Systemic Safety Project Selection Tool

U.S. Department of Transportation
Federal Highway Administration

Safe Roads for a Safer Future
Investment in roadway safety saves lives

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16. Abstract The Systemic Safety Project Selection Tool presents a process for incorporating systemic safety planning into traditional safety management processes. The Systemic Tool provides a step-by-step process for conducting systemic safety analysis; considerations for determining a reasonable distribution between the implementation of spot safety improvements and systemic safety improvements; and a mechanism for quantifying the benefits of safety improvements implemented through a systemic approach. The tool is intended for use by transportation safety practitioners in state, county, and local government agencies to plan, implement, and evaluate systemic safety improvement programs and projects that best meet their capabilities and needs.			
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Foreword

The Systemic Safety Project Selection Tool builds upon current safety management practices for identifying roadway safety problems and implementing highway safety improvement projects. The tool expands a transportation agency's analytical techniques and models beyond current site-specific analysis to a systemic safety analysis approach by helping an agency perform a systemwide evaluation for roadway attributes that are common to locations with a crash history. This process enables the agency to proactively address highway safety concerns.

The systemic analysis outlined in this tool can be used across the board by state agencies, transportation planning organizations, and county and local government agencies to plan, implement, and evaluate systemic safety programs and projects that best meet their capabilities and needs. The tool provides a step-by-step process for conducting systemic safety analysis; considerations for determining a reasonable distribution between implementing site-specific safety improvements and systemic safety improvements; and a mechanism for quantifying the benefits of safety improvements implemented through a systemic approach.

A comprehensive safety management program, including both site analysis and systemic approaches, will reduce the occurrence of, and the potential for, fatalities and serious injuries on our nation's roadways. For additional information, please visit the Systemic Approach to Safety: Using Risk to Drive Action website.

Tony Furst
Associate Administrator
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Preface

The "Moving Ahead for Progress in the 21st Century Act" continues the Highway Safety Improvement Program as a core Federal-aid highway program based in strategic planning and resulting in data-driven decisions that reduce the occurrence of fatalities and serious injuries on our nation's roadways. This act emphasizes the eligibility of systemic safety improvements and projects to reduce the potential for traffic-related fatalities and serious injuries on all public roads. The Systemic Safety Project Selection Tool (Systemic Tool) provides supporting information for state transportation departments and local government agencies to incorporate a systemic planning component into their existing safety management programs.

The Systemic Tool provides an overview of the role of systemic planning in the safety management process and outlines the process to select systemic safety improvements and projects. The Systemic Tool provides a framework for determining a reasonable funding distribution between spot safety and systemic safety improvements, and discusses the evaluation of systemic safety programs. The Systemic Tool is a valuable reference for state and local transportation safety practitioners working to advance the planning and implementation of systemic safety improvements. Hyperlinks in this document connect the user to valuable resources to assist with their decision-making processes.

Based on the latest research and state and local practices pertaining to systemic safety planning efforts, the Systemic Tool was developed with input from a technical oversight working group and revised based on feedback from several volunteer pilot agencies. The primary role of the technical oversight working group was to provide initial input into the scope and direction of the project and review major deliverables. Four volunteer pilot agencies then applied the systemic process documented in the Systemic Tool to their systems. The objective of this pilot effort was to assess the flexibility of the Systemic Tool by applying it to a variety of roadway systems, jurisdictions, and geographies. The feedback from these agencies and lessons learned during the pilot were incorporated into the final version of the Systemic Tool presented here. The pilot results are also incorporated via examples that are integrated throughout the Systemic Tool to illustrate its application across multiple systems.

The agencies that participated in the pilot effort are the Thurston County, Washington, Department of Public Works; the Kentucky Transportation Cabinet; the Missouri Department of Transportation; and the New York State Department of Transportation. In addition, the Minnesota Department of Transportation and the Rutgers Center for Advanced Infrastructure and Transportation provided information on their application of the systemic approach to safety. The gracious contributions and expertise of the technical oversight working group and pilot agencies will support the advancement of systemic safety planning and reduce the occurrence of and potential for fatalities and serious injuries on our nation's roadways.

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Acronyms

3R	Resurfacing, Restoration, and Rehabilitation
AASHTO	American Association of State Highway and Transportation Officials
ADT	Average Daily Traffic
AADT	Average Annual Daily Traffic
CAIT	Rutgers Center for Advanced Infrastructure and Transportation
CFR	Code of Federal Regulations
CMF	Crash Modification Factor
DOT	Department of Transportation
EB	Empirical Bayes
FARS	Fatality Analysis Reporting System
FDE	Fundamental Data Elements
FHWA	Federal Highway Administration
GIS	Geographic Information System
HEAT	Highway Enforcement of Aggressive Traffic
HSIP	Highway Safety Improvement Program
HSM	Highway Safety Manual
HTCM	High-Tension Cable Median
IHSDM	Interactive Highways Safety Design Model
KYTC	Kentucky Transportation Cabinet
MAP-21	Moving Ahead for Progress in the 21st Century Act
MIRE	Model Inventory of Roadway Elements
MIRE FDE	Model Inventory of Roadway Elements Fundamental Data Elements
MnDOT	Minnesota Department of Transportation
MoDOT	Missouri Department of Transportation
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NYSDOT	New York State Department of Transportation
PIE	Post Implementation Evaluation
SHSP	Strategic Highway Safety Plan
SIMS	Safety Information Management System
SRI	Smooth Roads Initiative
Systemic Tool	Systemic Safety Project Selection Tool
U.S.C.	United States Code
usRAP	United States Road Assessment Program

Introduction

Introduction to the Systemic Safety Project Selection Tool

Crashes on rural roads often account for a high percentage of all severe crashes, but the density of crashes associated with rural roadways or particular crash types is typically low. A low density of crashes typically does not lead to identifying crash issues or locations of concern within the traditional site-specific analysis process. Instead, this low-density distribution of crashes poses a challenge to addressing safety issues and concerns because a high percentage of severe crashes are not being identified for improvement projects. A further challenge to the low-density issue is that these crashes frequently occur on roadways that are part of the local system that might not have robust data to assist with identifying the locations of concern. This low-density crash situation is often viewed as a rural issue, but similar situations can exist in urban areas, such as crashes involving motorized vehicles and vulnerable road users (e.g., pedestrians, bicyclists, and motorcyclists).

Many traditional network screening techniques for identifying sites for potential safety improvement base investment decisions on the site analysis approach. Such techniques focus primarily on specific locations with a history of severe crashes (often referred to as hot spots or black spots). However, compelling evidence indicates that severe crashes actually are widely distributed across state and local highway systems, and very few individual locations in rural areas and on local systems experience a high number or sustained occurrence of severe crashes. As a result, states will have trouble meeting their safety performance goals by only investing in high-crash locations; some systemic deployment will be needed. Thus, some agencies added a systemic approach to their safety management efforts.

The "Moving Ahead for Progress in the 21st Century Act" (MAP-21) continues the Highway Safety Improvement Program (HSIP) as a core Federal-aid highway program and emphasizes reducing fatal and serious injury crashes on all public roads. The legislation acknowledges that a State's HSIP should identify projects to improve safety not only on the basis of crash history, but also on crash potential. MAP-21 places a significant emphasis on systemic safety improvements as part of the safety management process. MAP-21 clarifies that systemic safety improvements are eligible highway safety improvement projects. In addition, MAP-21 encourages each state to consider systemic safety improvements as they update their strategic highway safety plan (SHSP).

Systemic Approach to Safety

As part of the HSIP, the requirement to address the potential for crashes to occur suggests the need to include a systemic approach to safety in the safety management process. The systemic approach to safety involves widely implemented improvements based on high-risk roadway features correlated with specific severe crash types. The approach provides a more comprehensive method for safety planning and implementation that supplements and complements traditional site analysis. The approach also helps agencies broaden their traffic safety efforts and consider risk as well as crash history when identifying where to make low-cost safety improvements.

The systemic approach to safety is a data-driven process that involves analytical techniques to identify sites for potential safety improvement and suggests projects for safety investment not typically identified through the traditional site analysis approach. The intent of this complementary approach is to supplement traditional site analysis and provide a more comprehensive and proactive approach to preventing the most severe crashes on our nation's roadways. **Figure 1** illustrates that the systemic and site analysis approaches include the same basic planning elements (problem identification, countermeasure identification, and project prioritization) as reflected in most common safety management processes, including the HSIP. Systemic analysis, however, addresses the crash types that result in a significant number of fatal and serious injury crashes spread across the network rather than focusing only on specific sites experiencing a history of severe crashes (traditional site analysis). The systemic approach to safety does not replace traditional site analysis; high crash locations must still be addressed. Rather, both the site analysis and systemic approaches are necessary to advance a comprehensive safety management program.

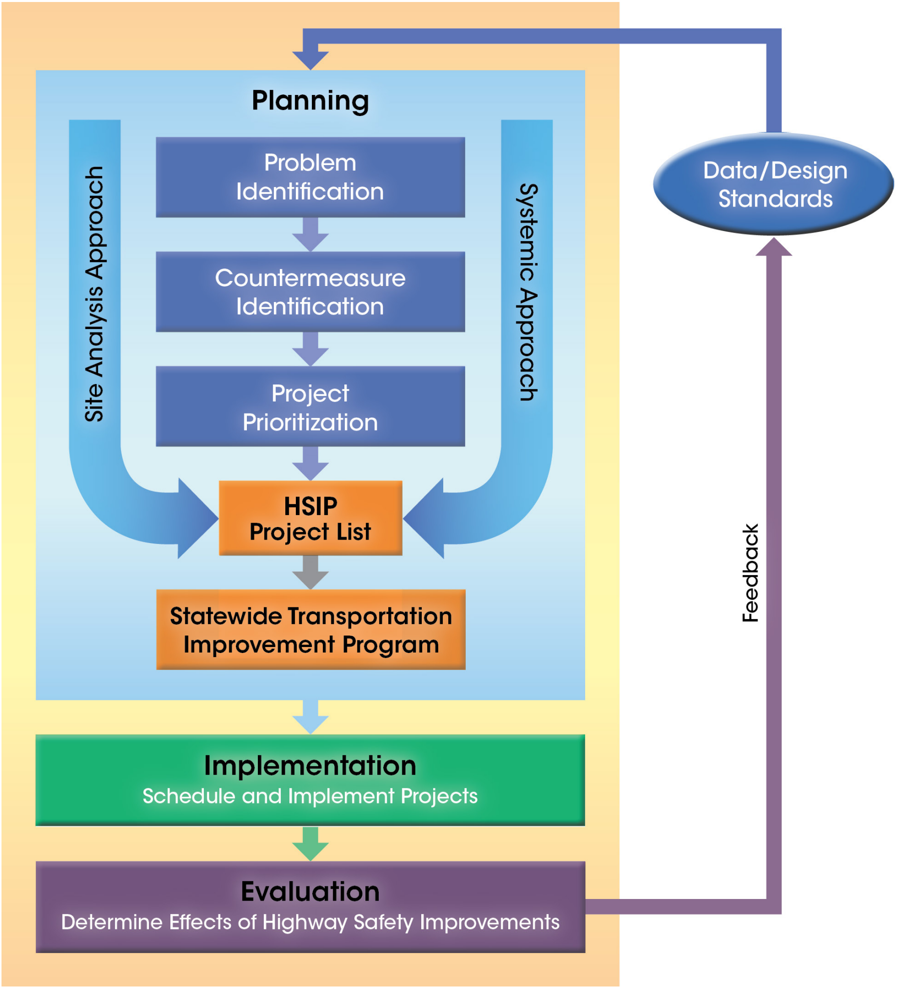
Attributes of a Systemic Safety Program

Systemic safety planning is the process of evaluating an entire system using a defined set of criteria to identify candidate locations for safety investments to reduce the occurrence of and the potential for severe crashes. The systemic approach to safety is a complementary analytical technique intended to supplement the traditional site analysis approach and results in a more comprehensive safety management program.

The systemic approach to safety:

- Identifies a "problem" based on systemwide data, such as rural lane departure crashes, urban pedestrian crashes, or rural unsignalized intersection crashes. These crashes are often spread across the network with few or no locations experiencing a "cluster" of crashes during a typical 3- to 5-year analysis period.
- Looks for characteristics (e.g., geometry, volume, or location) frequently present in severe crashes. These characteristics, also known as risk factors[1], can be used to identify and prioritize locations with few or no crashes that could be potential candidates for safety investments.
- Focuses on deploying one or more low-cost countermeasures to address the underlying circumstances contributing to crashes on a majority of roads. Addressing crash types experiencing low densities (crashes per intersection or mile) but high aggregate numbers steers the decision toward low-cost solutions widely deployed across the system in order to affect a large number of locations.

FIGURE 1. Highway Safety Improvement Program Process



- Identifies and prioritizes locations across the roadway network for implementation. The prioritization process might take on different forms such as implementing low-cost countermeasures as part of resurfacing, restoration, and rehabilitation (3R) projects or stand-alone safety projects. In either case, the systemic approach to safety represents one of several mechanisms to implement a state SHSP or other local safety plan.

[1] For purposes of the Systemic Safety Project Selection Tool, the term "risk factor" refers to a common characteristic of the locations where severe crashes occurred; therefore, the presence of a risk factor at other locations is an indicator of the potential for a future severe crash.

The key to the systemic planning process is the concept of evaluating an entire system using a defined set of criteria that will vary depending on the available data. The result is an inferred prioritization, indicating that some elements of the system are better candidates than others for safety investment. A key question this process sets out to answer is *Do all systems and crash types present equal opportunities for crash reduction, or do specific parts of the system and certain crash types offer a greater opportunity for crash reduction?*

Overview of the Systemic Safety Project Selection Tool

The Systemic Safety Project Selection Tool (Systemic Tool) builds upon current practices for identifying roadway safety problems and developing highway safety improvement projects. The Systemic Tool fills the current void of analytical techniques and models useful for conducting the systemic approach to roadway safety (current techniques and models focus on site-specific analysis).

Specifically, the Systemic Tool provides the following:

- A step-by-step process for conducting systemic safety planning
- Considerations for determining a reasonable distribution between the implementation of spot safety improvements and systemic safety improvements
- A mechanism for quantifying the benefits of safety improvements implemented through a systemic approach

The Systemic Tool outlines a process that agencies can integrate into existing safety management practices and safety analysis tools. The process guides agencies as they conduct systemic safety planning, determine funding levels for implementation of systemic safety improvement projects, and evaluate the effectiveness of systemic safety programs. The cyclical process illustrated in **Figure 2** reflects the three elements of the Systemic Tool as presented in this manual:

- **Element 1: The Systemic Safety Planning Process** (blue in Figure 2) helps safety analysts identify priority crash types and associated risk factors; evaluate proven, low-cost safety countermeasures; and prioritize alternative candidate locations for systemic safety investment.
- **Element 2: A Framework for Balancing Systemic and Traditional Safety Investments** (green in Figure 2) provides a framework for setting funding goals between systemic and site analysis programs. Finally,
- **Element 3: Evaluation of a Systemic Safety Program** (purple in Figure 2) provides high-level direction for evaluating the effectiveness of systemic safety programs.

FIGURE 2. Framework for the Systemic Safety Project Selection Tool

The Systemic Tool is designed to be flexible and easy to use, resulting in easy-to-understand output. The data requirements for the Systemic Tool are flexible and assist with identifying potential risk factors. The following describes each of these characteristics of the Systemic Tool:

- **Flexible**—The tool is applicable to a variety of systems, in a variety of locations, and with a variety of crash types.
- **Easy to use**—The processes are meant to be relatively straight-forward, requiring minimal training and technical assistance.
- **Easy-to-understand output**—The output is understandable by both program managers and project development engineers who might have no training in traffic safety analysis techniques.
- **Flexible data requirements**—The data requirements can be matched to what individual agencies can deliver.
- **Risk factors**—Where possible, the tool helps identify characteristics in addition to crash experience to support the identification of potential risk factors.

Organization of the Systemic Safety Project Selection Tool

This Systemic Tool is organized into five sections and an appendix. This section (Introduction) provides an overview of systemic safety planning and the Systemic Tool. The next three sections are devoted to the three elements of the Systemic Tool, and each of these sections contains examples that illustrate the systemic planning concepts explained in the text. Element 1 describes the four-step systemic safety planning process and concludes with a case study from the Minnesota Department of Transportation (MnDOT). Element 2 provides a framework for determining a reasonable distribution between the implementation of spot safety improvements and systemic safety improvements. Element 3 contains an overview and considerations for evaluating a systemic safety program based on approaches demonstrated to be useful. The final section (References) lists the works cited throughout the document and includes hyperlinks to access reports and websites. The appendix presents several national resources available to practitioners, along with guidance about how the resources can be used to support a systemic safety program.

While using the Systemic Tool, agencies should understand that the process presented needs to be tailored to fit the available data. This might mean that some agencies will have one or two risk factors to consider when prioritizing locations, and others agencies might be able to evaluate numerous characteristics as risk factors. Additionally, the examples and case study simply represent how some agencies have approached a systemic safety analysis process. In the application of the Systemic Tool, it is entirely appropriate for agencies to make changes to adapt to their own data systems.

Element 1: The Systemic Safety Planning Process

Overview of the Systemic Safety Planning Process

The systemic safety planning process (Element 1 of the Systemic Safety Project Selection Tool) consists of the four steps shown in **Figure 3**. Each step can be scaled based on the availability of technical resources and the quality or quantity of data available to support different analytical approaches. The systemic safety planning process is similar to most common safety management processes. The systemic safety planning process involves identifying the problem, screening and prioritizing candidate locations, selecting countermeasures, and prioritizing projects.

The premise that makes systemic safety planning different from traditional network screening techniques is that it looks for similar issues across the roadway system rather than focusing on select locations with high crash histories or densities. The systemic safety planning process begins by looking at systemwide data to analyze and identify focus crash types (those representing the greatest number of severe crashes) and potential risk factors. As the downward arrows indicate, the approach then moves to a micro-level risk assessment of locations across the network, which then leads to selecting relevant mitigating countermeasures most appropriate for broad implementation across those locations, and prioritizing projects for implementation. The upward arrows indicate that the results of one step might suggest the need to return to a previous step and make adjustments before continuing the process.

FIGURE 3. Systemic Safety Planning Process

The following chapters (Identify Focus Crash Types and Risk Factors, Screen and Prioritize Candidate Locations, Select Countermeasures, and Prioritize Projects) further describe the four steps of the systemic safety planning process. Each chapter includes a discussion of the objective, data needs, tasks, and outcomes, along with examples illustrating the fundamental process for each step.

Data Needs

The systemic safety planning process builds on the Federal Highway Administration (FHWA) guidance to develop SHSPs and structure an HSIP using data-driven processes. The four-step process uses basic types of crash, roadway, and traffic volume data that are recommended by the FHWA for use in safety analysis efforts. Several agencies actively applying the systemic approach to safety and conducting research relative to systemic safety improvement also use these types of data. The following chapters describe in detail the specific types of data associated with each step in the systemic safety planning process. These data are recommended for each step because they represent elements that can impact safety performance of a facility. Although agencies might not currently maintain all these data elements, more detailed data provide the opportunity to more specifically identify facility types and risk factors.

The systemic approach emphasizes a data-driven decision-making process. However, the Tool is intended to be flexible to support varying degrees of data availability.

Identify Focus Crash Types and Risk Factors

The basic objective of the systemic safety planning process is to identify candidates for safety investment. Candidate identification results from comparing the actual conditions of segments, curves, and intersections with a set of observed characteristics associated with the locations where the focus crash types actually occurred. The data-driven process identifies the observed characteristics (risk factors) associated with the focus crash type. The systemic safety planning process uses selected risk factors to differentiate one segment from another, one curve from another, and one intersection from another in order to prioritize these facilities and give higher priority to locations where there is greater potential for future severe focus crashes. The data suggested to support the systemic approach are not intended to be prescriptive; some agencies currently use these types of data to successfully advance a systemic approach to safety. The systemic safety planning process can be adapted to meet agency-specific needs or crash reduction goals, consistent with the data available. The systemic planning process produces results with minimal levels of data; greater levels of data, however, support a more refined prioritization.

Identify Focus Crash Types and Risk Factors

Objective

The objective of the first step in the systemic safety planning process is to identify risk factors commonly associated with each focus crash type experienced across a system. This step involves reviewing systemwide (i.e., macro-level) crash data and identifying potential risk factors for further analysis. Identification of potential risk factors does not necessarily imply the observed characteristics "caused" the crashes; rather, the characteristics are useful to identify the situations in which the crashes occurred, so that similar "looking" locations can be identified and prioritized.

Data Needs

The identification of focus crash types and risk factors results from using a range of data elements. Following are the minimum recommended crash data elements:

- System type
- Crash type
- Facility type
- Crash location type
- Location characteristics

The FHWA's Model Inventory of Roadway Elements Fundamental Data Elements (MIRE FDE) identified for the HSIP is a good starting point for determining which roadway data to collect for a systemic analysis because it includes many of the roadway and traffic volume data elements recommended for use in this first step (FHWA, 2012). However, other road characteristics, such as shoulder width and type or roadway curvature, should be investigated when possible. The road and intersection data inventory is typically available in a geographic information system (GIS) or database, which should be linked with the crash records system. Ideally, the various data sets would incorporate the same time period. When volume data are from an earlier time period than crash data, first consider if changes have occurred that make the volumes no longer relevant (i.e., economic growth). If little change has occurred,

Data for Identifying Target Crash Types and Location Characteristics

Recommended Minimum Data

- System type (e.g., state, local)
- Crash type (e.g., road departure, right angle, head-on, rear end, turning)
- Facility type (e.g., freeway, expressway, arterial, or collector)
- Crash location type (e.g., urban vs. rural, intersection vs. segment, tangent vs. curve)
- Location characteristics (e.g., topography, intersection elements, segment elements)

Additional Data for Identifying Risk Factors

- Traffic volumes for segments and intersections
- Roadway features (e.g., number of lanes, shoulder type and width, road edge features and quality, number and type of access, radius and superelevation of horizontal curves, density of horizontal curves, speed limit, speed differential between curves and tangents, medians, pavement condition and friction)
- Intersection features (e.g., number of approaches, skew, proximity to horizontal and vertical curves, number of approach lanes, signal timing, proximity to railroad crossing, traffic control devices, presence of street lighting, presence of commercial development)

agencies can consider using older traffic volumes. To compensate for greater change, agencies can estimate current traffic volumes by applying a growth factor appropriate for the region or jurisdiction.

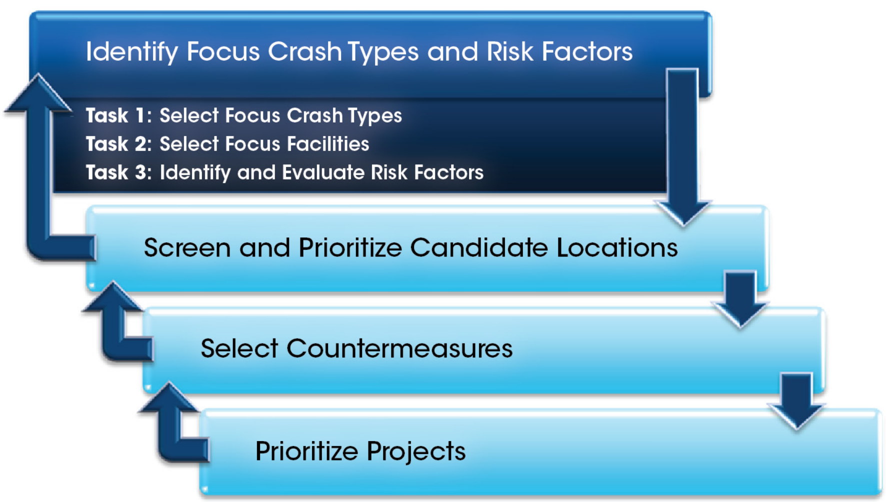
The systemic safety planning process focuses on severe crashes (defined as fatal plus serious injury crashes) to be consistent with national safety programs. Furthermore, focusing on severe crashes reduces the scale of the effort and resources required to gather supplemental data if needed.

The data-gathering effort is an iterative process; as such, all data do not need to be collected at the beginning of the process. For example, the focus facility types selected will determine the necessary roadway and volume data to be collected to identify potential risk factors.

Process

The first step of the systemic safety planning process—identifying and understanding the risk factors commonly associated with the focus crash types—includes a series of analyses involving three tasks (**Figure 4**). The first task refines the problem identification from all crashes to a few focus crash types for an entire system or subregion. Further investigation through additional analyses attains a more comprehensive understanding of the facility type and risk factors (i.e., roadway characteristics) commonly linked with the severe focus crash types.

FIGURE 4. Systemic Safety Planning Process: Tasks to Identify Focus Crash Types and Risk Factors



Task 1: Select Focus Crash Types

Task 1 in the step to identify focus crash types and risk factors involves conducting a systemwide analysis of crash types to select those representing the greatest potential to reduce fatalities and severe injuries. This effort typically results in identifying the crash types that represent the greatest number of severe crashes across the system being analyzed.

A good starting point for identifying focus crash types is a state or regional SHSP, which documents emphasis areas (i.e., focus crash types) for the state or region's safety program. These emphasis areas were likely identified through a data-driven process, which is a primary principle of the systemic safety planning process. State agencies with completed Roadway Departure and Intersection Safety Implementation Plans can identify these as focus crash types for their systemic safety programs. As such, the analysis summaries contained in the plans are useful for the subsequent tasks that identify focus facilities and risk factors. Agencies can also refer to safety plans in which emphasis areas specific to their jurisdiction have been identified through a similar data-driven approach.

If the state or regional SHSP does not cover the roadway type or region of interest, then referencing the emphasis areas identified in the American Association of State Highway and Transportation Officials (AASHTO) SHSP is useful to determine what types of crashes require further investigation. Depending upon their needs, an agency can add additional emphasis areas to the list of 22 emphasis areas in the AASHTO SHSP (AASHTO, 2005). Some common additions include winter weather crashes, animal crashes, and driveway/access crashes. If a state SHSP added emphasis areas to AASHTO's list, then, at a minimum, those same emphasis areas should be included in this task. In addition to a systemwide assignment of crashes into the emphasis areas,

The Kentucky Transportation Cabinet developed a Roadway Departure Safety Implementation Plan in 2010 to detail the key steps and actions necessary to implement the broad initiatives outlined in the roadway departure emphasis area of the state's SHSP. The agency chose their focus facility and crash type for the pilot effort based on this plan. The data analysis had already been performed as part of the planning efforts for the SHSP and Roadway Departure Safety Implementation Plan, so the agency was able to begin the systemic analysis process at Task 3 of Step 1.

