



SCAN TEAM REPORT

NCHRP Project 20-68A, Scan 16-01

LEADING PRACTICES IN THE USE OF THE HIGHWAY SAFETY MANUAL FOR PLANNING, DESIGN, AND OPERATIONS

Supported by the
National Cooperative Highway Research Program

The information contained in this report was prepared as part of NCHRP Project 20-68A U.S. Domestic Scan, National Cooperative Highway Research Program.

SPECIAL NOTE: This report IS NOT an official publication of the National Cooperative Highway Research Program, Transportation Research Board, or the National Academies of Sciences, Engineering, and Medicine.



Acknowledgments

The work described in this document was conducted as part of NCHRP Project 20-68A, the U.S. Domestic Scan program. This program was requested by the American Association of State Highway and Transportation Officials (AASHTO), with funding provided through the National Cooperative Highway Research Program (NCHRP). The NCHRP is supported by annual voluntary contributions from the state Departments of Transportation. Additional support for selected scans is provided by the U.S. Federal Highway Administration and other agencies.

The purpose of each scan, and of Project 20-68A as a whole, is to accelerate beneficial innovation by facilitating information sharing and technology exchange among the states and other transportation agencies, and identifying actionable items of common interest. Experience has shown that personal contact with new ideas and their application is a particularly valuable means for such sharing and exchange. A scan entails peer-to-peer discussions between practitioners who have implemented new practices and others who are able to disseminate knowledge of these new practices and their possible benefits to a broad audience of other users. Each scan addresses a single technical topic selected by AASHTO and the NCHRP 20-68A Project Panel. Further information on the NCHRP 20-68A U.S. Domestic Scan program is available at <http://144.171.11.40/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=1570>.

This report was prepared by the scan team for Domestic Scan 16-01, Leading Practices in the Use of the Highway Safety Manual for Planning, Design, and Operations, whose members are listed below. Scan planning and logistics are managed by Arora and Associates, P.C.; Harry Capers is the Principal Investigator. NCHRP Project 20-68A is guided by a technical project panel and managed by Andrew C. Lemer, PhD, NCHRP Senior Program Officer.

The scan team members include the following individuals:

John C. Milton, AASHTO Chair, Washington State Department of Transportation
Dennis Emidy, Maine Department of Transportation
Dave Duncan, Tennessee Department of Transportation
Jerry Roche, U.S. Department of Transportation, Federal Highway Administration
Samuel Sturtz, Iowa Department of Transportation
Michael Vaughn, Kentucky Transportation Cabinet
Darren J. Torbic, MRI Global, Subject Matter Expert (SME)

Disclaimer

The information in this document was taken directly from the submission of the authors. The opinions and conclusions expressed or implied are those of the scan team and are not necessarily those of the Transportation Research Board or its sponsoring agencies. This report has not been reviewed by and is not a report of the Transportation Research Board or the National Academies of Sciences, Engineering, and Medicine.



Scan 16-01

Leading Practices in the Use of the Highway Safety Manual for Planning, Design, and Operations

**REQUESTED BY THE
American Association
of State Highway and Transportation Officials**

PREPARED BY
John C. Milton, AASHTO Chair, Washington State Department of Transportation
Dennis Emidy, Maine Department of Transportation
Dave Duncan, Tennessee Department of Transportation
Jerry Roche, U.S. Department of Transportation, Federal Highway Administration
Samuel Sturtz, Iowa Department of Transportation
Michael Vaughn, Kentucky Transportation Cabinet
Darren J. Torbic, MRI Global, Subject Matter Expert (SME)

SCAN MANAGEMENT
Arora and Associates, P.C.
Lawrenceville, NJ

October 2018

The information contained in this report was prepared as part of NCHRP Project 20-68A U.S. Domestic Scan, National Cooperative Highway Research Program.

SPECIAL NOTE: This report IS NOT an official publication of the National Cooperative Highway Research Program, Transportation Research Board, or the National Academies of Sciences, Engineering, and Medicine.

TABLE OF CONTENTS

Table of Contents

Abbreviations and Acronyms.....	TOC-X
Executive Summary	ES-1
1 Introduction	1-1
Background	1-1
Project Objective and Scope	1-1
Lead States	1-2
Host Agencies	1-3
Agencies Participating Remotely	1-3
Scan Team.....	1-4
2 Status/Policy	2-1
Catalysts That Accelerated HSM Implementation.....	2-1
Champion Advocated for HSM Implementation	2-1
Executive-Level Training to Gain Upper Management Support	2-2
HSM Implementation Team and Plan.....	2-2
Involvement in AASHTO and TRB Committees and Subcommittees	2-6
Adoption of Toward Zero Deaths (TZD) Initiative	2-7
Incremental Steps Toward HSM Implementation.....	2-7
Influential Changes in Departmental Policies and Procedures That Promote HSM	
Implementation	2-11
Establishment of Executive Orders	2-11
Policies to Guide Decisions	2-13
Guidance Documents.....	2-14
Practices	2-16
Cultural Shift Due to HSM Implementation.....	2-17
3 Training	3-1
Special Features of HSM Training Programs.....	3-1
Funding Sources for HSM Training	3-6
Supplemental Information on HSM Training.....	3-7
4 Technical Functions	4-1
Guidance on Level of Safety Analyses Needed for Projects	4-1
Development of Tools to Implement HSM Methods	4-10
Calibration	4-18
Systemic Safety	4-18
Local Roads	4-20
5 Data	5-1
Develop Visions for Safety Data Use	5-1
Data Governance.....	5-4

TABLE OF CONTENTS

6 Cultural	6-1
7 Information Dissemination	7-1
Internal Communication to Implement HSM Procedures	7-1
Communication of HSM Analyses to External Stakeholders	7-1
Tort Liability Concerns Associated with Crash Data and HSM Analyses	7-2
8 Achieving Performance	8-1
9 Recommended Actions	9-1
Recommended Actions for State Transportation Agencies	9-1
Status/Policy	9-1
Training	9-2
Technical Function	9-2
Data	9-3
Cultural	9-3
Information Dissemination	9-3
Achieving Performance	9-3
Recommended Actions for AASHTO and FHWA	9-4
AASHTO	9-4
FHWA	9-4
Updates to HSM Training Courses and Future Research	9-4

List of Appendices

Appendix A:	Amplifying Questions.....	AA
Appendix B:	Key Contacts.....	AC
Appendix C:	Scan Team Contact Information	AC
Appendix D:	Scan Team Biographical Sketches	AD

List of Figures

Figure 1-1	Map of lead agencies and scan team members	1-3
Figure 2-1	FDOT HSM implementation policy ¹⁸	2-13
Figure 3-1	IDOT training program by skills and job responsibilities	3-3
Figure 3-2	Illinois HSM user guide ³³	3-3
Figure 3-3	WSDOT practical solutions HSM training	3-4
Figure 4-1	ODOT's level of safety analysis for non-complex projects	4-2
Figure 4-2	ODOT's level of safety analysis for complex projects	4-3
Figure 4-3	ODOT's level of safety analysis for projects with a safety component	4-4
Figure 4-4	IDOT's HSM crash prediction tool interface	4-12
Figure 4-5	ODOT's Economic Crash Analysis Tool	4-13
Figure 4-6	Example of IDOT's Safer Road Index and safety tier for rural, minor-leg stop-controlled intersections	4-14
Figure 4-7	IDOT's planning and programming performance measures ⁵⁰	4-15
Figure 4-8	Local map MDOT developed ranking roadway segments and intersections for potential safety improvement	4-21
Figure 5-1	Data governance activities ⁵⁵	5-5

List of Tables

Table 2-1	Summary of FDOT HSM implementation plan.....	2-4
Table 2-2	Summary of MoDOT HSM implementation plan.....	2-5
Table 2-3	Variables used in HSM Part C predictive methods ¹¹	2-8
Table 2-4	LADOTD priorities for data collection and analysis ⁹	2-10
Table 3-1	LADOTD training program by business unit and priority ⁹	3-2
Table 4-1	LADOTD HSM project applications guidance ⁴²	4-6
Table 4-2	Summary of safety analysis for intersection control analysis ²¹	4-9
Table 4-3	FDOT’s staff hour estimation guidelines for safety analyses for PD&E studies.....	4-10
Table 4-4	IDOT’s state-of-repair comparison ⁵⁰	4-15
Table 4-5	VDOT’s SMART SCALE project prioritization system ⁵¹	4-16
Table 5-1	Process for developing a safety data business plan ⁵⁵	5-3

ABBREVIATIONS AND ACRONYMS

Abbreviations and Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ALDOT	Alabama Department of Transportation
CMF	Crash Modification Factor
DOT	Department of Transportation
EB	Empirical Bayes
FAST Act	Fixing America's Surface Transportation Act
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
HSIP	Highway Safety Improvement Program
HSM	Highway Safety Manual
ICA	Intersection Control Analysis
IDOT	Illinois Department of Transportation
IHSDM	Interactive Highway Safety Design Manual
ISATe	Interchange Safety Analysis Tool enhanced
IT	Information Technology
KYTC	Kentucky Transportation Cabinet
LADOTD	Louisiana Department of Transportation and Development
LTAP	Local Technical Assistance Program
Maine DOT	Maine Department of Transportation
MAP-21	Moving Ahead for Progress in the 21st Century Act
MDOT	Michigan Department of Transportation
MIRE	Model Inventory of Roadway Elements
MMUCC	Model Minimum Uniform Crash Criteria
MoDOT	Missouri Department of Transportation
MPO	Metropolitan Planning Organization
NCHRP	National Cooperative Highway Research Program
NHI	National Highway Institute
NHTSA	National Highway Traffic Safety Administration
ODOT	Ohio Department of Transportation
PBASAP	Performance-Based, Advanced Safety Analysis Procedure
PD&E	Project Development and Environment
PDC	Planning District Commission
PSI	Potential for Safety Improvement (Virginia DOT)
ROR	Run Off Road (Washington State DOT)
S-HAL	Safety Handbook for Locals (Missouri DOT)
SHSO	State Highway Safety Offices
SHSP	Strategic Highway Safety Plan
SP&R	State Planning and Research
SPF	Safety Performance Function

ABBREVIATIONS AND ACRONYMS

SRI	Safer Roads Index (Illinois DOT)
TDOT	Tennessee Department of Transportation
TRB	Transportation Research Board
TZD	Toward Zero Deaths: A National Strategy on Highway Safety
VDOT	Virginia Department of Transportation
WSDOT	Washington State Department of Transportation

Executive Summary

The American Association of State Highway and Transportation Officials (AASHTO) Highway Safety Manual (HSM) provides safety knowledge and tools in a useful form to facilitate improved decision making based on safety performance. While other HSM initiatives have focused on examples of HSM implementation and results of analyses, AASHTO and the Federal Highway Administration (FHWA) sponsored a domestic scan to identify leading practices in the use of the HSM for planning, design, and operations.

The objectives of the scan were to:

- Evaluate the processes, job aids/tools, workforce training, and manner in which state transportation agencies have implemented and integrated the HSM into performance-based processes in planning, design, and operations
- Learn the practices of state transportation agencies that have most comprehensively implemented the HSM since its publication in 2010
- Disseminate information about leading practices in use of the HSM in planning, design, and operations to other state and local transportation agencies to help them reduce traffic fatalities and serious injuries on all public roads and make informed decisions to reduce project and operating costs

The scope of this scan extends beyond simply focusing on the implementation of analysis procedures described in the HSM and addresses, more broadly, the implementation of performance-based, advanced safety analyses to facilitate improved decision making.

The scan focused on the practices of state transportation agencies that have most comprehensively implemented and integrated the HSM and performance-based, advanced safety analyses in planning, design, and operations in seven areas of interest:

- Status/Policy
- Training
- Technical Functions
- Data
- Cultural
- Information Dissemination
- Achieving Performance

Ten state transportation agencies, considered leaders in HSM implementation, participated in the scan:

- Alabama Department of Transportation (ALDOT)
- Florida Department of Transportation (FDOT)
- Illinois Department of Transportation (IDOT)
- Louisiana Department of Transportation and Development (LADOTD)

- Maine Department of Transportation (MaineDOT)
- Michigan Department of Transportation (MDOT)
- Missouri Department of Transportation (MoDOT)
- Ohio Department of Transportation (ODOT)
- Virginia Department of Transportation (VDOT)
- Washington State Department of Transportation (WSDOT)

This report is intended to help state transportation agencies that have not yet begun to implement the HSM, are beginning to implement the HSM, or are looking to further enhance the implementation of the HSM within their agencies. Most of the recommended actions are also applicable to local transportation agencies and metropolitan planning organizations (MPOs) in similar situations regarding HSM implementation. The following actions, aligned with the seven areas of interest established at the outset of the scan, are recommended for state transportation agencies to help implement and integrate HSM and performance-based, advanced safety analysis procedures (PBASAPs) within their agencies:

Status/Policy

- An HSM champion is needed to advocate and seek support to incorporate HSM methods and PBASAPs within each of the programs and departments in the agency. The champion should communicate a vision, purpose, and need for HSM implementation within the agency.
- Executives and upper management should be provided training to understand the value of reliable and accurate data, the need for data integration, and quantitative safety analysis both within and outside of the safety program. The training may garner support and prioritization of agency policies regarding data collection and maintenance and PBASAPs.
- Agencies should consider developing an HSM implementation plan and/or an HSM implementation team to guide the direction of HSM implementation within their agency.
- Agencies should support their staff's participation on AASHTO and Transportation Research Board (TRB) committees and subcommittees that oversee the research and implementation of the HSM and PBASAPs. Through their participation on these committees and subcommittees, staff will better understand the importance of reliable and accurate data, training needs, and limitations and applications of various methods and procedures, and be better prepared to implement research results.
- Agencies should adopt the Toward Zero Deaths National Strategy on Highway Safety or other zero-based traffic safety initiatives, if they have not already done so, because it provides a platform for implementing and integrating HSM methods and PBASAPs within agencies.
- Agencies should identify incremental steps to implement certain aspects or applications of the HSM within their agencies and, over time, look to more fully integrate HSM procedures within their policies and programs throughout departments. Such steps could be incorporated into an HSM implementation plan (see the third item in this list).
- Agencies should develop executive orders, policies, procedures, and guidance documents to facilitate the implementation of HSM methods. Such policies and guidance should address the tort liability implications of using the term “safety” in planning, programming, and project development; align

project purpose and needs statements with safety evaluation, analysis, and diagnosis activities; and put into place agreements with oversight agencies (e.g., stewardship agreement).

Training

Agencies should develop a robust HSM training program that:

- Provides various levels and types of HSM training for target audiences.
- Demonstrates tools that can be used to implement HSM procedures and instructs users on how to properly use the tools to analyze safety and interpret the results.
- Addresses the type of data used in the HSM, such as site characteristics, traffic volume and crash data; presents PBASAPs; and demonstrates how users can access their agency's data for analyses.
- Uses a variety of training methods such as in-person sessions, webinars, and web-based tutorials that users can access on an as-needed basis.
- Is updated regularly to incorporate new material and address gaps in knowledge related to application of HSM procedures for planning, programming, and project development.
- Uses in-house staff to deliver training to increase trust and acceptance and provide support following training.

Technical Function

- Agencies should provide guidance on the recommended level of safety analysis expected for projects based on the purpose and need statement, the type and level of funding, the level of complexity, and other criteria to increase consistency among projects.
- Agencies should put processes in place to better understand project scope, definition, and design approach and incorporate safety performance quantification at the earliest stage of planning, programming, and project development so it can be effectively utilized and project delays are minimized.
- Agencies should recognize the value of evaluation, analysis, and diagnosis of safety performance needs across the various disciplines that have a responsibility for safety performance and decision making.
- Agencies should evaluate existing tools and commercially available software that apply HSM methods and PBASAPs and select or develop tools to meet their needs, making it easier for personnel to understand, implement, and apply HSM methods and PBASAPs as part of their job responsibilities.
- Agencies should consider supplementing their traditional, crash-based safety management approach with a systemic approach to address crash types that are widely dispersed across the highway network and are not well suited for remedy using a traditional, crash-based safety management approach.
- State transportation agencies should work with local agencies and MPOs to provide prioritized lists of sites with potential for safety improvement based on advanced safety analyses and reliable performance measures and assist them in developing their own local road safety plans.

Data

- Agencies should develop short-term and long-term visions for acquiring and using safety data. First, they should identify ways to use already available data to achieve early implementation of HSM methods and PBASAPs. Next, they should identify incremental steps for collecting additional data and integrating it into HSM methods and PBASAPs.
- Agencies should develop a safety data business plan to guide their safety data management practices.
- Agencies should establish and enforce data governance policies that address data needs in each business area.

Cultural

- Agencies should use HSM training programs and marketing material to educate their staff concerning the difference between nominal and substantive safety and the limitations associated with using crash rate as the primary measure of safety performance.
- Agencies should seek approaches and opportunities to achieve a cultural shift to institute performance-based processes within their respective agencies. Changes in culture can be driven by:
 - Establishing executive orders and policy directives that provide the foundation for integrating performance-based processes throughout the agencies' various programs and departments.
 - Implementing a process for leading change.
 - Establishing an HSM implementation team and/or plan.
 - Making safety analyses simpler and more accessible to internal and external staff.

Information Dissemination

- Agencies should use a variety of approaches (e.g., top-down, bottom-up, and peer-to-peer) to communicate internally to implement HSM methods and PBASAPs.
- When communicating safety analysis results to external stakeholders, agencies should use simple language; present information using visual aids such as maps; target the discussion to the specific audience; avoid discussing crash costs; and discuss all aspects of the project, including safety, operations, design, environment, and context.
- Staff whose primary responsibility is safety should periodically meet with their agency's legal counsel to understand liability concerns associated with HSM methods and PBASAPs.

Achieving Performance

- Agencies should set clear goals and objectives for HSM implementation and establish measures for tracking the success of their HSM implementation.

1 Introduction

Background

Performance-based processes that use data-driven safety performance measures offer potential for state and local transportation agencies to reduce the number of traffic fatalities and serious injuries that occur on the nation's highways and to make informed decisions to reduce project and operating costs. The American Association of State Highway and Transportation Officials (AASHTO) Highway Safety Manual (HSM) provides safety knowledge and tools in a useful form to facilitate improved decision making based on safety performance¹. The HSM enables transportation agencies to use performance-based statistical approaches when designing for the safety performance of a facility, rather than simply adhering to traditional design policies and standards as provided in resources such as the AASHTO A Policy on Geometric Design of Highways and Streets (i.e., Green Book²), the AASHTO Roadside Design Guide³, the Federal Highway Administration (FHWA) Manual on Uniform Traffic Control Devices⁴, and state design manuals.

In the fiscally constrained environment that transportation agencies operate in today, agencies may wish to revisit assumptions about safety performance benefits as well as processes and decisions that drive the project development process. Utilization of the HSM helps transportation agencies provide the highest level of safety performance within the financial resources available. While other initiatives have focused on analytical examples of implementation of the HSM, AASHTO and FHWA (through the National Cooperative Highway Research Program [NCHRP]) sponsored a domestic scan to identify leading practices in the use of the HSM for planning, design, and operations. The scan provided an opportunity for critical conversations around processes and work force components not usually included in HSM implementation-related presentations or meetings that occur elsewhere.

Project Objective and Scope

The objectives of scan were to:

- Evaluate the processes, job aids/tools, workforce training, and manner in which state transportation agencies have implemented and integrated the HSM into performance-based processes in planning, design, and operations.
- Learn the practices of state transportation agencies that have most comprehensively implemented the HSM since its publication in 2010.
- Disseminate information about leading practices in use of the HSM in planning, design, and operations to other state and local transportation agencies to help them reduce the number of traffic fatalities and serious injuries on all public roads and make informed decisions to reduce project and

-
- 1 Highway Safety Manual, American Association of State Highway and Transportation Officials, 2010, <http://www.highwaysafety-manual.org/Pages/default.aspx>
 - 2 A Policy on Geometric Design of Highways and Streets, American Association of State Highway and Transportation Officials, 2011, https://store.transportation.org/Item/CollectionDetail?ID=180&gclid=CjwKCAiAyMHhBRBIEiwAkGN6fJyNpczEWEa2jqTHqhVtu1NZA746E-uaEF3pkTRHniNn4ywi4AGK7xoCMwoQAvD_BwE (Note: Link is to the 2018 edition.)
 - 3 Roadside Design Guide, American Association of State Highway and Transportation Officials, 2011, https://store.transportation.org/Item/CollectionDetail?ID=105&gclid=CjwKCAiAyMHhBRBIEiwAkGN6fNVZR9osL-fDlykJ4IMGOkWn-Zc8TSoabujS7w_MOaY-LhmVY-eq4xoCi_cQAvD_BwE
 - 4 Manual on Uniform Traffic Control Devices, Federal Highway Administration, U.S. Department of Transportation, 2009, https://store.transportation.org/Item/PublicationDetail?ID=1550&gclid=CjwKCAiAyMHhBRBIEiwAkGN6fLqTgAOvchrkX2tdfulRgBh9pb4y-ofiwCBVmKp78UsE1gFl8-iuxxoCEYIQAvD_BwE

operating costs.

While the overall goal of the project was to learn about leading practices in the use of the HSM, discussions with the state transportation agencies that participated in the scan focused on the broader concepts of performance-based approaches to quantifying safety performance. In many cases, the state transportation agencies implemented procedures as described in the HSM, but in other cases the agencies used concepts, principles, and performance-based statistical approaches described in the HSM and incorporated them into tools or projects in various ways to inform decisions based on performance-based processes that use data-driven safety performance measures. Thus, the scope of this scan extends beyond simply focusing on analysis procedures directly described in the HSM and addresses in a broader sense performance-based advanced safety analysis procedures (PBASAPs) to facilitate improved decision making.

The scan focused on the practices of state transportation agencies that have most comprehensively implemented and integrated the HSM and performance-based advanced safety analyses in planning, design, and operations related to seven areas of interest:

- Status/Policy
- Training
- Technical Functions
- Data
- Cultural
- Information Dissemination
- Achieving Performance

Prior to meeting with the state transportation agencies, the scan team distributed a list of amplifying questions (see Appendix A) to the participating agencies to prepare for the scan. Information related to the areas of interest listed above is provided in further detail in subsequent sections of this report.

The primary audience for this report is state transportation agencies; however, local transportation agencies, metropolitan planning organizations (MPOs), FHWA, and AASHTO will also benefit from the information provided within the report. It is anticipated that state and local transportation agencies and MPOs in the early stages of implementing the HSM (or still contemplating how to implement the HSM) will be able to use this report to help them further integrate data-driven, performance-based processes into their policies and programs. In addition, it is anticipated that AASHTO and FHWA will be able to use this report to further assist agencies in their efforts to implement the HSM.

Lead States

In 2017, the scan team met with 10 state transportation agencies to evaluate how the agencies have implemented and integrated the HSM into performance-based processes in the areas of planning, design, and operations. The 10 state transportation agencies that participated in the scan are considered leaders in HSM implementation as determined based on information gathered through an internet search, a review of recent publications related to HSM implementation, knowledge gained through participation in sponsored research and volunteer activities on national committees, and communications with several key contacts. Five state transportation agencies hosted the scan team, while five transportation agencies traveled to meet with the team remotely at one of the lead agency's locations. Figure 11 shows the five lead states that hosted

meetings with the scan team and the five lead states that traveled to meet with the team. The 10 state agencies included:

Host Agencies

- Florida Department of Transportation (FDOT)
- Illinois Department of Transportation (IDOT)
- Louisiana Department of Transportation and Development (LADOTD)
- Ohio Department of Transportation (ODOT)
- Washington State Department of Transportation (WSDOT)

Agencies Participating Remotely

- Alabama Department of Transportation (ALDOT)
- Maine Department of Transportation (Maine DOT)
- Michigan Department of Transportation (MDOT)
- Missouri Department of Transportation (MoDOT)
- Virginia Department of Transportation (VDOT)

Staff in central and regional/district offices and from different departments or disciplines within the lead agencies, such as safety, planning, design, operations, and environment, participated in these meetings. Contact information for the primary contacts in each participating state is provided in Appendix B.

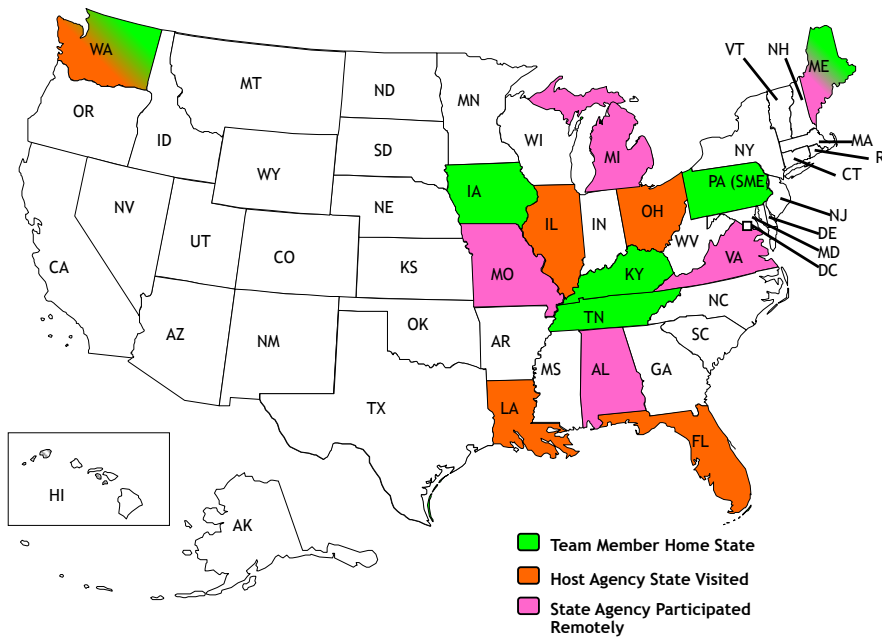


Figure 1-1 Map of lead agencies and scan team members

Scan Team

Members of the scan team included:

- John Milton, AASHTO Chair, WSDOT
- Dave Duncan, Tennessee DOT (TDOT)
- Jerry Roche, FHWA
- Dennis Emidy, Maine DOT
- Samuel Sturtz, Iowa DOT
- Michael Vaughn, Kentucky Transportation Cabinet (KYTC)
- Darren Torbic, MRIGlobal, Subject Matter Expert

Scan planning and logistics were managed by Arora and Associates, P.C. Harry Capers, PE, was the principal investigator. Figure 11 shows each scan team member's home state. Biographical information for the scan team members is provided in Appendix C; their contact information is provided in Appendix D.

2 Status/Policy

When the scan team met with the 10 agencies considered leaders in HSM implementation, the first topic of discussion focused on the status of HSM implementation within each agency. The scan team wanted to learn how long each agency had been using the HSM and the primary catalysts to HSM implementation within their agency. The scan team also wanted to learn how each of the different agencies had been implementing the HSM in planning, programming, environment, design, operations, and maintenance. By learning more about the status of HSM implementation in each agency, the scan team identified several catalysts that accelerated the use and implementation of the HSM, as well as quantitative safety analyses within the lead agencies and influential changes in departmental policies and procedures resulting from HSM implementation.

