TRANSPORTATION PLANNER'S
SAFETY DESK REFERENCE

Companion to NCHRP Report 500
Guidance for Implementation of the AASHTO Strategic Highway Safety Plan








UPDATED – Now Includes all 22 Emphasis Areas

TSP
TRANSPORTATION SAFETY PLANNING

Transportation Safety Planning
Working Group

with support from

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Federal Highway Administration

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16. Abstract

The updated *Transportation Planner's Safety Desk Reference* includes strategies derived from the National Cooperative Highway Research Program's (NCHRP) *Report 500 Guidance for Implementation of the American Association of State Highway and Transportation Officials (AASHTO) Strategic Highway Safety Plan.* All 22 emphasis areas are now covered, including five new ones (young drivers, bicycle collisions, speeding, head-on collisions on freeways, and motorcycles). Additional sections on collecting and analyzing highway safety data and developing emphasis area plans have also been added. This document discusses the planner's role in transportation safety and the incorporation of safety into the transportation planning process. Each emphasis area section includes: overview of the problem; data defining the problem; descriptions of safety strategies that are most relevant to planners; crash modification factors that can be used to determine the reduction in crashes anticipated from specific safety improvements; and additional resources and best practices, where available.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf

Foreword

This report is an update of the 2007 Transportation Planner's Safety Desk Reference, a reference document on safety for use by transportation planners and other related transportation safety practitioners. This report serves as a companion to the National Cooperative Highway Research Program's Report 500, Guidance for Implementation of the American Association of State Highway and Transportation Officials Strategic Highway Safety Plan. The updated version contains all of the 22 safety emphasis areas.

This report describes an overview of transportation safety planning, the potential roles that transportation planners can play to advance it, a framework for incorporating safety into the transportation planning process, available resources that may be accessed to fund safety and safety planning programs, and a menu of possible safety strategies. The Desk Reference is of special interest to transportation planners who wish to incorporate safety into their planning process to improve safety on their transportation systems. This document is being distributed electronically via the Transportation Planning Safety Working Group and Federal Highway Administration (Planning and Safety) Web sites.

The following chapters contain revised or new material:

- Safety Data and Analysis
- Development of an Emphasis Area Plan
- Young Drivers
- Pedestrian Collisions
- Bicycle Collisions
- Speeding
- Head-on Collisions on Freeways
- Motorcycles

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Transportation Planner's Safety Desk Reference

Report No. FHWA-HEP-10-001

prepared by
Cambridge Systematics Inc.
Bethesda, Maryland

prepared for
Federal Highway Administration
U.S. Department of Transportation

February 2010

Preface

The Transportation Planner's Safety Desk Reference is a resource providing a range of safety strategies in 22 emphasis areas that may be implemented by or coordinated by transportation planners. The strategies in the document are derived from the National Cooperative Highway Research Program's (NCHRP) *Report 500 Guidance for Implementation of the American Association of State Highway and Transportation Officials (AASHTO) Strategic Highway Safety Plan* that covers the 22 key emphasis areas identified in the *AASHTO Strategic Highway Safety Plan,* as well as additional sections on collecting and analyzing highway safety data and developing an emphasis area plan. Each emphasis area section provides an overview of the problem, data defining the problem, and descriptions of strategies that are most relevant to planners. When available, crash modification factors are included that can be used to determine the reduction in crashes anticipated from specific safety improvements. Each section provides lists of additional resources and best practices, when available.

The Desk Reference provides a summary of how safety can be integrated into the transportation planning process. The document describes the range of agencies and organizations involved in safety and their roles. The Desk Reference describes how the efforts of the engineering, enforcement, emergency response, and education communities are integrated and must collaborate for greatest efficacy in reducing transportation deaths and injuries. This document details how safety fits into the planning process and how safety must be integrated from the earliest stages of goal setting and performance measure development to achieve measurable results. The document also lists funding sources that may be accessed for safety programs.

The Transportation Planner's Safety Desk Reference is an initiative led by the Transportation Safety Planning Working Group, an ad hoc partnership of Federal Highway Administration, Federal Transit Administration, National Highway Transportation Safety Administration, Federal Motor Carrier Safety Administration, and professional associations representing the state Departments of Transportation (DOT), safety, law enforcement, traffic engineering, and planning communities. The Transportation Research Board (TRB) convenes and moderates the TSPWG. The development of this document is sponsored by the Federal Highway Administration.

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Acknowledgments

We would like to express our deep appreciation to the members of the Transportation Safety Planning Working Group for providing information and guidance during the development of this publication, including:

- America Walks;
- American Automobile Association;
- American Association of Motor Vehicle Administrators;
- American Association of State Highway and Transportation Officials;
- American Planning Association;
- American Public Transportation Association;
- American Public Works Association;
- Association of Metropolitan Planning Organizations;
- Community Transportation Association of America;
- Federal Highway Administration;
- Federal Motor Carrier Safety Administration;
- Federal Transit Association;
- Governors Highway Safety Association;
- Institute of Transportation Engineers;
- International Association of Chiefs of Police;
- National Association of County Engineers;
- National Association of Development Organizations;
- National Association of Regional Councils;
- National Conference of State Legislators;
- National Cooperative Highway Research Program;
- National Governors Association;
- National Highway Traffic
- Safety Administration;
- Society for the Advancement of Violence and Injury Research (SAVIR); and
- Transportation Research Board.

Special thanks also go to the following agencies for their contributions to the Desk Reference:

- Hampton Roads Planning District Commission;
- North Jersey Transportation Planning Authority;
- Mid-America Regional Council;
- Houston-Galveston Area Council;
- North Central Texas Council of Governments;
- Florida DOT; and
- Minnesota DOT.

SECTION I

Introduction

The *Transportation Planner's Safety Desk Reference* is an initiative of the Transportation Safety Planning Working Group (TSPWG), which is an ad hoc partnership of the U.S. Department of Transportation (DOT) agencies: Federal Highway Administration (FHWA), Federal Transit Administration (FTA), Federal Motor Carrier Safety Administration (FMCSA), and National Highway Traffic Safety Administration (NHTSA), and professional associations representing the state DOTs, safety, law enforcement, traffic engineering, and planning communities. The Transportation Research Board (TRB) convenes and moderates the TSPWG. The TSPWG has reviewed the guidance provided in the National Cooperative Highway Research Program's (NCHRP) *Report 500 Guidance for Implementation of the American Association of State Highway and Transportation Officials (AASHTO) Strategic Highway Safety Plan* that covers the key emphasis areas identified in the *AASHTO Strategic Highway Safety Plan.* This guidebook identifies and summarizes key strategies helpful to state and local transportation planners.

Safety planning is by its nature a multidisciplinary effort. Every state has gone through the process of developing a Federally required Strategic Highway Safety Plan (SHSP), which involves engaging a wide range of stakeholders. An excellent first step for transportation planners looking to advance safety through their planning process is to make contact with the state DOT, which has the responsibility for coordinating SHSP development and generally works closely with the State Highway Safety Office (SHSO). The SHSO is housed within the DOT in approximately one-third of states; in most other cases, it is located within the Department of Public Safety (DPS) or the Department of Motor Vehicles (DMV). Planners committed to improving transportation safety should not only use the SHSP as a resource for planning but also become involved in updating and implementing the SHSP. As planners incorporate safety into the planning process, the SHSP will be the major source of information in terms of problem identification and potential countermeasures. In addition, the Safe, Accountable, Flexible and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) legislation requires the consideration and implementation of projects, strategies, and services that will increase the safety of the transportation system for nonmotorized as well as motorized users on all public roads.

Transportation planners work to improve all forms of transportation, including roadway, freight, transit, pedestrian, and bicycle facilities. The SHSP process should include the full range of transportation agencies and is designed to consider a wide range of strategies. By providing mobility alternatives to the auto, transit reduces vehicle miles traveled (VMT), resulting in fewer traffic incidents, injuries, and fatalities. Transit ridership can be encouraged among the groups with the highest crash rates, such as young and older drivers, to reduce the potential for crashes. Guaranteed ride home programs at events can help prevent impaired driving.

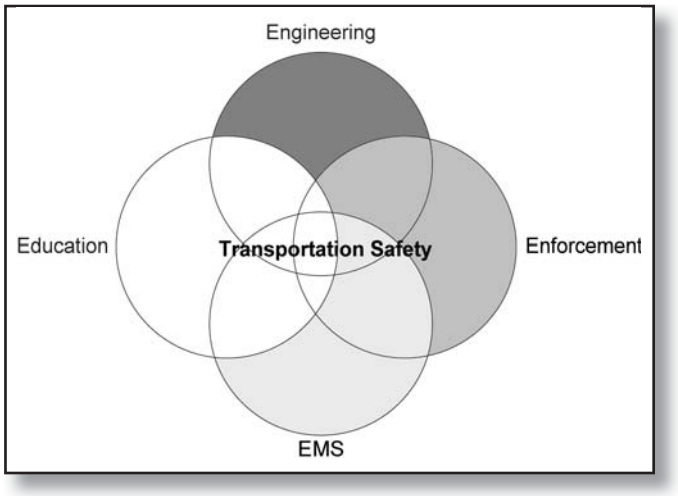
Elements such as sidewalks, pedestrian crossings, bicycle paths, and bicycle parking that support successful transit service also enhance bicycle use and walking, thus reducing VMT. Safe access to and egress from park-and-ride lots contributes to safe transit use. Two

sections of this Desk Reference specifically address pedestrian and bicycle safety. Transportation planners are encouraged to incorporate nonmotorized transportation and transit into their transportation safety planning.

The Four Es of Transportation Safety

When addressing transportation safety, the four Es are frequently referenced to describe the multidisciplinary nature of transportation safety planning. The four Es are Engineering, Education, Emergency Medical Services (EMS) or, more broadly emergency response, and Enforcement. The area in which planners have the most ability to effect change is likely to be engineering and the development of physical improvements to the transportation system. Since physical improvements to the transportation system are a shared responsibility of engineering and planning staff, the planner's role will be to inform the transportation infrastructure improvement process with safety principles and data and facilitate development of engineering safety strategies within the overall process.

EXHIBIT I-1
The Four Es of Transportation Safety



The education and behavioral aspects of transportation safety have historically resided largely under the responsibility of the State Highway Safety Office. Each SHSO receives a number of Federal grants targeting behavioral aspects of safety, primarily focusing on impaired driving and occupant protection. These offices execute nationally developed programs, such as "Click It or Ticket" targeting safety belt use. Planning agencies also can conduct safety education and awareness efforts. A wide range of educational programs impact highway safety and transportation planners are encouraged to consider educational efforts in the widest sense. Education can take the form of driver's education programs, education of the general public on driving risks such as distraction, or programs promoting safety belt use and prevention of impaired driving.

The safety community widely acknowledges education programs must be complemented by enforcement to be successful. For example, the "Click It or Ticket" program developed by NHTSA and implemented at the state level always combines enforcement with paid and earned media. A strong relationship with DPS and other enforcement agencies is an important part of the overall safety effort. Laws are only effective in deterring dangerous behavior if they are enforced. Underscoring the integrated nature of transportation safety is the fact that the crash data on which safety programs are based is collected in the field by local police officers, sheriffs, and state troopers who fill out traffic crash forms. Work with the enforcement community at the state and local level is a major component of an effective transportation safety program.

The fourth E, EMS, cannot be underestimated in its importance to the final outcome of a traffic crash. While many transportation safety strategies are designed to prevent crashes; once one does occur, quick medical treatment can mean the difference between life and death and mitigate injury severity. Transportation planners are encouraged to involve the medical community in their work on transportation safety for both injury prevention and the development of effective processes for administering emergency medical treatment to victims of traffic crashes.

The use of Intelligent Transportation Systems (ITS) tools, such as dynamic message signs, help manage the safe flow of traffic when an incident occurs and protect the safety of first-responders at the scene. Planners can play an important role in determining the best locations for trauma centers to ensure appropriate emergency vehicle routing and minimize transfer time so victims have the best chance of receiving treatment within the "golden hour." Potential sites for new hospitals and trauma centers should include consideration of transportation routes from potential high-crash locations, ensure routes avoid congested areas or dense neighborhoods, and identify alternative routes where possible.

The Planner's Role

Planners have the skills and multidisciplinary orientation that uniquely position them to make a difference in transportation safety. They have the ability to analyze crash data, use Geographic Information Systems (GIS) to map high-crash areas, and define safety problems. Their understanding of data and performance measures is a key building block for developing comprehensive approaches to safety. Planners are accustomed to working with diverse groups to help them understand an issue and develop solutions. Their collaborative orientation and experience with the public are tools for helping stakeholders work together. Planners are experienced at conducting public outreach through a variety of efforts such as during the long-range planning process.

Many transportation safety improvement tactics involve legislative or policy changes. Planners possess the data and analysis capability required to develop a rigorous case for policy change. They can explain that even the safest roadways cannot protect people who engage in dangerous behaviors, and legislation is needed to address behavioral aspects (e.g., requiring safety belt use or reducing the blood alcohol limit).

Transportation planners are trained to analyze operations at the corridor level. Many aspects of corridor management provide opportunities for safety improvements. The provision of transit, pedestrian, and bicycle facilities not only helps reduce congestion, but also reduces the number of vehicle trips and lowers roadway exposure. Corridor intersection treatments such as signal optimization can significantly improve travel times and reduce levels of frustration and aggressive driving. Access management policies may impact both the capacity and safety of roadways. Individual intersection improvements make turning movements safer for both drivers and pedestrians. Transportation planners can work with operations and engineering staff to identify operations and infrastructure problems and program improvements. Planners also can work with law enforcement on corridor-based efforts to reduce impaired driving and speeding and increase safety belt use.

Given the broad range of players in the transportation safety community, institutional challenges will arise identifying lead agencies for various strategies. Defining where the

appropriate resources and responsibilities exist for implementing strategies is one of the most challenging aspects of transportation safety. Difficulties will occur in determining whether the agency to implement a strategy should be the state DOT, highway safety office, state police/patrol, metropolitan planning organization (MPO), city, county, or another agency. A strong network of partnerships among people committed to safety will assist in overcoming this challenge. The transportation planner can serve as the facilitator and an advocate for facilitating agencies in addressing the common goal.

By making safety a priority, planners can significantly impact safety in their communities. Planners can increase their role in safety in the following ways:

- Make safety a priority – be an advocate or a champion;
- Develop a safety vision;
- Develop a comprehensive approach and performance measures;
- Collaborate with the safety community;
- Continue to improve data and analytical tools;
- Address policies and facilities (behavioral and physical);
- Integrate safety into plans and programs;
- Focus on investments that address safety;
- Inform and involve the community on safety issues;
- Use the state's SHSP;
- Monitor safety implementation; and
- Analyze effectiveness.

Safety Funding and Costs

Many of the institutional challenges will involve resources and funding. While some dedicated sources of transportation safety funding exist, many safety strategies can be incorporated into existing programs. For example, rumble strips can be incorporated into programmed infrastructure projects, such as roadway reconstruction and rehabilitation. Existing driver education and licensing programs can be improved. In many cases, it is not necessary to seek stand-alone funding to implement transportation safety countermeasures.

States and local jurisdictions will want to evaluate the benefit/cost ratio for strategies under consideration before implementation. Given the wide variation in the local application of solutions, each state or jurisdiction will need to make its own calculations. In some cases, due to limited information, such analyses will not be available or possible. The Resources sections throughout this guide include information on published references that provide guidance on this and other aspects of transportation safety planning.

Funding Sources

Many sources of funding exist that are either designated for safety projects or flexible and may be used for safety projects. For further information about eligibility of funds for safety improvements, please refer to "A Guide to Federal-Aid Programs and Projects" (http://www.fhwa.dot.gov/Federalaid/projects.cfm) or contact any FHWA Division Office.

Highway Safety Improvement Program (HSIP). This new core Federal-aid funding program began in Fiscal Year (FY) 2006 with the goal of achieving a significant reduction in traffic fatalities and serious injuries on all public roads. Each state is required to have a Strategic Highway Safety Plan (SHSP) that identifies and analyzes safety problems and opportunities to use HSIP funds for new eligible activities under 23 USC 148. HSIP requirements include a crash data system that can perform problem identification and countermeasure analysis. It must address all aspects of safety – engineering, education, enforcement, and emergency medical services – on all public roads.

High-Risk Rural Roads Program (HRRRP). This component of the HSIP supports road safety program efforts through construction and operational improvements on high-risk rural roads. The HSIP, including the HRRRP element, must consider all public roads.

Safe Routes to School (SRTS). This program is designed to enable and encourage children to walk and bicycle to school; to make walking and bicycling to school safe and more appealing; and to facilitate the planning, development, and implementation of projects that improve safety and reduce traffic, fuel consumption, and air pollution in the vicinity of schools. Each state is apportioned funds based on its relative share of total enrollment in primary and middle schools (kindergarten through eighth grade), but no state receives less than $1 million.

SAFETEA-LU State Highway Safety Grant Programs: Section 402 State and Community Highway Safety Grants. Section 402 funds can be spent on a full range of highway safety behavioral programs, including alcohol countermeasures; occupant protection; police traffic services (e.g., enforcement); emergency medical services; traffic records; motorcycle safety; pedestrian and bicycle safety; nonconstruction aspects of roadway safety; and speed. A minimum of 40 percent of a state's Section 402 funds must be expended by local governments, or be used for the benefit of local governments. To receive Federal highway safety grant funds, SHSOs must submit an annual Highway Safety Performance Plan (HSPP) to NHTSA.

SAFETEA-LU State Highway Safety Grant Programs: Section 405 Occupant Protection Incentive Grants. This program provides incentive grants to encourage states to adopt and implement effective programs to reduce highway deaths and injuries resulting from individuals riding unrestrained or improperly restrained in motor vehicles.

SAFETEA-LU State Highway Safety Grant Programs: Section 406 Safety Belt Performance Grants. This incentive program encourages states to enact and enforce primary safety belt laws. A state may use these grant funds for any behavioral or infrastructure safety purpose under Title 23, for any project that corrects or improves a hazardous roadway location or feature, or proactively addresses highway safety problems. However, at least $1 million of each state's allocation must be obligated for behavioral highway safety improvements.

SAFETEA-LU State Highway Safety Grant Programs: Section 408 State Traffic Safety Information System Improvement Grants. This program encourages states to adopt and implement effective programs to improve the timeliness, accuracy, completeness, uniformity, integration, and accessibility of state data needed to identify priorities for national, state, and local highway and traffic safety programs; to evaluate the effectiveness of efforts to make such improvements; to link the state's data systems, including traffic records, with other data systems within the state; and to improve the compatibility of the state's data system with national data systems and data systems of other states to enhance the ability to observe and analyze national trends in crash occurrences, rates, outcomes, and circumstances.

SAFETEA-LU State Highway Safety Grant Programs: Section 410. The purpose of this grant program is to provide an incentive to states that implement effective programs to reduce traffic safety problems resulting from impaired driving.

SAFETEA-LU State Highway Safety Grant Programs: Section 2010 Motorcyclist Safety Grants. The purpose of this program is to provide grants to states that adopt and implement effective programs to reduce the number of crashes involving motorcyclists. Funds can be used only for motorcycle training and motorist awareness programs.

CFR Title 49 Part 350 Commercial Motor Carrier Safety Assistance Program (MCSAP). This Federal grant program provides financial assistance to states to reduce the number and severity of crashes and hazardous materials incidents involving commercial motor vehicles (CMV). The goal of MCSAP is to reduce CMV-involved crashes, fatalities, and injuries through consistent, uniform, and effective CMV safety programs.

Resources

Each of the NCHRP 500 Series reports includes a lengthy list of references to which planners may refer for additional background. The references from all the 500 Series books are not reproduced here.

FHWA has posted fact sheets on SAFETEA LU programs under its Fact Sheets on Highway Provisions section. Fact sheets exist for HSIP, STP, HRRRP, SRTS, and Congestion Mitigation and Air Quality Improvement Program (CMAQ) at:
http://www.fhwa.dot.gov/safetealu/factsheets.htm.

The GHSA web site section on State Information and Laws includes information about Section 402, 405, 406, 408, 410, 2010, and 2011 grants:
http://www.ghsa.org/html/stateinfo/grants/.

A Guide to Federal-Aid Programs and Projects can be found at:
http://www.fhwa.dot.gov/Federalaid/projects.cfm.

SECTION II

Incorporating Safety into the Transportation Planning Process

State and Regional Planning

Safety should be integrated in the planning processes undertaken by state DOTs, MPOs, and regional planning agencies. The following reasons are identified in *NCHRP Report 546, Incorporating Safety into Long-Range Transportation Planning:*

- Travel safety is affected by how the transportation system is designed, constructed, operated, and maintained. Given that transportation planning leads to changes in the transportation system, safety should be integrated in the planning process.
- The economic impact of motor vehicle crashes is staggering. According to a study of 85 urban areas in the United States, the cost has reached $164.2 billion per year in just those communities, or an average of $1,051 per person in 2005 (AAA).
- Motor vehicle fatalities and injuries are a leading public health problem in the United States. In 2007, 41,059 people were killed and 2.5 million people were injured in motor vehicle crashes.[1]
- Crashes represent a major source of nonrecurring congestion, which is estimated in at least some locations to account for half of all congestion.
- Evidence from around the world and throughout the United States suggests that many crashes are preventable. In 2007, nearly 32 percent of U.S. motor vehicle fatalities involved alcohol and 32 percent of fatalities involved speeding (FARS).
- Effective safety programs involve a wide range of stakeholders. The transportation planning process can be an important forum for fostering safety program collaboration at the state and metropolitan levels.

The first step in transportation safety is problem identification. Where are crashes occurring, what types of crashes are occurring, what are the contributing factors, and what population segments are most at risk? To understand these issues, planners should obtain a copy of the state's SHSP from the state DOT. The SHSP will help identify the top transportation safety issues at a state level. The plan should be organized by key emphasis areas addressing the top problems identified via state crash data analysis. The SHSP provides a guide for identifying regional problems, developing goals, and targeting safety partners. Regional safety priorities should support and be consistent with the SHSP where proven appropriate through data analysis.

To conduct a safety analysis, the initial step is to assemble data. First, explore gaining access to state crash data. According to the Federal transportation legislation SAFETEA-LU passed

[1] NHTSA.

in 2005, all states must develop traffic records data systems. Your state already may have a system in place, or be in the process of developing or upgrading its management of crash data. Some MPOs have created a regional crash database for conducting regional crash data analysis.

Obtain a copy of the state crash form, which shows exactly the crash data elements captured and the types of analysis that can be performed. The focus should be on fatal and severe injury crashes to ensure that countermeasures are focused on the most severe problems and not on "fender-benders" where property damage is the main result. The section on Safety Data and Analysis in Part III provides detailed information on data sources and data analysis considerations.

Crash data helps planners:

- Identify high-crash corridors and intersections (ideally via GIS mapping);
- Determine types of crashes (e.g., rear-end collisions, lane departures);
- Identify contributing factors (e.g., failure to yield at a stop sign, excessive speed, distraction); and
- Determine key human factors or behaviors that are associated with number and severity of crashes (e.g., nonuse of safety belts or helmets, impairment by alcohol or drugs, etc.).

Road safety audits (RSA) provide additional information for identifying safety issues. RSAs are formal safety performance examinations of an existing or future road or intersection by an independent audit team. They qualitatively estimate and report on potential road safety issues and identify opportunities for safety improvements for all road users. An RSA seeks to answer:

- What elements of the road may present a safety concern, to what extent, to which road users, and under what circumstances?
- What opportunities exist to eliminate or mitigate identified safety concerns?

Road safety audits can be used in any phase of project development from planning to preliminary engineering, design, and construction. They can be used on any size project from minor intersection and roadway retrofits to megaprojects. RSAs present advantages over traditional safety review processes in place in most state DOTs because they involve a multidisciplinary team, consider all road users, address road user capabilities and limitations, generate a formal report, and require a formal response.

Once the state or region has an understanding of the major transportation safety issues, countermeasures can be developed, starting with the areas with the highest number of and most severe crashes. Safety countermeasures are strategies and tactics developed to address specific safety problems. For example, rumble strips address travel lane departure crashes, as well as distraction and fatigue. Transportation safety strategies are included in the SHSP.

A range of countermeasures is presented in this Desk Reference. Some strategies are more appropriate than others for inclusion at the state or regional level. The document focuses on outcomes; not methods or specific programs. The list of strategies is not all-inclusive. A number of additional strategies employed at state or regional levels, such as incident management and congestion management, can impact safety.

Most behavioral strategies will be implemented at the state level, such as legislation on impaired driving and occupant protection. Enforcement occurs at both the state level with state troopers, and at the local level with municipal police departments and sheriffs. State DOTs have a large role in implementing safety strategies as they conduct ongoing highway construction programs that address safety in some way. They also manage the Federally mandated HSIP. Every state has a highway safety office that manages the state highway safety grant programs from NHTSA and the Federally mandated Highway Safety Performance Plan (HSPP).

States and MPOs are required to include safety as a planning factor in project development. The planning process begins with safety data analysis. This knowledge will help determine safety's role in the vision for a transportation plan. How does safety factor in among the community goals of prosperity, environmental quality, and quality of life/social equity?

Safety must be established as a priority early in the process, when goals and objectives for the plan are developed. Goals and objectives lead to determining system performance measures. Performance measures target data collection and resulting information needs on those aspects of performance that decision-makers determine important for the state or region. For example, many transportation performance measures have been defined that monitor whether traffic safety, congestion, average speeds, system reliability, and mobility options have changed over time. Most importantly, performance measures are used to determine the effectiveness of safety policies and countermeasures and how changes in the system affect performance. Common safety performance measures include the following:

- Rate of traffic deaths – annual fatalities per 100 million VMT;
- Rate of traffic injuries – annual injuries per 100 million VMT;
- Rate of crashes – annual crashes per 100 million VMT;
- Annual number of fatalities; and
- Annual number of injuries.

Safety performance measures currently are undergoing analysis and discussion within the safety community. For example, fatality rates show improvements in safety as a function of miles traveled on the system and are an important measure of safety improvement related to population growth, vehicle miles of travel, or vehicle ownership. However, an improvement in fatality rate may not indicate real safety improvements – a rate reduction may result from the number of fatalities staying constant while the amount of travel increases. Rates can also be inconsistent between aggregate data and subsets of data. For example, VMT fatality rate comparisons can be misleading unless rural and urban rates are shown separately because rural rates are substantially higher than urban rates. The raw number of fatalities is another measure used by many states in their SHSPs. However, the limitation of raw numbers is that they do not consider other factors such as demographic and travel distance changes. GHSA, NHTSA, the states, et al. developed *Traffic Safety Performance Measures for States and Federal Agencies* (August 2008) and plans are in place for all states to begin using a minimum set of 14 performance measures in FY 2010 to achieve a level of consistency (www.ghsa.org). This guidance recommends use of a range of measures to provide a more complete picture of safety performance.

Performance measures may be defined based on specific aspects of safety, such as:

- Observed safety belt use;
- Percent of fatal crashes involving alcohol; and
- Percent of serious injury crashes involving excessive speed.

When incorporating safety into system performance measures, a number of issues should be considered. Performance measures must be sensitive enough to assess changes in safety performance after strategies are implemented. Agencies must be capable of collecting or accessing timely and accurate data relevant to the performance measures. Finally, the safety performance measures should be linked to the evaluation criteria for assessing the relative benefits of one project or strategy over others.

Performance measures must be understandable to transportation and enforcement professionals as well as decision-makers and the general public. Use of GIS to locate safety "hot spots" is helpful because maps of these data provide a visual mechanism for understanding safety issues and targeting where additional analysis may be warranted.

Transportation projects and strategies developed at the state and regional level are then evaluated for consideration. Most safety evaluation efforts use one of three methods: 1) listing the evaluation criteria and showing how the alternatives compare; 2) assigning weights or scores to the evaluation factors; or 3) conducting cost/benefit analysis. The priority setting process involves a multitude of stakeholders interested in a wide range of issues. Safety advocates must be part of the priority setting process.[2]

To ensure safety is integrated into the planning process in a meaningful way, a number of questions can be asked as part of an assessment. These questions are listed in Exhibit II-1.

The questions in Exhibit II-1 provide a point of departure for assessing whether the transportation planning process considers safety in meaningful and substantive ways. If the answer to any of the questions is "no" then safety issues should be given higher priority and greater emphasis in the transportation planning process.

The transportation planning process shown in Exhibit II-2 results in a wide range of planning products. States regularly develop long-range Statewide Transportation Plans, and MPOs develop and update Metropolitan Transportation Plans (MTP). These feed into the shorter-term Transportation Improvement Program (TIP) for MPOs and State Transportation Improvement Programs (STIP), identifying near term projects to be programmed and built. On an annual basis, MPOs develop their Unified Planning Work Program (UPWP) and states develop a State Planning and Research (SPR) program. Safety programs can be added to the UPWP such as safety forums, crash analysis programs, and coordination with law enforcement. To gain inclusion of safety programming in the STIP, planners must work closely with programmers to demonstrate the state's safety problems and solutions and advocate for safety countermeasures. If states or MPOs develop a separate transportation safety plan, it must be linked explicitly to the comprehensive transportation plan to ensure they work in tandem.

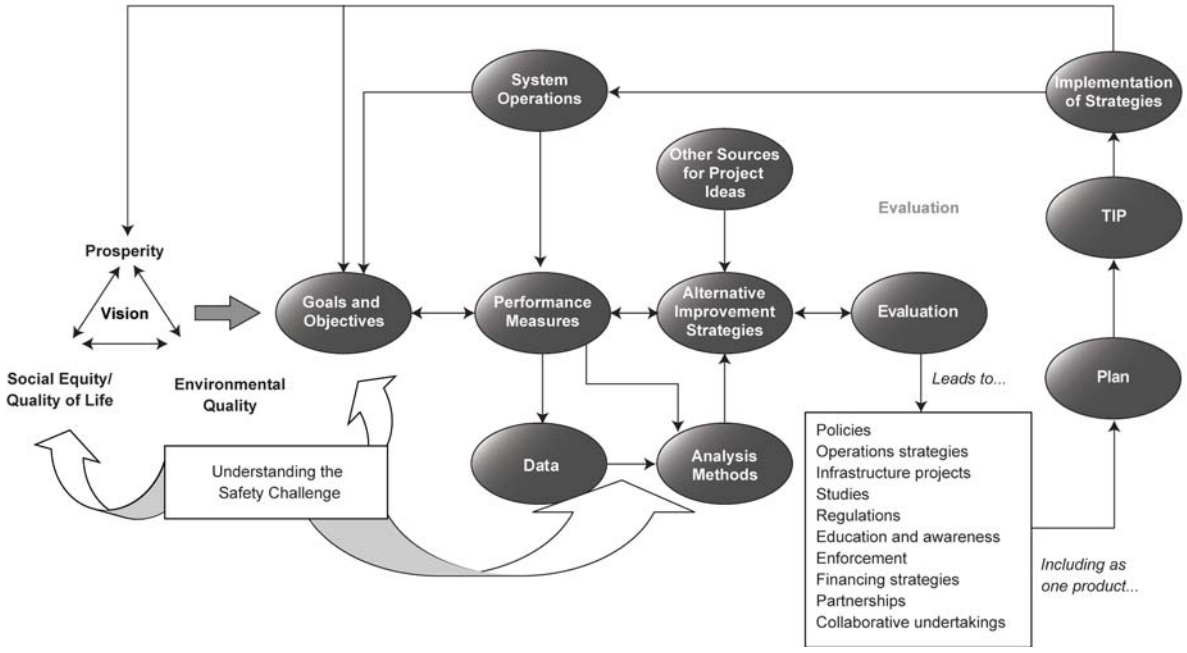
[2] NCHRP Report 546, *Incorporating Safety into Long-Range Transportation Planning*, 2006.

EXHIBIT II-1
Assessing the Role of Safety in the Planning Process

1. Does the vision for the planning process include safety?
2. Are at least one planning goal and two objectives related to safety?
3. Are safety-related performance measures part of the set being used by the agency?
4. Are safety-related data used in problem identification and for identifying potential solutions?
5. Are safety analysis tools used regularly to analyze the potential impacts of prospective strategies and actions?
6. Are evaluatin criteria used for assessing the relative merits of different strategies and projects, including safety-related issues?
7. Do the products of the planning process include at least some actions that focus on transportation safety?
8. To the extent that a prioritization scheme is used to develop a program of action for an agency, is safety one of the priority factors?
9. Is there a systematic monitoring process that collects data on the safety-related characteristics of transportation system performae, and feeds this information back into the planning and decision-making process?
10. Are all the key sstakeholders involved in the planning process?

