VOLUME 3

NCHRP

NATIONAL
COOPERATIVE
HIGHWAY
RESEARCH
PROGRAM

REPORT 500

Guidance for Implementation of the
AASHTO Strategic Highway Safety Plan

Volume 3: A Guide for Addressing Collisions with Trees in Hazardous Locations



TRANSPORTATION RESEARCH BOARD
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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Volume 3: A Guide for Addressing Collisions with Trees in Hazardous Locations

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SUBJECT AREAS
Safety and Human Performance

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TRANSPORTATION RESEARCH BOARD

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Academies was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state and local governmental agencies, universities, and industry; its relationship to the National Research Council is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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FOREWORD

By Charles W. Niessner
Staff Officer
Transportation Research Board

The goal of the AASHTO Strategic Highway Safety Plan is to reduce annual highway fatalities by 5,000 to 7,000. This goal can be achieved through the widespread application of low-cost, proven countermeasures that reduce the number of crashes on the nation's highways. This third volume of *NCHRP Report 500: Guidance for Implementation of the AASHTO Strategic Highway Safety Plan* provides strategies that can be employed to reduce the number of run-off-the-road crashes with trees. The report will be of particular interest to safety practitioners with responsibility for implementing programs to reduce injuries and fatalities on the highway system.

In 1998, AASHTO approved its Strategic Highway Safety Plan, which was developed by the AASHTO Standing Committee for Highway Traffic Safety with the assistance of the Federal Highway Administration, the National Highway Traffic Safety Administration, and the Transportation Research Board Committee on Transportation Safety Management. The plan includes strategies in 22 key emphasis areas that affect highway safety. The plan's goal is to reduce the annual number of highway deaths by 5,000 to 7,000. Each of the 22 emphasis areas includes strategies and an outline of what is needed to implement each strategy.

NCHRP Project 17-18(3) is developing a series of guides to assist state and local agencies in reducing injuries and fatalities in targeted areas. The guides correspond to the emphasis areas outlined in the AASHTO Strategic Highway Safety Plan. Each guide includes a brief introduction, a general description of the problem, the strategies/countermeasures to address the problem, and a model implementation process.

This is the third volume of *NCHRP Report 500: Guidance for Implementation of the AASHTO Strategic Highway Safety Plan*, a series in which relevant information is assembled into single concise volumes, each pertaining to specific types of highway crashes (e.g., run-off-the-road, head-on) or contributing factors (e.g., aggressive driving). An expanded version of each volume, with additional reference material and links to other information sources, is available on the AASHTO Web site at http://transportation1.org/safetyplan. Future volumes of the report will be published and linked to the Web site as they are completed.

While each volume includes countermeasures for dealing with particular crash emphasis areas, *NCHRP Report 501: Integrated Management Process to Reduce Highway Injuries and Fatalities Statewide* provides an overall framework for coordinating a safety program. The integrated management process comprises the necessary steps for advancing from crash data to integrated action plans. The process includes methodologies to aid the practitioner in problem identification, resource optimization, and performance measurements. Together, the management process and the guides provide a comprehensive set of tools for managing a coordinated highway safety program.

Contents

Acknowledgments

This series of six implementation guides was developed under NCHRP Project 17-18(3). The project was managed by CH2M HILL. The co-principal investigators were Ron Pfefer of Maron Engineering and Kevin Slack of CH2M HILL. Timothy Neuman of CH2M HILL served as the overall project director for the CH2M HILL team. Kelly Kennedy Hardy, also of CH2M HILL, participated in development of the guides.

This phase of the project involved the development of guide books addressing six different emphasis areas of AASHTO's Strategic Highway Safety Plan. The project team was organized around the specialized technical content contained in each guide. The CH2M HILL team included nationally recognized experts from many organizations. The following team of experts, selected based on their knowledge and expertise in a particular emphasis area, served as lead authors for each of the guides.

- Forrest Council of BMI led the development of "A Guide for Addressing Run-Off-Road Collisions"
- Doug Harwood of Midwest Research Institute led the development of "A Guide for Addressing Unsignalized Intersection Collisions"
- Hugh McGee of BMI led the development of "A Guide for Addressing Head-On Collisions"
- Richard Raub of Northwestern University Center for Public Safety led the development of "A Guide for Addressing Aggressive-Driving Collisions"
- Patricia Waller led the development of "A Guide for Addressing Collisions Involving Unlicensed Drivers and Drivers with Suspended or Revoked Licenses"
- Charlie Zegeer and Kevin Lacy of University of North Carolina Highway Safety Research Center led the development of "A Guide for Addressing Collisions Involving Trees in Hazardous Locations"

Development of the guides utilized the resources and expertise of many professionals from around the country and overseas. Through research, workshops, and actual demonstration of the guides by agencies, the resulting document represents best practices in each emphasis area. The project team is grateful to the following list of people and their agencies for their input on the guides and their support of the project:

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SECTION I

Summary

Introduction

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 the objects most commonly struck in run-off-road (ROR) collisions, and tree impacts are generally quite severe. This section addresses crashes involving impacts with trees.

Tree crashes are a subset of ROR crashes. Emphasis Area 15.1 addresses the general subject of ROR crashes. It covers strategies aimed at reducing the consequences of ROR crashes by keeping vehicles from leaving the roadway and reducing the severity of impacts after leaving the roadway. This volume focuses on measures directed at reducing the harm in tree crashes after encroachment on the roadside has occurred, such as removing trees and shielding motorists from trees. The reader should refer to Volume 6 of this report for strategies aimed at preventing tree crashes by keeping the vehicle on the roadway.

One of the key resources for guidance on reducing tree-related crashes is the *Guide to Management of Roadside Trees* (Zeigler, 1986). The guide addresses safety versus environmental issues. In particular, highway agencies may use it to

- Identify and evaluate higher-risk roadsides,
- Identify alternative treatments,
- Identify environmental considerations regarding roadside treatment,
- Provide guidelines for roadside tree removal and maintenance practices, and
- Provide documentation necessary to substantiate tree removal or alternative treatments.

Information from the *Guide to Management of Roadside Trees* was considered while developing this document. In addition, survey information was obtained from 14 state departments of transportation (DOTs) with respect to their methods for reducing tree crashes, including how environmental issues are considered.

The issue of tree hazards encompasses many DOT disciplines. Tree removal or other similar programs must address planning, design, construction, and maintenance as they relate to roadway and roadside features that affect tree crashes. The literature and experience of DOTs suggest the following:

- Implementation of an effective program must address concerns of construction and maintenance engineers. Guidance will be needed on roadside flattening and appropriate tree removal that may be part of a highway rehabilitation or reconstruction project.

- For safety engineers, describe how to identify roadway spots and sections with clusters of tree crashes to consider cost-effective tree removal for safety-enhancement projects.

- For design engineers, develop guidelines for construction of safe sideslopes, clear roadside recovery areas, and landscaping plans.

One of the hallmarks of the American Association of State Highway and Transportation Officials' (AASHTO's) Strategic Highway Safety Plan is to comprehensively approach safety problems. The range of strategies available in the guides will cover various aspects of the road user, the highway, the vehicle, the environment, and the management system. The guides strongly encourage the user to develop a program to tackle a particular emphasis area from each perspective. To facilitate this, hypertext linkages are provided in the electronic version of this document (see http://transportation1.org/safetyplan) to allow seamless integration of various approaches to a given problem. As more guides are developed for other emphasis areas, the extent and usefulness of this form of implementation will become more apparent.

The goal is to move away from *independent* activities of engineers, law enforcement, educators, judges, and other highway-safety specialists. The implementation process outlined in the guides promotes forming working groups and alliances that represent all of the elements of the safety system. In so doing, the groups can use their combined expertise to reach the bottom-line goal of targeted reduction of crashes and fatalities associated with a particular emphasis area.

General Description of the Problem

Collisions between vehicles and trees are a major type of traffic fatality. According to Fatal Accident Reporting System data for 1999 (Exhibit I-1), 10,967 fatal crashes involved a fixed object. Trees were the objects most often struck, involving 3,010 fatal crashes, or about 8 percent of all fatal crashes. Exhibit I-2 shows the distribution of fatal crashes by roadway functional class. Fatal tree crashes were most prevalent on local rural roads, followed by major rural collectors. Of all fatal tree crashes, 90 percent occurred on two-lane roads and 5 percent on four-lane roads (Exhibit I-2). While reducing tree-related fatal crashes will require addressing all classes of streets and highways in urban and rural areas, rural two-lane roads will receive much of the focus in the development of any program to reduce tree-related highway fatalities (Exhibit I-3).

Objectives of the Emphasis Area

The goal of this emphasis area is to eliminate tree crashes or reduce the harm that results from colliding with a tree. A primary way of accomplishing this is to keep the vehicle on the road. The strategies for this area are covered in Volume 6 of *NCHRP Report 500*. The objectives for this emphasis area are

- 16.1 A—Prevent Trees from Growing in Hazardous Locations
- 16.1 B—Eliminate the Hazardous Condition and/or Reduce the Severity of the Crash

While the occupants of the vehicle that leaves the roadway and potentially strikes a tree are the ultimate concern of this objective, the direct focus is on the roadside environment. These objectives are targeted at larger trees, generally greater than 4 in. in diameter. Smaller trees, like small wooden sign supports, typically break away or bend over and are less likely to result in serious consequences. Exhibit 1-4 summarizes the objectives and related strategies presented in this guide.

Environmental Considerations

Trees contribute significantly to the roadway environment. This can be a complicating factor in dealing with trees in hazardous locations. There is a strong movement nationally to

EXHIBIT I-1
Total and Fixed-Object Fatal Tree Crashes in 1999

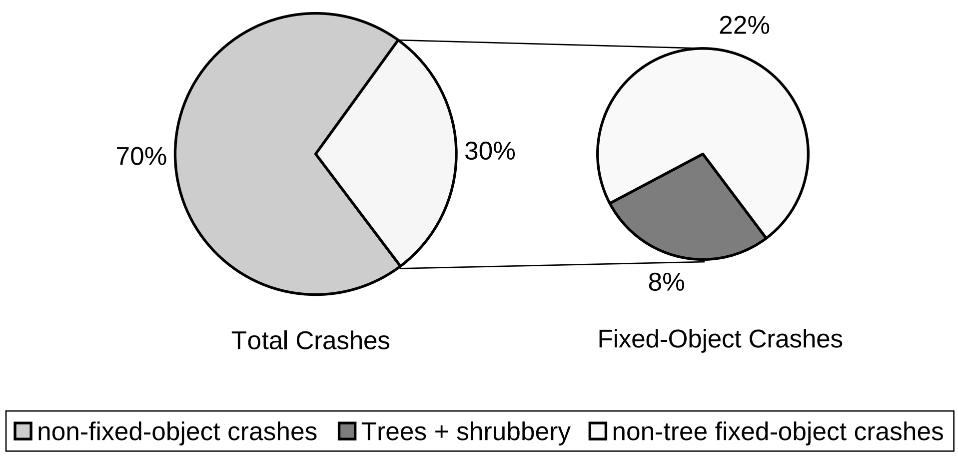


EXHIBIT I-2
1999 Fatal Tree Crashes by Functional Class

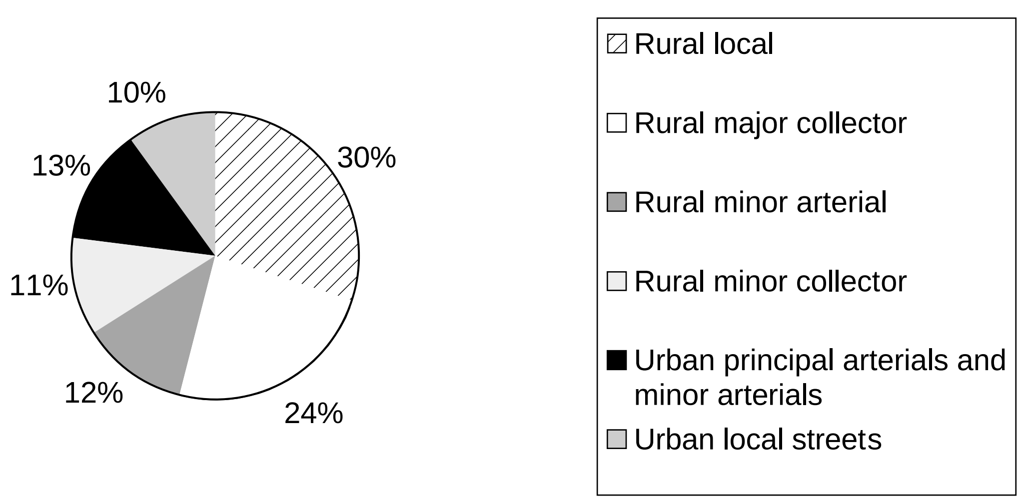


EXHIBIT I-3
Fatal Tree Crashes by Number of Travel Lanes, 1999

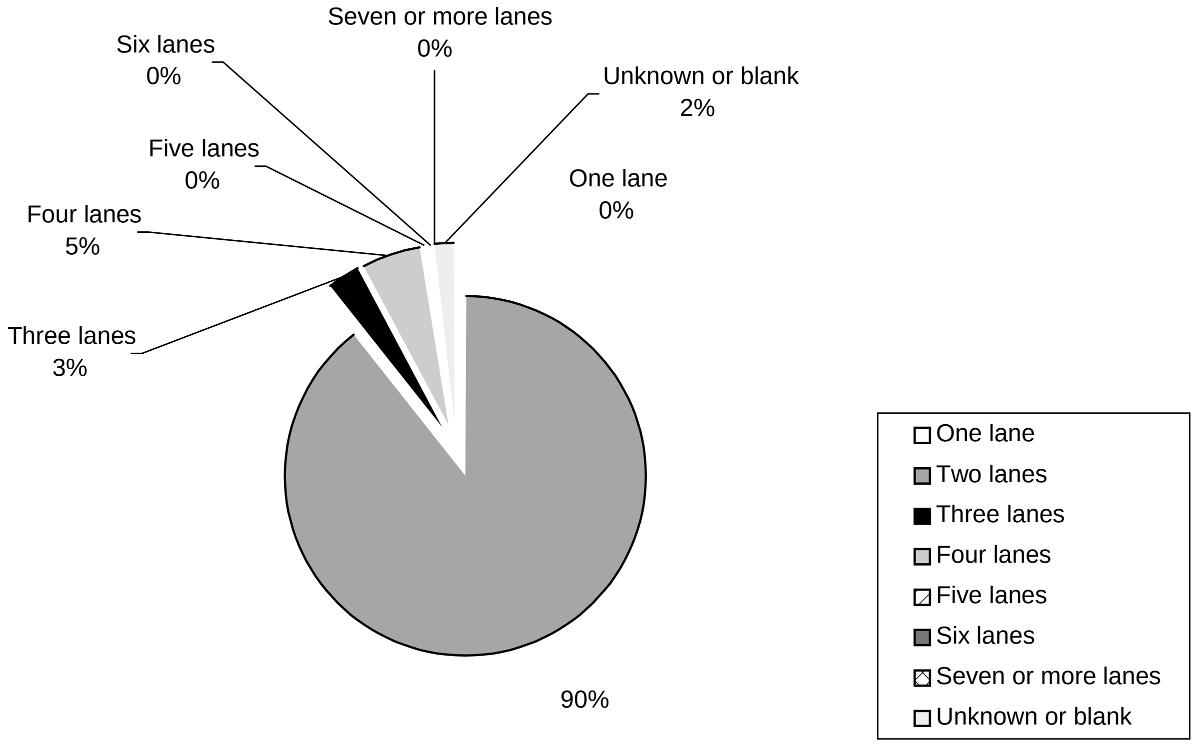


EXHIBIT I-4
Emphasis Area 16.1—Crashes with Trees in Hazardous Locations

Objectives	Strategies
16.1 A—Prevent Trees from Growing in Hazardous Locations	16.1 A1—Develop, Revise, and Implement Planting Guidelines to Prevent Placing Trees in Hazardous Locations
	16.1 A2—Mowing and Vegetation Control Guidelines
16.1 B—Eliminate the Hazardous Condition and/or Reduce the Severity of the Crash	16.1 B1—Remove Trees in Hazardous Locations
	16.1 B2—Shield Motorists from Striking Trees
	16.1 B3—Modify Roadside Clear Zone in the Vicinity of Trees
	16.1 B4—Delineate Trees in Hazardous Locations

maintain and preserve historic and scenic resources during construction and reconstruction of highways. Strategies that focus solely on the safety aspects of trees and promote tree removal over other measures will not be acceptable to important constituencies. Many states have developed extensive scenic byway programs. The concept of context-sensitive design has been adopted in much of the country, and it is endorsed by AASHTO. It encourages a comprehensive view of the design situation, in a collaborative framework.