Catalysts That Accelerated HSM Implementation

The HSM was published in 2010 and provides a variety of methods to conduct quantitative safety analyses, allowing safety to be quantitatively evaluated with other transportation performance measures, such as traffic operations, environmental impacts, and construction costs. For the first time in one resource, the HSM provides a comprehensive collection of quantitative safety analysis methods for transportation agencies to use. State transportation agencies and some local transportation agencies are familiar with the HSM at some level through marketing efforts and training programs intended to help agencies effectively use the HSM. However, most state and local agencies are only beginning to implement the HSM. Few state transportation agencies have taken full advantage of the safety performance, decision-making tools provided within the HSM. The following subsections describe several key catalysts that accelerated HSM implementation within one or more of the lead agencies, including:

- Champion advocated for HSM implementation
- Executive-level training to gain upper management support
- HSM implementation team and plan
- Involvement in AASHTO and Transportation Research Board (TRB) committees and subcommittees
- Adoption of Toward Zero Deaths (TZD) initiative
- Incremental steps toward HSM implementation

Champion Advocated for HSM Implementation

Within each lead agency, a champion or champions were responsible for advocating and gaining support to incorporate HSM methods within programs and departments. The champion spread knowledge of the HSM throughout the agency and communicated a vision, purpose, and need for HSM implementation within their agency.

LADOTD noted that successful implementation was dependent on having a champion within the agency committed to the HSM implementation effort and for promoting use of the HSM at all levels of the agency. For LADOTD, the highway safety administrator was the HSM champion. The LADOTD secretary also provided support for HSM integration into the agency's business units.⁵

⁵ Hull RE, E Wemple, J Fish, K Kolody Silverman, and D Perez-Bravo, State Policies and Procedures on Use of the Highway Safety Manual, Report No. FHWA-SA-16-119, Federal Highway Administration, September 2016, <https://safety.fhwa.dot.gov/hsm/spp/fhwasa16119.pdf>

At ALDOT, the former chief engineer was the chair of the AASHTO subcommittee overseeing the development of the HSM. It was his leadership that led ALDOT to adopt the HSM and advance its use within the department.

The state safety engineer of Illinois served as vice chair of the AASHTO HSM task group charged with direct input into the development of the HSM and as the chair of AASHTO's task group for safety technical publications. At IDOT, the state safety engineer led the state through national peer exchanges financed by the state safety funds and proposed a lead states initiative. These efforts were instrumental to advancing IDOT's HSM implementation.

Executive-Level Training to Gain Upper Management Support

The lead agencies considered executive-level training critical for gaining upper management support for HSM implementation. Without upper management support, it would be very difficult to integrate HSM methods in department programs and policies. Therefore, all lead agencies held HSM training sessions targeted toward upper management. Through training, executives gained a better understanding of the value of quantitative safety analysis both within and outside of the safety program, as quantitative safety analyses also impact policies and practices in design, operations, planning, and environment departments. Executives also came to realize the value of reliable and accurate data. Because of the executive-level training, staff in the lead agencies had the support from upper management to implement pilot projects and establish implementation plans and teams (see HSM Implementation Team and Plan) to move forward with HSM implementation.

In many cases, funding levels for safety became reflective of the support of upper management. Highway Safety Improvement Program (HSIP) funding is set at the national level. What each state transportation agency does with the funding is established at the state level. Some agencies may transfer their HSIP funding away from safety, while others may provide additional funding (e.g., through state planning and research [SP&R] program funds) to support safety programs and projects. For example, ODOT and LADOTD have two of the largest funded safety programs in the country. In 2017, ODOT dedicated approximately \$102 million for engineering improvements at high-crash and severe-crash locations⁶, and LADOTD's HSIP budget was around \$65 million for preconstruction and construction tasks associated with infrastructure projects on state routes⁷. IDOT provides additional funding through SP&R funds to support HSM implementation (e.g., research and safety performance function [SPF] development) and HSIP funds to calibrate HSM SPFs.

HSM Implementation Team and Plan

Several of the lead agencies established an HSM implementation team to guide the direction of HSM implementation and offer insights on specific barriers to be overcome, to identify technical and resource needs, to identify potential early successes, and to determine how to best incorporate changes in department policies or approaches⁸. Representation on the HSM implementation teams and the structure of the team varied across agencies. For example, LADOTD established an HSM implementation team that included internal and external stakeholders:

6 Ohio Highway Safety Improvement Program 2017 Annual Report, Ohio Department of Transportation, 2017, <https://safety.fhwa.dot.gov/hsip/reports/pdf/2017/oh.pdf>

7 Highway Safety Improvement Infrastructure Project Selection Guide for State Routes, Louisiana Department of Transportation and Development, September 2017, http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Multimodal/Highway_Safety/Misc%20Documents/FINAL_REVISIED_HSIP%20Infrastructure%20State%20Routes%20Project%20Selection%20Guide%20v17_REV.pdf

8 Neuman T, and I van Schalkwyk, HSM Implementation Guide for Managers, Report No. FHWA-SA-11-48, U.S. Department of Transportation, September 2011, https://safety.fhwa.dot.gov/hsm/hsm_mgrsguide/hsm_mgrsguide.pdf

-
- LADOTD internal sections
 - Highway Safety
 - Transportation Planning
 - Environmental
 - Traffic Engineering
 - Road Design
 - Pavement Preservation
 - District
 - LADOTD external partners
 - FHWA Division Office (Safety, Traffic Operations, and Planning)
 - Local Technical Assistance Program (Local Road Safety Program)

FDOT developed an implementation structure that includes champions at the central office and each district office, and a Core Implementation Team comprising multidisciplinary members, including the state safety engineer, the roadway design administrator, a roadway design engineer, a state project development engineer, a traffic systems studies engineer, and a transportation planner.

At Maine DOT, the Highway Safety Committee consists of the safety office manager, the assistant director of the Bureau of Planning, the state traffic engineer, the regional manager of Maintenance and Operations, the regional traffic engineer, the transportation manager/engineer, the HSIP engineer, the FHWA safety engineer, the bike and pedestrian coordinator, the assistant program manager of the Bureau of Highway Design, and the multimodal assistant manager.

At WSDOT, four groups support the Highway Safety Executive Committee, which consists of executives that set the formal policy that fosters HSM implementation:

- Highway Safety Working Group (managers and the Highway Safety Executive Committee chair)
- Highway Safety Issues Group (personnel who write and shape state policy)
- Headquarters Safety Technical Group
- Safety Technical Group (discusses technical issues when they arise and serves as technical support on HSM implementation to headquarters and the regions)

In addition to establishing HSM implementation teams, most of the lead agencies also developed HSM implementation plans of varying degree and complexity. LADOTD hired a consultant to develop its Louisiana HSM implementation plan⁹. The first section of the plan addressed the purpose for the plan, the benefits and driving forces of HSM implementation, and the challenges of HSM implementation. Section 2 focused on organizational support needed for implementation, including a champion and leadership team, executive support, district support, and marketing. Section 3 addressed data improvements necessary for full implementation of the HSM, which were identified through an HSM data readiness evaluation. Section 4 covered the LADOTD project delivery process and identified opportunities for using the HSM in

9 Louisiana HSM Implementation Plan, Louisiana Department of Transportation and Development, June 2012, http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Multimodal/Highway_Safety/Misc%20Documents/LADOTD%20HSM%20Implementation.pdf

the process. Section 5 identified specific HSM applications for various departments in LADOTD, including implementation strategies and training needs. Section 6 provided an implementation schedule for the strategies identified throughout the plan.

Table 2-1 summarizes the timeframe and activities associated with FDOT’s HSM implementation plan. The agency’s plan addressed data, calibration, upper management support, training, pilot projects, integration of HSM methods into specific practices and programs, and integration of HSM methods into manuals and guidebooks.

Begin Date	Activity/Event
4th Quarter 2010	Calibrate Equations for Florida Conditions – Assess the availability of the required data types and calibrate SPFs for Florida conditions.
4th Quarter 2010	Top Management Support - Request support and commitment from top management. Present need and urgency for implementation of HSM to key department staff. Agree on planned activities, reporting, and assistance.
4th Quarter 2010	Joint Director’s Meeting Presentation - District and Central Office directors
4th Quarter 2010	NCHRP 17-38 HSM Pilot Training – District and Central Office participants (40) from Design, Planning, Safety, and Traffic Operations.
4th Quarter 2010	NCHRP 17-50 HSM Lead State Initiative – Demonstrate Florida’s commitment to leadership and willingness to support local agencies and other states in HSM implementation.
1st Quarter 2011	Top-Down Management Presentations – Four top-down meetings will be held to extend the support and commitment to district management (Environmental Management Office, Design, Traffic Operations, and Safety).
2nd Quarter 2011	Executive Committee Workshop Presentation – Present HSM benefits and national and FDOT implementation efforts.
2nd Quarter 2011	District Pilot Projects – Identify four projects in each district (Project Development and Environment, Safety, Traffic Operations, Design) under the direction of the trained senior engineers that can benefit from applying the HSM methodologies. Work with CO to develop and review analysis.
3rd Quarter 2011	Publication/Recognition of Pilot Projects - Publicize the results of district pilot projects and recognize the manager/designer responsible for implementation.
3rd and 4th Quarter 2011	Deliver Training in Each District – Conduct HSM training in each district for in-house and consultant personnel working with FDOT and local projects.
4th Quarter 2011	Large Scale Project Implementation - Identify a minimum of 10 projects in each district (PD&E, Safety, Traffic Operations, and Design) under the direction of trained engineers that can benefit from applying the HSM methodologies.
1st Quarter 2012	Update FDOT Roadway Characteristics Inventory/Develop Calibration Database – Implement changes to inventory database required to recalibrate equations periodically. Finalize calibration software/spreadsheets.
1st Quarter 2012	Implement Network Screening Methods/Work Program Component – Establish a Roadway safety management process following HSM methodologies (Part B) for programming safety projects under the Highway Safety Improvement Program.
2nd Quarter 2012	Incorporation into Manuals, Guidelines, and Handbooks – Update procedures and criteria in department publications.
2nd Quarter 2012	Director of Transportation Management Reports – Integrate business rules resulting from quantitative safety analysis into the program development process. Best practices will be shared between districts.
Future	Training and Implementation of Additional Safety Performance Functions and Crash Modification Factors (Ver. 2) – Implement methodologies for freeways, six-lane roadways, etc.
Future	Standardized Training, Tools, and Annual Calibration

Table 2-1 Summary of FDOT HSM implementation plan

MoDOT developed an implementation plan that organizes specific action items under broader strategies to increase the application of the HSM within the agency. Table 2-2 shows a summary of MoDOT’s implementation plan.

Table 2-2 Summary of MoDOT HSM implementation plan

Strategy	Action Items
Obtain support materials	<ul style="list-style-type: none"> ■ Obtain: <ul style="list-style-type: none"> – Copies of the HSM – PowerPoint presentation about HSM – Safety analyst software license – Excel spreadsheets that perform HSM crash prediction methodology calculations – CMF Clearinghouse
Increase understanding of HSM within MoDOT	<ul style="list-style-type: none"> ■ Meet with executive team members to discuss: <ul style="list-style-type: none"> – HSM implementation framework – Formation of HSM implementation team – HSM support (in-house, consultant, etc.) ■ Meet with Chief Counsel’s Office (legal) to discuss its role in implementation ■ Meet with division heads (Planning, Design, Traffic) ■ Meet with district engineers ■ Give presentation at statewide planning/design meeting ■ Give presentation at statewide traffic meeting
Establish an HSM Implementation Team	<ul style="list-style-type: none"> ■ Include representation from: <ul style="list-style-type: none"> – Planning – Design – Traffic – Highway Safety ■ Include a power user from each district
Access or develop and provide training	<ul style="list-style-type: none"> ■ Identify and attend courses taught by FHWA ■ Develop workshop for districts to be taught by MoDOT ■ Identify and attend HSM Part D and CMF Clearinghouse Training
Develop policies/ guidance and integrate into processes	<ul style="list-style-type: none"> ■ Address: <ul style="list-style-type: none"> – Design exceptions – Network screening – safety analyst – Highway Safety Improvement Program projects (or other projects using safety funds) – Value engineering studies ■ Identify other processes (project prioritization, environmental impact studies, etc.)
Provide technical support and monitor HSM use	<ul style="list-style-type: none"> ■ Develop state-specific distribution values ■ Develop calibration factors ■ Identify/access HSM support (in-house, contractor)

MoDOT’s implementation plan includes additional action items to share its HSM knowledge and experience with peer states, external partners, and local agencies, including:

- Participate in HSM lead states NCHRP project
- Participate in HSM implementation pooled-fund study
- Support other states in implementing the HSM
- Expand awareness to outside partners
- Work with local technical assistance program (LTAP) to establish its role in HSM implementation on the local level
- Update the Safety Handbook for Locals

Involvement in AASHTO and TRB Committees and Subcommittees

The lead agencies in HSM implementation encouraged and supported their staff to actively participate on AASHTO and TRB committees and subcommittees, such as the AASHTO Committee on Safety and the TRB Highway Safety Performance Committee (ANB25). The AASHTO Committee on Safety focuses on the advancement of multidisciplinary approaches to eliminate crashes, particularly those resulting in traffic fatalities and serious injuries, on all public roads in the United States and in locations where roads interact with other modes. The committee's primary focus areas include strategic safety planning; programs and policies; road and facility users; effective countermeasures; safety performance, data analysis, and evaluation; workforce development; research; technical safety publications; and local road safety. The committee coordinates with other AASHTO committees and external organizations on issues of joint interest. The TRB Highway Safety Performance Committee's goal is the advancement, integration, and institutionalization of quantitative highway safety information to support transportation decision-making at all levels. The committee fosters the continual development, validation, and increased knowledge of science-based methods, procedures, and measures that will increase the safety of the nation's highways and roadways, including the development of the HSM. AASHTO and TRB committees coordinate with FHWA to advance implementation of the HSM beyond the lead states.

Through active participation on AASHTO and TRB committees, staff members of the lead agencies had a better understanding of concepts and analysis approaches included in the HSM. For instance, prior to the publication of the HSM, IDOT hosted a National SPF Summit in 2009 to provide information and enable discussions on various ongoing and emerging activities and issues regarding the development and implementation of SPFs. SPFs are integral to many of the analytical procedures included in the HSM. In 2010, IDOT also hosted a Highway Safety Manual Lead State Peer-to-Peer Workshop to facilitate the exchange of experiences and examples related to HSM implementation among states, which provided the opportunity for agencies to learn from others. This led the way for NCHRP Project 17-50, Lead States Initiative for Implementing the Highway Safety Manual. Through AASHTO committees and subcommittees, representatives from the lead agencies received updates on the status of NCHRP projects that resulted in material incorporated into the HSM and, in some cases, representatives from the lead agencies were on the NCHRP project panels that oversaw and guided the direction of the research. Through participation with AASHTO and TRB, representatives from the lead agencies were also able to review and provide comments on draft chapters of the first edition of the HSM and provide recommendations for future research needs to fill gaps. Because of these AASHTO and TRB experiences, the lead agencies and their staff were better prepared to implement the HSM upon its publication. The lead agencies also had a better understanding of training needs associated with the HSM, as training is an important step in HSM implementation.

AASHTO and TRB are already planning for the publication of the second edition of the HSM, anticipated

in 2019. Having the opportunity to keep abreast of the primary research being conducted to address knowledge gaps in the first edition of the HSM and to review draft text for the second edition, several of the lead agencies noted that they will be better prepared to implement the second edition when it is published.

Adoption of Toward Zero Deaths (TZD) Initiative

Transportation agencies implement many diverse initiatives and programs to improve safety on all public roads, and many agencies have their own strategic plan to guide their own activities. The purpose of Toward Zero Deaths: A National Strategy on Highway Safety and other national zero-based initiatives is to bring these agencies and stakeholders together with a common vision that will drive their individual and collaborative efforts¹⁰. Many state agencies have developed comprehensive TZD programs.

“TZD has been a strategy that Michigan has rallied around. It aligns with our agency mission and often provides perspective when weighing what direction to take on a decision.”

Dean Kanitz
Michigan DOT

For agencies that adopted this national strategy, it provided a platform to develop safety plans that prioritize traffic safety culture and promote the national TZD vision. The TZD initiative provides clear policy strategic goals and objectives targeted toward safety performance. Several of the lead agencies noted that their involvement in the TZD initiative provided the platform for their agencies to incorporate HSM methods in their strategic highway safety plans (SHSPs).

Incremental Steps Toward HSM Implementation

The analytical procedures in the HSM can be used in many ways within a transportation agency. HSM procedures can be used for planning, programming, environment, design, operations, and maintenance. HSM procedures can also be used for the HSIP program, for alternative analyses, design exceptions, access justification reports, pavement restoration, and performance-based project development. The lead agencies recognized that the HSM is a powerful tool but also realized that integration of the HSM into department policies and procedures was going to take time. Rather than trying to take full advantage of the capabilities of the HSM at the outset, the lead agencies took incremental steps toward implementing the HSM. Over time, HSM procedures were more fully integrated into policies and programs throughout their agencies.

The lead agencies took a variety of approaches toward incrementally incorporating HSM procedures within their policies and programs. At first glance, the data requirements to implement many of the HSM procedures can be overwhelming, particularly for the Part C predictive methods. Table 23 provides a summary of the roadway characteristics data requirements for use with the Part C predictive methods (i.e., HSM Chapters 10, 11, and 12). The data requirements change as a function of the facility type (e.g., two-lane, two-way rural road, multilane rural highway, and urban/suburban arterial) and whether an intersection or roadway segment is under consideration¹¹. Many of these variables are not readily available in existing roadway inventory files, nor are all of these variables easily collected for an entire roadway network.

Table 2-3 Variables used in HSM Part C predictive methods¹¹

10 Toward Zero Deaths: A National Strategy on Highway Safety, Toward Zero Deaths Steering Committee and Federal Highway Administration, June 2014, https://www.towardzerodeaths.org/wp-content/uploads/TZD_Strategy_12_1_2014.pdf

11 Highway Safety Manual Data Needs Guide, NCHRP Research Results Digest 329, Transportation Research Board, June 2008, <https://www.nap.edu/read/23089/chapter/1>

CHAPTER 2 : STATUS/POLICY

Variables	Chapter 10 Rural Two-Lane, Two-Way Roads	Chapter 11 Rural Multilane Highways	Chapter 12 Urban and Suburban Arterials
Roadway segments			
Area type (rural/suburban/urban)	X	X	X
Annual average daily traffic volume	X	X	X
Length of roadway segment	X	X	X
Number of through lanes	X	X	X
Lane width	X	X	
Shoulder width	X	X	
Shoulder type	X	X	
Presence of median (divided/undivided)		X	X
Median width		X	
Presence of concrete median barrier		X	
Presence of passing lane	X		
Presence of short four-lane section	X		
Presence of two-way, left-turn lane	X		X
Driveway density	X		
Number of major commercial driveways			X
Number of minor commercial driveways			X
Number of major residential driveways			X
Number of minor residential driveways			X
Number of major industrial/institutional driveways			X
Number of minor industrial/institutional driveways			X
Number of other driveways	X		
Horizontal curve length	X		
Horizontal curve radius	X		
Horizontal curve superelevation	X		
Presence of spiral transition	X		
Presence of centerline rumble strips	X		
Grade	X		
Roadside hazard rating	X		
Roadside slope		X	
Roadside fixed-object density			X
Roadside fixed-object offset			X
Percent of length with on-street parking			X
Type of on-street parking			X
Presence of lighting	X	X	X
Presence of automated speed enforcement	X	X	X
Intersections			
Area type (rural/suburban/urban)	X	X	X

Variables	Chapter 10 Rural Two-Lane, Two-Way Roads	Chapter 11 Rural Multilane Highways	Chapter 12 Urban and Suburban Arterials
Major-road average daily traffic volume	X	X	X
Minor-road average daily traffic volume	X	X	X
Number of intersection legs	X	X	X
Type of intersection traffic control	X	X	X
Left-turn signal phasing (if signalized)			X
Presence of right turn on red (if signalized)			X
Presence of red-light cameras			X
Presence of median on major road		X	
Presence of major-road left-turn lane(s)	X	X	X
Presence of major-road right-turn lane(s)	X	X	X
Presence of minor-road left-turn lane(s)		X	
Presence of minor-road right-turn lane(s)		X	
Intersection skew angle	X	X	
Intersection sight distance	X	X	
Terrain (flat versus level or rolling)		X	
Presence of lighting		X	X
Daily pedestrian volumes crossing all intersection legs			X
Presence of bus stops			X
Presence of schools			X
Presence of alcohol establishments			X

Rather than taking on a massive effort to collect all variables, which would require extensive time and financial resources, lead agencies initially used existing data and collected a few additional data elements that could be easily collected. Over time, the agencies collected more data and improved the quality of their data for HSM implementation. Meanwhile, they used the data that were available to implement portions of the HSM procedures. Over time their safety analysis procedures evolved, becoming more robust and accurate with the incorporation of additional and higher quality data.

Based on the available data, IDOT developed network screening level state-specific SPFs using HSM Part B criteria, which became the foundation for its roadway safety rating system. Table 24 reflects LADOTD's initial priorities for collecting data and establishing a dataset for HSM implementation. The agency's plan reflects the desire to develop calibration factors for SPFs for facility types based on data availability. Its next priority was to establish calibration factors for the remaining roadway segment SPFs, followed by developing calibration factors for intersections. As a result, LADOTD was first able to use the Part C predictive methods for roadway segments, followed by the procedures for intersections.

Table 2-4 LADOTD priorities for data collection and analysis⁹

Data Collection Strategy	Priority to Start	Anticipated Duration
Identify which SPFs to calibrate (e.g., based on data availability, traffic volumes, crash frequency/rates, etc.), collect the missing data, and develop the calibration factor.	Near-term	Ongoing
Use lessons learned from first calibration effort and develop calibration factors for the remaining roadway segment SPFs.	Mid-term	3 years
Complete the efforts of locating the intersections in the roadway elements database.	Mid-term	2 years
Identify methodology to estimate minor street traffic volumes at intersections.	Long-term	2 years
Collect missing data and develop calibration factors for the intersection SPFs.	Long-term	5 years

Similarly, when ODOT and MDOT were developing datasets for use with Safety Analyst¹² (safety management software that implements HSM Part B procedures), both agencies gave priority to developing datasets for roadway segments and intersections first, followed by datasets for ramps. As a result, they were able to conduct HSM Part B procedures within Safety Analyst, such as network screening to analyze roadway segments and intersections and then, over time, analyze ramps within the software.

Another way in which lead agencies took incremental steps toward implementing HSM procedures was by selecting pilot projects to demonstrate the use of HSM procedures. By selecting pilot projects, agencies could demonstrate the benefits of using HSM procedures and build support for HSM implementation.

FDOT selected a corridor widening project near Tampa Bay as a pilot to demonstrate the use and benefits of HSM predictive methods during the project development process and alternative analysis¹³. FDOT used the predictive method for urban and suburban arterials (Chapter 12) to evaluate the predicted safety performance of two alternative designs: four-lane divided and five-lane with a two-way, left-turn lane for a 20-year analysis period. Based on the results, the four-lane divided alternative was predicted to have a crash cost savings of approximately \$4.2 million compared to the five-lane with two-way left-turn-lane alternative. Use of the predictive method provided quantifiable evidence on why the four-lane alternative was the preferred alternative based on the crash cost savings and provided justification for the design engineer’s design decisions.

As a pilot project, LADOTD selected to apply HSM procedures to quantify the safety performance of proposed alternatives along a high-speed, four-lane, rural arterial highway between Interstate 12 and State Route 21 in Bush, Louisiana, to address regional transportation mobility needs and potentially stimulate economic growth¹⁴. LADOTD used FHWA’s Interactive Highway Safety Design Manual (IHSDM) to apply the HSM Chapter 11 predictive models for rural multilane highways to predict the number of crashes for each design alternative. Five alternative designs were considered, including the no-build scenario. To select the preferred alternative for construction, the U.S. Army Corps of Engineers assessed costs and benefits and considered public and agency comments developed as part of the environmental impact statement process. Safety was considered as part of the traffic and transportation impacts when assessing each alternative’s potential physical, natural, social, and environmental consequences. While the selected alternative was not expected to experience the fewest number of crashes among all of the design alternatives, it was still expected to experience fewer crashes and result in less societal cost expended than the no-build alternative.

12 Safety Analyst, American Association of State Highway and Transportation Officials, <http://www.safetyanalyst.org/>

13 Highway Safety Manual Case Study 3: Using Predictive Methods for Alternative Selection in Florida, Federal Highway Administration, U.S. Department of Transportation, (as of September 18, 2018), https://safety.fhwa.dot.gov/hsm/casestudies/fl_cstd.pdf

14 Louisiana Integrates Quantified Safety Performance into Design Decision on New Highway, Project Case Study FHWA-14-CAI-055, Federal Highway Administration, U.S. Department of Transportation, 2014, https://www.fhwa.dot.gov/innovation/everydaycounts/edc_4/pdf/case_study_la_oct2014.pdf

By selecting an alternative with a substantial reduction in crashes, but not the greatest reduction, the Corps exercised sound engineering judgment. It demonstrated that the agencies responsible for executing National Environmental Policy Act requirements and selecting the preferred alternative are not compelled to select the alternative believed to be the safest, nor the lowest-cost alternative, nor the alternative that has the least impact on an environmental asset. Rather, the decision-makers selected an alternative based on the consideration of all impacts that would achieve the project's purpose and address its stated need.

In the end, both pilot projects demonstrated the benefits of implementing HSM procedures and generated interest in using the HSM procedures throughout different departments of the agencies, and the pilot projects were able to demonstrate the value of quantitative safety analyses beyond the safety program.

The lead agencies were also thoughtful and selective in choosing the types of applications for initial implementation of HSM procedures. This prevented them from trying to incorporate HSM procedures into too many practices and programs all at once and not being successful with any. For example, ODOT and MDOT placed a priority on improving their network screening capabilities and decided to invest their time and effort into developing roadway inventory, traffic volume, and crash datasets for use within Safety Analyst, which provides state-of-the-art analytical procedures for safety management, including network screening. ALDOT focused on using HSM procedures initially for justification of design exceptions. As they were able to successfully integrate HSM procedures into their regular programs and practices, the lead agencies were then able to expand their application of HSM procedures into other areas.

Influential Changes in Departmental Policies and Procedures That Promote HSM Implementation

Following initial efforts to demonstrate the use and applications of the HSM, several of the lead agencies developed executive orders, policies, guidance documents, and practices that led to the further integration of HSM methods within the agencies. By taking these additional steps, the agencies established a clearer vision for integrating performance-based processes throughout different departments and programs within their agencies. These efforts also demonstrated the support from upper management for HSM implementation, while providing direction for staff.

