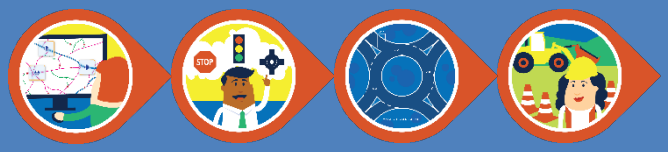

PEER EXCHANGE:

Data-Driven Safety Analysis (DDSA) Applications in Performance-Based Project Development

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16. Abstract

This report summarizes the Data-Driven Safety Analysis (DDSA) Applications in Performance-Based Project Development peer exchange hosted by Federal Highway Administration (FHWA) and the Highway Safety Manual Implementation Pooled Fund, including an overview of the peer exchange, key takeaways, overview of the presentations and resulting discussion, future research opportunities, and States' past and planned implementation efforts (State Action Plans). The peer exchange took place July 10 through July 12, 2018 at the Old Red Museum in Dallas, Texas. This meeting built on the momentum of a series of related peer exchanges in 2016, where participants strongly agreed that their State's DDSA implementation improved as a result. The purpose of the peer exchange was to showcase States' progress in implementing DDSA; share leading practices that use the Highway Safety Manual (HSM) for planning, design, and operations; and develop an Action Plan to guide States' future DDSA activities once Every Day Counts, Round Four (EDC-4) concludes. During the peer exchange there were plenary sessions, concurrent breakout sessions that included presentations and facilitated discussion, safety analysis tool demonstrations, road-mapping activity to develop Action Plans, and an HSM implementation pooled fund meeting. Topics included DDSA fundamentals, safety performance in planning and programming, performance-based practical design and analysis of design exceptions, intersection control evaluation, crash modification factors, Transportation System Management and Operations strategies, safety analysis in the project development process, benefit cost analysis, design-build projects and safety treatments, network screening, and systemic safety analysis. Participants noted that the diversity and representation helped connect representatives from the same State and the comprehensive approach of the peer exchange allowed attendees to learn information in their subject area and receive recommendations for methods to implement DDSA. Participants also highlighted the benefit of attending discussions outside their area of expertise, which helps to see topics from a different viewpoint and become interested in new ideas.

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Peer Exchange: *DDSA Applications in Performance-Based Project Development*
Dallas, TX, July 10-12, 2018

Data-Driven Safety Analysis (DDSA) Applications in Performance-Based Project Development Peer Exchange

Support for Every Day Counts Deployment Activities

FHWA GSA Schedule Order: DTFH61-15-F-00080

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ACRONYMS

AADT	annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
ADOT	Arizona Department of Transportation
ARA	Applied Research Associates
ATC	alternative technical concepts
B/C	benefit-cost
BCA	benefit-cost analysis
BOS	bus on shoulder
BSAP	Bicycle Safety Action Plan
CE	Collaborative Effort
CMF	crash modification factor
COG	council of governments
DDSA	data-driven safety analysis
DOT	department of transportation
EB	empirical Bayes
EDC-4	Every Day Counts-4
FDE	Fundamental Data Elements
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
GDOT	Georgia Department of Transportation
HCM	Highway Capacity Manual
HSIP	Highway Safety Improvement Program
HSIS	Highway Safety Information System
HSM	Highway Safety Manual
ICE	intersection control evaluation
IHSDM	Interactive Highway Safety Design Model

IDOT	Illinois Department of Transportation
Iowa DOT	Iowa Department of Transportation
ISATe	Enhanced Interchange Safety Analysis Tool
ITS	intelligent transportation system
KTC	Kentucky Transportation Center
KYTC	Kentucky Transportation Cabinet
LaDOTD	Louisiana Department of Transportation and Development
LOSS	level of service of safety
LTAP	Local Technical Assistance Program
MaineDOT	Maine Department of Transportation
MDOT	Michigan Department of Transportation
MIRE	Model Inventory of Roadway Elements
MoDOT	Missouri Department of Transportation
MPO	metropolitan planning organization
NCHRP	National Cooperative Highway Research Program
NCDOT	North Carolina Department of Transportation
NEPA	National Environmental Policy Act
ODOT	Ohio Department of Transportation
PBPD	performance-based practical design
PDO	property damage only
PennDOT	Pennsylvania Department of Transportation
PSAP	Pedestrian Safety Action Plan
RSA	road safety audit
SBF	safety benefit factor
SHIFT	Strategic Highway Investment Formula for Tomorrow
SHSP	Strategic Highway Safety Plan
SPF	safety performance functions
STI	strategic transportation investment

STIP	Statewide Transportation Improvement Plan
TDOT	Tennessee Department of Transportation
TRB	Transportation Research Board
TSMO	transportation system management and operations
TxDOT	Texas Department of Transportation
UDOT	Utah Department of Transportation
VDOT	Virginia Department of Transportation
WisDOT	Wisconsin Department of Transportation
WSDOT	Washington State Department of Transportation

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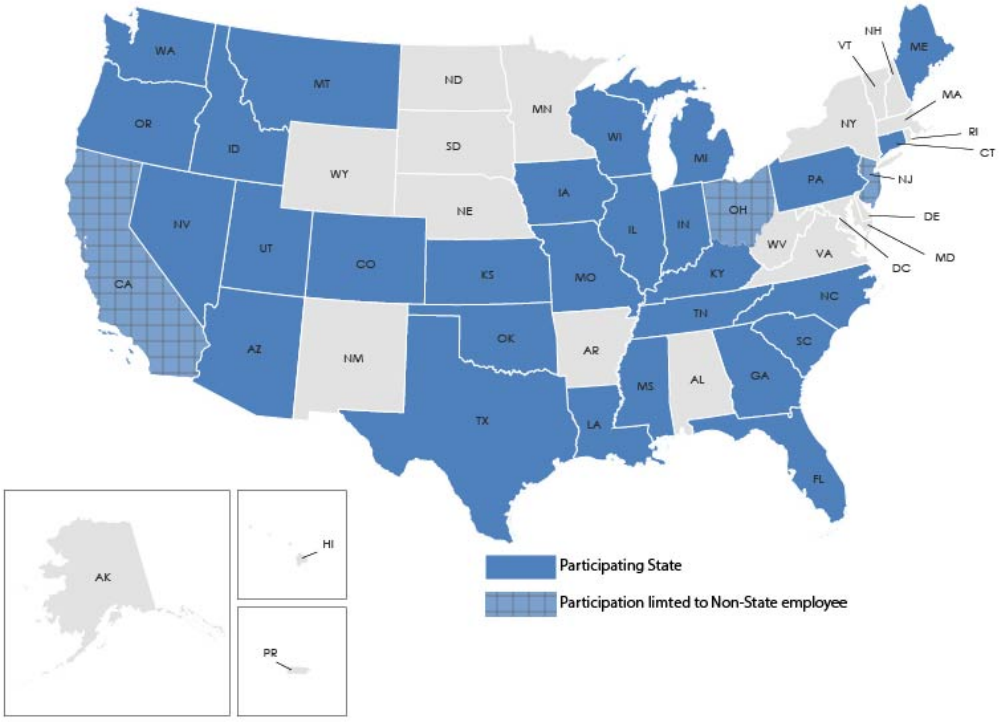
EXECUTIVE SUMMARY

This report summarizes the Data-Driven Safety Analysis (DDSA) Applications in Performance-Based Project Development peer exchange hosted by Federal Highway Administration (FHWA) and the Highway Safety Manual Implementation Pooled Fund, including an overview of the peer exchange, key takeaways, overview of the presentations and resulting discussion, future research opportunities, and States' past and planned implementation efforts (State Action Plans).

The peer exchange took place July 10 through July 12, 2018 at the Old Red Museum in Dallas, Texas. This meeting built on the momentum of a series of related peer exchanges in 2016, where participants strongly agreed that their State's DDSA implementation improved as a result. The purpose of the peer exchange was to showcase States' progress in implementing DDSA; share leading practices that use the Highway Safety Manual (HSM) for planning, design, and operations; and develop an Action Plan to guide States' future DDSA activities once Every Day Counts, Round Four (EDC-4) concludes.

The DDSA peer exchange included 31 States and over 150 participants from various disciplines including planning and programming, environment, design, traffic operations, and safety. Participants consisted of staff from State DOTs, one tribal nation, and FHWA Division Offices, Resource Center, and Headquarters.



State participation was based on one of two criteria: States were either 1) an HSM Implementation Pooled Fund State or 2) a State that is actively pursuing use of quantitative safety analysis in project development. The second criteria was determined on three factors: 1) a stated goal to advance DDSA implementation, 2) notable activity in EDC-4 progress reports, and 3) previous participation in Safety Analysis in Project Development peer exchanges held in 2016.

During the peer exchange there were plenary sessions, concurrent breakout sessions that included presentations and facilitated discussion, safety analysis tool demonstrations, road-mapping activity to develop Action Plans, and an HSM implementation pooled fund meeting. This was a State-led, practitioner-focused event where States shared their experiences with implementing DDSA practices throughout the project development process. Participants networked, learned techniques and practices from their peers, and used this information to enhance or create their State's Action Plan. Time was allotted after every session where moderators prompted additional follow up, encouraged participants to ask practical questions about application, and asked the session participants to identify future research needs.

Following the peer exchange, participants were asked to evaluate their experience. Overall, respondents rated the peer exchange positively, with evaluation scores indicating that knowledge on DDSA activities increased because of the exchange. Respondents noted an increase in their knowledge and skill level after the course, with many making note of plans to implement new techniques acquired at the event.

Additionally, many State Department of Transportation (DOT) representatives highlighted networking as a key benefit of the peer exchange and noted they had the opportunity to grow their list of contacts. Other highlights included interacting with different States and seeing various examples of DDSA principles/tools. In the technical demonstrations, States learned about different data analysis tools, based on other State's practices. In addition, the discussion/demonstrations provided opportunities for States to discuss implementation techniques different from their own.

Other key takeaways mentioned on the State evaluation forms included learning how to export crash modification factors (CMFs) from FHWA's CMF Clearinghouse, how to use the HSM for design exceptions, how to apply different approaches to safety design, how to use safety tools, and how to develop State-specific CMF lists. State DOTs also reported finding value in the multidisciplinary approach to the meeting as it made discussions on topics like planning and environment more relevant. Participants specifically mentioned the Scale and Scope of Safety Analysis in the Project Development, tool demonstrations, Leading Practices in the Use of the HSM, and sessions with group discussions as valuable highlights from the meeting. The discussions allowed States who may have been unsure of implementing DDSA to receive feedback and incorporate these ideas into their Action Plan.

The variety of disciplines represented at the peer exchange and multiple participants per State provided several benefits. First, this diversity and representation helped connect representatives from the same State. One response from the evaluation forms shared that, hearing best practices and having time at the exchange to meet with colleagues from safety, planning, and design areas in their own DOT allowed them to make plans for next steps. The comprehensive approach of the peer exchange allowed attendees to learn information in their subject area and receive recommendations for methods to implement DDSA. Participants also highlighted the benefit of attending discussions outside their area of expertise, which helps to see topics from a different viewpoint and become interested in new ideas. One respondent said, "I liked the mix of multidisciplinary folks, design, traffic, operations, planning, environmental, etc. It made topics and discussions more relevant."

State DOTs were not the only ones who felt that they gained new contacts and had the chance to learn from others. FHWA representatives agreed that the peer exchange provided great networking opportunities. One response noted the discussion on intersection control evaluation (ICE) and the environmental session was informative and is something they want to take back to their office and discuss with their team. FHWA attendees also noted the networking opportunities allowed them to learn from the experiences of other States, and brainstorm conversations to have with their transportation partners when they returned.

The HSM Implementation Pooled Fund Study held a meeting following the conclusion of the Peer Exchange. The meeting was open to Peer Exchange participants, specifically the 22 State Pooled Fund representatives. Topics included roadway data collection efforts and methods in Louisiana, intersection data collection efforts and tools in Vermont, SPF development and calibration in Kentucky, and developing State-specific CMFs. After participating in the Peer Exchange, two new states (Connecticut and Texas) joined the HSM Implementation Pooled Fund.

Overall, the multidisciplinary peer exchange comprised of representatives from State DOT and FHWA, helped to enhance the participants' understanding of DDSA and is expected to increase DDSA implementation in the project development process.

PEER EXCHANGE SUMMARY

The Data-Driven Safety Analysis (DDSA) peer exchange included 30 States and over 150 participants from various disciplines including planning and programming, environment, design, traffic operations, and safety. States were selected based on two criteria: States were either a Highway Safety Manual (HSM) Pooled Fund State or a State that uses quantitative safety analysis in project development. A complete list of the attendees can be found in Appendix A.

The purpose of the peer exchange was to showcase States' progress in implementing DDSA; share leading practices that use the Highway Safety Manual (HSM) for planning, design, and operations; and develop an Action Plan to guide States' future DDSA activities once Every Day Counts, Round Four (EDC-4) concludes. The peer exchange included a variety of sessions such as plenary sessions, concurrent breakout sessions that included presentations and facilitated discussion, safety analysis tool demonstrations, road-mapping activities to develop State Action Plans, and an HSM implementation pooled fund meeting. The topics were identified by potential participants during a planning call and the speakers were identified by a core team based on their knowledge of current practices and calls with Federal Highway Administration (FHWA) Division Offices and State Departments of Transportation (DOTs).

On the first day of the peer exchange, FHWA, State DOTs, and contractors provided plenary sessions on DDSA fundamentals and the HSM. Morning breakout sessions covered safety performance in planning and programming, performance-based practical design (PBPD) and analysis of design exceptions, and intersection control evaluation (ICE). The afternoon breakout sessions discussed safety analysis in environmental review, using crash modification factors (CMFs) and developing CMF lists, and safety performance of Transportation System Management and Operations (TSMO) strategies.

Plenary sessions on the second day addressed scale and scope of safety analysis in the project development process; strategies for incorporating operational, environmental, and user costs in highway safety benefit cost analysis (BCA); and a State's perspective on design-build projects to identify and implement safety treatments. Afternoon sessions included breakout sessions on network screening, hotspot and systemic safety analysis, quantifying safety impacts in freeway projects, and safety data and analysis tool demonstrations.

On the final day, there was a plenary session on Washington State DOT's approach to safety analysis with implementation and integration of DDSA. This was followed by a breakout session for States to compile their notes and begin developing Action Plans. Finally, all peer exchange participants were invited to attend the afternoon HSM Implementation Pooled Fund Meeting.

The complete agenda can be found in Appendix B. The following section provides detailed notes from the peer exchange. Copies of all presentations are available for download on the FHWA DDSA website.

PEER EXCHANGE NOTES

DAY 1: TUESDAY, JULY 10

The first day of the Peer Exchange began with several plenary sessions focused on general introductions to the event and a review of the DDSA process and other fundamental safety analysis-related topics to establish a baseline of knowledge for the meeting. The afternoon included two breakout sessions, each with three concurrent presentations.

