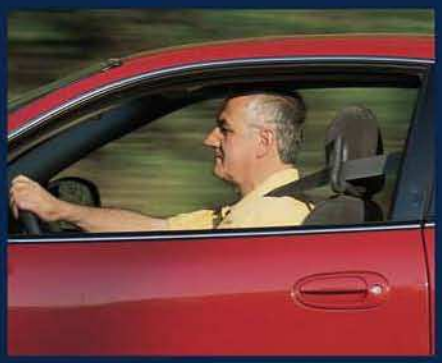
TRANSPORTATION PLANNER'S SAFETY DESK REFERENCE

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





with support from

Transportation Safety Planning Working Group

U.S. Department of Transportation
Federal Highway Administration

Foreword

This report is a reference document on safety for use by transportation planners. It serves as a companion to 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*. The report describes an overview of transportation safety, the potential roles that transportation planners can play to advance it, a framework for incorporating safety into the transportation planning process, available sources that may be accessed to fund safety programs, and a menu of possible safety strategies.

This report will be of interest to transportation planning staff who wish to more effectively incorporate safety into the planning process and improve safety on their transportation systems, including state departments of transportation, metropolitan planning organizations, and other organizations involved in transportation decision-making. It is being distributed electronically via the Transportation Planning Safety Working Group, FHWA, and other web sites.

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Transportation Planner's Safety Desk Reference

Report No. FHWA-HEP-07-005

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Federal Highway Administration
U.S. Department of Transportation

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Preface

The Transportation Planner's Safety Desk Reference is a resource providing a range of safety strategies in 17 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*. 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, accident modification factors are included that can be used to determine the reduction in crashes anticipated from specific safety improvements. Each section also provides lists of additional resources and best practices, when available.

The Desk Reference also 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 medical services, 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 development of performance measures to achieve measurable results. The document also lists funding sources that may be accessed to fund 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 DOTs, 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:

- American Automobile Association
- 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 Cooperative Highway Research Program
- National Governors Association
- National Highway Traffic Safety Administration
- Society for the Advancement of Violence and Injury Research (SAVIR)
- 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
- Minnesota DOT

SECTION I

Introduction

The Transportation Planners 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 that could be helpful to state and local transportation planners.

Safety planning is by its nature a multidisciplinary effort. Your state has likely gone through the process of developing a Strategic Highway Safety Plan (SHSP), which involves engaging a wide range of stakeholders. An excellent first step is to make contact with the state DOT, which has the responsibility for coordinating SHSP development and generally works closely with the Governor's Office of Highway Safety (GOHS). The GOHS is housed within the DOT in approximately one-third of states; and 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 would benefit from not only using the SHSP as a resource in their planning, but also becoming 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 recently enacted 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.

Transportation planners work to improve all forms of transportation, including roadways, freight, transit, and pedestrian and bicycle facilities. Multimodalism is a critical aspect of safety planning, because when exposure to roadways and traffic congestion is minimized, safety is increased. 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.

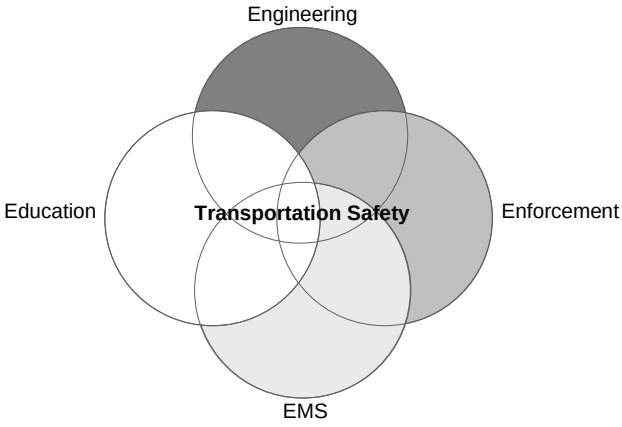
Elements such as sidewalks, pedestrian crossings, bicycle paths, and bicycle parking that support successful transit service also enhance bicycle use and walking, thus reducing VMT. Safe access to and egress from park-and-ride lots contributes to safe transit use. One section

of this Desk Reference specifically addresses pedestrian 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), 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 Governors' Representatives for highway safety (GR). Each state GR receives a number of Federal grants targeted to the 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. A wide range of educational programs can have significant impact on 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.

Within the safety community, there is wide acknowledgment that 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 bodies that oversee enforcement staff 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 that 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 can 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 effective processes for administering emergency medical treatment to victims of traffic crashes.

The use of Intelligent Transportation Systems (ITS) tools, such as variable message signs, can help manage the safe flow of traffic if an incident does occur and protecting the safety of first-responders at the scene. Planners also can play an important role in determining the best locations for trauma centers to ensure appropriate emergency vehicle routing and minimize transfer time so that 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, and ensure that routes avoiding congested areas or dense neighborhoods are possible. In addition, alternative routes to trauma centers should be considered in planning, such as in the case of places where a rail crossing could block an emergency route.

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 managing 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 long-range plans.

Many tactics that can improve transportation safety involve legislative or policy changes. Planners possess the data and analysis capability required to develop a rigorous case for why legislators should pursue such policy changes. They can explain that even the safest roadways cannot protect people who engage in dangerous behaviors, and that legislation is needed on the behavioral aspects of safety such as requiring safety belt use or reducing the blood alcohol limit in their state.

Transportation planners are trained to analyze operations at the corridor level. Many aspects of corridor management provide opportunities for safety improvements. The provision of good pedestrian and bicycle facilities not only helps to reduce congestion, but can reduce the number of vehicle trips and lower 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 can have a significant impact on both the capacity and safety of roadways. Individual intersection improvements can 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 help program improvements. Planners also can

work with enforcement on corridor-based efforts at enforcing traffic laws, reducing impaired driving, analyzing speeds, and increasing safety belt use.

Given the broad range of players in the transportation safety community, institutional challenges will arise in terms of identifying the 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 the goal of safety will assist in overcoming this challenge. The transportation planner can serve as the facilitator and an advocate for getting these agencies together to address the common goal of safety.

By making safety a priority, planners can have a significant impact on saving lives in their communities. The following are key ways for planners to increase their role in safety:

- 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 investments that address safety;
- Use the state's SHSP; and
- Monitor safety implementation and analyze effectiveness.

Safety Funding and Costs

Inevitably, many of the institutional challenges will be approached from the perspective of resources and funding. While some dedicated sources of transportation safety funding do exist, many safety strategies can be incorporated into existing programs. Safety countermeasures, such as rumble strips, can be implemented into programmed infrastructure projects, such as roadway reconstruction and rehabilitation. Existing driver education programs can be improved. Each state is required by SAFETEA-LU to develop a Strategic Highway Safety Plan (SHSP). 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 available, 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, which are discussed below.

Highway Safety Improvement Program (HSIP). New core Federal-aid funding program beginning in Fiscal Year (FY) 2006 to achieve a significant reduction in traffic fatalities and serious injuries on all public roads. By October 1, 2007, each state must have a Strategic Highway Safety Plan (SHSP) that identifies and analyzes safety problems and opportunities in order to use HSIP funds for new eligible activities under 23 USC 148. The plan is required to 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 is a component of the HSIP and 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.

Surface Transportation Program (STP). This program provides flexible funding that may be used by states and localities for projects on any Federal-aid highway, including the National Highway System (NHS), bridge projects on any public road, transit capital projects, and intracity and intercity bus terminals and facilities. The Federal share is generally 80 percent.

Safe Routes to Schools (SRTS). This 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 will improve safety, and reduce traffic, fuel consumption, and air pollution in the vicinity of schools. Each state is apportioned funds based on their relative shares of total enrollment in primary and middle schools (kindergarten through eighth grade), but no state will receive less than $1 million.

Congestion Mitigation and Air Quality (CMAQ). This provides funding for projects and programs in air quality nonattainment and maintenance areas for ozone, carbon monoxide (CO), and particulate matter (PM_{10}, $PM_{2.5}$), which reduce transportation-related emissions (23 USC 149(a)). The Federal share is generally 80 percent.

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.

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 amounts received by states must be obligated for behavioral highway safety activities.

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 that are 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 these states 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. Federal grant program that provides financial assistance to states to reduce the number and severity of accidents and hazardous materials incidents involving commercial motor vehicles (CMV). The goal of the MCSAP is to reduce CMV-involved accidents, 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 CMAQ at: http://www.fhwa.dot.gov/safetealu/factsheets.

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/.

SECTION II

Incorporating Safety into the 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 on America's roadways has reached $230.6 billion a year, or an average of $820 for every person living in the United States, in 2000 (Blincoe et al.).
- Motor vehicle fatalities and injuries are a leading public health problem in the United States. In 2005, 43,443 people were killed in motor vehicle crashes, representing a 1.4 percent increase over 2004 and the highest level since 1990. In that same year, 2.7 million people were injured in automobile crashes.[1]
- Crashes represent a major source of nonrecurring congestion, and nonrecurring congestion is estimated in at least some locations to account for one-half of all congestion.
- Evidence from around the world and throughout the United States suggests that many crashes are preventable. Over 39 percent of fatalities involved drugs or alcohol, and approximately 30 percent of motor vehicle fatalities involved speeding (NHTSA, 2006).
- Effective safety programs involve a wide range of stakeholders. An important forum for fostering safety program collaboration at the state and metropolitan levels could be the transportation planning process.

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 populations are primarily involved? To understand these issues, planners should obtain a copy of the state's SHSP from the state DOT. The SHSP will help you 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.

If your state has not yet completed its SHSP, or it does not provide enough detail for you to conduct regional problem identification, you may wish to do the analysis on your own. To conduct your own safety analysis, the initial step is to assemble data. First, explore gaining

[1] NHTSA.

access to state crash data. According to the Federal transportation legislation, SAFETEA-LU passed 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 databases for conducting regional crash data analysis.

Be sure to get a copy of the state crash form, which will show you exactly what crash data is captured in the state and what types of analysis can be performed. You may wish to focus your analysis 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.

Crash data will help 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 belt or helmet, impairment by alcohol or drugs).

Another means for identifying safety issues is by conducting road safety audits (RSA), which are formal safety performance examinations of an existing or future road or intersection by an independent audit team. Road safety audits can be used in any phase of project development from planning to preliminary engineering, design, and construction. RSAs also can be used on any size project from minor intersection and roadway retrofits to mega-projects.

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. Transportation safety strategies will be defined in the SHSP, and specific countermeasures and projects will be defined in an implementation plan.