AASHTO's 22 Emphasis Areas

Part 1: Drivers

- Instituting graduated licensing for young drivers
- Ensuring drivers are fully licensed and competent
- Sustaining proficiency in older drivers
- Curbing aggressive driving
- Reducing impaired driving
- Keeping drivers alert
- Increasing driver safety awareness

Part 2: Special Users

- Making walking and street crossing safer
- Ensuring safer bicycle travel

Part 3: Vehicles

- Improving motorcycle safety and increasing motorcycle awareness
- Making truck travel safer
- Increasing safety enhancements in vehicles

Part 4: Highways

- Reducing vehicle-train crashes
- Keeping vehicles on the roadway
- Minimizing the consequences of leaving the road
- Improving the design and operation of highway intersections
- Reducing head-on and across-median crashes
- Designing safer work zones

Part 5: Emergency Medical Services

- Enhancing emergency medical capabilities to increase survivability

Part 6: Management

- Improving information and decision support systems
- Creating more effective processes and safety management systems

subregional and jurisdictional analyses are an important consideration. The system-wide analysis can mask important localized issues—for example, differences between rural and urban locations or between state and local highway systems. Following are some typical sublevel summaries for severe crashes by emphasis area:

- State-maintained highways compared with local agency roads
- Jurisdictional subdivisions (e.g., county, city)
- Rural areas or districts compared to urban/suburban areas or districts
- Areas with unique geography, such as mountainous areas
- Areas with strong seasonal travel patterns, such as tourist destinations

Since the systemwide analysis identifies crash types for an aggregate crash data set, the results are not as sensitive to specific locations as are the results of a subregion analysis in which the crash data set is more focused on a specific geographical area. Comparing the results of the systemwide analysis to subregion analyses highlights those crash types and contributing factors that may be substantial only in a localized area. For example, intersection crashes could be the top crash type in all districts within the state, while pedestrian and bicycle crashes represent a sizable portion of severe crashes only in the urbanized district. In this case, the safety program manager will not identify pedestrian and bicycle crashes as a top emphasis for the state; however, the crash data justifies encouraging the urban district manager to develop a pedestrian and bicycle safety program.

Thurston County disaggregated data according to attributes recorded on crash reports (e.g., crash type, road geometry, lighting, and contributing circumstances), to identify their focus crash type.

Example 1 illustrates the data-driven selection of focus crash types by the New York State Department of Transportation (NYSDOT). Using crash data from the state's Safety Information Management System (SIMS) database, NYSDOT identified focus crash types by disaggregating the crash data by emphasis area and facility type. This example highlights how roadway systems in different jurisdictions or subregions require different priorities.

EXAMPLE 1. New York State Department of Transportation Data Analysis to Select Focus Crash Type

NYSDOT identified focus crash types by disaggregating the crash data by emphasis area and facility type. The emphasis areas are from the 2010 *New York State Strategic Highway Safety Plan*. As the bold text highlights, intersection crashes are the most frequent severe crash type statewide (41 percent), followed by roadway departure crashes (26 percent). Since roadway departure crashes are the most predominant crash type on the state-owned system (30 percent), NYSDOT chose to focus their systemic planning efforts on this severe crash type. The data disaggregation also shows that the most predominant crash type on the county roadway system is road departure and is intersection-related for the city street systems.

Fatal and Severe Injury Crashes from Safety Information Management System (2007-2011)
Percent by Jurisdiction

Emphasis Area	Statewide Total 114,592 mi	Statewide Percentage	State (01) 15,486 miles		County (02) 19,938 miles		City, Township, Village (03, 04, 12, 13) 76,735 miles		Parkway (05) 511 miles		Interstate (06, 07, 11) 575 miles		Other 1,347 miles	
Total Fatal/Serious Injury	63,443		31%	19,819	10%	6,572	45%	28,597	1%	407	2%	1,540	10%	6.508
Young drivers (under 21)	9,686	15%	17%	3,394	22%	1,441	13%	3,747	12%	48	13%	201	13%	855
Older drivers (over 64)	8,805	14%	17%	3,405	15%	978	11%	3,270	8%	34	10%	149	15%	969
Aggressive driving and speeding-related	15,378	24%	30%	5,905	33%	2,152	17%	4,979	45%	182	56%	866	20%	1,294
Drug and alcohol-related	6,175	10%	11%	2,227	16%	1,039	9%	2,581	9%	35	10%	147	9%	599
Inattentive, distracted, asleep drivers	13,258	21%	23%	4,631	20%	1,291	20%	5,598	15%	63	20%	302	21%	1,373
Pedestrian crashes	11,786	19%	9%	1,860	6%	421	28%	8,122	5%	19	4%	54	20%	1,310
Bicycle crashes	3,390	5%	3%	518	3%	187	8%	2,414	0%	2	0%	1	4%	268
Motorcycle crashes	852	1%	2%	360	2%	141	1%	283	1%	4	1%	20	1%	44
Heavy vehicle crashes	3,123	5%	6%	1,266	4%	234	4%	1,051	1%	6	19%	288	4%	278
Train-vehicle crashes	17	0%	0%	0	0%	6	0%	7	0%	0	0%	0	0%	4
Road departure crashes	16,668	26%	**30%**	**5,985**	**44%**	**2,892**	18%	5,128	44%	179	47%	722	27%	1,762
Intersection crashes	25,791	**41%**	25%	5,033	30%	1,957	**64%**	**18,270**	16%	65	4%	64	6%	402
Head-on and sideswipe crashes	3,071	5%	7%	1,439	7%	490	3%	887	2%	7	2%	37	3%	211
Workzone crashes	214	0%	1%	104	0%	16	0%	32	0%	1	**2%**	37	0%	24

Source: New York State Department of Transportation Office of Traffic Safety and Mobility

Depending on the focus crash type, further data disaggregation may be necessary to more specifically define a systemic safety problem. For example, Thurston County began their systemic planning effort with a focus on lane departure crashes that had been formulated from previous safety-related studies. **Example 2** illustrates the disaggregation of the County's lane departure crash data into various data elements available from the crash reports.

Helpful Hints and Other Considerations

How many crash types should I select?

How you disaggregate crash data depends on the data type, system capabilities, and agency past practices. Disaggregating crash data is about identifying statewide and regional trends regarding a focus for subsequent analytical efforts. Screening those trends to a manageable list of target crash types is very important because if the list is too long, then the associated level of effort could be a burden. If the systemic safety program is new, you might consider limiting your analysis to one or two crash types, which limits the scope while the methodology is developed and refined.

Should crashes be assigned to a single category or is double counting acceptable?

When completing the analysis, a single crash could involve more than one emphasis area. For example, a fatal intersection crash involving a drinking teen-driver covers three AASHTO emphasis areas. One approach is to identify the leading contributing factor, thereby assigning each crash to only one emphasis area. Another approach is to include the crash in each related emphasis area to determine the total number of crashes in each category. Regardless of the decision made, the process needs to be documented so that consistency is maintained across regional analyses and jurisdictions, and when the analysis is updated.

What criteria do I use to identify crashes in each emphasis area?

Crash record systems vary greatly by jurisdiction, so there are no guidelines or criteria that can be used to identify crashes in each emphasis area. Instead, the process to analyze crash data when developing the state SHSP might provide an answer or general guidance for local agency crash record systems. Also, FHWA and National Highway Traffic Safety Administration (NHTSA) provide guidance on how Fatality Analysis Reporting System (FARS) data can be used to identify various crash types, such as road departure or speeding-related crashes (NHTSA). These resources might provide insights on how local crash record systems can be used to identify crashes within each emphasis area.

As a local jurisdiction, can I select focus crash types different from statewide focus areas?

A Department of Transportation (DOT) district, county, or city should consider crash types that represent the greatest potential for crash reduction in their jurisdiction. For example, an urban DOT district might select pedestrian crashes for a district program because they represent a sizeable problem locally, even though pedestrian safety may not be a priority focus area statewide. Focus crash types for local jurisdictions should ideally be selected in consultation with the state DOT, particularly if the state agency establishes priorities for allocating funding.

Should the focus be on infrastructure-related crash types only or also include other factors, such as driver behavior?

Highway agencies should not be reluctant to select crash types that are related to driver behavior, such as unbelted vehicle occupants, speeding, or alcohol-related. Selecting these crash types as the focus of systemic safety planning efforts creates opportunities for coordinating with enforcement and driver education programs.

EXAMPLE 2. Thurston County Public Works Data Analysis to Select Focus Facilities

2006 - 2010 Collision History		Fatal and Serious Crashes: Thurston County Percentage	Fatal and Serious Crashes: All Counties Percentage	Fatal and Serious Crashes: Statewide Percentage
Overall Numbers	Total number of collisions	3	4	2
By Collision Type	Hit fixed object	48	41	27
	Overturn	10	14	11
	Angle (left turn)	9	13	16
	Head on	7	5	5
By Light Condition	Daylight	52	54	58
	Dark – no street lights	33	29	16
By Junction Relationship	Intersection-related	19	22	33
	Driveway-related	5	6	7
	Non-Intersection	77	72	60
Hit Fixed Object Crashes Only – By Fixed Object Hit	Tree/stump (stationary)	14	10	5
	Roadway ditch	7	6	3
	Utility pole	7	5	3
By Roadway Curvature	Straight and level	42	42	54
	Horizontal curve (all)	45	39	26
By Speed Limit (Number of Drivers)	35 mph	28	48	35
	50 mph	69	33	16
By Contributing Circumstance (Number of Drivers)	Exceeding safe/stated speed	48	41	31
	Under influence of alcohol/drugs	42	31	25
	Over centerline	16	12	10
	Inattention/distraction	11	13	13
By Driver Age Group	Ages 16-20	26	26	20
	Ages 41-50	28	23	26
By Seat Belt/Car Seat Use (Number of Occupants)	No restraint	33	35	25

Between 2006 and 2010, 177 fatal and serious injury crashes occurred in Thurston County, Washington. A spreadsheet program was used to disaggregate the lane departure crash data into various data elements available from crash reports. This dataset shows that the horizontal curve crashes are overrepresented in the County. Also, the proportion of roadway departure crashes in horizontal curves is greater in Thurston County than for either the combined County roadway system in Washington or the statewide roadway system. As a result, Thurston County selected lane departure crashes on horizontal curves as their focus crash type.

Source: Thurston County, Washington, Department of Public Works

Task 2: Select Focus Facilities

After selecting the focus crash types, Task 2 answers the question *Where are the crashes occurring?* A "crash tree" diagram is the recommended approach to answer this question. The crash tree can have a number of different formats, depending on agency capabilities and data availability. One such example is to begin the crash tree with the total number of severe crashes at the highest level. Each subsequent level separates the severe crashes by facility type.

Select
Focus Facilities

At a minimum, the crash tree analysis should include separation by urban and rural, ownership (state and local), segment and intersection, segment type, and intersection control type. This minimum level of detail allows for the refinement of facility types, which is useful to focus the identification of risk factors (i.e., characteristics associated with the locations where the focus crash types are occurring) and select relevant countermeasures.

Depending on the data set and the scope of the analysis, examples of potential combinations include the following:

- Segment versus intersection
- Segment type, including freeway, multilane, two-lane, and one-way (typical segment divisions)
- Intersection control type, including signalized, unsignalized, and uncontrolled (typical intersection divisions)
- On tangent versus on curve
- High-speed versus low-speed
- Presence of street lighting
- District or region

Examining the crash tree leads to the identification and selection of the facility types where the focus crash types most frequently occur. States with a Roadway Departure or Intersection Safety Implementation Plan may already have crash trees and could use these plans to identify focus facility types for either their roadway departure or intersection crashes. **Example 3** shows a crash tree diagram for the New York state roadway system.

Systemic approach:
Deploy countermeasures at locations with greatest risk.
Systematic approach:
Deploy countermeasures at all locations.

Helpful Hints and Other Considerations

How many levels will my crash tree include?

That will depend on the data and your starting point. For example, you might choose to begin the crash tree with only data for your jurisdiction or subregion instead of statewide, thereby eliminating one or more levels from the diagram.

Typically, most information used at this step will be reported by the officer on the crash report. Therefore, use whatever data are considered reliable and relevant for the focus crash type, but be careful not to create too many levels or the number of crashes will become small and the patterns difficult to identify.

Does the crash tree include all severe crashes or just severe crashes for one focus crash type?

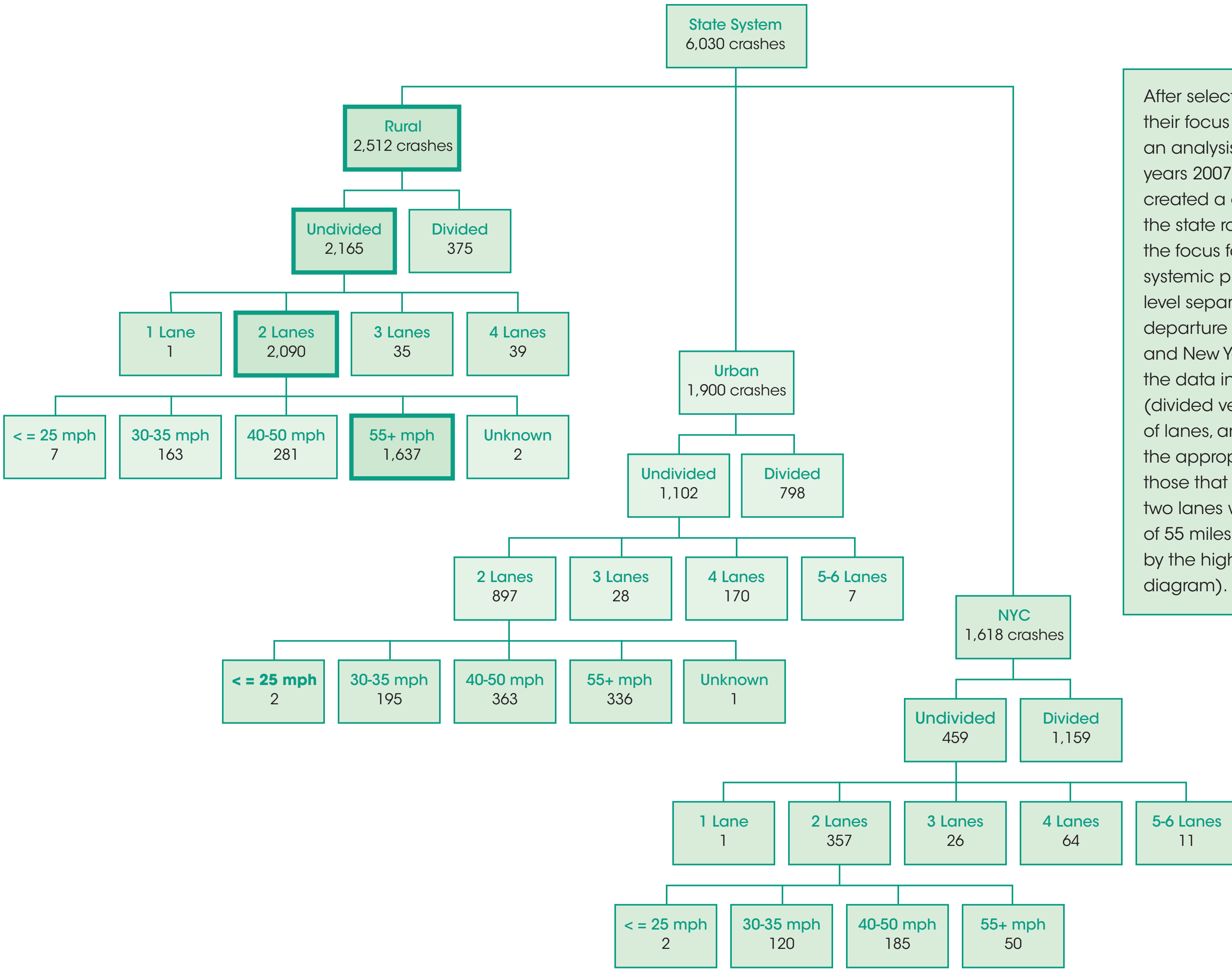
Either option is considered acceptable. If there are relatively few severe crashes, then it might be best to begin the crash tree with all crash types. However, if there are instead many severe crashes for a particular crash type, the crash tree might focus on just the one.

How many facility types should I select?

Selecting fewer facility types is generally advised because it will streamline the process of identifying candidates for investment, reduce effort to conduct follow-up evaluations, and simplify the identification process if changes in crash numbers are a direct result of the projects implemented. However, the selection does not have to be a single type of facility for each focus crash type: an intersection systemic safety program might choose both urban signalized and rural thru-stop intersections. There is no set rule on exactly how many or what proportion of the severe crashes must occur at the facility type to be selected. An important consideration is selecting facilities that have crash histories that permit the identification of patterns and risk factors.

If data or resources are not available to complete the remaining tasks and steps of the four-step systemic safety planning process, then an agency can still move forward with selecting and implementing countermeasures to address the focus crash types on the focus facility type. After identifying the focus crash type and facility type, a systematic deployment (deploy everywhere), instead of systemic (deploy at locations with greatest risk), of cost-effective countermeasures is a possibility. While a systematic deployment requires no further analysis to prioritize locations, the approach requires more funding since all locations are improved.

EXAMPLE 3. New York State Department of Transportation Crash Tree Diagram to Select Focus Facility



After selecting lane departure as their focus crash type based on an analysis of crash data for the years 2007 through 2011, NYSDOT created a crash tree diagram for the state roadway system to identify the focus facility type for their systemic planning effort. The first level separates the severe roadway departure crashes into rural, urban, and New York City areas. Separating the data into three more levels (divided versus undivided, number of lanes, and speed limit) identifies the appropriate focus facility as those that are rural, undivided, and two lanes with a posted speed limit of 55 miles per hour (represented by the highlighted boxes in the diagram).

Source: New York State Department of Transportation Office of Traffic Safety and Mobility

Identify and Evaluate Risk Factors

Task 3: Identify and Evaluate Risk Factors

Task 3 further defines the facility types selected in the previous task by documenting the most common characteristics of the locations where crashes occurred. For example, if the previous tasks suggested a focus on road departure crashes on rural two-lane segments, then this task might indicate that these crashes were over-represented on roads with poor edges, curvilinear alignment, and volume within a specific Average Annual Daily Traffic (AADT) range. Tasks 1 and 2 relied on data typically available in the crash records system. Task 3 is the first point where road and intersection inventories are likely needed to provide additional levels of detail to support the data analysis.

The first decision to be made for this task is determining which characteristics will be evaluated—in other words, the potential risk factors for the systemic network screening. The initial characteristics are further evaluated before selecting the final characteristics that represent the risk factors. Selecting characteristics for evaluation might be based on several considerations, but it is important that they can indicate greater potential for severe focus crashes to occur. For example, the shoulder surface type might be a risk factor for roadway departure crashes in a curve but not for right angle crashes at intersections. If not certain whether a characteristic might be a suitable risk factor, then first reference safety research before evaluating that risk factor for a specific jurisdiction. **Example 4** summarizes the research process the Kentucky Transportation Cabinet (KYTC) conducted to identify potential risk factors.

Additionally, the availability of the data element in existing databases, the ability to quickly gather data if not already available, and the applicability to the focus crash type and facility type (e.g., intersection characteristics do not need to be investigated for a systemic lane departure program) influence the selection of characteristics to review as potential risk factors. For data elements in an existing database, concerns about quality or the amount of time since the last update also may influence the decision of whether to evaluate that data element as a potential risk factor. Data that do not reflect current conditions could lead to implementing a countermeasure that is no longer appropriate or the best choice for addressing the focus crash type.

The list of potential risk factors suggests characteristics to be examined for curves, segments, and intersections. These characteristics are based on a review of published research and professional experience, many of which are inputs used by the predictive methods in the AASHTO *Highway Safety Manual* (HSM), and the degree to which many of these attributes might affect crash frequency is available within the HSM (AASHTO, 2010). The FHWA's Crash Modification Factor (CMF) Clearinghouse is another

Potential Risk Factors

Roadway and Intersection Features

- Number of lanes
- Lane width
- Shoulder surface width and type
- Median width and type
- Horizontal curvature, superelevation, delineation, or advance warning devices
- Horizontal curve density
- Horizontal curve and tangent speed differential
- Presence of a visual trap at a curve or combinations of vertical grade and horizontal curvature
- Roadway gradient
- Pavement condition and friction
- Roadside or edge hazard rating (potentially including sideslope design)
- Driveway presence, design, and density
- Presence of shoulder or centerline rumble strips
- Presence of lighting
- Presence of on-street parking
- Intersection skew angle
- Intersection traffic control device
- Number of signal heads vs. number of lanes
- Presence of backplates
- Presence of advanced warning signs
- Intersection located in or near horizontal curve
- Presence of left-turn or right-turn lanes
- Left-turn phasing
- Allowance of right-turn-on-red
- Overhead versus pedestal-mounted signal heads
- Pedestrian crosswalk presence, crossing distance, signal head type

Traffic Volume

- Average daily traffic volumes
- Average daily entering vehicles
- Proportion of commercial vehicles in traffic stream

Other Features

- Posted speed limit or operating speed
- Presence of nearby railroad crossing
- Presence of automated enforcement
- Adjacent land use type (e.g., schools, commercial, or alcohol-sales establishments)
- Location and presence of bus stops

EXAMPLE 4. Summation of Kentucky Transportation Cabinet Research Process to Identify Potential Risk Factors

Risk Factors with Potential Applicability for Run-Off-Road and/or On-Curve Crash Type

Risk Factors (Highway Safety Manual)	Compatible Highway Performance Monitoring System Attributes	Data Available	HSM – SPF Base Condition for Rural 2-Lane Road
From HSM Chapter 6 (run-off-road)			
Inadequate Lane Width*	Item 34 – lane width	Yes	12 feet
Slippery Pavement	16 attributes that are "pavement-related" Item 61 – climate zone	No	NA
Inadequate median width	Items 35, 36 – median type, median width	Yes	NA
Inadequate Maintenance	Item 54 – year roadway was last improved	No	NA
Inadequate Roadway Shoulders*	Items 37, 38, 39 – shoulder type and width	Yes	6 feet, paved
Poor Delineation (pavement markings, RPMs, chevron signs, object markers, PMDs)	None	No	Centerline Rumble Strips – None
Poor Visibility	None	No	Lighting – None
Excessive Speed*	None	No	Automated Speed Enforcement – None
From HSM Chapter 6 (vehicle rollover)			
Roadside Design (e.g. non-traversable side slopes, pavement edge dropoff)	None	Yes	Roadside Hazard Rating (RHR) = 3
Pavement Design	16 attributes that are "pavement-related"	No	NA
From HSM Chapter 6 (fixed object)			
Obstruction In or Near Roadway	None	Yes	Roadside Hazard Rating (RHR) = 3
Inadequate Lighting	None	No	Lighting – None
Inadequate Roadway Geometry*	Item 43 – curves Item 45 – grades Item 46 – percent passing sight distance	Yes (Curves)	Horizontal curvature – None Vertical curvature – None Passing Lanes – None
From HSM Chapter 13			
Roadway Signs (a CMF)	None	Yes	

The four risk factors selected by KYTC for the systemic risk assessment are: Horizontal curve density, lane width, shoulder type, and speed limit. These are denoted by an asterisk (*) in the table.

The Kentucky Transportation Cabinet (KYTC) consulted a variety of references to assist with identifying potential risk factors. A list of potential risk factors for the focus crash type (lane departure crashes on 2-lane rural roads) was generated based on risk factors presented in Chapters 6 and 13 of the *Highway Safety Manual*. The table shows the potential risk factors, of which four were selected for the systemic risk assessment.

The Highway Pavement Management System (HPMS) was then reviewed to determine if their database contained an attribute related to each risk factor. The table summarizes those potential risk factors for which data were either available or collected for this systemic planning effort.

Availability of data or the ability to collect data should be part of the decision process for selecting a risk factor so candidate locations can be identified based on their characteristics. KYTC also included the base conditions for the focus facility type from the *Highway Safety Manual* as another source of information to assist with evaluating and selecting risk factors.

Source: Kentucky Transportation Cabinet

Identify and Evaluate Risk Factors

TABLE 1. Potential Risk Factors for Example Focus Crash Types

Example Focus Crash Type	Potential Risk Factors
Rural Crashes	
Road Departure	• Road edge condition • Access density • Curve density • Traffic volume
Road Departure in Horizontal Curve	• Curve radius • Speed differential (from tangent approach) • Visual trap • Intersection in the curve • Traffic volume
Intersection	• Skewed approach • Proximity to horizontal and/or vertical curve • Presence of commercial development • Proximity to at-grade railroad crossing • Traffic volume • Distance from previous controlled intersection
Urban Crashes	
Pedestrian	• Intersection control type • Major road characteristics (e.g., number of lanes, divided or undivided) • Traffic volume • Traffic speed • Presence or proximity of pedestrian generator • Presence or proximity of transit stop • Presence of sidewalk
Intersection	• Left or right turn lanes • Left-turn signal phasing • Right-turn-on-red • Red-light enforcement • Intersection control • Number of lanes on major approach • Divided or undivided • Lighting • Traffic volume • Speed

source for information on the relationship between location characteristics and their potential to contribute to a severe focus crash type (refer to the Appendix for more information about the CMF Clearinghouse). **Table 1** shows examples of potential risk factors based on focus crash types.

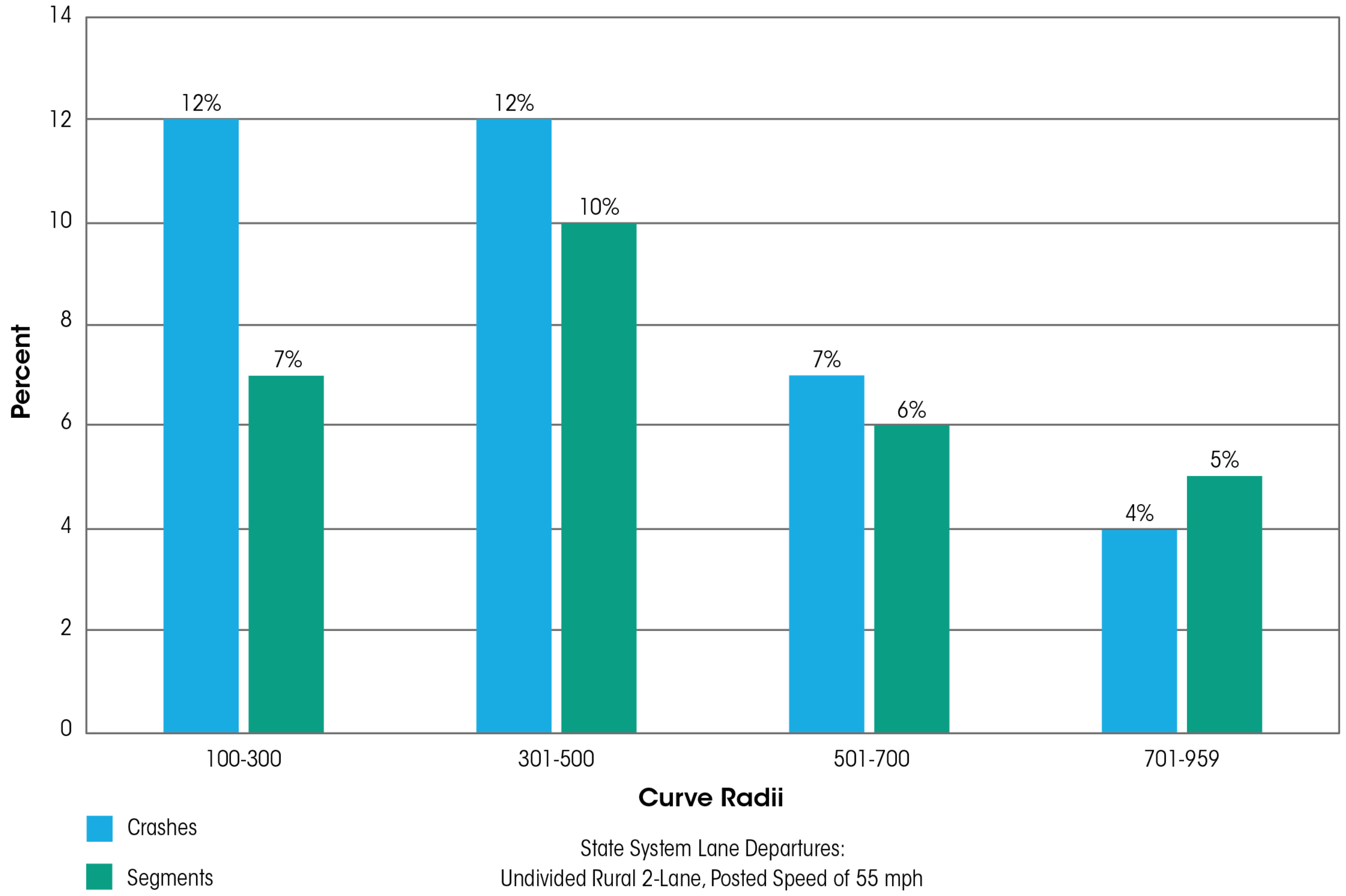
After potential risk factors have been identified, they are evaluated to determine whether the characteristics exhibit a relationship to future crash potential. Only those that positively demonstrate a relationship should be selected as risk factors. Two approaches to evaluate these relationships are using descriptive statistics and reviewing characteristics using CMFs from published research.

