VOLUME 13

NCHRP

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

REPORT 500

Guidance for Implementation of the AASHTO Strategic Highway Safety Plan

Volume 13: A Guide for Reducing Collisions Involving Heavy Trucks

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP REPORT 500

Guidance for Implementation of the AASHTO Strategic Highway Safety Plan

Volume 13: A Guide for Reducing Collisions Involving Heavy Trucks

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SUBJECT AREAS
Safety and Human Performance

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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FOREWORD

By Charles W. Niessner
Staff Officer
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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 thirteenth 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 heavy trucks. 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 thirteenth 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 heavy-truck guide:

- Ronald R. Knipling
  Virginia Tech Transportation Institute
- Patricia Waller

Development of the volumes of *NCHRP Report 500* utilized the resources and expertise of many professionals from around the country and overseas. Through research, workshops, and actual demonstration of the guides by agencies, the resulting documents represent best practices in each emphasis area. The project team is grateful to the following people and their agencies for supporting the project through their participation in workshops and meetings and additional reviews of the heavy-truck guide:

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This guide is dedicated to Dr. Patricia Waller, who played an instrumental role in the development of this guide and developed Volume 2 of this series. The project team, and the highway safety profession, is fortunate to have benefited from Dr. Waller's knowledge, experience, and professional dedication.

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. To facilitate such use, the online form of the material uses hypertext linkages to enable seamless integration of various approaches to a given problem. As more guides are developed for other emphasis areas, the extent and usefulness of this form of implementation will become ever more apparent.

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. The working groups and alliances 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.

Goal 12 in the Strategic Highway Safety Plan is *Making Truck Travel Safer*. Truck safety is the result of many interacting factors, some more directly under state control than others. However, even those aspects of trucking that fall primarily into the private sector (motor carriers, shippers, and receivers) fall under the jurisdiction of state and federal regulations. Both the regulations and their enforcement can affect truck safety.

Heavy-truck crashes, especially those involving other vehicles, are likely to result in serious injury. Because heavy-truck crashes have a variety of causes, a comprehensive effort to reduce them must focus on a range of targets, including behavioral, environmental, and operational targets. Effective solutions will require broad-based cooperation and the participation of both public and private entities. The private sector—the trucking industry and the many motor carriers composing it—plays the most fundamental role of managing carrier compliance with regulations and implementing safety processes beyond compliance that further enhance carrier safety. Federal, state, and local governments also play essential roles, focusing largely on regulation and enforcement, but also involving engineering and educational initiatives. In particular, state leadership and support can make a major difference in reducing truck crashes and resulting injury and death.

General Description of the Problem

The 2001 statistics from the Fatality Analysis Reporting System (FARS) show that, of 42,116 persons killed in motor vehicle crashes in the United States, 5,082, or 12.1 percent, were in

crashes involving heavy trucks, defined as having a gross vehicle weight rating (GVWR) of 10,001 pounds or more (Federal Motor Carrier Safety Administration [FMCSA], 2003a). One in eight traffic fatalities involved a heavy truck. Of these, most involved large trucks with a GVWR greater than 26,000 pounds. Heavy trucks have continued to account for between 12 and 13 percent of all traffic fatalities, with the largest proportion occurring to persons outside the truck (mostly occupants of other vehicles, but also nonoccupants, e.g., pedestrians and bicyclists). In 2001 there were also about 131,000 persons injured in heavy-truck crashes; again, most of these injuries were to persons other than the truck occupants. Although large-truck involvement in fatal crashes has decreased from 5.0 per hundred vehicle-miles traveled (VMT) in 1980 to 2.1 per 100 million VMT in 2001, this rate is still much higher than that for passenger vehicles, which was 1.3 in 2001 (FMCSA, 2003a). Exhibit I-1 shows the distribution of fatalities in large-truck crashes in 2001.

EXHIBIT I-1
Fatalities in Crashes Involving Large Trucks, 2001
(FMCSA, 2003a)

Victim Type	Number	% of Total
Occupants of Large Trucks	702	14
Single Vehicle	*392*	*8*
Multiple Vehicle	*310*	*6*
Occupants of Other Vehicles in Crashes Involving Large Trucks	3,953	78
Nonoccupants (Pedestrians, Pedal Cyclists, etc.)	427	8
Total	**5,082**	**100**

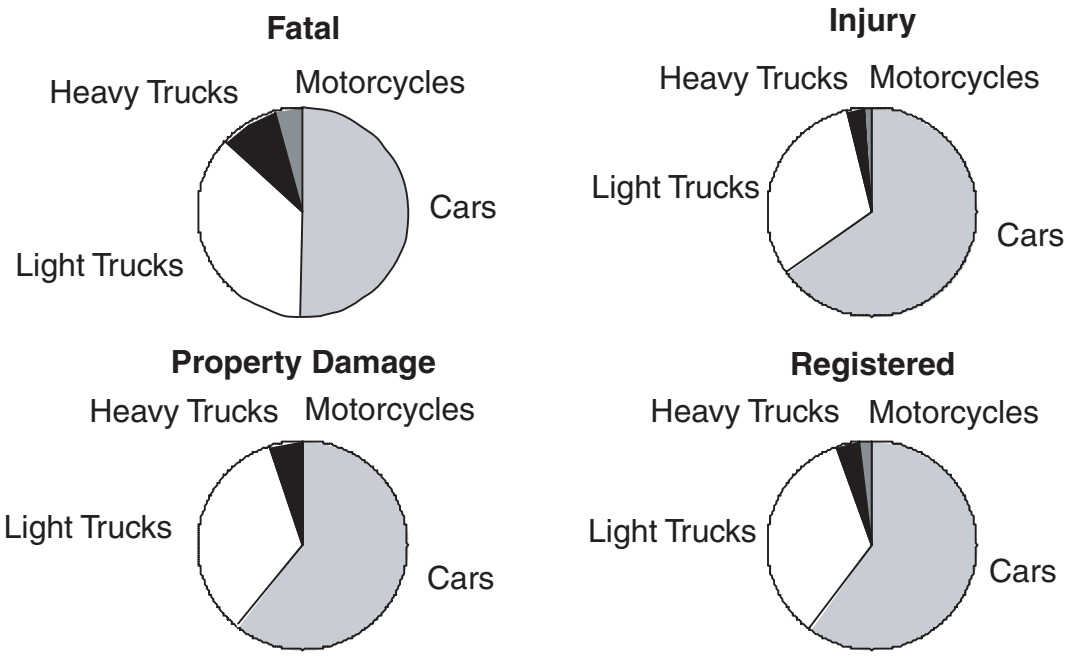
Yet drivers of heavy trucks appear to engage in fewer unsafe driving practices than do drivers in general. Analysis of driver-related factors in crashes between large trucks and passenger vehicles indicates that *passenger* vehicle driver errors or other driver factors are cited in more than two-thirds of these crashes, whereas truck driver errors are cited in less than one-third (FHWA, 1999c; Blower, 1999). Studies of vehicle highway speeds in North America indicate that drivers of heavy vehicles generally exceed posted speed limits less often, and by smaller margins, than drivers of light vehicles (Tardif, 2003; NHTSA, 1991). In addition, crash-involved truck drivers are much less likely than passenger vehicle drivers to drive under the influence of alcohol.

Even though truck drivers appear to be better drivers than those of other vehicles, truck crashes are more likely to result in fatality because of the vehicle's size, weight, and stiffness. In 1999, heavy trucks accounted for 4 percent of all registered vehicles and 8 percent of total vehicle-miles traveled, but they accounted for 9 percent of all vehicles involved in fatal crashes (NHTSA, 2001). Thus, heavy trucks are overrepresented in fatal crashes. Compared with passenger cars, when a heavy truck is involved in a crash, it is about 2.6 times as likely to result in a fatality. The average overall human and property "harm" in large-truck crashes is about twice the average of crashes involving only passenger vehicles (Wang et al., 1999). Heavy-truck crashes account for 23 percent of passenger vehicle occupant deaths in

multivehicle crashes and 12 percent of all passenger vehicle occupant deaths (Insurance Institute for Highway Safety, 2001). The factors contributing to truck crashes are many and include other drivers, truck driver errors, environmental characteristics, vehicle condition, and operational practices.

Exhibit I-2 shows the proportion of each vehicle type in crashes and in registered vehicles for 1999.

EXHIBIT I-2
Vehicle Type by Crash Severity and Registered Vehicles
(NHTSA, 2001)



Objectives of the Emphasis Area

To reduce the number of heavy-truck fatality crashes, the objectives should include the following:

- Reduce truck driver fatigue.
- Strengthen commercial driver's license (CDL) requirements and enforcement.
- Increase public knowledge about sharing the road.
- Improve maintenance of heavy trucks.
- Identify and correct unsafe roadway and operational characteristics.
- Improve and enhance truck safety data.
- Promote industry safety initiatives.

Explanation of Objectives

In general, safety can be enhanced by improvements to drivers, vehicles, or the roadway environment. In the case of truck safety, improved fleet safety management by motor carriers is an additional desirable focus. This report describes a variety of initiatives relating to all four focus areas; most are interventions likely to be implemented by state DOTs or departments of motor vehicles (DMVs). Truck crashes can be lessened by reducing the number of tired truck drivers (e.g., increasing the efficiency of existing parking spaces, creating additional parking spaces, and incorporating rumble strips into new or existing roadways to alert fatigued drivers who wander out of traffic lane); strengthening CDL requirements and enforcement (e.g., strengthening CDL testing procedures and increasing fraud detection with both state and third-party testers); increasing general knowledge of how to share the road with trucks (e.g., incorporating Share the Road information into driver materials and promulgating Share the Road information through print and electronic media); improving the maintenance of trucks (e.g., promoting regular preventive maintenance and conducting postcrash inspections to identify major problems and problem conditions); identifying and correcting unsafe roadway infrastructure and operational characteristics (e.g., identifying and correcting unsafe roadway configurations, installing interactive truck rollover signing, and modifying speed limits and increasing enforcement to reduce speeds); improving and enhancing truck safety data (e.g., increasing the timeliness, accuracy, and completeness of truck safety data); and promoting industry safety initiatives (e.g., including vehicle-based safety technologies and carrier safety management improvements).

Exhibit I-3 lists the objectives and several related strategies for reducing heavy-truck crashes. Details of these strategies are covered in the following narrative. Of course, this does not

EXHIBIT I-3
Emphasis Area Objectives and Strategies

Objectives	Strategies
12.1 A Reduce fatigue-related crashes	12.1 A1 Increase efficiency of use of existing parking spaces
	12.1 A2 Create additional parking spaces
	12.1 A3 Incorporate rumble strips into new and existing roadways
12.1 B Strengthen CDL program	12.1 B1 Improve test administration for the CDL
	12.1 B2 Increase fraud detection by state and third-party testers
12.1 C Increase knowledge re: sharing the road	12.1 C1 Incorporate Share the Road information into driver materials
	12.1 C2 Promulgate Share the Road information through print and electronic media
12.1 D Improve maintenance of heavy trucks	12.1 D1 Increase and strengthen truck maintenance programs and inspection performance
	12.1 D2 Conduct postcrash inspections to identify major problems and problem conditions

EXHIBIT I-3 (Continued)
Emphasis Area Objectives and Strategies

Objectives	Strategies
12.1 E Identify and correct unsafe roadway infrastructure and operational characteristics	12.1 E1 Identify and treat truck crash roadway segments—signing 12.1 E2 Install interactive truck rollover signing 12.1 E3 Modify speed limits and increase enforcement to reduce truck and other vehicle speeds
12.1 F Improve and enhance truck safety data	12.1 F1 Increase the timeliness, accuracy, and completeness of truck safety data
12.1 G Promote industry safety initiatives	12.1 G1 Perform safety consultations with carrier safety management 12.1 G2 Promote development and deployment of truck safety technologies

represent a listing of all possible strategies to reduce heavy-truck crashes. Many other activities occurring in the states are aimed at improving truck safety. However, each of the strategies included here either is currently in use by one or more states or has a sound rationale for implementing the strategy, e.g., data that support the measure.

Targets of the Objectives

Objective 12.1 A, reduce fatigue-related crashes, would primarily be implemented by state DOTs, which are responsible for building and operating driver rest areas along Interstates and other major highways. Strengthening the CDL program, Objective 12.1 B, will require action primarily on the part of state licensing agencies (usually DMVs). Objective 12.1 C, increasing knowledge on sharing the road with other vehicles, is aimed at drivers of both commercial vehicles and personal vehicles, but especially the latter, since there is strong evidence that, in car-truck crashes, the driver of the car is much more likely to be the precipitating factor. Objective 12.1 D, improving the maintenance of heavy trucks, is aimed at state enforcement and crash investigation. Objective 12.1 E, identifying and correcting unsafe roadway infrastructure and operational characteristics, will primarily be the responsibility of state DOTs and local governments. Objective 12.1 F, improve and enhance truck safety data, can be instated by states, local governments, and motor carriers. Finally, Objective 12.1 G, promoting industry safety initiatives, is for use by the trucking industry, including manufacturers and motor carriers, as well as state agencies interfacing with motor carriers.

SECTION II

Introduction

The AASHTO Strategic Highway Safety Plan identified 22 goals that need 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. To facilitate this, the online form of the material uses hypertext linkages to enable seamless integration of various approaches to a given problem. As more guides are developed for other emphasis areas, the extent and usefulness of this form of implementation will become ever more apparent.

AASHTO's overall goal is to move from *independent* activities of engineers, law enforcement officials, educators, judges, and other highway-safety specialists to *coordinated* efforts. The implementation process outlined in the series of guides promotes the formation of working groups and alliances that represent all elements of the safety system. The working groups and alliances 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.

Goal 12 in the Strategic Highway Safety Plan is *Making Truck Travel Safer*. Truck safety is the result of many interacting factors, some more directly under state control than others. However, even those aspects of trucking that fall primarily into the private sector (motor carriers, shippers, and receivers) fall under the jurisdiction of state and federal regulations. Both the regulations and their enforcement can affect truck safety. Measures that have been identified as worth pursuing include the following:

- Reduce truck driver fatigue.
- Strengthen the CDL program.
- Increase knowledge about sharing the road.
- Improve maintenance of heavy trucks.
- Identify and correct unsafe roadway and operational characteristics.
- Improve and enhance truck safety data.
- Promote industry safety initiatives.

Heavy-truck crashes are more likely to result in serious injuries and fatalities than are crashes involving only light vehicles. Because heavy-truck crashes have a variety of causes, a comprehensive effort to reduce them must focus on a range of targets, including behavioral, environmental, and operational targets. Effective solutions will require broad-based cooperation and the participation of both public and private entities. State government officials can play a key leadership role in reducing truck crashes and resulting injury and death. Industry also plays a critical role, since truck drivers operate under the aegis and safety management of a motor carrier.

Truck crashes can be lessened by the following:

- Reducing the number of tired truck drivers (increasing the efficient use of existing parking spaces for truckers, creating additional parking spaces for truckers, incorporating rumble strips into new or existing roadways to alert fatigued drivers who wander out of traffic lanes).
- Strengthening CDL requirements and enforcement (strengthening CDL testing procedures and increasing fraud detection by both state and third-party testers).
- Increasing general knowledge of how to share the road with trucks (incorporating Share the Road information into driver handbooks, knowledge tests, and license renewal notices).
- Promulgating Share the Road information through print and electronic media reporting.
- Improving the maintenance of trucks (promoting regular preventive maintenance and conducting postcrash inspections to identify major problems and problem conditions).
- Identifying and correcting unsafe roadway infrastructure and operational characteristics (installing interactive truck rollover signing on hazardous off-ramps and modifying speed limits and increasing enforcement to reduce truck and other vehicle speeds).
- Improving and enhancing truck safety data (increasing the timeliness, accuracy, and completeness of truck safety data).
- Promoting industry safety initiatives (including vehicle-based safety technologies and carrier safety management improvements).

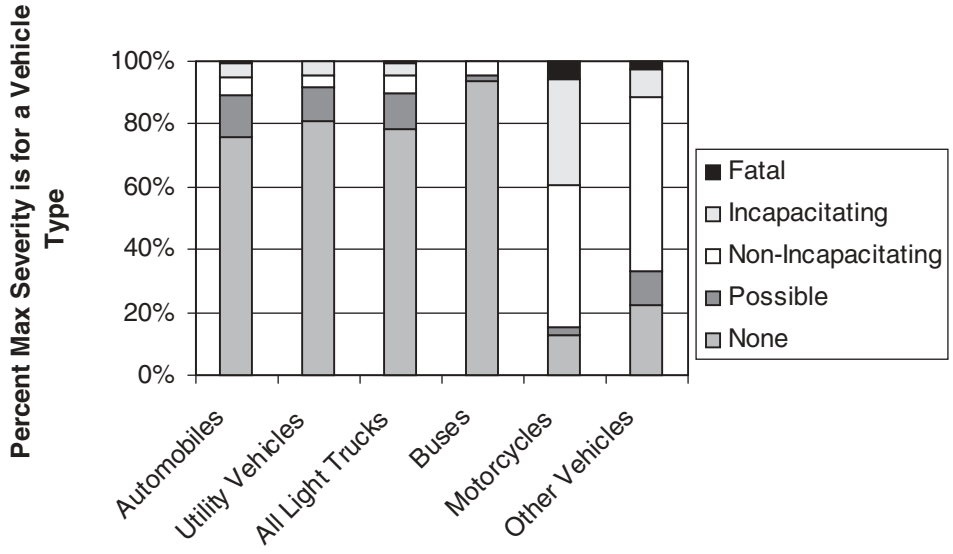
SECTION III

Type of Problem Being Addressed

General Description of the Problem

Exhibit III-1 shows that crashes involving medium and heavy trucks predominately do not involve serious injury except for motorcycles and special vehicles, such as farm equipment on the road.

EXHIBIT III-1
Maximum Severity for Vehicles Crashing with Medium- and Heavy-Weight Trucks



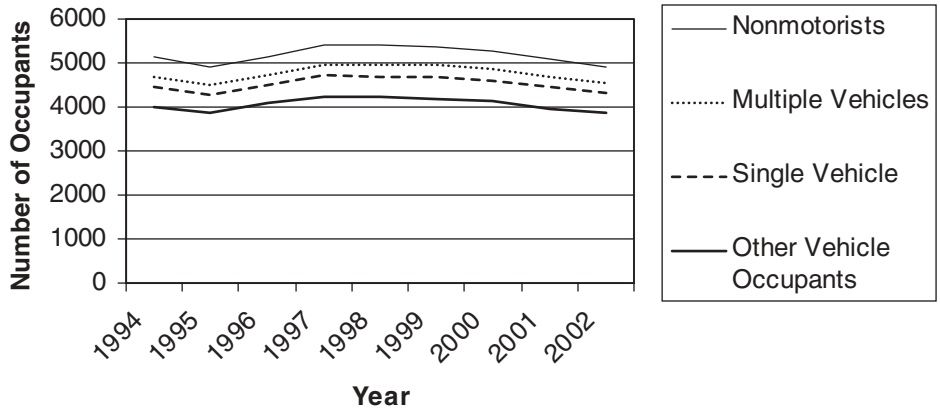
Note: Medium and heavy weight > 4,536 kg GVWR Source: GES 1999

Although the majority of large-truck crashes do not involve injury, the probability of a fatality is greater in large-truck crashes; for example, in 2001, 1.1 percent of large-truck crashes resulted in a fatality, versus 0.6 percent of the crashes involving all vehicles (FMCSA, 2003a; NHTSA, 2002).

Moreover, the number of fatalities associated with large-truck crashes is a significant portion of all crash fatalities. In 2002, 434,000 large trucks (with a GVWR greater than 10,000 pounds) were involved in traffic crashes in the United States; 4,542 were involved in fatal crashes. A total of 4,897 people died (11 percent of all the traffic fatalities reported in 2002), and an additional 130,000 were injured in those crashes. One in nine traffic fatalities involved a heavy truck. Of these, most involved trucks with a GVWR greater than 26,000 pounds.

The trend of heavy-truck fatalities is shown in Exhibit III-2 (FARS, 2002). Generally, 80 percent of the fatalities result from a crash with another vehicle in transport.

EXHIBIT III-2
Heavy-Truck Fatalities



Source: FARS 2002

Heavy trucks have continued to account for between 11 and 13 percent of all traffic fatalities, with the largest proportion occurring to persons outside the truck (mostly occupants of other vehicles, but also nonoccupants, e.g., pedestrians and bicyclists).

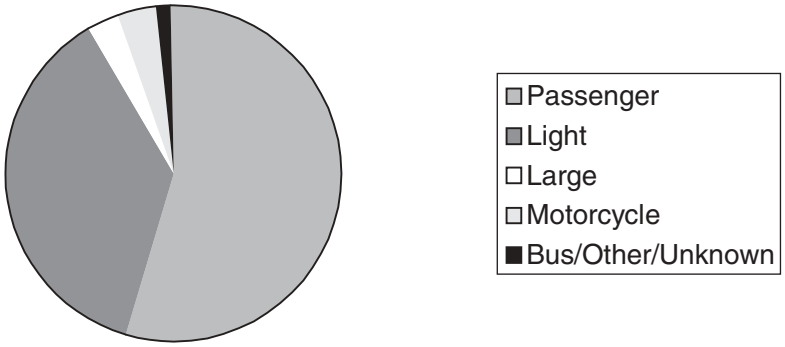
Of the fatalities that resulted from crashes involving large trucks, 79 percent were occupants of another vehicle, 7 percent were nonoccupants, and 14 percent were large-truck occupants. Of the injuries that resulted from crashes involving large trucks, 77 percent were occupants of another vehicle, 3 percent were nonoccupants, and 20 percent were large-truck occupants.

Exhibit III-3 shows that, of the fatalities that resulted from two-vehicle collisions involving a large truck, the vast majority were passenger-vehicle occupants or light-truck occupants (the latter would include sport utility vehicles [SUVs] and pickup trucks).

Large trucks were much more likely to be involved in a fatal multiple-vehicle crash—as opposed to a fatal single-vehicle crash—than were passenger vehicles (84 percent of all large trucks involved in fatal crashes, compared with 61 percent of all passenger vehicles). In 29 percent of the two-vehicle fatal crashes involving a large truck and another type of vehicle, both vehicles were impacted in the front. The truck was struck in the rear nearly 2.5 times as often as the other vehicle (17 percent and 7 percent, respectively).

In 2001, large trucks accounted for 4 percent of all registered vehicles and 7 percent of total VMT (2002 registered vehicle and vehicle miles traveled data not available). In 2002, large trucks accounted for 8 percent of all vehicles involved in fatal crashes and 4 percent of all vehicles involved in injury and property-damage-only crashes (NHTSA, 2003).

EXHIBIT III-3
Fatalities by Vehicle Type in Two-Vehicle Collisions Involving a Large Truck



Source: FARS 2002

In a multidimensional comparison of the quantitative crash experiences of various vehicle types, Wang et al. (1999) compared combination-unit trucks (tractor-trailers) with single-unit trucks ("straight" trucks) and all vehicles (predominantly cars, light trucks, and vans). Combination-unit trucks were found to have a markedly different crash involvement profile than that of vehicles in general. They have relatively low crash rates per mile traveled, but their high mileage exposures and the severity of their crashes combine to associate them with much greater crash costs per year and, over their operational lives, more than four times higher than most other vehicle types. This means that, from a cost-benefit standpoint, safety investments in tractor-trailers are likely to have much greater per-vehicle (or per-driver) benefits than similar investments in other vehicle types. Safety improvements to a fleet of tractor-trailers and/or their drivers have the potential to be much more cost-beneficial than similar investments in car or light-truck fleets of equal size.

Single-unit large trucks (straight trucks) have a less dramatic crash picture than do combination-unit trucks. Like tractor-trailers, single-unit trucks have relatively low crash involvement rates per mile traveled, but unlike tractor-trailers, their mileage exposure levels are generally not high because they are used mostly for short local trips rather than long-haul trips. Their crashes tend to be more severe than those of light vehicles but less severe than those involving a tractor-trailer. Overall, their quantitative crash experience on an individual vehicle level is more similar to light vehicles than to combination-unit trucks. Consequently, the per-vehicle or per-driver benefits from safety investments in single-unit trucks are likely to be more similar to those of light vehicles than to those of combination-unit trucks (Wang et al., 1999).

Specific Attributes of the Problem

As stated above, large trucks are defined in FARS as those trucks having a gross vehicle weight rating (GVWR) of more than 10,000 pounds. This includes both combination- and single-unit trucks. Passenger vehicles have a GVWR of 10,000 pounds or less, but most are less than 5,000 pounds. Over 90 percent of trucks in fatal crashes are more than 26,000

pounds. One analysis of trucks in fatal crashes found that almost half weighed more than 60,000 pounds at the time of the crash (FMCSA, 2000a). Obviously, the gross disparity in the weights of trucks and passenger vehicles places the occupants of the latter at a major disadvantage. In addition to weight per se, vehicle size, body stiffness, and bumper height contribute to the crash mismatch.

The Nature of Heavy-Truck Crashes

The General Estimate System (GES, operated by NHTSA) data for 1999 provide insights through the analysis of a variable called "critical event." GES identifies the critical event that made the crash imminent (i.e., something that occurred that made the collision possible). A critical event is coded for each vehicle and identifies the circumstances leading to the vehicle's first impact in the crash. GES does not provide the same classification for trucks as FARS, making direct comparisons difficult. However, Exhibit III-4 provides a picture of the nature of the critical events associated with all crashes involving a single-unit truck and a tractor truck (with or without its trailer).

There are two kinds of critical events: those associated with the truck and those associated with the other vehicle or a person or object. For single-unit trucks, about 30 percent of the critical events were associated with the truck, while for the tractor it was about 36 percent. This means that something other than the involved truck was associated with the critical event in between 64 and 70 percent of the crashes for these two types of vehicles.

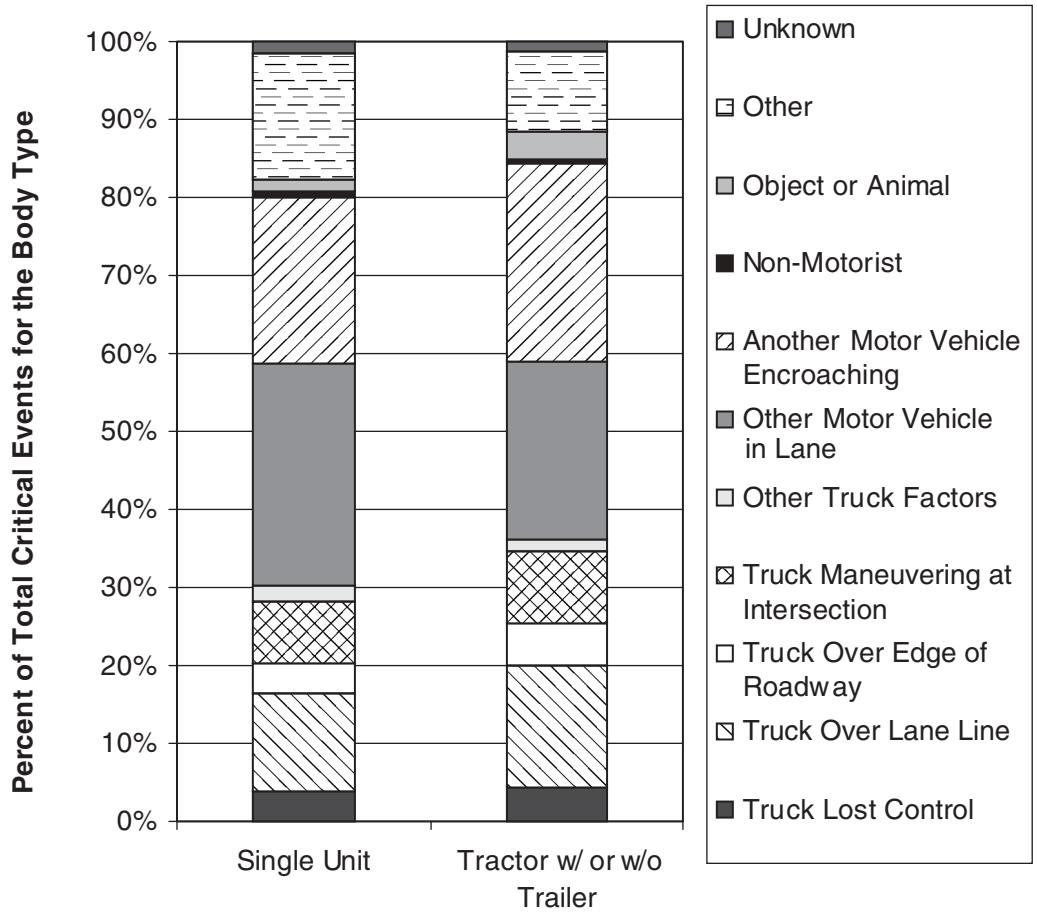
The FMCSA/NHTSA Large-Truck Crash Causation Study is beginning to provide statistical reports from its in-depth crash reconstructions of a nationally representative sample of serious large-truck crashes. A preliminary report (Craft and Blower, 2003b) cites data on 158 two-vehicle crashes involving a large truck and a light vehicle. Of these crashes, the critical event (after which the crash is inevitable) was a truck driver action in 29 percent and an action of the other driver in 60 percent. The remaining 11 percent were associated with the roadway, weather, truck vehicle failure, other vehicle failure, or other/unknown events.

In addition to the extensive crash data cited above, instrumented vehicle studies that directly record vehicle interactions in traffic have corroborated the crash data in regard to the source of most large-truck safety incidents. In an instrumented vehicle study of light-vehicle–heavy-vehicle interaction, Hanowski et al. (2001) captured and reviewed 142 driver errors (some of which resulted in near crashes) and observed that 117 (82 percent) were initiated by the actions of surrounding light-vehicle drivers, while 25 (18 percent) were initiated by the heavy-vehicle subjects in the study. The most common general error by drivers was allowing insufficient gaps or clearance, e.g., while making a lane change or left turn across the path of another vehicle.

The distribution of types of critical events does not vary significantly between the two types of large trucks shown in Exhibit III-4 (although, as noted earlier, tractor-trailers usually have much greater mileage exposure and, therefore, a greater probability of most types of crash and incident involvement). Slightly more than 20 percent of the crashes involve encroachment by another vehicle into the truck's lane, while slightly less than 15 percent of the crashes involve the truck encroaching on another lane. Less than 10 percent of the crashes involve critical events associated with truck maneuvers at an intersection (turning or

crossing). Between 20 and 30 percent of the crashes have a critical event involving the other vehicle in the same lane as the truck.

EXHIBIT III-4
Critical Event for Crashes Involving Single-Unit and Tractor Trucks



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

Heavy-truck crashes differ from crashes in general in several important ways. As noted above, major problems are created by the actions of other drivers, who are often not aware of the special characteristics of heavy trucks. These larger, heavier vehicles require greater stopping distance, and rapid lane changes may cause jackknifing in articulated trucks. Trucks with multiple trailers ("doubles" or "triples") are subject to problems with "rearward amplification," sometimes referred to as the "crack the whip" phenomenon. Each point of articulation increases side-to-side sway by approximately 70 percent, so that multiple trailers, especially those using coupling devices with two points of articulation, can develop

considerable sway in the last trailer (just as the last person in "crack the whip" experiences the greatest forces). Direct comparisons of the crash experience of multitrailer to single-trailer trucks are difficult, because multitrailer truck use is largely limited to Interstate highways in the less-populated Western states.

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

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

An analysis of two-vehicle crashes involving a large truck and a passenger vehicle found that 35 percent of the crashes involved the passenger vehicle moving into the No-Zone area. Exhibit III-5 shows the distribution of these No-Zone crashes, based on 1996 data.

EXHIBIT III-5
Estimated Potential No-Zone Crashes by No-Zone Area for 1996
(Pat Waller, www.nozone.org/mission/crash_est.htm)

Type of Crash	Estimated Total of No-Zone Related Crashes	Percent of All Crashes
Truck Encroaching—Non-Intersection (Right and Left No-Zones)	21,500	8.0
Truck Encroaching—Intersection	10,500	4.0
Front No-Zone	32,500	13.0
Rear No-Zone	25,000	10.0
Total Potential No-Zone	89,500	35.0
Total Two-Vehicle, Large Truck/Passenger Vehicle Crashes	258,000	100.0

Drivers of passenger vehicles cannot completely avoid moving into No-Zone areas, in that passing or being passed by a truck necessitates spending some time there. However, drivers should try not to remain in these areas any longer than necessary.

In crashes between large trucks and passenger vehicles, passenger vehicle driver errors or other driver factors are about twice as likely to be cited as are truck driver errors or other factors (FHWA, 1999c; Blower, 1999). Heavy-truck drivers generally exceed highway speed limits less frequently and by smaller margins than do drivers of light vehicles (Tardif, 2003; NHTSA, 1991). In fatal crashes, truck drivers are much less likely than passenger vehicle drivers to be legally intoxicated. In 2002, only 2 percent of large-truck drivers involved in

fatal crashes tested for blood alcohol content (BAC) at or above 0.08, while at least 25 percent of drivers of other vehicles tested at the same levels (NHTSA, 2003).

Drivers of large trucks were less likely to have a previous license suspension or revocation than were passenger car drivers (7 percent and 14 percent, respectively). On the other hand, almost 28 percent of all large-truck drivers involved in fatal crashes in 2002 had at least one prior speeding conviction, compared with 20 percent of the passenger car drivers involved in fatal crashes (NHTSA, 2003). As noted earlier, heavy-truck drivers have mileage exposures that are typically many times those of passenger car drivers, making comparisons of lifetime crash, violation, or incident involvements problematic.

In analyses of 1998 two-vehicle fatal crashes involving a large truck and a passenger vehicle, important driver differences were found (FMCSA, 2000a). Exhibit III-6 summarizes some of the differences identified. It should be noted that, for driver-related factors, more than one could be identified for each driver.

In fatal truck–passenger vehicle crashes, truck drivers are much less likely to be legally intoxicated, with only 1 percent or fewer having a BAC of 0.10 percent or higher, compared with 19 percent for passenger cars, 20 percent for light trucks, and 27 percent for motorcycles (NHTSA, 2001). However, because of the size, weight, and mileage exposure of the vehicles involved, even 1 percent of truck drivers operating with such high BACs is cause for concern. Safety belt usage is also much higher for truck drivers, based on crash reports. It is important to note that in a fatal crash involving a truck and a passenger vehicle, it is very likely that the fatalities occurred to the passenger vehicle occupants, so that reported belt

EXHIBIT III-6
Characteristics of Drivers in Two-Vehicle Fatal Crashes Involving a Large Truck and a Passenger Vehicle, 1998

Driver Characteristic	Heavy Truck	Passenger Vehicle
Driver < 26 years old	7.2 percent	24.2 percent
Driver > 65 years old	2.4 percent	20.1 percent
Invalid or no license	1.9 percent	10.2 percent
Driver restraint use	76.4 percent	48.8 percent
Driver alcohol use (any)	1.7 percent	18.8 percent
Driver alcohol > 0.10 percent	0.6 percent	13.5 percent
Driver factor recorded	26.4 percent	81.5 percent
Failed to yield	5.3 percent	20.3 percent
Ran off road/out of lane	4.8 percent	27.8 percent
Driving too fast	3.8 percent	14.9 percent
Failure to obey traffic devices	3.0 percent	12.1 percent
Inattentive	2.7 percent	9.8 percent

usage may be more readily erroneously reported for the truck driver. Yet independent investigation based on vehicle points of contact and other physical evidence at the scene of the crash, as well as witness reports, verifies that the truck driver is less likely to have made the critical driver error in such crashes (Craft and Blower, 2003b; Blower, 1999).

A report that focused on unsafe driving actions leading to fatal car-truck crashes again found that in such collisions the driver of the passenger vehicle is much more likely to be culpable (Kostyniuk et al., 2002). The report also found that, on the whole, unsafe driving actions that lead to fatal car-truck crashes are equally likely to lead to fatal car-car crashes. Indeed, five such factors, namely failing to keep in lane, failing to yield right-of-way, driving too fast for conditions or in excess of posted speed limit, failing to obey traffic control devices and laws, and being inattentive, accounted for about 65 percent of both car-car and car-truck fatal crashes. However, four factors were found to be more likely to lead to a fatal car-truck collision than to a fatal car-car collision:

- Following improperly;
- Driving with vision obscured by rain, snow, fog, sand, or dust;
- Driving while drowsy or fatigued; and
- Changing lanes improperly.

These four factors accounted for only about 5 percent of all fatal car-truck collisions, however. By and large, the precrash scenarios of car-truck and car-car fatal crashes are similar.

Truck crash probability may also be reduced by truck-focused programs. Of particular concern in heavy-truck crashes is the condition of the vehicle. In August 1996, Michigan initiated a program called FACT (Fatal Accident Complaint Team), in which investigations were conducted of trucks involved in fatal crashes. The program has been discontinued, at least for the present. Of 442 crashes occurring between program inception and February 2001, inspections were conducted on 354 fatal crash-involved trucks, or 80.1 percent, to determine the condition of the vehicle immediately prior to the crash. Trucks not inspected were either not available or so badly damaged that meaningful inspection was not possible.

Analyses of these data by Blower (2002) show that in almost 66 percent of the cases, a violation was found for either the truck or the truck driver. Over one-third of all inspected trucks had at least one out-of-service (OOS) violation for either the truck or the driver. Considering just the mechanical condition of the truck, almost 55 percent had at least one violation, and 28 percent had at least one OOS violation. Although this rate is high, 31.8 percent of trucks inspected in Michigan under the Motor Carrier Safety Assistance Program (MCSAP) in the 3-year period ending June 2001 were placed out of service. This figure is comparable to findings from other states.

Further analyses of FACT data reveal strong relationships between specific vehicle violations and crash types. In rear-end collisions, 27.3 percent of trucks that were struck had a brake violation, but 50 percent of trucks that were the striking vehicle had a brake violation. The only other vehicle inspection component associated with rear-end collisions was the lighting system. Here 15.4 percent of striking trucks had such violations, compared with 39.4 percent of the trucks that were struck, suggesting that truck conspicuity was a

factor in the crash. In opposite-direction crashes, in which one vehicle encroached into the other vehicle's right-of-way, almost half of the encroaching trucks (46.7 percent) had at least one brake defect, compared with only 19.7 percent of trucks that were encroached upon. Likewise, more encroaching trucks had an OOS brake condition than did trucks that were encroached upon. The other defect associated with truck encroachment in the opposite direction was steering. More encroaching trucks (26.7 percent) had preexisting steering defects than did trucks that were encroached upon (2.8 percent).

Although high rates of vehicle defects, including OOS problems, are found in heavy trucks in general, large trucks in crashes have higher rates of vehicle defects that relate to the types of crashes involved. Clearly the condition of heavy trucks on the roadway is of concern, and anything states can do to improve vehicle condition should reduce crash probability. However, although truck mechanical deficiencies are overinvolved in crashes, mechanical failure is apparently not a frequent principal cause of crashes. Preliminary data from the FMCSA/NHTSA Large-Truck Crash Causation Study indicate that only about 4 percent of the sampled crashes involved a principal truck vehicle factor, such as a defective component (Craft and Blower, 2003b).

Road-Related Characteristics

Exhibit III-7 shows the distribution of fatal heavy-truck crashes by roadway functional class. About two-thirds occur on rural roads, and about a quarter occur on Interstate and expressway facilities. The split of crashes between minor and principal facilities is about equal, which indicates the likelihood that at least half of the crashes are occurring on nonstate highways.

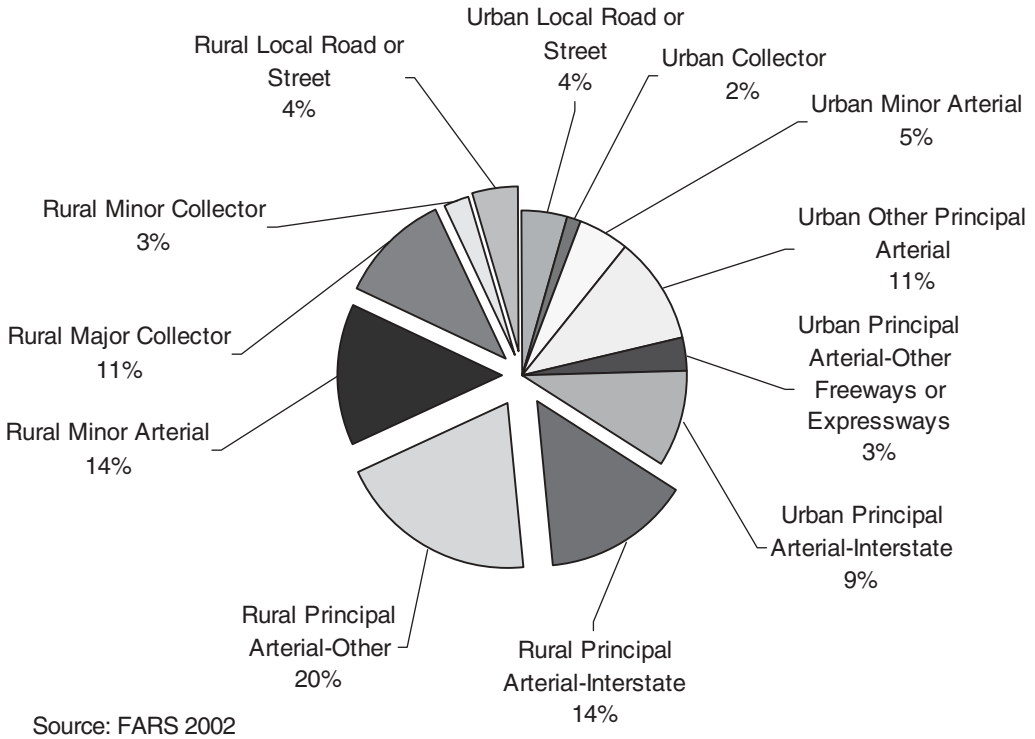
Exhibit III-8 further confirms the previous finding (FARS, 2002). It shows that the large majority of fatal heavy-truck crashes occur on two-lane roads. This is the case even though the majority of their travel is on Interstates or other divided highways (FHWA, 1999c).

Exhibit III-9 provides further insight by comparing the types of heavy-truck collisions resulting in fatalities for two-lane and multilane facilities. The multilane facilities experience proportionately more rear-end crashes, while the two-lane facilities experience proportionately more head-on and right-angle fatal crashes.

Exhibit III-10 depicts the variation in fatal heavy-truck collision type by time of day. The number of fatal heavy-truck crashes decreases in the evening and night hours, reflecting reduced volumes, but their proportionality changes. The change in proportions is exhibited in a different form in Exhibit III-11. These graphs demonstrate that rear-end crashes increase proportionately at night, while right-angle type crashes decrease. Evening-hour crashes can be related to many factors, including drowsy driving, driving under the influence, and inadequate lighting (both roadway and truck).

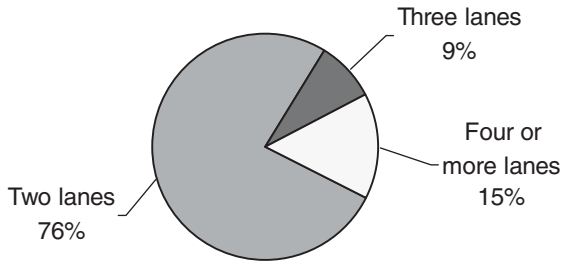
Exhibit III-12 focuses on the issue of light conditions. The results suggest that artificial lighting at night is not associated with a significantly different distribution of collision types than that of unlighted road sections after dark. The daylight distribution is somewhat different, however, with greater percentages of front-to-side opposite direction and front-to-front crashes and smaller percentages of rear-end crashes.

EXHIBIT III-7
Heavy-Truck Fatal Crashes by Functional Class



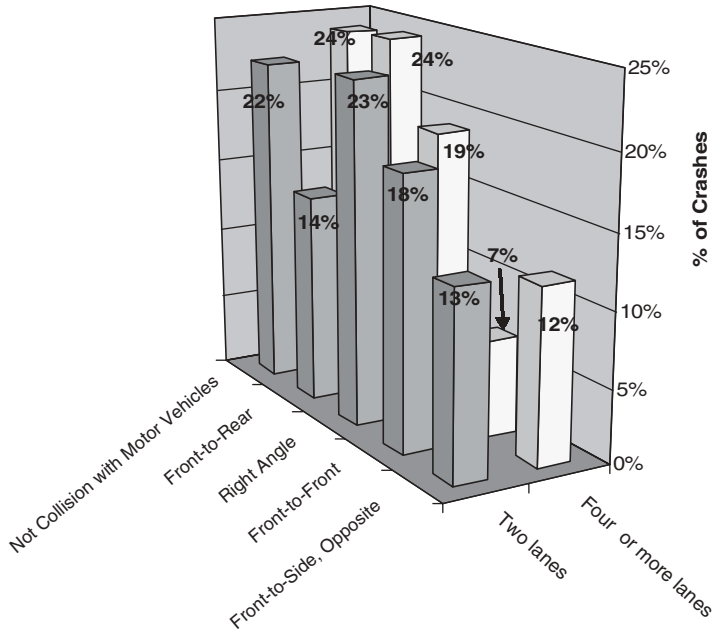
Source: FARS 2002

EXHIBIT III-8
Number of Travel Lanes for Fatal Crashes Involving Trucks



Source: FARS 2002

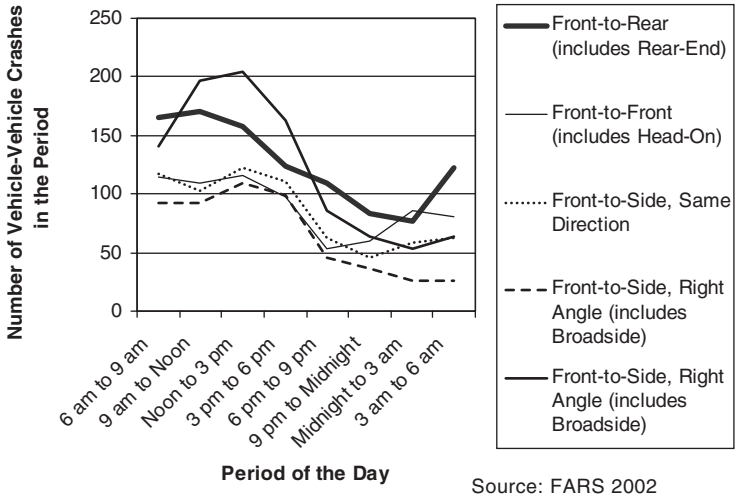
EXHIBIT III-9
Heavy-Truck Fatal Crashes: Manner of Collision for Two- and Multiple-Lane Roads



Source: FARS 2002

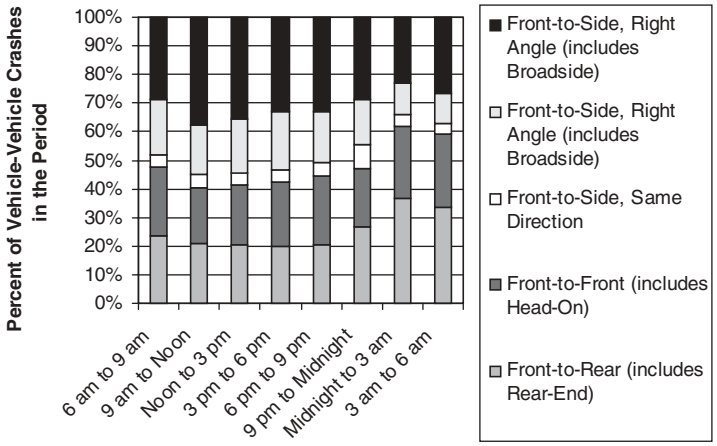
Note: percents are for a given number of lanes

EXHIBIT III-10
Fatal Truck Crashes: Number of Collisions versus Hour



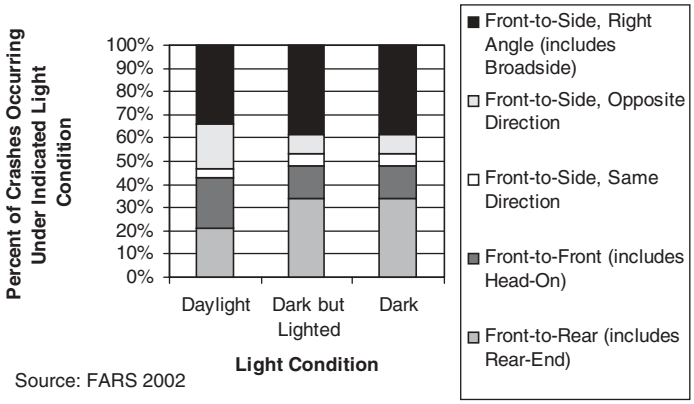
Source: FARS 2002

EXHIBIT III-11
Fatal Truck Crashes: Percent of Collisions versus Hour



Source: FARS 2002

EXHIBIT III-12
Heavy-Truck Fatal Crashes: Light Condition versus Manner of Collision



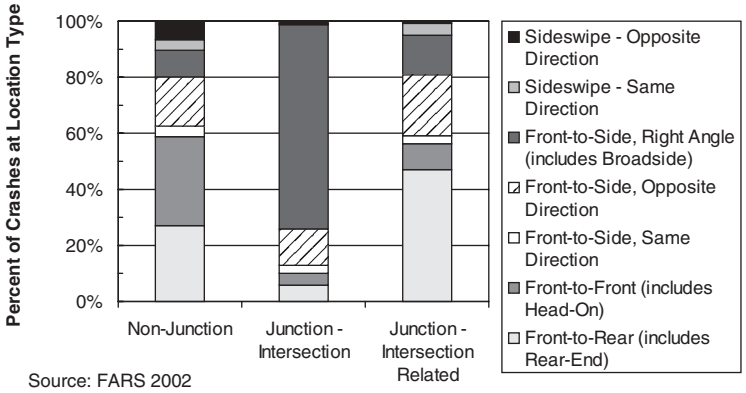
Source: FARS 2002

Is nighttime driving more risky for trucks than day driving? An FMCSA-sponsored study by Hendrix (2002) attempted to measure and compare combination-unit truck fatal crash involvement rates per mile traveled over the 24-hour day. Determining the relative risk per mile traveled between night and day would help the trucking industry and drivers to schedule their trips more safely. The study used roadside weigh-in-motion data to estimate VMT by hour-of-day in four states. These exposure distributions were compared with FARS fatal crash distributions for the same states. The study found no significant differences across the 24-hour day, implying that each truck mile driven has a roughly equivalent fatal crash risk, regardless of the time of day. In contrast, passenger cars and light trucks had fatal crash rates between midnight and 6 a.m. that were several times their rates during the other 18 hours of the day, in part reflecting the higher probability of alcohol involvement during the overnight hours for car and light-truck drivers.

Exhibit III-13 depicts the manner of collision of fatal large-truck crashes as they relate to the location along the road. Only those collision types with significant frequency are shown. The fatal collisions at intersections are predominantly right angle, while rear-end crashes are overrepresented for intersection-related crashes (presumably primarily on approaches to intersections). Nonjunction crashes in this data set showed a proportionately greater presence of head-on crashes.

The analysis of FARS data, for providing information regarding roadway and collision attributes, is a limited one. However, it demonstrates the value of detailed analysis of the data for a jurisdiction or area. PennDOT recently performed an analysis (Bryer, 2002) that provides a good example of what can be accomplished at the state level to increase understanding of the underlying crash factors and the applicability of candidate strategies.

EXHIBIT III-13
Fatal Heavy-Truck Crashes: Location versus Manner of Collision



Source: FARS 2002

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 upon such factors as the availability of usable space, the number of agencies involved, and, of course, costs. The range of costs may also vary for some of these strategies due to many of the same factors. Placement in the table below is meant to reflect the most commonly expected application of the strategy. The vehicle-technologies-related strategy (12.1 G2) has the longest timeframe for implementation because such technologies take many years to penetrate the fleet, especially if they are installed at the factory on new vehicles.

EXHIBIT IV-1
Classification of Strategies

Timeframe for Implementation	Relative Cost to Implement and Operate			
	Low	**Moderate**	**Moderate to High**	**High**
Short (less than a year)	12.1 A1 Increase efficiency of use of existing parking spaces 12.1 B1 Improve test administration for CDL 12.1 B2 Increase fraud detection of state and third-party testers 12.1 C1 Incorporate Share the Road information into driver materials	12.1 E3 Modify speed limits and increase enforcement to reduce truck and other vehicle speeds	—	—
Medium (1–2 years)	12.1 C2 Promulgate Share the Road information through print and electronic media 12.1 E1 Identify and treat truck crash roadway segments—signing	12.1 A2 Create additional parking spaces[b] 12.1 A3 Incorporate rumble strips into new and existing roadways[c] 12.1 E2 Install interactive truck rollover signing	12.1 D1 Increase and strengthen truck maintenance programs and inspection performance 12.1 D2 Conduct postcrash inspections to identify major problems and problem conditions 12.1 F1 Increase the timeliness, accuracy, and completeness of truck safety data[a]	

EXHIBIT IV-1 (Continued)
Classification of Strategies

Timeframe for Implementation	Relative Cost to Implement and Operate			
	Low	**Moderate**	**Moderate to High**	**High**
			12.1 G1 Perform safety consultations with carrier safety management	
Long (more than 2 years)			12.1 G2 Promote development and deployment of truck safety technologies	

[a] This strategy is effective immediately upon implementation, but it is anticipated that jurisdictions will be added over time, so that full implementation may extend over several years.
[b] Some measures, e.g., modifying weigh stations to make parking spaces, could be accomplished in a year or less.
[c] Although this strategy could be accomplished in a short time period, it can more readily be incorporated into a regular repaving program.

SECTION V

Descriptions of Strategies

Objectives

To reduce the number of heavy-truck fatality crashes, the objectives should include

- Reducing truck driver fatigue,
- Strengthening commercial driver's license (CDL) requirements and enforcement,
- Increasing public knowledge about sharing the road,
- Improving maintenance of heavy trucks,
- Identifying and correcting unsafe roadway and operational characteristics,
- Improving and enhancing truck safety data, and
- Promoting industry safety initiatives.

Explanation of the Objectives

Because truck crashes result from the interaction of so many factors, reducing crash probability requires comprehensive efforts addressing programs affecting truck drivers, other roadway users, vehicle condition, carrier operational practices, highway design and characteristics, and traffic records.

Commercial Driver Fatigue

In a major national forum on truck safety, the primary safety issue identified was driver fatigue. The reasons for driver fatigue are many, and only some of them may be addressed through state programs. However, states can take steps to increase the efficiency of use of existing parking space for drivers needing rest and/or required to stop driving because of hours-of-service regulations; states can also modify existing space and create new space to provide additional parking facilities. Rumble strips can alert tired drivers that they are leaving the traffic lane.

Commercial Driver's License

The commercial driver's license (CDL) established national standards for acquiring a license to operate heavy trucks. It has been fully implemented since April 1992. Although the CDL has achieved major improvements, e.g., reducing the problem of multiple licensing and consolidating driver history information, problems remain. The administration of the test can be improved, and measures can be taken to reduce fraud and improve the quality of both state and third-party testers.

Improved Driver Behavior

Most truck fatalities occur in multivehicle crashes, and in 2000, 78 percent of all heavy-truck–related fatalities occurred to occupants of the other vehicles. In crashes involving a heavy truck and a passenger vehicle (80 percent of all fatal truck crashes), it appears that the

principal culpability most often lies with the driver of the other vehicle. Consequently, some effort needs to focus on drivers in general to reduce truck fatalities. Drivers need better information on how to share the road with large trucks.

Improved Maintenance

Heavy trucks generally accumulate high mileage. In 2000, combination trucks averaged almost 65,000 miles, compared with almost 12,000 for passenger vehicles. State vehicle inspection programs (and not all states have them) are designed for passenger cars and usually require inspection only once a year. Large trucks need to be inspected much more frequently. Roadside inspections invariably identify sizeable proportions of trucks that need to be taken out of service immediately because they are considered too hazardous to continue operating. In-depth inspection of trucks in fatal crashes indicates that about one-third would have been removed from service if inspected just prior to the crash.

Improved Road Design and Operations

Highway configuration can create hazards for some large trucks. Programs to identify and correct highway segments that pose significant hazards to trucks can reduce crashes. While making changes to the highway is costly, providing information to drivers concerning upcoming hazards and providing real-time feedback on excessive speed for safe maneuvering can be implemented at relatively low cost.

Enhanced Safety Data

Good data are the backbone to any successful highway safety program. Timely and accurate data are required to identify problems (with both vehicles and drivers), establish priorities, design interventions, evaluate countermeasures, and detect emerging problems. Important data on heavy trucks and their operators come from law enforcement, the judicial system, driver records, vehicle registration, and motor carrier records. Rapid entry and compilation of such data can greatly improve the detection of problems and enable immediate intervention.

Promotion of Industry Safety Initiatives

Unlike the general population of drivers and vehicles, commercial drivers and trucks operate under management supervision. Effective supervision of drivers and the vehicle fleet requires active and systematic management to ensure compliance with all federal and state regulations. Moreover, regulatory compliance is not the only goal. Many safety management activities of the most safety-conscious fleets go well beyond minimum compliance requirements. States and motor carrier industry leaders can work together to provide consultation to carrier safety managers on best practices to ensure both regulatory compliance and safety practices above and beyond compliance. One practice to enhance fleet safety above minimum required levels is the purchase and use of truck safety technologies (such as improved brakes) and advanced technologies (such as collision avoidance warning systems).

Exhibit V-1 lists the objectives and several related strategies for reducing heavy-truck crashes. Details of these strategies are covered in the following narrative. It should be noted that this list does not represent all possible strategies to reduce heavy-truck crashes. AASHTO has chosen to concentrate efforts in this guide on lower-cost strategies that can be

implemented relatively quickly, including strategies that can be applied to "spots" on the roadway (e.g., curvature on off-ramps). With few exceptions, these lower-cost, quickly implementable strategies are covered in the following pages.

EXHIBIT V-1
Emphasis Area Objectives and Strategies

Objectives	Strategies
12.1 A Reduce fatigue-related crashes	12.1 A1 Increase efficiency of use of existing parking spaces (E)[a]
	12.1 A2 Create additional parking spaces (T)
	12.1 A3 Incorporate rumble strips into new and existing roadways
12.1 B Strengthen CDL program	12.1 B1 Improve test administration for the CDL (T)
	12.1 B2 Increase fraud detection of state and third-party testers (T, E)
12.1 C Increase knowledge re: sharing the road	12.1 C1 Incorporate Share the Road information into driver materials (T)
	12.1 C2 Promulgate Share the Road information through print and electronic media (T)
12.1 D Improve maintenance of heavy trucks	12.1 D1 Increase and strengthen truck maintenance programs and inspection performance
	12.1 D2 Conduct postcrash inspections to identify major problems and problem conditions (E)
12.1 E Identify and correct unsafe roadway infrastructure and operational characteristics	12.1 E1 Identify and treat truck crash roadway segments—signing (E)
	12.1 E2 Install interactive truck rollover signing (P)
	12.1 E3 Modify speed limits and increase enforcement to reduce truck and other vehicle speeds (T)
12.1 F Improve and enhance truck safety data	12.1 F1 Increase the timeliness, accuracy, and completeness of truck safety data (NA)
12.1 G Promote industry safety initiatives	12.1 G1 Perform safety consultations with carrier safety management (P)
	12.1 G2 Promote development and deployment of truck safety technologies (E)[b]

[a] Explanations of (E), (T), and (P) appear on page V-4.
[b] Mandated technologies are not considered to be experimental, although it would be advisable to carefully monitor and report them, as early as possible, upon an assessment of their introduction.

Types of Strategies

The strategies in this guide were identified from a number of sources, including the literature, contact with state and local agencies throughout the United States, and federal programs. Some of the strategies are widely used, while others are used at a state or even a local level. Some have been subjected to well-designed evaluations to prove their effectiveness. On the other hand, it was found that many strategies, including some that are widely used, have not been adequately evaluated.

The implication of the widely varying experience with these strategies, as well as the range of knowledge about their effectiveness, is that the reader should be prepared to exercise caution 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 them to be effective*. These strategies may be employed with a good degree of confidence, but understanding that any application can lead to results that vary significantly from those found in previous evaluations. The attributes of the strategies that are provided will help the user judge which strategy is the most appropriate for the particular situation(s).
- **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 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 them 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, reducing truck driver fatigue, is related to growing recognition of its role in both truck and passenger vehicle crashes. Truck driver fatigue is of special concern, because of the long hours of driving demanded by trucking and greater potential hazard posed by the heavy vehicle. Recent investigations (e.g., Fleger et al., 2002; Chen et al., 2002) have documented the shortage of adequate parking spaces for truckers seeking rest along Interstate and other major highways. This shortage makes it difficult to comply with federal hours-of-service restrictions. Although the CDL program has achieved many of its goals, there remain serious problems in the overall licensing program, including truck driver training schools using copies of the knowledge test to "teach the test" to candidate drivers and lax, and even fraudulent, administration of tests by third-party testers and state examiners. Because the general driving public is a major contributor to truck crashes, some effort needs to be targeted at this population

to communicate ways to share the road safely with trucks. Truck maintenance is a chronic problem, and vehicle defects contribute to serious crashes. Certain stretches of roadway, such as off-ramps or extended downgrades, are particularly hazardous for large trucks. Although making major changes in roadways may be prohibitively expensive, much less costly measures such as signs to alert drivers can reduce the risk. Trucks cross jurisdictional lines much more than other traffic, and enforcement of CDL requirements is much more effective if relevant data are made available quickly, accurately, and completely. Finally, industry—both the motor carrier industry and truck manufacturers—can play an active role in enhancing heavy-truck safety if encouraged and given good information on safety practices and equipment.

Related Strategies for Creating a Truly Comprehensive Approach

The strategies listed above, and described in detail below, are largely 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. These are of five 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 experience with PI&E campaigns in highway safety is to reach 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. Within this guide, where the application of PI&E campaigns is deemed appropriate, it is usually in support of some other strategy. In such a case, the description for that strategy will suggest this possibility (see the attribute area for each strategy entitled "Associated Needs"). In some cases, when PI&E campaigns are deemed unique for the emphasis area, the strategy is explained in detail. 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 driving under the influence (DUI), or driving without seatbelts. When that law is vigorously enforced, with well-trained officers, the frequency and severity of highway crashes can be significantly reduced. This should be an important element in any comprehensive highway safety program. Enforcement programs are conducted at specific locations by the nature of how they must be performed. The effect (e.g., lower speeds, greater use of seatbelts, safer vehicle-condition, and reduced impaired driving) may occur at or near the specific location where the enforcement is applied. Coordinating the effort with an appropriate PI&E program can often enhance this effect. 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). A pilot program is recommended when it is unclear how the enforcement effort may impact behavior or

where it is desired to try an innovative and untried method. Within this guide, where the application of enforcement programs is deemed appropriate, it is often in support of some other strategy. Many of those strategies may be targeted at either a whole system or a specific location. In such cases, the description for that strategy will suggest this possibility (see the attribute area for each strategy entitled "Associated Needs"). In some cases, where an enforcement program is deemed unique for the emphasis area, the strategy will be explained in detail. As additional guides are completed for the AASHTO plan, they may 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 level of severity and length of time that an individual spends in treatment. This is especially true when it comes to timely and appropriate treatment of severely injured persons. Thus, a well-based and comprehensive emergency care program is a basic part of a highway safety infrastructure. 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 there are improvements that can be made to this aspect of the system, especially for programs that are focused upon 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 essential to success. There should be in place a sound organizational structure, as well as 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 are often responsible for the majority of the road system and its related safety problems. They also know what the problems are better than others do. Moreover, commercial vehicle operations are unique in that they occur under the safety management—good or bad—of a transport company. Objective 12.1 F specifically addresses the data aspect of this area. As additional guides are completed for the AASHTO plan, they may address further details regarding the design and implementation of strategies for improving safety management systems.
- **Strategies That Are Detailed in Other Emphasis Area Guides:** Trucks operate around the clock, and the risk of certain types of crashes (e.g., fatigue and other road departure crashes) increases during the early morning hours. Falling asleep at the wheel is a particular problem for commercial drivers. Seatbelt use is a safety concern with passengers in heavy trucks just as it is with drivers of passenger vehicles. There are several strategies that can be used to alleviate the various problems. Some roadway-related strategies are briefly presented herein, but are not discussed in detail. More extensive information on applicable roadway design and operational strategies may be found in the following companion guides:

  – 5.1—Crashes Involving Alcohol Use
  – 8.1—Increasing Seatbelt Use
  – 15.1—Run-Off-Road Crashes
  – 15.2—Crashes on Highway Curves
  – 18.1—Head-On Crashes

Objective 12.1 A—Reduce Fatigue-Related Crashes

A major problem for many truck drivers, particularly over-the-road drivers, is finding a place to stop and rest at night, as well as for short periods during the day. Most states have existing space that could be used for additional truck parking during time periods that the space is not being used for its original intended purposes. Rest area spaces designed for passenger vehicles are usually underutilized during late night hours and could be made available to truckers seeking rest. Likewise, truck weigh stations that are not in use could be made available to truckers. Modifications to make such facilities available to truckers will not provide sufficient parking to meet the full needs of truckers, but they offer relatively inexpensive ways to quickly address the shortage of truck parking spaces.

Tennessee conducted an analysis of trucks parked adjacent to the Interstate highway and involved in crashes either while parked or when moving from a parked location along the Interstate, an Interstate ramp, or a rest area ramp. Tennessee found that, although such crashes are relatively rare, they have a much higher likelihood of resulting in fatality (5.3-fold) and a somewhat higher probability of injury (1.27-fold, Wegmann and Chatterjee, 1999).

Although truck parking space shortages are evident to any traveler on certain major Interstate highways, the dimensions of the problem were not established until 1996, when two reports were published documenting the severe shortage of parking spaces in both public and private facilities (Trucking Research Institute, 1996a; 1996b). The reports estimated that more than 28,000 additional parking spaces were needed nationwide. Three groups were surveyed—truck drivers at public and private rest areas, motor carrier executives, and truck stop operators. It was found that more than 90 percent of commercial drivers surveyed felt there was a shortage of parking facilities, especially for long-term or overnight parking. Drivers also expressed a preference for private facilities (truck stops) rather than public rest areas, citing both security concerns and the availability of amenities such as food and shower facilities. Motor carrier executives also believe there is a shortage of longer-term parking facilities, reporting that their drivers have to find places to park and sleep at shipper or consignee locations, shopping center parking lots, and exit and entry ramps to Interstates. However, truck stop operators are much less likely to recognize a problem. Nearly 7 in 10 respondents said there is no shortage of public rest area parking for truckers. All respondents reported regional differences, with the Northeast considered to have the greatest shortage. Cost and land availability pose major barriers to truck stop expansion.

In June 1999, the FHWA conducted a rest area forum in Atlanta, Georgia. There were more than 70 attendees representing various government, industry, and driver groups. Proceedings of the conference were published in December 1999 (Hamilton, 1999). A variety of issues were addressed, including safety and security, comparisons of commercial truck stops with public rest areas, alternative parking sites, funding issues, time limits, and quality of rest parking services. Participants made a number of specific suggestions for improvement of truck rest parking, some of which are discussed below.

More recently, in 2002, FHWA published two reports written in response to congressional direction to assess and analyze commercial truck parking demand and supply. In the first report, Fleger et al. (2002) conducted an inventory of public and commercial truck parking

spaces on the National Highway System, developed a truck parking demand model, surveyed truck drivers on the problem, estimated parking demand, identified major parking deficiencies, and identified improvements recommended by state partnerships to mitigate the problem. In the second report, a commercial driver survey (Chen et al., 2002) revealed widespread driver dissatisfaction with many different rest parking elements. Exhibit V-2 provides a summary of major findings.

EXHIBIT V-2
Truck Driver Assessment of Rest Parking Characteristics, in Percent

Usability Characteristic	Almost Always	Frequently	Sometimes	Rarely	Almost Never
Find available space, truck stop	9	25	51	12	4
Find available space, rest area	2	9	41	34	14
Parking convenient to highway	9	30	41	12	7
Facility has features needed	15	36	38	7	3
Parking time limits allow enough time	15	22	30	18	15
Enough room to drive in and out	8	24	48	15	6
Truck spaces used only by trucks	9	25	34	20	12

From Chen et al., 2002.

Increasing lengths of trucks plus trailers also compound the problem. Drivers of 75-foot car carriers report that they cannot fit into diagonal parking spaces designed for 45- or 53-foot trucks (Wegmann and Chatterjee, 2002). Even when they find a parking space, problems often develop. In another survey conducted by the OOIDA Foundation (1999), 15 percent of commercial driver respondents reported that they were awakened and told to drive on more than six times in the previous year. In some states, parking is limited to 2 or 3 hours, even when moving on would violate federal hours-of-service regulations. Almost three-fourths of respondents reported that this has happened to them. Furthermore, finding a space in a rest area does not necessarily allow restful sleep. Eighty-eight percent of the drivers expressed concern about robbery, with almost as many concerned about assault or theft. More than 10 percent report having been the victims of robbery in rest areas, and more than half say prostitutes have awakened them.

Private truck stops and public rest areas meet different needs, and both are needed. In the FHWA survey (Chen et al., 2002), drivers exhibited a strong preference for commercial truck stops for extended rest, meals, using phones, and performing minor maintenance. Public rest areas were preferred only for quick naps (2 hours or less) and for other quick stops like stops to use vending machines.

As noted above, drivers generally prefer commercial truck stops to public rest areas. The FHWA study of the adequacy of truck parking (Fleger et al., 2002) found that, according to driver preferences, the total demands for public and commercial rest parking were 23 percent and 77 percent, respectively. However, their inventory found that the actual number of spaces was about 10 percent public and 90 percent commercial. Thus, relative to spaces available, demand for truck rest parking at public rest areas is far more intense than that at commercial truck stops. Clearly, the inadequate number and quality of public rest parking for trucks undermines the quality of work life and contributes to fatigue for the nation's truck drivers.

Among the many possible interventions to improve truck rest parking (Hamilton, 1999; Fleger et al., 2002; Chen et al., 2002) are the following:

- Expand and improve public rest areas.
- Expand and improve commercial truck stops and travel plazas.
- Form public-private partnerships to support joint solutions, such as public purchase of lots adjacent to truck stops to increase capacity, or low-interest public loans to truck stops for expansion.
- Use alternative parking sites, e.g., weigh stations, government facilities (e.g., fairgrounds, stadiums), and receiving and shipping facilities.
- Improve parking layout to make parking easier and safer, e.g., employing more pull-through configurations.
- Improve amenities, lighting, and rest area design.
- Improve security at rest parking sites.
- Provide better information to truck drivers about rest parking availability, including real-time information on available spaces.
- Change enforcement practices, e.g., step up enforcement of parking rules to remove vehicles from ramps and shoulders, but extend time limits to allow better sleep.
- Conduct additional studies to continually assess demand and operational issues.

The remainder of this section describes three possible strategies for overcoming fatigue: one to increase efficiency of use of existing parking spaces, one to create additional parking spaces, and one to incorporate rumble strips into new and existing roadways.

Strategy 12.1 A1: Increase Efficiency of Use of Existing Parking Spaces

General Description

Drivers seeking a place to stop are rarely knowledgeable about space availability until they have actually driven into a rest area. If there are no spaces available, they are likely to "make" a space by parking on the exit ramp or in areas not designated for trucks. Knowledge about space availability prior to reaching the rest area would be helpful to drivers making decisions about whether to pull off the road in a given location.

Trombly (2003) reports a survey of state officials indicating that the provision of improved information on space availability to truckers is regarded as an improvement strategy of high potential effectiveness. The study suggests various ways that drivers can be better informed, including ways that real-time information on space availability can be provided.

On I-95, near the Virginia border, North Carolina is using a solar-assisted changeable message sign (CMS) about a quarter mile before the North Carolina Welcome Center. This sign is turned on when the Welcome Center has no more parking spaces available. The message reads "NC Welcome Center, Truck Parking Lot Full, Proceed to Next Exits."

The CMS includes a cell phone that enables remote access. Night custodial staff is trained to observe the truck parking lot. When it begins to fill up, they activate the computer to display the preprogrammed message on the CMS. This usually occurs about 10:30 to 11:00 p.m.; it is usually deactivated around 7:30 to 8:00 a.m.

EXHIBIT V-3
Strategy Attributes for Making More Efficient Use of Existing Parking Spaces

Attribute	Description
Technical Attributes	
Target	Truck drivers seeking a place to stop and rest.
Expected Effectiveness	In the North Carolina pilot study of providing real-time information on availability of parking spaces, it was shown to reduce overcrowding and parking on ramps. In the 2-week time period prior to sign implementation (in May 2001), at 7:00 a.m. there was an average of 34 trucks parked at and around the Welcome Station, which has only 19 legitimate spaces available. Counts in the 40s and even 50s were not unusual. In the first year following implementation, typical counts were in the low 20s. The number of trucks at the station has risen somewhat since, but is still well below the number before installation of the sign. North Carolina maintains that some crashes have been attributed to truck parking problems around rest areas. Although there are no studies showing a direct relationship between increasing parking facilities for truckers and crash reductions, what is known about fatigue and crashes, as well as truckers' response to increasing available parking space, indicates that such measures contribute to highway safety.
Keys to Success	Because parking facilities are often provided at state welcome centers, and because these are placed shortly after entering a state, providing timely information to drivers requires that adjoining states cooperate. This issue is of particular importance for "corridor" states, that is, states that truckers drive through on their way to their ultimate destination. Cooperative programs need to be established to enable presentation of information to drivers in time for them to make decisions about where to stop, and in corridor states, such agreements must be made for trucks entering the state and for those leaving it to enter another state. Although the North Carolina program is monitored by custodial personnel on duty at night, ideally the program would be automated, so that as parking spaces are filled, the sign would automatically be activated. Economical and practical devices to automate this function are not known to be available.

EXHIBIT V-3 (Continued)
Strategy Attributes for Making More Efficient Use of Existing Parking Spaces

Attribute	Description
Potential Difficulties	When power outages occur and the sign is not operating, the pre-implementation parking problems may reappear. Power outages also require that the system be reset. Custodial staff is not generally sufficiently computer-literate to handle this chore. Providing a supervisor with the capability of accessing the CMS from a personal computer should resolve the problem. If direction is provided to private truck stops off the Interstate, it will be strongly advisable to monitor available parking spaces in these private facilities, as well as those available in public rest areas. Such monitoring may be difficult, yet it will be important information for the driver. Unless there is a need for fuel and/or food, drivers are reluctant to spend 15 to 20 minutes seeking a parking space in a private truck stop, since there may not be one when they arrive. If significant overflow truck parking persists in illegal spaces at the rest facility, following implementation, consideration should be given to coordinating with local or state law enforcement officials to ticket illegally parked vehicles.
Appropriate Measures and Data	Process measures would include the extent to which the system is operated successfully by the custodial personnel and the extent to which the sign is activated and de-activated at appropriate times. To date, the North Carolina rest area parking staff has been highly reliable in performing these tasks. The number of locations at which a system is implemented is another useful measure. Safety impact measures should center upon crashes involving trucks, including total crashes, night crashes, and those in which drowsy driving was involved. Focus should be upon trucks that are parked or are entering or leaving a parked status. The latter will be difficult to acquire, because crashes involving parked trucks are relatively infrequent. Yet because of their severity, even a small reduction is important. However, to acquire sufficient data to relate improved parking information to such crash reduction requires that illicit parking be widely reduced over an extended period of time. Reduction in parking alongside the highway and on ramps, as well as reduction in illegal parking at rest areas affected by the message sign, can be used as a surrogate safety measure.
Associated Needs	If information for a welcome rest area is to be provided in time for an informed decision, cooperation with adjoining states is required. An information campaign, targeted at truck drivers, may be helpful to introduce improvements in parking.
Organizational and Institutional Attributes	
Organizational, Institutional, and Policy Issues	For all states, but especially for “corridor” states, Interstate agreements will be needed to provide drivers with information in time to make efficient decisions about where to seek a parking space. It would be especially useful if drivers could be given information about availability of parking spaces in private truck stops as well as public rest areas. To acquire this information in real time will require working with the private sector to ensure the timeliness and accuracy of information provided.
Issues Affecting Implementation Time	Programs such as the North Carolina Welcome Center can require implementation periods longer than a year, especially when they are the initial trial. Although the

(*continued on next page*)

EXHIBIT V-3 (Continued)
Strategy Attributes for Making More Efficient Use of Existing Parking Spaces

Attribute	Description
	strategy was identified in North Carolina in early 2000, it was not acted upon until February 2001. Night and early-morning data were compiled to determine the magnitude of the problem. Existing custodial personnel had to be trained to monitor and activate the system. The program was fully implemented May 20, 2001, less than 4 months from the outset of moving on the project.
Costs Involved	The costs for changeable message systems should be minimal. In North Carolina the cost is about $25,000 to $30,000, but because the DOT already owned this equipment, it was not an extra purchase. A permanent installation would be about the same cost or maybe slightly more. Cell phone usage costs about $20 monthly. The computer cost would be about $1,200, but in this case one was already owned. No additional personnel are needed.
Training and Other Personnel Needs	The nighttime custodial personnel already covering the Welcome Center had to be trained to monitor the number of trucks and to use the computer to activate the sign when the spaces were filled.
Legislative Needs	There do not appear to be any special legislative needs.
Other Key Attributes	
	None identified.

Information on Agencies or Organizations Currently Implementing this Strategy

The North Carolina Department of Transportation is implementing this strategy on I-95 at the Virginia state line. A point of contact is Ms. Jennifer Pitts, Rest Area Program Coordinator, NCDOT Roadside Environmental Unit, (919) 733-2920, jpitts@dot.state.nc.us.

Strategy 12.1 A2: Create Additional Parking Spaces

General Description

In some places, even more efficient use of existing parking spaces will not solve the problem. There simply may not be enough parking spaces to meet the demand. For example, a study conducted by the University of Tennessee (Chatterjee and Wegmann, 2000) observed 1,224 large trucks parked at night along Tennessee's Interstates and found that 470 (38 percent) were parked on ramps, shoulders, or other spaces not designated or intended for truck parking.

More spaces need to be created. As presented earlier in this chapter, a survey of drivers conducted by Chen et al. (2002) for the FHWA found that 48 percent of respondents felt that parking is rarely or almost never available at public rest areas. Only 9 percent of respondents reported being able to "almost always" or "frequently" find spaces in public rest areas. Trombly (2003) conducted a survey of state highway officials and found that expansion of existing rest areas was rated as one of improvement strategies with the highest potential for effectiveness. Tennessee's studies indicated a need for nearly 1,500 spaces on Tennessee's Interstates (Wegmann and Chatterjee, 1999). Kentucky determined that it needed more than 700 more parking spaces for truckers. Some modifications can be made to existing rest

stations to create more parking places in the space available, as well as allowing nighttime truck parking in spaces used by passenger vehicles during the day. Kentucky also developed the concept of "Rest Havens," whereby modifications are made to existing truck weigh stations to create additional parking spaces. Other possibilities include adding and/or opening of pullout areas and building entirely new rest areas.

Ideally, Rest Havens also include restrooms and vending machines. Clean restrooms help ensure that the overall facility is an attractive, quality location for drivers to rest.

The Rest Haven concept is one that can make optimal use of available space, but for this approach to work, truck drivers must be assured that their parking there will not subject them to increased probability of inspection, thus delaying them and increasing their risk of fines and/or being placed out-of-service.

EXHIBIT V-4
Strategy Attributes for Creating Additional Parking Spaces

Attribute	Description
Technical Attributes	
Target	Truck drivers seeking a place to stop and rest.
Expected Effectiveness	Additional parking spaces should allow for more available rest for truck drivers and thus reduce fatigue-related crashes. Although there are no studies showing a direct relationship between increasing parking facilities for truckers and crash reductions, what is known about fatigue and crashes, as well as truckers' response to increasing available parking space, indicates that such measures contribute to both driver wellness and highway safety.
Keys to Success	Several factors will increase the efficient use of additional parking spaces for truckers. First, if possible, drivers should be informed of space availability in time for them to make a judgment about whether to stop or continue to drive. Second, drivers need to feel secure in the available parking space. Robbery, assault, and soliciting for drugs and/or prostitution are problems that truckers confront in many rest areas. Lack of security reduces the attractiveness of parking spaces. Truck drivers prefer areas where passenger vehicles are not allowed, because the common belief among truckers is that "cars bring trouble." Kentucky is installing security cameras at Rest Havens to promote safety. Signs are displayed to indicate spaces that are reserved for trucks. Third, truckers need to feel secure from aggressive enforcement. Some states limit the length of time a trucker may stop and rest, even though requiring a trucker to move on may result in a violation of hours-of-service regulations. If truck weigh stations provide Rest Haven parking, drivers must be assured that using the spaces will not subject them to inspections they would not otherwise undergo. Publicizing Rest Haven availability can be accomplished through the trucking industry, trucking publications, and the media. Although not absolutely essential, amenities such as rest rooms and food services increase the attractiveness of rest areas. Success also depends upon support from the highest level, e.g., head of the department of transportation, for creation of Rest Havens in weigh stations.

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EXHIBIT V-4 (Continued)
Strategy Attributes for Creating Additional Parking Spaces

Attribute	Description
Potential Difficulties	Potential difficulties include the obverse of the keys to success. First there is the problem of funding. Kentucky added $2 million to the budget for new weigh stations to cover the cost of additional parking spaces, a building to house rest rooms, vending machines, and a monitor providing weather and road conditions in the area. The goal is to expand five stations in the state and create additional Rest Havens. Second, concerns about aggressive enforcement will reduce the use of available facilities. Motor vehicle enforcement personnel who staff weigh stations are likely to object to exempting truckers from inspection if they use the parking available in the Rest Haven. This opposition must be overcome, if the concept is to succeed. Third, concerns about physical assault and/or unwanted solicitations will discourage use of the Rest Haven. Also, if a driver needs food, or desires to use a rest room, the absence of these amenities may require continuing to another location. Fourth, some opposition may come from private truck stop operators who may consider the state's providing these facilities to be undue and unnecessary competition with private industry.
Appropriate Measures and Data	Process measures include the change in the number of parking spaces, or space-hours, made available to truckers. Safety impact measures should center upon crashes involving trucks, including total crashes, nighttime crashes, and crashes in which drowsy driving was involved. Focus should also be on trucks that are parked or are entering or leaving a parked status. The latter will be difficult to acquire, because crashes involving parked trucks are relatively infrequent. Yet because of their severity, even a small reduction is important. However, to acquire sufficient data to relate improved parking information to such crash reduction requires that illicit parking be widely reduced over an extended period of time. Reductions in parking alongside the highway and on ramps, as well as reductions in illegal parking at rest areas affected by the message sign, can be used as surrogate safety measures. Where Rest Havens have been constructed, feedback provided in suggestion boxes can be used.
Associated Needs	In addition to providing parking spaces, it would be beneficial to provide information to drivers concerning availability of space. It is also important that drivers know that parking in weigh stations will not subject them to an inspection that would not otherwise occur. An information campaign, targeted at truck drivers and employing trucker-oriented media or publications, may be helpful to introduce improvements in parking. Some arrangement must be made for custodial maintenance of the Rest Haven.
Organizational and Institutional Attributes	
Organizational, Institutional, and Policy Issues	There must be backing from the highest level for the Rest Haven concept to succeed. Motor carrier enforcement personnel, as well as the trucking industry, need to be onboard. Commercial truck stop owners and their trade associations (e.g., the National Association of Truck Stop Operators) are likely to point out that many private truck stops have unutilized spaces and that drivers should be responsible for planning ahead to park at legal locations and in accordance with hours-of-service regulations.

EXHIBIT V-4 (Continued)
Strategy Attributes for Creating Additional Parking Spaces

Attribute	Description
Issues Affecting Implementation Time	In Kentucky, it was estimated in 1996 that they had a shortage of 733 commercial parking spaces. Using available parking areas at loadometer stations, they were able to open their first Rest Haven in 1999 and are working to create others. Funding and availability of land are prime factors in the speed with which the Rest Haven concept can be realized.
Costs Involved	Costs will vary widely, based upon the option used to provide additional space. Renovating existing rest areas or creating Rest Havens in spaces already available in weigh stations will be relatively inexpensive. Providing new rest areas will be costly. Virginia estimates that its cost of creating a new rest area solely for trucks comes to about $51,000 per building. However, Kentucky estimates a cost of $10,000 per parking space in its Rest Havens. Kentucky also provides a 1,000-square-foot rest room/vending building with utilities that cost $150,000 each. Where these buildings are not yet constructed, "porta-potties" are provided.
Training and Other Personnel Needs	There should be no special training required for this strategy. However, an understanding and appreciation of the role of fatigue in truck crashes may generate more enthusiastic involvement than would otherwise be the case. Implementing this strategy will primarily require the skills and expertise of existing personnel in departments of transportation. However, there will be a need for custodial care of the new facilities.
Legislative Needs	There do not appear to be any special legislative needs, although legislative appropriations may be required for funding.
Other Key Attributes	
	The issue has been raised as to whether states should assume responsibility for providing adequate parking spaces for truckers. It is argued that truckers know where to find a place to park, and if they experienced severe consequences for parking on the roadside, they would stop parking there. It is not the state's responsibility to make life great for the trucking industry. Bigger companies often make arrangements for places to park their trucks. They have regular routes, know who their customers are, and know how/where their drivers can sleep. The opposing line of reasoning is that while this may be true for large operations, by far the majority of motor carriers have fewer than 10 trucks, with most having fewer than five. Simply ticketing drivers is problematic, in that the shortage of resting space arises from a wide range of sources, including shippers, motor carriers, and the competition for loads. Ticketing drivers and moving them on may create public safety problems.

Information on Agencies or Organizations Currently Implementing this Strategy

Appendix 1 is a state agency profile providing more information on the Kentucky Rest Haven initiative. *NCHRP Synthesis of Highway Practice 317: Dealing with Truck Parking Demands* (Trombly, 2003) includes 10 specific strategies for expanding and enhancing public facilities.

Strategy 12.1 A3: Incorporate Rumble Strips into New and Existing Roadways

General Description

Factors influencing driver alertness include time of day (i.e., "circadian troughs" like 3:00 to 5:00 a.m.), amount of sleep, and time on task (hours driving) (Wylie et al., 1996). Many commercial drivers obtain far less sleep than desired for full alertness (Wylie et al., 1996). One of the signature effects of reduced alertness is a deterioration of lane keeping (Wierwille et al., 1994). Thus, single vehicle run-off-the-road crashes are typical of drivers who fall asleep at the wheel. Head-on crashes may also result in two-lane and multilane undivided highways. Rumble strips have been shown to be effective in reducing this risk on Interstate highways and are now being pilot tested on other types of roads. Although most fatigue-related crashes involve drivers of passenger vehicles, truck drivers may be especially benefited because of their long hours of driving and the necessity of frequent nighttime driving.

The use of rumble strips is discussed at length in the guides addressing run-off-road crashes (Strategy 15.1) and head-on collisions (Strategy 18.1).

Objective 12.1 B—Strengthen CDL Program

In 1986, Congress enacted legislation providing for the commercial driver's license (CDL), that is, a special license for drivers operating large vehicles, transporting more than 15 passengers, or carrying hazardous materials. The legislation established mandatory federal standards for state licensing programs. These standards required that the driver hold only one license and meet certain minimum standards for testing and licensing. This legislation was implemented over a period of years, so that all drivers of the affected vehicles were covered by spring 1992. The Motor Carrier Safety Improvement Act of 1999 strengthened the earlier legislation and established a new federal agency, the Federal Motor Carrier Safety Administration, to administer the program.

Even with strong federal legislation mandating CDL requirements, there remain major problems with the program. Not all states comply with all of the provisions of the CDL, especially when it comes to Interstate reporting of infractions (FHWA, 1999a). Another serious concern is the fraudulent issuing of licenses, either by state examiners or by third-party testers. Because a CDL is, in effect, a license to hold a job, both drivers and motor carriers may resort to extreme measures.

Surveys conducted by the American Association of Motor Vehicle Administrators (AAMVA) in 2000 also found that some states routinely disregard some CDL program requirements. Of 10 states visited, 5 reported occurrences of not disqualifying commercial drivers due to convictions received through the Commercial Driver License Information System (CDLIS). Seven of the 10 states visited and 15 other states that responded to AAMVA reported that their courts enable drivers to avoid disqualification that technically should be implemented, through special licenses or permits to operate commercial motor vehicles (CMVs). The surveys uncovered other major problems as well.

Public health and safety in every state are placed at risk if even a few states fail to meet federal CDL requirements. This is because a CDL from one state allows a driver to operate in any other, and heavy trucks typically operate across state lines.

Some states conduct careful monitoring of CDL testing, whether by third parties or by their own examiners. Such monitoring can reduce the incidence of licensing unqualified drivers.

Failure of states to fully implement all elements of the CDL act could explain the negative results of a California study by Hagge and Romanowicz (1996). Using intervention time-series analyses, these authors found no evidence that California's implementation of the major provisions of the act in 1989 had any effect on subsequent heavy-vehicle crash rates. However, not all of the provisions were implemented, many drivers received waivers, and the commercial driver road test used by California was found to be unreliable in a parallel study by Clark (1995).

The need to strengthen the CDL program has been duly recognized at the state and federal levels and in 2002 resulted in a joint effort by AAMVA and FMCSA to reduce licensing and testing fraud by implementing a comprehensive set of 14 initiatives. The strategies embedded in these initiatives embrace and go well beyond the scope of the strategies presented in this guide. As such, an administrative mechanism has already been established to develop and implement the CDL enhancements proposed in this guide. The 14 initiatives are summarized below, along with their respective AAMVA staff contacts.

1. Develop and implement a comprehensive fraudulent document recognition training program for driver licensing and law enforcement personnel. Contact is Brett Robinson, 703-908-2808, brobinson@aamva.org.
2. Complete and distribute a model program of uniform identification procedures for issuing driver licensing and identification documents. Contact is Harold Kocken, 703-908-5774, hkocken@aamva.org.
3. Convene an international symposium on driver licensing fraud and document identification (completed).
4. Develop and maintain a manual setting forth "best practices" policies and guidelines for improving CDL competency assessment, driver control, and fraud detection. Contact is Kevin Lewis, 703-908-2823, klewis@aamva.org.
5. Develop and maintain an accessible online database and library for law enforcement and issuing agencies containing samples and exemplars of valid and counterfeit identification documents. Contact is Harold Kocken, 703-908-5774, hkocken@aamva.org.
6. Establish an electronic warning system for reporting incidents of licensing and identification fraud within jurisdictions. Contact is Harold Kocken, 703-908-5774, hkocken@aamva.org.
7. Develop an online DMV verification system to enable private-sector and governmental entities to verify the validity of state-issued driver's licenses and identification cards. Contact is Randy Holleger, 703-908-2844, rholleger@aamva.org.
8. Perform a pilot evaluation of a digitized driver licensing/identification image exchange program. Contact is Randy Holleger, 703-908-2844, rholleger@aamva.org.
9. Expand the computerized Commercial Driver License Information System (CDLIS) to provide Interstate license status and driving record history message exchanges among all

states. This capability currently exists for all CDL holders, but not for non-CDL truck drivers in some states. Contact is Randy Holleger, 703-908-2844, rholleger@aamva.org.

10. Develop an online verification system that interfaces "vital event" records (Immigration and Naturalization Services [INS], birth certificates, etc.). Contact is Randy Holleger, 703-908-2844, rholleger@aamva.org.
11. Identify a "best method" for implementing a uniform state digital certification procedure for use in certifying and validating documents and authenticating the issuing agency. Contact is Rich Carter, 703-908-8296, rcarter@aamva.org.
12. Establish a document security laboratory staffed by persons with expertise in licensing procedures relating to document security, maintenance, and machine-readable verification technologies. Contact is Rich Carter, 703-908-8296, rcarter@aamva.org.
13. Determine the minimum biometric identifiers for licensing and identification and define the operational requirements of individual matching. Contact is Rich Carter, 703-908-8296, rcarter@aamva.org.
14. Create and implement a new and enhanced driver license agreement (DLA) setting forth specific state procedures and policies relating to licensing, record maintenance, and monitoring of all drivers. Contact is Brett Robinson, 703-908-2808, brobinson@aamva.org.

The above initiatives are in various stages of progress, and some are not due for completion until 2005.

Initiative 4 has the most relevance to the present implementation guide because it directly relates to driver competency assessment and the objective of reducing fraud among DMV and third-party testers. In fact, the development of a "model program" or "best practices" manual addresses the same problem and strategy that are outlined in the following two strategies (12.1 B1 and 12.1 B2).

Strategy 12.1 B1: Improve Test Administration for the CDL

General Description

The knowledge test for CDL is lengthy and must cover many different areas or domains. Knowledge test construction is extremely difficult, so that usually only a few versions of a test in hard copy exist. However, printed versions of the test can fall into the hands of potential applicants. There is no way to totally prevent this from happening, but some states are moving toward computerized administration of knowledge tests, with randomized selection of questions, as well as randomized answer choices, so that no two applicants are likely to receive the same test. Even when not all licensing offices are equipped with computer test administration capability so that some tests must be offered in paper and pencil format, the computerized capabilities may allow the examiner to print out hard copies, each of which is a unique combination of test items and answer choices. The AAMVA has developed computerized testing software and a pool of over 600 test items for state use in testing CDL drivers. This system, which is currently in use or under consideration in many states, can develop unique tests of randomly selected items for each applicant. States that do not have automated testing capability can use the software to generate paper tests that are changed every several weeks.

EXHIBIT V-5
Strategy Attributes for Improving Test Administration for the CDL

Attribute	Description
Technical Attributes	
Target	Applicants for CDL.
Expected Effectiveness	The administration of the knowledge test, using randomized items with randomized answer choices, should reduce advance knowledge of specific test items. Since both items and answer choices will differ from one test to another and over time, memorizing items for later recall would be ineffective.
Keys to Success	Computerized creation of tests and administration of tests precludes copies of the test from being removed from the licensing office. In the case of stations that are not equipped to provide computerized testing, randomized copies of the test can be printed ahead of time to be used in those stations. Every test will be different, making it difficult for truck driver training schools to "teach the test." The computerized test is scored automatically and provides immediate feedback on incorrect answers, thus making the testing a potentially more effective learning situation. When an applicant reaches the point that he or she has failed or has answered enough questions correctly, the test is terminated.
Potential Difficulties	Because hard copies of the test are generated for manual administration in stations without computerized capability, there is the possibility of questions becoming publicly available. It is important that test security be maintained. Start-up costs could be a problem for some states.
Appropriate Measures and Data	Process measures would include the number, rate, and percentage of applicants processed using the improved techniques of administration. Reductions in examiner time involved in testing can also be measured. It will not be feasible to measure this strategy's effect on crash experience, as there are many other factors more directly involved in a crash. It is possible that one could measure the recidivism rate (both citations and crashes) of drivers taking the computerized exam versus those taking the paper-and-pencil version, but it is likely that these applicants differ in other ways as well. Surrogate impact measures include length of time taken to complete the computer-administered test compared with previous paper-and-pencil administration; the ease of test administration, that is, how well the programmed materials work; and the initial failure rate immediately following implementation of the computerized test administration. If copies of the test were previously available, it may be anticipated that failure rates would increase when the test administered is not the same as the previous versions.
Associated Needs	Good computer hardware and software are necessary, as well as computer support services.
Organizational and Institutional Attributes	
Organizational, Institutional, and Policy Issues	None identified.
Issues Affecting Implementation Time	The availability and costs of the necessary hardware and software, as well as the computer support required to implement and maintain the system, will affect the time required to implement.

(*continued on next page*)

EXHIBIT V-5 (Continued)
Strategy Attributes for Improving Test Administration for the CDL

Attribute	Description
Costs Involved	Costs include the hardware and software required, as well as the cost of computer support personnel and training.
Training and Other Personnel Needs	Some training of driver license personnel will be required.
Legislative Needs	There do not appear to be any special legislative needs.
Other Key Attributes	
	None identified.

Information on Agencies or Organizations Currently Implementing this Strategy

Georgia is in the process of implementing this strategy, and Pennsylvania, Delaware, and New York are using it statewide. A point of contact in Georgia is Mickey Rawls (678-413-8495, mrawls@dmvs.ga.gov). The Pennsylvania point of contact is Pam Gabriel (717-705-2418, pgabriel@state.pa.us). A point of contact for AAMVA is Kevin Lewis (703-908-2823, klewis@aamva.org). California has been considering this strategy but has not yet adopted it due to operational and budgetary constraints. Instead, it uses three equivalent test forms developed from a large item pool and randomizes the sequence of items on each printed form quarterly. It is believed that this reduces, but does not eliminate, the problem of applicants memorizing specific test items. Points of contact for California are Martha Boudreau (916-657-8267, mboudreau@dmv.ca.gov) and Robert Hagge (916-657-7030, rhagge@dmv.ca.gov).

Strategy 12.1 B2: Increase Fraud Detection of State and Third-Party Testers

General Description

Possession of a CDL is essential to hold certain kinds of employment. As such, it is highly prized, and some drivers, as well as some motor carriers, are willing to pay premium prices to see that CDLs are issued. According to AAMVA (1999a), most states have provisions for third-party testers. Many states do not cap the fee that may be charged, and average fees may run as high as $150. Given the importance of the CDL and the amount of money involved, there is room for fraudulent issuance of licenses in the absence of quality control (FMCSA, 2000b). Federal regulations require that third-party testers be audited at least once a year, but fraudulent issuance of licenses has been detected in several states. Not all states are adhering to federal requirements. To ensure the integrity of the licensing process, states need to have in place procedures that closely monitor both state examiners and third-party testers.

Although there are no state or national statistics quantifying the magnitude of the problem, the documented cases and anecdotal evidence suggest that fraud involving third-party testers and/or DMV personnel is cause for concern. In Pennsylvania, for example, a large number of third-party test providers were detected accepting bribes in connection with the training, testing, and licensing of truck drivers. The problem required the state to retest over 1,000 CDL drivers in order to certify their competency and withdraw licensure from those

who could not legitimately pass the skill and road test. In response, Pennsylvania instituted a number of truck safety initiatives to reduce third-party testing fraud. The program consists of the following strategies:

- Improved on-site auditing procedures,
- Computer analysis of transactions to identify suspicious or statistically deviant third-party providers and testers (i.e., analysis of test scores, failure rates, number of tests per day, etc.),
- Covert surveillance, and
- The requirement that third-party testers post a performance bond to cover the cost of any retesting.

The covert surveillance is performed by a private firm contracted by the state. An innovative feature of the covert surveillance is the use of undercover operatives posing as applicants and testing observers in follow-up vehicles. The authority to use covert observation is explicitly stated in the contractual certification of each third-party tester.

As noted above, AAMVA and FMCSA have been working to develop a "best practices manual" to assist the states in detecting and controlling fraud among both third-party and DMV test administrators. This manual is not yet published or otherwise available, but it is possible to outline here some of the concepts and issues that ultimately need to be addressed in developing a comprehensive program of fraud reduction and test quality control.

Test Auditing Standards. The use of covert observation as in the Pennsylvania program is a highly innovative approach to fraud detection that is promising. However, its expense and operational complexity might limit its use in some states. It therefore should be considered as one element of a comprehensive auditing model, as it is in Pennsylvania. The current federal audit regulations require that each certified third-party tester be audited once a year. The regulations do not specify the technical requirements of the audit with respect to sample size (number of tests reviewed) or the method of detecting statistical and psychometric aberrations in the audited tests or in other indices that might be indicative of fraudulent or sloppy test procedures.

California operates an employer testing program (ETP), since only third-party testers affiliated with a commercial driver employer are certified to give the test to their applicants. Approximately 1,000 ETP providers operate in California and roughly 7 percent of all commercial drivers are tested by ETP providers. These ETP providers frequently offer training, which means that the trainer and test examiner are not always independent and can be the same person. Pennsylvania licenses 60 percent of its truck drivers through third-party testers, but the third-party testers do not have to be employers; most of Pennsylvania's third-party testers also provide the training.

In most disciplines, it is normally not desirable for training and competency-certification to be performed by the same individual because the trainer, in a sense, ends up evaluating his or her own training and may also have an interest in pleasing the client. However, this tendency might be lessened when the training and testing are done by an employer because the employer has a strong vested and corporate interest in not employing incompetent drivers.

California audits each ETP provider once a year, and roughly 10 percent of the test score sheets are randomly selected for inspection in each audit. Over the past 3 years, approximately 32 sanctions per year have been taken against ETP providers, but there have been no instances of legally verifiable fraud. (However, there have been fraud cases involving DMV personnel.)

Like most states, California has no quantitative management information system or statistical quality control database for quickly detecting scoring variations and patterns among either DMV examiners or ETP providers/examiners. California, however, has performed periodic psychometric reliability and validity evaluations of its passenger vehicle road test. The California commercial driver skill and road tests are patterned after an objective route sampling and scoring procedure used for the passenger skill and road test and on the so-called Essex test described by Mackie et al. (1989). Since this approach has been found to be valid and reliable, the DMV believes that the current commercial road test is psychometrically sound. However, generalizing this deduction to tests administered by non-DMV staff involves a number of inferences and assumptions.

California has performed statistical analyses of the comparative crash rates of ETP-licensed and DMV-licensed commercial drivers (Chapman, 2003). It was found that ETP-tested drivers had 22 percent more fatal/injury crashes during the 2-year period following testing—a difference that was highly significant statistically ($p < 0.001$). However, Chapman properly cautions that the difference could be attributable to a number of confounding variables that were not available for analysis, most notably driving mileage and type of exposure.

The above analysis was made possible by the availability of the necessary data elements on the California driver record file, and the approach could be extended to examine test scoring indices and patterns among DMV and third-party testers if all test results were computerized and made linkable to individual driver records. In addition to identifying providers and testers with suspect score patterns, the existence of such a system could provide some deterrence against shoddy and fraudulent test practices. The major requirements for such a system would be converting test results to electronic format and establishing a common identification linkage across record systems.

It is possible to tabulate test volume and fail rate counts without linking data elements to individual driver records. However, most states do not currently maintain test score information that can be easily tabulated by individual state examiners or third-party providers. The 1997 survey by AAMVA (1999a) reported that the majority of states were unable to provide counts of either the volume or failure rate of CDL road tests administered by either state or third-party providers. Only 15 states could supply these statistics for CDL road tests administered by the state, and only 9 reported these statistics for third-party tests. The absence of such information limits the ability to (1) identify statistically aberrant state and third-party testers; (2) establish statistical baselines for use in assessing the effects of improved auditing procedures; and (3) implement statistical quality control systems for monitoring CDL road testing on an ongoing basis.

One of the strategies in the Pennsylvania fraud-detection program is to inspect data on the test scores, failure rates, and daily number of tested commercial drivers. This information is currently accessible electronically, and the potential exists for developing a statistical

management information system that would tabulate these statistics by area, month of testing, individual examiner, third provider, and organization (state versus private).

A final type of auditing that warrants serious consideration is for states to retest random or representative samples of third-party-certified drivers. In fact, such authorization is authorized in title 49 part 383.75 of the federal regulations and in California is explicitly authorized in the state's written agreement with each third-party employer. The AAMVA survey of state practices reported that 18 states randomly retest third-party-certified commercial drivers and six states randomly retest samples of state-tested commercial drivers (AAMVA, 1999a). The six states that randomly retest both state- and third-party-tested drivers are Colorado; Washington, D.C.; Kansas; Kentucky; Mississippi; and Montana.

If one can assume that the retest is reliable and valid, the retest policy provides a powerful mechanism for estimating the proportion of third-party and state-tested licensees who should have been failed. Although this approach would not be able to identify many individual incidents of fraud, it does address the more general question of the adequacy of a state's commercial driver licensing program. Moreover, in states where retesting is used for both state and third-party licensees, a comparison of retest failure rates provides information on whether the two test systems are approximately equivalent in terms of competency assessment. A substantial or increasing incidence of fraud would be among the factors causing a higher incidence of retest failures. Third-party providers with suspect retest failure rates and individual retest failure cases would then be subject to additional review for evidence of fraud. An analysis of retest failure rates over time also provides criteria for evaluating the effects of fraud-prevention strategies.

Two practical disadvantages of the above approach must be acknowledged. The first is cost. Commercial driver road tests are expensive. However, samples as small as 200 would provide relatively stable estimates and would not be cost-prohibitive for many states. A second problem is negative reactions of drivers to the inconvenience of being tested a second time.

Driver Competency Measurement. The detection and elimination of fraud in licensing commercial drivers is a valid goal in and of itself, apart from any nexus with public safety. As a safety initiative, however, it is anchored in the implicit premise that the skill and road test are reliable and valid indicators of driver competency. Guidelines for constructing reliable and valid tests are described by McKnight (1999), and applications to a state DMV program are described by Clark (1995) and Peck (1996). A model commercial driver testing program based on these principles is described in a study commissioned by AAMVA (Mackie et al, 1989). Whether competency assessment is done by state examiners or by third parties, the test should be based on sound psychometric principles and there should be periodic checks of two types of test reliability (internal consistency or "sampling" reliability and inter-rater reliability). Most states periodically review state and third-party exam score sheets but do not include a formal analysis of the reliability indices described by McKnight (1999). As noted above, a state's assessment of the quality of a third-party tester assumes that the test standards used by the state are reliable and valid.

The commercial skill and road test used by many states is based on the Essex model or subsequent variations of that test. To the extent that a state uses this validated model, it is permissible to conclude that the test has adequate sampling reliability based on a simple

content analysis and comparison with the model. However, this approach is much more tenuous in assessing the inter-rater reliability of the state test. This latter reliability is heavily dependent on the adequacy of examiner training and periodic examiner monitoring. These exigencies are likely to become more critical in generalizing reliability estimates to third-party testers and tests given by trainers.

State Implementation. The intent here is to present some of the elements that should be considered in developing a "best practices" manual for state use in strengthening the CDL through improved testing and fraud detection. Cost and operational feasibility are among the factors to consider in implementing these strategies.

EXHIBIT V-6
Strategy Attributes for Increasing Fraud Detection of State and Third-Party Testers

Attribute	Description
Technical Attributes	
Target	State examiners and third-party testers using careless or fraudulent methods that assist drivers in meeting CDL requirements.
Expected Effectiveness	Effective monitoring of third-party testers should reduce CDL issuance to applicants who do not meet CDL requirements. A strong program of auditing also reduces the need for re-testing of applicants who were not adequately tested originally. However, no formal evaluations are available.
Keys to Success	There must be a system for regular review and auditing of both third-party testers and state examiners. Undercover testing may be conducted in which an applicant deliberately performs poorly, e.g., crossing the center line several times. The performance is videotaped by another undercover person following in another vehicle, so that if the candidate is passed, there is evidence that he should have been failed. A statistical reporting system should be established to provide test scores or failure rates by individual examiners and third-party organizations. The reporting system should have the capacity to tabulate scores by month and provide periodic management information reports. Candidate examiners must be thoroughly evaluated, including a criminal history check and a driver history check. In the case of rejection, a candidate examiner has a right to appeal (e.g., if a criminal offense occurred years ago in one's youth and there is evidence that the person has led an exemplary life since then). Examiners should be recertified annually. To ensure that there will be third-party testers available in all parts of the state, new testers are solicited through a statewide bulletin akin to the Federal Register. The areas where testers are needed are identified, and testers are added only in those areas. Prior to program implementation, even though no new legislation may be required, the state legislative leadership should be briefed to ensure their understanding of the new program and why it was being implemented.
Potential Difficulties	When improper or fraudulent testing is detected, it is essential that all applicants who have been issued a license by the testers involved be recalled for re-testing. Because of the expense involved, third-party testers are required to post bond.

EXHIBIT V-6 (Continued)
Strategy Attributes for Increasing Fraud Detection of Third-Party Testers

Attribute	Description
	Where a performance bond is required, bond companies may have no experience with such a program. A bond requirement may also cause some potential third-party testers to avoid, or withdraw from, the program. Unlike state examiners, third-party testers charge fees that may be as much as $150 or more. Because the candidate is paying so much, the tester may feel that a license should be issued even if the performance is below standard. This tendency to want to pass a candidate, because of the high cost, must be resisted by the third-party tester. Although there is no charge for the exam if a state examiner conducts it, candidates may prefer a third-party tester for two reasons. First, there is no delay in scheduling a test. Second, unlike the state, the third-party tester can usually rent a vehicle to the applicant.
Appropriate Measures and Data	Process measures would include the number and type of changes made in the program, as well as the number and percent of applicants processed using the improved techniques of administration. Safety performance measures: It will not be feasible to measure the impact of this strategy on crash experience, as there are so many other factors more directly involved in a crash. Surrogate impact measures can include the rate of detection of fraudulent license issuance and the changes in this rate as tighter monitoring is implemented. Frequency of two types of problems should be monitored, namely, sloppy testing and fraudulent testing. Sloppy testing is when a candidate performs poorly but is still issued a license. Fraudulent testing is when portions of the testing are omitted entirely. In the case of sloppy testing, the testing privilege may be suspended until the third-party tester can provide an acceptable management plan for quality control. Fraudulent testing should lead to dismissal from the program, as well as payment for re-testing of all candidates who have gone through the program. Measuring the number of re-tests required is also of interest. Tracking pass/fail rates can also identify examiners who may be passing or failing too many applicants. Also, a high number of tests administered in a day can identify fraudulent testing, since a valid test takes significant time.
Associated Needs	None identified.
Organizational and Institutional Attributes	
Organizational, Institutional, and Policy Issues	The program would usually be administered through a DMV Bureau of Driver Licensing and requires no participation from other agencies. However, it may be appropriate to inform legislative leadership about what is being done and why.
Issues Affecting Implementation Time	In Pennsylvania, it took about a year and a half to develop new procedures and put them in place. However, there had been a prior system in place that divided the state into three sectors, each handled by a project manager. The project manager trained examiners, managed the program, and conducted audits. Under the new system, there is one contract manager who conducts the training. If the covert testing is to be conducted by a private organization, it will probably be necessary to go through the state bidding process, necessitating delay in implementation.

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EXHIBIT V-6 (Continued)
Strategy Attributes for Increasing Fraud Detection of Third-Party Testers

Attribute	Description
Costs Involved	With the implementation of the new program in Pennsylvania, state costs were actually reduced, in that three project managers were replaced with one. Auditing of third-party testers is now conducted by about 150 state examiners, but no one examiner audits the same site for more than 2 years to prevent close relationships from developing. With this new system, the rate of tester auditing increased from once a year to twice a year.
	Private-sector, third-party testers must provide a performance bond. If it is determined that persons they tested must be re-tested, the cost of re-testing must be covered. The amount of the performance bond is based upon the number of tests given. In Pennsylvania, it ranges from $100,000 to $250,000.
	There are normally no state costs for the third-party testing.
Training and Other Personnel Needs	With the implementation of the new system, all examiners, both state and those with third-party testers, should be re-certified. Examiners should be given in-service training and re-certified on a yearly basis to ensure quality control.
	If, through an audit, an examiner is identified as having a problem, that examiner must go through retraining before conducting any further exams. All examiners and third-party testers should be assembled annually to discuss any questions or issues of concern and to receive additional training.
Legislative Needs	Legislation may be needed to adopt the federal CDL requirements as a whole if they are not already adopted.
	It is advisable that key legislators be briefed about the program, including what is to be done, how, and why.
Other Key Attributes	
	None identified.

Information on Agencies or Organizations Currently Implementing this Strategy

The information provided is based particularly on Pennsylvania's program for ensuring quality control for CDL testing. A contact in Pennsylvania is Joy Gross (717-787-9930, joygross@state.pa.us). The information has also been influenced by joint in-progress activities of AAMVA and FMCSA as described above. A contact for AAMVA is Kevin Lewis (703-908-2823, klewis@aamva.org), and a contact for FMCSA is Bob Redmond (202-366-5014, Robert.Redmond@fmcsa.dot.gov). A contact for the California research and development program is Robert Hagge (916-657-7030, rhagge@dmv.ca.gov). A contact for California's employer test program (ETP) is Linda Stanley (916-657-8667, lstanley@dmv.ca.gov).

Objective 12.1 C—Increase Knowledge on Sharing the Road

About 85 percent of vehicle occupant fatalities resulting from large-truck crashes occur not in the truck but rather in other vehicles involved in the crash (FMCSA, 2003a). Analysis of driver-related factors in crashes between large trucks and passenger vehicles indicates that

passenger vehicle driver errors or other driver factors are cited in more than two-thirds of these crashes, whereas truck driver errors are cited in less than one-third (Craft and Blower, 2003b; FHWA, 1999c; Blower, 1999). Passenger vehicle driver behaviors such as improper lane changes have been found to be among the highest-risk behaviors around trucks (Kostyniuk et al., 2002).

Using a fleet of instrumented trucks, Hanowski et al. (2001) observed and analyzed 210 critical incidents (driver errors resulting in potentially unsafe conditions) involving the interaction of a large truck and light vehicle. The most common errors were lane changes without sufficient gaps, entrance onto the roadway without adequate clearance to the trailing truck, left turns without adequate clearance to the trailing truck, and late braking for stopped or stopping traffic. More than three-quarters of such incidents were attributed to drivers of light vehicles in the vicinity of trucks, rather than to truck drivers. Clearly, the driving public needs to improve its driving practices in the vicinity of large trucks. Drivers of passenger vehicles are making most of the errors leading to crashes and fatal crashes, and they are suffering most of the injury consequences.

The above findings indicate a need for a broad-based public understanding of the hazards associated with driving too close to heavy trucks. Public awareness and understanding of this issue is critical to heavy-truck safety, although it may take years to see significant improvements. In many ways, the task is analogous to the challenges associated with achieving public understanding and acceptance of safety belt effectiveness and the hazards associated with drinking and driving. It was not until there was sufficient public understanding of these issues that meaningful measures could be implemented. The effectiveness of these measures accounts for the major gains that have been made in highway safety over the past quarter century. In the same way, public understanding of the need to drive carefully in the vicinity of large trucks must be achieved. Although it will take time, the sooner it is initiated, the sooner the heavy-truck crash toll may be reduced.

Until recently, FMCSA outreach and other public information programs on sharing the road with heavy trucks have emphasized the "No Zone" concept. Like passenger vehicle drivers, truck drivers have blind spots in the rear and sides of their vehicle, but for trucks, these blind spots are much larger. It is especially hazardous for other vehicles to position their vehicles in the truck driver's blind spots, as well as in the area immediately in front of the truck. Truck maneuverability and stopping capabilities are of course much less than those of smaller vehicles. When a collision does occur, the massive size of large trucks compared with light vehicles (up to 25 times more mass) creates a huge injury potential for drivers and occupants of the smaller vehicles.

Understanding the "No-Zone" is a fundamental step for safer driving by motorists operating in the vicinity of large trucks. However, in recent years, FMCSA and its partners have shifted the focus of their program to the broader concept of "Share the Road." The intent is to target all road users and to increase public awareness of a broader range of potentially hazardous interactions among large and small vehicles. These include tailgating trucks and cutting in front of trucks when passing. FMCSA plans to implement a Share the Road pilot in one or more states, combining targeted, multimedia outreach and intensive enforcement of traffic laws prohibiting unsafe light-vehicle maneuvers around trucks such as cutting in front. This program is expected to become a centerpiece of the FMCSA Share the Road program.

Strategy 12.1 C1: Incorporate Share the Road Information into Driver Materials

General Description

The Share the Road Coalition (www.sharetheroadsafely.org) has been established as a public-private partnership of organizations embracing the goal of reducing crashes and fatal crashes involving large trucks and other vehicles. The coalition consists of FMCSA, NHTSA, AAMVA, the American Driver and Traffic Safety Education Association (ADTSEA), state and local governments, law enforcement, motor carriers, industry trade associations, insurance companies, and highway safety organizations. FMCSA public information and education programs have spearheaded the initiative.

An important first step is to incorporate information into state driver handbooks and knowledge tests for both passenger vehicle operators and CDL licensure. Most states have already done this to some degree, but many have not. State driver handbooks are read most often by young beginning drivers and, less frequently, by applicants who already hold a license from another state. Renewal applicants are not usually required to take a knowledge test, and even if they are, most do not read the handbook. Nevertheless, the handbook is an important place to start in disseminating information on sharing the road with trucks and avoiding the dangerous areas in the blind spots and directly in front of the truck.

ADTSEA is the professional association that represents traffic safety educators throughout the United States and abroad. The ADTSEA Web site (http://adtsea.iup.edu) contains a model curriculum for novice drivers that includes extensive lesson plans and supporting slides. These are available free in Adobe (pdf) format, and more usable formats (such as PowerPoint slides) may be purchased. Unit 8 of the model ADTSEA curriculum includes limited information on driving safety around trucks. Topics mentioned include the possibility of truck driver fatigue, truck wide right turns, side blind spots and safe passing, other "No-Zone" areas around trucks, and the importance of being able to see the truck driver in the truck's mirrors (so that he or she can also see you). More elaborate instruction on sharing the road with trucks is under development by AAMVA and will be incorporated into the ADTSEA curriculum as it is completed.

Because most renewal applicants will not read the driver handbook or take a renewal exam, they must be reached through other channels. One approach is through the renewal notice sent by the licensing authority. This mailing presents an opportunity to alert drivers on how to maneuver safely around large trucks. Brochures or other relevant material may be included in the renewal notice package to reach this audience. Another approach is to include the information in driver safety schools operated in conjunction with courts, where offenders are required to attend courses on driver improvement. An approach under consideration by FMCSA for a major pilot program is to disseminate educational brochures through rental car agencies.

EXHIBIT V-7
Strategy Attributes for Increasing Share the Road Knowledge

Attribute	Description
Technical Attributes	
Target	This strategy targets the general public, including all road users, but especially drivers in the presence of truck traffic.
Expected Effectiveness	Effectiveness will not be immediate, but over time, as the public becomes aware of how to drive around heavy trucks, there should be a reduction in truck–passenger vehicle crashes caused by passenger vehicles engaging in hazardous driving behaviors in the vicinity of trucks. Further formal evaluations of this strategy are needed.
Keys to Success	To provide good information to the public requires that there be a clear understanding of the behaviors that create hazardous car-truck interactions. A thorough analysis, preferably including state-based analysis, is an essential component of this strategy. However, as noted above, model instructional material is being developed by AAMVA and will soon be available from ADTSEA's Web site.
Potential Difficulties	Driver handbooks, driver knowledge tests, and courses are revised only periodically, and such information can be incorporated only when new versions are scheduled.
Appropriate Measures and Data	Process measures would include whether Share the Road information is included in the driver handbook and mailings, as well as covered on the driver knowledge tests, or in driver improvement courses. Measures may also be made of the estimated number of drivers who have been exposed to the material in some form. Surveys could be conducted to determine the extent to which the public is knowledgeable about Share the Road information. Safety impact measures would be more difficult to obtain, but impact could be measured by surveys of the public to obtain self-reports of changes in behavior based on Share the Road information.
Associated Needs	There are no known associated needs.
Organizational and Institutional Attributes	
Organizational, Institutional, and Policy Issues	It would be useful to work with both the state trucking association and organizations representing the public, e.g., AAA, Parents Against Tired Truckers (PATT). These groups can all review proposed changes to the driver handbook and provide useful feedback. They can also be of assistance in getting the information out to commercial drivers and other road users.
Issues Affecting Implementation Time	Implementation time will depend upon when new versions of the driver handbook and the driver knowledge tests are scheduled to occur. Once new versions are scheduled, implementation time should be minimal.
Costs Involved	This strategy should involve relatively minimal cost. Conferring with stakeholders and making changes to the driver handbook and driver knowledge tests and courses should not require major additional funding.
Training and Other Personnel Needs	There will be a need for developing the handbook material and the items for the knowledge testing and courses. Use should be made of materials currently available in the public domain.
Legislative Needs	None.
Other Key Attributes	
	None identified.

Information on Agencies or Organizations Currently Implementing this Strategy

Information and materials are available from several sources, including the FMCSA Outreach Division (202-493-0499). Information is also available at the Share the Road Coalition Web site, www.sharetheroadsafely.org. Finally, as noted above, AAMVA is developing Share the Road driver training materials that will be available in Adobe (pdf) format on the ADTSEA Web site (http://adtsea.iup.edu).

Virginia established a Large-Truck Safety Task Force in 2002 to develop recommended strategies to reduce large-truck crashes. Among the strategies recommended were to develop training resources and to seek means to educate both large-truck drivers and the general driving public about safe driving practices around trucks. A project survey indicated that 60 percent of large-truck drivers support more education for the public. The task force recommended that the Virginia Department of Education adopt No-Zone and Share the Road programs as part of the high school driver education programs. Information on the Virginia program is available from Robert L. Irving, Motor Carrier Service Operations, Virginia Department of Motor Vehicles (804-367-2865, dmvrli@dmv.state.va.us).

Strategy 12.1 C2: Promulgate Share the Road Information Through Print and Electronic Media

General Description

Because it will take years to reach all drivers through driver-related materials, the Share the Road information should also be promulgated in multiple ways. Newspapers often have a column on safe driving or tips for the road, and this information would be relevant to its readers. Television can also include Share the Road messages in public service announcements. The message needs to come from many sources over an extended period of time, so that drivers in general will be familiar with the material.

The experience with safety belt use and drinking and driving is critical to understanding the value of this strategy. A quarter of a century ago, it was generally accepted that we would never get safety belt use laws in the United States, and driving after drinking was widespread and widely considered harmless. The media played a major role in bringing about major changes in how safety belt use and drinking and driving are viewed. General public awareness of the Share the Road issue could be accomplished through similar means. If reports on truck–passenger vehicle crashes were to include this information, the public would eventually gain a deeper appreciation of this safety issue, as has been done with drinking and driving and with safety belt use. There are important differences between the Share the Road concept and safety belt use and drinking and driving, but the similarities are sufficiently strong to consider the latter as models for bringing about public behavior change.

The national Share the Road initiative provides a ready source for general public information on this safety topic. At the state level, Colorado developed a customized public information campaign focusing on one rapidly growing, high-truck-crash county (Weld County in Northeastern Colorado, which includes the city of Greeley), with plans to expand the program to the entire state. The Colorado Truck Safety 2000 initiative (Olsgard et al., 2002) included a detailed crash analysis that served as the basis for the development of a multifaceted truck safety initiative, including targeted enforcement, engineering strategies,

and public education. This program is described in more detail in the state profile accompanying this chapter. The public information and education initiative was named "Size Matters for Safe Driving in Weld County." It included the development of printed material featuring a project logo and special graphics. These materials were printed in both English and Spanish and included brochures, information sheets, wallet-sized plastic cards, and posters. Press and media were contacted and enlisted in the campaign to spread the safety message to citizens. The Weld County program will be a template for a larger statewide initiative.

EXHIBIT V-8
Strategy Attributes for Promulgating Share the Road Information Through Print and Electronic Media

Attribute	Description
Technical Attributes	
Target	Targets for this strategy are initially print and electronic media that cover highway safety issues and ultimately the motoring public.
Expected Effectiveness	With appropriate publicizing of Share the Road concepts and associated risks of heavy-truck crashes, the public should, over time, become aware of the problem and know more about how to share the road safely with heavy trucks. However, as in the case of safety belt use and drinking and driving, the impact of such reporting will occur over time.
Keys to Success	In truck/light-vehicle crashes, it is important that reporting does not imply culpability. Simply passing a truck, or being passed by a truck, means that the light vehicle will be in the dangerous zone at some point, and there is nothing illegal about that. However, it is important that drivers know it may be dangerous to remain for any length of time in such a relationship to a truck. Of course, it is extremely hazardous to swerve into the path of a truck traveling at high speed and assume that the truck will be able to stop as quickly as a passenger car. When such crashes result, it would be appropriate for the media to stress the dangers associated with these maneuvers. Therefore, finding means to involve and interest the media on a regular basis is another key to success. To achieve support for such reporting, it would be useful to have one or more champions in key leadership positions who would communicate the value of educating the public on how to drive safely around large trucks.
Potential Difficulties	It may be difficult to get the media interested in the topic. The media may also be especially reluctant to report hazardous driving on the part of the passenger vehicle, since truck–passenger vehicle crashes are more likely to produce serious or fatal injuries for the occupant(s) of the passenger vehicle. The same problem existed in regard to safety belt use. Yet, over time, the media became accustomed to reporting the information. The media must be persuaded that reporting this information should lead to a greater awareness on the part of the public and, ideally, a reduction in risky driving and resulting damage and injuries.
Appropriate Measures and Data	Process measures would include standard measures of the conduct of media campaigns, such as column inches or number of articles, minutes of television time, etc. Safety impact measures would include reductions in car-truck crashes, but it should not be expected that this relationship could be definitively established. Surrogate safety measures might be generated through a survey of the public's knowledge of both the concept of Share the Road and the possible contributing factors for specific relevant crashes in the geographic area being surveyed.

(*continued on next page*)

EXHIBIT V-8 (Continued)
Strategy Attributes for Promulgating Share the Road Information Through Print and Electronic Media

Attribute	Description
Associated Needs	Materials are available in the public domain to provide a basis for press releases and articles on Share the Road concepts. See: http://www.sharetheroadsafely.org/.
Organizational and Institutional Attributes	
Organizational, Institutional, and Policy Issues	It would be wise to contact the State Attorney General's office to ensure that there would be no legal consequences of media reporting of this information.
Issues Affecting Implementation Time	Widespread implementation is likely to take years. There were some newspaper editors who adamantly refused to report alcohol or safety belt use in crashes. Only after other newspapers were doing it routinely did such publications follow suit.
Costs Involved	Because Share the Road information is readily available on the Internet, there should not be significant costs associated with the production of materials. However, there will be a need for someone to work with the media to inform them and encourage them to address this topic.
Training and Other Personnel Needs	Someone, possibly in the Governor's Highway Safety Office, will need to become familiar with the Share the Road concept and materials and devise a plan for working with the media.
Legislative Needs	No legislation is required.
Other Key Attributes	
	None identified.

Information on Agencies or Organizations Currently Implementing this Strategy

Virginia and Pennsylvania are among the states that have established strategic goals to educate both passenger vehicle and truck drivers on hazardous driving behaviors around other vehicles. Virginia's public information on Share the Road is available at www.dmv.state.va.us/webdoc/general/safety/motorcarrier. Pennsylvania has developed a Share the Road brochure that may be distributed at rest areas or through other means. It is available from Gary Modi, Chief, Safety Management Division, PENNDOT Bureau of Highway Safety and Traffic Engineering (717-783-1190, gmodi@state.pa.us). There are no known jurisdictions reporting No-Zone violations directly to the media for wider dissemination of Share the Road information to the public.

The Colorado Weld County initiative, a multiagency program consisting of problem assessment, enforcement, engineering, and education strategies, is described in a state profile in Appendix 2. Points of contact in Colorado include Patricia Olsgard, Colorado Motor Carriers Association (303-433-3375, patti@cmca.com), and Stephanie Olson, CDOT Highway & Traffic Safety Division (303-757-9465, stephanie.olson@dot.state.co.us). The Colorado initiative is further documented in Appendix 2.

Objective 12.1 D—Improve Maintenance of Heavy Trucks

Vehicle maintenance is one of the most fundamental activities of commercial vehicle fleet safety management. The FMCSA and the states have various regulations and enforcement programs in place to ensure that vehicles have properly functioning equipment. Unfortunately, roadside inspection vehicle out-of-service rates for mechanical problems are quite high – generally in the range of 20 percent to 30 percent (Blower, 2002). Various studies of truck crash characteristics and causation have addressed the question of the degree to which truck mechanical problems contribute to crash involvement. Of heavy trucks involved in fatal crashes, about 3 percent are reported to have brake defects, and 1 percent are reported to have tire defects (Blower, 2002). Preliminary data from the Large-Truck Crash Causation Study indicate that about 4 percent of the sampled crashes involved a critical truck vehicle factor, such as a defective component (Craft and Blower, 2003b). On the other hand, in-depth investigations performed by Michigan's Fatal Accident Complaint Team (FACT) have indicated that as many as 55 percent of trucks involved in fatal crashes have at least one vehicle mechanical defect and that about half of these would be sufficient to place the vehicle out of service (Blower, 2002). The extent to which vehicle mechanical defects constitute a direct causal or severity-increasing factor is difficult to assess. Nevertheless, Blower (2002) concludes that truck brake, tire, and other mechanical defects contribute "substantially" to truck crashes.

In a survey of commercial truck and bus fleet safety managers and other experts, Knipling et al. (2003) found that the problems of neglect of vehicle maintenance or driver failure to inspect vehicles were not highly rated as safety problems relative to other problems. Ironically, though, fleet safety managers in the same survey rated regularly scheduled vehicle inspection and maintenance to be the most effective safety management practice of 28 practices included in the survey.

Strategy 12.1 D1: Increase and Strengthen Truck Maintenance Programs and Inspection Performance

General Description

State truck inspection programs are largely supported by the Motor Carrier Safety Assistance Program (MCSAP). MCSAP is a federal grant program that provides financial assistance to states to reduce the number and severity of commercial vehicle crashes and incidents. The program promotes consistent, uniform, and effective commercial motor vehicle safety programs. The program helps ensure that safety defects, driver deficiencies, and unsafe motor carrier practices are detected and corrected before they result in, or contribute to, crashes.

Key requirements for states to receive annual MCSAP funding include adoption and enforcement of state laws that are compatible with the Federal Motor Carrier Safety Regulations (FMCSRs) and the completion of a Commercial Vehicle Safety Plan (CVSP). Major MCSAP program elements include driver/vehicle inspections, traffic enforcement, carrier compliance reviews, public education and awareness, and data collection. The FMCSA Web site contains more information on MCSAP at http://www.fmcsa.dot.gov/safetyprogs/mcsap.htm.

FMCSR § 396.17 requires annual safety inspections of commercial vehicles, including both tractors and trailers, and roadside inspection programs are a continuous state activity to achieve adequate vehicle maintenance. Proper vehicle maintenance and a clean inspection record are considered fundamental by safety-conscious fleets. This includes compliance with federal and state requirements for pretrip, posttrip, and annual vehicle inspections. Many safety-conscious companies employ regular schedules for preventive maintenance (PM) and require their drivers to use checklists for pre- and posttrip inspections. In the safety management study by Knipling et al. (2003), "regularly scheduled vehicle inspection and maintenance" was practiced in more than 90 percent of the fleets surveyed and, as noted above, was rated by safety managers as the most effective safety management practice of 28 practices presented.

Not all motor carriers voluntarily implement strong fleet maintenance programs, however. The state of Maryland has a program that meets the requirements of FMCSR § 396.17 but that also requires that carriers conduct and document an ongoing PM program for their vehicles. Enforcement officers in the state of Maryland may enter the premises of any motor carrier at any time during regular business hours to inspect equipment and also to review and copy records relating to the carrier's PM program. This Maryland program to strengthen carrier PM programs has resulted in improved vehicle inspection performance both for vehicle inspections conducted at carrier sites and those conducted roadside.

EXHIBIT V-9
Strategy Attributes for Increasing and Strengthening Truck Inspection Programs

Attribute	Description
Technical Attributes	
Target	Mechanically unsafe trucks operating on public highways, including those engaged in both Interstate and intrastate operations.
Expected Effectiveness	The requirement of comprehensive carrier PM programs, in addition to annual vehicle inspections, is intended to force carriers to act proactively and systematically to ensure the mechanical safety of their vehicles. Potentially, this additional requirement will reduce mechanical defects, particularly relating to brakes and tires.
Keys to Success	The Maryland Division of State Documents publishes and distributes a PM Handbook that states the relevant Code of Maryland regulations and also extensive and very detailed inspection and other PM procedures.
Potential Difficulties	The effectiveness of the program is limited by the number of enforcement officers available to conduct the carrier-based inspections and PM program reviews.
Appropriate Measures and Data	Measures of program effectiveness would include number of PM program reviews conducted, vehicle pass-fail rates at the carrier site, and roadside inspection out-of-service rates. If a statewide program is implemented, state vehicle out-of-service rates can be compared with levels prior to the program or with national data. For example, in Maryland, the 2003 large-truck OOS rate is 17.6 percent, compared with the national rate of 25.4 percent.
Associated Needs	None identified.
Organizational and Institutional Attributes	
Organizational, Institutional, and Policy Issues	The program is limited by its budget and staff allocations.

EXHIBIT V-9 (Continued)
Strategy Attributes for Increasing and Strengthening Truck Inspection Programs

Attribute	Description
Issues Affecting Implementation Time	Available resources are a primary implementation factor.
Costs Involved	Proportional to the number of enforcement officers and carrier visits.
Training and Other Personnel Needs	Enforcement officers must be thoroughly trained on the details of the inspection and PM program procedures.
Legislative Needs	The Maryland program is mandated by legislation specified in the Code of Maryland Regulations Title 23 (Vehicle Laws) Subtitle 3 (Preventive Maintenance Program) and Title 11 (DOT) Subtitle 22 (Motor Vehicle Administration – Preventive Maintenance Program).
Other Key Attributes	
	None.

Information on Agencies or Organizations Currently Implementing this Strategy

More information on the Maryland PM program can be obtained from Administrative Officer Malcolm Rote, Maryland State Police (410-694-6116, mrote@mdsp.org).

Strategy 12.1 D2: Conduct Postcrash Inspections to Identify Major Problems and Problem Conditions

General Description

Extensive data can be compiled on trucks and other vehicles involved in crashes, including detailed information on the tractor, the trailer, and the cargo. Information on the truck driver should include physical condition, training and experience, recent sleep history, use of drugs and medications, hours of service, company policies, trip origin and destination, restraint use, and motor carrier characteristics. Additional data can be compiled on the crash itself, including detailed information on truck condition and damage. FMCSA and NHTSA have a joint program underway to collect crash reconstructions of a large representative sample of serious heavy-truck crashes (Craft and Blower, 2002).

Analyses of the collected data may reveal specific vehicle problems that appeared to be contributing to fatal crash risk (Blower, 2002). Also of interest is whether other factors, e.g., some commodities, routes, or types of carriers, result in a higher risk of crashes and should be examined for possible modifications.

Michigan initiated, but later discontinued, a state program to require investigations and vehicle inspections of trucks involved in fatal crashes. This program was called the Fatal Accident Complaint Team (FACT). Pennsylvania enacted legislation in 2001 (Section 4704 of the Pennsylvania Vehicle Code) requiring that all trucks in fatal crashes undergo an MCSAP inspection. Such state programs, over time, can compile sufficient state-specific data to enhance the overall truck safety efforts.

EXHIBIT V-10
Strategy Attributes for Conducting Postcrash Inspections to Identify Major Problems and Problem Carriers

Attribute	Description
Technical Attributes	
Target	Policy and program personnel in public agencies that will benefit from details regarding unsafe trucks operating on public highways.
Expected Effectiveness	This is an experimental strategy. No evaluations have been performed to provide estimates of effectiveness. Any consideration of this strategy should involve pilot testing, with carefully designed and executed evaluations.
Keys to Success	Support and cooperation of local enforcement agencies are essential for program success. It is these personnel who must make initial notification of a crash. Without voluntary notification, project investigators will not be able to respond, resulting in an incomplete database. In Michigan, local enforcement, at the outset, viewed the state as interfering in their jurisdiction. But they came to appreciate and support the program as it became evident that the investigators were not interfering with their activities and in many cases could contribute to their own safety programs. The Pennsylvania program was mandated in June 2001 in Section 4704(c)(2) of the state vehicle code. The measure specifies that “a qualified Commonwealth employee as designated by the department” shall perform inspections of all large trucks and transit vehicles involved in fatal crashes, as well as their drivers, before vehicle or driver is allowed to continue operations.
Potential Difficulties	Possible initial reluctance on the part of local enforcement, as well as reluctance on the part of state investigators to take on additional responsibilities, may have to be overcome. It is anticipated that experience with the program, if it is operated properly, will result in gaining their wholehearted support. Motor carriers may also be “lukewarm” to the program, but the better-run carriers may become supporters if it results in pressure on their competitors who cut corners on maintenance and operations. In Michigan, there was difficulty documenting program benefits. There was insufficient demand for study data and findings by government agencies, safety advocacy groups, researchers, and the trucking industry to justify its continuation (Powers, 2002). When conducting the investigations, Investigators need to distinguish between vehicle defects that preceded the crash and those that resulted from the crash. Also, distinction should be made between defects that contributed to the crash and those that are present but are not related to the crash.
Appropriate Measures and Data	Process measures would include the number of trained investigators in the field and the proportion of fatal truck crashes successfully investigated, providing usable data. Since this strategy is directed at a support system (information management), it will not be feasible to relate the effectiveness of the program directly to crashes, but findings from analyses of the data should provide feedback to the state to determine how vehicle inspection programs could be modified to address particular problems detected and to identify motor carriers for compliance reviews. Problem stretches of roadway can also be identified. Surrogate measures may be employed, such as the change in the incidence of unsafe trucks operating on the highway.
Associated Needs	A protocol for dealing with lawyers and motor carriers needs to be developed. In the case of FACT, because data were collected by government employees, they had to be made available upon request. However, lawyers were usually unable to interpret the data provided. The primary purpose of FACT was to achieve greater understanding of fatal truck crashes and how they might be prevented, not to support or refute the positions of any disputants.

EXHIBIT V-10 (Continued)
Strategy Attributes for Conducting Postcrash Inspections to Identify Major Problems and Problem Carriers

Attribute	Description
Organizational and Institutional Attributes	
Organizational, Institutional, and Policy Issues	As noted above, the cooperation of local enforcement agencies, as well as motor carriers, is essential for program success. These participants need to be informed well ahead of time about the program and its purpose. The potential value to these stakeholders should be highlighted.
Issues Affecting Implementation Time	The program in Michigan was developed and implemented in about 6 months. Time was required to develop the data forms, and care was taken to ensure that they were compatible with other data systems that were relevant, e.g., the national Trucks in Fatal Accidents (TIFA) file. Following implementation, revisions were made, so that it took about 1 year before the entire system was consistently collecting useful data.
Costs Involved	Because Michigan ranked in the top 10 states for number of fatal truck crashes, the federal government provided $100,000 to be used to address the problem. Costs were not a major problem, in that no new personnel were required. The program operated by expanding the duties of existing personnel, both local and state. However, the additional responsibilities were not significant, and eventually program participants became program enthusiasts. The major program cost was for data analysis.
Training and Other Personnel Needs	Motor carrier crash investigators will have to be trained to use the new report forms in most cases. This will be the major training requirement. In addition, local enforcement should be notified of the fatal crash occurrence. In Pennsylvania, personnel from many organizations may be called upon to perform the inspections. This includes the Pennsylvania State Police, the Public Utility Commission, PENNDOT, and selected local police departments. Individuals performing the inspections must be trained and certified. Responsibility for performing the inspection is determined based upon who initially responds to the crash (i.e., state or local police).
Legislative Needs	No legislation is required, although, as noted, the Pennsylvania program is mandated and supported by legislation.
Other Key Attributes	
	None identified.

Information on Agencies or Organizations Currently Implementing this Strategy

Michigan conducted this strategy for about 4 years but then discontinued it due to its expense, a need to redirect human resources participating in FACT, lack of demand for the data, and the consideration that FMCSA was launching a similar and broader study. There are no current plans to reinstate the program. A point of contact in Michigan is Capt. Robert R. Powers, Michigan State Police Motor Carrier Division (517-336-6447, powersr@state.mi.us). Additional information is available in Appendix 3.

Pennsylvania has enacted legislation that requires all trucks in fatal crashes to undergo an MCSAP inspection. The point of contact in Pennsylvania is Dan Smyser, Chief, Motor Carrier Division, PENNDOT (717-787-7445, smyser@state.pa.us). See Appendix 4 for further details.

Objective 12.1 E—Identify and Correct Unsafe Roadway Infrastructure and Operational Characteristics

General Description

The physical and operational characteristics of large trucks often place them near the safety limits imposed by highway geometric design and the traffic environment (Harwood et al., 2003a and 2003b). Thus, roadway features such as lane width, upgrades, downgrades, horizontal curves, and interchange ramps may be associated with heightened safety concerns relating to large trucks as compared with smaller, lighter vehicles. Although AASHTO (2001) roadway design guidelines, including design speeds, are based on a consideration of the designs of various large vehicles (i.e., large buses and various large-truck configurations), margins for driver error are far less than they are for smaller, more maneuverable vehicles.

There are roadway sections that are characterized by large numbers of heavy-truck crashes. Clearly, the volume of heavy-truck traffic is an important factor here, but it is still worthwhile to examine the roadway characteristics to determine what, if anything, might be done to reduce the toll. Most of the strategies related here are designed to either impact the speed of the truck or overcome the loss of control due to excessive speed. Several agencies are beginning to look at the safety impacts of lane restrictions for trucks or exclusive truck lanes, in addition to the historical use of this strategy to improve traffic operations. Appendix 9 discusses this idea.

Studies of vehicle highway speeds in North America indicate that the majority of drivers of both light and heavy vehicles consistently exceed posted speed limits (Tardif, 2003; NHTSA, 1991). Both light- and heavy-vehicle drivers exceed speed limits, but average heavy-vehicle speeds are typically slightly lower—on the order of 2 to 5 mph. Moreover, the percentage of truck drivers engaging in extreme speeding (e.g., 80+ mph) is far less than that of light-vehicle drivers.

Excessive speed still constitutes a major risk factor for large trucks, however. Possible interventions include improved signing to alert truck drivers as well as other drivers of the hazardous nature of a section of highway; using devices being developed under the Intelligent Transportation Systems (ITS) program to provide real-time feedback to truck drivers exceeding the safe speed; providing pull-offs at the top of the grade to enable drivers to prepare for maneuvering the grade safely; installing arrester beds (truck escape ramps) where appropriate; and installing median rumble strips or barriers in areas where crashes occur because trucks and/or passenger vehicles run off the left side of the road. In the case of barriers, most are not designed to contain heavy vehicles, although some jurisdictions have constructed large, heavy-duty guardrails at some high-risk locations to accommodate heavy trucks (Harwood et al., 2003a). Interchange areas are also potentially hazardous locations for trucks. Ramps with sharp curves and inadequate acceleration or deceleration lanes can be high-crash-risk locations.

Some of these proposed interventions will affect truck crashes somewhat indirectly by modifying the behavior of other drivers. For example, head-on collisions, both fatal and nonfatal, are much more likely to be precipitated by the other driver crossing the center line or median, rather than the large-truck driver (Blower, 1999). Therefore, median rumble strips or improved medians should have a greater effect on these drivers, where inattention or drowsy driving is a major factor, but the changes should reduce head-on collisions with trucks.

Many of the strategies that are applicable here are covered in other guides in this series:

- 15.1 Run-Off-Road Crashes
- 15.2 Crashes on Highway Curves
- 18.1 Head-On Crashes

Some of the strategies that are applicable to these problems would involve a major reconstruction effort. Since the orientation of the AASHTO guides is toward low-cost, short-term solutions, the most extensive and costly countermeasures are not discussed here.

Strategy 12.1 E1: Identify and Treat Truck Crash Roadway Segments—Signing

It is not always possible to make major changes in highway configurations, even when it is found that the current configuration may create problems for some drivers and vehicles. However, specific segments of highway that are identified as sites with a disproportionate occurrence of truck crashes can be treated to inform drivers of the hazards so that they can modify their driving accordingly. Signs may be the traditional fixed type or be activated and changeable (e.g., advisory speed signs). The signing may also advise of the likelihood of targeted traffic enforcement. In general, it is considered advisable to combine the signing with an enforcement effort. Details regarding traffic enforcement are covered under Strategy 12.1 E3. The special case of rollover advisory warning signs is covered under Strategy 12.1 E2.

Colorado's Weld Country truck safety initiative, a prototype for future statewide programs, includes engineering, enforcement, and education strategies. A principal engineering initiative is improved signage for trucks, including (a) directional signage relating to geographic locations such as major shippers and receivers; (b) signage concerning specific hazardous roadway locations; and (c) signage for truck routes and hazardous materials corridors.

With advancing technology, it appears that there will also be vehicle-based systems to provide in-cab advisories to commercial drivers when they are approaching high-crash locations. The U.S. DOT Intelligent Vehicle Initiative (www.its.dot.gov/ivi/ivi.htm) includes a major program of R&D focusing on commercial vehicle operations (CVO). A current study is the "Generation 0" field operational test of several safety technologies installed on Mack trucks. The three systems being tested are a lane tracking system, an in-cab advisory of potentially hazardous locations, and an automatic collision notification system (which automatically calls local EMS following a crash impact). Of interest here is the advisory system, which employs a global positioning system (GPS) both to identify locations and for positioning in the truck. Based on state crash data files and other roadway features (e.g., sharp curves, high-wind areas, tight exit ramps, narrow bridges, and recurring congestion), 500 high-truck-crash locations were identified in 12 states. For the study, these locations are termed "advisory sites" rather than "hazardous locations" because the latter might expose states to undue liability. Moreover, there is no control for truck traffic volume at these sites, so they are not necessarily the sites of greatest *risk* (this limitation applies to almost all current attempts to identify high-risk highway locations). The in-cab advisory (10 words or less specifying the nature of the potential hazard) is displayed on a small cathode ray tube (CRT) screen mounted on the truck instrument panel. The system is directionally sensitive (i.e., trucks must be approaching from the travel direction associated with high-crash potential) and provides the advisory about 1 mile before the critical location. This is a good example of

how vehicle-based technologies may be used to complement infrastructure signage and other countermeasures. Of course, fundamental limitations of such vehicle-based systems are that they take years to be deployed in the vehicle fleet, and their implementation depends mainly on truck buyers ordering them at the time of vehicle purchase.

EXHIBIT V-11
Strategy Attributes for Identifying and Treating Truck Crash Roadway Segments—Signing

Attribute	Description
Technical Attributes	
Target	Principally, the target is drivers of large trucks who may be traveling in a manner that is unsafe for the segment of roadway. Secondarily, the target is other drivers, who may be reached with the message to also use extra caution.
Expected Effectiveness	The strategy is considered experimental and, therefore, should be initially implemented on a pilot basis to allow evaluations to be conducted to ensure that the strategy is cost-effective. The separate effect of signing on crashes involving large trucks traveling in an unsafe manner has not been determined. Experiments with this are being evaluated by the Pennsylvania DOT. However, since these are often implemented in conjunction with a selective enforcement program, the effect of the signing will be difficult, if not impossible, to separate.
Keys to Success	A key to success is having a process and system to identify the locations considered especially hazardous for trucks. Success also requires the cooperation and support of state and local enforcement, which must provide intensified enforcement in these areas. There should be public information and education (PI&E) efforts to increase general awareness of the truck safety problem and increase the likelihood that the signed information will be heeded.
Potential Difficulties	Enforcement personnel need to be available for dedicated efforts at signage locations to reinforce their effectiveness. This strategy should not be viewed as a permanent substitute for highway engineering improvements, but rather should be considered an interim effort until such time as the highway itself can be modified.
Appropriate Measures and Data	Process measures include the number and type of signs that are placed, including the number of corridors and ramps treated (i.e., information versus interactive signs installed). Impact measures would include number of truck crashes, particularly the target crashes of the specific intervention(s), e.g., reduction in rollovers in response to installation of interactive truck rollover signing. The ultimate measure of effectiveness is whether heavy-truck crashes decline. Surrogate safety measures include unsafe driving maneuvers, truck and other vehicle speeds, speed differentials between trucks and other vehicles, and the difference between the operating speed of trucks and the design speed of a geometric element.
Associated Needs	Signing needs to be maintained, and the interactive signs need to be monitored to ensure that they are performing appropriately.
Organizational and Institutional Attributes	
Organizational, Institutional, and Policy Issues	Although signing can be implemented without the involvement of other agencies, the support of state and local enforcement is essential. In addition, it is always wise to keep key stakeholders informed of proposed changes. Key legislators, the state trucking association, truck drivers, organizations representing the driving public (e.g., AAA), and the insurance industry are candidate stakeholders to consider informing.

EXHIBIT V-11 (Continued)
Strategy Attributes for Identifying and Treating Truck Crash Roadway Segments—Signing

Attribute	Description
Issues Affecting Implementation Time	State crash data must be analyzed and field visits made to candidate sites to identify the specific locations of truck crashes, as well as the apparent causes, so that this strategy is applied where it is likely to have some impact.
Costs Involved	Costs include the original crash data analyses, the signing on selected corridors, and the enforcement required to maintain effectiveness. For details on the latter, see Strategy 12.1 E3.
Training and Other Personnel Needs	Personnel will be needed to conduct the detailed crash analyses, and state or local police will be needed to conduct enforcement efforts. Therefore, training on the special dynamics and needs for truck safety should be included in training for this type of personnel.
Legislative Needs	None.
Other Key Attributes	
	None identified.

Information on Agencies or Organizations Currently Implementing this Strategy

The Pennsylvania Department of Transportation (PENNDOT) Bureau of Highway Safety and Traffic Engineering is currently pursuing this strategy to identify highway stretches characterized by large numbers of truck crashes and to implement this strategy to address the problem. See Appendix 5 for further details.

Information on the Intelligent Vehicle Initiative (IVI) CVO "Generation 0"test of in-cab advisories of high-truck-crash locations (as well as information on other IVI commercial vehicle R&D) can be obtained from the FMCSA IVI CVO platform manager, Tim Johnson (202-385-2362, tim.johnson@fmcsa.dot.gov), or from the IVI Web site (www.its.dot.gov/ivi/ivi.htm).

Strategy 12.1 E2: Install Interactive Truck Rollover Signing

General Description

Large trucks have high centers of gravity, especially when their trailers are loaded. This physical characteristic renders them much more vulnerable than smaller vehicles to rollover on curves. Moreover, it appears that vehicle height has an effect on drivers' perception of speed; greater heights are associated with lower perceived vehicle speeds (Rudin-Brown, 2004). Further, drivers of tractor-semi-trailers cannot sense the level of lateral acceleration experienced by their trailers because of the articulation between the tractor and the trailer. Interstate and other freeway exit ramp curves can be dangerous locations for tractor-trailers because the driver must perceive the point at which to begin braking and the amount of braking needed to safely slow from full freeway speeds to a much lower speed to negotiate the ramp curve. In a survey of state DOTs, Harwood et al. (2003a) reported that 74 percent of responding states indicated that they had safety problems at such locations and that 57 percent of them employ special warning signs for trucks at their highest-risk locations. A smaller percentage (31 percent) employs advisory speed limits for trucks at these locations.

Highway ramps or curves that experience a high incidence of truck rollovers can be identified from state highway crash files. Interactive signs that include highway detectors can be installed at identified locations (Bushman and Lindsay, 2002). A typical "intelligent" interactive system includes sensors for both weight (i.e., weigh-in-motion) and speed and a display to flash a warning sign for trucks that are assessed to be at rollover risk. These systems may vary in complexity and cost; the simplest systems measure only vehicle speed or height (thus identifying a large truck), but more sophisticated systems can measure multiple vehicle parameters, including speed, height, and weight to calculate rollover risk more accurately and thus provide more targeted warnings (Harwood et al., 2003a). Warning displays may be programmed with a single warning or changeable messages for different situations (Bushman and Lindsay, 2002). If properly designed, installed, and maintained, these interactive systems can result in significantly decreased truck speeds on ramps and resulting decreased crash risks (Harwood et al., 2003a). Exhibit V-12 provides a schematic of an interactive truck rollover advisory as well as a picture of a dynamic display.

A similar principle can be applied to downhill speed advisories for trucks (Bushman and Lindsay, 2002). Just as truck drivers may have difficulty sensing unsafe speeds on curves, they may not appreciate the risks associated with high downhill speeds under some conditions. The layout of such truck downhill speed advisory systems is analogous to the warning system on curves. Vehicle weight is an important factor in determining loss-of-control risk, so optimal systems include weigh-in-motion capabilities. Maximum safe speeds are calculated based on a predetermined formula based on truck weights, speeds, roadway gradients, and truck braking capabilities. Each truck may be given a specific message conveying an advisory speed for that vehicle.

An alternative solution to infrastructure-based warning systems is a vehicle-based system to prevent rollovers. It will likely be 10 to 20 years before the system penetrates the majority of the heavy-truck fleet. Further information on this may be found in Appendix 7.

Another ITS concept is to equip heavy vehicles with embedded roadway maps indicating highway curve locations and a positioning system to determine vehicle location in relation to highway curves. Such a system would provide a warning to drivers if they entered a curve at excessive speed.

Information on Agencies or Organizations Currently Implementing this Strategy

The Pennsylvania Department of Transportation is currently pursuing the vehicle-highway interactive strategy at some Interstate exit ramps and other high-rollover-risk locations. See Appendix 6 for further details.

EXHIBIT V-12
Schematic of an Interactive Truck Rollover Advisory System and Photograph of Dynamic Display
Provided by the PENNDOT Bureau of Highway Safety and Traffic Engineering.

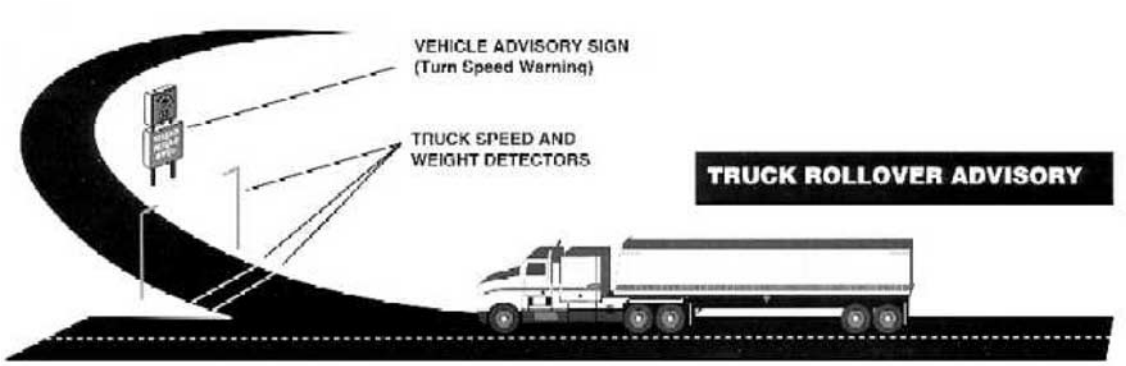


EXHIBIT V-13
Strategy Attributes for Installing Interactive Truck Rollover Signing

Attribute	Description
Technical Attributes	
Target	This strategy targets trucks operating at unsafe speeds on highway ramps or curves identified as having a high incidence of truck rollovers.
Expected Effectiveness	It is anticipated that truck drivers will respond appropriately to an interactive sign warning them that they are exceeding a safe speed for the highway location.
	Harwood et al. (2003a) reviewed implementation cases in a number of states, including California, Texas, Missouri, Virginia, Maryland, and Pennsylvania. Most cases resulted in significantly decreased truck speeds. Crash reductions were observed also, though they were less likely to be statistically significant because of their small numbers.
Keys to Success	A key to success is having a system to identify the locations considered especially hazardous for trucks. Moreover, targeted speed enforcement at these locations will reinforce the effectiveness of both conventional and interactive signing.
	The interactive signing must be calibrated for each location. If signs are slowing trucks well below safe speeds, the signs will lose their effectiveness as drivers discover the discrepancy. Baker et al. (2001) found that incorporating dynamic measures of vehicle weight into the sensor suite increases system accuracy and reduces false alarms.
Potential Difficulties	Costs may be significant; see below.
Appropriate Measures and Data	Process measures include the number and type of signs placed and the number of locations treated.
	Impact measures include measures of actual rollover crashes during an extended period of time prior to sign installation and following installation. Surrogates included speeds entering the ramps or curves and whether and how much speeds are reduced in response to the signing.
Associated Needs	None identified.
Organizational and Institutional Attributes	
Organizational, Institutional, and Policy Issues	None identified.
Issues Affecting Implementation Time	The process of identifying and evaluating candidate sites, as well as the design and installation of the system, will require significant time. Warning threshold speeds must be calibrated for each site and monitored to ensure that they are not too high (resulting in false negatives, i.e., speeding trucks not receiving speed warnings) or too low (resulting in false positives, i.e., too many trucks receiving speed warnings). Implementation could take a year.
Costs Involved	Costs vary with the capabilities and sophistication of the systems employed. In Pennsylvania the cost for installing sensors to detect truck speed and provide feedback to truck drivers has been approximately $210,000 per location.
Training and Other Personnel Needs	Highway engineers may require training or consultation on various aspects of high-risk location identification, system design, installation, maintenance, and evaluation.
Legislative Needs	None required, although it is always wise to keep key legislators informed for such programs.
Other Key Attributes	
	None identified.

Strategy 12.1 E3: Modify Speed Limits and Increase Enforcement to Reduce Truck and Other Vehicle Speeds

General Description

An obvious rationale for reducing posted speed limits is to reduce average speeds, with resulting reductions in crash incidence and/or average crash severity (Stuster et al., 1998), although relationships between posted speeds and prevailing operating speeds are not always strong (Fitzpatrick et al., 2003). Existing speed limits may be set too high for heavy trucks given their operational limitations such as longer stopping distances and greater vulnerability to rollover on curves (Harwood et al., 2003a). In addition to increased enforcement (as discussed above), it may be necessary to reduce existing truck speed limits.

If speed limits are reduced in response to a high incidence of truck crashes, should they be reduced for trucks only or for all vehicles? A rationale for differential speed limits is that trucks have much longer stopping distances than do light vehicles and have other speed-related risks such as rollover at lower speeds and vulnerability to loss of control in cross winds. Thus, trucks should maintain lower highway speeds. On the other hand, the advocates of uniform speed limits contend that differential truck-car speed limits increase vehicle speed variance on the roadway, resulting in more truck-car conflicts and potential for more rear-end and passing-related crashes. In a review of highway/heavy-vehicle interaction, Harwood et al. (2003a) reported that about one-third of the states employ differential speed limits for large trucks at some locations, either for particular classes of roadway (e.g., rural freeways) or for selected roadways. However, Harwood and others (e.g., Garber and Gadiraju, 1992) have found that reducing speed limits for trucks only (i.e., having differential speed limits) does not reliably reduce crashes, although it may change the distribution of various crash types.

Garber et al. (2003) compared the safety effects of uniform car-truck speed limits with differential speed limits on rural Interstate highways. A surprising finding was that, overall, vehicle speeds have not been significantly affected by the type of speed policy. Moreover, statewide changes in rural Interstate speed policy from uniform to differential, or vice-versa, have not resulted in consistent or significant changes in crash rates, including crash rates for rear-end crashes specifically.

Situations where differential speed limits may be advisable include curves and steep downgrades where it may be critical that trucks drive at a slower speed to avoid rollovers, brake failure, or disastrous potential runaway problems. Pennsylvania has a program to reduce the truck speed limit for trucks with a gross weight generally over 26,000 pounds, based on an engineering and traffic study. Based upon recommendations from the trucking industry, Pennsylvania uses a "hazardous grade speed limit" that is consistent with the speed at which these trucks climb the hill in the opposite direction.

Care must be taken to follow standards when establishing speed limits. The *Manual on Uniform Traffic Control Devices* (MUTCD) specifies that speed limits should be established "After an engineering study has been made in accordance with established traffic engineering practices" (Section 2B.13 Speed Limit Sign). It further specifies the following:

> At least once every 5 years, States and local agencies should reevaluate nonstatutory speed limits on segments of their roadways that have undergone a significant change

> in roadway characteristics or surrounding land use since the last review. . . . When a speed limit is to be posted, it should be within 10 km/h or 5 mph of the 85th-percentile speed of free-flowing traffic.
>
> Two types of Speed Limit signs may be used: one to designate passenger car speeds, including any nighttime information or minimum speed limit that might apply; and the other to show any special speed limits for trucks and other vehicles (MUTCD, 2003, http://mutcd.fhwa.dot.gov/kno-millennium.htm).

The Institute of Transportation Engineers (ITE) has a draft advisory on speed zoning available at http://www.ibiblio.org/rdu/ite-szg.html.

EXHIBIT V-14
Strategy Attributes for Modifying Speed Limits and Increasing Enforcement to Reduce Truck and Other Vehicle Speeds

Attribute	Description
Technical Attributes	
Target	The target is truck drivers exceeding established speed limits.
Expected Effectiveness	There have been variable results regarding the effect of speed limit changes on speeds. Also, there is no valid evidence that reducing speed limits for trucks will reduce large-truck crashes. The type of facility, as well as the initial and final speed limits will play important roles in the final result.
Keys to Success	To enhance the impact of this strategy, the state must work with the traffic law enforcement agencies and with the state motor carrier association to get the information out to truck drivers. It would also be helpful to actively involve local political representatives and the local media. It is especially important to involve trucking trade associations, companies, and drivers in the effort, so that the focus is on safety, rather than on identifying and punishing offenders.
Potential Difficulties	Care should be taken to avoid pressure to establish speed limits on a basis other than that specified by the MUTCD and to follow sound procedures of the type established by ITE.
Appropriate Measures and Data	Process measures would include number of locations, or miles of road, for which speed limits have been changed and hours (and officer-hours) of targeted speed enforcement. Impact measures would include changes in speed-related crashes in the affected areas. Changes in truck and passenger vehicle speed in the affected areas may be used as surrogate measures, but caution should be taken, since the connection to impacts on crashes is tenuous at best.
Associated Needs	Almost any enforcement program will be enhanced by a coordinated public information and education (PI&E) program.
Organizational and Institutional Attributes	
Organizational, Institutional, and Policy Issues	Change of speed limit is usually difficult to achieve and sometimes politically charged. It is advisable to involve all stakeholders in decision processes from an early point. Enforcement and engineering agencies should work in close cooperation.

EXHIBIT V-14 (Continued)
Strategy Attributes for Modifying Speed Limits and Increasing Enforcement to Reduce Truck and Other Vehicle Speeds

Attribute	Description
Issues Affecting Implementation Time	Achieving approval of a change of speed limit, including obtaining the studies that may be necessary, could result in an extended implementation period. Otherwise, once problem areas are identified, implementation should take no more than a few months.
Costs Involved	Strategies targeted at reductions in posted speeds should not be costly, but increased enforcement in affected areas will be. Because truck crashes, both fatal and nonfatal, occur most frequently during daytime and on weekdays, enforcement should be most effective during these times.
Training and Other Personnel Needs	No special training should be required, as this strategy is a standard part of engineering and enforcement agency operations.
Legislative Needs	It may be necessary to pass legislation in some cases where speed limits for trucks are to be changed on a systemwide basis.
Other Key Attributes	
	None identified.

Information on Agencies or Organizations Currently Implementing this Strategy

In 1996, Colorado raised its Interstate highway speed limit to 75 mph. Since that time, traffic volumes have dramatically increased in some areas of the state. On I-25 north of Denver to Fort Collins, the combination of increased speeds and increasing traffic volume raised the question of whether the speed limit should be reduced back to 65 mph along this section of Interstate. A number of truck drivers and carrier safety managers have expressed support for such a speed limit reduction, and the strategy was included in a recent Colorado truck safety initiative. However, opposition by commuters and other travelers in the area was anticipated, and the matter is unresolved at this writing.

Objective 12.1 F—Improve and Enhance Truck Safety Data

Strategy 12.1 F1: Increase the Timeliness, Accuracy, and Completeness of Truck Safety Data

General Description

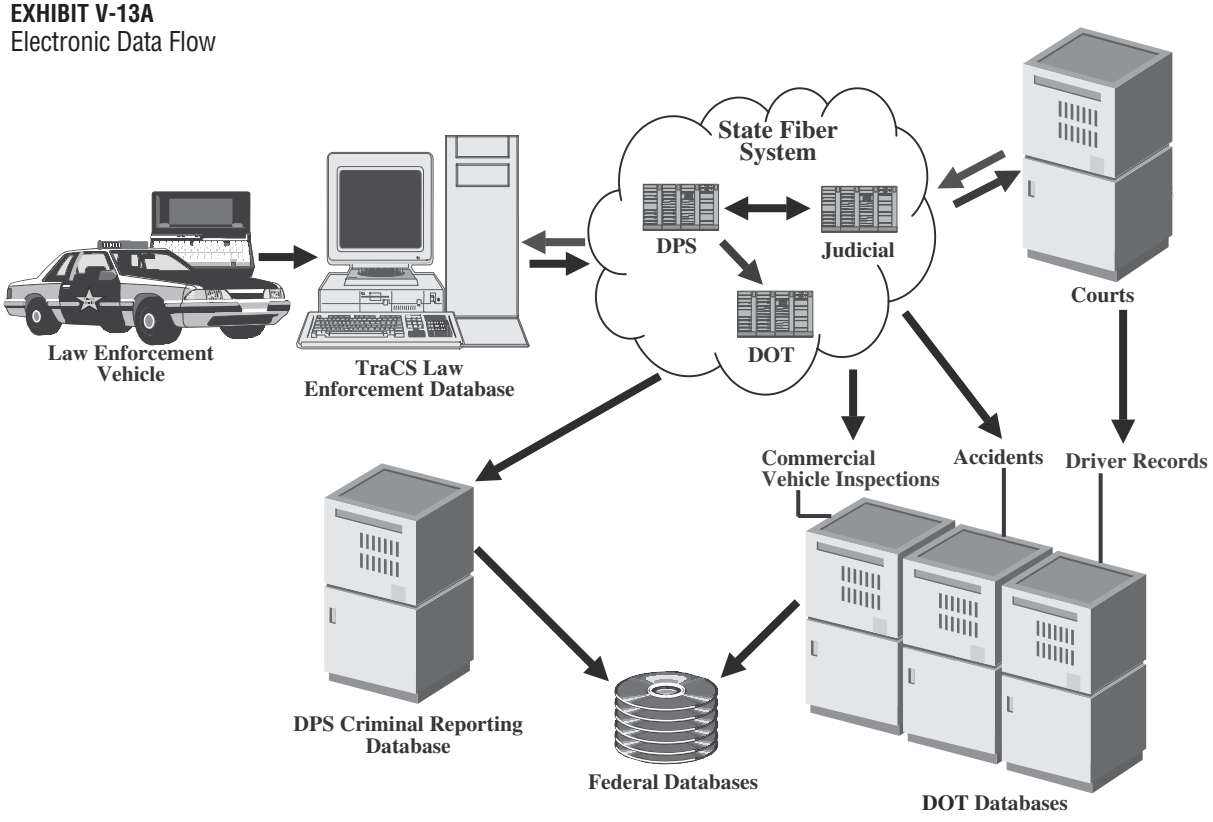
Trucks cross state lines much more often than other vehicle traffic does. Averaging almost 65,000 miles annually, combination trucks travel through many jurisdictions and consequently can incur violations in multiple districts. A primary purpose of the CDL is to limit a driver to holding a single license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

available rapidly and in complete and accurate form. Technology is available today to enable such data entry and accessibility, but few jurisdictions are currently utilizing it.

The state of Iowa, in partnership with the U.S. DOT, has developed "TraCS": Traffic and Criminal Software (see http://www.iowadot.org/natmodel/index.htm) under a national model program for demonstrating the use of new technologies for improving data collection and analysis. The system allows law enforcement officers and others to collect, validate, print, and receive information in the vehicle using a notebook or pen-based computer. This information can be transferred to central databases for reporting, analyses, and retrieval. TraCS has reduced time requirements for data collection and entry, increased accuracy, and made safety data rapidly available for analysis and action. It is being licensed to numerous other states for various applications. For a map of the partner states, see http://www.dot.state.ia.us/natmodel/otherstates.htm, and for further details, see http://www.dot.state.ia.us/natmodel/letpublication.pdf.

TraCS was not developed solely for truck safety applications. Nevertheless, one major component of TraCS is the Vehicle Safety Inspection System (VSIS), which is an alternative to a U.S. DOT–developed system called ASPEN. Both systems facilitate the collection and reporting of data from truck inspections. An advantage of TraCS is that it is easily linked to other police data systems such as systems for accident and citation reporting. In Iowa, truck enforcement officers writing truck inspection reports can, with one mouse click, also file their citation reports. This capability greatly expedites truck safety enforcement. Exhibit V-13a illustrates conceptually the electronic data flow of TraCS.

EXHIBIT V-13A
Electronic Data Flow



DPS = department of public safety.

EXHIBIT V-14
Strategy Attributes for Increasing the Timeliness, Accuracy, and Completeness of Truck Safety Data

Attribute	Description
Technical Attributes	
Target	This strategy targets law enforcement and members of the traffic safety system who are making planning, operational, and maintenance decisions that affect large trucks.
Expected Effectiveness	This strategy addresses a support system. It is not possible to directly relate the effectiveness of this strategy to large-truck crashes, due to the many intervening steps between provision of data and impact on truck operations. However, the improvement of data systems reduces paperwork at every stage of information processing and increases accuracy and timeliness of data. Iowa, using the TraCS system, has reduced the time in which incident information is electronically available to the state to as little as 1 day. They have also eliminated duplicate data entry by agency staff, significantly reduced errors on reports, and reduced time for completing reports. The time to make commercial vehicle inspection data available for analysis has decreased from 100 days to 6 days. The time between the occurrence of a crash and the availability of the crash data has decreased from 12-18 months to as little as 8 hours. Mobile data units in patrol cars, barcode technology, and “smart maps” on which officers can indicate incident location combine to reduce data entry time while accuracy increases. TraCS agencies without mobile laptops may still use TraCS on desktop computers at their agency. In this case, an officer must make notes in the field and bring them to the office to be entered by either the officer or a clerk. The advantages of creating a local database and being able to electronically transmit to the state provide enough benefits for many agencies to use this approach. Agencies using desktop set-ups are limited to reports that don’t require a driver signature, unless drivers are brought into the office. This is sometimes the procedure in small towns.
Keys to Success	Inter-agency coordination and cooperation are required for successful implementation. In Iowa, the Department of Transportation (Motor Vehicles Division and Information Technology Division), the Department of Public Safety (State Patrol, Governor’s Traffic Safety Bureau, Data Services Bureau), the Department of Natural Resources, multiple U.S. DOT agencies, and multiple county agencies are involved. More jurisdictions are joining the initiative as time and funding allow. The value of the system is enhanced as more jurisdictions participate, in that the breadth of information increases. Because agencies differ in their equipment, the software needs to be usable on a wide variety of platforms.
Potential Difficulties	The TraCS system may require the purchase of new equipment, such as upgraded computers, barcode scanners, and printers. And new equipment often means new staff training requirements. While traditional systems are cumbersome, they are also familiar. New systems must overcome the inevitable institutional inertia that is inherent in bureaucracies.
Appropriate Measures and Data	Process measures would include the number and proportion of agencies using the improved system. Operational impact measures include the time required to complete reports, changes in reporting errors, and time from incident to availability of information for retrieval. Personnel productivity measures will also indicate the impact of this strategy on operations. Impact on truck safety would be difficult to measure, but improved speed in identifying drivers who should lose licensure may serve as a proxy measure.

(*continued on next page*)

EXHIBIT V-14 (Continued)
Strategy Attributes for Increasing the Timeliness, Accuracy, and Completeness of Truck Safety Data

Attribute	Description
Associated Needs	None identified.
Organizational and Institutional Attributes	
Organizational, Institutional, and Policy Issues	The extent to which data system improvements are effective depends on the breadth of their use. If only the state police have such a system, then incidents coming under the jurisdiction of counties, towns, and cities will not be included and will have all the disadvantages of traditional systems. Inter-agency cooperation is essential for achieving optimal benefits from improved data systems. The program in Iowa began in 1994 with only eight enforcement agencies participating. Over the years it has expanded to include more than 200 agencies. In addition to enforcement agencies, current participants include the state DOT, division of motor vehicles, state and local engineering units, ITS, and the judicial system. Types of data handled include crash reports, citation data, drunk driving arrest and report forms, commercial motor vehicle citations, and arrest and complaint forms for criminal activities.
Issues Affecting Implementation Time	This strategy represents a major change in data collection and processing. It will require time for gaining approval, careful planning, software development, training, acquisition of new equipment, trial implementations, and final installation. It is anticipated that at least 18 months to 2 years will be required to carry through this process.
Costs Involved	As noted, the TraCS system may require up-front investment in hardware and software, as well as in training. Although the system may increase productivity and improve accuracy and timeliness, funds for the initial capital investment may be required for the system to be installed. New TraCS states need to create their forms using the Software Development Kit (SDK) provided with TraCS. TraCS and the SDK are provided free of charge, but there are development and deployment costs. Although TraCS works on a variety of computers and printers, devices that meet all requirements (performance, features, and durability) are usually expensive. The cost of the units varies as a function of the quality of the hardware used. Some agencies already have suitable laptops in their vehicles. Other agencies may use TraCS on a desktop at their office; newer computers can handle TraCS nicely. However, older computers may need to be upgraded or replaced.
Training and Other Personnel Needs	Personnel need to be trained on how to use the new equipment. Report forms, driver licenses, vehicle registrations, and other relevant documents need to be barcoded.
Legislative Needs	Ordinarily, no new legislation is required. However, some states may need legislation to allow for the use of digital signatures.
Other Key Attributes	
	None identified.

Information on Agencies or Organizations Currently Implementing this Strategy

Specific agencies, in addition to the Iowa DOT, that are involved in testing and implementing the national model effort may be found at http://www.iacptechnology.org/Programs/NationalModel.htm. Information may also be obtained from Mary Jensen, TraCS Program Manager, Motor Vehicle Division, Iowa DOT (515-237-3235, mary.jensen@dot.state.ia.us).

Objective 12.1 G—Promote Industry Safety Initiatives

Strategy 12.1 G1: Perform Safety Consultations with Carrier Safety Management

General Description

Enforcement strategies are intended to ensure that all motor carriers and drivers comply with certain fundamental safety requirements, ranging from driver medical condition and other qualifications, driver hours-of-service compliance, vehicle condition, highway speed compliance, and compliance with other carrier operational and traffic regulations. Federal, state, and local enforcement activities lay the foundation for ensuring a safe industry and for identifying and punishing noncompliant carriers and drivers.

However, punishment is not the only way to stimulate safety-related changes in the motor carrier industry. Educational approaches complement enforcement and indeed can address safety practices not related to compliance. As such, they are potentially much more comprehensive and are naturally more likely to be received positively by carriers. Development of a cooperative relationship between government and industry on the subject of motor carrier safety is strongly valued by most state motor carrier safety officials (Patten, 2001).

Regulatory compliance by motor carriers and their drivers is perhaps best viewed as an essential prerequisite for safe operations. However, compliance per se is probably not sufficient to ensure safe commercial vehicle operations. Active carrier safety management, addressing areas and practices beyond compliance, is necessary to achieve and sustain high operational fleet safety (Corsi and Barnard, 2003; Knipling et al., 2003; Stock, 2001, American Trucking Associations Foundation, 1999).

There are a number of initiatives that states and other levels of government can take to provide safety education and consultation to the motor carrier industry. Often these initiatives are most effective if they are conducted in partnership with industry, e.g., state motor carrier trade associations. Potential activities include distribution of safety-related publications (brochures, manuals, bulletins, etc.), seminars and workshops for fleet safety managers, seminars or other special training for drivers on topics such as defensive driving, "circuit rider" visits to motor carriers to provide free or low-cost safety consultation, volunteer mentoring for new or problem carriers by established safe carriers, nonpunitive compliance reviews, and advisory warning letters sent to problem carriers before any punitive actions are taken. Patten (2001) reviews a number of different types of state-sponsored education activities for motor carriers, the number of states using each activity (according to survey data), and state officials' ratings of their safety effectiveness. For example, 33 states conduct seminars, classes, or conferences, and 97 percent of the responding officials from these states rate the programs as effective or very effective. The number of motor carriers contacted through these programs averaged 68 per state annually, but varied widely across states from just a few to 5,000. Also addressed in the Patten report are state motor carrier association education and information dissemination activities.

The Tennessee Department of Safety has an Alternative Commercial Enforcement Strategies (ACES) program that provides compliance-related information to fleets in a nonthreatening

manner. In ACES, specially trained officers visit fleets using an advisory rather than an enforcement approach. The officers provide as much information as possible to help fleets to be more proactive in avoiding safety and compliance problems. Training services provided range from demonstrating vehicle inspection procedures to reviewing compliance paperwork requirements to training new drivers. Later visits may be enforcement oriented, but the initial visit is advisory and permits fleet operators to improve their practices. During 1999, the Tennessee ACES group made more than 700 industry contacts and also visited more than 2,000 schools to provide truck safety information and education to the public. In addition, Share the Road information was provided at a number of large public events such as parades, sporting events, and festivals.

The award-winning Tennessee ACES unit is composed of 12 sergeants/officers statewide. ACES is based on the concept of community-oriented policing where the "community" is the commercial vehicle industry of Tennessee. Companies visited are offered a variety of educational services free of charge, including

- Hours of service classes,
- Medical qualifications for commercial vehicles,
- Safe driving tips,
- Share the Road/No Zone program,
- Assistance in establishing drug/alcohol testing programs,
- Assistance in establishing vehicle maintenance programs,
- Assistance in establishing record-keeping requirements,
- Assistance in establishing file maintenance for drivers and vehicles,
- Informational Level 1 inspections,
- Programs for private carriers of passengers,
- Conducting new driver programs/orientation,
- Classes for hazardous materials regulations,
- Training on conducting pre- and posttrip inspections, and
- Educational contacts and compliance reviews.

An innovative approach to improving compliance, originating in the state of New York, is the "compliance letter." Instead of issuing a citation to carriers or conducting a full compliance review, the state may simply require that problem carriers write a letter to the state, stating that they are aware of the regulation(s) in question and current deficiencies in their operations and describing their plans to get into full compliance. Otherwise, these fleets receive no punishment at this stage. The state has found that this nonpunitive exercise often gets the attention of fleet management and motivates them to upgrade their safety and compliance practices proactively, prior to experiencing any major fines or other sanctions.

Colorado's Circuit Rider program is an industry-based initiative to provide free consultation to fleets on their safety compliance and management practices. The program, supported by a NHTSA 402 grant and managed by the Colorado Motor Carrier Association, employs veteran carrier safety managers who travel around the state visiting motor carriers that have requested the consultation. A major attraction of the Circuit Rider program to participating

fleets is that it is not related to enforcement and cannot result in punitive consequences to the carrier. Consultation with the fleet owner or safety manager might include the following:

- Review of the carrier operation, including staffing levels, equipment, driver files, and insurance;
- Review of the fleet's approach to compliance with key Federal Motor Carrier Safety Regulations (FMCSRs), such as driver drug and alcohol testing and driver hours of service;
- Advice on building a stronger safety program for the fleet; and
- Providing information and tools to support the carrier's safety management efforts, such as referrals to sources of information or consultation on specific safety practices.

In addition to the direct consultation provided to individual fleets, the Colorado Circuit Rider program conducts safety workshops for motor carrier managers, drivers, and dispatchers. Topics include FMCSR compliance, drug and alcohol testing requirements and procedures, driver selection and hiring, driver performance evaluation, carrier safety management, and vehicle maintenance. See Appendix 8 for further details on this program.

The Michigan Truck Safety Commission has established a nonprofit Michigan Center for Truck Safety (MCTS; www.truckingsafety.org) to provide free and low-cost training and consultation to truck drivers and carrier safety managers. The MCTS also manages public Share the Road education programs. Funding for the commission and the center comes from registration fees on heavy vehicles. Professional training includes driver coaching, "decision" driving courses (conducted on skid pads to teach drivers dynamic safety maneuvers such as pulling out of a jackknife), defensive driving, fatigue management, inspection training, load securement training, and safety manager training. There is also an annual Truck Exposition and Safety Symposium.

The FMCSA plans a multimedia "Safety is Good Business" program to provide educational materials directly to fleets (FMCSA, 2001a). The program will cover a full range of safety-effective practices that fleet owners and managers can implement immediately or in short timeframes to reduce crashes. A central theme will be the high costs of crash involvement and the benefits of crash prevention. This program, now under development, will target new and small motor carriers.

The educational and consultation outreach programs to the motor carrier industry can be viewed as somewhat analogous to FHWA-sponsored Local Technical Assistance Program (LTAP) and Circuit Training Assistance Program (CTAP) training. FHWA supports a network of 57 centers nationwide to provide workshops and consultation in a variety of topics relating to highway design and operation. In addition to course offerings, LTAP programs sponsor conferences and expositions, often attracting hundreds of state and local highway officials and contractors. Several of the motor carrier safety programs above have similarities to the LTAP/CTAP concept and have the potential to play a similar role in professional education and information dissemination.

EXHIBIT V-15
Strategy Attributes for Safety Consultation with Carrier Safety Management

Attribute	Description
Technical Attributes	
Target	The primary target is motor carrier fleet owners and safety directors.
Expected Effectiveness	Various fleet safety management practices are among the most salient discriminators between safe and unsafe fleets (Corsi and Barnard, 2003). Improved carrier safety management can significantly improve fleet safety performance, particularly in new or small fleets without systematic safety programs. Most state motor carrier officials with industry education/consultation programs rate them as effective or very effective (Patten, 2001).
Keys to Success	One key for this strategy is to provide information and consultation in a nonthreatening way, that is, separately from enforcement activities. In terms of methods, there are a variety of innovative approaches for disseminating safety management information; multiple media, including print, should be used to provide information since many small carriers are relatively low-tech.
Potential Difficulties	Materials that are entirely Web based may not reach all desired carriers. Since numerous different activities are covered by this strategy, programs must select the most effective ones for disseminating information and changing fleet practices. Also, many carriers may not avail themselves of these consulting services because of fear of exposing unsafe or noncompliant operations to the authorities, in spite of assurances that they will not be vulnerable to enforcement action.
Appropriate Measures and Data	Process measures would include the number of fleets receiving education or consultation and their aggregate size (e.g., number of drivers or trucks). The impact on truck safety would be measured by changes to fleet out-of-service, traffic violation, or crash statistics. Exposure variables would also be needed.
Associated Needs	A cooperative and collaborative relationship between government and industry will promote maximum effectiveness (Patten, 2001).
Organizational and Institutional Attributes	
Organizational, Institutional, and Policy Issues	Because these activities are not enforcement related, they may be viewed within some organizations as “icing on the cake” rather than as essential programs. Limitations of funding and/or personnel resources may prevent full implementation. Also, as noted, this strategy is greatly enhanced by government-industry collaboration.
Issues Affecting Implementation Time	Funding and development times for educational materials and courses.
Costs Involved	Depends on the nature of the activities. Cost elements include personnel to manage and operate the program; costs of materials, equipment, and facilities; and costs experienced by fleets as they institute new programs and procedures.
Training and Other Personnel Needs	Individuals providing consultation to fleets must be highly qualified and credible to be regarded as authoritative by fleet safety managers.
Legislative Needs	Ordinarily, no new legislation is required. However, some states may need legislation to fund or otherwise permit alternative enforcement strategies.
Other Key Attributes	
	None identified.

Information on Agencies or Organizations Currently Implementing this Strategy

Below are information sources for various safety consultation programs described above:

- Tennessee ACES program: Captain Steve Binkley, Tennessee Department of Safety (615-687-2317, steve.binkley@state.tn.us).
- New York Compliance Letters: Mark White, Manager, Permit Section, Traffic Engineering and Highway Safety Division, New York DOT (518-457-1795, mwhite@dot.state.ny.us).
- Colorado Circuit Rider program: Patricia J. Olsgard, Director, Safety, Training, and Research, Colorado Motor Carriers Association (303-433-3375, x304, patti@cmca.com, see Appendix 8).
- Michigan Center for Truck Safety: www.truckingsafety.org (800-682-4682).
- FMCSA Safety Is Good Business Program: Tony Schafer, Safety Action Programs Division (202-366-2953, Anthony.schafer@fmcsa.dot.gov).

Strategy 12.1 G2: Promote Development and Deployment of Truck Safety Technologies

General Description

Most of the truck safety strategies presented in this guide involve activities that are performed primarily by state motor carrier safety agencies, i.e., state DOTs or DMVs. However, many aspects of truck safety are influenced primarily by industry—the motor carrier transport industry and/or the truck manufacturing industry. One such safety element is vehicle safety design. Improved heavy-truck safety designs and technologies may help drivers (i.e., truck drivers or other drivers driving around trucks) avoid crashes or may be oriented toward improving occupant survivability during a crash.

Manufacturers play a principal role in determining vehicle safety design by the standard and optional safety equipment installed on their vehicles. For example, electronic braking systems are relatively new technologies that are beginning to penetrate the new truck market. Anti-lock brakes are a more mature technology that was mandated by NHTSA (in Federal Motor Vehicle Safety Standard [FMVSS] 121) for all new trucks and trailers in 1996.

The motor carrier industry also plays a principal role by selecting specific equipment for new vehicles—referred to as "spec-ing" the new vehicle. All new trucks must meet the FMVSSs (developed and enforced by NHTSA), but, beyond compliance with these standards, buyers of new trucks have considerable discretion in the safety-related features and components they select for their vehicles. Buyers may specify different engine performance specifications (e.g., related to maximum speeds and optimal fuel economy), different types of brakes, tires, mirrors, lighting and signaling configurations, and other components relevant to safe operations.

In addition to basic safety-related components such as brakes and tires, various advanced technology collision avoidance systems have been developed and marketed. For example, the Eaton-VORAD (Vehicle On-board RADar) forward collision warning system is associated with a 35-percent reduction in truck-striking-rear-end crashes, according to the

system's Web site (truck.eaton.com/vorad). Other advanced technologies under development or marketed include adaptive cruise control, roll stability advisors and controllers, and lane departure warning systems (FMCSA, 2003b). Advanced on-board sensor systems can provide diagnostic monitoring of safety-critical components such as brakes and tires. These advanced technology devices may be selected for installation on new vehicles at the time of purchase or may be purchased for retrofit for vehicles already in the fleet.

In addition to functioning as collision warning systems, advanced technologies can be used to monitor and modify commercial driver safety behavior. Such new or emerging technologies include adaptive cruise control, rollover detection and prevention systems, lane trackers and lane departure warnings, side sensing (proximity) devices, vehicle and cargo tracking systems, event data recorders ("black boxes"), and driver alertness monitoring (Roetting et al., 2003).

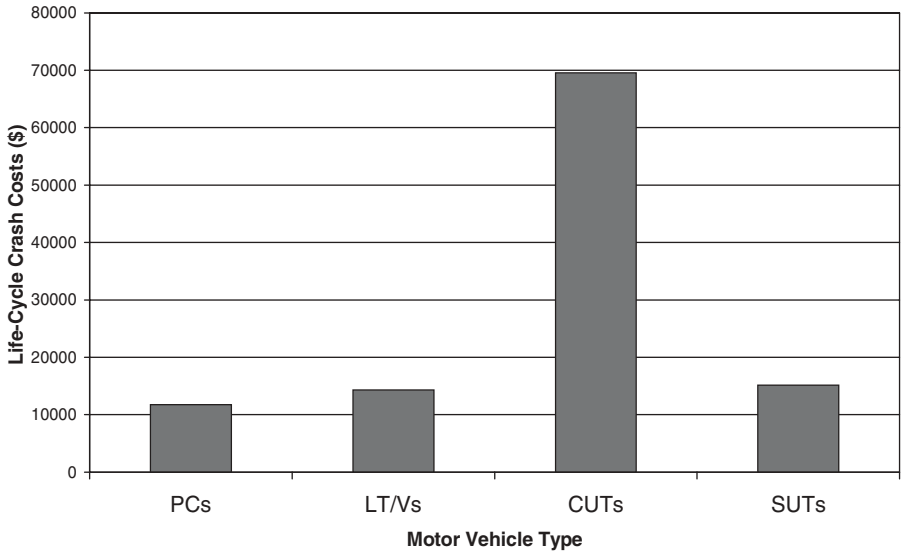
A review of truck safety technologies commissioned by PENNDOT (Parsons Brinckerhoff Quade and Douglas, Inc., et al., 2002) describes technologies and safety practices relating to underride (or underrun) prevention, improved braking systems, prevention of postcrash fires, tire failure, driver fatigue, collision warning, electronic vehicle speed regulation, improved cab structural integrity during rollovers, advanced side mirror designs, and enhanced truck/trailer conspicuity. The study reviews new developments occurring in both North America and Europe. Some European truck safety design and operational standards are more stringent than those in the United States, such as standards for truck cab structural integrity during rollovers and a requirement for use of on-board recorders (tachographs) for driver hours-of-service verification (Hartman et al., 2000).

In a survey, Knipling et al. (2003) found that most safety-conscious fleet safety managers carefully "spec" their new vehicles for basic safety equipment such as brakes, tires, mirrors, and conspicuity lighting, but that a minority currently order advanced technology safety devices such as forward radar obstacle detection systems.

As noted in Section III, combination-unit trucks are, of all vehicle types, the vehicle type most likely to be associated with highly positive cost-benefits from the installation of enhanced safety equipment. Although combination-unit trucks (tractor-trailers) have relatively low crash rates per mile traveled, their high mileage exposures and the severity of their crashes combine to associate them with much greater costs for an average crash, average crash costs per year, and average vehicle life-cycle crash costs. Average crash costs over the operational life of a combination-unit truck are more than four times higher than most other vehicle types (Wang et al., 1999); see Exhibit V-16. For combination-unit trucks, there are greater benefits per vehicle and per investment dollar than for other vehicle types. Thus, they are generally the vehicle platform of choice for early cost-effective deployment of motor vehicle safety technologies (Wang et al., 1999). Single-unit large trucks (also called straight trucks) do not generally have such high life-cycle crash costs because their annual and lifetime mileage exposures are more similar to passenger vehicles than to long-haul tractor-trailers. Thus, for most vehicle-based safety technologies, combination-unit trucks are a much more attractive platform than are single-unit trucks.

Truck vehicle safety technologies are not panaceas, however. Effective fleet deployments often require active vehicle maintenance and driver safety management. In a survey of

EXHIBIT V-16
Per-Vehicle Life-Cycle Crash Costs for Passenger Cars (PCs), Light Trucks/Vans (LT/Vs), Combination-Unit Trucks (CUTs), and Single-Unit Trucks (SUTs)
Source: Wang et al., 1999



motor carrier fleet safety managers, Knipling et al. (2003) found that specifying enhanced safety equipment on new vehicles was rated only average in effectiveness compared with other fleet safety management practices, and that the use of advanced technology collision avoidance systems (e.g., forward/rear obstacle detection) was rated below average. Of course, these systems are likely to become more popular and highly regarded as the technology is advanced in the coming years.

Depending upon the technology, driver acceptance and proper use of the equipment may be an issue. A study by Penn + Schoen Associates, Inc. (1995), found that commercial drivers were often skeptical of on-board technologies that they had not yet used and were especially wary of technologies perceived as invasions of privacy (e.g., monitoring systems) or as diminishing the role of driver judgment (e.g., driver advisory or warning systems). Driver resistance must be overcome if the full promise of these technologies is to be realized (Roetting et al., 2003).

EXHIBIT V-17
Strategy Attributes for Promoting Development and Deployment of Truck Safety Technologies

Attribute	Description
Technical Attributes	
Target	This strategy targets truck manufacturers, motor carrier fleet owners, and safety directors.
Expected Effectiveness	Effectiveness depends upon the safety device installed. Different technologies address different safety problems and target crashes, so comparisons are difficult.

(*continued on next page*)

EXHIBIT V-17 (Continued)
Strategy Attributes for Promoting Development and Deployment of Truck Safety Technologies

Attribute	Description
	Because this strategy is focused upon new technologies, their impact on fleet safety is initially going to be considered experimental. As noted above, there is often resistance to new technologies. Except for cases involving mandated technologies or safety designs, pilot studies are advisable before full implementation. This will allow fleet operators a better basis to judge their cost-effectiveness, as well as to provide experience for drivers to assess the reality of their concerns.
	Other factors being equal, safety design enhancements to combination-unit trucks are likely to have greater per-vehicle benefits than similar enhancements to single-unit large trucks because of the high life-cycle crash costs associated with combination-unit trucks.
Keys to Success	Success will be proportional to market penetration. Some vehicle-based, heavy-truck safety technologies require active fleet management monitoring and management for maximum benefits.
Potential Difficulties	Reliability and maintenance problems, driver nonacceptance, and driver misuse of devices (e.g., coming to rely on collision warning systems) are among the problems that may occur.
Appropriate Measures and Data	Process measures would include the number of large trucks equipped with various safety technologies or improved safety designs.
	Outcome measures would include effects on heavy-truck, out-of-service rates and crashes. Measures of exposure will also be needed. Because of the gradual market penetration process, rapid changes in these outcome statistics are not likely.
Associated Needs	Active management monitoring and evaluation of effects on driver safety behavior are needed. Initially, this should be through a pilot test program.
Organizational and Institutional Attributes	
Organizational, Institutional, and Policy Issues	Some devices, such as anti-lock brakes and enhanced conspicuity lighting on trailers, have been mandated by NHTSA. Many others are not mandatory and are purchased at the discretion of fleet owners and managers.
Issues Affecting Implementation Time	Complete penetration of new vehicle-based technologies in the heavy-truck fleet is likely to take two decades or more. The average operational life of large trucks is nearly 15 years, and most new safety technologies are ordered and installed as new vehicles are purchased.
Costs Involved	Costs depend upon the technology involved. In general, costs will decrease over time as a particular technology matures, manufacturing methods improve, and economies of scale are experienced. Cost elements include capital, operating and maintenance, and training of the drivers and those who handle maintenance and repair.
Training and Other Personnel Needs	Some devices require driver training, or at least a brief orientation. For example, anti-lock brakes are effective only if drivers learn how to use them properly. In addition, training will be needed for those who maintain and repair devices.
Legislative Needs	Ordinarily, legislation is not required. However, some safety design changes and technologies are mandated by NHTSA in the FMVSSs.
Other Key Attributes	
	None identified.

Information on Agencies or Organizations Currently Implementing this Strategy

Among the organizations involved nationally in promoting the use of truck safety technologies are NHTSA, FMCSA, the U.S. DOT Intelligent Transportation System Joint Program Office, the Truck Manufacturers Association, SAE (http://heavyduty.sae.org/), and the American Trucking Associations Truck Maintenance Council.

A Truck Manufacturers Guide Web site (www.cojoweb.com/truck_manuf.html) contains links to various heavy-truck and trailer manufacturers and equipment vendors.

The Transportation Research Board has a number of committees active in commercial vehicle design and other motor carrier safety issues. These include the Committee on Motor Vehicle Size and Weight (AT055) and the Committee on Truck and Bus Safety Research (ANB70). Information on these and other truck transportation committees can be found at http://www.trb.org/directory/comm_homepages.asp.

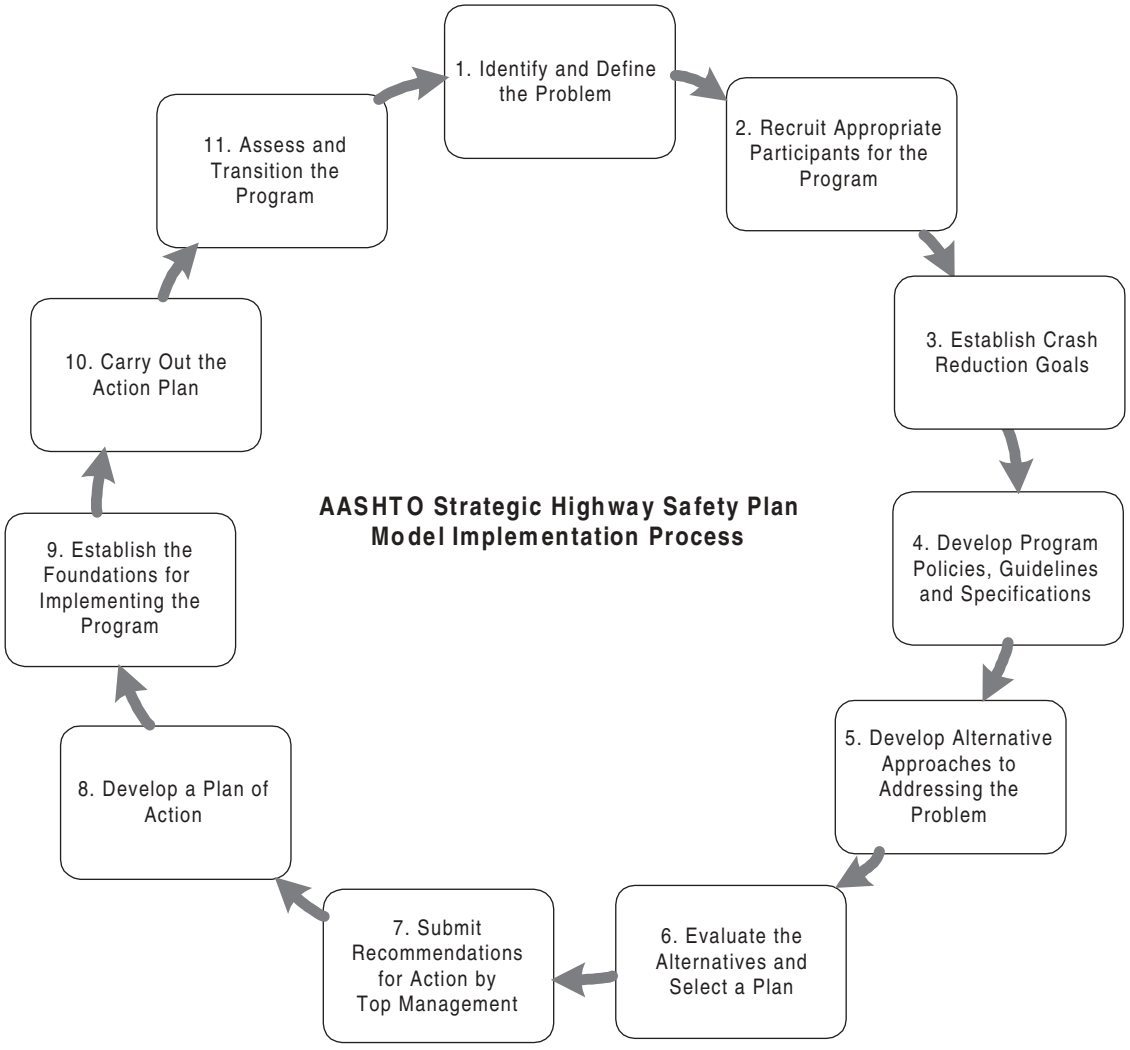
SECTION VI

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 Profile of State Agency Implementation Efforts: Kentucky
2 Profile of State Agency Implementation Efforts: Colorado
3 Profile of State and Local Agency Implementation Efforts: Michigan
4 Profiles of State and Local Agency Implementation Efforts: Pennsylvania (Strategy 12.1.D2)
5 Profiles of State and Local Agency Implementation Efforts: Pennsylvania (Strategy 12.1.E1)
6 Profiles of State and Local Agency Implementation Efforts: Pennsylvania (Strategy 12.1.E2)
7 Example of the Development of a Vehicle-Based Truck Roll Stability Advisory and Control System
8 Profile of State and Local Agency Implementation Efforts: Colorado
9 Truck Lane Restrictions and Exclusive Truck Lanes

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