Applying Safety Data and Analysis to Performance-Based Transportation Planning

November 2015

Safe Roads for a Safer Future

Investment in roadway safety saves lives

U.S. Department of Transportation

Federal Highway Administration

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Technical Report Documentation Page

1. Report No. FHWA-SA-15-089	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Applying Safety Data and Analysis to Performance-Based Transportation Planning		**5. Report Date** November 2015
		6. Performing Organization Code
7. Author(s) Nicole Waldheim, Elizabeth Wemple, P.E., Joseph Fish		**8. Performing Organization Report No.**
9. Performing Organization Name And Address Cambridge Systematics, Inc. 4800 Hampden Lane, Suite 800 Bethesda, MD 20814		**10. Work Unit No. (TRAIS)**
		11. Contract or Grant No. DTFH61-10-D-00020-T-14-020
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Highway Administration Office of Safety 1200 New Jersey Avenue, SE Washington, DC 20590		**13. Type of Report and Period Covered** Technical Report, September 2014 through October 2015
		14. Sponsoring Agency Code FHWA

15. Supplementary Notes

FHWA Project Manager (COTM): Chimai Ngo

Technical Panel: Dave Harris, Esther Strawder, and Jim Thorne

Additional FHWA Reviewers: Rob Ritter, James Garland, Ray Krammes, Lorrie Lau, Tameka Macon, Michelle Noch, Kevin Burgess, Rob Ayers, Keith Harrison, Gene Amparano, Bob Pollack, Danielle Betkey, Marc Starnes, and Stuart Thompson.

The FHWA Division Offices also provided inputs at the beginning of the project.

16. Abstract

This guidebook provides State departments of transportation (DOT) and metropolitan planning organization (MPO) planners with a framework for navigating the fundamentals and advanced methods of safety data collection and analysis. It also demonstrates how the results of that analysis can be applied to the performance-based transportation planning process to develop safety goals, objectives, performance measures, and targets; identify and prioritize projects; and evaluate progress towards safety priorities.

17. Key Words Transportation safety planning, crash data, data collection, data analysis, performance-based planning	**18. Distribution Statement** No restrictions

19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No. of Pages** 100	**22. Price** N/A

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

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1.0 Introduction

This guidebook provides State departments of transportation (DOT) and metropolitan planning organization (MPO) planners with a framework for navigating the fundamentals and advanced methods of safety data collection and analysis. It also demonstrates how the results of that analysis can be applied to the performance-based transportation planning process to develop safety goals, objectives, performance measures, and targets; identify and prioritize projects; and evaluate progress towards safety priorities.

Performance-based planning is not a new concept—for years transportation agencies have been tracking performance metrics, using the results to identify program and project investments to positively impact the system. Moving Ahead for Progress in the 21st Century Act (MAP-21), continues the focus on performance measurement, requiring State DOTs and MPOs to demonstrate progress in meeting seven national goals. One of the national goal areas is safety. Planners will track annual performance for number of fatalities and serious injuries and fatality and serious injury rate. The process for setting and tracking safety performance measures includes the following:

- Reviewing past, current, and future (if possible) safety trends—where are we now?
- Developing safety goals, objectives, measures, and targets—where do we want to go?
- Identifying transportation safety programs and projects to achieve results—how do we get there?
- Monitoring and evaluation—how are we doing?

This approach to safety fits within the context of the traditional transportation planning process, which agencies already use to set goals and objectives, complete data analyses, identify programs and projects, and evaluate progress towards safety priorities. Incorporating safety performance into the existing transportation planning process does not need to be complicated, but will require planners to understand and have access to safety data and analysis tools.

2.0 Audience, Purpose, and Guidebook Structure

2.1 Who Should Use this Guidebook?

Integrating safety in the transportation planning process requires many different considerations, one of which is using qualitative and quantitative analysis to understand the safety issues and trends, identify programs and projects, and evaluate the results. This guidebook will help transportation planners at DOTs and MPOs understand what types of safety data to use and where they can be accessed; analysis techniques to understand the key concerns; and opportunities to use the data and analysis to inform planning decisions. Practitioner examples are included throughout to demonstrate realistic approaches to addressing each of these topics.

2.2 Why the Guidebook is a Useful Tool?

Currently available literature and resources related to safety data, analysis, or planning typically focus on certain components of the process, such as types of safety data or how to use certain analysis tools. This guidebook provides users with a step-by-step approach for putting data and analysis together to inform safety decisions in the transportation planning process. Figure 2.1 demonstrates the type of questions this guidebook will help answer.

Figure 2.1 Flowchart. Guidebook Outline

Data Collection

- What types of data are available to address safety?
- What are data limitations and opportunities?
- Where can I go to obtain data?

→

Data Analysis

- What safety analysis tools and methods are available for the transportation planning process?
- How do they work and what do they tell me?
- What are examples of tools and methods in practice?

→

Application to Transportation Planning Process

- How does my agency use the results of the data analysis to develop safety goals, objectives, performance measures, and programs/projects?

Source: Cambridge Systematics, Inc.

2.3 Guidebook Components

The guidebook contains background information, strategies, and examples to help transportation planners obtain data, understand safety analysis tools/methods, and utilize the results to inform a data-driven transportation planning process. The following describes the contents of the guidebook.

2.3.1 Performance-Based Planning Process

Chapter 3 presents an overview of the performance-based transportation planning process and the opportunities to consider safety when setting goals and objectives, developing performance measures and targets, and identifying programs and projects. Topics addressed are:

- The transportation planning process;
- Considering safety in the transportation planning process; and
- Strategic Highway Safety Plans (SHSP) and how they serve as a resource.

2.3.2 Getting Started with Transportation Safety Planning—Data Collection

Chapter 4 discusses the opportunities to identify and use available data to consider safety during the transportation planning process. Topics addressed are:

- Institutional considerations necessary to initiate and sustain data collection efforts.
- Types of safety data and how they can inform transportation planning.
- Considerations, such as data quality, completeness, gaps, and availability. This also will include a discussion on overcoming potential data limitations to provide planners with ideas to initiate safety planning with limited data.
- Methods in which agencies can obtain data to initiate data analysis.

2.3.3 Safety Analysis Questions and Tools

Chapter 5 discusses the array of tools, methods, or approaches that planners can utilize to analyze safety data for application to the transportation planning process. Topics addressed are:

- Institutional considerations necessary to initiate and sustain safety analysis.
- Planning- and project-level analysis tools and methods and their functionality. With so many available tools and methods, this section focuses on those that are practical, affordable, and easy to use for planners.

- Analysis approaches and their relationships to the transportation planning process, including several examples from MPOs and DOTs.

2.3.4 Applying Safety Data and Analysis to Inform Decisionmaking

Chapter 6 discusses how the outputs of the data analysis can be used to inform the inclusion of safety in the transportation planning process, namely, safety goals, objectives, performance measures, and programs and projects. Topics addressed are:

- Institutional considerations necessary to initiate and sustain transportation safety planning; and
- How to use data and analysis to:
  - Develop safety goals and objectives;
  - Develop safety performance measures; and
  - Identify and prioritize transportation safety programs and projects.

3.0 Performance-Based Planning Processes

A key outcome of this guidebook is to describe how data (crash, roadway characteristics, vehicle miles traveled (VMT), etc.) and the outputs of analysis can be used by planners during the transportation planning processes to develop safety goals, objectives, performance measures, and targets; identify and prioritize projects; and evaluate progress towards safety priorities. States often possess robust safety data, and planners have the skills and tools to analyze an array of crash information to inform *safety-specific* plans or *safety components* of transportation plans. However, all too often, data and analysis are not used to inform safety considerations in all transportation decisionmaking and project prioritization.

The basics of the transportation planning process and opportunities to incorporate the outputs of safety analysis into that process are presented in this section. The goal is to help planners develop a performance-based framework for lowering fatalities and serious injuries. This section also provides an overview of SHSPs, describing how they may serve as a resource.

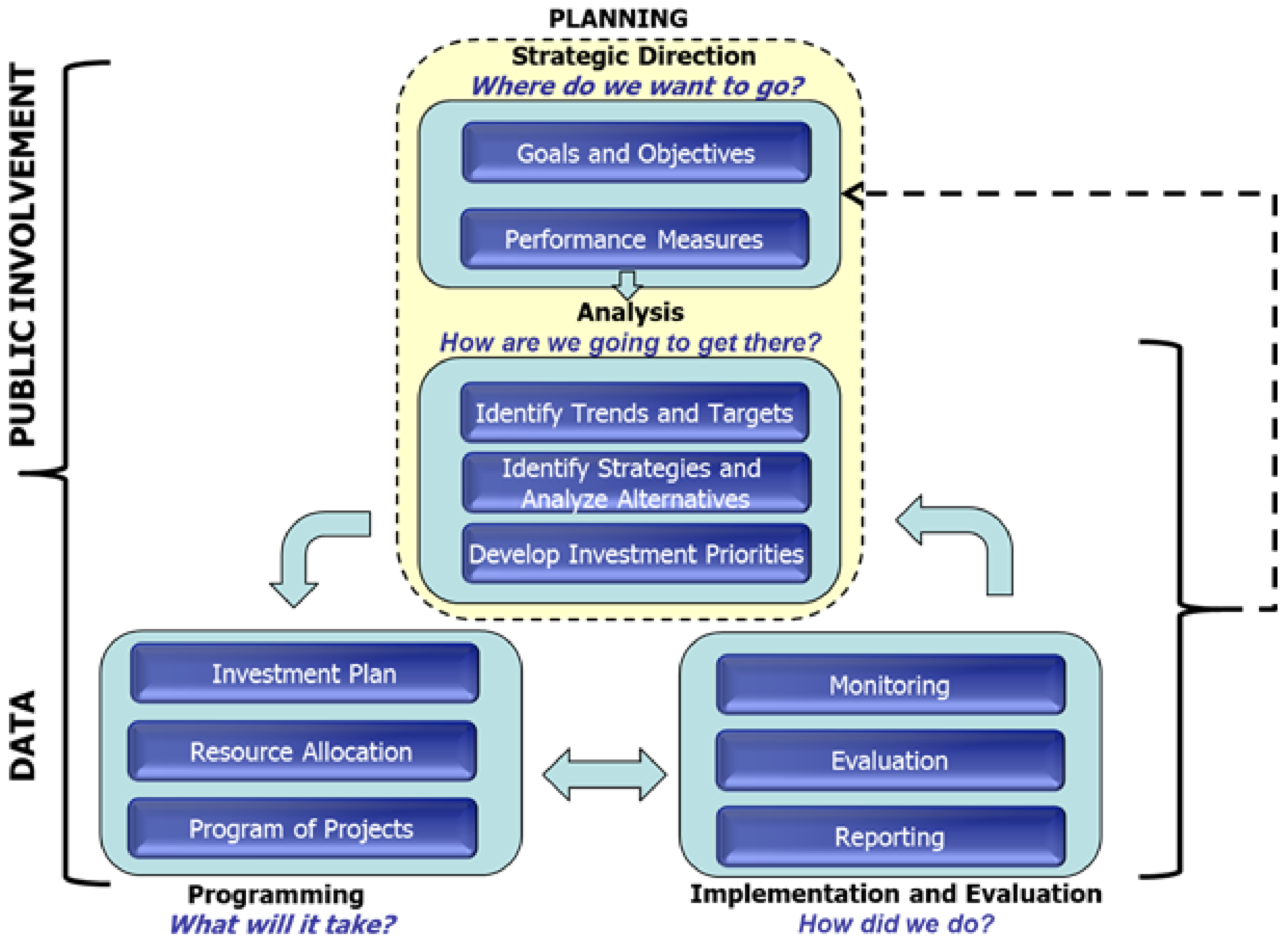
3.1 The Transportation Planning Process

Transportation plans come in many different varieties. Long-range transportation plans (LRTP) define an overarching vision for the future transportation system; establish goals and objectives that clarify and operationalize that vision; and guide the selection of transportation policies, programs, and projects consistent with the goals. Modal plans (i.e., bicycle/pedestrian, freight) function in the same way as long-range plans, but typically are focused on one transportation topic and identify short-, mid-, and long-term policies, programs, and projects. Corridor plans address a range of transportation topics or modal priorities along a certain portion of the transportation network and also identify short-, mid-, and long-term policies, programs, and projects. **Regardless of the type of plan, the ultimate goal is the same—use a performance-based transportation planning process to identify programmatic, policy, and project priorities to address current and future needs.** Figure 3.1 outlines a goal-driven process that can be used to construct any transportation planning document.

Why is "Data Driven" so Important to the Planning Process?

Transportation programs and projects need to demonstrate how they address the most pressing needs. Data allows planners to develop goals, objectives, performance measures, and targets, and to quantify the impacts of policies, programs, and projects.

Figure 3.1 Flowchart. Federal Highway Administration (FHWA) Performance-Based Planning and Programming Framework



Source: FHWA Performance-Based Planning and Programming Guidebook, September 2013.

Agencies may use different terminology or approach performance-based planning in slightly different ways than what is illustrated in figure 3.1, but the core planning tasks often include:

- **Data collection and analysis** to identify needs, priorities, policies, programs, and projects;
- **Goals and objectives** to frame those needs and priorities and establish evaluation criteria;
- **Performance measures and targets** to evaluate alternatives and track progress towards the goals and objectives;
- **Project prioritization and programming** to identify the mix of projects that meet the goals and objectives of the plan and contribute progress towards the performance target; and

- **Evaluation** to understand the extent to which safety performance for the transportation system, modes, or behaviors is changing and where future investments can be made.

3.1.1 Data Collection and Analysis

To initiate a planning process, planners obtain data to analyze current and future transportation issues and needs. Traditionally, issues and needs relate to capacity constraints, connectivity gaps, or system preservation. This analysis leads to the identification of goals and objectives, various transportation improvement strategies, and ultimately project priorities and investments to address those needs.

3.1.2 Goals and Objectives

Planners coordinate with stakeholders and the public, and consult data to develop goals and objectives. Goals define a desired result, or outcome, while objectives support the goal by providing additional details, or strategies, on how the goal will be achieved. Goals and objectives provide the framework necessary for planners to identify transportation programs and projects.

3.1.3 Performance Measures and Targets

Performance measures are tied to goals and objectives and are used to assess the effectiveness of programs and projects that address transportation issues and deficiencies (i.e., Will this project/program improve air quality? Will it reduce the number of fatalities? Will it increase person throughput?). Performance targets are a numeric goal and describe the extent to which an agency will address its goals, taking into account resources and funding (i.e., conformity attainment by 2015, 5 percent reduction in fatalities by 2020, 10 percent increase in person throughput by 2025).

3.1.4 Project Prioritization and Programming

Project prioritization is an evaluation process to identify the transportation programs and projects that best support the overall goals and/or objectives of the plan and help an agency make progress towards its performance targets with available resources. Agencies often develop a scoring/ranking methodology and identify evaluation criteria in which to assess the value and costs of transportation projects.

3.1.5 Evaluation

Transportation systems or specific projects can be evaluated to understand the extent to which crashes, fatalities, and/or serious injuries are increasing or decreasing. Many agencies use performance measures and targets to track and then evaluate progress towards programmatic safety goals and objectives. Some may also assess and evaluate the reduction potential for certain projects. Both programmatic and project evaluation provide information on how and where to invest limited resources.

Each of these individual planning tasks builds upon one another to form a framework, or process, for identifying and programming transportation priorities. The next section goes on to discuss how safety can be included during these tasks to lower fatalities and serious injuries.

3.2 The Strategic Highway Safety Planning Process

State DOTs are required to develop Strategic Highway Safety Plans (SHSP) in a cooperative process with Local, State, Federal, Tribal, and other safety stakeholders. This includes regional and metropolitan transportation planning organizations and county transportation officials. It is a data-driven plan that presents a framework for reducing fatalities and serious injuries on all public roads in the State. Each State's SHSP identifies safety problems, as well as key emphasis areas that direct safety resources for all public roads. For these plans, crash data and analysis must be used to inform selection of safety emphasis areas and strategies. Federal, State, and other funds can be used for efforts that support the priorities and strategies in the SHSP. For example, HSIP funds are applied to projects and initiatives that are consistent with the emphasis areas and strategies found in their State's SHSP. National Highway Traffic Safety Administration (NHTSA) funds (e.g., Section 402 (23 CFR Part 1200) and 405 (23 CFR Parts 1200.21, 1200.22, 1200.23, 1200.23(5), 1200.24, 1200.25, 1200.26, and 1200.20(e)(3)) also are often used to fund SHSP-related projects, particularly those related to behavioral countermeasures.

The SHSP is intended to be a coordinated planning effort. Legislation encourages coordination of the SHSP with various other planning documents (i.e., Highway Safety Plan (HSP), Commercial Vehicle Safety Plan (CVSP), local plans, etc.) and the LRTP must integrate directly, or by reference, the goals, objectives, performance measures, and targets described in other State transportation plans, such as the SHSP. The SHSP is an extremely useful tool, complimenting and enhancing safety efforts conducted during the transportation planning process. The relationship between the two documents is further described in Section 3.2.1.

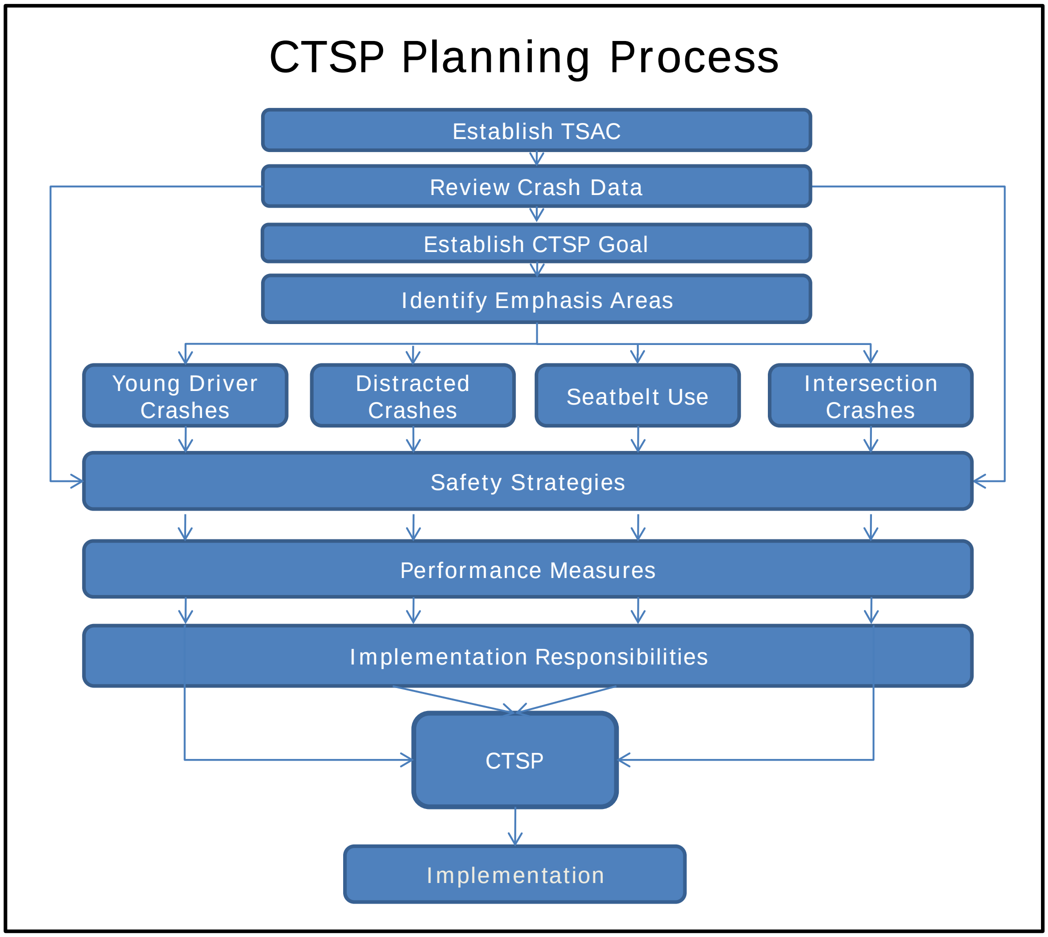
3.2.1 The SHSP Data-Driven Planning Process

The SHSP development and update process can be a model for planners interested in a data-driven approach to identifying safety programs and projects. The *SHSP Champion's Guidebook, Second Edition* provides the basic structure for SHSP development, including data collection and analysis; SHSP content (performance measures, goals and objectives, emphasis areas); and SHSP preparation (plan format). State and regional agencies interested in identifying safety priorities; developing safety goals, objectives, and performance measures; and prioritizing safety funding can use this framework when developing regional safety plans, mode-specific

> ***Funding Safety Plans***
>
> *In many instances, the DOT will provide funding to MPOs or local jurisdictions to complete safety plans. However, another source of funding can be the State Highway Safety Office. The Cheyenne MPO in Wyoming coordinated with the National Highway Traffic Safety Administration and the Wyoming Highway Safety Office to complete an update to their Safety Management Plan.*

safety plans, corridor plans, or integrating safety into other transportation planning documents. This SHSP-style planning approach can be seen in practice in Montana. Six communities developed community transportation safety plans. Figure 3.2 demonstrates the process used to identify emphasis areas, strategies, and performance measures through data and analysis.

Figure 3.2 Flowchart. Planning Process for Montana Safety Plans



Source: *Bozeman Community Transportation Safety Plan* *(CTSP)*, July 2013.

Although the SHSP is an important tool during the transportation planning process, planners also need to think beyond the contents of the SHSP and consider medium- to longer-term safety considerations during transportation plan development. Section 3.2.2 describes the differences between the two planning processes.

3.2.2 SHSPs and Transportation Plans

A common question asked by transportation planners is, "Why does safety need to be considered in transportation plans when the topic already is strategically addressed in the SHSP?" This should be done because:

- Transportation plans typically look at longer planning horizons than the SHSP and must consider how future infrastructure can be planned safer. To do so, safety is addressed in the LRTP to meet identified safety goals, objectives, and performance measures.

- Transportation planners must consider all modes, corridors, and the network as a whole during the planning process, whereas the SHSP addresses the most pressing and current data-driven safety issues at the statewide level. Planners need to think about the longer-term implications of the emphasis areas outlined in the SHSP, but also need to think beyond those and address topics such as freight, community, and transit safety, as well as other topics that link to safety, such as complete streets, sustainability, health, environment, and more.

- Transportation planning studies are necessary to focus on and pinpoint the range of safety issues, project locations, and countermeasures, beyond what would be expected in the SHSP. Specific projects, funding sources, or locations where safety needs to be addressed would be included in state and metropolitan transportation improvement programs (S/TIPs).

SHSPs assume a data-driven approach to identify goals (or emphasis areas), objectives, strategies, performance measures, and programs/projects. This process does compliment the transportation planning process to help with the identification of data-driven transportation safety priorities in LRTPs, modal plans, or other transportation documents.

3.3 Integrating Safety during the Transportation Planning Process

Planners utilize the transportation planning process as a framework for planning, prioritizing, programming investments, and advancing policies. Incorporating safety into planning does not require an entirely new process—it can be easily integrated into the common tasks that planners already undertake, including data collection and analysis, goal and objective setting, performance measures and targets, project prioritization and programming, and evaluation. Table 3.1 depicts the common transportation planning tasks, the opportunities to consider safety during those tasks, and MPO and State DOT examples of safety integration.

Why is it Important to Consider Safety in the Transportation Planning Process?

Transportation related fatalities occur every day. Transportation planners have an inherent responsibility to identify transportation projects and programs to meet safety goals and work towards reducing fatalities and serious injuries to zero.

Table 3.1 Safety Integration in the Transportation Planning Process

Transportation Planning Process—Key Planning Task	Safety Integration into Key Planning Task	Examples
Data Collection and Analysis	• Obtain safety data, which can include crash data, roadway characteristic data, traffic volume data, and safety information from public/stakeholder input. • Conduct safety analysis, which can range from basic analysis like identifying crash frequencies to more sophisticated approaches, such as network screening.	• In Ohio, crash and roadway data are obtained through the Ohio DOT. VMT estimates also are available for State and regional agencies. Ohio DOT has developed user-friendly tools, such as the Geographic Information System (GIS) Crash Analysis Tool (GCAT), which automate the analysis. • In New Mexico, State and regional agencies can access safety data through the University of New Mexico (UNM) Division of Government Research (DGR) Web site to access published reports, or they can submit a request to New Mexico DOT via email to the Crash Records reporting office (crash.records@state.nm.us) to request specific records and/or generated reports. • The Mid-Ohio Regional Planning Council (MORPC) analyzes pedestrian and bicycle high-crash locations to identify areas in need of physical safety improvements, as well as safety education programs.
Goal and Objective Setting	• Use the results of public/stakeholder input, outputs of data analysis, and information in other plans such as the SHSP to identify safety goals and objectives or incorporate safety into transportation goals.	• In Missouri, the Mid-America Regional Council utilized the results of stakeholder input and data analysis to identify the top safety issues in the region (infrastructure, behavioral, and special users) and strategies to address them. This data-driven approach to goal and strategy identification can be found in their Destination Safe plan. • In California, a number of the regional transportation planning organizations (RTPO), including the Del Norte Local Transportation Commission, adopted and customized relevant goals and strategies from the California SHSP for use in their LRTPs.