SECTION II

Introduction

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 the objects most commonly struck in ROR collisions, and tree impacts are generally severe. This section addresses fatal crashes involving impacts with trees.

Tree crashes are a subset of ROR crashes. Volume 6 addresses the general subject of ROR crashes. It covers strategies aimed at reducing the consequences of ROR crashes by keeping vehicles from leaving the roadway and reducing the severity of impacts after leaving the roadway. This guide (Volume 3) focuses on measures to reduce the harm in tree crashes after encroachment on the roadside has occurred, such as removing trees and shielding motorists from trees. The reader should refer to Volume 6 for ways to prevent tree crashes by keeping the vehicle on the roadway.

The *Guide to Management of Roadside Trees* (Zeigler, 1986) is a key resource for reducing tree-related crashes. It addresses safety versus environmental issues. In particular, highway agencies may use it to

- Identify and evaluate higher risk roadsides,
- Identify alternative treatments,
- Identify environmental considerations regarding roadside treatment,
- Provide guidelines for roadside tree removal and maintenance practices, and
- Provide documentation necessary to substantiate tree removal or alternative treatments.

In addition to various references, survey information was obtained from 14 state DOTs with respect to their methods for reducing tree crashes, including how environmental issues are considered.

Appendix 2 contains the nine-question survey form and a summary of responses by state. Appendix 1 contains proposed guidelines for tree plantings and clear zones by the North Carolina DOT Roadside Environmental Unit (which may not have received final approval from North Carolina DOT for use as yet). Appendix 3 contains excerpts from the Michigan DOT *Design Manual* related to tree removal.

Tree hazards encompass many DOT disciplines. Tree removal, or other similar programs, address planning, design, construction, and maintenance as they relate to roadway and roadside features that affect tree crashes. The literature and experience of DOTs suggest that

- Implementing an effective program must address the concerns of construction and maintenance engineers. Guidance will be needed on roadside flattening and appropriate tree removal that may be part of a highway rehabilitation or reconstruction project.

- For safety engineers, it will be necessary to describe how to identify roadway spots and sections with clusters of tree crashes to consider cost-effective tree removal safety enhancement projects.

- For design engineers, it will be necessary to develop guidelines for construction of relatively flat sideslopes, clear roadside recovery areas, and landscaping plans.

One of the hallmarks of AASHTO's Strategic Highway Safety Plan is to comprehensively approach safety problems. The range of strategies available in the guides will cover various aspects of the road user, the highway, the vehicle, the environment, and the management system. The guides strongly encourage the user to develop a program to tackle a particular emphasis area from each perspective in a coordinated manner. To facilitate this, the electronic guides use hypertext linkages to enable seamless integration of various approaches to a given problem. As more guides are developed for other emphasis areas, the extent and usefulness of this form of implementation will become more apparent.

The goal is to move away from *independent* activities of engineers, law enforcement, educators, judges, and other highway-safety specialists. The implementation process outlined in the guides promotes forming working groups and alliances that represent all of the elements of the safety system. The groups can use their combined expertise to reach the bottom-line goal of targeted reduction of crashes and fatalities associated with a particular emphasis area.

Section III

The Type of Problem Being Addressed

General Description of the Problem

Collisions between vehicles and trees are a major type of traffic fatality. According to Fatal Accident Reporting System (FARS) data for 1999 (Exhibit III-1), 10,967 fatal crashes involved a fixed object. Trees were the objects most often struck, involving 3,010 fatal crashes, or about 8 percent of all fatal crashes.

Exhibit III-2 shows the distribution of fatal crashes by roadway functional class. Fatal tree crashes were most prevalent on local rural roads, followed by major rural collectors. Of all fatal tree crashes, 90 percent occurred on two-lane roads and 5 percent on four-lane roads (see Exhibit III-3). While reducing tree-related fatal crashes will require addressing all classes of streets and highways in urban and rural areas, rural two-lane roads will receive much of the focus in the development of any program to reduce tree-related highway fatalities.

Specific Attributes of the Problem

Tree crashes are strongly correlated with traffic volume, roadway geometry, and overall roadside condition. Zegeer et al. (1990) included a detailed analysis of crashes involving specific types of roadside features. For average daily traffic (ADT) categories of 1,000 vehicles per day (vpd) and below, 22 to 24 percent of fixed-object crashes involve striking trees (Exhibit III-4). This compares to 16 percent involving tree crashes for roads with ADTs of 1,000 to 4,000 vpd, and 11 percent for ADT above 7,500 vpd.

Conversely, the percent of crashes involving utility poles, signs, and guardrail increases as ADT increases, which reflects increased numbers of such roadside features on higher-volume, generally higher-class roads. More insights are gained by examining the relationship between tree and other fixed-object crashes and traffic volume, as well as by looking at the frequency per-mile of such crashes. Given that total crashes increase as ADT increases, the frequency per-mile of crashes involving trees and other fixed objects increases as ADT increases. Exhibits III-5a through 5c demonstrate the relationship among tree crashes (per-mile per-year); ADT; distance of trees from the road; and "tree coverage" (i.e., percent of the roadside with one or more trees). The study was based on data for a 5,000-mi sample of mostly rural two-lane roads (Zegeer et al., 1987).

Exhibit III-5b corresponds to roadway segments having tree coverage of 15 to 30 percent and average tree distances of 0 to 30 ft from the roadway under various ADT categories. Here, sections having 15 to 30 percent tree coverage between 0 and 12 ft and having ADTs above 4,000 were found to average 0.25 tree crash per mile per year. Actual values for a given section will vary, depending upon roadway geometry (e.g., roadway width, roadway alignment); traffic factors (e.g., percent trucks); and driver factors (e.g., percent of drinking drivers, young drivers).

Perhaps the most important point illustrated by Exhibits III-5a through 5c is the relative infrequency of tree crashes on two-lane highways, even where traffic volumes are higher, tree coverage is significant, and the trees are close to the road. In such cases, one might

EXHIBIT III-1
Total and Fixed-Object Fatal Tree Crashes in 1999

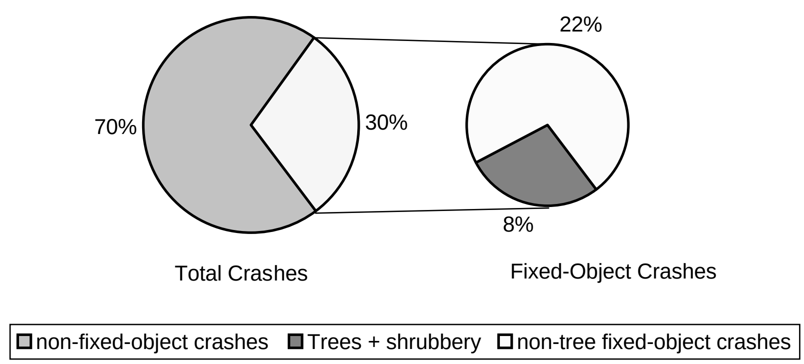


EXHIBIT III-2
1999 Fatal Tree Crashes by Functional Class

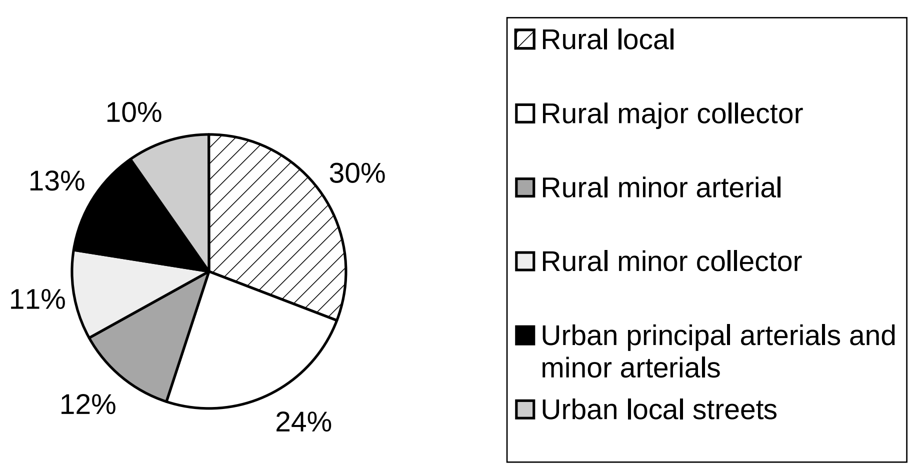


EXHIBIT III-3
Fatal Tree Crashes by Number of Travel Lanes, 1999

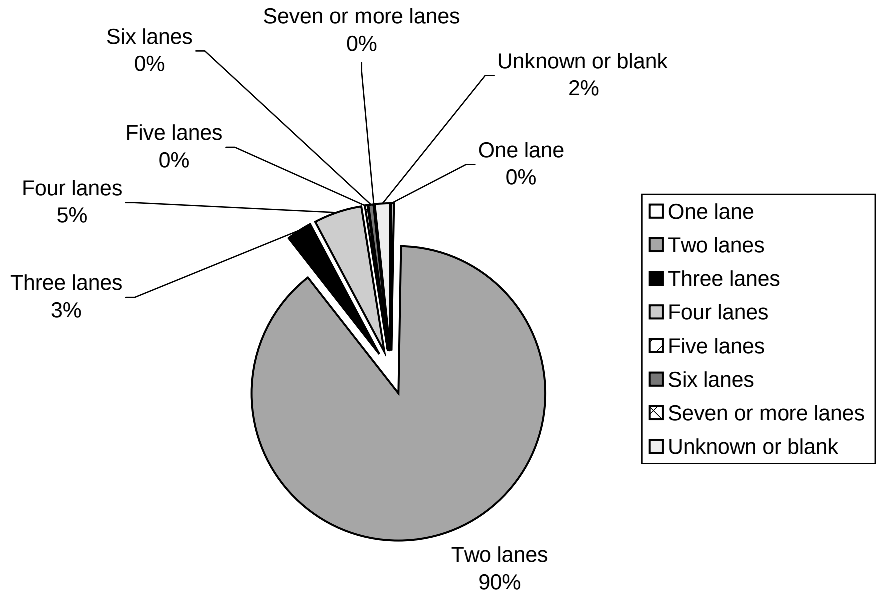
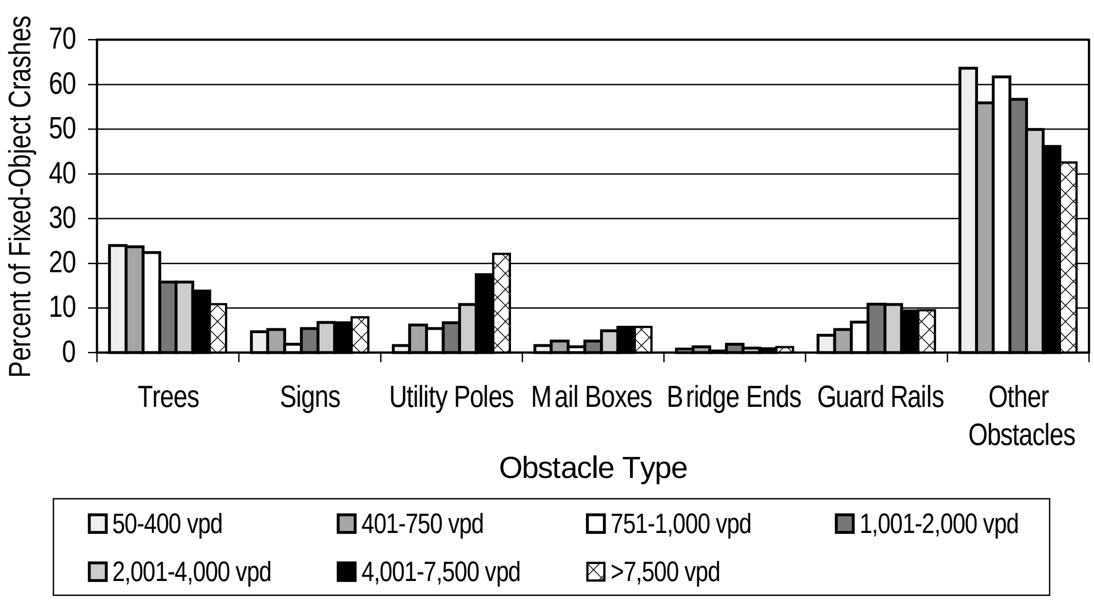


EXHIBIT III-4
Fixed-Object Crashes



Note: Database includes 1,741 urban and rural sections in six states (excludes Utah). (From Zegeer et al., 1987)

EXHIBIT III-5A
Tree Accidents/Mile/Year on Roads with Tree Coverage of Greater than 30 Percent

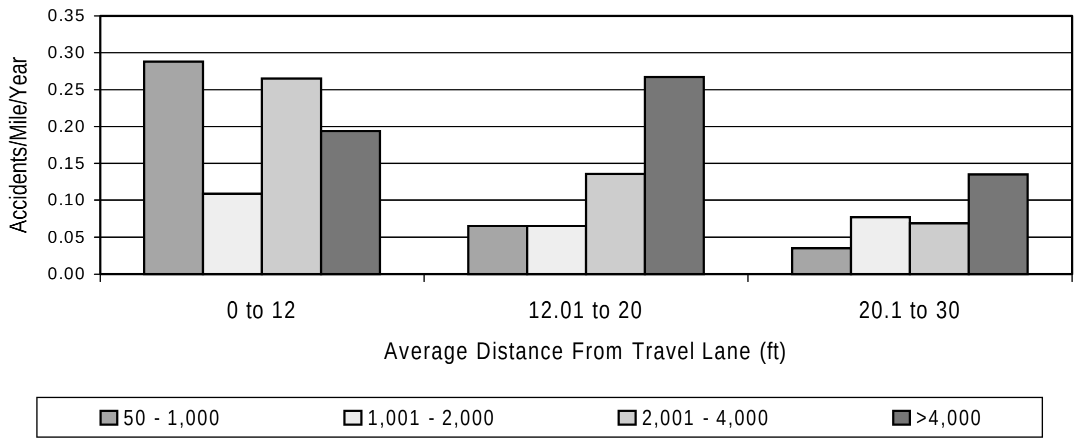


EXHIBIT III-5B
Tree Accidents/Mile/Year on Roads with Tree Coverage of 1 to 15 Percent