Welcome, Objectives, Introductions and Housekeeping

Mr. Jerry Roche, FHWA Office of Safety, opened the peer exchange with a general welcome and led a round of introductions of State representatives, FHWA representatives (i.e., Division Offices, Resource Center, Turner Fairbanks, and Headquarters), and the Peer Exchange Team (Applied Research Associates [ARA] and VHB).

Mr. Roche spoke to participants on the two main objectives of the peer exchange:

- To share leading practices of DDSA throughout project development.
- To develop an Action Plan to guide States' future DDSA activities once Every Day Counts- 4 (EDC-4) concludes.

Data-Driven Safety Analysis in the Project Development Process: Overview of Safety Analysis in the Project Development Process

Jerry Roche, FHWA

Mr. Roche provided an overview of DDSA. He explained that agencies can apply the approach at all levels in the project development process. Using an example from New Jersey, Mr. Roche showed how the engineers gained public support for a roundabout as a safety solution during the alternatives identification and analysis phase. He also showed examples where engineers selected alternatives with safety components. Although the final decision did not have the highest safety benefit, it was still a factor in the selection process. DDSA can also be incorporated in the preliminary and final design phases, where engineers can use performance based practical design to make design decisions and assess the safety impacts of design exceptions. There are other opportunities to incorporate DDSA in the project development process, including construction, operations, maintenance, and performance management.

Mr. Roche also introduced several State scale and scope efforts, including Michigan, Ohio, Oregon, Virginia, Washington, and Wisconsin. Some of these States have related guides or manuals such as Oregon's *Analysis Procedures Manual*, Virginia's *Traffic Operations and Safety Analysis Manual*, and Washington's *Safety Analysis Guide*.

Fundamentals of Data-Driven Safety Analysis

Frank Gross, VHB

Dr. Frank Gross presented on how DDSA quantifies safety impacts to support or justify decisions. He discussed two different opportunities to quantify safety performance: safety performance functions (SPFs) and CMFs. The SPF is an equation to predict crashes based on exposure and the CMF is a factor that represents the relative change in crashes due to a change in design or traffic operations.

Discussion/Q&A

Following questions from the audience, Dr. Gross emphasized or clarified the following points:

1. The national value of a statistical life is $9,600,000 while the presentation discussed $11,200,000 as the value of a fatal cash. The variation is a result of the fatal crash including the cost of the fatality plus the cost of other injuries and property damage involved in the crash.
2. Dr. Gross clarified that the CMFs in the example apply to the same crash types and severities, so one needs to use comparable CMFs. CMFs can be divided into different categories, like property damage only (PDO) or crash severity to compare dollar benefits. The dollar value of benefits can be combined for a final benefit-cost (B/C) ratio.

Leading Practices in the Use of the HSM-AASHTO Domestic Scan 16-01

Scan Team Members David Duncan, Tennessee Department of Transportation (TDOT); Dennis Emidy, Maine DOT (MaineDOT); Samuel Sturtz, Iowa DOT (Iowa DOT); Mike Vaughn, Kentucky Transportation Cabinet (KYTC)

The Domestic Scan 16-01 team evaluated how leading States/agencies have incorporated the HSM in planning, design, and operations. The Scan Team met with 10 "Lead States" implementing aspects of the HSM (AL, FL, IL, LA, ME, MI, MO, OH, VA, and WA). The team is going to conferences/meetings to give updates and is working on a final report for the end of 2018. Their goal is to get other State to adopt the HSM into everyday work experiences. The presentation covered seven key areas of interest: status and policy, cultural shifts, training, information dissemination, technical functions, data, and achieving performance.

Discussion/Q&A

Following the presentation, panel members provided time for questions and discussion. There were several key takeaways highlighted after the presentations and discussion. The following is a summary of the discussions by topic:

1. **How States quantify benefits related to safety target setting and linking to safety performance target setting.** Panel members acknowledge this was a topic that arose during the project and emphasized the importance of using trend lines to communicate

that change will occur over time. This is most useful when defending targets with executive level staff, specifically in zero-deaths States.

2. **How States quantify pavement preservation projects to demonstrate safety targets.** The panel noted that using Federal pavement preservation funds is a balancing act as not every project will need new improvements. Panel members stated that while there are CMFs for micro-surface projects, they are not all of the same quality. Practitioners will look to asset management and pavement management systems for better resources. Not every project needs a full HSM analysis but can include elements within the project.
3. **How agencies communicate in-house cultural shifts with consultants.** The panel noted that some States have successfully required consultants to take HSM training by incorporating the requirements into contracts. Additionally, States have advertised the training prior to proposal submission deadlines to allow consultants the time to take the training.

Highway Safety Manual 2nd Edition (HSM2)…what will it do?

Karen Dixon, Transportation Research Board (TRB) Highway Safety Performance Committee (ANB25)

Ms. Karen Dixon spoke about the revisions for HSM2 which will include redoing some chapters and updating all chapters. She also discussed several pending National Cooperative Highway Research Program (NCHRP) projects, pending American Association of State Highway and Transportation Officials (AASHTO) vetting for the bicycle and pedestrian chapter and noted the earliest that this would be available is 2020.

Discussion/Q&A

Following the presentation, there was robust discussion among the peer exchange participants. There were several key takeaways highlighted after the presentations and discussion. The following is a summary of the discussions by topic:

1. **New or updated categories.** In regard to urban and suburban, Ms. Dixon observed that crash experiences in these areas are still lower than other facilities, but this is something that is on the radar.
2. **Ongoing research on the relationship between the HSM and Highway Capacity Manual (HCM).** Ms. Dixon said there is no research currently on this topic, but people from the HCM community are on the HSM review committee, which is helping them learn from these two experiences. There was a comment that the HSM will help to bring safety to equal weight with operational and environmental considerations (e.g., the National Environmental Policy Act (NEPA) process could include results of safety analysis).
3. **Bicycle and pedestrian data collection.** Ms. Dixon said that the main limitation with data collection on bicycles and pedestrians is that many DOTs do not have this data in their database, so they do not have the exposure data needed to develop SPFs. The two SPFs they would like to develop would be for network screening and design. They are,

however, considering connecting pedestrian and bicycle exposure to annual average daily traffic (AADT) and looking at land use which is promising, particularly for bicycles. She also mentioned that some cities are trying to acquire information on bicycle and pedestrian volumes, which will be helpful in using the related HSM2 predictive methods.

CONCURRENT BREAKOUT SESSION 1

Participants could select from three concurrent sessions: Safety Performance in Planning and Programming (presentations), Analyzing Design Exceptions and PBPD (presentations), and ICE (panel discussion). States were encouraged to spread their representatives across the sessions and share the key takeaways during the Action Planning session on Day 3. The following sections provide brief summaries of the presentations, participant questions, and facilitated discussion.

1a: Safety Performance in Planning and Programming

Moderator: Nick Fortey, FHWA, Oregon Division Office
Types of Planning Activities – R.J. Porter, VHB
Safety Scoring for Project Prioritization in North Carolina – Brian Murphy, North Carolina DOT (NCDOT)
Kentucky Planning-Level CMFs – Mike Vaughn, KYTC
Facilitator: R.J. Porter, VHB

Summary

This session explored opportunities to incorporate DDSA into transportation planning and programming. Discussions covered practical applications for a range of planning activities as well as future needs.

Dr. R.J. Porter began the session by providing a high-level overview of the following topics:

- General activities of transportation planning.
- Primary products of planning activities.
- Coordinated transportation safety planning.
- Planning activities that are part of carrying out the Highway Safety Improvement Program (HSIP).

Dr. Porter then raised the topic of opportunities to incorporate DDSA into all planning activities, not only those that are part of the HSIP. He asked the States in attendance if any incorporated DDSA into all projects, even if the projects are not driven by a safety need. A few (3-4) States raised their hands. With that, he introduced Mr. Brian Murphy from North Carolina DOT (NCDOT).

Mr. Murphy provided an overview of North Carolina's Strategic Transportation Investments (STI), with a focus on where safety fits into project scoring criteria and weights. The STI has three project categories:

- Statewide mobility, addressing significant congestion and bottlenecks.
- Regional impact, improving connectivity within regions.
- Division needs, addressing local needs.

Both existing safety performance and safety benefits of a project are part of a project's score in each of these three categories. To quantify the safety benefits of a project, NCDOT has developed "Safety Benefit Factors" (SBFs), similar to what a couple of other States call "planning-level CMFs." The purpose of SBFs is to describe the safety benefit of projects within a reasonable number of improvement type categories, understanding that most projects are project concepts with few details at the time that SBFs are applied and projects are scored. Mr. Murphy then described NCDOT's process for developing and updating SBFs and presented an example application.

Mr. Mike Vaughn, KYTC, built on Mr. Murphy's discussion by providing background on Kentucky's efforts to develop "planning-level CMFs." Mr. Vaughn noted that they had adapted the idea from NCDOT, and originally utilized NCDOT's SBFs prior to creating their own Kentucky-specific, planning-level CMFs. Mr. Vaughn provided background and an overview of the Kentucky Strategic Highway Investment Formula for Tomorrow (SHIFT), including the SHIFT formula's five components (safety performance, congestion, economic growth, asset management, and B/C as well as the SHIFT safety benefit formula. He then covered recent efforts in Kentucky to improve SHIFT with the development of planning-level CMFs. Kentucky's planning-level CMF list currently includes 70+ project types; SHIFT 2018 incorporated 22 project types. Automating the linkage of the planning-level CMFs to the thousands of potential projects in their database is a main challenge that they continue to work on in steps. Mr. Vaughn also noted that the planning-level CMFs will have applications beyond project prioritization, including planning studies, preliminary engineering, and evaluation of operations/maintenance improvements.

Dr. Porter then concluded the presentations with a brief overview of potential DDSA opportunities in scenario planning, including the potential role of macro-level safety models and the potential role of crash predictions as part of traffic assignment in travel demand models.

Discussion/Q&A

There were several key takeaways highlighted during the facilitated open discussion that followed the presentations. The following is a summary of the discussions by topic:

1. **Safety data collection and analysis for prioritization.** One discussion topic focused on who within the State DOT receives and analyzes the crash data as part of project prioritization, particularly for those projects that are not part of the HSIP. Two different approaches came up. In one case, the planning/prioritization group within the DOT was responsible for requesting, receiving, and analyzing the crash data for prioritization. One identified challenge of this approach was the potential lack of expertise in managing and analyzing crash data within this group. In another case, the safety team within the DOT conducted all of the safety data preparation and analysis and fed the results to the

planning/prioritization team. Other points raised by the audience regarding DDSA practices in project prioritization included the following:

a. The need to automate the process, likely in some type of GIS-based framework.
b. Carefully documenting the support for SBFs or planning-level CMFs. The numbers are likely to be challenged during prioritization by different stakeholders representing different interests.

2. **Practices in allocating HSIP funds.** A significant portion of the discussion time was spent discussing allocation of HSIP funds, including geographically (e.g., across districts), by Strategic Highway Safety Plan (SHSP) focus area, and to Metropolitan Planning Organizations (MPOs) and local agencies. Practices varied with respect to allocation based on reactive versus proactive approaches. A couple of States with experience making systemic safety investments agreed that they may be reaching a point of diminishing returns with respect to systemic treatments. One State noted a practice of developing SPFs for specific crash and facility types that make up a significant proportion of their annual fatalities (e.g., run-off-road crashes on 50mph+ rural, two-lane roads), automating the process of updating those SPFs each year with new data, and using the SPFs to identify sites with promise. A final related point focused on the challenge of making investments based on expected crashes versus observed crashes (e.g., it has been hard to convince people to spend money on the 5-crash location versus the 15-crash location, even if the former has a higher longer term "expected" number). Several other States agreed, noting that observed crashes are still playing a significant role in project selection even with the general understanding that expected crashes could be a more informative measure. If data on observed crashes are lagged, a State could find themselves investing in a location where the "issue" based on observed crashes is no longer evident by the time of the project.

   Practices also varied with respect to allocations of HSIP funds to local agencies and the process for doing so. One State described an interesting experience and resulting process where the State decided to distribute HSIP funds to Councils of Governments (COGs) and MPOs to spend. In the first few years, projects picked by these agencies were limited to signage and striping projects. There were not enough funds going to larger projects. The process was revised and the COGs and MPOs now develop safety plans with HSIP funds to guide future investments. With this new focus and strategic approach, 60 percent of the safety funds are going to local agencies. While funds are going to locals, the State still delivers the projects.

   The discussion then switched to practices of setting minimum project amounts and project caps. At least one State has a practice of setting a minimum project amount. Several States set maximum project amounts as a function of predicted return on investment. On a related note, one State offered that HSIP funds are not available for projects showing a predicted B/C ratio less than one. Discussion noted a research need to go back and "close the loop" on actual return on investment over time.

3. **Links between DDSA, SHSPs, and Statewide long-range transportation planning.** The discussion concluded with some brief thoughts on how there must be some more

opportunities for States to improve their practices when it comes to coordination between safety planning and long-range transportation planning. The audience suggested a couple of preliminary ideas, including incorporation of safety processes and safety accomplishments into stakeholder outreach materials and meetings that are a key part of long-range planning and having long-range plans and SHSPs mirror each other in terms of links between priorities as well as overall look and feel.

1b: Analyzing Design Exceptions and Performance-Based Practical Design

Moderator: Don Peterson, FHWA, Washington Division Office
Performance-Based Design at Louisiana DOT and Development (LaDOTD) – Chad Winchester, LaDOTD
Utah's effort to Assess Safety Performance of Design Exceptions – W. Scott Jones, Utah DOT (UDOT)
Performance-based Design and Design Analysis at Washington State DOT (WSDOT) – John Tevis, WSDOT
Facilitator: Elizabeth Hilton, FHWA, Texas Division Office

Summary

This session focused on analysis of safety performance as part of PBPD. Opening discussions included a brief overview of PBPD in the U.S., future directions of geometric design policies, and State experiences. Presenters in this section noted that PBPD is important because it helps to remove the stigma associated with design exceptions. They also noted the importance of emphasizing that the documented design exceptions are the result of an analytical process.

Mr. Chad Winchester of Louisiana Department of Transportation and Development (LaDOTD) presented on Performance-Based Design at LaDOTD. He discussed the history of performance-based design, mentioned briefly above in the overview, discussed a history of Louisiana's practices of PBPD beginning in 2011, and discussed an LaDOTD three bridge study that evaluated the differences of implementing a "practical design" versus a typical design. The practical designs matched the existing conditions (where possible), and comparative designs met design standards. Results illustrated the potential for a 30-pereent savings by implementing practical design, which could translate to replacing one extra bridge for every three projects.

Mr. W. Scott Jones, Utah DOT (UDOT), spoke about UDOT's experience with PBPD. Notable characteristics of UDOT's design exception includes the following:

- Required when the design deviates from UDOT standards.
- Based on a data-driven engineering and safety analysis.
- Rigorous review/approval process.
- Approved on a case-by-case basis.

Mr. Jones discussed the UDOT design exception process and a study conducted in 2013 about these design exceptions and their impact on safety. The study examined 13 exceptions to design criteria, including design speed; lane, shoulder, and bridge widths; grade; superelevation; and vertical clearance. The primary findings found no significant differences in crash frequency or in crash severity distributions, thus validating UDOT's design exception review and approval process. Similar studies from Indiana and Kentucky yielded similar results.