Transportation Planning Process—Key Planning Task	Safety Integration into Key Planning Task	Examples
Performance Measures and Targets	• Establish performance measures and targets for fatalities and serious injuries and fatality and serious injury rates. • Establish performance measures and targets for other transportation safety goals, as appropriate.	• In Nevada, the Regional Transportation Commission (RTC) of Washoe County identified safety performance measures and targets in their most recent LRTP. • In Pennsylvania, Pennsylvania DOT provides Highway Safety Guidance Reports to every district, MPO, and regional planning organization (RPO) detailing region-specific performance measures and targets for safety goals. The goals, measures, and targets are all derived from a data-driven approach.
Project Prioritization and Programming	• Use results of data analysis to identify safety projects eligible for Highway Safety Improvement Program (HSIP) funds. • Leverage goals and objectives and results of data analysis to develop safety evaluation criteria for all transportation projects, regardless of funding source.	• In Arizona, the Central Arizona Governments (CAG) conducted an intersection network screening analysis and plans to submit an HSIP application to Arizona DOT to fund safety improvements at priority intersection locations. • In New Jersey, the South Jersey Transportation Planning Organization (SJTPO) coordinates a Local Safety Program to identify local safety projects eligible for HSIP funding. • In Virginia, the DOT is evaluating transportation projects against several criteria. In addition to demonstrating how a project mitigates congestion, improves accessibility, etc., it also must show how it expects to achieve reductions in fatal and serious injuries.
Evaluation	• Review safety performance measures to identify the extent to which safety goals and objectives are being met. • Review safety programs and projects to identify the extent to which they are reducing fatalities and serious injuries.	• The Champaign Urbana Urban Area Transportation Study has developed a report card to evaluate the safety performance measures identified in its LRTP. • Washington DOT regularly evaluates its cable median barrier program to assess its effectiveness of reducing fatalities and serious injuries.

Source: Cambridge Systematics, Inc.

4.0 Getting Started with Transportation Safety Planning—Data Collection

Data collection is one of the first steps in the transportation safety planning process. Data are needed to establish reasonable goals, objectives, performance measures and targets, or identify programs and projects. Fortunately, the data collection process is continually improving, as technology advances and organizational capacity improves. Data collection and maintenance nonetheless require an ongoing effort that needs to be carefully planned and implemented.

This section of the report provides an overview of safety data sources and considerations that transportation planners should be familiar with to get started with safety data analysis.

4.1 Institutional Considerations

Institutional arrangements and relationships among agencies can play a significant role in determining how easy or difficult it is for planners to access safety data. Although seemingly straightforward, the tasks of collecting, storing, and sharing data across agencies are far from trivial. Data standards, business rules, communications protocols, agency missions, legal and privacy concerns, and other factors come into play. It is important for DOTs and MPOs, who have a stake in transportation safety, to work together to improve the quality and usage of safety data.

Under MAP-21, States are required to have a Traffic Records Coordinating Committee (TRCC) to qualify for Section 405(c) funding. The purpose of the TRCC is to coordinate the activities of safety data stakeholders across each State in an effort to improve the timeliness, accuracy, completeness, uniformity, accessibility, and integration of the various traffic records systems throughout the State. Agencies with an interest in improving traffic safety data from any level of government should understand their State's TRCC structure and process. MAP-21 also requires that States employ a data-driven process to improve safety on all public roads. In particular, they must have a State safety data system to support problem identification and countermeasure analysis, project evaluation, and performance management.

4.1.1 Collaboration and Coordination

States and MPOs with successful transportation safety programs demonstrate collaboration and coordination across agencies and levels of government. For example, in Tennessee, the Department of Public Safety collects crash data, but works closely with the Long-Range Planning section to share the data with safety planning stakeholders. MPOs and RPOs interact with staff in the Planning division to access data and conduct safety planning activities. Communication and collaboration across agencies is seen as one of the keys to success for safety planning in Tennessee.

This type of cooperative approach is needed to ensure that safety data is collected and utilized to its fullest extent. Agencies that manage safety data must be willing to share it with other agencies in order for them to effectively address safety problems within their respective jurisdictions.

Collaboration goes beyond simply making data available to other agencies. For instance, a number of State DOTs ensure data is easily accessible through generated reports, Web interfaces, or other online tools; and provide educational resources to assist novice data users. Examples include Florida's Signal Four Analytics and Alabama's Critical Analysis Reporting Environment (CARE), which also includes training videos and documentation to assist users.

4.1.2 Organizational Capacity

An organization's staff capacity and resources go a long way in determining its ability to collect and manage safety data. This is true at every level of government, but especially applies to MPOs and local agencies, where collection and management of safety data may be considered as an optional function within the organization.

It is often the case that an agency's interest in safety planning and analysis is initiated or significantly enhanced through the efforts of a single staff member or a small group of staff. In the long term, however, it is important for agencies to dedicate staff resources to the collection and maintenance of safety data. This provides continuity in the event of staff turnover, and ensures that safety data collection and management are integrated into agency processes. MAP-21 safety data requirements institutionalize safety data collection and management at the State level, but do not address this need at the MPO and local level.

For those agencies just getting started with transportation safety planning, a full data collection approach may not be necessary. Instead, planners can coordinate with their State DOTs to understand what data already is available and the opportunities to access that information. It also might be possible for DOT staff to create annual custom or generated crash reports to reduce the burden of data collection efforts.

4.1.3 Funding

At a national level, NHTSA provides 405(c) Traffic Safety Information System Improvement Grants for States to develop and implement effective programs that improve the timeliness, accuracy, completeness, uniformity, integration, and accessibility of data needed to identify traffic safety program priorities. 23 U.S.C. section 405(c) funds are awarded to State highway safety offices, which, in turn, distribute funds to partner agencies to link data systems, including traffic records and systems that contain medical, roadway, and economic data, improve the compatibility and interoperability of State data systems with national data systems and the data systems of other States, and enhance the ability to observe and analyze trends in crash occurrences.

NHTSA is not the only source of funds that are eligible for safety data collection and management. HSIP funds also may be used to improve safety data collection, management, and analysis processes and systems if identified as an emphasis area in the SHSP. Although not limited to safety, State Planning and Research (SPR) funds may also be used to fund safety studies and to develop and implement HSIP requirements. Other Federal funds that may be used to support safety data collection include FMCSA funds (Motor Carrier Safety Assistance Program) and metropolitan planning (PL) funds. Additionally, State and local governments may elect to use non-Federal funds for safety data collection, such as traffic counts or collection of inventory data.

Liability Protections

The use of reports, data, or other information compiled to meet Federal safety program requirements as evidence in Federal or State courts is prohibited by 23 U.S.C. § 409 (section 409). In particular, the law reads: "Notwithstanding any other provision of law, reports, surveys, schedules, lists, or data compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential accident sites, hazardous roadway conditions, or rail-way-highway crossings, pursuant to sections 130, 144, and 148 [152] of this title or for the purpose of developing any highway safety construction improvement project, which may be implemented utilizing Federal-aid highway funds shall not be subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data."

Source: FHWA, Office of Safety Programs, Legal Issues, October 15, 2014.

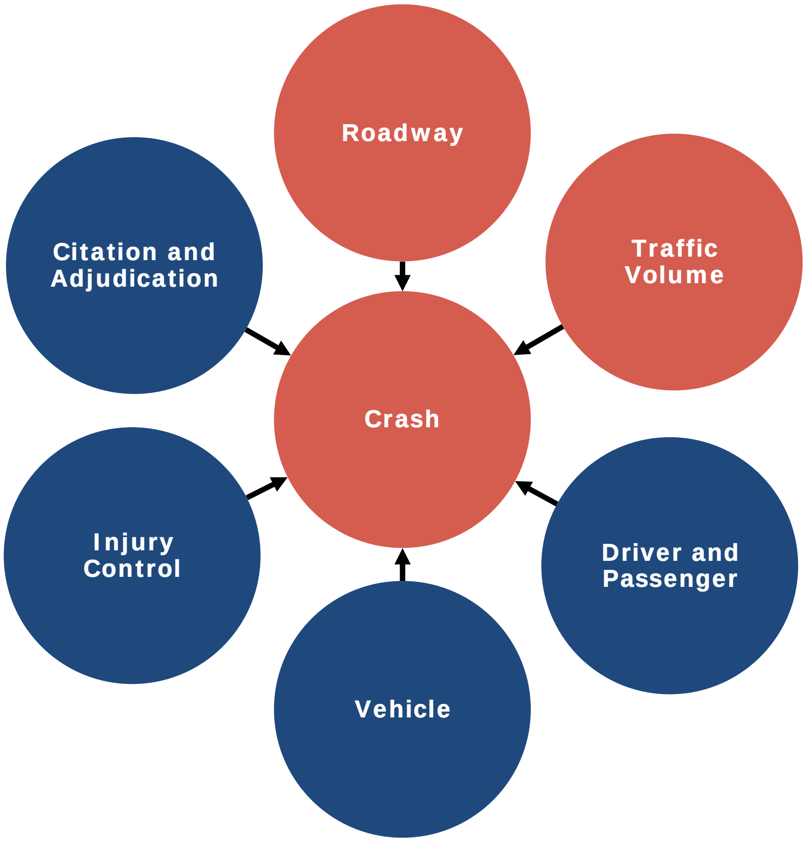
4.1.4 Liability

States differ with respect to their handling of liability concerns related to safety data. In general, State DOTs are protected against lawsuits arising from their collection, analysis, and reporting of safety data under 23 U.S.C. Section 409.

4.2 Common Types of Safety Data and Application to Planning Processes

There are several datasets that are part of the overall traffic records coordination process (figure 4.1), including crash data, roadway characteristics, traffic volume, driver and passenger information, vehicles, injury control (e.g., EMS response time), citation and adjudication (e.g., driver arrest record). For transportation planning purposes, the most commonly used are crash, roadway, and traffic volume (exposure) data. These datasets are shown in figure 4.1.

Figure 4.1 Relationship Diagram. Types of Safety Data



Datasets addressed in detail in this guidebook.

Other safety datasets that are not addressed in detail in this guidebook.

Source: Cambridge Systematics, modified from Federal Highway Administration's Crash Data Improvement Guide, April 2010.

4.2.1 Crash Data

Crash data is the foundation of transportation safety planning. For each crash that meets a minimum injury or property damage reporting threshold, a large set of information is collected and entered into a State database. (Reporting thresholds are set individually by States. In most States, crashes with one or more injuries or with a property damage threshold of around $1,000 are reported. The property damage threshold in particular can vary by State.)

The specific crash data elements that are collected vary by State, but generally are based on the guidelines outlined in the Model Minimum Uniform Crash Criteria (MMUCC). Officers who respond to the scene of a crash collect information on the crash itself (e.g., location, number of vehicles, type of crash); the vehicles or 'units' involved (e.g., model and year, estimated speed); and the people involved (e.g., driver, occupant, pedestrian, age, sex, impairment status).

One of the most important data fields in the crash report is the injury level of each person involved in the crash. The KABCO system is a standardized way of coding injury severity using the following injury codes:

- K—fatality;
- A—serious injury;
- B—nonincapacitating injury;
- C—possible injury; and
- O—no injury.

The standardization of injury coding is important for conducting comparisons across States or regions; however, the underlying definitions of each injury have varied historically. In a 2014 rulemaking that outlined HSIP performance measure requirements,[1] FHWA proposed to standardize the (A) injury level to be consistent with the 'suspected serious injury' definition in MMUCC (FHWA. *MMUCC Guideline: Model Minimum Uniform Crash Criteria*. Fourth Edition. 2012), which is "any injury, other than fatal, which results in one or more of the following:

Severe laceration resulting in exposure of underlying tissues, muscle, organs, or resulting in significant loss of blood;

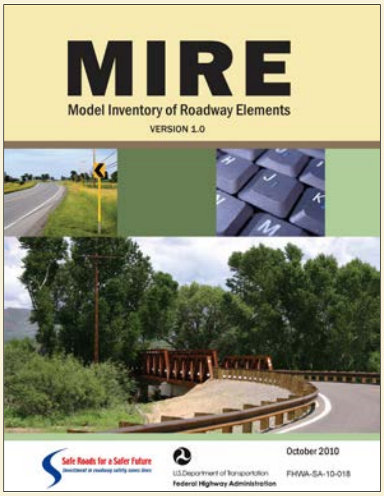
- Broken or distorted extremity (arm or leg);
- Crush injuries;
- Suspected skull, chest, or abdominal injury other than bruises or minor lacerations;
- Significant burns (second- and third-degree burns over 10 percent or more of the body);
- Unconsciousness when taken from the crash scene; or
- Paralysis.

Electronic Reporting and Storage of Crashes

States are moving toward collecting and submitting crash data electronically through the use of laptop computers in law enforcement vehicles. In addition to streamlining the data collection process, electronic crash reporting can help reduce errors and results in more timely submission of reports. This, in turn, allows agencies to more quickly identify and address emerging problems.

[1] 23 CFR Part 924. Department of Transportation. Highway Safety Improvement Program. Federal Register. Vol. 79, No. 60. March 28, 2014.

Another advantage of electronic crash reporting is that it allows for the integration of in-car mapping technologies within the crash form completion process. In other words, rather than record the crash location with a global positioning system (GPS) reading, street address, or distance from an intersection, an officer can click on the crash location on a digital map and have all of the necessary location data automatically entered into the crash report (e.g., county, city, latitude and longitude coordinates, proximity to intersection, etc.). This is a significant improvement, as the process of locating crashes by other means requires a substantial amount of staff resources and is more prone to errors. Several States are beginning to incorporate in-car crash mapping into law enforcement vehicles, including Ohio and Alabama.



Source: FHWA. Model Inventory of Roadway Elements: Version 1.0. 2010.

MIRE is the corollary to MMUCC for roadway characteristics. MIRE includes a detailed list of data elements that are recommended for collection by transportation agencies for the specific purpose of evaluating safety.

Once crash data have been collected and submitted to the State (through electronic or paper submission), crashes are stored in a centralized database. Generally, the data is stored using a relational database structure with separate tables for the crash, unit, and person information, as described above. These tables are linked through identifier fields in each table.

Depending on the institutional arrangements in the State, the crash data may be stored in its original form by the DOT, the State highway patrol, the Department of Revenue, another public agency, or even universities.

Many DOTs have found that storing the data in separate tables is not convenient for analysis and, thus, create a separate database for this purpose. As part of this process, DOTs may conduct a quality control check that addresses inconsistencies or omissions in the data, as submitted by the investigating law enforcement agency, assigns coordinates to crashes, and supplements, or enhances the crash report based on a review of the crash narrative. It is important for agencies which are getting started with safety data analysis to understand what information has been added or may be missing relative to the original crash report.

The State DOT's crash database is likely to contain the most important data for some types of analysis, but may not include the full range of information found in the original crash report. For example, State DOTs may be less interested in knowing the age of every crash victim than a public health department. It is important for agencies that are getting started with safety data analysis to understand what information has been added or may be missing relative to the original crash report.

Relevance to Planners

As a DOT or MPO planner, the first step is to identify where crash data is housed in your State, and then work with the data manager to understand what information is available for planning purposes and how to obtain it. The State DOT's crash database is likely to contain the most important data for planners. Crash data can be used to develop performance measures, identify trends and contributing factors, and create crash maps or other visualizations. State DOTs and MPOs may perform these analyses when they update their long-range plans, or for corridor- or project-level studies.

4.2.2 Roadway Characteristics

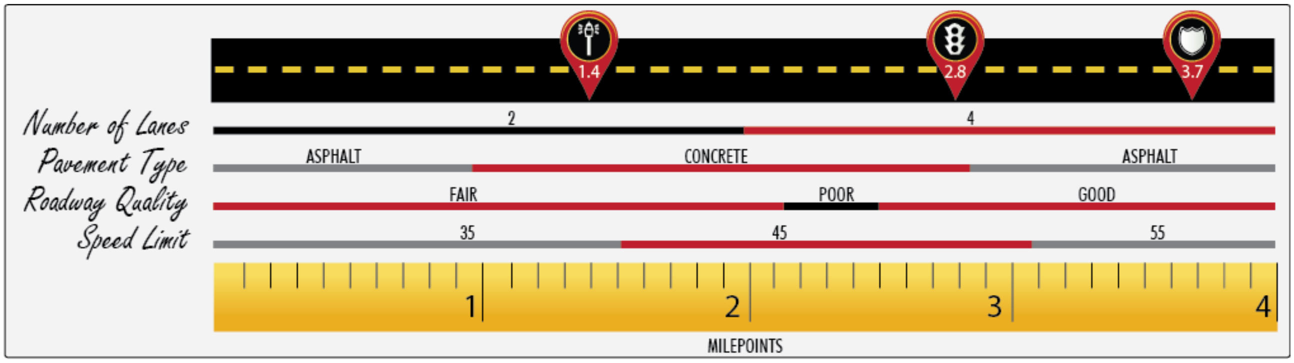
Roadway characteristics data refers to the set of information that describes the physical attributes and conditions of the street network. While some roadway characteristics are collected by law enforcement through the crash reporting process, a more comprehensive and reliable set of information is needed to fully evaluate the safety performance of the network.

Developing and maintaining a roadway inventory database is a complex and expensive task. This is true for State-maintained routes, but it is even more challenging to collect roadway characteristics on local street networks, which account for around 20 percent of fatalities nationwide (FHWA *Assessment of Local Road Safety Funding, Training, and Technical Assistance*, August 2013). Nonetheless, some States have developed databases that include certain data elements on all State and locally maintained roads. For example, Tennessee DOT collects a consistent set of roadway attributes and volume estimates for all public roads since 2012.

Roadway characteristics can be stored in various ways. Many DOTs use linear referencing, which allows roadway attributes, such as shoulders or speed limit, to be stored individually and to be defined by the route, along with the start and end points. Crashes also can be referenced using the same system.

The primary advantage of linear referencing is that it allows for a very detailed delineation of features along a route without breaking the route into very small segments (figure 4.2). A potential downside is that analyzing data stored in a linear referencing system requires a relatively high level of technical expertise.

Figure 4.2 Graph. Linear Referencing Conceptual Diagram



Source: Maryland State Highway Administration, One Maryland One Centerline Linear Referencing.

Roadway characteristics also may be associated with segments that begin and end at intersections (e.g., Main Street from Washington Street to Lincoln Street). This approach is more common at the local level. While intuitively appealing, a drawback of this segmentation scheme is that features relevant to safety may vary over the course of the segment. For example, sidewalks may be present on only one-half of the segment length. This is less likely in urban areas, but is not uncommon in suburban and rural areas with longer distances between intersections.

Regardless of how roadway characteristics data is organized, the relevant features must ultimately be associated with crashes. This association enables analysts to characterize crashes by roadway features. For example, a State or MPO may report the number of crashes per year by roadway functional class, number of traffic lanes, speed limit, or average daily traffic, among other factors.

Relevance to Planners

Roadway characteristics data provides context for crashes and allows planners to identify crash risk factors. Additionally, organizing crashes by roadway characteristics allows analysts to understand the relative performance of different facility types (e.g., two-lane versus four-lane rural roads). This type of information is needed to most effectively target countermeasures to observed crash patterns and also is necessary for more advanced methods of analysis, including crash prediction.

4.2.3 Traffic Volume

All States are required to collect and submit traffic count data through the FHWA's Highway Performance Monitoring System (HPMS). The HPMS requires data to be collected on a sample of roads so that State- and county-level traffic volume estimates can be made. State DOTs and other agencies typically also conduct traffic counts beyond these requirements. HPMS data can be obtained through the FHWA HPMS Web site.

The relationship between crashes and traffic volume can be expressed in a few different ways, depending on the analysis questions at hand. For intersections, volume is often expressed as million entering vehicles (MEV). For each intersection, the number of vehicles that enter the intersection is calculated on an annual or multiple-year basis. Crashes are then associated with the same intersection (often using a distance threshold such as 250 feet), and the number of crashes is divided by the traffic volume to determine the rate of crashes per entering vehicles, typically expressed as crashes per 100 million entering vehicles.

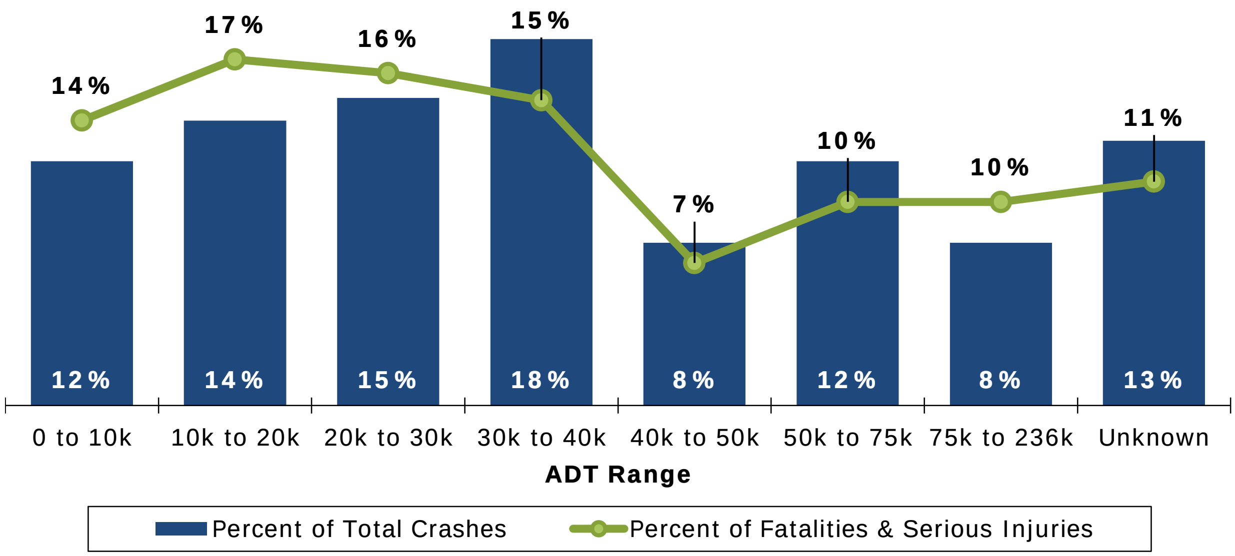
The process for calculating crash rates on segments is different than that used for intersections. Traffic counts conducted along segments are first converted to volume estimates by multiplying the count at a single location by the segment length. From there, the number of crashes along the segment is divided by the traffic volume to determine the number of crashes per million vehicle miles traveled (VMT). Calculating the crash rate at a regional or State level follows a similar process.

All Roads Network of Linear-Referenced Data

In 2012, FHWA announced a new requirement that States must submit a complete Linear-Referencing System for all public roads in their State. This dataset is referred to as the All Roads Network of Linear-Referenced Data (ARNOLD). The 2014 ARNOLD Reference Guide describes how this requirement can be met in different States. Once implemented, ARNOLD will greatly facilitate the process of locating crashes on local roads, which account for a substantial portion of fatalities and injuries. Further, it will provide a consistent linear-referencing system for the entire U.S.

Source: FHWA. Arnold Reference Manual: All Public Roads Geospatial Reference Study. 2014.

Figure 4.3 Chart. Crash Distribution by Average Daily Traffic Example



Source: Sample Data, Cambridge Systematics, Inc., 2015.

Relevance to Planners

Traffic volume data are essential to understanding the safety risk based on the amount of travel. For instance, if planners are conducting a safety review of intersections, they may discover that intersections with the same number of crashes can have very different risk profiles depending on the level of traffic. Like roadway characteristics data, traffic volume data also can be used to help characterize the relative safety performance of groups of roadways (e.g., what is the crash rate on arterials with more than 20,000 vehicles per day versus arterials with less than 20,000 vehicles per day?).

4.2.4 Integrating Crash, Roadway, and Volume Data

State DOTs and their safety partners dedicate a significant amount of resources to the tasks of organizing these individual datasets and linking them together. While each is useful on its own, linking the three sets of information together provides the greatest insight.

Since safety data analysis ultimately is concerned with addressing the factors that contribute to crashes, it is necessary to understand the roadway and traffic volume conditions at the locations where crashes have occurred. This requires each crash to be precisely located with respect to the roadway inventory.

As the crash data collection and management processes become increasingly automated, one of the main advances relates to the ability to more easily and more accurately locate crashes. State DOTs differ in the specifics of their approach, but many use automated processes to link location information provided in crash reports to roadway and traffic volume inventories.

In addition to linkages that occur at the crash data management stage, planners may use GIS processes to link crash data to local road segments or intersections. For example, the Mid-Ohio Regional Planning Commission has developed a methodology to assign crashes to intersections within a 250-foot buffer (Mid-Ohio Regional Planning Commission Top 40 Regional High-Crash Location Methodology, September 2014).

Once crashes have been linked to roadway or intersection inventories, a rich set of information is available for querying. Additionally, crashes along a given segment of road or at a particular intersection may then be aggregated to determine what types of crashes occur with the greatest frequency, and how each location performs relative to others. The use of advanced safety analysis methods, such as those outlined in the Highway Safety Manual (HSM), requires that crashes, roadway characteristics, and volume are integrated.

4.2.5 Other Safety Datasets

Citation and adjudication data, injury data, vehicle data, and driver and passenger information are less commonly used for transportation planning purposes, but are extremely important in other contexts. Citation and adjudication data refers to the arrest and conviction records of individual drivers for traffic offenses. States are moving toward implementation of centralized citation and adjudication systems which enable analysis of trends and problem identification. This capability supports targeted enforcement, which helps to reduce specific crash types such as impaired driving crashes and speed-related crashes.

Injury control data is concerned with the health care systems and processes that are involved in responding to motor vehicle crashes. Examples include prehospitalization (EMS) data, emergency department data, hospital discharge data, trauma registry data, and vital records data. Prehospitalization data provides insight into emergency response times, which are critical for reducing fatalities in particular. Hospital and trauma data provide a more accurate assessment of injury outcomes as compared to law enforcement crash reports. Additionally, hospital records include injuries from certain types of crashes that are not captured by most State data systems, such as those involving a single bicycle.

Vehicle data provides valuable information to regulatory agencies regarding the safety of vehicle technologies as well as any significant trends regarding the types of vehicles involved in crashes. Vehicle crash history also is used in some transportation planning analyses, such as identifying locations with a high incidence of commercial vehicle crashes or motorcycle crashes.

Passenger and driver information are frequently used to identify and document behavioral safety patterns, such as impaired driving or failure to wear seat belts. Similarly, tracking the age and other available demographic information of drivers and passengers involved in crashes provides a better overall understanding of traffic safety problems and sheds light on the effectiveness of education or legislative action, such as Graduated Driver's Licensing (GDL).