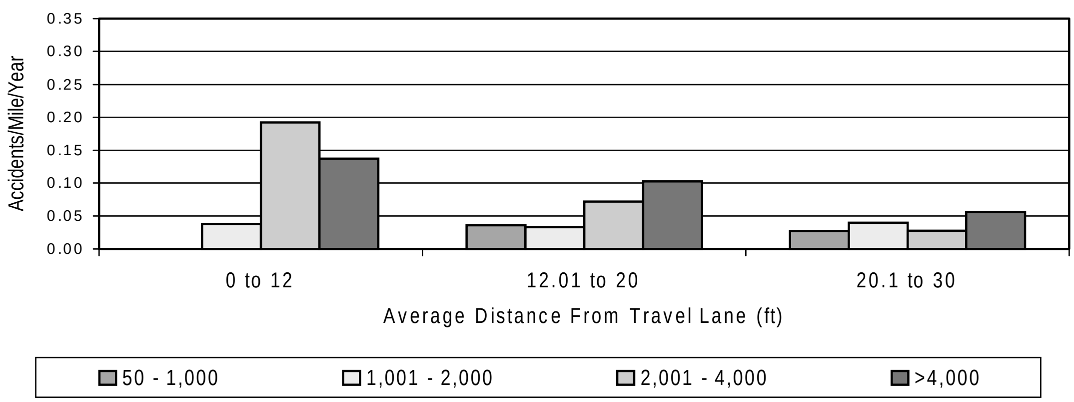
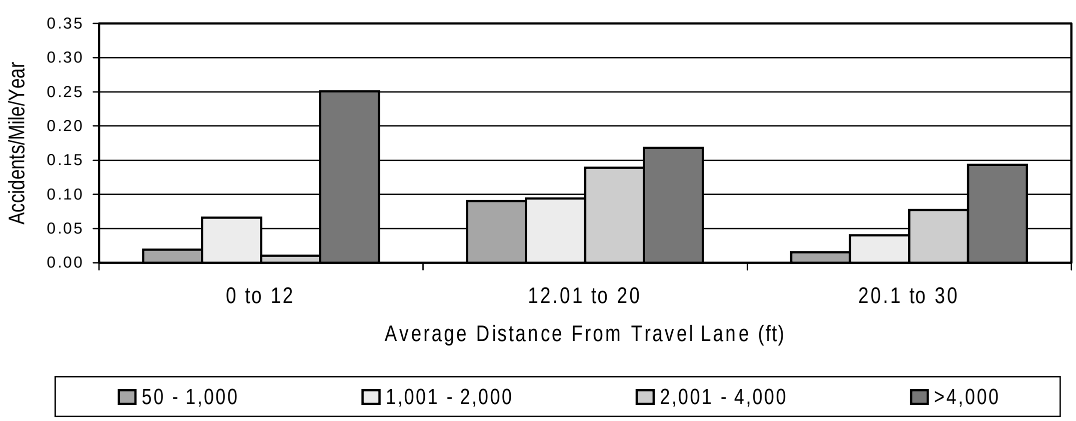


EXHIBIT III-5C
Tree Accidents/Mile/Year on Roads with Tree Coverage of 15 to 30 Percent



expect an average of one tree-related crash per mile every 3 to 5 years. A “high-crash” segment may be one in which no more than two or three tree-related crashes occur over a 5-year period. Indeed, one should not expect to find many locations where a specific tree represented a repeated, significant hazard over a 3- to 5-year period.

Other characteristics of fatal tree crashes (from FARS 1998 and 1999 data) include:

- About 56 percent of fatal tree crashes occurred under nighttime conditions. This is particularly significant given that much more traffic occurs in daylight hours versus night hours.
- Nearly half of all fatal tree crashes occurred on curved roads. Most road mileage is tangent; hence, this finding is particularly significant.
- Of the 1,562 fatal tree crashes in 1998 where alcohol use was suspected, 45 percent of crashes were cited as alcohol involved.

The legal issues resulting from tree crashes are complex and will not be covered in this guide. However, they should be considered when implementing the strategies in this guide. See Appendix 4 for further discussion and associated references. Furthermore, care must be taken when doing detailed site analyses to identify the role of the tree in crashes, to determine if the tree is really in a hazardous location, or if the hazard lies with some other design or environmental feature (Appendix 15).

SECTION IV

Index of Strategies by Implementation Timeframe and Relative Cost

The table below (Exhibit IV-1) provides a classification of strategies according to the expected timeframe and relative cost for this emphasis area. In several cases, implementation time will depend on such factors as the agency's procedures, the length of roadway involved, the need for additional right-of-way, the number of stakeholders involved, and the presence of any controversial situations. The range of costs may also be somewhat variable for some of these strategies because of many of the same factors. Placement in the table below is meant to reflect costs relative to the other strategies listed for this emphasis area only. The estimated level of cost is for the commonly expected application of the strategy.

EXHIBIT IV-1
Classification of Strategies According to Expected Timeframe and Relative Cost

		Relative Cost to Implement and Operate			
Timeframe for Implementation	**Strategy**	**Low**	**Moderate**	**Moderate to High**	**High**
Short (less than) a year)	16.1 A1—Develop, Revise, and Implement Planting Guidelines to Prevent Placing Trees in Hazardous Locations[a] (T)[b]	✓			
	16.1 A2—Mowing and Vegetation Control Guidelines (P)	✓			
	16.1 B4—Delineate Trees in Hazardous Locations (E)	✓			
	16.1 B1—Remove Trees in Hazardous Location[c] (P)		✓		
	16.1 B2—Shield Motorists from Striking Trees (P)		✓		
Medium (1–2 years)	16.1 B3—Modify Roadside Clear zone in the Vicinity of Trees (P)			✓	
Long (more than 2 years)					

[a] Timeframe used for guidelines is for their development. Additional time will be required for their application in the field.

[b] For an explanation of (T), (E), and (P), see page V-2.

[c] The cost of removing a single tree is relatively minimal. Even in the more commonly expected case of a tree-removal program for a significant portion of highways, the costs are expected to be relatively moderate, compared to roadside modifications for a similar mileage of highways.

Strategy 16.1.0.1, Apply Strategies in the AASHTO Strategic Highway Safety Plan Run-Off-Road Guide, is not represented in the table above due to the various costs and implementation times. Please refer to the AASHTO Strategic Highway Safety Plan Run-Off-Road Accident Guide for more details concerning these strategies.

SECTION V

Description of Strategies

Objectives

Once a problem with tree crashes has been identified, detailed analyses are needed at each site. Site investigations to determine potentially effective strategies contain two parts: (1) risk assessment and (2) benefits assessment. Risk assessment helps determine the relative risk of future tree crashes. Benefits assessment determines the local effects of removing trees or the application of other strategies. It may help for an agency to develop a structured approach to assess the risk and impacts. A proactive approach to preventing tree crashes involves use of policies and guidelines to prevent or remove unsafe tree growth. Various strategies are available to help achieve the objectives listed below.

The objectives for reducing the number of head-on fatality tree crashes are

- 16.1 A—Prevent Trees from Growing in Hazardous Locations and
- 16.1 B—Eliminate the Hazardous Condition and/or Reduce the Severity of the Crash.

The objectives and the applicable strategies are tabulated below in Exhibit V-1 and described in detail in the following tables.

EXHIBIT V-1
Emphasis Area 16.1—Crashes with Trees in Hazardous Locations

Objectives	Strategies
16.1 A—Prevent Trees from Growing in Hazardous Locations	16.1 A1—Develop, Revise, and Implement Planting Guidelines to Prevent Placing Trees in Hazardous Locations (T)[a]
	16.1 A2—Mowing and Vegetation Control Guidelines (P)
16.1 B—Eliminate the Hazardous Condition and/or Reduce the Severity of the Crash	16.1 B1—Remove Trees in Hazardous Locations (P)
	16.1 B2—Shield Motorists from Striking Trees (P)
	16.1 B3—Modify Roadside Clear Zone in the Vicinity of Trees (P)
	16.1 B4—Delineate Trees in Hazardous Locations (E)

[a] For an explanation of (T), (E), and (P), see next page.

Types of Strategies

The strategies in this guide 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 are widely used, while others are used at state or even local levels. Some have been subjected to well-designed evaluations to prove their effectiveness. On the other hand, it was found that many strategies, including some that are widely used, have not been adequately evaluated.

The implication of the widely varying experience with these strategies, as well as the range of knowledge about their effectiveness, is that the reader should be prepared to exercise caution before adopting a particular strategy for implementation. To help the reader, the strategies in the AASHTO guides have been classified into three types, each identified by a letter:

- **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 valid evaluations have not been found. These strategies, while in frequent or even general use, should be applied with caution, carefully considering the attributes cited in the guide and relating them to the specific conditions for which they are being considered. Implementation can proceed with some degree of assurance that there is not likely to be a negative impact on safety and very likely to be a positive one. As the experiences of implementation of these strategies continues under the AASHTO Strategic Highway Safety Plan initiative, appropriate evaluations will be conducted, so that effective information can be accumulated to provide better estimating power for the user, and the strategy can be upgraded to a "proven" one.
- **Experimental (E)—**Those strategies that have been suggested and that at least one agency has considered sufficiently promising to try on a small scale in at least one location. These strategies should be considered only after the others have proven not to be appropriate or feasible. Even where considered, their implementation should initially occur using a very controlled and limited pilot study that includes a properly designed evaluation component. Only after careful testing and evaluations show the strategy to be effective should broader implementation be considered. As the experiences of such pilot tests are accumulated from various state and local agencies, the aggregate experience can be used to further detail the attributes of this type of strategy so that it can be upgraded to a "proven" one.
- **Proven (P)—**Those strategies that have been used in one or more locations and for which properly designed evaluations have been conducted that show it to be effective. These strategies may be employed with a good degree of confidence, but understanding that any application can lead to results that vary significantly from those found in previous evaluations. The attributes of the strategies that are provided will help the user judge which strategy is the most appropriate for the particular situation.

Related Strategies for Creating a Truly Comprehensive Approach

The strategies listed above—and described in detail below—are those considered unique to this emphasis area. However, to create a truly comprehensive approach to the highway safety problems associated with this emphasis area, there are related strategies that should be included as candidates in any program planning process:

- **Public Information and Education Programs (PI&E)—**Many highway safety programs can be effectively enhanced with a properly designed PI&E campaign. The primary experience with PI&E campaigns in highway safety is to reach an audience across an entire jurisdiction or a significant part of it. However, a PI&E campaign can be focused on a location-specific problem. While this is a relatively untried approach, as compared with areawide campaigns, use of roadside signs and other experimental methods may be tried on a pilot basis. Within this guide, where the application of PI&E campaigns is deemed appropriate, it is usually in support of some other strategy. In such a case, the description for that strategy will suggest this possibility (see the attribute area for each strategy entitled "Associated Needs for, or Relation to, Support Services"). In some cases, the strategy is explained in detail for PI&E campaigns deemed unique for the emphasis area. As additional guides are completed for the AASHTO plan, they may detail PI&E strategy design and implementation. When that occurs, the appropriate links will be added from this emphasis area guide.

- **Enforcement of Traffic Laws—**Well-designed and well-operated law-enforcement programs can have a significant effect on highway safety. It is well established, for instance, that an effective way to reduce crashes and their severity is to have jurisdictionwide programs that enforce an effective law against driving under the influence (DUI) or driving without seat belts. When that law is vigorously enforced, with well-trained officers, the frequency and severity of highway crashes can be significantly reduced. This should be an important element in any comprehensive highway safety program. Enforcement programs, by nature, are conducted at specific locations. The effect (e.g., lower speeds, greater use of seat belts, and reduced impaired driving) may occur at or near the specific location where the enforcement is applied. This can often be enhanced by coordinating the effort with an appropriate PI&E program. However, in many cases (e.g., speeding and seat-belt usage) the impact is areawide or jurisdictionwide. The effect can be either positive (i.e., the desired reductions occur over a greater part of the system), or negative (i.e., the problem moves to another location as road users move to new routes where enforcement is not applied). Where it is not clear how the enforcement effort may affect behavior, or where it is desired to try an innovative and untried method, a pilot program is recommended. Within this guide, where the application of enforcement programs is deemed appropriate, it is often in support of some other strategy. Many of those strategies may be targeted at either a whole system or a specific location. In such cases, the description for that strategy will suggest this possibility (see the attribute area for each strategy entitled "Associated Needs for, or Relation to, Support Services"). In some cases, where an enforcement program is deemed unique for the emphasis area, the strategy will be explained in detail. As additional guides are completed for the AASHTO plan, they may detail the design and implementation of enforcement strategies. When that occurs, the appropriate links will be added from this emphasis area guide.

- **Strategies to Improve Emergency Medical and Trauma System Services—**Treatment of injured parties at highway crashes can significantly affect the level of severity and length of time an individual spends in treatment. This is especially true when it comes to timely and appropriate treatment of severely injured persons. Thus, a basic part of a highway safety infrastructure is a well-based and comprehensive emergency care program. While the types of strategies included here are often thought of as simply support services, they can be critical to the success of a comprehensive highway safety program. Therefore, for this emphasis area, it should be determined if improvements can be made to this aspect of the system, especially for programs focused on location-specific (e.g., corridors) or area-specific (e.g., rural areas) issues. As additional guides are completed for the AASHTO plan, they may detail the design and implementation of emergency medical systems strategies. When that occurs, the appropriate links will be added from this emphasis area guide.

- **Strategies Directed at Improving the Safety Management System—**The management of the highway safety system is vital to success. A sound organizational structure should be in place, as well as infrastructure of laws, policies, etc., to monitor, control, direct and administer a comprehensive approach to highway safety. A comprehensive program should not be limited to one jurisdiction, such as a state DOT. Local agencies often have most of the road system and its related safety problems to deal with. They also know, better than others, what the problems are. As additional guides are completed for the AASHTO plan, they may detail the design and implementation of strategies for improving safety management systems. When that occurs, the appropriate links will be added from this emphasis area guide.

- **Strategies That Are Detailed in Other Emphasis Area Guides—**One very logical manner for preventing crashes with trees alongside the road is to keep the vehicles on the road and in their proper travel lane—i.e., prevent ROR crashes. This objective is Goal 15 of the AASHTO Strategic Highway Safety Plan. The 1999 FARS data show that of 37,043 fatal crashes, nearly 39 percent were single-vehicle ROR crashes. Volume 6 of this report has been developed for addressing run-off-road crashes. It is strongly recommended that the set of strategies in Volume 6 be considered in combination with the strategies in this guide.

  Any program targeted at the safety problem covered in this emphasis area should be created having given due consideration to the inclusion of other applicable strategies covered in the following guides:

  - Volume 4, Head-On Crashes
  - Volume 5, Unsignalized Intersections

Objective 16.1 A—Prevent Trees from Growing in Hazardous Locations

This objective subscribes to the adage that prevention is better than the cure. This is true in many circumstances with roadside trees. The approach is a proactive one. While trees provide many benefits, they can cause hazardous situations if they are too close to the road. Not only can trees develop into a fixed-object hazard, but they can also block important signs, decrease sight distance at intersections and curves, and obstruct drivers' vision of pedestrians and other roadway users. This objective is not intended to prevent the planting and growing of roadside trees. Instead, it encourages the DOT, communities, and conservation groups to develop planting and maintenance guidelines where trees and roadways can safely co-exist to meet reasonable safety, aesthetics, and operational standards.