Source: NCHRP Report 546: *Incorporating Safety into Long-Range Transportation Planning.*

EXHIBIT II-2
The Transportation Planning Process

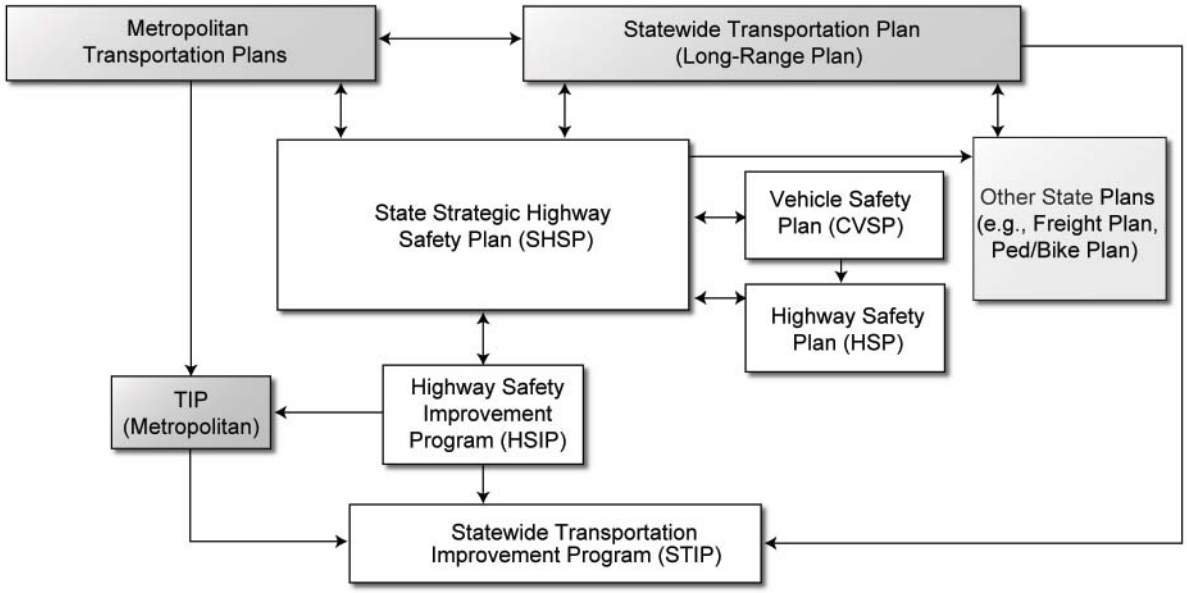


Source: NCHRP Report 546: *Incorporating Safety into Long-Range Transportation Planning.*

How safety is reflected in state and MPO plans defines how safety is addressed in the planning process. All states have developed Federally required SHSPs coordinated by the state DOT that involve engaging a wide range of stakeholders. The new planning rule encourages transportation planning to be consistent with the SHSP,[3] and long-range statewide and MPO plans should include a safety element that incorporates or summarizes the priorities, goals, countermeasures, or projects contained in the SHSP.[4] Safety stakeholders must be closely involved throughout the process to ensure transportation plans include projects, programs, and strategies with safety benefits.

States and regions develop a range of other plans that should be consistent with the SHSP. The state's Commercial Vehicle Safety Plan (CVSP) under the guidance of the FMCSA addresses safety strategies to reduce heavy truck crashes. The Highway Safety Plan (HSP) developed by the Governor's Office of Highway Safety (GOHS) mainly addresses the behavioral aspects of safety. The Highway Safety Improvement Program (HSIP) developed by state DOTs defines infrastructure improvements to address safety and also feeds into the STIP. In addition, a state or region may develop other plans such as bicycle and pedestrian plans, freight plans, or motorcycle safety plans that should be consistent with the SHSP. The relationship between the wide range of transportation planning products and safety plans is shown in Exhibit II-3. To most effectively address safety, it is critical that each of these plans be data driven and coordinated to ensure that transportation funds are spent most efficiently on areas with the greatest opportunity for safety improvements.

EXHIBIT II-3
Relationship of Safety Planning to the Planning Process



Source: FHWA SHSP Champion's Guide, modified.

[3] 23 CFR 450.208(h) and 450.306(h).
[4] 23 CFR 450.214(d) and 450.322(h).

Although state DOTs and MPOs follow essentially the same planning process, the implementation of strategies differs. MPOs are largely advisory agencies and seldom directly implement safety projects. MPOs must work closely with state and local governments to include safety analysis or strategies in their corridor studies, identification of problem locations, capital projects, etc. This makes planning and collaboration that much more important in safety implementation. The need for certain strategies and their likely effectiveness must be clearly demonstrated so the various governments will pursue implementation. TIP development usually involves advisory or coordinating committees with representatives from various governmental agencies. These groups should consider safety when prioritizing projects and developing implementation strategies.

While an MPO, Regional Planning Agency (RPA), or Area Development District (ADD) may not identify emphasis areas itself, Section III – Development of an Emphasis Area Plan may be useful for regional planning agencies to:

- Improve understanding of the variety of safety issues and possible measures;
- Understand the SHSP planning process;
- Provide a menu of strategies that could be used in the region to support the SHSP;
- Refine proposed projects or strategies to improve safety based on emphasis area research;
- Identify potential Crash Modification Factors (CMF) for use in project evaluation for the long-range plan or TIP;
- Identify approaches and strategies to consider in the long-range plan, corridor plans, safety studies, and regional safety plans;
- Assist nonmotorized or other planning committees in considering the safety implications of proposed projects and strategies and in developing new approaches; and
- Serve as a resource for developing the long-range plan's safety element.

Local Planning

Incorporating safety into local planning is the first step to including projects in the MPO's regional long-range plan and TIP. Seventy-seven percent of all roads are locally owned and maintained,[5] and many key safety improvements are implemented at a local level.

If a local jurisdiction has a crash database and conducts its own safety analysis, it will be a primary resource for identifying where and what types of safety improvements are needed. Crash databases maintained by local jurisdictions may be housed in a range of departments, such as traffic engineering, public works, or police departments. Larger jurisdictions are more likely to maintain a crash data system than smaller jurisdictions. The types of information that can be extracted from these data are described in the previous section. Additional discussion of data sources is located in Section III under Safety Data and Analysis.

[5] FHWA, 2006 Conditions and Performance Report, http://www.fhwa.dot.gov/policy/2006cpr/es02h.htm.

If local data are not available, local jurisdictions can obtain data and analysis from the state or MPO. Local transportation planners can then work with their public works and engineering departments to review crash data and gain an understanding of where the problems are in the community. Local and district engineers and local law enforcement also may provide useful input on key transportation safety issues.

Planners can work with traffic, engineering, and public works staff to develop a policy to implement safety countermeasures that can be incorporated into rehabilitation or improvements of roadways as standard practice. New projects to address critical safety issues also can be developed. Safety is often an issue that local residents find very personal and compelling, and jurisdiction staff will likely find local support for work on safety issues.

Local planning staff also can take on the role of facilitator with stakeholders outside local government. They can present data on safety issues to key partners, such as utility companies to discuss placement of utility poles or area agencies on aging to discuss the provision of alternative transportation for older populations. Local staff can meet with local law enforcement to discuss enforcement efforts and learn what officers are observing about traffic safety in the field. Planners can distribute educational materials in local government offices, or identify appropriate partners to help with the dissemination of information. Many opportunities exist to implement relatively low-cost, but effective, safety countermeasures at the local level.

Local resources are limited, and to maximize efficiency local planners can adopt programs such as model ordinances for access management. These ordinances should be included in local comprehensive plans and/or implementing ordinances.

This Desk Reference does not include all strategies that can be implemented on a local level to improve safety. It focuses on the emphasis areas profiled in the NCHRP Report 500 series. Other local strategies, such as land use planning, access management, and nonmotorized transportation strategies, are methods for impacting traffic volumes and congestion and improving traffic safety.

Resources

- NCHRP Report 546, *Incorporating Safety into Long-Range Transportation Planning,* 2006.
- *Considering Safety in the Transportation Planning Process,* U.S. DOT, undated, http://tmip.fhwa.dot.gov/clearinghouse/320/.
- NCHRP Research Results Digest 299, *Crash Reduction Factors for Traffic Engineering and Intelligent Transportation System Improvements: State-of-Knowledge Report,* November 2005.
- FHWA Office of Safety Road Safety Audits web site: http://safety.fhwa.dot.gov/rsa/.
- NHTSA Crash Forms Catalogue: http://www.nhtsa-tsis.net/crashforms/.
- NCHRP Synthesis 321: *Roadway Safety Tools for Local Agencies:* http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_syn_321.pdf.

SECTION III

Safety Emphasis Areas

This section presents the 22 safety emphasis areas, plus sections on Safety Data and Analysis and Development of an Emphasis Area Plan. Each discussion consists of a brief description of the problem, followed by a discussion of data relating to the problem. Multiple potential solutions are then presented in the form of objectives, under which multiple strategies for achieving those objectives are provided. In addition, examples of best practices and additional information resources are noted under each objective, if available.

The discussions in this section also address costs, crash modification factors, and evaluations associated with the strategies presented. More detail on how the discussions treat these issues is given below.

Costs

If data exist on costs or benefits for a specific strategy, information is provided in parentheses or in a text box adjacent to the strategy. The relative cost to implement and operate a strategy is categorized in four levels: low, moderate, moderate to high, and high costs. These categorizations do not relate to exact ranges of costs, but represent the relative cost of various strategies. The following icons are used next to the strategies to indicate their relative cost:

- Low – $;
- Moderate – $$;
- Moderate to High – $$$; and
- High – $$$$.

Crash Modification Factors

The crash reduction benefits of some engineering strategies are available. The primary source for data included here is NCHRP Report 617, *Accident Modification Factors for Traffic Engineering and ITS Improvements.* The forthcoming Highway Safety Manual (HSM) transitions use of the term Accident Modification Factor (AMF) to Crash Modification Factor (CMF). To be consistent with the HSM this document uses the term CMF. This publication includes CMFs to estimate the reduction in crashes from a specific safety treatment or installation. CMFs are multiplied by the current crash rate to generate the expected new crash rate after a new safety treatment is implemented. For example, if a treatment is expected to reduce the number of crashes by 15 percent, the CMF is 0.85. One of the challenges of using CMFs is that they are generally calculated based on individual treatments, while in practice more than one treatment is often implemented at once. Therefore, it is unknown whether predictions based on combining CMFs accurately capture the combined effect.

In NCHRP Report 617, a level of predictive certainty was assigned to each CMF, based on reviews of the caliber of existing research on that countermeasure. CMFs are included in this Desk Reference only for strategies with a high- or medium-high-level of predictive certainty. The *Desktop Reference for Crash Reduction Factors* published by FHWA provides additional crash reduction factors for intersection, roadway departure, and pedestrian crashes. NCHRP Report 622, *Effectiveness of Behavioral Highway Safety Countermeasures,* is a manual for application of behavioral highway safety countermeasures, and a framework and guidance for estimating the costs and benefits of emerging, experimental, untried, or unproven behavioral highway safety countermeasures. The new web-based CMF Clearinghouse is a one-stop location for resources related to CMFs (for more information see Other Safety Analysis Tools in Section III).

Research on costs and effectiveness of countermeasures is ongoing, and planners should make use of new research results when they are available. The HSM is a tool for highway designers that will provide information on safety design features and countermeasures with associated crash modification factors. This tool will be of use in preliminary or advanced design and include prediction models to compare the safety performance of design options. The document is expected to be available in early 2010.

Use and Evaluation of Strategies

The strategies listed in this document were derived from the NCHRP Report 500 series on Guidance for Implementation of the AASHTO Strategic Highway Safety Plan. These strategies were identified from a number of sources, including the literature, contact with state and local agencies throughout the United States, and Federal programs. Some of the strategies have been widely used, and some have been subjected to well-designed evaluations to prove their effectiveness. However, many strategies have been widely used, but not adequately evaluated. Therefore, the reader should be prepared to use caution in many cases before adopting a particular strategy for implementation. To provide guidance as to the extent of use and evaluation, most strategies have been classified into one of three categories. To identify the cases and research to document whether a strategy is proven or tried, planners will need to refer to the full NCHRP reports. Each category is identified by a letter symbol throughout the guide:

- **Proven (P) –** Strategies used in one or more locations and for which properly designed evaluations have been conducted that show them to be effective;
- **Tried (T) –** Strategies implemented in a number of locations and may even be accepted as standards or standard approaches, but for which evaluations have not been documented; and
- **Experimental (E) –** Suggested strategies that at least one agency has considered sufficiently promising to try on a small scale in at least one location.

Emphasis Areas

The full list of emphasis areas addressed in this section is provided below. The first two sections provide guidance on safety data and analysis and identification of priority emphasis areas and strategies, which apply to all of the subsequent emphasis areas:

- Safety data and analysis;
- Development of an emphasis area plan;
- Older persons' safe mobility;
- Young drivers;
- Pedestrian collisions;
- Bicycle collisions;
- Aggressive driving;
- Speeding;
- Unlicensed drivers;
- Signalized intersections;
- Unsignalized intersections;
- Run-off-road collisions;
- Head-on collisions;
- Head-on collisions on freeways;
- Horizontal curves;
- Tree collisions;
- Utility pole collisions;
- Occupant protection;
- Heavy truck collisions;
- Motorcycle collisions;
- Work zone collisions;
- Drowsy or distracted driving;
- Rural emergency medical services; and
- Alcohol-involved collisions.

Safety Data and Analysis

Problem Description

The basic principle for developing an effective safety plan is to achieve the greatest results with the least cost, or to identify the strategies and countermeasures with the greatest benefit/cost (B/C) ratio for each safety concern (location, user group, vehicle type, or crash type), and the combination of strategies that provide the best B/C ratio across the entire system. To determine what these ratios are, data about crashes and the vehicles and people involved in them, as well as data associated with the effectiveness and costs of each countermeasure must be collected, organized, linked, and analyzed.

In many cases, the available data are limited or unknown. While police crash records are the most basic form of roadway safety data, the information recorded on the report may vary from location to location, as different forms are used in different places. The crash location also can be reported with varying levels of specificity. Other data sources, such as hospital and other medical records, insurance records, and licensing information, may or may not be available and may or may not be linked to crash data. Roadway inventory information in some jurisdictions is detailed and linked to crash records, while in others the information is limited and may be difficult to link to crash data. Also, for many of the strategies suggested in the following sections, valid studies exist to provide expected crash reduction factors.

Data Sources

Local and Statewide Crash Data

Records on traffic crashes are derived from the law enforcement report form that is usually completed by investigating police officers at the crash site. A typical crash report contains about 100 pieces of information that describe the crash, the location, and the people and vehicles involved. Crash reports may be used individually to explore the circumstances and factors that contributed to a particular event, and they may be used in aggregate to develop a picture of the safety performance of a given location or jurisdiction. Model Minimum Uniform Crash Criteria (MMUCC) is a voluntary guideline that helps states collect consistent crash data for a wide range of transportation safety planning applications.

FARS – Fatality Analysis Reporting System

FARS contains annual data on a census of fatal traffic crashes within the 50 states, the District of Columbia, and Puerto Rico. According to NHTSA, "…to be included in FARS, a crash must involve a motor vehicle traveling on a trafficway customarily open to the public, and must result in the death of an occupant of a vehicle or a nonmotorist within 30 days of the crash." FARS data are available annually back to 1975. Each new year's file is typically available about six months following the end of the year; however, the FARS analyst in each state has access to their own state's fatal crashes at all times. It contains more than 100 data elements related to the driver, vehicle, involved persons, and the crash itself. FARS has proven to be a rich information source for research and program evaluation focusing on fatal crashes. The quality of FARS data is quite high due to extensive training provided to the FARS analysts.

CODES – Crash Outcome Data Evaluation System

CODES is an enhanced state-based crash data system in which police crash data are linked with detailed information on the medical consequences of the crash. At a minimum, basic statewide police crash data is supplemented with hospital data and either EMS data or emergency department data. Some states also add data for each driver and other occupant concerning driver license status, vehicle registration, citation/conviction records, insurance claims, rehabilitation and long-term care, and other items. The linkage of medical information to crash and driver data is done through "probabilistic linkage technology" since direct linkage is not often possible due to missing personal information and privacy concerns.

MCMIS – Motor Carrier Management Information System

MCMIS is a comprehensive truck safety database that is the source of data for many of the FMCSA's other data files (e.g., Safety and Fitness Electronic Records System (SAFER)) and analysis procedures (e.g., SafeStat). Data are entered into MCMIS via the SafetyNet system accessed by personnel in each state's Motor Carrier Safety Assistance Program (MCSAP) agency. The database is maintained by FMCSA to allow analysis of motor-carrier issues. MCMIS consists of five files, with input to each file from each state and from carriers subject to Federal truck safety regulations in all states:

- Registration ("Census") file;
- Crash file;
- Roadside Inspection file;
- Compliance Review file; and
- Enforcement file.

MCMIS data are the primary safety data used by FMCSA and state truck safety staff in all safety-related efforts. State-based crash tables can be used to look at major factors associated with truck crashes.

Roadway Inventory Data

State Inventory Data

Each state highway agency and some local transportation and public works departments and regional planning agencies (e.g., MPO, RPA) collect and maintain roadway inventory data on each section of roadway within the highway systems for which they are responsible. The data are generally "cross-section" information on the roadway – number of lanes, shoulder type and width, median descriptors, pavement types, etc. Most states have supplemental files describing bridges (as part of the National Bridge Inventory) and railroad grade crossings (as part of the Federal Railroad Administration's Railroad Grade-Crossing Inventory) that can usually, but not always, be linked to the basic roadway inventory file. A very few state systems also include information on curves and grades, two important safety predictors. A limited number of states have developed intersection and interchange inventory files providing detailed descriptions of such items as intersection type, traffic control type, turning lanes, mainline and crossroad traffic volumes, interchange type, ramp length, etc. Additional roadway-oriented supplemental files may exist on such safety-related information as skid numbers, intersection turning counts, intersection signalization phasing, pavement condition, and speed profiles.

HPMS – Highway Performance-Monitoring System

Many of the state roadway inventory systems were expansions of the HPMS system, a 1978 congressionally mandated data system to collect data on the nation's highways. HPMS is similar to the state inventory systems but is based on a sample of locations from different functional classifications in each state, rather than containing the full state system. It contains limited data on all public roads. Data are input each year by every state, analyzed, and reported to Congress by FHWA. In general, the state analyst will use the state system data, which is usually far more complete and accurate than HPMS data, in state-based safety analyses.

Other Roadway and Intersection Characteristic Data

Other data on roadway and intersection characteristics can be obtained from photologs or aerial photographs. In particular, orthophotos are geographically converted to allow accurate measurement. The ongoing development of asset management databases by

state and local highway agencies will provide a potentially valuable source of roadway and intersection characteristics data. These data sources may be particularly useful in development of safety plans if they can be linked to the location reference system used in crash data.

Model Inventory of Roadway Elements (MIRE)

Though not referenced in the NCHRP 500 Series, the Model Inventory of Roadway Elements (MIRE) provides a listing of roadway inventory and traffic elements essential to safety management and proposes standardized coding for each. The final report, containing MIRE 1.0, will be completed in the summer of 2010 and will be available on the FHWA Office of Safety website (http://safety.fhwa.dot.gov/).

Traffic Volume Data

State highway agencies collect and maintain data on traffic volumes (Average Annual Daily Traffic – AADT) for roads on the state-controlled system. In addition to AADT, state agencies also collect and maintain large-truck counts or percentages for each roadway section. Local jurisdictions will have traffic volume information, but the consistency and quality varies by jurisdiction. In general, traffic volume data is more limited in local jurisdictions than for the state-system roads.

Driver History Files

Departments of Motor Vehicles (DMV) maintain driver records of all licensed drivers in the state. Driver records are typically generated when a person enters the state licensing system to obtain a license or when unlicensed drivers have a violation or crash in the state. The record contains basic identifiers (e.g., name, address, driver license number), demographic information on the driver (e.g., birth date, gender), and information relevant to license and driver improvement actions (e.g., license issuance and expiration/renewal dates, license class, violation dates, suspension periods). In some states, information on crash involvements (e.g., occurrence date, crash severity) is also available. Driver records are especially useful for examining issues related to driving history and rates of recidivism (e.g., reoffending for moving violations and traffic-related criminal convictions).

Vehicle Registration Files

Departments of motor vehicles maintain motor vehicle registration files for use in vehicle licensing and taxation. These files contain information on the vehicle identification number (VIN); plate number; and vehicle weight, model, make, and year. Vehicle registration data can be used in developing safety strategies when, for example, information on the number of licensed vehicles by type is needed.

SWISS – Statewide Injury Surveillance System

With the growing interest in injury control programs within the traffic safety, public health, and enforcement communities, a number of local, state, and Federal initiatives are driving the development of a SWISS. These systems typically incorporate prehospital (EMS),

trauma, emergency department (ED), hospital in-patient/discharge, rehabilitation, and morbidity databases to track injury causes, magnitude, costs, and outcomes. Often, these systems rely upon other components of the traffic records system to provide information on injury mechanisms or events (e.g., traffic crash reports). The custodial responsibility for various files within the SWISS is typically distributed among several agencies and/or offices within a State Department of Health. The SWISS should support integration of the injury data with police-reported traffic crashes and make this information available for analysis to support research, public policy, and decision-making. In most states, this integration is most likely to happen through a CODES probabilistic linkage process.

NEMSIS – National Emergency Medical Services Information System

The ability to evaluate and improve EMS systems has long been hampered by the lack of consistent and detailed EMS data at either the state or national level. While a state's EMS system is usually coordinated at the state level, with EMS providers trained and certified by the state EMS office, the system itself is composed of multiple local providers. Thus, the data required in a state (and ultimately national) database must be collected by these local agencies. Because of both the lack of a universal set of "endorsed" data variables and the fact that there is often no legal requirement for systematic collection of such data, state EMS data systems have varied greatly in terms of the composition and completeness of their data. Working with the Centers for Disease Control (CDC) and the Health Resources and Services Administration (HRSA), NHTSA is coordinating the NEMSIS project, which will ultimately lead to a national EMS database, populated from participating state databases. The raw data will continue to be collected by the individual local providers, but the data collected will be based on a data dictionary containing standardized variables and codes.

Population Census Files

The U.S. Census Bureau and the state demographer maintain data on population characteristics that can be useful in safety analyses. Typically, these data will give estimates of total population with gender, age, and ethnicity subpopulations broken out within political subdivisions. These data can be used to develop measures of crash risk, injury risk, and fatality risk for specific groups based upon residence location and any demographic characteristics recorded in the crash and population databases. While these types of analyses are most often used for epidemiological research, they are gaining acceptance among highway safety practitioners because of the additional insight they provide into a jurisdiction's crash experience, especially when countermeasures may involve education or road user behavior-related programs.

Citation Tracking and DUI Tracking Files

A special case of multiagency data sharing is the creation of citation and DUI tracking databases. The citation tracking system is viewed as a "cradle to grave" database of every citation issued in the state. From the point of initial printing, through assignment to an agency, and/or individual officer, issuance by that officer, processing by the Court or administrative processes, and final disposition, the citation is trackable. This supports a variety of safety-related analyses that are not possible if each agency controls their own citations and does not track what happens after the officer issues them. States have

found that citation tracking systems are useful in detecting recidivism for serious traffic offenses earlier in the process (i.e., prior to conviction) and for tracking the behavior of law enforcement agencies and the courts with respect to dismissals and plea downs. Such analyses can be useful in identifying training needs for law enforcement officers, prosecutors, court clerks and judges.

DUI tracking systems incorporate some features of a citation tracking system (however, only for drunk- or drugged-driving offenses) and add several other functions. In particular, a DUI tracking system is likely to contain data that could be used to evaluate the effectiveness of court-ordered and administrative actions required of offenders. The system can be used to track recidivism rates for people assigned to various treatment programs, or subject to various license restrictions. In this way, the state can learn which measures are most effective for ensuring offenders do not repeat prior behavior.

Local Data Files

Local engineering and law enforcement agencies are likely to maintain data on roadways and incidents (crashes, citations, etc.) in their jurisdictions. The roadway data may closely mirror that in a statewide system, but could also contain additional traffic counts, more precise or up-to-date information on changes to the roadway network and, perhaps, inventories of signs, markings, traffic control devices, and other roadside appurtenances. Where such data exist, the state DOT and other users can potentially access it to develop a more complete description of safety experience in the state by including details for the local roadway system that may not exist in state files. Many local engineering agencies use GIS and have sophisticated mapping capabilities that users can access.

Local law enforcement agencies often have a record of every crash in the jurisdiction, and may have complete citation records as well. Law enforcement agencies use these records for manpower allocation and crime mapping, among other purposes. Other users may find the data useful in developing a more comprehensive view of traffic safety in a local area. Crashes that fall below the state's reporting threshold may still be of interest to engineers looking for high-crash locations. Even crashes on private property may have some use for special analyses. One example would be an analysis of crashes in which one or more vehicles is backing up – the vast majority of such crashes occur in parking lots and are usually not recorded in the statewide crash database. The local law enforcement crash database provides a potential source for valuable information not already captured in the statewide crash database.

Other types of local databases may exist. For example, in the absence of a statewide EMS run database, or a statewide trauma registry, it may still be possible to obtain this information from local sources (EMS providers or trauma registries at designated trauma centers). A MPO or regional planning council/commission is often an excellent source of traffic data, projections, and other highway design and usage information. With a few notable exceptions, court records are almost always obtainable only at the local level (if at all). These may be used to track citations through the court processes, look at recidivism rates, and document the frequency of plea bargaining in traffic-related cases.

Other Safety Files

A variety of other files that might be useful in safety studies is sometimes available in a jurisdiction. Because of their effectiveness in reducing fatalities and serious injuries, perhaps the most important of the "other" safety data is occupant restraint (shoulder belt) use data collected in each state since 1998 in compliance with TEA 21 requirements. NHTSA developed detailed sampling criteria for data collection, and produces annual reports on changes in restraint use for all states (see an example at http://www.nhtsa.gov/people/injury/airbags/809713.pdf). These data are usually collected by the SHSO as part of the National Occupant Protection Use Survey (NOPUS).

Speed surveys are collected by both state and local agencies. Note, however, that since statewide speed surveys on Interstate roads were essentially ended in 1995 with the repeal of the National Maximum Speed Limit, very few jurisdiction-wide speed surveys are conducted. Instead, speed surveys are usually conducted at specific sites where a change in speed limit is being considered or has been recently implemented. The speed data collected at these "special" locations should not be considered good indicators of jurisdiction-wide speeds. Thus, safety planning that needs speed data usually requires in-field speed data collection.

Trauma registry and EMS data can be used to enhance the completeness of crash data in much the same way as medical records are used through the CODES database (see above). Data on roadway maintenance histories, including the types of maintenance actions and their locations and dates may be useful in development of safety plans.

Finally, public opinion and customer service data can provide key inputs to safety plan development. Many highway agencies conduct or have access to results of surveys of the general public or, more specifically, of motorists. For example, NHTSA has a requirement for telephone surveys to measure the effect of media-based public information programs. Some state and local agencies may maintain customer service call logs, where the type and number of reported concerns can be tracked by location. Customer service data, including complaints from the public, may provide useful information on problem locations or safety programs that are not functioning as designed. The Youth Risk Behavior Surveillance System monitors health-risk behaviors of youth and young adults and includes an annual national school-based survey.

Time Dimension of Data

Some types of data used in safety planning by their nature cover specific time periods. For example, crash data and citation data document events that occurred at a specific time, and data files generally cover a specified time period.

A second type of data file provides supplementary information gathered subsequent to a crash that, to be useful, must be linked to the crash record. Examples include medical records, which can be linked through the CODES database, and trauma registry data. Such data may not include the actual time or location of the crash and must, therefore, be linked through the victim's identity.

A third type of data represents a snapshot of a population at a given point in time, but does not necessarily include the full history of that population. For example, driver history files

typically include only drivers with active licenses at a specific point in time. The records for drivers who die or move out of state are deleted, so a current driver "history" file does not necessarily contain the history for all drivers during a given time period. Planning based on complete driver history data may need to consider historical files as well as current files.

Development of an Emphasis Area Plan

This section defines the three-stage process for developing an emphasis-area plan, choosing treatment strategies, and targeting them. Additional information on choosing emphasis areas of interest and setting the injury and death-reduction goals is covered in NCHRP Report 501: *Integrated Safety Management Processes.*

Objective 1. Identify a Target Emphasis Area

The safety planning team will first need to define or choose the most pressing issues (emphasis areas) that need to be addressed. Numerous safety problems could be treated in any jurisdiction. However, extensive efforts have been made to identify the best possible low-cost but effective treatment strategies for use in the AASHTO 22 emphasis areas, thus making the development of a jurisdiction-specific safety program much easier. While not always the case, the same critical problems would most likely exist in any jurisdiction. So "defining" here is usually related to determining which of the 22 identified emphasis areas addressed in this guide are most critical in the jurisdiction.

Strategy

The analyst will generally first perform multiple data runs of each variable in the crash data (e.g., driver age, crash type) to determine which variables show high frequencies of crashes. Since some crashes are more severe than others, crash severity as well as frequency should be considered. One method of combining both frequency and severity is through weighting each crash or each crash type by an economic cost based on its severity.

Objective 2: Set a Fatality and Injury Reduction Goal

The emphasis-area team will then use a series of factors to define a reduction goal for death and injuries in each of the emphasis areas chosen.

Strategy

The death and injury reduction goal will be based on outputs of the Objective 1 analyses (i.e., the problem size, total crash cost, over-representation, and related outputs of the problem-identification/drill-down analyses), on some estimate of possible strategy effectiveness, and on the budget established for the emphasis area. NCHRP Report 501 defines both an initial process and a revised process for establishing these goals. The initial process will be likely based on "best judgment" of the factors above. The revised process is much more iterative and analysis-driven where initial goals are modified based on analyses that indicate what is realistic given the nature and size of the problem, the known or assumed countermeasure effectiveness for the final list of chosen countermeasures, and the optimization of the

existing budget either within a given emphasis area or across emphasis areas.

Objective 3: Define the Alternative Treatments that Allow the Jurisdiction to Reach the Goal

Having now defined the issue/emphasis area(s) to be treated (e.g., run-off-road crashes, crashes involving impaired drivers) and having defined the crash/injury reduction goal (e.g., a 10 percent reduction in the number of fatal and serious injury run-off-road crashes on two-lane rural roads), the next step is to define the treatment strategies to be employed and the target population for each strategy.

Depending on the emphasis area and strategy, the term "population" may refer to humans (e.g., older drivers, pedestrians), vehicles (e.g., large trucks, motorcycles), or roadway sites (i.e., individual roadway features, segments, corridors, intersections, interchanges). High-level safety planning requires the limited available safety funds be used in the most effective ways. Funds should not be spent on treatments whose effects are small if those same funds could be used for other treatments that provide greater benefits. Thus, at a minimum, the goal should be to implement only treatments whose benefits exceed their costs, and the ultimate goal should be to implement the treatments with the highest ratio of benefits to costs.

Crash Reduction Factor versus Crash Modification Factor

The *level of effectiveness* of a treatment is referred to in much of the current safety literature as a Crash Reduction Factor (CRF) or Crash Modification Factor (CMF). The two terms are just different ways of expressing treatment effectiveness levels. A CRF provides the expected proportional reduction in crash frequency, for all crashes or for specific crash severity levels, so a 15 percent reduction in crashes would correspond to a CRF = 0.15.

Likewise, a 20 percent reduction in fatal and serious injury crashes would correspond to a CRF=0.20. A CMF is developed by subtracting the CRF from 1.00, with an CMF of 1.00 representing no effect on safety. Thus, a treatment with 15 percent effectiveness would have an CMF of 0.85 (i.e., 1.00-0.15). CMFs above 1.00 indicate that the treatment can be expected to result in an increase in crashes.

However, to base safety planning decisions on benefits and costs, the effectiveness of each potential treatment must be defined (e.g., treatment "X" will reduce run-off-road crashes by 15 percent; treatment "Y" will reduce older driver crashes by 20 percent). A review of any of the NCHRP Report 500 Guides will indicate many treatments that have been tried, in some cases used very widely, and are generally considered to have a positive effect on safety, but have never been formally evaluated in a well-designed study from which an acceptable quantitative *level of effectiveness* (i.e., a specific CRF or CMF) has been developed.

Strategies

Given the number of treatments that have been applied without formal evaluation, the process of choosing treatments and choosing targets for each treatment can be addressed via four different procedures:

- Procedure 1 – Choosing Roadway-Based Treatments and Target Populations When Treatment Effectiveness is Known, and Both Crash and Non-Crash Data are Available;

- Procedure 2 – Choosing Roadway-Based Treatments and Target Populations When Treatment Effectiveness is Known and Crash Data are Available, but Detailed Inventory Data are not Available;
- Procedure 3 – Choosing Driver, Vehicle or Roadway Treatments and Target Populations When Treatment Effectiveness in Terms of Crash/Injury Reduction is not Known; and
- Procedure 4 – Choosing Treatments and Target Populations in Emphasis Areas for Which Some Candidate Treatments Have Known Effectiveness Estimates and Other Treatments Do Not.

Procedures 1 and 2 are based on an economic (benefit/cost) analysis. Procedure 3 is not based on economic analysis, while Procedure 4 combines economic and noneconomic procedures. The selection and targeting of driver- and vehicle-based treatments is not based on an economic analysis.

Procedures 1 and 2 generally result in plans whose expected safety benefits are more accurately known than Procedures 3 and 4, because Procedures 1 and 2 are applicable to treatments whose effectiveness has been well documented. Therefore, the safety planning process should generally exhaust funding opportunities under Procedures 1 and 2 before proceeding to Procedures 3 and 4. Key considerations in choosing one of the four procedures are whether the effectiveness of the treatment(s) is known and whether the location data are available.

In many states, the achievement of a statewide goal for crash reduction will involve consideration of treatments both with and without known effectiveness and consideration of roads under both state and local jurisdiction, which are likely to involve crash data sets with and without location data. Many states may need to use more than one of the four procedures. For detailed guidance on how to apply each of these procedures, consult NCHRP Report 500 Volume 19: *A Guide for Collecting and Analyzing Highway Safety Data.*

Other Safety Analysis Tools

The procedures presented above supply a goal-oriented approach to developing plans for safety improvement programs. Users should be aware of other analytical tools under development. FHWA's *SafetyAnalyst* software, released in July 2009, is intended for application to safety management of a highway system and may be an effective tool for safety planning. SafetyAnalyst is location- and budget-oriented, unlike the procedures presented above, which are goal-oriented.