Establishment of Executive Orders

An executive order is a written, signed, and published directive from the commissioner or secretary of Transportation that manages operations of the DOT. WSDOT put forth three executive orders that established direction for the department regarding safety and provided the foundation for establishing policies related to how the HSM would be incorporated into departmental policies and procedures. The three executive orders were related to:

- Business practices to promote a healthy economy, environment, and communities
- Implementation of least cost planning and practical design principles during project delivery
- Expectations related to safety, preservation, mobility, environment, and stewardship

Executive Order 1082 (Business Practices for Moving Washington) established the expectation that all WSDOT employees will conduct WSDOT's business in a manner that contributes to and promotes the state's economy, environment, and communities¹⁵. This direction is intended to reinforce the ethic of

¹⁵ Business Practices for Moving Washington, Secretary's Executive Order No: E 1082.00, Washington State Department of Transportation, Olympia, August 14, 2012, <https://www.wsdot.wa.gov/NR/rdonlyres/7C14650A-97B3-44BF-88C7-9E02E425F479/0/SecEO1082.pdf>

sustainability tied to the fundamental commitment to conduct business in a manner respectful to both the built and natural environments. This direction supports work to operate, maintain, and improve the state’s transportation facilities and services. In summary, the executive order establishes the expectation that decision making will be sustainable and cost-effective in support of the economy, environment, and communities. Examples of sustainable transportation practices that this executive order supports through the promotion of sustainable maintenance, preservation, and safety, include:

- Installation of roundabouts to reduce collisions and keep traffic flowing
- Guidance to achieve significant reductions in fatalities and serious injuries on all public roads
- Reduction of crashes and worker exposure in work zones during construction using up-to-date work zone safety techniques

Executive Order 1090 (Moving Washington Forward: Practice Solutions) directs WSDOT employees to implement least cost planning and practical design principles throughout all phases of project delivery to improve transportation decision making¹⁶. Least cost planning is an approach to making planning decisions that considers a variety of conceptual solutions to achieve desired system performance targets at the least cost. It results in the best mix of practical policy and capital investments to optimize total transportation system performance. Practical design is an approach to making project decisions that focuses on the specific problem the project is intended to address. This performance-based approach looks for lower cost solutions that produce the best return on investment to meet outcomes identified by communities and stakeholders. It allows more flexibility and freedom to innovate and considers incremental solutions to address uncertainties in future scenarios. The executive order suggests the HSM as a reference to help WSDOT employees implement least cost planning and practical design principles.

Executive Order 1096 (WSDOT 2015-17: Agency Emphasis and Expectation) asserts that WSDOT will deliver transportation priorities established by the Washington legislature in the areas of safety, preservation, mobility, environment, and stewardship¹⁷. The executive order provides clear guidance and expectations to employees in carrying out WSDOT transportation services, programs, and projects in the implementation of WSDOT’s budget and strategic plan. The safety of WSDOT’s customers, partners, and employees is WSDOT’s number one priority. Toward this end, the executive order states that WSDOT employees are expected to operate and maintain WSDOT facilities, ferry terminals and vessels, and other assets to safely benefit all users; the needs of all modes are to be considered during the planning and design process; and solutions should be science-based and data-driven. The executive order also states that WSDOT employees are expected to apply the HSM to achieve this goal.

“The development of executive policy set clear direction and expectation for WSDOT across multiple disciplines. This was one of the single most important factors of successful incorporation of data-driven safety analysis into our business practices.”

John Milton

Washington State DOT

In summary, the executive orders established the expectation that all WSDOT practices will promote safety; by implementing least cost planning and practical design principles throughout all phases of project delivery, transportation decision making will be improved. One approach to implementing cost-effective safety solutions is by applying HSM methods, which are science-based and data-driven.

16 Moving Washington Forward: Practical Solutions, Secretary’s Executive Order No: E 1090.00, Washington State Department of Transportation, 2014

17 WSDOT 2015-17: Agency Emphasis and Expectations, Secretary’s Executive Order No: E 1096.00, Washington State Department of Transportation, 2015

Policies to Guide Decisions

“The FDOT HSM Implementation Policy positively affected implementation efforts by formally receiving approval by executive management and encouraging active involvement across multiple offices in the department. Having the policy in place helps support the department’s need and commitment to implement the HSM.”

Joseph Santos
Florida DOT

Policies are basic principles adopted by the department to guide decisions. Several lead agencies developed policy statements that promoted the use of the HSM or incorporated language into existing policies regarding use of the HSM within their agencies. In 2016, FDOT adopted its HSM implementation policy that encourages use of HSM methods where applicable (see Figure 21). The policy document is short and simple, stating that it is FDOT’s policy to incorporate safety into the project development process. To implement this policy, the transportation analyst is encouraged to use HSM methods, where applicable, to measure safety benefits from proposed improvements. The HSM implementation policy will be integrated into FDOT’s internal manuals, guidelines, and related documents governing the planning, design, construction, maintenance, and operation of transportation facilities.

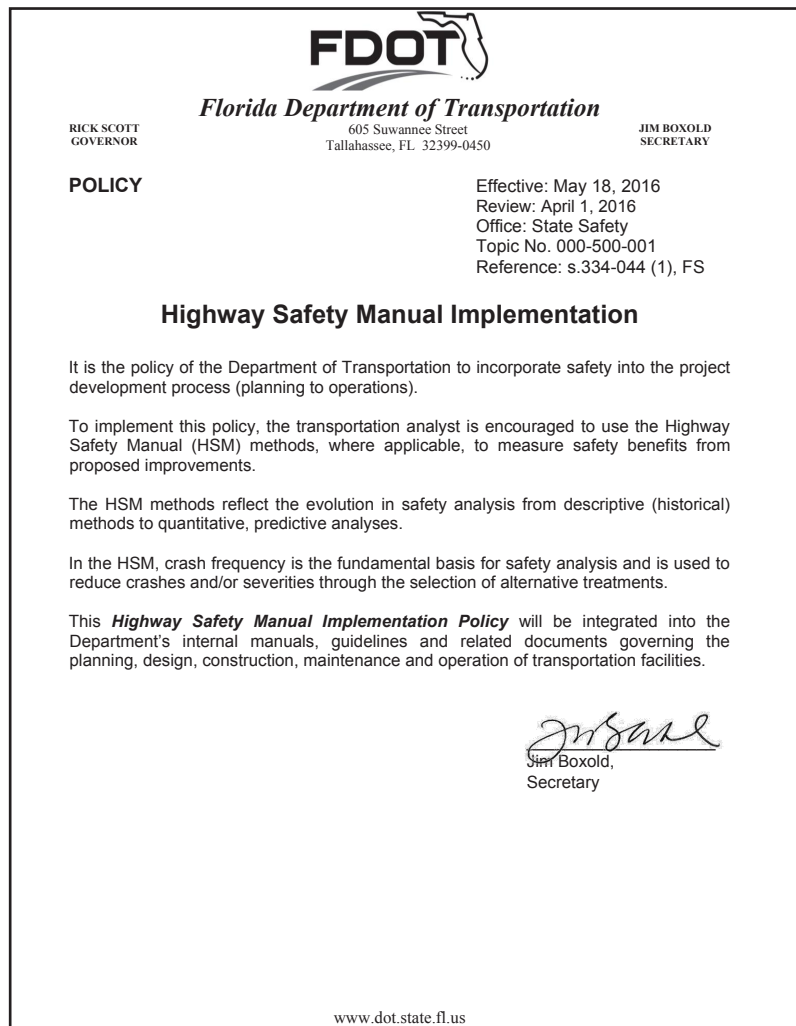


Figure 2-1 FDOT HSM implementation policy¹⁸

ODOT recently revised its policy for its HSIP¹⁹. The policy established procedures for project evaluation and statewide prioritization and development of the HSIP program. Eligible projects will be considered for funding and evaluated and prioritized based on the ability to improve safety and reduce the severity and long-term average frequency of crashes. The policy statement defines crash frequency as the basic measure of crashes in the HSM. The policy statement also indicates that ODOT will study the designated number of priority locations for improvement produced by Safety Analyst, as reviewed and accepted by the districts. Safety Analyst implements HSM Part B procedures for roadway safety management.

By adopting new policies that indicate the DOT will use HSM methods or by incorporating language into existing policies regarding use of the HSM, policy statements increased the use of HSM throughout departments and, as a result:

- Agencies sought opportunities to implement HSM practices that are trusted and have been developed through scientifically valid research.
- HSM methods were incorporated earlier in planning, programming, and project development.
- There was better alignment among tasks and activities at the central office, regions, and districts.

IDOT has integrated many of the HSM principles into its processes (e.g., network screening, calibrated SPFs, benefit-cost analysis, and research requirements) and has drafted several policies that will further incorporate language regarding use of the HSM. The policies will address:

- HSIP
- Road safety assessments
- Design exceptions
- Project development process
- Access justification reports
- Work zone safety and mobility

Guidance Documents

By establishing direction through executive orders and policies regarding use of the HSM, several lead agencies had the basis for incorporating language either referencing the HSM or the use of data-driven safety performance measures within certain guidance documents. By incorporating language into guidance documents, DOT employees had a better sense of how to incorporate HSM methods into their practices and programs. WSDOT integrated HSM language into two guidance documents that it recently developed, Safety Guidance for Corridor Planning Studies and a Safety Analysis Guide.

Safety Guidance for Corridor Planning Studies provides the foundation for developing the safety chapter in a corridor planning study²⁰. Development of a safety chapter assumes a general understanding of the fundamentals of how WSDOT approaches highway safety (sustainable highway safety) and the direct relationship with Washington's strategic highway safety plan (Target Zero). The guidance supports consistency across the agency; maximizes the potential benefit of the planning study for program and project development; and increases the likelihood of meeting the expectations of the public, elected officials, safety

19 Highway Safety Improvement Program Guidance, Ohio Department of Transportation, February 2017, http://www.dot.state.oh.us/Divisions/Planning/ProgramManagement/HighwaySafety/HSIP/Safety_Study/HSIP%20Procedures%20Manual.pdf

20 Safety Guidance for Corridor Planning Studies, Washington State Department of Transportation, June 2015, https://www.wsdot.wa.gov/NR/rdonlyres/8922DE13-C9DF-4369-8229-56811D836600/0/SafetyGuidance_CorridorPlanningStudies_June2015.pdf

stakeholders, and WSDOT on achieving high levels of safety performance for Washington’s highways. To achieve optimal results, guidance indicates that staff working on planning studies should internally consult with safety experts during early stages of the planning effort. This approach optimizes the benefits of investment in safety performance and properly scales analysis efforts to reduce unnecessary expenditures.

The guidance document also establishes three levels of analyses (i.e., basic, intermediate, and advanced) recommended for the safety chapter of a corridor planning study. With the advanced analysis level, a predictive analysis component is recommended to assess the safety performance of alternative corridor development scenarios using HSM predictive methods (see Guidance on Level of Safety Analyses Needed for Projects for additional details).

WSDOT’s Safety Analysis Guide provides guidance to WSDOT staff regarding expectations for safety analysis²¹. The guide defines the focus, scale, and scope of safety analyses across different program areas as well as safety analysis outside the typical program areas. The audience for the document is staff that are responsible for safety analysis as part of program and project development and associated activities. The goal of the guide is to support integration of safety performance considerations throughout planning, project development, operations, maintenance, and other WSDOT activities, projects, and programs without creating undue burden. The guide is intended to supplement guidance provided in WSDOT’s Design Manual regarding safety analyses for different project types (see Guidance on Level of Safety Analyses Needed for Projects for additional details).

FDOT recently integrated language about use of the HSM into several of its manuals, including their:

- Project Development and Environment (PD&E) Manual
- Plans Preparation Manual
- Manual on Uniform Traffic Studies

The process outlined in FDOT’s PD&E Manual is the department’s procedure for complying with the National Environmental Policy Act of 1969, Title 42, United States Code (U.S.C.) § 4321, et seq., and associated federal and state laws and regulations²². The PD&E Manual provides a framework for consistent development of analysis, technical studies, and environmental documents for transportation projects to achieve compliance with federal and state laws, regulations, and requirements. The HSM spreadsheets and Safety Analyst are listed along with other tools, such as HCS²³, Synchro²⁴, SIDRA²⁵, CORSIM²⁶, and Vissim²⁷ as common tools available to FDOT for conducting analyses. The manual states that HSM methods may be used to assess existing safety performance and evaluate the potential safety implications of a project. The HSM can be used to support the following project development activities:

- Evaluate purpose and need for the project
- Develop and refine the project alternatives
- Analyze and evaluate project alternatives

21 Safety Analysis Guide, Washington State Department of Transportation, September 2017, http://www.wsdot.wa.gov/publications/fulltext/design/ASDE/Safety_Analysis_Guide.pdf

22 Project Development and Environment Manual, Florida Department of Transportation, June 14, 2017, <https://www.fdot.gov/environment/pubs/pdeman/pdeman1.shtm>

23 HCS™ (Highway Capacity Software, McTrans, Transportation Institute, University of Florida, <https://mctrans.ce.ufl.edu/mct/index.php/hcs/>

24 Synchro, Synchro Software, <https://www.synchrold.com/>

25 SIDRA Intersection, Akcelik & Associates Pty Ltd, <http://www.sidrasolutions.com/>

26 TSIS-CORSIM™, McTrans, Transportation Institute, University of Florida, <https://mctrans.ce.ufl.edu/mct/index.php/tsis-corsim/>

27 PTV Vissim, PTV Group, <http://vision-traffic.ptvgroup.com/en-us/products/ptv-vissim/>

FDOT's Plans Preparation Manual sets forth geometric and other design criteria and procedures for preparation of contract plans for roadways and structures on FDOT projects²⁸. Chapter 23 addresses design exceptions and variations and states that use of HSM predictive methods are acceptable for conducting benefit-cost analyses of design exceptions. Chapter 23 also includes HSM calibration factors and crash distributions specific to Florida conditions for use with the HSM predictive methods.

FDOT's Manual on Uniform Traffic Studies establishes minimum standards for conducting traffic engineering studies on roads under FDOT's jurisdiction²⁹. Chapter 5 addresses traffic safety studies and provides guidance on data collection requirements for conducting safety analysis, including application of the HSM. The chapter addresses urban and suburban arterials and rural roads, including both roadway segments and intersections, and provides data collection forms for use with the HSM spreadsheet tools. Use of HSM predictive methods are also incorporated into procedures for justification of roadway lighting in Chapter 14.

Practices

Lead agencies have incorporated HSM methods into specific tasks and activities within their safety programs. All of the lead agencies have integrated HSM methods into their HSIP, noting that HSM procedures provide more effective methods for reducing target crash types and help inform decisions to obtain the best return on investments.

IDOT developed state-specific state and local roadway SPFs with safety tier categories to perform network screening and identify those locations with the highest potential for safety improvement. ODOT and MDOT have been using the Safety Analyst software for several years for conducting network screening, identifying potential countermeasures, and prioritizing and selecting infrastructure-related safety improvement projects. FDOT, IDOT, and WSDOT plan to use Safety Analyst soon for roadway safety management and their HSIP but are still preparing their data for use within Safety Analyst.

ALDOT uses HSM practices in its selection of HSIP projects. Where feasible, ALDOT performs HSM-level evaluations to determine implementation of various safety improvements³⁰. Maine DOT uses HSM methods to develop a list of priority intersection locations for further evaluation based on observed, predicted, and expected crashes³¹. Similarly, MoDOT uses the HSM when performing alternative analysis of safety countermeasures for a project, often using CMFs from the CMF Clearinghouse, and to estimate the safety benefit for a project to both justify using safety dollars and prioritize the project³².

LADOTD integrated the HSM into its project development process. It implemented the Part C predictive methods utilizing both spreadsheet tools and the IHSDM to perform calculations. The agency uses the HSM for:

- Alternative analysis
- Practice design/practical solutions

28 Plans Preparation Manual, Florida Department of Transportation, 2017 (Note: Link is to manual that is effective beginning January 2018.), <https://www.fdot.gov/roadway/ppmmanual/ppm.shtm>

29 2015 FDOT Manual on Uniform Traffic Studies, Florida Department of Transportation, 2015 (Note: Link is to 2016 manual.), https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/content/traffic/trafficervices/studies/muts/muts-final-01.2016.pdf?sfvrsn=7f52579e_0

30 Alabama Strategic Highway Safety Plan, Alabama Department of Transportation, July 2017, https://www.dot.state.al.us/dsweb/divted/TrafficSOS/pdf/Alabama_SHSP_081117.pdf

31 Maine Highway Safety Improvement Program 2017 Annual Report, Maine Department of Transportation, 2017, <https://safety.fhwa.dot.gov/hsip/reports/pdf/2017/me.pdf>

32 Missouri Highway Safety Improvement Program 2017 Annual Report, Missouri Department of Transportation, 2017, <https://safety.fhwa.dot.gov/hsip/reports/pdf/2017/mo.pdf>

- Design exceptions
- System sustainability projects
- Performance-based design

“The HSM has enabled the LADOTD to make more informed decisions using our limited resources. We have to be strategic and smarter with our transportation investments, and the HSM is one tool in our toolbox.”

April Renard

Louisiana DOTD

Alternatives analyses can be performed during the feasibility, environmental, and/or the design phases of a project. The predictive methods provide the ability to quantify the anticipated safety performance for each alternative in terms of its anticipated crash frequency and severity. Analyses can include comparison with a no-build alternative and, if desired, translation of crash reductions into economic benefits based on guidance in HSM Part B. Practical design stresses making the best strategic decisions to produce the most efficient design to meet the system and project objective statements. Practical design components are considered on all projects. Every project must match or improve the facility’s safety performance.

Where applicable, HSM methods are used to assess the safety performance of projects. Consideration of safety is the central focus of approving a design exception. Safety analyses using procedures set forth in the HSM are expected. To be approved, results must justify how the design exception will not introduce or exacerbate a safety issue. With system sustainability projects, HSM Parts B and D are used for diagnosis and countermeasure selection to identify effective low-cost safety improvements to incorporate into pavement preservation projects. LADOTD is revising its design guidelines to be more performance based. The HSM will serve as a design tool for performance-based designs.

In summary, the lead agencies have incorporated HSM methods into a variety of practices and applications including:

- HSIP
- Alternative analyses
- Design exceptions
- Practical design/practical solutions
- System sustainability/pavement restoration projects
- Access justification reports
- Performance-based design

Cultural Shift Due to HSM Implementation

Through HSM implementation, a cultural shift occurred within the lead agencies. In many cases, safety has become a fundamental part of programming and project development and not simply constrained to HSIP programs. Increased collaboration has occurred between the safety office and other offices throughout the DOT (planning, design, environment, operations). The HSM is recognized to support, not replace, engineering judgment and increase reliability of project selection. (See Cultural for additional details on cultural changes due to HSM implementation).

3 Training

The lead agencies recognized that training was key to implementing the HSM within their respective DOTs. Training programs varied greatly among the lead agencies. The agencies used HSM training programs offered by FHWA and the National Highway Institute (NHI). Agencies developed their own training courses in consultation with academic institutions and consultants and one agency used its LTAP center to conduct training.

Even though their HSM training programs differed, several common themes were identified. HSM training needs to be conducted at all levels within the department, from upper management to entry-level engineers, planners, designers, traffic engineers, environmentalists, and maintenance personnel. It should be offered to personnel at central, regional, and district offices. It should be tailored to the appropriate audience such that training requirements are identified by discipline, focused on need, and have clear expectations defined for the audience. Training should be continuous, meaning that it should not simply occur once when an agency decides to implement the HSM. Rather, training should occur over time to introduce new concepts, principles, and fundamentals; as they are understood, more advanced training can be conducted to further illustrate and demonstrate other applications of HSM methodologies. Additionally, due to staff turnover or changes in job assignments and responsibilities, training courses should be offered at least annually.

Training should also focus on how to use, interpret, and present HSM methods. Many of the concepts, principles, and fundamentals are new so staff must be able to understand how to use the HSM methods and interpret the results. In many cases, the HSM results are too complicated and difficult for people unfamiliar with the methods, such as public officials and the public, so simple language and graphics should be used to convey the results.

The following sections address:

- Special features of HSM training programs that the lead agencies developed to train their own staff and, in some instances, consultants to successfully implement the HSM within their agencies
- Sources of funding lead agencies used to cover the costs of HSM training
- Supplemental information that agencies should consider when developing their HSM training programs or continuing existing training programs

Special Features of HSM Training Programs

This section highlights special features of HSM training programs that the lead agencies developed to train their staff and consultants and covers common themes important to HSM training.

As part of its HSM implementation plan⁹, LADOTD developed a training program categorized by business unit and prioritized based on the importance of the training to be offered (see Table 3.1). The program included training for the offices of multimodal planning, engineering, and operations and covered a range of disciplines such as safety, planning, design, environment, traffic, project development, construction, intelligent transportation systems, and maintenance. The program included training for staff in the central office and district offices and identified different skill sets needed based on job responsibilities within each business unit. By setting priorities, the training occurred over time.

Table 3-1 LADOTD training program by business unit and priority⁹

DOTD Office/ Section	Skills						
	Part B					Part C	Part D
	Safety Fundamentals ¹	Network Screening Concepts	Diagnosis and Countermeasure Selection	Benefit-Cost Analysis	Safety Effectiveness Evaluation	Predictive Method	Crash Modification Factors
Office of Multimodal Planning							
Highway Safety	A	A ²	A	A	A	A	A
Data Collection Management and Analysis	C	A ²	N/A	N/A	B	B	B
Transportation Planning	A	A	A	A	N/A	A	A
Office of Engineering							
Environmental	A	N/A	B	A	N/A	A	A
Traffic Engineering	A	B	A	A	B	A	A
Project Development	A	N/A	B	A	N/A	A	A
HQ Construction	B	N/A	B	C	N/A	N/A	B
District Construction	B	C	B	C	N/A	N/A	B
Office of Operations							
Intelligent Transportation Systems	B	N/A	A	B	B	N/A	A
Maintenance	B	N/A	B	N/A	N/A	N/A	B
District Design	A	B	A	A	N/A	A	A
District Traffic Engineering	A	A	A	A	C	A	A
District Area Engineers	A	A	N/A	N/A	N/A	N/A	N/A

A = high priority, B = medium priority, C = low priority, N/A = not applicable

- 1 The exhibit includes safety fundamentals for all of the business units. This course would teach fundamental transportation safety concepts to support the goal of integrating safety into all aspects of transportation at the DOTD.
- 2 Provide training on both concepts and software.

Similarly, IDOT developed its HSM training program by identifying skills and job responsibilities by discipline (i.e., planning, operations, and design) within the central and district offices (see Table 3.1). As a result, staff received training on specific parts of the HSM most directly related to their job responsibilities. Furthermore, IDOT recognized that HSM training materials available through FHWA and NHI were developed for general applications and not necessarily applications specific to Illinois. Therefore, IDOT developed its own AASHTO Highway Safety Manual Illinois User Guide³³ to reflect specific HSM applications in Illinois with project examples and case studies, along with an HSM predictive method tool with Illinois calibration factors imbedded (see Figure 3.2). Training was tailored to use the Illinois HSM predictive tool and Illinois processes for network screening and benefit-cost analysis.

33 AASHTO Highway Safety Manual Illinois User Guide, Illinois Department of Transportation, March 2014, http://www.idot.illinois.gov/assets/uploads/files/transportation-system/memos-&-letters/safety/hsm_il_userguide_11062014.pdf

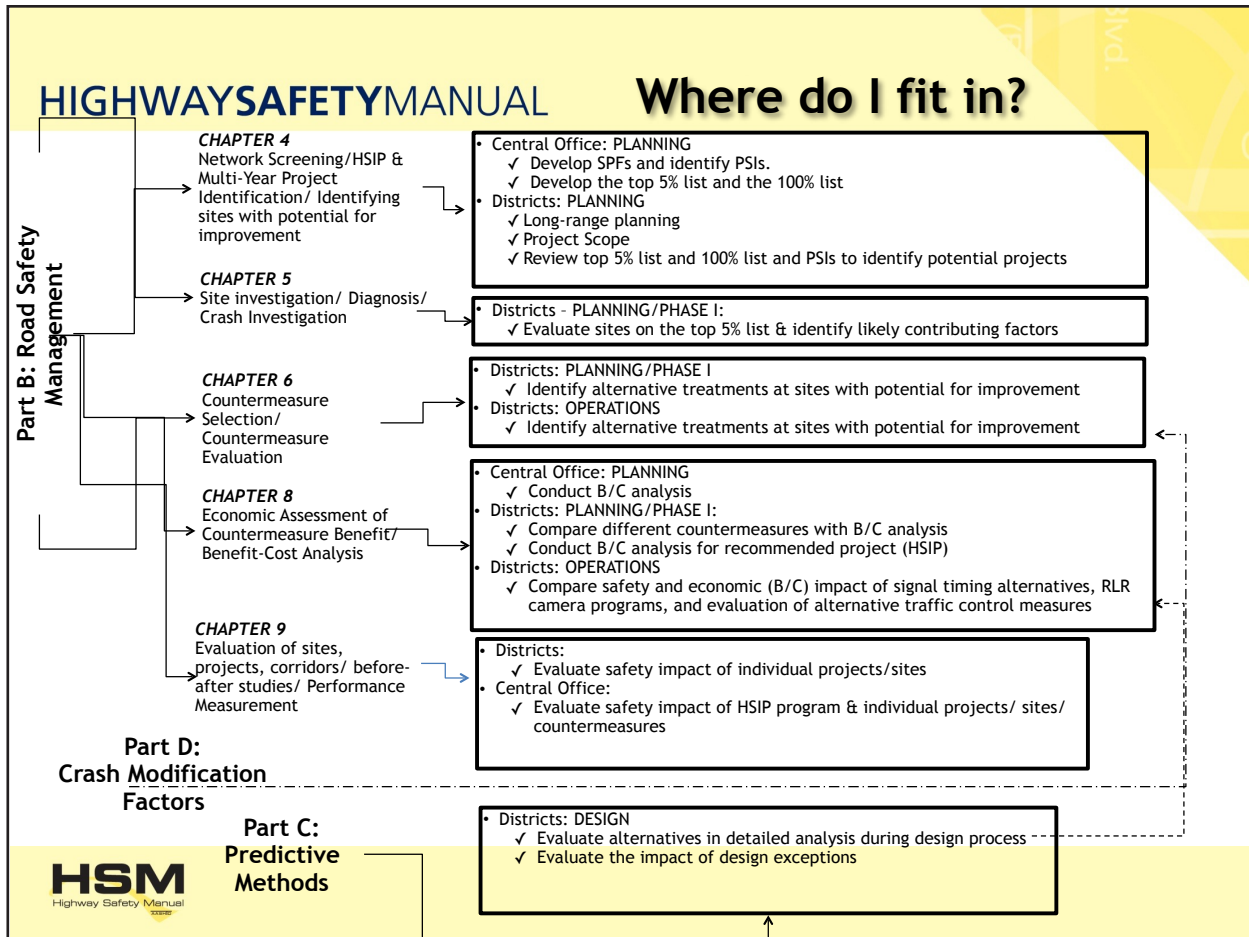


Figure 3-1 IDOT training program by skills and job responsibilities

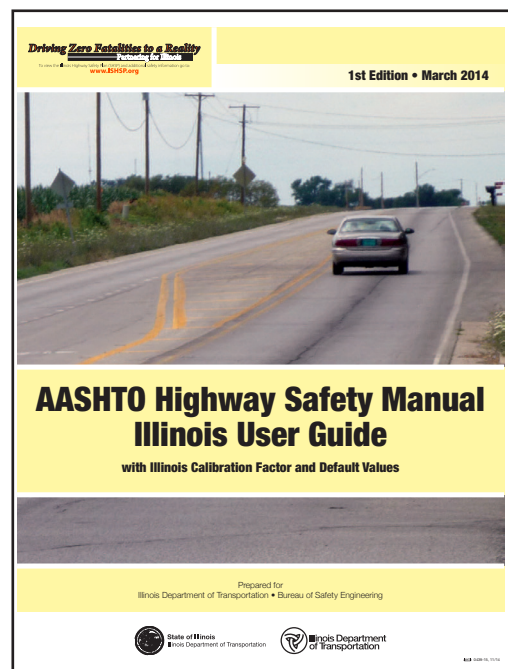


Figure 3-2 Illinois HSM user guide³³

WSDOT integrated its HSM training with its practical solutions program to make safety data and analysis training part of the program to prepare staff to deliver practical solutions. WSDOT developed its training program by first identifying the target audience, topics, and goals (see Figure 3-3). At the highest level (i.e., Level A), everyone received training on the fundamentals of practical solutions to understand safety in practical solutions, Target Zero, and sustainable safety, and to learn how each program complements the others. Level B training was designed for process managers, team leads for planning studies, and project development teams, and focused on the basics of processes, tools, and outputs. Level C training was designed for project development teams and focused on fundamentals of analysis and selection of countermeasures. Common learning outcomes between Levels B and C training, but with different depths of discussion, included:

- Explaining the safety performance metrics at WSDOT and how they relate to federal legislation and state plans
- Identifying opportunities to incorporate safety analysis into the planning and project development process
- Describing the role of the HSM and related tools in quantifying safety performance for alternatives, different intersection control types, and projects
- Explaining how to interpret and apply results from a safety analysis to tradeoffs on projects and decision making
- Recognizing the need to include the 23 U.S.C. 409 exclusion to safety analysis and any input to safety analysis
- Overseeing appropriate handling of sensitive documents such as crash reports and crash data

Safety experts at headquarters and regional offices received the most detailed training on advanced safety analyses to be performed during planning and project development.