Mr. John Tevis of Washington State DOT (WSDOT) presented on a safety analysis for design exceptions. WSDOT provides Safety Analysis Guidance for both projects (preservation, improvement and traffic operations) and reports (interchange access requests, environmental reports, traffic impact analysis, ICE, work zones, and design exceptions). There are multiple reasons for including safety analysis in design exception reports. First, if the underlying reason for the project is based on the potential for safety improvement (e.g., higher than expected fatal and/or serious injury crashes), then design exceptions related to the project must include a safety analysis and WSDOT documents how the design element affects safety performance. Second, if the options considered for the design exception are expected to impact safety performance, then the design exception report must include a safety analysis. In this case, WSDOT compares the safety performance to determine the preferred option. The Design Exception report includes the following:

1. Signature cover sheet.
2. Background, including if safety triggered the project and the contributing factors of the crashes.
3. Design element description.
4. Design criteria description.
5. Option evaluation, including safety performance, metric and performance (e.g., five crashes per year), and performance tradeoffs.
6. Preferred option, with safety reasons and safety trade-off mitigation.
7. Appendices, such as crashes, HSM Predictive Method Input and Output Sheets, CFMS.

Discussion/Q&A

Following the presentations, the floor opened for discussion. There were several key takeaways highlighted after the presentations and discussion. The following is a summary of the discussions by topic:

1. **How to address design exceptions and design deviations.** LaDOTD requires documentation if there are deviations from a standard. There have been many design exceptions since implementing this approach, which they feel is a good thing. The exceptions will be defended if they are documented. A participant State noted their experience with design exceptions and expressed the need for LaDOTD's policy. LaDOTD noted the national guidance is a helpful resource for practitioners in that it explicitly states a design exception is not violating a policy.
2. **Impacts to project development and cost.** LaDOTD explained that while there is some initial effort in documentation, there has been minimal extra effort and they do not view the process as a burden.
3. **In regard to WSDOT's presentation, explain the wording choice of the following statement: why we can't or shouldn't follow the Design Manual Criteria?'** WSDOT responded that there are situations where practitioners cannot meet the criteria but

there are also situations where the solution may work better for traffic and safety but still deviates from the design policy.

4. **How and where does the NEPA process fit into the design process.** WSDOT responded that design criteria are a range, so it must be documented regardless of a design exception and can occur pre-NEPA with revisions later in the process. They are not alternatives but rather options within the context and is only a factor during an Environmental Impact Statement. WSDOT also develops one alternative that meets criteria in order to quantify safety performance.
5. **Does the HSM process specify for both the design and the "meet criteria" condition? Does the HSM process require a BCA?** In Washington, the condition does not require a BCA but could if needed. WSDOT calculates costs but does not add it in in every case.
6. **In Washington, which CMFs require approval, and which do not?** WSDOT created a standard list of statewide approved CMFs. If a situation exists where there is no standard CMF, a CMF can be added, but it must be approved.
7. **The role of DDSA in other State's design exception process.** Florida DOT (FDOT) uses historical data due to the lack of research on controlling elements such as low speed, urban, and suburban facilities. They primarily apply the HSM on freeways.
8. **The relationship between HSM and design exception.** The HSM role is to help identify a base calculation for a site (segment or intersection) and the expected average crash frequency. States can compare historic data to the value. However, States should recognize there are situations that do not fit HSM models. States should balance the context and other needs of the project with the safety component.
9. **Challenges and successes related to PBPD for planning level or system performance needs.**
    a. Kansas DOT uses HSM more in 1R and 3R projects and they are encouraging more collaboration between traffic and design offices with the planning level staff to improve efforts.
    b. Montana DOT (MTDOT) is using SPFs to develop higher level tools for executive staff to use in planning. They are finding that the more this occurs, the more they can leverage HSIP funding.
10. **Future research needs.**
    a. Explore speed limits (35 and 50 mph) on urban and suburban streets and managing speeds at cross sections through transition areas.
    b. Sharing the road between trucks with large turning movements and non-motorized users.
    c. How and what vehicle technologies will compensate for driver limitations?
    d. Address how to develop HSM analyses for situations that do not fit the HSM model.
    e. Build on previous studies that found few safety differences in urban and suburban arterials to understand the traffic impacts associated with managed lanes on freeways.

1c: Intersection Control Evaluation

Moderator: Millie Hayes, FHWA, Texas Division Office
Panel Discussion on ICE Policies: Brian Porter, Wisconsin DOT (WisDOT); Dirk Schmidt, Indiana DOT (INDOT); Alan El-Urfali, FDOT; David Adams, Georgia DOT (GDOT)
Facilitator: Kara Peach, VHB

Summary

This session covered experiences and future opportunities in developing and implementing ICE policies and procedures. States reviewed their existing ICE policies and provided insight for States currently assessing ICE policies. Mr. Brian Porter presented on Wisconsin DOT's (WisDOT) ICE process. He provided an overview of their history, process overview, successes, challenges, and what they hope to do in the future with ICE. Mr. Dirk Schmidt presented on Indiana's ICE process. Mr. Schmidt discussed the need for ICE in Indiana and noted that because of ICE there is a greater awareness of alternative/innovative intersections, leading to an agreement on a decision-making process for this purpose. Mr. Schmidt also made it clear that in Indiana, they also refer to ICE as the Intersection Decision Guide. Mr. Alan El-Urfali, FDOT, discussed Florida's approach with ICE. Like the other States, there was a two-step process that FDOT used. However, FDOT is new in their approach to ICE. This year [2018] they are beginning training and acclimation, in 2019 they hope to have districts identify and conduct ICE analysis for additional locations, and in 2020 FDOT hopes to see a full ICE procedure implementation by districts. Mr. David Adams, GDOT, shared a similar challenge to Indiana on the lack of non-traditional alternatives, so in 2013 they began to seek to implement ICE. In July of 2017 the ICE policy became effective.

Concluding the panel presentations, the following key takeaways were concluded:

1. The best way to develop an ICE policy is to look to other States' best practices, especially neighboring States.
2. There is no one process for developing an ICE policy. Each panel State used a different process based on their agency's context and organization.
3. Although they used different processes, the general format of the policies is the same. ICE policies from the four panel States follow a two-step process that is flexible.
4. Buy-in from upper management is essential to developing an ICE policy. Documentation and sample policies are both helpful in the discussion with executives.
5. The ICE policy will take time to implement following development and approval.
6. The ICE policy will also need enough 'teeth' to be effective, but enough flexibility to be practical.
7. States should understand that the ICE policy is a living document and will require updates over time.

Discussion/Q&A

Ms. Kara Peach, the facilitator for this session, gave a quick overview on behalf of the Texas DOT (TxDOT) on the ICE peer exchange in Denver earlier in the summer for western States. Ms. Peach said that States got together to develop actions of how to develop and implement ICE policies within their States. This information will be coming out soon or interested States can contact Mr. Jeff Shaw (FHWA) or Dr. Porter (VHB) for more information.

Following the presentations, the floor opened for discussion. There were several key takeaways highlighted after the presentations and discussion. The following is a summary of the discussions by topic:

1. **Using waiver concepts.** GDOT has several reasons for a waiver and provided two examples. First, converting an undivided road to a median would justify a waiver for the corridor. Another case would be if three possible design options advance, but local posture opposes one alternative. This could justify a waiver, assuming it still justifies safety funds. FDOT does not use waivers.
2. **The ICE policy approval process.** In Georgia, a State engineer approves the document. Wisconsin does not have an approval process. Instead, they use more of a concurrence process. Indiana DOT's (INDOT) approval process happens in the project proposal phase (at the district level), so a district may sign off on the project, but there is no central office approval needed. FDOT has an approval process where they document on forms and district engineers sign off on the selected design.
3. **Issues associated with gaps resulting from roundabout corridors.** INDOT does not look at corridors as part of ICE policy. FDOT has an ICE process for isolated intersections; however, they are looking to corridor analysis in the future. Wisconsin has many roundabouts with corridors, so this has been a concern, but there is not solid evidence. There may be a need for appropriate wayfinding guidance through roundabouts on corridors.
4. **Appropriate projects for the ICE process?** GDOT requires ICE on all Federally-funded projects (State roads) and the policy is optional for anything off-system. GDOT encourages ICE when they work with their local partners but does not require the policy for locally-funded projects. WisDOT requires ICE on all federally-funded projects and encourages use of ICE on other projects. INDOT's ICE policy applies to all projects, but it does not replace typical scoping analysis. FDOT requires ICE on State systems and encourages its use on local systems.
5. **Integrating ICE policies with the TSMO process.** FDOT does not integrate unless there is a change in the traffic control. They work very closely with the TSMO office, who is fully aware of the ICE process. Indiana does not have an interaction with TSMO and ICE. WisDOT does not have an interaction with TSMO and ICE. TSMO in Wisconsin has a separate pool of funds; therefore, the two are separate. GDOT does have some interaction with TSMO because they have been involved in a working group.
6. **Weighting projects based on funding or safety.** GDOT's ICE tools standardize weighting, so it is not a funding source issue anymore. WisDOT initially developed a

policy for reconstructions, but this has since changed. INDOT does not consider the funding source for a preferred alternative, and the funding source comes after. FDOT does not tailor projects for HSIP funds.

7. **Impact of the ICE policy on fatal/serious injury crashes.** Data is not yet available on the results in FDOT, but it is critical to setup a system to track progress. INDOT implemented their ICE policy in 2014, so most projects impacted by ICE would be built in 2019. WisDOT has implemented several roundabouts as part of the ICE process, and many of these have seen a large reduction (40-50 percent) in fatal/injury crashes.
8. **Defining context zones.** FDOT established context zones based on land uses and the context surrounding the roadway, particularly the function of many factors rather than just population driven.
9. **Resources for developing ICE policies.** Panel States responded that it was helpful to look to neighboring States. WisDOT used Minnesota as an example and FDOT looked to Pennsylvania, among other States.
10. **Building interest in the policy from their agency.** INDOT noted the State Traffic Engineer was critical for their team. And, a sample policy was useful for gaining buy-in from executive level staff. Discussions around implementing roundabouts was the catalyst for the policy in Wisconsin. FDOT conducted a peer exchange, where Traffic Operations were nominated to lead the ICE process. Other key partners in FDOT's process include Planning and Design.
11. **Future research needs.**
    a. Explore if corridors of roundabouts create an issue related to lack of gaps.
    b. Develop tools and flexibility to add new alternative designs to current evaluation processes.

CONCURRENT BREAKOUT SESSION 2

Peer exchange participants could select from three concurrent sessions: Safety Analysis in Environmental Review (panel discussion), Using CMFs and Developing CMF Lists (presentations), and Safety Performance of Transportation System Management and Operations (TSMO) Strategies (presentations). States were encouraged to spread their representatives across the sessions and share the key takeaways during the Action Planning session on Day 3. The following sections provide brief summaries of the presentations, participant questions, and facilitated discussion.

2a: Safety Analysis in Environmental Review

Moderator: Rick Drumm, FHWA, Indiana Division Office
Colorado's Efforts – Matt Jagow, Colorado DOT (CDOT)
North Carolina's Efforts – Brian Murphy, NCDOT
Facilitator: Emeka Ezekwemba, FHWA, Colorado Division Office

Summary

This purpose of this session was to discuss opportunities to consider quantitative safety in the environmental review process, including opportunities to tie the level of safety analysis to the level of environmental review. It also addressed existing policies and considerations for developing a related policy.

Mr. Matt Jagow from Colorado DOT (CDOT) presented on a Planning and Environmental Linkage study conducted on I-25, an important corridor that connects two major metropolitan areas with heavy congestion and impacts to businesses, residents, and recreational opportunities. CDOT selected the collaborative and integrated approach to transportation decision-making approach to engage with those impacted on the corridor and to identify significant environmental constraints. The project purpose and need included safety in terms of improving vehicular safety, wildlife-vehicle collisions, and incident response.

Mr. Brian Murphy presented on how NCDOT is incorporating safety in the NEPA planning process. Safety is considered during project scoping and alternative screening, with other opportunities to address the topic during public involvement, permitting agency meetings, and specific design concerns. Scoping is an opportunity to conduct detailed crash analysis and mapping to identify crash patterns the project should address. Safety can be evaluated during alternatives analysis, using predictive analysis and SPFs to estimate an existing or proposed roadway's expected safety performance based on crash, roadway, and traffic volumes.

The remainder of the time was allotted for a panel discussion with open conversation. The key takeaway from the session is that both panel members and participants believe the term safety is too generic to have any value if not clearly defined in a purpose and need statement. To

further the field, States and FHWA are looking for examples of projects that successfully include safety performance in their purpose and need statement. Additionally, from an environmental standpoint, animal and wildlife crashes are an essential issue to NEPA-related projects; however, other safety-related data analysis typically excludes animal data. There is also a need for potential research on effective wildlife countermeasures. Finally, States discussed working with consultants on large-scale NEPA projects. Some States are requiring more training or a more stringent pre-qualification process.

Discussion/Q&A

There were several key takeaways highlighted after the presentations and discussion. The following is a summary of the discussions by topic:

1. **Defining and including safety in environmental documents.** Panel members and participants agreed that safety is frequently defined differently, depending on the agency and situation. In order to be useful in NEPA purpose and need statements, the group agreed that the definition should refer to safety performance and be very specific, such as including the number of fatal and serious injury crashes. These terms emphasize the seriousness of the crashes but can also highlight counterintuitive situations where sideswipe and rear end crashes may increase, it is not as concerning. However, this is a difficult message to convey to the public. In other cases, it is helpful to examine both serious and non-serious crashes. For example, a corridor project may not have fatal or serious injury crashes but would benefit from systemic and low-cost improvements.
2. **Addressing wildlife crashes in safety analysis and environmental documents.** NCDOT excludes animal crashes in the HSIP program and they do not have low-cost countermeasures to address those. However, because of the environmental focus of NEPA projects, NCDOT provides animal structures (fencing) when warranted. CDOT considers wildlife in HSIP because it is one the most frequent crash types in the State. Decisions to include are on a case by case basis and evaluated by balancing available resources, funding, purpose, and need. CDOT is experienced with installing deer fencing and developed a CMF based on their experiences and past research. They have a standard process to evaluate effectiveness after project implementation, which helps to identify countermeasures that were not successful, like deer-activated warning lights. The expected CMF was 20 percent, but there was an increase of 5 to 10 percent. One reason for the unexpected increase in deer crashes included the location of the system (i.e., the crossing was not in the prime location to match the actual migration patterns). There were also inherent issues with this treatment. CDOT was unable to see the actual data because the animal factors are so unreliable. The detectors worked, but deer do not cross where you want them to cross. Another issue arose when it was not possible to use the countermeasure in some of the areas that should have been prime. CDOT started to pull the systems and is looking at the over/under pass to help with migration patterns in the area.