FHWA's Interactive Highway Safety Design Model (IHSDM) is a suite of software analysis tools for evaluating safety and operational effects of geometric design decisions on two-lane rural highways. IHSDM will likely be expanded in the future to address other facility types.

The forthcoming HSM, scheduled for publication in early 2010, will present formal procedures for estimating the crash/injury reduction effectiveness of specific improvement types, including an expanded set of CRFs and CMFs representing countermeasure effectiveness. CMFs developed for NCHRP Project 17-25 are presented in NCHRP Report 617.

An additional tool not referenced in the NCHRP 500 Series, the CMF Clearinghouse offers transportation professionals a central, web-based repository of CMFs, as well as additional information and resources related to CMFs. Both CMFs and CRFs are presented in the clearinghouse because both are widely used in the field of traffic safety. Features of the CMF Clearinghouse include the ability to search by countermeasure, crash type, crash severity, and roadway type via a quick search. The advanced search tool enables searches by additional parameters such as intersection type, traffic control, and whether the CMF is included in the Highway Safety Manual. The Clearinghouse provides information about applying CMFs as well as training, resources and publications.

The following sections will address transportation safety emphasis areas and provide potential safety countermeasures.

Resources

NCHRP Report Volume 19: *A Guide for Collecting and Analyzing Highway Safety Data:* http://safety.transportation.org/guides.aspx.

FARS Web-Based Encyclopedia provides links to national reports and statistics: http://www-fars.nhtsa.dot.gov/.

FARS data also can be obtained from NHTSA on a CD or via download from an ftp site: ftp://ftp.nhtsa.dot.gov/fars/.

CODES information, including links to some participating states: http://www.nhtsa.dot.gov/people/ncsa/codes/.

MCMIS Data Dissemination Program Catalog listing variables in the crash files: http://mcmiscatalog.fmcsa.dot.gov/beta/Catalogs&Documentation/.

CMF Clearinghouse: http://www.CMFClearinghouse.com.

MIRE://www.mireinfo.org.

Commercial motor vehicle safety reports and analysis tools can be found at: http://www.fmcsa.dot.gov/facts-research/facts-research.htm.

The "Crash Profiles On-Line" tool within the "Analysis and Information On-Line" suite of tools provides state-by-state truck crash statistics: http://ai.fmcsa.dot.gov/mcspa.asp.

NEMSIS details and status: http://www.nemsis.org/.

IHSDM web site: http://www.tfhrc.gov/safety/ihsdm/ihsdm.htm.

SafetyAnalyst web site: www.safetyanalyst.org.

HSM details and status: http://www.highwaysafetymanual.org.

Examples of the application of Procedure 1: http://safety.fhwa.dot.gov/intersection/ and http://safety.fhwa.dot.gov/roadway_dept/.

Crash Cost Estimates by Maximum Police-Reported Injury Severity within Selected Crash Geometries provides information on economic cost per crash by severity level for 22 different crash types categorized by speed limit category: http://www.tfhrc.gov/safety/pubs/05051/.

NCHRP Report 501: Integrated Safety Management (Appendix D): http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_501.pdf.

Model Minimum Uniform Crash Criteria: http://www.mmucc.us/.

Desktop Reference for Crash Reduction Factors (FHWA) http://www.transportation.org/sites/safetymanagement/docs/Desktop%20Reference%20Complete.pdf.

NCHRP 617: *Accident Modification Factors for Traffic Engineering and ITS Improvements* http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_617.pdf.

NCHRP Report 622: *Effectiveness of Behavioral Highway Safety Countermeasures* http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_622.pdf.

Older Persons' Safe Mobility

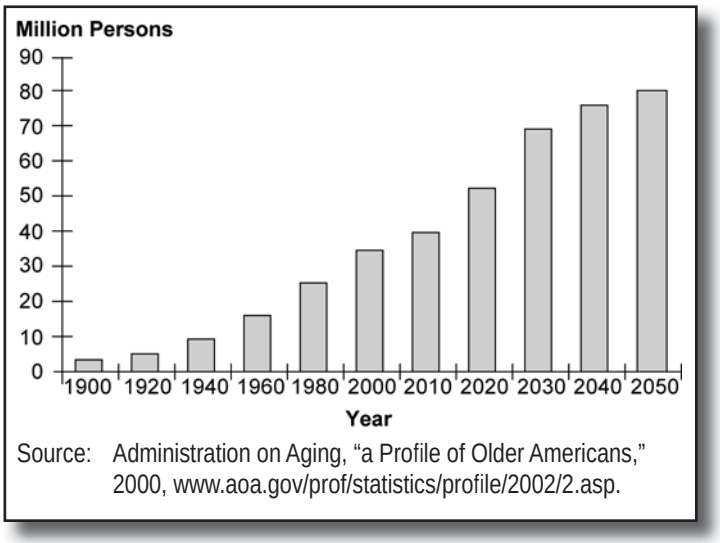
Problem Description

Older persons are at greater risk when driving because of their potentially reduced cognitive, perceptual, and physical capabilities. Although older drivers may drive fewer miles than other drivers, they have an increased rate of crashes based on miles traveled. The real safety concern for older drivers arises when one takes into consideration their increased likelihood of getting injured or killed in a crash. The safety problem confronting older adults is as much an issue of crash survivability as it is crash avoidance.

Data

- In 2007, 13 percent of the total U.S. resident population was people age 65 and older.
- The United States population of older adults will double between 2000 and 2030. One in five Americans will be age 65 or older by 2030.
- Aging affects a variety of skills needed for safe driving. In particular, the aging population experiences deterioration in physical, perceptual, and cognitive skills.
- When crash rates are calculated on the basis of miles traveled, older adults are at increased risk. Drivers age 85 and older have about the same high crash rate per mile driven as 20- to 24-year olds.

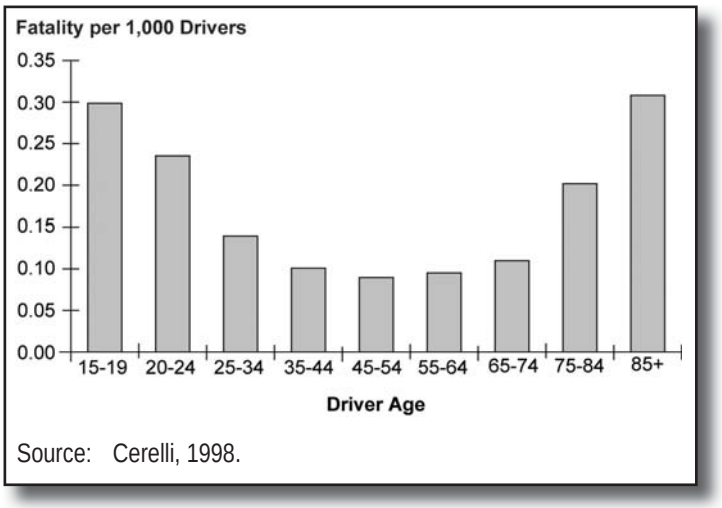
EXHIBIT III-1
Projected Growth in U.S. Population Age 65 and Older



Source: Administration on Aging, "a Profile of Older Americans," 2000, www.aoa.gov/prof/statistics/profile/2002/2.asp.

- Older drivers have an increased likelihood of being injured or killed in a crash. Compared with an overall fatality rate of 2 per 1,000 crashes, persons ages 65 to 74 have a fatality rate of 3.2. For those 75 to 84, the rate is 5.3, and at 85 or older the rate climbs to 8.6.
- The likelihood of being at fault in a crash also has been shown to increase with age: nearly 70 percent of drivers ages 75 and older involved in fatal two-vehicle crashes were at fault, compared with fewer than 40 percent for drivers aged 45 to 64. Specific crash types for which older drivers are increasingly likely to be found at fault include angle collisions, turns across traffic collisions, and slowing or stopping collisions, indicating that older drivers may be more challenged by intersection situations than younger drivers.

EXHIBIT III-2
Fatalities by Age of Driver



Source: Cerelli, 1998.

- Ninety percent of trips taken by older adults are in a personal vehicle. Of those trips, 70 percent involve the older person driving the vehicle.

Objective 1: Plan for an Aging Population

Strategies

Addressing the mobility needs of an aging population requires two approaches: increasing safety for older drivers and providing alternative mobility options, including pedestrian facilities and transit for those who cannot or choose not to drive. However, research clearly shows older persons who are no longer physically able to drive also are unlikely to be able to walk or use transit.

The first overarching strategy to plan for an aging population is to establish a broad-based coalition to plan for older adults' transportation needs. This coalition should be comprised of as many stakeholders as possible, including the state DOT, DMV, MPOs, transit agencies, and local planning offices, as well as specific advocacy or medical organizations with services for older people such as Area Agencies on Aging, and AAA.

Strategies generated by such groups may be very broad and extend beyond the activities that planners would implement. However, encouragement and facilitation of other groups by the planner may enable implementation of strategies that will complement the planner's activities. The goal of screening and remedial programs is to maintain safe mobility for older drivers as long as possible to preserve quality of life.

To identify older drivers at increased risk of crashing and preventative intervention measures, the following strategies are recommended:

- Strengthen the role of medical advisory boards that may set policies on how medical conditions are addressed with respect to driving privileges (T, $);
- Update procedures for assessing medical fitness to drive, such as determining the level of functional impairment for all persons with conditions known to affect driving ability (P, $$);
- Encourage external reporting of at risk drivers to licensing authorities by medical personnel, enforcement officers, and private citizens (friends and family) (T, $); and
- Provide remedial assistance to help functionally impaired older drivers lower their crash risk, such as training at local driving schools, mandatory adaptive equipment to be added to the driver's vehicle, and occupational therapy (T, $).

To improve the driving competency of older adults in the general driving population, the following strategies are recommended:

- Establish resource centers within communities to promote safe mobility choices, such as a facility or call center that provides information on a variety of older people's needs, including transportation, with one call (T, $$); and
- Provide educational and training opportunities to the general older driver population, including distribution of materials, such as those developed by the FHWA, NHTSA, and AAA, to help identify changing abilities (T, $$).

To reduce the risk of injury and death to older drivers and passengers involved in crashes, the following strategy is recommended:

- Increase safety belt use by older drivers and passengers through education and enforcement programs (P, $).

The fragility of older persons in crashes is one reason they are more at risk for death or injury. While the rate of safety belt use is high among this age group, 18 percent of adults aged 70 and older do not buckle up. A main reason that older people do not buckle up is comfort.

Objective 2: Improve the Roadway and Driving Environment to Better Accommodate Older Drivers' Special Needs

Strategies

Several approaches help older drivers navigate the roadways more safely. Signage can be an important factor for helping drivers make timely decisions. The placement of advanced warning signs should be considered before changes in the roadway or environment, such as in advance of speed limit reductions, sharp curves, merging, pedestrian areas, or construction zones. Guide signs that provide

EXHIBIT III-3
Advance Street Name Sign
Tyler District, TxDOT

Source: NCHRP Report 500, Volume 9: A Guide for Reducing Collisions Involving Older Drivers.

route identification, interchanges, or destinations that are placed well in advance of a roadway decision point give the driver additional time to make necessary lane changes or route selection decisions. This additional time is especially important for older drivers, who generally take longer to process and react to information on signs. In addition, modifications to intersections, in terms of turn signals and clearance intervals, will assist with ensuring that those with diminished reaction time clear an intersection safely. In addition, larger signs, lighting, and roadway markings help with roadway visibility for older drivers, especially at night.

The minimum STOP sign size, according to the Manual on Uniform Traffic Control Devices (MUTCD), is 24 x 24 inches. The Florida DOT, however, is replacing all of its 24 x 24-inch or 30 x 30-inch STOP signs with 48 x 48-inch signs to help accommodate the needs of its older driver population.

- Provide advance warning signs such as those that notify drivers that an intersection with a stop sign or traffic signal is ahead (T, $);
- Provide advance-guide and street sign names that notify drivers that an intersection with a major roadway is ahead (T, $);
- Increase the size and letter height of roadway signs for greater visibility (T, $);
- Provide all-red clearance intervals at signalized intersections to ensure all cars have time to pass through an intersection safely (T, $);
- Provide more protected left-turn signal phases at high-volume intersections to allow people to execute left turns without having to judge the speed of oncoming traffic (T, $);
- Improve lighting at intersections, horizontal curves, and railroad grade crossings (T, $$$);
- Improve roadway delineation to improve the driver's understanding of the roadway operating area, including improved painted or raised pavement markings (T, $);
- Replace painted channelization with raised channelization to clearly define desired vehicle movements, discourage undesired movements within an intersection, and minimize points of conflict for turning vehicles (P, $$); and
- Improve traffic control at work zones (T, $).

EXHIBIT III-4
Modify Signal Change Interval

Crash Type (Injury Crashes Only)	Crash Modification Factor
All Crashes	0.88
Multiple-Vehicle Crashes	0.91
Rear-End Crashes	1.08[a]
Right-Angle Crashes	1.06[a]
Pedestrian/Bicyclist Crashes	0.63

[a] Results were not significant at a 90 percent confidence level. CMF of 1.0 recommended for these crash types.

Note: Both the yellow change interval and the red clearance interval were adjusted at the treatment sites to conform to the ITE *Determining Vehicle Change Intervals: A Proposed Recommended Practice.*

Best Practices

Model Driver Screening and Evaluation Program (2003): http://www.nhtsa.dot.gov/people/injury/olddrive/modeldriver.

AAA education materials:

- http://www.aaafoundation.org/pdf/driver55.pdf;
- http://www.aaafoundation.org/pdf/older&wiser.pdf; and
- http://www.aaafoundation.org/pdf/ODlarge.pdf.

Resources

NCHRP Report 500 Volume 9: *A Guide for Reducing Collisions Involving Older Drivers:* http://safety.transportation.org/guides.aspx.

Countermeasures that Work: A Highway Safety Countermeasure Guide for State Highway Safety Offices, Governors Highway Safety Association, (2009): http://www.ghsa.org/html/publications/index.html#countermeasures.

NHTSA and American Association of Motor Vehicle Administrators 2003 survey of all Medical Advisory Boards:
http://www.aamva.org/NR/rdonlyres/4C38EEE9-5DC7-449C-A496-15757A99C3F6/0/SummaryOfMedicalAdvisoryBoardPractices1.pdf.

F*HWA Highway Design Handbook for Older Drivers and Pedestrians:*
http://www.tfhrc.gov/humanfac/01103/coverfront.htm.

FHWA Roadway Delineation Practices Handbook:
http://www.fhwa.dot.gov/tfhrc/safety/pubs/93001/93001.pdf.

Young Drivers

Problem Description

In the United States, motor vehicle crashes are the leading cause of death for 15- to 20-year olds,[6] and young drivers are overrepresented in motor vehicle crashes. Most novice drivers do not have sufficient experience to handle the complex task of driving when they are first licensed. Moreover, the late teen years involve continuing developmental changes that characterize the transition from childhood to adulthood. These result in a variety of behaviors that may be risky when they occur in a motor vehicle. Young drivers are more likely than older adults to engage in risky driving behaviors such as speeding and allowing shorter headways. Although such behaviors are sometimes intentional, young driver crashes generally result from errors in attention, failing to recognize hazards, and driving too fast for conditions. Reducing young driver crashes will involve effectively addressing both the youthful propensity to engage in risky behaviors and lack of experience.

Data

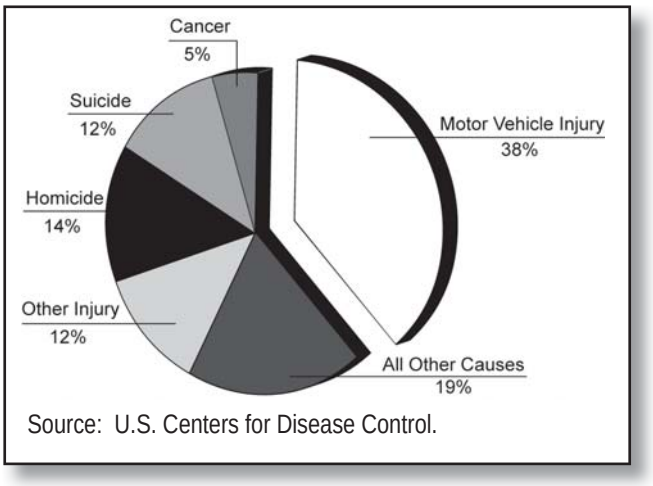
Young drivers are more likely to be involved in a motor vehicle crash than any other age group. This is the case whether crash rates are measured per population, per licensed driver

[6] 2005 data, National Center for Health Statistics.

or per mile traveled. This greater crash involvement also results in additional injury risks because the youngest drivers tend to carry the largest number of passengers, typically other teens. And this group – drivers and passengers alike – is least likely to wear safety belts, foregoing the best protection against injury in the event of a crash.

- In 2007, 3,174 drivers between the ages of 15 and 20 years were killed in motor vehicle crashes (NHTSA).
- Although 15- to 20-year-olds represented 8.5 percent of the U.S. population and 6.4 percent of licensed drivers, they accounted for 12.5 percent of drivers involved in fatal motor vehicle crashes (NHTSA, 2007).
- One-quarter (24.2 percent) of persons killed in crashes involving 15- to 17-year-old drivers are occupants of a vehicle other than the teen's and another 7.5 percent are nonmotorists, e.g., a bicyclist or pedestrian (AAA, 2006).
- Only about 15 percent of the miles driven by 16- and 17-year-olds are during the period from 9:00 p.m. to 6:00 a.m., but more than 40 percent of their fatal crashes take place during these hours (Williams & Pruesser, 1997).
- In 2007, 31 percent of the young drivers (15 to 20 years old) killed in crashes had a blood alcohol concentration (BAC) of .01 grams per deciliter or higher, and 26 percent had a BAC of .08 or higher. Drivers age 21-24 had the highest rate of alcohol involvement of all age groups, with 35 percent of those killed having BAC of .08 or higher.
- Crash rates for newly licensed drivers are highest during the first six months of driving alone.

Exhibit III-5
Cause of Death among Persons Ages 16 to 20, U.S.



Source: U.S. Centers for Disease Control.

Objective 1: Implement or Improve Graduated Driver Licensing (GDL) Systems

Strategies

A growing body of evidence suggests GDL systems are highly effective in reducing young driver crashes and the resulting injuries and fatalities. Most states have implemented GDL systems, although the specific provisions of GDL vary from state to state, and many are insufficient to provide the needed protection for young drivers as they develop from complete novice to moderately experienced driver. Simply having a GDL program in place, however, is not sufficient. It is important for GDL systems to include the most beneficial risk-reducing restrictions, such as the following:

- Enact a Graduated Licensing System (P, $);
- Require at least six months of supervised driving for beginners starting at age 16 (P, $);
- Implement a night driving restriction that begins at 9:00 p.m. (P, $);
- Implement a teenage passenger restriction allowing no young passengers (T, $); and
- Prohibit cell phone use by drivers with a GDL license (T, $).

Objective 2: Publicize and Enforce Laws Pertaining to Young Drivers

Strategies

Some laws pertain specifically to young drivers, such as "zero tolerance" for driving after drinking and laws governing novice driver licenses. To ensure effectiveness, these laws must be adequately enforced. Other laws that govern all drivers are particularly important for young drivers because of their lower inclination to comply (e.g., safety belt and speed laws). Strategies include:

- Publicize and enforce GDL restrictions (E, $$);
- Publicize and enforce laws pertaining to underage drinking and driving (P, $$$); and
- Publicize and enforce safety belt laws (P, $$).

Source: NCHRP 500 Volume 19: *A Guide for Reducing Collisions Involving Young Drivers*

Objective 3: Assist Parents/Adults in Managing Teen Driving

Strategies

Parents are inescapably involved in the licensing process of their children even though they may not recognize the extent of their potential influence. They supervise their teen's early driving experience, they determine the timing of licensure, they govern access to (and choice of) vehicles, and they may impose restrictions on driving privileges. In addition, they provide a highly salient model of driving behavior, whether consciously or not, which will affect their children's driving. Strategies include:

- Facilitate parental supervision of learners (T, $$$);
- Facilitate parental management of intermediate drivers (E, $$); and
- Encourage selection of safer vehicles for young drivers (T, $).

Objective 4: Improve Young Driver Training

Strategy

The model followed by current driver education programs in the United States was developed in the late 1940s. There is widespread belief that both what is taught and how it is taught can be improved significantly, with the promise that young driver crashes can be reduced as the result. Although there is no evidence indicating that formal driver education classes are effective in reducing subsequent crash rates among young drivers, a number of promising improvements that can be made in the training administered by states. The key strategy is:

- Improve content and delivery of driver education/training (E, $$$).

Objective 5: Employ School-Based Strategies

Strategies

Nearly all beginning drivers are in high school. This affords an opportunity to adopt strategies to reduce young driver crashes by implementing policies that take advantage of this natural grouping in both space and time to alter that environment. Recent developments in understanding human sleep needs indicate teenagers need more sleep than either younger children or adults, and they need to be asleep in the early morning hours. When transportation plans are developed for new or expanded schools, it is important to take into account that a high concentration of inexperienced teens will be driving in the vicinity of the high school. Strategies include:

- Eliminate early high school start times (e.g., before 8:30 a.m.) (T, $$); and
- Review transportation plans for new/expanded high school sites (E, $).

Best Practices

In recent years, a growing number of states have passed legislation prohibiting any cell phone use (either handheld or "hands-free") by drivers with a GDL license, such as Colorado, Connecticut, and Delaware. Some cities and states such as California, New York, New Jersey, Chicago, and the District of Columbia prohibit handheld cell phone use for all drivers.

In 1997, Connecticut began requiring learners to hold permits for at least six months (four months for those who completed formal driver education). Fatal/injury crashes decreased by 22 percent among 16-year-old drivers following the longer learner permit period (Ulmer et al., 2001).

Delaware has a 90-minute GDL orientation program for parents to learn about GDL and about teen driving issues: http://www.dmv.de.gov.

In North Carolina, the night restriction begins at 9:00 p.m. for teens with an intermediate license. After GDL was introduced, crashes between 9:00 p.m. and 5:00 a.m. decreased by 43 percent among 16-year-old drivers, whereas daytime crashes decreased by 20 percent

(Foss et al., 2001). Michigan's night restriction begins at midnight. Following GDL, there was a 24 percent reduction in 16-year-old driver crashes during the daytime (5:00 a.m.-8:59 p.m.), a nearly identical 21 percent reduction in crashes during the evening (9:00 p.m.-11:59 p.m.) and a 53 percent reduction in nighttime crashes (midnight-4:59 a.m.) (Shope et al., 2001).

The law enforcement community in Maine began the SAFEGuard program in 2005 to increase teen driver safety by partnering with parents. Police call the parents of teen drivers and their passengers following a traffic violation. Contact the Maine State Police at 207-624-7203 for more information or visit: http://www.themtsc.org/documents/Safeguardbrochure-FINAL.pdf.

The Raleigh, North Carolina Police Department has experimented with a program where parents receive a letter from the police department when their teen is found to violate GDL.

In Iowa, teen drivers are referred to a remedial driver improvement process if they receive a moving violation or are involved in a crash to which the driver contributed. Both the teen driver and a parent/guardian must participate in an interview with a DOT official who, based on the circumstances of the incident, may impose additional driving restrictions or recommend license suspension. At a minimum, the teen driver must maintain a crash- and violation-free driving period after the incident before qualifying for the next licensing level. The remedial driver improvement process in Iowa has not yet been formally evaluated (Stutz, 2007).

In North Carolina, multiteen-occupant crashes declined by 30 percent among 16-year-old drivers and by 13 percent among 17-year-old drivers following enactment of a restriction that limited intermediate-level drivers to carrying a single young passenger (Foss et al., 2006).

Resources

NCHRP Report 500: *A Guide for Addressing Collisions Involving Young Drivers:* http://safety.transportation.org/guides.aspx.

A list of young driver licensing requirements for all 50 states is maintained by the Insurance Institute for Highway Safety: http://www.iihs.org/laws/state_laws/grad_license.html.

National evaluation of GDL: http://www.nhtsa.dot.gov/people/injury/NewDriver/GDLReport/index.html.

NHTSA (2007) *Traffic Safety Facts: Young Drivers.* DOT HS 811 001: http://www-nrd.nhtsa.dot.gov/Pubs/811001.PDF.

"Novice Driver's Road Map" from the Network of Employers for Traffic Safety: http://trafficsafety.org/shop/novice-drivers-road-map.

"Family Guide to Teen Driver Safety" from the National Safety Council: http://shop.nsc.org/Family-Guide-to-Teen-Driver-Safety-P2049.aspx.

NHTSA (2005) *Increasing teen safety belt use: A program and literature review.* Report No. DOT 809 899: http://www.nhtsa.dot.gov/people/injury/NewDriver/TeenBeltUse/index.htm.

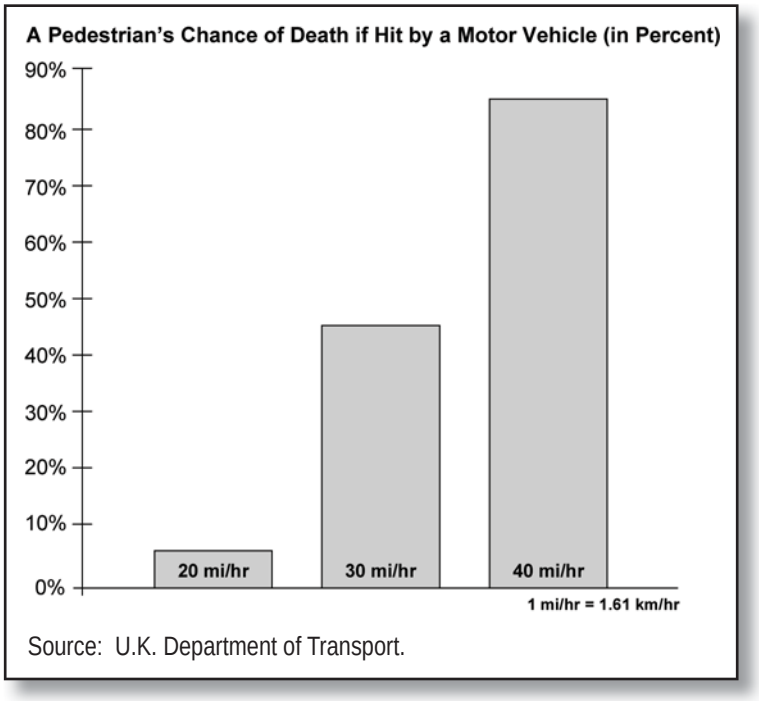
Pedestrian Collisions

Problem Description

Walking is a basic human activity, and almost everyone is a pedestrian at one time or another. The AASHTO Green Book (2001) states that "pedestrians are a part of every roadway environment and attention should be paid to their presence in rural as well as urban areas." An additional consideration for the provision of pedestrian facilities is that when people are walking in a safe environment or accessing transit versus using an automobile for transportation their exposure in a vehicle is reduced.

A portion of almost every trip includes walking, and there are specific groups that do not or cannot drive and depend on walking for transportation, including children, the elderly, the disabled, and low-income populations. Whether building new infrastructure or renovating existing facilities, walking is a form of transportation and all plans should accommodate pedestrians.

EXHIBIT III-6
A Pedestrian's Chance of Death Based on Speed of Vehicle



Source: U.K. Department of Transport.

Several factors must be examined when trying to determine how and why pedestrian injuries and fatalities occur. While driver behavior is often a significant factor in the severity of crashes involving pedestrians, pedestrian behavior influences the likelihood of a crash. Alcohol involvement and speed are factors that negatively impact all crashes, especially those involving pedestrians.

The location of crashes involving pedestrians also must be studied when trying to reduce crashes. Pedestrian crashes occur most often in urban areas where the volume of both pedestrian and vehicle traffic is high and the large number of intersections presents opportunities for conflict. Rural areas also can be dangerous for pedestrians, as many rural areas do not have sidewalks, paths, designated crosswalks, or shoulders to serve as pedestrian facilities. In addition, lighting is often not adequate. Time of day also should be considered in reducing crashes involving pedestrians. FHWA has found pedestrian fatalities are most prevalent during nighttime hours, with 62 percent of fatalities occurring between 6 p.m. and 6 a.m.[7]

[7] FHWA, http://www.tfhrc.gov/safety/pedbike/pubs/03042/part2.htm,.

Approximately three-quarters of pedestrian fatalities occur at nonintersection locations, and one-quarter of pedestrian fatalities occur at intersections (Traffic Safety Facts 2008, NHTSA). Some of the more common nonintersection crashes are referred to as midblock crashes. Midblock crashes include those where the pedestrian walked or ran into the roadway and was struck by a vehicle. The motorist's view of the pedestrian may have been blocked until an instant before the impact, and/or the motorist may have been speeding. Pedestrians also may be struck when getting in or out of a stopped vehicle, or while crossing the road to/ from a mailbox, newspaper box, or ice cream truck, etc. At intersections, pedestrians may be struck by a vehicle traveling straight through the intersection or while the vehicle is turning right or left.

Safe Routes To School (SRTS) is an initiative to enable and encourage students and parents to walk and bicycle to school; to make walking and bicycling to school safe and more appealing; and to facilitate the planning, development, and implementation of projects that improve safety and health and reduce traffic, fuel consumption, and air pollution in the vicinity of schools.

This program is funded through SAFETEA LU, and every state receives funding to implement SRTS programs.

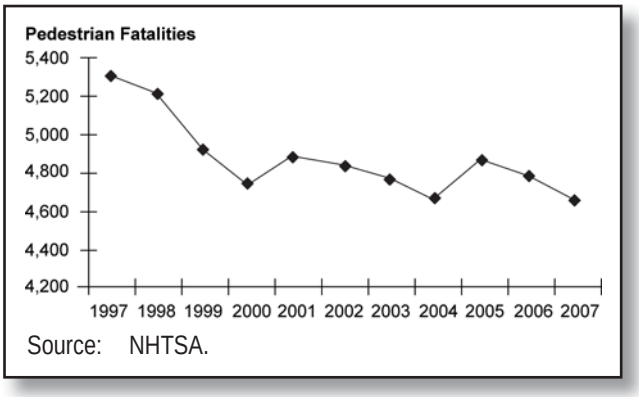
Both land use and transportation planners have strong qualifications to improve safety for pedestrians. Planners understand the origins and destinations of trips in their communities or regions and know where heavy pedestrian activity occurs. They also hear from the public about locations with safety concerns. As more communities pursue mixed-use zoning to encourage walkability, create vibrant business districts, and manage traffic congestion, emphasis on pedestrian safety will continue to increase.

Data

The percentage of journey-to-work trips on foot estimated in the 2000 Census is 2.9 percent, a decrease from the 1990 estimate of 3.9 percent. While the U.S. DOT's National Biking and Walking Study's goal was to increase the percentage of trips made by walking, the percentage has been decreasing. This may partly be due to land use patterns and lack of pedestrian facilities.

In 2007, 4,654 pedestrians were killed in traffic crashes in the Unites States – a decrease of 13 percent from the 5,321 pedestrians killed in 1997. Seventy thousand pedestrians were injured in traffic crashes in 2007. The number of conflicts and fatalities remains high in many urban areas and for specific segments of the population. One-fifth of the children between the ages of five and nine killed in traffic crashes were pedestrians.

Exhibit III-7
Pedestrian Fatalities by Year 1997-2007



Source: NHTSA.

Objective 1: Reduce Pedestrian Exposure to Traffic

Strategies

Sidewalks and walkways provide people with space to travel within the public right-of-way separated from vehicles on the roadway. Pedestrian signals provide gaps in traffic long enough for pedestrians to safely cross the roadway. Other measures to reduce exposure are separation of pedestrian and roadway crossings and reduction of vehicle traffic in areas with high pedestrian use. Strategies include:

EXHIBIT III-8
Walkways Should be Part of Every New and Renovated Roadway

Source: Dan Burden.

- Develop comprehensive pedestrian system plans (T, $);
- Provide sidewalks/walkways and curb ramps as part of every new and renovated roadway, and make every effort to retrofit streets that currently lack sidewalks (P, $$$);
- Install or upgrade traffic and pedestrian signals (P, T, & E, $$$);
- Construct pedestrian refuge islands and raised medians that allow pedestrians a safe place to wait if they cannot cross all lanes of the roadway at once (P, $$$);
- Provide vehicle restriction/diversion measures to limit auto through traffic by preventing certain turning movements or blocking access to certain streets (P & T, $$$);
- Install overpasses and underpasses for pedestrians over and under busy roadways or rail tracks when appropriate; these may not be appropriate for certain communities because they are perceived as unsafe due to the potential of crime (P, $$$$); and
- Provide school route improvements, such as sidewalks, bicycle routes, and trained crossing guards (T, $).

EXHIBIT III-9
It Is Sometimes Useful to Supplement Crosswalk Markings with Motorist Warning Signs

Source: Michael Ronkin.