A range of countermeasures is presented in this Desk Reference. Some strategies will be more appropriate than others for inclusion at the state or regional level. The document focuses on outcomes and not methods or specific programs. The list of strategies in this Desk Reference is not all-inclusive. A number of additional strategies employed at a state or regional level, such as incident management and congestion management, also can have a significant impact on traffic 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 nearly all 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 HSP (Highway Safety Plan).

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

For safety to be included as a factor in evaluating potential projects, it must be established as a priority early in the process, when goals and objectives for the plan are developed. Goals and objectives will lead to determining system performance measures. Through the analysis process, planners will determine how the system is performing and how changes in the system will affect performance.

In order to ensure that safety becomes an integrated part of the plan, incorporating safety into the transportation planning goals and objectives is important. In addition, safety should be included into the system performance measures. 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; and
- Annual number of fatalities.

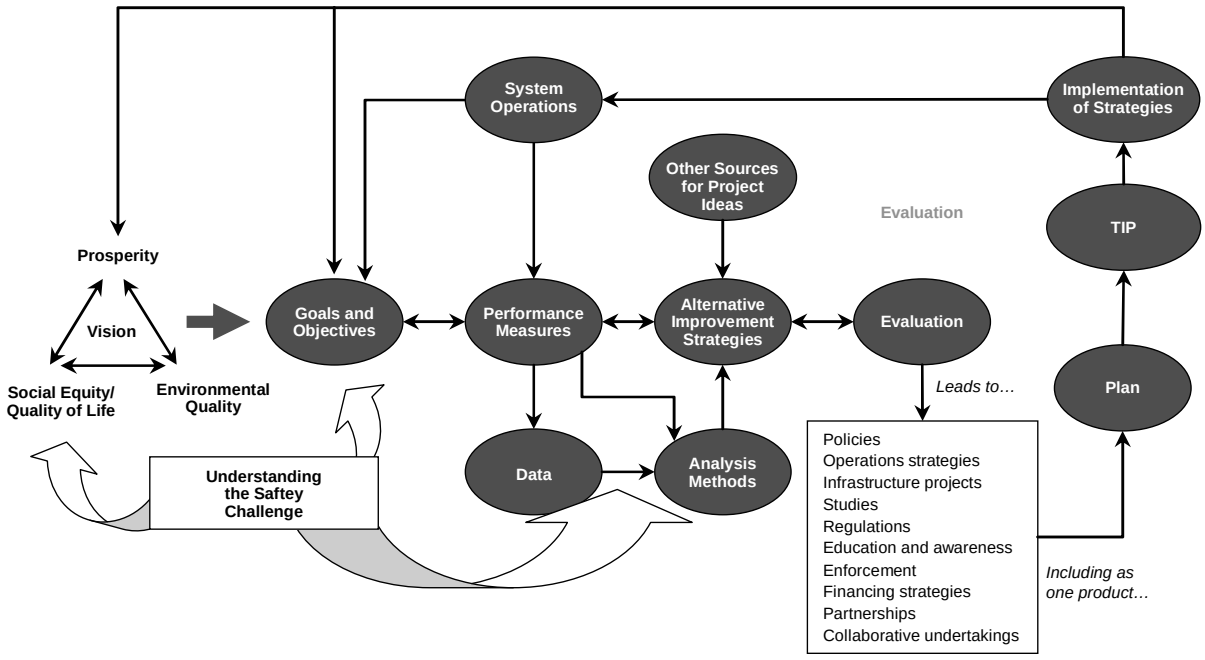
Performance measures also may be defined based on specific aspects of safety, such as the following:

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

Projects developed at the state and regional level would then be evaluated for consideration in plans. 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]

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

EXHIBIT II-1
The Transportation Planning Process

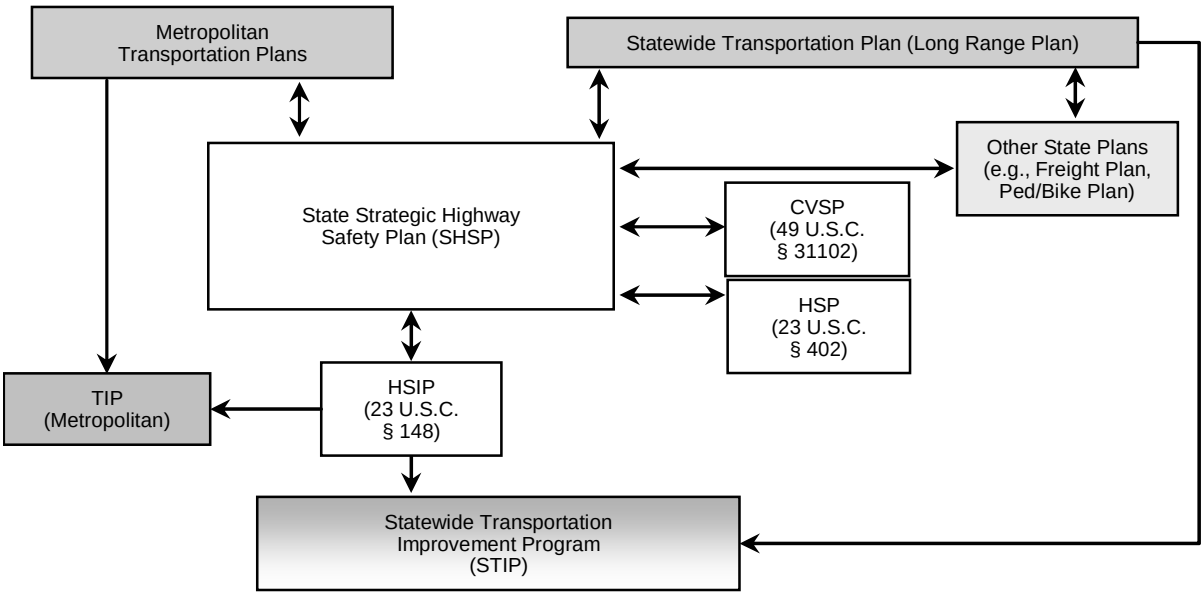


Source: NCHRP Report 546, *Incorporating Safety into Long-Range Transportation Planning*, 2006.

The transportation planning process can result in a wide range of planning products. States and MPOs regularly develop and update 20- to 30-year long-range programs. These feed into the shorter-term Transportation Improvement Program (TIP) for MPOs and State Transportation Improvement Plan (STIP) for states, identifying near-term projects to be programmed and built. On an annual basis, the 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 will need to 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 is critical that it be linked explicitly with the comprehensive transportation plan to ensure that they both work in tandem. How safety is reflected in state and MPO plans is reflective of how safety is addressed in the planning process. Plans need to be proactive on safety and not simply mention safety.

Although state DOTs and MPOs follow essentially the same planning process, the implementation of strategies may differ somewhat. MPOs are largely advisory agencies and lack a legislative body to directly implement safety projects. MPOs must work closely with state and local governments to include safety strategies in their TIPs. 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 are ideal groups to educate about safety and to solicit in developing implementation strategies.

EXHIBIT II-2
Safety Planning Relationship to Planning Process



Local Planning

Incorporating safety into local planning is the first step to having projects included in the MPO's regional long-range plan and TIP, and considered for the state STIP. In addition, many key low-cost safety improvements are implemented at a local level. For example, signage, pavement markings, and pedestrian and bicycle facilities are all a part of roadway and trail maintenance and management, and present opportunities to include safety countermeasures at the 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 in your planning area may be housed in a range of departments, such as traffic engineering, public works, or police. Larger jurisdictions are more likely to maintain a crash data system than smaller jurisdictions. The types of information that can be extracted from this data are described in the previous section.

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 have 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. Staff can present data on safety issues to key partners, such as utility companies, to discuss placement of utility poles or area agencies on aging on 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 that mirror those of the MPO or state, 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/docs/safety/.
- NCHRP Research Results Digest 299, *Crash Reduction Factors for Traffic Engineering and Intelligent Transportation System Improvements: State-of-Knowledge Report,* November 2005.
- ITE Resource Center, FHWA Office of Safety RSA web site: http://www.roadwaysafetyaudits.org/default.asp.

SECTION III

Safety Emphasis Areas

This section presents discussions of 17 safety emphasis areas. 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 practice and additional information resources are noted under each objective, if available.

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

Costs

Wherever data exists on costs or benefits for a specific strategy, it is provided in parentheses or in a text box adjacent to the strategy. The relative cost to implement and operate a strategy is categorized into 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 – $$$$.

Accident Modification Factors

The crash reduction benefits of some engineering strategies are available. The primary source for this data is the *NCHRP Research Results Digest 299* published in November 2005. This publication includes Accident Modification Factors (AMF) to estimate the reduction in crashes from a specific safety treatment or installation. AMFs are multiplied by the current crash rate to generate the expected new crash rate after a new safety treatment is put in place. For example, if a treatment is expected to reduce the number of crashes by 15 percent, the AMF is 0.85. One of the challenges of using AMFs 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 AMFs accurately capture the combined effect.

In *Research Results Digest 299*, a level of predictive certainty was assigned to each AMF, based on reviews of the caliber of existing research on that countermeasure. AMFs are included in this desk reference only for strategies with a high- or medium-high level of predictive certainty.

In addition, active research on costs and effectiveness of countermeasures was in process at the time of publication, and planners should make use of research results when they are available. The objectives of NCHRP Project 17-33, *Effectiveness of Behavioral Highway Safety Countermeasures*, are to develop 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. This project is scheduled to be completed in 2007.

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, as ratings were available from the NCHRP Report 500 series. 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 letter symbol throughout the guide:

- **Proven (P) –** Those strategies that have been used in one or more locations and for which properly designed evaluations have been conducted that show them to be effective;
- **Tried (T) –** Those strategies that have been implemented in a number of locations and may even be accepted as standards or standard approaches, but for which value 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:

- Older persons' safe mobility;
- Pedestrian collisions;
- Aggressive driving;
- Unlicensed drivers;
- Signalized intersections;
- Unsignalized intersections;
- Run-off-road collisions;
- Head-on collisions;
- Horizontal curves;
- Tree collisions;
- Utility pole collisions;
- Occupant protection;
- Heavy truck collisions;
- Work zone collisions;
- Drowsy or distracted driving;
- Rural emergency medical services; and
- Alcohol-involved collisions.