4.3 Data Quality

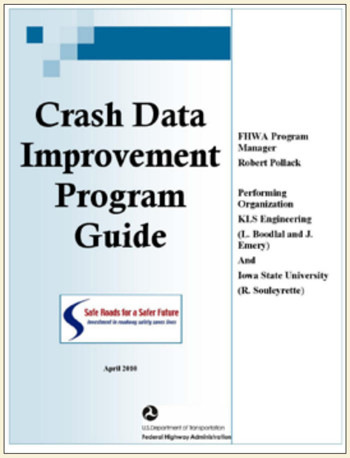
The successful application of safety data to the transportation planning process is contingent on the availability of high-quality data. The following six characteristics for evaluating the quality of State safety databases have been identified: timeliness, accuracy, completeness, consistency/uniformity, integration, and accessibility (FHWA Crash Data Improvement Program Guide, April 2010). Each of these factors affects the ability to use or draw conclusions from State safety databases. Transportation safety planners should be familiar with these criteria and consider how their data performs with respect to each area. A brief of discussion of crash data quality characteristics is provided below.

4.3.1 Timeliness

Timeliness is concerned with how quickly crash reports are entered into the State database and become available for analysis. The timely availability of crash data allows planners to identify and address emerging safety concerns. A difference of several months could result in several crashes being prevented, including some serious injuries or fatalities. Electronic crash reporting and better integration of crash data systems have allowed some States to provide access to crashes with very short delays, such as a few days.

4.3.2 Accuracy

The accuracy of crash data has a direct effect on the conclusions that can be drawn from the data. It is expected that crash databases will have some level of error or missing information, but accuracy can be improved substantially through the use of 'business rules.' Business rules ensure that crash data reports submitted to State databases are logical and consistent. For example, a crash report that indicates there were zero vehicles involved would fail a basic validation requirement. Incorporating edits and validation rules into data entry will result in significant accuracy improvements.



Source: FHWA. Crash Data Improvement Program Guide. 2010.

FHWA's Crash Data Improvement Program Guide provides an indepth discussion of the six data quality performance measures: Timeliness, Accuracy, Completeness, Consistency, and Integration. It is an excellent resource for understanding the crash data collection process and considerations.

4.3.3 Completeness

Crash data completeness refers to the degree to which each crash is represented in the database, as well as whether all relevant information has been provided for each crash. In both cases, incomplete data can hamper the safety planning process. For example, if one county fails to report one-half of its crashes, it would appear that their roads are much safer than is actually the case. Similarly, if a report for a curve-related crash does not indicate that the crash occurred along a curve, planners will not be able to determine the role that the curve may have played in the crash.

4.3.4 Consistency/Uniformity

Consistency of crash reporting across agencies is important to ensure that differences in reporting practices do not influence safety funding decisions. For example, if one law enforcement agency routinely checks for impaired drivers in crashes, while another does not, an analysis of impaired driving crashes will report a significant difference in impaired driving crashes in these two areas. Injury definitions and application on crash reports also must be carefully defined and consistently reported to allow for appropriate comparisons between regions or States.

4.3.5 Integration

Integration of safety data applies not only to crash, roadway, and traffic volume data, as discussed above, but also to citation, Emergency Medical Service (EMS), and injury data. Relating these datasets to crashes and to each other provides a more complete assessment of driver risk factors (e.g., previous driving under the influence (DUI) offenses), emergency response times, and injury outcomes, with respect to the other information provided in the crash data. Full integration of safety datasets is a worthwhile goal, but is challenging due to legal and privacy concerns, institutional challenges, and technical hurdles. States vary with respect to the current level of integration of their safety datasets.

Integration of State and local data is another aspect of data quality with relevance to safety planning. Some local and regional agencies collect data on roadway features and traffic volume, but these data are not always easily integrated with State sources. They may use a different spatial reference or data definitions that make it difficult to take advantage of information from both sources.

4.3.6 Accessibility

The ease with which safety stakeholders can access and use safety datasets is an important consideration for safety data managers. Users beyond State DOTs must be able to access crash data to develop their safety-related programs. For example, an MPO interested in developing a pedestrian safety campaign may wish to develop safety messages based on pedestrian crash data specific to their region and to target their effort to geographic areas or populations with a high number of pedestrian crashes.

4.4 Obtaining Safety Data

Knowing the types of safety data available in a State and potential data limitations is important—however, the next step is to obtain data to initiate transportation planning activities. Safety data comes in many formats and can be accessed in a variety of ways. Raw crash data often is needed to conduct customized analysis with the greatest amount of flexibility. However, if staff or resources limit the use of raw data, standard reports generated by State DOTs, online tools, or custom inquiries or input from stakeholders can be used to identify safety problems.

4.4.1 Raw Data

In the context of safety planning and analysis, raw data refers to data that has not been aggregated or significantly modified from its initial state. Raw crash data often is available in text file or similar tabular format, where each row of data represents one crash, and columns represent the attributes or characteristics of the crash. Similarly, roadway characteristics data may be provided in tabular format, where each row corresponds to a roadway segment, and columns represent the characteristics of the road. Raw data often is provided as a spatial file, or contains the information needed to develop a spatial file based on the records in a tabular file.

Raw Data in a Nutshell

Working with raw data affords planners the greatest opportunity to dive into the safety data for their region. With raw data it is possible to investigate a wide variety of questions that may arise during the planning process. Additionally, it is possible to account for combinations of crash factors that provide a more nuanced understanding of the circumstances that are contributing to crashes and injuries. Sophisticated online tools can provide similar functionality, but are expensive and time-consuming to develop.

Although working with raw data affords the greatest flexibility, it can be time-consuming and resource-intensive to work with raw data files. Staff with data management and analysis skills are needed to effectively leverage raw data.

Table 4.1 Raw Crash Data Sample

Unique_Crash_Identifier	Severity_Code	Crash_Type_Code	Crash_Location_Type	Offset_Distance	Offset_Direction	Fatalities	Incapacitating_Injuries	Non_Incapacitating_Injuries	Possible_Injuries	Intersection_Related	Functional_Class	DOT_Maintained_Roadway	Roadway_Departure_Crash
1138927103	5	7	1	0.03	N	1	0	0	0	Y	5	1	0
2520002700	4	14	1	0.2	S	0	1	0	0	N	3	1	0
4878061929	3	6	1	0.3	E	0	0	2	0	N	5	0	1
7448081765	4	11	3	0	–	0	2	0	0	Y	7	0	0
5085793336	4	9	1	0.22	N	0	1	1	0	N	7	0	0
8605042833	2	7	1	0.05	W	0	0	0	1	N	5	0	0
5853315093	2	15	2	0.01	E	0	0	0	2	Y	4	0	0
8669234119	3	12	3	–	–	0	0	1	0	Y	3	1	0
9418456907	2	16	1	0.1	N	0	0	0	1	N	5	1	1
3565407865	2	10	1	0.2	S	0	0	0	1	N	7	0	1

Source: Sample Data, Cambridge Systematics, Inc., 2015.

4.4.2 Generated Reports

The easiest way to learn about basic safety statistics for a State, region, or county is through reports that already have been prepared. Many State DOTs or other agencies prepare summary reports on a regular basis. Additionally, the NHTSA Fatality Analysis Reporting System (FARS) Web site has indepth State-level reports on fatalities.

FARS

The Fatality Analysis Reporting System (FARS) is a national database of motor vehicle traffic fatalities. It includes detailed information such as drivers, vehicles, and locations; and are available to the public. Fatalities reported through FARS may differ slightly from other State reports due to definitional differences.

Reports generated by State agencies are likely to provide an overall understanding of crash trends at the given reporting level. For example, they may report on fatality and serious injury trends, provide an indication of the most prevalent crash types or contributing factors in an area, or identify high-crash locations. For planners who do not have the time or resources to analyze raw data, these reports provide a basic amount of information to initiate transportation safety planning. For example, Louisiana DOT, through the Highway Research Group, provides its regional transportation coalitions with annual data on basic trends, contributing factors, and high-crash segments and intersections. Pennsylvania DOT provides all its districts, MPOs, and RPOs a biannual report on fatality and serious injury trends, performance target data for contributing factors, and a list of high-crash locations with GIS functionality.

Generated reports may provide enough information to identify general causes or areas of concern, which can lead to the development of safety goals and objectives. They are less likely to answer questions about where and why specific crash problems exist in an area. Further analysis, such as systemic safety analysis, network screening, or road safety assessments, can provide more insight into project and program identification.

4.4.3 Web Interfaces and Tools

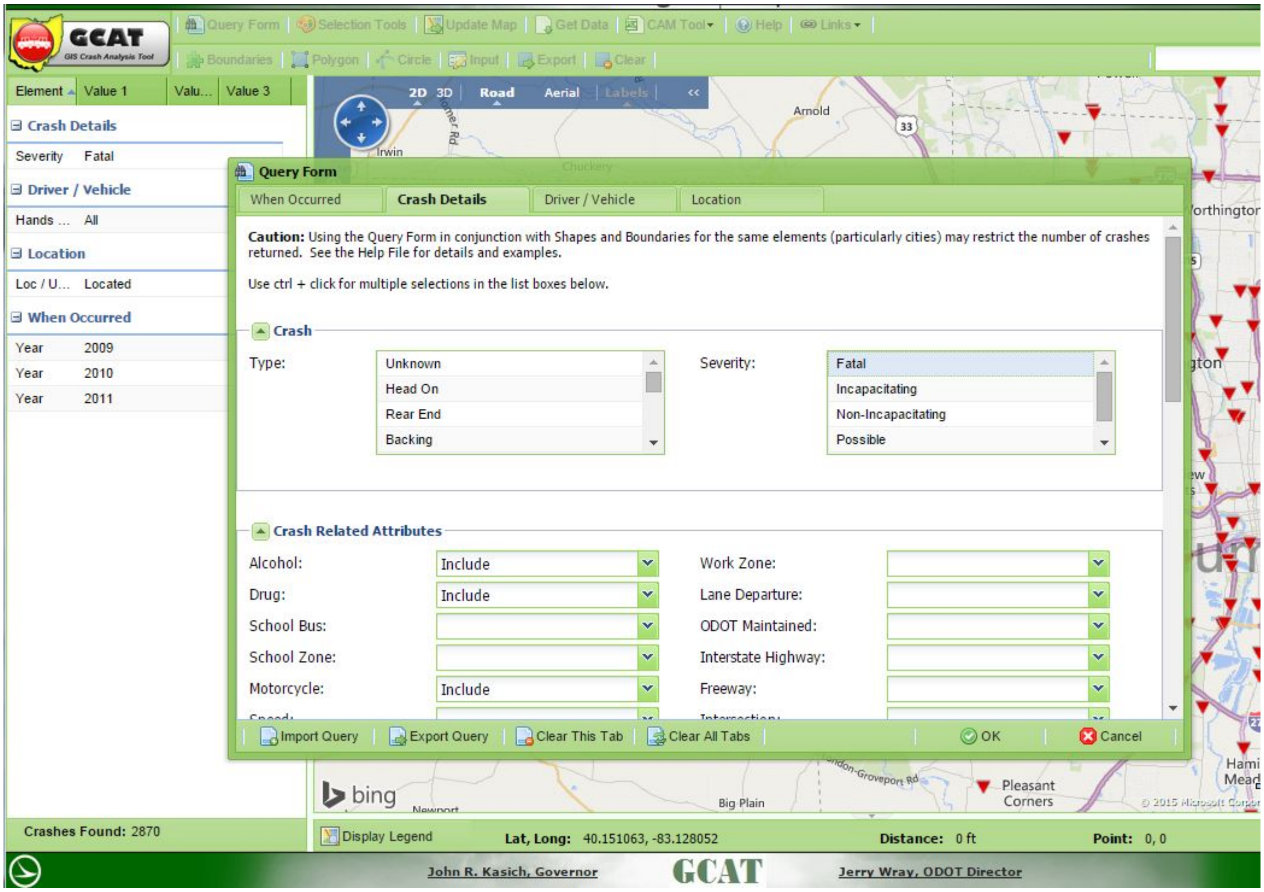
Several State DOTs provide access to crash data and other datasets for safety stakeholders through Web interfaces. This is a convenient format that makes it easy for planners to access data, while also reducing the need for data owners to respond to data requests.

It is common for some level of analysis capabilities to be incorporated into these data access tools. Users may have the ability to filter data based on criteria such as year, type of crash, injury severity, geographic location, or other factors. From there, they can download the raw data or generated reports based on the selected criteria.

***Montana DOT Statistics and Data Web Site** (**Montana DOT Statistics and Data**)*

The Montana DOT provides up-to-date crash data summaries that are accessible to the public via the Montana DOT Statistics and Data Web site. Users can download an Excel spreadsheet that allows them to view crash totals based on their selected county, city, or Tribal reservation. Category reports are available for each emphasis area identified in the SHSP.

Figure 4.4 Screenshot. Ohio DOT's Geographic Crash Analysis Tool (GCAT) Query Form and Map



Source: Ohio DOT GIS Crash Analysis Tool.

Web interfaces and tools are meant to enhance transportation safety planning activities, providing data and analysis in a user-friendly way, but a primary limitation for planners is the lack of training or knowledge on the tool. A number of States do offer trainings to overcome this barrier. For instance, training on the Crash Mapping Analysis Tool (CMAT), a software program that provides convenient access to crash data in Iowa, is offered regularly and free of charge to cities, counties, State employees, consultants, and researchers in Iowa.

4.4.4 Custom Inquiries

An alternative to using Web interfaces is for safety stakeholders to request data on an as-needed basis. Such arrangements make sense where a Web interface has not been provided, or data users do not have the capacity to access the data electronically.

Custom inquiries should be limited and address a specific question (e.g., how many run-off-road crashes were there along a specific corridor over a given three-year period?). In these cases, going through the process of analyzing raw data would be too time-consuming; whereas, the data owner is likely able to answer the question with minimal effort.

5.0 Using Safety Analyses for Planning

For many transportation planning organizations, the biggest barrier to integrating quantitative safety analysis into the planning process is staff time and expertise. While this can be a significant barrier, agencies can begin to address safety with a low level of effort. First and foremost, planners should coordinate with data managers in their States to learn about data availability, analyses already complete, and/or options for analytical support specific to the planning jurisdiction. For example, the State SHSP may include data analysis and/or safety emphasis areas that are relevant to the planning agency. Funding for transportation safety analysis, research, and/or project implementation may be available through the State DOT HSIP; or the State TRCC may have resources available for data collection, analysis, or evaluation projects.

Another way to overcome these barriers is to start small. Many of the analyses using descriptive statistics can be conducted using common spreadsheet tools. Summarizing the who, what, when, where, and why of crashes will provide an excellent starting point to understanding safety conditions in the community. This information can serve as talking points to elected officials and local partners and raise the importance of safety in the community.

This section provides an overview of the basic safety analysis categories, questions answered in each category, how this can be included in transportation planning, and analysis methods to answer these questions. The topics covered are presented in table 5.1. This guidebook focuses on basic analysis methods. As data, expertise, resources, and interest grows, more advanced methods should be considered. A more detailed version of table 5.1, including methods, data needs and tools is included in appendix B.

Table 5.1 Safety Analysis Categories and Questions

Analysis Category	Analysis Question
Benchmarking	• How many fatalities and serious injuries are occurring in my area? • How does this compare to other areas or my State?
Identify Crash Trends and Contributing Factors	• Who is involved in crashes? • When are the crashes occurring? • What are the major contributing factors to crashes?
Identify and Evaluate Focus Crash Types	• What are the most common crash types? • What are the most common contributing factors? • What are the characteristics of the over representation?
Network Screening—Identify Sites for Safety Improvement	• What locations (intersections or segments) show the most potential for safety improvements?
Systemic Analysis—Identify Safety Risk Factors	• What are the common characteristics of locations with crashes? • What are the countermeasures to address these characteristics? • How should we prioritize systemwide implementation?
Corridor and Intersection Planning Safety Analysis	• What are the safety effects of alternative roadway or intersection cross sections?

Source: Cambridge Systematics, Inc.

5.1 Benchmarking

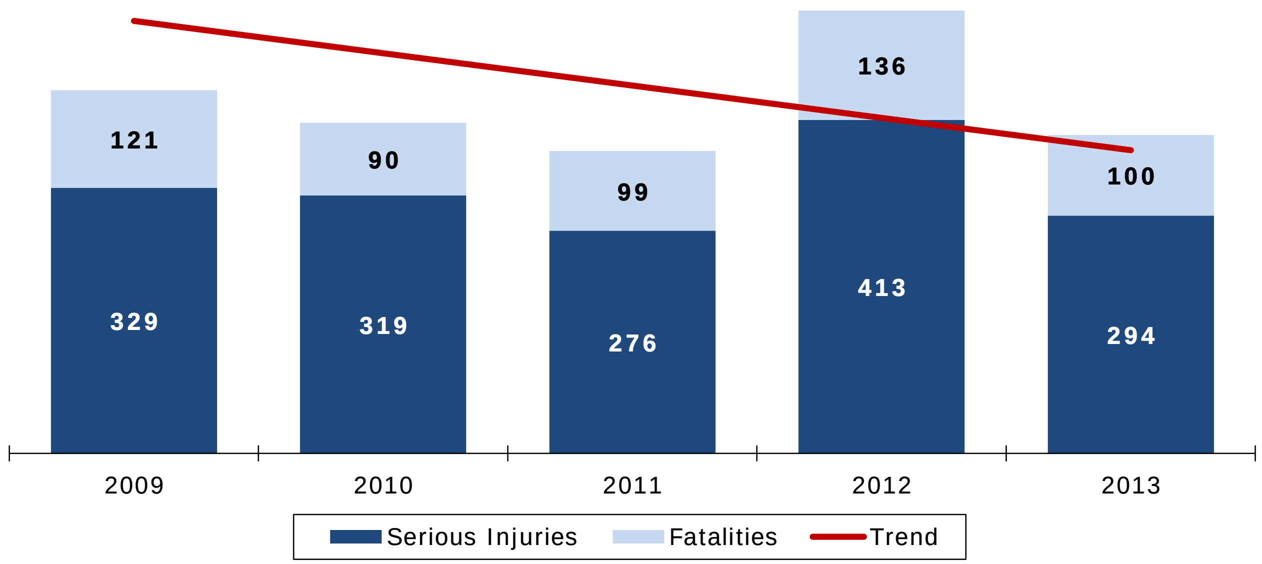
Integrating safety analysis into planning- and project-level activities starts with understanding the scope and scale of safety concerns in the planning area. Initially, planners need to understand performance measures such as: number of fatalities; number of serious injuries; rate of fatalities; and rate of serious injuries.

Benchmarking the area's safety performance for a particular period is useful in the long-range planning process as part of setting plan vision and goals and establishing performance measures and evaluation criteria for the plan. Fundamentally, benchmarking like this makes it possible to monitor safety performance within the area, as well as assess performance of the system relative to other comparable areas and/or the State. At the highest level, these performance measures quantify the number of people killed or seriously injured over time in the area. Monitored annually, this will provide the agency with information about overall effectiveness and safety planning and programming in the area and will help transportation agencies determine the appropriate safety focus areas moving forward.

5.1.1 Methods for Benchmarking

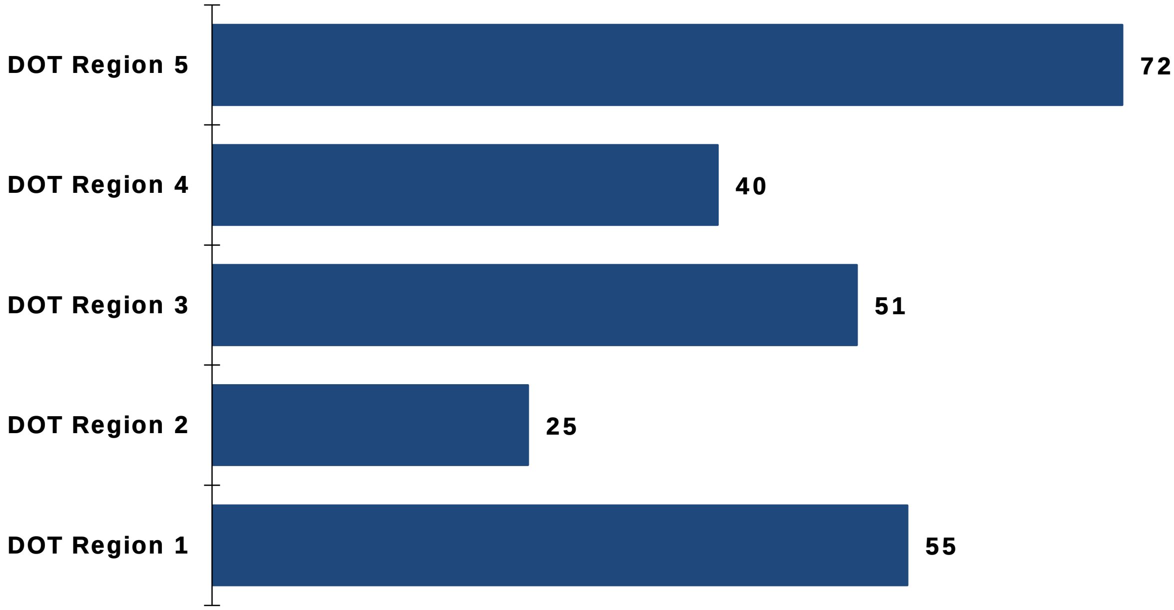
In descriptive analyses for benchmarking, areawide crash frequency and crash severity per year are tallied for a period of years to develop a simple trend summary. This trend can be summarized for the area only to evaluate current performance to past years, or performance in a specific year can be compared to similar data from other areas to compare performance across areas. Figure 5.1 shows annual total crash fatalities and serious injuries for a community for the years 2009 to 2013. Figure 5.2 shows a comparison of fatalities by DOT region.

Figure 5.1 Chart. Fatalities and Serious Injuries per Year



Source: Sample data, Cambridge Systematics, Inc., 2015.

Figure 5.2 Chart. Comparison of Fatalities by Region



Source: Sample data, Cambridge Systematics, Inc., 2015.

Forecasting Long-Range Safety Performance

An advanced method for integrating safety into transportation planning is to develop models that predict long-range (20-year) safety performance of transportation networks as a function of traditional transportation planning data, such as land use, population, VMT, and roadway. While not yet common, long-range safety planning models could be used to predict long-term safety performance as part of long-range planning alternatives evaluation or scenario testing to select alternative transportation networks.

5.2 Identify Crash Trends and Contributing Factors

The next category of safety analysis is conducted to identify major crash trends and contributing factors in a community. The crash trends and contributing factors tell the safety "story" of who, what, when, where, and why people are involved or injured in crashes:

> ***Contributing Factors and Countermeasures Defined***
>
> *Crash-contributing factors are driver behaviors, events, or roadway infrastructure characteristics that contribute to the occurrence of the crash. Examples include texting while driving, low roadway friction around a curve, sight distance constraints, or inadequate lighting. Crashes typically have multiple contributing factors.*
>
> *Countermeasures/treatments refer to strategies implemented to reduce a specific crash type or crash severity.*

- **Who?** Age distribution and gender of crash victims.
- **What?** Number and type of vehicles (single or multivehicle crashes, commercial vehicles or passenger vehicles), pedestrians, motorcyclists, bicyclists, etc., involved in the crash.
- **When?** Year, month, day, and hours of crashes.
- **Where?** Crash location by roadway functional classification, intersection or roadway segment, urban or rural environment, transportation analysis zone, or subdistrict within the community.
- **Why?** Behavioral and environmental factors, such as driver impairment, driver distraction, speeding, pavement condition, or road curvature.

The objective of this analysis is to understand the major safety trends in a community and identify if there are crash types or contributing factors that are more common than expected; and, as a result, should be a focus of project planning, policy or programming, and prioritization. Analyses like these can be conducted for safety-specific plans, or can be conducted as part of an existing conditions assessment in a long-range or corridor plan. Knowing crash trends and contributing factors can help transportation agencies determine appropriate safety countermeasures during these planning processes.

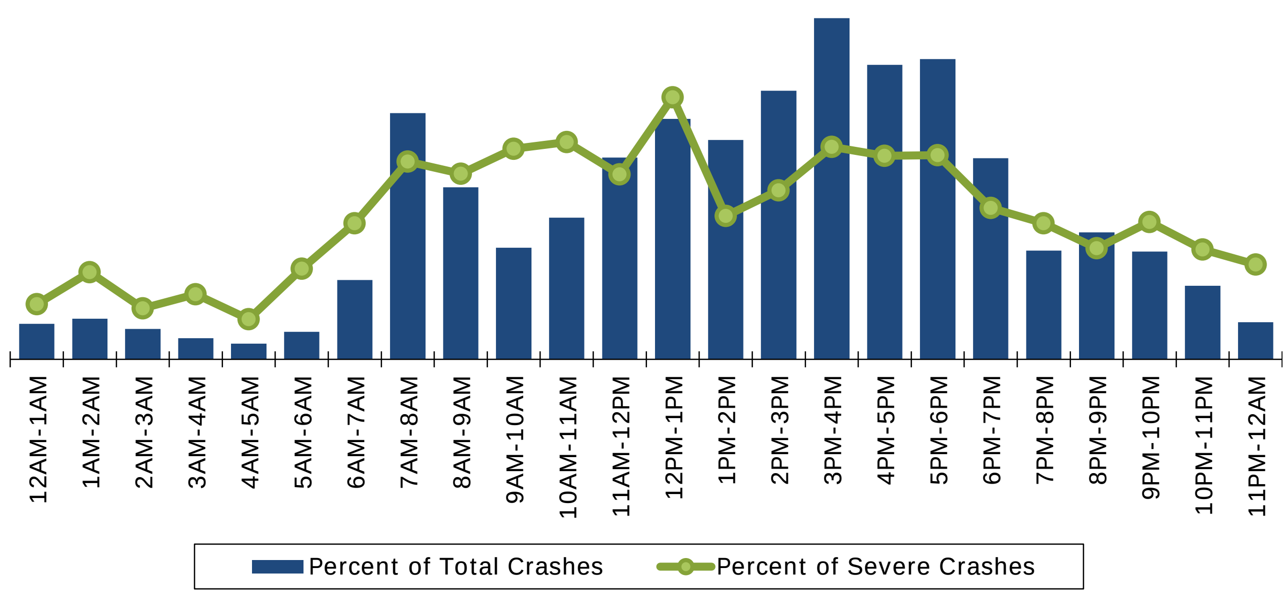
5.2.1 Methods for Identifying Crash Trends and Contributing Factors

Descriptive statistics count and compare the number (i.e., frequency), type, severity of crashes, and/or contributing factors that have occurred historically. Typically, this is done for the most recent three- to five-year period at a site, along a corridor or in an area. As described in the bullets above, there are many possible contributing factors and categories to count. As such, it is advisable to start with a small number of categories to keep the process manageable. As specific concerns arise within any given category, it may be necessary to dig deeper into the data.