Objective 2: Improve Sight Distance and Visibility for Motor Vehicles and Pedestrians

Strategies

The intent of marked crosswalks is to indicate the optimal locations for pedestrians to cross. Crosswalks help designate the right-of-way and may encourage motorists to yield to pedestrians. Acceptable crosswalk marking patterns are given in the Manual on Uniform Traffic Control Devices (MUTCD). Marked crossings are encouraged in areas of high pedestrian traffic and may be combined with other roadway enhancements, such as warning signs or flashing warning lights. Countermeasures include:

EXHIBIT III-10
Install Raised Median at Crosswalks

Total Pedestrian Crashes (All Severities)	Crash Modification Factor
Marked Crosswalks	0.54
Unmarked Crosswalks	0.61
Applicable to urban and suburban multilane roads (up to 8 lanes) with traffic volumes greater than 15,000 vpd	

- Provide crosswalk enhancements, such as bright pavement markings and motorist warning signs (P, $);
- Implement lighting and crosswalk illumination measures, such as continuous streetlights in pedestrian areas and lighting of approaches to crosswalks (P, $$$);
- Eliminate screening by physical objects by ensuring that, particularly on arterials and higher-speed facilities, drivers' sight distance to crossing pedestrians is adequate with strategies, such as restricting parking in advance of a crosswalk and preventing vehicles from yielding too close to the crosswalk (T, $$); and
- Provide signals to alert motorists that pedestrians are crossing, such as pedestrian-activated yellow beacons and in-pavement lighted markers at uncontrolled crossings (T, $$).

Objective 3: Reduce Motor Vehicle Speed

Strategies

Continued growth and decentralization throughout the United States have increased the volume of vehicles on streets and highways. Traffic calming measures to reduce vehicle speed are generally of two types: 1) those requiring motorists to change their direction of travel; or 2) those requiring motorists to change elevation. When considering traffic calming measures or context-sensitive solutions, planners must balance the needs of pedestrians, bicyclists, motorcyclists, and emergency transit vehicles with vehicle throughput needs for a specific type of street and area. Safety concerns must be addressed and balanced in narrowing roads, permitting on street parking, and potentially restricting access of emergency vehicles before decisions are made.

- Implement road narrowing measures, such as reducing lane widths and using excess pavement for bicycle lanes or shoulders, extending sidewalks and landscaped areas, and adding on-street parking (T, $$);

EXHIBIT III-11
Chicane

Source: Dan Burden.

A Chicane consists of alternatively placed curb extensions into the street that creates a horizontal shift in traffic and reduces vehicle speeds.

- Install traffic calming on road sections, such as speed humps, serpentine street design, alternatively placed curb extensions in the street causing a horizontal shift in traffic, or a choker with two curb extensions on opposite sides of the street narrowing the street (P, $$); and
- Install traffic-calming at intersections, including extending curbs to reduce the pedestrian crossing distance and raised circular islands in the center of residential intersections (P, $$).

Objective 4: Improve Pedestrian and Motorist Safety Awareness and Behavior

Strategies

Strategies that may be effective in improving pedestrian, motorist, and motorcyclist safety awareness and behavior include providing education, outreach, training, and enforcement. A combination of enforcement and public information and education (PI&E) campaigns can effectively increase driver awareness of the obligation to share the roadway with pedestrians and bicyclists. Police enforcement of the traffic code is the most potent means of giving credibility to traffic control devices and traffic safety educational programs (P, $$).

Best Practices

City of Edgewood, Washington guidance on crossing islands:
http://www.ci.edgewood.wa.us/Police/safe%20journey/library/matrix.htm.

City of Los Altos Neighborhood Traffic Management Program:
http://www.ci.los-altos.ca.us/commdev/engineering/ntmp.html.

Resources

FHWA Safety Office web site on pedestrian safety includes a Toolbox of Countermeasures, Pedestrian Safety Guide for Transit Agencies, and other materials:
http://safety.fhwa.dot.gov/PED_BIKE/ped/index.htm.

NCHRP Report 500, Volume 10: *A Guide for Reducing Collisions Involving Pedestrians:*
http://safety.transportation.org/guides.aspx.

Pedestrian and Bicycle Information Center, including design and engineering guidance:
http://www.walkinginfo.org/.

National Safe Routes to School Clearinghouse: http://www.saferoutesinfo.org.

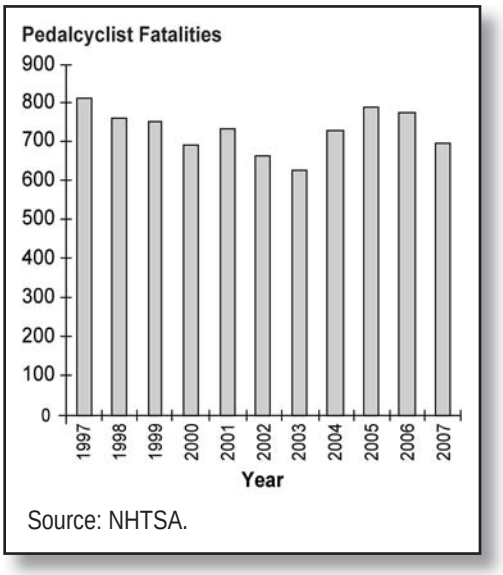
Institute of Transportation Engineers web site on traffic calming measures:
http://www.ite.org/traffic/index.html.

Project for Public Spaces, Traffic Calming 101:
http://www.pps.org/imagedb/category?gallery_id=837.

Bicycle Collisions

Problem Description

EXHIBIT III-12
Pedalcyclist Fatalities, 1997-2007



Source: NHTSA.

Bicyclists are recognized as legitimate roadway users. The FHWA bicycle program provides guidance on numerous issues that include examples of statutory language emphasizing bicyclists as users of the transportation system and concludes bicyclists "should be included as a matter of routine" in the planning, design, and operation of transportation facilities (FHWA, 1999).

The safety interests of bicyclists are sometimes in conflict with the interests of motorists given the substantially different characteristics of the two modes of transportation. Although bicycles can be ridden on most types of roads, the design interests of accommodating higher motor vehicle traffic volumes and speeds during peak-hour congestion may create situations that are less safe for bicyclists. This section includes road treatments, countermeasures, and other options that support multiple users of the transportation system.

Data

- In 2007, 698 pedalcyclists[8] were killed and 43,000 were injured nationwide in traffic crashes.
- In 2007, pedalcyclists under age 16 accounted for 15 percent of all cyclists killed and 29 percent of those injured in traffic crashes, which represents a decline from 1997 when the share was 31 percent of those killed and 44 percent of those injured.
- The proportion of fatalities among adults ages 25 and up has been increasing, from 46 percent of all cyclist fatalities in 1997 to 64 percent in 2007.
- Most of the pedalcyclists killed in 2007 were males (88 percent).
- Alcohol involvement – either for the driver or the pedalcyclist – was reported in more than one-third of the crashes resulting in pedalcyclist fatalities in 2007.
- In 2007, 26 percent of pedalcyclist fatalities occurred between the hours of 5:00 p.m. and 9:00 p.m.
- Nearly three-quarters (72 percent) of bicycle fatalities occurred in urban areas, reflecting the greater populations and more frequent riding that typically occur in urban areas.

[8] Includes bicyclists and other cyclists riding two-wheel nonmotorized vehicles, tricycles, and unicycles powered solely by pedals. Data includes crashes involving motor vehicles on public roads only.

- Nearly two thirds (64 percent) of pedalcyclist fatalities occurred at nonintersection locations in 2007.
- The types of crashes that are most severe are parallel path, rather than crossing path, crashes. Crossing path crashes occur at junctions (intersections or driveways) and more often in urbanized areas where speeds are often slower.

Objective 1: Reduce Bicycle Crashes at Intersections

Strategies

A variety of strategies can be undertaken to reduce the number and severity of intersection crashes involving bicycles, including increasing intersection visibility, signage, pavement markings, and altering vehicle movements. Strategies include:

- Improve visibility at intersections by improving the sight distance/sight lines near the intersection and/or by improving the conspicuity of traffic control devices at and near intersections (T, $$$);
- Improve signal timing for bicycles and detection of bicycles at actuated signals (T, $$);
- Improve signing such as those indicating when vehicles must yield to bikes and intersection warning signs (T, $);
- Improve pavement markings at intersections (T, $$);
- Improve intersection geometry (T, $$$);
- Restrict right turn on red (RTOR) movements (E, $);
- Accommodate bicyclists through roundabouts, which can be difficult for bicyclists to navigate (T, $$); and
- Provide an overpass or underpass for bicycles (T, $$$$).

EXHIBIT III-13
Intersection Realignment

CMF = exp (0.0040 SKEW) For three-legged intersections

and

CMF = exp (0.0054 SKEW) For four-legged intersections

where:

CMF = Crash modification factor

SKEW = Intersection skew angle (degrees), expressed as the absolute value of the difference between 90 degrees and the actual intersection angle.

Multiplying the CMF by the proportion of bicycle/motor vehicle accidents at an intersection would give an indication of the expected number of bicycle/motor vehicle accidents that would be reduced due to this treatment.

Note: Research conducted at unsignalized intersections on rural two-lane highways.

Source: Harwood et al., 2000.

Objective 2: Reduce Bicycle Crashes along Roadways

Strategies

Roadway facilities that better identify appropriate travel areas for all road users and their expected behavior may provide a safer environment for bicyclists traveling along parallel paths and help reduce crashes. Strategies include:

- Provide safe roadway facilities for parallel travel, such as striped bicycle lanes and shared lane markings (T, $$);

- Provide contraflow bicycle lanes, which establishes a two-way street for bicyclists on a street that only allows one-way motor vehicle traffic (T, $$$);
- Improve bicyclists' visibility via lighting (T, $$$);
- Improve roadway signage, e.g., designate bike routes, indicate shared roadways, prohibit parking in bike lanes, and indicate when to yield in compliance with the latest version MUTCD and AASHTO Bicycle Guide (T, $); and
- Provide bicycle-tolerable rumble strips, which decrease the level of vibration experienced by bicyclists (T, $$).

EXHIBIT III-14
Chevron Shared Lane Marking in San Francisco

Source: Deirdre Weinberg, San Francisco Metropolitan Transportation Agency, 2004.

Objective 3: Reduce Bicycle Crashes at Midblock Locations

Strategies

Midblock bicycle crashes most often occur at major driveways. Reducing the speed of vehicles and the number of driveways mitigates this risk. Strategies include:

- Improve driveway intersections, such as using tighter turn radii to slow vehicles and skip striping of bicycle lanes to alert riders that vehicles may turn into the driveway (T, $$$); and
- Implement access management strategies (e.g., limit the number of driveways and allow right-in and right-out only movements (T, $$$). See the section on Unsignalized Intersections for more information about access management.

Objective 4: Improve Safety Awareness and Behavior of Bicyclists

Strategies

Safety behavior and awareness are major factors in many bicycle crashes. Strategies include:

- Provide bicyclist education (T, $); and
- Improve enforcement of bicycle-related laws, such as helmet laws (T, $$).

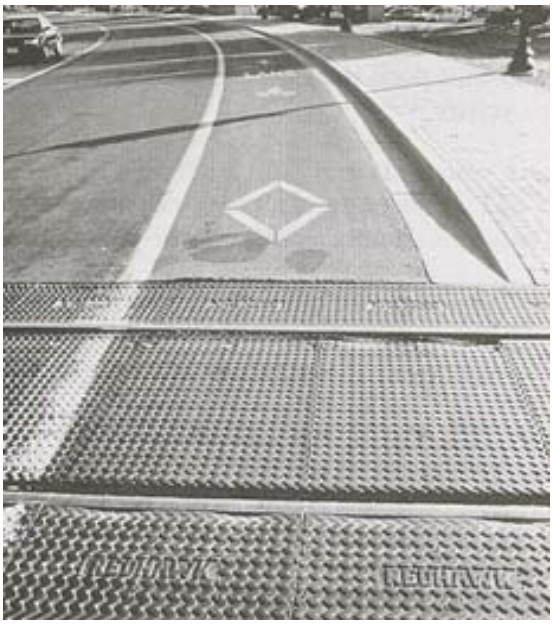
Objective 5: Increase Use of Bicycle Safety Equipment

Strategies

While wearing a helmet will not prevent a crash, studies have shown that riders wearing helmets are 70 to 88 percent less likely to suffer serious head injuries or fatalities in a bicycle crash than unhelmeted riders. Additionally, other devices and clothing that increase visibility can help prevent a crash. Strategies are:

- Increase use of bicycle helmets via education and legislation (P, $$); and
- Increase rider and bicycle visibility via use of front white lights and rear red reflectors and wearing of retroreflective clothing (T, $).

EXHIBIT III-15
Rubberized Railroad Crossing to Improve Bicycle Safety



Source: Clarke and Tracy, 1995.

Objective 6: Reduce Effect of Hazards

Strategies

Surface quality directly impacts the safety of bicyclists. A pothole that an automobile would hardly notice can have a large impact on a bicycle rider's control and safety. Strategies include:

- Fix or remove surface irregularities, such as railroad crossings, drainage grates, potholes, and utility covers (T, $$); and
- Provide routine maintenance of bicycle facilities, including patching roads to a high standard, clearing sand and debris to the right edge of the road, and maintaining pavement markings and signs (T, $$).

Best Practices

State and local design or planning guidelines on bicycling safety: http://www.bicyclinginfo.org/engineering/.

Portland, Oregon's Bicycle Design and Engineering Guidelines: http://www.portlandonline.com/transportation/index.cfm?c=47426&.

Oregon DOT Bicycle and Pedestrian Program: http://www.oregon.gov/ODOT/HWY/BIKEPED/planproc.shtml.

San Francisco Bay Area Metropolitan Transportation Commission's Bicycle and Pedestrian Safety Toolbox: http://www.mtc.ca.gov/planning/bicyclespedestrians/.

Wisconsin Bicycle Facility Design Handbook: http://www.dot.wisconsin.gov/projects/state/docs/bike-facility.pdf.

The "Bicycle Safety Education Resource Center," developed by FHWA and hosted by PBIC at www.bicyclinginfo.org includes a database with hundreds of case studies, examples, and recommended education messages and practices for all age groups.

The FHWA's Pedestrian and Bicycling Safety website contains a variety of resources: http://safety.fhwa.dot.gov/ped_bike/.

The two-day NHTSA course "Community Bicycle Safety for Law Enforcement" provides guidance to officers interested in working with their communities to encourage bicycling and improve bicycle safety, with a focus on assessing safety needs and promoting bicycle safety programming: http://www.bicyclinginfo.org/enforcement/training.cfm.

NHTSA resource guide on laws related to pedestrian and bicycle safety: http://www.nhtsa.gov/people/injury/pedbimot/bike/resourceguide/index.html.

Resources

NCHRP Report 500: *A Guide for Addressing Collisions Involving Bicycles,* at http://safety.transportation.org/guides.aspx.

National Strategies for Advancing Bicycle Safety includes goals, strategies, and short- and long-term actions that can be taken to reduce injury and mortality associated with bicycle-related incidents: http://www.nhtsa.dot.gov/people/injury/pedbimot/bike/bicycle_safety/.

"BikeSafe" software package developed by The Pedestrian and Bicycle Information Center (PBIC) and FHWA provides guidance on improvement measures and matching countermeasures to precipitating causes, as well as a catalogue of more than 70 case studies: http://www.bicyclinginfo.org/bikesafe.

PBIC hosts "BikeCost," a benefit-cost estimation tool for bicycle-related infrastructure construction and maintenance: http://www.bicyclinginfo.org/bikecost.

National Bicycling and Walking Study: Ten Year Status Report, October 2004, FHWA: http://www.fhwa.dot.gov/environment/bikeped/study/index.htm.

Safe Routes to School programs are comprehensive programs that involve making safety-related changes to the built environment, implementing extensive child bicyclist (and pedestrian) safety education, and increasing traffic law enforcement around schools. Safe Routes to School On-Line Guide: http://www.saferoutesinfo.org/guide/.

Manual on Uniform Traffic Control Devices for Streets and Highways, 2003, FHWA: http://mutcd.fhwa.dot.gov/.

FHWA resource site about rumble strips: http://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips/.

U.S. Department of Transportation and Federal Highway Administration *Course on Bicycle and Pedestrian Transportation:* http://safety.fhwa.dot.gov/ped_bike/univcourse/swtoc.htm.

American Association of State Highway and Transportation Officials (AASHTO) *Guide for the Development of Bicycle Facilities.* Washington, D.C., 1999.

Nabti, J.M., and M.D. Ridgway. *Innovative Bicycle Treatments: An Informational Report of the Institute of Transportation Engineers (ITE) and the ITE Pedestrian and Bicycle Council.* Institute of Transportation Engineers, 2002.

As of February 2009, there were 22 state laws (including the District of Columbia) requiring minors to wear helmets while bicycling, and at least another 192 local ordinances, some of which cover bicyclists of all ages. For a comprehensive, state-by-state review on bicycle laws in the United States, visit http://www.helmets.org/mandator.htm.

The Bicycle Helmet Safety Institute study on the effect of bicycle helmet legislation on bicycling fatalities: http://www.helmets.org/leggrant.htm.

League of American Bicyclists guidance on use of lights: http://www.bikeleague.org/resources/better/advancedcycling.php.

Aggressive Driving

Problem Description

"Aggressive driving" is operating a motor vehicle in a selfish, pushy, or impatient manner, often unsafely, that directly affects other drivers. Traffic safety experts suggest that the following elements constitute aggressive driving:

- Driving or attempting to drive at a speed different than the prevailing speed and doing any of the following:
  - Maneuvering to cause other drivers to react or take evasive action;
  - Flashing headlights or blowing the horn;
  - Following others too closely;
  - Preventing faster drivers from passing;
  - Directing verbal or nonverbal expressions of anger toward other drivers designed to encourage retaliation on the part of other drivers;
  - Deliberately ignoring traffic controls, especially by increasing speed or failing to slow for the controls; and
  - Driving in a way that attempts to gain an advantage over other drivers (e.g., appearing to be taking an unfair advantage or breaking notions of equity, such as violating ramp meters and driving on the shoulder).

One important contributor to aggressive driving is frustration, which has been found to lead to aggression in other situations. The assumption is that drivers, when exposed to congestion and other frustrating situations, will experience increasing levels of aggression. This concept is important because addressing driver behavior may not be effective unless external frustration-causing elements also are addressed.

One approach to reducing aggression is use of variable message signs to inform drivers about travel-time reliability. These signs can help reduce the uncertainty about how long it will take to reach their destination.

Most driver-focused strategies to date have addressed aggressive driving through specific traffic-enforcement programs. Some agencies have reported program successes measured by a reduction in crashes. With few exceptions, programs reporting success also have applied intensive traffic law enforcement aimed at all traffic violations. While these programs can be effective, the duration of most programs is limited because most police agencies do not have the resources for long-term maintenance. These strategies, combining

education, enforcement, and engineering, will be most successful in combination; they will likely not have the desired impact if used independently.

Data

- According to a NHTSA survey about aggressive driving attitudes and behaviors, more than 60 percent of drivers see unsafe driving by others, including speeding, as a major personal threat to themselves and their families.
- More than one-half of people in a NHTSA survey admitted to driving aggressively on occasion.

Objective 1: Deter Aggressive Driving by Specific Populations, including those with a History of Such Behavior, and at Specific Locations

Strategies

Enforcement at problem locations targeting specific aggressive driving actions may help demonstrate aggressive behavior will not be tolerated. In this way, enforcement agencies may be able to target repeat offenders and gain an understanding of what conditions at a location cause such behavior.

- Conduct highly visible and intense enforcement complemented by a publicity campaign and targeted in locations identified as having a problem with aggressive driving (T, $) that is.
- Conduct education and public information campaigns to help newer drivers (T, $$):
  - Learn to cope with situations where other drivers are displaying aggressive driving behaviors; and
  - Recognize and modify their own tendencies toward aggressive driving.
- Educate and impose sanctions against repeat offenders (E, $) by:
  - Identifying drivers with frequent crashes and citations resulting from aggressive driving;
  - Conducting courses using structured curricula designed to counter specific driving behaviors and teach anger management; and
  - Instituting driver sanctions, including license suspension or revocation, or vehicle impoundment, especially for repeat offenders with serious offenses.

Objective 2: Improve the Driving Environment to Eliminate or Minimize Aggressive Driving "Triggers"

Strategies

Operational changes in the roadway system that reduce congestion and facilitate good driving conditions would theoretically help mitigate driver frustration and minimize

aggressive driving triggers. ITS strategies can be used to provide accurate and timely traffic information about incidents or congestion and alternative route choices. These strategies have not been tested, however, and planners are encouraged to conduct a pilot before proceeding on any significant scale. Strategies include:

- Change or mitigate effects of identified elements in the driving environment (E, $$$), such as the following:
  - Uncoordinated signals or sequencing that encourages speeding and red-light running (the FHWA estimates that 75 percent of all signals need modernization, including signal coordination);
  - Lack of signal optimization, encouraging red-light running, especially for turning movements;
  - Lack of adequate turn bays or acceleration or deceleration lanes, encouraging shoulder or median driving;
  - Lack of adequate entrance ramps, encouraging improper merging;
  - Speed limits not representative of road design and external factors that encourage their disregard; and
  - Ineffective or undesirable traffic control in work zones.
- Reduce nonrecurring delays and provide better information about these delays through ITS strategies (E, $$$), such as the following:
  - Incident management systems that help to clear incidents more quickly; and
  - Variable message signs (VMS) to warn drivers of incidents ahead and allow them to modify their route.

See Exhibit III-4 for Crash Modification Factors for signal change interval modification.

Best Practices

Washington State Patrol Aggressive Driver Apprehension Team: http://safety.transportation.org/htmlguides/site_map/default.htm.

North Central Texas Council of Governments (NCTCOG) Freeway Incident Management Course: http://www.nctcog.org/trans/safety/FIM.asp.

Resources

NCHRP Report 500 Volume 1: *A Guide for Addressing Aggressive-Driving Collisions:* http://safety.transportation.org/guides.aspx.

Countermeasures That Work: A Highway Safety Countermeasures Guide for State Highway Safety Offices, Chapter 3 – Aggressive Driving and Speeding: http://www.ghsa.org/html/publications/index.html#countermeasures.

Intelligent Transportation Systems 2005 Update: Benefits, Cost, and Lessons Learned: http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/14073_files/14073.pdf.

ITE A Toolbox for Alleviating Traffic Congestion and Enhancing Mobility, 1997: http://drusilla.hsrc.unc.edu/cms/downloads/Toolbox_AlleviateCongestion1997.pdf.

NHI incident management course: http://ops.fhwa.dot.gov/incidentmgmt/training.htm.

FHWA Office of Operations: http://ops.fhwa.dot.gov/siteindex.htm.

Speeding

Problem Description

Excessive or inappropriate speeds result from two basic problems, both of which involve human factors. Driver behavior, i.e., choosing a clearly inappropriate speed, is one aspect of the problem. The second is associated with driver response to the environment. For example, inadvertent selection of a speed that is inappropriate or unsafe, failure to adjust or change speeds, or failure to perceive the speed environment can result in a collision.

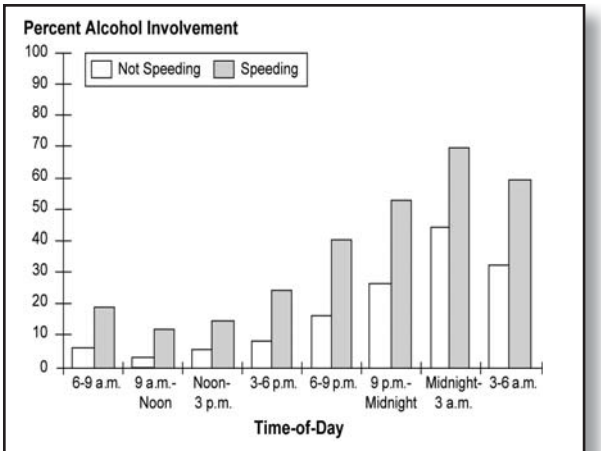
See section on Aggressive Driving for additional discussion relevant to speeding.

NHTSA defines a speeding-related crash as one in which "the driver was charged with a speeding-related offense or if an officer indicated that racing, driving too fast for conditions, or exceeding the posted speed limit was a contributing factor in the crash." Approximately one-third of all fatal traffic crashes involve speeding. Excessive speed reduces a driver's ability to react and maneuver and requires a greater stopping distance. The severity of a collision increases dramatically with its speed. Alcohol use is common with speeding violations. Additionally speeding occurs more commonly during nighttime hours, as shown in Exhibit III-16.

Data

- In 2007, 32 percent of traffic fatalities involved speeding.
- In 2007, approximately 10 percent of all traffic fatalities and 31 percent of all speeding-related fatalities occurred on low-speed roadways. These roads are defined as those with a speed limit of 40 mph or less.
- High-speed roadways (with speed limits of 45 mph or more) accounted for 66 percent of speeding-related fatalities (21 percent of all fatalities).
- Of speeding-related fatal crashes, 41 percent occurred in urban areas and 57 percent in rural areas.
- Sixty-seven percent of speeding-related fatalities occurred on two-way, undivided roadways. Of

EXHIBIT III-16
Intoxicated and Speeding Drivers in Fatal Collisions by Time of Day (2007)



Source: Traffic Safety Facts 2007- Speeding, NHTSA.

these crashes, the predominant first harmful event in the crash was collision with a fixed object (34 percent of all speeding-related fatalities).

- Approximately 42 percent of speeding-related fatal crashes occurred on horizontal curves.
- Speeding-related fatalities occur primarily in single-vehicle crashes; 70 percent of speeding-related fatalities on low-speed roads and 65 percent on high-speed roads were single-vehicle crashes.
- Thirty-eight percent of speeding drivers in fatal crashes were under the age of 25.

Objective 1: Set Appropriate Speed Limits

Strategies

Setting speed limits consistent with the roadway environment can help improve driver respect for speed limits. Speed limits that appear inconsistent may sometimes be ignored by drivers, contributing to a lack of respect for speed limits and other traffic laws. Strategies include:

- Set reasonable and prudent speed limits that account for roadway design, traffic, and environment (T, $);
- Implement variable speed limits that depend on weather, lighting, work zone, school zone, and traffic conditions (T, $); and
- Implement differential speed limits for heavy vehicles if appropriate (high speed only) (T, $).

For data on the relationship of auto speed to pedestrian fatalities, see Exhibit III-6.

Objective 2: Heighten Driver Awareness of Speeding-Related Safety Issues

Strategies

Informing drivers of the risks – both to themselves and to other road users – associated with speeding is intended to encourage drivers to obey speed limits and drive at speeds safe for the roadway environment. Strategies include:

- Increase public awareness of risks of driving at unsafe speeds (T, $$);
- Increase public awareness of potential penalties for speeding (T, $);
- Increase public awareness of risks of not wearing safety belts (T, $);
- Implement neighborhood speed watch/traffic management programs (low speed only) (T, $); and
- Implement Safe Community Programs (low speed only) (T, $$).

Objective 3: Improve Efficiency and Effectiveness of Speed Enforcement Efforts

Strategies

Many crashes are caused or aggravated by drivers' noncompliance with traffic control devices or traffic laws. Effectiveness of enforcement can be increased if drivers perceive there is a significant chance they will be cited for speeding and given a hefty fine. Visible conventional or automated enforcement programs, increased fines for repeat offenders, and upholding of citations and levying of fines by courts can increase drivers' awareness of the enforcement-related risks of speeding. Strategies include:

- Use targeted conventional speed enforcement programs at locations known to have speeding-related crashes (P, $$);
- Implement automated speed enforcement (T, $$);
- Increase penalties for repeat and excessive speeding offenders (T, $);
- Strengthen the adjudication of speeding citations to enhance the deterrent effect of fines (T, $); and
- Increase fines in special areas (low speed only) (T, $).

Objective 4: Communicate Appropriate Speeds through Use of Traffic Control Devices

Strategies

Speed information, including permanent speed limits, variable speed limits, and warning speeds, needs to be conveyed clearly to drivers at appropriate locations. Pavement markings can encourage drivers to proceed at appropriate speeds without actually posting the speed limit. Even though drivers have the responsibility to drive at a safe speed, they need to receive information from the roadway environment on what that safe speed is. Strategies include:

- Improve speed limit signage (T, $);
- Implement active speed warning signs (including truck rollover warnings) at high-risk locations where excessive speeds and potential conflicts are expected (T, $);
- Use in-pavement measures to communicate the need to reduce speeds (T, $$); and
- Implement variable message signs to display information on appropriate speeds for current conditions, as well as technologies to monitor conditions (high speed only) (T, $).

Objective 5: Ensure Roadway Design and Traffic Control Elements Support Appropriate and Safe Speeds

Strategies

Roadway sections, intersection geometric design features, and traffic signal operations need to reflect desired speeds. Geometric elements that affect operating speeds, such as horizontal and vertical curves, can be designed in combination to encourage appropriate speeds. Intersections should be designed in a way that is appropriate for the context of the roadway. Providing proper signal coordination through intersections along a corridor can create uniform speeds and reduce the need for drivers to stop at the intersections. Strategies include:

- Use combinations of geometric elements to control speeds (horizontal and vertical curves, cross section), including design consistency along an alignment (T, $$$$);
- Effect safe speed transitions through design elements and on approaches to lower speed areas (T, $$$$);
- Provide appropriate intersection design for speed of roadway (T, $$$);
- Provide adequate change and clearance intervals at signalized intersections (P, $);
- Operate traffic signals appropriately for intersections and corridors (signal progression) (T, $);
- Provide adequate sight distance for expected speeds (high speed only) (P, $$$);
- Implement protected-only signal phasing for left turns at high-speed signalized intersections (T, $$$);
- Install lighting at high-speed intersections (T, $$); and
- Reduce speeds and/or volumes on both neighborhood and downtown streets with the use of traffic calming and other related countermeasures (low speed only) (T, $$$).

For Crash Modification Factors for signal change intervals, see Exhibit III-4.

For additional traffic calming strategies, see section on Pedestrians.

See sections on Signalized and Unsignalized Intersections for additional information on intersections.

Best Practices

The Smooth Operator Program in the Washington, D.C. metropolitan area brought multiple agencies together to educate motorists of the risks involved with speeding and aggressive driving, and to stigmatize this behavior on the region's roads: http://www.smoothoperatorprogram.com/about.html.

Neighborhood Speed Watch Program examples include:

- Seattle: http://www.seattle.gov/transportation/speedwatch.htm.
- Salt Lake City: http://www.ci.slc.ut.us/transportation/TrafficManagement/speedwatch.htm.

Neighborhood Traffic Management Program (NTMP) examples include:

- Albuquerque, New Mexico: http://www.cabq.gov/streets/ntmp.html.
- Middleton, Wisconsin: http://www.ci.middleton.wi.us/City/Departments/works/Engineering/NTMP%20Report.pdf

Automated speed enforcement combines radar with cameras to photograph speeding vehicles and issue tickets. About 75 countries rely on cameras to enforce speed limits, which reduce high travel speed and crashes, according to the Insurance Institute for Highway Safety (IIHS). In some countries, automated enforcement generates the majority of the speeding citations. Automated speed enforcement technology is beginning to be used more widely in U.S. communities. One example is the Montgomery County, Maryland program: http://www.montgomerycountymd.gov/poltmpl.asp?url=/content/pol/ask/speed.asp.

Resources

NCHRP Report 500: *A Guide for Reducing Speeding-Related Crashes:* http://safety.transportation.org/guides.aspx.

NHTSA on-line table of penalties and state laws for speeding violations: http://www.nhtsa.dot.gov/PEOPLE/INJURY/enforce/speedlaws501/summary_table.htm.

NHTSA April 2006 Summary of State Speed Laws, DOT HS810572 http://www.nhtsa.dot.gov/people/injury/enforce/Summary_StateSpeedLaws.pdf.

NHTSA guidelines for developing a municipal speed enforcement program: http://www.nhtsa.dot.gov/people/outreach/safesobr/12qp/guidelines.html.

NHTSA National Survey of Speeding and Other Unsafe Driving Actions, Volume III: Countermeasures: http://www.nhtsa.dot.gov/people/injury/aggressive/unsafe/counter/Chapt2.html.

Insurance Institute for Highway Safety status of automated enforcement laws: http://www.iihs.org/laws/automated_enforcement.aspx.

Unlicensed Drivers

Problem Description

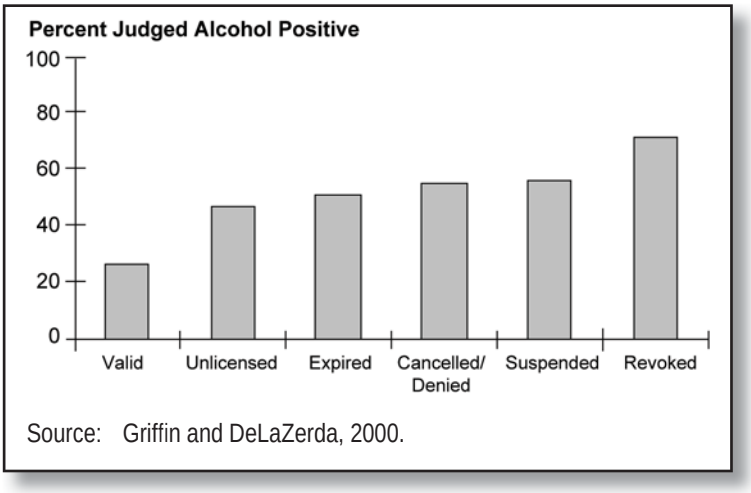
No matter how well our highways and vehicles are designed and maintained, ultimately highway safety depends upon road user behavior, especially drivers. Every state has a driver-licensing program charged with ensuring licensed drivers are competent to operate on the roadway system. However, states generally require relicensure only once every several years (usually four or five); and this interval has been lengthened by many states in an effort to cut costs and reduce delays at license issuing facilities. Some states do not even require an in-person renewal, and those that do usually administer only perfunctory evaluation. There are strong pressures on licensing programs to limit imposition, including

costs, on renewal applicants. At the same time, licensing agencies have a legal responsibility to the greater public to license only qualified drivers and to keep unqualified drivers off the road.

In some regions of the country, drivers who have never held a proper license are often noncitizens who fear detection if licensure is sought. Convicted impaired drivers (i.e., DUI, DWI, or OWI offenders) probably represent the group of unlicensed, suspended, or revoked (U/S/R) drivers of greatest concern as they are overrepresented in fatal and serious crashes.

Planners can play a significant role in this area by working to provide alternatives to driving for those who have lost the privilege of driving. By improving transit and non-motorized transportation options, transportation planners can reduce the likelihood of people driving without proper licensure.

EXHIBIT III-17
Percentage of Drivers Judged to be Alcohol Positive by License Status



Source: Griffin and DeLaZerda, 2000.

Data

- It is estimated that as many as three-fourths of drivers with suspended or revoked licenses continue to drive.
- A recent report analyzing five years of Fatality Analysis Reporting System (FARS) data found that one out of five fatal crashes involves at least one driver not properly licensed (unlicensed, suspended/revoked (S/R), expired, canceled or denied, unknown).
- According to a California study, drivers who have never sought a proper license, many of whom are illegal immigrants, are reported to be even more overrepresented in crashes than drivers with S/R licenses by a factor of 4.9 to 1.
- S/R drivers are predominantly male and younger than the average age of drivers (on average more than eight years younger in a California study). They also are more likely to have convictions for nontraffic offenses, including violent offenses (De Young, 1990).

Traditional sanctions have been less effective with drivers that are unlicensed or have had their licenses suspended or revoked. When unlicensed drivers also are undocumented, it is not likely that traditional sanctions will keep them off the road as transportation is essential for their employment. Multiple DUI offenders have often failed to respond to more conventional sanctions or efforts to "rehabilitate" them, so the focus is moving from changing the individual's behavior to modifying the environment to make it more difficult for the offender to operate a vehicle. Despite the marked over-involvement of improperly licensed drivers in fatal crashes, traffic violations are often not treated seriously enough in the court system, where prosecutors consider burglaries, assaults, and other crimes of greater importance (even though people are at much greater risk of a crash injury than of being the victim of a crime). Traffic courts that handle only traffic offenses increase the likelihood of appropriate sanctions.

Objective 1: Eliminate the Need to Drive

Strategies

- Provide alternative transportation, such as fixed-route or demand-response transit, to offer unlicensed people a transportation choice other than driving, especially when drinking (P, $$$).
  - This may take the form of specific programs that prevent drinking and driving, such as free transit rides or taxi rides on New Year's Eve;
  - This strategy is most effective when transit service is available at any time of the day, such as having taxi service available when transit service ends, and if service is timely; and
  - To be effective, alternative ride programs require that training be conducted with bar managers and employees.

Objective 2: Apply Special Enforcement Practices

Strategies

Increased enforcement and checking license status can aid in the apprehension of unlicensed/suspended/revoked drivers who carry a license that appears valid. Countermeasures include the following:

- Selective enforcement in areas where U/S/R driving has been detected, complemented with a publicity campaign, and with cooperation of DMV and judicial personnel (T, $);
- Routine checks of drivers' records against all citations to determine license status, ideally in real time when a citation is issued (T, $); and
- Create and distribute "hot sheets" (T, $) to enforcement agencies containing lists of drivers who live in the vicinity and whose license has been suspended or revoked.

Objective 3: Restrict Mobility through License Plate Modification

Strategies

These strategies seek to mark the vehicles driven by U/S/R offenders so that they are prevented from using a vehicle or can be monitored by enforcement. Countermeasures include the following:

- Install zebra stripes on license plates or registration renewal stickers of vehicles owned and/or driven by U/S/R drivers to facilitate enforcement; the striping is considered probable cause for an officer to stop a vehicle and check license status (P, $$); and
- Impound or destroy license plates of U/S/R drivers arrested three or more times via an administrative process implemented by enforcement or the DMV (P, $$).

Best Practice

Aspen Colorado's Tipsy Taxi program: http://www.tipsytaxi.com/.

Resource

NCHRP Report 500 Volume 2: *A Guide for Addressing Collisions Involving Unlicensed Drivers:* http://safety.transportation.org/guides.aspx.

Signalized Intersections

Problem Description

The crossing and turning maneuvers at intersections create opportunities for vehicle-vehicle, vehicle-pedestrian, and vehicle-bicycle conflicts. Thus, intersections are likely points for concentrations of traffic crashes.

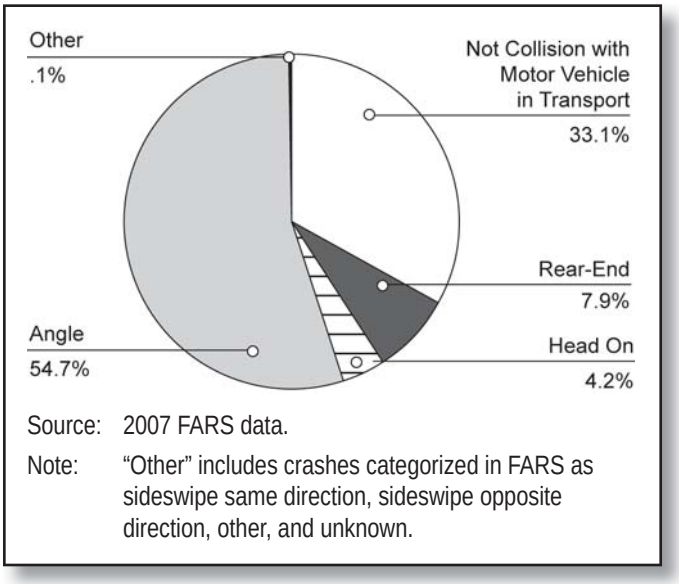
Signalized intersections are generally the most heavily traveled intersection types, and are therefore a major element of the highway fatality and crash problem nationally. Fatal crashes at signalized intersections are primarily multivehicle. Signalized intersections are operationally complex, with many factors contributing to potential safety problems. The intent of a signal is to control and separate conflicts between vehicles, pedestrians, and cyclists to enable safe and efficient operations. Good geometric design combined with effective traffic control can result in an intersection that operates efficiently and safely.

One of the major tasks transportation planners face is managing congestion. When planners evaluate how a corridor functions, signalization is a key consideration and traffic signal optimization is a major tool for improving traffic flow and safety. The improvement of corridor operations may reduce driver frustration and aggressive driving. Planners also are skilled at considering the multiple users of an intersection when improvements are made, including the safety of pedestrians and bicyclists. For example, if dedicated turning lanes are added to an intersection, planners can help make sure intersection modifications do not negatively impact the pedestrian experience by ensuring sufficient crossing time and pedestrian amenities are provided. The planner can work with the engineering staff to ensure these kinds of problems are recognized and solutions are implemented.

Data

- Intersection-related crashes constitute more than 50 percent of all crashes in urban areas and over 30 percent in rural areas (Kuciemba and Cirillo, 1992).
- Based on 2007 FARS data:
  - Twenty-two percent of fatal crashes occur at intersections;
  - Seven percent of all fatal crashes occur at signalized intersections;
  - Seventy percent of fatal single-vehicle crashes at signalized intersections involve pedestrians or bicyclists; and
  - Eighty-three percent of fatal crashes at signalized intersections occur in urban areas.

EXHIBIT III-18
Manner of Collision for Fatal Crashes at Signalized Intersections



Source: 2007 FARS data.

Note: "Other" includes crashes categorized in FARS as sideswipe same direction, sideswipe opposite direction, other, and unknown.

Objective 1: Reduce Frequency and Severity of Intersection Conflicts through Traffic Control and Operational Improvements

Strategies

Effective management of traffic signals can allow for safer turning movements, better traffic flow, and a reduction in the potential for conflicts with other vehicles and with nonmotorized transportation modes. Strategies include the following:

See Exhibit III-4 for Crashes Modification Factors for signal change interval modification.

- Employ multiphase signal operation, including protected left-turn phases and split phases that provide individual phases for opposing approaches (P, $);
- Optimize clearance intervals between the end of one green phase and the beginning of the next green phase for a conflicting movement (P, $);
- Restrict or eliminate turning maneuvers, including left turns or right-turn-on-red (T, $);
- Employ signal coordination that allows a group of vehicles to proceed without stopping at multiple signalized intersections (P, $$);
- Employ emergency vehicle preemption that extends the green on an emergency vehicle's approach or replaces the phases for the whole cycle (P, $$);
- Improve operation of pedestrian and bicycle facilities at signalized intersections, including pedestrian-only phase of signal operation, prohibition of right-turn-on-red, pedestrian signs and markings, and "Bicyclist Dismount" signs at intersections (P, $); and
- Remove unwarranted signals when traffic conditions no longer require them (P, $).

EXHIBIT III-19
Remove a Traffic Signal (Urban Environment)

Crash Type	Crash Modification Factor
All Crashes	0.76
Right Angle/Turning	0.76
Rear End	0.71
Pedestrian	0.82
Fixed Object	0.69
Light Conditions (All Severities)	
Day	0.78
Night	0.70
Injury Severity	
Severe	0.47
Minor	0.76

Objective 2: Reduce Frequency and Severity of Intersection Conflicts through Geometric Improvements

Strategies

By controlling turning movements, providing improved pedestrian facilities, and other geometric improvements, intersection conflicts may be reduced in numbers and severity. Strategies include the following:

- Provide/improve left-turn channelization to guide vehicles through turning paths and reduce potential conflicts (P, $$) (see section on Unsignalized Intersections, Objective 2);

- Provide/improve right-turn channelization to guide vehicles through turning paths and reduce potential conflicts (P, $$) (see section on Unsignalized Intersections, Objective 2);
- Improve geometry of pedestrian and bicycle facilities (P, $), such as signed and marked crosswalks, median refuge areas, pedestrian/bicycle overpasses, widened outside through lanes or bike lanes, and physical barriers to restrict pedestrian crossing maneuvers at higher-risk crossing locations;
- Revise geometry of complex intersections, such as improving intersection skew angle and converting a four-leg intersection into two T intersections (P, $$$$); and
- Construct special solutions, such as reconstructing intersections, converting two-way streets to a one-way pair, and constructing interchanges (T, $$$$).

Objective 3: Improve Sight Distance and Driver Awareness at Signalized Intersections

Strategies

Improving the sight distance and visibility at intersections provides better awareness of maneuvers required in advance of entering the intersection. Strategies include the following:

- Clear sight triangles by removing vegetation or other obstructions (T, $);
- Redesign intersection approaches via horizontal or vertical realignment (P, $$$$);
- Improve visibility of intersections on approaches with methods, such as larger signs, improved delineation of lanes and roadway, and rumble strips on approaches (T, $); and
- Improve visibility of signals and signs at intersections with techniques, such as visors to shade signal lenses from sunlight, backplates, and larger (12-inch) signal lenses (T, $).

Objective 4: Improve Driver Compliance with Traffic Control Devices

Strategies

Safety problems at signalized intersections cannot always be solved with engineering countermeasures. Traffic enforcement and/or public education campaigns may improve intersection safety.
Strategies include:

- Provide public information and education on safety problems at intersections (T, $);
- Provide targeted traffic law enforcement (T, $$);
- Implement automated enforcement of red light running with cameras (P, $$);

EXHIBIT III-20
Install Red-Light Cameras

Crash Type	Crash Modification Factor
All Crash Severities	
Rear-End Crashes	1.15
Right-Angle Crashes	0.75
Injury Crashes Only	
Rear-End Crashes	1.24
Right-Angle Crashes	0.84

- Implement automated enforcement of approach speeds with cameras (T, $$); and
- Control speed on approaches (E, $$) via geometric design, signal control technology, and traffic calming treatments.

Objective 5: Improve Access Management Near Signalized Intersections

Limiting the number of driveways in the area of an intersection reduces the number of potential vehicle conflict points. Strategies include:

- Restrict access to properties using driveway closures, consolidations, or turn restrictions, especially within 250 feet of an intersection (T, $); and
- Restrict cross-median access near intersections (T, $).

Objective 6: Improve Safety through Other Infrastructure Treatments

Additional safety improvements at intersections may include addressing the roadway surface, drainage, or providing clear zones adjacent to the roadway. Strategies include:

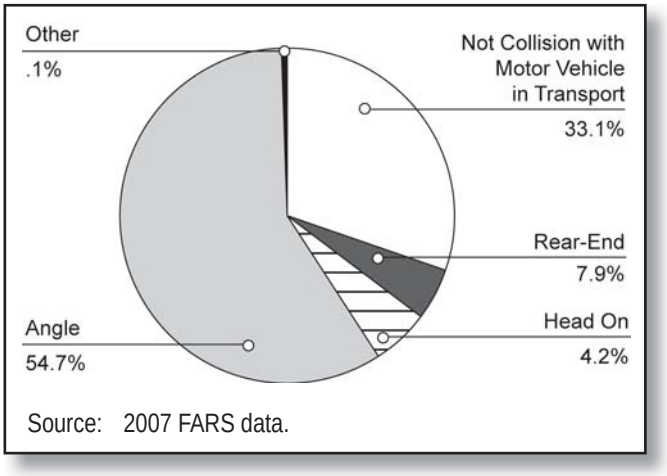
- Improve drainage in intersections and on approaches (T, $$);
- Provide skid-resistance in intersection and on approaches, such as grooving or overlaying existing pavement (T, $$);
- Coordinate closely spaced signals near at-grade railroad crossings to avoid vehicle queues forming across the railroad tracks (T, $$);
- Relocate signal hardware out of the clear zone and as far from the pavement as possible (T, $$); and
- Restrict or eliminate parking on intersection approaches (P, $).

Resources

NCHRP Report 500 Volume 12: A Guide for Reducing Collisions at Signalized Intersections: http://safety.transportation.org/guides.aspx.

See the next section for additional intersection resources.

EXHIBIT III-21
Manner of Collision for Fatal Crashes at Unsignalized Intersections



Source: 2007 FARS data.

Unsignalized Intersections

Problem Description

Nationally, many more unsignalized intersections are in place than signalized, so the number of crashes is undoubtedly much higher at unsignalized intersections than at signalized intersections. As population and

development increases, traffic volume at unsignalized intersections grows as does the number of crashes. There is increasing demand for signalization of urban and suburban intersections, and, even in rural areas, signalized intersections are becoming more common. However, experience shows that intersection crash rates frequently increase with signal installation, although the crashes may be less severe.

Data

- Fifteen percent of fatal crashes were at unsignalized intersections in 2007.

Objective 1: Improve Access Management Near Unsignalized Intersections

Strategies

Access management near intersections reduces the number of potential conflict points in the intersection area. Access management is often addressed through state or municipal codes, and also can be addressed at the time a new development is proposed. Strategies include:

- Close, consolidate, or relocate driveways within 250 feet of an unsignalized intersection from the major-road approach to the minor-road approach (T, $$); and
- Implement driveway turn restrictions, such as limiting turns in and/or out of a property to only right turns (T, $).

Objective 2: Reduce the Frequency and Severity of Intersection Conflicts through Geometric Design Improvements

Strategies

Improved channelization at intersections, clarified paths through intersections, and restricted turning movements may help reduce rear-end collisions. Countermeasures include the following:

- Provide left-turn lanes at intersections, so that vehicles waiting to turn left are protected from conflict with through-traffic (P, $$);
- Provide longer left-turn lanes at intersections to allow for vehicle deceleration and waiting (T, $);
- Provide offset left-turn lanes at intersections, so that vehicles in opposing turn lanes on the major road do not block vision of oncoming traffic (T, $$$); and
- Provide median acceleration lanes at divided highway intersections for vehicles making a left turn and entering the highway (T, $$).

EXHIBIT III-22
Add Exclusive Left-Turn Lane

Total Intersection Crashes (All Severity Levels, All Crash Types)	Crash Modification Factor	
	One Approach	Both Approaches
Rural stop-controlled intersection (4 legs)	0.72	0.52
Rural stop-controlled intersection (3 legs)	0.56	–
Rural signalized intersection (4 legs)	0.82	0.67
Rural signalized intersection (3 legs)	0.85	–
Urban stop-controlled intersection (4 legs)	0.73	0.53
Urban stop-controlled intersection (3 legs)	0.67	–
Urban signalized intersection (4 legs)	0.90	0.81
Urban signalized intersection (3 legs)	0.93	–
Fatal and Injury Intersection Crashes (All Crash Types)		
Rural stop-controlled intersection (4 legs)	0.65	0.42
Rural stop-controlled intersection (3 legs)	0.45	–
Urban stop-controlled intersection (4 legs)	0.71	0.50
Urban stop-controlled intersection (3 legs)	0.65	–
Urban signalized intersection (4 legs)	0.91	0.83
Urban signalized intersection (3 legs)	0.94	–
Project-Related Crashes (All Severity Levels)[a]		
Rural stop-controlled intersection (4 legs)	0.63	0.40
Rural stop-controlled intersection (3 legs)	0.38	–
Urban stop-controlled intersection (4 legs)	0.74	0.55
Urban signalized intersection (4 legs)	0.87	0.76

[a] Project-Related Crashes: All crashes involving one or more vehicles that had made, were making, or intended to make the specific left-turn maneuver(s) for which the left-turn lane(s) being evaluated were installed.

- Provide right-turn lanes at intersections to remove slow vehicles that are decelerating to turn right from the through-traffic stream (P, $$);
- Provide longer right-turn lanes at intersections to reduce conflict when a queue of vehicles overflows the right-turn lane (T, $$);
- Provide offset right-turn lanes at intersections to prevent collisions between turning vehicles and through traffic, and to prevent right-turning vehicles from obstructing the view of the minor-road driver (T, $$$);
- Provide right-turn acceleration lanes at intersections to prevent collisions between through traffic and vehicles turning right into the roadway (T, $);
- Provide full-width paved shoulders in intersection areas to provide space for motorists, pedestrians and bicyclists (T, $);
- Restrict or eliminate turning maneuvers with signing, such as prohibiting turns during peak hours (T, $);
- Restrict or eliminate turning maneuvers by providing channelization or closing median openings and using signing (T, $);

- Close or relocate "high-risk" intersections when less-restrictive measures have been tried and failed (T, $$$$);
- Convert four-legged intersections to two T intersections that operate independently of each other (T, $$$$);
- Realign intersection approaches to reduce or eliminate intersection skew so the intersection area is not confusing, sight angles are good, and the paths through the intersection are not excessively long (P, $$$$); and
- Use indirect left-turn treatments to minimize conflicts at divided highway intersections such as the use of jug-handle roadways before the crossroad or loop roadways beyond the crossroad (T, $$).

EXHIBIT III-23
Add Exclusive Right-Turn Lane

Total Intersection Crashes (All Severity Levels, All Crash Types)	Crash Modification Factor	
	One Approach	Both Approaches
Rural stop-controlled intersection (4 legs)	0.86	0.74
Rural signalized intersection (4 legs)	0.96	0.92
Urban signalized intersection (4 legs)	0.96	0.92
Urban signalized intersection (3 legs)	0.96	–
Urban stop-controlled intersection (4 legs)	0.86	0.74
Fatal and Injury Intersection Crashes (All Crash Types)		
Rural stop-controlled intersection (4 legs)	0.77	0.59
Rural signalized intersection (4 legs)	0.91	0.83
Urban signalized intersection (4 legs)	0.91	0.83
Urban signalized intersection (3 legs)	0.91	–
Urban stop-controlled intersection (4 legs)	0.77	0.59

Objective 3: Improve Sight Distance at Unsignalized Intersections

Strategies

Appropriate sight distance is acknowledged as a major contributor to safety at unsignalized intersections. Strategies include the following:

- Clear sight triangles on stop- or yield-controlled approaches to intersections by removing vegetation and other obstructions, so that drivers have full intersection sight distance (T, $);
- Clear sight triangles in the medians of divided highways near intersections to prevent sight obstruction of the intersection by vegetation or other obstacles (T, $);
- Change horizontal and/or vertical alignment of approaches to provide more sight distance if other strategies have been tried and are not effective (T, $$$$); and
- Eliminate parking that restricts sight distance, especially if it is located in the sight triangle of an intersection (T, $).

Objective 4: Improve Availability of Gaps in Traffic and Assist Drivers in Judging Gap Sizes at Unsignalized Intersections

Strategies

Drivers' misjudgment of the distance to an oncoming vehicle results in intersection collisions. Techniques for assisting drivers in judging gaps or increasing the size of gaps include the following:

- Provide an automated real-time system to inform drivers of the suitability of available gaps for making turning and crossing maneuvers, such as a light that flashes when oncoming traffic is present (E, $$);
- Provide roadside markers or pavement markings to assist drivers in judging the suitability of available gaps for making turning and crossing maneuvers, such as roadside markers or pavement markings at a fixed distance from an intersection (E, $); and
- Retime signals adjacent to stop-controlled intersections to create longer gaps in opposing traffic at stop-controlled intersections (T, $).

Objective 5: Improve Driver Awareness of Intersections as Viewed from the Intersection Approach

Strategies

Many unsignalized intersections are not readily visible to approaching drivers, particularly on major-road approaches that are not controlled by stop signs or yield signs. Strategies for improving the visibility of intersections include the following:

- Improve visibility of intersections by providing enhanced signing and delineation, such as advanced guide signs and breaks in pavement markings (T, $);
- Improve visibility of the intersection by providing lighting, such as streetlights at rural intersections (P, $$$);
- Install splitter islands (channelizing islands separating traffic in opposing directions of travel) on the minor-road approach to an intersection to call attention to the presence of the intersection (T, $$);
- Provide a stop bar (or a wider stop bar) on minor-road approaches (T, $);
- Install larger regulatory and warning signs at intersections (T, $);
- Call attention to the intersection by installing rumble strips on intersection approaches (T, $);
- Provide dashed markings (extended left edgelines) for major-road continuity across the median opening at divided-highway intersections to distinguish the median roadway from the through roadway (T, $);
- Provide supplementary stop signs mounted over the roadway (T, $);
- Provide pavement markings with supplementary messages, such as STOP AHEAD (T, $);

- Provide improved maintenance of stop signs to ensure that they are clean, legible, and not obstructed from view by vegetation or construction materials (T, $); and
- Install flashing beacons at stop-controlled intersections (T, $).

Objective 6: Choose Appropriate Intersection Traffic Control to Minimize Crash Frequency and Severity

Strategies

Signalization of intersections should be implemented only when warranted because new signals may introduce congestion and increase crashes. Strategies for managing intersection control include:

- Avoid signalizing through roads as new signals may increase the likelihood of certain types of crashes (T, $$$$);
- Provide all-way stop signs at appropriate intersections (where warranted) (P, $); and
- Provide roundabouts at appropriate locations to maintain traffic flow (P, $$$$).

EXHIBIT III-24
Convert to All-Way Stop Control from Two-Way Stop Control

Type of Collision (All Severities)	Crash Modification Factor
All Crashes	0.53
Right-Angle Crashes	0.28
Rear-End Crashes	0.87
Left-Turn Crashes	0.80
Pedestrian Crashes	0.61
Crash Severity (All Collision Types)	
All Crashes	0.53
Injury Crashes	0.29

EXHIBIT III-25
Install Roundabout

Lane Environment	Crash Modification Factor
Single-Lane – Urban/Suburban (prior control – two-way stop controlled)	
All Crashes	0.44
Injury Crashes	0.22
Single-Lane – Rural (prior control – two-way stop controlled)	
All Crashes	0.29
Injury Crashes	0.13
Multilane – Urban/Suburban (prior control – stop sign)	
All Crashes	0.82
Injury Crashes	0.28
Single/Multilane – Urban/Suburban (prior control – signal)	
All Crashes	0.52
Injury Crashes	0.22
All Sites	
All Crashes	0.65
Injury Crashes	0.24

Objective 7: Improve Driver Compliance with Traffic Control Devices and Traffic Laws at Intersections

Strategies

Employ enforcement and public education to reduce unsafe and illegal driver behavior at intersections. Strategies include:

- Provide targeted enforcement to reduce stop sign violations (T, $$); and
- Provide targeted public information and education on safety problems at specific intersections (T, $).

Objective 8: Reduce Operating Speeds on Specific Intersection Approaches

Strategies

Employ efforts to reduce speeds approaching intersections and the possibility of more severe collisions. Strategies include the following:

- Provide targeted speed enforcement (P, $$);
- Provide traffic calming at intersection approaches through a combination of geometric and traffic control devices (T, $$); and
- Post appropriate speed limits on intersection approaches (T, $).

Objective 9: Guide Motorists More Effectively through Complex Intersections

Strategies

At complex intersections, the correct path for the motorist may not be clearly defined, or motorists may become confused as to appropriate movements. Strategies to guide motorists through complex intersections include:

- Provide turn path markings, such as dashed lines, to indicate the path through the intersection (T, $);
- Provide a double yellow centerline on the median opening of a divided highway at intersections to prevent undesirable behaviors such as side-by-side queuing on the median roadway in the same direction and stopping at an angle on the median roadway (T, $); and
- Provide lane assignment signing or pavement markings at complex intersections (T, $) to minimize driver indecision about lane choice.

Best Practice

Minnesota DOT Access Management Guidelines:
http://www.oim.dot.state.mn.us/access/guidelines.html.

Resources

NCHRP Report 500 Volume 5: *A Guide for Addressing Unsignalized Intersection Collisions:* http://safety.transportation.org/guides.aspx.

FHWA Access Management Publications and Resources: http://ops.fhwa.dot.gov/access_mgmt/resources.htm.

AASHTO, 2001, *Policy on Geometric Design for Highways and Streets.*

Pline, 1999, *Traffic Engineering Handbook,* Institute of Transportation Engineers.

Neuman, 1985, *NCHRP Report 279, Intersection Channelization Design Guide,* Transportation Research Board of the National Academies.

Harwood et al., 1995, *NCHRP Report 375: Median Intersection Design,* Transportation Research Board of the National Academies.

Harwood, Mason, Brydia, Pietrucha, and Gittings, 1996, *NCHRP Report 383: Intersection Sight Distance,* Transportation Research Board of the National Academies.

Blackburn and Gilbert, 1995, *NCHRP Synthesis of Highway Practice 219: Photographic Enforcement of Traffic Laws,* Transportation Research Board of the National Academies.

Staplin, Lococo, and Byington, 1998, *Older Driver Highway Design Handbook,* FHWA RD 97 135.

Federal Highway Administration, Manual on Uniform Traffic Control Devices (MUTCD), 2003: http://mutcd.fhwa.dot.gov/.

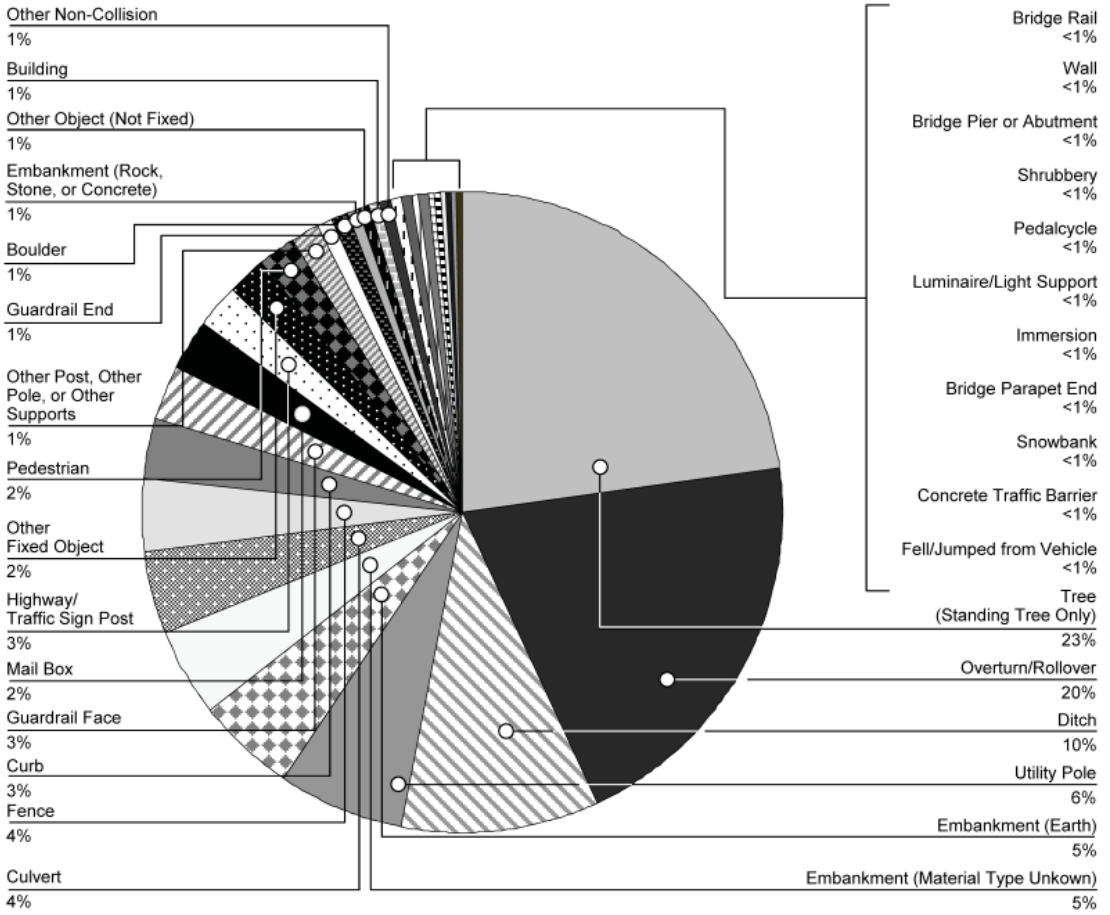
Knapp, 2000, *Traffic-Calming Basics,* Civil Engineering, Volume 70, Number 1.

Run-Off-Road Collisions

Problem Description

Run-Off-Road (ROR) collisions comprised 43 percent of all fatal collisions in 2007. The first harmful event in a crash is the first event or object hit, which may or may not result in injury or fatality. Information about the first harmful event in ROR crashes, shown in Exhibit III-26, provides insight into roadside objects initially struck in crashes that may need to be removed or modified. Analysis of the most harmful event, shown in Exhibit III-27, shows the most severe elements of crashes and can help in defining strategies that can minimize crash severity. For example, a crash may begin with a vehicle hitting a signpost (first harmful event), followed by a rollover resulting in a fatality (most harmful event). This section provides information on the various countermeasures effective in addressing ROR collisions. Working with safety practitioners who are knowledgeable about multiple factors impacting roadway safety will be important in choosing the most effective approach.

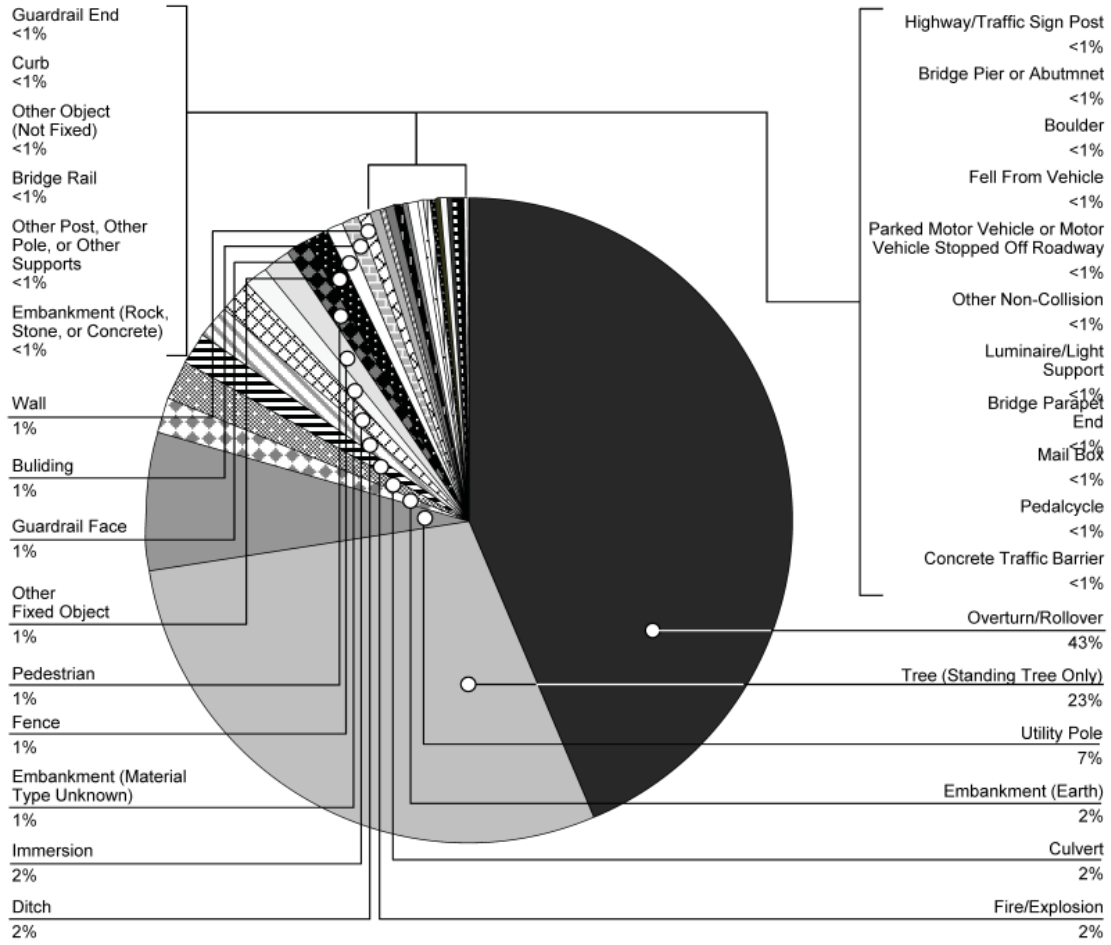
EXHIBIT III-26
Distribution of Single-Vehicle ROR Fatalities for Two-Lane, Undivided, Noninterchange, Nonjunction Roads
First Harmful Event



Source: 2007 FARS Data.