Older Persons' Safe Mobility

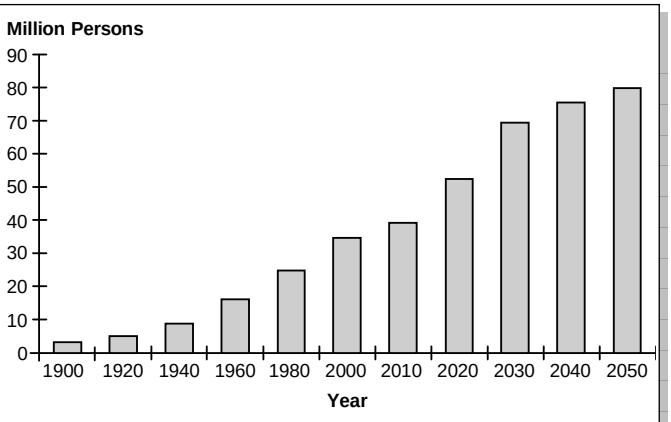
Problem Description

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

- The United States population of older adults will double over the next 30 years. By 2030, 1 in 5 Americans will be age 65 or older.
- 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.

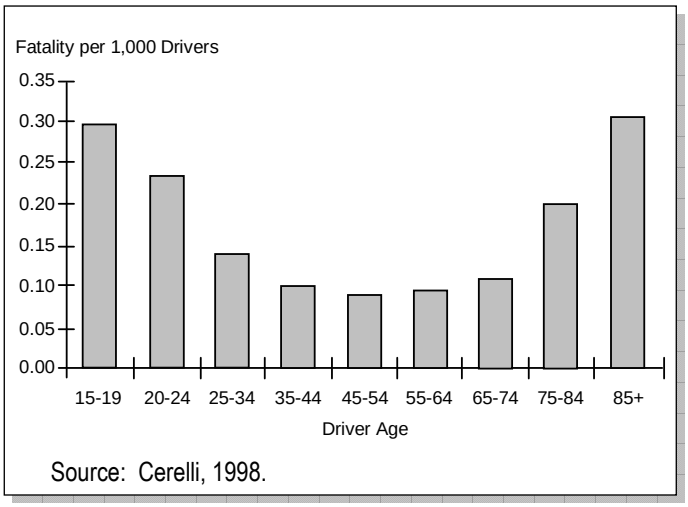
EXHIBIT III-1
Projected Growth in U.S. Population Age 65 and Older



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.

EXHIBIT III-2
Fatalities by Age of Driver



Source: Cerelli, 1998.

- 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.
- 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.

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 the American Automobile Association (AAA).

Strategies generated by such groups may be very broad and extend beyond the activities that planner would implement. However, encouragement and facilitation of other groups by the planner can 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 intervene, 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 already 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 can 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 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 can help with roadway visibility for older drivers, especially at night.

- 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 that 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, $);

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

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.

EXHIBIT III-4
Modify Signal Change Interval

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

* Results were not significant at a 90 percent confidence level.

Note: Both the yellow change interval and the red clearance interval were adjusted at the treatment sites to conform to the ITE *Proposed Recommended Practice for Determining Vehicle Change Intervals* (1985).

- Improve lighting at intersections, horizontal curves, and railroad grade crossings (T, $$$);
- Improve roadway delineation to improve the driver's understanding of the roadway operating area, including improving painted or raised pavement markings (T, $);
- Replace painted channelization with raised channelization whose purposes include clearly defining desired vehicle movements, discouraging undesired movements within an intersection, and minimizing points of conflict for turning vehicles (P, $$); and
- Improve traffic control at work zones (T, $).

Best Practices

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

AAA education and information 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, 2005:
http://www.ghsa.org/html/publications/pdf/GHSA_Countermeasures.pdf.

NHTSA and American Association of Motor Vehicle Administrators 2003 survey of all Medical Advisory Boards:
http://www.aamva.org/Documents/drvSummaryofMedicalAdvisoryBoardPractices.pdf.

FHWA 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.

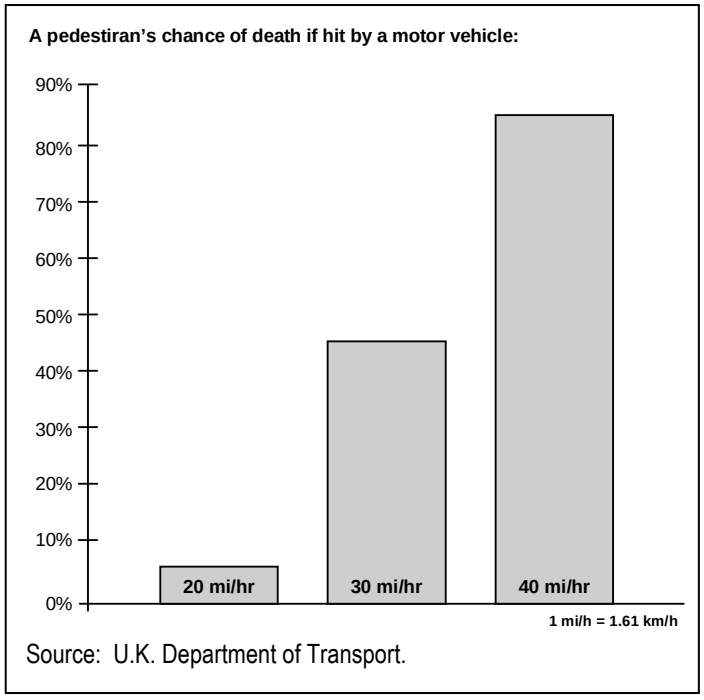
Pedestrian Collisions

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.

Specific groups that do not or cannot drive primarily depend on walking for transportation, including children, the elderly, and low-income populations. These groups are in need of safe walking environments. Whether building new infrastructure or renovating existing facilities, walking should be an assumed form of transportation and all plans should accommodate pedestrians.

EXHIBIT III-5
Fatalities 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. Driver behavior is often a significant factor in the severity of crashes involving pedestrians. 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 frequently in urban areas where the volume of both pedestrian and vehicle traffic is high. 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. Time of day also should be considered in reducing crashes involving pedestrians. NHTSA has found that pedestrian crashes are most prevalent during morning and afternoon peak periods, when both pedestrian and vehicle traffic are heavy.

Safe Routes To Schools (SRTS) is an initiative 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 will improve safety and reduce traffic, fuel consumption, and air pollution in the vicinity of schools. This

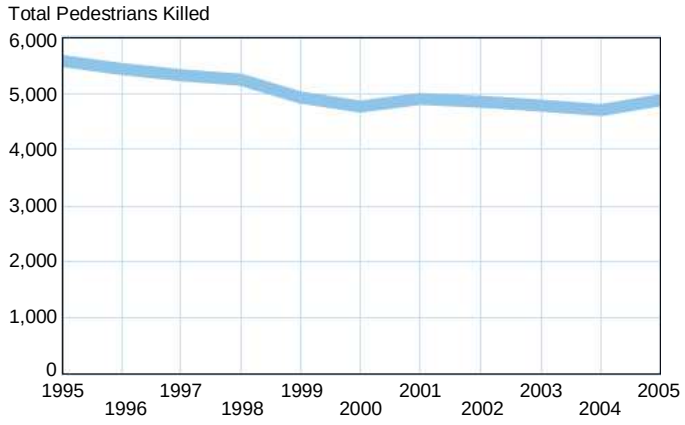
program is funded through SAFETEA-LU, and every state receives funding to implement SRTS programs.

Both land use and transportation planners have strong qualifications to improve safety for pedestrians. Planners understand the origins and destinations of people in their community or region 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 make more destinations accessible on foot, create vibrant business districts, and manage congestion, emphasis on pedestrian safety will only 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 2005, 4,881 pedestrians were killed in traffic crashes in the Unites States – a decrease of 13 percent from the 5,584 pedestrians killed in 1995. The number of conflicts and fatalities remains high in many urban areas and for specific segments of the population.

EXHIBIT III-6
Trends in Pedestrian Fatalities, 1995-2005



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 that is 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:

- Provide sidewalks/walkways and curb ramps as part of every new and renovated roadway, and make every effort to retrofit streets that currently do not have 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 (P, $$$$); and
- Provide school route improvements, such as sidewalks, bicycle routes, and trained crossing guards (T, $).

EXHIBIT III-7
Walkways Should Be Part of Every New and Renovated Roadway

Source: Dan Burden.

EXHIBIT III-8
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 also help to designate the right-of-way and may encourage motorists to yield to pedestrians. Acceptable crosswalk marking patterns are given in the 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-9
Install Raised Median at Crosswalks

Total Pedestrian Crashes (All Severities)	Accident 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 the Speed of Motor Vehicles

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, 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. Additionally, 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, $$);
- Install traffic calming on road sections, such as serpentine street design, alternatively placed curb extensions in the street causing a horizontal shift in traffic, or a choker with two curb extensions on opposite sides of the street narrowing the street (P, $$); 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, $$).

EXHIBIT III-10
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.

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 campaigns 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/Cops/Safe%20Journey/Library/countermeasures/25.htm.

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

Resources

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: www.ite.org/traffic/index.html.

Project for Public Spaces, Traffic Calming 101: http://www.pps.org/imagedb/category?gallery_id=829.

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. No effort has specifically addressed the engineering elements related to aggressive driving. 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; and
- 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

Targeted enforcement at problem locations targeting specific aggressive driving actions may help demonstrate that 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 targeted in locations identified as having a problem with aggressive driving (T, $) that is complemented by a publicity campaign.
- 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 "Triggers" of Aggressive Driving

Strategies

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

triggers of aggressive driving. 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.

Note:
See Older Persons' Safe Mobility for Accident Modification Factors for signal change timing modification on page III-7.

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.nhtsa.dot.gov/people/injury/airbags/Countermeasures/images/Countermeasures.pdf.

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://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/5dz01!.pdf.

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

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

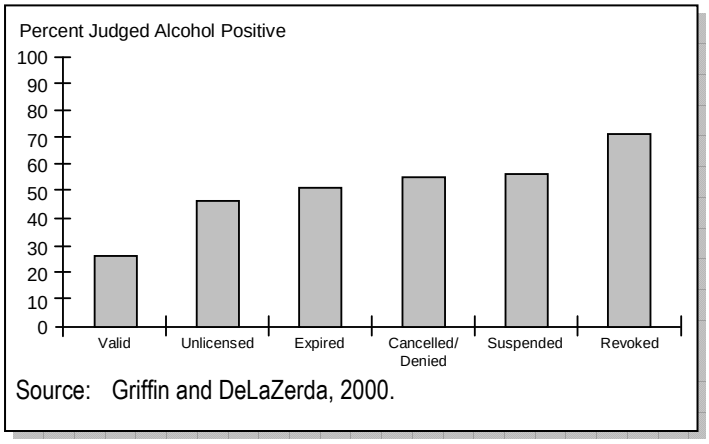
Unlicensed Drivers

Problem Description

No matter how well our highways and vehicles are designed and maintained, ultimately highway safety depends upon the behavior of the user, especially drivers. Every state has a driver-licensing program that is charged with ensuring that drivers who are issued a license 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 drunken 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.