> ***Descriptive Analysis Examples***
>
> *New Mexico DOT provides descriptive statistics reports and maps for communities and counties in the State.*
>
> *Utah DOT also provides an online Web-based tool summarizing basic descriptive crash data for communities in the State.*

Figures 5.3 through 5.6 show example analyses. Figure 5.3 shows for a one-year period, the percentage of all crashes occurring during each hour of a day and the percent of severe crashes by hour of day. As shown, in this data set, the greatest percentage of severe crashes is occurring between noon and 1:00 p.m. Considering all crashes, 3:00 to 4:00 p.m. is the most common period for crashes.

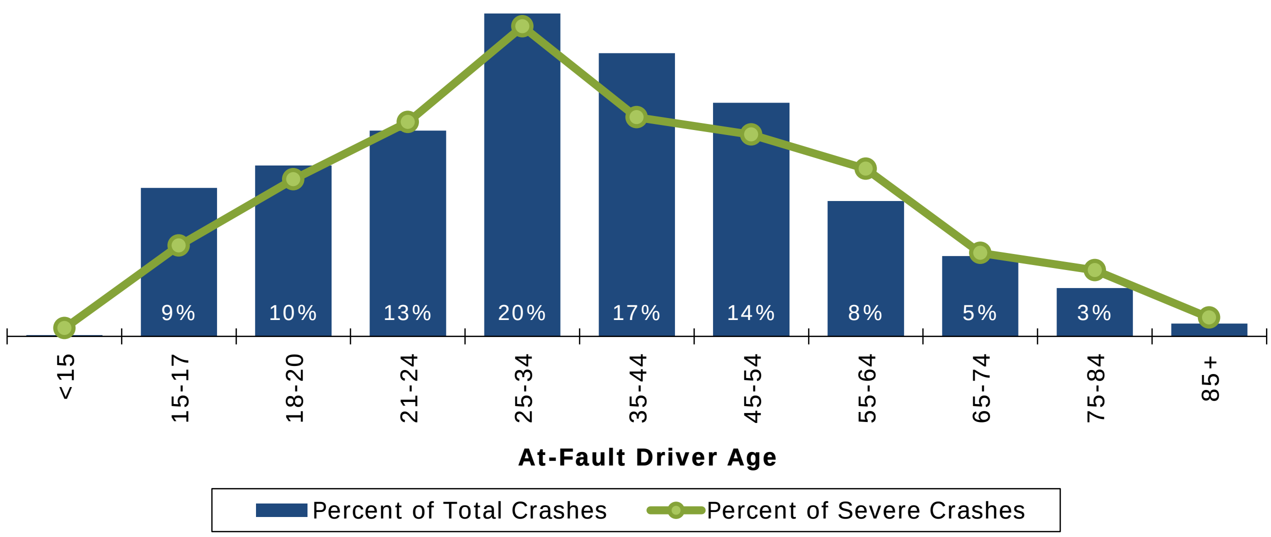
Figure 5.3 Chart. Distribution of Total and Severe Injury Crashes *by Time of Day*



Source: Sample data, Cambridge Systematics, Inc., 2015.

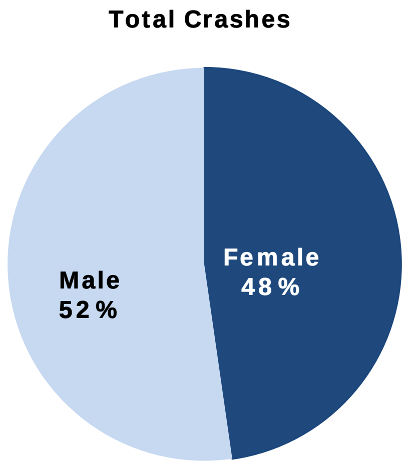
Figures 5.4 through 5.6 show crash distribution by age and gender. In this data set, 25- to 34-year-olds have the most crashes, severe and total. This figure also shows that approximately half of all crashes and nearly two-thirds of all severe injury crashes involve a male.

Figure 5.4 Chart. Distribution of Total and Severe Injury Crashes by Age



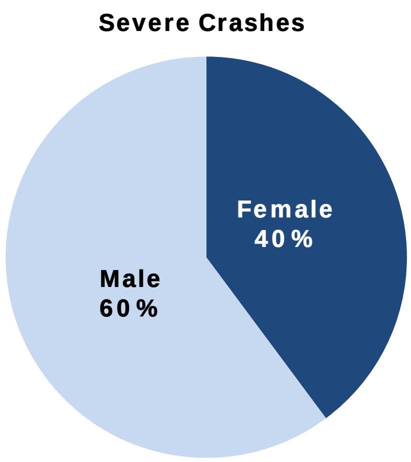
Source: Sample data, Cambridge Systematics, Inc., 2015.

Figure 5.5 Chart. Distribution of Total Crashes by Gender



Source: Sample data, Cambridge Systematics, Inc., 2015.

Figure 5.6 Chart. Distribution of Severe Injury Crashes by Gender



Source: Sample data, Cambridge Systematics, Inc., 2015.

5.3 Identify and Evaluate Focus Crash Types

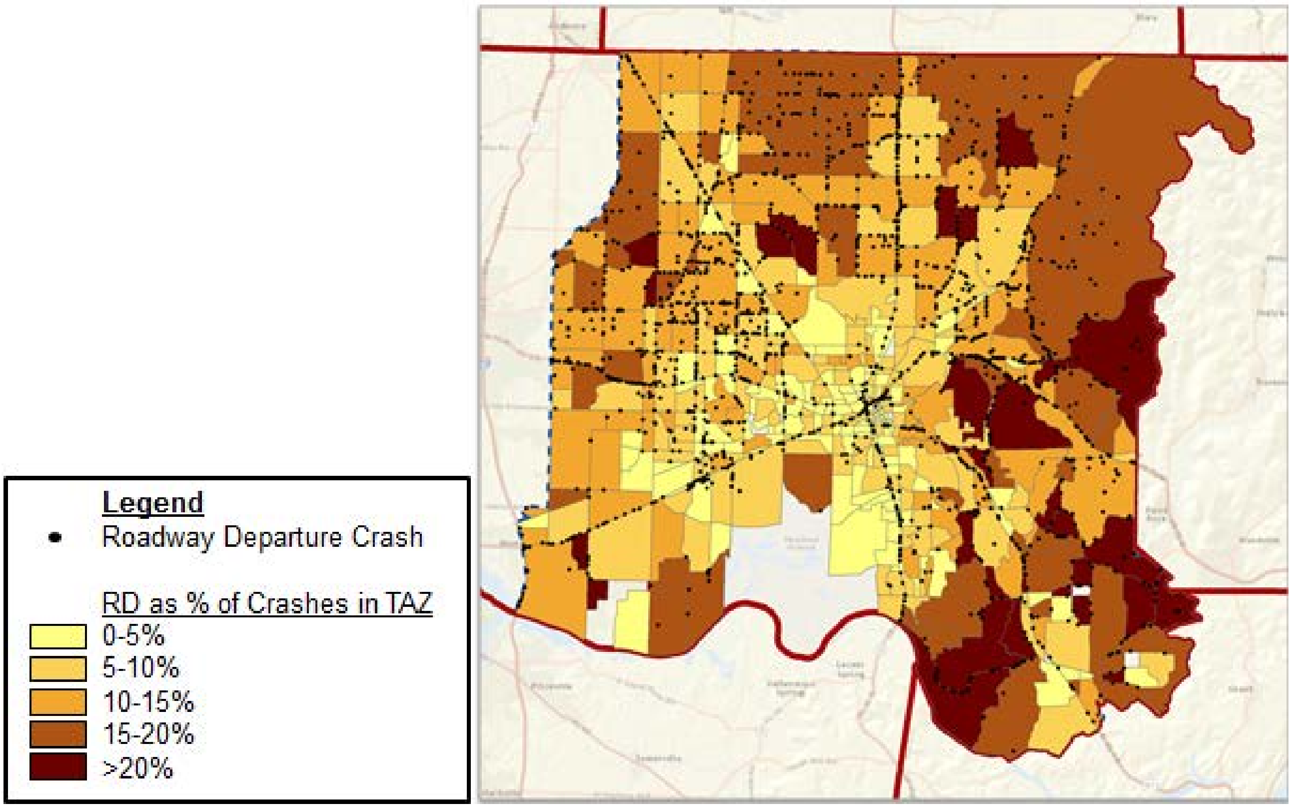
With an understanding of the major crash trends and contributing factors, the planning agency may select one or more of the more prominent crash trends or contributing factors as a focus for planning and programming activities. For example, the crash trend assessment may show more pedestrian or bicycle crashes than expected for a particular area of the community. As a result, a pedestrian/bicycle safety action plan could be developed for the particular area, or the community may find roadway departure crashes in the rural part of the community are overrepresented. In this analysis, the planner would review and summarize crash data to understand such topics as:

- What is the manner of collision? Rear-end, angle, roadway departure, head-on? Was a pedestrian or bicycle involved?
- What is the crash severity? Which crash types are most severe and where are they occurring?
- What crash types or contributing factors are overrepresented?
- What is the geographic distribution of the focus crash type?
- What are common roadway features?

As an outcome of this analysis, the transportation planner would understand the categories of crashes by type, severity, contributing factor, or geography that may be a focus for planning, programming, and countermeasure identification; or the types of crashes or contributing factors that should be a consideration in non-safety-specific projects.

For example, figure 5.7 considers crash distribution by Transportation Analysis Zone (TAZ). The figure shows the percentage of roadway departure crashes per TAZ as a total of all crashes in each TAZ. As shown, roadway departure crashes are more common on the east side of the region, particularly in the southeast.

Figure 5.7 Map. Distribution of Roadway Departure Crashes by Transportation Analysis Zone



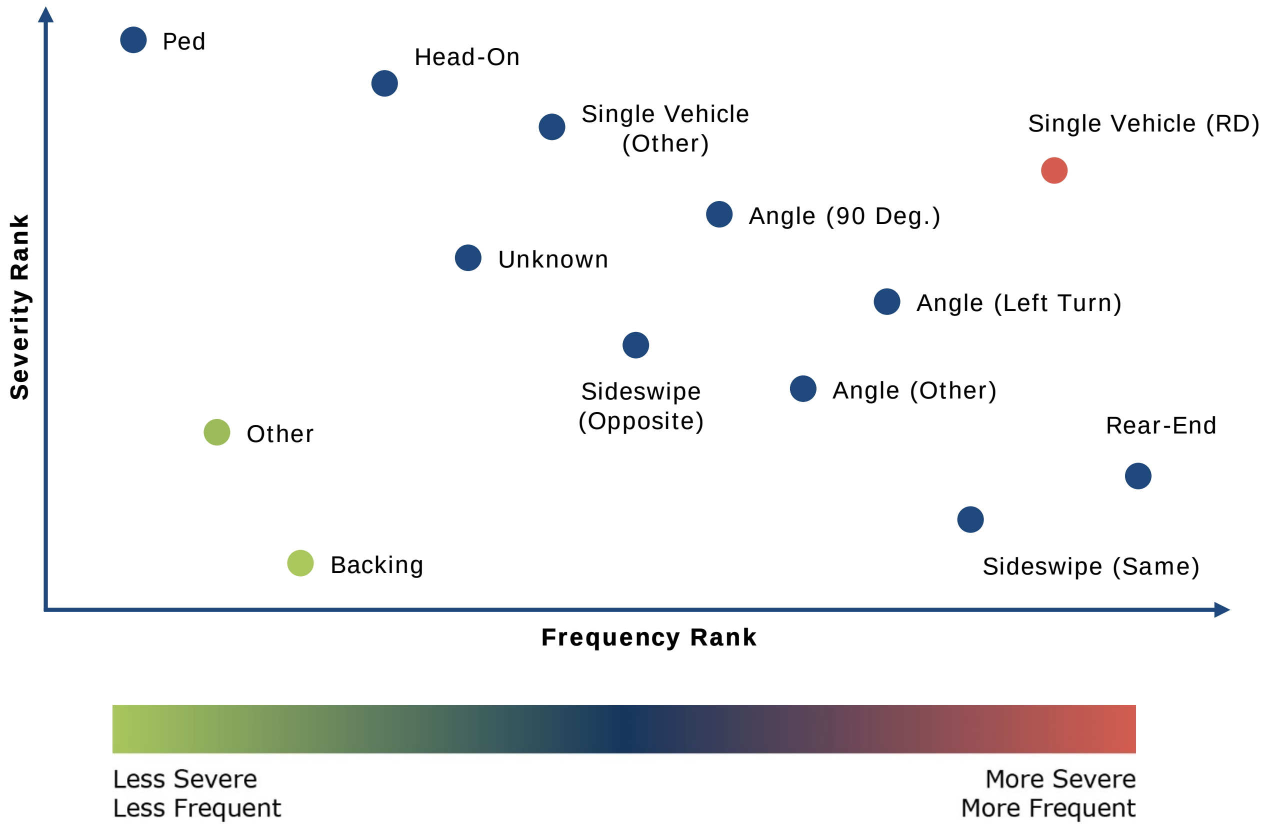
Source: Cambridge Systematics, Inc., unpublished, prepared for Alabama Department of Transportation.

5.3.1 Methods for Identifying and Evaluating Focus Crash Types

Scatterplot

The scatterplot (figure 5.8) illustrates a simple method for evaluating the relative occurrence of various crash types in terms of frequency and severity. The *x*-axis represents the crash type frequency rank, while the *y*-axis indicates the crash type severity rank (percentage of crashes that result in a severe injury). In this example, the single-vehicle (RD) crash type stands out as being highly ranked in both frequency and severity. At the other extreme, backing and other crashes are ranked in the bottom in both frequency and severity and, therefore, are relatively unimportant. Depending on the interest of the MPO, greater emphasis could be placed on frequency or severity.

Figure 5.8 Scatterplot. Crash Types by Frequency and Severity Ranking

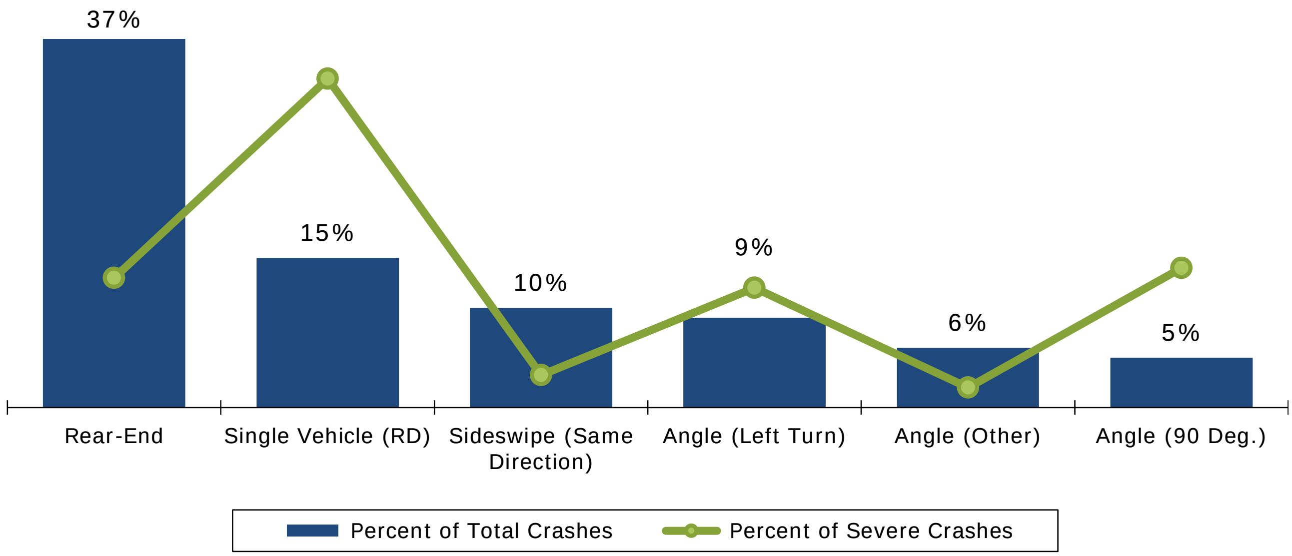


Source: Sample Data, Cambridge Systematics, Inc., 2015.

Overrepresentation

Overrepresentation is another measure of whether a crash type or contributing factor should be prioritized as a safety issue in the planning area. One way to visualize overrepresentation is to compare the percentage of all crashes accounted for by a given factor with the percentage of severe crashes (those resulting in a fatal or serious injury) accounted for by that same factor. For example, figure 5.9 shows 15 percent of all crashes are single vehicle roadway departure crashes, yet 33 percent of all severe crashes are roadway departure crashes.

Figure 5.9 Chart. Overrepresentation of Severe Crashes among Select Crash Types



Source: Sample Data, Cambridge Systematics, Inc., 2015.

Risk Ratio

Another method for identifying if a particular crash type, contributing factor, or severity should be considered as a focus for the area is called risk ratio. The risk ratio compares the severity of crashes associated with a particular factor to the severity of all other crashes. Using the risk ratio analysis method shown in appendix C, it is possible to learn if a particular crash type in a given situation is over represented. Crash types or factors with a risk ratio greater than 1 are overrepresented with respect to severe crashes and could be considered as a focus crash type for the agency. For example the risk ratio calculation could show that crashes in rural areas are 2.7 times more likely to result in a fatality or serious injury than those in urban areas.

5.4 Network Screening—Identify Sites for Safety Improvements

Some transportation planning organizations may choose to identify and prioritize specific locations (also known as sites) for safety improvements. This analysis, also called network screening, identifies locations that are experiencing more crashes than would be expected for comparable sites. Historically, this has been called a list of “hot spots” or “black spots.” Intersections (stop or signal controlled) and roadway segments can be considered sites. From this analysis, the agency learns what specific locations may benefit from safety improvements and, with more detailed analysis, the specific modifications for any given site. For example, New Hampshire DOT imports the safety data into AASHTOWare Safety Analyst™ and distributes the tool to MPOs to use in their analysis. Ohio DOT has approached FHWA for assistance in integrating their State and MPO data and are striving to provide this information to MPOs in Ohio. This analysis can support an existing conditions assessment of a long-range

Using Safety Analyst for Planning

The AASHTO software Safety Analyst conducts statewide network screening, site prioritization, countermeasure identification, and benefit-cost analysis. It applies network screening methods from the HSM. The level of effort to deploy Safety Analyst is substantial; however, once functional it is a powerful tool for conducting network screening and prioritization analysis. Ohio, Washington State, and New Hampshire are leaders in the development and deployment of Safety Analyst. If available, Safety Analyst results can be used at the regional level.

plan or corridor planning analysis; could be used to help transportation agencies determine appropriate countermeasures at locations for a safety plan; or it could be integrated into a prioritization process by giving a scoring benefit to projects or programs, which also address a site with potential for safety improvements.

Chapter 4: Network Screening of the AASHTO HSM provides detailed explanations of many different network screening methods. The simplest methods are frequency, crash rate, and equivalent property damage only. There are strengths and weaknesses to each of these methods; however, if facilities are organized into groups of comparable facility type and traffic volume, many of the common challenges are overcome.

5.4.1 Methods for Network Screening

Network Screening Methods

Chapter 4 of the AASHTO HSM also includes network screening methods to compare observed site crash frequency to "expected" crash frequency for comparable sites. The expected crash frequency is a more reliable estimate of long-term safety performance at a site than estimates based on a three-year average. Calibrated Safety Performance Functions (SPF) are needed to calculate expected crash frequency or severity. Many State DOTs are developing calibration factors and/or State-specific SPFs. Be sure to check with your State DOT colleagues to determine if these are available. It may also be possible for your State partners to conduct the network screening analysis in your area.

Crash Frequency

The crash frequency method for network screening counts the number of crashes that have occurred at an intersection or roadway segment over a specified time period, typically three to five years. The locations are ranked from highest to lowest crash frequency. Locations with relatively higher crash frequency are selected as possible sites for detailed investigation and subsequent safety improvement.

Crash frequency is an attractive quantitative screening technique because the only data required are crashes and their physical locations. Other data like traffic volume and roadway features are not necessary for using this technique, making it relatively quick and easy. However, it does have shortcomings. The crash frequency method does not take traffic volumes or roadway elements into account. Because higher-volume locations are likely to have more crashes than lower volume locations, this method has an intrinsic bias toward higher-volume locations.

Crash frequency also is subject to issues associated with regression to the mean. If regression to the mean is not accounted for, a site might be selected for study because the annual number of crashes that occurred was higher than "usual" due to a random fluctuation in the data. Conversely, a site that should be selected for study might be overlooked because an unusually low number of annual crashes occurred there. To reduce the influence of regression to the mean the agency should calculate the average of the most recent three to five years of crash data to determine the average crash frequencies. This minimizes, but does not entirely overcome, the year-to-year fluctuations in data and is appropriate if site conditions (e.g., traffic volume, land use, driveway access, and roadway configuration) have not changed. A more detailed explanation of regression to the mean can be found in appendix D.

Crash Rate

Crash rates describe the number of crashes in a given period as compared to some measure of exposure. Crash rates are calculated by dividing the total number of crashes at a given roadway section or intersection over a specified time period (typically three to five years) by a measure of exposure. While traffic volume is the most typically used measure of exposure, others such as population, lane, or roadway miles, and licensed drivers within a community also can be used. The locations are then ranked from high to low by crash rate. Crash rate screening is able to identify low-volume, high-crash risk locations that do not necessarily experience a high total number of crashes.

It is important to note that crash rates also are influenced by regression to the mean and tend to overemphasize sites with lower traffic volumes. It is best to use crash rates as a comparison tool only for sites that have similar functional classifications, number of lanes, surrounding land uses, and traffic volume.

Equivalent Property Damage Only

In the equivalent property damage only (EPDO) method, weighting factors related to the societal costs of fatal, injury, and property damage-only crashes are assigned to crashes by severity (typically, at a given location over three to five years) to develop an EPDO score that considers frequency and severity of crashes. The sites are ranked from high to low EPDO score. Those sites at the upper end of the list may be selected for investigation. To apply the EPDO method for ranking sites, it is necessary to know the number of crashes per year and the severity of crashes per year per site. In this method, all injury crashes (incapacitating, nonincapacitating, minor injury) are grouped together.

Heat Map

Heat maps show the density of crashes per unit area (e.g., crashes per square mile) on the roadway system. Crash data must be geolocated; and then using GIS tools, the crash density can be plotted. As shown in figure 5.10, heat maps are useful for crash data visualization as it can be difficult to decipher patterns based on a map of individual crashes. They can help planners to focus their analysis on areas with higher crash concentrations. They also can quickly reveal corridors that may be worthy of attention; whereas, analyzing corridors using other techniques can be quite challenging. Based on the result from a heat mapping exercise, field investigations could be conducted at the locations with a higher crash density to identify if there is potential for safety improvement.

Figure 5.10 Heat Map. Density of Crashes per Unit Area

Source: Cambridge Systematics, Inc., unpublished, Central Arizona Governments.

5.5 Systemic Analysis—Identify Safety Risk Factors

Another form of safety analysis is called systemic analysis. The systemic approach to reducing crash frequency and severity involves wide implementation of low-cost safety improvements to address high-risk roadway features correlated with specific severe crash types. The approach provides a more comprehensive method for safety planning and implementation and compliments site-specific analysis.

Systemic analysis identifies if there are the transportation system characteristics that can be commonly associated with particular types of crashes. These characteristics are called risk factors. For example, if roadway departure crashes are most frequently occurring on two-lane roads with a particular curve radius, this combination of characteristics (i.e., two-lane roads with specific curve radii) can be considered risk factors. The transportation system is then evaluated to identify all the locations where these characteristics exist. The locations are subsequently prioritized to develop a list of locations for implementing low-cost safety treatments.

Proven Safety Countermeasures

FHWA Office of Safety maintains a Web site of proven safety countermeasures. These countermeasures are research proven but not yet widely implemented. The FHWA Web site describes each of these countermeasures and provides background, guidance, and resources for each countermeasure. The countermeasures are: roundabouts, corridor access management, backplates with retroreflective borders, longitudinal rumble strips and stripes on two-lane roads, enhanced delineation and friction for horizontal curves, safety edge, medians and pedestrian crossing islands in urban and suburban areas, pedestrian hybrid beacon, and road diets.

With an understanding of the risk factors associated with particular crash types and the countermeasures addressing the particular risk factors, the transportation planning organization can consider these risk factors and potential treatments as part of other corridor planning or site-specific projects; or in the prioritization process, if a project includes addressing known risk factors, it could be given additional scoring benefits. For example, several DOTs have installed cable median barriers to address cross-median crashes, which often result in severe injuries. Ohio has installed over 300 miles on its roadway network and has found the technology to be a cost-effective solution when applied in the appropriate context.