This objective is intended to prevent trees from growing in hazardous locations. This sounds simple and straight to the point, but there is more to it than that. Some hazardous locations are easily recognizable, as exemplified by the resilient tree in Exhibit V-2, but others are not as simple as this. Questions such as, "What defines a hazardous location?" or "How big a tree is too big?" require a significant amount of work with safety engineers, landscape architects, community representatives, and conservation groups before they can be answered. Simply developing a "one size fits all" guideline does not address the important issues of all stakeholders. For instance, requiring a 30-foot clear zone in all cases is not reasonable, as pointed out by the AASHTO *Roadside Design Guide* (1996). As with many controls used in highway design, the planting and maintenance guidelines should also consider vehicle speed, roadway curvature, purpose of the roadway, and type of facility users.

EXHIBIT V-2
A Tree Located in an Obviously Hazardous Location

Although resilient, this tree shows the scars of vehicle strikes on both sides of the tree facing traffic.

The public expects higher standards on higher-classified facilities. This expectation includes the areas of safety, operations, and aesthetics, each of which is being increasingly considered equal in producing a design. The three areas are not mutually exclusive and can coexist without detracting from each other. In addition, legal liability issues will come into play.

See Appendix 12 for details involved in identifying and addressing hazardous locations.

Strategy 16.1 A1—Develop, Revise, and Implement Planting Guidelines to Prevent Placing Trees in Hazardous Locations (T)

General Description

This strategy involves developing guidelines for placing trees along streets and highways during new construction, widening, re-landscaping, and other projects. It pertains to placing trees along the roadside or in the median of divided facilities. During the planning and design phases of highway projects, transportation officials, engineers, and community representatives have the greatest opportunity to meet the needs and desires of all stakeholders. An agency should develop planting guidelines to help protect future projects from developing into hazardous situations after the roadside trees mature and to avoid environmental and community issues that may be encountered when mitigating the hazards of trees in dangerous roadside locations. (See Exhibit V-3.)

Application Opportunities

There are many opportunities to apply the products of this strategy (the planting guidelines) throughout the normal operations of a transportation agency, including designing and constructing new facilities. Construction of new facilities does not occur as frequently as roadway widening and lower-cost projects. Consideration should also be given to smaller projects of this type as candidates for applying planting guidelines. For further details, see Appendix 5.

Components of a Planting Guideline

Planting guidelines should define the boundaries for planting areas along new and existing facilities. The operations and purpose of the road should have a bearing on the placement of trees and other plants next to the roadway. Some states have defined minimum distances from the traveled way at which plants may be placed, as a function of speed limit. While there are several components that planting plans must specifically address, the most important two for safety are the offset from the road and the conditions that affect the offset. The conditions that affect the offset are road curvature; tree size; design speed (operating speed for existing facilities); and steepness of the sideslope. Other important issues include defining tree size (what determines "large" and "small" trees); tree species; overhead environment; and who is responsible for approving planting plans, as well as permitting exceptions to the guidelines. For further details, see Appendix 6.

EXHIBIT V-3
Strategy Attributes for Developing, Revising, and Implementing Planting Guidelines to Prevent Placing Trees in Hazardous Locations (T)

Technical	
Target(s)	This strategy indirectly targets errant motorists and motor vehicles that leave the traveled way and are at risk of striking trees along the roadside or in the median of a divided roadway.
Expected Effectiveness	Policies often take considerable time after implementation before it is possible to develop sufficient data to analyze impact. The effectiveness of the strategy is dependent upon three main factors: the guidelines, the level of implementation, and the frequency of exceptions.
	The guidelines must address wide-ranging issues such as lateral displacement of encroaching vehicles, the purpose of the roadway, community values, environmental issues, and other safety concerns. If the guidelines are too weak, they will be ineffective. If the guidelines are too strict, it will be difficult to gain support. The quality of the guidelines also affects other factors that influence strategy effectiveness.
	The level of implementation has an effect on the success. If the guidelines are implemented sparingly, the effectiveness will more than likely be negligible. If the guidelines are applied only to major arterials, most of the roadways will not be covered, and the effectiveness of the strategy will be limited.
	It is practically impossible to develop guidelines that accommodate every situation. Therefore, there will be exceptions. If there are frequent exceptions, this is a sign of inadequate guidelines. A large number of exceptions creates holes that reduce the effectiveness of the strategy and encourages other exceptions.
Keys to Success	A key to the success of this strategy is implementing a comprehensive planting guideline that meets the safety needs of the facilities, is environmentally acceptable, and is sensitive to community values.

EXHIBIT V-3 (Continued)
Strategy Attributes for Developing, Revising, and Implementing Planting Guidelines to Prevent Placing Trees in Hazardous Locations (T)

	Inclusiveness is part of the key to success. When developing planting guidelines, the agency must include representatives from landscape architecture, environmental and scenic organizations, traffic safety engineering, roadside maintenance engineering, and other stakeholders with interest in highway safety, roadside environment, and community aesthetics. While jointly developing and adopting a guideline with the participation of all stakeholders is important, it may not be sufficient unless upper management of the responsible agency is in agreement with it.
Potential Difficulties	Many states and local DOTs may already have planting guidelines, but could overlook this strategy. While it may be true that planting guidelines exist, the extent of their application, effectiveness, and thoroughness should be reviewed to determine if tree crashes are declining both in frequency and severity. A guide may exist that does not meet the current needs. A review of the origins of the existing guidelines, and who the participating organizations were, can help determine if the planting guidelines are meeting the needs of current stakeholders. The frequency with which challenges, exceptions, and general disagreement occurs among the stakeholders is an indication of possible need to review the guidelines. In many jurisdictions, the agencies responsible for the design, approval, and maintenance of the roadside may not be familiar with the safety implications of the roadside environment. These agencies are often responsible for the environmental and aesthetic concerns of the roadside, which while important, should not conflict with the safety of the motorist. Landscaping plans should require levels of scrutiny similar to those applied to other areas of highway design dealing with fixed objects along the roadway.
Appropriate Measures and Data	The single most important process measure is the ultimate existence of a planting guide. This may include rating it in terms of adequacy of elements addressed, as well as the degree to which it meets current understanding of safety considerations. The number and rate of exceptions to the guidelines are other process measures. A thorough guideline will have few exceptions. Finally, the number and percent of projects meeting guidelines can be used to indicate how well the guides are being applied. Appropriate performance measures for this strategy include the number and rate of tree crashes, including severity. However, the initial effect may be small because most guidelines are not applied retroactively to previously implemented planting projects. Crash and roadway/roadside data (focusing upon tree crashes) are key items needed to provide the information for evaluation work.
Associated Needs	A brochure may be needed to inform organizations such as the local chapters of the Institute for Transportation Engineers, American Society of Landscape Architects, Scenic America, and other interested organizations of the changes being implemented regarding roadside-planting guidelines.
Organizational and Institutional	
Organizational, Institutional, and Policy Issues	State DOTs and many local agencies have the organizational structures to implement this strategy. On new construction and changes to the existing roadway, engineers responsible for the inspection and acceptance of the work would also ensure that the guidelines are applied.

(*continued on next page*)

EXHIBIT V-3 (Continued)
Strategy Attributes for Developing, Revising, and Implementing Planting Guidelines to Prevent Placing Trees in Hazardous Locations (T)

	Stakeholders from other organizations need representation when developing or revising guidelines. These organizations and institutions exist at various levels with different organizational structures. The agency responsible for developing and implementing the guidelines should actively recruit participation from landscape architects, environmental and scenic organizations, and other community representatives.
Issues Affecting Implementation Time	Developing consensus among the various stakeholders may take time; however, participants at the National Tree Symposium held in 2000, who represented a variety of disciplines, indicated that there is a desire to develop guidelines that reflect the values of engineering, environmental, and community organizations. The development, revision, and adoption process may vary from one jurisdiction to another. A thorough review, discussion, and resolution may take several months. Depending upon the practices of each agency, it may take more time to adopt the revised plan and to train the individuals responsible for applying the policy.
Costs Involved	The key cost component is personnel time to develop, review, and revise the planting guidelines.
Training and Other Personnel Needs	Training currently provided to design engineers, construction engineers, and those persons responsible for reviewing and approving plans must cover planting guidelines, along with other highway design topics. Emphasis must be placed upon the connection between highway safety and the guidelines that have been established.
Personnel Needs	No additional personnel should be required for implementation; however, some personnel resources will be required to develop, revise, and disseminate the guidelines.
Legislative Needs	None.
Other Key Attributes	None.

Strategy 16.1 A2—Develop, Revise, and Implement Mowing and Vegetation Control Guidelines (P)

Introduction

This strategy involves developing guidelines for maintaining the roadside in a way that prevents the natural growth of trees in hazardous locations or prevents trees developing into other hazards such as sight obstructions or overhead hazards. Many of the same concepts described in the planting guideline strategy (16.1 A1) apply here. The major difference is that the target trees in this strategy are not purposefully planted (often referred to as “volunteers”). Since this aspect of planting management is often dealt with by different parts of the DOT, the material is presented separately from general planting guidelines. However, where similarities exist, reference is made to the coverage in the planting guideline strategy (16.1 A1).

This strategy has been proven to reduce the severity and frequency of a variety of crashes such as fixed object crashes and crashes caused by obstructed sight distance. However, this strategy targets trees that grow naturally in hazardous locations. Trees are living organisms that reproduce at rates that vary according to the tree species and roadside environment. The main purposes of the mowing and vegetation guidelines are to achieve consistency and to provide guidance to field personnel responsible for maintaining the roadside.

The application of this strategy is feasible to all road types. Many state and local agencies have mowing and vegetation control plans, and much has been written on the subject (e.g., see http://transportation1.org/safetyplan/pubs_progs/strbrowse.asp?ele=hws&goa=16&str=46). The guides are developed to make sure that signs, guardrails, other traffic control devices, and safety appurtenances are visible and effective. Routine maintenance also helps maintain sight distance at intersections and horizontal curves. Regular mowing (even close to safety appurtenances) cuts saplings when they are small, before they grow into a roadside hazard. Removing the trees while they are small also diminishes the temptation to save the trees if they were left to mature in a hazardous location near the roadside. (See Exhibit V-4.)

EXHIBIT V-4
Strategy Attributes for Developing, Revising, and Implementing Mowing and Vegetation Control Guidelines to Prevent the Natural Growth of Trees in Hazardous Locations (P)

Technical	
Target(s)	By preventing trees from growing in hazardous locations, this strategy indirectly targets errant motorists and motor vehicles that leave the travel lanes and are at risk of striking trees along the roadside or in the median of a divided facility.
Expected Effectiveness	Refer to the Planting Guidelines Strategy Attributes section on "expected effectiveness."
Keys to Success	Refer to the Planting Guidelines Strategy Attributes section on "keys to success."
Potential Difficulties	Refer to the Planting Guidelines Strategy Attributes section on "potential difficulties."
Appropriate Measures and Data	Refer to the Planting Guidelines Strategy Attributes section on "appropriate measures and data."
Associated Needs	Refer to the Planting Guidelines Strategy Attributes section on "associated needs."
Organizational and Institutional	
Organizational, Institutional, and Policy Issues	Agencies should consider including in the mowing contracts removing small trees from around roadside objects like signs and mailboxes. Uprooting trees while they are very young requires little physical effort and does not damage the roadside.
Issues Affecting Implementation Time	Refer to the Planting Guidelines Strategy Attributes section on "issues affecting implementation time."
Costs Involved	Refer to the Planting Guidelines Strategy Attributes section on "cost involved."
Training and Other Personnel Needs	Refer to the Planting Guidelines Strategy Attributes section on "training and other personnel needs."
Legislative Needs	None.
Other Key Attributes	None.

Objective 16.1 B—Eliminate the Hazardous Condition and/or Reduce the Severity of the Crash

This actually addresses two objectives, because an agency will consider each simultaneously when investigating and treating high-crash locations. In most cases, engineers decide on a treatment after an investigation has been conducted. It is preferable to keep the vehicles on the road in the proper lane. Emphasis area 15.1 deals with these in the context of ROR crashes. This section describes strategies that lessen the severity of crashes after a vehicle enters the shoulder or median.

Removing tree(s) in the clear zone, shielding vehicles from tree(s) with attenuation devices, or improving the clear zone can lessen the severity of a crash. While these strategies are not new and not only applicable to tree crashes, they can improve roadside safety. These strategies are typically responsive, rather than proactive. However, an agency may choose to develop a proactive program using one or more of these strategies as the desired treatment.

Strategy 16.1 B1—Remove Trees in Hazardous Locations (P)

Tree removal involves identifying and removing trees along highways having a history of tree crashes and/or removing trees with a high likelihood of being struck. The application of this strategy is primarily a responsive approach to treat high tree-crash locations. However, this strategy can be applied proactively to locations with high likelihood of developing tree-crash histories. Identifying the sites requiring treatment, in both responsive and proactive applications, is one of the major challenges. Another considerable, and often more difficult, challenge is overcoming public resistance to removing trees. For further discussion on assessing the value of trees, see Appendix 13.

Once the decision is made to selectively remove trees, there are other safety considerations. Not only is tree removal dangerous to the individuals performing the task, but it is also important to make sure that the remaining roadside is left in a safe condition. Large stumps, stumps on the sideslopes, and deep depressions are hazards that may remain after removing the tree. (See Exhibit V-5.) For further details on stump removal, see Appendix 9.

EXHIBIT V-5
Strategy Attributes for Removing Trees in Hazardous Locations (P)

Technical	
Target(s)	(Responsive) This strategy directly targets locations where errant motorist and motor vehicles leave the traveled way and strike a tree in the median or on the roadside. (Proactive) This strategy targets locations that have a high likelihood of a vehicle leaving the roadway and striking a tree in the median or on the roadside.
Expected Effectiveness	The effectiveness of this strategy depends on how comprehensive the program has been in providing a sufficient clear zone on each section of highway. However, there is little doubt that a well-targeted program that provides an ample clear zone can significantly reduce tree impacts. The Pennsylvania DOT has developed a table (see Appendix 8) for estimating crash reduction for situations where numerous trees are present, relating the reduction to the distance of the tree line from the traveled way.

EXHIBIT V-5 (Continued)
Strategy Attributes for Removing Trees in Hazardous Locations (P)

Keys to Success	(Responsive) Having a data analysis methodology and supporting database that can enable an agency to easily identify roadway spots and sections that experience tree crashes is one key to success. (Proactive) Developing a set of parameters that define locations with a high likelihood of tree crashes occurring is the first key to success when applying this strategy in a proactive manner. Another key is identifying the locations either through a database that contains quantitative information concerning the parameters noted for both responsive and proactive approaches or through a safety audit program. The third key is to implement a countermeasure at the locations to prevent or reduce the severity of future crashes. Involvement of all stakeholders, from the beginning of the effort, is important to optimize the results and avoid costly and contentious resistance to plans. Any tree removal program needs to target a substantial sample of road sections each year to have any effect on overall problems. Limiting the program to too few locations will not have a noticeable impact for a long time and may erode confidence in the program.
Potential Difficulties	Preservation of trees as part of the roadway's scenic character is a hallmark of the rapidly growing context-sensitive design movement. Citizens and environmental groups often strongly oppose the removal of trees within highway rights-of-way, even if there has been a long history of tree-related motor vehicle crashes, deaths, and injuries. There are also specific cases where certain trees cannot be removed, such as trees along historic routes. An objective assessment of the risks and benefits of the removal of trees in hazardous locations is essential when mitigating these circumstances. A thorough investigation can limit the impacts of treating the potentially hazardous locations. Care must be taken that tree removal be accompanied by other appropriate actions, such as removal of other hazardous roadside objects. Not completing these activities may not reduce the hazard to the driver, but merely transfer the hazard, resulting in a no net safety gain. Finally, the great amount of relatively low-volume highway mileage and prevalence of trees suggest that it will be difficult for any agency to identify substantial numbers of locations with a demonstrated tree hazard. Reliance on analysis of historic crash data for particular locations as the basis for a tree removal program may not be an effective approach. Systemic or proactive approaches may be necessary. Exhibit V-6 shows a tree-lined residential road with relatively low-traffic volumes and speeds; and having no pavement markings for the edge or centerlines. Even though the trees are relatively close to the road, they should not be targets of a tree-safety program, unless there is a demonstrated safety problem. For situations like these, if engineers attempt to establish larger clear zones along the entire length of the street, confrontations may result that will lead conservationists and community leaders to resist removal of every tree, even the ones with documented tree-crash problems. In general, care must be taken to choose the appropriate places to remove trees, focusing upon locations where problems are most severe.