EXHIBIT III-11
Percentage of Drivers Judged To Be Alcohol Positive by License Status



Source: Griffin and DeLaZerda, 2000.

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 nonmotorized transportation options, transportation planners can reduce the likelihood of people driving without proper licensure.

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 who is 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). The use of separate traffic courts that handle only traffic offenses will 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
  - Such a program requires that training on alternative rides is conducted with bar managers and employees.

Objective 2. Apply Special Enforcement Practices

Strategies

Increased enforcement and checking of licensure status can aid in the apprehension of drivers who have lost licensure, but who still 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 driver's record against all citations to determine license status, ideally in real time when the 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 licensure 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 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 multi-vehicle. Signalized intersections are operationally complex, with many factors contributing to the 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 good 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 drivers' 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 that intersection modifications do not negatively impact the pedestrian experience by ensuring that sufficient crossing time and pedestrian amenities are provided. The planner can work with the engineering staff to ensure that these kinds of problems are recognized and solutions are implemented.

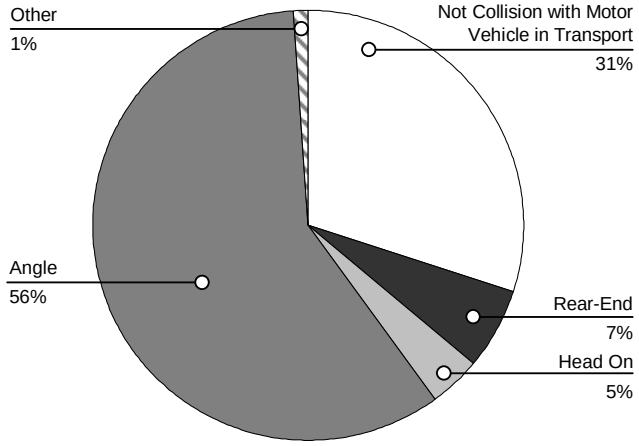
Data

- 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 2005 FARS data:

- Twenty-two percent of fatal crashes occur at intersections;
- Seven percent of all fatal crashes occur at signalized intersections;
- Seventy-three percent of fatal single-vehicle crashes at signalized intersections involve pedestrians or bicyclists; and
- Eighty-one percent of fatal crashes at signalized intersections occur in urban areas.

EXHIBIT III-12
Manner of Collision for Fatal Crashes at Signalized Intersections



Source: 2005 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:

Note:
See Older Person's Safe Mobility for Accident Modification Factors for signal change timing modification on page III-7.

- Employ multiphase signal operation (P, $), including protected left-turn phases and split phases that provide individual phases for opposing approaches;
- 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 (P, $), including pedestrian-only phase of signal operation, prohibition of right-turn-on-red, pedestrian signs and markings, and "Bicyclist Dismount" signs at intersections; and
- Remove unwarranted signals (P, $) when traffic conditions no longer require them.

EXHIBIT III-13
Remove a Traffic Signal

Crash Type	Accident Modification Factor
All Crashes	0.76
Right-Angle/Turning	0.76
Rear-End	0.71
Pedestrian	0.82
Fixed-Object	0.69
Light Condition (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 clearly guide vehicles through turning paths and reduce potential conflicts (P, $$) (see section on Unsignalized Intersection Collisions, Objective 2);

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

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

Strategies

Improving the sight distance and visibility at intersections provides drivers better awareness of what maneuvers will be 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 only with engineering countermeasures. Enforcement of traffic regulations or public education campaigns may improve intersection safety. Strategies include:

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

EXHIBIT III-14
Red-Light Running Cameras

Crash Type	Accident Modification Factor
All Crash Severities	
Rear-End Crashes	1.15
Right-Angle Crashes	0.75
Injury Crashes Only	
Read-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:

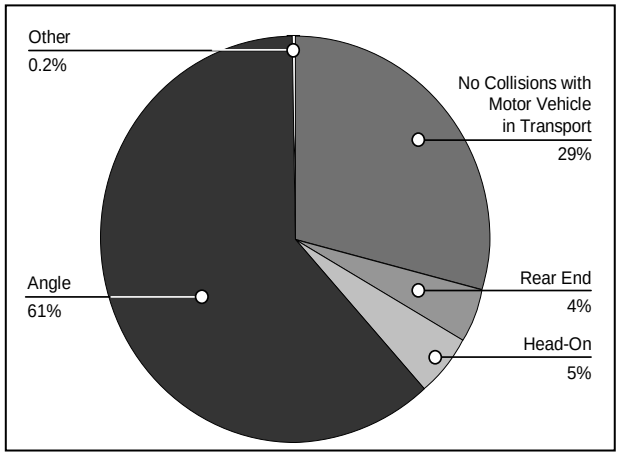
- Improve drainage in intersection and on approaches (T, $$);
- Provide skid-resistance in intersection and on approaches, such as grooving or overlaying existing pavement (T, $$);
- Coordinate closely spaced signals near at-grade railroad crossings to avoid vehicle queues forming across the railroad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

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

EXHIBIT III-15
Manner of Collision for Fatal Crashes at Unsignalized Intersections



Source: 2005 FARS data.

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 2005.

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

Improvements to channelize turning traffic at intersections, clarifying paths through intersections, and restricting turns 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, $$);
- Provide longer left-turn lanes at intersections to allow for vehicle deceleration and waiting (T, $);
- Provide offset left-turn lanes at intersections, so that vehicles in opposing turn lanes on the major road do not block vision of oncoming traffic (T, $$$);
- Provide median acceleration lanes at divided highway intersections for vehicles making a left turn and entering the highway (T, $$);
- Provide right-turn lanes at intersections to remove slow vehicles that are decelerating to turn right from the through-traffic stream (P, $$);
- Provide longer right-turn lanes at intersections to reduce conflict when a queue of vehicles overflows the right-turn lane (T, $$);
- Provide offset right-turn lanes at intersections to prevent collisions between turning vehicles and through traffic, and to prevent right-turning vehicles from obstructing the view of the minor-road driver (T, $$$);

EXHIBIT III-16
Add Exclusive Left-Turn Lane

Total Intersection Crashes (All Severity, All Crash Types)	Accident 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 Accidents (All Accident 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 signalized intersection (4 legs)	0.91	0.83
Project-Related Crashes (All Severity Levels)*		
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

* Project-Related Accidents: All accidents 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 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 to avoid potential accidents and for pedestrian and bicycle use (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 (T, $$$$) when less-restrictive measures have been tried and failed;
- Convert four-legged intersections to two T-intersections (T, $$$$) that operate independently of each other;
- Realign intersection approaches to reduce or eliminate intersection skew, so that the intersection area is not confusing, there are good sight angles, and the paths through the intersection are not excessively long (P, $$$$); 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-17
Add Exclusive Right-Turn Lane

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

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 (T, $$$$) if other strategies have been tried and are not effective (T, $$$$); 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 can result 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
- Re-time 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 as new signals 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-18
Convert to All-Way Stop Control from Two-Way Stop Control

Type of Collision (All Severities)	Accident 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-19
Install Roundabout

Lane Environment	Accident Modification Factor
Single-Lane – Urban	
(prior control-stop sign)	
All Crashes	0.28
Injury Crashes	0.12
Single-Lane – Rural	
(prior control – stop sign)	
All Crashes	0.42
Injury Crashes	0.18
Multilane – Urban	
(prior control – stop sign)	
All Crashes	0.95
Injury Crashes	-
Single/Multilane – Urban	
(prior control – signal)	
All Crashes	0.65
Injury Crashes	0.26
All Conversions	
All Crashes	0.60
Injury Crashes	0.20

Objective 7. Improve Driver Compliance With Traffic Control Devices and Traffic Laws at Intersections

Strategies

To reduce unsafe and illegal driver behavior at intersections, enforcement and public education can be employed. 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

To reduce speeds approaching intersections and the possibility of more severe collisions, efforts to manage driving speeds can be employed. Strategies include the following:

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

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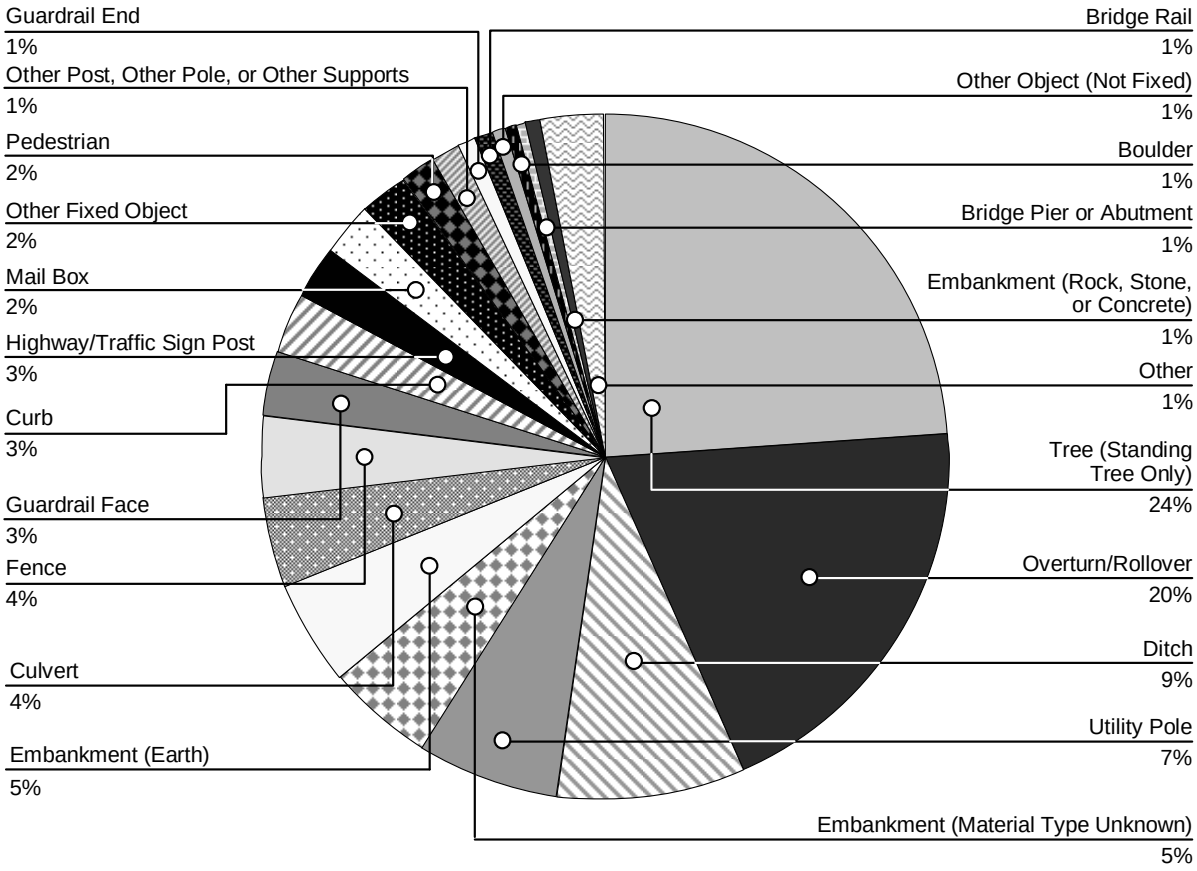
Run-Off-Road Collisions

Problem Description

Run-Off-Road (ROR) collisions comprise more than one-third of all fatal collisions. The first harmful event in a crash is the first event or object hit, which may or may not result in injury or fatality. The most harmful event is that of the higher severity (i.e., death). Analysis of the first harmful event in ROR crashes, shown in Exhibit III-20, provides insight into ways that roadside objects can be eliminated or that drivers can be protected from them. Analysis of the most harmful event, shown in Exhibit III-21, provides insight into the types of strategies that can minimize the severity of crashes. This section provides information on the various countermeasures that have been effective in addressing ROR collisions. Working with safety practitioners will be important in choosing the most effective approach.

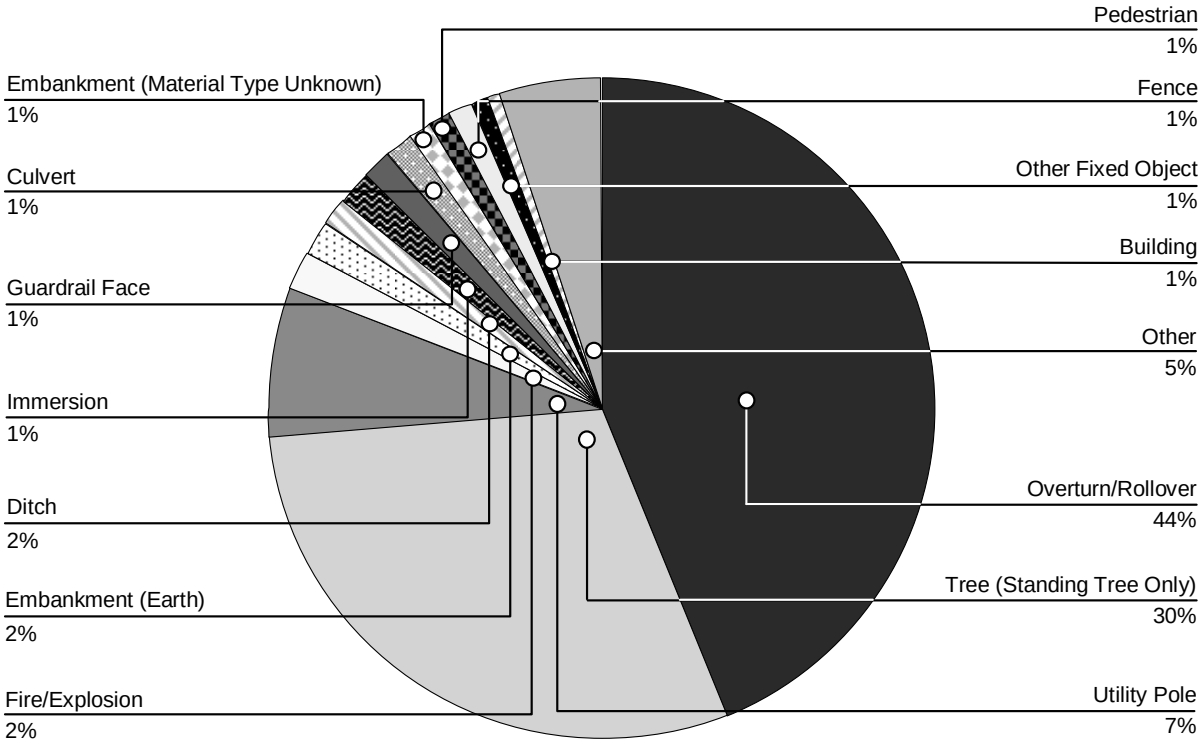
EXHIBIT III-20
Distribution of Single-Vehicle ROR Fatalities for Two-Lane, Undivided, Noninterchange, Nonjunction Roads
First Harmful Event



Source: 2005 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-21
Distribution of Single-Vehicle ROR Fatalities for Two-Lane, Undivided, Noninterchange, Nonjunction Roads
Most Harmful Event



Source: 2005 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 2005 FARS data:

- Forty percent of fatal crashes were single-vehicle ROR collisions;
- Seventy-five percent of single-vehicle ROR fatalities on two-lane undivided, non-interchange, non-junction roads were on rural roads;
- Twenty-three percent of single-vehicle ROR fatalities on two-lane undivided, non-interchange, non-junction roads were on rural local roads and 24 percent were on rural major collectors; and
- On two-lane rural roads, 50 percent of single-vehicle ROR crashes were 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 that they are straying from their lane to the roadside, and to give them a chance to recover, 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, as many segments of road with high ROR crashes do not have wide paved shoulders (E, $);
- Install rumble strips in the center of the travel lane, so that encroachment on the roadside 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-22
Add Shoulder Rumble Strips

	Accident 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, $$$$);
- Provide enhanced pavement markings, such as high-contrast, wider, or raised markings (T, $);
- Provide skid-resistant pavement surfaces via methods, such as changing pavement aggregates, adding overlays, or adding texture (T, $$); and
- Apply shoulder treatments to allow vehicles to recover if they begin to leave the roadway, such as eliminating shoulder drop-offs (E, $) and widening and/or paving shoulders (P, $).

EXHIBIT III-23
Change Shoulder Width and/or Type

$AMF = (AMF_{WRA}AMF_{TRA}-1.0)P_{RA}+1.0$

where:

AMF = Accident modification factor for total accidents.

AMF_{WRA} = Accident modification factor for single-vehicle ROR and multiple vehicle opposing and same direction sideswipe crashes, based on shoulder width.

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

Shoulder Width	Average Daily Traffic (ADT)		
	≤ 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

AMF_{TRA} = Accident modification factor for single-vehicle ROR and multiple vehicle opposing and same direction sideswipe crashes, based on shoulder type.

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

Shoulder Type	Shoulder Width (Feet)							
	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 accidents constituted by related accidents.

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

Objective 2. Minimize the Likelihood of Crashing into an Object or Overturning If the Vehicle Travels Beyond the Edge of the Shoulder

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 that the driver can attempt to 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 or utility poles with retroreflective tape to improve their visibility, so drivers have more incentive to stay on the road and so "safer escape route" information is available to vehicles that do leave the roadway (E, $).

EXHIBIT III-24
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 Accident* 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%

* "Related accidents" would be the total of ROR, head-on, and sideswipe crashes.

EXHIBIT III-25
Percentage Reduction in "Related Accidents" Due to Increasing the Roadside Clear Recovery Distance on Two-Lane Rural Roads

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

Strategies

Roadside hardware should be evaluated to ensure that 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-26
Install/Upgrade Guardrail along Embankment

ROR Crashes	Accident 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.dot.state.ia.us/design/00_toc.htm#Chapter_8.

Resources

NCHRP 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/fourthlevel/pro_res_road_nchrp350.htm.

Head-On Collisions

Problem Description

Most head-on crashes are likely to result from a motorist making an "unintentional" maneuver – the driver falls asleep, is distracted, or travels too fast in a curve. Affecting head-on fatalities is clearly more complex than simply providing adequate passing zones. Indeed, most head-on crashes are similar to run-off-road crashes – in both cases, the vehicle strays from its travel lane. This section provides information on the various countermeasures that have been effective in addressing head-on collisions. Working with safety practitioners will be important in choosing the most effective approach.

Data

- Eleven percent of non-interchange, non-junction fatal crashes involved two vehicles colliding head-on, according to 2005 FARS data;
- 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 non-passing situations; and
- On two-lane divided roadways, 80 percent of head-on fatal crashes are "going straight," and 20 percent are "negotiating a curve."

EXHIBIT III-27
Centerline Rumble Strips Implemented in Maryland

Objective 1. Keep Vehicles from Encroaching into Opposite Lane

Strategies

Engineering strategies that alert drivers that they are moving into an oncoming lane, and that provide better visibility of centerline lane markings can help drivers stay alert and aware of their position on the roadway. Roadway design providing more space for drivers may offer a safety benefit, but it also is a higher-speed design, which presents risks. Buffers between opposing flows of traffic may provide protection from head-on collisions. Strategies include the following:

EXHIBIT III-28
Add Centerline Rumble Strips

Crash Type (All Severities)	Accident 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 centerline rumble strips for two-lane roads that alert drivers they are straying into an oncoming lane (T, $);
- Install profiled thermoplastic strips for centerline that provide an audible/tactile effect for drivers straying from their lanes and a longer visibility distance at night (T, $);
- Provide wider cross sections on two-lane roads with wider lanes, wider 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," so narrower lanes slow traffic and a buffer is placed between opposing flows (T, $).

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

Strategies

Providing either space for passing that prevents the need to travel into an oncoming lane, or a physical barrier to prevent vehicles from entering a lane of oncoming traffic may prevent head-on collisions. Countermeasures include the following:

EXHIBIT III-29
Add Passing Lanes
Two-Lane Roads

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

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

Resources

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

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 there are more than 10 million horizontal curves in the United States on two-lane highways alone. State highway agencies generally operate crash records systems that track accident 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 accident data. Thus, safety concerns on horizontal curves can only be identified indirectly, and there is typically no formal means of reviewing all horizontal curves and identifying 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.

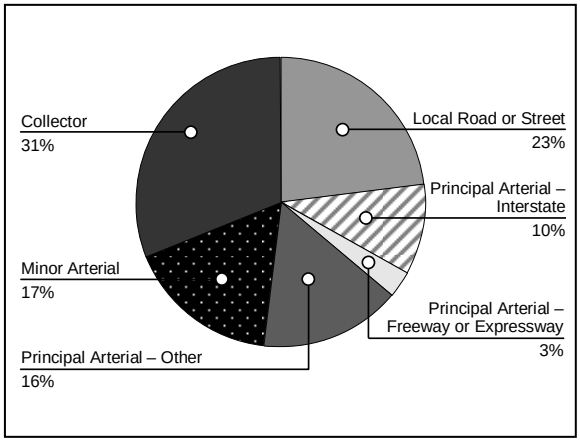
Accidents on horizontal curves cause a significant amount of pain and injury to those involved because of the nature of the collisions. For example, while only slightly less than 2 percent of all crashes on curved roadway segments are fatal crashes, approximately 40 percent involve some type of injury.

The safety of curves is both a reflection of the roadway itself and the roadside environment. The first harmful event of a crash 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 the various countermeasures that have been effective in addressing horizontal curve collisions. Working with safety practitioners will be important in choosing the most effective approach.

Data

- Twenty-six percent of fatal crashes occurred along horizontal curves, according to 2005 FARS data;
- Approximately 73 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 crashes; and
- Fifty-one percent of fatal crashes at horizontal curves in 2005 were at night.

EXHIBIT III-30
Location of Fatal Crashes on Horizontal Curves by Roadway Classification



Objective 1. Reduce the Likelihood of a Vehicle Leaving Its Lane and Crossing the Roadway Centerline or Leaving the Roadway at a Horizontal Curve

Strategies

To reduce the likelihood of leaving the roadway on a curve, strategies can help alert drivers to the presence of a curve and clearly delineate the roadway boundaries in the curve, so they drive more slowly and carefully. In addition, engineering treatments may be implemented to make the roadway alignment and surface safer. Strategies also can be implemented to alert drivers when their vehicle is leaving the roadway. Countermeasures 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, $);
- 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, $$);

See Lane Departure section for Accident Modification Factors for shoulder rumble strips on page III-33.
See Head-on Collisions section for Accident Modification Factor values for centerline rumble strips on page III-37.

- Provide grooved pavement with longitudinal or transverse cuts to improve drainage and reduce wet-weather crashes (T, $$);
- Provide lighting of the curve (T, $$);
- 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, $$);

See Lane Departure section on page III-34 for Accident Modification Factor values for shoulder improvements.

- Widen the roadway, including widening travel lanes, adding or widening shoulders, or adding a buffer zone in the middle of the roadway (P, $$$);
- Improve or restore superelevation, which works with friction between the tires and the pavement to counteract cornering forces on the vehicle (P, $$$);
- Modify horizontal alignment, such as 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

EXHIBIT III-31
Improve Curve Superelevation

Superelevation Deficiency (SD)	Accident 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: Accident Modification Factor applies to total accidents occurring on curved roadway segments. **Accident Modification Factor applies to rural two-lane roads only.**

- 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 does leave 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 have more incentive to stay on the road and so "safer escape route" information is available to vehicles that do leave the roadway (E, $);

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

Best Practices

FHWA Listing of state rumble strips contacts:
http://safety.fhwa.dot.gov/roadway_dept/rumble/expertcontacts.htm.

Resource

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, in particular, involves vehicles leaving the road and striking a fixed object. Trees are generally 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 help to weigh transportation safety considerations against landscaping and beautification considerations. They can help determine the most effective strategies that will have the least negative impact on community appearance.

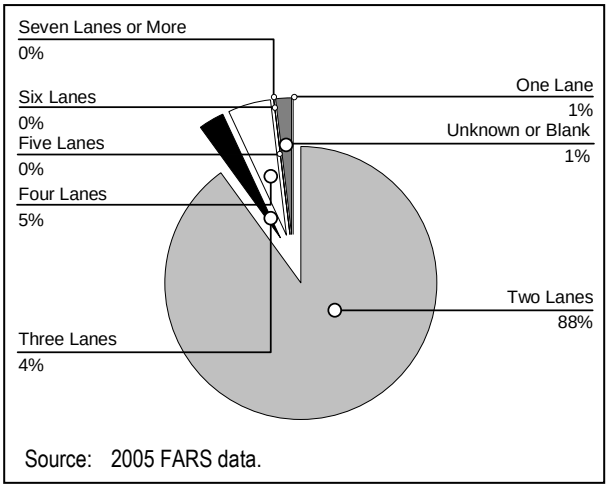
Data

- Two-thirds of fatal tree crashes in 2005 were on rural roads.
- Of all fatal tree crashes, 88 percent occur on 2-lane roads and 5 percent on 4-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 reflect increased numbers of such roadside features on higher volume, generally higher-class roads.

- Fifty-eight percent of fatal tree crashes occurred under nighttime conditions, which is significant given that much more traffic occurs in daylight hours versus night hours.
- Forty-four percent of all fatal tree crashes occurred on curved roads.

Strategies for keeping vehicles on the road are an important aspect of reducing head-on collisions and addressed under Addressing Run-Off-Road Collisions. This section focuses on preventing trees from growing in hazardous locations, eliminating hazardous conditions, and reducing the severity of the crash.

EXHIBIT III-32
Fatal Tree Crashes by Number of Travel Lanes, 2005



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 will need to provide guidance on roadside flattening and tree removal that may be part of a highway rehabilitation or reconstruction project;
- Safety engineers will need to help with identification of cost-effective locations for tree removal safety enhancement projects; and
- Design engineers will need to help 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 roadside trees in hazardous locations, the DOT, communities, and conservation groups can be encouraged to plant and grow roadside 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, while considering the operations and purpose of the roadway (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 is critical to enable identification of 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 ensuring that after tree removal the roadside is safe and free of stumps or deep depressions (P, $$);
- Provide guardrails to reduce crash severity by shielding motorists from striking trees (P, $$);
- Modify roadside clear zone in the vicinity of trees by implementing strategies, such as flattening sideslopes and adding shoulder improvements, so that vehicles leaving the roadway can recover before striking a tree (P, $$$); and
- Delineate trees in hazardous locations using methods, such as adding reflective stripes 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 are fixed-object crashes that involve vehicles leaving the travel lane and striking a utility pole. Utility poles represent one of the more substantial objects that are 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.

EXHIBIT III-33
High-Speed Rural Road with Utility Poles Less Than 15 Feet from the Edge of the Outside of a Horizontal Curve

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

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 will be important in choosing the most effective approach.

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;
- Twenty-five percent of pole crashes occur in adverse weather conditions; and
- One-half of pole crashes occur in full daylight.

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. 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 with a history of hazard);
- Relocate poles in high-crash locations farther from the roadway and/or to less vulnerable locations (P, $);
- Use breakaway devices, so that vehicles pass through the pole and do not require the vehicle to absorb as much energy, reducing the severity of the crash (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-34
Percent Reduction in Crashes for Moving Poles Farther from the Roadway

Expected Percent Reduction in Pole Crashes									
Pole Line Before Removal	Pole Line After Removal (Feet)								
(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 ensure that each pole within the boundaries of a specific transportation project be 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 areas along a corridor include the following:

- Place utilities underground as possible, given that 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 Practices

Washington State DOT policy on utility placement:
http://safety.transportation.org/htmlguides/site_map/default.htm.

Examples of Utility Companies' Roadside Safety Policies:
http://safety.transportation.org/htmlguides/site_map/default.htm.

Resource

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

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 these secondary enforcement laws have been successful in raising restraint use above 50 percent in most cases, permitting standard, or primary, enforcement for violations of the restraint laws has produced the highest use rates seen in the United States (and internationally).

"It would be impossible to overstate the lifesaving and dollar-saving impact of increases in safety belt use."[3] 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 usage 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 usage among those who have not yet been reached by educational or enforcement messages.

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

EXHIBIT III-35
Safety Belt Use Rates by State
2003 and 2004

State	2003	2004	State	2003	2004
Alabama	77.4%	80.0%	Montana	79.5%	80.9%
Alaska	78.9%	76.7%	Nebraska	76.1%	79.2%
Arizona	86.2%	95.3%	Nevada	78.7%	86.6%
Arkansas	62.8%	64.2%	New Hampshire[1]	49.6%	NA
California	91.2%	90.4%	New Jersey	81.2%	82.0%
Colorado	77.7%	79.3%	New Mexico	87.2%	89.7%
Connecticut	78.0%	82.9%	New York	84.6%	85.0%
Delaware	74.9%	82.3%	North Carolina	86.1%	86.1%
Dist. of Columbia	84.9%	87.1%	North Dakota	63.7%	67.4%
Florida	72.6%	76.3%	Ohio	74.7%	74.1%
Georgia	84.5%	86.7%	Oklahoma	76.7%	80.3%
Hawaii	91.8%	95.1%	Oregon	90.4%	92.6%
Idaho	71.7%	74.0%	Pennsylvania	79.0%	81.8%
Illinois	80.1%	83.0%	Rhode Island	74.2%	76.2%
Indiana	82.3%	83.4%	South Carolina	72.8%	65.7%
Iowa	86.8%	86.4%	South Dakota	69.9%	69.4%
Kansas	63.6%	68.3%	Tennessee	68.5%	72.0%
Kentucky	65.5%	66.0%	Texas	84.3%	83.2%
Louisiana	73.8%	75.0%	Utah	85.2%	85.7%
Maine	NA	72.3%	Vermont	82.4%	79.9%
Maryland	87.9%	89.0%	Virginia	74.6%	79.9%
Massachusetts	61.7%	63.3%	Washington	94.8%	94.2%
Michigan	84.8%	90.5%	West Virginia	73.6%	75.8%
Minnesota	79.4%	82.1%	Wisconsin	69.8%	72.4%
Mississippi	62.2%	63.2%	Wyoming	NA	70.1%
Missouri	72.9%	75.9%	Puerto Rico	87.1%	90.1%

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

[1] The 2003 rate for New Hampshire was not reported by the State. It was obtained by Preusser Research Group using methods compliant with Section 157.

NA = Not Available.

Raising national use rates to higher levels will have significant economic benefits as well as saving lives. 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.

Child restraints have been found effective in reducing the risk of death 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 not ensuring the general use of child restraints, but ensuring their *proper* use.

