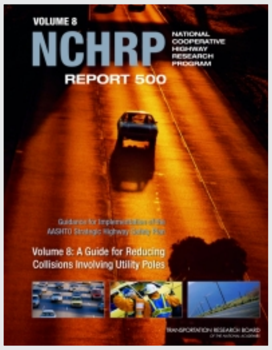

A Guide for Reducing Collisions Involving Utility Poles

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP REPORT 500

Guidance for Implementation of the AASHTO Strategic Highway Safety Plan

Volume 8: A Guide for Reducing Collisions Involving Utility Poles

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SUBJECT AREAS
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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NCHRP PROJECT G17-18(3) PANEL
Field of Traffic—Area of Safety

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 eighth 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 collisions involving utility poles. 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 eighth 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-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 volume of *NCHRP Report 500* was developed under NCHRP Project 17-18(3), the product of which is a series of implementation guides addressing the emphasis areas of AASHTO's Strategic Highway Safety Plan. The project was managed by CH2M Hill, and 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 team. Kelly Hardy, also of CH2M Hill, served as a technical specialist on the development of the guides.

The project team was organized around the specialized technical content contained in each guide, and the team included nationally recognized experts from many organizations. The following team of experts, selected based on their knowledge and expertise in this particular emphasis area, served as lead authors for the utility pole guide:

- Kevin Lacy
  North Carolina Department of Transportation
- Raghavan Srinivasan
  University of North Carolina Highway Safety Research Center
- Charles V. Zegeer
  University of North Carolina Highway Safety Research Center

Developing the volumes of *NCHRP Report 500* required 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 documents represent best practices in each emphasis area. The project team is grateful to the following list of people and their agencies for supporting the project through their participation in workshops and meetings and additional reviews of the utility pole guide:

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SECTION I
Summary

Introduction

The AASHTO Strategic Highway Safety Plan identified 22 goals to be pursued to achieve a significant reduction in highway crash fatalities. One of the hallmarks of the plan is to approach safety problems in a comprehensive manner. The range of strategies available in the guides will ultimately 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 of these perspectives in a coordinated manner.

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

This emphasis area is specifically identified in Goal 16, *Minimizing the Consequences of Leaving the Road.* Utility pole crashes are a subset of run-off-road (ROR) crashes. Emphasis Area 16.1 addresses the general subject of ROR crashes and covers strategies aimed at reducing the consequences of ROR crashes by (1) keeping vehicles from leaving the roadway and (2) reducing the severity of impacts after leaving the roadway. Ideally, keeping the vehicle on the roadway and in its appropriate lane is preferred. The reader should refer to the other strategy documents for strategies aimed at keeping the vehicle on the roadway. This guide focuses on measures directed at reducing the harm in utility pole crashes after encroachment on the roadside has occurred—strategies such as removing or relocating specific utility poles, placing utilities underground, and shielding motorists from utility poles.

Utility pole crashes are fixed-object crashes that involve vehicles leaving the travel lane, encroaching on the roadside, and striking a utility pole.

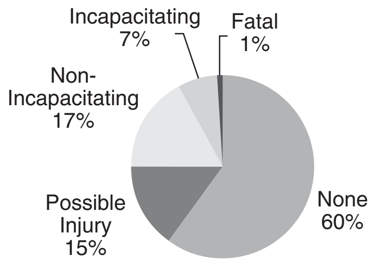
Utility poles can also contribute to the severity of other crash types. Many crashes are not classified as ROR or fixed-object crashes where one or more vehicles strike a utility pole. Crashes are often classified by "first harmful event." In some cases, striking the utility pole is a secondary event that may be as severe as, or more severe than, the first harmful event. Crashes involving utility poles as secondary events easily go unnoticed when examining the total magnitude of the utility pole crash problem.

Type of Problem

Utility poles represent one of the more substantial objects that are intentionally placed on roadsides. "The U.S. has over 88 million utility poles on highway rights-of-way."[1] They are substantial both in sheer number and in structural strength. The only object type more frequently struck in fatal fixed-object crashes is trees.[2] Because of the structural strength and small vehicle contact area of utility poles, these crashes tend to be severe.

In 2002, there were 1,008 fatal crashes[3] associated with utility poles reported in the Fatality Analysis Reporting System (FARS; see http://www-fars.nhtsa.dot.gov/). Although the National Highway Traffic Safety Administration (NHTSA) General Estimates System (GES) does not report utility pole crashes separately, the data for 1999 show that fatal crashes were only about 1 percent of all pole crashes. However, about 40 percent of pole crashes involve some type of injury. The data also show that about 25 percent of pole crashes occur in adverse weather conditions, and only about half occur in full daylight, while another 25 percent occur under lighted conditions at night.

EXHIBIT I-1
Distribution of Maximum Severity for Pole Crashes



Crashes with all poles, including utility poles
Source: GES 1999

Objectives of the Emphasis Area

To reduce the severity and number of fatality utility pole crashes, the objectives should be to

- Treat specific utility poles in high-crash and high-risk spot locations,
- Prevent placing utility poles in high-risk locations, and
- Treat several utility poles along a corridor to minimize the likelihood of crashing into a utility pole if a vehicle runs off the road.

A comprehensive safety program to address utility pole crashes would be missing very important opportunities if non-engineering methods were not also considered. While not

[1] "Safer Roadsides Through Better Utility Pole Placement, Protection, Construction," *Texas Transportation Researcher,* Volume 35, Number 1 (1999).
[2] American Association of State Highway and Transportation Officials. *Roadside Design Guide.* AASHTO, Washington, D.C. January 1996.
[3] This number was obtained assuming that the collision with the utility pole was the first harmful event in the fatal crash.

specifically targeting pole crashes, some of these methods, such as increased speed enforcement and increased use of seatbelts, can help reduce the severity and risk of utility pole crashes. These systemic strategies have a much broader reach than utility pole or fixed-object crashes. However, the authors encourage the reader to refer to the guides that specifically address these strategies and to work with the appropriate agencies to apply the strategies.

Explanation of the Objectives

A multifaceted approach is ideal and includes combining the efforts of highway agency and utility personnel, treating existing isolated problem locations and high-risk sites, preventing the development of new high-risk sites, and systematically reviewing and treating high-risk corridors. The time and cost to relocate or remove utility poles sometimes causes the strategy to receive less attention than is appropriate to effectively reduce the severity and impact of utility pole crashes. The lack of attention received by this strategy is a reason to develop a focused and well-documented program to maximize the safety improvements' effectiveness.

The first objective represents an approach to identify and treat locations with a history of utility pole crashes. While many agencies have not kept the necessary data to systematically identify high-risk locations in a proactive approach, other techniques such as safety audits can be used to flag high-risk locations for investigation and possible treatment. Strategies for this objective focus on a relatively small number of poles in high-risk locations that may need a rapid response.

A comprehensive safety program should always have a prevention component. Utility pole crashes are not an exception. The design and construction phases of roadway and utility projects are the best opportunities to practice "preventative medicine" by not placing poles in vulnerable locations. The strategy for meeting this objective is generally a long-term, systemic approach that requires steady and consistent application. The opportunities for application range from initial design of new facilities, 3R (resurfacing, restoration, and rehabilitation) projects, and utility rehabilitation, to even smaller projects where turn lanes are built with private funding, such as by developers.

One of the major hurdles of safety programs targeting utility poles is the sheer number of poles on the roadside. It took decades to "plant" all the poles on the roadside. Utility poles were along roadsides when horses were drawing carriages. Therefore, it is unrealistic and unnecessary to expect to treat all the poles at the same time. A program is needed with both short-term and long-term components. These components should target and treat both the high-risk poles (such treatment tends to be done in the short term) and systematically treat poles along corridors on a continuing basis. This two-pronged approach helps avoid overwhelming agencies, utility companies, or other potential stakeholders. This approach recognizes that it is not financially possible to fix all the potentially hazardous poles immediately. Nevertheless, organized and targeted strategies to treat roadsides over time can significantly reduce the likelihood of a vehicle striking a utility pole or of that event causing injuries.

Often, it is not feasible to remove, relocate, or place underground the utilities carried by potentially hazardous roadside poles. However, it may be possible to lessen the severity of injuries involved in crashes where a vehicle does strike such a pole. When other objectives are impractical, this approach includes strategies that redirect errant vehicles, lessen the severity of impacts, or alter the operating conditions to create less severe impact conditions.

Exhibit I-2 lists the objectives and several related strategies for reducing the consequences and frequency of utility pole crashes. This exhibit does not represent a listing of all possible strategies to reduce the frequency and severity of utility pole crashes. For example, many strategies that focus on keeping vehicles on the roadway are not listed, but they would be very effective in reducing utility pole crashes. The reader may refer to the guides that specifically address the ROR crash issue for details on these strategies.

EXHIBIT I-2
Emphasis Area Objectives and Strategies

Objectives	Strategies
16.2 A Treat specific utility poles in high-crash and high-risk spot locations.	16.2 A1 Remove poles in hazardous locations.
	16.2 A2 Relocate poles in hazardous locations further from the roadway or to a less vulnerable location.
	16.2 A3 Use breakaway poles.
	16.2 A4 Shield drivers from poles in hazardous locations.
	16.2 A5 Improve the drivers' ability to see poles in hazardous locations.
	16.2 A6 Apply traffic calming measures to reduce speeds on high-risk sections.
16.2 B Prevent placing utility poles in high-risk locations.	16.2 B1 Develop, revise, and implement policies to prevent placing or replacing poles within the recovery area.
16.2 C Treat several utility poles along a corridor to minimize the likelihood of crashing into a utility pole if a vehicle runs off the road.	16.2 C1 Place utilities underground.
	16.2 C2 Relocate poles along the corridor farther from the roadway and/or to less vulnerable locations.
	16.2 C3 Decrease the number of poles along the corridor.

Target of the Objectives

The first objective addresses the locations that have a collision history or are recognized as high-risk locations. The application of these strategies is generally limited to a single pole or a few poles. For example, one pole on the outside of a horizontal curve can be moved to a less exposed location on the inside of the same curve. The target of the second objective is placing new utility poles along the roadway or relocating poles for 3R projects or other roadway projects, including widening. In addition, the second objective targets poles that will be replaced when utility companies periodically reconstruct their facilities. The third objective targets utility poles along longer sections of roadway where crashes are spread out along the corridor and not clustered around a small number of poles. It is important to mention that cooperation is a joint responsibility between highway agencies and utility companies and is an essential ingredient to promoting utility safety.

SECTION II

Introduction

The AASHTO Strategic Highway Safety Plan identified 22 goals to be pursued to achieve a significant reduction in highway crash fatalities. One of the hallmarks of the plan is to approach safety problems in a comprehensive manner. The range of strategies available in the guides will ultimately 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 of these perspectives in a coordinated manner.

AASHTO's overall goal is to move away from independent activities of engineers, law enforcement, educators, judges, and other highway-safety specialists and to move to coordinated efforts. The implementation process outlined in the series of guides promotes the formation of working groups and alliances that represent all of the elements of the safety system. In so doing, the guides can draw upon their combined expertise to reach the bottom-line goal of targeted reduction of crashes and fatalities associated with a particular emphasis area. An example of how one state DOT has involved stakeholders in utility issues may be found at http://www.state.me.us/mdot/utilities/utaskforce.php.

This emphasis area is specifically identified in Goal 16, *Minimizing the Consequences of Leaving the Road.* Utility pole crashes are a subset of run-off-road (ROR) crashes. Emphasis Area 16.1 addresses the general subject of ROR crashes and covers strategies aimed at reducing the consequences of ROR crashes by (1) keeping vehicles from leaving the roadway and (2) reducing the severity of impacts after leaving the roadway. Ideally, preventing the vehicle from leaving the roadway and keeping the vehicle in its appropriate lane is preferred. The reader should refer to the other strategy documents for strategies aimed at keeping the vehicle on the roadway. This guide focuses on measures directed at reducing the harm in utility pole crashes after encroachment on the roadside has occurred—strategies such as removing or relocating specific utility poles, placing utilities underground, and shielding motorists from utility poles.

Utility pole crashes are fixed-object crashes that involve vehicles leaving the travel lane, encroaching on the roadside, and striking a utility pole.

Utility poles can also contribute to the severity of other crash types. There are many crashes not classified as ROR or fixed-object crashes where one or more vehicles strike a utility pole. Crashes are often classified by "first harmful event." In some cases, striking the utility pole is a secondary event that may be as severe as, or more severe than, the first harmful event. Crashes involving utility poles as secondary events easily go unnoticed when examining the total magnitude of the utility pole crash problem.

SECTION III

Type of Problem

Utility poles are one of the more substantial objects that are intentionally placed on roadsides. "The U.S. has over 88 million utility poles on highway rights-of-way."[1] They are substantial both in sheer number and in structural strength. The only object type more frequently struck in fatal fixed-object crashes is trees.[2] Because of the structural strength and small impact area of utility poles, these crashes tend to be severe.

In 2002, there were 1,008 fatal crashes[3] associated with utility poles reported in the Fatality Analysis Reporting System (FARS; see http://www-fars.nhtsa.dot.gov/). Although the National Highway Traffic Safety Administration (NHTSA) General Estimates System (GES) does not report utility pole crashes separately, the data for the first harmful event in 1999 show that fatal crashes were only about 1 percent of all pole crashes. However, about 40 percent of pole crashes involve some type of injury. The data also show that about 25 percent of pole crashes occur in adverse weather conditions, and only about half occur in full daylight, while another 25 percent occur under lighted conditions at night.

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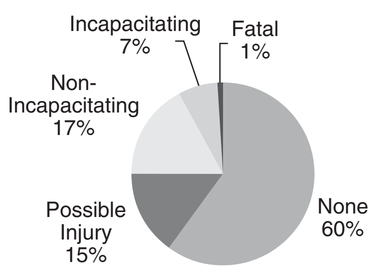

Crashes with all poles, including utility poles
Source: GES 1999

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[1] "Safer Roadsides Through Better Utility Pole Placement, Protection, Construction," *Texas Transportation Researcher,* Volume 35, Number 1 (1999).
[2] American Association of State Highway and Transportation Officials. *Roadside Design Guide.* Washington, D.C. January 1996.
[3] This number was obtained assuming that the collision with the utility pole was the first harmful event in the fatal crash.

SECTION IV

Index of Strategies by Implementation Timeframe and Relative Cost

Exhibit IV-1 provides a classification of strategies according to the expected timeframe and relative cost for this emphasis area. In several cases, the implementation time will depend on such factors as the agency's procedures, the need for additional right-of-way (ROW), and the need to follow environmental impact processes. The range of costs also may vary for some of these strategies because of many of the same factors. Placement in the exhibit is meant to reflect the most commonly expected application of the strategy.

EXHIBIT IV-1
Classification of Strategies

Timeframe for Implementation	Relative Cost to Implement and Operate			
	Low	Moderate	Moderate to High	High
Short (less than 1 year)	16.2 A1 Remove poles in high-crash locations[a] 16.2 A2 Relocate poles in high-crash locations farther from the roadway and/or to less vulnerable locations[a] 16.2 A4 Shield drivers from poles in high-crash locations 16.2 A5 Improve the drivers' ability to see poles in high-crash locations	—	—	—
Medium (1–2 years)	16.2 B1 Develop, revise, and implement policies to prevent placing or replacing poles within the clear zone[b]	16.2 A6 Apply traffic calming measures to reduce speeds on high-risk sections	16.2 A3 Use break-away devices 16.2 C3 Decrease the number of poles along the corridor[c]	16.2 C2 Relocate poles along the corridor farther from the roadway and/or to less vulnerable locations[c]
Long (more than 2 years)	—	—	—	16.2 C1 Place utilities underground[c]

[a] Placement here is based upon the assumption that this will be for application to individual poles with a history of hazard.
[b] The development of policies will be a relatively low-cost effort, but the potential results of the new policies could require fairly significant resources and time to implement.
[c] Placement here is based upon the assumption that this will be for application along corridors, involving a large number of poles.

SECTION V

Description of Strategies

Objectives

The initial objective of good roadway design, maintenance, and operation is to keep vehicles on the road and in their respective lanes. Motorists will not purposely move onto the shoulder unless an emergency occurs and they need to pull over to slow or stop their vehicle. However, errant vehicles may encroach upon the shoulder and then upon the roadside, sometimes ending in a run-off-road (ROR) crash. This guide specifically addresses the incidents in which a vehicle leaves the roadway for any number of reasons and strikes a pole on the roadside. The reader may find information concerning ROR crashes, crashes at high-crash curves, and trees in high-crash locations in other related emphasis area guides.

To reduce the number and severity of crashes involving utility poles, luminaire poles, traffic signal supports, and other poles and supports (the terms "pole crash" and "utility pole crash" are interchangeable), the objectives include

- Reduce the hazard of specific utility poles in high-crash and high-risk locations,
- Prevent placing utility poles in high-risk locations, and
- Minimize the likelihood of crashing into a utility pole when vehicles run off the road.

This emphasis area is specifically identified in Goal 16 of the Strategic Highway Safety Plan, *Minimizing the Consequences of Leaving the Road.* Utility pole crashes are a subset of ROR crashes. The guide for Emphasis Area 15.1 addresses the general subject of ROR crashes and covers strategies aimed at reducing the consequences of ROR crashes by (1) keeping vehicles from leaving the roadway and (2) reducing the severity of impacts after leaving the roadway. Ideally, preventing the vehicle from leaving the roadway and staying in its appropriate lane is preferred. The reader should refer to the other guide for strategies for keeping the vehicle on the roadway. This briefing paper focuses on reducing the harm in utility pole crashes after encroachment on the roadside has occurred—strategies such as removing or relocating specific utility poles, placing utilities underground, and reducing the severity of collisions by shielding motorists from utility poles.

Utility pole crashes are fixed-object crashes that involve vehicles leaving the traveled way, encroaching on the roadside, and striking a utility pole. Utility poles are one of the more substantial and most common objects that are *intentionally placed* on the roadside. They are substantial in both their sheer number and their rigidity (each one representing a significant fixed-object hazard). The only object type more frequently struck in fatal fixed-object crashes is a tree.[1] Because of the structural strength and small impact area of utility poles, these crashes tend to be severe.

[1] American Association of State Highway and Transportation Officials. *Roadside Design Guide.* Washington, D.C. January 1996.

The adverse safety effects of utility poles extend beyond the ROR crash type. Utility poles can also contribute to the severity of other crash types. Crashes are often categorized by "first harmful event." There are many crashes not classified as ROR, or fixed-object, crashes, where one or more vehicles strike a utility pole. In these cases, striking the utility pole is a secondary event that may be as severe as, or more severe than, the first harmful event. Crashes involving utility poles as secondary events easily go unnoticed when accident reports only identify the first harmful event.

This emphasis area deals with utility pole crashes, which involve vehicles that leave the traveled way, encroach onto the shoulder and roadside, and strike a utility pole or guy wire. It is also recommended that problem-identification analyses include crashes where a vehicle strikes a utility pole as a secondary event. (One may argue that the only reason these vehicles strike a pole is because of the initial event causing the driver to lose control of the vehicle. A rebuttal to this argument is that most vehicles that strike utility poles are out of control for some reason, because reasonable drivers do not purposefully run into fixed objects. In any event, the presence or absence of a pole will usually have a measurable effect on the severity of injuries.)

Agencies may face many challenges in developing a pole safety program. One will be investigating the consequences of pole crashes, regardless of the culpability of the operators of the vehicles that strike the poles. Failing to investigate and evaluate treatment of these conditions is not a cost-effective strategy. In fact, the "do nothing" option is often the more costly approach, even when neglecting the potential liability cost, which could be considerable.[2]

Exhibit V-1 lists the objectives and several related strategies for reducing the consequences and frequency of utility pole crashes. It does not list all possible strategies to reduce the frequency and severity of utility pole crashes. For example, many strategies that focus on keeping vehicles on the roadway are not listed, but they would be very effective in reducing utility pole crashes. The reader may refer to the guides that specifically address the ROR crash issue for details on these strategies. These strategies can be applied in the planning, design, construction, maintenance, and operation phases.

Given the objectives of AASHTO's Strategic Highway Safety Plan, this guide is focused on lower-cost strategies that can be implemented relatively quickly. This implies strategies that are focused upon "spots" (poles or pole lines) or small areas of the roadway. For perspective, though, note that it has taken decades (probably more than a century in some states and cities) to place the millions of poles along roadsides. For this reason, states and other agencies should also consider including long-term strategies to make gradual improvement in locations with less urgent or demonstrated needs. This will eventually lead to minimizing the overall occurrence of pole crashes.

[2] Ivey, D. L., and C. P. Scott. *Utilities on Roadside Safety*, State-of-the-Art Report 9. Prepared by the Utility Safety Task Force, Committee on Utilities (A2A07), TRB, 2004. This report estimates that safety treatments for exposed poles actually result in saving utility maintenance funds.

EXHIBIT V-1
Emphasis Area Objectives and Strategies

Objectives	Strategies
16.2 A Treat specific utility poles in high-crash and high-risk spot locations.	16.2 A1 Remove poles in high-crash locations. (P)
	16.2 A2 Relocate poles in high-crash locations farther from the roadway and/or to less vulnerable locations. (P)
	16.2 A3 Use breakaway devices. (T)
	16.2 A4 Shield drivers from poles in high-crash locations. (P)
	16.2 A5 Improve the drivers' ability to see poles in high-crash locations. (E)
	16.2 A6 Apply traffic calming measures to reduce speeds on high-risk sections. (T)
16.2 B Prevent placing utility poles in high-risk locations.	16.2 B1 Develop, revise, and implement policies to prevent placing or replacing poles within the recovery area. (T)
16.2 C Treat several utility poles along a corridor to minimize the likelihood of crashing into a utility pole if a vehicle runs off the road.	16.2 C1 Place utilities underground. (P)
	16.2 C2 Relocate poles along the corridor farther from the roadway and/or to less vulnerable locations. (P)
	16.2 C3 Decrease the number of poles along the corridor. (P)

Explanation of Strategy Types

The strategies in this guide were identified from a number of sources, including a literature review, 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 a state or even a local level. Some strategies have been subjected to well-designed evaluations to prove their effectiveness. However, 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 in many cases, before adopting a particular strategy for implementation. To help the reader, the strategies have been classified into three types, each identified by letter throughout the guide:

Proven (P): Those strategies that have been used in one or more locations and for which properly designed evaluations have been conducted that show it to be effective. These strategies may be employed with a good degree of confidence, but 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 make judgments on which is the most appropriate for the particular situation.

Tried (T): Those strategies that have been implemented in a number of locations and that may even be accepted as standards or standard approaches, but for which there have not been found valid evaluations. 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. It is intended that as the experiences of implementation of these strategies continues under the AASHTO Strategic Highway Safety Plan initiative, appropriate evaluations will be conducted so that effectiveness information can be accumulated to provide better estimating power for the user and so that the strategy can be upgraded to a "proven" one.

Experimental (E): Those strategies that are ideas 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 they are 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. It is intended that 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.

Targeting the Objectives

The first objective addresses locations that are exhibiting multiple crashes or that are recognized as high-risk locations. The application of these strategies is generally limited to a single pole or a few poles. For example, one pole on the outside of a horizontal curve can be moved to a less exposed location on the inside of the same curve. The target of the second objective is new utility poles placed along the roadway or poles that require relocation to accommodate a 3R[3] or other roadway project, including minor widening. In addition, the second objective targets poles that will be replaced when utility companies periodically reconstruct their facilities. The last objective targets utility poles along longer sections of roadway where crashes are spread out along the corridor and not clustered in a small number of poles.

For any strategy to work, it is important for partnering, communication, coordination, and cooperation between the utility companies and highway agencies. It is important for all these agencies to work as a team by sharing information on crashes and claims, conducting joint field visits, and taking a proactive approach in addressing utility pole crashes. For example, AmerenUE, a major utility company in Missouri, and Missouri DOT are working together to identify and develop procedures involving improvements to locations where utility poles are experiencing vehicle collisions (see Appendix 1). Florida DOT, through its partnership with utility companies for many years, has developed a utility accommodation manual that regulates the location, manner, installation, and adjustment of utility facilities along, across, or on any transportation facility under the jurisdiction of Florida DOT (see Appendix 2). Pennsylvania DOT is working with the utility companies in developing a master agreement that, if ratified, will allow Pennsylvania DOT to pay for a portion of the cost of relocating a utility pole that is determined to be in a hazardous location (see Appendix 3). It is in the best interest of the utility companies to work with the highway agencies to develop a plan to reduce utility pole crashes and to reduce the liability of these crashes.

[3] 3R refers to resurfacing, restoration, and rehabilitation.

Related Strategies for Creating a Truly Comprehensive Approach

The strategies listed above are considered unique to this emphasis area. However, to create a truly comprehensive approach to the highway safety problems associated with this emphasis area, related strategies may be included as candidates in any program planning process. There are five candidate types:

- **Public Information and Education (PI&E) Programs—**Many highway safety programs can be effectively enhanced with a properly designed PI&E campaign. The primary goal of PI&E campaigns in highway safety is to modify the behavior of an audience across an entire jurisdiction, or a significant part of it. However, it may be desired to focus a PI&E campaign 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. In general, PI&E campaigns do not directly reduce crashes involving poles. One related instance in which PI&E campaigns may be effective involves persuading the utility companies to understand the issue and their part in finding a solution. There are, however, appropriate additional PI&E programs for related strategies dealing with such problems as speed control, driving under the influence (DUI), and seatbelt usage. Each of these programs can help reduce the incidence and/or severity of crashes involving utility poles. As additional guides are completed for the AASHTO plan, they may address the details regarding PI&E strategy design and implementation.
- **Enforcement of Traffic Laws—**Well-designed and -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 DUI or driving without seatbelts. While the effectiveness of speeding enforcement programs is less well documented, it may be appropriate to apply such a program to reduce incidents of vehicles running off the road, and ultimately into utility poles. When the 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 the nature of how they must be performed, are conducted at specific locations. The effect (e.g., lower speeds, greater use of seatbelts, and reduced impaired driving) may occur at or near the specific location where the enforcement is applied. This effect can often be enhanced by coordinating the effort with an appropriate PI&E program. However, in many cases (e.g., speeding and seatbelt 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 impact behavior, or where it is desired to try an innovative and untried method, a pilot program is recommended. The application of enforcement programs is not anticipated to be directly applicable to the strategies in this guide. However, as noted above, the use of enforcement is appropriate for complementary strategies. As additional guides are completed for the AASHTO plan, they may address the details regarding the design and implementation of enforcement strategies.
- **Strategies to Improve Emergency Medical and Trauma System Services—**Treatment of injured parties at highway crashes can have a significant impact on the injury severity

and the 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-structured and comprehensive emergency care program. While the types of strategies that are 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, an effort should be made to determine if improvements can be made to this aspect of the system, especially for programs that focus 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 address the details regarding the design and implementation of emergency medical systems strategies.

- **Strategies Directed at Improving the Safety Management System—**The management of the highway safety system is foundational to success. There should be in place a sound organizational structure, as well as an infrastructure of laws, policies, etc., to monitor, control, direct, and administer a comprehensive approach to highway safety. It is important that a comprehensive program not be limited to one jurisdiction, such as a state DOT. Local agencies often have the majority of the road system and its related safety problems to deal with. They also know, better than others do, what the problems are. As additional guides are completed for the AASHTO plan, they may address the details regarding 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 Detailed in Other Emphasis Area Guides—**Any program targeted at the safety problem covered in this emphasis area should give due consideration to the inclusion of other applicable strategies covered in the following guides:
  - 15.1 ROR Crashes
  - 15.2 Crashes at Highway Curves
  - 12.1 Trees in Hazardous Locations

Objective 16.2 A—Treat Specific Utility Poles in High-Crash and High-Risk Spot Locations

Strategy 16.2 A1: Remove Poles in High-Crash Locations (P)

General Description

This strategy targets specific poles located in high-crash locations. The locations would have a history of pole crashes (responsive) or are in locations where the risk of future pole crashes is likely (proactive). The locations may be identified through the crash database or utility maintenance records. In these cases, the identification process is a responsive approach, but a very good place to start, assuming that location descriptions are adequate to locate the specific pole or poles. Conducting safety audits on roadways and identifying poles that are in high-risk locations is a proactive approach.

When investigating locations with a history of utility pole crashes, an important question that should be asked is, “Is this pole necessary?” If the answer is no, then remove the pole. In some cases, the utility may have abandoned the pole and the pole no longer serves a purpose. While these cases are obvious, the difficulty begins when the pole actually has a purpose, whether the purpose is for utilities, street lighting, or another reason. The next question is "Is there another way to serve the same need while removing the poles from the high-crash location?" If the answer is yes, then consider removing the poles and relocating the function of the pole as a countermeasure for treating the location.

Exhibit V-2 shows poles close to the roadway that are not necessary. The purpose of these poles is to carry the power to one pedestrian-actuated signal. The power is provided from another signal approximately ¼ mile from the pedestrian crossing. This location had a history of vehicles running off the road and striking poles, and the city relocated all the streetlights farther from the road. However, that project did not affect the poles serving the pedestrian signal because the state DOT owned these poles. These poles continued to be struck by vehicles but were unnecessary because the power for the pedestrian signal could have been provided via the same conduit used for the streetlights. As much as this is an example of an unnecessary pole too close to the roadway, it is also an example of why DOTs need to improve the communication between themselves and local agencies.

See Appendix 4 for an example of one state's approach to relocating utilities to improve roadside safety.

EXHIBIT V-2
Series of Unnecessary Utility Poles
These unnecessary poles carry a single power cable for the pedestrian signal. The conduit hat provides power to the luminaire poles placed further from the road could have also provided service to the signal.

EXHIBIT V-3
Strategy Attributes for Removing Select Poles (P)

Attribute	Description
Technical Attributes	
Target	Poles hit by drivers of errant vehicles at specific "spot" locations where there have been a history of pole crashes, or poles located in potentially high-risk locations, such as the outside of a curve, end of lane drops, and in traffic islands.
Expected Effectiveness	While this strategy does not prevent the vehicle leaving the roadway, it does provide a mechanism to reduce the severity of a resulting crash. If the pole is not there, then it cannot be struck. The effectiveness of the strategy in reducing the severity of the crash depends largely upon remaining conditions after the pole is removed. For example, if there are trees or other fixed objects remaining, then the impact may simply be transferred to another object type. If the shoulder is steep and contributes to vehicles overturning, then the problem is shifted to a different sequence of events without really improving the overall safety at the location.
Keys to Success	The keys to success include being able to identify locations and removing the appropriate poles. An accurate and detailed safety information and maintenance record system is essential for this strategy to be feasible (see the description on page V-6 of "Strategies Directed at Improving the Safety Management System"). In the absence of such systems, one must rely on local knowledge and a monitoring process.

(*continued on next page*)

EXHIBIT V-3 (Continued)
Strategy Attributes for Removing Select Poles (P)

Attribute	Description
	The use of standardized investigation forms and documentation for site investigations is important to provide the data for decision making. This helps ensure that site investigations are consistent across different regions and promotes rapid site evaluation.
Potential Difficulties	Utility pole crashes can induce a considerable amount of litigation. Well-documented investigations serve two purposes: (1) to help determine the best remedial action to take and (2) to provide documentation for actions taken or not taken.
	On tangent sections of roadways where there are high frequencies of pole crashes, removing a pole may lead to the crashes migrating to the next available pole. In these cases, it is very important to understand why the vehicles are leaving the roadway in the first place. Refer to the ROR guide for specific strategies.
Appropriate Measures and Data	Process measures include the number of sites investigated, the number of poles removed from the roadside, and the cost to remove the poles.
	Impact measures include the number, severity, and rates of target crashes. In this case, the target crashes should include all ROR, fixed-object crashes and any crashes involving poles at the specific site. Evaluations should consider the overall severity of the targeted crashes to determine that there was an actual safety improvement and not a problem transferal. To account for crashes migrating to the next available pole or other object, it is prudent to make the study area large enough to cover the problem area. If the study area is too small, then the crashes may have migrated beyond the boundaries and go undetected in the evaluation.
Associated Needs	None identified.
Organizational and Institutional Attributes	
Organizational, Institutional and Policy Issues	Pole removal programs require regular participation of the utility companies, which own most of the poles. The utility companies should be involved at an early stage in the programs.
	New or revised policies may be needed to ensure consistent and appropriate pole removal, as well as to facilitate cooperation with utility companies.
Issues Affecting Implementation Time	Review time for utility companies may extend the implementation period to beyond a year.
Costs Involved	The cost of removing a single pole includes relocating all services carried on the pole, as well as removing the actual pole. Determining the financial responsibility of removing the pole is necessary. In some jurisdictions, if the pole is located on public right-of-way and becomes a hazard to the traveling public, then it is the responsibility of the pole owner to remove or relocate it.
Training and Other Personnel Needs	None identified.
Legislative Needs	There may be situations where utility companies have rights regarding poles in public rights-of-way that allow the utility companies to ignore or reject requests for removal. Law changes may be appropriate where a more balanced and responsive relationship is desired.
Other Key Attributes	
	None identified.

Strategy 16.2 A2: Relocate Poles in High-Crash Locations Farther from the Roadway and/or to less Vulnerable Locations (P)

General Description

This strategy targets specific poles located in high-crash locations, i.e., locations that have a history of pole crashes or that are placed where the risk of future pole crashes is likely. High-crash locations are to include only poles considered necessary, i.e., poles for which no alternatives exist to provide the service carried by the poles.

FHWA's *Program Guide: Utility Relocation and Accommodation on Federal-Aid Highway Projects,* Sixth Edition—January 2003 (http://www.fhwa.dot.gov/reports/utilguid/if03014.pdf) states the following as one of the criteria for federal participation in utility relocation: "The utility relocation involves implementing safety corrective measures to reduce the roadside hazards of utility facilities to highway users."

O'Day (1979) found in Michigan that vehicles are more likely to run off the road on the outside of curves than on the inside (see Exhibit V-4). This is also intuitive to any driver who has rounded a curve and experienced the centrifugal force. Therefore, it is reasonable that poles placed along the outside of curves are more likely to be struck by errant vehicles. Exhibit V-5 is a photograph of a high-speed rural road where utility poles have been placed less than 15 feet from the outside of a horizontal curve: these locations were found to be associated with frequent utility pole crashes due to vehicles running off the road. In the case of isolated curves immediately downstream from long tangent sections, relocating poles may be particularly important because these locations are susceptible to ROR crashes. There are two alternatives to support the poles: (1) with a small number of breakaway strain poles on the outside of the curve and (2) with compression struts on the inside of the curve.

EXHIBIT V-4
Curve Direction and Crash Frequency
Source: O'Day, 1979

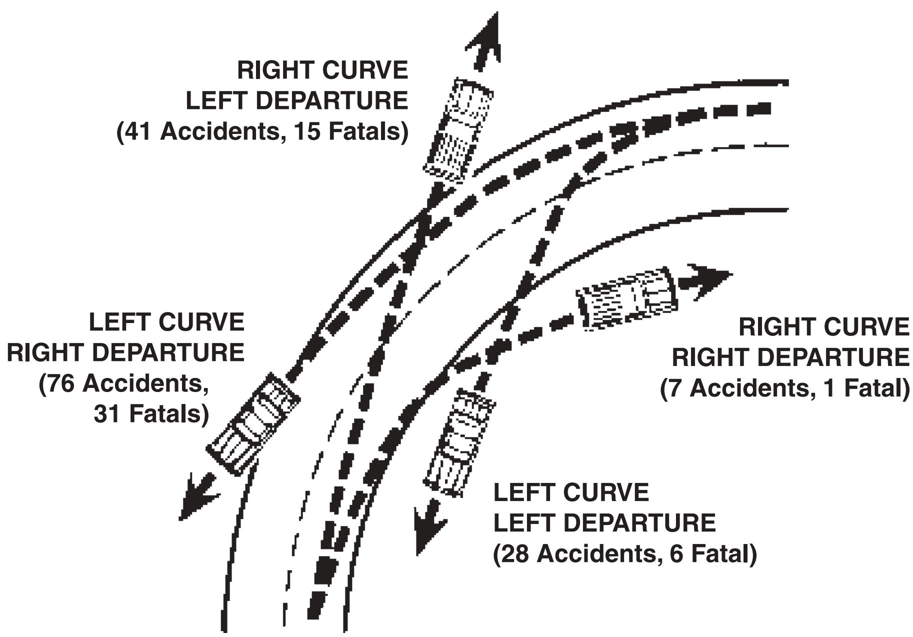

EXHIBIT V-5
High-Speed Rural Road with Utility Poles Less than 15 Feet from the Edge of the Outside of a Horizontal Curve
This site has experienced several utility pole crashes due to vehicles running off the road.

Lane drops, intersections, and sections where the pavement narrows are locations where drivers may inadvertently leave the roadway. Exhibit V-6 shows an example of a pole in a vulnerable location after a lane drop. A similar situation may occur after widening the road surface for turn lanes or when the pavement narrows for other reasons. Exhibit V-7 shows a T-intersection that has experienced frequent collisions with utility poles because vehicles run off the road as they make a left turn.

In most cases, poles are not placed in the roadway. However, placing poles on traffic islands puts poles very close to the traveled way. Traffic islands serve purposes for channelization,

EXHIBIT V-6
Schematic Diagram of a Pole in a Vulnerable Location at the End of a Lane Drop
Source: Ivey and Mak, 1989, Photo: Lacy

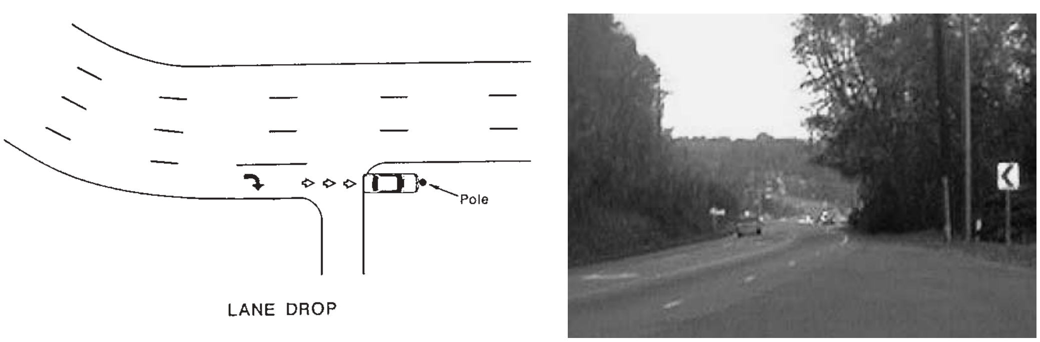

EXHIBIT V-7
T-Intersection that Has Experienced Frequent Utility Pole Crashes when Left-Turning Vehicles Lose Control and Run Off the Road

directional separation, and placing small signs. Not only can poles interfere with drivers' line of sight, but also they are often in areas that may be traversed by errant vehicles. There are similar issues with placing poles in the medians of divided highways (see Exhibit V-8).

See Appendix 4 for an example of one state's approach to relocating utilities to improve roadside safety.

EXHIBIT V-8
Schematic Diagram of Poles Placed in Vulnerable Locations on Traffic Islands and in a Median
Source: Ivey and Mak, 1989

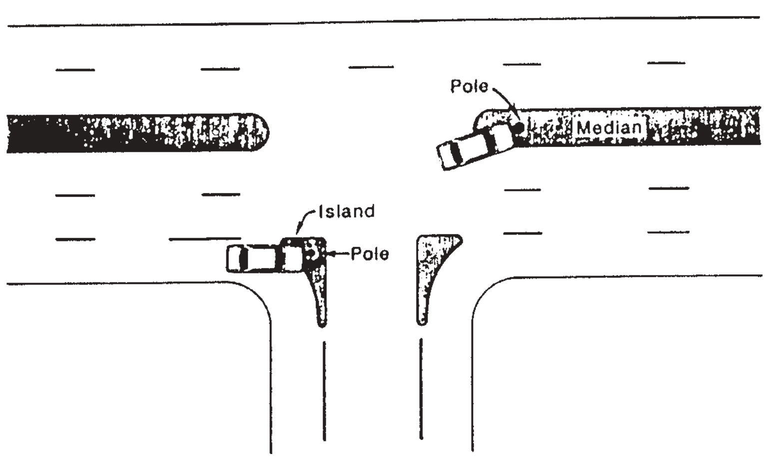

EXHIBIT V-9
Strategy Attributes for Relocating Poles in High-Crash Locations (P)

Attribute	Description
Technical Attributes	
Target	Poles struck by errant vehicles at specific “spot” locations where there have been a history of pole crashes, or poles in locations such as the outside of a curve, end of lane drops, and in traffic islands.
Expected Effectiveness	Zegeer and Parker (1984) and Zegeer and Cynecki (1984) found that crashes decreased as the distance between the poles and the roadway increased. Large improvements were observed by moving the poles at least 10 feet from the roadway. As the offset[4] was increased beyond 10 feet, the safety effects increased but at a slower rate. Exhibit V-9A shows the expected percent reduction in crashes (crash reduction factors) as poles are moved away from the roadway for ADT = 10,000 and pole density = 40 poles/mile. The crash reduction factors were not found to change significantly for different ADT and pole density values (crash reduction factors for different combinations of ADT and pole density are available from Zegeer and Cynecki, 1984). The crash reduction factors shown in Exhibit V-9A assume no other roadside fixed objects apart from the utility poles. To account for the presence of other roadside objects, Zegeer and Cynecki (1984) developed roadside adjustment factors that are discussed in Appendix 5.

EXHIBIT V-9A
Percent Reduction in Crashes for Moving Poles Farther from the Roadway
Source: Zegeer and Cynecki (1984)

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

[4] Offset is defined as the distance between the roadway edgeline and the utility pole.

EXHIBIT V-9 (Continued)
Strategy Attributes for Relocating Poles in High-Crash Locations (P)

Attribute	Description
Keys to Success	An accurate and detailed safety information and maintenance record system is essential for this strategy to be feasible. In the absence of such systems, one must rely on local knowledge and a monitoring process. The use of standardized investigation forms and documentation for site investigations is important to provide the data for decision making. This helps ensure that site investigations are consistent across different regions and promotes rapid site evaluation.
Potential Difficulties	If there are other nearby fixed objects in addition to the poles, relocating the poles may not have the desired effect if the other objects are not treated. In these cases, if the remaining objects continue to be involved in crashes, the expense of relocating the pole may not be justified. Transferring the object struck to another object type or crash type that is as severe is not an acceptable outcome.
Appropriate Measures and Data	Process measures would include the number of sites investigated, the number of poles relocated, and the cost to relocate the poles. Impact measures include the number, severity, and rate of target crashes. In this case, the target crashes should include all ROR, fixed-object crashes and any crashes striking poles at the specific site. The impact should consider the overall severity of the target crashes to determine that there was an actual safety improvement and not a problem transferal. To account for crashes migrating to the next available pole or other object, it is prudent to make the study area large enough to cover the problem area. If the study area is too small, then the crashes may have migrated beyond the boundaries and go undetected in the evaluation.
Associated Needs	None identified.
Organizational and Institutional Attributes	
Organizational, Institutional and Policy Issues	Pole relocation programs require a regular participation of the utility companies, which own most of the poles. The utility companies should be involved at an early stage in this program. New or revised policies may be needed to ensure consistent and appropriate pole relocation and to facilitate cooperation with utility companies.
Issues Affecting Implementation Time	Review time for utility companies may extend the implementation period to beyond a year.
Costs Involved	The cost of relocation of a single pole involves placing the pole in a new location, moving the utilities, and providing proper support for the poles.
Training and Other Personnel Needs	None identified.
Legislative Needs	None identified.
Other Key Attributes	
	None identified.

Strategy 16.2 A3: Use Breakaway Devices (T)[5]

General Description

This strategy targets specific poles located in high-crash locations where removing or relocating the poles is not feasible or cost-effective. The locations have a history of pole crashes or are in locations where the risk of future pole crashes is likely. The application of breakaway devices is directed at reducing the severity of the pole crashes. The unforgiving nature of a traditional utility pole contributes to the severity of the crash by causing vehicles to rapidly decelerate. Studies of non-breakaway poles show that about 31 percent of the poles are knocked down or severely damaged upon impact (Mak and Mason, 1980). This means that the vehicles striking the poles absorb a sizable amount of the energy (via the crush) created by the crash. Breakaway poles allow vehicles to pass through the pole and therefore do not require the vehicle to absorb as much energy. Breakaway poles are designed so that service will not be interrupted in the case of a crash.

While there are several designs and techniques for breakaway devices, only the steel reinforced safety pole was specifically designed for utility poles. The original design was funded by the FHWA and has gone through modifications. The latest design is called the AD IV (Ivey and Scott, 2004; Alberson and Ivey, 1994). For a depiction of the device, see Appendix 11. The criteria for applying breakaway devices are as follows:

- The pole is located in the clear zone area.[6]
- The alternatives for removing and relocating the poles are not practical because of right-of-way constraints, roadside environment, or economics.
- The pole is a class 4–40 or smaller and does not have heavy devices attached.
- There is a safe recovery area behind the pole, free of roadside hazards.
- The pole is not located near a zone of significant pedestrian activity.
- The final position of the pole and conductors (wires) should not create a hazard for pedestrians, other vehicles, and adjacent property owners.

In addition to utility poles, guy wires can reduce the recovery area and make the pole a larger target. The use of breakaway guy wires should be considered where guy wires are deemed necessary. Foster-Miller, Inc., under a Small Business Innovation Research (SBIR) study, designed, tested, and developed a protruded fiberglass link for a breakaway guy wire.[7]

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[5] An alternative to breakaway poles is energy absorbing utility poles. These recently developed poles are designed to "capture" the vehicle and stop it gently enough so that velocity change and deceleration do not exceed requirements established for the safety of a vehicle's occupants. Further information about this technology can be obtained from the following sources: http://international.fhwa.dot.gov/Pdfs/Euroroadlighting.pdf, http://www.skp-cs.com/poleproducts/td/pdf/energyabsorbpoles.pdf.

[6] The clear zone is a traversable and unobstructed roadside area. The clear zone distance is a function of many factors including the design speed of the roadway section, traffic conditions (ADT), alignment, and the roadside slope (*Roadside Design Guide*, AASHTO, 2002).

[7] Foster-Miller can manufacture this breakaway guy wire in-house. Further information on this system can be obtained from http://www.ce.utexas.edu/em2000/papers/KKasturi.pdf or by contacting Srinivasan Kasturi at skasturi@foster-miller.com.

UTD, Inc., also designed, tested, and developed four different versions of a steel link for a breakaway guy wire,[8] also under an SBIR study. In the mid 1980s, the Texas Transportation Institute designed, crash tested, and developed a non-proprietary breakaway guy wire that consists of a 6-foot-long section of 3/4-inch galvanized steel pipe (Ivey and Morgan, 1986).

EXHIBIT V-10
Strategy Attributes for Using Breakaway Devices (T)[9]

Attribute	Description
Technical Attributes	
Target	Poles being struck by vehicles in locations where removing and relocating the poles are not feasible or cost-effective.
Expected Effectiveness	Field data from Massachusetts (five crashes) indicate that in the limited applications, there have been no serious injuries from crashes involving the AD-IV steel reinforced safety pole. In addition, there has been no loss of service, there have been no safety problems relative to lineworkers, and the average repair time is 90 minutes.
	Texas reported one crash involving the AD-IV design pole. This crash did not involve a serious injury, although erosion had reduced the pole's effectiveness. The pole was replaced and the side slope restored to a functional condition.
Keys to Success	Identify specific locations where a breakaway device is an acceptable option. These locations do not have other nearby fixed objects on the roadside and the potential for removing or relocating the poles is poor.
	An accurate and detailed safety information and maintenance record system is essential for this strategy to be feasible. In the absence of such systems, one must rely on local knowledge and an effective monitoring process.
	The use of standardized investigation forms and documentation for site investigations is important to provide the data for decision making. This helps ensure that site investigations are consistent across different regions and promotes rapid site evaluation.
Potential Difficulties	Breakaway devices will require modest periodic maintenance and repairs subsequent to collisions that would not be necessary if the poles were removed or relocated to less vulnerable locations.
Appropriate Measures and Data	Process measures of program effectiveness would include the number of breakaway devices placed in service, the frequency of inspections and maintenance, the initial cost, and the cost to repair and maintain the devices.
	Impact measures include the number, severity, and rates of target crashes. In this case, the target crashes are those crashes that strike the specific poles before and after the installation of the breakaway devices. Monitoring these crashes can help determine proper installation or other issues specific to the devices.
Associated Needs	None identified.

(*continued on next page*)

[8] Further information about this product can be obtained from John Hill at JohnHill3@UTDinc.com.
[9] Contrary to the impression given by the term breakaway, current designs approved under *NCHRP Report 350* do not reduce the load carrying capacity of the pole.

EXHIBIT V-10 (Continued)
Strategy Attributes for Using Breakaway Devices (T)[9]

Attribute	Description
Organizational and Institutional Attributes	
Organizational, Institutional and Policy Issues	Pole replacement programs require a regular participation of the utility companies, which own most of the poles. The utility companies should be involved at an early stage in this program. New or revised policies will be needed to establish design criteria and warrants for placement of the new types of poles, as well as to facilitate both consistent and appropriate pole replacement and cooperation of utility companies.
Issues Affecting Implementation Time	Review time for utility companies may extend the implementation period during the first installations.
Costs Involved	Both initial and maintenance costs must be considered. Some specific cost figures may be found in Appendix 6.
Training and Other Personnel Needs	The affected utility companies will need to be trained in how to properly install, repair, and maintain the devices used on their poles.
Legislative Needs	None identified.
Other Key Attributes	
	If the breakaway devices used are not the type that can be repaired, then replacement devices need to be inventoried.

Information on Agencies or Organizations Currently Implementing this Strategy

The following states have applied the Steel Reinforced Safety Poles (Ivey and Scott, 2004):

- In 1987, Kentucky installed 10 poles using the FHWA design. Because of roadway projects, only 6 poles remain in service. These poles have not been involved in collisions.
- In 1990, Massachusetts installed 19 poles. One pole has been struck three times and performed as designed. However, the pole was replaced by a conventional pole because of the failure in the wood adjacent to the through bolts in the upper connection. Eighteen poles are still in service.
- In 1991, Virginia installed five poles. These poles have experienced no maintenance problems, have survived several instances of high winds, and have not been involved in a collision.
- In 1994, Texas installed six poles. One collision has been recorded without significant injury to the driver.

Strategy 16.2 A4: Shield Drivers from Poles in High-Crash Locations (P)

General Description

The target of this strategy is poles in high-crash locations where removing, relocating, or redesigning the poles (i.e., redesigning the poles as breakaway) is not feasible or not cost-effective. This strategy shields the driver from striking the poles by using a number of different devices such as guardrail, crash cushions, and concrete barriers. However, the potential hazards of the safety device itself must be considered in the economic analyses. These devices may themselves be struck by vehicles and are designed to markedly reduce the severity of a crash, not to prevent the crash.

Guardrails and Other Roadside Barriers

The purpose of guardrails and other roadside barriers (e.g., Jersey barriers) is to redirect errant vehicles away from a roadside hazard so drivers may regain control of the vehicle or arrive at a safer stop than would result from striking the hazard. Shielding drivers from poles is a proper use of guardrails when based upon engineering judgement or a cost-effectiveness study. A cost-effectiveness study should consider the type of barrier and end treatment proposed, as well as the level of injuries that are expected to occur from a vehicle striking them. The methodology for conducting a cost-benefit analysis can be found in the AASHTO Roadside Design Guide. The criteria for the application of guardrails to shield utility poles are as follows:

- The pole is located in the clear zone area.
- The alternatives for removing and relocating the poles are not practical because of right-of-way constraints, roadside environment, or economics.
- Breakaway poles cannot be used because of utility load, size of pole, or other requirements.
- The guardrail and the end treatments or barrier will not create a greater hazard than the poles.
- The guardrail will not redirect the vehicles into a higher-crash roadside area.
- The face of the guardrail will not be closer than 2 feet from the edge of the travel lane.
- The guardrail should be placed far enough in front of the object that a vehicle does not impact the object by knocking the guardrail backward.

Crash Cushions

The purpose of crash cushions is to shield vehicle occupants from rigid objects that cannot be removed, relocated, or made breakaway. Engineering judgement or an economic analysis may justify the use of crash cushions to treat poles in high-crash locations. Crash cushions reduce the severity of crashes from that which would take place if the vehicle hit the unshielded object. They do this by absorbing the energy of errant vehicles in a controlled manner. The criteria for the application of crash cushions to shield utility poles are as follows:

- The pole is located in the clear zone area.
- The alternatives for removing and relocating the poles are not practical because of right-of-way constraints, roadside environment, or economics.
- There is adequate space between the travel lane and in front of the pole to accommodate the selected crash cushion.
- The final resting position of the crash cushion, the debris from the crash cushion, and the impacting vehicle will not cause a hazard to other vehicles.
- There should be a sufficient clear zone area around the crash cushion to provide for redirected vehicles.

EXHIBIT V-11
Strategy Attributes for Shielding Poles in High-Crash Locations (P)

Attribute	Description
Technical Attributes	
Target	Poles that cannot be removed from the roadside or relocated to less vulnerable locations or cannot be treated with a breakaway device. Occupants of vehicles that crash with these poles.
Expected Effectiveness	These devices are traditionally used along roadsides to protect vehicle occupants from a variety of fixed objects. However, the effectiveness of the devices depends largely upon how close they are to the roadway and the specific design of the devices. 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 of the *Roadside Design Guide* to complete economic analyses of the existing and proposed conditions. The economic analysis is necessary to determine if the benefits of shielding the poles outweigh the disadvantages.
Keys to Success	A key to success is developing an effective process to identify poles in high-crash locations and to establish an effective set of criteria concerning where to shield poles instead of removing or relocating the poles. An accurate and detailed safety information and maintenance record system is essential for this strategy to be feasible. In the absence of such systems, local knowledge must be tapped and an effective monitoring system established. The use of standardized investigation forms and documentation for site investigations is important to provide the data for decision making. This helps ensure that site investigations are consistent across different regions and promotes rapid site evaluation. Another key to success is proper maintenance of the shielding devices.
Potential Difficulties	The devices that are used to shield roadside hazards are fixed objects that may themselves be struck by errant vehicles. A major pitfall can be expending resources in the name of safety, but experiencing no net improvement or even a net degradation in safety.
Appropriate Measures and Data	Process measures for a program would include the number and type of safety devices placed into service, the number and length of the locations treated, and the cost. Impact measures include the number, severity, and rate of target crashes. In this case, the target crashes are those that strike the specific poles or the specific safety device after it is installed. It is also necessary to consider the number and severity of all crashes that strike the safety device used at the specific site to ensure that there is a net safety improvement. Monitoring these crashes can help determine proper installation and maintenance of the roadside hardware used.
Associated Needs	None identified.
Organizational and Institutional Attributes	
Organizational, Institutional and Policy Issues	New or revised policies may be needed to ensure consistent and appropriate pole shielding.
Issues Affecting Implementation Time	To be determined.

EXHIBIT V-11 (Continued)
Strategy Attributes for Shielding Poles in High-Crash Locations (P)

Attribute	Description
Costs Involved	The types of roadside devices for shielding drivers from roadside hazards are relatively common, and the best sources for construction and maintenance costs are the individual DOTs.
Training and Other Personnel Needs	None identified.
Legislative Needs	None identified.
Other Key Attributes	
	None identified.

Strategy 16.2 A5: Improve the Drivers' Ability to See Poles in High-Crash Locations (E)

General Description

This strategy is generally used when the first four strategies are not feasible or cost-effective. In this strategy, the pole is delineated or lighted to make the pole more visible. For example, Pennsylvania DOT has started introducing reflective taping on utility poles to improve the driver's ability to see these poles at night (see Exhibit V-12). While this strategy does not reduce the severity of the crash, it may help drivers see the object and take the necessary evasive actions. This line of reasoning assumes that the errant vehicles are under some level of control or can be brought under control after the driver is alerted to the presence of the pole. However, if the vehicle is out of control, then the fact that the pole is delineated or more visible does not reduce the probability of the crash.

A major problem with this strategy is that its low cost may make it appear attractive, but it may not provide any real improvement in safety. Application of this strategy should be limited to poles where other strategies cannot be applied. The AASHTO *Roadside Design Guide* places the order of preference for treating objects in the clear zone as follows:

- Redesign the facility to reduce ROR crash potential (new or redesigned roads).
- Remove the object; relocate the object.
- Redesign the object to lessen the impact; shield the object.
- Delineate the object.

Effective maintenance is also important. Exhibit V-13 shows an object marker behind a utility pole. The marker had previously been in front of a pole. That pole was struck and replaced, but the marker was never moved. This marker has since been removed because it proved ineffectual in preventing the crash.

EXHIBIT V-12
Reflective Taping Used by Pennsylvania DOT

EXHIBIT V-13
New Pole Placed in Front of Object Marker
An object marker failed to prevent the crash that took out the original pole it delineated. The new pole was placed in front of the object marker.
(Photo: Brian Murphy)

EXHIBIT V-14
Strategy Attributes for Improving the Drivers' Ability to See Poles in High-Crash Locations (E)

Attribute	Description
Technical Attributes	
Target	Involves poles where other strategies cannot be applied or are not cost-effective. Targets the driver of the errant vehicle, by informing the driver of the presence of the pole, when it might not otherwise be detected before the crash.
Expected Effectiveness	The low cost of signing and other delineating devices may show large returns in terms of cost-benefits, if a reduction in crashes is assumed. However, it is difficult to predict this strategy's effectiveness, because most errant vehicles are out of control and cannot be maneuvered around objects. The strategy is experimental and may produce no benefits. Pilot testing, with carefully designed evaluation, is appropriate here.
Keys to Success	A key to success is establishing effective criteria to indicate when delineating the poles is the cost-effective treatment, such as on very low-volume roads and where application of other strategies is not cost-effective. It is important, in such cases, that the investigation and the justification for not recommending a more effective strategy be fully documented. Another key to success is effective maintenance. Delineation devices must be regularly cleaned and replaced. When poles are replaced, delineation devices must be replaced properly (see Exhibit V-13).
Potential Difficulties	Delineating the object may not have the desired effect in reducing pole crashes at the location. If pole crashes continue to occur at the location and the delineators are replaced after each crash, then simply delineating the pole is not effective and other countermeasures need to be considered. If a delineated pole is struck, the driver may sue the highway agency, arguing that by delineating the pole, the agency recognized the pole as a hazard and had the duty to provide a superior treatment.
Appropriate Measures and Data	Process measures of program effectiveness would include the number and type of delineation devices placed into service and the number and length of the locations treated. Impact measures include the number, severity, and rate of target crashes. In this case, the target crashes are those crashes that involve striking the specific poles, all ROR fixed-object crashes, and any crash where a pole was struck at the specific site.
Associated Needs	None identified.
Organizational and Institutional Attributes	
Organizational, Institutional and Policy Issues	New or revised policies may be needed to ensure consistent and appropriate pole delineation or lighting.
Issues Affecting Implementation Time	None identified.
Costs Involved	The cost of signing and other delineating material is low. However, the material may require maintenance, as well as occasional testing for retroreflectivity.
Training and Other Personnel Needs	None identified.
Legislative Needs	None identified.
Other Key Attributes	
	None identified.

Strategy 16.2 A6: Apply Traffic Calming Measures to Reduce Speeds on High-Crash Highway Sections (T)

General Description

The application of this strategy is generally for urban residential and collector streets, where the poles are placed close to the roadway and it is not economically feasible to remove, relocate, or shield the poles. These roads are not typically high-speed roads, but they may have poor speed compliance that contributes to vehicles striking poles on the roadside. Implementing traffic calming measures to achieve lower speeds at high-crash locations can reduce the severity of the crash by decreasing the energy of the crash. Lower speed may also have some influence on reducing the frequency of crashes as well. This strategy should not be interpreted as simply reducing the speed limit, especially if the speed compliance is already low. Traffic calming measures may also divert traffic from these roads, thus reducing the exposure. This guide is not intended to serve as a reference for traffic calming measures. More details are provided in the pedestrians' guide. An excellent source for additional information about traffic calming measures is the Institute of Transportation Engineers web site (www.ite.org/traffic/index.html).

Objective 16.2 B—Prevent Placing Utility Poles in High-Crash Locations

Strategy 16.2 B1: Develop, Revise, and Implement Policies to Prevent Placing or Replacing Poles within the Recovery Area (T)

General Description

This strategy involves developing and implementing policies that prevent placing (or replacing) poles within the recovery area along streets and highways during new construction, widening, and other projects that will affect existing or new poles. This is primarily a proactive systemic strategy. It is designed to prevent pole crashes by requiring that each pole in a project's boundaries be reviewed to determine the level of risk to drivers and treated if necessary. An example of a state policy on utility placement may be found in Appendix 4 (WSDOT, 1992 and 2002). Examples of state studies that lead to policy formulation may be found in Appendix 7, Appendix 8, and Appendix 9. Information about roadside safety policies formulated by utility companies may be found in Appendix 10.

There are frequent opportunities to apply the products of this strategy throughout the normal operations of a transportation agency. The design and construction of new facilities are obvious opportunities. However, roadway widening and other low-cost projects occur more frequently than new construction, so policies in these areas would be used more frequently.

New roads typically offer the greatest opportunity to meet highway safety objectives. Agencies should require poles to be placed near the edge of the right-of-way, or as far from the traveled way as possible. 3R and widening projects are also good opportunities to relocate the poles further from the roadway or to better locations. Typically, many smaller widening projects result from residential development where the developer pays to widen the road to add turn lanes. Utility placement and relocation policies should also cover these smaller more localized projects. These projects should require improvements to the roadside if widening degrades the roadside safety. Moreover, the policies should cover the placement of poles for signal supports.

EXHIBIT V-15
Strategy Attributes for Developing, Revising, and Implementing Policies to Prevent Placing or Replacing Poles within the Recovery Area (T)

Attribute	Description
Technical Attributes	
Target	Poles located within the boundaries of roadway construction, reconstruction, widening, etc., that can be relocated farther from the roadway or revised in some way to reduce the probability of errant drivers striking them in the future.
Expected Effectiveness	Changes often take considerable time to develop sufficient data to analyze. The effectiveness of the strategy is dependent upon three main factors: (1) the policies themselves, (2) the level of implementation, and (3) the frequency of exceptions.
Keys to Success	If the policies are too weak, then they will be ineffective. If the policies are too strict, then gaining support will be difficult. The policies must address several issues such as the lateral displacement of encroaching vehicles, the purpose of the roadway, the location of underground utilities, roadside conditions, the prevailing speed of the roadway, and the volume of the roadway. It is practically impossible to develop policies that fit every situation; therefore, there will be exceptions. However, all exceptions should require a cost-effectiveness study and an engineering recommendation. A large number of exceptions reduces the effectiveness of the strategy and encourages other exceptions. Inclusiveness is also important to attain success. When developing utility pole placement policies, the agency should include representatives from the traffic safety, design, legal, and utilities divisions of agencies. Developing and adopting policies with the participation of all stakeholders is important. It is also important to gain “buy-in” from the upper management of the highway agency.
Potential Difficulties	Many states and local DOTs may already have policies in place that specifically address the use of the roadway right-of-way by utilities. There may be resistance to change. However, it is prudent to review the policies and determine if they contribute to development of safer roadsides. In addition, the application of the policies may not be consistent throughout the agencies. In many jurisdictions, the agencies responsible for the design and approval of the placement of poles along the roadside may not be familiar with the safety implications of the roadside environment.
Appropriate Measures and Data	Process measures of program effectiveness would include the adoption of the desired policies, the number of projects covered by the policies, the total mileage covered, and the number of exceptions granted to the policy. Impact measures include the number, severity, and rate of target crashes on locations meeting the policy requirements. In this case, the target crashes are those crashes within the project boundaries that strike poles, all ROR, fixed-object crashes, and any crash where a pole was struck at the specific site.

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EXHIBIT V-15 (Continued)
Strategy Attributes for Developing, Revising, and Implementing Policies to Prevent Placing or Replacing Poles within the Recovery Area (T)

Attribute	Description
Associated Needs	A brochure may be needed to inform field engineers, utility company personnel, and individuals of the requirements for placing or replacing poles along the roadway right-of-way.
Organizational and Institutional Attributes	
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 policies are applied. A key to success is establishing organizational mechanisms for including all stakeholders in the development of the policies.
Issues Affecting Implementation Time	Involving a range of stakeholders may affect the implementation time. Dissemination of the policy may also take time, depending upon the organizational structure of the agency.
Costs Involved	The key cost component is the personnel time required to develop, review, and revise the placement guidelines.
Training and Other Personnel Needs	Training currently provided to design engineers, construction engineers, and those persons responsible for reviewing and approving plans needs to cover the policies concerning the placement of poles along the roadside. Emphasis needs to be placed upon the connection between highway safety and the policies that have been established.
Legislative Needs	None identified.
Other Key Attributes	
	Where safety audits are performed, this policy should be reflected in the review of existing sites.

Objective 16.2 C—Treat Several Utility Poles along a Corridor to Minimize the Likelihood of Crashing into a Utility Pole if a Vehicle Runs Off the Road

This objective, unlike Objective 16.2 A1, has a corridor orientation. The first objective focused upon specific high-crash locations where vehicles were striking poles (e.g., on the outside of a curve). Objective 16.2 A2 is a systemic, proactive strategy that helps prevent placing poles in vulnerable locations. However, some pole problems are not confined to a short distance and are located on roadways where there are no plans for reconstruction. Thus new policies would not affect the placement of poles on those roadsides.

Corridors where poles are placed within the recovery area (i.e., clear zone) are the target locations for this objective. Typically, the pole crashes are spread along the corridor and there is not a single pole or cluster of poles that are in greater need of mitigation than the rest. See Appendix 4 for an example of one state's approach to relocating utilities to improve roadside safety.

Strategy 16.2 C1: Place Utilities Underground (P)

General Description

This strategy involves removing the utility poles and placing the utilities underground. If the roadside exhibits a suitable recovery area, then this strategy could have a sizeable effect. However, in many cases, there are other objects within the recovery area or there are other roadside hazards present that may reduce the strategy's effectiveness. If the poles are used to support streetlights, in addition to utilities, removing the streetlight may reduce the overall safety of the area. Jones and Baum (1980) found that 34 percent of urban utility poles in their sample also had streetlights attached to them (for example, see Exhibit V-16). In order to reduce the frequency and severity of utility pole crashes in such situations, one could place utilities underground and install breakaway (slip-base or frangible) light poles farther away from the road (behind the sidewalk) with luminaires on extension arms.

While placing utilities underground is a high-cost strategy, it is important to realize that safety is not the only reason for doing this strategy. Many communities have programs for placing utilities underground to improve aesthetics and possibly for security. Partnering with these groups, safety engineers can help justify and prioritize the corridors where utilities will be moved underground.

EXHIBIT V-16
Urban Location with Utility Poles Very Close to the Roadway and with Streetlights Attached to the Poles

EXHIBIT V-17
Strategy Attributes for Placing Utilities Underground (P)

Attribute	Description
Technical Attributes	
Target	Corridors where poles are placed close to the road and there is a history of pole crashes along the corridor or where there is a high possibility of pole crashes.
Expected Effectiveness	The effectiveness of this strategy is difficult to determine because of issues such as the location of other objects in the recovery area, the steepness of side slopes, and the net effect of placing street lamps on separate luminaire poles or removing the streetlights altogether. With so many factors influencing crash severity and frequency, it is difficult to provide a simple table for expected effectiveness. Agencies are referred to the FHWA computer program ROADSIDE 5.0 of the *Roadside Design Guide* to complete economic analyses of the existing and proposed conditions (removing poles, adding or not adding luminaire poles, etc.). Economic analysis is necessary, to determine if the benefits of placing the utilities underground outweigh the disadvantages. Although it is difficult to place a dollar value on the aesthetic improvements, it is important that this benefit be reflected in decision making. Therefore, a cost-effectiveness analysis is desired, in addition to a cost-benefit analysis (See Section VI for further details).
Keys to Success	A key to success is the condition of the recovery area, if the utilities are placed underground and the poles are removed. If other high fixed objects are in the recovery area, such as trees, buildings, and large plant boxes, or if there are steep side slopes, then these hazards also should be mitigated. Partnering with other organizations that are interested in placing utilities underground can help the potential for success. However, the priorities for these groups may be oriented more toward commercial and tourism interest than safety.
Potential Difficulties	The high cost of the strategy is the primary difficulty. Pole lines may carry many different utilities. If there is limited room in the underground channel, it may not be possible to relocate all the utilities there.
Appropriate Measures and Data	Process measures for a program would include the miles of utilities placed under ground and the number of poles eliminated. Impact measures include the number, severity, and rate of target crashes on locations meeting the policy requirements. In this case, the target crashes are those crashes within the project boundaries that strike poles, run off the road, or strike other fixed objects.
Associated Needs	None identified.
Organizational and Institutional Attributes	
Organizational, Institutional and Policy Issues	DOTs should work with municipalities that are placing utilities underground for other purposes to maximize the returns on limited funds. DOTs are working with local agencies to establish cost-sharing policies for utility relocation. Another institutional issue is maintenance. Restoration of power lines that are felled by storms consumes resources and can be avoided if placed underground. However, major maintenance underground can be burdensome and costly. Another policy issue concerns DOT use of right-of-way to generate revenue (e.g., placing cable and cell towers) within right-of-way.

EXHIBIT V-17 (Continued)
Strategy Attributes for Placing Utilities Underground (P)

Attribute	Description
Issues Affecting Implementation Time	The time required to work with other agencies and to acquire the necessary funding, as well as to complete construction, will result in this process requiring more than a year to implement in most cases.
Costs Involved	The costs are high and will vary depending on the complexities encountered along the corridors.
Training and Other Personnel Needs	None identified.
Legislative Needs	None identified.
Other Key Attributes	
	None identified.

Strategy 16.2 C2: Relocate Poles Along the Corridor Farther from the Roadway and/or to Less Vulnerable Locations (P)

General Description

This strategy seeks to reduce pole crashes by locating the poles in less vulnerable locations or by increasing the distance of the poles from the roadway. Fox et al. (1979) found that poles at the curb were three times more likely to be struck than poles placed 10 feet from the curb. Mak and Mason (1980) also found that pole crashes were overrepresented within 10 feet of the roadway. Zegeer and Parker (1983) developed a model using nearly 10,000 utility pole crashes in four states. This predictive model related the number of pole crashes as a function of the average offset from the travel lane, the average daily traffic, and pole density. When poles closer than 10 feet from the roadway were relocated to points beyond 10 feet, it was found that the crash reduction was greater than for poles that originally were located beyond 10 feet from the road and that were subsequently farther removed.

Strategy Attributes

Strategy 16.2 A2 focused upon a single pole, or very few poles, at a specific location, such as the outside of a curve or the end of a lane drop. Strategy 16.2 C2 focuses on longer sections of roadway where many poles are involved. This strategy's attributes are the same as for Strategy 16.2 A2, except that the cost will be considerably higher since it affects more poles. Exhibit V-9A shows the crash reduction factors from the Zegeer and Cynecki (1984) data for relocating a line of poles farther from the roadway along two-lane rural highways with shoulders and no curbs.

Strategy 16.2 C3: Decrease the Number of Poles Along the Corridor (P)

General Description

This strategy consists of reducing the number of poles on the roadside by increasing the pole spacing, placing poles on one side of the street only, or jointly using the poles (i.e., placing multiple utility services on the same pole). The strategy is to reduce pole density along the corridor. Jones and Baum (1980) found that pole density was the factor with the highest correlation to pole crashes. The Zegeer and Parker (1983) model also includes pole density as a variable in predicting the number of pole crashes.

The spacing between utility poles differs, depending upon the type of utility and the general practices of the specific company. As poles are placed farther apart, the openings that will allow a vehicle to pass through without striking a pole get larger. Exhibit V-18 demonstrates the concept. As pole "A" is moved farther from the pole next to the vehicle, then the opening (lightly shaded area) increases. If there is space between the poles and behind the poles as a suitable recovery area, then the larger spacing allows a vehicle more space to recover.

Another way to reduce the pole density along a corridor is to have poles located only on one side of the road. If the pole spacing can be maintained the same by placing multiple utility services on the same pole, then this strategy should reduce the overall pole density by half. However, the side of the roadway where the poles remain would not be expected to realize a safety improvement since the conditions on that side remain the same.

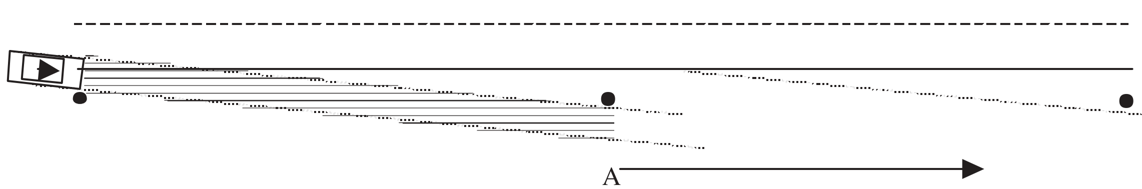
Exhibit V-19 shows the strategy attributes for decreasing the number of poles along the corridor. Exhibit V-20 shows a nomograph that relates the expected number of pole crashes per mile per year to the average daily traffic, the pole density, and the average pole offset from the roadway. The nomograph is based on the following equation that Zegeer and Parker (1983) estimated:

$$ACC / MI / YR = \frac{9.84 \times 10^{-5}(ADT) + 0.0354(DEN)}{(OFF)^{0.6}} - 0.04$$

where:

ACC/MI/YR = Expected number of pole crashes per mile per year
DEN = Number of utility poles per mile
OFF = Average pole offset (i.e., average distance between roadway edgeline and utility pole) in feet
ADT = Average daily traffic volume

EXHIBIT V-18
Schematic Showing How Increasing the Pole Spacing Provides Large Areas for Errant Vehicles to Pass through without Striking a Pole



The example in the nomograph shows a road with an ADT of 10,000 vehicles per day, a pole density of 60 poles per mile, and an average pole offset of 5 feet. The expected number of crashes is 1.15 pole crashes per mile per year. If the pole density is reduced by half by placing all utilities on one side of the highway, then the expected number of crashes is reduced to 0.75 pole crashes per mile per year (a 35-percent reduction). If the pole offset was increased to 15 feet, rather than reducing the pole density, then the predicted number of crashes reduces to 0.6 pole crashes per mile per year (a 48-percent reduction). However, the better option would be to reduce the pole density AND increase the offset. The crash reduction in this case would be a 65-percent reduction to approximately 0.4 pole crashes per mile per year. This nomograph only predicts the number of pole crashes and does not determine the number of ROR crashes or other fixed-object crashes.

EXHIBIT V-19
Strategy Attributes for Decreasing the Number of Poles Along the Corridor (P)

Attribute	Description
Technical Attributes	
Target	Poles along a corridor where the pole density contributes to the frequency of pole crashes.
Expected Effectiveness	See Exhibit V-20 to derive an estimate of the number of pole crashes predicted, based upon the average daily traffic, the pole density and the average pole offset from the traveled way. To calculate the pole crash reduction, find the estimate for the current conditions and the proposed conditions.
	There may be an increase in the number of ROR crashes. Jones and Baum found that ROR crashes generally had a lower severity than pole crashes. The authors show that injury and fatal crashes comprised approximately 51 percent of pole crashes compared with 29 percent of the ROR crashes. Although not quantified, the increase in ROR crashes may also be offset more by an increase in the number of errant vehicles that recover and never are reported as a crash.
Key to Success	The key to success is that there are no additional hazards along the roadway where decreasing pole density will only allow vehicles to strike other fixed objects. The program should not reduce the number and severity of pole crashes by transferring the problem to other non-pole objects.
Potential Difficulties	Increasing the pole spacing or placing all the utilities on one side of the road may require using larger poles. Larger poles may cause an increase in the severity of the crashes involving the remaining poles.
	Reducing the number of poles may require the cooperation of utility companies, which may be resistant to relocation of their utilities and sharing of poles.
Appropriate Measures and Data	Process measures for a program would include the number of miles of roadway where the pole density was reduced, the change in pole density for the specific corridors, the number of poles eliminated, and the cost to complete the project.
	Impact measures include the number, severity, and rate of target crashes. In this case, the target crashes include all ROR crashes, fixed-object crashes, and any crashes striking poles at the specific site. The impact should consider the severity of the target crashes to determine that there was a safety improvement and not a problem transferal.
Associated Needs	None identified.

(*continued on next page*)

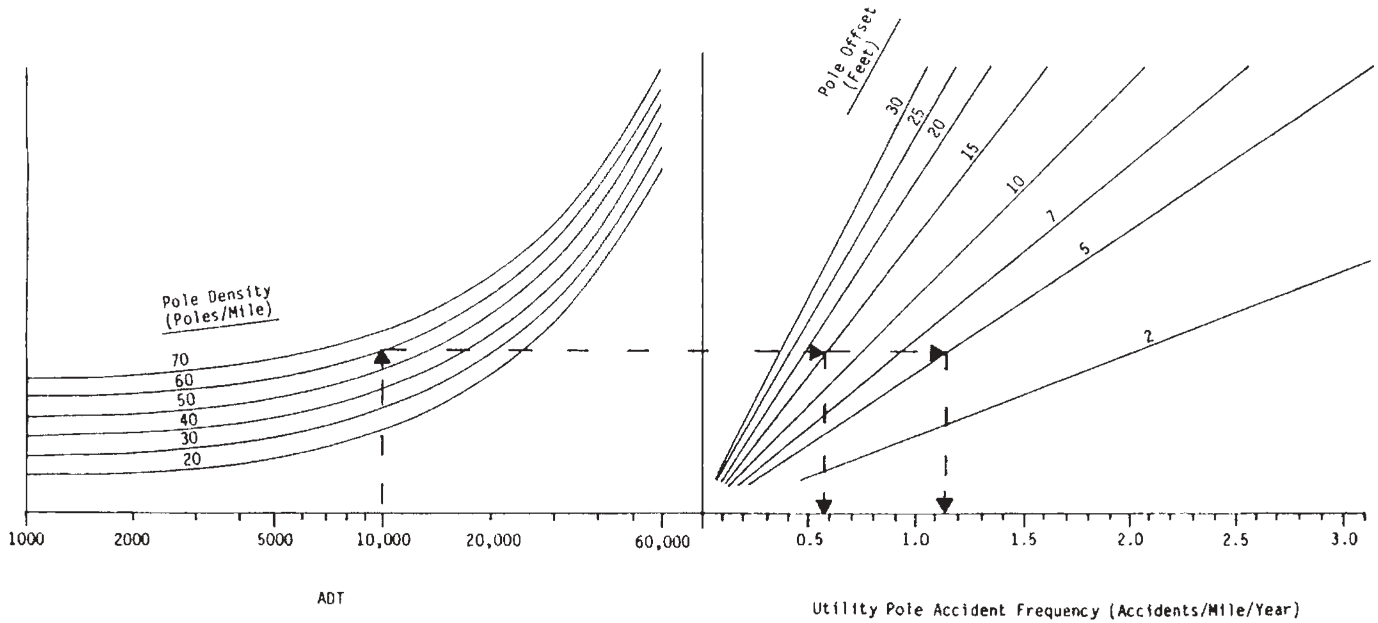
EXHIBIT V-19 (Continued)
Strategy Attributes for Decreasing the Number of Poles Along the Corridor (P)

Attribute	Description
Organizational and Institutional Attributes	
Organizational, Institutional and Policy Issues	A number of issues may arise that will require cooperative effort to arrive at a satisfactory resolution. These include responsibility for pole maintenance, roles and responsibilities of the involved parties when problems occur, and leasing or payment rights. Involvement of legal departments will be necessary to work out arrangements.
Issues Affecting Implementation Time	The cost of the projects and the required coordination to relocate the services with multiple utility companies may affect the implementation time.
Costs Involved	It will be costly to relocate the services carried on the poles, remove the poles, and possibly use larger and/or stronger poles. However, economic analyses may show that it is a worthy investment. The cost may be offset if the application of the strategy is in conjunction with a roadway project where the utilities would be required to relocate in any case.
Training and Other Personnel Needs	None identified.
Legislative Needs	None identified.
Other Key Attributes	
	None identified.

EXHIBIT V-20

Nomograph to Determine the Number of Pole Crashes Per Mile Per Year Based upon the Average Daily Traffic, Pole Density, and Average Pole Offset

Source: Zegeer and Parker (1983)



Note:

1 foot = 0.3 m
1 pole/mile = 0.6 poles/km
1 accident/mile/year = 0.6 accidents/km/year

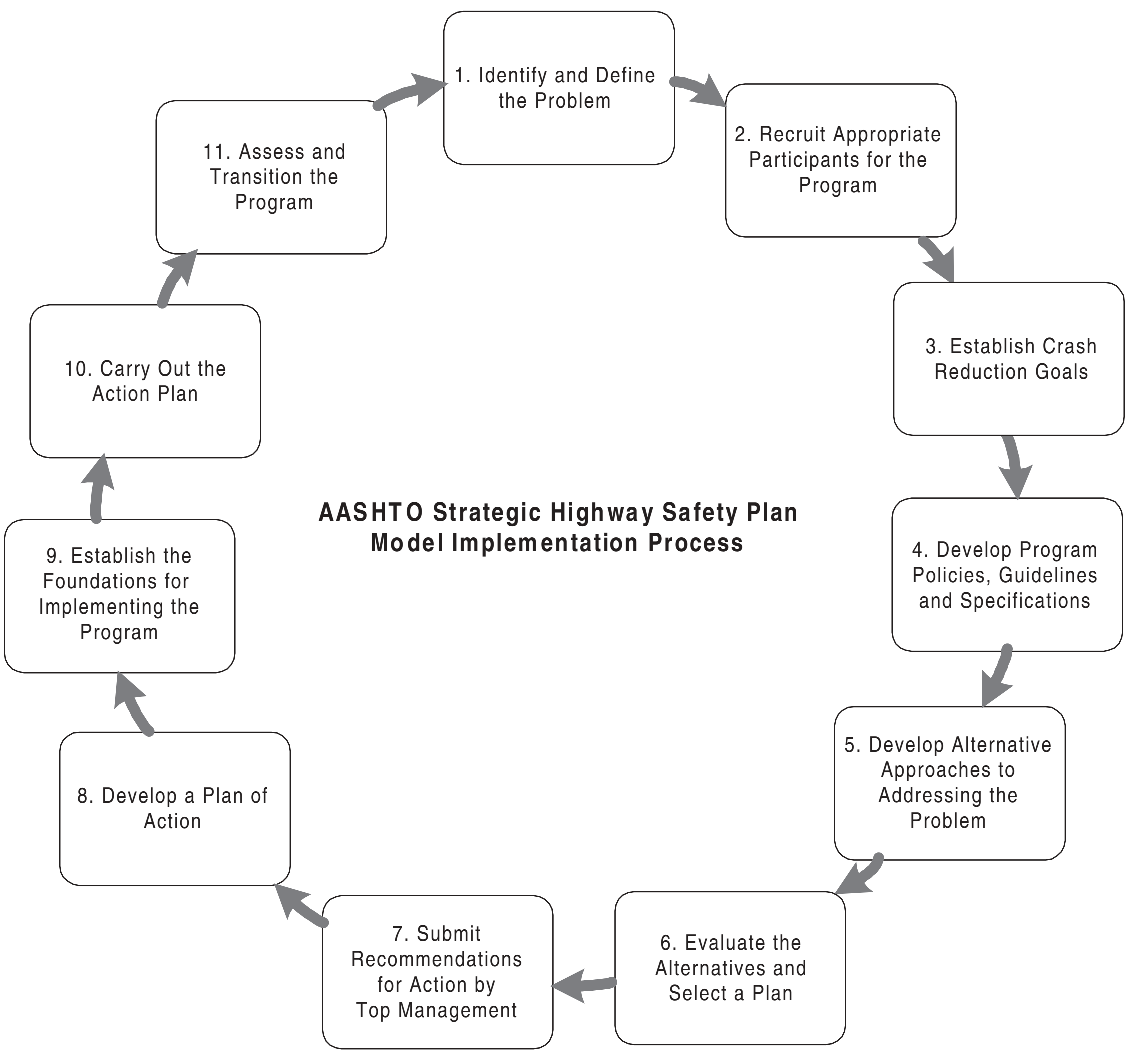
SECTION VI

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 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/practice/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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Appendixes

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

1 Partnerships between Missouri DOT and Utility Companies to Reduce Utility Pole Crashes
2 Florida's Aboveground Fixed-Object Safety Program
3 Pennsylvania's Program to Reduce Utility Pole Crashes
4 Illustration of Washington State DOT's Aboveground Utility Object Collision Reduction Program
5 Roadside Adjustment Factors for Increasing Pole Offset
6 Estimate of Costs for Breakaway Utility Poles
7 Alabama DOT Study of Utility Pole Crashes
8 City of Huntsville, Alabama, Study of Roadside Object Crashes
9 North Carolina's Approach to Reducing Utility Pole Crashes
10 Utility Company Programs
11 Depiction of the AD-IV Design for a Breakaway Utility Pole

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 Programme: 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
W Program Evaluation—Its Purpose and Nature
X Traffic Safety Plan for a Small Department

Y Sample District-Level Crash Statistical Summary
Z Sample Intersection Crash Summaries
AA Sample Intersection Collision Diagram
BB Example Application of the Unsignalized Intersection Guide

Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety 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
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation