research projects selected for Phase 2; and,
2. Endorse the advancement of six projects to Phase 3.

This memo summarizes the process undertaken by FHWA's Office of Safety and the SHRP2 Safety Task Force of the American Association of State Highway and Transportation Officials (AASHTO). A more detailed report from AASHTO's SHRP2 Safety Task Force will be delivered to the Federal Highway Administration (FHWA) at a later point.

Meeting Overview

On May 2-3, 2017, AASHTO's SHRP2 Safety Task Force (STF) met to receive presentations of the early research findings from each of the nine state DOT teams participating in Phase 2 of the Round 4 Implementation Assistance Program (IAP).

The STF was tasked with reviewing the status of the DOT research; analyzing the submissions; and providing endorsements to the FHWA as to which research would most likely lead to some combination of implementable countermeasures, education, and policy changes. The ultimate goal of these activities would be to improve safety performance on our roads and highways.

Background

As noted above, in March 2014, 11 research studies, sponsored by 10 state DOTs, were selected by FHWA with input from the STF for Phase 1 funding through the IAP. The goal for the Phase 1 projects was to demonstrate proof-of-concept in applying the SHRP2 Naturalistic Driving Study

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(NDS) and the Roadway Information Databases (RID) to specific research problems in order to identify new or improved safety countermeasures, driver education efforts, and enforcement strategies.

In October 2015, the STF met and heard the Phase 1 research results. Following thorough discussions and analysis, the Task Force subsequently presented their endorsements to FHWA's Office of Safety. FHWA chose to fund nine of the original eleven for Phase 2. The goal of Phase 2 is to refine the models and methodologies from Phase 1 to larger data sets to obtain new sharper insights concerning crash-contributing factors and countermeasures to improve safety on the road. Much of the Phase 2 work will continue for the remainder of 2017.

The FHWA has $1,987,125 of remaining SHRP2 funds available to fund Phase 3 development. Any amount of this balance, partial or full, may be obligated and funding decisions will be based on the quality and promise of the research to date. Any awarded funding for Phase 3 must be obligated prior to September 30, 2017.

In order to provide FHWA with sufficient time to approve the award and to follow through with contractual logistics, the STF chose to conduct this "Early Research Findings" meeting while Phase 2 was underway for all teams. This was done with the understanding that the results and conclusions are still somewhat works in progress. Each of the nine IAP teams were asked to develop reports (and related presentations) that included early research findings, an implementation plan, and proposed budget for potential Phase 3 efforts. The reports were evaluated by the STF members against criteria that were provided to the IAP teams prior to the development of the reports.

STF Endorsements

Following all the presentations, the Task Force discussed each of the projects, their progress, and their potential to produce effective, novel countermeasures. The members had an opportunity to update their scoring after the presentations; revised aggregate scores were used to determine the Phase 3 endorsements provided below. A summary table of their endorsements for consideration by the FHWA can be found in **Attachment 1**. A description of each project is provided in **Attachment 2,** along with summary comments on the Phase 2 early research findings and Phase 3 proposals.

The STF endorsements include several modifications to the Phase 3 budgets requested by the IAP participants based on the evaluations of all the teams. For the proposed Phase 3 work conducted by Michigan and Minnesota, the STF has suggested partial funding. For Wyoming, the Task Force has suggested a modified and expanded scope and proposed cost.

The proposed Phase 3 budgets for two of the Washington State DOT teams, Washington/Speeding and Washington/Lighting, included a base cost and an optional cost for some suggested additional research. The STF endorses awarding the optional funding to the Washington/Speeding study but not the Washington/Lighting study (see **Attachment 1**).

Funding and Schedule

As noted above, the maximum funding available from FHWA for Phase 3 implementation is $1,987,125. The total funding for Phase 3 projects endorsed by the STF is $1,942,777. In addition to this total, matching funds will be provided by four of the six states, totaling $418,702.

Justification

The STF suggests that the six projects that have been shown to be the most promising for the development of implementable countermeasures during Phase 3 be funded. The STF unanimously excluded three projects on their prioritized list due to a combination of methodology concerns, inability to lead to an implementable product, and/or high proposed Phase 3 budgets.