Descriptive statistics. Descriptive statistics are used to compare the proportion of locations where the location characteristics exist with the percentage of severe crashes. For example, consider a scenario where an analysis of an intersection database identifies only 10 percent of rural unsignalized intersections are skewed, yet more than 40 percent of the severe rural unsignalized crashes occurred at skewed intersections. This indicates skew is overrepresented at rural unsignalized locations experiencing a severe crash. By extension, skew would be a good choice for one risk factor when prioritizing locations. Another option is to compare the crash density of locations exhibiting the characteristic with locations without the characteristic. Where the crash density differs between locations with and without the characteristic, then that characteristic could be used to differentiate between locations for prioritization.

Reviewing characteristics using CMFs from published research. The safety effectiveness of design features and traffic characteristics can be used instead of descriptive statistics to select risk factors. For example, intersection skew has been shown to increase crash frequency (CMF greater than 1.0) while intersection lighting has been proven to reduce crashes (CMF less than 1.0). By applying CMFs documented in safety research results, an agency could select intersection skew and the absence of intersection lighting as risk factors in lieu of local crash analysis. Furthermore, combining the findings and CMFs from research with the results of the local descriptive statistics might increase confidence in the final selection of risk factors. For example, if a county agency has a relatively small data set to evaluate risk factors for severe intersection crashes, then the descriptive statistics might not be conclusive for skew and lighting. However, CMFs for skew and lighting might reinforce or confirm the patterns seen in the local descriptive statistics, providing greater confidence that these characteristics are risk factors for a future severe crash.

Example 5 depicts the descriptive statistics application used by NYSDOT to identify curve radii as a risk factor.

EXAMPLE 5. New York State Department of Transportation Evaluation of Curve Radii as a Potential Risk Factor



NYSDOT chose curve radii as a potential risk factor because of the typical geometry of their focus facility — rural, undivided, two-lane roadways. When compared with all curves along the focus facility type, those segments with curve radii between 100 and 500 feet are overrepresented when compared with the proportion these curves represent of the focus facility segments. NYSDOT selected a curve radius less than 300 feet as a risk factor because the data show that 12 percent of severe crashes occurred in curves with radii less than 300 feet, while only 7 percent of all reviewed curves have radii less than 300 feet.

Source: New York State Department of Transportation Office of Traffic Safety and Mobility

As illustrated in **Example 6**, Thurston County also used descriptive statistics to compare the proportion of severe curve-related roadway departure crashes on various functional classifications of roadways to the proportion of those functional classifications represented on the entire county roadway system.

Helpful Hints and Other Considerations

How can I test a characteristic even if it is not part of an existing data set or if my data set cannot be merged with the crash data?

You could either review published CMFs or consider sampling locations for evaluation. Instead of a systemwide comparison, sample locations that have severe crashes and compare them with sampled locations without severe crashes. Video logs, online aerial imagery, or windshield surveys can be used to cost-effectively collect information on the characteristics. This also allows you to understand the magnitude of effort needed to collect the information for an entire system before choosing the characteristic as a risk factor. Does the crash tree include all severe crashes or just severe crashes for one focus crash type?

Either option is considered acceptable. If there are relatively few severe crashes, then it might be best to begin the crash tree with all crash types. However, if there are instead many severe crashes for a particular crash type, the crash tree might focus on just the one.

How many risk factors should I select?

There is no rule on how many risk factors must be selected. At a minimum, you would need two to three risk factors to differentiate between sites. Of these, the presence of one or more fatal or serious injury crashes can be viewed as a risk factor. Selecting more—up to seven to ten—requires more time to perform the screening but also helps to determine the likelihood of future crashes.

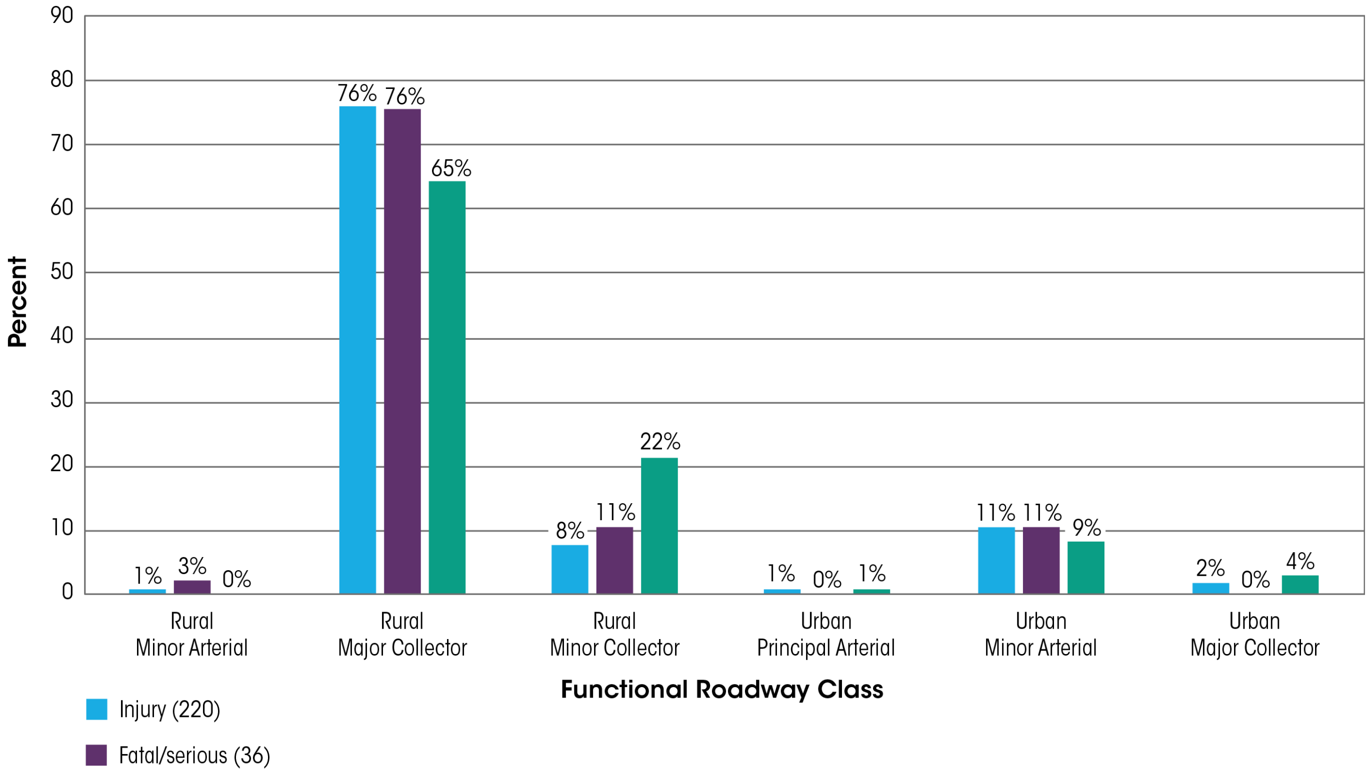
Should potential risk factors be combined during the evaluation process?

There might be occasions in which individual risk factors do not appear to be overrepresented in the crash data set. In these cases, you can perform the descriptive statistics analysis for combinations of risk factors to determine whether the related crashes are overrepresented. For example, one agency's crash data indicated that neither shoulder width nor shoulder surface type were risk factors for road departure crashes in horizontal curves. Engineering judgment suggested further analysis was required. Combining the data associated with these two risk factors revealed that severe crashes were found to be overrepresented in curves that had either narrow gravel shoulders or wide paved shoulders (which were also high volume corridors).

Can you still identify risk factors if you do not have local Average Annual Daily Traffic (AADT) information?

Unless the range of volumes across the network being evaluated is very narrow, it is generally desirable to consider AADT as a risk factor. Since higher volume may not always relate to higher risk, agencies should conduct a descriptive statistics analysis to identify the range of volumes with the highest risk for potential crashes. If traffic volume data are not available to perform a descriptive statistics analysis for AADT, then agencies are strongly encouraged to do a qualitative assessment (e.g., categorizing AADT as high, medium, or low to evaluate if AADT is indeed an important risk factor).

EXAMPLE 6. Thurston County Public Works Evaluation of Roadway Functional Class as a Potential Risk Factor



Thurston County compared the proportion of severe curve-related roadway departure crashes on various functional classifications of roadways to the proportion those functional classifications represent of the entire County roadway system. The data show that the focus crash type occurs on roadways with a Rural Major Collector functional classification in a greater proportion than this roadway type represents for the County system. Based on this descriptive statistics analysis, Thurston County chose Rural Major Collector functional classification as a risk factor.

Source: Thurston County, Washington, Department of Public Works

Outcome

Completing the first step of the systemic safety planning process provides an understanding of the focus crash types, focus facilities, and risk factors that represent the core of the developing systemic safety program. This information informs the risk assessment process in the next step of the systemic safety planning process.

Answering Some Common Concerns

Q: Is there a minimum number of crashes on a system that is considered necessary to provide credible results?

A: That will depend on the data and your starting point. For example, you might choose to begin the crash tree with only data for your jurisdiction or subregion instead of statewide, thereby eliminating one or more levels from the diagram.

Typically, most information used at this step will be reported by the officer on the crash report. Therefore, use whatever data are considered reliable and relevant for the focus crash type, but be careful not to create too many levels or the number of crashes will become small and the patterns difficult to identify.

Q: What if my data system cannot provide the ideal level of data?

A: The process can be modified to work with the data that are available, but the analysis outcomes might not be as detailed as desired. If existing road and intersection data are limited, then video logs, aerial imagery, or field visits might supply useful information. However, these data collection efforts would require additional investment to synthesize the data into a usable format.

Q: What if my jurisdiction has developing areas for which land use patterns are changing and traffic volumes are growing?

A: The process ideally relies on the most recent crash, volume, and roadway data available. If these data do not reflect current conditions, then the process might still be applicable, depending upon the crash type and countermeasure selection. For example, if traffic volumes are increasing on a facility but access is not changing, then the risk rating and the countermeasure selection might still be appropriate. A possible exception is when the type of countermeasure assigned for very low-volume facilities is different than moderate- and high-volume facilities. In this case, you should consider the countermeasures identified for moderate- and high-volume areas based on the volume growth rate. On the other hand, if the growth in the area is resulting in modified land use patterns, access density, and roadway cross-section, then the countermeasures derived from the process might not be as useful for preventing crashes given the current volumes and roadway configurations. In these situations, you should critically review the analysis to determine whether the risk rating and selected countermeasure will apply to conditions in the near future.

Screen and Prioritize Candidate Locations

Objective

The objective of the second step in the systemic safety planning process is to develop a prioritized list of potential locations on the roadway system (e.g., segments, curves, intersections) that could benefit from systemic safety improvement projects. The results of this step answers the question *Are all elements of my system equally at risk for the focus crash types or are some more at risk than others?*

The process to screen and prioritize candidate locations evaluates specific sites (i.e., individual segments, curves, and intersections) at the micro-level. The tasks in this step involve reviewing all elements from the focus facility types and assigning a level of risk to each element. Risk is inferred from the presence of crashes and risk factors, which are roadway and traffic features commonly associated with the locations where the focus crash types occur.

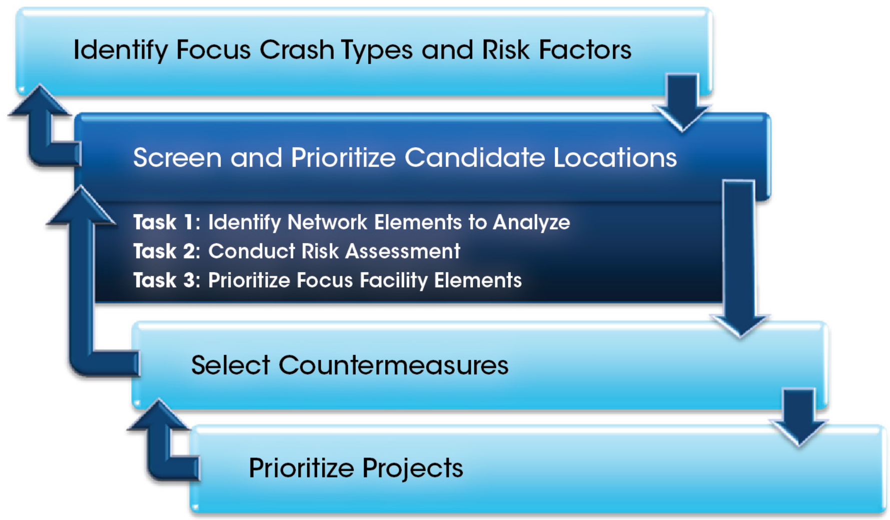
Data Needs

The screening and prioritization process requires two primary types of data. The first type is site-specific crash information, including severity, type, and any contributing factors relevant to the focus crash types and facility types. The second data type is the basic features of the road system, especially geometric or traffic elements selected as risk factors in the previous step of the systemic safety planning process. This information is available in from variety of sources, including electronic databases of roadway features and traffic characteristics, archives of as-built plans, aerial photography and street views, video logs, traffic control device inventories, and traffic flow maps.

Process

As **Figure 5** illustrates, screening and prioritizing candidate locations involves three tasks: selecting the locations or elements of the roadway system to review, verifying selected crash risk factors, and prioritizing these elements based on the presence of the risk factors at each location. In this process, the more risk factors present infers a higher priority as a candidate for safety investment.

FIGURE 5. Systemic Safety Planning Process: Tasks to Screen and Prioritize Candidate Locations



Task 1: Identify Network Elements to Analyze

Task 1 identifies the elements from the focus facility types, which represent the locations where the focus crash types tend to occur. For spot-based applications such as curves and intersections, all relevant locations are identified first. For segment applications, corridors are split into elements with consistent design (i.e., cross-section) to establish homogeneous segments. Additionally, the segment elements should have uniform traffic and design characteristics whenever possible, especially with respect to the selected risk factors. Homogeneous segments allow for consistent application of risk assessment and the same countermeasure to be selected for the entire element. For example, a rural two-lane corridor might be divided into segments extending from the limits of one small rural community to the limits of the next community. The Highway Safety Improvement Program Manual provides additional guidance for identifying network elements (FHWA, 2010).

After identifying the network elements to analyze, assemble the information in a format useful for conducting the risk assessment and documenting the results. Refer to the Minnesota Department of Transportation Case Study for an illustration of how to document identified network elements.

Conduct
Risk Assessment/
Prioritize Focus
Facility Elements

Helpful Hints and Other Considerations

What other data should I collect when reviewing locations for risk factors?

When examining specific locations, in addition to collecting information about the risk factors, you should also collect information that might impact countermeasure selection. For example, if the focus crash type is lane departure on rural two-lane highways, data related to shoulder width, shoulder surface type, and lane width can help select countermeasures, such as shoulder rumble strips, edgeline rumble strips, or enhanced edgeline markings.

You might not be able to gather every possible piece of data that impacts the project type selection, especially the first time going through a systemic analysis. However, the point is to think this through to prevent (or at least minimize) having to scan the part of the system selected for treatment a second time.

Task 2: Conduct Risk Assessment

In Task 2, agencies assess the risk of the systems and specific locations selected for analysis. The purpose of this assessment is to identify and document roadway and traffic characteristics pertaining to the selected risk factors, as well as total crash history, if applicable, for each location. For purposes of the Systemic Tool, the term "risk assessment" means the effort to collect the roadway/traffic data and to characterize the potential for a severe focus crash to occur at a given location or along a given segment of roadway based on certain characteristics present at these network elements.

The roadway and traffic characteristics could be available in a database format or can be collected as part of a field review of the road system. Roadway and traffic characteristics might also be collected in a virtual environment with field confirmation, as appropriate. Agencies with experience developing systemic approaches have found that roadway features can be documented in the office using video logs, aerial photography, and traffic volume data bases. Also, local agencies can provide some basic information about design features and traffic control devices.

The process to document the presence of a risk factor at a given network element involves recording if the risk factor is present or not. Presence can be indicated with a "1" or an asterisk or some other identifier that can be tabulated. Summing the number of risk factors present provides the ability to compare and prioritize network elements. The MnDOT Case Study at the end of this section provides an example of the documentation produced for a risk assessment.

After identifying and documenting the network elements for the prioritization process, consider if the selected risk factors are feasible for a systemwide analysis. A risk factor is not useful to prioritize locations if it is present at every location on the focus facility. For example, speed limit may need to be removed as a risk factor if it is the same for all roadway segments identified for the screening process. Also, curve radii may not be an appropriate risk factor if every curve on the focus facility type has the same radius. After considering, remove or add risk factors if necessary. This revision may be necessary if risk factors were selected using CMFs or a sample of locations on the focus facility. The MnDOT Case Study contains an example of the determination of risk factor feasibility.

Task 3: Prioritize Focus Facility Elements

Task 3 generates the prioritized lists of segments, horizontal curves, and intersections based on the presence of the selected risk factors—the more risk factors present, the greater the potential for the focus crash type and the higher the priority as a candidate for safety investment. Systemic analysis approaches might weigh risk factors equally, which simply means the more risk factors present, the higher the location's priority. However, risk factors also can be given relative weights. In this case, particular risk factors—if found to have a stronger association with locations where severe focus crashes occurred—can be given larger weights. The values for relative weights may be high/medium/low or based on integers that infer a higher level of confidence in the weights. **Example 7** illustrates how Thurston County weighted their selected risk factors based on their level of confidence in the data representing that risk factor.

Agencies can adjust the thresholds (the number of risk factors present or a weighted value) used to identify high-priority candidates based on the level of funding anticipated for implementation. To set the threshold, agencies should identify more candidate locations than can be implemented in a given year. There are two reasons for this. First, the effort creates a backlog or shelf life for the analysis so that it does not have to be completed annually. Second, locations might drop off the list as a result of field conditions or where additional time or funding is needed to implement the selected countermeasure. Having identified more candidates than can be implemented in one year provides flexibility to ensure all available funding can be allocated to priority projects. The MnDOT Case Study contains an example illustration of how risk assessment results are useful to establish a threshold for candidate locations.

EXAMPLE 7. Thurston County Public Works Risk Factor Prioritization

Risk Factor Weights[1]

Category	Higher Confidence	Lower Confidence
Crash Over-representation	> 10%	≤10%
Crash Total	≥ 30%	< 30%
Weight	1 point	0.5 point

[1] *Served as a guide, not a standard.*

Risk Factor Prioritization Results

ID	Risk Factor	1 Point Range	½ Point Range
01	Federal/Functional Classification	Major Rural Collector	Urban Minor Arterial
02	Intersection	Yes	—
03	Vertical Curves	—	Yes
04	Visual Trap	—	Yes
05	Edge Risk Assessment Rating = 3	Yes	—
06	Paved Shoulder Width	> 4 feet	—
07	Average Daily Traffic	3,000 - 7,500	0 - 1,500
08	Speed Differential (native shoulders)		0 to 5 mph Width < 4 feet at 25 mph
09	Speed Differential (paved shoulders)		20 mph
10	Type of Advance Warning Sign		W1-5

In a systemic review of road departure crashes on horizontal curves, Thurston County prioritized their selected risk factors by weighting them based on their level of confidence in the data representing that risk factor. Using the results of the descriptive statistics analysis performed on the potential risk factors, those factors present in at least 30 percent of the severe crashes and overrepresented by at least 10 percentage points (when comparing the proportion of all locations with the proportion of severe crash locations) were considered to have a high confidence and were assigned a weighted value of one point in the risk assessment process. Of the risk factors that were selected but did not meet these criteria, Thurston County had a lower confidence in them and each was assigned a relative weight of one-half point. The Risk Factor Weights table summarizes these criteria. This prioritization was used as a guideline, not a strict standard, for assigning weights to risk factors. The Risk Factor Prioritization Results table summarizes the results of the weighting process for the ten risk factors selected by Thurston County.

Source: Thurston County, Washington, Department of Public Works

Prioritize Focus Facility Elements

The final result of Task 3 is a prioritized list of focus facility elements that represents the locations with the greatest potential for the focus crash type to occur. At a minimum, the list includes information about the element location and the risk assessment score. **Example 8** shows the eight horizontal curves on the Thurston County Rural Major Collector system that have the highest risk scores and, therefore, represent the highest priority locations for systemic safety improvements. This list shows the value of systemic safety planning—more than half of these locations with risk factors present do not have a documented severe crash. However, the risk assessment indicates these locations have common characteristics with locations where severe crashes have occurred and, therefore, have the potential for a future severe crash.

Outcome

The outcome of this step is a risk assessment and ranking of the focus facility elements. The elements of the focus facilities carried forward to the next phase represent the locations with greatest potential for safety improvement.

Answering Some Common Concerns

Q: What if I do not have enough data to either document the characteristics of locations with crashes or to conduct the risk assessment of focus facilities?

A: The key objective of this step is to determine whether one part of a system is more at risk than another, which might require only one or two risk factors which could be based on data readily available, such as number of lanes or roadway curvature.

Q: How do I know if the characteristics I select really represent an increased level of risk?

A: Three keys to improve the success of your program include (1) be evidence driven [descriptive statistics and CMFs] in your selection of risk factors and consistent in their application, (2) exercise your judgment and conduct annual follow-up evaluations to see how the process is working, and (3) make adjustments if and when necessary.

Q: How many locations should I select in my initial prioritized list?

A: You can determine exactly how many locations to select for your initial prioritized list using factors such as anticipated funding amount and implementation goals. If your initial threshold identifies too few locations, then add locations in their established priority order until the target funding level is reached.

EXAMPLE 8. Thurston County Public Works Results of Segment Prioritization for Focus Facility Type Based on Risk Factor Scoring

These eight horizontal curves on the Thurston County Rural Major Collector system have the highest risk scores and, therefore, represent the highest priority locations for systemic safety improvements. This list shows the value of systemic safety planning — more than half of these locations with risk factors present do not have a documented severe crash.

Curve ID	Road Name	Scoring	5-year Crash Rate	Fatal or Serious Crash
182	Hawks Prairie Road NE	6.5	1.2	Yes
194	Boston Harbor Road NE	6.0	1.1	No
143	Delphi Road NW	6.0	0.9	No
203	Johnson Point Road NE	5.5	0.4	No
202	South Bay Road NE	5.5	0.2	No
136	Waddell Creek Road SW	5.5	10.3	Yes
238	Morris Road SE	5.5	2.6	Yes
58	Bald Hill Road SE	5.5	7.2	No

Source: Thurston County, Washington, Department of Public Works

Select Countermeasures

Objective

The objective of the third step in the systemic safety planning process is to assemble a small number of low-cost, highly effective countermeasures to be considered for project development at candidate locations. The countermeasures are selected based on research related to the systemwide data analysis results from the first step (Identify Focus Crash Types and Risk Factors), and specific jurisdictional experience, policies, and practices regarding potential countermeasures.

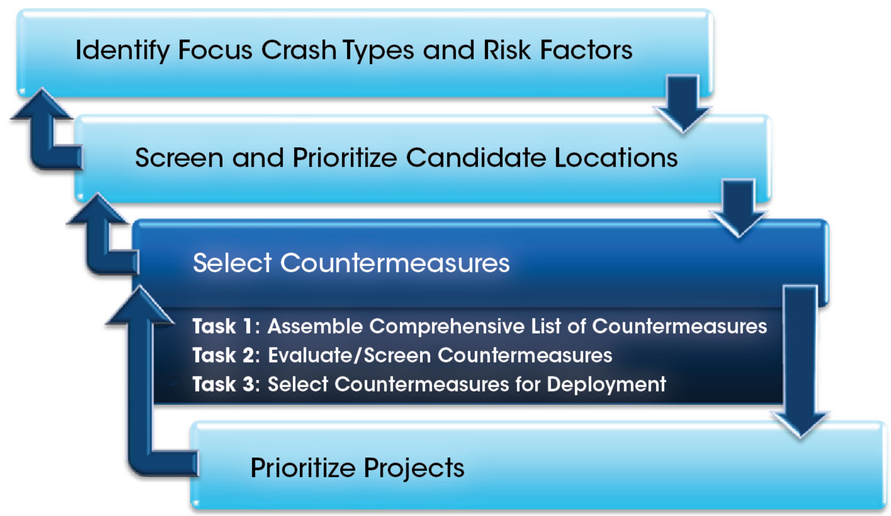
Data Needs

The National Cooperative Highway Research Program (NCHRP) Report 500 series is a suggested source of information for assembling the initial list of safety countermeasures (TRB, Various). These 24 volumes provide an extensive list of countermeasures for each of AASHTO's safety emphasis areas plus they provide insight about implementation costs. Recent countermeasure effectiveness information is available in the HSM and the CMF Clearinghouse. The National Highway Safety Traffic Administration's (NHTSA's) *Countermeasures That Work* report provides effectiveness information about behavioral countermeasures (NHTSA, 2013). These resources provide information about the expected effectiveness of the countermeasures, and documentation of implementation and maintenance costs. Other information needed to support countermeasure selection is gathered from the crash, roadway, and traffic data assembled in the previous two steps.

The information documented for the countermeasures might indicate whether the countermeasure is proven or tried, the expected safety effectiveness of the countermeasure, estimated implementation and maintenance costs, and consistency with agency policies and practices. In addition to assisting with countermeasure selection, this information is useful to the safety planning process because it provides:

- Documentation of proven, effective, or tried countermeasures which support a level of confidence about forecasted crash reductions.
- Effectiveness measures which assist in computing an expected crash reduction associated with deployment across a system.
- Implementation costs which are critical in the safety investment decision-making process.
- A final check of deployment feasibility in relation to agency policies and practices.

FIGURE 6. Systemic Safety Planning Process: Tasks to Select Countermeasures



Process

Countermeasure selection involves assembling a comprehensive list of potential countermeasures and evaluating each countermeasure to determine a select few most appropriate for systemic deployment. **Figure 6** shows the three primary tasks conducted to define the safety countermeasures for implementation at the candidate locations.

Task 1: Assemble Comprehensive List of Countermeasures

Task 1 involves assembling a comprehensive list of the safety countermeasures associated with each focus crash type. The list is assembled after reviewing the latest research and other available information (e.g., agency experience or engineering judgment) to identify those countermeasures with the greatest potential to address the focus crash types. As previously mentioned, the NCHRP Report 500 series, HSM, and CMF Clearinghouse are suggested starting points for the research effort. A state SHSP or other local safety plans also might include countermeasures already defined for particular focus crash types. Other resources, such as FHWA's illustrated guide sheets for 77 intersection countermeasures, may be used for developing the initial list of countermeasures (FHWA, Office of Safety). An agency's existing maintenance program could also be a source for identifying potential countermeasures. For example, a countermeasure could be to replace missing or damaged traffic signs with signs that meet current retroreflectivity standards. The MnDOT Case Study provides an illustration of the process to assemble a comprehensive list of countermeasures.