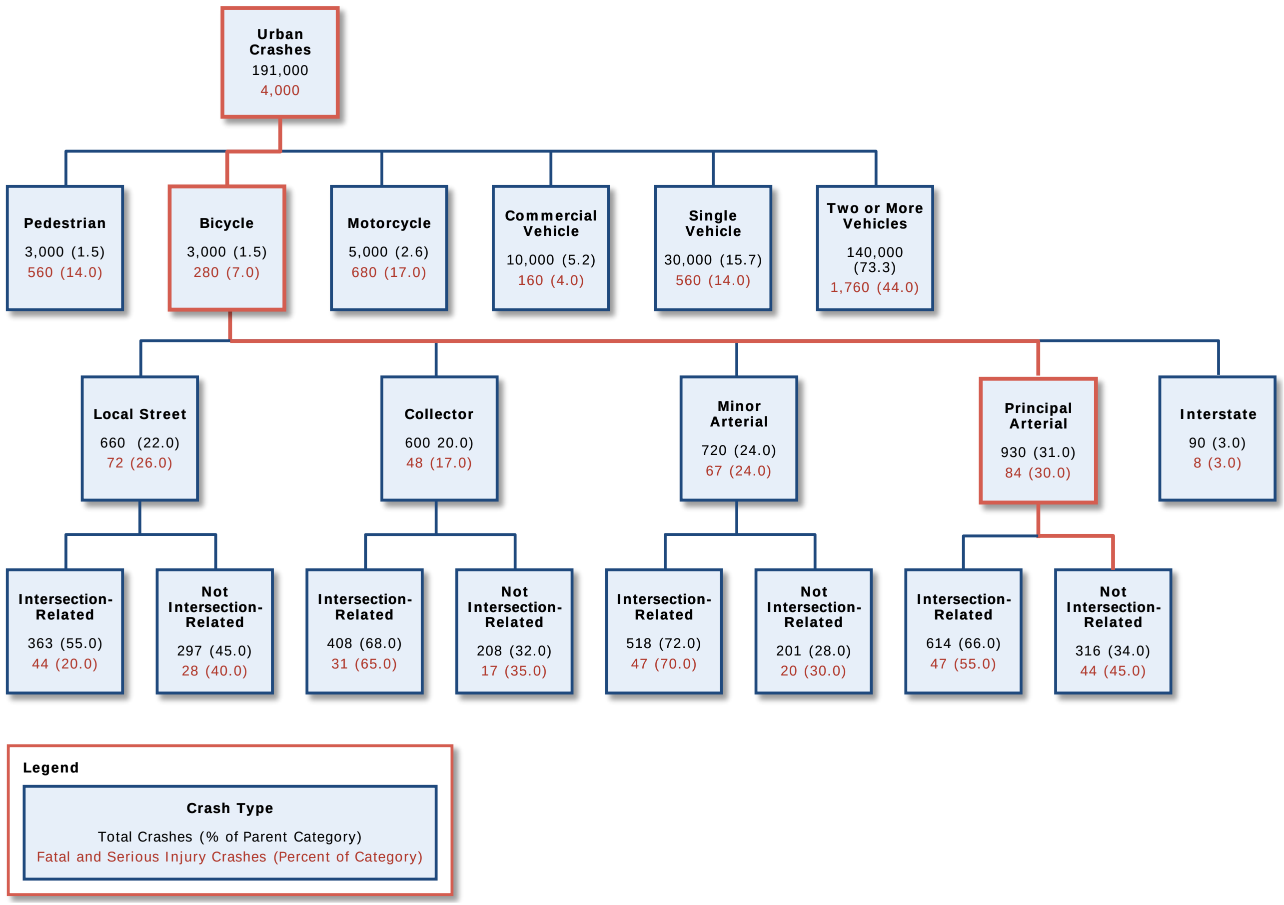
5.5.1 FHWA Systemic Safety Project Selection Tool

The FHWA guidebook *The Systemic Safety Project Selection Tool* provides the following:

- A step-by-step process for conducting systemic safety planning;
- Considerations for determining a balance between spot and systemic safety improvements; and
- Analytical techniques for quantifying the benefits of a systemic safety program.

The guidebook can be downloaded from the FHWA Systemic Safety Analysis Web site. Missouri DOT and Minnesota DOT have been leaders in systemic analysis for many years. Missouri DOT started their systemic safety efforts in the mid-2000s. More recently, Minnesota DOT has conducted systemic analysis for every county in the State. Figure 5.11 shows an example crash tree analysis (hypothetical data), which is a common step in systemic analysis. This figure shows that of the 191,000 statewide urban crashes, 3,000 are bicycle related and 280 are fatal and serious injury crashes. Fatal and serious injury bicycle crashes are most common on Principal Arterials, and on the Principal Arterials the fatal and serious injury crashes are roughly equally distributed between intersection and nonintersection crashes. A crash tree allows the user to identify trends per mode and facility type.

Figure 5.11 Flowchart. Example Crash Tree Analysis



Source: Sample data, Cambridge Systematics, Inc., 2015.

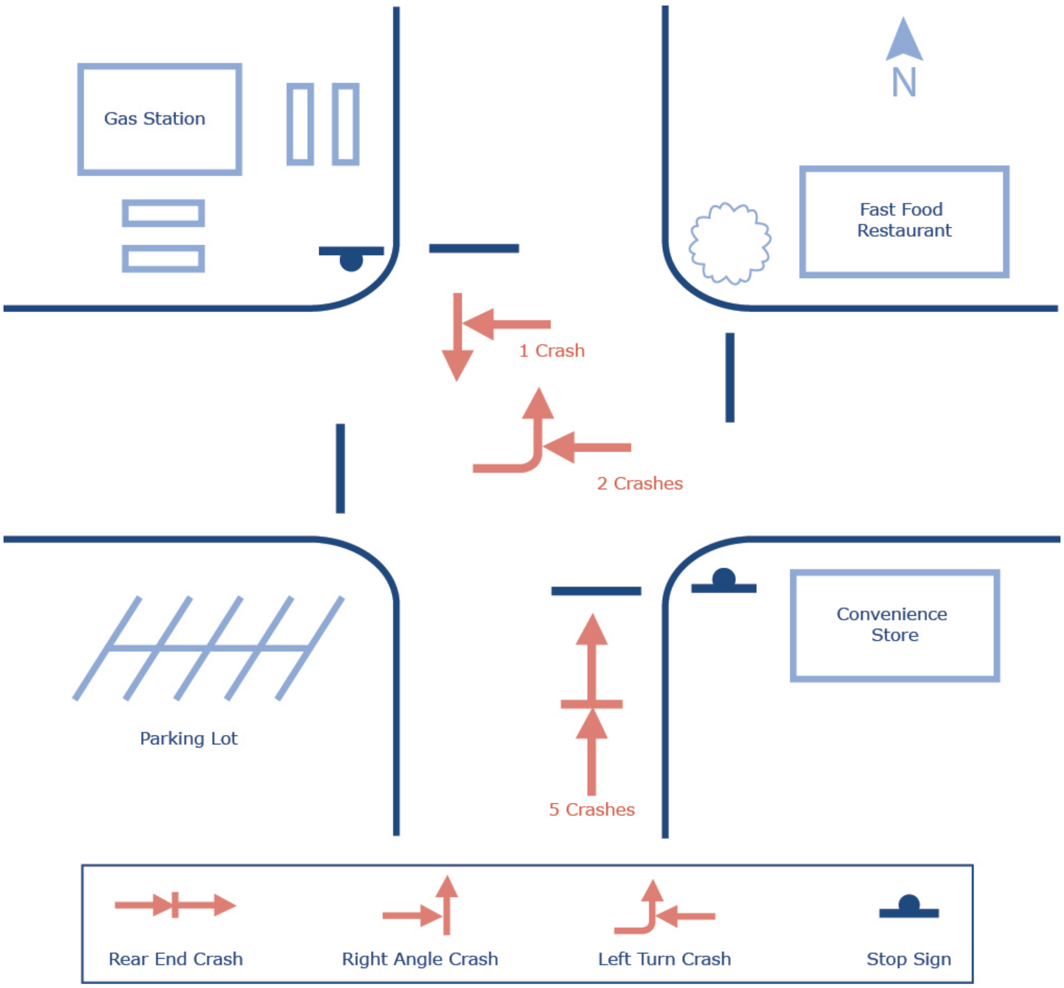
5.6 Corridor and Intersection Planning Safety Analysis

Typical corridor or intersection planning projects will evaluate the impact different facility cross section alternatives have on mobility, reliability, environmental impacts, or construction costs. These projects can and should include an evaluation of changes in crash frequency or severity that can be associated with various roadway cross sectional features. Traffic volume and roadway features, such as the number of lanes, form of intersection control, lighting, shoulder type and width, horizontal curvature, and many other features, influence the expected crash frequency and severity at an intersection or along a roadway segment. The inclusion of these variables in the analysis greatly improves the ability to predict future safety outcomes. Evaluating alternatives that address safety performance can help agencies determine appropriate short- or long-term safety goals, objectives, and countermeasures.

5.6.1 Crash Diagrams

Crash diagrams are hand-drawn or computer-generated sketches of the type and severity of crashes at a site. The site (e.g., roadway segment or intersection) is sketched in plan view. Each crash is sketched onto the drawing in the approximate location where the crash occurred. Arrows and other common symbols are used to represent each crash type. The diagram makes it possible to visualize the location, type, and number of crashes of each type to see if there are any trends. Figure 5.12 is a simplified crash diagram for a hypothetical intersection. In this example, there are a five of rear-end crashes at the south approach to the intersection, two left-turning crashes, and one right angle crash. Additional notes could be added to the diagrams to include severity of the crashes, time of day, weather, or lighting conditions.

Figure 5.12 Graphic. Example Simplified Collision Diagram



Source: Sample data, Cambridge Systematics, Inc., 2015.

5.6.2 Crash Modification Factors

A crash modification factor (CMF) is a multiplicative factor used to compute the expected number of crashes at a site after implementing a given countermeasure. The expected (or observed) crash frequency at the site without treatment is multiplied by the value of the CMF to estimate the new number of crashes at the site after implementing the treatment. A CMF greater than 1.0 indicates an expected increase in crashes, while a value less than 1.0 indicates an expected reduction in crashes. For example, a CMF of 0.8 indicates an expected safety benefit; specifically, a 20 percent reduction in crashes. A CMF of 1.2 indicates an expected degradation in safety; specifically, a 20 percent expected increase in crashes.

The FHWA CMF Clearinghouse is one of the current tools available for identifying and selecting countermeasures. The CMF Clearinghouse serves as a central online repository of CMFs. Users are able to query the Clearinghouse' database to identify treatments, the crash type and severity the treatment will address, and the CMF associated with the treatment. For each CMF, the database provides users with published information, such as how it was developed, the research quality behind the CMF, and a link to the publication from which the CMF was extracted. Based on this, users are able to determine the most applicable CMF for their condition.

The Clearinghouse is updated regularly to incorporate the latest safety research. The CMF Clearinghouse also reports which CMFs are included in the HSM; these CMFs typically have a higher quality rating given the strict HSM inclusion criteria.

In the planning process as alternative roadway configurations for a site or corridor are considered, the CMFs for various treatments can be included in the investigation to consider the potential safety effects of different features and again include a quantitative safety evaluation criterion as part of the analysis.

5.6.3 AASHTO HSM Predictive Method

The AASHTO HSM predictive method calculates an expected number and severity of crashes at sites with similar geometric and operational characteristics for one or more of the following: existing conditions, future conditions, or roadway design alternatives.

The predictive method provides a quantitative measure of expected average crash frequency under both existing conditions and conditions that have not yet occurred. This allows proposed roadway conditions to be quantitatively assessed along with other considerations, such as community needs, capacity, delay, cost, right-of-way, and environmental considerations.

The predictive method can be used for evaluating and comparing the expected average crash frequency of situations, such as the following:

- Existing facilities under past or future traffic volumes;

- Alternative designs for an existing facility under past or future traffic volumes;
- Designs for a new facility under future (forecast) traffic volumes;
- The estimated effectiveness of countermeasures after a period of implementation; and
- The estimated effectiveness of proposed countermeasures on an existing facility (prior to implementation).

Interactive Highway Design Model

IHSDM is a safety decision support tool that provides estimates of a highway design's expected safety and operational performance.

Part C of the AASHTO HSM presents the detailed methodology for applying the predictive method on two-lane rural highways, rural multilane highways, urban and suburban arterials, and freeway facilities. The HSM predictive method is based on safety performance functions (SPF), crash modification factors and calibration factors. SPFs are equations used calculate predicted crash frequency as a function of traffic volume and roadway characteristics. Crash modification factors and calibration factors are used to modify the prediction to reflect local conditions. The Interactive Highway Design Model (IHSDM) is a software available at no cost from FHWA, which can be used to apply the predictive method from the HSM. Florida, Washington, Utah, Illinois, and Ohio DOTs have been very active in training and deploying HSM predictive methods. Planners can reach out to the safety analysis division within the DOT to initiate or obtain assistance on these more advanced safety analysis techniques. Spreadsheets also are available for applying the HSM predictive method (NCHRP 17-38 HSM Predictive Method Spreadsheets).

6.0 Applying Safety Data and Analysis to Inform Decisionmaking

Chapter 4.0 and chapter 5.0 provide planners with an understanding of the types of safety data and analysis techniques available for use in the transportation planning process. Chapter 6.0 describes how to use the information to develop data-driven safety goals, objectives, performance measures, and projects.

6.1 Institutional Considerations

6.1.1 Legislation

Transportation legislation dating back to the Intermodal Surface Transportation Efficiency Act (ISTEA) and continuing through MAP-21 makes clear the importance of safety in transportation planning. Safety has long been one of the factors transportation planners are required to consider during the transportation planning process and reflected in statewide and regional transportation plans. More recent requirements have looked to strengthen the link between SHSPs and other transportation planning processes and documents. As a result, planners are developing transportation safety goals and objectives based on the results of data and analysis as well as by adopting or customizing safety goals identified in other planning documents, such as the SHSP.

6.1.2 Collaboration and Coordination

The development of transportation safety goals, objectives, performance measures/targets, and projects/programs relies on obtaining crash data and conducting analysis. Crash databases, data owners, and analysis tools differ across States, but a critical step in the planning process is to collaborate across State and regional agencies to understand where the data is housed, how it can be obtained, and what technical resources exist to analyze the information.

Examples of Collaborating on Safety Planning

Where Data is Housed: *In Alabama, the DOT informs all transportation planning agencies of the CARE system, which provides convenient access to crash data.*

How to Obtain Data: *In Louisiana, transportation planners know to coordinate with the DOTD Highway Safety Section staff for safety data and analysis. In New Mexico, planners submit an email request to the New Mexico DOT Crash Records reporting office.*

What Technical Resources Exist: *Transportation agencies in Ohio use the Geographic Crash Analysis Tool (GCAT). To ensure planners can utilize the tool, Ohio DOT offers frequent training opportunities.*

An opportunity for coordination can come through multidisciplinary collaboration. As part of the transportation planning process, committees are formed to provide input into a plan. To ensure safety interests are represented during a plan update, a transportation agency can choose to form a safety subcommittee or invite safety stakeholders to participate.

The SHSP and TRCC planning, update, and/or implementation processes also are essential processes planners should be engaged in for purposes of information sharing, and coordination. By being actively involved, planners will:

- Gain exposure to a data-driven safety planning process, which could be replicated during their transportation planning processes;
- Gain access to and better understand available crash, roadway, and volume data and tools to use it;
- Connect with other transportation safety stakeholders;
- Understand the safety emphasis areas and proven strategies, which could be adopted and customized for other transportation planning documents;
- Influence and coordinate safety goals and objectives in order to integrate the processes (e.g., SHSP and transportation planning); and
- Understand the SHSP which is a strategic document and does not include projects, but planners will still gain an understanding of the various funding and prioritization processes to better position themselves to leverage limited safety improvement resources.

Committees

For a recent LRTP update, the York MPO in Pennsylvania formed a safety committee to provide input into the Plan. The committee included representation from MPO staff, local law enforcement, PennDOT District staff, the County Center for Traffic Safety, and the local Bicycle Council.

Other agencies incorporate safety stakeholders into transportation focused committees. For an Interchange Area Management Plan in Oregon, the DOT invited State traffic safety designers as well as the local police and fire departments to be part of the committee, to inform safety considerations in the transportation plan.

Participation in Committees

In Florida, State DOT planners and MPOs are encouraged to participate in the SHSP planning and implementation processes. As a result of this engagement, planners are able to effectively utilize State-developed data to incorporate the SHSP goals and performance measures into their processes. The MPOs also provide their local data to the State and report activities that relate to SHSP to the State via a database entry system.

In both Michigan and Vermont, a high level of coordination exists between the TRCC's strategic planning efforts and the SHSP effort. This arrangement ensures planners can address any data-related issues related to safety planning in a timely manner.

6.1.3 Organizational Capacity

Planners often wear many different hats, dealing with an array of transportation topics. Because of this, they may not have the staff or resources to adequately address safety, instead relying on the State SHSP to address all safety needs and priorities in the State. However, as mentioned in section 3.2.2, the SHSP does not necessarily address all the statewide or regional transportation safety issues and needs. Opportunities to begin dedicating resources to study transportation safety include the following:

- **Weave safety into other plans.** Considering safety in the planning process does not necessarily entail the development of a stand-alone safety plan. Some agencies identify efficiencies by considering safety within the context of other planning documents. For example, the Hillsborough MPO in Florida has integrated crash analysis into the congestion management process. Other examples could be related to freight planning, bike and pedestrian plans, or corridor planning.
- **Develop reports or other technical assistance.** Many State DOTs and some MPOs create custom crash data reports to reduce the burden of agencies completing their own analysis. For instance, Pennsylvania DOT creates a high-crash location list in GIS for each of its MPOs and RPOs every two years. They use these lists during planning and project prioritization processes. Other agencies will identify opportunities to provide safety technical assistance—for instance, Louisiana DOTD relies on its local technical assistance program (LTAP) to assist local jurisdictions with the identification of safety issues and priorities.
- **Invest in tools that can advance analysis.** A number of tools and approaches exist to conduct crash data analysis, but some need to be purchased and all require staff resources to run and manage. Consider which tool or tools might make sense to your agency and during budget cycles, and identify what opportunities exist to leverage resources to support safety analysis.
- **Hire consultants.** Without in-house staff expertise, some agencies hire consultants to prepare crash analysis and assist with program/project identification.
- **Enlist University assistance.** State DOTs and MPOs may rely on students or programs at universities and colleges to perform safety analysis activities.
- **Add safety staff or make safety part of someone’s job responsibility.** If feasible, agencies may create a position for a safety planner or, at a minimum, ensure it is 25 to 50 percent of an appropriate technical representative’s job responsibilities.

6.1.4 Funding

Transportation safety planning activities can be funded using FHWA statewide or metropolitan planning (PL), HSIP, SPR, NHTSA 402 and 405, or FMCSA funds. Some States also may have discretionary funds for planning activities that could be used for safety. For example, Arizona

DOT administers the Planning Assistance for Rural Areas (PARA) programs, which funds multimodal planning studies, some of which have addressed safety issues and needs.

6.2 Using Safety Data and Analysis to Develop Goals and Objectives

The purpose of setting goals and objectives during the planning process is to identify the desired outcomes for the transportation system and how those outcomes can be achieved.

> ***Safety Vision***
>
> *Prior to establishing goals and objectives, many agencies will develop a long-term vision for the transportation system to guide programs, policies, and projects. Some vision statements are transportation focused but incorporate elements of safety. Other agencies have developed safety-specific vision statements, such as Towards Zero Deaths (TZD). The Mid-America Regional Council has taken this latter approach.*

6.2.1 Qualitative Safety Goals

Safety goals can be developed in a number of ways. A primary focus of Section 6.2.2 is to provide examples of data-driven goals, but it is clear that not all goal setting occurs in a quantitative manner. Qualitative goal setting can be just as effective because, at a minimum, it establishes safety as a priority during the planning process and sets the stage for the identification of data-driven objectives, performance measures and targets, and projects to help meet that safety goal. Types of qualitative goal setting include:

- **Safety Planning Factor:** It is common for transportation agencies to reference the Federally required planning factors as their transportation goals. When it comes to safety, "increase the safety of the transportation system for motorized and nonmotorized users," or something similar, can be utilized as the safety goal for a planning document.
- **Public/Stakeholder Input:** Another common approach is to identify transportation goals through committee, stakeholder, and/or public input. Information can be obtained either through surveys, comment cards, open houses, committee meetings, mapping tools, or other. This type of input can vary drastically depending on stakeholders or public participants, but presenting the same information to everyone and asking pointed questions can reduce the possibility of wide variations. Planners can utilize the information to inform a single or multiple goals. The goal could be safety specific or safety could be woven into other goals.

> ***Example of Safety Goal Setting—Public and Stakeholder Input***
>
> *During a committee meeting for the development of their Community Safety Transportation Plan, the City of Hamilton (Montana) asked committee members to discuss their safety goals. Input included increase education regarding texting and driving, address increased speed around schools, continue safe routes to school, and many more. From this input, the following safety goal was created: preserve and enhance the quality of life by improving transportation safety for all users.*

- **Goals in Other Plans:** Another qualitative approach to safety goal setting is to review and adopt applicable goals from other planning documents. Documents to review include the SHSP, HSP, Commercial Motor Vehicle Safety Plan, State and MPO LRTPs and Modal Plans, and Comprehensive Plans. Ideally, planners should have a sense, based on public/ stakeholder input or preliminary analysis, as to what the key safety issues/needs are, so only relevant goals will be adopted.

6.2.2 Data-Driven Safety Goals

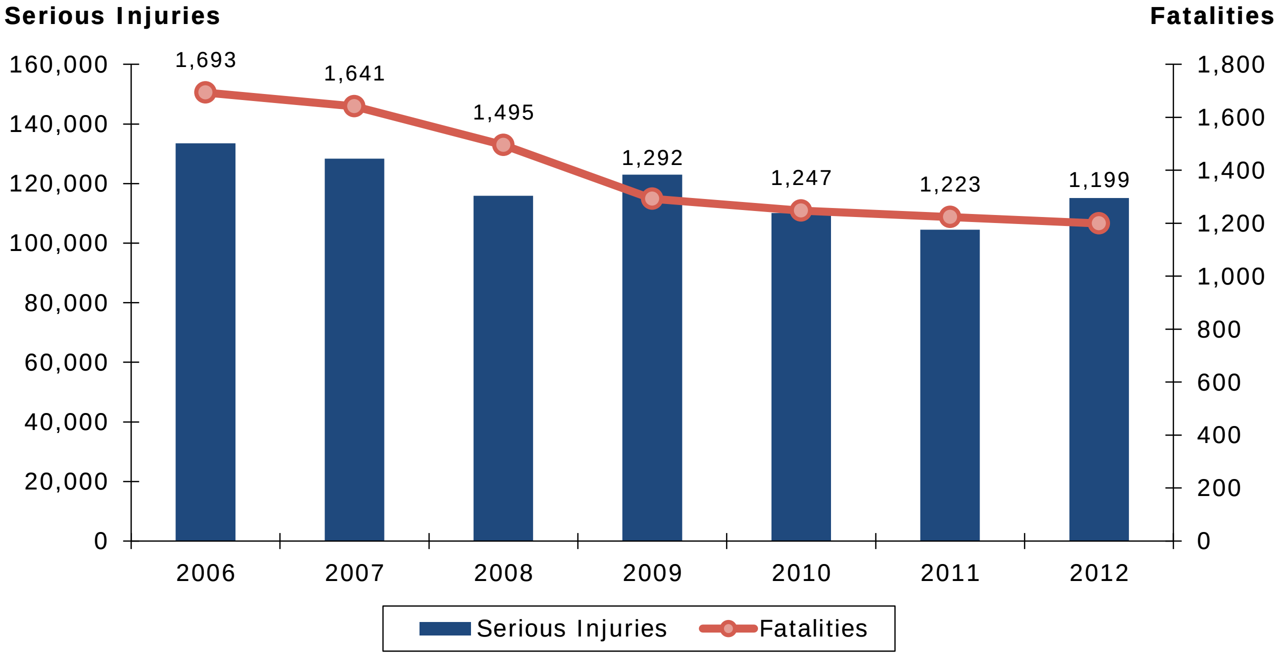
The results of data analysis identify general as well as specific safety issues and needs and can be used to develop transportation goals. The data used to develop safety goals can range from basic analysis, such as reviewing the results of crash frequency to more sophisticated analysis, like network screening to identify more specific goals.

> ***SHSP Goals***
>
> *MAP-21 requires that the transportation planning process must integrate directly or by reference, the goals, objectives, performance measures, and targets described in other State transportation plans, such as the SHSP.*

Trend Analysis

Many agencies use basic time trend analysis to understand how safety fatalities and serious injuries have changed over the years. Reviewing trends on an annual basis can encourage an agency to consider safety more prominently as a goal area. For instance, if safety trends demonstrate a high number of crashes or increases over time, safety should be recognized as a priority goal area over the long term. By looking at the trend data in figure 6.1, an agency could conclude that both serious injuries and fatalities are a concern based on the numbers and a safety goal would be appropriate to develop. How the goals are stated can vary, but based on this amount of data, agencies could likely develop a broad safety goal, such as: “Increase safety for all users by reducing transportation-related fatalities and serious injuries.”

Figure 6.1 Chart. Trends
Safety Goal Setting



Source: Sample data, Cambridge Systematics, Inc., 2015.

Contributing Factors

For every vehicle crash, there are numerous factors contributing to its severity. Many agencies will review and analyze the different elements (i.e., speeding, alcohol, unbelted) that played a role in the crash to draw conclusions regarding program and project investments. This information also can be used to establish safety goals. Figure 6.2 shows data reviewed by the Capital Region Safety Coalition in Louisiana during the development of a regional safety plan. Based on this data, the coalition decided to establish four safety-specific goals, which were:

- Reduce roadway departure fatalities;
- Reduce impaired driving fatalities;
- Reduced occupant protection-related fatalities; and
- Reduce young driver fatalities.