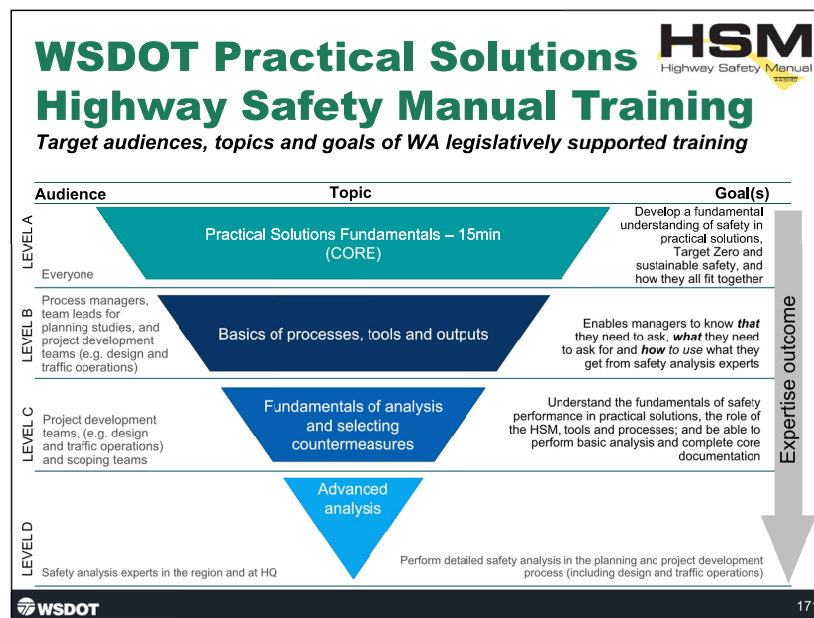


Figure 3-3 WSDOT practical solutions HSM training

ODOT developed four levels of HSM training:

- Introduction to HSM
- HSM Methodology and Part C Calculation Training
- HSM Freeway Supplement Training
- ODOT Traffic Academy – Safety Studies

The first three levels focused on the components and methodologies of the HSM. The fourth level focused on how to use the HSM methods to apply for HSIP funding and incorporate the principles into safety studies, transportation planning, and project development analyses. The goals and objectives of the safety studies course were to:

- Provide an understanding of what a safety study is and when and why a safety study needs to be completed
- Describe what information is required for a safety study
- Describe how and where to obtain the required information
- Discuss evaluation of obtained information
- Discuss presentation and format of the information for the safety study
- Describe changes to ODOT's safety program and safety study processes as a result of the implementation of the HSM

The ODOT Traffic Academy – Safety Studies course was incorporated into the statewide Traffic Academy Training program administered through LTAP. ODOT initially targeted its existing safety staff and a pool of consultants for HSM training. Then designers became interested in the HSM training after their involvement in several HSM pilot projects. The ODOT Traffic Academy – Safety Studies course is a prequalification for consultants to work on specific project types in Ohio.

When FDOT developed its initial training program, it developed training sessions covering the basic components of the HSM, including:

- An introduction to the HSM
- Fundamentals of the HSM
- Individual sessions on each predictive chapter in Part C
- CMFs
- HSM software tools such as the IHSDM, HiSafe (a safety analysis tool that replicates the Part C methods in the HSM), and HSM spreadsheet tools

Soon afterward, in 2015, FDOT published its own FDOT Highway Safety Manual User Guide³⁴, which provides an abbreviated overview for practitioners of the HSM. Eventually, FDOT added individual training sessions for freeways and ramps. More recently, FDOT developed full-day HSM training courses covering four core areas: design, PD&E, planning, and traffic operations. In each full-day course, detailed cases

34 015 FDOT Highway Safety Manual User Guide, Florida Department of Transportation, 2015, https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/safety/safety/11a-safetyengineering/transsafeng/strategicplandocs/2015fdothsmuserguide.pdf?sfvrsn=217d6331_0

studies demonstrate how the HSM can be applied in these areas.

All of the lead agencies focused their training programs to teach their own staff how to implement the HSM, but several agencies also offered training to consultants. Several agencies, including FDOT, LADOTD, and ODOT, require consultants to have HSM training to work on particular types of projects and provide HSM training to the consultants as an option. MDOT requires proposed safety projects on state roads to be documented with HSM analysis methods.³⁵

As part of NCHRP Project 17-38, Highway Safety Manual Implementation and Training Materials,³⁶ spreadsheet tools were developed for training purposes to demonstrate the crash prediction procedures for rural two-lane two-way roads (HSM Chapter 10), rural multilane highways (HSM Chapter 11), and urban and suburban arterials (HSM Chapter 12). The spreadsheets provided the capability to modify inputs to the crash prediction procedures and quickly compare results so users could better understand the procedures and the sensitivity of the procedures to the different inputs. However, several of the lead agencies believed the spreadsheet tools could be improved to simplify the HSM procedures and align with their state's needs, so they developed their own spreadsheet tools for training and implementing HSM procedures on their own projects. (See Development of Tools to Implement HSM Methods for additional details on HSM spreadsheet tools developed by the lead agencies).

Funding Sources for HSM Training

The lead agencies have primarily used three sources of funding for HSM training. The Fixing America's Surface Transportation (FAST) Act was signed into law in 2015 and continued the HSIP. The HSIP is a core federal-aid program with the overall purpose to achieve a significant reduction in traffic fatalities and serious injuries on all public roads, including non-state-owned roads and roads on tribal land, through the implementation of infrastructure-related highway safety improvements. The HSIP is legislated under Section 148 of Title 23, United States Code (23 U.S.C. 148) and regulated under Part 924 of Title 23, Code of Federal Regulations (23 CFR Part 924). Training is an eligible expense under core federal-aid programs and all of the lead agencies have used HSIP funds for HSM training,^{37, 38}

The State and Community Highway Safety Grant Program was initially authorized by the Highway Safety Act of 1966 and has been reauthorized and amended several times, most recently under the FAST Act,^{39, 40} The program is legislated under Section 402 of Title 23, United States Code (23 U.S.C. 402) and is jointly administered by the National Highway Traffic Safety Administration (NHTSA) and FHWA at the federal level and by the State Highway Safety Offices (SHSO) at the state level. The Section 402 program provides grants to states to improve driver behavior and reduce deaths and injuries from motor vehicle-related crashes. State agencies have used Section 402 funds to support countermeasure strategies and projects identified in the states' highway safety plan. Some lead agencies have used Section 402 funds for HSM training.

35 Every Day Counts: Creating Efficiency Through Technology and Collaboration, EDC-3 Final Report, Federal Highway Administration, U.S. Department of Transportation, May 2017, https://www.fhwa.dot.gov/innovation/everydaycounts/reports/edc3_finalreport.pdf

36 NCHRP 17-38: Highway Safety Manual Implementation and Training Materials, The National Academies of Sciences, Engineering, and Medicine <http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=464>

37 Fixing America's Surface Transportation Act or "FAST Act," Federal Highway Administration, U.S. Department of Transportation, 2016, <https://www.fhwa.dot.gov/fastact/factsheets/hsipfs.cfm>

38 Highway Safety Improvement Program, Federal Highway Administration, U.S. Department of Transportation, (as of April 4, 2018), <https://safety.fhwa.dot.gov/hsip/>

39 Section 402 State and Community Highway Safety Grant Program, Governors Highway Safety Association, (as of April 5, 2018), <https://www.ghsa.org/about/federal-grant-programs/402>

40 Highway Safety Grant Funding Guidance, National Highway Traffic Safety Administration, U.S. Department of Transportation, 2013, https://www.nhtsa.gov/staticfiles/administration/programs-grants/Highway_Safety_Grant_Funding_Guidance.docx

States set aside 2% of the apportionments they receive from the Interstate Maintenance, National Highway System, Surface Transportation, Highway Bridge, Congestion Mitigation and Air Quality Improvement, and Equity Bonus programs for state planning and research activities, thereby establishing the SP&R. The SP&R program is legislated under Section 505 of Title 23, United States Code (23 U.S.C. 505) and regulated under Part 420 of Title 23, Code of Federal Regulations (23 CFR Part 420). Several lead agencies have used SP&R funds for HSM training.⁴¹

Supplemental Information on HSM Training

This section describes additional information that agencies should consider when developing their own HSM training programs or for training programs they have already developed. The information is based on lessons learned from WSDOT staff while developing and implementing its HSM training program and by participating in or assisting with other HSM training programs around the country. The key points to consider are as follows:

- Develop training to support career development
 - Training should cover the fundamentals of highway safety concepts, principles, and procedures. This is particularly true for new personnel whose primary responsibility is highway safety; however, it also applies to personnel that have been working in highway safety for many years because there has been a major shift from nominal safety to substantive safety and from use of crash rates to predicted and expected crash frequencies. It also applies to personnel whose primary responsibility is not highway safety, such as designers, planners, and environmental engineers who should be considering safety in their daily responsibilities. More advanced HSM training should also be available so that over time it helps personnel advance in their career development. This means creating building blocks and making courses part of a series.
 - It is recommended that agencies provide copies of the HSM to personnel who attend training. This provides an additional incentive for staff to take HSM training if it is not required. The copies are also a resource for staff after training to review the information they learned in the course and to perform their job responsibilities. Without their own copies of the HSM or easy access to available copies, it is unlikely that personnel will retain the information they learned during training and they will not have the proper resources to implement HSM methods as part of their job responsibilities.
- Create training courses for the target audience
 - Many staff (i.e., managers) cannot dedicate the time to attend a full-day training course. Therefore, training courses should cover topics in shorter time periods (i.e., from 15 minutes to 4 hours), focusing on the job responsibilities and necessary skills of the target audience. By condensing training into shorter time periods, personnel receive more value from the training and show more interest during the training sessions. In other words, training sessions should be designed so that personnel will be less likely to be distracted from the topic under discussion.
- Build in practical case studies
 - Do not use elaborate examples that are pre-worked to demonstrate procedures and calculations; rather, use actual projects that a regional or district office is dealing with or will be working

41 Oversight & Stewardship (<https://www.fhwa.dot.gov/publications/research/general/spr/os.cfm>) and Legislation/Regulation (<https://www.fhwa.dot.gov/publications/research/general/spr/legsregs.cfm>), Summary Report, State Planning and Research (SP&R) Guide, Federal Highway Administration, U.S. Department of Transportation, (each page last modified January 31, 2017)

on soon. Work through case study calculations as appropriate, but also spend time discussing various options and scenarios. Training is also a great opportunity to share where the HSM provides clear answers and where there are grey areas in HSM procedures and applications. For example, Chapter 10 of the HSM can be used to analyze three intersection configurations and traffic control types on rural two-lane, two-way roads:

- Three-leg intersections with minor-road stop control
 - Four-leg intersections with minor-road stop control
 - Four-leg intersections with signal control
 - However, Chapter 10 cannot be used to analyze three-leg intersections with signal control on rural two-lane, two-way roads. There is no clear methodology in the HSM for how such an intersection should be evaluated, and it is important for personnel to understand the applications and limitations of the first edition of the HSM.
- Connect training to your DOT business
 - Training materials should look and feel like materials your DOT typically produces, including color schemes, logos, and specific terminology used by your agency. By doing so, personnel will feel more vested in the training program because they will view the training materials as their own and will minimize potential confusion over differences in terminology.
 - Allow your own DOT staff to conduct the training or a portion of the training
 - Personnel from your agency should present at least some of the HSM information and material during training. This could be the HSM champion within your agency or other personnel at the central or district offices with knowledge of HSM methods and procedures. Personnel from your own agency will understand your agency's organizational structure and policies to better describe how HSM methods could be applied within your agency. Also, after training, your personnel will have an identified person within your agency to contact with questions related to the HSM. By presenting, your own personnel may also better understand the challenges districts and/or local offices face in implementing or conducting safety analyses.
 - Involve FHWA in HSM training
 - FHWA is heavily involved with providing HSM training. Your agency should involve FHWA at some level within your own HSM training program. This is an opportunity to seek insight and learn about the HSM from experts, and for your staff to connect and build relationships with FHWA representatives that will prove valuable beyond HSM training.

4 Technical Functions

This section presents various ways that lead agencies guided their personnel on how to use or implement HSM procedures. It covers a variety of topics, including guidance on the level of safety analyses needed for projects, development of tools to implement HSM procedures, calibration of HSM SPF's to local conditions, use of systemic safety management approaches to reduce crashes, and development of local road safety plans. The following subsections provide more details about how lead agencies use the HSM in these different technical functional areas.

Guidance on Level of Safety Analyses Needed for Projects

The level of safety analysis that should be performed for a given project can vary for several reasons. It may vary based on the project's type (e.g., preservation versus improvement) and intent. If safety is the primary need for a project, then a detailed safety analysis is expected. However, if the primary need for a project is to improve operation, then a detailed safety analysis may not be necessary. Project cost is another factor. If the overall budget for a project is relatively low (e.g., only a few thousand dollars), a brief review of the crash history may be sufficient to cover the level of safety analysis expected for the project. As the overall budget and complexity of a project increases, the complexity and level of the safety analysis should likewise increase. Several of the lead agencies developed guidance on the level of safety analysis expected for a project to increase consistency among projects within their agency.

ODOT distinguishes three levels of safety analysis recommended for projects based on whether safety considerations are specified in the purpose and need statement and whether projects are intending to use safety funds. When safety is not a consideration in the purpose and need statement and safety funds are not planned for use, the recommended level of safety analysis is relatively simple; however, as safety considerations are worked into the purpose and need statement and safety funds are requested, the complexity of the safety analysis increases. The three levels of safety analyses are distinguished as follows:

- Non-complex projects (no alternative analysis) (see Figure 4-1)
- Complex projects (alternative analysis) (see Figure 4-2)
- Projects with safety component (see Figure 4-3)

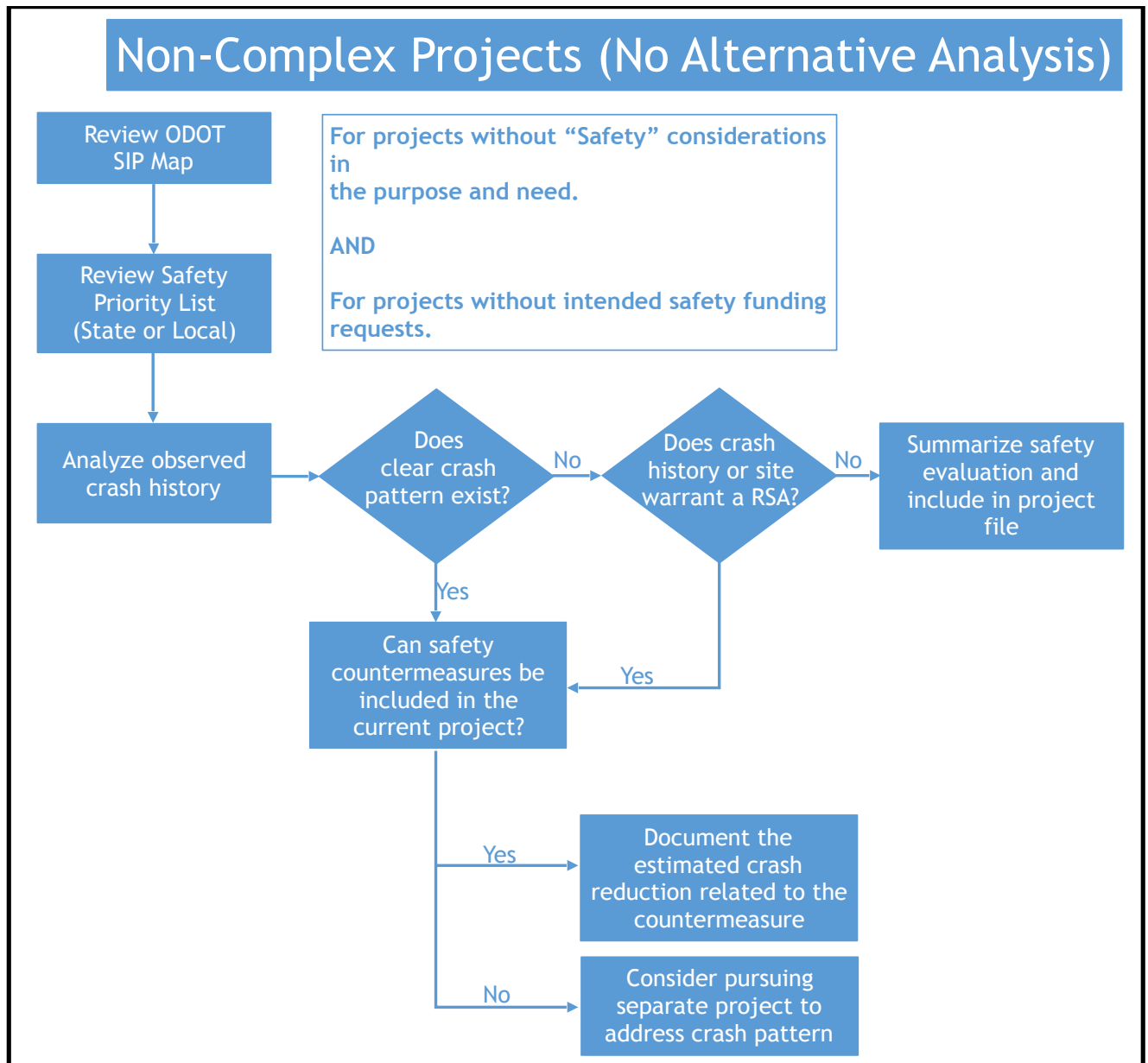


Figure 4-1 ODOT’s level of safety analysis for non-complex projects

Non-complex projects with no alternative analyses are distinguished as projects without safety considerations addressed in the purpose and need statement and without intended safety funding requests. For non-complex projects, a very basic level of safety analysis is recommended. It is expected that the observed crash history will be analyzed and assessed to identify potential crash patterns of interest. If crash patterns of interest are identified, then an assessment should be made of whether a countermeasure should be incorporated into the project, and the estimated crash reduction related to the countermeasure should be documented. Otherwise, if no crash patterns of interest are identified, then a road safety audit may be conducted if deemed necessary to identify countermeasures that could potentially reduce crashes at the site.

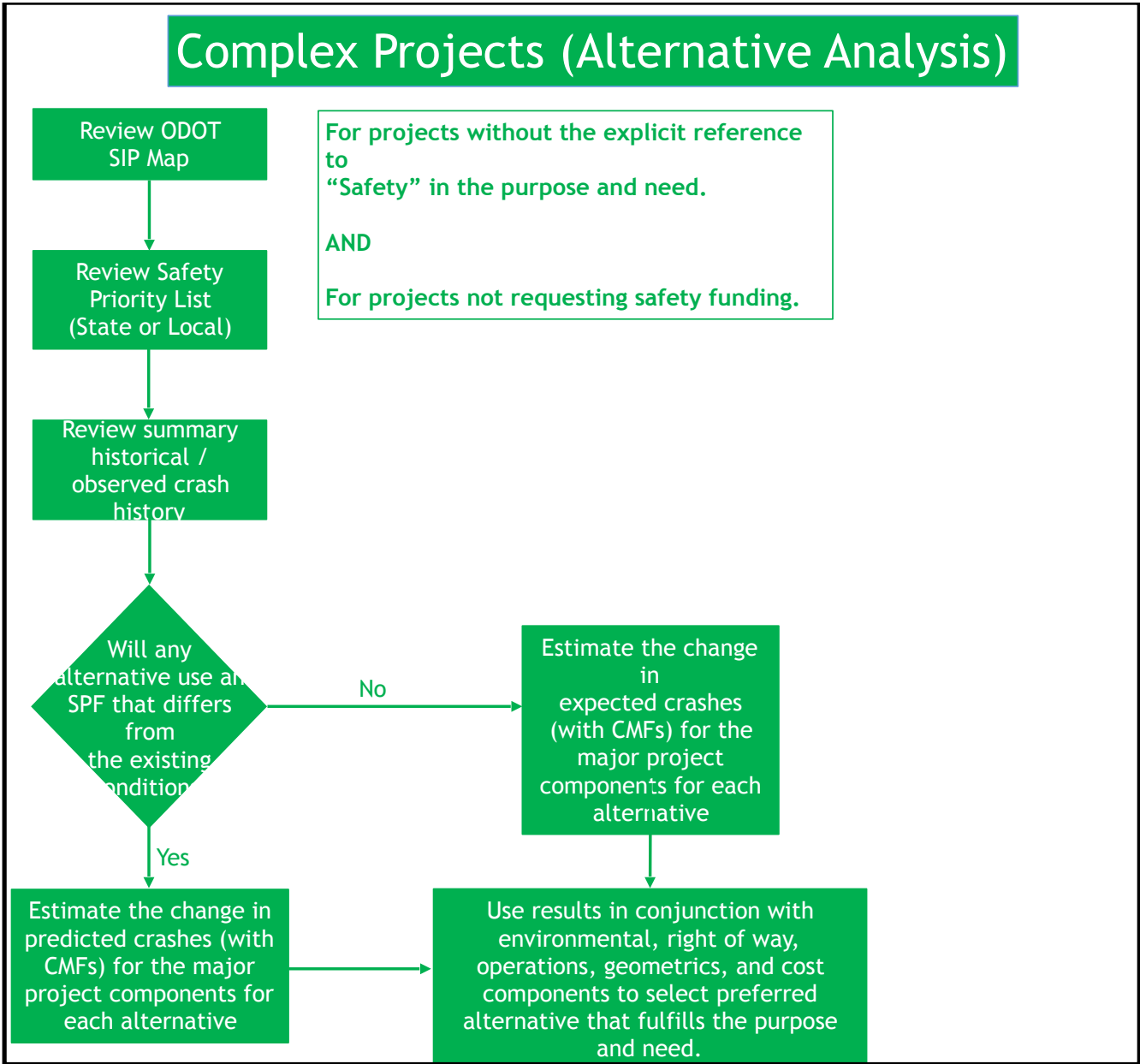


Figure 4-2 ODOT’s level of safety analysis for complex projects

Complex projects with alternative analyses are defined as projects without explicit reference to safety in the purpose and need statement and that do not request safety funding. For complex projects with alternative analyses, after a review of the observed crash history, SPFs should be used to estimate predicted and/or expected crash frequencies of each alternative. The results should be used in conjunction with environmental, right-of-way, operation, geometrics, and cost components to select a preferred alternative that meets the project’s purpose and need.

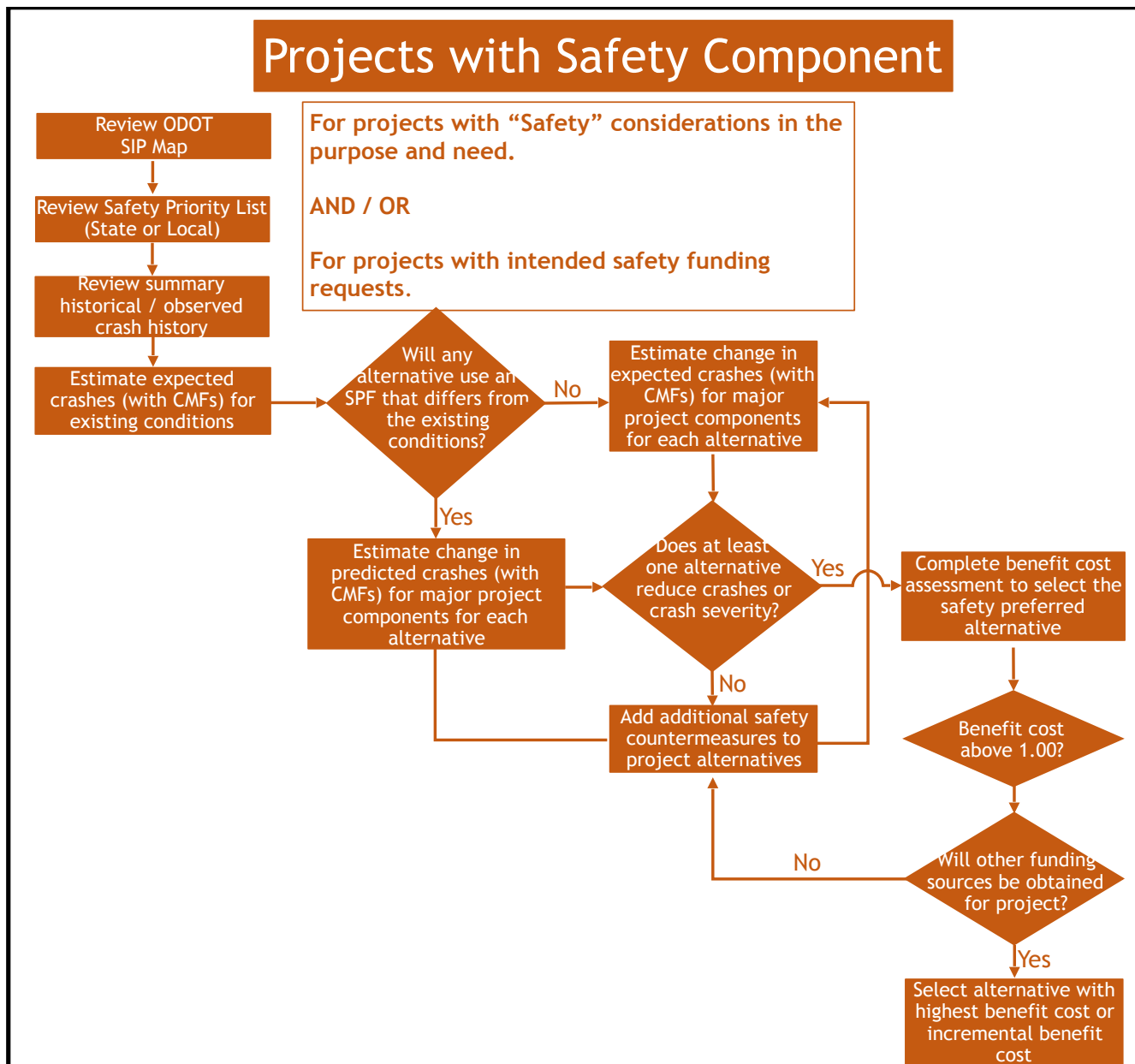


Figure 4-3 ODOT’s level of safety analysis for projects with a safety component

“By including safety analysis in all projects, Ohio hopes to move toward zero deaths. Projects with limited scope (resurfacing and repair) have fewer countermeasures that can be easily included in the project. By reducing the analysis requirements for these projects, it allows staff to review all the projects and find small improvements to reduce crashes.”