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EXHIBIT V-5 (Continued)
Strategy Attributes for Removing Trees in Hazardous Locations (P)

Appropriate Measures and Data	Due to the improvements, performance measures may include the reduction in the number and percent of tree crashes, as well as in the number of related deaths and injuries. Process measures may include number of trees removed, number of sites treated, total expenditure for tree removal, and some measure of net change in clear zone width or area. To determine the effectiveness of the strategy, appropriate comparisons are needed of periods before and after the improvements are made. (Responsive) A listing of sites and sections with a high incidence of tree-related crashes should be produced. If possible, this listing should account for different roadway types, area type (urban or rural), etc. The top 50 or 100 sites within each highway district could be identified, so some areas of the state are not left out of the process. After identifying high tree-crash sites, supplemental information should be obtained for each site, such as traffic volume, sideslope, tree locations, and characteristics of the roadside. Many of the data elements needed require either a well-developed roadway inventory system, or special reconnaissance of selected sites.
Associated Needs	To be effective, this strategy does not require educating the public to drive differently. However, it will most likely be desirable to work with local environmental groups and to educate the public concerning the benefits of the program before implementing tree removal activities. It may be advantageous to develop materials describing the relative hazards of trees and describing how DOTs will deal with trees in a context-sensitive environment.
Organizational and Institutional	
Organizational, Institutional, and Policy Issues	States and local DOTs have the organizational structures to implement this strategy. District offices or contractors hired by the DOT often perform this work. A key here is to develop the systems to encourage a cooperative planning effort involving the highway agency, environmental agency, and private groups.
Issues Affecting Implementation Time	Lack of data relating to tree-related crashes and their locations could adversely affect the implementation times, especially if special data collection is required. In addition, if any trees are considered environmentally significant, historically significant, or not located on the right-of-way, the process needed to determine if it is possible to remove a tree may require significant time. These factors may require use of alternative strategies to mitigate a safety problem. After the decision to proceed with a program, the process moves relatively quickly if there is little resistance and the trees are within the right-of-way. It is possible to have a tree-removal program implemented within a year.
Costs Involved	Costs will vary due to a variety of factors. Most highway agencies have considerable experience with tree removal, so generalized cost estimates are not needed here.
Training and Other Personnel Needs	Ideally, experienced and trained tree removal crews will carry out the actual tree removal and no additional training will be required for this task. (Responsive) If DOTs do not have personnel experienced in identifying hazardous locations, some training will be necessary to identify the locations at which to implement the strategy.
Legislative Needs	Legislatures in some states are involved in tree-related issues. For example, the North Carolina State Legislature recently passed a bill that encourages planting trees next to highways for beautification purposes. State DOTs must consider such legislation when establishing guidelines for tree removal. For example, such a bill might lead to plans for

EXHIBIT V-5 (Continued)
Strategy Attributes for Removing Trees in Hazardous Locations (P)

	replacing cut-down trees either with trees that would never grow to more than 4 in. in diameter or by replanting new trees in other, less hazardous locations.
Other Key Attributes	Completing and documenting the risk and benefit assessment conducted at the investigated sites should be an integral part of implementing this strategy. Consideration should be given to developing a standard investigation form for all hazardous tree sites to standardize the approach. This information will be valuable when working with citizen groups and other individuals when considering tree removal as an option.

Strategy 16.1 B2—Providing Guardrail to Shield Motorists from Striking Trees (P)

This strategy involves installing guardrail beyond the edge of the roadway to reduce the risk of motorists running into trees. When applying this strategy, keep in mind that guardrail is reported to be the fourth most frequently struck fixed object for fatal crashes in the United States. Another area to consider, when applying this strategy, is the additional costs and risks associated with guardrail end treatments. These costs and risk typically make this a responsive strategy. However, there are no technical reasons for not applying the strategy as a proactive approach.

EXHIBIT V-6
A Tree-Lined Residential Road

This strategy is proven to reduce the severity of fixed-object crashes. The expected effectiveness depends upon a wide variety of factors, and the reader should consult the AASHTO *Roadside Design Guide* (1996) and associated software to determine the level of effectiveness for the specific conditions. See Appendix 7 for additional illustration and Appendix 10 for further considerations.

The placement of a guardrail or median barrier may increase the frequency of crashes in the treated area, but should lower crash severity. A 1999 study by Hunter et al. found that installing a median barrier on a freeway section significantly increased the frequency of crashes. The barrier also contributed to decreases in the number of fatal and severe injury crashes and the severity index. While in this case the purpose of the barrier was to prevent across-median crashes, one expects similar trends (increase in total crashes and decrease in severity) with the installation of barriers for other purposes.

Most in-service barriers have few environmental impacts, but the construction of the barriers may affect nearby environmentally sensitive areas. The placement of the barriers may also interfere with snow removal and restrict sight distance, especially in curves and at intersections, when placed close to the traveled way.

Increased maintenance and the difficulty in mowing around the barriers need consideration as well. The cost of repairs and maintenance will vary with the type of guardrail used, but these are often not negligible. Some agencies attempt to collect repair costs from the drivers, or their insurance companies, who strike the barriers. For example, one state collects roughly $2 million annually to help cover the expense of guardrail repairs due to motor vehicle crashes. While the collected amount is considerably less than the actual expense incurred by the DOT to repair the damaged guardrail, it is still a significant part of it. (See Exhibit V-7.)

EXHIBIT V-7
Strategy Attributes for Providing Guardrails to Shield Motorists from Striking Trees (P)

Technical	
Target(s)	This strategy targets the errant motorist and motor vehicle that leaves the travel lane and is at risk of striking a tree along the roadside. The design of the barrier either redirects or cushions the vehicle, providing a less severe impact.
Expected Effectiveness	Guardrail installations in front of trees will typically reduce crash severity of ROR crashes, although crash frequency may increase in some cases, since a rigid object is placed closer to the roadway than are the trees or other objects being shielded. Guardrail installation may be particularly useful to reduce severity of crashes at sites with long, steep (e.g., 3:1 or steeper) sideslopes, since vehicles on steep slopes are likely to travel to the bottom of the slope (and tree removal would not prevent severe vehicle rollovers). It would also be useful in environmentally sensitive areas where trees may not be removed. With so many factors influencing the crash severity and the change in crash frequency, it is difficult to provide a simple table for expected effectiveness. Agencies are referred to the FHWA computer program ROADSIDE 5.0, or Appendix A of the *Roadside Design Guide* (1996) to complete economic analyses of the existing and proposed conditions (installing guardrail). The economic analysis is necessary to determine if the benefits of placing the barrier outweigh the disadvantages.
Keys to Success	A key to success is developing an effective process to identify trees in hazardous locations and to establish an effective set of criteria on when and how to install guardrails in these conditions instead of removing trees or implementing other strategies.
Potential Difficulties	A major pitfall exists when sites are improperly chosen for guardrail application. The difficulty will arise from expending resources in the name of safety, but experiencing either no net safety gain or a net degradation in safety, given the presence of the guardrail as a fixed object. Guardrail designs may not exist that meet the aesthetic requirements of those involved in the effort. Therefore, it may become necessary to develop special rails to address context-sensitive design issues on a project. These would have to meet existing design and test requirements (e.g., *NCHRP Report 350*, Ross et al. [1993]).
Appropriate Measures and Data	Impact measures can include the change in frequency, percent, and severity of ROR and fixed-object crashes, by type. Process measures include the number of feet/miles of guardrail installed, expenditures on new guardrail, and maintenance and repair expenditures. Good crash and roadway data are needed regarding sites where tree crashes are a problem, along with follow-up information on roadside/roadway characteristics to decide whether guardrail installation is appropriate. Good data are also required on the safety performance of guardrail and end sections for ranges of speed and roadway conditions.

EXHIBIT V-7 (Continued)
Strategy Attributes for Providing Guardrails to Shield Motorists from Striking Trees (P)

Associated Needs	It may be advantageous to develop materials explaining the relative safety merits of guardrail versus tree removal, or untreated conditions, for use by planners and designers working on environmentally sensitive projects.
Organizational and Institutional	
Organizational, Institutional, and Policy Issues	State and local DOTs are responsible for guardrail installation. However, it is important to involve all stakeholders in the process of identifying where problems exist, as well as identifying and selecting strategies to implement.
Issues Affecting Implementation Time	Lack of data and analytical tools to identify locations with high concentrations of tree crashes could affect implementation time. Where a project involves environmentally sensitive areas, the need for involving a range of groups to agree on a course of action may cause significant delays.
Costs Involved	Costs of guardrail installation and maintenance will vary significantly by the type used. Most highway agencies have adequate experience for their jurisdiction, so no specific numbers need be provided here.
Training and Other Personnel Needs	No additional training required. Trained DOT personnel or contractors are needed to correctly install, repair, and maintain the guardrail. Highway agencies must be sure that their staff is kept up to date on developments in this area.
Legislative Needs	None identified.
Other Key Attributes	Well-planned policies and guidelines are needed in the DOT on when, where, and how to install guardrails.

Strategy 16.1 B3—Modify Roadside Clear Zone in the Vicinity of Trees (P)

This strategy involves any change to the sideslope or roadside clear zone designed to reduce the likelihood of tree crashes by increasing the chances that an ROR vehicle can successfully recover without striking a tree. While both tree removal and shielding strategies modify the roadside, this strategy may be implemented in a variety of ways, such as flattening or grading sideslopes, regrading ditch sections, adding shoulder improvements, or providing protective plantings on the roadside. The cost to modify the roadside is often considerably higher than tree removal and guardrail installation. However, applying this strategy on specific curves or short tangent sections of roadway may help manage the costs. Further discussion may be found in Appendix 11.

This strategy has been proven to reduce the severity of ROR crashes and rollover crashes. While no specific studies were identified that related to only trees, much work has been completed on the benefits of improving the geometry of the roadside to allow vehicles to recover when they encroach the roadside. (See Exhibit V-8.)

EXHIBIT V-8
Strategy Attributes for Modifying Roadside Clear Zone in the Vicinity of Trees (P)

Technical	
Target(s)	This strategy targets the errant motorist and motor vehicle that leave the traveled way and are at risk of striking a tree along the roadside. The principle of the strategy is to provide a larger recovery area in locations with a high frequency of tree collisions.
Expected Effectiveness	Effectiveness depends upon the type of improvement. For example, flatter sideslopes reduce the probability of rollover and fixed-object collisions. The following table provides information on crash reductions that may be expected due to improvements that flatten various sideslopes (based on Zegeer et al., 1987).
Keys to Success	The DOTs' willingness, and the availability of resources, to spend adequate funds to improve the roadside are important, because the job must be done completely and properly if the desired impact is to be attained. A partial effort within a project will not be sufficient. It is important that estimates of effectiveness of the proposed treatment be clearly defined in terms of differences in both frequency and severity of impact with the tree(s). Otherwise, unrealistic expectations may be created.
Potential Difficulties	This strategy may be feasible only on roads in flat to mildly rolling terrain. Significant roadside improvements in mountainous terrain are typically impractical due to cost and constructibility.
Appropriate Measures and Data	Process measures include the number of linear feet (or miles) of road where improvements are made (by type), a measure of change in clear-zone width or area, and expenditures on improvement, by type. One might also calculate the number of trees no longer in a hazardous location. The impact measures are the frequency, percent, and severity of tree crashes, ROR crashes, and total crashes. Reliable data are needed on locations of tree crashes and on the characteristics of the roadsides at the most hazardous sites. These are needed to determine where (and how) this strategy should be applied, as well as to conduct performance analyses.
Associated Needs	None.
Organizational and Institutional	
Organizational, Institutional, and Policy Issues	A carefully crafted policy/practice is needed within the DOT on the types of roadsides that warrant specific roadside improvements and how those improvements are to be designed.
Issues Affecting Implementation Time	The time required to implement this strategy will vary, depending upon the specific type of improvement, extent of treatment to the roadside, and other factors. For projects that can be developed within the right-of-way and that do not involve roadway realignment, the period can be relatively short – on the order of 1 to 2 years. For projects that require right-of-way acquisition or major construction, a longer time – 2 to 5 years – may be typical. In environmentally sensitive areas, the projects may require environmental permits, which can add significant delays.
Cost Involved	The cost of the project depends upon the extent and type of roadside improvement. Most highway agencies have sufficient history with these types of improvements to quickly estimate costs.
Training and Other Personnel Needs	Training is needed in both problem identification and proper installation methods. Both types of training are applicable to many aspects of DOT operations and already exist. Typically, DOT maintenance personnel or contractors would complete these improvements.

EXHIBIT V-8 (Continued)
Strategy Attributes for Modifying Roadside Clear Zone in the Vicinity of Trees (P)

Legislative Needs	None identified.
Other Key Attributes	Applying this strategy to projects already planned can reduce the cost of improvements of this type since a significant portion of smaller projects contain a "mobilization" cost, which is difficult to quantify.

EXHIBIT V-9
Expected Percent Crash Reduction from Sideslope Flattening

Sideslope in Before Condition	Sideslope in After Condition				
	3:1	**4:1**	**5:1**	**6:1**	**7:1 or Flatter**
2:1	2	10	15	21	27
3:1	0	8	14	19	26
4:1	–	0	6	12	19
5:1	–	–	0	6	14
6:1	–	–	–	0	8

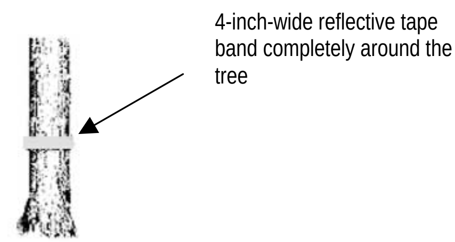
Strategy 16.1 B4—Delineate Trees in Hazardous Locations (E)

This strategy follows the hierarchy as presented in the AASHTO *Roadside Design Guide* (1996):

- Remove the object or obstacle (Strategy 16.1 B1);
- Redesign the roadway, object, or obstacle so it can be safely traversed (partially included in Strategy 16.1 B3 and covered proactively in Strategies 16.1 A1 and 16.1 A2);
- Relocate the object (covered in a proactive manner in Strategies 16.1 A1 and 16.1 A2);
- Reduce the impact severity;
- Shield drivers from the object (Strategy 16.1 B2); and
- Delineate the obstacle if the above alternatives are not appropriate.

Notice that the last bullet indicates that delineating the object only if the other alternatives are NOT appropriate. This strategy should not be considered a substitute for other, more appropriate strategies just because it is very low cost. The effectiveness of this strategy is not known and is currently under study in Pennsylvania. Pennsylvania places a 4-in. band of reflective tale around trunk. (See Exhibit V-10 and Appendix 14.)