Note: "Other" includes events that each represent less than 0.5 percent of the total first harmful events: bridge parapet end, immersion, shrubbery, longitudinal barriers (concrete or other), pedal cycle, other noncollision, fire hydrant, snow bank, fell/jumped from vehicle, transport device used as equipment, animal, unknown, pavement surface irregularity, fire/explosion, other type of nonmotorist, vehicle occupant struck or run over by own vehicle, impact attenuator/crash cushion, railroad train, or gas inhalation.

EXHIBIT III-27
Distribution of Single-Vehicle ROR Fatalities for Two-Lane, Undivided, Noninterchange, Nonjunction Roads
Most Harmful Event



Source: 2007 FARS Data.

Note: "Other" includes events that each represent less than 0.5 percent of the total first harmful events: bridge parapet end, immersion, shrubbery, longitudinal barriers (concrete or other), pedal cycle, other noncollision, fire hydrant, snow bank, fell/jumped from vehicle, transport device used as equipment, animal, unknown, pavement surface irregularity, fire/explosion, other type of nonmotorist, vehicle occupant struck or run over by own vehicle, impact attenuator/crash cushion, railroad train, or gas inhalation.

Data

Based on 2007 FARS data:

- Forty-one percent of fatal crashes were single-vehicle ROR collisions;
- Seventy-six percent of single-vehicle ROR fatalities on two-lane undivided, noninterchange, nonjunction roads occurred on rural roads;
- Twenty-three percent of single-vehicle ROR fatalities on two-lane undivided, noninterchange, nonjunction roads occurred on rural local roads and 25 percent were on rural major collectors; and
- On two-lane rural roads, 50 percent of single-vehicle ROR crashes occurred on curves and 50 percent on straight sections.

Objective 1: Keep Vehicles from Encroaching on the Roadside

Strategies

Methods can be employed to alert drivers who stray from their lanes, or provide enhanced warning of dangerous areas such as curves. Strategies include the following:

- Install shoulder rumble strips (T, $);
- Install rumble strips, such as milled-in "edgeline" rumble strips on sections with narrow or unpaved shoulders (E, $);
- Install rumble strips in the center of the travel lane, so a vehicle leaving the travel lane is signaled by the inside tires' contact with the rumble strip (E, $);
- Provide enhanced shoulder or in-lane delineation and marking for sharp curves, such as chevrons, large arrow signs, flashing beacons, or pavement markings that create a sense of danger (P, T, & E, $);

EXHIBIT III-28
Add Shoulder Rumble Strips

	Crash Modification Factor
All Freeways (Rural and Urban)	
All Single-Vehicle ROR Crashes	0.82
Injury Single-Vehicle ROR Crashes	0.87
Rural Freeways	
All Single-Vehicle ROR Crashes	0.79
Injury Single-Vehicle ROR Crashes	0.93

- Provide improved highway geometry for horizontal curves, such as flattening, to increase the curve radius (P, $$$$);
- Provide enhanced pavement markings (e.g., high-contrast, wider, or raised markings) (T, $);
- Provide skid-resistant pavement surfaces by changing pavement aggregates, adding overlays, or adding texture (T, $$); and
- Apply shoulder treatments to allow vehicles to recover if they begin to leave the roadway (e.g., eliminate shoulder drop-offs (E, $) and widen and/or pave shoulders (P, $).

EXHIBIT III-29
Change Shoulder Width and/or Type

$CMF = (CMF_{WRA}CMF_{TRA}-1.0)P_{RA}+1.0$

where:

CMF = Crash modification factor for total crashes.

CMF_{WRA} = Crash modification factor for related crashes, based on shoulder width.

CMF_{WRA} is calculated by dividing the CMF for the after improvement by the CMF for the before condition. Each can be selected from the following table.

	Average Daily Traffic (ADT)		
Shoulder Width	**< 400**	**400 to 2,000**	**> 2,000**
0 feet	1.10	$1.1 + 2.5 \times 10^{-4}$ (ADT-400)	1.50
2 feet	1.07	$1.07 + 1.43 \times 10^{-4}$ (ADT-400)	1.30
4 feet	1.02	$1.02 + 8.125 \times 10^{-5}$ (ADT-400)	1.15
6 feet	1.00	1.00	1.00
8 feet	0.98	$0.98 + 6.875 \times 10^{-5}$ (ADT-400)	0.87

CMF_{TRA} = Crash modification factor for related crashes, based on shoulder type.

CMF_{TRA} is calculated by dividing the CMF for the after-improvement condition by the CMF for the before condition. Each can be selected from the following table.

	Shoulder Width (Feet)							
Shoulder Type	**0**	**1**	**2**	**3**	**4**	**6**	**8**	**10**
Paved	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Gravel	1.00	1.00	1.01	1.01	1.01	1.02	1.02	1.03
Composite	1.00	1.01	1.02	1.02	1.03	1.04	1.06	1.07
Turf	1.00	1.01	1.03	1.04	1.05	1.08	1.11	1.14

P_{RA} = Proportion of total crashes constituted by related crashes.

P_{RA} = 0.35 (estimated from distribution of crash types).

Objective 2: Minimize the Likelihood of Crashing into an Object or Overturning for Vehicles Traveling Beyond the Shoulder Edge

Strategies

If a vehicle does leave the roadway, strategies can be employed to reduce the severity of a crash by removing dangerous elements or marking them, so drivers can avoid them, including the following:

- Design safer slopes and ditches to prevent rollovers, which comprise 42 percent of the most harmful events for fatal single-vehicle ROR crashes (P, $$$);
- Remove/relocate objects in hazardous locations such as trees, poles, and signposts or shield objects with breakaway devices or crash cushions (P, $ – assuming removal/ relocation of small appurtenances); and
- Delineate trees and utility poles with retroreflective tape to improve their visibility and provide “safer escape route” information if vehicles do leave the roadway (E, $).

EXHIBIT III-30
Percentage Reduction of Single-Vehicle and Total Crashes Due to Sideslope Flattening on Two-Lane Rural Roads

Amount of Increased Roadside Recovery Distance, Meters (Feet)	Percent Reduction in Related Crash[a] Types
1.5 (5)	13%
2.4 (8)	21%
3.1 (10)	25%
3.7 (12)	29%
4.6 (15)	35%
6.2 (20)	44%

[a] "Related crashes" would be the total of ROR, head-on, and sideswipe crashes.

EXHIBIT III-31
Percentage Reduction in "Related Crashes" Due to Increasing the Roadside Clear Recovery Distance on Two-Lane Rural Roads

Sideslope								
	After Condition							
	1:4		1:5		1:6		1:7 or Flatter	
Before Condition	SV	Total	SV	Total	SV	Total	SV	Total
1:2	10	6	15	9	21	12	27	15
1:3	8	5	14	8	19	11	26	15
1:4	0	-	6	3	12	7	19	11
1:5	-	-	0	-	6	3	14	8
1:6	-	-	-	-	0	-	8	5

Source: Zegeer et al., 1987.

Objective 3: Reduce Crash Severity

Strategies

Roadside hardware should be evaluated to ensure the design chosen and the method of installation will inflict the least damage in the event of a crash. Strategies include the following:

- Improve design of roadside hardware, such as bridge rails and guardrail ends (T, $$$); and
- Improve design and application of barrier and noise attenuation systems (T, $$$).

EXHIBIT III-32
Install/Upgrade Guardrail along Embankment

ROR Crashes	Crash Modification Factor
Fatal Injury Crashes	0.56
All Injury Crashes	0.53

Best Practices

Summary of Survey Results of State DOTs on Tree Crash Reduction Programs: http://safety.transportation.org/htmlguides/trees/app02.htm.

Iowa DOT Office of Design, Design Manual: http://www.iowadot.gov/design/.

Resources

NCHRP Report 500 Volume 6: *A Guide for Addressing Run-Off-Road Collisions:* http://safety.transportation.org/guides.aspx.

AASHTO Roadside Design Guide (2002): http://design.transportation.org/?siteid=59&pageid=848.

FHWA web site on safe roadside hardware: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/.

Head-On Collisions

Problem Description

Head-on crashes result when motorists fall asleep, are distracted, or are traveling too fast in a curve. Affecting head-on fatalities is more complex than simply providing adequate passing zones. Indeed, most head-on crashes are similar to run-off-road crashes (e.g., in both cases, the vehicle strays from its travel lane). This section provides information on various effective countermeasures to address head-on collisions. Working with safety practitioners is important in choosing the most effective approach.

Data

- Eleven percent of noninterchange, nonjunction fatal crashes involved two vehicles colliding head-on, according to 2007 FARS data.
- Nearly two-thirds of head-on crashes occur on rural roads.
- Seventy-two percent of head-on crashes occur on undivided two-lane roads.
- In nearly all cases, fatal head-on crashes occur in nonpassing situations.
- On two-lane divided roadways, 83 percent of head-on fatal crashes are "going straight," and 17 percent are "negotiating a curve."

EXHIBIT III-33
Centerline Rumble Strips Implemented in Maryland

Source: NCHRP 500 Volume 18: A Guide for Reducing Head-On Collisions.

Objective 1: Keep Vehicles from Encroaching into the Opposite Lane

Strategies

Engineering strategies to alert drivers they are moving into an oncoming lane and provide better centerline lane marking visibility help drivers stay alert and aware of their positions on the roadway. Roadway designs that provide more space for drivers may offer a safety benefit, but they are higher-speed designs, which present risks. Buffers between opposing flows of traffic may provide protection from head-on collisions. Strategies include the following:

- Install centerline rumble strips for two-lane roads to alert drivers they are straying into an oncoming lane (T, $);

EXHIBIT III-34
Add Centerline Rumble Strips (Rural two-lane roads)

Crash Type (All Severities)	Crash Modification Factor
All Crashes	0.86
Frontal/Opposing-Direction Sideswipe Crashes	0.79
Injury Crashes	
All Crashes	0.85
Frontal/Opposing-Direction Sideswipe Crashes	0.75

- Install profiled thermoplastic strips for the centerline that provide an audible/tactile effect and longer sight distance at night (T, $);
- Provide wider cross sections on two-lane roads with wider lanes and full-strength shoulders and high-speed alignment offering 100 percent passing sight distance (E, $$$);
- Install center two-way left turn lanes on four- and two-lane roads to provide a buffer between opposing directions of travel (T, $$); and
- Reallocate total two-lane width (lane and shoulder) to include a narrow "buffer median," to slow traffic and place a buffer between opposing flows (T, $).

Objective 2: Minimize the Likelihood of Crashing into an Oncoming Vehicle

Strategies

Provide space for passing to prevent the need to travel into an oncoming lane or a physical barrier. Countermeasures include the following:

- Install alternate passing lanes or four-lane sections at key locations to reduce passing-related, head-on crashes (T, $$$); and
- Install median barriers for narrow medians on multilane roads, especially in rural areas where speeds are higher and the need for median openings is less (T, $$).

EXHIBIT III-35
Add Passing Lanes
Two-Lane Roads

Type of Passing Lane	Crash Modification Factor
One-Way (Single Direction of Travel)	0.75
Two-Way (Short Four-Lane Sections)	0.65

Resources

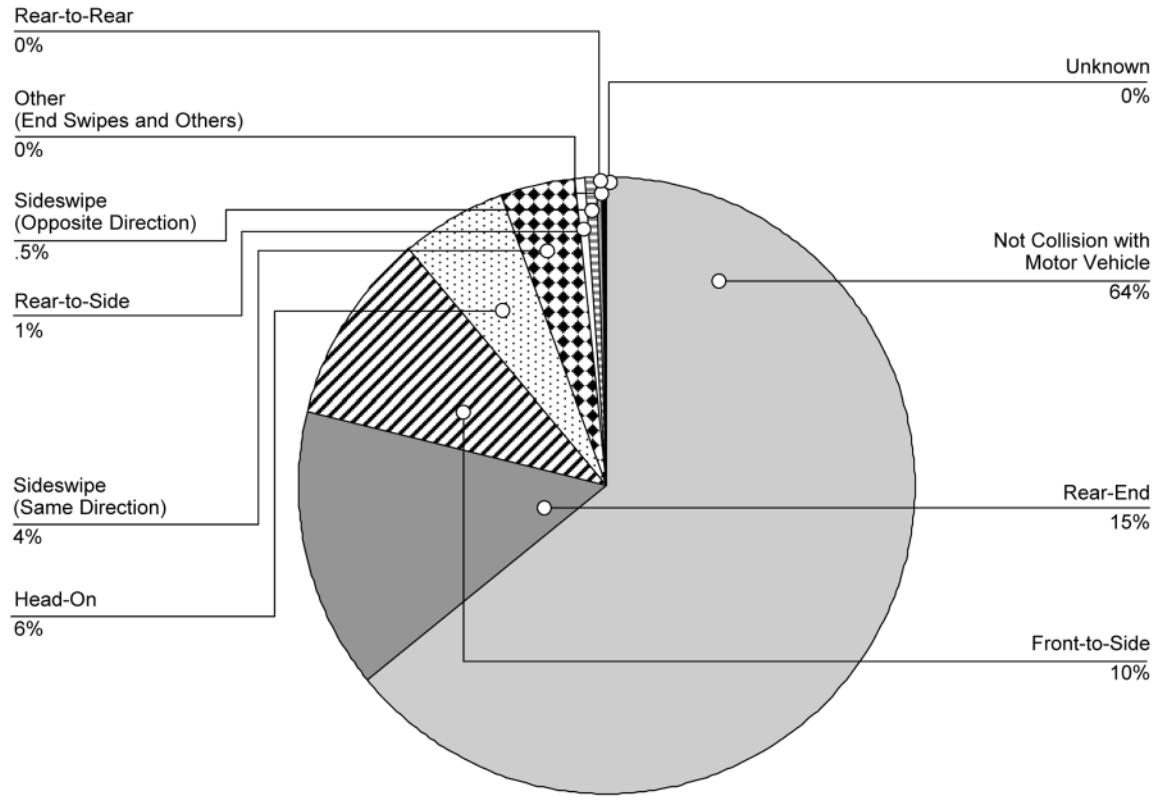
NCHRP Report 500 Volume 4: A Guide for Addressing Head-On Collisions: http://safety.transportation.org/guides.aspx.

Head-On Collisions on Freeways

Problem Description

This emphasis area addresses head-on crashes associated with freeways and expressways with full access control. A head-on crash typically occurs when a vehicle crosses the median and crashes into a vehicle traveling in the opposite direction. A head-on crash also can occur when a vehicle inadvertently travels the wrong way in the traffic lane. In either event, these crashes are inherently severe. Head-on cross median crashes may be the result of inadvertent actions by a driver, potentially combined with other adverse circumstances such as weather conditions. As shown in Exhibit III-36 showing fatal crash types, six percent of fatal interstate/freeway crashes are head-on crashes.

EXHIBIT III-36
Fatal Crashes by Manner of Collision on Interstates/Freeways



Source: 2007 FARS data.

Data

- In 2007, according to FARS, 334 fatal cross-median head-on crashes occurred on U.S. interstates and freeways. Although the number may seem small when compared to the overall crashes and to the percentage of all interstate/freeway-related crashes, head-on crashes are extremely severe.
- A study in Iowa showed that between 1990 and 1999, though only 2.4 percent of all interstate crashes were cross-median, they produced 32.7 percent of interstate fatalities during that period.
- Median crashes are three times more severe than other highway crashes (NCDOT).
- In 2007, almost two-thirds of fatal interstate/freeway crossover crashes involved male drivers.
- Thirty-eight percent of the fatal interstate crossover crashes occur during dark conditions.
- Twenty-two percent of fatal interstate crossover crashes occur during nondaylight but lighted conditions.

Objective 1: Keep Vehicles from Departing the Travel Way

Strategies

Strategies to keep vehicles in their travel lanes include enhanced traffic control devices to engage the driver's attention or installation of improved pavement capability to reduce skidding. In addition, if a driver strays from the road, a strategy of providing left median shoulder rumble strips is suggested to give an audible alert to the driver. Strategies include:

See Exhibit III-28 for CMFs for shoulder rumble strips.

- Install left shoulder rumble strips (T, $);
- Provide enhanced pavement markings and median delineation (T, $); and
- Provide improved pavement surfaces (T, $$).

Objective 2: Minimize the Likelihood of Head-On Crashes with an Oncoming Vehicle

Strategies

This objective considers the situation in which the vehicle has already left the lane and is in the median. The strategies are designed to prevent the vehicles from crossing over into the other direction of travel and help redirect the vehicle in the direction of flow. The objective is to minimize head-on crashes.

Utilization of the median is central to the objective. Medians separate opposing traffic streams, provide a recovery area for out-of-control vehicles, and provide a place for vehicles to stop in the event of an emergency. In addition, some median and median barriers can reduce oncoming headlight glare from vehicles. Strategies include:

- Provide wider medians (P, $$$$);
- Improve median design for vehicle recovery such as fixing pavement edge drop-offs, paving median shoulders, and designing safer slopes (T, $$$);
- Install median barrier, such as cable barriers for narrow width medians (P,$$); and
- Implement channelization, lighting, signing, and striping improvements at interchanges susceptible to wrong-way movements (T, E, $$).

Objective 3: Reduce the Severity of Median Barrier Crashes

Strategy

The goal of this strategy is to reduce the severity of the crash. Some of the less costly strategies may include replacing nonbreakaway or outdated roadside hardware with newer technology at selected locations. In considering this key strategy, reference should be made to the AASHTO Roadside Design Guide:

- Improve design and application of barrier and attenuation systems (T, $$$).

Objective 4: Enhance Enforcement and Awareness of Traffic Regulations

Strategies

For any number of reasons, some stretches of roadway appear more challenging to drive. The reasons may relate to the location, climate, the local driving population, or other factors not directly related to roadway design. As a consequence, these roadways may experience a high rate of severe motor vehicle collisions, injuries, and fatalities. One strategy that may be considered to address these roadways is to designate the facility as a "Highway Safety Corridor," and apply more frequent enforcement, low-cost engineering improvements, and education efforts to enhance safety along the corridor. Strategies include:

- Designate "Highway Safety Corridors" (T, $);
- Enforce traffic laws (T,[9] $$); and
- Conduct Public Information and Education campaigns (T, $$).

Best Practices

The Georgia Department of Transportation working with FHWA demonstrated the ability to construct the "Safety Edge" with no impact on production and at less than one percent additional material cost. Based on successful performance, GDOT incorporates the "Safety Edge" design into all resurfacing projects. Local city and county governments in Georgia, such as Gwinnett County, also are making the safety edge part of their routine overlay design. Other state DOTs (e.g., Indiana and New York) implemented the safety edge on several pilot projects in 2005. (See http://safety.fhwa.dot.gov/roadway_dept/index.htm.)

SCDOT installed 315.5 miles of three-strand cable on interstate segments with median widths less than 60 feet wide. In a three-year period, 1,913 vehicles were stopped by the barrier, and only 15 vehicles (one percent) penetrated the cable barrier. According to the study, cable median barriers were 99 percent effective in saving lives. Before installation of the barrier in 1999-2000, data showed that more than 70 people lost lives in 57 separate interstate median crashes.

NCDOT in Public Roads 2005 reported that the installation of median barriers resulted in:

- An estimated 90 percent reduction in freeway cross-median crashes;
- Approximately 25 to 30 lives saved each year; and
- Hundreds of injuries prevented or reduced each year.

A number of states, including California, New Jersey, New Mexico, Oregon, Pennsylvania, Virginia, and Washington, established highway safety corridors. Oregon and California doubled moving violation fines within safety corridors, and Virginia implemented a maximum fine of $500 for speeding and $2,500 for reckless driving and driving under the influence. North Carolina and Washington provided enhanced enforcement but not increased fines.

[9] Proven for DWI and restraint use, *Countermeasures that Work,* 2008.

Resources

NCHRP Report 500 Volume 18: *A Guide for Reducing Head-On Collisions on Freeways*
http://safety.transportation.org/guides.aspx.

Federal Highway Administration "Rumble Strip Community of Practice" web page:
http://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips/.

Federal Highway Administration "Roadside Hardware" web site:
http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/.

Horizontal Curves

Problem Description

Collisions on horizontal curves represent a significant proportion of fatal crashes. These crashes occur predominantly on two-lane rural highways that are often not part of the state DOT system. Management of safety on horizontal curves is a major challenge for highway agencies. It has been estimated that more than 10 million horizontal curves exist in the United States on two-lane highways alone. State highway agencies generally operate crash records systems to track crash locations. However, very few highway agencies have inventory files that identify the locations or geometrics of horizontal curves in a form that can be linked to crash data. Thus, safety concerns on horizontal curves can only be identified indirectly, and typically, no formal means exists to review horizontal curves and identify those with adverse safety performance. Agencies that cannot identify potential problems on horizontal curves by automated means should consider other methods, including noting public complaints, skid marks, and damage to roadside hardware, trees, and utility poles.

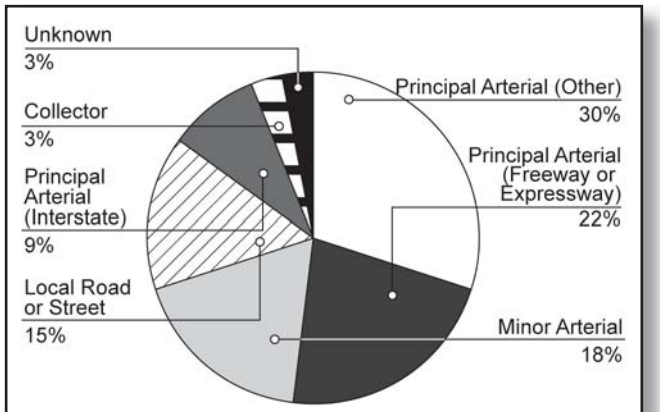
Crashes on horizontal curves result in significant amounts of injury because of the nature of the collisions. Slightly less than two percent of all crashes on curved roadway segments are fatal, but approximately 40 percent involve some type of injury.

The safety of curves is both a reflection of the roadway itself and the roadside environment. The first harmful event on a curved highway segment is just as likely to occur on the traveled way as off the traveled way. This section provides information on various effective countermeasures for addressing horizontal curve collisions. Working with safety practitioners is important in choosing the most effective approach.

Data

- In 2007, 28 percent of fatal crashes occurred along horizontal curves.
- Approximately 74 percent of curve-related fatal crashes were single-vehicle crashes, in which the vehicle left the roadway and struck a fixed object or overturned.
- Eleven percent of curve-related crashes were head-on.
- Fifty-three percent of fatal crashes at horizontal curves occurred in nondaylight conditions.

EXHIBIT III-37
Location of Fatal Crashes on Horizontal Curves by Roadway Classification



Source: FARS 2007.

Objective 1: Reduce the Likelihood of a Vehicle Leaving Its Lane and Crossing the Roadway Centerline or Leaving the Roadway on Horizontal Curves

Strategies

To reduce the likelihood of leaving the roadway on a curve, strategies should alert drivers to the presence of a curve and clearly delineate the roadway boundaries in the curve. In addition, engineering treatments may be implemented to make the roadway alignment and surface safer. Countermeasures for addressing curve-related crashes include the following:

- Provide advance warning of unexpected changes in horizontal alignment using "Curve" signs, pavement markings, or advisory speed signs (T, $);
- Enhance delineation along the curve with markers, such as chevrons, post-mounted delineators, lane lines, or edgelines (T, $);
- Provide adequate sight distance that is not less than the stopping sight distance (T, $ – assuming no redesign of vertical curvature);
- Install shoulder rumble strips to alert the driver that the vehicle is straying from the roadway (P, $);

See Exhibit III-28 for Crash Modification Factors for shoulder rumble strips.

See Exhibit III-29 for Crash Modification Factors for shoulder improvements.

See Exhibit III-34 for CrashModification Factors for centerline rumble strips.

- Install centerline rumble strips to alert the driver when a vehicle strays from its travel lane into oncoming traffic (T, $);
- Prevent edge drop-offs by retaining the shoulder at the same elevation as the travel lane or smoothing the transition between the traveled way and the shoulder (T, $ – assumed to be done at low cost as part of regular paving program);
- Provide skid-resistant pavement surfaces by adding overlays or microsurfacing (T, $$);
- Provide grooved pavement with longitudinal or transverse cuts to improve drainage and reduce wet-weather crashes (T, $$);

- Provide curve lighting (T, $$);
- Provide dynamic curve warning system, such as a radar device with a variable message sign listing the driver's speed and a message to drivers traveling at excessive speeds to slow down (T, $$);
- Widen travel lanes and shoulders or add shoulders or a buffer zone in the middle of the roadway (P, $$$);
- Improve or restore superelevation, which works with friction between the tires and the pavement to counteract cornering forces on the vehicle (P, $$$);

EXHIBIT III-38
Improve Curve Superelevation

Superelevation Deficiency (SD)	Crash Modification Factor
< 0.01	1.00
0.01 < SD < 0.02	1.00+6 (SD-0.01)
> 0.02	1.06+3 (SD-0.02)

Note: Crash Modification Factor applies to total crashes occurring on curved roadway segments. Crash Modification Factor applies to rural two-lane roads only.

- Modify horizontal alignment by increasing the radius of the curve, providing spiral transition curves that smooth the transition into and out of the curve, or eliminating compound curves (P, $$$$);
- Install automated anti-icing systems that pretreat the roadway surface with chemicals before precipitation occurs (T, $$$); and
- Prohibit/restrict trucks with very long semitrailers on roads with horizontal curves that cannot accommodate off-tracking, where the truck's rear wheels follow a track to the inside of the front axle path (T, $$$).

Objective 2: Minimize the Adverse Consequences of Leaving the Roadway at a Horizontal Curve

Strategies

If a vehicle leaves the roadway, strategies can be implemented to reduce the severity of a crash, which also are discussed under the ROR crash section, including:

- Design safer slopes and ditches to prevent rollovers (P, $$$), which comprise 42 percent of the most harmful events for fatal single-vehicle ROR crashes;
- Remove/relocate objects in hazardous locations, such as trees, poles, and signposts; or shield objects with breakaway devices or crash cushions (P, $);
- Delineate trees or utility poles with retroreflective tape to improve their visibility, so drivers stay on the road and "safer escape route" information is available to vehicles that leave the roadway (E, $);
- Add or improve the design of roadside hardware, such as bridge rails and guardrail ends (T, $$$); and
- Improve design and application of barrier and noise attenuation systems (T, $$$).

Resources

FHWA Roadway Departure Research and Resources web site:
http://safety.fhwa.dot.gov/roadway_dept/research/.

NCHRP Report 500 Volume 7: *A Guide for Reducing Collisions on Horizontal Curves:*
http://safety.transportation.org/guides.aspx.

Tree Collisions

Problem Description

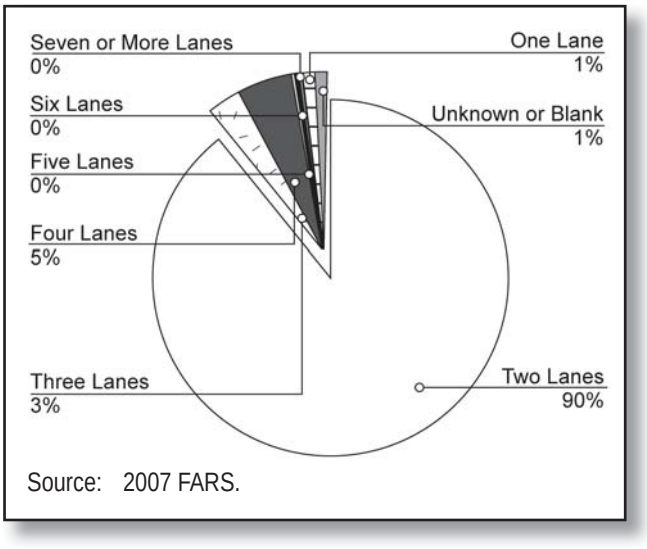
One of the most common causes of fatal and severe injury crashes on rural roads is vehicles leaving the road and striking a fixed object. Trees are the objects most commonly struck in ROR collisions, and tree impacts are generally quite severe. Tree crashes are strongly correlated with traffic volume, roadway geometry, and overall roadside condition. Planners play an important role because they can weigh transportation safety against landscaping and environmental considerations. They can determine the most effective strategies with the least negative impact on community appearance.

Data

- In 2007, over two-thirds of fatal tree crashes occurred on rural roads.
- Of all fatal tree crashes, 90 percent occur on two-lane roads and five percent on four-lane roads.
- For average daily traffic (ADT) categories of 1,000 vehicles per day or below, 22 to 24 percent of fixed-object crashes involve striking trees. This compares to 16 percent involving tree crashes for roads with ADTs of 1,000 to 4,000 vehicles per day, and 11 percent above 7,500 vehicles per day. Conversely, the percent of crashes involving utility poles, signs, and guardrails increases as ADT increases, which reflects the increased number of these roadside features on higher volume, generally higher-class roads (Zegeer et al., 1990).
- In 2007, 58 percent of fatal tree crashes occur under nondaylight conditions, which is significant given that much more traffic occurs in daylight hours.
- Forty-seven percent of fatal tree crashes occur on curved roads.

Strategies for keeping vehicles on the road are important for reducing head-on collisions. These are included in the section on Addressing Run-Off-Road Collisions. This section focuses on preventing trees from growing in hazardous

EXHIBIT III-39
Fatal Tree Crashes by Number of Travel Lanes
2007



Source: 2007 FARS.

locations, eliminating hazardous conditions, and reducing the severity of crashes.

According to the literature and a survey of DOTs in 14 states, the issue of tree management must be addressed by several transportation disciplines working together, including the following:

- Construction and maintenance engineers need to provide guidance on roadside flattening and tree removal as part of highway rehabilitation or reconstruction projects;
- Safety engineers need to identify cost-effective locations for tree removal safety enhancement projects; and
- Design engineers need to develop guidelines for construction of relatively flat sideslopes, clear roadside recovery areas, and landscaping plans.

Objective 1: Prevent Trees from Growing in Hazardous Locations

Strategies

To prevent placing trees in hazardous locations, the DOT, communities, and conservation groups can be encouraged to plant and grow trees only in areas that are considered reasonably safe. Strategies include:

- Develop, revise, and implement planting guidelines to prevent placing trees in hazardous locations along new and existing facilities (T, $); and
- Develop, revise, and implement mowing and vegetation control guidelines to control trees that grow naturally in hazardous locations (P, $).

Objective 2: Eliminate the Hazardous Condition and/or Reduce the Severity of the Crash

Strategies

Tree removal can be approached reactively to address trees that have a history of crashes or proactively to address trees with a high likelihood of being struck. Good data are critical to identify hazardous locations. A tree removal program needs to target a substantial sample of road sections each year to have any effect on the problem. Limiting the program to too few locations will not have a noticeable impact for a long time and may erode confidence in the program. Providing engineering treatments to shield drivers from striking trees is another approach to minimizing the impacts, although these treatments also may be struck by vehicles, resulting in less severe crashes. Strategies include the following:

- Remove trees in hazardous locations and ensure the roadside is free of stumps or deep depressions (P, $$);
- Provide guardrails to reduce crash severity by shielding motorists from striking trees (P, $$);

- Modify roadside clear zones in the vicinity of trees by implementing strategies, such as flattening sideslopes and adding shoulder improvements, so vehicles leaving the roadway can recover before striking a tree (P, $$$); and
- Delineate trees in hazardous locations using reflective stripes and other methods to make them more visible to drivers, if other strategies are not possible (E, $).

Best Practices

Caltrans Maintenance Manual, *Vegetation Control Plan,* Chapter C2: http://www.dot.ca.gov/hq/maint/manual/chc2(final).pdf.

Resources

NCHRP Report 500 Volume 3, *A Guide for Addressing Collisions with Trees in Hazardous Locations:* http://safety.transportation.org/guides.aspx.

Zeigler, 1986, *Guide to Management of Roadside Trees:* http://safety.transportation.org/htmlguides/trees/assets/GuideMgmtRoadSideTrees.pdf.

Utility Pole Collisions

Problem Description

Utility pole crashes involve vehicles leaving the travel lane and striking a utility pole. Utility poles represent one of the more substantial objects intentionally placed on roadsides, both in sheer number and in structural strength. Because of the structural strength and small vehicle contact area of utility poles, these crashes tend to be severe.

Utility pole crashes also can contribute to the severity of other crash types. Many crashes are not classified as ROR or fixed-object crashes, where one or more vehicles strike a utility pole. Crashes are often classified by "first harmful event." In some cases, striking the utility pole is a secondary event that may be as severe as the first event. Crashes involving utility poles as secondary events often go unnoticed. This section provides information on the various countermeasures that have been effective in addressing utility pole collisions. Working with safety practitioners is important in choosing the most effective approach.

EXHIBIT III-40
High-Speed Rural Road with Utility Poles Less Than 15 Feet from the Edge of the Outside of a Horizontal Curve

Source: NCHRP 500 Volume 8: A Guide to Reduce Collisions Involving Utility Poles.

Note: This site has experienced several utility pole crashes due to vehicles running off the road.

Data

- Forty percent of pole crashes involve some type of injury.
- One percent of pole crashes are fatal, and seven percent of injuries are incapacitating, according to 1999 GES data.
- Twelve percent of fatal pole crashes occurred in adverse weather conditions in 2007.
- One-third (34 percent) of fatal pole crashes occurred in full daylight in 2007.

Objective 1: Treat Specific Utility Poles in High-Crash and High-Risk Spot Locations

The first step for this set of strategies is to identify poles located in high-crash locations or locations where the risk of future pole crashes is high. Removal or relocation of utility poles must be done in cooperation with the utility companies, and those companies should be involved in program planning as early as possible. Ideally through a partnership with the utility company a policy can be developed to proactively guide the location of new poles to maximize safety. Strategies that address the location of utility poles, shielding drivers from utility poles, and reducing the severity of these crashes include:

- Remove poles in high-crash locations identified either reactively based on high numbers of crashes or proactively via safety audits (P, $ – assumes that individual poles are targeted as high risk);
- Relocate poles in high-crash locations farther from the roadway and/or to less vulnerable locations (P, $);
- Use breakaway devices, so vehicles pass through the pole, which does not require the vehicle to absorb as much energy and reduces crash severity (T, $$$);
- Shield drivers from poles in high-crash locations with guardrails, other roadside barriers, or crash cushions on the poles (P, $);
- Improve drivers' ability to see poles in high-crash locations with reflective taping if other strategies have been tried and failed (E, $); and
- Apply traffic calming measures to reduce speeds on high-risk sections, such as those listed under "Objective 3: Reduce the Speed of Motor Vehicles" in the section on "Pedestrian Collisions" (T, $$).

EXHIBIT III-41
Percent Reduction in Crashes for Moving Poles Farther from the Roadway

Expected Percent Reduction in Pole Crashes									
Pole Line Before Removal (feet)	Pole Line After Removal (Feet)								
	6	8	10	12	15	17	20	25	30
2	50	58	64	68	72	74	77	80	82
3	35	46	53	58	64	67	70	74	77
4	22	35	44	50	57	60	65	69	73
5	11	26	36	43	51	55	59	65	69
6	-	17	28	36	45	49	54	61	65
7	-	8	20	29	39	44	50	57	62
8	-	-	13	23	33	39	45	53	58
10	-	-	-	11	23	29	37	45	52
11	-	-	-	5	18	25	33	42	49
12	-	-	-	-	14	20	29	39	46
13	-	-	-	-	9	16	25	35	43
14	-	-	-	-	4	12	21	32	40
15	-	-	-	-	-	8	17	29	37

Source: Zegeer and Cynecki (1984).

Objective 2: Prevent Placing Utility Poles in High-Risk Locations

Strategy

- Develop, revise, and implement policies to prevent placing or replacing poles within the recovery area, which ensures each pole within the boundaries of a specific transportation project is reviewed to determine the level of risk to drivers and treated, if necessary (T, $).

Objective 3: Treat Several Utility Poles along a Corridor to Minimize the Likelihood of Crashing into a Utility Pole If a Vehicle Runs Off the Road

Strategies

Strategies designed to create a clear zone or improved recovery area along a corridor include the following:

- Place utilities underground if possible since urban utility poles also may have streetlights attached to them (P, $$$$);
- Relocate poles along the corridor farther from the roadway (10 feet or more from the curb) and/or to less vulnerable locations (P, $); and
- Decrease the number of poles along the corridor by increasing pole spacing, placing poles on one side of the street only, or by using poles for multiple purposes (P, $$$).

Best Practice

Washington State DOT policy on utility placement: http://www.wsdot.wa.gov/publications/manuals/fulltext/m22-86/UtilitiesAccommodationPolicy.pdf.

Resource

NCHRP Report 500 Volume 8: *A Guide for Reducing Collisions Involving Utility Poles:* http://safety.transportation.org/guides.aspx.

TRB State of the Art Report 9: Utilities and Roadside Safety: http://onlinepubs.trb.org/onlinepubs/sar/sar_9.pdf.

Occupant Protection

Problem Description

This section addresses increasing the proper use of safety belts; child safety seats, including infant carriers and booster seats; and motorcycle helmets. When mandatory safety belt use laws were enacted in most states in the 1980s, they usually differed from most other traffic laws in one specific aspect: a police officer could not stop a vehicle if the only visible

violation was failure to use a safety belt. The officer could take enforcement action only if unrestrained passengers were identified following a traffic stop for some other purpose. This type of law is generally referred to as "secondary enforcement." While secondary enforcement has been successful in raising restraint use, permitting standard, or primary, enforcement has produced generally higher use rates.

"It would be impossible to overstate the lifesaving and dollar-saving impact of increases in safety belt use."[10] The single most effective strategy for improving occupant restraint use rates is enactment of standard enforcement laws in all states, and all secondary law states with support from NHTSA are working toward this goal. The focus here, however, is on what can be accomplished by single agencies or local coalitions. While use rates have steadily increased, the rate of increase has slowed. The "easy" converts to restraint use have buckled up. The challenge now is to increase restraint use among those who have not yet been convinced by educational or enforcement messages.

While laws prove helpful in increasing occupant restraint use, the laws alone are not sufficient. The public must be made aware of the law and have a reasonable expectation that the laws will be enforced.

Raising national use rates to higher levels will save lives, reduce injuries, and produce significant economic benefits. Other studies have shown that those with the highest crash risk (generally young male drivers from less educated and lower socioeconomic levels) also are those with the lowest restraint use rates. Therefore, even though the increases in percent use will be smaller, the potential savings in both lives and economic loss can be proportionately higher.

EXHIBIT III-42
Safety Belt Use Rates by State
2006 and 2007

State	2006	2007	State	2006	2007
Alabama	82.9%	82.3%	Montana	79.0%	79.6%
Alaska	83.2%	82.4%	Nebraska	76.0%	78.7%
Arizona	78.9%	80.9%	Nevada	91.2%	92.2%
Arkansas	69.3%	69.9%	New Hampshire	63.5%	63.8%
California	93.4%	94.6%	New Jersey	90.0%	91.4%
Colorado	80.3%	81.1%	New Mexico	89.6%	91.5%
Connecticut	83.5%	85.8%	New York	83.0%	83.5%
Delaware	86.1%	86.6%	North Carolina	88.5%	88.8%
Dist. of Columbia	85.4%	87.1%	North Dakota	79.0%	82.2%
Florida	80.7%	79.1%	Ohio	81.7%	81.6%
Georgia	90.0%	89.0%	Oklahoma	83.7%	83.1%
Hawaii	92.5%	97.6%	Oregon	94.1%	95.3%
Idaho	79.8%	78.5%	Pennsylvania	86.3%	86.7%
Illinois	87.8%	90.1%	Rhode Island	74.0%	79.1%
Indiana	84.3%	87.9%	South Carolina	72.5%	74.5%
Iowa	89.6%	91.3%	South Dakota	71.3%	73.1%
Kansas	73.5%	75.0%	Tennessee	78.6%	80.2%
Kentucky	67.2%	71.8%	Texas	90.4%	91.8%
Louisiana	74.8%	75.2%	Utah	88.6%	86.8%
Maine	77.2%	79.8%	Vermont	82.4%	87.1%
Maryland	91.1%	93.1%	Virginia	78.7%	79.9%
Massachusetts	66.9%	68.7%	Washington	96.3%	96.4%
Michigan	94.3%	93.7%	West Virginia	88.5%	89.6%
Minnesota	83.3%	87.8%	Wisconsin	75.4%	75.3%
Mississippi	73.6%	71.8%	Wyoming	63.5%	72.2%
Missouri	75.2%	77.2%	Puerto Rico	92.7%	92.1%

Source: NHTSA. Rates in states and territories are from surveys conducted in accordance with Section 157, Title 23, U.S. Code.

Child restraints have been found effective in reducing the risk of death and injury to infants and children. However, crashes continue to occur in which apparently restrained children are being injured and killed, largely due to improper use of restraint systems. The issue to be addressed then is ensuring their proper use.

Planners understand the limits on resources for transportation infrastructure improvements. Given that not every roadway will be able to undergo all the safety improvements that may be desired, the most effective strategy to reduce death and serious injury on the roadways is to ensure that all persons in a vehicle are wearing safety belts. Planners can help communicate the messages that work to change the culture of safety and people's

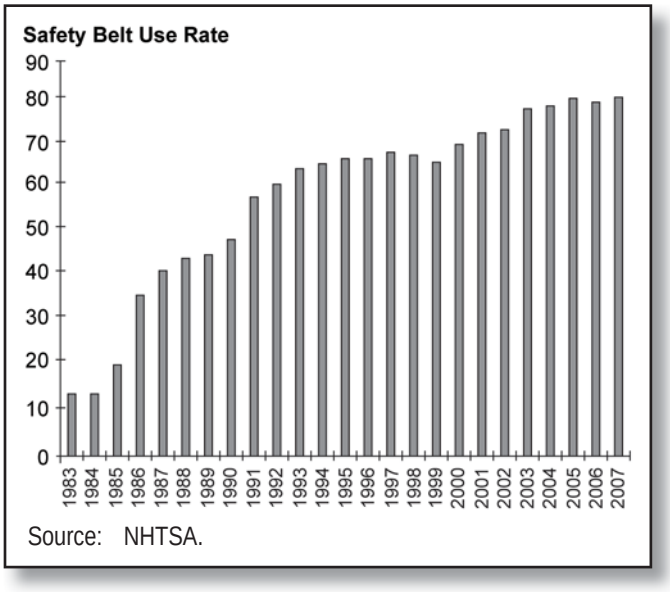
[10] Former NHTSA Administrator Jeffrey W. Runge, M.D. in a November 17, 2003 news release.

behavior must be done in tandem with roadway safety improvements. Improving safety belt compliance by just a few percent would save many lives.

Data

- Of passenger vehicle occupant fatalities, 54 percent were unrestrained in 2007.
- Two-thirds of pickup truck drivers killed in crashes were unrestrained in 2007.
- In 2007, on a national level, safety belt use was 82 percent, with 32 states and the District of Columbia exceeding 80 percent.
- As of July 2008, 26 states and the District of Columbia had primary safety belt laws in place, and only one state (New Hampshire) lacked a mandatory use law for those over age 18.
- In 2007, restraint use varied by state from 64 percent (New Hampshire) to 95 percent or higher (California, Hawaii, Oregon, and Washington).
- Research has found that when lap/shoulder seat belts are used, the risk of fatal injury to front-seat passenger car occupants is reduced by 45 percent and the risk of moderate to critical injury by 50 percent (NHTSA).
- Seventy-three percent of child seats were misused according to a 2004 study by NHTSA.

EXHIBIT III-43
Safety Belt Use Rates
1983-2007



Source: NHTSA.

Objective 1: Initiate Programs to Maximize the Use of Occupant Restraints by All Vehicle Occupants

Strategies

Large-scale enforcement of safety belt laws is critical to demonstrate to the public that failure to wear a safety belt is breaking the law. Past work in this area has shown enforcement must be complemented with public information and education campaigns to be effective. Strategies include:

- Conduct highly publicized enforcement campaigns to maximize restraint use, such as the national model "Click it or Ticket" campaign that uses checkpoints and a massive media campaign (P, $$);
- Provide enhanced public education to population groups with lower than average restraint use rates, and gain support by group leaders prior to implementation of education programs (P, $); and
- Encourage the enactment of local laws that permit local primary enforcement of restraint laws in states without primary safety belt laws (T, $).

Objective 2: Ensure Restraints, Especially Child and Infant Restraints, Are Properly Used

Strategies

In most cases, child and infant seats are used improperly out of ignorance. To ensure parents and caregivers use child and infant restraints properly, education and inspections can be conducted through several forums. Strategies include the following:

- Provide community locations for instruction in proper child restraint use that are almost always available (e.g., public safety agencies and health care providers) (T, $);
- Conduct high-profile child-restraint inspection events at multiple community locations with an emphasis on education versus enforcement (P, $); and
- Train law enforcement personnel to check for proper child restraint use in all motorist encounters (T, $$).

Objective 3: Provide Access to Appropriate Information, Materials, and Guidelines for those Implementing Programs to Increase Occupant Restraint Use

Strategy

Create a state-level clearinghouse for materials on programs to increase restraint use that organizes and catalogues the range of materials available (E, $$).

Best Practices

Summary of the State of California's highly regarded car seat law:
http://www.carseat.org/Legal/6_sum_CA_Law.pdf.

Hoffman Estates, Illinois ordinance permitting local primary enforcement of safety belt use:
http://safety.transportation.org/htmlguides/site_map/default.htm.

Resources

NCHRP Report 500 Volume 11: *A Guide for Increasing Seatbelt Use:*
http://safety.transportation.org/guides.aspx.

Countermeasures that Work: A Highway Safety Countermeasure Guide for State Highway Safety Offices, Governors Highway Safety Association (2009): http://www.ghsa.org/html/publications/index.html#countermeasures.

AAA: http://www.aaafoundation.org/products/index.cfm.

NHTSA Occupant Protection Program:
http://www.nhtsa.dot.gov/portal/site/nhtsa/menuitem.cda13865569778598fcb6010dba046a0/.

Heavy Truck Collisions

Problem Description

In 2006, large trucks accounted for four percent of all registered vehicles and seven percent of total VMT. Combination-unit trucks were found to have a markedly different crash involvement profile than vehicles in general (Wang et al., 1999), given their high-mileage exposure and the severity of their crashes. Overall, the quantitative crash experience for single-unit large trucks (straight trucks) on an individual vehicle level is more similar to light vehicles than to combination-unit trucks.

The GES system data for 1999 provides data on the "critical event" that made a crash imminent, as shown in Exhibit III-44. There are two kinds of critical events: 1) those associated with the truck; and 2) those associated with the other vehicle, person, or object. A preliminary report from the FMCSA/NHTSA Large-Truck Crash Causation Study shows the critical event preceding a crash between a heavy truck and light vehicle was a truck driver action in 29 percent of crashes and an action of the other driver in 60 percent of crashes. The remaining 11 percent were associated with the roadway, weather, truck vehicle failure, other vehicle failure, or other/unknown events.

When other vehicles dart in front of and around heavy trucks, truck drivers may be forced to take avoidance measures that, in turn, may cause problems with controlling the truck. Of particular concern is the area around the truck that has been referred to as the "No-Zone." This space is especially dangerous for passenger vehicles, because it includes driver blind spots, as well as space required for the truck to decelerate. The "No-Zone" area includes the areas:

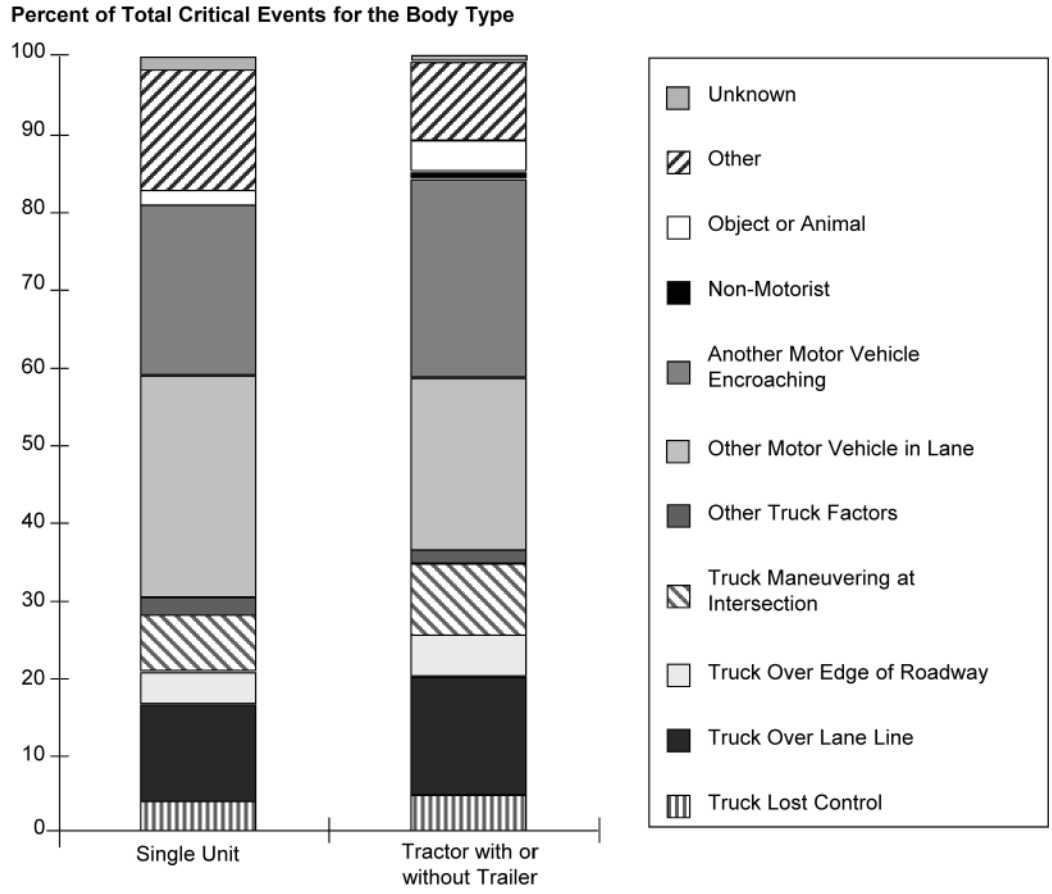
- Immediately behind the large truck and within its same lane;
- Immediately in front of the large truck and within its same lane;
- To the left of the large truck, adjacent to the cab and in the adjoining lane; and
- To the right of the large truck, behind the cab and in the adjoining lane.

An analysis of two-vehicle crashes involving a large truck and a passenger vehicle found 35 percent of the crashes involved the passenger vehicle moving into the No Zone. A driver of a passenger car will know they are in the "No Zone" if the driver cannot see the head of the truck driver through a window or mirror.

According to analysis of a Michigan program called Fatal Accident Complaint Team (FACT) that investigated trucks involved in fatal crashes, 66 percent of trucks had at least one out-of-service (OOS) violation by either the truck driver or the truck. Although high rates of vehicle defects, including OOS problems, are found in heavy trucks in general, large trucks in crashes have higher rates of vehicle defects related to the types of crashes involved.

The split of crashes between minor and principal facilities is about equal, which indicates the likelihood that at least one-half of crashes are occurring on nonstate highways. The majority of heavy-truck crashes occur on two-lane roads. This section provides information on effective countermeasures for addressing heavy truck collisions. Working with safety practitioners is important in choosing the most effective approach.

EXHIBIT III-44
Critical Event for Crashes Involving Single-Unit and Tractor Trucks



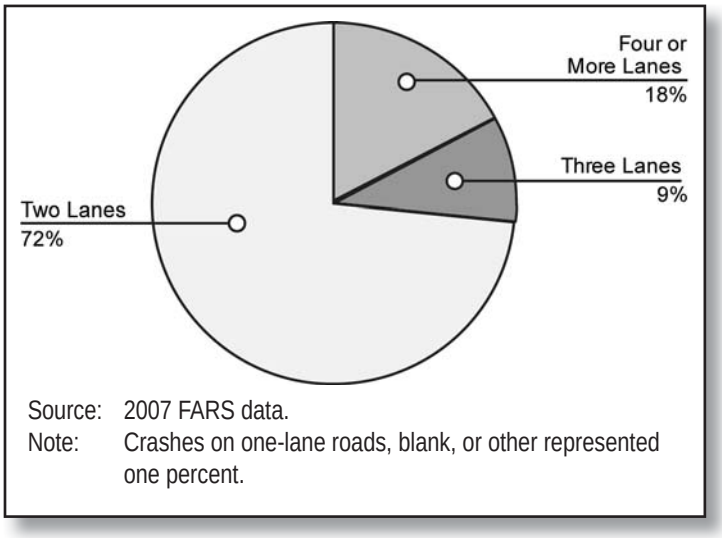
Source: GES 1999.

Note: For medium and heavy weight >4,536 kg GVWR.

Data

- In 2007, large trucks accounted for eight percent of vehicles involved in fatal motor vehicle crashes.
- One out of nine traffic fatalities in 2007 resulted from a collision involving a large truck.
- Of the fatalities resulting from crashes involving large trucks, 75 percent were occupants of another vehicle, 8 percent were nonoccupants, and 17 percent were occupants of a large truck.

EXHIBIT III-45
Number of Travel Lanes for Fatal Crashes Involving Trucks



Source: 2007 FARS data.
Note: Crashes on one-lane roads, blank, or other represented one percent.

- In crashes between large trucks and passenger vehicles, passenger vehicle driver errors or other factors are twice as likely to be cited as truck driver errors or other factors (FHWA, 1999; Blower, 1999).
- Sixty-three percent of fatal heavy-truck crashes occurred on rural roads and 37 percent occurred on urban facilities in 2007.
- Seventy-two percent of fatal crashes involving trucks occurred on two-lane roads in 2007.

Objective 1: Reduce Fatigue-Related Crashes

Strategies

A major problem for many truck drivers is finding a place to stop and rest at night, as well as during the day. The inadequate number and quality of public rest stops contributes to fatigue for the nation's truck drivers. Strategies include:

- Increase efficiency of existing truck parking spaces at rest areas by providing improved information on space availability to truckers, such as variable message signs before an exit (E, $);
- Create additional parking spaces at rest areas, including allowing trucks to use spaces for private vehicles during nighttime hours when they are often underutilized (T, $$); and
- Incorporate rumble strips into new and existing roadways to help maintain driver alertness (N/A, $$).

Objective 2: Strengthen the Commercial Driver's License (CDL) Program

Strategies

The need to strengthen the CDL program has been recognized. In particular, it is critical that all states achieve parity in their adherence to Federal requirements because a CDL from one state allows a driver to operate in any other state, and heavy trucks typically operate across state lines. Strategies include:

- Improve test administration for the CDL, such as offering computerized tests (T, $); and
- Increase fraud detection of state and third-party testers to ensure interstate reporting of infractions and reduce fraudulent license issuing (T, $).

Objective 3: Increase Knowledge about Sharing the Road

Strategies

Drivers of private vehicles are twice as likely to be cited for driver error in crashes involving heavy trucks and private vehicles than truck drivers. In one study analyzing critical incidents involving the interaction of large trucks and light vehicles, the most common errors were lane changes without sufficient gaps, entrance onto the roadway without adequate clearance to the trailing truck, left turns without adequate clearance to the trailing truck, and late braking for stopped or stopping traffic. More than three-quarters of such incidents were attributed to drivers of light vehicles in the vicinity of trucks. Clearly, the driving public needs to improve its driving practices in the vicinity of large trucks. Strategies include:

- Incorporate information from the "Share the Road Safely" campaign developed by FMCSA and its partners into driver education materials, such as those developed by the American Driver and Traffic Safety Education Association (T, $); and
- Disseminate "Share the Road Safely" information developed by FMCSA and its partners via the media, including public service announcements (T, $).

Objective 4: Improve Maintenance of Heavy Trucks

Strategies

The extent to which vehicle mechanical defects constitute a direct causal or severity-increasing factor is difficult to assess. Nevertheless, one study[11] showed that truck brake, tire, and other mechanical defects contribute "substantially" to truck crashes. Strategies include:

[11] Blower, 2002.

- Increase and strengthen truck maintenance programs and inspections, which are largely supported by the Motor Carrier Safety Assistance Program (MCSAP) funding to states (N/A, $$$); and
- Conduct post-crash inspections to identify major problems and conditions that will contribute to a body of state-specific data to enhance overall truck safety efforts (E, $$$).

Objective 5: Identify and Correct Unsafe Roadway Infrastructure and Operational Characteristics

Strategies

Trucks have higher centers of gravity and are vulnerable to rollovers in certain locations. Additionally, the greater heights of the vehicles are associated with lower perceived vehicle speeds[12] by drivers. Therefore, warning signs of high-risk areas can be useful to truck drivers. Strategies include:

- Identify and treat high truck crash roadway segments with methods such as signing to alert drivers and modify their driving (E, $);
- Install interactive truck rollover signing that uses weight and speed detectors and flashes a warning sign for trucks assessed to be at rollover risk, located at high-risk locations such as highway ramps or curves (P, $$); and
- Modify speed limits and increase enforcement to reduce truck and other vehicle speeds at dangerous locations, such as curves and steep downgrades (T, $$).

Objective 6: Improve and Enhance Truck Safety Data

Strategy

Trucks cross state lines much more often than other vehicle traffic. Averaging almost 65,000 miles annually, combination trucks travel through many jurisdictions and consequently may incur violations in multiple districts. A primary purpose of the CDL is to limit a driver to a single license and to establish a reporting system that compiles a single record incorporating data from all jurisdictions where infractions or crashes occur. Because of truck speed and distance covered, for data to be useful, they must be complete, accurate, and available rapidly.

- Increase the timeliness, accuracy, and completeness of truck safety data through models, such as the Vehicle Safety Inspection System (VSIS) within the Traffic and Criminal Software (TraCS) program or the U.S. DOT-developed ASPEN program (N/A, $$$).

[12] Rudin-Brown.

Objective 7: Promote Industry Safety Initiatives

Strategies

Enforcement strategies are intended to ensure that all motor carriers and drivers comply with certain fundamental safety requirements. However, punishment is not the only way to stimulate safety-related changes in the motor carrier industry. Educational approaches complement enforcement and can address safety practices not related to compliance. Strategies include:

- Perform safety consultations with carrier safety management (P, $$$); and
- Promote development and deployment of truck safety technologies (E, $$$).

Best Practices

Maryland has a preventive maintenance program for trucks that is among the most stringent in the nation. Maryland commercial vehicle operators are required to regularly inspect their vehicles, maintain paperwork, and prove compliance in a manner far more detailed than Federal law. Information on the preventive maintenance program is located at: http://www.mdot.state.md.us/MMCP/PMProgram.html.

Iowa TraCS: Traffic and Criminal Software is a national model for using new technologies for improving data collection and analysis (http://www.iowatracs.us/).

Tennessee Department of Safety Alternative Commercial Enforcement Strategies uses specially trained officers to visit fleets in an advisory rather than enforcement approach (http://www.state.tn.us/safety/CVE/ACES.html).

Michigan Center for Truck Safety offers free and low-cost training and consultation to truck drivers and carrier safety managers (http://www.truckingsafety.org/).

FMCSA offers their Safety is Good Business Program (http://www.fmcsa.dot.gov/safety-security/good-business/index.htm).

Resources

NCHRP Report 500 Volume 13: *A Guide for Reducing Collisions Involving Heavy Trucks:* http://safety.transportation.org/guides.aspx.

Share the Road Safely: http://www.sharetheroadsafely.org.

American Driver and Traffic Safety Education Association (ADTSEA): http://adtsea.iup.edu/adtsea/.

Motor Carrier Safety Assistance Program: http://www.fmcsa.dot.gov/safety-security/safety-initiatives/mcsap/mcsap.htm.

Motorcycles

Problem Description

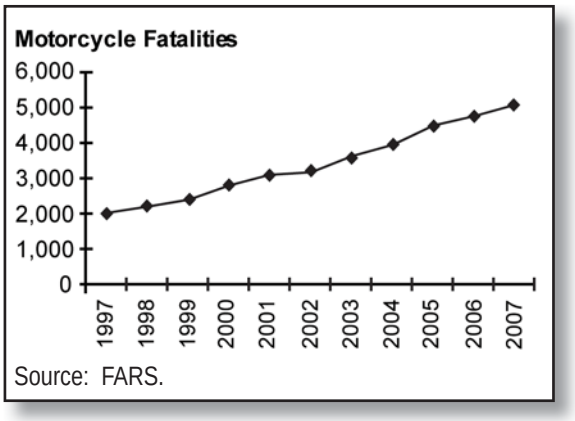
Motorcycling provides a gas saving alternative to driving and the joy of operating a powered two wheeled vehicle. However, operating a motorcycle requires a much greater level of finesse and skill than operating an automobile, or even a bicycle.

Motorcyclists are about 35 times more likely to die in a crash than someone riding in a passenger car, and eight times more likely to be injured (NHTSA). Motorcycle fatalities have more than doubled since 1997, accounting for 13 percent of all traffic fatalities in 2007 (FARS).

Creating a motorcycle-friendly environment includes:

- Keeping the roadway free of foreign debris;
- Providing a safe roadside free of obstacles to motorcyclists;
- Maintaining safe roadway surfaces and proper signage during maintenance projects; and
- Providing sufficient warning devices to motorcyclists prior to encountering potentially dangerous zones.

EXHIBIT III-46
Motorcycle Fatalities
1997-2007



Source: FARS.

Behavioral issues are major factors in motorcycle safety. Alcohol-related fatalities among motorcyclists are proportionally higher than in any other motor vehicle group. Speeding is more common among motorcyclists than drivers of passenger vehicles. Helmets are the single most important piece of equipment for motorcyclists' safety, but helmets are not required in all states and their use has been declining. Furthermore, safe (FMVSS 218- compliant) helmets often are not used in those states with helmet laws; as a result, the users of "fake" helmets experience increased injury. Operation of a motorcycle requires specialized training and licensing in all 50 states, yet a significant proportion of riders involved in motorcycle crashes are unlicensed.

Data

- Motorcycle fatalities rose seven percent from 4,837 in 2006 to 5,154 in 2007. 103,000 motorcyclists were injured in 2007.
- Forty-one percent of motorcyclists killed in a crash were not wearing a helmet, according to 2007 FARS data.
- The National Occupant Protection Use Survey (NOPUS) has shown that usage of FMVSS 218[13] compliant helmets declined from 71 percent in 2000 to 58 percent in 2007.

[13] The National Highway Traffic Safety Administration (NHTSA) has developed and enforces Federal Motor Vehicle Safety Standard 218 (FMVSS 218), which provides minimum performance requirements for helmets designed for use by motorcyclists.

- Helmets are estimated to be 37 percent effective in preventing fatal injuries to motorcyclists. This means that for every 100 motorcyclists killed in crashes while not wearing a helmet, 37 of them could have been saved had all 100 worn a helmet.
- One-half of all fatal motorcycle crashes are single-vehicle crashes versus 44 percent of all motor vehicle crashes, according to 2007 FARS data.
- Speed is a contributing factor in 36 percent of fatal crashes involving motorcycles, compared to 24 percent for drivers of passenger cars and 19 percent for drivers of light trucks (FARS 2007).
- One-fourth (26 percent) of motorcycle operators involved in a fatal collision did not have a valid license at the time of collision in 2007. Typically, riders who are operating a motorcycle with an invalid license are actually operating a vehicle "out of class," meaning that the rider has an automobile license but the license is not lawfully endorsed for motorcycle operation.
- Nearly one-half (49 percent) of motorcyclist fatalities involved riders age 40 or older in 2007, compared to 33 percent of fatalities involving this age group in 1997.

Objective 1: Reduce the Number of Motorcycle Crashes by Incorporating Motorcycle-Friendly Roadway Design, Traffic Control, Construction, and Maintenance Policies and Practices

Strategies

Shoulders to accommodate roadside recovery and breakdown are desirable for all vehicle types including motorcyclists. Selection of roadside hardware and pavement marking material should also consider motorcycle safety as well as other vehicle types. Pavement that is not maintained, grooved, or uneven, particularly in work zones, presents a significant risk to motorcyclists. Signage alerting motorcycles to uneven pavement and low-traction pavement markings is helpful. Additionally, roadway debris poses a greater problem for motorcycles than for larger vehicles. Strategies include:

- Provide fully paved shoulders to accommodate roadside motorcycle recovery and breakdowns (T, $$$$);
- When considering roadside barriers ensure that the type selected improves safety for motorcycles as well as other vehicle types (E, $$$);

See Exhibit III- 29 for Crash Modification Factors for shoulder width and type.

- Replace low-traction pavement markings, surface materials, and other treatments with high-traction material (T, $$$);
- Maintain the roadway to minimize surface irregularities and discontinuities (T, $);
- Maintain roadway surfaces in work zones to facilitate safe passage of motorcycles (T, $);
- Reduce debris from the roadway and roadside such as gravel, shorn treads, snow and ice control treatments (sand/salt), and debris resulting from uncovered loads (T, $$$);

- Provide warning signs to alert motorcyclists of low-traction and irregular roadway surfaces (T, $$$);
- Incorporate motorcycle safety considerations into routine roadway inspections (E, $); and
- Provide a mechanism for road users to notify highway agencies of roadway conditions that present a potential problem for motorcyclists (E, $$).

Objective 2: Reduce the Incidence of Rider Impairment on the Highway

Strategies

Motorcycles require a greater level of finesse and skill to operate than automobiles, small trucks, and bicycles in traffic. Anything that impairs that concentration, coordination, and judgment can potentially be fatal. Strategies include:

- Increase motorcyclist awareness of the risks of impaired motorcycle operation (T, $);
- Expand existing impairment prevention programs to include motorcycle riders and specific motorcycle events (T, $); and
- Target law enforcement to specific motorcycle rider impairment behaviors that have been shown to contribute to crashes (T, $).