3. **Connecting safety analysis to the HSM.** CDOT presented on TSMO and its evaluation, which they are trying to incorporate into PELs and NEPA documents, safety analysis, and Intelligent Transportation System (ITS). This is becoming a standard practice for inhouse and it is a good guidance for consultants to be able to follow. As a follow up, someone asked CDOT if they do safety analysis for Categorical Exclusion (CE) projects. In referencing back to the TSMO evaluation that has a three-part section, the project manager will send consultants a form and CDOT answers basic questions in safety analysis and the project managers make recommendations to implement safety items to include in the document. If the project manager cannot fit something in, they must document why, retain that information, and consider it in the future. In regard to including wildlife crashes in the HSM, a participant noted that total number of animal crashes need to be separate and then run the model separately. HSM predictive modeling and calibration will not complete this step.
4. **Providing consultants guidance for including safety analysis in environmental documents.** NCDOT uses a prequalification process for safety data that is very involved where consultants must do testing for crash analysis and be familiar with the statewide data. Every State has processes for addressing safety and collecting/managing data, so consultants must have the understanding to effectively complete the work. CDOT balances between consultants and inhouse staff depending on the nature of the project. For example, they hired consultants for the I-25 project because the project covered two regions and they did not have staff in-house to do that type of large-scale analysis. However, the two regions were involved in the project, collaborating in the proposal review process and in the early phases of the project. CDOT uses resources at headquarters to help with safety analysis for smaller scale projects. They do not have a scoring system, instead in-house staff review the consultant's work. Currently, they are lacking staff who can help with modeling, so they are working on creating more training. CDOT wants to bring more in-house so they do not have to rely so heavily on consultants. FDOT provides consultants training, which is available online and introduces the HSM, but it is not a prequalification requirement.
5. **Future research needs.**
    a. Develop a synthesis of sample purpose and need statements and safety performance. FHWA is requesting examples of projects that are in the public information process or beyond. Statements must be specific in order to be measurable.
    b. Develop training materials for both consultants and in-house staff. WSDOT has developed training materials on related topics that they would be willing to share as examples.
    c. Explore the issue of wildlife crossings:
        i. Identify examples of States effectively using wildlife crossings as factors in the alternatives.
        ii. Develop CMFs for wildlife countermeasures. Follow up with partners who have explored the issue, such as Iowa State University Local Technical Assistance Program (LTAP) (deercrash.org) or TRB committees.

2b: Using Crash Modification Factors (CMF) and Developing CMF Lists

Moderator: John McFadden, FHWA
Pennsylvania's Efforts – Jason Hershock, Pennsylvania DOT (PennDOT)
Utah's Efforts – Scott Jones, UDOT
Washington's Efforts – John Tevis, WSDOT
Facilitator: Frank Gross, VHB

Summary

This session discussed the application of CMFs in the project development process, focusing on the opportunities and challenges related to developing a standardized CMF list. Speakers from Pennsylvania, Utah, and Washington discussed their efforts to develop and use a standardized CMF list and how to accommodate strategies that are not on the list.

Mr. Jason Hershock, Pennsylvania DOT (PennDOT), presented first on Pennsylvania's efforts. PennDOT first partnered with the Pennsylvania State University to develop the *Pennsylvania CMF Guide* in 2014. This guide provides a standardized list of high-quality CMFs appropriate for use in Pennsylvania based on data obtained mainly from the FHWA CMF Clearinghouse; there were no new CMFs developed based on Pennsylvania-specific data and only CMFs with 3+ stars were considered. PennDOT then hired a consultant in 2016 to develop the *CMF Practitioner's Guide*, which establishes a consistent approach to the application of CMFs within the context of the HSM and the related PennDOT analysis tools. The CMFs were categorized into 19 tables with information on their applicability. Mr. Hershock indicated the following as pros of a standardized list:

- Uniform Statewide list of part D CMFs.
- Can be printed and used as a book.
- Used to develop consistent results in PennDOT's HSM analysis tool.
- Shows higher quality CMFs (3 stars or higher).
- Shows CMFs that used Pennsylvania data.

He then identified the following as cons of a standardized list:

- Outdated once it was published because the FHWA CMF Clearinghouse is always being updated.
- Not web based and as easy to access.
- Not as easy to use as CMF Clearinghouse.
- Does not include the CMF ID numbers.
- Harder to reference more information about the CMF(s) selected.
- Expensive to develop.
- Includes some CMFs that are not used in PA.

Mr. Scott Jones, UDOT, presented next on Utah's efforts. UDOT has been using CMFs since the 1990's when they borrowed research from Texas. Then, in the 2000's they borrowed research from Kentucky, and finally, in the 2010's, they moved to CMF publications. Mr. Jones indicated that common challenges to using the CMF Clearinghouse include the large number of CMFs for some countermeasures (e.g., hundreds of CMFs when searching for "rumble") and the constant updates to the CMF Clearinghouse. There is a need for a consistent process when applying CMFs so projects can be compared equally when applying for funding. To develop a standardized CMF list, UDOT employs the following steps annually:

1. Review current CMF list
    a. Check references
    b. Look at source reliability
    c. Review research for selected studies
2. Remove outdated CMFs
3. Add CMFs that have become a focus
4. Simplify application for automation purposes
5. Republish new CMF list

Finally, Mr. John Tevis, WSDOT, presented on Washington's efforts to develop a standardized CMF list. He noted that the CMF Short List is not intended to replace the CMF Clearinghouse. Instead, it is meant to provide the vital few CMFs most needed by analysts. This helps to reduce the amount of time needed for analysts to identify and select an appropriate and approved CMF. Mr. Tevis listed the following as the four key considerations for CMFs used at WSDOT:

1. Quality of the research
2. Context of the treatment
3. Target crash type & crash severity
4. Quality, statistically significant, countermeasures

Discussion/Q&A

There were several key takeaways highlighted after the presentations and discussion. The following is a summary of the discussions by topic:

1. **Required level of effort to develop a standardized CMF list.?** The responses ranged from minor to major. PennDOT included a large number of CMFs and partnered with a university to develop the list, so this became a large effort. UDOT noted that it has been a light effort because it was done internally and is an ongoing effort. A participant added that their state recommended CMFs while developing SPFs for all road types.
2. **How many CMFs to include in a standardized CMF lists.** The lists do not need to be comprehensive. Instead, an agency can develop a standardized CMF list that focus on the most common countermeasures used in their jurisdiction. PennDOT included more than 1,000 CMFs in their CMF Guide, but reduced the number to approximately 100 for their related tool. UDOT has 38 unique CMFs on their list, including 15 for intersection

countermeasures and 23 for segment-related countermeasures. WSDOT has 45 CMFs available on their CMF Short List.

3. **How to document decisions.** WSDOT documents every CMF chosen for the Short List on a CMF Review Form in detail along with the reasons for choosing that particular CMF. The WSDOT CMF Short List and the CMF Review Form for each CMF are available to staff on the WSDOT Intranet.
4. **What to include in the CMF list.**
    a. Mr. Hershock, PennDOT, noted the importance of including the CMF ID number in the documentation as that helps to reference the original CMF if there is a need to go back and review the applicability. He also noted that they include CMFs by crash type and severity where possible.
    b. WSDOT includes the following for each CMF in the list:
        i. CMF ID number
        ii. Countermeasure Title and Context
        iii. Crash Pattern/Type and Severity Affected
        iv. CMF and Standard Error
        v. Date Approved
        vi. Study Reference
        vii. Star Rating (Our users wanted to know)
        viii. Special Notes to help users further understand:
            1. The appropriate application of the CMF
            2. Circumstances where the CMF is not applicable
    c. Utah includes the following in the CMF list:
        i. Manner of Collision
        ii. Countermeasure
        iii. Crash Events Addressed
        iv. Service Years
        v. Unit
        vi. Unit Cost
        vii. Facility Characteristics
        viii. CMF by Crash Severity
        ix. Standard Error
        x. Reference Link
        xi. Comments
5. **What to do when a CMF is not on the list.** The speakers concurred that centralized approval is the common method for addressing CMFs not on the approved list. This helps to ensure that appropriate CMFs are selected and added to the list as needed.
    a. UDOT provides the following guidance to help analysts identify CMFs that are not on the standardized list: 1) use the CMF Clearinghouse to search for applicable CMFs and compare the available CMFs using Clearinghouse tools, 2) if a CMF is not found for the countermeasure of interest, consider other countermeasures that address similar crash characteristics, and 3) request UDOT approval.

   b. Mr. Tevis, WSDOT, noted that the HSM Part C predictive methods, with built in CMFs, meet the needs of most of our users. When the HSM Part C predictive methods do not meet users' needs, the CMF Short List meets most of their needs. If the Short List does not have a needed CMF, WSDOT helps users find an approved CMF in the CMF Clearinghouse and adds the CMF to the Short List.

6. **Are States using a weighted average of multiple CMFs rather than one CMF?** Two States responded that they have looked at the range of CMFs available to develop planning level CMFs. Another noted that you should check the underlying research to ensure the results apply to your state.
7. **Challenges to developing a standardized CMF list.** Potential challenges in developing a standardized CMF list include resources and data availability. This is a particular concern when trying to develop State-specific CMFs for the list. One possible solution to addressing limited resources is to partner with local universities. Specifically, graduate students may be looking for projects and can help to develop CMFs. Pooling data across States or agencies can help to overcome issues related to limited data. However, data from multiple States can increase the standard error of the CMF.
8. **Frequency of CMF list updates.** Mr. Hershock mentioned the PennDOT CMF Guide is outdated quickly because the CMF Clearinghouse changes rapidly. He said PennDOT is considering an update soon. PennDOT is going to have a symposium with several universities to discuss the options. PennDOT will also decide whether to duplicate the CMF Clearinghouse, depending on future updates to the CMF Clearinghouse. UDOT and WSDOT update their CMF lists on an ongoing basis as CMFs are requested that are not on the list.
9. **How to ensure consistent application of CMFs.** Mr. Jones, UDOT, identified two groups of analysts using CMFs for BCA. One is for prioritization of safety programs, which the safety staff performs. The second group is at the project level, which includes the development of an operational safety report through a B/C worksheet and use of approved CMFs. The safety group reviews all analyses to ensure consistency in analyses. Another state noted that they give extra weight to projects that have conducted HSM analyses when comparing projects for regional funds. Further, the project will be weighted even higher if they show they compared multiple options as part of the analysis.
10. **How many CMFs can be applied to estimate the combined effect of multiple countermeasures.** Mr. Jones, UDOT, indicated that they use a conservative approach and do not apply a CMF for the same group of crashes to different countermeasures. Even if the CMF applies to all cashes, they only apply the CMF to target crashes because UDOT prefers to use a conservative estimate of the benefits. For example, UDOT will look at CMFs for rumble strips and shoulder widening if they are part of the same project and will only use the CMF with the highest benefit, not both. Mr. Hershock commented that PennDOT will combine two CMFs in an analysis. Mr. Tevis said WSDOT requires approval for the combination of CMFs. Others noted that their agency use up to three CMFs in combination, but they check to make sure the analysis applies to the same crash types and severities.

11. **Appropriate service life for countermeasures.** UDOT obtained some information from the original Kentucky study that reported service life. They update the service life as needed. For some countermeasures, such as median cable barrier, they use a shorter lifespan to account for replacements within the service life (e.g., 7 years instead of 10).
12. **Exporting CMFs from the CMF Clearinghouse.** To export all CMFs from the CMF Clearinghouse, leave the keyword blank in the search field and click the search button. This can take a while to process, but once the entire list of CMFs is returned, you can export to a spreadsheet.
13. **Filtering CMF by State in the CMF Clearinghouse.** Mr. Tevis noted that WSDOT only filters international versus U.S. Dr. Gross noted that it is possible to leave the keyword blank, search for all CMFs, download the Excel file, and then filter by State in the Excel spreadsheet.
14. **Is there a CMF wish list?** Anyone can enter their desired CMFs through a feature on the CMF Clearinghouse. One person noted that this is not often a problem, but one example is CMFs for the presence of a sidewalk. They are hopeful that more pedestrian and bicycle research will lead to more related CMFs.
15. **Are States developing CMFs to replace CMFs in Part C of the HSM?** Mr. Hershock responded that PennDOT has adjustment factors for their SPFs by region, which shows that some factors have different relationships by region. He added that some factors have no impact on safety in some regions and some adjustment factors do not exist in total in some regions. Ohio also found that adjustment factors differ by SPFs across their State. There was some discussion of extending the Part C predictive methods to include additional CMFs. Specifically, it may be appropriate to apply external CMFs to Part C predictions, but users should be careful to make sure that the CMF fit the context and apply to the base conditions. Further, the CMFs for additional variables may have inter-relationships with adjustment factors included in the predictive method.
16. **Future research needs.** The discussion identified the following research needs.
    a. States need more guidance on when and how to apply CMFs to the HSM Part C Predictive Method.
    b. States need more information on disaggregate CMFs by crash type and severity; having only a CMF for total crashes may not be informative enough for economic analysis.
    c. States need more CMFs for pedestrian and bicycle countermeasures.

2c: Safety Performance of Transportation System Management and Operations (TSMO) Strategies

Moderator: John Broemmelsiek, FHWA, Louisiana Division Office
I-35E/US 67 Southern Gateway Project – Ashton Strong, TxDOT
I-25/US 36 Bus on Shoulder Feasibility Study – Guy Norris, CDOT
Safety Analysis Needs for TSMO and Noteworthy Practices – R.J. Porter, VHB
Facilitator: R.J. Porter, VHB

Summary

This session explored existing practices, capabilities, and future needs with respect to analyzing the safety performance impacts of TSMO strategies, including ITS, traffic operations and management, travel demand management, planning, and policy development.

Mr. John Broemmelsiek opened the session by pointing out that the presentations and discussion will be a good opportunity to identify what we know and do not know about safety performance impacts of TSMO. He noted that there may be some who are under the impression that we already know a lot more with certainty in this area than we do.

Ms. Ashton Strong, TxDOT, spoke about the I-35E/US 67 Southern Gateway project in Dallas, Texas. The purpose of the project is to relieve congestion, improve safety, improve area mobility, and improve system linkage. TxDOT is seeking to achieve this by changing the two general purpose lanes and one HOV lane in each direction to three general purpose lanes in each direction and one reversible, non-tolled managed express lane. Interchange ramp improvements are also part of the project. The project seeks to utilize existing infrastructure with no right-of-way impacts, identify design exceptions and mitigate where feasible, and utilize predictive safety analysis. The project team used the Enhanced Interchange Safety Analysis Tool (ISATe) to estimate safety in the no-build condition, build condition, and build condition with design exceptions. The analysis showed that both build scenarios had lower crash rates than the no build scenario, but the comparison was not able to incorporate the safety performance of HOV lanes in the no build scenario or the safety performance of the reversible lane in the build scenarios. Ms. Strong noted the importance of estimating traffic volumes for the different alternatives.

Mr. Guy Norris, CDOT, presented overviews of an I-25/US 36 Bus on Shoulder (BOS) Feasibility Study and efforts occurring under Federal Boulevard Corridor Study. In conducting the BOS Feasibility Study, CDOT searched for related literature that had addressed safety performance of BOS at some level and looked at crash experience at BOS facilities in Minnesota, Illinois, and California. The feasibility team also conducted an HSM analysis using ISATe to estimate expected changes in safety performance if general purpose lanes were narrowed to widen

shoulders for bus use. The analysis did not address other elements of BOS that could impact safety performance, including merge and diverge points. In the end, Guy concluded that more work is needed in the area of safety analysis methods to address BOS facilities.