Derek Troyer

ODOT

For projects with a safety component (defined as projects with safety considerations in the purpose and need statement and with intended safety funding requests), the safety analysis is expected to include an additional level of complexity beyond what is generally conducted for complex projects with alternative analyses. In addition to using SPFs to estimate the predicted and/or expected crash frequencies of each

alternative, at least one of the alternatives should reduce crash frequency or severity; if not, additional countermeasures should be considered. Also, a benefit-cost analysis should be conducted to select the alternative with the highest benefit-cost or incremental benefit-cost.

The LADOTD has a Highway Safety Manual Project Applications fact sheet that discusses which parts and chapters of the HSM could be considered for different project types (see Table 4.1)⁴². Project types that are addressed in the fact sheet include:

- Alternatives evaluation (Stage 0 – Planning, Stage 1 – Environmental)
- Locations with potential for safety improvement
- Access management studies
- Corridor studies
- Design and design exceptions (Stage 3)
- Interchange justification/modification reports
- Intersection operations studies
- Project purpose and need
- Resurfacing projects
- Traffic impact studies
- Transportation management plans

For each project type, the fact sheet describes how the specific parts of the HSM (Parts B, C, and D) could be applied during project development.

⁴² Highway Safety Manual Project Applications, Destination Zero Deaths, Louisiana Department of Transportation and Development, http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Multimodal/Highway_Safety/Misc%20Documents/Louisiana%20Fact%20Sheet%20Project%20Map.pdf

Table 4-1 LADOTD HSM project applications guidance⁴²

Project Type	Highway Safety Manual Project Application	
Alternatives Evaluation	Predictive Method Part C – Chapters 10-12 ^a	As alternative cross-sections are considered and evaluated, the associated impact to crash frequency or severity can be calculated with the predictive method. There are methods for two-lane rural highways, rural multilane highways, and urban and suburban arterials. Freeways will be available soon.
Stage 0 – Planning	Crash Modification Factors Part D – Chapters 13 – 17 ^b	Crash modification factors (CMFs) can also be used in an alternatives evaluation to evaluate the safety impacts (changes in crash frequency or severity) of various countermeasures. Impacts to safety can then be considered alongside other performance measures such as mobility, accessibility, or environmental impacts.
Stage 1 – Environmental	Benefit-Cost Analysis Part B – Chapters 7-8	The change in expected crash frequency or severity (safety impact) of various alternatives determined using the predictive method or CMFs can be converted to monetary costs and benefits and incorporated into a benefit-cost analysis.
Locations with Potential for Safety Improvement	Diagnosis and Countermeasure Selection Part B – Chapters 5 and 6	Chapter 5 of the HSM outlines the diagnosis process which can be used to provide an understanding of crash patterns and physical characteristics of sites listed in the abnormal location listing. Chapter 6 then provides information to help identify potential contributing factors to the crashes and outlines steps for selecting countermeasures.
	Crash Modification Factors Part D – Chapters 13 – 17 ^b	The Part D CMFs provide an indication of the effectiveness of various countermeasures in reducing crash frequency. CMFs also provide a quantitative estimate of the safety benefits (crash reduction) to use in a benefit-cost analysis.
	Benefit-Cost Analysis Part B – Chapters 7-8	The estimated change in crash frequency or severity of different roadway modification concepts can be converted to dollars and incorporated into a benefit-cost analysis. Chapter 7 of the HSM outlines methods to do this. The project prioritization methods in Chapter 8 can be used to prioritize projects for implementation.
Access Management Studies	Diagnosis and Countermeasure Selection Part B – Chapters 5 and 6	When conducting an access management study, the diagnosis process in Chapter 5 can be used to identify existing crash patterns and assess the site conditions. Chapter 6 can be used to identify potential contributing crash factors and outlines steps for selecting countermeasures.
	Predictive Method Part C – Chapters 10-12 ^a	Depending on the type of road being evaluated, the Part C predictive method can be used to compare the expected safety performance of different access management alternatives.
	Crash Modification Factors Part D – Chapters 13 – 17 ^b	Part D CMFs can also be used to identify and assess the effectiveness of potential countermeasures.
Corridor Studies	Diagnosis and Countermeasure Selection Part B – Chapters 5 and 6	The Chapter 5 diagnosis process can be used when conducting a corridor study to identify crash trends and assess site conditions to identify potential safety needs. Chapter 6 provides guidance for identifying contributing factors and for selecting treatments to address the observed crash trends.
	Predictive Method Part C – Chapters 10-12 ^a	For a corridor study, the Part C predictive method can be used to provide a quantitative assessment of the expected safety (crash frequency or severity) of various alternatives under consideration.
	Crash Modification Factors Part D – Chapters 13 – 17 ^b	CMFs can be used in a corridor study to estimate the change in crash frequency due to potential countermeasures.
Stage 3 – Design and Design Exceptions	Predictive Method Part C – Chapters 10-12 ^a	During the design stage (including design exceptions), the predictive method can be used to compare the expected crash frequency of different design alternatives to aid in the alternatives selection process. The predictive method results also provide documentation for a design exception.
	Crash Modification Factors Part D – Chapters 13 – 17 ^b	If the predictive method is not applicable, CMFs from Part D can be used to evaluate the safety impact of different design features under consideration. CMFs also provide documentation for a design exception.
	Benefit-Cost Analysis Part B – Chapters 7-8	Chapters 7 and 8 can be used to conduct an economic evaluation of different design alternatives and to determine the recommended alternative. The change in crash frequency or severity estimated in using the predictive method or CMFs can be converted to a dollar value.

Project Type	Highway Safety Manual Project Application	
Interchange Justification/Modification Reports	Diagnosis and Countermeasure Selection Part B – Chapters 5 and 6	During the preparation of an interchange justification/modification report, Chapter 5 diagnosis procedures can be used to examine the existing crash trends on the facility, and Chapter 6 can be used to identify potential contributing factors.
	Predictive Method Part C – Forthcoming Freeway Chapters	The forthcoming chapters on the predictive method for freeways can be used to evaluate the different alternatives under consideration.
Intersection Operations Studies	Diagnosis and Countermeasure Selection Part B – Chapters 5 and 6	Chapters 5 and 6 can be used in an intersection operations study to identify existing crash patterns, contributing factors, and potential countermeasures to implement at the intersection to improve safety.
	Crash Modification Factors Part D – Chapters 13 – 17 ^b	CMFs can be used to assess the effectiveness of potential countermeasures in terms of crash reduction and aide in the selection process.
Project Purpose and Need	Network Screening Part B – Chapter 4	LADOTD Highway Safety Staff use Chapter 4: Network Screening to develop the Abnormal Site List. Sites on this list should also be given consideration in the purpose and need assessment.
	Diagnosis Part B – Chapter 5	The diagnosis procedures provided in Chapter 5 can be used to identify any existing crash trends and determine if safety should be included in the project purpose and need.
Resurfacing Projects	Diagnosis and Countermeasure Selection Part B – Chapters 5 and 6	Chapters 5 and 6 can be used on resurfacing projects to identify existing crash patterns, contributing factors, and potential countermeasures to integrate into the resurfacing project.
	Predictive Method Part C – Chapters 10-12 ^a	The predictive method can be used for resurfacing projects to evaluate the impact on safety in terms of changes in expected crash frequency or severity associated with potential changes in roadway cross-section.
	Crash Modification Factors Part D – Chapters 13-17 ^b	CMFs can be used to estimate the impact on crash frequency or severity of various safety treatments being considered in a resurfacing project.
	Benefit-Cost Analysis Part B – Chapters 7-8	Chapters 7 and 8 can be used to evaluate the monetary impacts of changes in crash frequency or severity and relate to project costs to prioritize roadway segments for resurfacing based on the associated return on investment in terms of safety.
Traffic Impact Studies	Diagnosis and Countermeasure Selection Part B – Chapters 5 and 6	During a traffic impact study, the diagnosis procedures outlined in Chapter 5 can be used to identify existing crash patterns at the sites under consideration. Chapter 6 can be used to identify potential contributing crash factors and alternative countermeasures.
	Predictive Method Part C – Chapters 10-12 ^a	For a large development with a significant trip generation, the predictive method could be used to evaluate the estimated changes in expected crash frequency or severity associated with the development or changes in roadway configuration to accommodate the additional traffic.
	Crash Modification Factors Part D – Chapters 13-17	CMFs can be used to assess the safety impact of roadway modifications recommended to accommodate additional traffic volumes associated with the proposed development.
Transportation Management Plans	Diagnosis and Countermeasure Selection Part B – Chapters 5 and 6	When preparing transportation management plans, Chapter 5 can be used to identify existing crash patterns, and Chapter 6 can be used to identify potential contributing crash factors and countermeasures to incorporate into the plans.
	Crash Modification Factors Part D – Chapters 13-17 ^b	CMFs can be used to evaluate the effectiveness of potential countermeasures or treatments being considered.

CMF – Crash Modification Factor

- a It is most desirable to use the predictive method with calibration factors. If the method is applied without calibration factors, the results of the analysis are applicable only for conducting a relative comparison of facilities. For example, if comparing the performance of two different multilane rural highway cross-sections, the analysis results could be reported as the percent difference in the number of crashes of one alternative over the other but not the actual difference in the number of crashes. Note that comparing the predicted safety of two different facility types, such as comparing a rural two-lane alternative to a rural multilane alternative, cannot be made without calibration factors.
- b When using CMFs, it is important to make sure the site conditions of the site under investigation are similar to the site conditions

in the study from which the CMF was developed. Additionally, the CMF star rating in the CMF Clearinghouse or the CMF standard error in the HSM should be considered to determine the quality or confidence in the results of using the CMF. Additional information on using CMFs can be found in the [Guidance for Using Crash Modification Factors](#) document on the DOTD website.

WSDOT published two documents that provide guidance for conducting safety analyses for various types of projects. *Safety Guidance for Corridor Planning Studies*²⁰ provides the foundation for developing the safety chapter in a corridor planning study. The document states that personnel working on planning studies should conduct internal consultation with safety experts beginning at the earliest stages of the planning effort. This approach supports consistency with DOT policies and business practices, optimizes the benefits to investment in safety performance, and properly scales analysis efforts to reduce unnecessary expenditures. Working with safety experts early in the process also increases the likelihood that analyses are scoped at the appropriate level and decreases the likelihood of rework since agreements are up front rather than later in the process.

The safety corridor planning guide provides guidance for different levels of safety analyses for corridor planning studies. Scaling and scoping studies are an important part of providing the right level of information to support decision making and developing solutions, programs, or projects. The guide describes three levels of safety analyses recommended for corridor planning studies based on the complexity and need of the study consistent with WSDOT policies, procedures, and actions that occur throughout planning, programming, and project development. Consultation with the safety expert team is used to set the appropriate level of analysis.

- **Basic Analysis Level**—A basic analysis addresses the general safety performance of the corridor using the most recent five years of data. This level provides general descriptive information regarding current crash performance in the corridor. Findings of the safety assessment serve as input to the scoping and project development process. This level of safety analysis only presents factual conclusions about current conditions.
- **Intermediate Analysis Level**—An intermediate analysis includes the basic analysis level content and adds countermeasure selection to the evaluation. This analysis supports the development of conclusions and recommendations and how to use specific countermeasures to address the identified crash contributing factors. In addition, the potential benefits of using the selected countermeasures are included in the discussion.
- **Advanced Analysis Level**—An advanced analysis includes the content of the basic analysis level, and adds a safety performance predictive analysis component. Forecasted assessments are used to test different corridor development scenarios. The scenario evaluations include countermeasures and potential alternatives based on the corridor's other needs (e.g., environmental, mobility, and modes).

More recently, WSDOT published the *Safety Analysis Guide*²¹ to provide guidance to WSDOT staff regarding expectations for safety analysis. The guide defines the focus, scale, and scope of safety analyses across different WSDOT program areas as well as safety analysis outside typical program areas. The guide steps through the primary funding mechanisms and discusses safety analysis for the following program types and activities:

- Preservation (pavement, bridges, and other highway facilities)
- Highway improvement (mobility, safety, economic initiatives, and environmental retrofit)
- Traffic operations
- Interchange justification reports

- Environmental impact statement/environmental assessment
- Developer reviews – traffic impact analysis
- Crash analysis report
- Intersection control analysis
- Work zones

The guide provides a table for each program type/activity that addresses what triggers an analysis, the study area, study period, scope of analysis, methodology, suggested tools, goals, and documentation requirements.

Each table summarizes the safety analysis needed for a project in the program type/activity. Table 4-2 provides an example of the table that describes the scope and scale of a safety analysis for an intersection control analysis (ICA) activity. For an ICA, both an operation and safety analysis of a potential change to an intersection are conducted.

Table 4-2 Summary of safety analysis for intersection control analysis²¹

Trigger	An ICA has safety as a project need as noted in DM Chapter 1300.051.
Study Area	If the ICA is a standalone document, the study area should be the intersection of interest corresponding to the study area of the ICA. If the ICA is part of a larger project, follow the guidance associated with that funding source found in Chapter 7 of this document.
Study Period	Select the study period in accordance with Chapter 6.3 of this document.
Scope	Analyze the no-build and all feasible alternatives to match the alternatives analyzed in the operational analysis section of the ICA.
Methodology	Analyze the segments and intersections with the HSM predictive method described in the applicable chapter (Chapter 10, 11, 12, or 19). If the HSM predictive method cannot be used, the observed crash history can be used along with CMFs. Perform a human factors review of the feasible alternatives and document a review of the fatal and serious injury crashes and any crashes involving pedestrians or bicyclists. Define mitigation strategies to address changes in safety performance.
Tools	For freeway ramp terminals, use the Interchange Safety Analysis Tool enhanced (ISATe). For other facility types, use the applicable extended HSM predictive method spreadsheet. The tools can be found online at http://www.wsdot.wa.gov/Design/Support.htm
Goal	To have a quantitative analysis supplemented with a qualitative discussion that can help select a preferred alternative.
Documentation	Incorporate the safety analysis into the ICA. The safety analysis write-up should quantitatively contrast and compare all feasible alternatives. If the preferred alternative is not the best performing from a crash analysis perspective, document your reasoning in the ICA. Include the details of the safety analysis in an appendix.

FDOT developed project development and engineering guidelines to assist project managers in preparing staff hour estimates for PD&E studies. A PD&E study is typically a standalone contract. However, activities from the design standard scope of services may be combined with the PD&E scope of services as a part of the statewide acceleration transformation process. When the activities are combined, FDOT developed design staff hours estimation guidelines to estimate such activities. Among the engineering analyses that must be performed for PD&E studies, safety analyses are required.

Table 4-3 is an excerpt from FDOT’s Project Development and Engineering Guidelines that shows staff hour estimation guidelines for performing safety analyses. Three levels of safety analyses (i.e., low, mid, and high) are specified based upon the type of project (e.g., is the project relatively short and only include a few intersections, is the project longer and incorporate major intersections, or is the project relatively long and in an urban area) and the anticipated effort to complete the task based on the context and intensity of impacts. The guidelines also note that the hour ranges do not represent a maximum and minimum for that

task. Rather, the ranges are estimates of the efforts needed to accomplish most projects; exceptions for both higher and lower estimates for the tasks will occur.

Table 4-3 FDOT’s staff hour estimation guidelines for safety analyses for PD&E studies⁴³

Task	Units	Staff Hour Range	Basis for Staff Hour Range			
			Staff Hour Estimation Guidelines	Field time and meeting time are included in field reviews and meetings and presentations tasks, respectively. Hours associated with managing and supervising staff are included in each task.		
				Low Range	Mid Range	High Range
Historical Crash Analysis *	LS	24 to 80	This task includes the tabulation of crash data, the determination of high crash sections, and the safety analysis of the existing facility and alternatives. The criteria for estimating the hours needed for this task are the number of years being analyzed, number of major intersections, length of the project, and, if available, the number of crashes on the facility.	Project includes few intersections, or is a short (1 to 2 miles) project (24 to 40 hrs)	Project includes major intersections improvements or a corridor 2 to 5 miles long in an urban area (40 to 60 hrs)	Project is on urban or urbanized area and is 5 or more miles (60 to 80 hrs)
HSM Safety Analysis*	LS	48 to 200	This task includes assessment of historical crashes on the project, assessment of crash countermeasures based on CMFs and development of conclusions and recommendations, and assessment of safety performance of the corridor using predictive analysis.	Project includes few intersections, is short (1 to 2 miles), or is in a rural area (48 to 80 hrs)	Historical crash analysis, CMFs, and project includes major intersections improvements or a short interstate project. (80 to 120 hrs)	Historical crash analysis and safety performance predictive analysis project or project is in urban or urbanized areas (120 to 200 hrs)
Documentation of Safety Analysis	LS	24 to 120	This task includes documenting findings from conducting a safety analysis. Hours are reduced if documentation is included in the Project Traffic Analysis Report (PTAR).	Project includes few intersections, is short (1 to 2 miles), or is in a rural area (24 hrs)	Project includes major intersections improvements or a corridor 2 to 5 miles long in an urban area (24 to 72 hrs)	Project is in urban or urbanized area and is 5 or more miles (72 to 120 hrs)

* Denotes that the task is subject to quality control

Development of Tools to Implement HSM Methods

The HSM provides transportation professionals with current knowledge, techniques, and methodologies to estimate future crash frequency and severity and to identify and evaluate options to reduce crash frequency and severity¹. The more statistically rigorous predictive methods in the HSM reduce the vulnerability of historical crash-based methods to random variations in crash data and provide a means to estimate crashes based on geometry, operating characteristics, and traffic volumes. However, users can be overwhelmed with

43 Project Development and Environment Guidelines, Excel Spreadsheet, Florida Department of Transportation. https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/designsupport/scope/pde-sh-guidelines.xlsm?sfvrsn=c516b326_2

the volume and complexity of the information presented in the HSM. Therefore, in addition to the HSM training programs described previously, lead agencies developed various tools or made use of commercially available software to make it easier for their personnel to implement and apply HSM concepts and procedures as part of their job responsibilities.

As indicated previously, two agencies (FDOT and IDOT) developed their own HSM user guides to provide an abbreviated overview of the HSM for practitioners and provide guidance on the application of the HSM. FDOT published its FDOT Highway Safety Manual User Guide³⁴ in 2015. The guide includes the following information:

- Chapter 1 explains the purpose of the HSM and how it is organized.
- Chapter 2 provides definitions and descriptions of key terms and concepts in the HSM, such as SPFs and base conditions.
- Chapter 3 summarizes the 18-step method in HSM Part C to estimate crashes for a given facility.
- Chapter 4 suggests steps for selecting appropriate CMFs or crash reduction factors (CRFs) from among the thousands available.
- Chapter 5 describes general steps to apply CMFs to estimate the change in crash frequency resulting from a selected countermeasure.
- Chapter 6 presents additional information on the HSM and CMFs, including information on the CMF Clearinghouse, an HSM online user discussion forum, and a FHWA guide for developing quality CMFs.

In 2014, IDOT published its AASHTO Highway Safety Manual Illinois User Guide³³ to provide guidance on incorporating HSM methods into roadway safety management practices in Illinois. The guide mainly focuses on the calculation of predicted and/or expected crash frequency using HSM methodology and includes the following information:

- Chapter 1 introduces the background and main contents of the guide.
- Chapter 2 discusses the HSM predictive method and terminology.
- Chapter 3 provides step-by-step procedures for calculating the predicted and expected crash frequency using HSM methodology
- Chapter 4 includes examples that incorporate HSM methodology into the highway safety management practices with detailed procedures.
- Appendices A and B include Illinois SPF calibration factors and default distribution values derived based on Illinois data for use with the predictive methods.

Several lead agencies custom designed their own software tools or purchased commercially available software to help their staff and practitioners apply the HSM methods. As part of NCHRP Project 17-38, several spreadsheets were developed to implement the HSM Part C methodologies and were also used to demonstrate the procedures for training. Several lead agencies modified these spreadsheets to make them more user-friendly and unique to their needs. ALDOT and VDOT jointly funded a project to update the NCHRP Project 17-38 HSM Part C spreadsheets with the initial intention to:

- Eliminate the need for user manipulation of the site total worksheet to perform the site-specific empirical Bayes (EB) method

- Create an automated report that summarizes the results of the analysis in table, graphic, and text format
- Perform a multiyear analysis⁴⁴

LADOTD modified the spreadsheets developed under the NCHRP Project 1738 and incorporated its own calibration factors. MDOT took the NCHRP Project 17-38 spreadsheets and integrated them into a single spreadsheet tool that also incorporated calibration factors for Michigan.

Using the NCHRP Project 17-38 spreadsheets as a starting point, IDOT developed its own HSM crash prediction tool to provide a more robust and user-friendly interface for applying the three HSM Part C predictive methods (see Figure 4-4).

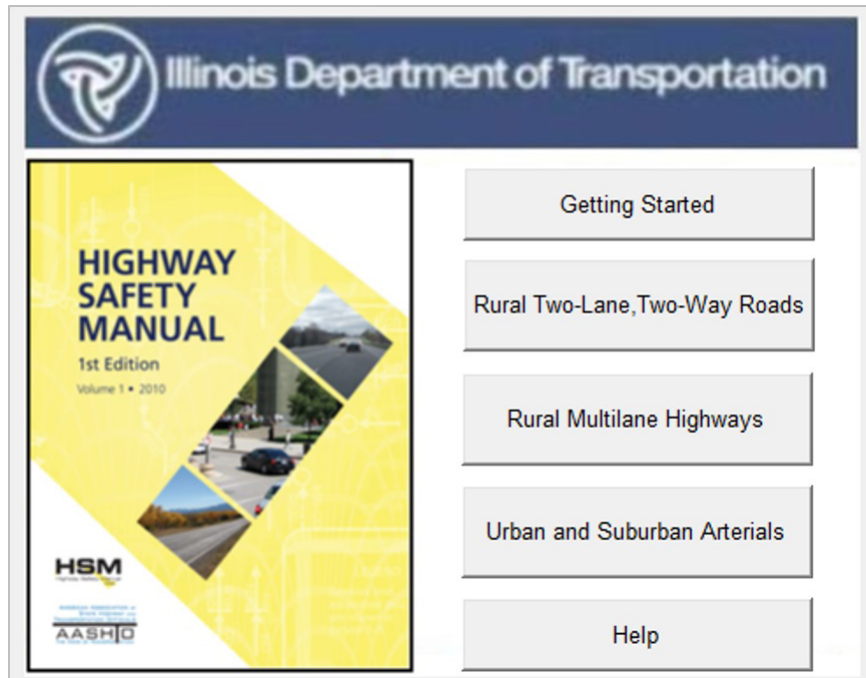


Figure 4-4 IDOT's HSM crash prediction tool interface

Several features of IDOT's HSM crash prediction tool include:

- Improved user interface
- Incorporation of Illinois-specific calibration factors and crash distribution tables
- Ability to perform corridor analyses for up to 50 segment/intersection locations
- Ability to analyze up to five years of data
- Ability to apply a growth factor
- Improved summary sheets
- Additional data entry options using tabular format

ODOT reviewed the NCHRP Project 17-38 spreadsheets and developed the Economic Crash Analysis Tool, a single spreadsheet tool to complete the HSM calculations based on the agency's specific needs (see Figure 4-5). This tool can be used to calculate predicted crash frequencies, complete EB calculations, predict crash frequencies for proposed

⁴⁴ Extended HSM Spreadsheets, Alabama Department of Transportation and Virginia Department of Transportation, December 23, 2011, <https://cpb-us-w2.wpmucdn.com/sites.udel.edu/dist/1/1139/files/2013/12/Extended-Spreadsheets-Instructions-1sojoa7.pdf>

conditions, conduct alternatives analyses, and complete benefit-cost analyses.

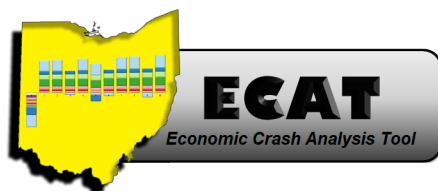


Figure 4-5 ODOT’s Economic Crash Analysis Tool

The lead agencies are utilizing software tools such as the IHSDM, ISATe, and Safety Analyst to implement the HSM procedures. The agencies don’t use the IHSDM and ISATe as frequently but they are used regularly. As discussed in *Incremental Steps Toward HSM Implementation*, LADOTD used the IHSDM on a pilot project to apply HSM procedures and evaluate proposed alternatives along a corridor between Interstate 12 and State Route 21 in Bush, Louisiana¹⁴. The results of the safety analyses were considered in conjunction with other potential physical, natural, and social environmental impacts when selecting the preferred design alternative. Now designers at LADOTD are using the IHSDM more regularly³⁵.

Maine DOT used the IHSDM to develop calibration factors for rural two-lane highways. ALDOT has used the IHSDM on select projects, in particular those that have alternative analyses, and most recently used the IHSDM to evaluate an urban arterial in Montgomery, Alabama, to address pedestrian concerns.

ODOT used ISATe to quantify the expected safety performance of alternative designs in reconstructing an interchange near Columbus, Ohio⁴⁵. The interchange operates as a system interchange to the west and a service interchange to the east. ODOT applied alternative analysis with predictive models using ISATe to evaluate and compare the expected safety performance of three alternative configurations, which allowed safety to be expressly considered along with other project goals in selecting the preferred design alternative.

MoDOT used ISATe to develop calibration factors for freeways and interchanges⁴⁶ and have used ISATe in conjunction with several access justification reports. IDOT has also used ISATe for analysis of multiple alternative configurations for interchange reconstructions.

“The ability to modify our HSIP priority list over the years using Safety Analyst has enabled us to better target locations that are studied each year. Additionally, the development of the source files for Safety Analyst has helped improve overall data quality at the DOT for safety data.”