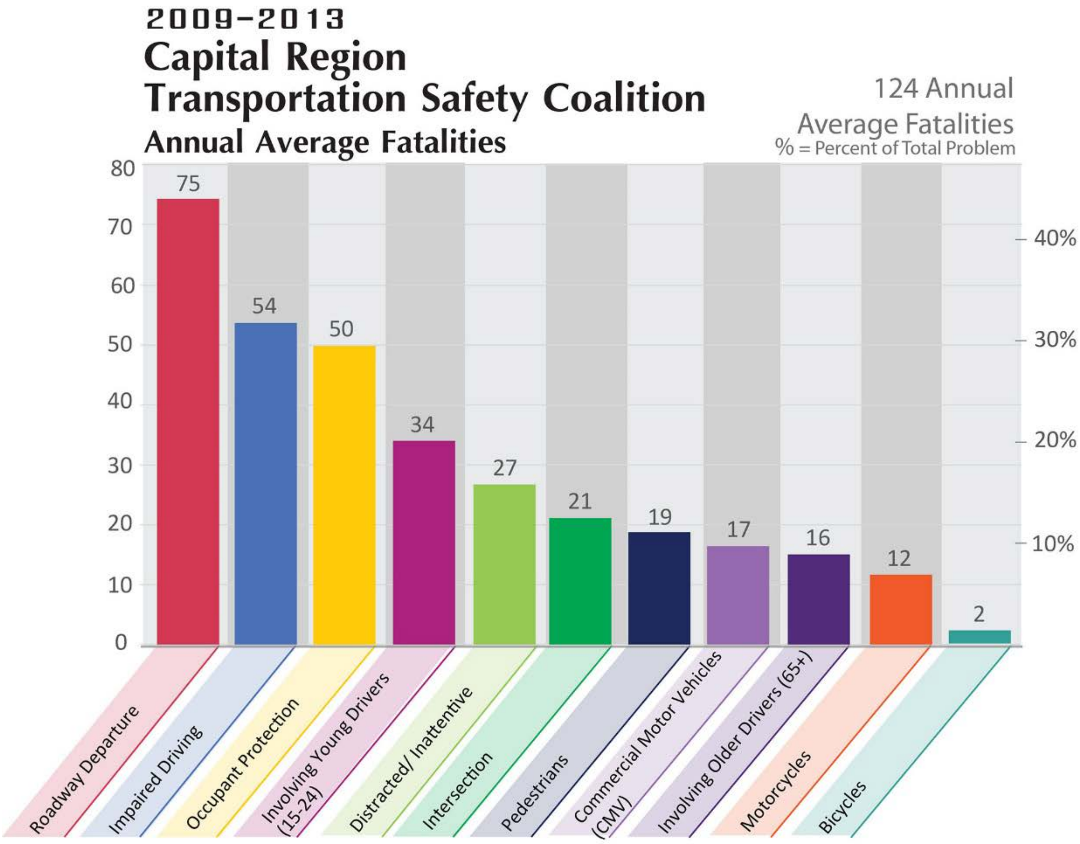
However, goal statements based on contributing factor data, can vary. For instance, an agency may still wish to draw broad safety goals based on this data. Different text options could be:

- Increase safety for all users by reducing transportation-related fatalities; or

- Improve safety by reducing the prevalence of infrastructure, impaired driving, occupant protection, and young driver-related fatalities.

Figure 6.2 Chart. Contributing Factors

Safety Goal Setting

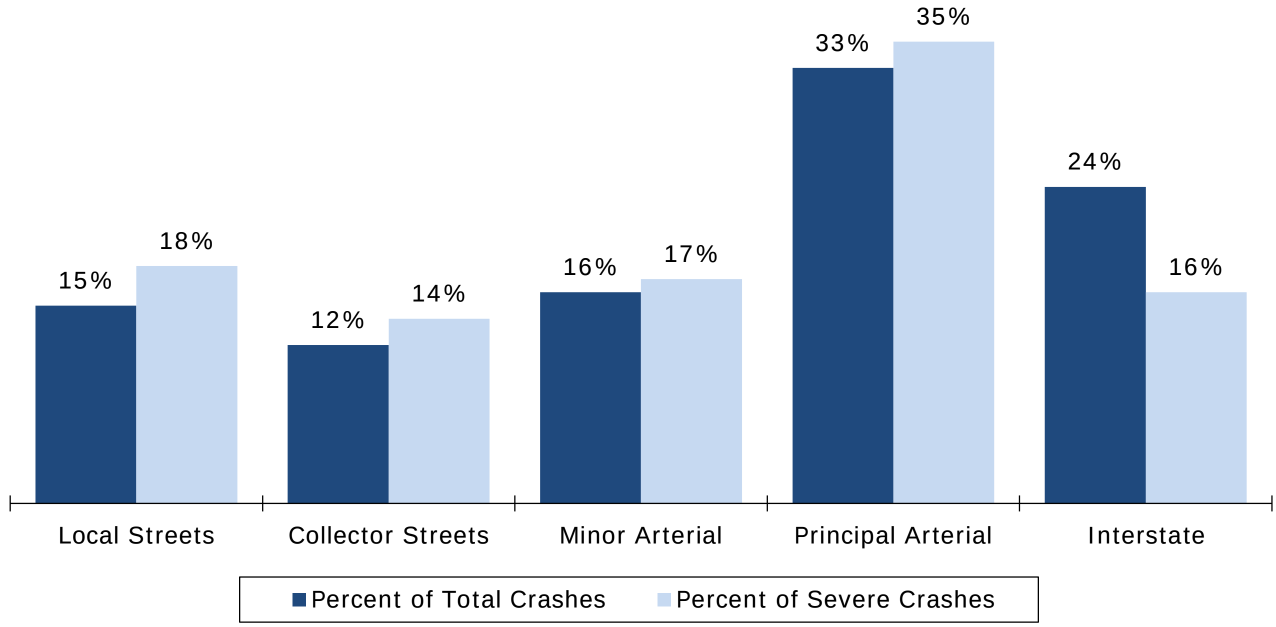


Source: Louisiana Highway Safety Research Group, Capital Region Transportation Safety Coalition Level II Data.

Other Characteristics

Agencies review crash data in a multitude of ways, more than can be presented in this section; however, other ways planners may look at data, which can be extrapolated into safety goals is by geography (rural and urban), mode of travel (single vehicle, commercial vehicle, motorcycle, etc.), or functional class. Figure 6.3 examines functional class, showing that a higher proportion of crashes are occurring on principal arterials. As a result, an agency may decide to create a specific safety goal, to focus on reducing severe crashes on principal arterials. The goal could read as: “Improve multimodal safety by reducing crashes on principal arterials throughout the State.” This same type of approach—reviewing data and developing goals—could be done when looking at data by geography and mode of travel.

Figure 6.3 Chart. Functional Class
Goal Setting



Source: Sample data, Cambridge Systematics, Inc., 2015.

Advanced Analysis

The results of more sophisticated analysis, such as network screening or systemic analysis also can provide useful information for goal setting. Network screening, for instance, provides planners with information on specific segments or intersections that have a safety record higher or lower than expected. Table 6.1 shows sample high-priority intersections for a region. Based on this data, a general safety goal could be developed to capture the entirety of the network screening process or a specific goal could be identified to consider intersection safety. Possible safety goals stemming from a network screening analysis include:

- **General Goal:** Increase safety for all users by reducing transportation-related fatalities and serious injuries at sites with the most potential for safety improvements; or
- **Specific Goal:** Improve safety by reducing fatalities and serious injuries at intersections.

Table 6.1 Network Screening
Safety Goal Setting

Final Rank	Intersection	Frequency Rank	Crash Rate Rank	EPDO Rank	Composite Rank
1	U.S. Highway 60 at Radanovich Boulevard	4	3	2	9
2	SR 87/Beeline Highway at Longhorn Road at U.S. Highway 260	1	1	9	11
3	SR 260 Valley Road at Highline Drive	4	5	12	21
3	SR 87/Beeline Highway at Bonita Street	10	4	7	21
5	SR 188/Apache Trail at U.S. Highway 60 at Russell Road	2	10	10	22
6	U.S. Highway 60/Ash Street at Hill Street	7	11	8	26
7	U.S. Highway 60/Ash Street at Hill Street	6	7	15	28
8	U.S. Highway 60 at Escudilla Drive at Main Street	3	2	24	29
9	SR 347/John Wayne Parkway at Papago Road	12	18	3	33
10	SR 87/Beeline Highway at Main Street	7	26	5	38

Source: Cambridge Systematics, Inc., unpublished, Central Arizona Governments.

Developing a safety goal or goals may not be entirely data-driven, but when possible, available safety analysis results, either qualitative or quantitative, can be used to inform this initial portion of the planning process.

6.2.3 Data-Driven Safety Objectives

Regardless of the approach used to establish transportation safety goals, objectives are necessary to define how the goals will be met. Ultimately, objectives should provide enough specificity to help planners identify programs and projects that will meet the goals of the planning document. Although objectives can be identified in a qualitative fashion, such as through public/stakeholder input or adopted from other planning documents, elements of data analysis should still be included to ensure objectives are specific and measurable and progress towards the goals can be tracked. An example of this is found in the South Carolina Multimodal Transportation Plan shown in figure 6.4. The safety goal itself is general, but the objectives are descriptive and measurable to ensure the South Carolina DOT understands exactly how to achieve its safety goal.

Figure 6.4 Screenshot. Defining Safety Goals with Measurable and Specific Objectives

Safety Goal

Improve the safety and security of the transportation system by implementing transportation improvements that reduce fatalities and serious injuries as well as enabling effective emergency management operations.

Background: Safe travel conditions are vital to South Carolina's health, quality of life and economic prosperity. SCDOT partners with other safety on the state's transportation system. SCDOT maintains extensive data on safety; however, even state-of-the-art planning practices often cannot connect investment scenarios with safety outcomes.

Proposed Objective	OP	I	SC	F	T	R	Potential Measures
Plan Level							
Improve substandard roadway.	X	X	X				% of substandard roadway improved
Implementation Level							
Reduce highway fatalities and serious injuries.	X	X	X				Number or rate of fatalities and serious injuries
Reduce bicycle and pedestrian fatalities and serious injuries.	X		X				Number or rate of bike/pedestrian fatalities and injuries
Reduce roadway departures.	X	X	X				Number of roadway departure crashes involving fatality or injury
Reduce head-on and across median crashes.	X	X	X				Number of head on and cross median
Reduce preventable transit accidents.					X		Number of accidents per 100,000 service vehicle miles
Reduce rail grade crossing accidents.						X	Number of rail grade crossing accidents

Source: South Carolina Department of Transportation 2040 Multimodal Transportation Plan, December 2014.

Public and Stakeholder Input

Objective Setting—
Public and Stakeholder Input

The Capital Region Transportation Safety Coalition in Louisiana utilized data to identify four safety goals. Based on this, stakeholders developed specific objectives to achieve the goals. Stakeholders were provided with a list of countermeasures that work and other proven strategies to assist them in the selection of data-driven objectives.

Public and stakeholder input can be used to set objectives, but as described in the goals section, this type of input has the potential to yield a number of different priorities. When relying on this information to develop objectives, it is important to share data results and priorities in advance to better shape the input public and stakeholders provide. For instance, if bicycle and pedestrian safety has been identified as an issue in your State or region, available crash data trends and information about potential treatments (i.e., Countermeasures that Work (CTW), or FHWA CMF Clearinghouse) should be shared with the public and stakeholders to guide the input. Doing this will increase the chances that objectives, and eventually strategies/actions, are developed based on data versus perceptions.

Customizing Objectives From Other Plans

Transportation planning documents typically include specific objectives to achieve the goals of a plan. In developing or updating a plan, it is not always necessary to start from scratch, but instead review other objectives already developed in other plans, such as the SHSP. This approach to objective setting can be quantitative. For example, an RPO in California, the Del Norte Local Transportation Commission, identified the safety issues and needs for their region based on data and stakeholder input. Equipped with this knowledge, agency planners were better able to review and customize the goals and objectives outlined in the California SHSP and customize those to meet the needs in their own planning environment, as shown in figure 6.5. When reviewing the goals or objectives from other plans try to review statewide, regional, or local crash data first to have a better understanding of what objectives would be relevant to your transportation plan.

Figure 6.5 Screenshot. Adopting Objectives/Strategies from Other Planning Documents

Challenge 7 Improve Intersection and Interchange Safety – Goal: Reduce the number of intersection crash fatalities by 15 percent from their present level.

State Strategies/Actions: Improve land use planning regarding impacts to intersections, improve roadway design, increase enforcement, research and apply advanced technology and reduce high risk rural road collisions.

Del Norte Strategies/Actions: Encourage streetscape projects that incorporate land use and traffic measures which increase the safety of bicyclists, pedestrians and motorists.

Challenge 8 Make Walking and Street Crossing Safer – Goal: Reduce the number of pedestrian fatalities attributed to vehicle collisions by 25 percent from their 2000 level.

State Strategies/Actions: Smart growth policies, enforcement, improve visibility, implement complete streets.

Del Norte Strategies/Actions: Implement RTP, US 101 Gateway Treatment and Bicycle and Pedestrian plan improvement projects. Consider pedestrian facility improvements in the Klamath and Smith River communities along US 101.

Challenge 9 Improve Safety for Older Roadway Users – Goal: Reduce the number of fatalities attributed to drivers age 65 and older by 10 percent from their present level.

Source: Del Norte Local Transportation Commission Regional Transportation Plan, June 2011.

Crash Analyses

The results of crash analyses also play a large role in objective setting. Data can assist with setting numeric or specific objectives, outlining how the safety goals will be achieved. For example, by reviewing rolling five-year average crash data trends, it is possible to identify: 1) a baseline for fatalities and serious injuries by modal or topic area (i.e., roadways, bicycle, freight, transit, intersections, segments, etc.); and 2) the extent to which fatalities and serious injuries are increasing or decreasing overall, or by specific mode or topic.

If the baseline data shows roadway crashes are an issue and the trend data shows that these crashes have been steadily increasing over the previous five years, safety goals and objectives may be:

Goal—Increase the safety of the transportation system for all users.

- **Potential objectives:**
  - Reduce the total number of crashes on roadways in the State (or region); or
  - Reduce the total number of crashes by five percent by 2020.

If the baseline data shows motorcycle crashes as an area of concern, goals and objectives may be:

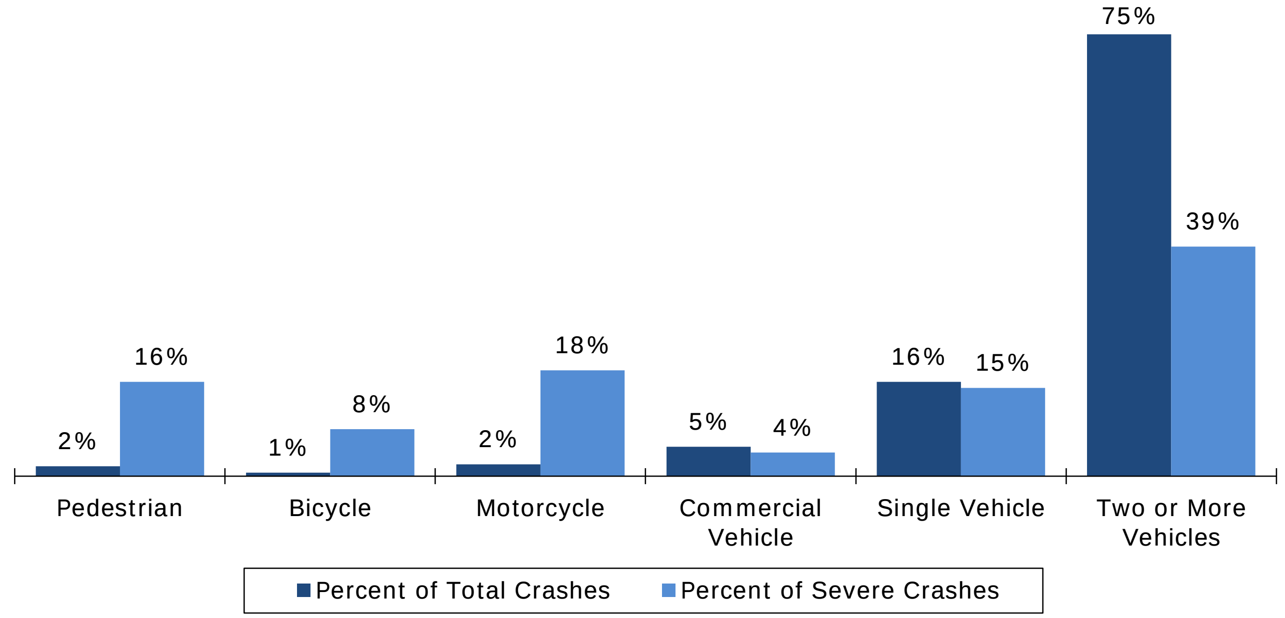
- **Potential goal:**
  - Increase the safety of the transportation system for all users; or
  - Improve motorcycle safety throughout the transportation network.
- **Potential objectives:**
  - Reduce motorcycle fatalities and serious injuries in the State (or region); or
  - Reduce the number of motorcycle fatalities and serious injuries by five percent by 2030.

If additional data is available beyond the basic trend information, it is possible to specify objectives even further. For example, if the majority of crashes are known to take place on major arterials or are the result of people running off the road, more specific objectives could be:

- Identify systemic, low-cost countermeasures to implement to reduce roadway departure fatalities and serious injuries; and
- Identify the major arterials with high-crash severity indices to determine the need for road safety assessments and safety improvements.

The results of other analyses, besides trend analysis, also can help shape safety objectives. Figure 6.6 shows the results of a systemic analysis (total crashes are shown in the left bar and severe crashes are shown in the right bar). This data tells planners that pedestrian, bicycle, and motorcycle crashes are substantially overrepresented among severe crashes.

Figure 6.6 Chart. Using the Results of Analysis to Inform Objectives



Source: Sample data, Cambridge Systematics, Inc., 2015.

Equipped with this information, safety goals and objectives may be:

Goal—Reduce fatalities and serious injuries on the transportation system for all users.

- **Objective:** Reduce bicycle crashes.
- **Strategies:**
  - Identify low-cost bicycle safety improvements for local roads;
  - Promote bicycle public education campaigns, including the shared use of roadways; and
  - Facilitate coordination among jurisdictions and business to address missing bicycle links.

Another option may be:

Goal—Reduce bicycle crashes.

- **Objective:**
  - Reduce the number of crashes involving bicyclists by five percent; or
  - Implement 5 to 10 percent of the safety projects in the bicycle plan.

The development of data-driven objectives provides planners with specific information for how they can accomplish their safety goal.

6.3 Using Safety Data and Analysis to Develop Performance Measures and Targets

The purpose of setting performance measures and targets during the planning process is to have a means to track and evaluate progress towards transportation goals and objectives. If targets are not being met, it provides planners the opportunity to reevaluate programs and projects to identify how to invest differently.

6.3.1 Performance Measures

Performance measures are a useful tool to understand programmatic progress towards transportation goals. Every DOT and MPO will eventually need to adopt the national performance measures, which include number and rate of fatalities and serious injuries. These measures will help transportation agencies track progress towards their safety goal(s). Table 6.2 depicts an example of what this could look like in practice.

Table 6.2 Sample Safety Goal and Nationally Required Performance Measures

Goal	Objective	Performance Measure	Data
Achieve a significant reduction in traffic fatalities and serious injuries on all public roads	Reduce fatalities	Number of fatalities per year	FARS
Achieve a significant reduction in traffic fatalities and serious injuries on all public roads	Reduce serious injuries	Number of injuries per year	State Data
Achieve a significant reduction in traffic fatalities and serious injuries on all public roads	Reduce fatality rates	Fatality rate 100 million VMT	FARS, HPMS
Achieve a significant reduction in traffic fatalities and serious injuries on all public roads	Reduce serious injury rates	Serious injury rate 100 million VMT	State Data, HPMS

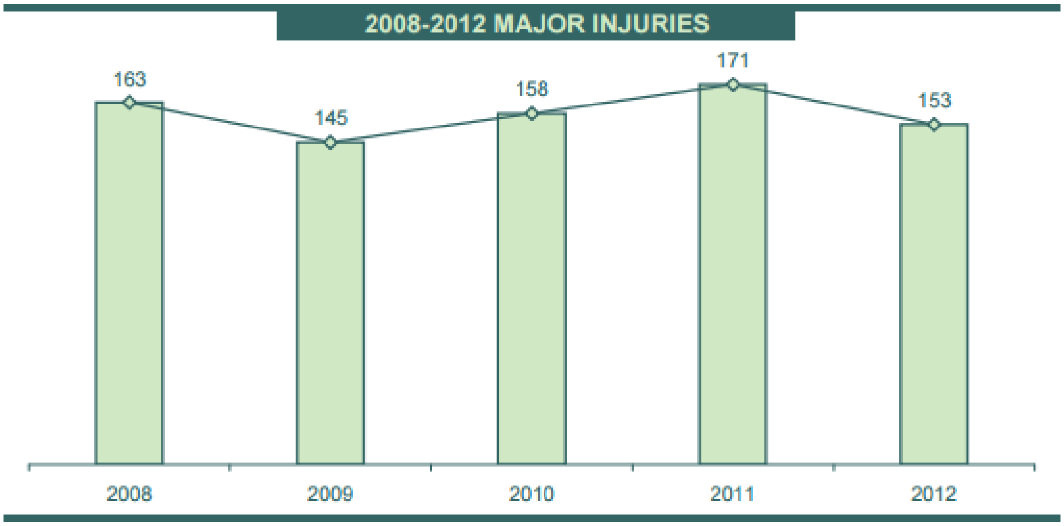
Source: Sample text, Cambridge Systematics, Inc., 2015.

To track performance measures on a regular basis, agencies will utilize annual or average data (combining a certain number of years of data into an average for a single year) from FARS or the State crash database. An example of annual performance tracking is shown in figures 6.7 and 6.8 from the Lehigh Valley Planning Commission in Pennsylvania.

Figure 6.7 Chart. Tracking National Performance Measures
Fatalities, 2008-2012

Source: Lehigh Valley Planning Commission Traffic Safety Plan for the Lehigh Valley 2008 to 2012.

Figure 6.8 Chart. Tracking National Performance Measures
Major Injuries, 2008-2012



Source: Lehigh Valley Planning Commission Traffic Safety Plan for the Lehigh Valley 2008 to 2012.

Other agencies may want to set performance measures beyond what is nationally required. To identify other performance measures, the first step is to review the goals and objectives in a transportation plan and identify which performance measures will accurately track their progress. If goals and objectives were developed based on data, data also should be available to track performance. Table 6.3 provides an example of the direct relationship between goals, objectives, performance measures, and data.

Table 6.3 Relationship between Performance Measures and Goals and Objectives

Goal	Objective	Performance Measure	Data Sources
Increase the safety of the transportation system for all users	Reduce roadway fatalities	Number of roadway fatalities per year	FARS
Increase the safety of the transportation system for all users	Reduce bicycle crashes	Number of bicycle crashes per year	Local law enforcement crash database
Increase the safety of the transportation system for all users	Reduce transit crashes	Number of preventable transit crashes per 100,000 miles	National Transit Database

Source: Sample text, Cambridge Systematics, Inc., 2015.

6.3.2 Performance Targets

Performance targets are numeric and describe the extent to which an agency will address its performance measures, taking into account resources and funding. They should be developed in relationship to the goals, objectives, and performance measures. Whereas performance measures are a tool to help planners and communities assess progress towards goals and objectives, targets specify what your agency would like to achieve in those goal/objective areas. Table 6.4, from the RTC of Washoe County in Nevada, illustrates an example of the connectivity between goals, measures, and targets.

Table 6.4 Relationship between Goals, Performance Measures, and Targets

Transportation Plan Goal	Annual Performance Measure	Target
Improve Safety	Preventable transit accidents per 100,000 miles of service	0
Improve Safety	Number of crashes and number of crashes per VMT	Reduce by 50% by 2020
Improve Safety	Number of serious injuries per VMT	Reduce by 50% by 2020
Improve Safety	Number of fatalities and fatalities per VMT	0; Reduce by 50% by 2020
Improve Safety	Miles of bicycle lane added and percent of Bicycle Pedestrian Master Plan completed	3% to 7% of plan implemented per year
Improve Safety	Miles of sidewalk added or enhanced and percent of the Americans with Disabilities Act (ADA) Transition Plan completed	3% to 7% of plan implemented per year

Source: RTC of Washoe County Annual Report, 2013.

Some DOTs and MPOs have begun setting targets for the national performance measures (number and rate of fatalities and serious injuries) and other measures, as interested (as shown in the RTC example). Although a number of different target-setting approaches have been identified, at the core, is data and analysis. One of the primary data-driven ways to set targets is through trend analysis. Using this approach, multiple years of data can be reviewed to establish a baseline, and then targets can be set based on:

> ***Target Setting Resource***
>
> *Further information on the state of the practice in safety target setting as well as ideas for developing or updating transportation safety targets, can be found in the FHWA Safety Target Setting Final Report.*

- Previous annual or average trend reductions (staying the course); and
- A prediction based on the expected safety benefits of programs and projects (this would entail an understanding of the crash reduction factors associated with types of transportation projects and the extent to which they would be implemented.)

Table 6.5 demonstrates how data is identified and trends are analyzed to set safety performance targets.

Table 6.5 Data-Driven Performance Targets Related to Safety Goal

Goal	Performance Measure	Baseline	Target	Data Source
Increase the safety and security of the transportation system for motorized and nonmotorized users	Decrease five-year average fatalities	125 (2007 to 2011)	Decrease fatalities by 5% by 2020	FARS
Increase the safety and security of the transportation system for motorized and nonmotorized users	Decrease five-year average serious injury crashes	243 (2007 to 2011)	Decrease serious injury crashes by 8% by 2020	State DOT database
Increase the safety and security of the transportation system for motorized and nonmotorized users	Decrease five-year average pedestrian and bicycle crash-related injuries	36 (2007 to 2011)	Decrease pedestrian and bicycle crash-related injuries by 3% by 2020	Local law enforcement crash data

Source: Sample text, Cambridge Systematics, Inc., 2015.