Motorcycle fatalities rose 13 percent from 4,028 in 2004 to 4,553 in 2005; and almost one-half of the people who died were not wearing a helmet.

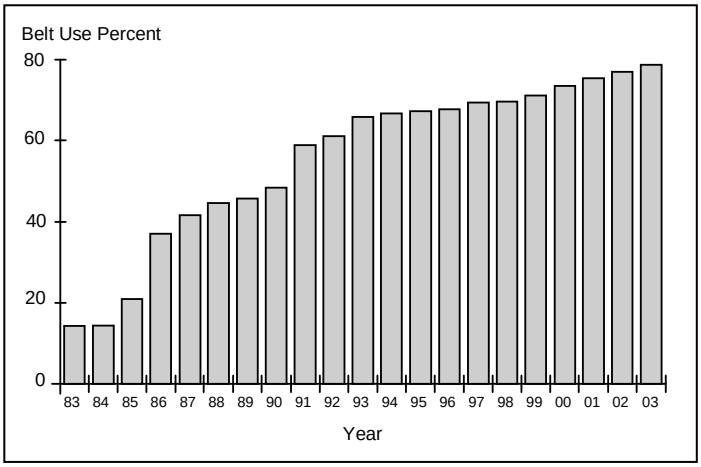
Planners understand the limits on resources for transportation infrastructure improvements. Given that not every roadway will be able to undergo all the safety improvements that may be desired, the most effective strategy to reduce death and serious injury on the roadways is to ensure that all persons in a vehicle are wearing safety belts. Planners can help communicate the messages that work to change the culture of safety and people's behavior must be done in tandem with roadway safety improvements. Improving safety belt compliance by just a few percent can mean many lives saved.

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

Data

- More than one-half (55 percent) of passenger vehicle occupants killed were unrestrained in 2005, according to NHTSA.
- In 2005, on a national level, safety belt use was 82 percent, with 28 states and the District of Columbia exceeding 80 percent.
- As of July 2006, 25 states and the District of Columbia have primary safety belt laws in place, and only one state (New Hampshire) lacks a mandatory use law.
- In 2005, restraint use varied by state from just under 50 percent (New Hampshire) to more than 90 percent (Arizona, California, Hawaii, Maryland, Michigan, Oregon, and Washington).

EXHIBIT III-36
National Seatbelt Use Rates,
1983-2003



Source: National Highway Traffic Safety Administration, 2004b.

- Vehicle occupants are about 50 percent more likely to be hospitalized from crash-related injuries if they were not wearing safety belts at the time of the crash (Boyle and Sharp, 1997a, 1997b).
- Seventy-three percent of the people who were in a fatal crash in 2001 and were restrained survived; of those who were not restrained, only 44 percent survived.
- Eighty-five percent of child seats were misused according to a 1999 study by the National Safe Kids Campaign.
- Per vehicle mile traveled, motorcyclists are about 32 times more likely than passenger car occupants to die in motor vehicle traffic crashes and 6 times more likely to be injured.[4]
- According to NHTSA's National Occupant Protection Use Survey, helmet use declined by 13 percentage points over 4 years, from 71 percent in 2000 to 58 percent in 2004.
- 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.

[4] NHTSA, 2003.

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

Strategies

Large-scale enforcement of safety belt laws is critical to demonstrate to the public that by not wearing their safety belts they are breaking the law. Past work in this area has shown that 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, $);
- Encourage the enactment of local laws that will permit local primary enforcement of restraint laws in states without primary safety belt laws (T, $); and
- Enact a mandatory helmet law (T, $).

Objective 2. Ensure that 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 that 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, including both public safety agencies and health care providers, that are almost always available (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 implementing programs to increase restraint use that organizes and catalogues the range of materials available from various organizations and agencies (E, $$).

Best Practices

Summary of the State of California's highly regarded car seat law: 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.

Central sources for public education materials on occupant restraint:

- AAA: www.aaafoundation.org/products/index.cfm; and
- Buckle Up America: www.buckleupamerica.org.

Resources

NCHRP Report 500: *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, 2005, Governors Highway Safety Association: http://www.ghsa.org/html/publications/pdf/GHSA_Countermeasures.pdf.

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

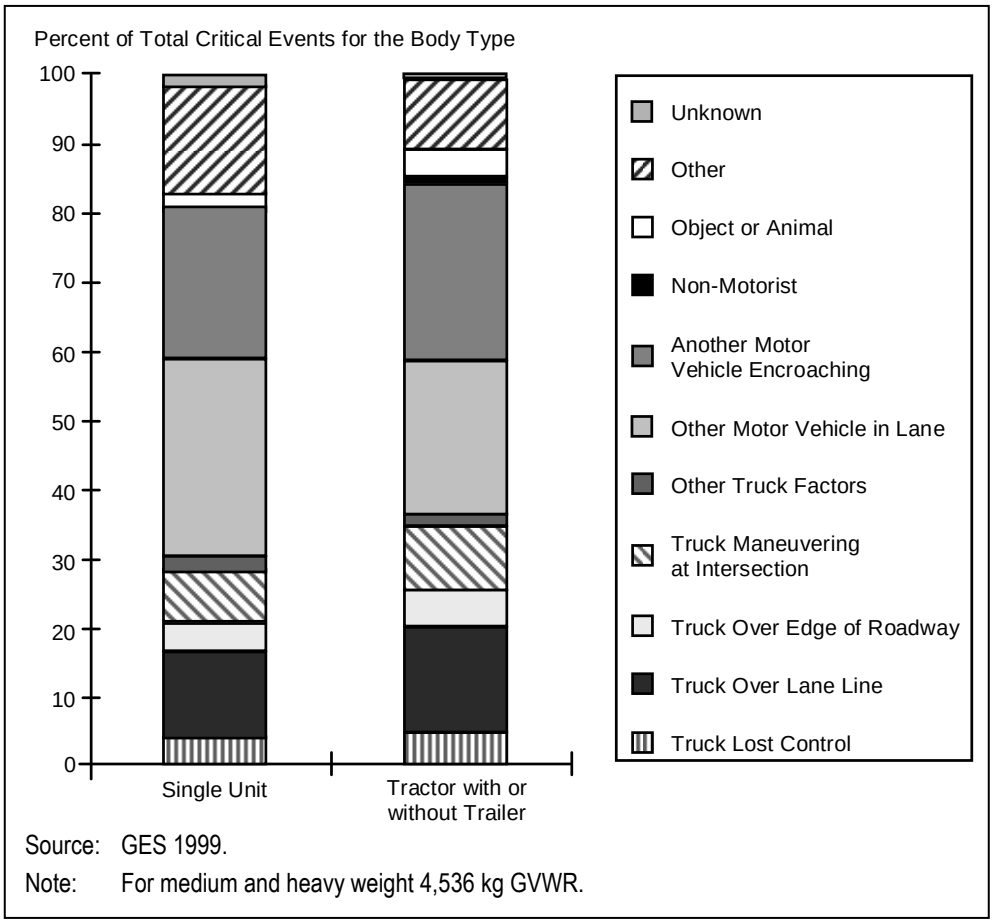
Heavy Truck Collisions

Problem Description

In 2001, 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 that of vehicles in general (Wang et al., 1999), given their high-mileage exposures 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-37. There are two kinds of critical events: 1) those associated with the truck; and 2) those associated with the other vehicle or a person or object. A preliminary report from the FMCSA/NHTSA *Large-Truck Crash Causation Study* shows that 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.

EXHIBIT III-37
Critical Event for Crashes Involving Single-Unit and Tractor Trucks



Source: GES 1999.
Note: For medium and heavy weight 4,536 kg GVWR.

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-spot locations, 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 that 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. Therefore, the driver cannot see them.

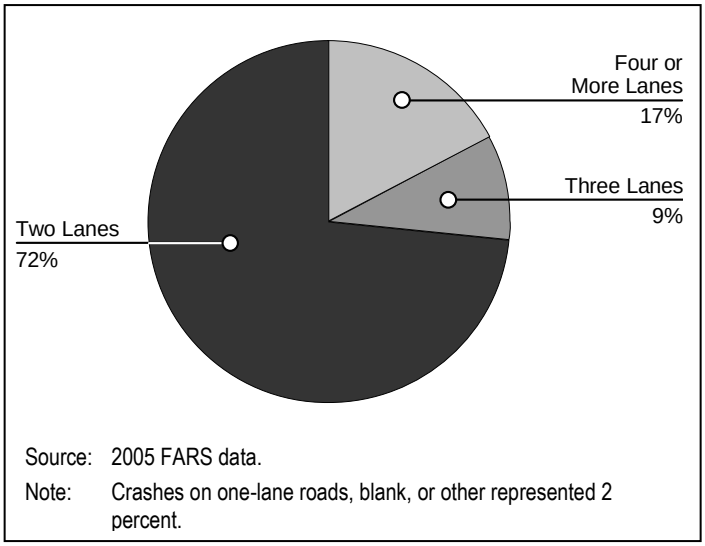
According to analysis of a Michigan program called Fatal Accident Complaint Team (FACT) that investigated trucks involved in fatal crashes, 66 percent of trucks had at least one out-of-service (OOS) violation by either the truck driver or the truck. Although high rates of vehicle defects, including OOS problems, are found in heavy trucks in general, large trucks in crashes have higher rates of vehicle defects that 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 the various countermeasures that have been effective in addressing heavy truck collisions. Working with safety practitioners will be important in choosing the most effective approach.

Data

- Seven percent of people killed in motor vehicle crashes in 2005 were in crashes involving heavy trucks;
- Sixty-one percent of fatal heavy-truck crashes occur on rural roads and 30 percent occur on Interstate and expressway facilities;
- In crashes between large trucks and passenger vehicles, passenger vehicle driver errors or other factors are twice as likely to be cited as are truck driver errors or other factors (FHWA, 1999c; Blower, 1999); and

EXHIBIT III-38
Number of Travel Lanes for Fatal Crashes Involving Trucks



Source: 2005 FARS data.
Note: Crashes on one-lane roads, blank, or other represented 2 percent.

- Seventy-two percent of fatal crashes involving trucks occur on two-lane roads.

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 for short periods 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 use 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, $$); and
- Incorporate rumble strips into new and existing roadways to help maintain drivers' alertness when they stray from the travel lane (N/A, $$).

Objective 2. Strengthen Commercial Drivers 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 (T, $) to ensure interstate reporting of infractions and reduce fraudulent issuing of licenses.