Derek Troyer

Ohio DOT

“AASHTOWare Safety Analyst has allowed Michigan a better data-driven approach to safety performance management. Provided that Safety Analyst is a researched and documented process, it can be referenced upon request. The software has also allowed us to consider crash and roadway data across the whole system, reducing our dependencies on multiple other processes. Use of Safety Analyst has greatly increased our efficiencies.”

Dean Kanitz

Michigan DOT

Several lead agencies, including ODOT, MDOT, WSDOT, IDOT, and FDOT, have Safety Analyst licenses. As indicated in *Practices*, for years ODOT and MDOT have been using the Safety Analyst software to implement state-of-the-art

45 Predictive Safety Analysis Aids in Selection of New Design for an Outdated Interchange in Ohio, Project Case Study FHWA-14-CAI-058, Federal Highway Administration, U.S. Department of Transportation, 2014, https://www.fhwa.dot.gov/innovation/everydaycounts/edc_4/pdf/case_study_oh_oct2014.pdf

46 Sun C, P Edara, H Brown, C Nemmers, B Claros, and A Khezerzadeh, Highway Safety Manual Applied in Missouri – Freeway/Software, Report No. CMR16-009, Missouri Department of Transportation, June 2016, <https://library.modot.mo.gov/RDT/reports/TR201405/cmr16-009.pdf>

analytical procedures in HSM Part B for use in the decision-making process to identify, prioritize, and select infrastructure-related safety improvement projects. WSDOT, IDOT, and FDOT are preparing their data for use within the software and plan to use Safety Analyst soon for roadway safety management and their HSIP.

ODOT found that a big advantage of using Safety Analyst is the ability to quickly apply the more sophisticated screening methods within the HSM⁴⁷. With Safety Analyst, ODOT can easily analyze locations based on specific site subtypes and test and compare multiple screening methods. This has been particularly beneficial, resulting in greater identification of rural corridors and projects. Also, it enables ODOT to address more factors contributing to fatal and injury crashes across the state instead of being limited to high-crash locations in urban areas, where crashes often result in minor or no injuries.

IDOT developed a unique approach to incorporate HSM methods into its overall transportation management process by establishing the Safer Roads Index (SRI rating) and safety tiers for state-maintained routes, with the goal of integrating quantitative safety performance into project planning and programming⁴⁸. Using state-specific SPFs, the safety performance of roadway segments and intersections are calculated based on excess crash frequencies (i.e., how much a site’s expected safety performance exceeds the predicted), focusing on fatal and severe injury crashes. Then, sites of similar facility types (e.g., rural two-lane roadway segments) are categorized or grouped into safety tiers designated as top 5%, high, medium, low, and minimal to understand the relative performance of a location compared to similar types of roadways or intersections. For example, a rural two-lane roadway segment would be compared to other similar rural two-lane roadway segments statewide and would not be compared to an urban multilane facility. Figure 4-6 illustrates a sample safety tier categorization for rural, minor-leg, stop-controlled intersections. The safety tiers allow more locations to be identified and analyzed for similar roadway features and potential crash trends.

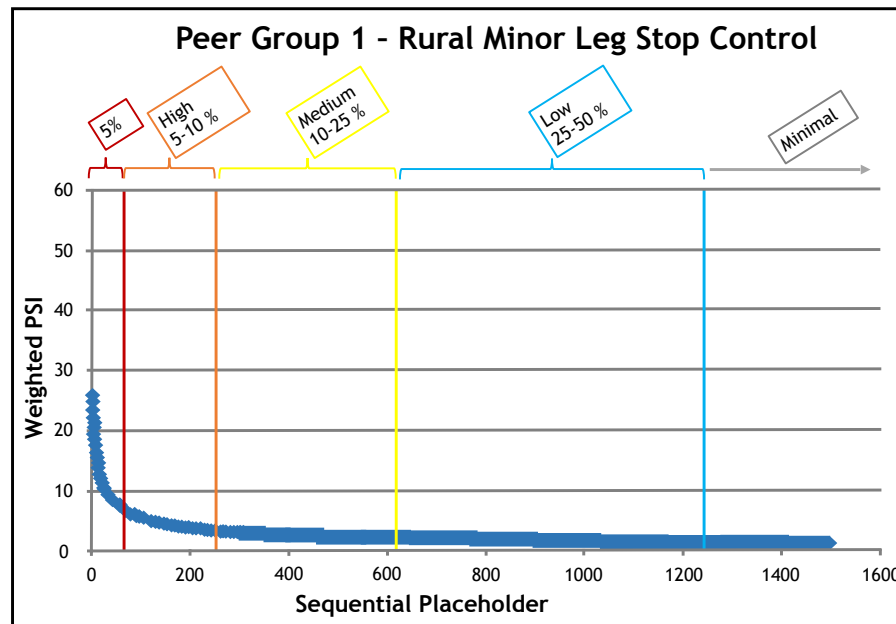


Figure 4-6 Example of IDOT’s Safer Road Index and safety tier for rural, minor-leg stop-controlled intersections⁴⁹

47 Highway Safety Manual Case Study 2: Implementing a New Roadway Safety Management Process with Safety Analyst in Ohio, Federal Highway Administration, U.S. Department of Transportation, 2011, https://safety.fhwa.dot.gov/hsm/casestudies/oh_cstd.pdf

48 Illinois Improves Transportation Decision Making Through Safer Roads Index (SRI) Ratings and Safety Tiers, Illinois Department of Transportation, (as of September 18, 2018), <http://www.idot.illinois.gov/Assets/uploads/files/Transportation-System/Specialty-Lists/Safety/SRI%20write%20up.pdf>

49 Tobias P, Integrating Safety into the Transportation Decision Making Process, Illinois Department of Transportation, February 17, 2016, <http://www.theconf.com/presentations/2016/Data%20Driven%20Safety.pdf>

The SRI (and resulting safety tiers) are then considered together with pavement condition and roughness indices to improve selection and prioritization of transportation projects. For pavement condition, the Condition Rating System represents the pavement’s loss of load-carrying capacity or structural breakdown. For pavement roughness, the international roughness index provides a rating of the excessive roughness impacting the functional usability and causing drive discomfort. Table 4-4 presents the three indices and relative ratings IDOT uses to leverage limited resources and expand its safety efforts to improve decision making. Figure 4-7 presents an example of the side-by-side comparison of three roadway rating indices IDOT uses in transportation planning and programming.

Table 4-4 IDOT’s state-of-repair comparison⁵⁰

	State of Repair
Safer Roads Index (SRI) Range	
Minimal	Good
Low	Minor
Medium	Moderate
High	Severe
5%	5 %
Condition Rating System (CRS) Range	
9.0 to 7.6	Excellent
7.5 to 6.1	Good
6.0 to 4.6	Fair
4.5 to 1.0	Poor
International Roughness Index (IRI) Range (in/mi)	
1 to 94	Good
95 to 177	Fair
> 177	Poor

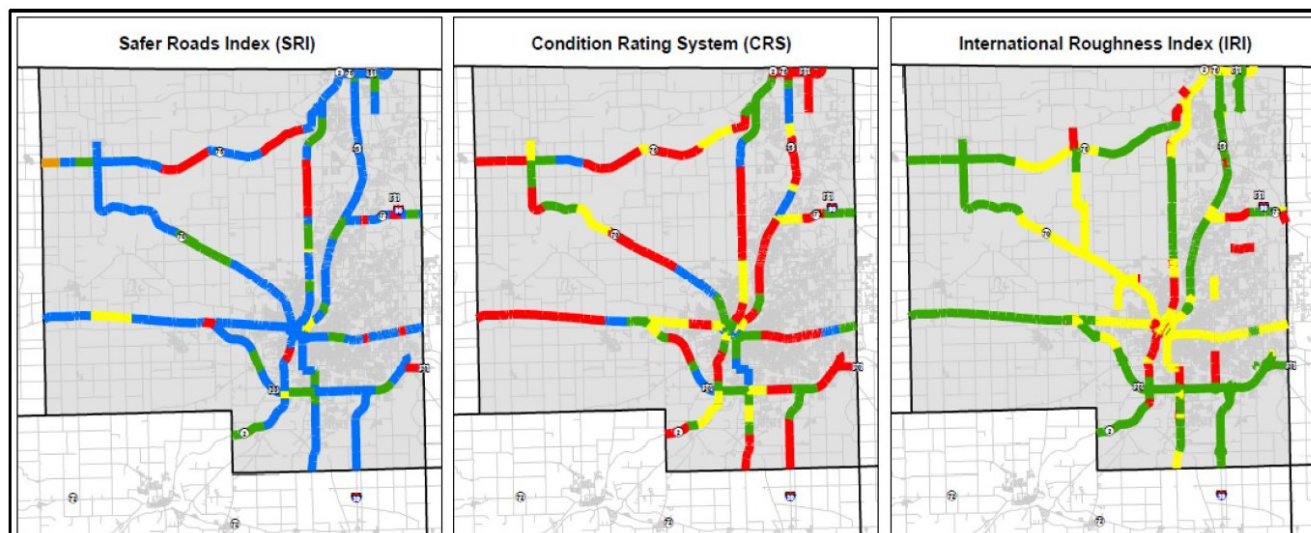


Figure 4-7 IDOT’s planning and programming performance measures⁵⁰

VDOT took a slightly different approach in developing tools to implement a data-driven process for

prioritizing safety projects and other multimodal infrastructure and operational capital projects. For HSIP project planning and prioritization, network screening is conducted using SPFs developed from Virginia data for all of the Safety Analyst site subtypes. Each year, the SPFs are calibrated for each of the nine VDOT construction districts. The potential for safety improvement (PSI) is determined for all roadway segments and intersections in VDOT’s linear referencing system (approximately 98% of the statewide network). Using the last five years of PSI for total and fatal-plus-injury crashes, sites with more than three years of both PSI (total) and PSI fatal-plus-injury greater than zero are denoted as targeted safety need locations. A listing and map of the top 100 intersections and 100 miles of targeted safety need locations in each VDOT district is published each year online.

Due to legislation, VDOT was required to develop a prioritization process using a scoring system for its six-year improvement program project selection that incorporated quantifiable, objective measures in six areas: safety, congestion mitigation, accessibility, environmental quality, economic development, and land use⁵⁰. The result was the development of the SMART SCALE tool to fund transportation projects through a prioritization process that evaluates each project’s merits in the above-listed areas. SMART SCALE projects may be submitted through an online portal by MPOs, planning district commissions (PDCs), public transit agencies, counties, cities, and towns that maintain their own infrastructure. Several types of projects may be considered for SMART SCALE funding, including: highway, transit, rail, road, operational improvements, and transportation demand management projects and strategies. Table 4-5 summarizes the performance measures and scoring system for project prioritization based on the six areas. Proposed projects are screened for scoring if they are on a PSI location or have a documented safety or roadway design concern.

Table 4-5 VDOT’s SMART SCALE project prioritization system⁵¹

Area of Interest	Measure Name	Weight	Measure Description	Measure Objective
Safety	EPDO of Fatal and Injury Crashes	50% ^a	EPDO of fatal and injury crashes expected to be avoided due to project implementation	Estimate number of fatalities and injury crashes (weighted by EPDO crash value scale [ratio] used by FHWA) at the project location and the expected effectiveness of project-specific countermeasures in reducing crash occurrence.
	EPDO Rate of Fatal and Injury Crashes	50%	EPDO of fatal and injury crashes per 100 million vehicle miles traveled (VMT) expected to be avoided due to project implementation	By focusing on the change in fatality and injury crashes (weighted by EPDO crash value scale [ratio] used by FHWA) per VMT, the measure considers projects that address areas with a high rate of crashes that may be outside of high-volume roadways.
Congestion mitigation	Person Throughput	50%	Increase in corridor total (multimodal) person throughput attributed to the project	Assess the potential benefit of the project in increasing the number of users served within the peak period.
	Person Hours of Delay	50%	Decrease in the number of person hours of delay in the corridor	Assess the potential benefit of the project in reducing peak period person hours of delay.

50 SMART SCALE Technical Guide, Virginia Department of Transportation, revised November 13, 2017, http://vasmartscale.org/documents/20171115/ss_technical_guide_nov13_2017.pdf

Area of Interest	Measure Name	Weight	Measure Description	Measure Objective
Accessibility	Access to Jobs	60%	Change in cumulative jobs accessibility within 45 minutes (within 60 minutes for transit projects)	Measure assesses the change in cumulative access to employment opportunities as a result of project implementation based on the GIS accessibility tool.
	Access to Jobs for Disadvantaged Populations	20%	Change in cumulative job accessibility for disadvantaged populations and accessibility within 45 minutes (within 60 minutes for transit projects)	Measure assesses the change in existing cumulative access to employment opportunities as a result of project implementation based on the GIS accessibility tool.
	Access to Multimodal Choices	20%	Assessment of the project support for connections between modes, and promotion of multiple transportation choices	Measure assigns more points for projects that enhance interconnections among modes, provide accessible and reliable transportation for all users, encourage travel demand management, and offer potential to support emergency mobility.
Environmental	Air Quality and Energy Environmental Effect	50%	Potential of project to improve air quality and reduce greenhouse gas emissions	Measure rates a project's potential benefit to air quality and ability to increase energy efficiency or alternative energy use weighted by the total number of users served.
	Impact to Natural and Cultural Resources	50%	Potential of project to minimize impact on natural and cultural resources located within project buffer	Measure evaluates how much sensitive land would be affected within project buffer around the project and rates projects highest that have minimal or no impacts and are providing benefits in other factor areas.
Economic development	Project Support for Economic Development	60%	Project consistency with regional and local economic development plans and policies and support for local development activity	Measure evaluates if the project supports new and existing economic development and the progress made toward development in the project corridor at the local level. Progress is assessed through use of a checklist of desired actions.
	Intermodal Access and Efficiency	20%	Rate projects based on the extent to which the project enhances access to critical intermodal locations, interregional freight movement, and/or freight-intensive industries.	Measure evaluates the level to which the project: a) Enhances access to distribution centers, intermodal facilities, manufacturing industries or other freight intensive industries b) Supports enhanced efficiency on a primary truck freight route (or high-volume/high-value truck or rail freight corridor) c) Enhances access or reduces congestion at or adjacent to VA ports/ airports.
	Travel Time Reliability	20%	Improvement in travel time reliability attributed to the project	Measure estimates the project's expected impact on improving reliability, which supports efforts to retain businesses and increase economic activity.
Land use	Transportation and Efficient Land Use	100%	Project support for mixed-use development with multimodal choices, in-fill development, and corridor access management policies	Measure evaluates the degree to which the project and adjacent future land use will support transportation-efficient land-use patterns and local policies.

EPDO – Equivalent Property Damage Only
GIS – Geographic Information System

a 100% for transit projects.

“Having planners and engineers for MPOs, PDCs, transit agencies, counties, cities, and towns submit projects and having VDOT staff support the effort and become familiar with and consider the expected safety benefits with their proposals has elevated the conversation about and consideration of highway safety in our communities.”

Stephen Reid

Virginia DOT

Regarding the SMART SCALE safety measures, projects are evaluated based on how well each project addresses multimodal transportation safety concerns through implementation of best practice crash-reduction strategies. Estimated reductions in equivalent-property-damage-only crash frequencies and rates are calculated for each project, making use of the most recent five years of data and CMFs applicable to the SMART SCALE project types.

CMFs for use in SMART SCALE were selected from the range of values for larger project level improvements in the CMF Clearinghouse. For larger widening projects with multiple improvements, CMFs were developed based on the ratio of crash rates for the facility types and number of lanes. CMFs for traffic demand management and transit projects were developed based on the ratio of the build to no-build vehicle miles traveled (VMT) on roadway segments impacted by the improvement. Using this CMF-based method to assess the safety benefits of every capital project, combined with a weighted safety score for prioritization, allows for more consideration (and thus funding) of projects to reduce fatal and injury crashes. This is particularly evident in non-urbanized areas where safety has a higher weight and comprises more of the total score than the other measures, like congestion relief.

Through the implementation of SMART SCALE, VDOT has found that applicants are submitting more projects involving innovative intersection designs that reduce conflicts and projects that mitigate roadway departures combined with nonmotorized accommodations. These larger project types have become cost prohibitive through the typical HSIP prioritization process; however, now, through SMART SCALE, they are being programmed, funded, and constructed.

Calibration

All of the lead agencies developed calibration factors and crash distributions specific to their local conditions for use in network screening and/or the crash prediction models in HSM Part C. Before going through the process of developing calibration factors or state-specific SPFs, the lead agencies weighed the benefits of doing so based on return on investment and use. One of the primary benefits of calibrating versus developing state-specific SPFs was that agencies could quickly implement HSM procedures. In several cases, a few of the lead agencies, such as MDOT and WSDOT, still went through the process of developing state-specific SPFs in addition to developing local calibration factors. Lead agencies often used universities or consultants to develop calibration factors and/or state-specific SPFs. Using cure plots to check goodness of fit and considering statewide versus regional calibration and univariate versus multivariate models, lead agencies worked to define acceptable calibration factors and state-specific SPFs.

Systemic Safety

Many of the lead agencies supplement their traditional, crash-based safety management approach

to improving high-crash locations with a systemic safety management approach to safety improvements. The traditional, crash-based approach refers to the selection and treatment of sites based on site-specific crash frequency and severity. The systemic approach refers to the selection and treatment of sites based on site-specific geometric and operational attributes known to increase crash potential⁵¹. The systemic safety management approach is proactive in nature because sites can be prioritized for safety improvements even if they do not have a history of crashes. When applying systemic safety management procedures, agencies typically focus on reducing fatal and severe-injury crashes of crash types that are widely dispersed across the highway network and that are not well suited for remedy using a crash-based safety management approach. The systemic safety management approach can be used to address such crash types by treating many sites with lower-cost treatments.

Several lead agencies have implemented the systemic safety management approach in certain projects or for specific crash or treatment types. WSDOT has been implementing systemic safety treatments since the 1990s. Its systemic safety approach is linked to its SHSP and TZD indicators, and its focus has been on implementing run-off-road (ROR) and intersection treatments such as cable median barrier, shoulder and centerline rumble strips, and roundabouts.

Maine DOT has been implementing treatments similar to those of WSDOT as part of its systemic safety management approach. In Maine, head-on and ROR crashes accounted for approximately 70% of fatalities statewide. To address facilities where head-on crashes are overrepresented, Maine DOT installed approximately 250 miles of centerline rumble strips between 2015 and 2016 on two-lane rural roadways with speed limits greater than 45 mph and annual average daily traffic greater than 6,000 vehicles per day (vpd). Another 150 miles of centerline treatments are also planned. Maine DOT also improved edgeline striping and curve signing, installed edgeline and centerline rumble strips on sharp curves to reduce ROR crashes, and installed 26 roundabouts on state roads in conjunction with its systemic safety management program.

In the past, VDOT focused on roadway departure and signalized intersection systemic safety improvements. However, most recently, VDOT is using a systemic safety management approach for prioritizing installation of low-cost countermeasures at its 80,000 unsignalized intersections with stop control on the minor approaches. This effort supports Virginia's 2012-2016 Strategic Highway Safety Plan, which includes intersections as an emphasis area. VDOT has collected five years of crash data, volumes, and other characteristics for all 80,000 intersections. It is identifying the features and characteristics it will use to categorize the intersections and is looking for intersection characteristics that are overrepresented in the crash data. VDOT also developed a list of low-cost treatments that can be used to address the crash patterns identified in the data⁵². The treatments are intended to warn of the stop ahead, to make the stop sign and stop location more visible on the minor road, and to warn of the intersection ahead on the major road.

IDOT performed systemic analysis using its state-specific SPFs and has been implementing centerline rumble strips, horizontal curve signs, and median cable rail as part of a systemic safety approach. Also, several agencies, including FDOT, LADOTD, MDOT, VDOT, and WSDOT, have taken a systemic approach to address pedestrian and bicycle crashes.

51 Gross F, Highway Safety Improvement Program (HSIP) Evaluation Guide, Report No. FHWA-SA-17-039, Federal Highway Administration, U.S. Department of Transportation, May 2017, <https://safety.fhwa.dot.gov/hsip/docs/fhwasa17039.pdf>

52 Cottrell BH and I Lim, Systemic Low-Cost Countermeasures for an Unsignalized Intersection Safety Improvement Plan for Virginia, Report No. VTRC 19-R5, Virginia Department of Transportation, August 2018, http://www.virginiadot.org/vtrc/main/online_reports/pdf/19-r5.pdf

Local Roads

“Safety is not just a job for a single agency. Everyone has a role to play in the reduction and elimination of fatal and severe crashes, so why not include the local system in the process?”

Dean Kanitz

Michigan DOT

“Our Local Programs Division has been instrumental in driving data-driven safety analysis to our local partners. Their approach recognizes the balance between limited data availability for some of our partners, and the potential increased benefits from a more robust approach that HSM methods provide.”

John Milton

Washington State DOT

Due to HSIP requirements to improve safety on all public roads, all of the lead agencies have reached out to local jurisdictions within their states to assist in various ways. For example, IDOT, MDOT, and ODOT develop regional and county maps for local agencies to help identify high crash locations based on advance network screening techniques in the HSM. Figure 4-8 illustrates a map MDOT developed for local jurisdictions that prioritizes roadway segments and intersections for potential safety improvement. IDOT has also developed local road SPFs and provided them to local agencies and MPOs along with instructions on how to utilize them in their planning efforts.

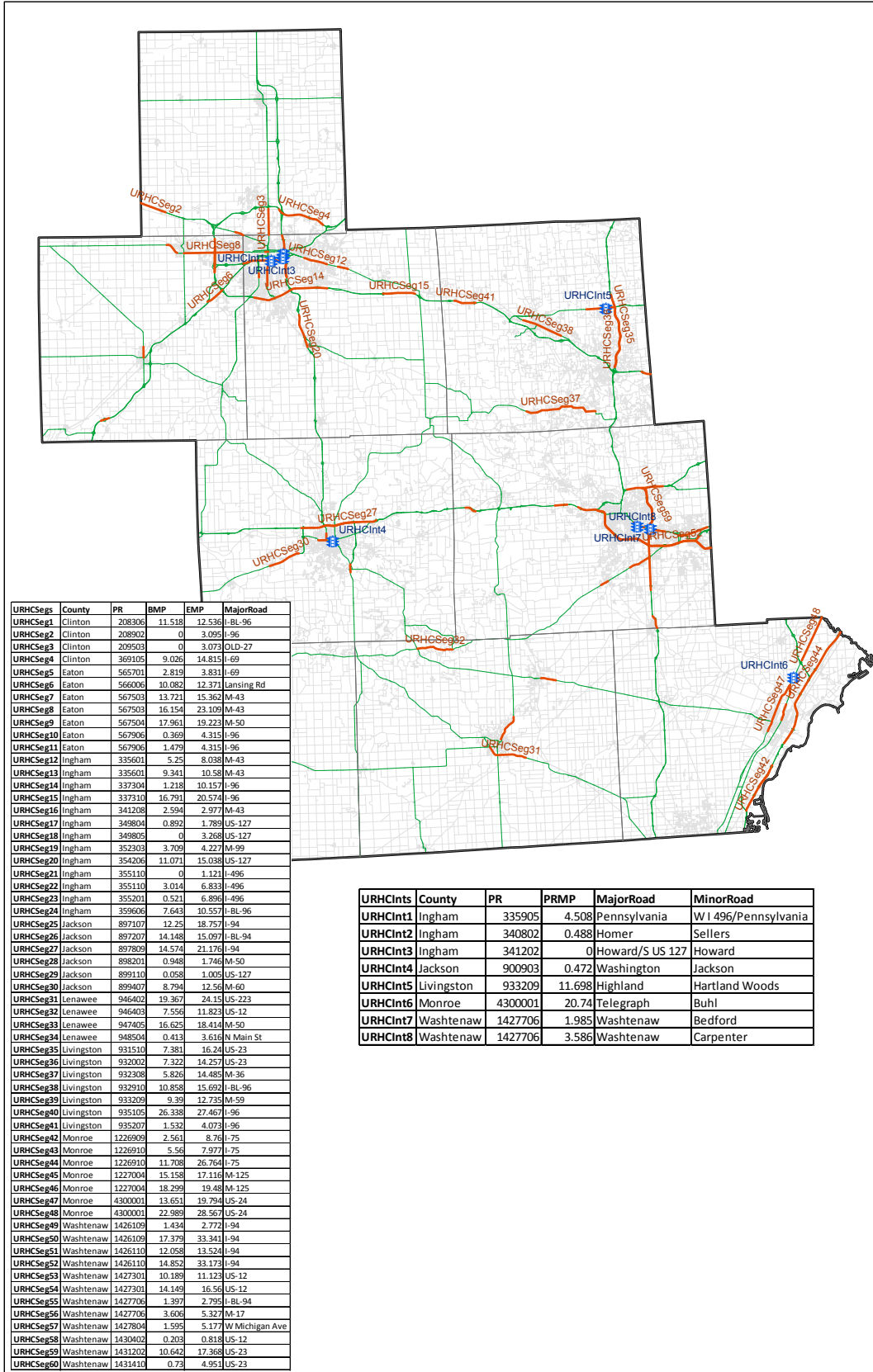


Figure 4-8 Local map MDOT developed ranking roadway segments and intersections for potential safety improvement

WSDOT allocates approximately 70% of its HSIP funds to local safety investments. WSDOT assists local agencies develop local road safety plans, which can be detailed or simple. WSDOT recommends the following steps for developing a local road safety plan:

1. Analyze crash data to identify focus/priorities.
2. Analyze individual fatal/serious crashes to identify common factors contributing to crashes on roadways based on crash data, traffic volumes, roadway and intersection data, and other features.
3. Select the most common factors contributing to crashes.
4. Analyze the roadway network for the presence of these common contributing factors.
5. Create a prioritized list of roadway locations where engineering improvements should be made, based on the presence of the most common contributing factors.
6. Identify specific countermeasures necessary to address the prioritized locations.
7. Prioritize projects using those countermeasures.

To assist local agencies, MoDOT published its fourth edition of the S-HAL: Safety Handbook for Locals⁵³. The handbook is a comprehensive traffic safety resource for local communities in Missouri and mirrors the HSM in using a systematic and data-driven approach to improving traffic safety. The S-HAL covers the same topics as the HSM, introducing the theory and techniques presented in the HSM, but in less detail. The S-HAL focuses on facilities that are of more interest to local communities, so freeway and expressway facilities are not addressed. Topics covered in the S-HAL include establishing a traffic records system, screening for problem locations, analyzing conflict and crash patterns, designing safety improvements, conducting road safety audits, and accessing national and regional safety resources.

53 S-HAL: Safety Handbook for Locals, Missouri Department of Transportation, 2014, http://epg.modot.org/files/3/35/907.5_SHAL.pdf

5 Data

Three types of data are required to apply most HSM procedures: site characteristic data, traffic volume data, and crash data. However, data requirements vary depending on the facility type being considered (e.g., an urban or rural arterial roadway segment, intersection, freeway, ramp, or ramp terminal). The type of analysis also factors into the data requirements to apply HSM procedures. Planning-level analyses performed using HSM Part B procedures require less data than project-level analyses performed using HSM Part C procedures.