Task 2: Evaluate and Screen Countermeasures

The second task in the countermeasure selection process is to evaluate and screen the initial list of countermeasures based on documented safety effectiveness at reducing the focus crashes, implementation and maintenance costs, and consistency with the agency's policies, practices, and experiences. Implementing countermeasures that are proven to be effective at reducing crashes provides agencies the highest possible level of confidence that their investment will have a positive outcome—a reduction in the focus crashes. The HSM and the CMF Clearinghouse provide the most current information about countermeasure effectiveness. Evaluation results from previous countermeasure implementation efforts (discussed in Element 3 of the Systemic Safety Project Selection Tool) offer additional critical information for evaluating and selecting future countermeasures. The key is to follow the evidence and select the countermeasures with the greatest potential to address the focus crash type not just at a single location, but across the prioritized focus facility elements.

Helpful Hints and Other Considerations

Should I seek input from others when screening countermeasures?

To generate awareness of the systemic safety planning process and support among safety partners, you may conduct safety workshops during this task. Agency staff representing Engineering, Enforcement, Emergency Medical Services, and Driver Education could participate in a day-long workshop focused on sharing information about the process to select target crash types, and then discussing and prioritizing safety countermeasures. Also, within the engineering group, experts beyond just traffic and safety (e.g., construction, maintenance, public affairs representatives) should be involved.

Is safety effectiveness the only issue to consider when evaluating countermeasures?

An equally important consideration in the process of screening the countermeasures is the implementation and maintenance cost. The systemic approach is focused on mitigating types of crashes that are widely scattered across a roadway system. The key to addressing low crash densities is implementing low-cost countermeasures, so that resources are adequate to widely deploy them across a system. Furthermore, policies and practices might limit the ability to use some countermeasures such as automated enforcement. The practical ability to implement a countermeasure equally influences the screening process.

Is there an optimum number of countermeasures for my agency's short list?

Not really—too few countermeasures can limit flexibility to address the various conditions and constraints that are typical across a roadway system. Too many countermeasures can make project development more challenging and follow-up evaluations more difficult (too few samples of any one countermeasure to provide statistical reliability).

Why would I want to remove countermeasures from the list?

In many cases, there are simply too many potential countermeasures to discuss in any meaningful way at a stakeholder meeting or workshop. There are going to be some countermeasures that are just not consistent with an agency's practices and should be removed before investing time and energy to discuss further.

Are the CMFs developed for specific high-crash locations applicable to a systemic implementation?

While CMFs in the CMF Clearinghouse present the best information available to date, it is important to recognize that most CMFs were developed from before-after studies conducted when the countermeasure was implemented at a high-crash location. However, it is unknown whether the same results will be achieved when implementing these countermeasures on a systemic basis. Because systemic countermeasures are deployed at some locations with no crash history, it is possible that a systemic application of a countermeasure may not achieve as high of an average percentage reduction in crashes as a high-crash location. Therefore, you are encouraged to conduct follow-up evaluations as described in Element 3 to determine the true effect of implementing safety countermeasures.

The screening process should consider maintenance requirements for the countermeasures because a countermeasure cannot perpetually provide the potential for crash reduction if it is not maintained or replaced when necessary. Thus, agencies should consider their ability to perform and fund routine maintenance of countermeasures implemented through a systemic deployment program. A countermeasure is likely not going to be a viable improvement and should be removed during the screening process if it will not be maintained. The MnDOT Case Study provides an illustration of how to evaluate and screen countermeasures.

Agencies can also screen potential countermeasures by performing a benefit-cost analysis of various countermeasures applicable for a typical section that represents the focus facility type. A spreadsheet tool is useful to automate the benefit-cost ratio calculations. **Example 9** illustrates the benefit-cost analysis used to identify countermeasures for roadway departure crashes on bridges in Salem County, New Jersey. When performed in this manner, a benefit-cost analysis can help to determine the most cost-effective way to spend the funding allocated to systemic improvements.

Task 3: Select Countermeasures for Deployment

The result of the countermeasure screening process is the selection of one or more countermeasures for each focus crash type. This short list would include primarily low-cost countermeasures, along with a few higher-cost countermeasures. Agencies use this list of countermeasures to develop safety projects at specific locations across their roadway system. Although an agency might choose to deploy one particular countermeasure, there might also be locations where that countermeasure is not an ideal choice. As a result, having alternatives to choose from provides flexibility and acknowledges that all candidate locations in a system are not the same. Additionally, including alternative countermeasures offers an opportunity to incorporate a few higher-cost countermeasures proven to significantly reduce crashes. Agencies should use these higher-cost countermeasures in a limited number of circumstances and only in situations that might not be effectively addressed by the low-cost countermeasures in the short list. The high-priority locations identified in the second step (Screen and Prioritize Candidate Locations) also might influence the final countermeasure selection, which is why it is important to identify a range of countermeasures appropriate for the range of high-priority sites selected for project development. The final selection represents the highest-priority countermeasures that agencies will maintain for safety investment, based on expected crash reductions and estimated implementation costs. The MnDOT Case Study provides an illustration of how to select countermeasures for deployment.

Outcomes

An outcome of this step is documentation of the countermeasures, which will be used in future program evaluation. The primary outcome of this step is a short list composed mainly of effective, low-cost countermeasures and a few higher-cost countermeasures for each focus crash type. These countermeasures then become the focus of the safety project development efforts that are described in the next step of the systemic safety planning process.

EXAMPLE 9. Rutgers Center for Advanced Infrastructure and Transportation Benefit Cost Analysis to Evaluate and Screen Countermeasures

Countermeasure 2: Rumble Strips

Service Life: 3 years

Step		Year (Years in Service Life)/ Annual Average Daily Traffic 2012 (0)/ 1,400	2013 (1)/ 1,428	2014 (2)/ 1,457	2015 (3)/ 1,486	Total Number of Crashes	Total Benefit
Step 1 WITHOUT Countermeasure Number of Crashes (Expected Before)	Total	0.0090	0.0092	0.0094	0.0097	**0.0283**	
	Fatal and Injury	0.0029	0.0030	0.0030	0.0031	**0.0091**	
	Property Damage Only	0.0061	0.0063	0.0064	0.0066	**0.0092**	
Step 2 WITH Countermeasure Number of Crashes (Expected After)	Total		0.0073	0.0075	0.0076	**0.0224**	
	Fatal and Injury		0.0016	0.0016	0.0016	**0.0048**	
	Property Damage Only		0.0063	0.0064	0.0066	**0.0192**	
Step 3 Change in Number of Crashes (Expected)	Total		0.0019	0.0020	0.0020	**0.0059**	
	Fatal and Injury		0.0014	0.0014	0.0015	**0.0043**	
	Property Damage Only		0.0	0.0	0.0	**0.0**	
Step 4 Benefit and Maintenance Calculations	Change in Number of Crashes (Fatal and Injury)		0.001391	0.0	0.0		
	Fatal and Injury Crash Cost		$158,200	$158,200	$158,200		
	Annual Maintenance Cost (Fatal and Injury)		$220	$220	$230		
	Change in Number of Crashes (Property Damage Only)		0.0	0.0	0.0		
	Property Damage Only Crash Cost		$7,400	$7,400	$7,400		
	Annual Maintenance Cost (Property Damage Only)		$0	$0	$0		
	Annual Maintenance Cost (Total)		$220	$220	$230		
Step 5 Present Value Calculation	Present Value		$212	$203	$204		$619

Cost/Benefit Ratio

Category	Benefit (Net Present Value)	Cost	Benefit/ Cost Ratio
Guiderail	$1,685.55	$4,200	0.401
Rumble Strips	$619.41	$126	4.915
Rumble Stripes	$0.00	$268	0.0000
Pavement Markings	$813.67	$284	2.865
Pavement Resurfacing	$162.22	$3,675	0.044
High-Friction Surfacing	$1,171.71	$1,386	1.278

The Rutgers Center for Advanced Infrastructure and Transportation (CAIT) Transportation Safety Resource Center performed a systemic safety analysis for Salem County, New Jersey, to develop a prioritized list of HSIP-eligible projects. CAIT conducted a cost-benefit analysis of potential countermeasures selected based on identified risk factors.

CAIT used safety performance functions (from the HSM predictive method procedures) and crash modification factors (from the CMF Clearinghouse) to estimate the difference between the expected number of crashes with and without the countermeasure (the benefit of implementing the countermeasure). After calculating the net present value of the implementation and maintenance costs, the automated process estimated the benefit-cost ratio of each countermeasure.

The resultant prioritization of the countermeasures was used to create safety projects for sites with particular combinations of lane width and traffic volume.

Source: Rutgers CAIT Transportation Safety Resource Center

Prioritize Projects

Objective

The objective of the fourth and final step in the systemic safety planning process is to identify and develop a list of high-priority safety improvement projects for implementation. This process considers the prioritized at-risk locations identified in the second step (Screen and Prioritize Candidate Locations) and applies the most appropriate countermeasures from the list developed in the third step (Select Countermeasures) to develop a list of high-priority safety improvement projects. For the purposes of the Systemic Tool, the term projects includes dedicated safety projects as well as safety improvements implemented as one component of a traditional construction or maintenance project (e.g., resurfacing) or as part of routine maintenance efforts.

Data Needs

The information needed to support the project prioritization process includes a basic understanding of an agency's priorities, practices, and policies as they relate to project and program development. This understanding is especially important to ensure the countermeasures identified in this step are only included in projects for areas where they fit with local practices for installation and maintenance. In addition, defining specific safety projects requires current information about countermeasure implementation costs and estimated effectiveness.

Process

Prioritizing projects involves developing a decision process so that selected countermeasures can be consistently assigned to projects for the prioritized focus facility elements identified in the second step. This fourth and final step results in a prioritized implementation order for safety projects. **Figure 7** shows the three basic tasks conducted to prioritize systemic safety projects.

FIGURE 7. Systemic Safety Planning Process: Tasks to Prioritize Projects

Task 1: Create Decision Process for Countermeasure Selection

Creating a decision process for each focus crash type provides a means to consistently assign countermeasures to focus facility locations. A decision process is simply a set of criteria that considers issues such as volume, environment, adjacent land use, or cross-section, and uses them to identify the appropriate countermeasure for high-priority locations. An important distinction of the systemic safety planning process is that the decision-making process does not just identify the most appropriate countermeasure for each location (like when addressing hot spots), it also considers multiple locations with similar crash and risk characteristics to select preferred one or more countermeasures suitable and affordable for widespread implementation. Alternative countermeasures, and the criteria for deploying each countermeasure, might consider typical variations in site conditions.

For example, urban intersection and rural road departure systemic safety programs address uniquely different problems. Therefore, each program needs countermeasures specific to the problem and different decision processes for selecting the final countermeasure. Additionally, programs addressing similar issues on different facility types (e.g., road departure on rural divided expressways versus two-lane highways) might have some of the same countermeasures, but the criteria and thresholds for selecting the countermeasures might be completely different. An agency can develop a process recognizing that no single countermeasure is likely to be best for every location due to the variety of features and characteristics that are encountered along a roadway system. The MnDOT Case Study illustrates a decision tree created to select countermeasures.

A Quick Illustration: Addressing Road Departure Crashes on Rural Two-Lane Highways

Shoulder rumble strips may be the preferred countermeasure for addressing rural road departure crashes that happen due to driver inattention. Factors that might influence the actual decision to implement shoulder rumble strips at any given location include the shoulder surface type and width, lane width, and the presence of adjacent residential development. These factors could point to selecting an alternative countermeasure, such as edge-line rumble strips (also known as rumble stripes), if there is no paved shoulder and no noise concerns. An enhanced edgeline using a wider edgeline or wet-reflective material might be considered in the case of either really low-volume, narrow lanes with no paved shoulder or due to noise concerns in areas with residential development.

Criteria should also consider when any higher-cost alternatives are selected. In this same scenario, a higher-cost alternative could be paving shoulders with adding rumble strips. Criteria might suggest this as the preferred project if the gravel shoulder is sufficiently wide and the countermeasure is appropriate for the site conditions and agency practices. Other criteria for choosing a higher-cost countermeasure could include high volumes, a relative high frequency of severe road departure crashes, or a curvilinear alignment where recovery area outside the edgeline is viewed as important.

Task 2: Develop Safety Projects

The next task in the project prioritization process is to apply the decision process to identify one or more specific countermeasure for each candidate locations selected for safety investment. Safety projects are developed by providing a detailed site description (e.g., route number, mile point, intersecting roadway, and segment termini), identifying the specific countermeasure selected, estimating the implementation cost, and summarizing how the site scored with the risk factors. After the countermeasures for safety investments are selected, agencies can then decide how to most efficiently bundle projects into a design package for contract letting. The MnDOT Case Study shows an example of the documentation produced during the process to develop a safety project.

Task 3: Prioritize Safety Project Implementation

Lastly, projects are prioritized for implementation by considering factors such as funding, other programmed projects, time to develop project plans, expected crash reduction, amount of public outreach needed, and environmental and right-of-way constraints. The prioritized list of locations infers a particular order based on the number of risk factors present at a given location. However, other factors often influence the ability to let a specific project. For example, a project might need to be included in an established capital improvement program or coordinated with other projects/programs. The next chapter presents a case study that illustrates how MnDOT applied the systemic safety planning process to develop prioritized projects for deployment on the county roadway network throughout the state.

Outcome

The outcome for this step is development of a safety project for each identified at-risk candidate location along a roadway system. The roll-up of the prioritized projects produces the systemic safety program for the city, county, district, region, or state. This final step completes the systemic safety planning process, which is Element 1 of the Systemic Safety Project Selection Tool.

Answering Some Common Concerns

Q: I have selected a preferred countermeasure to mitigate the focus crash type and now I find that I cannot implement this countermeasure at a particular location (e.g., due to a lack of support by maintenance crews, complaints by residents, lack of support by local politicians, geometric constraints). What do I do?

A: You should have multiple countermeasures identified, which will provide flexibility to adapt to the many constraints and/or features that are typical across roadway systems. The decision process should account for such issues by providing alternative countermeasures.

Q: If I have a list of suggested safety projects in my possession and I choose not to implement some, either immediately or ever, am I at risk from a tort liability perspective?

A: This question comes up regularly in conversations with local agencies. Agencies should have clear documentation of the process used to identify and prioritize safety investments. Tort law in a number of states provides agencies with discretionary immunity related to decisions about the allocation of resources. In addition, federal law (23 U.S.C. 409) and a U.S. Supreme Court case (Pierce County, Washington v. Guillen) protects agencies participating in statewide safety planning efforts that support the HSIP by shielding the outcomes of those efforts from plaintiff's attorneys; the information generated (e.g., data, lists of at-risk facilities, lists of suggested projects) is not discoverable and cannot be used against an agency in tort cases. Agencies should seek legal counsel to determine the extent of protection provided by these Federal statutes.

Q: The process has identified more projects than there are funds available—is this a problem?

A: No, systemic safety planning is not expected to be fiscally constrained. It is desirable to identify more projects than could be implemented in a single year because funding agencies will have a multiyear backlog of high-priority projects (and will not need to perform annual analysis updates). A good target would be to assume a of 3- to 5-year shelf life for the results of the analytical process, after which the process would be updated.

Q: Can I use HSIP funds to supplement regular funding sources for reconstruction?

A: Federal regulation (23 CFR 924.5) states that improvements to safety features that are routinely provided as part of a broader federal-aid project should be funded from the same source as the broader project. States should address the full scope of their safety needs and opportunities on all roadway categories by using all available funding sources. For example, if an improvement project identified through the HSIP planning and programming process encompasses an area identified through the systemic planning process a location for safety improvements, it makes logical sense to combine the two efforts to reduce the cost of two projects (less administration, only one mobilization cost, etc.).

Q: My high-priority segments, curves, and intersections are listed in a very specific rank order. Do the suggested safety projects need to be implemented in that exact order?

A: No, the prioritization process results in a rank ordering of the system based on a comparison to the adopted risk factors. However, a variety of factors (i.e. cost effectiveness) likely will enter into an agency's decision as to how projects will fit into their capital improvement program. Agencies would benefit from a systemic prioritization process that considers these other factors to the extent feasible.

Case Study: Minnesota Department of Transportation's Application of the Systemic Safety Planning Process

The following case study illustrates how the Minnesota DOT applied the systemic safety planning process as part of a statewide effort to develop county road safety plans for each of their 87 counties. The focus crash types were severe lane departure crashes on rural segments and curves, severe right-angle crashes at rural thru-stop and urban signalized intersections, and severe pedestrian crashes in urban areas. The FHWA's HSIP Noteworthy Practice Series provides information about this effort (FHWA, Office of Safety). The FHWA's *Developing Safety Plans: A Manual for Local Rural Road Owners* provides guidance for developing local road safety plans (FHWA, 2012). The case study provides illustrations of each successive task of the systemic safety planning process, using the same data set throughout. Each illustration describes the purpose, provides a description, and typically shows example data and analysis results.

Case Study

Emphasis Area		Statewide Percentage	Statewide: State System		Statewide: County System		Statewide: City, Township, & Other System	
Total Fatal and Serious Injury Crashes		8,300	2,998		3,379		1,923	
Drivers	Young drivers (under 21)	24%	21%	638	25%	839	28%	539
	Unlicensed drivers	8%	8%	251	7%	237	9%	164
	Older drivers (over 64)	14%	18%	527	13%	429	11%	206
	Aggressive driving and speeding-related	20%	20%	606	20%	661	22%	432
	Drug and alcohol-related	26%	23%	680	26%	949	26%	497
	Inattentive, distracted, asleep drivers	20%	23%	693	19%	638	16%	300
Occupants	Unbelted vehicle occupants	25%	26%	782	26%	872	21%	400
Special Users	Pedestrian crashes	8%	6%	180	7%	222	15%	291
	Bicycle crashes	4%	2%	54	3%	113	8%	157
Vehicles	Motorcycle crashes	16%	14%	416	17%	591	15%	293
	Heavy vehicle crashes	10%	15%	456	7%	249	6%	114
Highways	Train-vehicle crashes	0%	0%	1	0%	7	1%	17
	Road departure crashes	28%	27%	807	32%	1,090	22%	420
	Intersection crashes	42%	40%	1,212	42%	1,422	45%	871
	Head-on and Sideswipe (opposite) crashes	15%	17%	51	14%	489	14%	263
	Work zone crashes	2%	2%	69	1%	38	1%	20

KEY:
15% Top 5 Emphasis Areas by Jurisdiction

Note: Numbers are not additive, as one crash may involve a young driver at an intersection.
The numbers represent severe crashes (Fatal and A-type Injury crashes).

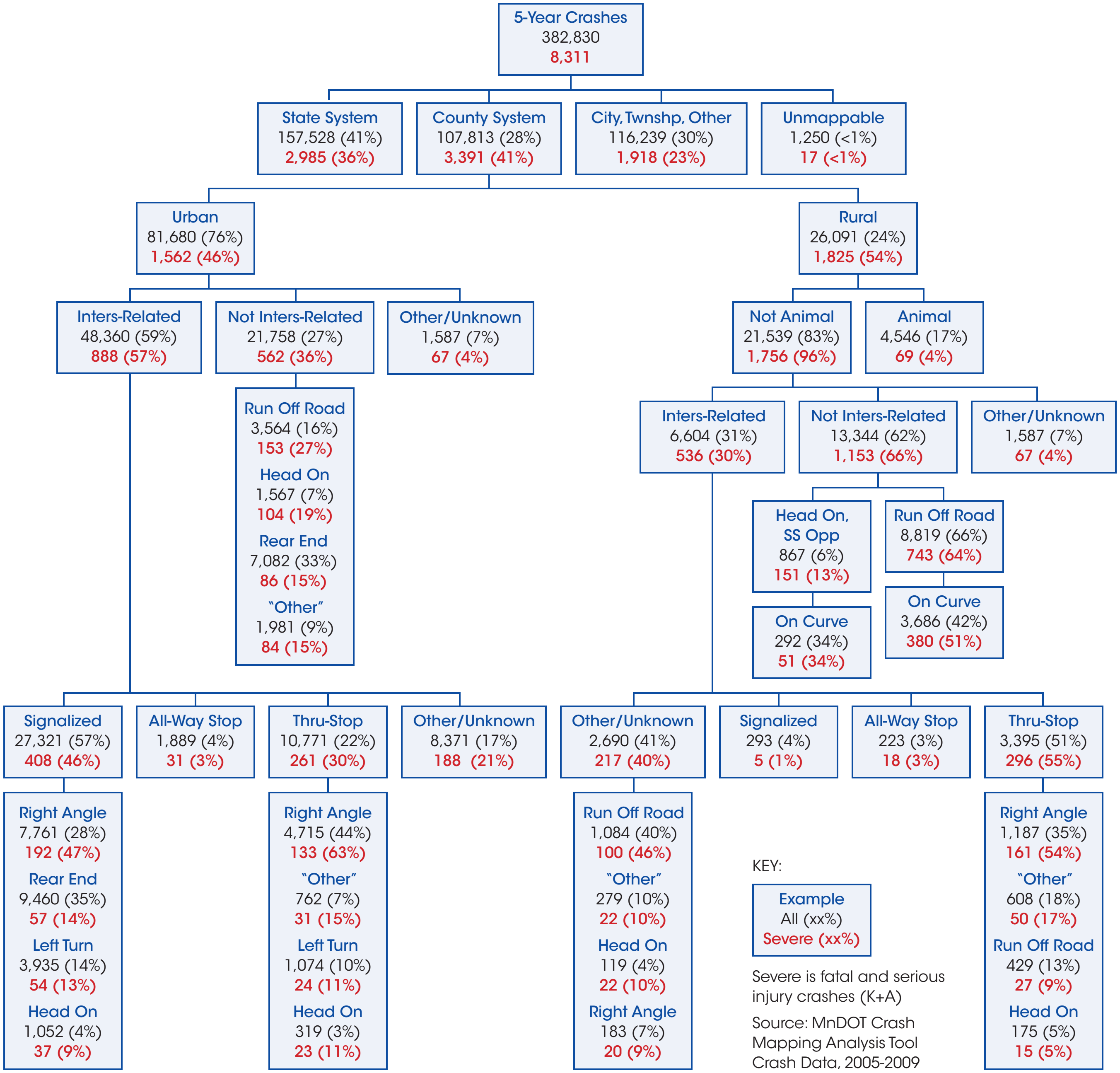
Source: Department of Public Safety Crash Data Records, 2006 to 2010

Purpose

Identify the high-priority emphasis area — categories of severe crashes that represent the greatest opportunities for reduction.

Description

- Demonstrates disaggregation of Minnesota's statewide crash data into AASHTO's designated emphasis areas.
- In this case, the data suggests Minnesota's high-priority emphasis areas (focus crash types) include:
  - Drivers
    — Seatbelt usage
    — Impaired driving
    — Young drivers
  - Highways
    — Intersections
    — Road departure
- The data also supports the importance of actively including the county highway system in statewide safety planning efforts.



Purpose

Identify where crash types most frequently occur.

Description

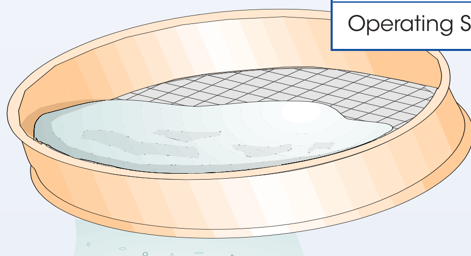
- This is a crash tree analysis focusing on the county highway system in Minnesota.
- Analysis shows there are more severe crashes on the county system than the state system, and the majority of these crashes are rural, involve road departure, and occur on curves more than 50 percent of the time.
- Rural intersection crashes primarily occur at thru-stop controlled intersections. The most common crash type is a right-angle crash.
- Urban intersection crashes primarily occur at signalized intersections. The most common crash type is a right-angle crash.
- This chart provided a reasonable preview of the likely outcome of the safety analysis — the safety focus of Minnesota's County Roadway Safety Plans has been rural, road departure, curves, and angle crashes at intersections.

Case Study

Road Features
Shoulder Width/Type
Horizontal Curvature
Access Density
Roadside Rating
Intersection Skew

Traffic Volume
Average Daily Traffic (ADT)

Other Features
Presence of Commercial Development
Proximity to Rail Crossing
Distance from Previous Stop
Operating Speed



Data screened by:

— Agency Experience

— Availability

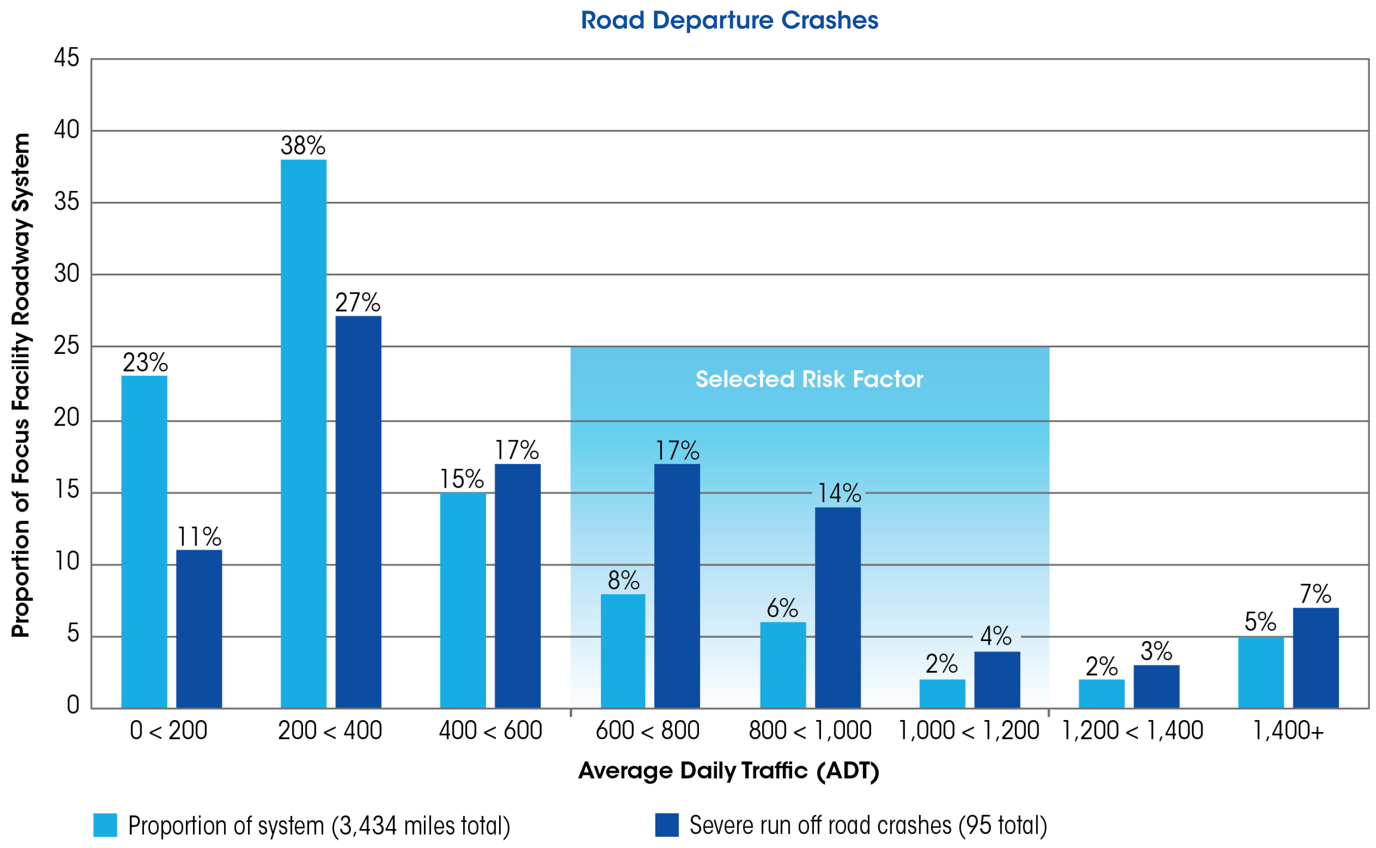
Facility	Potential Risk Factors
Rural Segments	ADT, curve density, access density, edge rating
Rural Curves	ADT, radius, intersection, visual trap
Rural Intersections	ADT, geometry, RR crossing, commercial development, distance from previous stop
Urban Signals	Speed, geometry, commercial development

Purpose

Identify roadway characteristics to use as an initial set of potential risk factors to be further evaluated for use in systemic network screening.