Objective 3: Reduce the Number of Unlicensed and Untrained Motorcycle Riders on the Highway

Strategies

Motorcycle licensing programs and requirements for testing are in place in all states and the District of Columbia. Licensing components include a special motorcycle operator's manual, knowledge test, skills test, learner's permit, and license endorsement.[14] In many states, licensing programs are waived for completion of a state-approved motorcycle rider training course. Strategies include:

- Increase awareness of the causes of crashes due to unlicensed or untrained motorcycle riders (E, $);
- Ensure licensing and rider training programs adequately measure skills and behaviors required for crash avoidance (T, $); and
- Identify and remove barriers to obtaining the training or testing required for a motorcycle endorsement.(T, $).

[14] An endorsement is a notation on a driver's license indicating a person has met the requirements for operating a motorcycle.

Objective 4: Increase the Visibility of Motorcyclists

Strategies

A common complaint of motorcyclists is that passenger car drivers often do not see them and, as a result, violate the motorcyclists' right-of-way. It is incumbent upon motorcyclists to recognize how visibility issues affect their safety and to prepare accordingly. Strategies include:

- Increase the awareness of the benefit of high-visibility clothing in bright colors with retroreflective material (E, $); and
- Identify and promote visibility-enhancement methods and technology such as improved headlights and brake lights (T, $).

Objective 5: Reduce the Severity of Motorcycle Crashes

Strategies

If a motorcycle crash occurs, protective gear can make the difference between life and death. When worn, FMVSS 218-compliant helmets are estimated to be 37 percent effective in preventing fatalities in crashes. Strategies include:

- Increase the use of FMVSS 218-compliant helmets (P, $$); and
- Increase awareness of the benefit of protective clothing such as garments of leather or ballistic nylon with body padding or armor (T, $$).

Objective 6: Increase Motorcycle Rider Safety Awareness

Strategies

Motorcycle riding/driving is significantly more risky than driving or riding in a car. Rider education should include not only skills training, but also a discussion of the potential consequences of unsafe and aggressive riding. Safety behavior and awareness are major factors in many motorcycle crashes. Motorcycle rider safety awareness strategies include:

- Increase awareness of the consequences of aggressive riding, riding while fatigued or impaired, and unsafe riding of large, powerful motorcycles (T, $$);
- Educate operators of other vehicles to be more conscious of the presence of motorcyclists (T, $).

Objective 7: Increase Safety Enhancements for Motorcycles

Strategy

Many advances are being made with Intelligent Transportation Systems (ITS), but often the technology is developed without considering motorcycles in the design. For example, traffic management strategies frequently employ the use of sensors embedded in the pavement; however, these sensors often cannot detect the presence of a motorcycle. The key strategy is:

- Include motorcycles in the research, development, and deployment of ITS (E, $$$).

Objective 8: Improve Motorcycle Safety Research, Data, and Analysis

Strategies

Motorcycles are often overlooked during crash data gathering efforts. The frequency of motorcycle crashes is considerably lower than the frequency of automobile crashes; therefore, motorcycle crash data analysis is often limited to the evaluation of rider compliance with legislated safety measures (e.g., helmets, licensing). To improve the ability to develop effective motorcycle strategies improved data collection is needed. Strategies include:

- Develop and implement standardized data gathering and reporting for motorcycle crashes in cooperation with law enforcement agencies (N/A, $$);
- Include motorcycle attributes in vehicle exposure data collection programs (N/A, $$$); and
- Develop a set of analysis tools for motorcycle crashes (N/A, $$$).

Other Strategies

While not included in the 500 series guides, the following strategies from the FHWA Office of Safety are accepted safety practices: (For more information see http://safety.fhwa.dot.gov/mac/)

- Fix or remove surface irregularies, such as railroad crossings, utility covers, potholes, and road/shoulder resurfacing locations where pavement edges make for unsafe motorcycle travel (Objective 1);
- Install motorcycle-friendly rumble strips (Objective 1);
- Remove roadside hazards (Objective 1; see section on Run-off-Road Collisions);
- Raise awareness and provide training for law enforcement on cues that a motorcyclist may be impaired; (Objective 2);
- Improve enforcement of motorcycle-related laws, such as helmet and licensing laws (Objective 3); and
- Increase motorcycle safety education at state licensing facilities, motorcycle dealers, and other venues (Objective 3).

Best Practices

Examples of cities that have implemented pothole hotlines and Internet-based notification systems include:

- St. Louis, Missouri: http://stlcin.missouri.org/csb/csb2.cfm?CategoryId=48; and
- Seattle, Washington: http://www.cityofseattle.net/transportation/potholereport.htm.

Wisconsin Motorcycle Safety Program materials, including *Motorcycle Safety Action Plan 2004:* http://www.dot.wisconsin.gov/safety/vehicle/motorcycle/.

A Motorcycle Safety Advisory Board has served Washington State since 1982. Information is available at: http://apps.leg.wa.gov/RCW/default.aspx?cite=46.20.520.

Massachusetts tips for sharing the road with motorcyclists: http://www.mass.gov/rmv/motorcycle/tips.htm.

Wisconsin has linked motorcycle crash information with hospital information to determine the impact of helmet use and alcohol consumption on motorcycle crashes:

http://www.chsra.wisc.edu/codes/motorcycle_crash_information.htm.

The Minnesota Motorcycle Safety Program provides training and education, rider testing and licensing, free safety materials, and public safety announcements:

http://www.motorcyclesafety.state.mn.us.

Resources

NCHRP Report 500: *A Guide for Addressing Collisions Involving Motorcycles:* http://safety.transportation.org/guides.aspx.

The National Agenda for Motorcycle Safety, NHTSA and Motorcycle Safety Foundation: http://www.nhtsa.dot.gov/PEOPLE/injury/pedbimot/motorcycle/00-NHT-212-motorcycle/toc.html.

NHTSA Motorcycle Safety Program, January 2003: http://www.nhtsa.dot.gov/portal/site/nhtsa/menuitem.d7975d55e8abbe089ca8e410dba046a0/.

NCHRP Report 486: *Systemwide Impact of Safety and Traffic Operations Design Decisions for Resurfacing, Restoration, or Rehabilitation (RRR) Projects:* http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_486_full.pdf.

The National Association of State Motorcycle Safety Administrators (SMSA) samples of campaigns, advertisements, billboards, posters, brochures and bumper stickers to reduce impaired riding: http://www.smsa.org/motorcycle_awareness/promotional_materials/.

The Motorcycle Safety Foundation (MSF) free PSA materials: http://msf-usa.org.

Current status of motorcycle helmet legislation is summarized by the Insurance Institute for Highway Safety: http://www.iihs.org/laws/HelmetUseCurrent.aspx.

Costs of Injuries Resulting from Motorcycle Crashes: A Literature Review, 2003, National Highway Traffic Safety Administration: http://www.nhtsa.dot.gov/people/injury/pedbimot/motorcycle/Motorcycle_HTML/appa.html.

Governors Highway Safety Administration, Survey of the States: Motorcycle Safety Programs (2008): http://www.ghsa.org/html/publications/survey/survey_ofthe_states.html.

Work Zone Collisions

Problem Description

The safe and efficient flow of traffic through work zones is a high priority for transportation officials and the motoring public. Work zones are estimated to contribute 10 percent of all congestion in the United States. According to the FHWA, as congestion builds within and approaching work zones, crash rates increase. Additionally, the safety of workers in work zones is of primary importance. Roadway workers are killed at a rate nearly three times as high as other construction workers and eight times higher than general industry workers.

The need for continued focus on work zone safety becomes more apparent because of the current emphasis on system preservation rather than construction of new facilities. In 2000, the share of capital funds used for system preservation was 52 percent and this percentage is expected to continue to rise. Thirteen percent of the National Highway system is under construction each year, during the peak summer work season (Wunderlich and Hardesty, 2003). This section provides information on effective countermeasures for addressing work zone collisions. Working with safety practitioners is important in choosing the most effective approach.

Data

- In 2007, half of all fatal work zone crashes occurred during daylight.
- Thirty percent of work zone fatal crashes occurred on either urban or rural Interstates.
- Overall, slightly more fatal crashes occurred in urban work zones than in rural work zones.
- Sixty-one percent of work zone fatal crashes occurred on roads with a posted speed limit of 55 mph or greater.
- Single-vehicle crashes accounted for one-half of all work zone fatal crashes in 2007.
- Heavy trucks were involved in nearly one-fourth (24 percent) of fatal work zone crashes.
- Alcohol was involved in 36 percent of work zone fatalities in 2007 (National Work Zone Safety Information Clearinghouse).

Objective 1: Reduce the Number, Duration, and Impact of Work Zones

Strategies

Reducing the number of work zones and the length of time work zones are set up will reduce the exposure of drivers and workers to crashes. Strategies include:

- Improve maintenance and construction practices to accelerate construction and manage assets better (P, $$$);

- Utilize full-time roadway closure for construction operations to complete work faster, more cost-effectively, and more safely (T, $);
- Utilize time-related contract provisions to ensure construction schedules are as efficient as possible (P, $$);
- Use nighttime road work so work is conducted during less heavily trafficked periods and exposure is reduced (P, $);
- Use demand management programs, such as carpooling, vanpooling, and transit, to reduce volume through work zones (P, $$$); and
- Design future work zone capacity into new or reconstructed highways and make work zone considerations an explicit tradeoff on decision-making for new construction and reconstruction (T, $$$$).

Objective 2: Improve Work Zone Traffic Control Devices

Strategies

Traffic control devices are used to communicate with drivers in advance of and within work zones. It is important to inform the driver of the desired actions and the correct path through the work zone. ITS also can be used to inform drivers of delays and alternative routes. Strategies include:

- Implement ITS strategies to improve safety (E, $$);
- Improve visibility of work zone traffic control devices (T, $$); and
- Improve visibility of work zone personnel and vehicles (varies, $$).

EXHIBIT III-47
Type III Barricade Spaced at Intervals in Closed Lane to Reduce Intrusion Risk

Source: NCHRP 500 Volume 17: A Guide for Reducing Work Zone Collisions.

Objective 3: Improve Work Zone Design Practices

Strategies

Changes in the basic approach to designing work zones may offer opportunities for improved safety:

- Establish work zone design guidance on topics, such as lane transitions, lane widths, and edge drop-offs (T,$);
- Implement measures to reduce work space intrusions and limit the consequences of intrusions (T, $$$); and
- Improve work zone safety for pedestrians, bicyclists, motorcyclists, and heavy-truck drivers (T, $$$).

Objective 4: Improve Driver Compliance with Work Zone Traffic Controls

Strategies

Frequent and visible enforcement is generally accepted as highly effective in gaining compliance with traffic laws and regulations in work zones. The physical presence of a law enforcement officer in the work zone is the most effective way to maximize compliance. Strategies include:

- Enhance enforcement of traffic laws in work zones (T, $$), including automated enforcement;
- Improve credibility of signs (E, $) by ensuring they are updated to reflect actual conditions and are informative; and
- Improve application of increased driver penalties in work zones (T, $).

Objective 5: Increase Knowledge and Awareness of Work Zones

Strategies

Public information and education campaigns can be used to educate drivers on work zone safety issues at both a high level and a project level. Training programs for staff who design work zones are important. Strategies include:

- Disseminate work zone safety information to road users through DOT web site postings and other venues (T, $$); and
- Provide work zone training programs and manuals for designers and field staff (T, $).

Objective 6: Develop Procedures to Effectively Manage Work Zones

Strategies

- Develop or enhance agency-level work zone crash data systems, which include data beyond that in a crash database on a range of aspects of each work zone (T, $$).
- Improve coordination, planning, and scheduling of work activities, such as coordinating a series of work zones along a corridor (T, $$).
- Use incentives to create and operate safer work zones, such as award programs to recognize the best outreach and training programs on work zone safety (T, $$).
- Implement work zone quality assurance procedures, such as safety inspections or audits (T, $$).

Best Practices

Virginia DOT's Work Area Protection Manual:
http://virginiadot.org/business/resources/1-WEBwapmCOVER.pdf.

Work Area Protection Guide, Illinois DOT, Bureau of Operations, 1997 order form:
http://www.dot.state.il.us/blr/publication.html.

Illinois Bureau of Design and Environment Manual, 2002 Edition:
http://www.dot.state.il.us/desenv/bdemanual.html.

Washington State DOT's Design Manual:
http://www.wsdot.wa.gov/Publications/Manuals/M22-01.htm.

Resources

NCHRP Report 500 Volume 17: *A Guide for Reducing Work Zone Collisions:*
http://safety.transportation.org/guides.aspx.

NCHRP Report 627: *Traffic Safety Evaluation of Nighttime and Daytime Work Zones:*
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_627.pdf.

National Work Zone Safety Information Clearinghouse: http://wzsafety.tamu.edu/.

NCHRP Synthesis 215: Determination of Contract Time for Highway Construction Projects:
http://www.trb.org/news/blurb_detail.asp?id=3342.

FHWA Safety resources on work zone safety: http://safety.fhwa.dot.gov/wz/.

Drowsy or Distracted Driving

Problem Description

Crash investigations are retrospective reconstructions of crashes based primarily on crash scenarios, driver and witness statements, and physical evidence at the scene. Police and other investigators are reluctant to allege driver factors, such as drowsiness and distraction, without explicit statements from drivers or witnesses or a crash scenario that clearly indicates these factors. Unlike the case of alcohol, no objective way exists to identify whether someone is too drowsy or distracted to drive. In general, crash data are thought to significantly underestimate the contribution of distracted and drowsy driving to crashes.

Another challenge is reducing distracted and drowsy driving crashes and fatalities, which necessitates a change in driver behavior. Some success can be achieved by improving roadways and vehicles to make them more forgiving and by incorporating new technologies to alert an inattentive driver. Ultimately, however, we must change drivers themselves so they are less likely to operate vehicles when drowsy or distracted. This section provides information on effective countermeasures for addressing collisions involving drowsy or distracted driving.

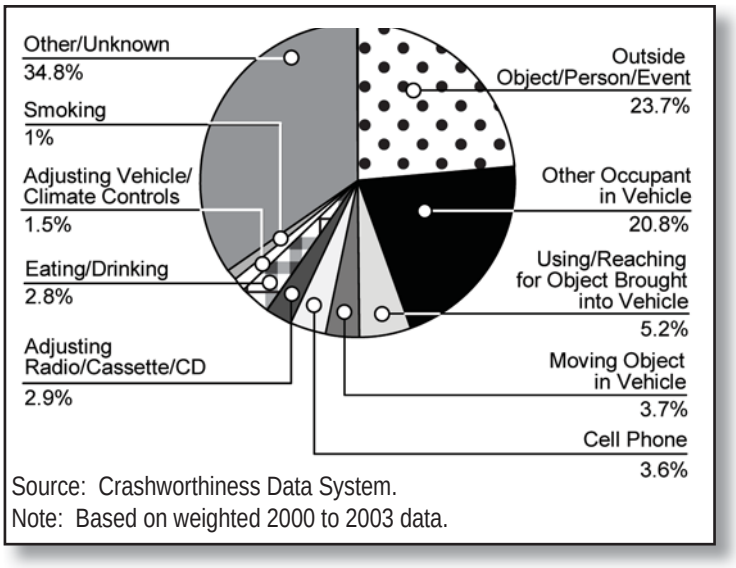
Data

The primary source of national data on the role of driver inattention in traffic crashes is the Crashworthiness Data System (CDS), which is based on a national sample of police-reported traffic crashes involving at least one passenger vehicle that was towed from the crash scene. An analysis of 2000 to 2003 CDS crash data shows overall the percentage of crashes with one or more drivers identified as inattentive (e.g., distracted, fatigued, or "looking but not seeing") was 25.5 percent, and the actual percentage is likely higher.

The CDS data provide information on the specific sources of driver distraction. Exhibit III-48 shows the sources of distraction for the 6.6 percent of drivers identified as distracted at the time of their crash. The most frequently cited distraction was an object, person, or event outside the vehicle. Examples include other cars and drivers on the roadway, pedestrians, work zones, crash scenes, and general "rubbernecking" (i.e., gawking at a crash scene). "Other occupant in vehicle" was cited nearly as often, with frequent reference to infants and young children.

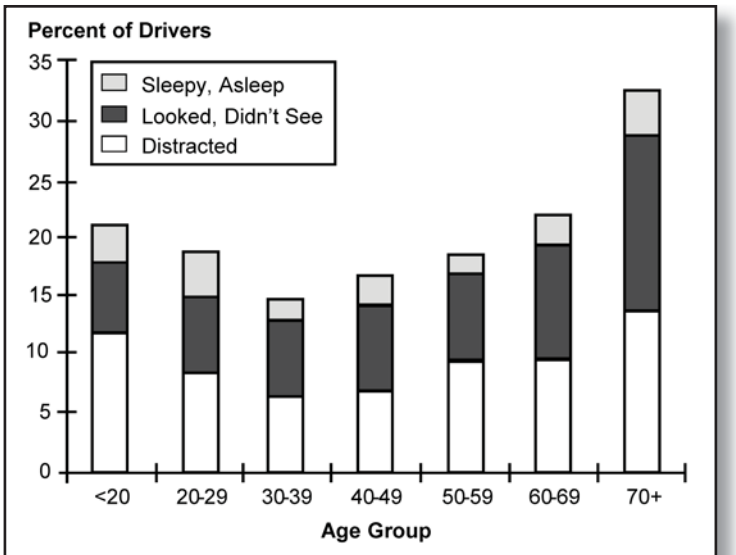
While younger drivers under the age of 20 are especially likely to be distracted at the time of a crash, all age groups are affected, as shown in Exhibit III-49. Drivers in the 20 to 29 age group have the highest percentage of "sleepy/asleep" crashes, while the oldest age groups (60 to 69 and 70+) are overrepresented in "looked but didn't see" crashes.

EXHIBIT III-48
Specific Sources by Percentage of Driver Distraction



Source: Crashworthiness Data System.
Note: Based on weighted 2000 to 2003 data.

EXHIBIT III-49
Distribution of Driver Attention Status with Categories of Driver Age



Source: Crashworthiness Data System.
Note: Based on weighted 2000 to 2003 data.

The Model Minimum Uniform Crash Criteria (MMUCC) Third Edition (2008) recommends state crash report forms collect information on driver distraction at the time of a crash (in addition to the data element for driver physical condition, which includes codes for fatigue and loss of consciousness or fell asleep). Although many states have added this data element to their crash report forms, there is as yet no documented evidence that such information can be reliably collected and reported by officers who investigate crashes. Indeed, the high level of "missing" and "unknown" data for the driver attention status variable in the CDS data suggests that reliable data collection may be a problem. New approaches for improving data quality may be needed.

Objective 1: Make Roadways Safer for Drowsy and Distracted Drivers

Strategies

Drowsy driving crashes typically involve a single vehicle traveling on a higher-speed roadway departing the roadway or travel way (NHTSA/NCSDR, 1998). While there is less data on distracted driving, these crashes also appear more likely to be single-vehicle lane departures. Therefore, strategies to reduce lane departures may be effective, including the following:

- Install shoulder and/or centerline rumble strips to alert the driver if they are leaving the roadway (P, $$); and
- Implement other roadway improvements to reduce the likelihood and severity of run-off-road and/or head-on collisions as outlined in the sections on Addressing Run-Off-Road Collisions and Addressing Head-On Collisions (P, $$$).

See Exhibit III-28 for shoulder rumble strip CMFs and Exhibit III-34 for centerline rumble strip CMFs.

Objective 2: Provide Safe Stopping and Resting Areas

Strategies

Rest areas are important for safe motor vehicle operation. The FHWA recommends facilities be provided every 50 miles or one hour of driving time on major roadways. However, since most distracted and drowsy crashes occur on two-lane rural roadways, the construction of full-scale rest areas generally located on Interstates may not address the problem. To address the need for safe stopping and resting areas on less-traveled roadways, it is recommended that states provide a continuum of options for safe stopping, ranging from smaller rest areas with most of the usual amenities to simple roadside parks with minimal or no amenities. Strategies include:

- Improve access to safe stopping and resting areas (T, $$$); and
- Improve rest area security and services, such as establishing state police substations or satellite offices at key locations, installing security lighting, providing direct telephone access to the police, and employing uniformed DOT maintenance personnel with 24-hour staffing at select rest areas (T, $$).

Objective 3: Increase Driver Awareness of the Risks of Drowsy and Distracted Driving and Promote Driver Focus

Strategies

Education via a multifaceted and sustained intervention over time can succeed in changing behavior if it alters the public mindset about what is acceptable and unacceptable behavior. The intention of such a campaign would be to communicate it is unacceptable to choose to drive while drowsy or engage in potentially distracting activities, such as talking on a cell phone.

Enactment of legislation prohibiting or restricting drivers from using cell phones or engaging in other potentially distracting activities while driving is a controversial topic. The National Conference of State Legislatures reports since 1999 every state has considered legislation related to the use of wireless phones.[15] However, no state currently bans talking on all types of cell phones while driving. As of March 2009, six states have banned talking on handheld telephones (California, Connecticut, New Jersey, New York, Utah, and Washington), and several local jurisdictions have also enacted such bans.[16] Strategies include:

- Conduct education and awareness campaigns targeting the general driving public (T, $$); and
- Visibly enforce existing statues to deter distracted and drowsy driving (E, $).

Objective 4: Implement Programs that Target Populations at Increased Risk of Drowsy or Distracted Driving Crashes

Strategies

Groups that may suffer increased risk of drowsy or distracted driving include teens and employees who drive a large number of hours. Programs that specifically target these groups may be effective at reducing drowsy or distracted driving, including:

- Strengthen graduated driver licensing requirements for young novice drivers (P&T, $) with provisions such as restricted nighttime driving for teens and restrictions on cell phone use;
- Incorporate information on distracted/fatigued driving into education programs and materials for young drivers (T, $);
- Encourage employers to offer fatigue management programs to employees working nighttime or rotating shifts, who are estimated to comprise 20 percent of the U.S. population and on average get five hours of sleep per night (P, $$);
- Enhance enforcement of commercial motor vehicle hours of service regulations with mobile inspection units (P, $$);

[15] Sundeen, 2003.

[16] http://www.iihs.org/laws/cellphonelaws.aspx.

- Encourage trucking companies and other fleet operators to offer fatigue management programs (T, $$); and
- Implement targeted interventions for other high-risk populations (T, $$).

Best Practices

Utah's "Sleep Smart Drive Smart" program: http://www.sleepsmartdrivesmart.com.

New Jersey's "Maggie's Law" allows criminal prosecution of fatigued drivers who cause injury to someone in a crash: http://www.njleg.state.nj.us/2002/Bills/PL03/143_.PDF.

AT&T program for novice drivers about the importance of managing distractions while driving, including cell phone use: http://www.wireless.att.com/learn/articles-resources/be-sensible.jsp.

Resources

NCHRP Report 500 Volume 14: *Reducing Crashes Involving Drowsy and Distracted Drivers:* http://safety.transportation.org/guides.aspx.

Countermeasures that Work: A Highway Safety Countermeasure Guide for State Highway Safety Offices, Governors Highway Safety Association (2009): http://www.ghsa.org/html/publications/index.html#countermeasures.

National Sleep Foundation release of Sleep in America Poll and the dangers of drowsy driving: http://www.drowsydriving.org.

AAA Foundation for Traffic Safety "How to Avoid Drowsy Driving" and "Distractions in Everyday Driving" brochures: http://www.aaafoundation.org/products/index.cfm?button=free.

Network of Employers for Traffic Safety information about distracted driving and driver fatigue: http://trafficsafety.org/safety.

NHTSA Drowsy and Distracted Driving Safety Materials: http://www.nhtsa.dot.gov/portal/site/nhtsa/menuitem.54757ba83ef160af9a7ccf10dba046a0/.

Commercial Transportation Operator Fatigue Management Reference, U.S. DOT (2003): http://scitech.dot.gov/research/human/docs/fatigue/fmr07-03.doc.

National Institutes of Health science-based high school curriculum, including information on the risks of drowsy driving: http://science.education.nih.gov/Customers.nsf/HSSleep.htm.

National Safety Council resources on distracted driving: http://www.nsc.org/resources/issues/distracted_driving.aspx.

Rural Emergency Medical Services

Problem Description

Because not all crashes can be prevented, it is important to understand how to best care for crash victims. Victims of motor vehicle crashes suffer disproportionately higher fatality rates in rural areas than in urban areas.

Nearly three-quarters (74 percent) of fatal crashes on roadways with high-speed limits (55 mph or higher) occur in rural areas. Thus, EMS providers in rural areas must respond to a disproportionately high number of calls where the crash victims are likely to be severely or fatally injured as a result of high-speed travel.

Emergency medical care experience has shown for many serious injuries, time is critical. In trauma care, the goal is to get seriously injured patients into the operating room of a trauma center with an experienced team of surgeons within the "golden hour" after an injury occurs. Meeting this goal requires a highly efficient and effective EMS system. A key aspect of this system is ensuring good routes to emergency medical care are available and trauma centers are located in accessible areas. Additionally, first responders need to know alternative routes if a primary route is blocked.

Planners can gather data on response times and raise this issue with elected officials so it can be proactively addressed. Additionally, transportation planners should be involved when land use decisions are made to site medical facilities. The accessibility of the trauma center to major roadways will play a major role in how quickly patients are treated and whether lives are saved.

Data

According to Traffic Safety Facts 2006:

- For 36 percent of rural fatal crashes, the time from the crash to hospital arrival is between one and two hours; and
- For 11 percent of urban fatal crashes, the time between the crash and hospital arrival is one to two hours.

Objective 1: Integrate Services to Enhance Emergency Medical Capabilities

Strategies

Integration of the work of EMS personnel into highway safety efforts may take the form of EMS personnel contributing to crash data or their involvement in multidisciplinary community-based safety efforts, including the following:

- Integrate information systems and highway safety activities so data about the crash scene and victim(s) collected by EMS personnel can be integrated with the traffic records system (T, $$$); and

- Integrate EMS systems into the Safe Communities effort, which seeks to give communities ownership over transportation-related safety problems and injury prevention (T, $).

Objective 2: Provide/Improve Management and Decision Tools

Strategy

- Provide rural EMS program evaluation results to elected and administrative officials at the county and local levels so they understand response issues (T, $).

Objective 3: Provide Better Education Opportunities for Rural EMS Providers

Strategies

Improved education can take the form of EMS personnel learning about traffic safety or emergency response personnel and "bystanders" gaining basic EMS training. Strategies include the following:

- Include principles of Traffic Safety and Injury Prevention as part of EMS continuing education, so EMS personnel in the field can use their expertise to educate the community and reduce the number of traffic incidents (E, $$);
- Require first care training for all public safety emergency response personnel, including law enforcement officers (T, $$); and
- Provide "bystander care" training programs targeting new drivers, rural residents, truck drivers, interstate commercial bus drivers, and motorcyclists (T, $$).

Resources

NCHRP Report 500 Volume 15: *A Guide for Enhancing Rural Emergency Medical Services,* http://safety.transportation.org/guides.aspx.

Bystander Care National Standard Curriculum, (NHTSA, Perez et al. 2003) and other related materials – order form: http://www.nhtsa.dot.gov/people/injury/ems/new_item.htm.

Emergency Medical Services in Rural America, National Conference of State Legislatures, http://www.ruralsafety.umn.edu/clearinghouse/topics/documents/EMS_in_rural_america_NCSL_Jun07.pdf.

Alcohol-Involved Collisions

Problem Description

Alcohol-impaired driving is among the most common contributors to motor vehicle fatal crashes in the United States. In 2007, 32 percent of fatalities involved alcohol-impaired driving (NHTSA). The two fundamental methods to reduce alcohol-related crashes are: 1) to reduce excessive drinking through policies and programs to control alcohol sales and inform drinkers of the dangers of excessive drinking; and 2) to deter driving while impaired by alcohol.

Every state has passed a law making it illegal to drive with blood-alcohol concentration (BAC) of .08 percent or higher. The DWI criminal justice system of laws, enforcement, prosecution, adjudication, sanctions, and offender monitoring is complex. All elements of this system must function well to ensure that DWI offenders are frequently detected, routinely charged, effectively prosecuted, suitably punished when convicted, and appropriately treated for alcohol abuse or dependency.

Data

- In single-vehicle crashes, the relative risk of a driver with BAC between .08 and .10 is at least 11 times greater than for drivers with a BAC of zero (NHTSA).
- Twenty-two percent of drivers in fatal crashes had a BAC of .08 or higher in 2007.
- In fatal crashes in 2007, the highest percentage of drivers with a BAC level of .08 or higher was ages 21 to 24 (35 percent), followed by ages 25 to 34 (29 percent), and 35 to 44 (25 percent).
- About one-quarter of all persons convicted for a first DWI offense are estimated to be alcohol dependent (Simpson et al., 1996).
- About 30 percent of persons involved in an alcohol-related fatal crash have been previously convicted of DWI or a comparable alcohol-related offense (Tashima and Helander, 2000).
- Recent estimates suggest that, on average, individuals may make anywhere from 50 to 200 impaired trips before being arrested (Hedlund and McCartt, 2002).
- Males, motorcyclists, and persons between the age of 21 and 34 are more likely than others to drive while impaired by alcohol.

Objective 1: Reduce Excessive and Underage Drinking

Strategies

Prevention of underage drinking reduces impaired driving by this population. Responsible service, increased taxes on alcoholic beverages, and health screenings can reduce excessive alcohol consumption. Strategies include:

- Increase the state excise tax on beer, which is the alcoholic beverage consumed most commonly by those arrested for drunk driving (T, $);
- Require responsible beverage service policies for alcohol servers and retailers (P, $$);
- Conduct well-publicized compliance checks of alcohol retailers to reduce sales to underage persons (T, $$$); and
- Employ screening and brief interventions in health care settings to identify and treat people with alcohol problems (T, $).

Objective 2: Enforce DWI Laws

Strategies

Drivers need to have a reasonable expectation of being caught when driving impaired. Therefore, enforcement must be ongoing and well publicized, including strategies such as:

- Conduct regular, well-publicized DWI checkpoints (P, $);
- Enhance DWI detection through special DWI patrols and related traffic enforcement (T, $); and
- Publicize and enforce zero tolerance laws for drivers under age 21 having any alcohol in their system when driving (P, $$).

Objective 3: Prosecute, Impose Sanctions on, and Treat DWI Offenders

Strategies

Sanctions that are swift and certain provide a strong deterrent against impaired driving, such as the following:

- Suspend driver licenses administratively upon arrest (P, $);
- Establish stronger penalties for BAC test refusal than for test failure (T, $);
- Eliminate diversion programs and plea bargains to nonalcohol offenses (T, $$); and
- Screen all convicted DWI offenders for alcohol problems and require treatment when appropriate (P, $$$).

Objective 4: Control High-BAC and Repeat Offenders

Strategies

Repeat offenders often have serious alcohol problems, and these drivers present a significant danger on the road. Strategies to prevent recidivism require considerable intervention, including:

- Seize vehicles or license plates administratively upon arrest (P, $$);

- Require ignition interlock devices to test the driver's breath for the presence of alcohol in the vehicle as a condition of license reinstatement (P, $$);
- Closely monitor DWI offenders through DWI Court, probation, home confinement, or other methods (P, $$$); and
- Incarcerate offenders as a last resort if other sanctions are ineffective, ideally in dedicated detention facilities (P, $$$).

Best Practices

In 2001, Alaska established a dedicated therapeutic court system to handle DUI cases and provide offender rehabilitation. These courts offer a systematic and coordinated approach for prosecuting, sentencing, treating, and monitoring DUI offenders. Information is available at:
http://www.dot.state.ak.us/stwdplng/hwysafety/impaired_program_acs.shtml.

New Mexico requires an ignition interlock license and installation of the device for anyone convicted of a DWI, including first time offenders:
http://www.dps.nm.org/lawEnforcement/dwi/dwiIgnitionInterlock.php.

The San Juan County, NM Detention and Treatment Program provides a 28-day treatment program for offenders housed in a 72-bed minimum security detention facility. During their 28-day stay, offenders participate in daily treatment/educational sessions:
http://www.sjcounty.net/Dpt/DwiFacility/Index.aspx.

The Illinois State Police developed a web site where teenagers can anonymously report underage drinking parties: http://www.drunkstopper.com.

Resources

NCHRP Report 500 Volume 16: *A Guide for Reducing Crashes Involving Alcohol:*
http://safety.transportation.org/guides.aspx.

Countermeasures that Work :A Highway Safety Countermeasure Guide for State Highway Safety Offices, Governors Highway Safety Association (2009):
http://www.ghsa.org/html/publications/index.html#countermeasures.

Partners in Prevention, State Alcohol Agencies' Approach to Underage Drinking Prevention, Pennsylvania Liquor Control Board and NHTSA, 2002:
http://www.nhtsa.gov/people/injury/alcohol/dotpartners/index.htm.

A Guide to Sentencing DWI Offenders, 2nd edition, 2005, NHTSA, DOT HS 810 555:
http://www.nhtsa.dot.gov/people/injury/alcohol/DWIOffenders/index.htm.

Screening and Brief Intervention Tool Kit for University and College Campuses, 2007:
http://www.nhtsa.dot.gov/people/injury/alcohol/StopImpaired/3672Toolkit/index.htm.

Uniform Guidelines for State Highway Safety Programs – Guideline No. 8 Impaired Driving:
http://www.nhtsa.dot.gov/nhtsa/whatsup/tea21/tea21programs/pages/ImpairedDriving.htm.

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