Over the past couple of decades, NHTSA, FHWA, and others have been promoting and encouraging agencies to collect more data in a consistent format to develop more reliable and robust datasets for safety analyses. NHTSA and FHWA have taken the lead in developing the Model Minimum Uniform Crash Criteria (MMUCC) and Model Inventory of Roadway Elements (MIRE). MMUCC is a set of guidelines that identify a minimum set of motor-vehicle crash data elements and their attributes that states should consider collecting and including in their crash data systems. MIRE is a set of guidelines that define the critical inventory and traffic data elements needed by state and local jurisdictions to meet current safety analysis needs. Included within the MIRE are a set of 37 elements designated as the fundamental data elements needed to conduct enhanced safety analyses.

Despite these efforts by NHTSA, FHWA, and others, many state agencies are still struggling to develop reliable datasets to conduct robust safety analyses such as those described in the HSM. Common themes heard, even from the lead agencies implementing the HSM, relate to challenges collecting or estimating reliable traffic volume data, locating crashes on the network (particularly near interchange ramps), working with local agencies to obtain data for non-state-maintained (i.e., local) roads, and collecting exposure data for pedestrians and bicyclists. The following sections describe recommendations for assembling a reliable dataset to conduct enhanced safety analyses and provide guidance related to data governance.

Develop Visions for Safety Data Use

To efficiently develop a reliable dataset to conduct enhanced safety analyses, transportation agencies should develop short-term and long-term visions for use of their data. To develop their visions, agencies should start by understanding the purpose and use of the data in the various types of safety analyses and the tradeoffs and opportunities that data provide. As indicated above, the primary types of data necessary for safety analyses include inventory (i.e., site characteristics), traffic volume, and crash data. Certain types of data are necessary for planning-level analyses (i.e., HSM Part B procedures), such as network screening, while other types of data are necessary for project-level analyses (i.e., HSM Part C procedures), such as when alternative analyses are performed.

By understanding how data elements are used in different procedures, agencies can better understand the importance of including certain data elements in their datasets. Therefore, agencies should identify the types of facilities and level of safety analyses that they are interested in performing and identify the required data elements. Table 23 is a starting point; it provides a summary of the site characteristics and traffic volume variables used in HSM Part C procedures for HSM Chapters 10, 11, and 12. Additional details about the data for HSM Part C procedures can be found in the Highway Safety Manual Data Needs Guide¹¹. This guide does not, however, include the data elements necessary for analyzing freeways and ramps addressed in the 2014 supplement to

the HSM or specific data requirements for HSM Part B procedures, so agencies will need to do some additional work to complete this task.

Next, transportation agencies should conduct an inventory of their existing data to determine what type of data they currently have, who owns or maintains the data, and the quality of the data. As part of the data quality check, the existing data should be reviewed against the MMUCC and MIRE guidelines to assess if they are consistent with the recommended formats in MMUCC and MIRE. This existing inventory can then be compared to the purpose and use of data elements defined in the previous step as part of a gap analysis. Based on this initial comparison, agencies can determine what types of facilities and analyses can be performed with the existing data. Then agencies can set priorities for collecting additional data in the short term and long term.

In setting priorities, agencies should consider the level of effort needed to collect additional data elements and the potential benefit of having a database of those elements. In general, agencies should give higher priority to collecting those data elements that require minimal effort and provide expanded analysis capabilities in the short term and lower priority to collecting data elements that will require extensive resources to collect and provide minimal expanded capabilities. In so doing, agencies can capture the benefits of existing or easily collected data in the short term while establishing a vision for collecting additional data elements over the long term to expand capabilities. As a rule, agencies should initially focus on collecting any MIRE fundamental data elements missing from their existing datasets in the short term, consistent with 23 CFR 924.17, and understand that the complexity and types of applications will evolve over time as more data are collected and the reliability of their datasets improve.

As another short-term goal, transportation agencies should integrate their inventory (site characteristics), traffic volume, and crash data into a system that is user friendly and accessible by staff and eligible partners. Otherwise, staff and eligible partners will not be able to easily use the data and unnecessary delays will occur when conducting safety analyses.

Agencies attempting to develop an integrated dataset should begin on a small scale. They should develop an integrated dataset beginning with a select area or region rather than the entire network; otherwise, the task can become overwhelming. When the integrated dataset is complete for the selected area or region, expanding the dataset to include the entire network should be more manageable. While expanding the dataset to include the entire network, agencies should demonstrate how the integrated dataset for the selected area or region can be used to implement HSM procedures to create enthusiasm for use with potential projects. This can be done as a pilot or demonstration project.

Transportation agencies should develop a long-term vision for use of their safety data, including a safety data business plan that describes an agency's data management challenges, vision and mission for safety data, framework for data governance, and actions for improving its safety data system. Effective data management practices are necessary to integrate safety data and make it readily available to support enhanced safety analyses. Agencies should develop strategies based on circumstances and need to incrementally develop a more robust and reliable dataset over time.

Recently, FHWA published a Guide for State Department of Transportation Safety Data Business Planning⁵⁴ to assist state agencies in developing, implementing, and maintaining a safety data business plan. The guide describes seven steps for developing and implementing a safety data business plan. Table 5-1 summarizes supporting actions and key outcomes associated with each step.

54 Vandervalk A, D Snyder, and JK Hajek, Guide for State Department of Transportation Safety Data Business Planning, Report No. FHWA-SA-17-047, Federal Highway Administration, U.S. Department of Transportation, July 2017, <https://safety.fhwa.dot.gov/rsdp/downloads/fhwasa17047.pdf>

Table 5-1 Process for developing a safety data business plan⁵⁵

Steps	Supporting Actions	Key Outputs/Work Products
<p>Step 1 Plan for Safety Data Management and Governance</p>	<ul style="list-style-type: none"> • Identify stakeholders for safety data systems • Engage stakeholders • Define safety data management challenges • Research state efforts in data management and governance • Establish vision and mission for safety data management • Develop outcome statement 	<ul style="list-style-type: none"> • Stakeholder registry • Community of interest diagram • Stakeholder engagement plan • Survey instrument on safety data management challenges • Problem statement • Survey instrument on data governance initiatives • Vision and mission for safety data governance • Outcome statement for the safety data business plan
<p>Step 2 Assess Current State Safety Data System</p>	<ul style="list-style-type: none"> • Identify data systems to include in the assessment • Document current business processes • Document spatial, temporal, and data resolution and accuracy standards in each data source • Research and summarize current and past assessment efforts • Update past assessments • Conduct capability maturity assessment 	<ul style="list-style-type: none"> • Identification of data systems for the assessment • Use case diagrams and accompanying narratives on business processes and workflows for safety data systems • Summary of similarities and differences in data resolution and accuracy standards across all data • Summary of past assessment recommendations in matrix form • Update on state progress in implementing past assessment recommendations • Assessment tools • Assessment of current and desired levels of maturity for each dimension of the capability maturity model • Identification of actions needed to advance from current to desired capability
<p>Step 3 Establish a Governance Program</p>	<ul style="list-style-type: none"> • Develop data principles • Develop a governance model • Establish roles and responsibilities for governance • Develop information technology (IT) project governance • Develop governance documentation 	<ul style="list-style-type: none"> • Core data principles • Governance model • Roles and responsibilities • IT project selection process • Data governance charter • Data governance manual • Data catalog • Business terms glossary • Common resolution and accuracy standards for linking data sources
<p>Step 4 Identify Needs for Safety Tools and Technology</p>	<ul style="list-style-type: none"> • Identify needs for improved technology • Develop plan for improved use of tools 	<ul style="list-style-type: none"> • Summary of needs and weaknesses related to safety tools and technology • Plan for enhancing or replacing safety tools and technology • Tool training needs and opportunities defined
<p>Step 5 Develop Action Plan</p>	<ul style="list-style-type: none"> • Summarize gaps and improvements • Identify priorities • Develop action plan • Develop road map for implementation 	<ul style="list-style-type: none"> • Summary of system, technology, and institutional gaps • Priorities for addressing gaps • Action plan • Road map for implementation
<p>Step 6 Document the Safety Data Business Plan</p>	<ul style="list-style-type: none"> • Document the safety data business plan 	<ul style="list-style-type: none"> • Safety data business plan
<p>Step 7 Implement and Sustain the Safety Data Business Plan</p>	<ul style="list-style-type: none"> • Assign roles and responsibilities • Establish performance metrics • Implement the safety data business plan • Conduct training • Monitor progress • Communicate changes 	<ul style="list-style-type: none"> • Designation of governance champion or small team to guide implementation • Performance metrics for measuring success • Implementation of the safety data business plan • Training program on data governance • Progress updates

“The safety data business plan assisted WSDOT in understanding that the need for safety data collection, use, and integration into business practices has significant impacts on WSDOT meeting its strategic goals and objectives. Far too often, the importance of data is not well understood at different decision-making levels. Because of this, cross-departmental implications are not explicitly considered as a decision in one office and may dramatically affect another office’s delivery or decision-making. The safety data business plan helps reduce these occurrences.”

John Milton

Washington State DOT

WSDOT developed a safety data business plan following the seven-step process described in FHWA’s guide⁵⁵ to model its safety data management practices. The primary purpose of the plan is to manage and maintain integrated data systems that are user friendly and easily accessible to WSDOT staff and partners for their business analyses.

Data Governance

Data governance is the management of an organization’s data assets to achieve its business purposes and compliance with relevant legislation, regulations, and business practices⁵⁵. Data governance is quickly becoming a priority for state agencies as they strive to operate more efficiently, meet the increasing demand for accurate and timely information, and get the most value from their data to support state and federal mandates. Furthermore, state agencies are coming to recognize that data are a strategic asset that should be institutionally collected, managed, and protected.

Establishing data governance as an institutional framework will result in data that support an agency’s pursuit of improved and defensible decision-making and more efficient use of public funds. The primary benefits for state agencies adopting data governance from a policy, practical, and technical perspective are as follows:⁵⁶

- Data governance promotes the understanding of data as a valuable asset to the organization and encourages the management of data from a technical and business perspective.
- Data governance provides access to data standards, policies, and procedures on an enterprise basis. It provides a central focus for identifying and establishing rules for the collection, storage, and use of data in the organization.
- Data governance results in reducing the need to maintain duplicate data systems, improving data quality, and providing opportunities to implement better tools for managing and integrating data.

Figure 5-1 depicts the key activities associated with data governance⁵⁵:

- **Create and align rules:** The program establishes the policies and decision-making process for managing data and formalizes the roles and responsibilities of all stakeholders.
- **Enforce rules and resolve conflicts:** The program safeguards that stakeholders apply data management rules and processes correctly; it also provides a forum for resolving conflicts, if necessary.
- **Provide ongoing support:** The program provides ongoing support to stakeholders who are applying data management rules and processes and identifies opportunities for creating rules or adapting existing ones, continuing the data governance life cycle.

55 Draft Data Governance Findings & Recommendations Summary Report, Ohio Department of Transportation, 2017

56 National Cooperative Highway Research Program Report 666: Target-Setting Methods and Data Management to Support Performance-Based Resource Allocation by Transportation Agencies, Cambridge Systematics, Inc., Boston Strategies International, Inc., Gordon Proctor and Associates, and MJ Markow, Transportation Research Board of the National Academies, 2010, http://boston-strategies.com/images/nchrp_rpt_666.pdf

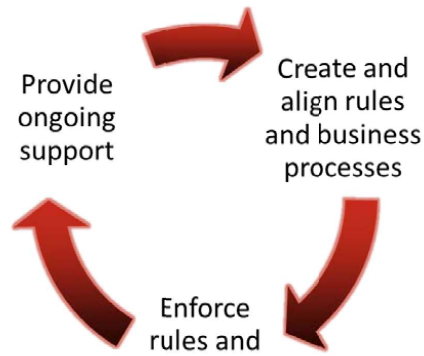


Figure 5-1 Data governance activities⁵⁵

MDOT incorporates data governance into its standard business operations to improve its safety data systems and processes⁵⁷. MDOT began implementing data management policies as part of its asset management program in the 1990s and has a top-down data governance structure established by the governor’s office via an executive directive in 2013. In response, MDOT established:

- **A Data Governance Council**, whose purpose is to establish policies for data governance and develop data dictionaries and metadata for all major systems and data sources. Membership includes representation from major business process areas and the Information Technology (IT) Department.
- **The role of chief data steward**, whose purpose is to implement data management within the department and chair the Data Governance Council.
- **Data stewards**, who are responsible for data quality and the establishment of business rules/ definitions that govern data in each business area, including safety data systems.

Benefits realized by MDOT through their data governance experience include:

- The program encourages management of MDOT data as an asset with the goal of data being created once, published once, and used many times.
- The program establishes and enforces data governance policies at the enterprise level, which results in clear identification of data governance policies, procedures, and responsibilities at the agency.
- The program provides perspective for database design and application development across an entire enterprise, not just for a specific business area.
- The program defines business rules for governing data in each business area, which eliminates confusion over which office is primarily responsible for which data system(s).

“With data being a cornerstone of business and Safety Analyst, it is important to have a defined structure to your data and processes. We have been fortunate to have had a long history of data governance and data governance structure to make our programs successful. As our organization has evolved, our data stewards have been strong supporters of it moving to new processes and programs.”

Dean Kanitz
Michigan DOT

⁵⁷ Michigan Department of Transportation Safety Data Processes and Governance Practices, Case Study FHWA-SA-15-059, Federal Highway Administration, U.S. Department of Transportation, November 2015

ODOT is examining how its data assets are currently being maintained throughout the full life cycle of the data and throughout the agency⁵⁶. Several of the key steps that ODOT has identified for establishing an overall process to meet their data governance needs include:

- Developing a Data Governance Oversight Committee to provide the venue for collaboration between the chief data officer, executive management, and business units/data owners.
- Designating a Chief Data Office to serve as a single point of contact between business units, districts, and IT and to provide assurance that the management of ODOT data follows strategic goals of the ODOT enterprise.
- Developing a data governance framework that provides guidelines for enterprise data governance and ensures enterprise data management is considered from a strategic viewpoint to gain the most value from all ODOT data assets.
- Developing an agency-wide, executive level, approved policy for data governance that provides clear definition of data governance and data stewardship roles and responsibilities and promotes workflow efficiencies across all business areas and districts.

“Data governance will ensure that new and old data sets will be able to be integrated. This is important to enable ODOT to continue to make strategic investments that serve citizens and businesses of Ohio.”

Derek Troyer

Ohio DOT

6 Cultural

This section focuses on how the culture of quantitative safety analysis changed within the lead agencies and on the effects of those cultural changes within the agencies. The primary reason that a cultural change occurred, as it relates to safety quantification and the HSM, was through a combination of federal legislation and initiatives taken by HSM champions within the agencies.

Federal legislation through the Moving Ahead for Progress in the 21st Century Act (MAP-21) mandated that state agencies implement performance-driven, outcome-based transportation planning processes to address challenges facing the U.S. transportation system, including improving safety. However, it was through the initiatives of HSM champions that changes in planning and programming were facilitated within each state transportation agency. Key roles that HSM champions played in facilitating this change included:

- **Advocacy** – Seeking support for HSM implementation by communicating to internal and external personnel that the use of the HSM procedures is essential
- **Removing roadblocks** – Effectively removing impediments such as funding, resource allocation, and resistance to change
- **Explanation** – Speaking about the importance of the HSM to groups and individuals at events
- **Appreciation** – Recognizing internal and external personnel who implemented the HSM on pilot projects

One of the first cultural shifts that occurred within the lead agencies that enabled them to institute performance-based processes was understanding the difference between nominal and substantive safety. Safety performance has traditionally been judged on nominal safety. Nominal safety is the evaluation of safety based on whether a roadway, design alternative, or design element meets minimum design standards or warrants. Substantive safety is defined in terms of actual or expected performance and is measured by frequency and severity of crashes. Some roadways may be nominally safe (i.e., all design elements meet design criteria) but at the same time substantively unsafe (i.e., experience a high crash frequency relative to expectations). Other roadways may be nominally unsafe (one or more design elements do not meet design criteria) and still function at a high level of substantive safety. Through HSM-related training, personnel learned that the substantive or long-term safety performance of a roadway does not always directly correspond to its level of nominal safety and that the safety performance of facilities should be based on substantive safety, not whether a facility meets all design criteria.

A second cultural shift that occurred within the lead agencies that enabled them to institute performance-based processes was recognizing the limitations of using crash rate as the primary measure of safety performance. Crash rate normalizes the frequency of crashes with the exposure, measured by traffic volume. For years, most agencies used crash rates to prioritize sites for safety improvement. Crash rate as a performance measure, however, has several limitations. When regression-to-the-mean is not accounted for, comparisons cannot be made across sites with significantly different traffic volumes; low-volume, low-collision sites could mistakenly be given a high prioritization¹. Upon recognizing the limitations of crash rate through HSM-related training, the lead state agencies moved away from traditional approaches of measuring safety performance and started to use performance measures that address regression-to-the-mean bias and produce more reliable results, such as expected average crash frequency with EB adjustments and excess expected average crash frequency with EB adjustments.

As these cultural shifts were occurring within the lead agencies, the agencies were able to demonstrate the

benefits of implementing HSM procedures on pilot projects, which built trust in the HSM procedures. As the lead agencies more fully integrated the HSM procedures into their programs, HSM procedures became accepted as a reliable best practice.

Additionally, lead agencies were able to achieve a cultural shift to institute performance-based processes within their respective agencies by:

- Establishing executive orders and policy directives that provided the foundation for integrating performance-based processes throughout the agencies' various programs and departments
- Implementing a process for leading change, such as
 - Create a sense of urgency
 - Build a guiding coalition
 - Form a strategic vision and initiatives
 - Enlist a volunteer army
 - Enable action by removing barriers
 - Generate short-term wins
 - Sustain acceleration
 - Institute change⁵⁸
- Establishing an HSM implementation team and/or plan, which created a sense of urgency, kept the department on task, and coordinated programs and implementation efforts
- Making safety analysis and procedures simpler and accessible to internal and external staff, which reduced training requirements and increased the likelihood that the procedures would be used

As these cultural shifts occurred and the lead agencies integrated performance-based processes into their programs, staff within the lead agencies realized that improving the safety performance on all public roads is everyone's responsibility. It is more than simply the responsibility of staff within the safety program; safety is the responsibility of planners, designers, and staff at all levels within the department. Safety is also more than simply the HSIP. For example, projects for which the primary need is to improve operations or pavement restoration can still be evaluated to determine if treatments can be economically incorporated into the project to improve safety. In this way safety funds are shared with other programs and projects to reduce project and operating costs while reducing traffic fatalities and serious injuries that occur on the nation's highways.

Another cultural shift that occurred within the lead agencies was the realization that performance-based processes encourage engineers to use engineering judgment rather than simply develop projects that meet design standards. For example, engineers should understand that the HSM is a good tool for conducting safety analyses; however, it is not the only tool. Engineers should also understand the limitations of HSM analyses and recognize the importance of more reliable analyses to inform decision making. When selecting CMFs, engineers should understand the context and conditions to which the CMF applies. Thus, performance-based processes support the use of engineering judgment during the decision-making process.

58 8-Step Process for Leading Change, Kotter Inc., (as of April 5, 2018), <https://www.kotterinc.com/8-steps-process-for-leading-change/>

7 Information Dissemination

This section describes how the lead agencies effectively communicated with internal personnel to implement the performance-based procedures of the HSM and with external stakeholders to share results of HSM analyses. This section also discusses tort liability concerns of using crash data and results of HSM analyses against state and local agencies in lawsuits.

Internal Communication to Implement HSM Procedures

The lead agencies found it beneficial and necessary to use various approaches to communicate internally to implement performance-based safety procedures. Agencies such as WSDOT and FDOT used a top-down approach to communication by establishing executive orders and policies supported by upper management, which served to provide direction to the entire department regarding quantitative safety performance. A bottom-up approach to communication was also necessary and often was the first approach toward implementation of the HSM. HSM champions sought the support of upper-level management by communicating that use of HSM procedures was essential. Peer-to-peer communication was also effective. All lead agencies participated in programs and projects such as the FHWA HSM Pooled Fund Study⁵⁹ and NCHRP Project 17-50, Lead States Initiative for Implementing the Highway Safety Manual⁶⁰, intended to facilitate and foster communication among agencies so that agencies could learn from each other. IDOT also hosted several workshops to facilitate the exchange of experiences and examples related to HSM implementation among states.

It was also important for staff to know who to contact for help with HSM-related questions, whether they be an HSM champion in the central or district office, members of the HSM implementation team, or instructors from their agency who led HSM training courses.

Communication of HSM Analyses to External Stakeholders

When the lead agencies communicated results from enhanced safety analyses to external stakeholders, such as public officials or members of the community, the lead agencies found it necessary to use simple language. They did not want to get caught up in semantics and differences in the definitions between such words as observed, predicted, and expected crash frequencies. Other key points that helped the lead agencies communicate results from enhanced safety analyses to external stakeholders included:

- Presenting the safety analysis results visually using maps
- Targeting the discussion to the audience
- Not showing crash costs
- Discussing the project as a whole, including safety, operations, design, environment, and context, so the safety results would not be presented in a vacuum

59 Highway Safety Manual Implementation, Study Detail View, Transportation Pooled Fund Program, National Cooperative Highway Research Program, <https://www.pooledfund.org/details/study/484>

60 NCHRP Project 17-50, Lead States Initiative for Implementing the Highway Safety Manual, National Cooperative Highway Research Program, January 2012, http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-50_peerexchange1_report.pdf

The lead agencies also found the HSM helpful in responding to perceived safety concerns and calls from the public, elected officials, and the media. The HSM is a nationally recognized document for quantitatively estimating safety and the procedures are recognized as best practices, so use of HSM procedures in response to perceived safety concerns and calls has made the public, elected officials, and the media more accepting of the results.

Tort Liability Concerns Associated with Crash Data and HSM Analyses

During development of the HSM and after its publication, there have been concerns that crash data and results of HSM analyses could be used against agencies in lawsuits. The HSM explicitly states that the documentation used, developed, compiled, or collected for any analysis conducted in connection with the HSM may be protected under federal law (23 U.S.C. §409)⁶¹. In the early 1980s, the U.S. DOT recognized that state agencies might be reluctant to collect data for the HSIP in fear of it being used against them in a tort lawsuit⁶¹. In response to this concern, Congress enacted 23 U.S.C. §409 in 1987, and several amendments followed. The U.S. Code states:

Notwithstanding any other provision of law, reports, surveys, schedules, lists, or data compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential accident sites, hazardous roadway conditions, or railway-highway crossings, pursuant to sections 130, 144, and 148 of this title or for the purpose of developing any highway safety construction improvement project which may be implemented utilizing federal-aid highway funds shall not be subject to discovery or admitted into evidence in a federal or state court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data.

In 2012, as part of MAP-21, Congress amended 23 U.S.C. §148, which sets forth the broad provisions of the HSIP. Included within that section is 23 U.S.C. §148(h)(4), which affords similar protection provided by 23 U.S.C. §409 and extends the protection to all safety data collected for any purpose related to the HSIP. 23 U.S.C. §148(h)(4) states:

Notwithstanding any other provision of law, reports, surveys, schedules, lists, or data compiled or collected for any purpose relating to this section, shall not be subject to discovery or admitted into evidence in a federal or state court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location identified or addressed in the reports, surveys, schedules, lists, or other data.

What the lead state agencies have found is that the protection afforded by §409 and §148(h)(4) is sufficient, in that they have not experienced any lawsuits related to the implementation of the HSM and it provides greater ability to disseminate safety data publicly. It was also noted that agencies can find themselves vulnerable to tort liability by not properly following processes or procedures or not documenting their decisions.

61 The Alabama Transportation Planner's Guide to Safety Data Access and Documentation: Policies and Practices Guidebook, Alabama Department of Transportation, June 2016, <https://www.dot.state.al.us/dsweb/divted/TrafficSOS/pdf/ALDOTSafetyData-AccessGuidebookJune2016.pdf>

8 Achieving Performance

As measuring the performance of a program provides the opportunity to learn from past decisions and influence future decisions, the scan team set out to learn how the 10 state agencies that participated in the scan defined acceptable performance in achieving HSM goals, objectives, and targets. The performance measures that one or more of the state agencies described as using to measure the success of their programs are as follows:

- Old processes that used to be based on crash rates are now based on more appropriate performance measures such as expected and excess crash frequencies.
- A framework has been established within the agency to implement HSM methods. As examples:
 - The HSM has been integrated into policies, procedures, and guidelines.
 - Clearly defined objectives and goals for performance measures are tied into systemic and strategic approaches.
 - Staff understand limitations and applications of HSM methods.
 - Staff know from whom to seek assistance with HSM-related questions.
 - Training is available continuously to improve performance and address knowledge gaps.
 - The HSM is used earlier in planning and project development so it can be effectively used and not create delays.
 - Staff are equipped with appropriate tools to perform their jobs.
- The percentage of projects that are based on an informed decision using performance-based, data-driven safety analyses as described in the HSM has increased.
- The percentage of departments (e.g., safety, planning, design, traffic operations, environment, and maintenance) within the organization that is using performance-based, data-driven safety analyses as described in the HSM has increased.

9 Recommended Actions

Based on the lessons learned from the lead agencies in HSM implementation, the recommendations presented below are intended to help state agencies that have not yet begun to implement the HSM, are beginning to implement the HSM, or desire to further enhance the implementation of the HSM within their agencies. Most of the recommended actions are also applicable to local agencies and MPOs using or planning to use the HSM. Recommendations are also provided for AASHTO and FHWA to further assist agencies in their efforts to implement the HSM. Finally, several recommendations for updates to HSM training courses and future research are provided.

Recommended Actions for State Transportation Agencies

The following actions are recommended for state transportation agencies to help implement and integrate HSM methods and performance-based, advanced safety analysis procedures (PBASAPs) within their agencies. Many of the recommendations may also apply to regional and local transportation agencies interested in using the HSM methods or other PBASAPs. The recommended actions are aligned with specific implementation-related topics shown in the following headings.

Status/Policy

- An HSM champion is needed to advocate and seek support to incorporate HSM methods and PBASAPs within each of the agency's programs and departments. The champion should communicate a vision, purpose, and need for HSM implementation within the agency.
- Executives and upper management should be provided training to understand the value of reliable and accurate data and quantitative safety analysis both within and outside of the safety program. The training may garner support and prioritization of agency policies regarding data collection and maintenance and PBASAPs.
- Agencies should consider developing an HSM implementation plan and/or an HSM implementation team to guide the direction of HSM implementation within the agency.
- Agencies should support participation of their staff on AASHTO and TRB committees and subcommittees that oversee the research and implementation of the HSM methods and PBASAPs. Through their participation on these committees and subcommittees, staff will better understand the importance of reliable and accurate data, training needs, and the limitations and applications of various methods and procedures; be better prepared to implement updates to methods and procedures; and be better prepared to implement research results.
- Agencies should adopt the TZD or other zero-based traffic safety initiatives, if they have not already done so, because they provide a platform for implementing and integrating HSM methods and PBASAPs within agencies.
- Agencies should identify incremental steps to implement certain aspects or applications of the HSM within the agency and, over time, look to more fully integrate HSM procedures within their policies and programs throughout departments. Such steps could be incorporated into an HSM implementation plan (see third bullet above).

- Agencies should develop executive orders, policies and procedures, and guidance documents to facilitate the implementation of HSM methods. Such policies and guidance should address the tort liability implications of using the term safety in planning, programming, and project development; align project purpose and needs statements with safety evaluation, analysis, and diagnosis activities; and put into place agreements with oversight agencies (e.g., stewardship agreement).

Training

Agencies should develop a robust HSM training program that:

- Provides various levels and types of HSM training for target audiences
- Demonstrates tools that can be used to implement HSM procedures and instructs users on how to properly use the tools to analyze safety and interpret the results
- Addresses the type of data used in HSM methods, such as site characteristics, traffic volume, and crash data; presents PBASAPs; and demonstrates how users can access their agency's data for analyses
- Uses a variety of training methods such as in-person sessions, webinars, and web-based tutorials that users can access on an as-needed basis
- Is updated regularly to incorporate new material and address gaps in knowledge related to application of HSM procedures for planning, programming, and project development
- Uses in-house staff to deliver training to increase trust and acceptance and to provide support following training.

Technical Function

- Agencies should provide guidance on recommended level of safety analysis expected for projects based on the purpose and need statement, type and level of funding, level of complexity, and other criteria to increase consistency among projects.
- Agencies should put processes in place to better understand project scope, definition, and design approach, and incorporate safety performance quantification at the earliest stage of planning, programming, and project development so it can be effectively utilized and project delays are minimized.
- Agencies should recognize the value of evaluation, analysis, and diagnosis of safety performance needs across the various disciplines that have a responsibility for safety performance and decision making.
- Agencies should evaluate existing tools and commercially available software that apply HSM methods and PBASAPs and select or develop tools to meet their needs, making it easier for personnel to understand, implement, and apply HSM and PBASAPs as part of their job responsibilities.
- Agencies should consider supplementing their traditional, crash-based safety management approach with a systemic approach to address crash types that are widely dispersed across the highway network and are not well suited for remedy using a traditional, crash-based, safety management approach.

-
- State agencies should work with local agencies and MPOs to provide prioritized lists of sites with potential for safety improvement based on advanced safety analyses and reliable performance measures and assist them in developing their own local road safety plans.

Data

- Agencies should develop short-term and long-term visions for acquiring and using safety data. First, they should identify ways to use already available data to achieve early implementation of HSM methods and PBASAPs. Next, they should identify incremental steps for collecting additional data and integrating it into HSM methods and PBASAPs.
- Agencies should develop a safety data business plan to guide their safety data management practices.
- Agencies should establish and enforce data governance policies that address data needs in each business area.

Cultural

- Agencies should use HSM training programs and marketing materials to educate their staff concerning the difference between nominal and substantive safety and the limitations associated with using crash rate as the primary measure of safety performance.
- Agencies should seek approaches and opportunities to achieve a cultural shift to institute performance-based processes within their respective agencies. Changes in culture can be driven by:
 - Establishing executive orders and policy directives that provide the foundation for integrating performance-based processes throughout the agency's various programs and departments
 - Implementing a process for leading change
 - Establishing an HSM implementation team and/or plan
 - Making safety analyses simpler and more accessible to internal and external staff

Information Dissemination

- Agencies should use a variety of approaches (e.g., top-down, bottom-up, and peertopeer) to communicate internally to implement HSM methods and PBASAPs.
- When communicating safety analysis results to external stakeholders, agencies should use simple language; present information using visual aids such as maps; target the discussion to the specific audience; avoid discussing crash costs; and discuss all aspects of the project, including safety, operations, design, environment, and context.
- Staff whose primary responsibility is safety should periodically meet with their agency's legal counsel to understand liability concerns associated with HSM methods and PBASAPs.

Achieving Performance

- Agencies should set clear goals and objectives for HSM implementation and establish measures for tracking the success of their HSM implementation.

Recommended Actions for AASHTO and FHWA

The following actions are recommended for consideration by AASHTO and FHWA to help state and local agencies implement HSM methods and performance-based advanced safety analyses.

AASHTO

- Regularly update the HSM website⁶² with relevant material (e.g., research reports from recently completed NCHRP and FHWA projects related to the HSM and tools that agencies developed to implement HSM procedures that other agencies may find helpful).

FHWA

- Enhance the CMF Clearinghouse⁶³ search engine by providing a pull-down menu to search items by countermeasures.
- Provide guidance to state agencies for reviewing and evaluating HSM analyses, such as common errors and assumptions made by agencies.

Updates to HSM Training Courses and Future Research

Based on discussions with the 10 state agencies considered leaders in HSM implementation, several gaps in HSM knowledge and considerations for future research to address those gaps were discussed. Most of the discussions focused on the need for additional crash prediction models for roundabouts, diverging-diamond intersections, pedestrians, and bicycles. It was noted that several ongoing NCHRP projects, including NCHRP Project 17-70, Development of Roundabout Crash Prediction Models and Methods⁶⁴, and NCHRP Project 17-84, Pedestrian and Bicycle Safety Performance Functions for the Highway Safety Manual, will address some of these gaps. The state agencies also commented that it would be desirable to include additional information on systemic safety management and human factors in the second edition of the HSM. As part of NCHRP Project 17-71, Proposed AASHTO Highway Safety Manual⁶⁵, Second Edition⁶⁶, expanded sections on systemic safety and human factors are planned for the second edition of the HSM, which may include material from NCHRP Project 17-77, Guide for Quantitative Approaches to Systemic Safety Analysis⁶⁷. As new material on roundabouts, systemic safety, human factors, pedestrians, and bicyclists becomes available and is incorporated into the HSM, HSM training courses developed by state agencies, NCHRP, FHWA, AASHTO, and others should be updated to include the new material. Also, it is recommended that future research be conducted to develop crash prediction models for diverging-diamond intersections for incorporation into the HSM.

62 Highway Safety Manual, American Association of State Highway and Transportation Officials, <http://www.highwaysafetymanual.org>

63 Crash Modification Factors Clearinghouse, Federal Highway Administration, <http://www.cmfclearinghouse.org/>

64 NCHRP Project 17-70, Development of Roundabout Crash Prediction Models and Methods, The National Academies of Sciences, Engineering, and Medicine, <http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3663>

65 NCHRP Project 17-84, Pedestrian and Bicycle Safety Performance Functions for the Highway Safety Manual, The National Academies of Sciences, Engineering, and Medicine, <http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4203>

66 NCHRP Project 17-71, Proposed AASHTO Highway Safety Manual, Second Edition, The National Academies of Sciences, Engineering, and Medicine, <http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3874>

67 NCHRP Project 17-77, Guide for Quantitative Approaches to Systemic Safety Analysis, The National Academies of Sciences, Engineering, and Medicine, <http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=4053>

Appendix A: Amplifying Questions

This appendix includes the list of amplifying questions that the scan team formulated to provide a framework for discussions with the 10 participating state transportation agencies during the scan. The amplifying questions address seven areas of interest:

- *Status/Policy*
- *Training*
- *Technical Functions*
- *Data*
- *Cultural*
- *Information Dissemination*
- *Achieving Performance*

The amplifying questions were distributed to the participants prior to their meeting with the scan team.

Amplifying Questions

Status/Policy

- **How long has your state been using the HSM?**
- **What was the catalyst to start using the HSM within your state or department?**
- **How did you establish HSM goals, objectives, and targets for your agency?**
- **Do you have an executive or departmental policy for implementing the HSM (or conducting quantitative safety analyses) within department procedures?**
 - If yes, what were the key contributing factors for establishing the policy?
 - ◆ What have been the most influential changes in actual departmental procedures resulting from your policy?
 - If not, what have been the primary factors keeping your agency from establishing the policy?
- **What is the status of HSM implementation in the following areas: planning, programming, environment, design, operations, and maintenance?**
- **Does your agency have an HSM or data-driven safety analysis champion? Where is that role located within your agency? Are there any lessons learned that the champion would like to share?**
- **Does your agency have a committee to foster HSM implementation? How often does it meet? What departments are represented?**
- **How does your agency discuss HSM needs, practices, and implementation considerations?**
- **Has your agency developed an HSM implementation or action plan? If so, how helpful has it been in advancing implementation within your agency?**
- **What aspects of the HSM/data-driven safety analysis have been incorporated into your strategic highway safety plan?**
- **Are there any lessons learned concerning HSM policy development that would be beneficial to share with the group?**
- **How is your agency funding HSM implementation, training, information dissemination, research, and data needs?**

Training

- What were your first steps with HSM training?
- What training did you highlight or focus on?
- Do you focus training on a particular group of individuals within your agency? If so, why the focus?
- What type of HSM training do you provide to consultants, local agencies, state highway safety offices, and/or metropolitan planning organizations?
- Is HSM training mandatory for certain staff and is it part of an HSM curriculum or individual classes?
- Do you provide different levels of HSM training for different user groups? For example:
 - One-day or half-day HSM overview training for project managers and/or leadership?
 - Multiday intensive HSM training for day-to-day users?
 - Training on Part B procedures or Part C procedures?
 - Other training?
- What methods of training delivery do you use? Available training programs include the following:
 - HSM Online Overview Course – Free online course through the National Highway Institute
 - NHI HSM Training Courses – Training courses on specific parts of the HSM offered through National Highway Institute
 - Webinar Series – FHWA HSM webinar series (recorded)
 - Training Webinars – Webinars available from the FHWA Resource Center
 - Locally Developed Course – Training courses developed by consultants, LTAP, or universities
- How do you market HSM training to different groups internally and externally?
- How effective has your approach to HSM training been? How can it be improved?
- Is there a particular type of HSM training that your agency desires or needs that has not been offered?
- What other resources have been the most useful in terms of educating or training your staff on HSM implementation (e.g., What supplemental HSM-related resource does your staff most frequently reference to implement HSM procedures?)?
- How often does your staff use one or more of the following resources:

Resource	Do not use	Once or twice a month	Three or more times a month
HSM Users Guide	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
HSM Implementation Guide for Managers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Integrating the HSM into the Highway Project Development Process	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Safety Performance Function Development Guide: Developing Jurisdiction Specific SPFs (i.e., SPF Development Guide)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Safety Performance Function Decision Guide: SPF Calibration versus SPF Development (i.e., SPF Decision Guide)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
User's Guide to Develop Highway Safety Manual Safety Performance Function Calibration Factors (i.e., SPF Calibration Guide)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Integration of Safety in the Project Development Process and Beyond: A Context Sensitive Approach	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
State Policies and Procedures on Use of the Highway Safety Manual	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Scale and Scope of Safety Assessment Methods in the Project Development Process	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Technical Functions

- What triggers the use of the HSM? Where in project development does that trigger occur (planning, environmental, or design)?
- How did you identify the HSM processes for use within your agency's planning, programming, environment, design, operations, and maintenance activities?
- How did you identify who and what department will carry out the technical processes you identified? Are HSM analyses primarily performed by staff within the central office or do staff in the district/regional offices also perform HSM analyses?
- How do you determine the level of HSM analysis required for different types of projects (e.g., design versus operations, large versus small projects)?
- How has the policy in your agency's traffic engineering and design manuals related to the quantification of safety changed due to the HSM?
- Is the HSM used to document design exceptions, performance-based practical design concepts, engineering analysis requirements of the Manual on Uniform Traffic Control Devices, environmental requirements, alternatives analysis, prioritization, and/or economic evaluations? What are your priorities related to these emphasis areas?
- How do documentation requirements vary based on the scope and complexity of projects?
- What process did you go through to determine whether to calibrate, develop your own safety performance functions, or do both? Did you develop statewide SPFs or regional SPFs? Did you determine this approach internally, externally, or both?
- Does your agency have a policy on the use of crash modification factors? Does this policy specify how to use the CMF Clearinghouse? If so, how is the star rating considered? Has your agency developed its own internal list of CMF values to use for consistency within the agency?
- What resources or tools (such as ISATe, the IHSDM, Safety Analyst, or agency-developed tool) does your state use to streamline the use of the HSM? Can you share the costs for developing and using these tools?
- Does your agency use the HSM to perform network screening to identify potential safety deficiencies or "black spots?" If so, what performance measures and/or methodologies are most frequently used to prioritize sites and what tools do you use with this process?
- Does your agency use a benefit-to-cost analysis for safety improvements? When are these analyses conducted (i.e., as needed or all the time)? What scale of projects are economic analyses conducted (e.g., low-cost safety improvements or EA/EIS)? Do you use a tool or spreadsheet for your analysis? Do you use the KABCO costs of crashes presented in the HSM or do you have state-specific costs? How were those state-specific costs determined?
- Have you used the HSM to perform alternative analyses during the project development phase? What tool or tools do you use to conduct these analyses?
- What level of quality assurance do you perform on HSM analyses done outside of your department (or otherwise externally)?
- What have been the benefits of implementing the HSM within your agency? Have you tried to quantify the benefits of HSM implementation?
- What program areas have integrated HSM processes outside of the safety office and how?

Data

- What are some of the data challenges you are facing with the HSM? How have you overcome these challenges?
- Are there data that you do not have and believe that you need to increase the reliability of

the HSM methods?

- How is data collection and integration funded? How have you convinced your organization regarding the need for this data?
- What has been your experience working with local agencies to share data for local routes and address safety on roadways that are not under state jurisdiction? How can you overcome these challenges?
- Through the development of data for HSM practice, have new data practices been developed? Have there been connections identified to other business areas because of these data efforts?

Cultural

- How have you gone about fostering and creating the urgency and need for change as it relates to safety quantification and the HSM?
- What was the internal and external marketing process for promoting and accepting safety quantification for your agency?
- What change in HSM support from your agency has occurred? Has this change been at the executive/senior leadership or staff levels? What are the key aspects that have led to this change? If you have not seen much change, what has prevented this change?
- How do you engage field staff; central/headquarters office; and partners, such as local agencies, the SHSOs, MPOs, consultants, or local universities to follow safety quantification policies, procedures, and processes?

Information Dissemination

- How do you present and communicate internally HSM policy, procedures, and needs to increase departmental acceptance of the HSM?
- How do you present and communicate the HSM processes, procedures, and findings to the public, executives, and stakeholders?
- How do you document your HSM findings within the planning, programming, and project development processes?
- How are you handling the concerns with liability and risk associated with the HSM? Do MPOs and SHSOs have concerns with the use of these types of safety analyses as they relate to crash data, the sharing of HSM safety analyses, or reports containing safety analyses?
- Do you consider issues related to 23 USC 409 and 23 USC 148?
- Have you had legal or professional challenges to HSM analyses?
- Are there any examples of HSM information dissemination that you can share that have been unsuccessful?
- Are there any examples of HSM information dissemination that you can share that have been successful?

Achieving Performance

- How do you define acceptable performance to achieving HSM goals, objectives, and targets?
- Can you share any lessons learned and challenges throughout HSM implementation and institutionalization?

APPENDIX B : KEY CONTACTS

Appendix B: Key Contacts

APPENDIX B : KEY CONTACTS

Alabama

Timothy E. Barnett, PE, PTOE
State Traffic & Safety Operations Engineer
Alabama Department of Transportation
1409 Coliseum Boulevard
Montgomery, AL 36110
Phone: (334) 242-6123
E-mail: barnettt@dot.state.al.us

Florida

Joseph B. Santos, PE
State Safety Engineer
Florida Department of Transportation
605 Suwannee Street, MS 53
Tallahassee, FL 32399-0450
Phone: (850) 414-4097
E-mail: joseph.santos@dot.state.fl.us

Illinois

Priscilla Tobias, PE
Director, Office of Program Development
Illinois Department of Transportation
2300 South Dirksen Parkway
Springfield, IL 62764
Phone: (217) 782-3568
E-mail: priscilla.tobias@illinois.gov

Louisiana

Dan Magri, PE
Deputy Assistant Secretary
Office of Planning 1201 Capitol Access Rd
Louisiana Department of Transportation and Development
Baton Rouge, LA 70804-9245
Phone: (225) 379-1871
E-mail: dan.magri@la.gov

April Renard, PE
Highway Safety Manager
Louisiana Department of Transportation and Development
PO Box 94245
Baton Rouge, LA 70804-9245
Phone: (225) 379-1919
E-mail: april.renard@la.gov

Maine

Dennis E. Emidy, PE
HSIP Engineer
Maine Department of Transportation
16 State House Station
Augusta, ME 04333
Phone: (207) 557-4604
E-mail: dennis.emidy@maine.gov

Edward W. Hanscom, PE
Head of Transportation Analysis Section
Bureau of Planning
Maine Department of Transportation
State House Station 16
Augusta, ME 04333-0016
Phone: (207) 624-3320
E-mail: ed.hanscom@maine.gov

Michigan

Dean Kanitz, PE
Safety Data & Analysis Engineer
Michigan Department of Transportation
425 West Ottawa Street
Lansing, MI 48909
Phone: (517) 335-2855
E-mail: kanitzd@michigan.gov

Tracie Leix, PE
Local Agency Programs Section Supervisor
425 West Ottawa Street
Lansing, MI 48906
Phone: (517) 373-8950
E-mail: leixt@michigan.gov

Missouri

John P. Miller, PE
Traffic Safety Engineer
Missouri Department of Transportation
1511 Missouri Boulevard
Jefferson City, MO 65102
Phone: (573) 526-1759
E-mail: john.p.miller@modot.mo.gov

Ray Shank, PE
Traffic Safety Engineer
Missouri Department of Transportation
1511 Missouri Boulevard
Jefferson City, MO 65102
Phone: (573) 526-4293
E-mail: raymond.shank@modot.mo.gov

Ohio

Derek A. Troyer, PE
Highway Safety Program – Safety Engineer
Ohio Department of Transportation
1980 West Broad Street
Columbus, OH 43223
Phone: (614) 387-5164
E-mail: derek.troyer@dot.ohio.gov

APPENDIX B : KEY CONTACTS

Virginia

Stephen Read, PE
HSIP Program Manager
Traffic Engineering Division
Virginia Department of Transportation
1401 East Broad Street, Suite 207
Richmond, VA 23219
Phone: (804) 786-9094
E-mail: stephen.read@vdot.virginia.gov

Washington State

John C. Milton, PhD, PE
Director of Quality Assurance and Transportation System Safety
Washington State Department of Transportation
310 Maple Park Avenue SE
Olympia, Washington 98504
Phone: (360) 704-6363
E-mail: miltonj@wsdot.wa.gov

APPENDIX C : SCAN TEAM CONTACT INFORMATION

Appendix C: Scan Team Contact Information

APPENDIX C : SCAN TEAM CONTACT INFORMATION

John C. Milton, PhD, PE, AASHTO Chair

State Safety Engineer, Director of Transportation Safety, Quality and Enterprise Risk
Washington State Department of Transportation
310 Maple Park Avenue SE
Olympia, WA 98504
Phone: (360) 704-6363
E-mail: miltonj@wsdot.wa.gov

Dave Duncan

Transportation Manager 1, Region 4
Strategic Transportation Investments Division
James K. Polk Building, Suite 1000
505 Deaderick Street
Nashville, TN 37243-0344
Phone: (615) 532-6131
E-mail: david.a.duncan@tn.gov

Dennis Emidy, PE

HSIP Engineer, Bureau of Planning
Maine Department of Transportation
16 State House Station
Augusta, ME 04333
Phone: (207) 624-3309
E-mail: dennis.emidy@maine.gov

Jerry Roche, PE

U.S. Department of Transportation, Federal Highway Administration
Office of Safety – Data & Analysis Tools Team
105 6th Street
Ames, IA 50010
Phone: (515) 233-7323
E-mail: jerry.roche@dot.gov

Samuel Sturtz

Transportation Planner
Office of Systems Planning
Iowa Department of Transportation
Phone: (515) 239-1788
E-mail: samuel.sturtz@iowadot.us

Michael Vaughn, PE

Highway Safety Improvement Program
Division of Traffic Operations
Kentucky Transportation Cabinet
Phone: (502) 782-4923
E-mail: mike.vaughn@ky.gov

Darren J. Torbic, PhD, Subject Matter Expert Principal Traffic Engineer

MRI Global
2332 Raven Hollow Road
State College, PA 16801
Phone: (814) 237-8831
E-mail: dtorbic@mriglobal.org

Appendix D: Scan Team Biographical Sketches

JOHN C. MILTON (AASHTO CHAIR) works for the Washington State DOT (WSDOT) where he is the state safety engineer, and the director of Transportation Safety, Quality and Enterprise Risk. He is leading WSDOT in implementing the Highway Safety Manual and associated tools throughout planning, design, and operations. He is a licensed engineer with over 30 years of experience in multimodal safety, design, traffic operations, and data analysis. Milton holds a bachelor's degree in civil engineering, a master's degree in engineering management from St. Martin's College, and a master's degree and a doctorate in civil engineering from the University of Washington. His research focus has been on crash frequency and severity prediction. Milton has a broad background in highway safety and has served on numerous National Academy of Engineering research panels, with an emphasis on safety, human factors, data analysis, and geometric design. He is chair of the Transportation Research Board's Highway Safety Performance Committee (ANB25), where he is leading the development of the second edition of the American Association of State Highway Transportation Officials (AASHTO) Highway Safety Manual. He has been actively involved with the HSM since its inception in 1999 and was a leader in the delivery of the first edition of the HSM as the HSM content chair. Milton is active with AASHTO and is a member of the Committee on Safety, where he chairs the Data and Performance Measurement Task Group. He is also a member of the Special Committee on Research and Innovation and the Risk Management Sub-Committee. Milton is a member of the United States National Committee to the World Road Association, where he is the working group lead for the Permanent International Association of Road Congresses Road Safety Manual.

DAVE DUNCAN is the civil engineering manager within the Strategic Transportation Investments Division of Tennessee DOT (TDOT), which helps to provide strategic support for projects that address safety, congestion, and economic development needs across the state. His major responsibilities include providing support to help TDOT assess the feasibility of any potential commitments (i.e., investments) and overseeing the development of planning and project scoping documents. Projects that are studied range from low-cost safety improvements to major investments that include new interchanges and interchange modifications, bridge replacements, reconstruction and widening projects, and new roadways. Duncan also provides technical support to help prioritize projects in the development of TDOT's three-year Multimodal Transportation Program. Most of his projects include some level of safety quantification and analysis. He has helped develop road safety audits, planning documents that provide crash and safety analysis, helped in the network screening process for TDOT's HSIP program, and has provided planning-level crash analysis for project prioritization. He is a member of the Tennessee sections of the Institute of Transportation Engineers and the American State Highway Engineers and is a member of TDOT's HSM implementation committee. Duncan has a bachelor's degree in civil and environmental engineering from Tennessee Technological University and is a licensed professional engineer in Tennessee.

DENNIS E. EMIDY is the Highway Safety Improvement Program engineer for the Maine Department of Transportation (MaineDOT). In his current position, he is responsible for utilizing the HSM throughout the HSIP process, which includes network screening, safety project evaluations, design alternatives, benefit-to-cost analysis, and priority ranking of spot safety projects. He was a member of the NCHRP 17-50 Lead States initiative for implementing the HSM. This experience allowed him to serve as a lead team member for implementing the HSM for MaineDOT, which included calibration of different facility types and working with IT in developing HSM network screening (excess expected average crash frequency with EB adjustments). Emidy has worked for MaineDOT since 1990 as a highway designer, signal and lighting designer, senior transportation/traffic analyst, and regional traffic engineer. He is a civil engineering graduate of University of Massachusetts Lowell and a licensed professional engineer in Maine.

JERRY ROCHE is a highway safety engineer with the Federal Highway Administration (FHWA) and works on the Safety Design Team housed in within the Office of Safety. He is involved at the national level, assisting state, local, and tribal agencies with safety data analysis systems, methodologies, and tools, and

currently serves as the team leader for FHWA's Every Day Counts initiative on data-driven safety analysis.

SAMUEL STURTZ is a transportation planner in the Iowa DOT's Office of Systems Planning. As part of the planning team, his responsibilities include performing statewide analysis and screening reports using the agency's extensive crash and roadway datasets. He is also involved in many of the long-range planning activities for the department, including the update to Iowa's long-range transportation plan, Iowa in Motion 2045, and the update to Iowa's strategic highway safety plan. Since 2016 Samuel has been a member of Iowa's HSM Implementation Team, which has focused on the calibration of the HSM's safety performance functions and the development of an Iowa-specific crash modification factor list. Before working at the Iowa DOT, Sturtz was a graduate student at the University of Iowa's School of Urban and Regional Planning, where he concentrated in transportation.

MICHAEL VAUGHN is a transportation engineer specialist for the Kentucky Transportation Cabinet (KYTC) within the Division of Traffic Operations at the Central Office in Frankfort. In his current role, Vaughn administers the KYTC's \$41 million Highway Safety Improvement Program (HSIP), overseeing all aspects of the HSIP and HSIP-funded projects. This includes overseeing the statewide network screening for prioritizing and selecting HSIP projects, directing HSIP project programming, managing the entire development of HSIP projects (e.g., field reviews, crash data analysis, preliminary engineering, project-level analysis of safety improvements, and final design), reviewing construction change order requests for HSIP projects, and overseeing the annual HSIP evaluation and report. Vaughn was recently selected as the KYTC's representative on the American Association of State Highway Transportation Officials (AASHTO) Standing Committee on Highway Traffic Safety – Subcommittee on Safety Management (SCOHTS-SM). He also chairs a study advisory committee for a KYTC research project titled, "Evaluation and Implementation of Highway Safety Manual Methodologies," which seeks to determine what data, technical support, tools, and training the KYTC needs to further the implementation of the HSM in the Divisions of Planning and Highway Design. In previous roles with the KYTC, Vaughn has served as the statewide value engineering coordinator, the District 7 bridge engineer, and a highway design engineer within District 7. Vaughn is a graduate of the University of Kentucky with a bachelor's degree in civil engineering. He is a licensed professional engineer in Kentucky.

DARREN J. TORBIC (SUBJECT MATTER EXPERT) is a principal traffic engineer for MRIGlobal. He has 24 years of experience in highway safety, geometric design, traffic engineering, and bicycle and pedestrian transportation research. Torbic has served as the principal investigator for numerous FHWA and NCHRP studies and provides technical support to other projects in MRIGlobal's Transportation Research Center. He had a key role in several projects directly related to the development of the first edition of the HSM and is leading several projects to expand the safety knowledge and improve the crash prediction methods for the second edition of the HSM. Prior to joining MRIGlobal in 2001, he was a research assistant at the Pennsylvania Transportation Institute at the Pennsylvania State University. Torbic holds three degrees in civil engineering from the Pennsylvania State University and a bachelor's degree in physics from Westminster College. He is a current member of TRB's Geometric Design Committee (AFB10) and a former member of the Pedestrian Committee (ANF10) and the Truck Size and Weight Committee (AT055). He is an active friend of the TRB Highway Safety Performance Committee (ANB25) and has been the instructor for a number of HSM-related workshops. In 2014, Torbic was the recipient of TRB's D. Grant Mickle Award.