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 breaking 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[5] showed that truck brake, tire, and other mechanical defects contribute "substantially" to truck crashes. Strategies include:

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

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[6] by drivers. Therefore, warning signs of high-risk areas can be useful to truck drivers. Strategies include:

- Identify and treat truck high-crash roadway segments with methods, such as signing to alert drivers of high-truck crash incidence, so they can modify their driving accordingly (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 holding a single license and to establish a reporting system that compiles a single record

[5] Blower, 2002.

[6] Rudin-Brown.

incorporating data from all jurisdictions where infractions or crashes occur. Because of trucks' 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, $$$).

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. Frequently asked questions and information about ordering Maryland's Preventive Maintenance handbook are located at: http://www.dsd.state.md.us./p.m.-faq.htm.

Iowa TraCS: Traffic and Criminal Software, a national model for using new technologies for improving data collection and analysis: http://www.tracsinfo.us/tracs_home.asp.

Tennessee Department of Safety Alternative Commercial Enforcement Strategies using specially trained officers to visit fleets in an advisory rather than enforcement approach: Captain Steve Binkley, Tennessee Department of Safety (615-687-2317, steve.binkley@ state.tn.us).

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

FMCSA Safety is Good Business Program: Tony Schafer, Safety Action Programs Division (202-366-2953, Anthony. schafer@fmcsa.dot.gov).

Resources

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

Share the Road Safely: 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.

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 the various countermeasures that have been effective in addressing work zone collisions. Working with safety practitioners will be important in choosing the most effective approach.

Data

According to 2005 FARS data:

- More than one-half of all fatal work zone crashes occurred during the day;
- Twenty-eight 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;
- Fifty-seven percent of work zone fatal crashes occurred on roads with a posted speed limit of 55 mph or greater; and
- Single-vehicle crashes accounted for one-half of all work zone fatal crashes.

Other facts regarding work zone safety include:

- Heavy trucks were involved in more than 20 percent of fatal work zone crashes (FMCSA, 2004); and
- Alcohol was involved in 39 percent of fatal work zone crashes in 2003 (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, $$$);
- Utilize full-time roadway closure for construction operations to complete work faster, more cost-effectively, and more safely (T, $);
- Utilize time-related contract provisions to ensure that construction schedules are as efficient as possible (P, $$);
- Use nighttime road work so that 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-39
Type III Barricade Spaced at Intervals in Closed Lane to Reduce Intrusion Risk

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 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 that 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 also are important. Strategies include:

- Disseminate work zone safety information to road users, such as work zone information on DOT web sites (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 that 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, $$); and
- Implement work zone quality assurance procedures, such as safety inspections or audits (T, $$).

Best Practices

Virginia DOT's Work Area Protection Manual:
http://www.virginiadot.org/business/resources/1-%20WEBwapmCOVER.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/fasc/engineeringpublications/manuals/designmanual.pdf.

Resources

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

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 Make Work Zones Better Workshop:
http://www.fhwa.dot.gov/construction/washto02/zones.htm.

FHWA Work Zone Mobility and Safety Program Best Practices Guide:
http://ops.fhwa.dot.gov/wz/practices/practices.htm.

National Work Zone Safety Awareness Week cosponsored by the FHWA and AASHTO:
http://safety.fhwa.dot.gov/wz/wz_awareness.htm.

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 that the reduction of crashes and fatalities due to distracted and drowsy driving 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 that they are less likely to operate their vehicles when drowsy or distracted. This section provides information on the various countermeasures that have been effective in addressing collisions involving drowsy or distracted driving. Working with safety practitioners will be important in choosing the most effective approach.

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 has been towed from the crash scene. An analysis of 2000 to 2004 CDS crash data shows that 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 also provides information on the specific sources of driver distraction. Exhibit III-40 shows the sources of distraction for those 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 here include other cars and drivers on the roadway, pedestrians, work zones, accident scenes, and general "rubbernecking" (i.e., looking at scenery or landmarks). "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 their crash, all age groups are affected, as shown in Exhibit III-41. 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-40
Specific Sources by Percentage of Driver Distraction Identified in the Weighted 2000 to 2003 CDS Data

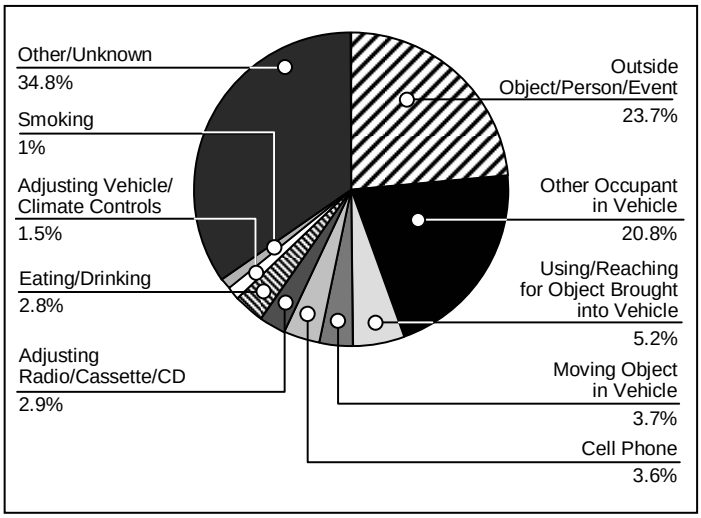
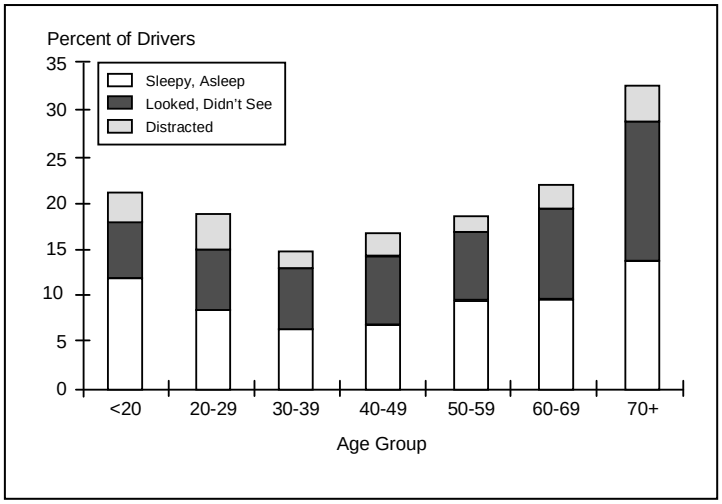


EXHIBIT III-41
Distribution of Driver Attention Status within Categories of Driver Age, Based on Weighted 2000 to 2003 CDS Data



The 2003 revision of the Model Minimum Uniform Crash Criteria (MMUCC) recommends the addition of a new data element on state crash report forms to 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 traveled 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 (P, $$) to alert the driver if they are leaving the roadway; and
- Implement other roadway improvements to reduce the likelihood and severity of run-off-road and/or head-on collisions as outlined in the sections on Addressing Run-Off-Road Collisions and Addressing Head-On Collisions (P, $$$).

See Lane Departure section for shoulder rumble strip Accident Modification Factors on page III-33 and Head-on Collisions section for centerline rumble strips Accident Modification Factors on page III-37.

Objective 2. Provide Safe Stopping and Resting Areas

Strategies

Rest areas are important for safe motor vehicle operation. The FHWA recommends that facilities be provided every 50 miles or 1-hour 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 that are generally located on Interstates may not address the problem. To address the need for safe stopping and resting areas on smaller 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 that 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 that since 1999 every state has considered legislation related to the use of wireless phones.[7] However, no state currently bans talking on all types of cell phones while driving. A few states and jurisdictions have banned talking on handheld phones (New York, New Jersey, the District of Columbia, Chicago). 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 drivers 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, $$);
- Enhance enforcement of commercial motor vehicle hours of service regulations with mobile inspection units (P, $$);
- Encourage trucking companies and other fleet operators to offer fatigue management programs (T, $$); and
- Implement targeted interventions for other high-risk populations (T, $$).

[7] Sundeen, 2003.

Best Practices

Utah "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://sleepfoundation.org/press/index.php?secid=&id=89.

Cingular Wireless program for novice drivers about the importance of managing distractions while driving, including cell phone use: www.be-sensible.com.

Resources

NCHRP Report 500 Volume 14: *A Guide for 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: http://www.ghsa.org/html/publications/pdf/GHSA_Countermeasures.pdf.

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

AAA Foundation for Traffic Safety "Pay Attention" and "Wake Up" brochures: http://www.aaafoundation.org/products/index.cfm?button=free.

Network of Employers for Traffic Safety "Who's Driving" and "Asleep at the Wheel" programs: http://www.trafficsafety.org/index2.asp.

NHTSA Drowsy 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/supplements/nih3/sleep/default.htm.

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.

More than 70 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 that 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 that good routes to emergency medical care are available and that trauma centers are located in accessible areas. Additionally, first responders need to know alternative routes if a primary route is blocked.

The average EMS response time for rural crashes is nearly an hour. Planners can gather data on response times and raise this issue with elected officials so that 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 can be saved.

Data

- The average EMS response time for rural crashes is 53 minutes and for urban crashes is 36 minutes.
- Thirty percent of EMS response times in rural settings are between one and two hours, according to 2004 NHTSA data.

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 that data about the crash scene and victim(s) collected by EMS personnel can be input into 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

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 that 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.

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

Alcohol-Involved Collisions

Problem Description

Alcohol-impaired driving has been a subject of great concern among traffic safety professionals in the United States for the past three decades. During this time, alcohol-related crashes have decreased substantially. 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.

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

- 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 (Hedlunch and McCartt, 2002).
- Males, motorcyclists, and persons between the age of 21 and 35 are more likely than others to drive while impaired by alcohol.

Objective 1. Enforce DWI Laws

Strategies

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

- Conduct regular well-publicized 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 2. Prosecute and Impose Sanctions on DWI Offenders

Strategies

Sanctions that are swift and certain provide a strong deterrent against drunk driving, such as the following:

- Suspend driver's license administratively upon arrest (P, $); and
- Seize vehicles or vehicle license plates administratively upon arrest (P, $$), or immobilize the vehicle with a "boot" locking device.

Resources

NCHRP Volume 16: *A Guide for Reducing Alcohol-Related Collisions*:
http://safety.transportation.org/guides.aspx.

Countermeasures that Work: A Highway Safety Countermeasure Guide for State Highway Safety Offices, Governors Highway Safety Association:
http://www.ghsa.org/html/publications/pdf/GHSA_Countermeasures.pdf.

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