Attachment 1
Summary of STF Endorsements

Rank (Based on Averages)	State	Research Topic	Proposed Phase 3 Cost		
			Requested FHWA Support	Requested FHWA Support (Optional)	Matching Funds (DOT and Other)
1	Washington 1/SP	Examining Episodic Speeding	$ 349,561	$ 172,296	---
2	Wyoming	Weather Conditions	$ 320,920	---	$ 43,242
3	Florida	Pedestrians at Signalized Int	$ 250,000	---	$ 75,460
4	Washington 2/LT	Role of Rdway Lighting in Crashes	$ 350,000	---	---
5	Minnesota	Speed and Distraction in Wrk Zn	$ 200,000	---	$ 100,000
6	Michigan	Effect of Sp Lmts on Drv Behavior	$ 300,000	---	$ 200,000
		Totals	**$ 1,770,481**	**$ 172,296**	**$ 418,702**
7	Iowa	Drv and Rd Char in RD Crashes	$ 420,750	---	$ 250,000
8	Utah	Closely Spaced Interchange Ramps	$ 407,000	---	$ 100,000
9	North Carolina	Horv/Vert Curve on Rural 2-Lane	$ 180,000	---	
		Totals	**$1,007,750**	**$ 0**	**$ 350,000**

STF Endorsements for Phase 3
STF Does Not Endorse for Phase 3

Attachment 2
Phase 2 Early Research Findings and Phase 3 Proposals – Overview and Evaluation

SHRP2 Safety IAP Phase 2 Early Research Findings and Phase 3 Proposed Implementation – Overview and Evaluation

Projects Endorsed by the STF

The following is a summary of each of the nine state DOT research proposals conducted under Phase 2 of the IAP. They are listed in ranking order, with the project receiving the highest score at the top.)

Washington DOT - *Research to Deployment Using the SHRP2 NDS Influence of Roadway Design Features on Episodic Speeding in Washington State*

Goal:

To identify characteristics of roadway segments that facilitate episodic speeding or generally lead to faster driving because of intentional or unintentional speed-maintenance behavior. More broadly, the focus is on obtaining a deeper understanding of how specific roadway features individually, and in combination with other features, affect driver speed behavior. Additionally, a practical goal of this project is to apply this understanding to develop countermeasures that would provide engineers with better tools and solutions to control speeding while addressing fast driving in general.

Phase 2 Early Findings:

- Speeding was characterized by two measures derived from the NDS data:
  - Speeding episode (i.e. a segment of driving in which the driver chose a speed more than 10mph over the posted speed limit). This is a dichotomous variable with a value of yes (speeding on the segment) or zero (not speeding on the segment).
  - Maximum speed exceedance (i.e. highest speed above the posted speed limit along the segment).
- Analyses confirmed existing relationships found in previous literature and policy.
- Analyses found new relationship between speed and other factors, such as presence of medians and visual confinement, that can potentially be used to develop new countermeasures for speed control.
- The research team developed an approach for measuring natural influences of roadway characteristics on speed that are minimally affected by individual driver differences.

Phase 2 Questions to be Answered During Remaining Phase 2 Effort:

- How can design decisions influence or manage episodic speeding moving forward?
- Can the SHRP2 data be used to identify and assess the effects of specific roadway and traffic engineering features on speed behavior?
- Given these effects, what new safety countermeasures can be developed to provide improvements to existing designs and operational strategies?

Phase 3 Implementation Plan:

- Develop 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 assist with design problems and solutions that agencies encounter or are currently addressing.
- 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.

Considerations:

- Project has broad application of interest to many states.
- Implementable deliverables.
- Defensible methodology.
- Works to address problems in infrastructure and human behavior.

Wyoming DOT - *Driver Performance and Behavior in Adverse Weather Conditions: An Investigation Using the SHRP2 NDS*

Goal:

To model driver's responses to various adverse weather and road conditions (i.e., speed adaptation, lane maintenance, and car following), specifically addressing these defined research questions:

1. Can inclement weather trips be identified effectively using NDS and RID data?
2. Can driver responses (e.g., speed and headway adaptation, and lane wandering) during inclement weather (e.g., reduction in visibility due to heavy rain) be characterized efficiently from NDS data?
3. What are the best surrogate measures for weather-related crashes that can be identified using NDS data?
4. What types of analysis can be performed and what conclusions can be drawn from the resulting data set?
5. Can the NDS data be extrapolated to provide real-time weather information in the context of the Road Weather Connected Vehicle Applications?

Phase 2 Early Findings:

- Better understanding about what drivers are doing during adverse weather and road conditions.
- Early results showed that NDS data are very useful in understanding driver behavior in light and heavy rain, snow, and fog compared to clear weather driving.

Phase 3 Implementation Plan:

- Integrate human factors considerations within the Variable Speed Limit system to improve system effectiveness and help in achieving the Vision Zero goal of no fatalities or serious injuries.
- Formulate a road segment-based system that could be used to communicate adverse weather condition information to the Wyoming traffic management center (TMC) and then disseminate information to drivers in real-time to mitigate the increased risk.
- Develop practice-ready guidelines for the establishment and use of Variable Speed Limits, particularly as these might be related to adverse road and weather conditions.

Considerations:

- Strong results to date.
- Immediate applicability to other states in national guidance on variable speed limits.
- Explained both high-level ideas and details of modeling with good connection between the two.

Florida DOT - *Understanding Interactions between Drivers and Pedestrian Features at Signalized Intersections*

Goals:

1. Complete research based on the foundation built in Phase 1 to better understand the interactions between drivers and pedestrian features at signalized intersections.
2. Seek development of effective and implementable countermeasures based on research findings for future improvements to pedestrian safety at signalized intersections via the improvement of driver compliance with pedestrian features and traffic control signing.

Phase 2 Early Findings:

- Identified four pedestrian features used at signalized intersections that are directly related to pedestrian safety.
- Developed effective and implementable countermeasures in engineering, education, and enforcement areas.

Phase 3 Implementation Plan:

- Develop engineering countermeasures

- Design education countermeasures (outreach)
- Develop enforcement countermeasures
- Conduct pilot study to evaluate countermeasures
- Design statewide plan for implementation

Considerations:

- Florida is home to many of the most dangerous cities for pedestrians nationally.
- Clear vision of goals and implementation.
- Good use of NDS applied to high risk field of pedestrian safety.
- Investment of matching funds from FDOT and University of South Florida.

Washington DOT – *Impact of Roadway Lighting on Nighttime Crash Performance and Driver Behavior*

Goal:

To investigate in-depth the safety impact of roadway lighting, focusing on interchange areas where traffic conditions tend to be more complicated. This study seeks to determine if lighting improves safety performance and, if so, at what level.

Phase 2 Early Findings:

For both freeway merging/diverging locations at interchanges and intersections on surface streets (principal arterials, minor arterials, and major collectors), the Phase 2 research includes the following analyses:

- Conducted time series analysis of vehicle kinematic data. Analysis sought to understand how roadway lighting metrics can be correlated with driver behavior variables relevant to safety.
- For freeway mainline on- or off-ramp locations there were few significant correlations between lighting variables and visual behavior.

Phase 3 Implementation Plan:

- Recommend modifications to existing lighting design guides and standards.
- Develop tools to support and facilitate state roadway lighting design.
- Develop guidelines for potential roadway lighting Crash Modification Factors.
- Disseminate results and develop training and other materials for safety-oriented lighting design.
- Conduct pilot training.
- Implement standards and guidelines in pilot lighting design projects.

- Assess cost-benefits of new lighting design standards.
- Deliverables:
  - Training package including all training materials.
  - Guidelines for lighting design guides at state DOTs.
  - Design tools to facilitate roadway lighting design for state DOTs.

Considerations:

- Project provides much needed design guidance for roadway lighting and lighting standards.
- Analysis methods, countermeasures and recommendations will need to be vetted well and clearly explained.

Minnesota DOT - *Evaluation of Work Zone Safety Using the SHRP2 Naturalistic Driving Study Data*

Goals:

- Develop models to predict driver reaction to work zone features.
- Develop models to predict speed within a work zone.

Phase 2 Early Findings:

Phase 2 focused on narrowing Phase 1 research to find actual work zones. Using 511 data, the NDS/RID data was reduced to 1,680 trips out of greater than two million potential work zone trips.

The team was able to back-calculate for each work zone trip where drivers were located, relative to speed profile. This has use in combination with geometric characteristics (RID), environmental factors, etc.

- 44.8% of drivers reacted and decreased speed within 200 meters of a **Dynamic Speed Feedback Sign** (DSFS) sign.
- 5.5% reacted and decreased speed with **Dynamic Message Sign** (DMS) (1.62 times more likely than regular Work Zone sign).

As part of its research, the team developed a speed prediction model. Preliminary analysis looked at four-lane divided highways with speed limits between 45 mph and 55 mph and lane closure.

- Model showed that drivers decreased speed until they drove 300 meters past the taper and then the deceleration typically stopped.
- Distracted drivers drove an average of 3.9 mph faster than non-distracted drivers through work zones, a situation that creates concerns about crash frequency and crash severity.

Phase 3 Implementation Plan:

Ideas for Phase 3 – each are independent.

1. Develop toolbox of recommended changes to traffic control manuals – inform agencies which traffic control devices are most effective.
   - Develop recommendations for work zone traffic control signing, layout, and use of countermeasures based on project results and other research.
   - Host two-to-three focus groups to develop consensus and recommendations on proposed recommendations.
   - Develop a toolbox of recommendations and outreach materials.
   - Host workshops and webinars to provide training and outreach.
2. Develop recommended policies for restriction of cell phones in work zones – help states come up with policies to ban cell phones (using actual data). End result: develop guidance document to be used by stakeholders.
   - Develop a technical advisory committee of stakeholder states/agencies.
   - Utilize data gathered in Phase 2 to further refine the research models and address the gaps (i.e., quantify cell phone use in work zones versus normal [upstream] driving).
   - Develop guidance documents that can be used by stakeholders to develop policies.
   - Host workshops and webinars to provide training and outreach.
3. Implement and evaluate recommended work zone countermeasures.
   - Develop a technical advisory committee of stakeholder states/agencies.
   - Identify three to five countermeasures that show the most promise and are of the most interest to stakeholders.
   - Develop work zone traffic control plans to incorporate countermeasures.
   - Work with Minnesota and Iowa to implement countermeasures in work zones. Longer term work zones will be selected, and countermeasures will be rotated so that their effectiveness can be compared. For instance, DMS, DSFS, and highly visible channelizing devices would be alternated.

Considerations

- STF endorses moving forward with fixed methodology and clear recognition of the modeling of order of sign appearance to drivers.
- Reduced funding – requires explicit hypotheses when testing data.
- Important policy component – nationwide demand for outcomes based on speed effects on safety with distracted driving.
- Note – the STF endorses a partial scope, consisting of numbers 1 and 2 from their proposed implementation plan above. As part of this endorsement, the Minnesota team has agreed to

address some methodology concerns that surfaced during the Early Research Findings deliberation without requesting additional Phase 2 budget for the correction efforts. The STF does not endorse number 3.

Michigan DOT - *The Interrelationships between Speed Limits, Geometry, and Driver Behavior*

Goal:

To develop and demonstrate procedures for effectively leveraging the information from the NDS and RID in order to examine the interrelationships between driver, vehicle, and roadway factors with driver speed selection and crash risk.

Phase 2 Early Findings:

- Speeds are primarily affected by level of traffic congestion.
- Factors of relevance to transportation agencies include posted speed limit, junctions, weather conditions, and work zones.

Phase 3 Implementation Plan:

The research team will work with the Michigan DOT to evaluate several implementation strategies, with emphases on the following:

- Evaluating immediate and near-term impacts of speed limit increases;
- Contrasting methods for identifying candidate locations for speed limit increases;
- Improving driver speed selection in work zone environments;
- Improving driver speed selection under adverse weather conditions; and,
- Improving driver speed selection on horizontal curves.

Considerations:

- Broad application of interest to many states.
- Portions of the current research may overlap NCHRP 17-76 and NCHRP 17-79. The STF requests that this NCHRP research be closely reviewed to eliminate any overlap.
- The integration of data from the NDS and RID allowed for a detailed examination of these issues, which is generally challenging to accomplish through alternative study designs.
- Note – the STF endorses a partial scope, consisting of implementation of sign placement strategy and implementation of traffic control strategies. As part of this endorsement, the Michigan team has agreed to address some methodology concerns that surfaced during the Early Research Findings deliberation without requesting additional Phase 2 budget for the correction efforts.

Projects Not Endorsed by the STF

Iowa DOT - *Use of SHRP2 NDS Data to Evaluate Roadway Departure Characteristics*

Goal:

To better understand the relationship between driver, roadway, and environmental characteristics and roadway departures. The research focuses on assessing the impacts of specific roadway factors and countermeasures in order to provide agencies with better information about which countermeasures are effective and why.

Phase 2 Early Findings:

- Main findings – correlation between roadway departure countermeasures and lateral position. Smaller change in speed as curve radius increases. Little change in speed seen for advisory speeds.
- Drivers slowed more from the point of curvature to center of curve than from advance of curve to PC. As radius increases, change in speed decreases. 40 mph advisory speed only significant change seen (drivers aren't really slowing down much for advisory speeds).
- Drivers on outside drive more towards centerline. As lane width increases, drivers move more towards shoulder (less so with rumble strips present). No shoulder – drivers drive closer to centerline.
- Reflective Pavement Markings – smaller change as radius increases. Older drivers had smaller change in lateral position at night and when roads were wet. No change seen for drivers under 65. Similar model on curves without RPMs showed no effect for older drivers at night or under wet roadway conditions.
- When shoulder and edgeline rumble strips are present, drivers make a smaller change in lateral position between 300-meter-spaced points. This effect decreases as lane width increases.

Phase 3 Implementation Plan:

- Develop roadway departure risk factors (reduced dataset for all safety critical events).
- Code more segments to fine tune the models (distraction, night driving, older drivers).
- Use high-performance computing to run more models.
- Prospective countermeasures from Phase 3 research would address:
  - Rumble strip vs lane width
  - Curve advisory speed
  - Raised retroreflective pavement markers (RRPM)

Considerations:

- Methodological concerns with some of the models.
- It could be challenging to achieve desired results due to the number of variables included in the research.
- Unclear from applicability perspective what will be accomplished.
- Phase 3 schedule was not presented in report or presentation.

Utah DOT - *Driver Behavior and Performance in the Vicinity of Closely Spaced Interchange Ramps on Urban Freeways*

Goal:

To identify a set of “causal type groupings” for crashes in the vicinity of closely spaced interchange ramps and a corresponding set of alternative, implementable countermeasures for each “causal type grouping.” Through exploring driver behavior and performance in the vicinity of closely spaced interchange ramps using the SHRP2 NDS data and examining sequences of events that lead to crashes and near-crashes in areas with closely spaced interchange ramps, this research seeks to uncover possible changes in design criteria, signing, and markings as well as other promising countermeasures to reduce crash frequencies and severities in these areas.

Phase 2 Early Findings:

- In general, earlier lane changes occur when auxiliary lane is present.
- On exiting trips, generally see vehicles exiting earlier when auxiliary lanes present.
- Vehicles entering later when less ramp space is available.
- Did not notice as much sensitivity with lane change duration and speed differentials in Phase 2 as other variables.
- For speed differentials, generally seeing 10 mph slower than through traffic on same facility.

Phase 3 Implementation Plan:

- Will link driver behavior with crash and near-crash events.
- Verify the effect of implemented countermeasures on targeted driver behavior.
- Develop countermeasures that are the result of improved understanding of driver behavior.
- Changes in surrogates provide estimates on changes in safety.
- Conduct pilot test/field implementation/measurement of driver behavior – video data.
- Implement these changes, as appropriate: pavement marking signing, striping, physical gores, right-turn channelization.

Considerations:

- Concerns with methodology.
- No specific countermeasures identified.
- Data challenges where lane change maneuvers exceed the accuracy of the GPS.
- PI left research team for another opportunity. May have been hard to backfill some of the research context prior to the presentation.

North Carolina - *Evaluation of the Interaction between Horizontal and Vertical Alignment on Rural Two-lane Roads: An Investigation Using the NDS*

Goals:

1. Develop an automated process for identifying vertical curves from the RID.
2. Analyze driver performance associated with different alignment combinations and travel direction of horizontal and vertical curve by explicitly considering the direction of travel (*travel direction was not considered in Phase 1*).
3. Identify possible countermeasures that may be effective in reducing crashes at these locations.

Phase 2 Early Findings:

The analysis of the NDS data showed that the alignment categories that include a horizontal curve have the worst performance in terms of the lane-deviation measures. In addition, sharper horizontal curves are associated with the higher absolute values of lane deviation. Comparison of the crash modification factors (CMFs) from Bauer and Harwood (2014) with the performance measures show a good match with the lane-deviation measures, indicating that the lane-deviation measures could serve as good surrogates for crash propensity.

- Highest lane deviation occurred when traveling in the inside of a horizontal curve. Second was traveling downhill or level.
- Drivers going downhill on the inside of a horizontal curve on a type 2 sag curve (as defined in AASHTO Green Book) had consistently high values in all three measures.

Phase 3 Implementation Plan:

- No identified specific countermeasures, but based on published literature and conversation with NCDOT, several possible countermeasures could be developed.
- Implementation of countermeasures may include: curve warning or chevron signs, curve related pavement markings, roadside hardware, alerting devices, high friction surface, and shoulder or edge-line rumble strips.

Considerations:

- Not as far along in research as other teams.

- Goal 1 was accomplished. Based on report and presentation, does not appear that goals 2 and 3 were accomplished.
- No clear Phase 3 recommendation provided in report or presentation.