Description

- MnDOT reviewed published research to identify roadway features strongly related to crash experience. MnDOT compared these findings to available data and identified potential crash risk factors to apply to:
    - Two-lane rural county highways
    - Rural horizontal curves
    - Rural thru-stop intersections
    - Urban signalized intersections — focus on angle and pedestrian crashes
- The potential risk factors for each facility type selected by MnDOT are shown in the bottom table.



Purpose

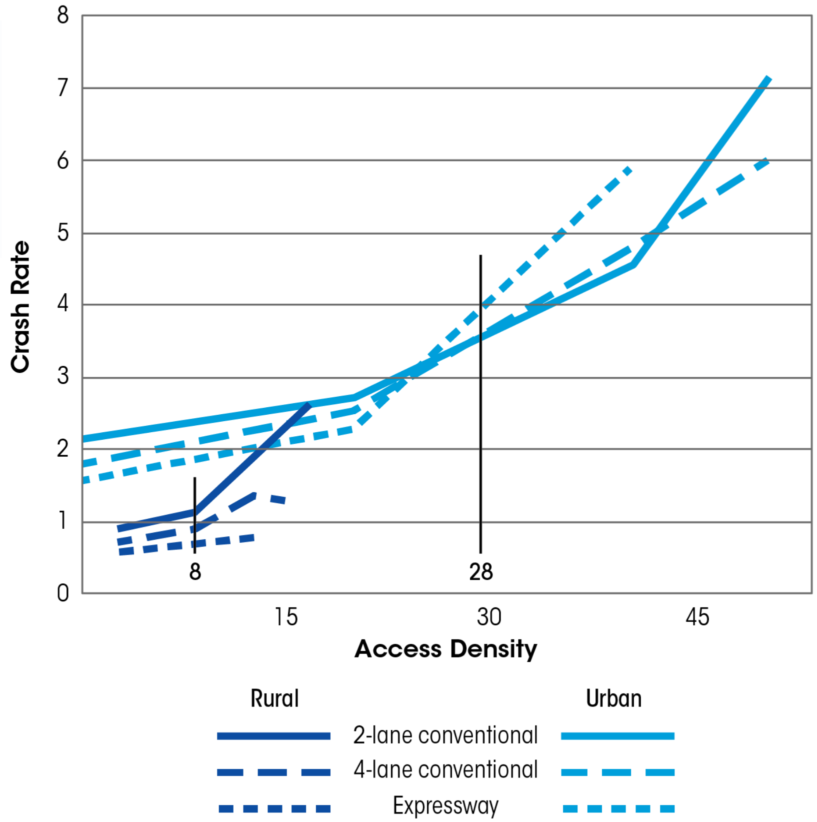
Use descriptive statistics to evaluate Average Daily Traffic (ADT) as a potential risk factor.

Description

600 - 1,200 ADT was selected as a risk factor because severe crashes were overrepresented on roadways with ADTs in this range.

Case Study

Crash Rate for Minnesota State Highways Based on Access Density



Notes:

- Rural refers to non-municipal areas and cities with a population fewer than 5,000.
- 8 is the average access density for rural highways.
- 28 is the average access density for urban highways.

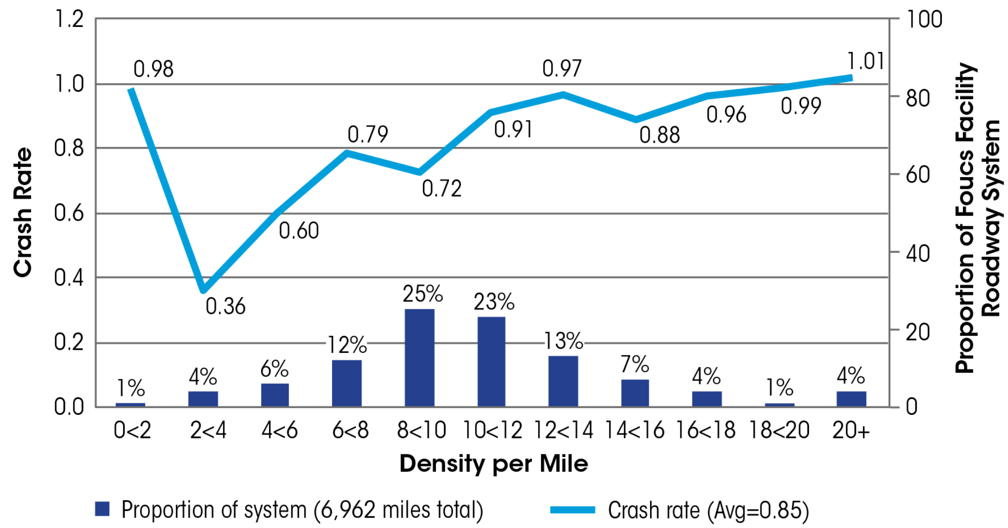
Purpose

Evaluate access density as a potential risk factor.

Description

- Illustrates macro analysis showing that as access density increases, crash rates increase.
- Shows significant relationship between density and crash rate — risk factor selected for systemic network screening.

Crash Rate for Rural Minnesota County Roadways Based on Access Density



Edge Risk Assessment Categories

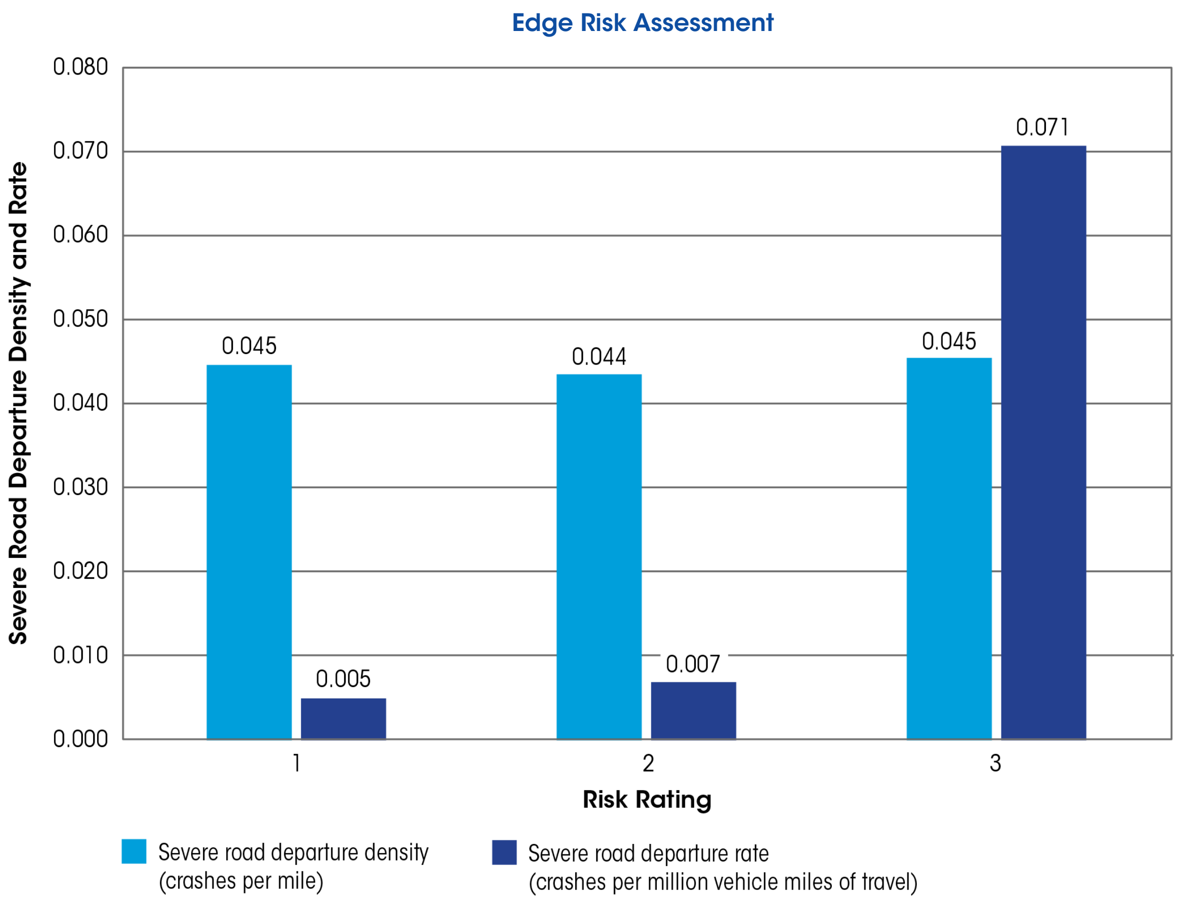
1 – Good Shoulder, Good Clear Zone

2 – Good Shoulder, No Clear Zone

2 – No Shoulder, Good Clear Zone

3 – No Shoulder, No Clear Zone

Case Study



Purpose

Use descriptive statistics to evaluate edge risk assessment as a potential risk factor.

Description

- Severe road departure density is the number of crashes per mile per year, which illustrates the frequency of these crashes.
- The crash rate is the number of crashes normalized by vehicle miles traveled, indicating the relative risk based on exposure.
- Shows that a roadside condition of no usable shoulder and the presence of fixed objects (Risk Rating = 3) generates a higher severe road departure rate.

Corridor	Route Type	Route Number	Start	End	Length (miles)	Average Daily Traffic
144.01	CNTY	89	CSAH-30	CSAH-30	1.4	480
40.04	CSAH	40	New London Corp Limit	CSAH-2	5.9	450
131.01	CNTY	89	CSAH-30	MNTH-23	0.7	145
9.02	CSAH	9	CR-90, Willmar Corp Limit	CSAH-10	5.6	940
5.06	CSAH	5	150th Ave NW, CSAH-29	CSAH-1	10.1	628
31.02	CSAH	31	New London Corp Limit	MNTH-23	1.6	920
8.01	CSAH	8	Renville County Line	Lake Lillian Corp Limit	3.6	750
4.01	CSAH	4	CSAH-8	CSAH-20	6.7	320
2.05	CSAH	2	CSAH-10	MNTH-23	9.8	385
4.04	CSAH	4	CR-98	CSAH-40	2.4	290
38.01	CSAH	38	CSAH-40	CSAH-48	2.1	130
132.01	CNTY	89	CSAH-8	CSAH-8	2.2	190
42.01	CSAH	42	CSAH-7	County Line	0.5	120
9.03	CSAH	9	CSAH-10	CSAH-40, Redwood Street	4.9	1,800
25.01	CSAH	25	CSAH-5	USTH-71	3.2	1,315
1.03	CSAH	1	MNTH-23	Pennock Corp Limit	7.0	333
116.02	CNTY	89	CSAH-3	MNTH-40	7.0	98
2.04	CSAH	2	Atwater Corp Limit	CSAH-10	6.7	1,018
28.02	CSAH	28	CSAH-2	County Line	2.0	315
KEY: CSAH = County State Aid Highway CNTY = County Road MNTH = Minnesota Trunk Highway						

This table represents 19 of the 77 segments.

Purpose

Identify the network elements from the focus facility types which represent the locations where the focus crash types tend to occur. The elements are for use in network screening.

Description

- For the application of the Systemic Safety Planning Process on corridors, the Minnesota process split corridors into segments with consistent design features (e.g., cross section or volume) to minimize the variation of risk factors within a corridor and so that the same countermeasure could be applied to the entire segment.
- The end points of the segments also considered practical issues about how projects could be deployed. Segments typically ended at the edge of cities since the preferred countermeasure, shoulder and edgeline rumble strips, could not be deployed within cities.
- The table on this page illustrates the results of segmentation of Minnesota 2-lane county roads.

Case Study

Rank	Corridor	ADT Range	Road Departure Density	Access Density	Curve Critical Radius Density	Edge Risk	Totals
1	144.01	★	★	★	★	★	★★★★★
2	40.04	★	★	★	★	★	★★★★★
3	131.01		★	★	★	★	★★★★
4	9.02	★	★	★	★		★★★★
5	5.06	★	★	★	★		★★★★
6	31.02	★	★	★	★		★★★★
7	8.01	★	★			★	★★★
8	4.01		★	★		★	★★★
9	2.05			★	★	★	★★★
10	4.04			★	★	★	★★★
11	38.01			★	★	★	★★★
12	132.01			★	★	★	★★★
13	42.01			★	★	★	★★★
14	9.03		★	★	★		★★★
15	25.01		★	★	★		★★★
74	1.03						
75	116.02						
76	2.04						
77	28.02						

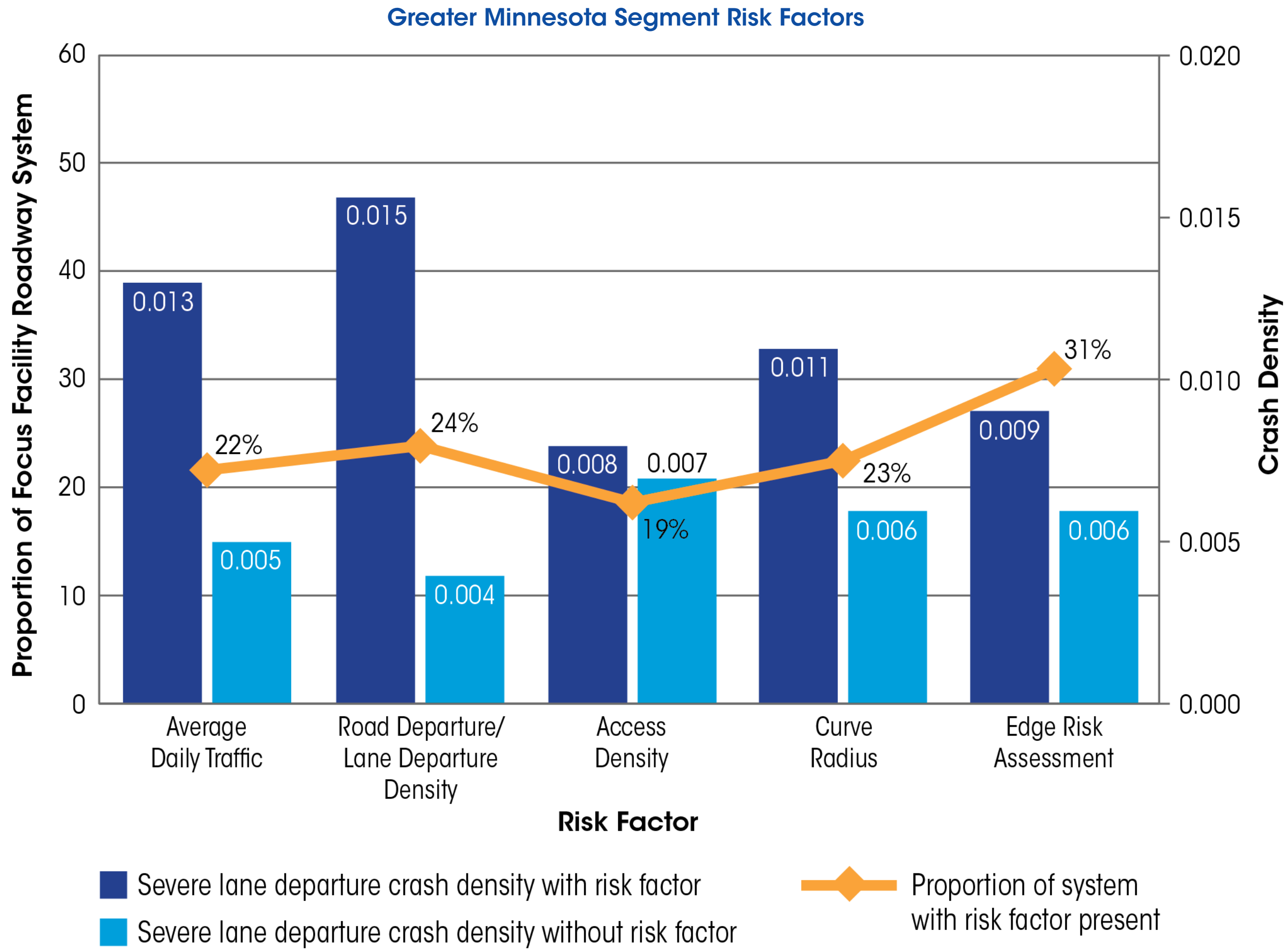
This table represents 19 of the 77 segments.

Purpose

Evaluate the risk factors of the systems and locations selected for analysis using roadway and traffic characteristics in order to rank/ prioritize at-risk locations.

Description

- Risk factors are not weighted.
- A star (★) indicates the corresponding risk factor is present.
- More ★s identify locations as higher priority candidate for safety investment.

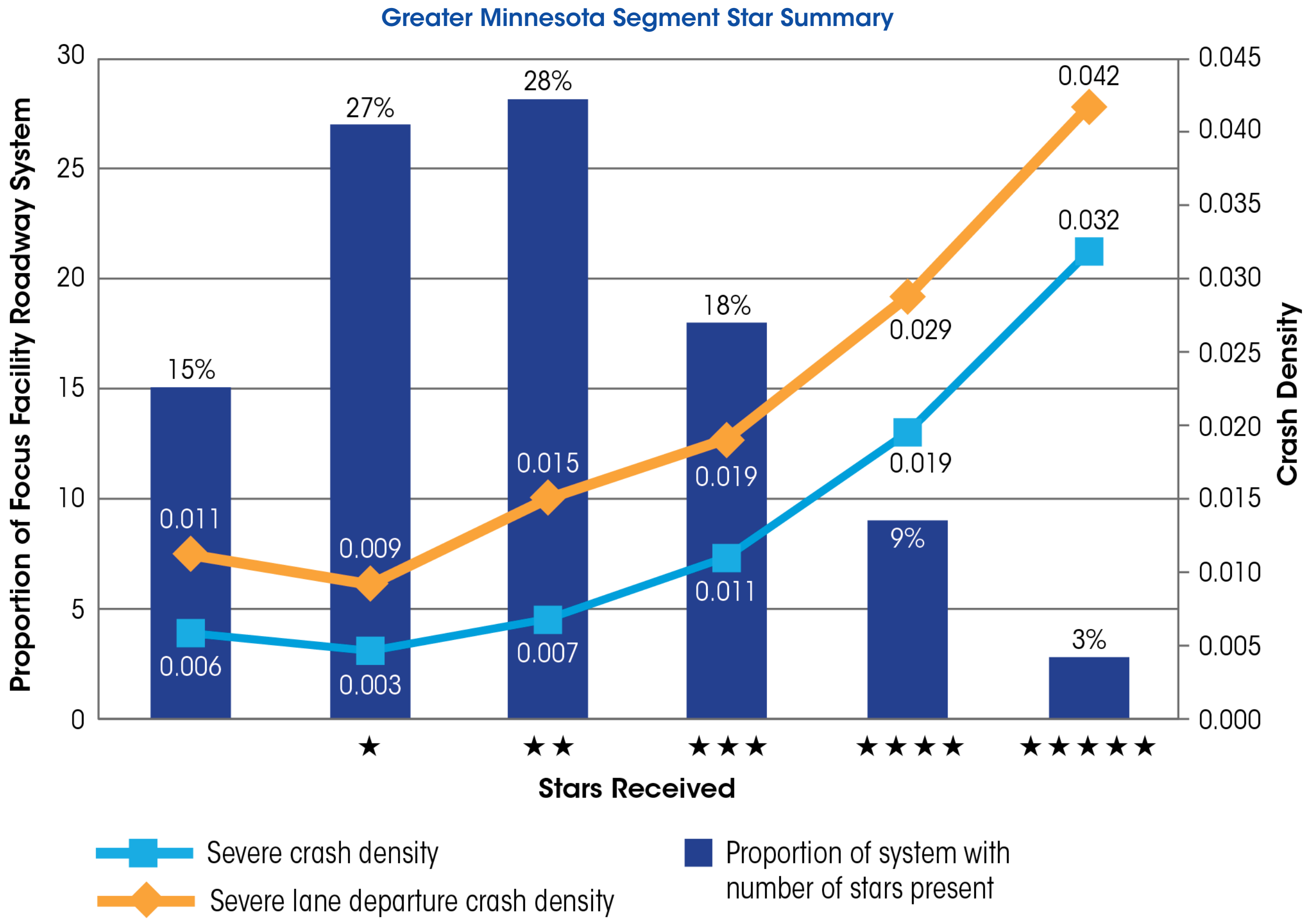


Purpose

Assess selected risk factors to determine their feasibility for differentiating between elements (curves, segments, and intersections) on the focus facility type.

Description

- The line representing the percent of focus facility locations with the risk factor present indicates that the risk factors generally appear in 20 to 30 percent of focus facility type segments.
- MnDOT concluded these percentages are high enough to distinguish between segments, but not so high that most or all segments had the risk factor present (making it difficult to distinguish between segments for prioritization purposes.)
- Additionally, the bars representing segments with the risk factors present show a higher severe lane departure crash density than segments without the risk factor.



Purpose

Summarize the locations based on the number of risk factors present to establish a threshold for selecting candidate locations.

Description

The bars indicate the percent of the system that has the number of risk factors present (i.e., stars received). Additionally the chart shows that the severe crash density and severe lane departure crash density increases as more risk factors are present. MnDOT used this chart to determine that those locations with three or more stars present, approximately 30 percent of the focus facility type, would be candidate locations for systemic safety projects.

Purpose

Review NCHRP 500 Reports, Highway Safety Manual, CMF Clearinghouse, FHWA Office of Safety website, and state Strategic Highway Safety Plans to identify a comprehensive list of potential countermeasures for each focus crash type.

Description

- The key is to review the latest research and other available information to identify those countermeasures with the greatest potential to address the focus crash types.
- The countermeasures will be screened using:
  - Crash data,
  - Effectiveness,
  - Cost, and
  - Agency policies, procedures, and experience.
- The end result will comprise a short list of countermeasures for each focus crash type to use in development projects.

Case Study

Objectives	Countermeasures	Relative Cost to Implement and Operate	Effectiveness	Typical Timeframe for Implementation
15.1 A: Keep vehicles from encroaching on the roadside	15.1A1: Install shoulder rumble strips	Low	Tried	Short
	15.1 A2: Install edgelines "profile marking", edgeline rumble strips or modified shoulder rumble strips on section with narrow or no paved shoulders	Low	Experimental	Short
	15.1 A3: Install midlane rumble strips	Low	Experimental	Short
	15.1 A4: Provide enhanced shoulder or delineation and marking for sharp curves	Low	Tried/Proven/ Experimental	Short
	15.1 A5: Provide improved highway geometry for horizontal curves	High	Proven	Long
	15.1 A6: Provide enhanced pavement markings	Low	Tried	Short
	15.1 A7: Provide skid-resistance pavement surfaces	Moderate	Proven	Medium
	15.1 A8: Apply shoulder treatments — Eliminate shoulder drop-offs — Shoulder edge — Widen and/or pave shoulders	Low	 Experimental Experimental Proven	Medium
15.1 B: Minimize the likelihood of crashing into an object or overturning if the vehicle travels off the shoulder	15.1 B1: Design safer slopes and ditches to prevent rollovers	Moderate	Proven	Medium
	15.1 B2: Remove/relocate objects in hazardous locations	Moderate to High	Proven	Medium
	15.1 B3: Delineate trees or utility poles with retroreflective tape	Low	Experimental	Short
15.1 C: Reduce the severity of the crash	15.1 C1: Improve design of roadside hardware	Moderate to High	Tried	Medium
	15.1 C2: Improve design and application of barrier and attenuation systems	Moderate to High	Tried	Medium

KEY:

Short: (<1 year)
Medium: (1-2 years)
Long: (>2 years)

Source: NCHRP 500 Volume 6 (2003)

Purpose

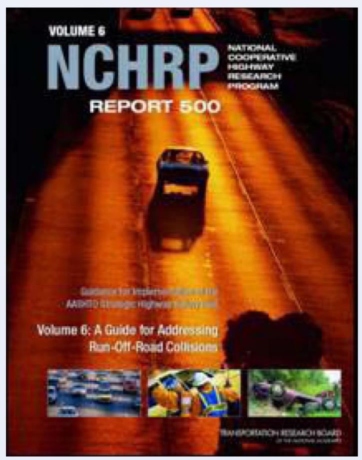
Assemble an initial comprehensive list of countermeasures associated with focus crash type.

Description

Initial list of countermeasures MnDOT identified to reduce road departure crashes using the NCHRP 500 Volume 6 report.

Proven
Graduated drivers licensing
Safety belt enforcement campaigns
DWI checkpoints
Street lights at rural intersections
Access management
Roadside safety initiatives
Pave/widen shoulders
Roundabouts
Exclusive left turn signal phasing
Shoulder rumble strips
Improved roadway alignment
Cable median barrier
Removing unwarranted traffic signals
Removing trees in hazardous locations
Pedestrian crosswalks, sidewalk, and refuge islands
Left turn lanes on urban arterials

Tried
Rumble strips (on the approach to intersections)
Neighborhood traffic control (traffic calming)
Overhead red/yellow flashers
Increased levels of intersection traffic control
Indirect left turn treatments
Restricting turning maneuvers
Pedestrian signals
Improve traffic control devices on minor intersection approaches



Experimental
Turn and bypass lanes at rural intersections
Dynamic warning devices at horizontal curves
Static/dynamic gap assistance devices
Delineating trees in hazardous locations
Marked pedestrian crosswalks at unsignalized intersections

Source: NCHRP 500 Reports

Purpose

Evaluate and screen the initial list of countermeasures based on documented effectiveness of reducing the focus crash types and consistency with the agency's policies, practices, and experiences.

Description

MnDOT used the NCHRP 500 reports to determine an initial estimate of effectiveness with their classification of each countermeasure as Proven (effective), Tried, or Experimental to narrow down the initial list of countermeasures.