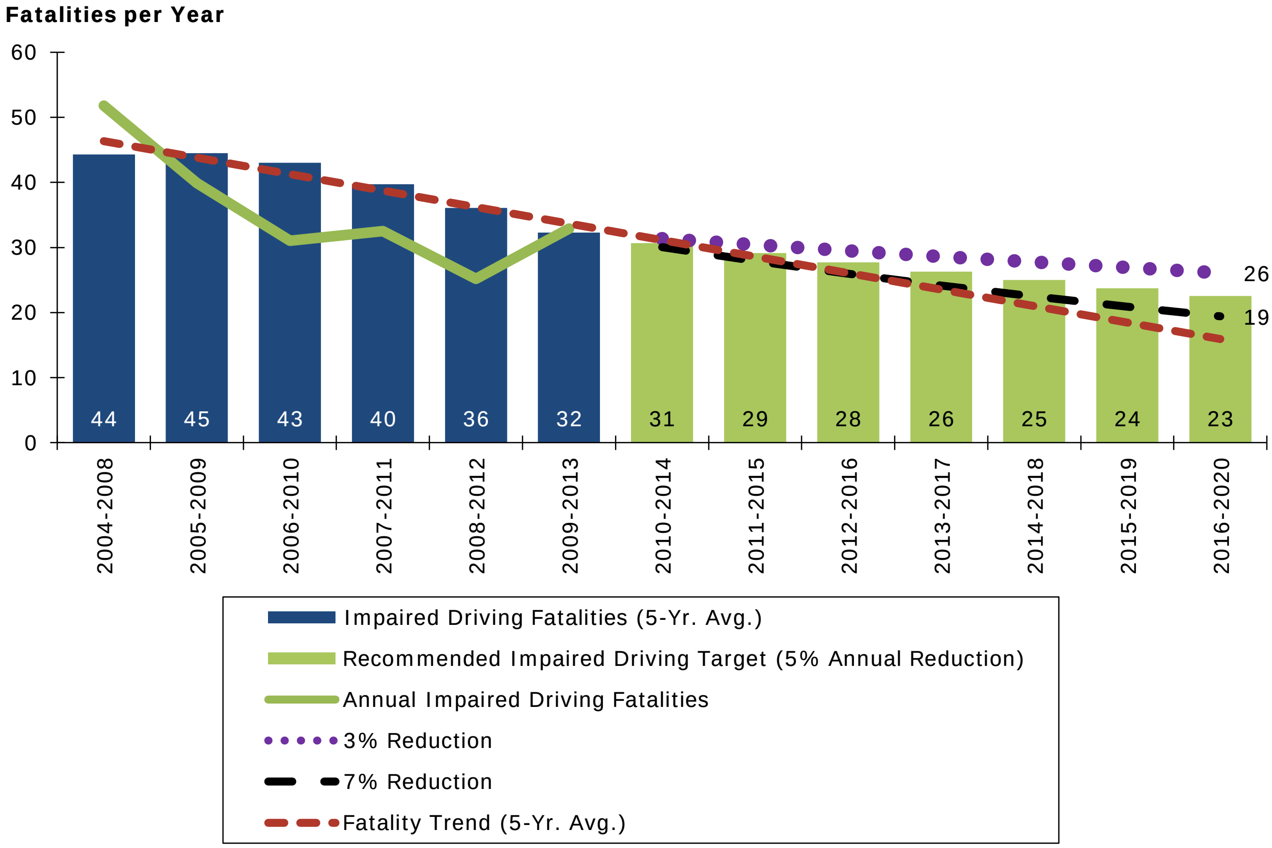
Table 6.6 and figure 6.9 demonstrate another example of how trend data can be utilized to establish data-driven safety targets for identified goals and objectives. The recommended target is to reduce fatalities by five percent by 2020, but the graphic demonstrates the range of target options based on previous years trends.

Table 6.6 Data-Driven Performance Targets Related to Safety Goal

Goal	Objective	Performance Measure	Performance Target	Data Source
Improve safety	Reduce impaired driving fatalities	Number of impaired driving fatalities	Reduce impaired driving fatalities by 5% by 2020 based on five-year averages.	State DOT database

Source: Sample data, Cambridge Systematics, Inc., 2015.

Figure 6.9 Chart. Data-Driven Performance Targets Related to Safety Goal

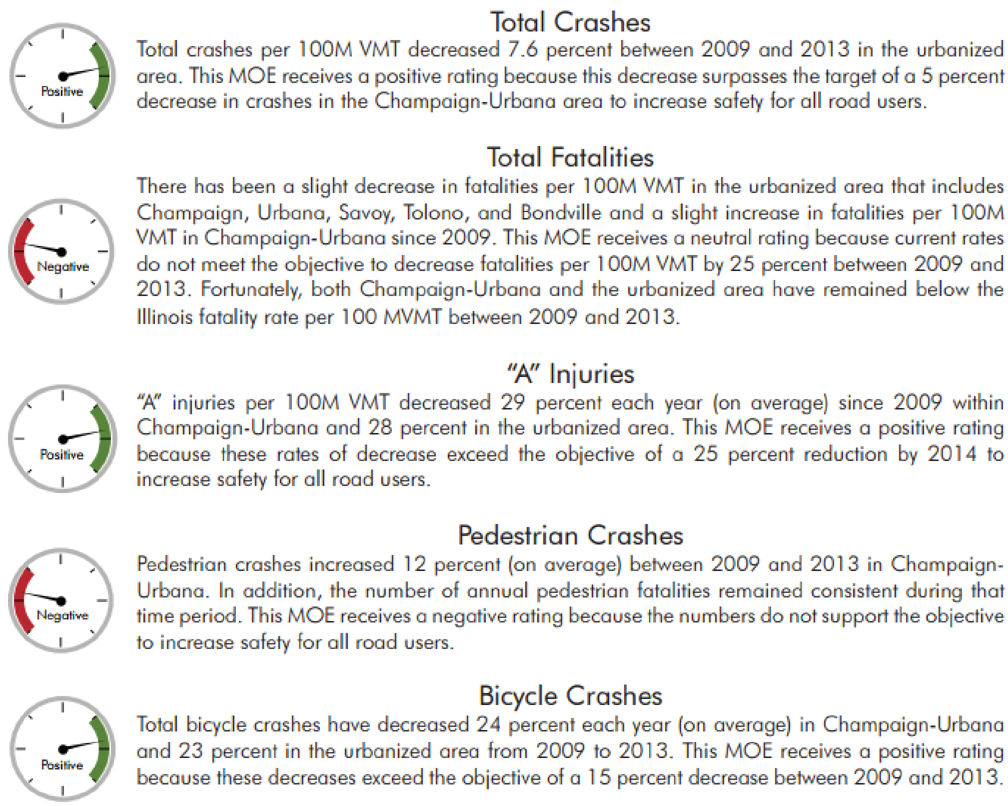


Source: Sample data, Cambridge Systematics, Inc., 2015.

6.3.3 Evaluating System Performance

With limited resources, safety performance measures and targets help planners identify the extent to which safety goals and objectives are being met. Monitoring crash trends and targets over time will demonstrate whether crash numbers have increased or decreased. An increase would trigger a review of goals and objectives to determine where future funding could better be utilized to improve performance. Decreases would suggest that safety goals and objectives are working and would help determine whether to maintain future funding levels or direct resources to other safety issues. To evaluate performance, agencies may produce an annual report, report card, or utilize performance tracking information. For example, the Nevada DOT publishes a Performance Management Report on an annual basis. A portion of the 2014 Report focuses on the goal of reducing crashes, discussing current and future performance, what strategies have been initiated and worked to reduce crashes, those that have not been successful, and future strategies that have the potential to lower crash numbers. This annual evaluation process allows the Nevada DOT to review progress towards performance goals and targets to re-evaluate programmatic investments. The Champaign Urbana Urbanized Area Transportation Study, an MPO in Illinois, produces an annual LRTP Report Card, which details the progress made on the goals and objectives in the document. Figure 6.10 demonstrates tracking dials, which provide a quick snapshot of system-level performance. This information is used by the MPO to adjust performance information, if necessary and revisit objectives and strategies for meeting safety goals.

Figure 6.10 Graphic. Example Evaluation Report Card



Total Crashes

Positive

Total crashes per 100M VMT decreased 7.6 percent between 2009 and 2013 in the urbanized area. This MOE receives a positive rating because this decrease surpasses the target of a 5 percent decrease in crashes in the Champaign-Urbana area to increase safety for all road users.

Total Fatalities

Negative

There has been a slight decrease in fatalities per 100M VMT in the urbanized area that includes Champaign, Urbana, Savoy, Tolono, and Bondville and a slight increase in fatalities per 100M VMT in Champaign-Urbana since 2009. This MOE receives a neutral rating because current rates do not meet the objective to decrease fatalities per 100M VMT by 25 percent between 2009 and 2013. Fortunately, both Champaign-Urbana and the urbanized area have remained below the Illinois fatality rate per 100 MVMT between 2009 and 2013.

"A" Injuries

Positive

"A" injuries per 100M VMT decreased 29 percent each year (on average) since 2009 within Champaign-Urbana and 28 percent in the urbanized area. This MOE receives a positive rating because these rates of decrease exceed the objective of a 25 percent reduction by 2014 to increase safety for all road users.

Pedestrian Crashes

Negative

Pedestrian crashes increased 12 percent (on average) between 2009 and 2013 in Champaign-Urbana. In addition, the number of annual pedestrian fatalities remained consistent during that time period. This MOE receives a negative rating because the numbers do not support the objective to increase safety for all road users.

Bicycle Crashes

Positive

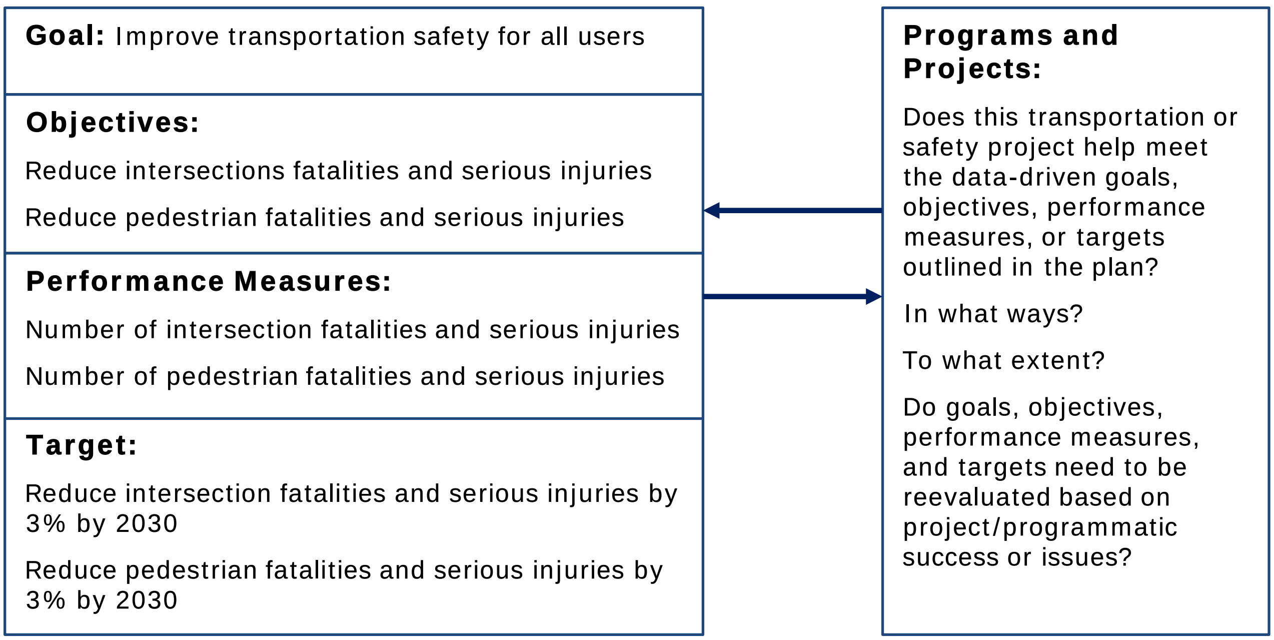
Total bicycle crashes have decreased 24 percent each year (on average) in Champaign-Urbana and 23 percent in the urbanized area from 2009 to 2013. This MOE receives a positive rating because these decreases exceed the objective of a 15 percent decrease between 2009 and 2013.

Source: Champaign Urbana Urbanized Transportation Study 2014 LRTP Report Card, April 2015.

6.4 Using Safety Data and Analysis for Project Prioritization and Programming

Tying together goals, objectives, performance measures and targets, are transportation and safety projects and programs. With limited resources, programs and projects should be identified, evaluated, and prioritized based on whether or not they address (or have the likelihood to address) the goals in the plan and the extent to which they contribute to meeting performance targets. Over time, it is possible to see the effect programs and projects have on the goals of the plan. These should be reevaluated regularly to ensure they are consistent with project and program outcomes. Figure 6.11 shows the relationship between the already discussed planning tasks and programs/projects.

Figure 6.11 Flowchart. Relationship between Data-Driven Planning Tasks and Programs/Projects



Source: Cambridge Systematics, Inc.

To get to this point in the planning process, data have been utilized to pinpoint the key goals, objectives, and a reliable means to measure success. Now, it is time to decide how programs and projects can contribute solutions to the identified issues. There are two opportunities to do this—one is to incorporate safety evaluation criteria into the scoring approach for all transportation projects; and the other is to identify safety projects (i.e., crash reduction factors, countermeasures).

6.4.1 Transportation Projects Integrating Safety

Many common evaluation criteria for transportation projects, such as mobility, congestion, and air quality, can be generated by travel demand model results. A common challenge for safety is the difficulty in predicting how transportation projects will influence safety over the medium and long term. The HSM is a tool that can assist planners identify and assess safety benefits for specific projects, which is summarized here, but described in detail in Section 5.6. However, basic data analysis also can be used to identify the safety benefits for transportation projects, helping to meet the goals outlined in the plan.

> ***Safety Index***
>
> *Utah DOT has a safety index on State routes, including a mapping tool, which represents the degree of risk to the driver, in terms of both crash rate and severity. This tool has been used during corridor and other planning efforts to evaluate how to meet transportation safety goals and targets.*

A range of data can be used during the transportation project prioritization process to help determine the safety benefits of a project. For instance, some States, including Utah, use a severity index to rank segments or intersections, determining where on the transportation system the safety issues lie. Planners then use this information when evaluating and prioritizing their transportation projects. If a potential transportation improvement is in a location with a high safety index or a comparable area, the opportunity exists to consider safety improvements within the context of the transportation project. As such, the project would score higher because, in addition to meeting other transportation goals, it also presents the opportunity to lower fatalities and serious injuries. Some States combine severity with other factors, use high-crash location lists, the results of network screening, or systemic analysis to consider how to incorporate safety considerations in the context of all their transportation projects. Figure 6.12 depicts the safety project prioritization criteria for highway and State bridge projects in the North Jersey Transportation Planning Agency metropolitan region. Figure 6.13 shows how the North Carolina DOT evaluates safety criteria for capacity projects to determine the need for future safety improvements with project limits.

Figure 6.12 Screenshot. Incorporating Safety into Project Prioritization

H.Rep.2 **Will the project improve a safety problem?** **Max - 110**

High:	Safety improvements to roadways or intersections designated by the NJTPA or NJDOT as safety priority locations or included in "Safe Corridor" programs. (110)
Med/High:	Safety improvements to roadway segments where the severity-weighted accident rate exceeds that of the regionwide average for the same facility type. (83)
Med:	Improvements to local roadways or pedestrian areas to address safety issues of local concern, e.g., traffic calming projects. (55)
Low:	Drainage, rockfall, and pavement rehabilitation/resurfacing projects. (28)

Source: NJTPA Project Prioritization Criteria, January 2007.

Figure 6.13 Screenshot. Incorporating Safety into Project Prioritization

Safety

Definition

A measure of existing crashes along/at the project based upon a three year rolling average of accident statistics (years 2010-2012). The following components (equally weighted) added together constitute the quantitative score for this criteria:

- Crash Density: The crash density of the study area versus the average crash density of similar facilities.
- Severity Index: Crashes are categorized by five levels of severity. An index is created using crash severity data.
- Critical Crash Rate: The most severe crashes within the levels of severity are identified as critical crashes. The critical crash rate along the route is determined vs. the critical crash rate for the study area.

Intersection safety scores will be calculated manually by the Mobility and Safety Division and all other safety scores are automatically generated. Regarding the score for a project the higher the crash density, severity index and critical crash rate, the more points awarded (and therefore indicates poor performing roadway/intersection location).

Formula

The calculation of safety scores varies depending on whether the project is located along a roadway segment or at an intersection:

Segments -- (Crash Density x 33%) + (Severity Index x 33%) + (Critical Crash Rate x 33%)

Intersections -- (Crash Frequency x 50%) + (Severity Index x 50%)

Source: North Carolina DOT Strategic Prioritization Process.

Another example of using safety analysis during transportation project prioritization comes from the Virginia DOT. Legislation requires Virginia DOT to develop and implement a quantifiable prioritization process for their transportation projects. Safety evaluation criterion is considered very highly in the scoring process for transportation projects. Each project must demonstrate the expected reductions in fatalities and serious injuries and rate. This is calculated by summing the annual number of crashes where a project is located, and multiplying it by the expected crash modification factor (this will be based on FHWA and Virginia-specific CMF). This type of prioritization attempts to identify appropriate safety improvements in correlation with the project prioritization instead of waiting until the scoping or design phase to officially address any potential safety improvements.

Additional Prioritization Approaches

Examples from other agencies that incorporate safety criteria into their prioritization process to help meet the safety goals and objectives in their planning documents include: Erie County, Harrisburg Area Transportation Study, Indian Nations Council of Governments, and Centre County MPO.

In Louisiana, the DOTD and all the MPOs must complete a Stage 0 Preliminary Scope and Budget Checklist for highway projects. To advance to Stage 1, Planning and Environmental, a number of criteria must be identified and addressed, including the results of any safety analyses performed and whether abnormal crash locations or overrepresented crash types exist within the project limits. This early review of projects ensures safety issues are captured and can be factored into project planning and design.

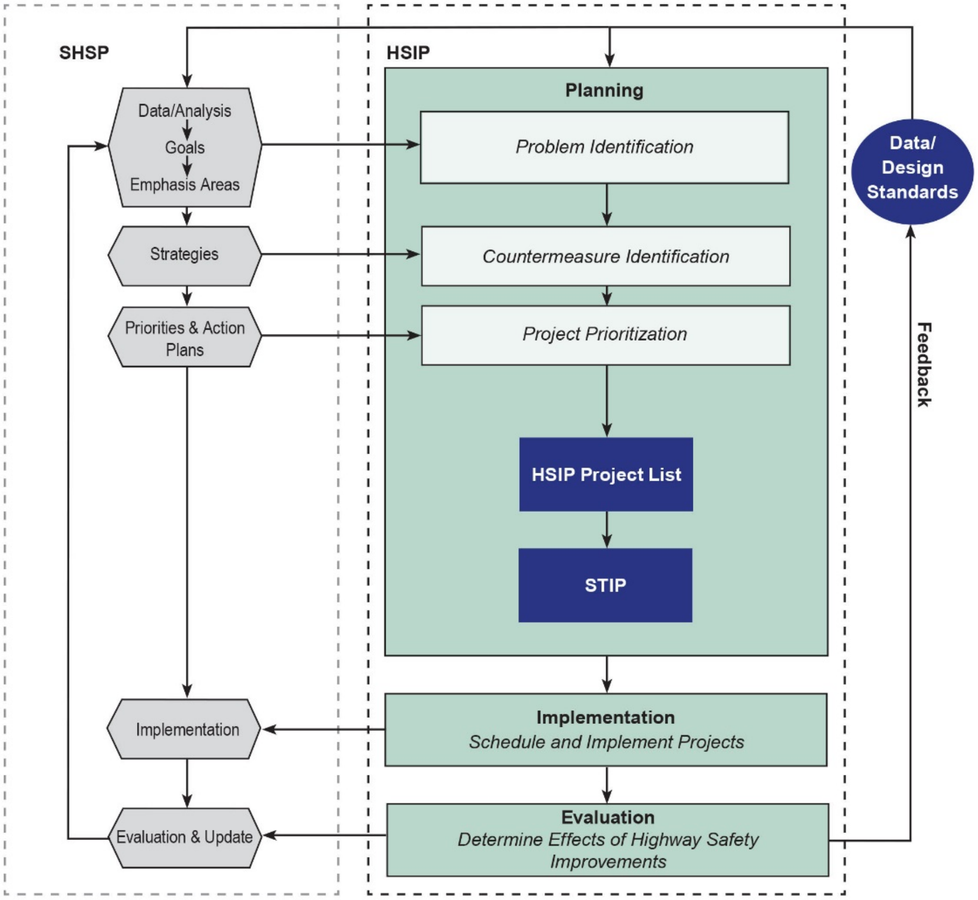
States also are starting to use the HSM during corridor planning and alternatives analysis to predict the safety performance of a roadway or intersection project based on physical characteristics. Part C of the HSM allows planners to quantify the safety effects of alternatives and compare those with other project criteria, such as capacity, delay, community needs, and others.

6.4.2 Safety Projects

Chapter 5.0 outlines the range of analysis options that can be undertaken to identify safety programs and projects. However, these programs and projects should be identified based on how well they meet the safety goals, objectives, performance measures, and targets identified earlier in the planning process.

The SHSP planning process and HSIP prioritization process provide a good example of this linkage. At the statewide level, significant reductions in traffic fatalities and serious injuries on public roads are meant to be accomplished through the development and implementation of the SHSP. The SHSP, a strategic document, outlines a framework for addressing safety using goals, emphasis areas, and strategies. However, it does not typically identify safety projects. Instead, additional analysis is conducted within the context of the SHSP goal and emphasis areas to drive the States' HSIP investment decisions. Figure 6.14 describes the relationship between the SHSP and HSIP process. A number of States also have developed HSIP project prioritization manuals to ensure planners understand how to identify safety projects—one such example is from the Ohio DOT.

Figure 6.14 Flowchart. Relationship between the SHSP and HSIP



Source: FHWA Highway Safety Improvement Program Manual, January 2010.

This same approach also can work to identify and prioritize safety projects during the transportation planning process. Similar to the SHSP, the LRTP outlines strategic goals, objectives, and policies, which are used to guide decisionmaking for transportation investments. From here, additional analysis is typically needed to identify transportation safety programs and projects that support this framework. The following example from the Lee County MPO demonstrates the link between strategic transportation safety goals and objectives with the identification and development of safety programs/projects:

- LRTP Goals: For the 2035 Collier and Lee County LRTP update, planners identified the following safety goal: **A transportation system that is safe and secure for existing and future residents, visitors, and businesses.**

- LRTP Objectives: To support this goal, a number of objectives were developed, but two of particular note are: **Safety planning shall be consistent with and reflect the goals and objectives of the State's SHSP; and Reduce crash rates that involve conflicts among different modes of transportation through engineering and public education (autos, trucks, buses, trains, motorcycles, pedestrians and bicyclists).**

- From here, the question became how can safety in the region be enhanced and programs/ projects identified to make progress towards these established goal and objectives? This is where additional plans or studies can be used to analyze data further, identify potential countermeasures, and prioritize and select projects. The Lee County MPO took this approach during the development of a Bicycle and Pedestrian Safety Action Plan. The Plan was initiated to further explore and support the bicycle and pedestrian safety goals outlined in the Florida SHSP and the Lee County LRTP.
- Using crash data sources from the Florida Department of Highway Safety and Motor Vehicles as well as the FDOT Crash Analysis Reporting System, Lee County was able to identify a specific set of actions (figure 6.15), which included programs and projects, to support the overarching bicycle and pedestrian goals for the region.

Figure 6.15 Graphic. Data-Driven Safety Actions

Action Items

Action Plan

The following table below presents Action Items with expanded key details including the **lead agency/partner** expected to champion each action, the estimated **amount of time** required to complete or significantly address the action, a potential suggested **funding source**, and an **estimated cost** if applicable. Full descriptions of each action item were presented on pages 7—9.