Federal Boulevard is the second busiest bus corridor in the Denver metropolitan area, and it has experienced a significant number of pedestrian fatalities. CDOT assessed safety performance of Federal Boulevard using Vision Zero Suite and Colorado SPFs. CDOT does not have SPFs for the 5-lane Federal Boulevard cross section, so the analysis used SPFs for 4-lane cross sections instead. Diagnostics were carried out at intersections with a "total crash" or fatal and injury crash level of service of safety (LOSS) of III or IV. CDOT also used Vision Zero Suite to look for crash patterns along the entire corridor. The following proposed projects resulted from the analysis:

- Install raised medians to address approach turn and broadside crashes at midblock/unsignalized locations.
- Convert timing at signalized intersections to protected-only left turns to address approach turn crashes.
- Install three pedestrian hybrid beacons.

CDOT estimated B/C ratios for the three project categories using a state-specific CMF list.

Dr. R.J. Porter, VHB, presented on a Safety Analysis Needs Assessment for TSMO that he and his team are conducting for the FHWA Office of Safety with oversight of the HSM Pooled Fund Implementation States. R.J. said he and his team looked at TSMO rather broadly and mentioned safety performance is often not the primary objective of TSMO; however, it is an important consideration. R.J. then provided reasons why the HSM has few predictive methodologies that can be applied to TSMO strategies. He then provided an overview of how he and his team when about gathering safety-related information about TSMO and identifying strategy-specific needs as well as methodological needs. He concluded with several examples of safety analysis needs and then asked the audience to discuss their experiences estimating the safety performance impacts of TSMO strategies or design alternatives that incorporated TSMO.

Discussion/Q&A

There were several key takeaways highlighted during the facilitated open discussion that followed the presentations. The following is a summary of the discussions by topic:

1. **State of knowledge on safety performance of TSMO.** The key overall theme of much of the discussion built on the presentations, emphasizing that a lot is still unknown about safety performance impacts of strategies that fall under TSMO. Audience members highlighted the unknown efficacy of developing and applying CMFs and SPFs to predict safety outcomes of TSMO, as well as the challenge of conducting HSM-type safety analyses in work zones.

2. **Alternative Technical Concepts (ATCs).** There was some discussion on ATCs for complex projects, such as the I-35E/US 67 Southern Gateway project in Dallas and the need to learn more about how DDSA can be incorporated into analyzing innovative solutions.
3. **Focus crash types.** Some audience members noted that there could be very specific crash types that are associated with certain TSMO strategies and raised the question of whether analyses should look only at these crash types, all crash types, or both.
4. **Strategy-specific questions.** An attendee asked whether data exist that show the benefit of Integrated Corridor Management, especially when major incidents are present on the freeways and the parallel facilities have different traffic patterns as a result of providing traveler information about the incident. All generally agreed that this is a tough question, as it is challenging to consider so many factors, including the change in traveler behavior over some broader area. Similarly, an audience member asked about what is known on safety performance of variable speed limits. There are a few safety studies on variable speed limits that Dr. Porter's team synthesized in the needs assessment, and there is an ongoing study funded by FHWA Office of Safety Research & Development.
5. **Ongoing analyses within State DOTs.** Dr. Porter asked the audience to share their thoughts on existing capabilities for incorporating safety analysis into TSMO. Maine developed a corridor planning report for freeways. They analyzed TSMO for both safety and operational effects but were lighter on the safety side. A representative from Ohio commented that Ohio DOT (ODOT) estimated safety for hard shoulder running by adapting HSM approaches. They are looking at a hard shoulder running application in Columbus and weighted the predicted average number of crashes using traffic when lanes were open and closed. They are also kicking off a ramp metering project and exploring ways to analyze safety. FDOT is just beginning a research effort to look at operational and safety impacts of TSMO.
6. **Operational mechanisms leading to safety performance.** Some of the discussion focused on the associated/expected safety benefits of variable speed limits and other strategies and what specifically is expected to lead to safety improvements. In other words, do reductions in queuing and speed, driver warnings, speed harmonization, or some other change lead to the safety improvement? Speaking from the standpoint of the needs assessment, Dr. Porter responded that he did not recall any clear quantitative evidence in the literature that made these distinctions. He did not believe his review uncovered anything in the studies that would isolate the causes or mechanisms of observed safety effects, whether that is speed regulation, speed harmonization, or queue warning effects. However, he noted that the needs assessment does try to characterize,

at a high level, the operational performance measures that are a target of different strategies.

7. **Behavioral responses to TSMO.** One audience member asked a question about analysis capabilities with respect to TSMO strategies in general (operations as well as safety). The audience member was specifically interested in what we know about how people change their trip in response to traveler information from TSMO. Another attendee responded that it depends on the TSMO strategy and location. Diversion rates, for example, seem to be highly specific to the location. The ability to have a predictive equation for strategies that involve this type of traveler behavior is just not there. There are various tables that one might come across in the literature showing significant reductions in traffic volume resulting from some TSMO strategies. Creators of these tables then apply SPFs or crash rates to show significant safety benefits. Dr. Porter notes that there has been a lot of relevant work with dynamic traffic assignment and, as a next step in the needs assessment, he wants to look at how traveler behavior changes resulting from TSMO are being modeled and estimated, the extent of those changes, and whether it is enough to have a noticeable safety impact. Another attendee added that when diverting traffic from a controlled access facility that typically has a lower crash rate to an arterial, we must consider the broader level of analysis to get overall safety impacts, even if the analysis becomes complicated.

DAY 2: WEDNESDAY, JULY 11

The second day of the peer exchange included plenary sessions and two breakout sessions. Topics included development of the scale and scope for safety analysis, BCA as a tool, network screening, and safety impacts.

Scale and Scope of Safety Analysis in the Project Development Process

Ohio Perspective, Kendra Schenk, Burgess & Niple
Michigan Tool Matrix, Mark Bott, Michigan DOT (MDOT)

Summary

Ms. Kendra Schenk, a consultant with Ohio DOT, presented on Ohio's process to determine the scale and scope of safety analysis in Ohio's project development process. She walked through the minimal safety assessment steps for non-complex projects, complex projects with no safety component, and complex projects with a safety component. There is very little analysis for non-complex projects, but the potential to mitigate lower-ranking safety hotspots. For complex projects with no safety component, the analyst should estimate the change in expected or predicted crashes as appropriate for the major components of each alternative. These results are then considered with the environmental, right-of-way, operation, geometric, and cost components to select a preferred alternative that fulfills the purpose and need. For complex projects with a safety component, there is a need to perform an HSM analysis to establish baseline conditions and then estimate the change in expected or predicted crashes as appropriate for the major components of each alternative. This has resulted in improved scoping because it requires the crash analysis be completed prior to scoping the project. The following were noted as important aspects of the purpose and need statement:

- Only include safety in the purpose and need when there is a documented crash pattern or site is performing worse than its peers.
- Additional analysis will be required if safety is included in the purpose and need.

Discussion/Q&A

Peer exchange participants asked a series of questions following Ms. Schenk's presentation. The following is a summary of the discussion.

1. **Is this a policy?** Yes, ODOT incorporates policy in related manuals. The new policy is under review but will likely be the final policy. Safety study guidelines will change to safety analysis guidelines, and all other manuals will reference the safety analysis guidelines.
2. **Will this apply to state or local roads?** This will include local roads that are part of projects on the ODOT project development process. ODOT is also encouraging local agencies to adopt these or similar methods to perform safety analysis on all projects.

3. **How specific is the purpose and need statement regarding safety?** For example, in other states, there is wording like, "projects improve safety," but some may not have a safety need. Ms. Schenk said that ODOT will only include safety in the P&N if the site is on the HSIP priority list or the that a particular crash pattern is above the statewide average for that site type. The ODOT flow charts document these triggers as to when safety should be included.
4. **Does the safety analysis occur before or after the purpose and need?** Others noted that an analysis should occur during the NEPA process to determine the preferred alternatives. This will help to identify other parts of the flow chart during the safety planning process.

Summary

Mr. Mark Bott, MDOT, presented on Michigan's process to determine the scale and scope of safety analysis in their project development process. Specifically, he described their Safety Tool Matrix, which they developed based on the 2016 FHWA guide, *Scale and Scope of Safety Assessment Methods in the Project Development Process*. The matrix includes four tiers of safety analysis based on the project type and subtype. The four related project types include routine maintenance (Tier I), 3R—resurfacing, restoration, and rehabilitation (Tier II), 4R—reconstruction or replacement (Tier III), and new construction (Tier IV). Tier I includes a brief examination. Tier II and Tier III include the use of CMFs or systemic treatments. Tier IV includes the use of site-specific models. Next steps include developing thresholds for metrics, developing a safety analysis map, completing the CMF library, incorporating the process into MDOT Design Guidance, and providing training.

Discussion/Q&A

The following themes arose from the audience discussion.

1. **Does MDOT incorporate safety elements into routine maintenance?** Yes, but it has been difficult. This was part of the NEPA process, which is new. Funding is currently not in the scope, so those efforts have not been successful. MDOT is trying to address this issue so they can employ this approach in the future. For now, they may have to seek additional funding.
2. **Is there buy-in and commitment from the agency and upper management?** Mr. Bott said upper management has been supportive. One challenge is getting buy-in from districts or regions. The key to getting others involved is to demonstrate how to perform the analysis and the value of the results.
3. **Does MDOT conduct the safety analysis in house or with a consultant?** Mr. Bott said for the prework (e.g., developing maps and thresholds) they use a consultant. MDOT performs the design in-house once they receive the information for the safety analysis. The consultant will add it to the boilerplate requirements, control the type of model they use, and run the Interactive Highway Safety Design Model (IHSDM). MDOT also discusses

the budget early in the process because there may be variability between the budget and the recommendations from the consultants.

4. **Is MDOT expecting higher cost due to the level of effort?** Mr. Bott said they think it will lead to a cost increase. Changes in schedule will vary costs, as will the hours consultants believe they need to put into a project.

Highway Safety BCA Guide & Tool- Incorporating Operational, Environmental, and User Costs in Highway Safety BCA

Frank Gross, VHB

Summary

Dr. Frank Gross provided an overview of the *Highway Safety Benefit-Cost Analysis Guide* and related spreadsheet tool. The target audience for the guide and tool includes transportation professionals with and without a deep understanding of economic analysis. He noted the project costs include the initial costs, continuing costs, and end-of-life costs. Project benefits include safety, travel time, travel time reliability, vehicle operating costs, and externalities. This guide and tool covers the direct and indirect safety benefits (i.e., the change in travel time, travel time reliability, vehicle operating costs, and externalities due to a change in safety). He explained how the direct and indirect safety benefits are estimated and converted to dollar values. He then provided a brief demonstration of the tool to show the inputs and outputs. Finally, he discussed the use of the tool for a systemic project application.

Discussion/Q&A

Following the presentation, the floor opened for questions, which resulted in several themes.

1. **Do the travel time benefits account for the changes in travel characteristics?** Dr. Gross noted that the travel time benefits are derived from the change in crashes. He broke this down by explaining the average travel time savings per crash. The multiplier is based on the severity of crashes. This does not account for primary mobility benefits. Instead, there is a need to use microsimulation or other methods to calculate travel time savings that are not related to the change in crashes.
2. **Does crash prediction occurs within or outside of the spreadsheet?** Dr. Gross said that there are multiple ways it can occur. Using the tool, one can enter the long-term crashes and the CMF based on observed crash history or the Empirical Bayes (EB) method. One can also enter the estimated change in crashes if computed from another tool.
3. **How does the tool estimate travel time reliability?** Dr. Gross notes that the model is based on a SHRP2 report to assess changes in travel time reliability. As a follow-on, there was discussion about how the model considers seasonal variations in the assessment. Dr. Gross said he would have to look at the underlying SHRP2 study because reliability gets into daily and hourly benefits. He added that this is an area that needs more research to determine the impact on safety.

4. **Are there plans to include the BCA tool in the 17-38 spreadsheets?** Dr. Gross said that the option is there, but there are no plans at this point. Ohio DOT and other States have a BCA tool, but these focus mainly on the crash benefits. The Highway Safety BCA Tool considers both the crash and safety-derived benefits, not just crash benefits as in other tools. He also commented that this is a great opportunity to merge with existing tools.

Safety Design-Build Project

Jon Nelson and David Simmons, Missouri DOT (MoDOT)

Summary

Mr. Jon Nelson and Mr. David Simmons, Missouri DOT (MoDOT), spoke about Missouri's decline in fatal and serious injury crashes and their agency's approach. They provided an overview for the steps MoDOT takes to select projects for design build and an overview of the project schedule. The goal is to use a data-driven approach to deliver a project within a specific budget ($24.11 million) that will maximize safety improvements and reduce fatal and serious injury crashes, while minimizing impacts to the public during construction and be completed in a short timeframe. MoDOT presented a project delivery method selection flowchart that maps their project selection process from assessing the initial project risk to identifying a method that allows the State to appropriately allocate project risks and opportunities. Following documentation, the project will go to either design build, with a detailed risk assessment, or design bid build, where the project is evaluated based on innovative solutions for contracts. Opportunities for innovation include additional applicable standards (products, designs, specifications not currently used by MoDOT) and CMFs (pre-approved CMFs were included in the contract but teams were encouraged to propose others). After a request for qualifications, five teams were selected for full proposals which were scored based on safety improvements, maintenance and durability of improvements, mobility during and after construction, and the completion schedule. Ultimately, the team with the maximum reduction in fatalities and serious injuries was awarded the contract.

Discussion/Q&A

Following Mr. Nelson and Mr. Simmons' presentation the floor was opened for questions, which resulted in the subsequent themes.

- **Is there an opportunity to see implications with CMFs in the next three to four years?** MoDOT will continue to analyze the implications of the CMFs in the coming years, with special interest in HFST and how the aggregate responds to snow and polish.
- **How does MoDOT handle NEPA in design-build projects?** NEPA is not required in all design-build projects, as there are times where the process is completed through the proposal development. The procurement process is very analytical and therefore may

also include some design. This results in a very clear concept prior to submitting the proposal.

- **What is the breakdown of costs for design and construction, specifically low-cost versus systemic?** Project costs, specifically low-cost versus systemic improvements, is an important consideration but was not essential to selection process. Price breakdowns are used for tracking spending and comparing to historical data. MoDOT's primary concern was distributing the $21 million for projects in an equitable fashion. Funding was comprised of HSIP and some pavement resurfacing funds, with a focus on safety. Price was not a deciding factor in the proposal competition due to the price ceiling.
- **Does this process apply to all projects?** MoDOT indicated that this process may not apply to all projects and they are interested in simplifying the process. With more time, MoDOT could improve the process by using predictive network screening instead of actual crash history. They may also consider aligning the timeline with the Statewide Transportation Improvement Plan (STIP) cycle.
- **Does MoDOT allow for ATC-type projects for something that does not have a CMF?** MoDOT approaches design-build projects without an intended solution, which allows for alternative concepts for something that did not have a CMF. The benefit of the design-build is the flexibility in the design, rather than starting with a fully designed project. MoDOT is currently starting the process with 30-percent concepts, but this may change in the future. They found 45 different CMFs, with some combinations of two or more CMFs.

CONCURRENT BREAKOUT SESSION 3

There were two concurrent breakout sessions for peer exchange participants to select from: Network Screening – Hot Spot and Systemic Safety Analysis (presentation) and Quantifying Safety Impacts in Freeway Project (presentations). States were encouraged to spread their representatives across the sessions and share the key takeaways during the Action Planning session on Day 3. The following sections provide brief summaries of the presentations, participant questions, and facilitated discussion.

3a: Network Screening: Hot Spot and Systemic Safety Analysis

Moderator: Caroline Trueman, FHWA, New Jersey Division Office
State and Local SPF Development – Filiberto Sotelo, Illinois DOT (IDOT)
Pedestrian and Bicycle Safety Action Plan (PBSAP) – Kerry Wilcoxon Arizona DOT (ADOT)
Local Safety Plans – Matthew Enders, WSDOT
Virginia DOT (VDOT) Pedestrian Safety Action Plan (PSAP) and Local Outreach – Ian Hamilton, VHB
Facilitator: Ian Hamilton, VHB

Summary

This session explored practices in network screening techniques for motorized and non-motorized modes and methods for effectively communicating results to safety stakeholders. During this session, Illinois, Arizona, Washington, and Virginia discussed the various steps and information needed to conduct network screening in their State to identify hot spots and systemic safety analysis. It is important to note that data quality is critical in the initial steps. Communication is important to raise awareness of safety issues and data availability, to raise awareness of need for quality data, and to explain the information to districts/counties. The real concern for evaluation purposes is the regression-to-the-mean. Since there are concerns for a reversal of crash outcomes when evaluating recent HSIP projects, there is a need to use more reliable methods to account for general crash trends. Systemic measures included getting locals involved and part of the process, providing tools, and highlighting data for safety plans. However, exposure data is a challenge for pedestrian screening and safety plans.

Discussion in this breakout session occurred following individual presentations with no general discussion at the conclusion. The following sections provide summaries of the presentations and discussions that follow.

Summary of IDOT's Experiences

Mr. Filiberto Sotelo presented on IDOT's State and local SPF development. This overview included critical data needs, technical specifications of model development, and the application of SPFs to network screening. He indicated that data quality is critical in the development of SPFs, as low-quality crash, traffic, and roadway data will negatively impact model effectiveness. He also stressed the importance of communication with local administrators and practitioners. County and district engineers should have time to digest the data to provide critical feedback and become comfortable with the network screening methods.

The following questions were addressed during the discussion period:

1. **How does IDOT handle miscoded crashes and crash data quality control?** Illinois has an office dedicated to reviewing crash location and details. Updates previously occurred once per year, but now the database receives updates every two to three years because of the required level of effort.
2. **What are the major causes of the delay?** Some of the delay is due to the review process, and some delay is due to non-electronic reporting in some jurisdictions.
3. **Does the screening cover the entire network?** Yes, IDOT developed SPFs for State and Local roads.

Summary of Arizona DOT (ADOT) Experiences

Mr. Kerry Wilcoxon, ADOT, presented on non-motorized data driven safety analysis in Arizona. This effort specifically informed the State's Bicycle Safety Action Plan (BSAP) and Pedestrian

Safety Action Plan (PSAP). The presentation outlined recent trends in pedestrian safety in Arizona, including a steady decline in pedestrian fatalities prior an increase in the recent years. Mr. Wilcoxon discussed some of the State's methods that identified crash hot spot locations and candidate locations for improvement. He mentioned the difficulty dealing with the low density of crashes, as well as limited or unavailable exposure data for pedestrians. Too many emphasis areas in the State's SHSP can spread attention too thinly; safety-specific plans have helped to focus attention and target strategies. Finally, the State is moving away from crash hot spot targeting in favor of more predictive models (such as the Level of Service of Safety, LOSS).

The following topics were discussed after the presentation:

1. **How does Arizona manage the relationship with Tribal agencies for bicycle/pedestrian safety purposes?** One challenge has been data availability and quality. Furthermore, the State typically experiences a long lag time with data submittal. ADOT assists Tribal and local agencies with completing road safety audits (RSAs) and HSIP applications.
2. **Does ADOT devote a portion of HSIP funds for bicycle and pedestrian-specific projects?** Currently they do not because the State focuses on projects with the biggest return on investment. Many of these projects would address bicycle and pedestrian needs.
3. **Does ADOT directly coordinate technical support with local agencies?** Yes, they raise awareness of available data and opportunities for technical support from the central office. This is a key part of the process.
4. **Does ADOT consider regression-to-the-mean when evaluating previous projects?** Yes, prior to the recent increase in fatalities, regression-to-the-mean made everything look great based on a simple before-after comparison. They do have a fear of a reversal in crash trends when they evaluate recent HSIP projects.
5. **How many RSAs does ADOT complete in a year?** It is based on requests, so the State conducts a handful or so per year; however, the State would like to conduct more RSAs.

Summary of WSDOT's Experiences

Mr. Matthew Enders, WSDOT, discussed local safety plans using network screening. He provided an overview of the development steps in preparing a local road safety plan. He described the required tools, including data and some analysis, training and technical assistance, and plan templates. These plans identify common risk factors and prioritize action strategies to address these issues. This may be the result of crash tree analysis, land use concerns, or engineering features (e.g., rural curvature). The local transportation agency develops a list of priority projects that should address these targeted emphasis areas. Mr. Enders noted that locals need to own the process and should use qualitative information as needed.

The following topics were discussed after the presentation:

1. **How does WSDOT grade potential projects if they use different risk factors?** WSDOT does not use B/C analysis; it is all based on risk analysis, focus crash type, and suggested countermeasures.
2. **Do all WSDOT counties have an engineer?** Yes, they require an engineer in each county to stamp plans to receive funding. Some counties have hired consultants, but most did it in-house.

Summary of VDOT's Experiences

Mr. Ian Hamilton, VHB, discussed the Virginia DOT (VDOT) PSAP. He outlined the data and methods applied to pedestrian network screening, as well as the outreach to local stakeholders for plan implementation and countermeasure selection. Similar to Arizona's experience exposure data is a notable challenge for accurately assessing pedestrian risk; however, Census data could be a good proxy. He added that crash history and land use factors can support the risk analysis. Mr. Hamilton explained that identifying locations based on certain risk factors allowed practitioners to develop a systemic program of countermeasures to address those common concerns. These countermeasures could be low-cost and widely distributed.

The following questions were addressed during the open discussion period:

1. **Did the study identify infrastructure, such as sidewalks?** VDOT's intent was to focus on low-cost improvements. However, this is a future consideration.
2. **What is the relationship between pedestrian safety (walkability) and bicycle safety?** Pedestrian safety improvements can contribute to improvements for bicyclists, such as channelizing.
3. **What is the relation of lighting to identifying locations?** While lighting was not used in the analysis, the topic was considered in the list of potential improvements. Time of day was identified as a risk factor.
4. **How did VDOT move from corridor selection to countermeasure?** They used summary sheets which included suggested countermeasures, but the local agency needs to verify and accept the suggested measure(s).

Discussion/Q&A

At the conclusion of the breakout session, participants identified the following research needs related to network screening:

1. What is the reliability of apps that obtain pedestrian/bicycle counts? How can States and agencies collect better data on pedestrians/bicyclists?
2. Will capturing data allow for modeling origin-destinations?
3. What is the performance of switching between lighting types (e.g., sodium to LED)?
4. Is there a snowbird effect in southern States with increases in aging drivers and pedestrians?

3b: Quantifying Safety Impacts in Freeway Project

Moderator: Norah Ocel, FHWA
Introduction to Freeway Safety Prediction Using IHSDM And Predicting Safety in Alternatives Analysis Using The PA I-70 Case Study – Scott Himes, VHB
Freeway Analysis Case Study using ISATe – Adriane McRae and Ryan Hoyt, LaDOTD
What to Do When No HSM Predictive Methods Exist – Ida Van Schalkwyk and John Tevis, WSDOT
Facilitator: Scott Himes, VHB

Summary

This session provided an overview of methods available for quantifying safety performance in freeway projects and provided a forum for discussing the use of engineering judgment for situations where no predictive method exists. During this session, attendees heard about case studies in Pennsylvania and Louisiana that quantified safety impacts in freeway projects using HSM Supplemental Chapters 18 and 19 implementation tools. Additionally, Ms. Ida Van Schalkwyk and Mr. John Tevis provided insights into human factors approaches to considering safety when no predictive method exists.

Dr. Scott Himes, VHB, provided an introduction to the freeway safety predictive method and implementation using IHSDM. He discussed the HSM predictive method as well as freeway segmentation and analysis. Dr. Himes talked about examples in segmentation analysis and CMFs for base freeway segments and speed change segments.

Next, Ms. Adriane McRae and Mr. Ryan Holt presented a freeway analysis in Louisiana using ISATe. LaDOTD determined ISATe to be the best tool to perform safety analysis for this project and the agency requested assistance from the DDSA team for segmenting the existing facility. Ms. McRae and Mr. Holt then provided information as to why they chose ISATe and the safety analysis results.

Ms. Ida Van Schalkwyk and Mr. John Tevis presented on quantifying safety impacts on freeway projects, particularly what to do when no HSM predictive methods exist. They split their presentation into three parts. The first part focused on putting predictive methods into perspective. The second and third parts identified and then discussed human factors approaches to complement DDSA, such as considering visual behavior like eye fixations, driver versus pedestrian points of views, and how speed impacts viewing distance. Other human factor considerations include task analysis and driver workload.

Following the presentation, the floor opened for questions.

Discussion/Q&A

There were several key takeaways highlighted during the facilitated discussion that followed the presentations. The following is a summary of the discussions by topic:

1. **Selecting the most appropriate tool.** Both models implement the HSM predictive method and will yield similar results. The primary deciding factors should be project scale, scope, timeline, and available data files. LaDOTD opted to use ISATe over IHSDM due to their familiarity with the tool, previous training and availability of DDSA technical assistance, and the smaller scope of their selected project. IHSDM requires a full network to create the interchange while ISATe allows interchange elements to be entered directly. IHSDM may be a good option for those with CAD files and experience in the tool. WSDOT is in the process of developing a decision matrix for tool selection. FHWA also provides onsite contractors as a free service to provide training for agencies.
2. **Solutions for when models do not fit or work with the scenario.** There are two approaches to addressing the issue: adapt and apply methods regardless of the values to develop the model or more conservatively, do not use predictive models if the situation is not appropriate. Statistical models have limitations in terms of reliability and applicable range of values.
3. **Future research needs.**
    a. Develop freeway models that are able to divide the bi-directional analysis for conducting directional analysis.
    b. Explore the full understanding of relating operational characteristics to freeway safety performance, including reoccurring congestion.
    c. Explain how analysts can adapt the predictive method to situations where prediction is not directly applicable. For example,, the predictive method does not cover a diverging diamond interchange, but there is a CMF available for converting a diamond interchange to a diverging diamond interchange. In this case, an analyst could use the predictive method to estimate the safety performance of the diamond interchange, and then apply the applicable CMF to estimate the safety performance of the diverging diamond interchange.
    d. Analyze crashes on high occupancy vehicle and high occupancy toll lanes.

Safety Data and Analysis Tool Demonstrations

AASHTOWare Safety Analyst – Ian Hamilton, VHB
Spreadsheet Tools (17-38 and ISATe) – Scott Himes, VHB
IHSDM – Mike Dimaiuta, FHWA
Systemic Data Summary Tools: Spreadsheet Template and Crash Tree Diagram – Frank Gross, VHB and Matthew Enders, WSDOT
FDOT SPICE Tool – Alan El-Urfali, FDOT

Summary

In this session, peer exchange participants rotated through four different sessions of technical demonstrations of safety data and analysis tools. Rotations lasted 20 minutes, with an expert providing brief tutorials using real examples to demonstrate the tools in real time.

Mr. Hamilton and Mr. Sotelo provided a demonstration of AASHTOWare Safety Analyst™. The demonstration introduced all modules of the software, covering the admin tool and the safety analytical tool in detail. Participants were shown how to change default settings in the admin module (e.g., CMFs, crash costs, and SPFs) to state-specific values. The demonstration of the Analytical Module mostly covered the site selection, network screening, countermeasure evaluation, and systemic improvement tools.

Dr. Himes provided example applications of predictive analyses using the updated HSM spreadsheets for a rural multilane highway with several segments and intersections, as well as a freeway application using ISATe. The objective was to describe the data entry process and to show users how to run the software and interpret the output. An attendee asked when it was better to use IHSDM or the HSM spreadsheets. Dr. Himes responded that both tools implement the exact same methodology and will provide the same results; it is a matter of preference and context of the project being analyzed.

Mr. Mike Dimaiuta provided an overview of IHSDM, which is a tool implementing the HSM predictive method for all facility types included in the HSM and provides various software tools for project-level geometric design analysis for rural, two-lane highways. An attendee asked if there are any recommendations on how to handle shorter segment lengths. Mr. Dimaiuta responded that it may not matter with predictive analysis alone, but you have to consider segment length due to accuracy issues for crash-locating if conducting an EB analysis.

Dr. Gross and Mr. Enders demonstrated the use of two tools to support the systemic approach to safety. The first part of the demonstration featured the County X Summary Spreadsheet developed by WSDOT. This spreadsheet helps to identify over-represented crash contributing factors based on police-reported data (e.g., crash type, weather, road characteristics, driver factors). The second part of the demonstration featured the Crash Tree Maker developed by the

Ohio DOT. This Excel-based tool generates crash tree diagrams to illustrate and identify potential risk factors and appropriate countermeasures using the systemic approach. An attendee asked if these tools are available and Dr. Gross indicated these tools are available upon request and with permission from WSDOT and ODOT. Another attendee asked if the Crash Tree Maker is customizable. Dr. Gross responded that yes, there is the potential to adapt this tool based on data availability and variables of interest. Additionally, another attendee asked what data are needed to use the County X spreadsheet. Dr. Gross responded this spreadsheet can be as extensive or as limited as desired based on the data available. It uses the information from police reports, so it is possible to use this with almost any level of crash data as long as there are some details related to the contributing factors for each individual crash. There is also a need for a comparison group, which could include total crashes if you are looking for over-representation of fatal and injury crashes or it could include other similar facility types such as statewide data for comparison to an individual county.

Mr. El-Urfali provided a demonstration of the Florida Safety Performance for Intersection Control Evaluation (SPICE) Tool, which is a tool to perform predictive safety analysis of at-grade intersection forms/control types and ramp terminal intersections. The tool implements HSM methodologies and only requires data inputs readily available to the analyst. The tool applies SPFs when available and CMFs on an as-needed basis. The tool outputs include total and fatal and injury crash predictions for the opening year, design year, and total project life cycle. The CMFs used in the tool can be customized and local calibration factors can be applied to improve prediction.

DAY 3: THURSDAY, JULY 12

The peer exchange concluded the morning of the third day. All peer exchange participants were invited to attend the HSM Implementation Pooled Fund meeting in the afternoon. There was one plenary session in the morning with the remainder of the morning reserved for the State road-mapping activity where participants worked with their colleagues to document the major takeaways from the peer exchange and identify the applicable noteworthy practices and opportunities for their State in an Action Plan. The following sections provide summaries of the plenary session, HSM Implementation Pooled Fund Study, and the Action Plans that resulted from the road-mapping activity.

Implementation and Integration of DDSA- A New Approach to Safety Analysis

Ida van Schalkwyk, WSDOT

Ms. Ida van Schalkwyk spoke about a different approach WSDOT takes when using the HSM. WSDOT uses data-driven science-based methods and tools. She mentioned that they also continue their efforts toward Target Zero. She then provided an overview and background of how WSDOT arrived at the method they use today, and what substantive safety looks like.

The following points were made during the open discussion period:

1. **Does WSDOT provide tools to local agencies?** WSDOT does not currently provide locals the tools to analyze their own data. However, they are working closely with MPOs to provide data. AZ DOT will be hosting a peer exchange later in 2018 about local agencies and safety analysis.
2. **How does WSDOT handle design exceptions?** WSDOT does not have design exceptions or alleviations anymore. They instead use design analysis, which is a big shift they will be working on over the next year.
3. **How does WSDOT consider injuries in the analysis?** One of the challenges to examining less serious injuries (crash level C) is an inconsistent definition of the injury and where the injury is recorded and when. Because of this limitation, WSDOT focuses on serious crashes and injuries.

State Road-Mapping Activity

Participants met with their State representatives to document the major takeaways for the peer exchange and identify the applicable noteworthy practices and opportunities for their State. For each opportunity, States identified the steps necessary for implementation and identified potential partners responsible for the tasks. See the State Action Plans and Progress section for more information on the plans.

Peer Exchange Closing Remarks and Adjourn

Mr. Roche closed the peer exchange with gratitude for all speakers, presenters, and participating State agencies. Peer exchange participants were invited to participate in the HSM Implementation Pooled Fund Meeting following lunch.

HSM IMPLEMENTATION POOLED FUND MEETING

HSM IMPLEMENTATION POOLED FUND OVERVIEW

The HSM Implementation Pooled Fund Study was developed to advance ongoing State efforts to implement the HSM and expand HSM implementation to all States. The study was developed to support ongoing AASHTO, FHWA, and TRB activities and coordinate with projects developing content for future HSM editions.

There are 22 member State agencies (CA, CT, ID, IL, KS, KY, LA, MI, MO, MS, NC, NH, NV, OH, OK, OR, PA, TX, UT, WA, WI, WV) committing funds to support the efforts. Each State sends one representative to participate in the Technical Working Group responsible for conducting research and developing products that enable and encourage implementation. Representatives also participate in peer exchanges for sharing information, best practices, lessons learned, and challenges associated with HSM implementation.

The afternoon session was an open meeting for all Pooled Fund representatives, as well as other State agencies interested in the topic. The following provides a brief overview of the presentations discussed at the meeting.

Model Inventory of Roadway Elements (MIRE) Fundamental Data Elements (FDE) Collection Methods and Tools

FUGRO Data Collection, Adriane McRae and Dan Magri, LaDOTD
Vermont Intersection Data Collection, Ian Hamilton, VHB

Ms. Adriane McRae and Mr. Dan Magri, LaDOTD, presented on roadway data collection efforts in Louisiana. They provided an overview of the different methods they used historically to collect traffic data, and the methods they use now. Following Ms. McRae and Mr. Magri's presentation, the floor opened for questions.

1. **Frequency of data collection.** LaDOTD funded the effort to collect local data. Moving forward, LaDOTD will continue to collect data for the State, but they will no longer collect data for the local agencies. Data maintenance is always a challenge, so they are working with the locals to possibly create a web-based portal to upload information as it is updated.
2. **Continued local involvement.** Local involvement is incentivized with data collection efforts. Additionally, several local agencies are using additional data for pavement and preservation programs so LaDOTD is exploring how to use those agencies as champions.
3. **Future plans to address intersections.** Safety will have to be the catalyst to move the intersection inventory forward. Intersection data was collected, but it needs to be formatted.

Mr. Ian Hamilton, VHB, presented on Vermont Intersection Data Collection. He identified the different data elements for future exploration and why it is important to collect these different

types of data. Mr. Hamilton provided several examples of using the different tools. Following Mr. Hamilton's presentation, the floor opened for questions.

1. **How many intersections?** The project initially estimated 17,000 sites, but it ended up being closer to 10,000.
2. **Automated or manual collection?** The State system was small enough to allow for manual collection.
3. **Did the data collection use the Highway Safety Information System (HSIS) as a template?** The project focused on AASHTOWare Safety Analyst™ requirements and not the HSIS data dictionary.
4. **Are there plans for future iterations?** There were no plans for future iterations to explore intersections or elements such as added left-turn lanes.

CMF/SPF Calibration and Development-

SPF development and Calibration, Eric Green, Kentucky Transportation Center (KTC)
CMF Development, Frank Gross, VHB

Dr. Eric Green, Kentucky, presented on SPF development and calibration. He provided an overview of Kentucky's calibration experience and use of SPFs. The method they used to evaluate SPFs was the overdispersion parameter. Dr. Green provided examples to show how they implement this method.

Dr. Frank Gross, VHB, presented on CMF Development. He discussed what you need to consider when analyzing CMFs as well as the biggest challenges to developing State-specific CMFs, like staffing and tools. Following the presentation, the floor opened for questions.

1. **How did you handle small samples in SPF development?** Intersections without a sufficient sample to develop a reliable model were flagged.
2. **What was the purpose of the SPFs (planning or design level)?** The primary purpose was to do network screening with SPFs.

FUTURE RESEARCH NEEDS

At the end of each session, moderators prompted the peer exchange participants to identify research needs, tools, guidance, or assistance that would assist their agency in future implementation of DDSA concepts. There were many research questions and needs discussed during the peer exchange. The following overview summarizes the research questions identified over the course of the peer exchange:

- Do corridors with multiple roundabouts create an issue of lack of gaps?
- How and what vehicle technologies will compensate for driver limitations we currently design for that can be overcome (i.e., what will crash prediction/analysis look like over the next 5, 10, 15, 20 years)?
- Can freeway models be developed for directional analyses?
- Can research address reoccurring congestion impacts on urban freeways? The predictive methods currently assume average normal operations.
- How do we design roads to share between trucks with large turning movements and non-motorized users (pedestrians, bicycles, etc.), particularly in tight environments?
- Can more guidance on when and how to apply CMFs to Part C predictions and conducting an economic analysis be provided?
- There is a fundamental challenge trying to find pedestrian and pedalcyclist counts.
    - Some States, like Florida, have reached out to app providers to temporarily obtain the data. Is this acceptable, or is this just a stop-gap with a need for more research and better methods?
- When we capture data, can we model origin-destinations?
- What is the performance of switching between lighting type (e.g., sodium to LED)?
    - Some States, like Colorado, have adaptive LED lighting and would like to evaluate this topic.
- What is the best process (or noteworthy practices) for partnering with universities to support safety analysis (e.g., developing SPFs, CMFs, or CMF lists)?
- How does one handle small samples of data in SPF development?
- How often should an agency recollect the MIRE FDE?
- How can State agencies entice locals to help collect and maintain data?
- How do States prioritize projects and split funding between different safety programs (e.g., hotspot vs. systemic, ped/bike vs. intersection, state vs. local)?
- What is the relationship between pedestrian safety (walkability) and bike safety? Does one help the other? For example, if there is a large community, do bike improvements improve pedestrian safety?
- How do you best define the term safety for inclusion in NEPA purpose and need statements? Are there best practices/examples?
- What are the best practices for mapping crashes and conveying crash statistics for public consumption?
- What are the best tools for conveying alternative intersections to the public? There is a need for more success stories, best practices, handouts, and other tools.

- What is the correlation between congestion and rear-end crashes?
- Is there a snowbird effect in southern States (elderly walkers/drivers)?

States discussed additional areas needing more research including:

- Crashes, specifically more crashes, than general purpose on HOT and HOV lanes.
- Flexibility to add new alternative designs to current evaluation processes.
- Safety performance on urban and suburban streets with 35 to 50 mph. There is a need to understand interrelationships between safety performance, managing speeds, and cross sections (lanes, curbs, etc.) through transition areas. Most elements significantly associated with crash frequency/severity on other facilities are not significant on urban/suburban streets. This does not leave much room for quantifying the effects of changes in geometry on these streets.
- Freeways that have a lot of congestion and the possible link to a high number of rear-end crashes.
- More information on disaggregate CMFs by crash type and severity for countermeasures. Having only a CMF for total crashes may not be informative for economic analysis.

STATE ACTION PLANS AND PROGRESS

Note taking pages were distributed at each of the concurrent breakout sessions over the course of the peer exchange. Participants were encouraged to use these pages as a tool for recording notes, lessons learned, strategies with potential in their State, and contacts for follow up. The morning of the third day, peer exchange participants met with members of their State for a road-mapping activity where they shared the information collected over the course of the sessions. States were tasked with using this information to develop a 2018 Action Plan that outlines DDSA-specific goals and objectives. The State can then use the Action Plan as a tool to track, evaluate, and update implementation.

States who participated in the 2016 peer exchanges in Louisiana, Virginia, and Missouri were also provided their previous plans to evaluate their progress toward goals and identify relevant goals to include in their 2018 Action Plan.

The following section provides a summary of the actions States have implemented from 2016 to 2018 followed by a summary of the 2018 State Action Plans.

DDSA IMPLEMENTATION: 2016 - 2018

States who participated in the 2016 peer exchanges were provided their Action Plan to review while drafting their 2018 Action Plan. Some States may have completed action items, while other States are still in the early stages. The following are actions States listed in their 2016 Action Plan:

- Re-establish the HSM Implementation Team to include planning, design, and operation (AZ, KY, MO).
- Design a variance exception process by developing memos (CO).
- Incorporate TSMO Evaluation Guidelines into the scale and scope process of project development (CO).
- Create a design exception process to include safety analysis and different analysis levels (CT).
- Develop State-specific CMFs (CT, IA).
- Develop a project prioritization process that screen potential projects (CT).
- Explore and used AASHTOWare Safety Analyst tool more to begin applying safety analysis (IL).
- Implement data-driven safety principles into management practices (IA).
- Establish partnerships with a university to calibrate State-specific HSM models (IA).
- Update two-lane highway SPFs/calibrations; finalize and calibrate multilane highway SPFs (KS).
- Create a 3R Guide to help coordinate efforts across disciplines for the State's HSM (KS).
- Improve appropriate scoping and scaling for projects (MI).
- Establish HSM training for more districts and local agencies that use HSM (PA, OR).

2018 Action Plan Summary

Table 1 lists 2018 Action Plan themes.

Table 1. Summary plan of State's 2018 Action Plan.

Action	State
HSM implementation	Arizona, Colorado, Connecticut, Georgia, Idaho, Illinois, Iowa, Kansas, Kentucky, Maine, Michigan, Mississippi, Montana, Pennsylvania, South Carolina, Texas, Wisconsin
Implement new tools or explore training opportunities (e.g., Safety Analyst, FHWA Crash Cost Guide, IHSDM, ISATe)	Colorado, Connecticut, Georgia, Idaho, Indiana, Iowa, Kansas, Kentucky, Maine, Michigan, Missouri, Montana, North Carolina, Oregon, Pennsylvania, Wisconsin
Consider increasing HSIP funds	Georgia, Missouri
Promote/educate staff on benefits of DDSA	Colorado, Connecticut. Iowa, Kentucky, Michigan, Mississippi
Create consistency across District Offices for safety analysis	Georgia, Indiana, Oregon
Integrate DDSA into project prioritization	Arizona, Connecticut, Georgia, Iowa, Kentucky, Missouri, South Carolina, Utah
Incorporate DDSA into NEPA processes	Connecticut, Idaho, Illinois, Missouri, North Carolina, Pennsylvania
Integrate performance-based practical design	Illinois, Iowa, Kentucky
Develop ICE policy or processes	Arizona, Colorado, Connecticut, Georgia, Idaho, Illinois, Iowa, Kentucky, Kansas, Missouri, Montana, North Carolina, Oregon, Pennsylvania, Texas, Wisconsin
Enhance ICE policy or processes	Georgia, Indiana, Utah
Explore TSMO strategies	Colorado, Illinois, Indiana, Michigan, Texas, Utah
Consider safety in goals and performance measures	Connecticut, Illinois, Kentucky, Maine, Missouri, Montana, Oregon, Pennsylvania
Predictive analysis	Mississippi, North Carolina

Action	State
Systemic analysis	Georgia, Idaho, Illinois, Kentucky, Maine, Mississippi, Missouri, Oregon, Texas
Group low-cost improvements on a larger contract	Illinois, Maine
Calibrate HSM models to the State	Georgia, Iowa
Develop SPFs	Arizona, Idaho, Indiana, Kentucky, Mississippi, Pennsylvania, South Carolina, Texas
Incorporate HSM methodologies into network screening process	North Carolina, South Carolina
Enhance network screening and integrate in project development	Connecticut
Develop project-level CMFs or State-specific CMF lists	Connecticut, Georgia, Illinois, Iowa, Kansas, Kentucky, Mississippi, Missouri, Oregon, Pennsylvania, South Carolina, Texas, Wisconsin
Develop planning-level CMFs	Georgia, Iowa, Kansas, Michigan, Mississippi, Missouri, Oregon
Promote State-specific CMF lists	Indiana, Kentucky, Michigan, Texas, Utah
Safety data management (e.g., automate crash locating, create intersection inventory)	Kansas
Educate staff on specific crash types and severity	Idaho, Illinois, Indiana, Maine, Montana
Develop a way to dissect crash data	Arizona, Kentucky, Maine, Oregon
Explore the use of "crash trees"	Colorado, North Carolina
Create a post evaluation of safety improvements	Idaho

In addition to continuing goals set in the 2016 Action Plans, many States incorporated new goals that reflected information sharing with other States at the peer exchange. Several States reference implementing DDSA based on the information provided during Dr. Gross'

presentation on safety fundamentals and the breakout session that discussed safety performance in planning and programming. Other States noted the CMF and developing CMF lists breakout session provided the opportunity to hear from States' experiences developing CMF lists and have now set goals to create State-specific CMFs. As a result of learning about other State's experiences, the 2018 Action Plans include several outreach actions. Specifically, several States plan to contact other States they met at the peer exchange for support to learn more about a particular action or ask for support during implementation.

EVALUATION FORMS

Following the peer exchange, attendees completed an evaluation form rating their experiences and describing the subject areas that were most relevant, improvements, and highlights. Table 2 provides a detailed summary of the quantitative results from the peer exchange. Before the peer exchange, on average, knowledge on DDSA applications in performance-based project development was 3.3 out of 5. After the peer exchange, the average score rose to 3.9 out of 5. The two highest averages for State DOTs and FHWA representatives were, the presentations were pertinent to the subject matter, and they would recommend attending the peer exchange to a peer.

In the evaluation forms, participants were also asked what subject areas were most relevant to their job to help move implementation forward. Table 3 provides a summary of the responses by agency.

Attendees listed their highlights from participating in the peer exchange. Overall, many, regardless of agency, highlighted networking as a key benefit of the peer exchange and noted they had the opportunity to grow their list of contacts. States also highlighted the value of tools demonstrations and examples of DDSA principles. More highlights, by agency, are in table 4.

Table 2. Evaluation Summary of 2018 peer exchange.

The Peer Exchange…	Average:	State Average:	FHWA Average:	Consultant/ Other/Not Listed Average:
Sessions were inclusive of the entire project development process.	4.2	4.2	4.6	4.0
Presentations were pertinent to the subject matter.	4.6	4.6	4.6	4.3
Content was consistent with the session description and objectives provided.	4.5	4.5	4.3	4.2
Subject matter is applicable in my new job.	4.5	4.5	4.7	4.6
Facilitated discussion aided in generating new ideas.	4.3	4.4	4.2	4.1
Provided opportunities for me to participate.	4.6	4.6	4.4	4.3
Handout materials were useful, clear and legible.	4.2	4.3	4.1	3.7
Road-mapping activity will help improve my State's ability to move DDSA implementation forward.	3.8	3.9	4.1	3.4
Schedule has adequate time for breaks and networking.	4.3	4.3	4.3	3.8
Is something I would recommend to a peer.	4.3	4.4	4.6	3.7
Your Knowledge & Skill Level				
Before the course, could be rated as…	3.1	3.2	3.2	2.7
After the course, could be rated as…	3.9	4.0	3.7	3.2

Table 3. Summary of responses for subject areas relevant to moving implementation forward.

Agency	Subject Areas Most Relevant
State DOT	• Implementing DDSA into project delivery and processes (e.g., PBPD in project development from purpose and need to alternatives design criteria, design exceptions, freeways). (6) • IHSDM and prioritizing projects within HSIP. (5) • Intersection control evaluation. (4) • CMFs (general). (4) • HSM implementation and leading best practices. (4) • Safety in NEPA design and purpose and need statements. (4) • Learning about other State DOT examples (e.g., structures, processes, selecting capital projects). (4) • Design exception decisions. (3) • Integrating safety into other programs at any level. (3) • Safety analysis. (2) • Network screening tools. (3) • Project analysis: tools, training, acceptance. • Implementation plans. • Creating State-specific CMFs. • Creating SPFs. • Safety as a factor in environmental analysis. • Presenting safety concepts to the public. • Develop a B/C analysis guide and tool. • Recommendations for buy-in from executive level, legal, etc.
FHWA	• Arizona presentation on non-motorized and demonstration of analysis tools. • Implementing safety in the project development process within my agency. • DDSA processes and procedures. • Tools available and examples of how States are using them for DDSA. • TSMO.

Consultant/ Not listed	• Better formatting tools for creating crash analysis, data analysis, and to report bugs to agencies and FHWA. • ICE implementation. • Design build safety projects. • DDSA integration in the project delivery process. • PBPD and analysis of design exceptions. • Incorporating operational, environmental, and user costs in BCA.

* Parenthesis denote number of evaluation forms reporting the same theme.

Table 4. Summary of highlights from the peer exchange.

Agency	Highlights
State DOT	• Tool demonstrations. (4) • State presentations and examples. (4) • Interacting with people from other States and learning about their policies, programs, and procedures. (3) • Discussions that occurred during breakout sessions and after presentations. (2) • Collaborating with staff from the same agency in discussions and the road mapping activity. (2) • Design Build. • Scale and scope guidance. • The mix of multidisciplinary attendees from design, traffic operations, planning, environment. • ICE. • How to use HSM for design exceptions using B/C ratios. • Using HSM in purpose and need. • Training and contract requirements for consultants to perform and deliver DDSA.
FHWA	• Networking opportunities. (2) • Breakout panel discussions. (2) • ICE. • Integrating safety in environmental sessions. • Hearing how other States have developed DDSA processes and procedures to drive their programs.
Consultant/ Not listed	• Meeting new people and contacts. (2) • Learning from peers. • Presentations of how States overcome some obstacles. • Design-build strategies. • The breakout sessions.

* Parenthesis denote number of evaluation forms reporting the same theme.

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APPENDIX B: PEER EXCHANGE AGENDA

Day 1: Tuesday, July 10

7:30 AM **Registration**

8:00 AM **Welcome, Objectives, and Housekeeping**

Great Hall

- Opening Remarks – *Al Alonzi, FHWA Texas Division*
- Opening Remarks – *Ida van Schalkwyk, WSDOT & HSM Implementation Pooled Fund*
- Opening Remarks – *Karen Dixon, TRB Highway Safety Performance Committee (ANB25)*
- Objectives – *Jerry Roche, FHWA Office of Safety*

8:30 AM **Data-Driven Safety Analysis in the Project Development Process**

Great Hall

- Overview of Safety Analysis in the PDP – *Jerry Roche, FHWA*

9:15 AM **Fundamentals of Data-Driven Safety Analysis**

Great Hall

- Fundamentals of Predictive Safety Analysis – *Frank Gross, VHB*

9:45 AM **Break**

10:00 AM **Leading Practices in the Use of the HSM**

Great Hall

- AASHTO Domestic Scan 16-01 – *Scan Team Members David Duncan, TDOT; Dennis Emidy, MaineDOT; Samuel Sturtz, Iowa DOT; Mike Vaughn, KYTC*

11:00 AM **Highway Safety Manual 2nd Edition**

Great Hall

- HSM2…what will it do? – *Karen Dixon, TRB Highway Safety Performance Committee (ANB25)*

11:30 AM **Lunch (provided)**

Day 1: Tuesday, July 10 (continued)

1:00 PM **Concurrent Breakout Session 1**

- **1a: Safety Performance in Planning and Programming**

  First Floor Gallery

  This session will explore opportunities to incorporate quantitative safety performance analysis into transportation planning and programming. Discussions will cover practical applications for a range of planning activities as well as future needs.
  - Moderator: Nike Fortey, OR FHWA Division Office
  - Overview: Planning and Programming Activities and DDSA Opportunities – *R.J. Porter, VHB*
  - Kentucky Planning-Level CMFs – *Mike Vaughn, KYTC*
  - Facilitated Discussion: R.J. Porter, VHB (facilitator); Scott Himes, VHB (notetaker)
- **1b: Performance-Based Practical Design/Analysis of Design Exceptions**

  Great Hall

  This session will cover analysis of safety performance as part of performance-based practical design (PBPD). Opening discussions will include a brief overview of PBPD in the U.S., future directions of geometric design policies, and experiences in three States.
  - Moderator: Don Petersen, WA FHWA Division Office
  - Performance-Based Design at LA DOTD – *Chad Winchester, LA DOTD*
  - Safety Performance of Design Exceptions in Utah – *W. Scott Jones, UDOT*
  - Performance-based Design and Design Analysis at WSDOT – *John Tevis, WSDOT*
  - Facilitated Discussion: Elizabeth Hilton, FHWA (facilitator); Ian Hamilton, VHB (notetaker)
- **1c: Intersection Control Evaluation (ICE)**

  Restoration Room

  This session will cover experiences and future opportunities in developing and implementing ICE policies and procedures. Discussions will cover experiences in States with existing ICE policies as well as perspectives from States currently assessing whether to move forward with their own ICE policies.
  - Moderator: Millie Hayes, TX FHWA Division Office
  - Panel Discussion on ICE Policies and Procedures–*Brian Porter, WisDOT*; *Dirk Schmidt, INDOT*; *Alan El-Urfali, FDOT; David Adams, GDOT*

- Key Takeaways from Western States Peer Exchange on ICE – *Kenneth Mora, TxDOT*
- Facilitated Discussion: Kara Peach, VHB (facilitator); Frank Gross, VHB (notetaker)

2:30 PM **Break**

3:00 PM **Concurrent Breakout Session 2**

- **2a: Safety Analysis in Environmental Review**

  First Floor Gallery

  This session will discuss opportunities to consider quantitative safety in the environmental review process, including opportunities to tie the level of safety analysis to the level of environmental review. It will also discuss existing policies and the considerations for developing a related policy.
  - Moderator: Rick Drumm, IN FHWA Division Office
  - Incorporating Safety into the NEPA Planning Process – *Brian Murphy, NCDOT*
  - Using Data to Develop the Purpose and Needs and Assess Alternatives – *Matt Jagow, CDOT*
  - Facilitated Discussion: Emeka Ezekwemba, CO FHWA Division Office (facilitator); Kara Peach, VHB (notetaker)
- **2b: Using Crash Modification Factors and Developing CMF Lists**

  Great Hall

  This session will discuss the application of CMFs in the project development process, focusing on the opportunities and challenges related to a standardized CMF list. It will discuss the process for developing a standardized CMF list and how to accommodate strategies that are not on the list.
  - Moderator: John McFadden, FHWA
  - Pennsylvania's Experience – *Jason Hershock, PennDOT*
  - Utah's Experience – *Scott Jones, UDOT*
  - Washington's Experience – *John Tevis, WSDOT*
  - Facilitated Discussion: Frank Gross, VHB (facilitator); Scott Himes, VHB (notetaker)
- **2c: Safety Performance of Transportation System Management and Operations (TSMO) Strategies**

  Restoration Room

  This session will focus on existing practices, capabilities, and future needs with respect to analyzing the safety performance impacts of TSMO strategies, including intelligent transportation systems, traffic operations and

management, travel demand management, planning, and policy development.

- Moderator: John Broemmelsiek, LA FHWA Division Office
- Safety Analysis Needs for TSMO and Noteworthy Practices – *R.J. Porter, VHB*
- Safety Analysis of the I-35E/US 67 Project: The Southern Gateway – *Ashton Strong, TxDOT*
- Federal Corridor Study and I-25/US-36 Feasibility Study – *Guy Norris, CDOT*
- Facilitated Discussion: R.J. Porter, VHB (facilitator); Ian Hamilton, VHB (notetaker)

4:30 **End of Day Wrap-Up**

Great Hall

5:00 **Adjourn**

Day 2: Wednesday, July 11

7:45 AM **Museum opens**

8:00 AM **Scale and Scope of Safety Analysis in the Project Development Process**

Great Hall

- Ohio Perspective – *Kendra Schenk, Burgess & Niple*
- Michigan Perspective – *Mark Bott, MDOT*

8:30 AM **Benefit Cost Analysis (BCA) Guide & Tool**

Great Hall

- Incorporating Operational, Environmental, and User Costs in Highway Safety BCA – *Frank Gross, VHB*

9:00 AM **Safety Design-Build Project**

Great Hall

- Missouri DOT Perspective – *Jon Nelson and David Simmons, MoDOT*

9:30 AM **Break**

9:45 AM Concurrent Breakout Session 3

- **3a: Network Screening: Hot Spot and Systemic Safety Analysis**
  Restoration Room
  This session explores practices in network screening techniques for motorized and non-motorized modes. Discussions will also address methods for effectively communicating results to safety stakeholders.
  - Moderator: Caroline Trueman, NJ FHWA Division Office
  - State and Local SPF Development – *Filiberto Sotelo, IDOT*
  - Ped/Bike efforts (PBSAP) – *Kerry Wilcoxon, ADOT*
  - Local Safety Plans – *Matthew Enders, WSDOT*
  - VDOT Pedestrian Safety Action Plan and Local Outreach – *Ian Hamilton, VHB*
  - Facilitated Discussion: Ian Hamilton, VHB (facilitator); Frank Gross, VHB (notetaker)
- **3b: Quantifying Safety Impacts in Freeway Projects**
  Great Hall
  This session provides an overview of methods available for quantifying safety performance in freeway projects and provides a forum for discussing the use of engineering judgment for situations where no predictive method exists.
  - Moderator: Norah Ocel, FHWA
  - Freeway Safety Prediction with IHSDM/PA I-70 Case Study – *Scott Himes, VHB*
  - Freeway Analysis Case Study using ISATe – *Adriane McRae & Ryan Hoyt, LaDOTD*
  - What to do when no HSM predictive methods exist – *Ida Van Schalkwyk & John Tevis, WSDOT*
  - Facilitated Discussion: Scott Himes, VHB (facilitator); Kara Peach, VHB (notetaker)

11:45 AM Lunch (provided)

1:00 PM Safety Data and Safety Analysis Tool Demonstrations

- AASHTOWare Safety Analyst – *Ian Hamilton, VHB and Filiberto Sotelo, IDOT* (Great Hall)
  - Interactive Highway Safety Design Model (IHSDM) – *Mike Dimaiuta, FHWA Geometric Design Lab* (Great Hall)
  - Spreadsheet Tools (17-38 and ISATe) – *Scott Himes, VHB and State DOT TBD* (Restoration Room)

- Systemic Data Summary Tools: Spreadsheet Template and Crash Tree Diagram – *Frank Gross, VHB and Matthew Enders WSDOT* (First Floor Gallery)
- *FDOT SPICE Tool – Alan El-Urfali, FDOT* (First Floor Classroom)

3:00 PM **Break**

3:15 PM **Breakout Session Report Outs**

Great Hall

Breakout session facilitators will report-out on key takeaways from the first two days of breakout sessions, setting the stage for State road-mapping.

- Moderator: Kara Peach, VHB

4:15 PM **State Road-mapping Instructions**

Great Hall

- Overview of Day 3 State Road-Mapping Activity – *Jerry Roche, FHWA*

4:45 PM **End of Day Wrap Up**

Great Hall

5:00 PM **Adjourn**

Day 3: Thursday, July 12

7:45 AM **Museum opens**

8:00 AM **Implementation and Integration of DDSA**

Great Hall

- A New Approach to Safety Analysis – *Ida van Schalkwyk, WSDOT*

9:00 AM **State Road-mapping Activity**

States will document the major takeaways from the peer exchange and identify the applicable noteworthy practices and opportunities for their State. For each opportunity, States will identify the steps necessary for implementation and identify potential partners who can own the tasks.

10:00 AM **Break**

10:15 AM **State Road-mapping Activity, continued**

11:15 AM **Peer Exchange Closing Remarks**

Great Hall

- Closing Remarks – *Jerry Roche, FHWA*

11:45 AM **Adjourn**

HSM Implementation Pooled Fund Meeting (<u>All States Welcome</u>)

1:00 PM **Welcome and Roll-Call**

1:15 PM **HSM Implementation Pooled Fund Overview (for prospective States)**

1:30 PM **MIRE FDE Collection Methods and Tools**

- FUGRO Data Collection Efforts – *Adriane McRae/Dan Magri, LaDOTD*
- Vermont Intersection Data Collection – *Ian Hamilton, VHB*

2:30 PM **Break**

2:45 PM **CMF/SPF Calibration and Development**

- SPF Development and Calibration – *Eric Green, KTC*
- CMF Development – *Frank Gross, VHB*

3:45 PM **Business Meeting**

5:00 PM **Adjourn**