EXHIBIT V-10
Reflective Band on a Tree



The *Manual for Uniform Traffic Control Devices* (MUTCD; FHWA, 2000) provides guidance on the height of object markers. The guidance states:

> *When used for marking objects in the roadway or objects that are 2.4 m (8 ft) or less from the shoulder or curb, the mounting height to the bottom of the object marker should be at least 1.2 m (4 ft) above the surface of the nearest traffic lane.*
>
> *When used to mark objects more than 2.4 m (8 ft) from the shoulder or curb, the mounting height to the bottom of the object marker should be at least 1.2 m (4 ft) above the ground.*

Please note that the 4-in. band does not meet the Type 2 standard requirements in the MUTCD, the minimum width of the MUTCD standard is 6 in. wide with a minimum 12 in. in length.

There are no valid evaluations of this strategy, primarily because it is relatively untried. It is currently being experimented in several counties in Pennsylvania.

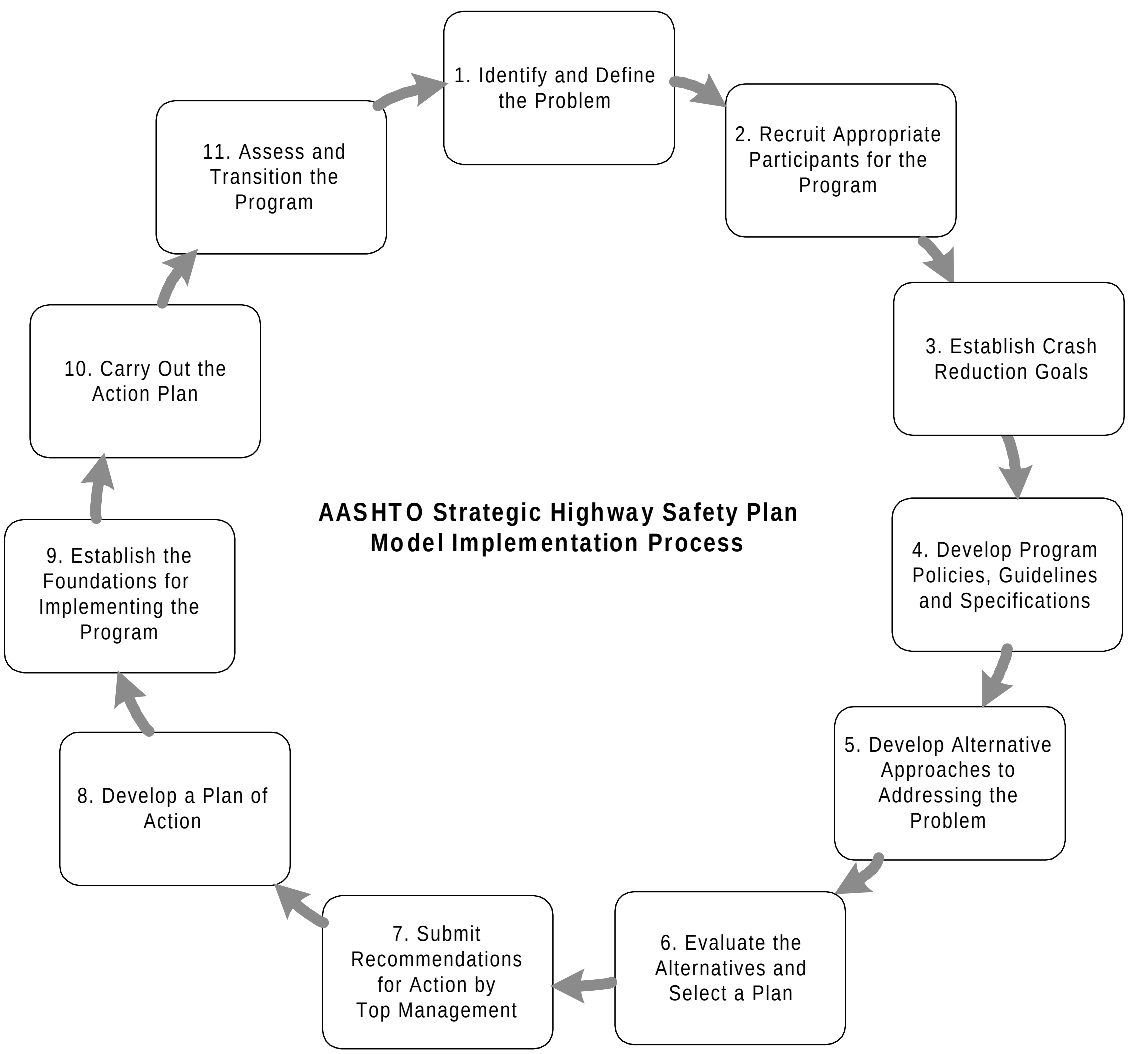
Section VI

Guidance for Implementation of the AASHTO Strategic Highway Safety Plan

Outline for a Model Implementation Process

Exhibit VI-1 gives an overview of an 11-step model process for implementing a program of strategies for any given emphasis area of the AASHTO Strategic Highway Safety Plan. After a short introduction, each of the steps is outlined in further detail.

EXHIBIT VI-1



Purpose of the Model Process

The process described in this section is provided as a model rather than a standard. Many users of this guide will already be working within a process established by their agency or working group. It is not suggested that their process be modified to conform to this one. However, the model process may provide a useful checklist. For those not having a standard process to follow, it is recommended that the model process be used to help establish an appropriate one for their initiative. Not all steps in the model process need to be performed at the level of detail indicated in the outlines below. The degree of detail and the amount of work required to complete some of these steps will vary widely, depending upon the situation.

It is important to understand that the process being presented here is assumed to be conducted only as a part of a broader, strategic-level safety management process. The details of that process, and its relation to this one, may be found in a companion guide. (The companion guide is a work in progress at this writing. When it is available, it will be posted online at http://transportation1.org/safetyplan.)

Overview of the Model Process

The process (see Exhibit VI-1, above) must be started at top levels in the lead agency's organization. This would, for example, include the CEO, DOT secretary, or chief engineer, as appropriate. Here, decisions will have been made to focus the agency's attention and resources on specific safety problems based upon the particular conditions and characteristics of the organization's roadway system. This is usually, but not always, documented as a result of the strategic-level process mentioned above. It often is publicized in the form of a "highway safety plan." Examples of what states produce include Wisconsin DOT's Strategic Highway Safety Plan (see Appendix A) and Iowa's Safety Plan (available at http://www.iowasms.org/toolbox.htm).

Once a "high-level" decision has been made to proceed with a particular emphasis area, the first step is to describe, in as much detail as possible, the problem that has been identified in the high-level analysis. The additional detail helps confirm to management that the problem identified in the strategic-level analysis is real and significant and that it is possible to do something about it. The added detail that this step provides to the understanding of the problem will also play an important part in identifying alternative approaches for dealing with it.

Step 1 should produce endorsement and commitments from management to proceed, at least through a planning process. With such an endorsement, it is then necessary to identify the stakeholders and define their role in the effort (Step 2). It is important at this step to identify a range of participants in the process who will be able to help formulate a comprehensive approach to the problem. The group will want to consider how it can draw upon potential actions directed at

- Driver behavior (legislation, enforcement, education, and licensing),
- Engineering,

- Emergency medical systems, and
- System management.

With the establishment of a working group, it is then possible to finalize an understanding of the nature and limitations of what needs to be done in the form of a set of program policies, guidelines, and specifications (Steps 3 and 4). An important aspect of this is establishing targets for crash reduction in the particular emphasis area (Step 3). Identifying stakeholders, defining their roles, and forming guidelines and policies are all elements of what is often referred to as "chartering the team." In many cases, and in particular where only one or two agencies are to be involved and the issues are not complex, it may be possible to complete Steps 1 through 4 concurrently.

Having received management endorsement and chartered a project team—the foundation for the work—it is now possible to proceed with project planning. The first step in this phase (Step 5 in the overall process) is to identify alternative strategies for addressing the safety problems that have been identified while remaining faithful to the conditions established in Steps 2 through 4.

With the alternative strategies sufficiently defined, they must be evaluated against one another (Step 6) and as groups of compatible strategies (i.e., a total program). The results of the evaluation will form the recommended plan. The plan is normally submitted to the appropriate levels of management for review and input, resulting ultimately in a decision on whether and how to proceed (Step 7). Once the working group has been given approval to proceed, along with any further guidelines that may have come from management, the group can develop a detailed plan of action (Step 8). This is sometimes referred to as an "implementation" or "business" plan.

Plan implementation is covered in Steps 9 and 10. There often are underlying activities that must take place prior to implementing the action plan to form a foundation for what needs to be done (Step 9). This usually involves creating the organizational, operational, and physical infrastructure needed to succeed. The major step (Step 10) in this process involves doing what was planned. This step will in most cases require the greatest resource commitment of the agency. An important aspect of implementation involves maintaining appropriate records of costs and effectiveness to allow the plan to be evaluated after-the-fact.

Evaluating the program, after it is underway, is an important activity that is often overlooked. Management has the right to require information about costs, resources, and effectiveness. It is also likely that management will request that the development team provide recommendations about whether the program should be continued and, if so, what revisions should be made. Note that management will be deciding on the future for any single emphasis area in the context of the entire range of possible uses of the agency's resources. Step 11 involves activities that will give the desired information to management for each emphasis area.

To summarize, the implementation of a program of strategies for an emphasis area can be characterized as an 11-step process. The steps in the process correspond closely to a 4-phase approach commonly followed by many transportation agencies:

- Endorsement and chartering of the team and project (Steps 1 through 4),
- Project planning (Steps 5 through 8),
- Plan implementation (Steps 9 and 10), and
- Plan evaluation (Step 11).

Details about each step follow. The Web-based version of this description is accompanied by a set of supplementary material to enhance and illustrate the points.

The model process is intended to provide a framework for those who need it. It is not intended to be a how-to manual. There are other documents that provide extensive detail regarding how to conduct this type of process. Some general ones are covered in Appendix B and Appendix C. Others, which relate to specific aspects of the process, are referenced within the specific sections to which they apply.

Implementation Step 1: Identify and Define the Problem

General Description

Program development begins with gathering data and creating and analyzing information. The implementation process being described in this guide is one that will be done in the context of a larger strategic process. It is expected that this guide will be used when the strategic process, or a project-level analysis, has identified a potentially significant problem in this emphasis area.

Data analyses done at the strategic level normally are done with a limited amount of detail. They are usually the top layer in a "drill-down" process. Therefore, while those previous analyses should be reviewed and used as appropriate, it will often be the case that further studies are needed to completely define the issues.

It is also often the case that a core technical working group will have been formed by the lead agency to direct and carry out the process. This group can conduct the analyses required in this step, but should seek, as soon as possible, to involve any other stakeholders who may desire to provide input to this process. Step 2 deals further with the organization of the working group.

The objectives of this first step are as follows:

1. Confirm that a problem exists in this emphasis area.
2. Detail the characteristics of the problem to allow identification of likely approaches for eliminating or reducing it.
3. Confirm with management, given the new information, that the planning and implementation process should proceed.

The objectives will entail locating the best available data and analyzing them to highlight either geographic concentrations of the problem or over-representation of the problem within the population being studied.

Identification of existing problems is *a responsive approach*. This can be complemented by a *proactive approach* that seeks to identify potentially hazardous conditions or populations.

For the responsive type of analyses, one generally begins with basic crash records that are maintained by agencies within the jurisdiction. This is usually combined, where feasible, with other safety data maintained by one or more agencies. The other data could include

- Roadway inventory,
- Driver records (enforcement, licensing, courts), or
- Emergency medical service and trauma center data.

To have the desired level of impact on highway safety, it is important to consider the highway system as a whole. Where multiple jurisdictions are responsible for various parts of the system, they should all be included in the analysis, wherever possible. The best example of this is a state plan for highway safety that includes consideration of the extensive mileage administered by local agencies. To accomplish problem identification in this manner will require a cooperative, coordinated process. For further discussion on the problem identification process, see Appendix D and the further references contained therein.

In some cases, very limited data are available for a portion of the roads in the jurisdiction. This can occur for a local road maintained by a state or with a local agency that has very limited resources for maintaining major databases. Lack of data is a serious limitation to this process, but must be dealt with. It may be that for a specific study, special data collection efforts can be included as part of the project funding. While crash records may be maintained for most of the roads in the system, the level of detail, such as good location information, may be quite limited. It is useful to draw upon local knowledge to supplement data, including

- Local law enforcement,
- State district and maintenance engineers,
- Local engineering staff, and
- Local residents and road users.

These sources of information may provide useful insights for identifying hazardous locations. In addition, local transportation agencies may be able to provide supplementary data from their archives. Finally, some of the proactive approaches mentioned below may be used where good records are not available.

Maximum effectiveness often calls for going beyond data in the files to include special supplemental data collected on crashes, behavioral data, site inventories, and citizen input. Analyses should reflect the use of statistical methods that are currently recognized as valid within the profession.

Proactive elements could include

- Changes to policies, design guides, design criteria, and specifications based upon research and experience;
- Retrofitting existing sites or highway elements to conform to updated criteria (perhaps with an appropriate priority scheme);
- Taking advantage of lessons learned from previous projects;
- Road safety audits, including on-site visits;
- Safety management based on roadway inventories;
- Input from police officers and road users; and
- Input from experts through such programs as the NHTSA traffic records assessment team.

The result of this step is normally a report that includes tables and graphs that clearly demonstrate the types of problems and detail some of their key characteristics. Such reports should be presented in a manner to allow top management to quickly grasp the key findings and help them decide which of the emphasis areas should be pursued further, and at what level of funding. However, the report must also document the detailed work that has been done, so that those who do the later stages of work will have the necessary background.

Specific Elements

1. Define the scope of the analysis
    - 1.1. All crashes in the entire jurisdiction
    - 1.2. A subset of crash types (whose characteristics suggest they are treatable, using strategies from the emphasis area)
    - 1.3. A portion of the jurisdiction
    - 1.4. A portion of the population (whose attributes suggest they are treatable using strategies from the emphasis area)
2. Define safety measures to be used for responsive analyses
    - 2.1. Crash measures
        - 2.1.1. Frequency (all crashes or by crash type)
        - 2.1.2. Measures of exposure
        - 2.1.3. Decide on role of frequency versus rates
    - 2.2. Behavioral measures
        - 2.2.1. Conflicts
        - 2.2.2. Erratic maneuvers
        - 2.2.3. Illegal maneuvers
        - 2.2.4. Aggressive actions
        - 2.2.5. Speed
    - 2.3. Other measures
        - 2.3.1. Citizen complaints
        - 2.3.2. Marks or damage on roadway and appurtenances, as well as crash debris
3. Define measures for proactive analyses
    - 3.1. Comparison with updated and changed policies, design guides, design criteria, and specifications
    - 3.2. Conditions related to lessons learned from previous projects
    - 3.3. Hazard indices or risk analyses calculated using data from roadway inventories to input to risk-based models
    - 3.4. Input from police officers and road users
4. Collect data
    - 4.1. Data on record (e.g., crash records, roadway inventory, medical data, driver-licensing data, citations, other)
    - 4.2. Field data (e.g., supplementary crash and inventory data, behavioral observations, operational data)
    - 4.3. Use of road safety audits, or adaptations
5. Analyze data
    - 5.1. Data plots (charts, tables, and maps) to identify possible patterns, and concentrations (See Appendixes Y, Z and AA for examples of what some states are doing)

- 5.2. Statistical analysis (high-hazard locations, over-representation of contributing circumstances, crash types, conditions, and populations)
- 5.3. Use expertise, through road safety audits or program assessment teams
- 5.4. Focus upon key attributes for which action is feasible:
    - 5.4.1. Factors potentially contributing to the problems
    - 5.4.2. Specific populations contributing to, and affected by, the problems
    - 5.4.3. Those parts of the system contributing to a large portion of the problem

6. Report results and receive approval to pursue solutions to identified problems (a*pprovals being sought here are primarily a confirmation of the need to proceed and likely levels of resources required*)
    - 6.1. Sort problems by type
        - 6.1.1. Portion of the total problem
        - 6.1.2. Vehicle, highway/environment, enforcement, education, other driver actions, emergency medical system, legislation, and system management
        - 6.1.3. According to applicable funding programs
        - 6.1.4. According to political jurisdictions
    - 6.2. Preliminary listing of the types of strategies that might be applicable
    - 6.3. Order-of-magnitude estimates of time and cost to prepare implementation plan
    - 6.4. Listing of agencies that should be involved, and their potential roles (including an outline of the organizational framework intended for the working group). Go to Step 2 for more on this.

Implementation Step 2: Recruit Appropriate Participants for the Program

General Description

A critical early step in the implementation process is to engage all the stakeholders that may be encompassed within the scope of the planned program. The stakeholders may be from outside agencies (e.g., state patrol, county governments, or citizen groups). One criterion for participation is if the agency or individual will help ensure a comprehensive view of the problem and potential strategies for its resolution. If there is an existing structure (e.g., a State Safety Management System Committee) of stakeholders for conducting strategic planning, it is important to relate to this, and build on it, for addressing the detailed considerations of the particular emphasis area.

There may be some situations within the emphasis area for which no other stakeholders may be involved other than the lead agency and the road users. However, in most cases, careful consideration of the issues will reveal a number of potential stakeholders to possibly be involved. Furthermore, it is usually the case that a potential program will proceed better in the organizational and institutional setting if a high-level "champion" is found in the lead agency to support the effort and act as a key liaison with other stakeholders.

Stakeholders should already have been identified in the previous step, at least at a level to allow decision makers to know whose cooperation is needed, and what their potential level of involvement might be. During this step, the lead agency should contact the key individuals in each of the external agencies to elicit their participation and cooperation. This will require identifying the right office or organizational unit, and the appropriate people in each case. It will include providing them with a brief overview document and outlining for them the type of involvement envisioned. This may typically involve developing interagency agreements. The participation and cooperation of each agency should be secured to ensure program success.

Lists of appropriate candidates for the stakeholder groups are recorded in Appendix K. In addition, reference may be made to the NHTSA document at http://www.nhtsa.dot.gov/safecommunities/SAFE%20COMM%20Html/index.html, which provides guidance on building coalitions.

Specific Elements

1. Identify internal "champions" for the program
2. Identify the suitable contact in each of the agencies or private organizations who is appropriate to participate in the program
3. Develop a brief document that helps sell the program and the contact's role in it by
    - 3.1. Defining the problem
    - 3.2. Outlining possible solutions
    - 3.3. Aligning the agency or group mission by resolving the problem
    - 3.4. Emphasizing the importance the agency has to the success of the effort

   3.5. Outlining the organizational framework for the working group and other stakeholders cooperating on this effort
   3.6. Outlining the rest of the process in which agency staff or group members are being asked to participate
   3.7. Outlining the nature of commitments desired from the agency or group for the program
   3.8. Establishing program management responsibilities, including communication protocols, agency roles, and responsibilities
   3.9. Listing the purpose for an initial meeting
4. Meet with the appropriate representative
   4.1. Identify the key individual(s) in the agency or group whose approval is needed to get the desired cooperation
   4.2. Clarify any questions or concepts
   4.3. Outline the next steps to get the agency or group onboard and participating
5. Establish an organizational framework for the group
   5.1. Roles
   5.2. Responsibilities

Implementation Step 3: Establish Crash Reduction Goals

General Description

The AASHTO Strategic Highway Safety Plan established a national goal of saving 5,000 to 7,000 lives annually by the year 2003 to 2005. Some states have established statewide goals for the reduction of fatalities or crashes of a certain degree of severity. Establishing an explicit goal for crash reduction can place an agency "on the spot," but it usually provides an impetus to action and builds a support for funding programs for its achievement. Therefore, it is desirable to establish, within each emphasis area, one or more crash reduction targets.

These may be dictated by strategic-level planning for the agency, or it may be left to the stakeholders to determine. (The summary of the Wisconsin DOT Highway Safety Plan in Appendix A has more information.) For example, Pennsylvania adopted a goal of 10 percent reduction in fatalities by 2002,[1] while California established a goal of 40 percent reduction in fatalities and 15 percent reduction in injury crashes, as well as a 10 percent reduction in work zone crashes, in 1 year.[2] At the municipal level, Toledo, Ohio, is cited by the U.S. Conference of Mayors as having an exemplary program. This included establishing specific crash reduction goals (http://www.usmayors.org/uscm/uscm_projects_services/health/traffic/best_traffic_initiative_toledo.htm). When working within an emphasis area, it may be desirable to specify certain types of crashes, as well as the severity level, being targeted.

There are a few key considerations for establishing a quantitative goal. The stakeholders should achieve consensus on this issue. The goal should be challenging, but achievable. Its feasibility depends in part on available funding, the timeframe in which the goal is to be achieved, the degree of complexity of the program, and the degree of controversy the program may experience. To a certain extent, the quantification of the goal will be an iterative process. If the effort is directed at a particular location, then this becomes a relatively straightforward action.

Specific Elements

1. Identify the type of crashes to be targeted
    - 1.1. Subset of all crash types
    - 1.2. Level of severity
2. Identify existing statewide or other potentially related crash reduction goals
3. Conduct a process with stakeholders to arrive at a consensus on a crash reduction goal
    - 3.1. Identify key considerations
    - 3.2. Identify past goals used in the jurisdiction
    - 3.3. Identify what other jurisdictions are using as crash reduction goals
    - 3.4. Use consensus-seeking methods, as needed

[1] Draft State Highway Safety Plan, State of Pennsylvania, July 22, 1999

[2] Operations Program Business Plan, FY 1999/2000, State of California, Caltrans, July 1999

Implementation Step 4: Develop Program Policies, Guidelines, and Specifications

General Description

A foundation and framework are needed for solving the identified safety problems. The implementation process will need to be guided and evaluated according to a set of goals, objectives, and related performance measures. These will formalize what the intended result is and how success will be measured. The overlying crash reduction goal, established in Step 3, will provide the context for the more specific goals established in this step. The goals, objectives, and performance measures will be used much later to evaluate what is implemented. Therefore, they should be jointly outlined at this point and agreed to by all program stakeholders. It is important to recognize that evaluating any actions is an important part of the process. Even though evaluation is not finished until some time after the strategies have been implemented, it begins at this step.

The elements of this step may be simpler for a specific project or location than for a comprehensive program. However, even in the simpler case, policies, guidelines, and specifications are usually needed. Furthermore, some programs or projects may require that some guidelines or specifications be in the form of limits on directions taken and types of strategies considered acceptable.

Specific Elements

1. Identify high-level policy actions required and implement them (legislative and administrative)
2. Develop goals, objectives, and performance measures to guide the program and use for assessing its effect
    - 2.1. Hold joint meetings of stakeholders
    - 2.2. Use consensus-seeking methods
    - 2.3. Carefully define terms and measures
    - 2.4. Develop report documenting results and validate them
3. Identify specifications or constraints to be used throughout the project
    - 3.1. Budget constraints
    - 3.2. Time constraints
    - 3.3. Personnel training
    - 3.4. Capacity to install or construct
    - 3.5. Types of strategies not to be considered or that must be included
    - 3.6. Other

Implementation Step 5: Develop Alternative Approaches to Addressing the Problem

General Description

Having defined the problem and established a foundation, the next step is to find ways to address the identified problems. If the problem identification stage has been done effectively (see Appendix D for further details on identifying road safety problems), the characteristics of the problems should suggest one or more alternative ways for dealing with the problem. It is important that a full range of options be considered, drawing from areas dealing with enforcement, engineering, education, emergency medical services, and system management actions.

Alternative strategies should be sought for both location-specific and systemic problems that have been identified. Location-specific strategies should pertain equally well to addressing high-hazard locations and to solving safety problems identified within projects that are being studied for reasons other than safety.

Where site-specific strategies are being considered, visits to selected sites may be in order if detailed data and pictures are not available. In some cases, the emphasis area guides will provide tables that help connect the attributes of the problem with one or more appropriate strategies to use as countermeasures.

Strategies should also be considered for application on a systemic basis. Examples include

1. Low-cost improvements targeted at problems that have been identified as significant in the overall highway safety picture, but not concentrated in a given location.
2. Action focused upon a specific driver population, but carried out throughout the jurisdiction.
3. Response to a change in policy, including modified design standards.
4. Response to a change in law, such as adoption of a new definition for DUI.

In some cases, a strategy may be considered that is relatively untried or is an innovative variation from past approaches to treatment of a similar problem. Special care is needed to ensure that such strategies are found to be sound enough to implement on a wide-scale basis. Rather than ignoring this type of candidate strategy in favor of the more "tried-and-proven" approaches, consideration should be given to including a pilot-test component to the strategy.

The primary purpose of this guide is to provide a set of strategies to consider for eliminating or lessening the particular road safety problem upon which the user is focusing. As pointed out in the first step of this process, the identification of the problem, and the selection of strategies, is a complex step that will be different for each case. Therefore, it is not feasible to provide a "formula" to follow. However, guidelines are available. There are a number of texts to which the reader can refer. Some of these are listed in Appendix B and Appendix D.

In addition, the tables referenced in Appendix G provide examples for linking identified problems with candidate strategies.

The second part of this step is to assemble sets of strategies into alternative "program packages." Some strategies are complementary to others, while some are more effective when combined with others. In addition, some strategies are mutually exclusive. Finally, strategies may be needed to address roads across multiple jurisdictions. For instance, a package of strategies may need to address both the state and local highway system to have the desired level of impact. The result of this part of the activity will be a set of alternative "program packages" for the emphasis area.

It may be desirable to prepare a technical memorandum at the end of this step. It would document the results, both for input into the next step and for internal reviews. The latter is likely to occur, since this is the point at which specific actions are being seriously considered.

Specific Elements

1. Review problem characteristics and compare them with individual strategies, considering both their objectives and their attributes
    - 1.1. Road-user behavior (law enforcement, licensing, adjudication)
    - 1.2. Engineering
    - 1.3. Emergency medical services
    - 1.4. System management elements
2. Select individual strategies that do the following:
    - 2.1. Address the problem
    - 2.2. Are within the policies and constraints established
    - 2.3. Are likely to help achieve the goals and objectives established for the program
3. Assemble individual strategies into alternative program packages expected to optimize achievement of goals and objectives
    - 3.1. Cumulative effect to achieve crash reduction goal
    - 3.2. Eliminate strategies that can be identified as inappropriate, or likely to be ineffective, even at this early stage of planning
4. Summarize the plan in a technical memorandum, describing attributes of individual strategies, how they will be combined, and why they are likely to meet the established goals and objectives

Implementation Step 6: Evaluate Alternatives and Select a Plan

General Description

This step is needed to arrive at a logical basis for prioritizing and selecting among the alternative strategies or program packages that have been developed. There are several activities that need to be performed. One proposed list is shown in Appendix P.

The process involves making estimates for each of the established performance measures for the program and comparing them, both individually and in total. To do this in a quantitative manner requires some basis for estimating the effectiveness of each strategy. Where solid evidence has been found on effectiveness, it has been presented for each strategy in the guide. In some cases, agencies have a set of crash reduction factors that are used to arrive at effectiveness estimates. Where a high degree of uncertainty exists, it is wise to use sensitivity analyses to test the validity of any conclusions that may be made regarding which is the best strategy or set of strategies to use. Further discussion of this may be found in Appendix O.

Cost-benefit and cost-effectiveness analyses are usually used to help identify inefficient or inappropriate strategies, as well as to establish priorities. For further definition of the two terms, see Appendix Q. For a comparison of the two techniques, see Appendix S. Aspects of feasibility, other than economic, must also be considered at this point. An excellent set of references is provided within online benefit-cost guides:

- One is under development at the following site, maintained by the American Society of Civil Engineers: http://ceenve.calpoly.edu/sullivan/cutep/cutep_bc_outline_main.htm.
- The other is *Guide to Benefit-Cost Analysis in Transport Canada*, September 1994, http://www.tc.gc.ca/finance/bca/en/TOC_e.htm. An overall summary of this document is given in Appendix V.

In some cases, a strategy or program may look promising, but no evidence may be available as to its likely effectiveness. This would be especially true for innovative methods or use of emerging technologies. In such cases, it may be advisable to plan a pilot study to arrive at a minimum level of confidence in its effectiveness, before large-scale investment is made or a large segment of the public is involved in something untested.

It is at this stage of detailed analysis that the crash reduction goals, set in Step 3, may be revisited, with the possibility of modification.

It is important that this step be conducted with the full participation of the stakeholders. If the previous steps were followed, the working group will have the appropriate representation. Technical assistance from more than one discipline may be necessary to go through more complex issues. Group consensus will be important on areas such as estimates of effectiveness, as well as the rating and ranking of alternatives. Techniques are available to assist in arriving at consensus. For example, see the following Web site for an overview: http://web.mit.edu/publicdisputes/practices/cbh_ch1.html.

Specific Elements

1. Assess feasibility
    1.1. Human resources
    1.2. Special constraints
    1.3. Legislative requirements
    1.4. Other
    1.5. This is often done in a qualitative way, to narrow the list of choices to be studied in more detail (see, for example, Appendix BB)
2. Estimate values for each of the performance measures for each strategy and plan
    2.1. Estimate costs and impacts
        2.1.1. Consider guidelines provided in the detailed description of strategies in this material
        2.1.2. Adjust as necessary to reflect local knowledge or practice
        2.1.3. Where a plan or program is being considered that includes more than one strategy, combine individual estimates
    2.2. Prepare results for cost-benefit and/or cost-effectiveness analyses
    2.3. Summarize the estimates in both disaggregate (by individual strategy) and aggregate (total for the program) form
3. Conduct a cost-benefit and/or cost-effectiveness analysis to identify inefficient, as well as dominant, strategies and programs and to establish a priority for the alternatives
    3.1. Test for dominance (both lower cost and higher effectiveness than others)
    3.2. Estimate relative cost-benefit and/or cost-effectiveness
    3.3. Test productivity
4. Develop a report that documents the effort, summarizing the alternatives considered and presenting a preferred program, as devised by the working group (for suggestions on a report of a benefit-cost analysis, see Appendix U).
    4.1. Designed for high-level decision makers, as well as technical personnel who would be involved in the implementation
    4.2. Extensive use of graphics and layout techniques to facilitate understanding and capture interest
    4.3. Recommendations regarding meeting or altering the crash reduction goals established in Step 3.

Implementation Step 7: Submit Recommendations for Action by Top Management

General Description

The working group has completed the important planning tasks and must now submit the results and conclusions to those who will make the decision on whether to proceed further. Top management, at this step, will primarily be determining if an investment will be made in this area. As a result, the plan will not only be considered on the basis of its merits for solving the particular problems identified in this emphasis area (say, vis-à-vis other approaches that could be taken to deal with the specific problems identified), but also its relative value in relation to investments in other aspects of the road safety program.