Case Study

Objectives	Countermeasures	Relative Cost to Implement and Operate	Effectiveness	Typical Timeframe for Implementation
15.1 A: **Keep vehicles from encroaching on the roadside**	15.1A1: Install shoulder rumble strips	Low	Proven*	Short
	15.1 A2: Install enhanced pavement markings, edgeline rumble strips or modified shoulder rumble strips on section with narrow or no paved shoulders	Low	Experimental/ Tried	Short
	15.1 A3: Install centerline rumble strips	Low	Proven*	Short
	15.1 A4: Provide enhanced shoulder or delineation and marking for sharp curves	Low	Tried/Proven	Short
	15.1 A5: Provide improved highway geometry for horizontal curves	High	Proven	Long
	15.1 A8: Apply shoulder treatments — Eliminate shoulder drop-offs — Shoulder edge — Widen and/or pave shoulders	Moderate*	 Experimental Experimental Proven	—
15.1 B: **Minimize the likelihood of crashing into an object or overturning if the vehicle travels off the shoulder**	15.1 B1: Design safer slopes and ditches to prevent rollovers	Moderate to High*	Proven	Medium
	15.1 B2: Remove/relocate objects in hazardous locations	Moderate to High*	Proven	Medium
Short: (<1 year) Medium: (1-2 years) Long: (>2 years)	* Low: (<$10,000/mile) * Moderate: ($10,000-$100,000/mile) * High: (>$100,000/mile)			

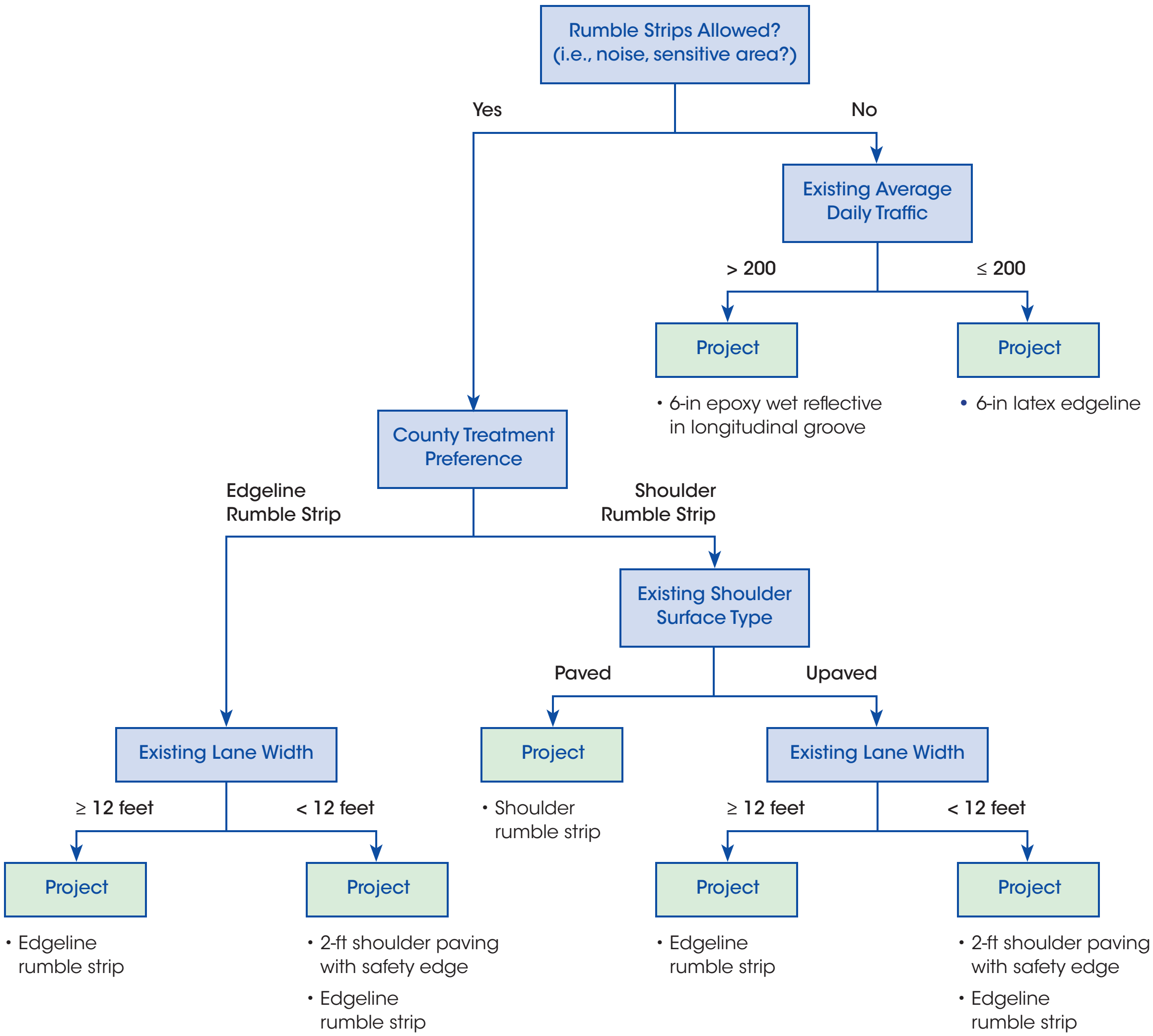
Source: NCHRP 500 Volume 6 (2003) information updated by CH2M HILL (*)

Purpose

Identify and select a few countermeasures for each focus crash type based on the evaluation of the countermeasures and consideration of agency priorities, practices, and policies.

Description

MnDOT paired down the list of countermeasures identified in Task 1 to address road departure crashes based on the evaluation. These countermeasures were selected to develop safety projects.



Purpose

Develop a decision process to facilitate consistency in the selection of countermeasures.

Description

- Adapted from Minnesota County Road Safety Plan Project to represent a typical decision process for selecting roadway departure countermeasures on county roads.
- Utilizes Average Daily Traffic (ADT), lane width, and shoulder surface type to determine project type for rural 2-lane segments.

Key Point

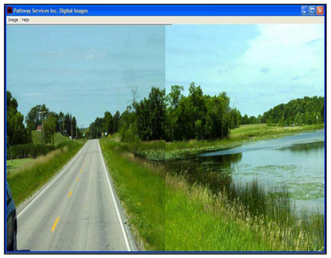
Provides county engineer with opportunity to identify treatment preferences while selecting projects that MnDOT is comfortable funding.

Case Study

County Highway 26 from State Highway 23 to County Highway 15

Roadway Data

Type: County Highway
Number: 6
Start: State Highway 23
End: State Highway 15
City/Rural: Rural
County:
District: 4
ADT: 888
Facility Type: 2-Lane
Lane Width: 12
Shoulder Width: 2
Shoulder Type: Gravel
Length (miles): 8.0
Rumble Installed: None



5-Year Crash Data (2005-2009 MnCMAT Crash Data)

	Type	Road Dept	K+A
Crashes	15	11	1
Density (per mile per year)	0.38	0.28	0.03
Rate (per million vehicle miles of travel)	1.52	1.19	0.11

Ranking Criteria

	Value	Critical	Risk Ranking
ADT Range	634	600 to 1,200	★
Road Departures Density	0.28	0.08	★
Access Density	8.88	4.30	★
Curve Critical Radius Density	0.75	0.59	★
Edge Risk	2	2 or 3	★
			★★★★★

Short List of Countermeasures Considered

	Type	Cost Per Mile	Mileage	Cost
2-ft Shoulder Pave + RS + Safety Edge	Proactive	$40,000	0.0	$0
Rumble Strip	Proactive	$3,000	0.0	$0
Rumble StripE	Proactive	$3,500	6.0	$21,000
6-in Edgelines	Proactive	$650	0.0	$0
Ground in Wet-Reflective Markings	Proactive	$8,500	2.0	$17,000

Note: Noise sensitive area adjacent to Big Lake

Implementation Cost

Federal Funds	$34,200
Local Match (10% of total project cost)	$3,800
Total Project Cost	**$38,000**

Rank: 1
Segment ID: 26.01
Date: 2/12/2011

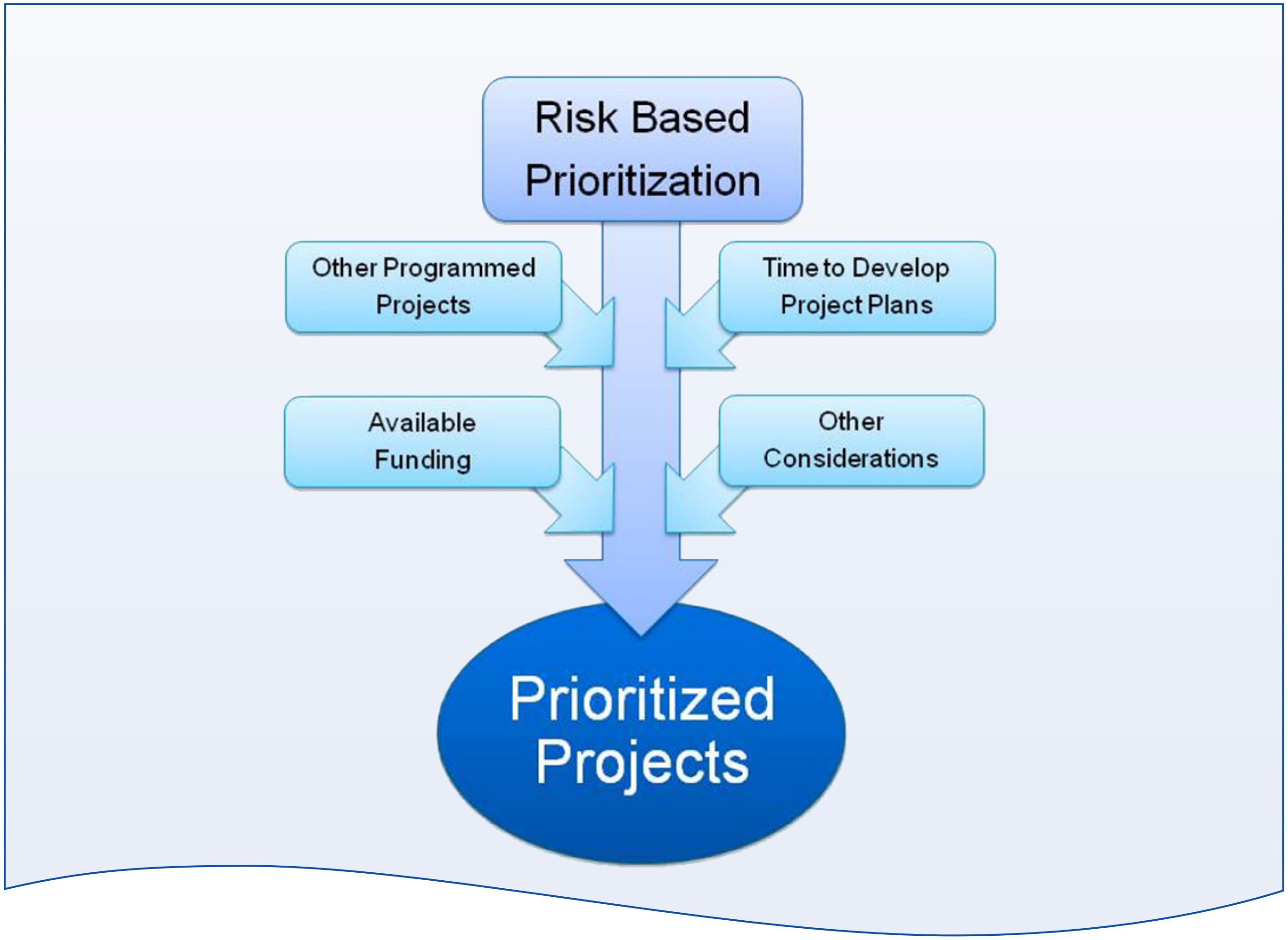
Purpose

Apply decision process to develop specific safety projects for each candidate site selected for safety investment.

Description

- County Highway 26 Segment Project Form (left), provides information on:
    - Roadway Data — Average Daily Traffic (ADT), length, lane width, shoulder width/type
    - Crash Data — total and road departure crashes, density, rate
    - Deficiencies — risk ranking
    - Countermeasures Considered
    - Selected Countermeasure
    - Project Cost
- The table on this page provides regional summaries of the projects identified using the systemic process.

Region	2-ft Shoulder Pave, Rumble Strips, and Safety Edge (miles)	Shoulder Rumble Strips (miles)	Edgeline Rumble Strips (miles)	6-inch Edgelines (miles)	Ground in Wet-Reflective Markings (miles)	Total Project Value
1	180	373	673	50	636	$16,106,107
2	151	147	560	210	180	$10,095,868
3	153	91	332	46	306	$10,196,428
4	106	139	758	200	85	$8,158,210
Total	591	749	2,323	505	1,207	$44,556,613



Purpose

Identify the order in which projects will be implemented.

Description

Prioritizing the projects for implementation will start with the number of risk factors present at a given location. Several other factors may play a role in the selection process, such as funding availability, other programmed projects, time to develop project plans amount of public outreach needed, etc. For example, a lower priority project may be selected over a higher priority project if the location is in an established capital improvement program.

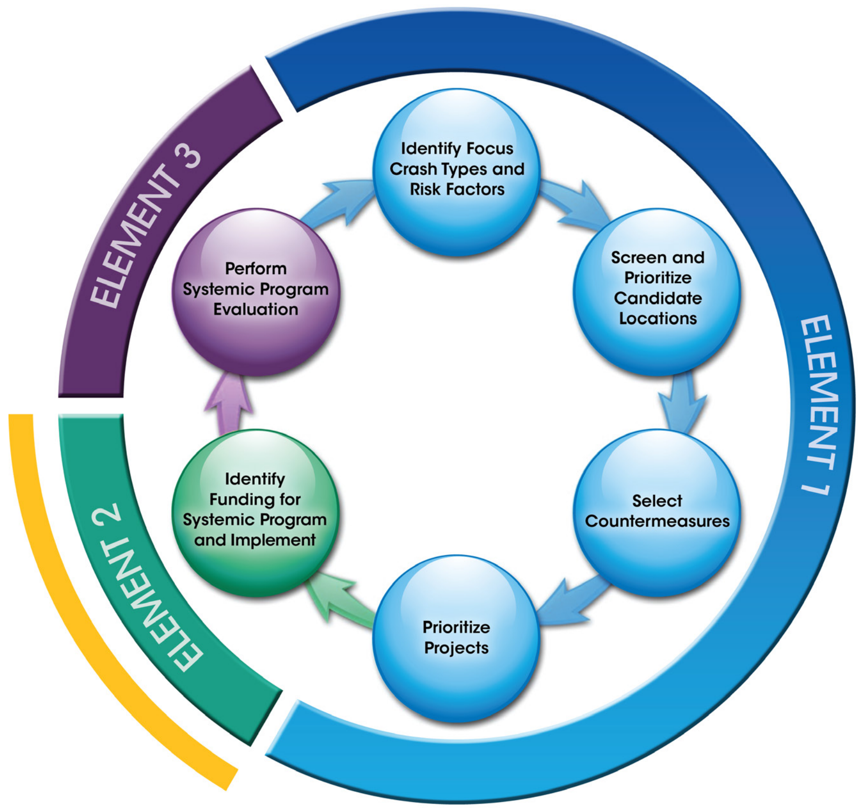
Summary

Element 1 of the Systemic Safety Project Selection Tool presents a general process for conducting systemic safety planning efforts, which is intended to complement an agency's site-specific analysis process—not replace it. This systemic safety planning process involves four steps:

1. Identifying the problem by looking at systemwide data;
2. Screening and prioritizing candidate locations across the network;
3. Selecting relevant mitigating countermeasures most appropriate for broad implementation across those locations; and
4. Prioritizing projects for implementation.

The systemic safety planning process is a data-driven process that identifies the types of crashes which represent the greatest opportunity for substantially reducing the number of severe crashes, the locations that have the greatest potential for severe crashes but do not have a high crash history, and a short list of highly effective countermeasures. The systemic safety planning process is flexible. Any agency can adapt the tool to fit their needs, and this flexibility allows agencies to develop a process that leads to implementation within the constraints of their data availability, program requirements, staff capabilities, and funding. While there can be variation in the detail and time invested or specific actions conducted for each task, the ultimate goal is to direct low-cost, effective countermeasures where the greatest opportunities exist to prevent severe crashes and improve safety.

Element 2:
A Framework for Balancing Systemic and Traditional Safety Investments



Introduction to Balancing Systemic and Traditional Safety Investments

Agencies interested in adding a systemic component to their highway safety program quickly realize their next decision involves determining how to distribute their safety investments among projects identified through the traditional site analysis approach and projects identified through the systemic approach. Element 2 of the Systemic Safety Project Selection Tool provides a framework determining an appropriate balance of safety investments between the site analysis and systemic approaches. The framework supports a program manager's decisions about the general distribution of the safety investments given particular crash and roadway system characteristics. A framework is more appropriate than a prescriptive process because each agency has unique considerations.

Decision Support Framework

The decision support framework begins with a review of historical safety investments and crash history to gain an understanding of past agency decisions. Looking back is often instructive when considering a new path to move forward. The path forward is then based on a combination of understanding the effectiveness of historical safety investments, understanding how an agency's goals, priorities, and crash and roadway characteristics lend themselves to a systemic approach, and assessing the potential benefit to be gained with systemic investment.

Consideration of an agency's goals, priorities, and crash and roadway characteristics provides a safety program manager with useful clues for making decisions about adding a systemic component to their safety program and allocating funding in support of identified projects. Following are some examples of these considerations:

- Adopting a goal to reduce severe crashes suggests a need to include a systemic component to safety management efforts because severe crashes tend to be scattered across a roadway system, making it difficult to isolate high-crash locations.
- Adopting cross-median head-on crashes as a priority suggests a need to include a systemic component because these types of crashes rarely occur at the same location, but supporting data may show that these crashes occur in similar locations (e.g., overrepresented in the vicinity of interchanges).
- Adopting deployment of center-line rumble strips as a priority safety countermeasure suggests the need to include a systemic component because it is rare for multiple severe head-on crashes to occur at the same location.
- Adopting a goal to address safety on the rural secondary system as a priority suggests the need to include a systemic component because, although these road systems often account for a high percentage of severe crashes, they typically have very low crash densities.

Thus, the decision to invest funding in systemic improvements is influenced by program goals rather than justified solely through analysis of the benefits to be gained from implementation and maintenance costs expended.

Review of Past Funding Practices

Reviewing past funding practices helps answer the following questions about an agency's historical investment in safety improvement projects:

- Which countermeasures were implemented?
- Where were countermeasures implemented (i.e., what roadway systems)?
- Which crash types were these countermeasures addressing?
- Were these crash types and countermeasures identified as a priority in the SHSP?
- What was the outcome (i.e., countermeasure influence on focus crashes)?

Answers to these questions provide insight for safety program managers. If the review determines that the historical safety investments were consistent with SHSP priorities, the investments effectively reduced focus crashes, the results of the historical investments were satisfactory, and the same crash types and roadway facilities are expected to be a priority going forward, only a small portion of an agency's safety investments would likely need to be diverted to supporting projects identified through a new systemic approach. However, if the review determines that these criteria were not achieved, then safety program managers might conclude that it may be necessary to redirect safety investments. This new direction might include allocating safety funds to a systemic safety program aimed at proactively deploying low-cost countermeasures systemwide.

Table 2 illustrates an example of one agency's efforts to review their historical highway safety investments. This state's HSIP records were searched, and the investments were disaggregated by project type within three basic categories: Intersection Improvements, Lane Departure Improvements, and Other Improvements. The safety program managers concluded that the Intersection Improvements and Lane Departure Improvements categories were consistent with their SHSP priorities, but several of the specific project types were not. Specifically, the proportion of funding for all safety improvement projects related to traffic signal installation and revisions substantially exceeded the proportion of severe crashes occurring at signalized intersections. In addition, the program managers concluded that within the Lane Departure Improvements category, they had underinvested in road edge enhancements and overinvested in median barriers. This determination was based on crash characteristics that indicated more than seven times as many road departure crashes on two-lane rural roads than cross-median crashes on divided roadways. It is important to understand that the funding distribution was a byproduct of the site analysis approach used to focus on locations with multiple severe crashes. This approach resulted in costly investments at relatively few locations that addressed a small percentage of the total severe crashes. Finally, the safety program managers noted that all of these safety investments were directed toward projects deployed along the state's highway system, but over 40 percent of their severe crashes occurred on the local system. Based on this review, the safety program managers intend to modify their HSIP investments; going forward, a greater portion of their HSIP funds will be directed toward proactive, low-cost road edge improvement projects developed using the systemic safety planning process and located along two-lane roads on both the state and local highway systems.

TABLE 2. Example Historical Highway Safety Improvement Program Funding Review

Funding Category	Project Description	Level of HSIP Funding
Intersections	Turn lanes	$20,000,000
	Turn lanes and signal revisions	$8,000,000
	Install traffic signals	$4,000,000
	Traffic signal revisions	$12,000,000
	Roundabout	$1,000,000
	Intersections Total	**$45,000,000**
Lane Departure	Cable barrier	$27,000,000
	Concrete barrier	$16,000,000
	Centerline rumble strips	$1,000,000
	Edgeline rumble strips	$1,000,000
	Guardrail	$16,000,000
	Shoulders	$9,000,000
	Lane Departure Total	**$70,000,000**
Other	Other Total	**$39,000,000**

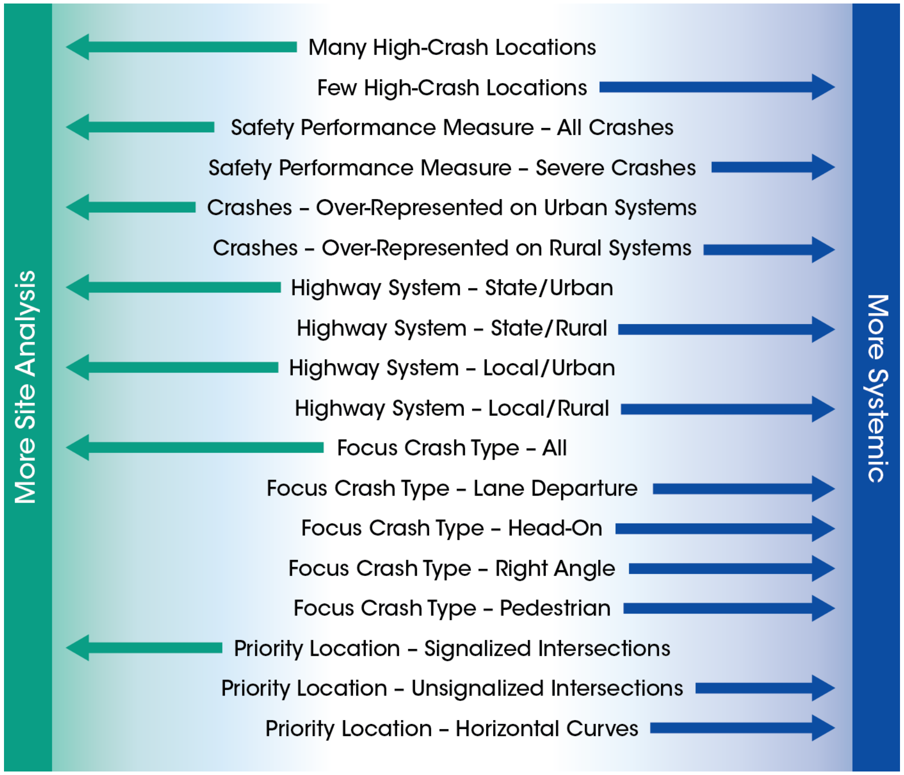
Funding Determination Framework

A funding determination framework assumes two key points. First, there is no suggestion or expectation that any roadway agency's safety program will be 100 percent oriented toward deployment of systemic projects. This framework suggests, however, that in every agency there will be some balance between projects derived from the site analysis approach and projects derived from the systemic approach. The systemic safety planning process to identify candidates for safety investment complements an agency's site analysis approach rather than replaces it. Secondly, there is no suggestion or expectation that one particular portion of the safety investments would apply uniformly across an agency's entire safety program. The balance between projects implemented through each approach is likely different in different regions of a state (e.g., urban versus rural), on different components of the roadway system (e.g., state versus local), and for different focus crash types (e.g., rear end versus road departure crashes).

Agencies should consider a variety of crash and roadway characteristics to determine the balance of safety investments between site analysis and systemic projects. Such considerations suggest a general balance along a safety funding continuum, with one end representing all site analysis projects and the other end representing all systemic projects. Agencies can develop a continuum with characteristics appropriate for their system. **Figure 8** illustrates a continuum using the following recommended characteristics for the funding determination framework:

- **Are there many or few high-crash locations in a system?** Many high-crash locations suggest directing more HSIP funds toward site analysis projects; few high-crash locations suggest directing more HSIP funds toward systemic projects.
- **Is an agency's safety performance measure total crashes or severe crashes?** A performance measure based on total crashes suggests a site analysis safety program; a performance measure based on severe crashes suggests a more systemic safety program.
- **Are crashes (or specific focus crash types) overrepresented in urban or rural areas?** An overrepresentation of crashes in urban areas suggests a site analysis safety program; an overrepresentation of rural crashes suggests a more systemic safety program might be appropriate.
- **What are the identified focus crash types?** A safety program focused on all crash types suggests a site analysis program; a focus on specific crash types suggests a more systemic program.

FIGURE 8. Characteristics to Consider in Balancing the Distribution of Safety Investments



- **What are the identified priority locations?** A focus on signalized intersections suggests a site analysis program; a focus on unsignalized intersections and horizontal curves suggests a more systemic focus.

Example 10 illustrates the application of this funding determination framework by Minnesota DOT, which is now directing a considerable portion of their safety investments to systemic projects. In the two years since adopting this plan, MnDOT has found that their safety investments are consistent with their safety investment goals, and spending on systemic projects is actually slightly above the minimum goals set for both rural and urban areas.

EXAMPLE 10. Minnesota Department of Transportation Application of Funding Determination Framework

MnDOT applied the Funding Determination Framework to assess their decisions related to balancing safety investments between site analysis and systemic projects.

The MnDOT safety program managers shared information they used to support their funds distribution decisions. The following key facts about MnDOT's organization, priorities, and roadway and crash characteristics are relevant to their funding determination process:

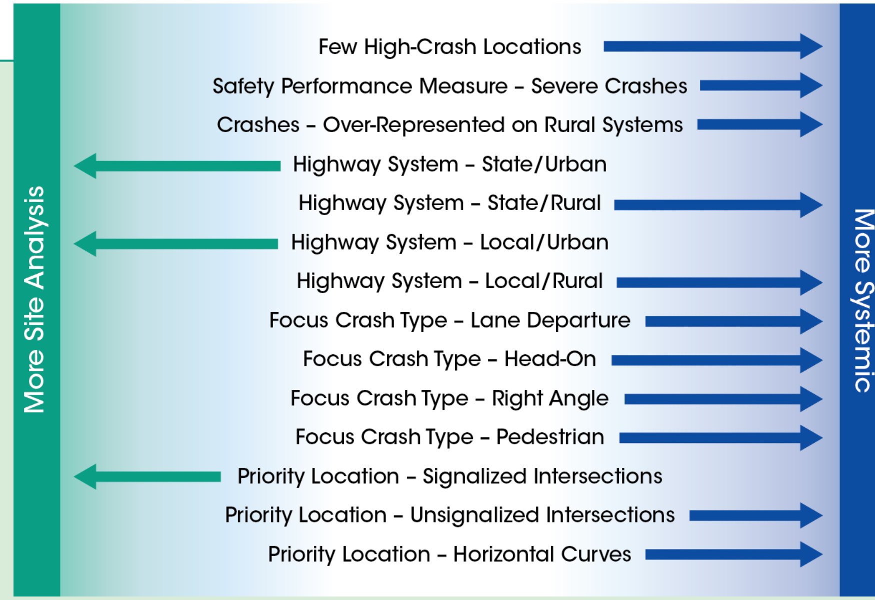
- MnDOT is decentralized, with seven districts in rural areas of the state and one in a major metropolitan area.
- Minnesota has almost 140,000 total miles of roadways; the state system consists of approximately 12,000 miles, and the local secondary system consists of 45,000 miles (which is administered by counties and is virtually all rural).
- MnDOT's adopted safety performance measure is severe crashes, which are almost equally distributed between the state and local secondary system.
- Almost 70 percent of fatal crashes and 60 percent of serious injury crashes occur outside of Minnesota's one major metropolitan area.
- Focus crash types include road departure and angle crashes at unsignalized intersections in rural areas, and angle and pedestrian crashes at signalized intersections in urban areas.
- An additional priority location was determined to be horizontal curves along rural two-lane roadways. Almost 30 percent of all severe road departure crashes on MnDOT's system are in horizontal curves, and more than 50 percent of the severe road departure crashes on the local secondary system are in horizontal curves (by mileage, curves make up less than 10 percent of each of these systems).

To determine a division of their safety investments, MnDOT reviewed historical funding practices and determined that, although severe crashes were almost equally distributed between state and local systems, more than 90 percent of safety investments were directed toward projects on the state system. MnDOT also determined that they did not select projects consistently with priorities indicated by their crash data. Rather, a disproportionate amount of funding had been directed to projects in Minnesota's major urban area, and a disproportionate amount of that funded the traffic signal installation and revision projects. As a result of this review and a commitment in their SHSP to address severe crashes on all roads in the state, MnDOT adopted an entirely new approach to distributing their HSIP funds. The following framework shows the crash and roadway characteristics the safety program managers considered.

Using this information, MnDOT's safety program managers decided their overall safety investments needed to be more systemic than site-specific. To accomplish this, the safety program managers:

- Redistributed their safety funds by district based on the distribution of severe crashes. This resulted in directing 70 percent of their safety funds to the seven districts outside of the metropolitan area, which is the opposite of their historical practice.

Characteristics Considered by MnDOT for Balancing the Distribution of Safety Investments



- Divided the safety funds within each district between the state and the local secondary systems based on the distribution of severe crashes. Statewide, this approach resulted in more than 50 percent of the safety investments being directed toward projects on the local secondary system.
- Analyzed crash characteristics resulting in two conclusions: 1) there were no high crash locations on the local secondary system, and 2) crash densities on the local secondary system were a fraction of those on the state system. The analysis also showed that more than 80 percent of severe crashes were on rural roads; focus crash types were road departure (especially in curves) and angle crashes at through/STOP intersections.
- Directed 100 percent of the safety funds dedicated to local roads to low-cost proactive projects with a focus on dealing with rural road edges, enhanced curve delineation, and STOP-controlled intersections, as a result of the analysis of the crash characteristics.
- Noted that virtually no high crash locations were in their rural districts, and set a goal to direct at least 70 percent of their safety investment to systemic projects on the state system. In the urban district, where some high crash locations did exist, they set a goal to direct at least 30 percent of their safety investment toward systemic projects.

Source: Minnesota Department of Transportation

Programmatic Assessment of the Benefit to be Gained through Systemic Investment

Safety program managers can perform a programmatic evaluation of their systemic safety planning process to help determine how much funding to invest in systemic improvements. One purpose for the programmatic evaluation is to gain an understanding of the expected crash reduction based on different levels of investment in the systemic countermeasures. To assist with gaining this understanding, several states have developed spreadsheet tools (similar to the one shown in **Figure 9**) that estimate the potential crash reduction expected for a systemic program.

These spreadsheet tools use the number of severe crashes or fatalities and serious injuries that occurred across the focus facility type and the size of focus facility type (i.e., number of intersections, curves or miles of roads) (columns with light green shading in Figure 9) to estimate the average annual crash densities (column with dark green shading). With the typical construction cost and applicable crash reduction/ modification factor (columns with light blue shading), a spreadsheet tool can quickly estimate the crash reduction and construction cost (columns with dark blue shading) when testing different levels of deployment (the input by the safety program manager in the column with dark red shading). Including service life, interest rate, maintenance costs, and traffic growth rates (columns with light purple shading) in the tool provides the ability to calculate the benefit-cost ratio for the life of the countermeasure (column with dark purple shading). The output, an estimate of the severe crashes or fatalities and serious injuries that could be prevented across the roadway system, provides safety program managers with information about the value of the systemic investment. Another benefit of this approach to programmatic evaluation is that similar calculations can be completed with the same spreadsheet tool for driver behavior countermeasures, providing documentation about the expected crash or injury reduction for a comprehensive safety management program.

FIGURE 9. Benefit Cost Analysis Spreadsheet *(continued on next page)*

Engineering		Entered Values											
Systemic Countermeasure		Injury Data			Road System Data		Crash Reduction Information		Treatment Costs			Treatment Deployment
		Fatalities	Major Injuries	Years	Mileage or Feature Count	Traffic Growth Rate	CRF	Unit	Unit Cost	Other Annual Cost	Service Life	Amount Deployed
Lane Departure — Rumble Strips on Roads												
Primary Road System *2-Lane*	Edgeline	150	550	5	5,500 miles	1.0%	20%	of run-off-road injuries on paved rural roads	$3,500 miles	$-	10	2,500 miles
	Shoulder	150	550	5	5,500 miles	1.0%	30%	of run-off-road injuries on paved rural roads	$3,000 miles	$-	10	2,500 miles
	Centerline	175	350	5	5,500 miles	1.0%	15%	of head-on injuries on paved rural roads	$3,000 miles	$-	10	300 miles
Secondary Road System *Paved Roads*	Edgeline	250	779	5	17,500 miles	0.5%	20%	of run-off-road injuries on paved rural roads	$3,500 miles	$-	10	2,500 miles
	Shoulder	250	779	5	17,500 miles	0.5%	30%	of run-off-road injuries on paved rural roads	$3,000 miles	$-	10	2,500 miles
	Centerline	50	165	5	17,500 miles	0.5%	15%	of head-on injuries on paved rural roads	$3,000 miles	$-	10	300 miles
Lane Departure — Curve Delineation on Rural Curves												
Primary Road System *2-Lane*	Advance Warning Signs	50	125	5	2,000 curves	1.0%	20%	of injuries in curves on paved rural roads	$1,000 curves	$100	6	1,000 curves
	Chevrons	50	125	5	2,000 curves	1.0%	15%	of injuries in curves on paved rural roads	$3,500 curves	$100	6	1,000 curves
Primary Road System *All Other Roads*	Advance Warning Signs	25	75	5	600 curves	1.0%	20%	of injuries in curves on paved rural roads	$1,000 curves	$100	6	1,000 curves
	Chevrons	25	75	5	600 curves	1.0%	15%	of injuries in curves on paved rural roads	$3,500 curves	$100	6	1,000 curves
Secondary Road System *Paved Roads*	Advance Warning Signs	75	225	5	8,250 curves	0.5%	20%	of injuries in curves on paved rural roads	$500 curves	$100	6	1,000 curves
	Chevrons	75	225	5	8,250 curves	0.5%	15%	of injuries in curves on paved rural roads	$1,500 curves	$100	6	1,000 curves

FIGURE 9. Benefit Cost Analysis Spreadsheet *(continued from previous page)*

Engineering		Computed Values							
		Injury Losses		Benefits			Costs		
Systemic Countermeasure		Value of All Severe Injuries	Average Loss per Severe Injury	Severe Injury Density	Avoided Injuries in First Year	Present Value of Avoided Injury Losses	Initial Cost	Present Value of All Costs	Benefit Cost Ratio
Lane Departure — Rumble Strips on Roads									
Primary Road System *2-Lane*	Edgeline	$657,000,000	$938,571	0.0255	12.73	$101,041,373	$8,750,000	$8,750,000	11.55
	Shoulder	$657,000,000	$938,571	0.0255	19.09	$151,562,059	$7,500,000	$7,500,000	20.21
	Center-line	$696,500,000	$1,326,667	0.0191	0.86	$9,640,454	$900,000	$900,000	10.71
Secondary Road System *Paved Roads*	Edgeline	$1,061,960,000	$1,032,031	0.0118	5.88	$50,261,031	$8,750,000	$8,750,000	5.74
	Shoulder	$1,061,960,000	$1,032,031	0.0118	8.82	$75,391,546	$7,500,000	$7,500,000	10.05
	Center-line	$214,600,000	$998,140	0.0025	0.11	$914,104	$900,000	$900,000	1.02
Lane Departure — Curve Delineation on Rural Curves									
Primary Road System *2-Lane*	Advance Warning Signs	$205,000,000	$1,171,429	0.0175	3.50	$22,012,245	$1,000,000	$1,524,214	14.44
	Chevrons	$205,000,000	$1,171,429	0.0175	2.63	$16,509,184	$3,500,000	$4,024,214	4.10
Primary Road System *All Other Roads*	Advance Warning Signs	$105,500,000	$1,055,000	0.0333	6.67	$37,760,843	$1,000,000	$1,524,214	24.77
	Chevrons	$105,500,000	$1,055,000	0.0333	5.00	$28,320,632	$3,500,000	$4,024,214	7.04
Secondary Road System *Paved Roads*	Advance Warning Signs	$316,500,000	$1,055,000	0.0073	1.45	$8,140,881	$500,000	$1,024,214	7.95
	Chevrons	$316,500,000	$1,055,000	0.0073	1.09	$6,105,661	$1,500,000	$2,024,214	3.02

Summary

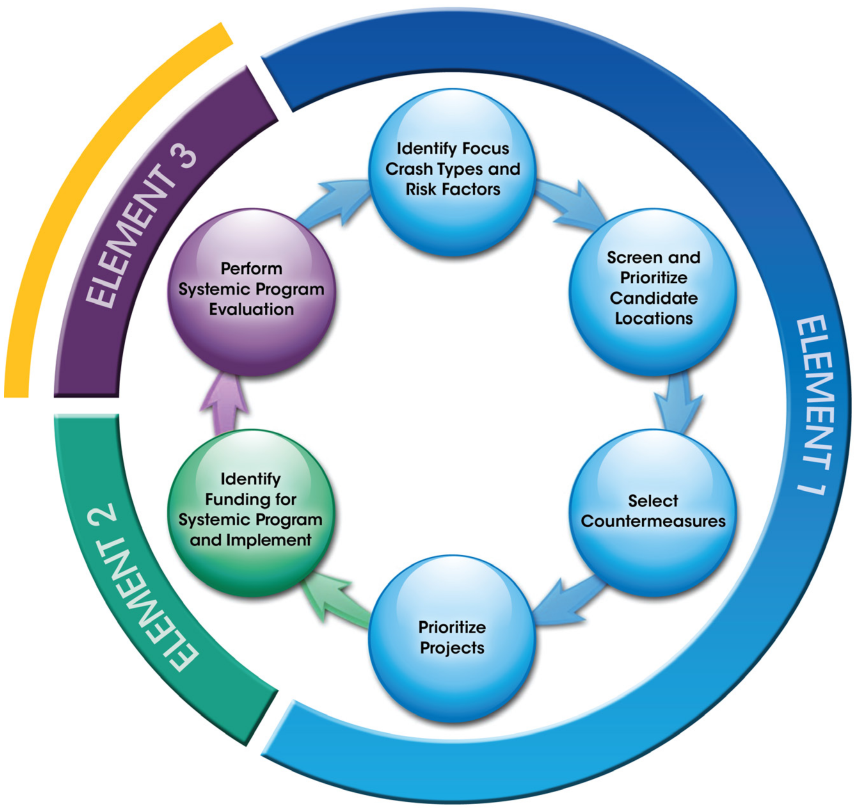
Element 2 of the Systemic Safety Project Selection Tool presents a general framework for balancing site analysis and systemic safety investments. The following three components make up the recommended framework for developing a safety investment plan for systemic and site analysis programs:

- Review past funding practices to provide insight into historical safety spending patterns.
- Apply the funding determination framework to determine the appropriate balance of safety investments.
- Assess the potential benefit to be gained by investing funding in systemic improvements.

Using this data-driven framework, safety program managers can determine general goals for the distribution of safety investments based on crash and roadway characteristics. The framework provides agencies the flexibility to craft funding plans that are consistent with their established goals, priorities, and culture.

There is no precise answer for any agency regarding the distribution of safety investments between candidate projects developed using either a site analysis or systemic approach. Safety program managers are encouraged to decide how to distribute safety investments, move forward, and then review following implementation to determine whether the results are consistent with expectations. If the results indicate a positive effect because of a downward trend in focus crashes, then moving forward would involve continuing along the same safety investment track. If the results were not in line with expectations, then the agency would need to reassess the distribution of the safety investments the following year. The review process continues on an annual basis.

Element 3:
Evaluation of a Systemic Safety Program



Introduction to Systemic Safety Program Evaluation

Systemic safety programs are relatively new and evolving in the United States, as is the practice of evaluating systemic safety program effectiveness. Evaluating the performance of countermeasures implemented in locations that have no recent crash history—but that exhibit other characteristics that indicate the potential for a severe crash—is challenging, especially for specific locations or corridors. However, quantifying effectiveness is a critical aspect of systemic safety planning. Evaluating program performance is the last element of the Systemic Safety Project Selection Tool, and it provides useful feedback into the systemic safety planning process. Effectiveness information gained through the process of evaluating the performance of implemented countermeasures provides input to agencies that is useful for modifying and evolving their safety programs to prevent and reduce more severe crashes. Evaluating effectiveness also addresses an agency's responsibility to invest resources in a way that best serves the traveling public and builds confidence that a systemic safety program is a worthwhile investment.

> Quantification of effectiveness is critical to generate support for the systemic approach and to build institutional and cultural support to invest funding for this type of analysis and implementation.

Another benefit to be gained by evaluating the safety effectiveness of systemic safety improvements is that positive results may generate support for the systemic approach and build institutional and cultural support to invest funding for this type of analysis and implementation. Building institutional support for systemic safety begins with the knowledge gained through the systemic planning process related to the systemic safety program's focus on crash types, facility types, risk factors, and countermeasures to all offices within an agency. This promotion of safety throughout an agency is important because planning, design, operations, and maintenance activities all provide opportunities to implement systemic safety countermeasures on focus facilities. In other words, countermeasures do not have to be implemented solely through dedicated safety projects. Through these additional implementation channels for safety improvements, the systemic approach reaches more locations in less time than safety funding alone accomplishes. Sharing the benefits of the approach helps all agency offices understand the justification for adopting changes and the results expected (i.e., fewer severe crashes) if traditional practices are modified to incorporate systemic safety priorities. Performance evaluation results, especially lives saved and injuries prevented, can be compelling information to bring about changes in business practices within agencies.

This section introduces the safety performance evaluation process for a systemic safety program. As the systemic safety evaluation process is new and continually evolving, this section does not present a process or a framework for evaluation. Instead, the following chapter provides an overview of an approach and potential methods, including the data needs and performance measures for these methods. This chapter also discusses several scenarios agencies might face as they evaluate their program. As the systemic approach to safety evolves and implementation continues, additional research is necessary to confirm systemic safety evaluation techniques.

Data Needs

Data required to evaluate the systemic portion of an agency's safety program depends upon the level of analysis—systemwide versus improved locations. Evaluating improved locations requires the crash, roadway, and traffic data assembled during the systemic safety planning process (Element 1) and for a minimum of three years after implementation, and details about the implementation of specific systemic safety countermeasures. Data required to perform program evaluations include statewide, regionwide or systemwide crash and roadway data within the study area. The countermeasure-specific data are for the actual sites where projects (the term "projects" includes dedicated safety projects as well as safety improvements implemented as one component of a traditional construction or maintenance project like resurfacing or as part of routine maintenance efforts) were implemented and include key, descriptive information about the project type, a detailed definition of the location , site conditions, and documentation of when specific countermeasures were implemented. The *Recommended Protocols for Developing Crash Modification Factors* report describes the collection and use of evaluation data to assess countermeasure effectiveness (Carter, 2012).

Crash data support the effort to evaluate countermeasure effectiveness relative to changes in crash frequency. As a result, it is important to consider statistical reliability, which is highly influenced by sample size. Thus, while crash data would likely be documented on a site-by-site basis, data should ultimately be "rolled up" to represent the entire system along which a particular countermeasure was deployed. This "roll up" of crash data to the system level recognizes that, in the systemic approach, some deployment might take place at locations with a history of no or few crashes, which means that change in crash frequency at specific locations does not sufficiently tell the whole story about effectiveness. Also, rolling the crash data up to the system level maximizes the crash data sample size, which provides the greatest chance for statistical reliability. Analyzing at least three years of crash data after implementation also helps to attain a sufficient sample of crashes.

Although many states evaluate their safety program annually to meet Federal reporting requirements, a countermeasure's effectiveness should not be based on a single year of data.

Suggested Evaluation of Data

Countermeasure

- Definition of improvement implemented at site
- Precise implementation location
- Precise implementation date

Crash Data

- Severe crash data for focus crash type before implementation
- Severe crash data for focus crash type after implementation

Before and After Site Conditions

- Roadway or intersection geometry
- Intersection traffic control device
- Shoulder surface width and type
- Road division
- Median width and type
- Speed limit
- Average daily traffic volumes
- Average daily entering vehicles
- Roadway classification
- Area type (rural/urban/suburban)

Systemic Safety Performance Measures

The Systemic Safety Project Selection Tool relies on severe crash history and other indicators, such as risk factors, to determine future crash potential of particular sites. The resulting widespread deployment of countermeasures is intended to reduce the future crash potential. Therefore, the systemic safety program's effectiveness can be measured by reduced system risk. Depending on the availability of data applied in the project identification process, risk might not be easily quantifiable. Instead, changes in the number of severe focus crash types, especially on the focus facility types, become the long-term performance measurement.

The recommended systemic safety evaluation process occurs at three levels, as follows:

- **Output:** What is the output of the systemic safety program? Is the systemic safety program being implemented as planned and programmed? Are high priority countermeasures being deployed at the right type of locations and at the number of locations planned?
- **Focus Crash Type:** Has implementation effectively reduced the identified focus crash types? That is, are the severe crashes trending down?
- **Countermeasure Performance:** Within each crash type, are deployed countermeasures performing as expected?

The following information provides an overview of these evaluation levels by identifying the purpose of each part of the evaluation and describing a general approach. This overview does not provide step-by-step instructions for specific analysis methodologies. This chapter concludes with sources for additional information to support systemic safety program evaluation efforts.

Systemic Safety Program Output

The first level of evaluation is an interim evaluation because, at such an early stage in program development, the evaluation is of "output," rather than "outcome." A period of at least three years is ideal to evaluate changes in crashes (the outcome); therefore, instead of waiting, agencies should begin annually reviewing their funding decisions to evaluate if selected improvements are consistent with the systemic funding goal (the output). Comparing allocated funding to the planned systemic safety program on an annual basis reveals opportunities to better align the following year's systemic safety programming with program goals. Agencies might need to adjust funding within the systemic allocation or between the systemic and site-specific allocations.

The process of balancing safety investments between projects identified through the site analysis approach versus the systemic approach involves reviewing past funding practices (Element 2) to gain an understanding of whether funded projects were directed toward the focus crash types and facilities identified through the systemic safety planning process (Element 1). Each funding cycle provides the opportunity to perform an interim evaluation using this same review technique. If there is a preference for and more familiarity with historical practices, projects selected for safety funding could easily stray from the focus crash type, focus facility type, or preferred countermeasure in new and evolving systemic safety programs. If this were to happen, then the outcome could very well fall short of what is expected of a systemic safety program.

An output evaluation of the planned funding and implementation, as compared with actual funding, should consider the following:

- Did systemic safety projects reach the dollar amount set as a goal? If a goal was set for individual focus crash types, how do the planned and actual distributions compare? The answers indicate whether the goals for implementing improvements developed through a systemic risk assessment have been achieved.
- Were projects implemented on the focus facility types, especially locations consistent with the identified risk factors?
- Were investments distributed regionally (e.g., by district) and jurisdictionally (i.e., state versus local) as intended?
- Were the preferred countermeasures successfully selected for most candidate locations? The answer provides feedback about the list of priority countermeasures and the effectiveness of the countermeasure selection process.

Answering Some Common Concerns

Q: What if the program fell short of the overall spending goal and more systemic projects should have been implemented?

A: Consider two possible questions that may help to identify the reason:

- Was agency culture a limiting factor? That is, did funding decisions revert to previous practice?
- Were a sufficient number of sites reviewed to fulfill the funding available?

Addressing issues related to the first question requires continued effort to educate peers about the new systemic safety program, possibly providing assistance with selecting projects for programming. The second question addresses the systemic safety program design. Consider whether the problem might be the criteria used to identify which locations were eligible for project programming. A threshold that is overly strict can identify too few locations. Setting lower thresholds will allow the identification of more locations during the project identification process.

Q: What if plenty of locations were identified, but few projects were programmed because the countermeasure did not prove to be implementable at most of the locations?

A: A countermeasure may not be implementable at certain locations because of noise or lighting concerns, roadway cross-section, pavement condition or right-of-way constraints. Consider if the preferred countermeasure is appropriate for the focus facility types, especially locations that rank high in the prioritization process. For those locations where it is not appropriate, return to Element 1 to identify other countermeasures. Also review the decision process created in Element 1 that assigned a project to each location—were several applicable countermeasures assigned properly? Make sure the project selection process has appropriate alternatives with clear guidelines on when they can be used.

Q: There was not an issue with allocating funding, but what if I'm not certain enough locations were improved to make a difference in crash reduction or the potential for crash reduction?

A: A key aspect to a systemic safety program is widespread deployment of effective countermeasures. If funding needs to cover more locations, review the preferred and alternative countermeasures and the decision process that identifies the project type for each location. If the preferred countermeasure is too costly, then search for an alternative that is less costly to implement. Also refine the project type selection process to allow greater use of low-cost countermeasures by ensuring criteria do not allow overuse of higher-cost countermeasures. This decision-making process may be enhanced if CMFs are applied to understand crash reduction potential for the improved locations. An agency can estimate the expected benefits based on the crash reduction for all improved locations.

Observed Trends in Crash Frequency or Severity

The second level of evaluation is based on program-level trends that characterize the impact the countermeasures have on safety. This outcome evaluation addresses questions like *What happened to the number of severe focus crash types, especially on focus facilities?* The systemic safety program focuses on severe crashes using an approach that relies on a long-term outlook across entire roadway systems (e.g., rural freeways, rural county highways, urban signalized intersections). Widespread implementation of systemic countermeasures requires a long-term perspective because several funding cycles may be necessary to fund the improvements, culture change takes time, and at least three years of crash data should be gathered to determine countermeasure effectiveness that is useful for program modifications. Therefore, evaluation also requires a long-term perspective. Continuous long-term tracking is critical for identifying program impacts and useful life.

As previously discussed, communicating the program results is important to encourage agencies to embrace systemic safety efforts in their daily activities and to promote stakeholder and public support for continuing a systemic safety program. Simple charts and graphs are one method to visually disseminate program results to technical or non-technical audiences. A chart that presents information in an easy-to-understand format allows stakeholders and program managers to comprehend the potential relationship between crash reduction and implementation of systemic safety countermeasures. While not a statistical test, these simple tools easily demonstrate the relationship between actions and results to various audiences, including stakeholders, elected officials, and executive management.

Figure 10 is an example of a chart that displays Minnesota's statewide traffic fatalities for certain crash types (total, lane departure, and aggressive/speeding driving) along with the time period when related systemic safety improvement programs were initiated (Minnesota DOT, 2012). The figure shows that total fatalities were on

The NYSDOT has developed a tool to track safety projects to support a "before versus after" evaluation. The tool is called the Post Implementation Evaluation (PIE) System. PIE is organized by project type; documents where the project was implemented and when construction began and was completed; links with the crash record system to document the number of crashes in the before and after periods; and computes a CMF.

FIGURE 10. Program Results for Addressing Lane Departure and Speeding-Related Fatalities

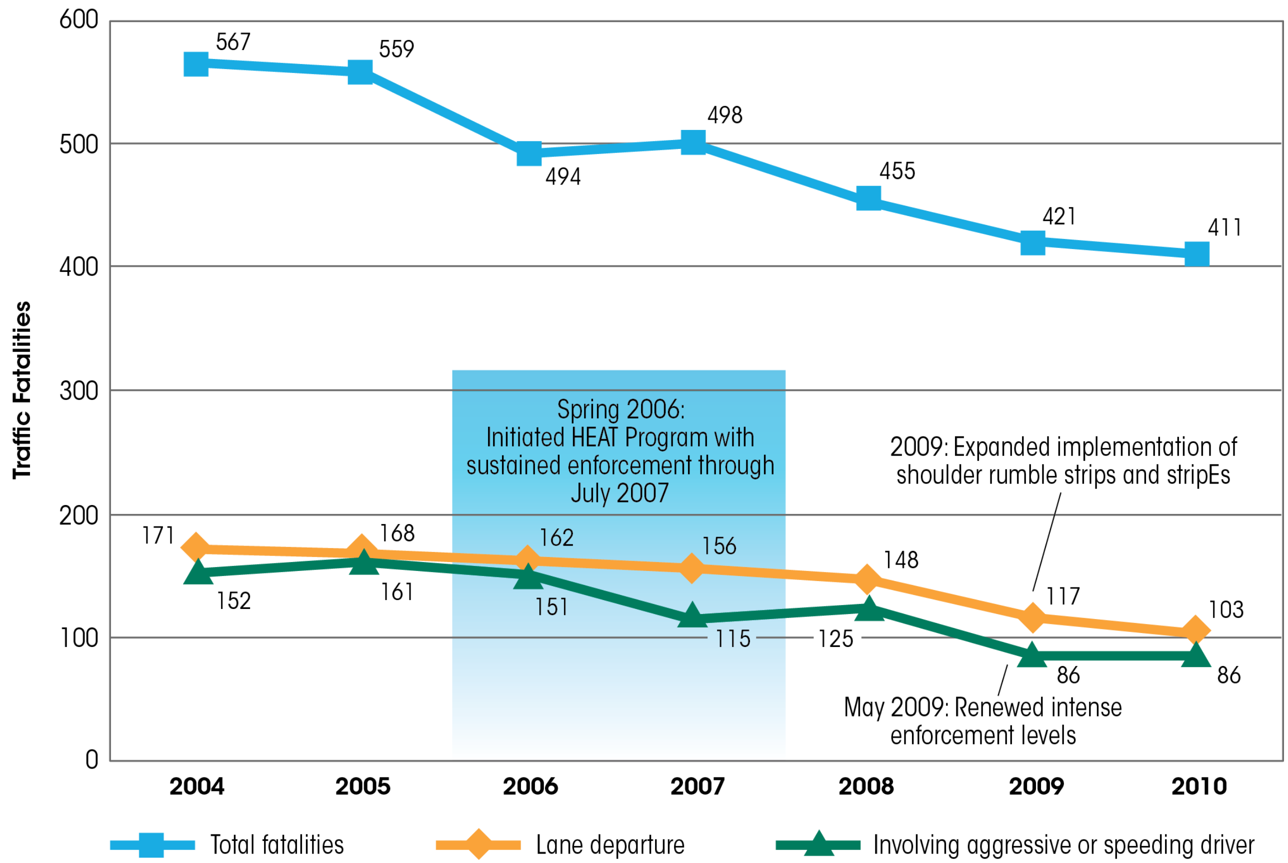
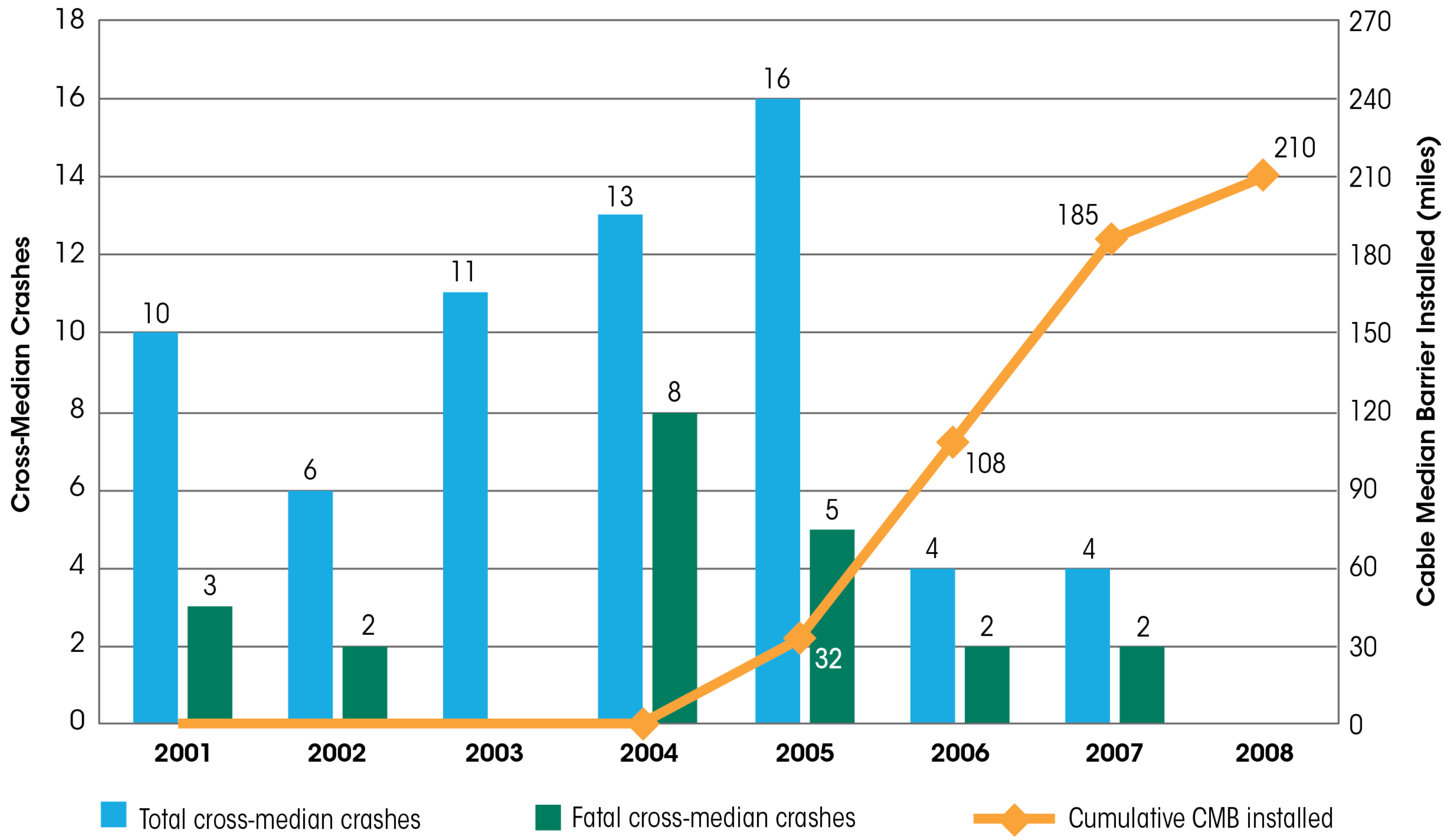


FIGURE 11. Illinois Department of Transportation Illustration of Cable Median Barrier Program Results for Treated Locations



a downward trend starting in 2005. However, lane departure and speeding-related fatalities were relatively constant (or decreasing at a rate slower than total fatalities) until their respective countermeasure programs were initiated. Minnesota began a targeted enforcement campaign called Highway Enforcement of Aggressive Traffic (HEAT) in the spring of 2006. High enforcement levels were sustained through mid-2007 and reinitiated in 2009. Figure 10 illustrates that related fatalities dropped each year of the enforcement campaign. Likewise, MnDOT began widely implementing countermeasures to address lane departure crashes during the 2009 construction program. At about the same time, the data appear to indicate that lane departure fatalities began decreasing at a faster rate. These charts were well received by managers and stakeholders and helped them understand the potential impact the programs had on severe crashes.

In addition to looking at annual totals only, MnDOT separated the data for the portions of the year when HEAT was in effect and when it was not. The analysis revealed that traffic fatalities were occurring at a faster pace than the previous year until HEAT began. Following the initiation of HEAT, the number of fatalities per month decreased and the state finished the year with fewer fatalities than the previous year. This approach focusing specifically on crashes that occurred during the targeted time intervals might better highlight the specific impact of safety programs.

Figure 11 provides a chart showing information about the potential impact of a systemic safety countermeasure on a focus crash type. This chart presents data for a focus facility rather than for all roads in the state, as presented in Figure 10. Figure 11 compares the numbers of total and fatal cross-median crashes (left axis) to the miles of high-tension cable median (HTCM) barrier (right axis) installed between 2005 and 2008 (Illinois DOT, 2009). Prior to HTCM installation, an annual average of 11 total cross-median crashes (range of 6 to 16) and less than 4 fatal cross-median crashes occurred at these locations. The chart data demonstrate that the number of cross-median crashes began decreasing the year after installation began (2006) and continued to decrease to a low of zero during the final year of construction.

This illustration technique was also used to demonstrate the positive results achieved after installing HTCM barrier along Interstate 70 across Missouri (Chandler, 2007). For another example, the NYSDOT report *Centerline Rumble Strips on Secondary Highways: A Systemic Crash Analysis* includes a simple line chart that compares the number of head-on fatality crashes with the installation of centerline rumble strips (NYSDOT, 2011). The same positive result of implementing systemic safety improvements is clearly discernible from the chart. This example is similar to the Minnesota example in that the chart shows statewide data for head-on fatality crashes rather than just data for the improved locations as the Illinois and Missouri examples show.

Another method to communicate a systemic safety program's overall effectiveness is the dissemination of performance metrics such as cost effectiveness or benefit-cost ratio data. The cost-effectiveness performance measure expresses the cost invested to prevent each severe crash—that is, dollars spent per severe crash (or fatal crash or fatality) prevented. From a funding perspective, the lower the cost-effectiveness value or the higher the benefit-cost ratio, the more successful the program is at reducing severe crashes. The method is also useful to compare systemic safety programs addressing different focus crash types as a way to normalize each program. Within a focus crash type, calculating cost-effectiveness values or benefit-cost ratios for individual districts, jurisdictions, and facility types allows comparison of the subareas to understand which parts of the program have been the most successful.

Answering Some Common Concerns

Q: What if I do not see a noticeable change in severe crashes at the program level?

A: To see results at the program level, you will first have to improve enough locations so that results are noticeable. If you have not been able to implement enough projects to observe results systemwide, focus on the locations that have been improved and aggregate the data for all improved locations. Remember to collect data for a sufficient amount of time before any countermeasures are implemented to establish a baseline crash frequency so that impacts are observable. This may reveal effectiveness at the implemented locations that simply is not observable systemwide.

If severe crash reductions are still not visible when looking only at improved locations, you may need to move onto evaluating countermeasure performance. This will provide you greater detail on how specific countermeasures have performed, which could reveal that implementation has been too focused on a specific countermeasure that hasn't proven effective at reducing the severe focus crash type.

Countermeasure Performance

The first two levels of evaluation consider whether or not the systemic component of a safety program is being funded and/or implemented as intended and whether the overall program is a success. The outcome of these evaluations provides feedback about the consistency of an adopted funding goal to direct some fraction of safety investments toward improvements identified through a systemic risk assessment and long-term, systemwide crash trends. The third level of evaluation identifies how individual countermeasures perform on a systemic basis. This information allows program managers to understand the individual parts of the program and identify which countermeasures successfully reduced specific focus crash types and which did not. In the interest of an owner agency's responsibility to invest resources in a way that best serves the traveling public, this third-level evaluation provides the opportunity for agencies to continue directing investments toward effective countermeasures and discontinue funding countermeasures not achieving desired results. However, given that a systemic safety program very likely will direct investments to facilities with few or no crashes, specific locations or corridors should never be evaluated. Instead, all improved locations should be aggregated and evaluated as a single set. This provides an estimate of the countermeasure's effectiveness for a typical facility.

More advanced techniques can play a greater role in this third level of evaluation. These techniques include Empirical Bayes (EB) to account for regression to the mean, multivariable regression to account for more than one independent variable, or confidence tests that determine the level at which the results are statistically reliable. When these methods are not options (e.g., a lack of safety performance functions to apply EB adjustments), then simple techniques (e.g., a before-after evaluation with control sites) can increase the confidence of the results. Also, benefit-cost or cost effectiveness evaluations quantify the crash reductions in monetary terms.

It is important to understand that the approach described here and illustrated by **Example 11** is the best available at this time. Additional research and future studies will define a best practice to evaluate countermeasure performance for systemic projects.

EXAMPLE 11. Missouri Department of Transportation Evaluation Using Empirical Bayes Methodology

The MoDOT applied Empirical Bayes methodology with safety performance functions to evaluate the performance of countermeasures implemented to reduce lane departure crashes.

Using the Empirical Bayes evaluation methodology with safety performance functions, the Missouri Department of Transportation (MoDOT) evaluated their Smooth Roads Initiative (SRI), which improved 2,300 miles of roadways with resurfacing, improved markings, and centerline rumble strips or shoulder/edgeline rumble strips (including combinations of these countermeasures) in 2005 and 2006 (MoDOT, 2011). This evaluation computed a benefit-cost ratio for the improvements and the percent reduction in crashes for fatal crashes, fatal plus disabling injury crashes (also known as severe crashes), and fatal plus all injury crashes. The analysis was structured so that each combination of countermeasures was analyzed for each facility type for which it was implemented.

Disaggregating the analysis to this level of detail allowed MoDOT to understand the degree to which individual countermeasures reduced crashes or the potential for crashes on each facility type. This study of 18 countermeasure combinations concluded that all have statistically significant results with benefit-cost ratios substantially greater than 1.0. Of the 18 combinations, the following four were reported as being particularly cost-effective:

- Wider markings with resurfacing on rural multilane undivided highways: benefit-cost ratio = 146
- Wider markings with resurfacing on urban two-lane highways: benefit-cost ratio = 118
- Wider markings and both centerline and edgeline rumble strips with resurfacing on rural two-lane highways: benefit-cost ratio = 36
- Wider markings without resurfacing on urban multilane divided highways: benefit-cost ratio = 29

MoDOT also conducted an evaluation of a subsequent project that installed edgelines along 650 miles of low volume rural, two-lane roads in 2009. During the two years before the countermeasure was implemented, 105 fatal and injury crashes and 576 total crashes occurred along these roadway segments. During the two years afterward, 46 fatal and injury crashes and 327 total crashes occurred along the same segments.

MoDOT used their Countermeasure Evaluation Tool to perform a "Before vs. After" evaluation. The Countermeasure Evaluation Tool is a customized spreadsheet that incorporates Empirical Bayes methodology to estimate the effectiveness of the implemented countermeasure. The tool was created during the development of Missouri safety performance functions.

The countermeasure effectiveness is based on a comparison of the expected number of crashes with and without the edgeline treatment for the two years before the installation and the two years after the installation of the edgelines in 2009. Data input into the spreadsheet included segment beginning/end mile posts, Average Annual Daily Traffic, crash frequencies for each segment, and roadway type (i.e., rural two-lane undivided).

With regard to the expected number of total crashes, the analysis revealed a 15 percent decrease in crashes occurred after the countermeasure was put into place, including a finding of significance at the 95 percent confidence level (indicating a high degree of certainty that the edgelines contributed to the reduction in total crashes). Based on the expected number of fatal and injury crashes with and without the countermeasure, the analysis found a 19 percent decrease in crashes; however this was not significant at the 90 percent confidence level. Despite a 19 percent decrease in the expected number of fatal and injury crashes following the deployment of edgelines, the relatively low density of injury crashes prevented the result from being statistically significant. While the result was viewed positively by the MoDOT, the result of statistical significance means there is a lesser degree of certainty that the edgelines contributed to the reduction in fatal and injury crashes.

Source: Missouri Department of Transportation

A detailed breakdown of results by countermeasure and facility type (as Example 11 shows) provides the opportunity to refine a systemic safety program by directing subsequent funding to proven projects and countermeasures. These refinements allow agencies to further their efforts to maximize crash reduction by allocating funding where it will provide the greatest benefit toward reducing of the frequency of severe focus crashes.

A benefit of evaluating countermeasures is that the effort directly leads to developing CMFs that are specific for the systemic safety program. These results are useful for the particular agency's efforts to incorporate safety into planning, design, operations, and maintenance projects. These CMFs are also useful to augment the common body of knowledge for systemic safety planning. As mentioned previously, many of the current CMFs were developed from programs that treated locations identified through the site analysis approach and may not be relevant to systemic safety programs. The availability of CMFs developed specifically for systemic safety improvements assists all agencies to better predict potential outcomes of safety countermeasure alternatives.

Program managers might also consider alternative performance measures to determine the effectiveness of individual countermeasures. Results such as reduced travel speeds, changes in citations issued, fewer red-light-running violations, and fewer maintenance repairs might indicate that the countermeasure deployment has changed driver behavior. Additionally, feedback from staff who spend a considerable amount of time in the field (e.g., maintenance staff, law enforcement) or citizens can provide early feedback on countermeasure performance.

Answering Some Common Concerns

Q: What if my countermeasure is sufficiently proven effective, but a systemwide reduction in severe crashes is still not visible?

A: Continue implementing the countermeasure. As deployment increases, systemwide results will become visible.

Q: What if my preferred countermeasure is not proving effective?

A: Begin reviewing the process to identify locations for improvements. Review the risk factors to confirm their ability to indicate potential for a severe focus crash type and as necessary, adjust future risk analysis to compensate for any lessons learned.

Q: If my low-cost preferred countermeasure is not effective as the higher cost alternative, how do I achieve a balance in future implementation?

A: You should strive for a balance that maximizes the number of locations improved by selecting the lower-cost countermeasure where appropriate but relies on the higher cost scenario where justified. For the high priority locations, an analysis that computes the potential crash reduction for different implementation scenarios can help identify the plan that should achieve the greatest system results.

Where to Go for More Information

Several resources provide information about countermeasure evaluation practices, both for individual locations and for systemic safety programs. The following lists a few of these resources:

- The *Highway Safety Manual* (AASHTO, 2010) contains detailed information on countermeasure evaluation in Part B.
- *The Art of Appropriate Evaluation, A Guide for Highway Safety Program Managers* is published by the NHTSA (2008) for use in evaluating traffic safety programs, especially those that focus on driver education and enforcement. The guide contains practical advice that is applicable to systemic engineering programs.
- More detail on the evaluation approach to MoDOT's Smooth Roads Initiative program can be found in the *Benefit/Cost Evaluation of MoDOT's Total Striping and Delineation Program: Phase II – Final Report* (MoDOT, 2011).
- *A Guide to Developing Quality Crash Modification Factors* (FHWA, 2010), provides direction to agencies developing CMFs, including selecting appropriate evaluation methods and data considerations.
- The NCHRP report, *Recommended Protocols for Developing Crash Modification Factors* (Carter, 2012), provides guidance about data to collect and a process to follow for evaluating countermeasures. The report documents protocols that should be used in the development of CMFs, the goal of which is to describe what pieces of the research study should be documented by the study authors and how various potential biases should be addressed.

Summary

Performance evaluation provides useful feedback for safety program decision-making and, as such, is an important aspect of continuing agency efforts to reduce severe crashes. Documenting systemic safety program effectiveness also helps agencies understand the impact a systemic safety program will achieve if incorporated into other standard agency practices for planning, design, operations, and maintenance activities.

Evaluating a systemic safety program comes with unique challenges, especially because implementation is based on risk factors in addition to historical crash performance. Therefore, it is necessary to evaluate the system at a program level and not at individual project sites. The evaluation process includes three levels. The first, an interim evaluation, is a check on output or projects programmed and constructed. This first evaluation is especially important in new systemic safety programs because modifications to the project identification and selection process might be required, and the program will be more successful if these are made sooner rather than later. Tracking long-term performance at the program level is the second level of analysis. Data about systemic countermeasure performance are especially useful for communicating results to stakeholders, executive management, and other interested parties. The third level, evaluating specific countermeasures, allows program managers to understand how individual elements are performing, identify where changes are needed, and adjust future funding to maximize return on investment. As with any evaluation, planning ahead is important. Identifying data needs in advance ensures that all relevant data are gathered at the appropriate time after projects are implemented.

References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ELEMENT 2
ELEMENT 3
Identify Focus Crash Types and Risk Factors
Screen and Prioritize Candidate Locations
Select Countermeasures
Prioritize Projects
Identify Funding for Systemic Program and Implement
Perform Systemic Program Evaluation

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Appendix

ELEMENT 1
ELEMENT 2
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Identify Focus Crash Types and Risk Factors
Screen and Prioritize Candidate Locations
Select Countermeasures
Prioritize Projects
Identify Funding for Systemic Program and Implement
Perform Systemic Program Evaluation

Applying Existing Tools and Resources in a Systemic Safety Program

Agencies can incorporate a systemic safety program into their existing tools and resources along with national resources developed specifically for this purpose. Agencies may also wish to develop customized tools for their safety management system based on data availability, staffing resources, policies, and procedures. This appendix discusses the following national-level tools and provides general advice on the type of tasks and outputs they can support:

- Strategic Highway Safety Plan (SHSP)
- Roadway Departure and Intersection Safety Implementation Plans
- Fatality Analysis Reporting System (FARS)
- Crash Modification Factors (CMF) Clearinghouse
- National Cooperative Highway Research Program (NCHRP) Report 500 and Federal Highway Administration's (FHWA's) Nine Proven Safety Countermeasures
- Highway Safety Manual (HSM)
- SafetyAnalyst and Interactive Highway Safety Design Model (IHSDM)
- United States Road Assessment Program (usRAP)

Strategic Highway Safety Plan

The American Association of Highway and Transportation Officials (AASHTO) SHSP, last updated in 2005, provides a list of contributing factors and crash types that represent the greatest potential to reduce fatal and serious injuries. The topics covered include driver behavior, vehicle type, infrastructure, emergency medical services and data management. Additionally, each state has prepared their own SHSP, using state-level information to identify key emphasis areas within the state. Additionally, many areas are developing regional safety plans for urban areas, counties, or regions/districts. Therefore, it may be appropriate to review all available documents for selected emphasis areas that represent potential focus crash types.

Roadway Departure and Intersection Safety Implementation Plans

FHWA provided several states with assistance in developing implementation plans to address severe roadway departure or intersection crashes. These plans include an analysis of the states' crash data that is directly applicable in Element 1 of the Systemic Safety Project Selection Tool. For example, the roadway departure safety implementation plans include information useful for focus facility type selection. Additionally, the example roadway departure plan also includes information useful to identify average daily traffic (ADT) ranges where severe crashes are concentrated, which could be a risk factor as defined in Element 1 of the Systemic Safety Project Selection Tool. Furthermore, the intersection safety implementation plan methodology suggests an approach to disaggregate total intersection crashes by jurisdiction, urban and rural area types, and traffic control type. This method is similar to the approach highlighted in the Minnesota Department of Transportation (MnDOT) Case Study. Whether the process is applied to severe or total intersection crashes, it can help agencies select the focus facility types (e.g., differentiating the relative importance between urban signalized versus rural STOP controlled intersections). Both plans identify low-cost countermeasures for systematic deployment at locations that meet minimum crash level thresholds. These example countermeasures are appropriate treatments in a systemic safety program and were identified from a process similar to that outlined in the Systemic Safety Project Selection Tool. FHWA has also prepared an example data analysis package that agencies can use if they were not part of the program to develop these plans. Through numerous examples, the example data analysis package provides a framework for roadway and intersection crashes, which agencies can modify as necessary.

The key difference between the implementation plan process and the Systemic Safety Project Selection Tool is the criteria that allow the location to be eligible for treatment. The implementation plan process suggests crash frequency thresholds to identify priority locations and then treating the locations with the highest frequencies. While crash frequency can be a risk factor in the systemic safety planning process, it does not have to be the only criteria used to prioritize locations. Instead, the tool allows the agency to identify multiple risk factors. Thus, a site could be identified as a candidate for safety investment if it has multiple risk factors but no crash history.

Fatality Analysis Reporting System

The National Highway Traffic Safety Administration (NHTSA) maintains an online database of fatal crash records that could be used by agencies with no crash records. These data records contain much of the same information that was suggested for consideration when selecting focus crash types and facility types. However, it contains limited information about the road and traffic characteristics (e.g., shoulder width and type) needed for identifying, evaluating, and selecting risk factors. FARS has an online query tool that creates pin maps to display crash locations. Agencies can use pin maps to locate the fatal crashes within their jurisdiction and identify associated road and traffic characteristics. If there are enough fatal crashes within the jurisdiction, a risk factor can be determined from patterns identified in the crash characteristics.

Crash Modification Factors Clearinghouse

The CMF Clearinghouse is an online, searchable database of CMFs from past safety effectiveness studies. The FHWA allows researchers to submit recently completed studies to keep the information current. Submitted studies are rated to provide the Clearinghouse user with information about the quality of the study design and reliability of the results.

The CMF Clearinghouse can serve two purposes in a systemic safety planning process. The first is identifying and selecting countermeasures. The searchable database allows users to identify countermeasures that address the focus crash type for the focus facility type. The CMF and the study's quality rating are used to determine whether the specific countermeasure is reliable and appropriate for a systemic safety program.

The CMF Clearinghouse is also beneficial for instances where an agency does not have the capability to link crash records with road or traffic information for the purpose of identifying characteristics that are overrepresented in severe crashes, i.e., risk factors. Reviewing local crash records is the preferred way to select risk factors; however, information from the CMF Clearinghouse can identify characteristics found through research to have a proven impact on safety performance. For example, narrow travel lanes and shoulder surface type are roadway characteristics with CMFs available in the Clearinghouse for which an agency could use as potential risk factors for a rural lane departure focus crash type. When using CMFs in this way, make sure the facility types in the study are representative of the systemic safety program's focus facility types. For example, lane width CMFs from rural or interstate studies are not appropriate to consider for an urban program. If available, state or local studies can augment the consideration and may help confirm if the characteristic is a risk factor within the jurisdiction.

When using CMFs from the Clearinghouse or any other source, it is important to note that some CMFs were developed from before-after studies when the countermeasure was implemented at a high crash location. Not enough information is available at this time to determine how appropriate these CMFs might be for predicting the success of a systemic safety program. Specifically, it is unknown whether the countermeasure will be as effective at reducing crashes in a systemic safety program as it was for a specific location identified through the site analysis approach. Until systemic safety programs mature and are evaluated, understand that some CMFs may not accurately reflect expected outcomes of a countermeasure implementation on a systemic basis.

NCHRP Report 500 and FHWA's Nine Proven Safety Countermeasures

The NCHRP Report 500 series and FHWA's Nine Proven Safety Countermeasures provide a similar resource to the CMF Clearinghouse. The NCHRP Report 500 series is a 24-volume set that contains hundreds of countermeasures covering topics in the areas of engineering, enforcement, education, emergency medical services, and data management. Each document provides information regarding implementation cost and what was known regarding effectiveness when the guide was published. (Note: The CMF Clearinghouse may contain results from newer studies. Countermeasures identified in the NCHRP 500 series should be checked in the CMF Clearinghouse to find the latest available safety effectiveness information.) The Nine Proven Safety Countermeasures, first published in 2008 and updated in 2012, generally represent low-cost countermeasures appropriate for systemwide implementation.

Like the CMF Clearinghouse, these resources assist with assembling an initial list of countermeasures for the systemic safety program. Like the CMF Clearinghouse, these resources may help identify characteristics that could be used as risk factors if local crash data cannot be linked with geometric and traffic data sets.

The Highway Safety Manual

The HSM represents a collection of information and recommended practices for safety management and evaluation. Currently, the HSM includes predictive methods for rural two-lane, rural multi-lane, and urban/suburban arterials. The basis of the predictive method is crash prediction models, which are equations that use geometry, traffic and/or land use information to predict annual crash frequency for an intersection or a roadway segment. As research continues, AASHTO will update the HSM with new predictive methods and CMFs.

The HSM predictive method represents two potential uses for a systemic safety program. The first potential use is a means to identify risk factors. Based on national-level research, the inputs into the predictive method are found to directly impact crash frequency. In fact, some of the inputs (e.g., bus stops, schools, alcohol sales establishments) for the vehicle-pedestrian prediction model are surrogates to identify areas with high pedestrian densities or possibly at-risk users, such as school-age children. These factors do not necessarily cause crashes, but the models acknowledge that their presence indicates greater potential for a vehicle-pedestrian crash. Therefore, predictive method inputs could be considered as potential risk factors in a systemic safety program. Using the output of the crash prediction models is a second potential application of the HSM for a systemic safety program. The models provide a predicted average number of crashes per year, which is an estimate of the average crash potential for the site, i.e., a measurement of risk. In some cases, crash prediction model results are separated by severity and/or crash types, and then the different severities and crash types are summed together to generate the total crash potential. In such a case, the result that most closely matches the focus crash type is the ideal choice. For example, a predictive method may have one model which predicts single vehicle crashes resulting in fatalities or injuries. This might be the best and most direct comparison if the focus crash type is fatal road departure crashes and may be a more appropriate estimate of the risk being addressed by the systemic safety program than total predicted crashes. Likewise, instead of total predicted crashes, a pedestrian systemic safety program could incorporate the results of a vehicle-pedestrian crash prediction model.

SafetyAnalyst and Interactive Highway Safety Design Model

SafetyAnalyst and IHSDM are software programs that provide state-of-the-art analytical tools useful to identify and manage a systemwide program of site-specific improvements that enhance highway safety. SafetyAnalyst is capable of summarizing crashes by type and facility, which is useful to identify focus crash types and focus facilities. Additionally, SafetyAnalyst can apply the HSM predictive method for locations with data input into the software. Therefore, an agency with their system imported into the software could apply the predicted method as a means to quantify risk potential. Additionally, the systemic analysis for prioritizing locations could use some of the methods in the network screening module.

IHSDM applies the HSM predictive methods for existing and proposed corridors. The software performs detailed design reviews of corridors and is not a tool applicable to network screening. As a result, IHSDM's application in a systemic safety program is to complete a thorough estimate of crash reduction when multiple countermeasures are considered.

United States Road Assessment Program

The U.S. Road Assessment Program (usRAP), sponsored by the AAA Foundation for Traffic Safety, systematically addresses risk to identify locations where fatal and serious injury crashes can be reduced by implementing countermeasures. usRAP aims to ensure that highway infrastructure improvements are programmed based on rational assessment of risk. usRAP has developed a risk-mapping protocol that highway agencies can use to create color-coded risk maps that show variations in the level of crash risk across a road network. The results can guide priorities for highway infrastructure improvements and targeted enforcement strategies. usRAP also provides highway agencies with usRAP Tools software that can develop a recommended program of location-specific crash countermeasures for any road network based on benefit-cost analysis. A strength of the usRAP Tools software is that it uses input data based on roadway and traffic control features to assess risk and does not require site-specific crash data. While the usRAP Tools software can be used by any highway agency, it is particularly well suited for highway agencies that lack good crash data or have lower volume roads with sparse crash experience. The roadway and traffic control input data can be obtained from existing highway agency databases or, with simple training, can be coded from Internet-based photo images with an average of 20 minutes of labor per mile.

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HSIP Highway Safety Improvement Program
Data Driven Decisions