	Short Description	Lead Agencies/Partners	Estimated Time Frame	Funding Source	Estimated Cost
1	Develop a Press Kit.	Lee County MPO and law enforcement agencies with support from other stakeholders	Within One Year	In-house and grant funded	$5,000 initially + Minor maintenance
2	Develop an education outreach campaign.	FDOT, Lee County MPO, Stay Allive..Just Drive, Cape Coral, BikePed, BikeWalkLee, and Injury Prevention Coalition	Within One Year	FDOT/CTST support	$300,000
3	Re-energize and empower the Lee Community Traffic Safety Team (CTST).	FDOT, CTST, with support from MPO and participation from all stakeholders	Within One Year & Ongoing	In-house	N/A
4	Establish a Process for Crash Data Reporting and Distribution.	LeeDOT, FDOT, CTST, MPO, with support from all stakeholders	Within One Year & Ongoing	In-house with possible additional support (board approval)	Minimal initially + possible additional support
5	Measure progress on an annual basis.	Lee County MPO	Within One Year & Ongoing	In-house task	Minimal
6	Undertake Bicycle & Pedestrian Road Safety Audits (RSA) on high-crash corridors.	FDOT, CTST, Lee County MPO with participation and support from all stakeholder agencies	Within One Year & Ongoing	Requires board approval	Up to $15,000 per corridor
7	Implement a strong law enforcement program.	Lee County MPO, FDOT, Law Enforcement Agencies	Within One Year & Ongoing	FDOT	Varies
8	Provide free bicycle lights for stakeholders to distribute.	Lee County MPO, FDOT, Law Enforcement Agencies	Within One Year & Ongoing	CTST & local agencies	Minimal cost per light
9	Adopt design standards for right-turn channelization.	Lee County, City of Fort Myers, City of Cape Coral, FDOT	Within Two Years	In-house	Minimal
10	Revise design standards for arterial intersection design.	Lee County, City of Fort Myers, City of Cape Coral	Within Two Years	In-house	Minimal
11	Develop and utilize project design review checklist.	Lee County MPO, Lee County, City of Fort Myers, City of Cape Coral, FDOT	Within Two Years	MPO	$15,000
12	Develop a policy for pedestrian signal accomodation at signalized intersections	Lee County, City of Fort Myers, City of Cape Coral, FDOT	Within Five Years & Ongoing	In-house task	Minimal
13	Adopt design standards for pedestrian crossings at transit stops.	Lee County MPO, LeeTran, FDOT	Within Five Years	In-house task	N/A
14	Implement enhanced safety/design techniques on high-crash corridors.	Lee County, City of Fort Myers, City of Cape Coral	Within Five Years	In-house	Minimal
15	Identify potential corridors for "road diets."	FDOT, Lee County, City of Fort Myers	Within Five Years & Ongoing	In-house	Minimal
16	Incorporate pedestrian and bicycle design improvements into 3R.	Lee County, City of Fort Myers, City of Cape Coral, FDOT	Within Five Years & Ongoing	Requires board approval	Minimum of $200,000 annually
17	Engage judiciary in the safety discussion.	Lee County MPO, Stay Alive...Just Drive, Cape Coral, FDOT, BikePed, BikeWalkLee, and Injury Prevention Coalition	Within Five Years & Ongoing	Local activist groups	Mimimal
18	Review all previously created bicycle/pedestrian plans to incorporate a safety component.	Lee County MPO, Lee County, City of Fort Myers, City of Cape Coral	Within 5 Years & Ongoing	In-house	Minimal

Source: Lee County Bicycle and Pedestrian Safety Action Plan, September 2013.

> **[FHWA Highway Safety Improvement Program Manual]**
>
> *Describes the relationship between the SHSP and HSIP and presents the HSIP's four basic steps—analyze data, identify potential countermeasures, prioritize and select projects, and determine effectiveness.*

Departments of Transportation and some MPOs and other agencies use a similar approach to meet SHSP or LRTP goals, but do so by specifically identifying projects for HSIP funding. For example, the North Central Pennsylvania Regional Planning and Development Commission developed a goal in their LRTP to increase safety for roadway users, especially on their Core System Roadways. To implement this goal, they developed the North Central Regional Safety Study, which utilizes a data-driven approach to identify and prioritize safety projects throughout the region. The analysis included a combination of data from PennDOT, including, but not limited to, high-crash locations, crash clusters, and public input. This was used to identify locations, investigate the safety issues further at those locations, and eventually identify countermeasures to implement. From there, they prioritized locations based on a cost-benefit analysis and came up with a list of 45 safety improvements. Many of the priority projects were then included in the TIP for funding.

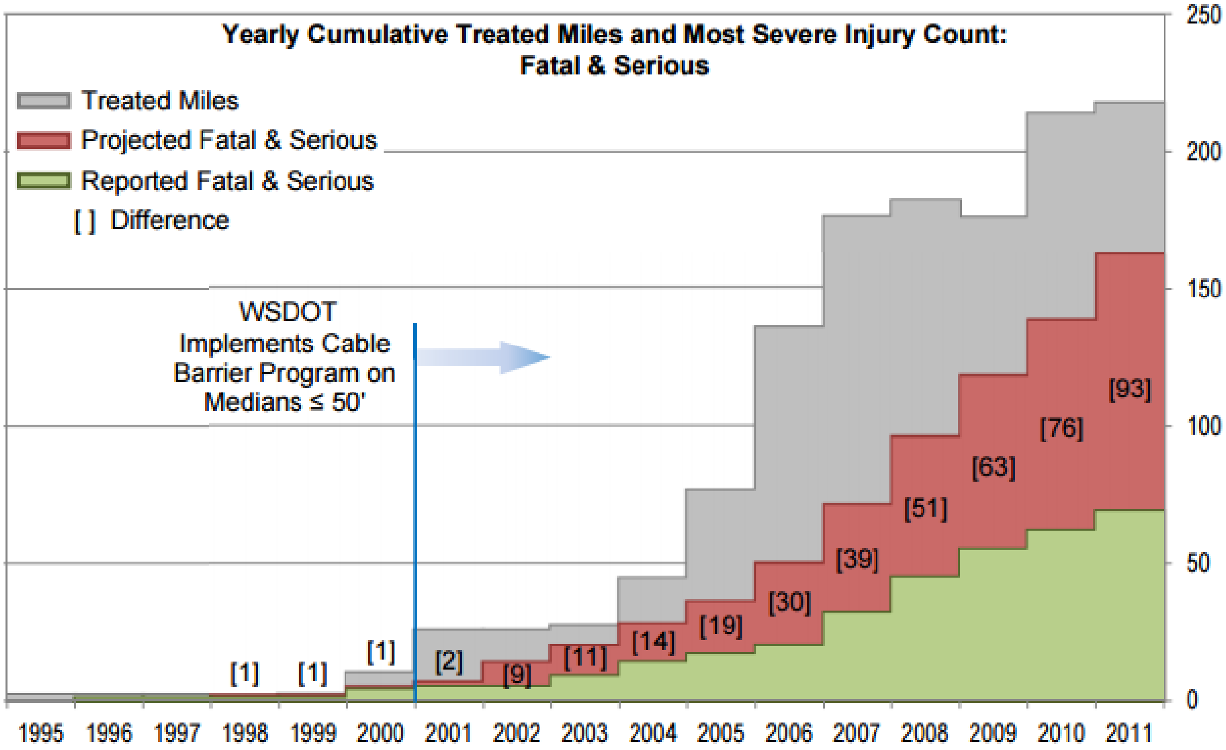
Another example where data and analysis are being used to identify safety countermeasures for HSIP funding is the South Jersey Transportation Planning Organization (SJTPO). The MPO administers a Local Safety Program, consisting of a five-step data-driven process. SJTPO shares the results of network screening and systemic analyses with local jurisdictions to identify priority locations. Once locations are identified, road safety audits are conducted to better understand the problems and possible solutions. Based on the results of the audits, safety countermeasures are identified and a benefit costs analysis is run to understand the effectiveness of each improvement. As a last step, a technical committee reviews the projects. This process of data review; data analysis; and safety program/project (countermeasure) selection can be utilized by any agency wishing to identify transportation safety projects.

6.4.3 Evaluating Projects

With limited resources, programs and projects should be evaluated to identify if they address the goals in the plan and the extent to which they contribute to lowering fatalities and serious injuries. Options to better understand the contribution of a program or project to lowering fatalities and serious injuries is conducting before and after studies and employing proven countermeasures or crash modification factors whenever possible.

Before and after studies provide planners with information on the extent to which investment decisions are meeting expectations. For safety improvements, planners would expect to understand how well individual projects or programs of projects, such as systemic improvements, are performing to lower fatalities and serious injuries. If positive changes are not being seen, planner can refocus investments to other options. As an example, Washington DOT has studied and evaluated its cable median barrier program since 2007 to understand the effects of the program and how significantly it improves safety. In addition to reviewing the program systemwide, they also monitor and evaluate installations for specific locations. As a result of the ongoing before and after evaluation, Washington DOT has identified value in the cable median barrier program and plans to continue implementing it to save lives (figure 6.16).

Figure 6.16 Chart. Before and After Studies



Source: Cable Median Barrier Program in Washington State, June 2013.

In addition to before and after studies, proven safety countermeasures can be considered an evaluation tool. When implemented appropriately, countermeasures increase the chances of lowering fatalities and serious injuries. For example, in Florida, the implementation of longitudinal rumble strips and stripes in the center of two-lane urban roads has reduced head on collisions by 64 percent. Tracking the results of implemented countermeasures in a State or region and then sharing the results can increase the use of certain types of safety projects, yielding positive evaluation results. Resources for countermeasure selection include Countermeasures That Work, PEDBIKESAFE, FHWA Proven Countermeasures, and the CMF Clearinghouse. Some States, like Oregon, have identified State-specific countermeasures.

7.0 Conclusions

This guidebook describes safety data collection and safety analysis approaches, with the goal of assisting State DOTs and MPOs apply the results to the performance-based transportation planning process. Soon, state and regional planning agencies will need to demonstrate how plans, programs, and projects are achieving progress towards meeting seven national goals, including safety. To do so will require planners to understand crash trends (where are we now) and expected crashes (what are the future priorities); conduct safety analyses (what are the impacts of transportation safety in our State or region); and identify safety goals, objectives, measures and targets, and projects in planning documents (what is our framework for achieving a safer future). Current literature typically focuses on each of these tasks (data collection, analysis, and plan integration) individually, but this Guidebook provides a step-by-step approach for incorporating the results of safety data and analysis into existing transportation planning processes. Answers to the above questions are provided throughout the Guidebook, including both basic and advanced examples.

Appendix A. Tools and Resources

The table below presents other available resources to learn more about crash data collection, safety analysis, and the integration of safety data in the transportation planning process.

Table A.1 Safety Data, Analysis, and Application Resources and Tools

Title	Description
Data and Analysis Resources and Tools: FHWA Roadway Safety Data Program Toolbox	This Web link includes an extensive list of 68 tools, including software, application guides, and information guides to help users navigate the many intricacies of data and analysis. Brief descriptions for each tool are provided, which includes many of the resources listed in this guidebook, such as the HSM, Safety Analyst, GIS, HSIP Manual, MIRE, MMUCC, systemic analysis, network screening, usRAP, and more.
Data and Analysis Resources and Tools: Roadway Safety Data Program (RSDP) Web site	The RSDP Web site provides information and resources that can help an agency improve its roadway safety data. Data and analysis are two areas of RSDP's comprehensive safety program. Resources on the Web site include: noteworthy practices, access to technical assistance, webinar recordings, case studies, and information on trainings.
Transportation Safety Planning Resources: National Cooperative Highway Research Program (NCHRP) Report 05-46, *Incorporating Safety into Long-Range Transportation Planning*, 2006	Report 546 was one of the first publications to provide MPO and DOT transportation planners with an approach to integrate safety in the planning process. It discusses opportunities to incorporate safety into goal and objectives setting and performance measures. Discussion of data collection approaches is limited, but the safety analysis section is robust. It includes a discussion of the fundamental concepts of safety analysis, appendix C lists a number of safety analysis tools, and appendix D discusses a planning-level forecasting model.
Transportation Safety Planning Resources: NCHRP Report 08-76, *Institutionalizing Safety in the Transportation Planning Process*, 2011	Report 876 was the second in a NCHRP series discussing opportunities to integrate safety into the planning process. The document outlines a seven-principle transportation safety planning framework (Transportation Safety Planning (TSP) Framework) and describes a set number of specific strategies, instead of general concepts, to implement the Framework. The strategies were based on extensive practitioner input (surveys, interview, and focus groups). The report introduces the concept of using crash data to develop transportation safety goals, objectives, and performance measures; and includes basic ideas to get started with crash data collection and analysis to inform transportation plans. The report is limited to the fundamental steps a planner would need to take to get started with crash data and analysis.
Transportation Safety Planning Resources: NCHRP Report 811, *Institutionalizing Safety in Transportation Planning Processes: Techniques, Tactics, and Strategies*, 2015	Report 811 is based on input from five lead States and two peer States that tested the TSP Framework, developed for the original report. Transportation and safety planners in each State participated in a workshop to identify strategies, approaches, tools, and challenges for integrating safety throughout the transportation planning process in their own unique planning environments. The report captures these ideas and offers a number of approaches for planners to address safety in the planning process during committee meetings, data collection and analysis, goal and objective setting and performance measurement, and project prioritization and programming.

Title	Description
Transportation Safety Planning Resources: FHWA Integrating Safety in the Rural Transportation Planning Process, 2015	This report identifies opportunities for RPOs to incorporate safety into the different tasks that constitute the planning process. It addresses topics such as where to retrieve crash data, opportunities to analyze the information, and how the outputs of the analysis can be used to establish goals, objectives and performance measures. It also has a short section on steps to develop a stand-alone safety plan.
Transportation Safety Planning Resources: FHWA Developing Safety Plans: A Manual for Local Rural Road Owners, 2012	This manual provides local rural road practitioners with a process and high-level information to develop a safety plan, including sections on data collection and analysis, and identifying data-driven emphasis areas, strategies, and priorities. These sections do not provide much "how to" information, but do reinforce the importance of data in safety planning. There also is a section on common issues, which recognizes the reality of data limitations and offers resources and strategies to collect other types of safety data (i.e., road safety audits or the development of an emphasis area on data collection). These strategies would be useful to highlight or reference in the e-handbook.
Transportation Safety Planning Resources: FHWA Strategic Highway Safety Plans—A Champion's Guidebook to Saving Lives, Second Edition, 2013	This guidebook reviews the basic principles and important considerations concerning the development of a Strategic Highway Safety Plan (SHSP). This document outlines the basic processes for data collection, analysis, and application to emphasis areas, strategies, and performance measures. The process used to develop an SHSP is transferable to other transportation planning processes to address safety.
Transportation Safety Planning Resources: NCHRP Report 500, Volume 21: Safety Data and Analysis in Developing Emphasis Area Plans, 2008	This document addresses a number of items, but most relevant to the e-handbook are the sections on crash data and process. The crash data section explains the types of data that are necessary for making good safety decisions, as well as the data that are helpful, but not required, to develop and implement a safety plan. The process section introduces a three-stage approach for identifying a target emphasis area, setting an appropriate injury (and fatality) reduction goal, and defining the treatments that will allow the jurisdiction to reach that goal.
Performance-Based Planning Resources: FHWA Transportation Performance Management Web site	This Web site provides a comprehensive list of resources to support target setting practices at State DOTs and MPOs. Resources include: Safety Targets Setting Final Report, A Compendium of State and Regional Target Setting Practices, the results of a Safety Target Setting Peer Exchange, Target Setting Literature Review, and the Urbanized and Nonurbanized Safety Target Setting Final Report.
Performance-Based Planning Resources: FHWA A Primer on Safety Performance Measures for the Transportation Planning Process, 2009	This primer is a tool to help State and local practitioners, transportation planners, and decisionmakers identify, select, and use safety performance measures as a part of the transportation planning process. It describes types of data and how to use it to develop performance measures for goals and objectives.
Performance-Based Planning Resources: FHWA Performance-Based Planning and Programming Guidebook, 2013	This guidebook presents a process for incorporating performance into the transportation planning process. It discusses the steps to a performance-based planning process (PBPP), which includes the development of goals and objectives, performance measures, planning analysis, trends and targets, strategies and alternatives, and identification of priorities. Data and analyses are key components of this process; and although it does not address safety directly, the PBPP can be adopted and used by planners to identify safety goals, objectives, performance measures, and targets.

Title	Description
Performance-Based Planning Resources: NHTSA Traffic Safety Performance Measures for State and Federal Agencies, 2008	This publication explains the minimum set of safety performance measures, which are required by States in the development and implementation of behavioral highway safety plans and programs. The 14 (now 15) measures must be reported in Highway Safety Plans and Annual Reports. The measures are based on available data for each State and also could be used/referenced by other agencies (MPO/council of governments (COG), RPO) in a State when identifying/developing safety performance measures and targets.
Performance-Based Planning Resources: FHWA Strategic Highway Safety Plan Evaluation Process Model, 2013	This document is meant to assist safety professionals with program evaluation of an SHSP. However, evaluating the performance of safety goals and objectives is a key component to any planning process. Conducting an evaluation requires data to establish performance measures and monitor the results over time. This report discusses the basics of collecting data, establishing output and outcome performance measures and continuous evaluation.

Appendix B. Safety Analysis Objectives and Methods

Table B.1 Safety Analysis Categories, Questions, Tools, and Data Needs

Analysis Category	Safety Analysis Question	What Tools are Available?	Data Needs
Benchmarking	• How many fatalities and serious injuries are occurring in my area? • How does this compare to other areas or my State?	• Descriptive Statistics • FARS data	• Total crashes • Total fatalities and serious injuries • High-level roadway data—roadway ownership, functional classification • Agency geographic boundary information
Identify Crash Trends and Contributing Factors	• Who is involved in crashes? • When are the crashes occurring? • What are the major contributing factors to crashes?	• Descriptive Statistics • Trend analysis	• Crash severity—fatality, injury type, property damage, only • Crash incidence data—time of day, day, month, weather, etc. • Crash type—road departure, intersection, head-on, angle, etc. • Contributing factors—age, impairment, seatbelt usage, speed, etc.
Identify and Evaluate Focus Crash Types	• What are the most common crash types? • What are the most common contributing factors? • What are the characteristics of the overrepresentation?	• Descriptive Statistics • GIS Mapping • Scatterplot • Overrepresenta-tion • Risk Ratio	• Crash severity—fatality, injury type, property damage, only • Crash incidence data—time of day, day, month, weather, etc. • Crash type—road departure, intersection, head-on, angle, etc. • Contributing factors—age, impairment, seatbelt usage, speed, etc.
Network Screening—Identify Sites for Safety Improvement	• What locations (intersections or segments) show the most potential for safety improvements?	• AASHTO HSM Part B Network Screening—Includes descriptive and predictive methods • AASHTOWare Safety Analyst™ • GIS Heat Mapping	• Crash severity • Crash location • Roadway and roadside characteristics—intersection control, number of lanes, presence and type of shoulder, presence and type of median, posted speed, horizontal and vertical alignment, etc. • Traffic volume data—intersection total entering traffic volume, roadway segment volume per million vehicle miles • Calibrated safety performance functions, if predictive methods are used

Analysis Category	Safety Analysis Question	What Tools are Available?	Data Needs
Systemic Analysis—Identify Safety Risk Factors	• What are the common characteristics of locations with crashes? • What are the countermeasures to address these characteristics? • How should we prioritize systemwide implementation?	• FHWA Systemic Safety Project Selection Tool	• Crash severity • Crash location • Roadway and roadside characteristics—intersection control, number of lanes, presence and type of shoulder, presence and type of median, posted speed, horizontal and vertical alignment, etc. • Traffic volume data—intersection total entering traffic volume, roadway segment volume per million vehicle miles
Corridor and Intersection Planning Safety Analysis	• What are the safety effects of alternative roadway or intersection cross sections?	• AASHTO HSM Part C Predictive Method and NCHRP 17-38 Spreadsheets • Interactive Highway Safety Design Model (IHSDM) • Crash Modification Factors (e.g., FHWA Crash Modification Factor Clearinghouse) • Collision Diagrams	• Crash severity • Crash location • Roadway and roadside characteristics—intersection control, number of lanes, presence and type of shoulder, presence and type of median, posted speed, horizontal and vertical alignment, etc. • Traffic volume data—intersection total entering traffic volume, roadway segment volume per million vehicle miles • Calibrated safety performance functions if predictive methods are used

Appendix C. Risk Ratio

The risk ratio compares the severity of crashes associated with a particular factor to the severity of all other crashes (e.g., the percentage of angle crashes that result in a serious injury or fatality divided by the percentage among all other crashes, excluding angle crashes). Crash types or factors with a risk ratio greater than 1 are overrepresented with respect to severe crashes. Formally, the risk ratio is defined by the following equation.

Figure C.1 Equation. Risk Ratio

$$\frac{A/(A+B)}{C/(C+D)}$$

Where:

A = the number of severe crashes of a particular type or emphasis area;

B = the total number of nonsevere crashes of the same type as in A;

C = the number of severe crashes, excluding those of the same type as in A; and

D = the total number of nonsevere crashes, excluding those of the same type as in A.

To illustrate this concept further, a few examples are provided below. Conventionally, data used to compute the risk ratio (variables A, B, C, and D) are arranged in a 2×2 matrix, where the first row corresponds to the numerator values in the formula above, and the second row corresponds to the denominator values.

Table C.1 Risk Ratio Data for Crashes in Rural Areas

	Severe Crash	Not a Severe Crash	Total Crashes
Rural Area	523 (A)	5,768 (B)	6,291 (A+B)
Not a Rural Area (Urban Area)	700 (C)	24,396 (D)	25,096 (C+D)

Source: Sample data, Cambridge Systematics, Inc., 2015.

Given this data, the formula to calculate the risk ratio is as follows:

Figure C.2 Equation. Severe Crash Risk Ratio for Rural Areas

$$\frac{523/6{,}291}{700/25{,}096} = \frac{.083}{.028} = 3.0$$

Based on this calculation, crashes in rural areas are around three times more likely to result in a fatality or serious injury than those in urban areas.

A similar example for DUI crashes is provided here:

Table C.2 Risk Ratio Data for DUI Crashes

	Severe Crash	Not a Severe Crash	Total Crashes
DUI	201 (A)	1,589 (B)	1,790 (A+B)
Not a DUI	1,022 (C)	28,575 (D)	29,597 (C+D)

Source: Sample data, Cambridge Systematics, Inc., 2015.

Figure C.3 Equation. Severe Crash Risk Ratio for DUI Crashes

$$\frac{201/1{,}790}{1{,}022/29{,}597} = \frac{.112}{.035} = 3.3$$

A risk ratio can also be developed for a combination of factors. An example for DUI crashes in rural areas is shown here:

Table C.3 Risk Ratio Data for Rural DUI Crashes

	Severe Crash	Not a Severe Crash	Total Crashes
Rural DUI Crash	93 (A)	597 (B)	690 (A+B)
Not a Rural DUI Crash	1,130 (C)	29,567 (D)	30,697 (C+D)

Source: Sample data, Cambridge Systematics, Inc., 2015.

Figure C.4 Equation. Severe Crash Risk Ratio for DUI Crashes in Rural Areas

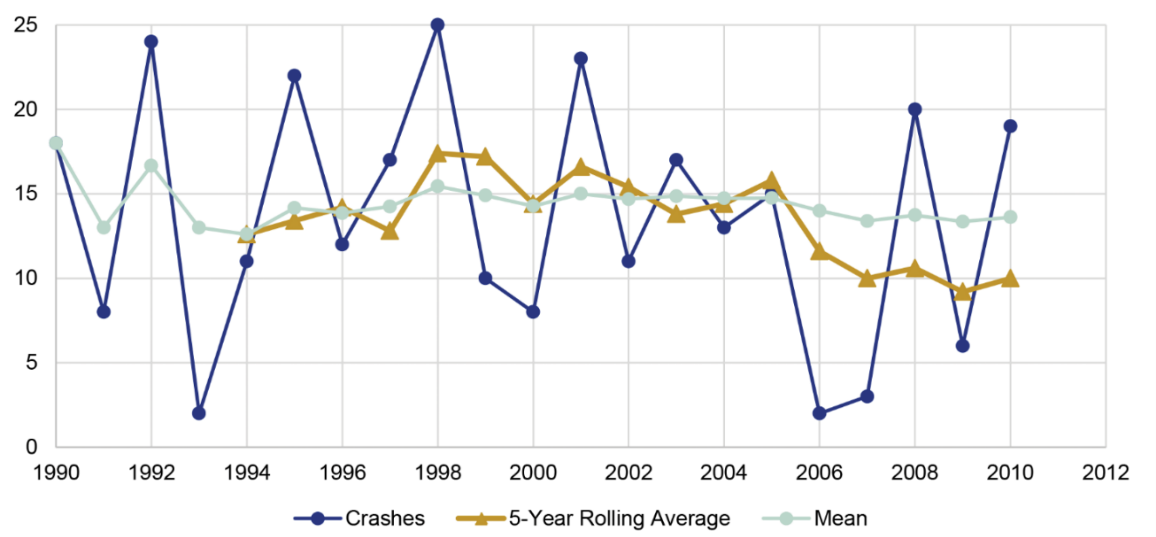
$$\frac{93/690}{1{,}130/30{,}697} = \frac{.135}{.037} = 3.7$$

As an outcome of this step, the transportation planner would understand the categories of crashes by type, severity, contributing factor, or geography that may be a focus for planning and programming or that should be a consideration in nonsafety-specific projects.

Appendix D. Regression to the Mean

From year to year, the number of crashes at a site will randomly fluctuate up and down. Overtime, however, this random fluctuation will balance out to what can be considered the long-term expected average number of crashes at the site. Figure D.1 demonstrates regression to the mean and the effects of average crash frequency across multiple years. The 'Crashes' line shows hypothetical 1990 to 2010 annual crash frequency at a site. The crash frequency varies up and down from year to year. The 'Mean' line represents the long-term average crash frequency at the same hypothetical site. As shown, the five-year rolling average stabilizes at approximately 14 crashes per year. For example, the first five-year average is from 1990 to 1994 and is plotted in 1994, the second is from 1991 to 1995 and plotted on 1995. The five-year rolling average more closely approximates the long-term average then the annual crash frequency alone.

Figure D.1 Chart. Example of Regression to the Mean



Source: Federal Highway Administration. Improving Safety on Rural Local and Tribal Roads: Safety Toolkit. August 2014.

If regression to the mean is not accounted for, a site might be selected for study because the annual number of crashes that occurred was higher than "usual" due to a random fluctuation in the data. Conversely, a site that should be selected for study might be overlooked because an unusually low number of annual crashes occurred there.

To reduce the influence of regression to the mean, the agency should calculate the average of the most recent three to five years of crash data to determine the average crash frequencies. This minimizes year-to-year fluctuations in data and is appropriate if site conditions (e.g., traffic volume, land use, driveway access, and roadway configuration) have not changed. However, if site conditions have changed significantly during the analysis period, it may be more appropriate to monitor the site and evaluate safety after conditions have stabilized.

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Office of Safety
1200 New Jersey Avenue, SE
Washington, DC 20590

FHWA-SA-15-089

November 2015