This aspect of the process involves using the best available communication skills to adequately inform top management. The degree of effort and extent of use of media should be proportionate to the size and complexity of the problem being addressed, as well as the degree to which there is competition for funds.

The material that is submitted should receive careful review by those with knowledge in report design and layout. In addition, today's technology allows for the development of automated presentations, using animation and multimedia in a cost-effective manner. Therefore, programs involving significant investments that are competing strongly for implementation resources should be backed by such supplementary means for communicating efficiently and effectively with top management.

Specific Elements

1. Submit recommendations for action by management
    - 1.1. "Go/no-go" decision
    - 1.2. Reconsideration of policies, guidelines, and specifications (see Step 3)
    - 1.3. Modification of the plan to accommodate any revisions to the program framework made by the decision makers
2. Working group to make presentations to decision makers and other groups, as needed and requested
3. Working group to provide technical assistance with the review of the plan, as requested
    - 3.1. Availability to answer questions and provide further detail
    - 3.2. Assistance in conducting formal assessments

Implementation Step 8: Develop a Plan of Action

General Description

At this stage, the working group will usually detail the program that has been selected for implementation. This step translates the program into an action plan, with all the details needed by both decision makers, who will have to commit to the investment of resources, and those charged with carrying it out. The effort involves defining resource requirements, organizational and institutional arrangements needed, schedules, etc. This is usually done in the form of a business plan, or plan of action. An example of a plan developed by a local community is shown in Appendix X.

An evaluation plan should be designed at this point. It is an important part of the plan. This is something that should be in place before Step 9 is finished. It is not acceptable to wait until after the program is completed to begin designing an evaluation of it. This is because data are needed about conditions before the program starts, to allow comparison with conditions during its operation and after its completion. It also should be designed at this point, to achieve consensus among the stakeholders on what constitutes "success." The evaluation is used to determine just how well things were carried out and what effect the program had. Knowing this helps maintain the validity of what is being done, encourages future support from management, and provides good intelligence on how to proceed after the program is completed. For further details on performing evaluations, see Appendix L, Appendix M, and Appendix W.

The plan of action should be developed jointly with the involvement of all desired participants in the program. It should be completed to the detail necessary to receive formal approval of each agency during the next step. The degree of detail and complexity required for this step will be a function of the size and scope of the program, as well as the number of independent agencies involved.

Specific Elements

1. Translation of the selected program into key resource requirements
    - 1.1. Agencies from which cooperation and coordination is required
    - 1.2. Funding
    - 1.3. Personnel
    - 1.4. Data and information
    - 1.5. Time
    - 1.6. Equipment
    - 1.7. Materials
    - 1.8. Training
    - 1.9. Legislation
2. Define organizational and institutional framework for implementing the program
    - 2.1. Include high-level oversight group
    - 2.2. Provide for involvement in planning at working levels
    - 2.3. Provide mechanisms for resolution of issues that may arise and disagreements that may occur
    - 2.4. Secure human and financial resources required

3. Detail a program evaluation plan
    - 3.1. Goals and objectives
    - 3.2. Process measures
    - 3.3. Performance measures
        - 3.3.1. Short-term, including surrogates, to allow early reporting of results
        - 3.3.2. Long-term
    - 3.4. Type of evaluation
    - 3.5. Data needed
    - 3.6. Personnel needed
    - 3.7. Budget and time estimates
4. Definition of tasks to conduct the work
    - 4.1. Develop diagram of tasks (e.g., PERT chart)
    - 4.2. Develop schedule (e.g., Gantt chart)
    - 4.3. For each task, define
        - 4.3.1. Inputs
        - 4.3.2. Outputs
        - 4.3.3. Resource requirements
        - 4.3.4. Agency roles
        - 4.3.5. Sequence and dependency of tasks
5. Develop detailed budget
    - 5.1. By task
    - 5.2. Separate by source and agency/office (i.e., cost center)
6. Produce program action plan, or business plan document

Implementation Step 9: Establish Foundations for Implementing the Program

General Description

Once approved, some "groundwork" is often necessary to establish a foundation for carrying out the selected program. This is somewhat similar to what was done in Step 4. It must now be done in greater detail and scope for the specific program being implemented. As in Step 4, specific policies and guidelines must be developed, organizational and institutional arrangements must be initiated, and an infrastructure must be created for the program. The business plan or action plan provides the basis (Step 7) for this. Once again, the degree of complexity required will vary with the scope and size of the program, as well as the number of agencies involved.

Specific Elements

1. Refine policies and guidelines (from Step 4)
2. Effect required legislation or regulations
3. Allocate budget
4. Reorganize implementation working group
5. Develop program infrastructure
    - 5.1. Facilities and equipment for program staff
    - 5.2. Information systems
    - 5.3. Communications
    - 5.4. Assignment of personnel
    - 5.5. Administrative systems (monitoring and reporting)
6. Set up program assessment system
    - 6.1. Define/refine/revise performance and process measures
    - 6.2. Establish data collection and reporting protocols
    - 6.3. Develop data collection and reporting instruments
    - 6.4. Measure baseline conditions

Implementation Step 10: Carry Out the Action Plan

General Description

Conditions have been established to allow the program to be started. The activities of implementation may be divided into activities associated with field preparation for whatever actions are planned and the actual field implementation of the plan. The activities can involve design and development of program actions, actual construction or installation of program elements, training, and the actual operation of the program. This step also includes monitoring for the purpose of maintaining control and carrying out mid- and post-program evaluation of the effort.

Specific Elements

1. Conduct detailed design of program elements
    - 1.1. Physical design elements
    - 1.2. PI&E materials
    - 1.3. Enforcement protocols
    - 1.4. Etc.
2. Conduct program training
3. Develop and acquire program materials
4. Develop and acquire program equipment
5. Conduct pilot tests of untested strategies, as needed
6. Program operation
    - 6.1. Conduct program "kickoff"
    - 6.2. Carry out monitoring and management of ongoing operation
        - 6.2.1 Periodic measurement (process and performance measures)
        - 6.2.2 Adjustments as required
    - 6.3 Perform interim and final reporting

Implementation Step 11: Assess and Transition the Program

General Description

The AASHTO Strategic Highway Safety Plan includes improvement in highway safety management. A key element of that is the conduct of properly designed program evaluations. The program evaluation will have been first designed in Step 8, which occurs prior to any field implementation. For details on designing an evaluation, please refer to Step 8. For an example of how the New Zealand Transport Authority takes this step as an important part of the process, see Appendix N.

The program will usually have a specified operational period. An evaluation of both the process and performance will have begun prior to the start of implementation. It may also continue during the course of the implementation, and it will be completed after the operational period of the program.

The overall effectiveness of the effort should be measured to determine if the investment was worthwhile and to guide top management on how to proceed into the post-program period. This often means that there is a need to quickly measure program effectiveness in order to provide a preliminary idea of the success or need for immediate modification. This will be particularly important early in development of the AASHTO Strategic Highway Safety Plan, as agencies learn what works best. Therefore, surrogates for safety impact may have to be used to arrive at early/interim conclusions. These usually include behavioral measures. This particular need for interim surrogate measures should be dealt with when the evaluation is designed, back in Step 8. However, a certain period, usually a minimum of a couple of years, will be required to properly measure the effectiveness and draw valid conclusions about programs designed to reduce highway fatalities when using direct safety performance measures.

The results of the work is usually reported back to those who authorized it and the stakeholders, as well as any others in management who will be involved in determining the future of the program. Decisions must be made on how to continue or expand the effort, if at all. If a program is to be continued or expanded (as in the case of a pilot study), the results of its assessment may suggest modifications. In some cases, a decision may be needed to remove what has been placed in the highway environment as part of the program because of a negative impact being measured. Even a “permanent” installation (e.g., rumble strips) requires a decision regarding investment for future maintenance if it is to continue to be effective.

Finally, the results of the evaluation using performance measures should be fed back into a knowledge base to improve future estimates of effectiveness.

Specific Elements

1. Analysis
   - 1.1 Summarize assessment data reported during the course of the program
   - 1.2 Analyze both process and performance measures (both quantitative and qualitative)

    1.3 Evaluate the degree to which goals and objectives were achieved (using performance measures)
    1.4 Estimate costs (especially vis-à-vis pre-implementation estimates)
    1.5 Document anecdotal material that may provide insight for improving future programs and implementation efforts
    1.6 Conduct and document debriefing sessions with persons involved in the program (including anecdotal evidence of effectiveness and recommended revisions)
2. Report results
3. Decide how to transition the program
    3.1 Stop
    3.2 Continue as is
    3.3 Continue with revisions
    3.4 Expand as is
    3.5 Expand with revisions
    3.6 Reverse some actions
4. Document data for creating or updating database of effectiveness estimates

SECTION VII

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SECTION VIII

Glossary

Acronym or Term	Meaning	Comments
3R	Rehabilitation, Resurfacing, and Restoration	Refers to type of project that is intended to be less comprehensive than complete reconstruction
AAA	American Automobile Association	
AAAM	Association for the Advancement of Automotive Medicine	
AAMVA	American Association of Motor Vehicle Administrators	
AASHTO	American Association of State Highway and Transportation Officials	
ADAT	Aggressive Driving Apprehension Team	Washington State Patrol
ADT	Average Daily Traffic	
AG	Aggressive Driving	
AMA	American Medical Association	
AMF (or CMF)	Accident Modification Factor	Also may be referred to as Crash Modification Factor
ARTBA	American Road and Transportation Builders Association	
ASCE	American Society of Civil Engineers	
AWS	Accident Warning System	
B/C	Benefit-Cost Ratio	
BCT	Breakaway Cable Terminal	End treatment for guardrail
CAE	Computer Aided Engineering	
CCS	Collision Countermeasure System	
CDL	Commercial Driver's License	
CHSIM	Comprehensive Highway Safety Improvement Model	Recently changed name to *The SafetyAnalyst*
CSD	Context-Sensitive Design	
DDC-ADD	Defensive Driving Course—Attitudinal Dynamics of Driving	

Acronym or Term	Meaning	Comments
DDSS	Design Decision Support System	
DES	Detailed Engineering Studies	
DMV	Department of Motor Vehicles	
DOT	Department of Transportation	
DUI/DWI	Driving Under the Influence (of alcohol or drugs)/Driving While Impaired	
DUS	Driving Under Suspension (of driver's license)	
DWR	Driving While Revoked	
DWS	Driving While Suspended	
EM	Electronic Monitoring	
FARS	Fatality Analysis Reporting System	Formerly referred to as Fatal Accident Reporting System
FHWA	Federal Highway Administration	Division of the U.S. Department of Transportation
F+I	Fatal Plus Injury (crash)	
FO	Fixed Object	
GHSA	Governors Highway Safety Association	Formerly NAGHSR (National Association of Governors' Highway Safety Representatives)
Green Book	AASHTO Policy on Geometric Design of Highways	
H.A.D.	Halt Aggressive Driving	Lubbock, Texas
HAL	High Accident Location	
HCM	Highway Capacity Manual	TRB publication
HES	Hazard Elimination Study	
HO	Head On (accident)	
HOS	Hours of Service	For commercial vehicle drivers
HRR	Highway Research Record	TRB publication
HSIS	Highway Safety Information System	
HSM	Highway Safety Manual	
IES	Illumination Engineering Society	
IHSDM	Interactive Highway Safety Design Model	
IID	Ignition Interlock Device	
ISD	Intersection Sight Distance	

Acronym or Term	Meaning	Comments
ITE	Institute of Transportation Engineers	
LCCA	Life Cycle Cost Analysis	
MAB	Medical Advisory Board	State-level organization
MADD	Mothers Against Drunk Driving	
MUTCD	Manual on Uniform Traffic Control Devices	FHWA publication
NCHRP	National Cooperative Highway Research Program	
NHI	National Highway Institute	FHWA training office
NHTSA	National Highway Traffic Safety Administration	Division of the U.S. Department of Transportation
NSC	National Safety Council	
NTSB	National Transportation Safety Board	
NYSTA	New York State Thruway Authority	
PCR	Police Crash Report	
PDO	Property Damage Only (accident)	
PI&E	Public Information & Education	
RDG	Roadside Design Guide	AASHTO publication
RID	Remove Intoxicated Drivers	Citizen group
ROR	Run-Off-Road (accident)	
ROW	Right-of-Way	
RPM	Raised Pavement Marker	
RSA	Road Safety Audit	
RSPM	Raised Snowplowable Pavement Marker	
SADD	Students Against Destructive Decisions	
SBPD	Santa Barbara Police Department (California)	
SHSP	Strategic Highway Safety Plan	
SKARP	Skid Accident Reduction Program	
SPF	Safety Performance Function	
SSD	Stopping Sight Distance	
SUV	Sports Utility Vehicle	
SV	Single Vehicle (accident)	

Acronym or Term	Meaning	Comments
TCD	Traffic Control Device	
TRB	Transportation Research Board	
TRR	Transportation Research Record	TRB publication
TRRL	Transport and Road Research Laboratory	United Kingdom organization
TSIMS	Transportation Safety Information Management System	Developed by AASHTO
TTI	Texas Transportation Institute	
TWLTL	Two-Way, Left-Turn Lane	
U/S/R	Unlicensed/Suspended/Revoked	Drivers without licenses, or whose licenses have been suspended or revoked
UVC	Uniform Vehicle Code	Model national traffic law
VPD	Vehicles Per Day	
WSP	Washington State Patrol	

See also: Glossary of Transportation Terms online
http://transweb.sjsu.edu/comglos2.htm#P

Appendixes

The following appendixes are not published in this report. However, they are available online at http://transportation1.org/safetyplan.

1 Potential Tree Hazards
2 Summary of Survey Results from State DOTs on Tree Crash Reduction Programs
3 Excerpts on Tree Removal from Michigan DOT Design Manual
4 Roadside Tree Legal Issues
5 Application Opportunities for a Tree Planting Guide
6 Components of a Planting Guideline
7 Trees Shielded by Roadside Devices
8 Pennsylvania DOT Tree Crash Reduction Factors
9 Considerations for Finishing Off After Tree Removal
10 Implementation Issues for Barriers Applied to Trees in Hazardous Locations
11 Implementation of Roadside Modifications
12 Identifying Risks at Hazardous Locations Involving Trees
13 Assessing the Benefits of the Roadside Tree
14 Delineating Trees in Pennsylvania
15 Some Tree Crashes Are Not Related to Trees

A Wisconsin Department of Transportation 2001 Strategic Highway Safety Plan
B Resources for the Planning and Implementation of Highway Safety Programs
C South African Road Safety Manual
D Comments on Problem Definition
E Issues Associated with Use of Safety Information in Highway Design: Role of Safety in Decision Making
F Comprehensive Highway Safety Improvement Model
G Table Relating Candidate Strategies to Safety Data Elements
H What is a Road Safety Audit?
I Illustration of Regression to the Mean
J Fault Tree Analysis
K Lists of Potential Stakeholders
L Conducting an Evaluation
M Designs for a Program Evaluation
N Joint Crash Reduction Program: Outcome Monitoring
O Estimating the Effectiveness of a Program During the Planning Stages
P Key Activities for Evaluating Alternative Program
Q Definitions of Cost-Benefit and Cost-Effectiveness
R FHWA Policy on Life Cycle Costing
S Comparisons of Benefit-Cost and Cost-Effectiveness Analysis
T Issues in Cost-Benefit and Cost-Effectiveness Analyses
U Transport Canada Recommended Structure for a Benefit-Cost Analysis Report
V Overall Summary of Benefit-Cost Analysis Guide from Transport Canada

Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation