U.S. Department of Transportation

Federal Highway Administration

Federal Transit Administration

Considering Safety in the Transportation Planning Process

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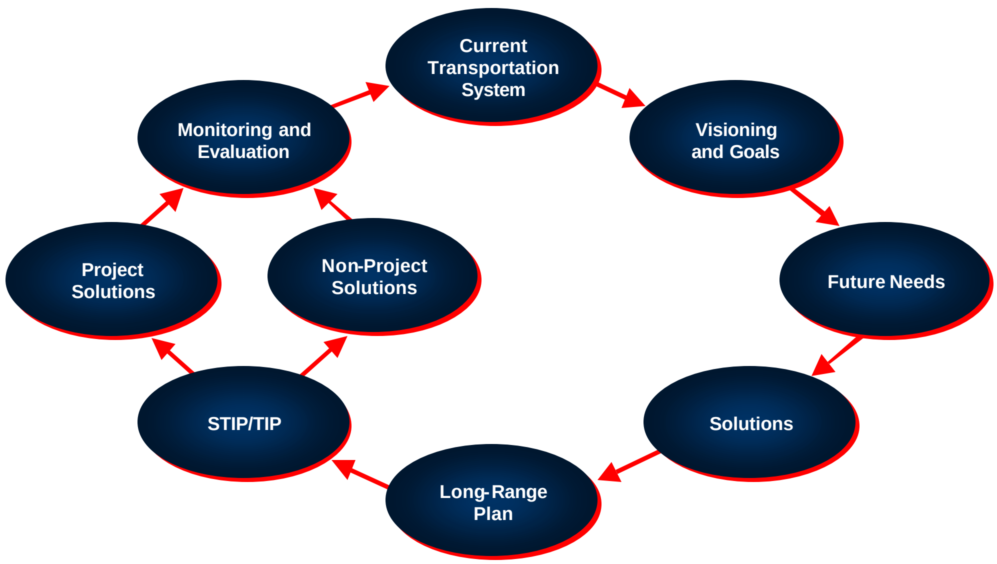

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Chapter 1
Institutional Framework for Safety Planning

Scope and Organization of This Report

This report examines the integration of safety into the transportation planning process. Safety is an essential part of transportation and needs to be considered by all agencies involved—state departments of transportation (DOTs), metropolitan planning organizations (MPOs), transit agencies, local governments, special districts, and non-profit organizations. Improving the safety of the transportation network requires an active, conscious approach to monitoring the transportation system for safety problems and anticipating problems before they occur.

The focus of this report is on incorporating safety into the transportation planning process for the multi-modal transportation system and on providing planners with information and techniques to better understand the role of safety within this process. To improve its understanding of the current framework and industry practices for the integration of safety in the planning process, the study team began the project with a comprehensive literature review. This review helped to identify U.S. agencies whose planning efforts have led to successful safety improvements. These agencies were then screened more closely for their dedicated safety efforts and for their coordination efforts with other agencies within their states. Ultimately, the team chose Oregon, Michigan, and Pennsylvania for the study, and the report draws particularly on the experiences in these states. Both the literature review and the case studies are available on the Federal Highway Administration (FHWA) planning websites. During this study, FHWA and the Transportation Research Board (TRB) jointly sponsored state forums to bring together transportation planners at all levels to discuss safety and planning efforts as well as possibilities for increased coordination. The study team participated in several of these forums to further understand industry efforts. The objective of this report is to illustrate how safety can be integrated into transportation planning. Too little experience in safety planning has been gained, particularly at the local level, to identify best practices. However, the report illustrates a variety of approaches that have been used and compares their strengths and weaknesses.

This report outlines the multi-modal planning process, emphasizing the areas where safety could be considered. The report is organized into five chapters. The remainder of this chapter discusses the importance of safety in planning, the legislative background, the agencies involved in safety and transportation planning, the role of safety as part of the transportation planning process at the state and metropolitan planning levels, sources of funding for transportation safety activities, and some of the institutional challenges to incorporating safety into the planning process.

Chapter 2 examines different approaches to DOT's and MPO's long-range safety planning processes. This chapter starts with a discussion of states' long-range plans and identifies ways in which safety should be included. While federal law does not mandate long-term safety goals, improving safety over the long term is implicit in most of the legislative actions that Congress and the states have taken. Reducing fatalities, injuries, and crashes on the nation's transportation network is a common goal of most safety programs. Different strategies for improving safety over the long term are illustrated.

Chapter 3 examines the short-range transportation planning process in the context of the transportation improvement program. This chapter looks at specialized studies and their role in the planning process, as well as the MPO's role as the coordinator. Chapter 3 also analyzes truck and transit safety and planning approaches and discusses various methods for benefit-cost analysis.

Chapter 4 details how a crash database is constructed and managed. It includes discussion of the traditional database approach, as well as the newer geographic information system (GIS) approach. Various tools used for safety analysis are described, as well as some available software.

Finally, Chapter 5 discusses other agencies and organizations having programs relating to safety planning. It outlines some of their projects and presents examples of their successful partnerships.

Background

Why Safety is Important for Transportation

The public expects, and demands, that the transportation system be safe and efficient for all users. Transportation is an essential part of modern existence, linking the various activities in which people participate—home, work, school, shopping, and recreation.

Improving transportation safety can help to alleviate a myriad of health, financial, and quality-of-life issues for travelers. Fatalities and injuries from motor vehicle crashes are a major public health problem. The National Highway Traffic Safety Administration (NHTSA) reported 41,821 deaths resulting from 37,409 motor vehicle crashes in 2000. While the fatality rate per 100 million vehicle miles traveled (VMT) has been decreasing consistently and is the lowest on record (1.54 per 100 million VMT), motor vehicle crashes continue to be a major cause of death in the United States. Fatalities from motor vehicle crashes are the leading cause of death for all ages from 1 through 24.[a]

[a] The comparison is for fatalities from "unintentional injuries," which includes most deaths from injury and poisoning. The category excludes homicides (including legal intervention), suicides, deaths for which none of these categories can be determined, and war deaths (NSC, 2000, 8). By comparing National Safety Council with National Vital Statistics Systems data, it can be seen that fatalities from motor vehicle crashes exceed all other causes for ages from 1 through 24 (NSC, 2000, 8; DHHS, 2000, 176-77).

Vehicle crashes are a major source of congestion on the road system. Intelligent transportation system (ITS) priorities of the past 10 years have included improving the response of emergency services in relieving congestion from incidents along heavily traveled roadways, an indirect consequence of the debilitating effects of motor vehicle crashes.

Perhaps the most important reason for actively encouraging safety on the transportation system is that crashes of all sorts can be prevented. We no longer view crashes as accidents or random events. We now understand that certain populations (teenagers) are more likely to be involved in deadly crashes, that alcohol contributes to the likelihood of crashes, that unsafe vehicles are more likely than safer vehicles to produce injuries to their occupants, and that certain locations are more likely to have crashes. We also understand that transit riders, pedestrians, and bicyclists are equally important users of the roadways, and we need to understand how the transportation network operates as a system, as opposed to as independent modes.

Transportation safety has improved since the early 1970s, when the federal government started to promote safety and to demand that states and local governments take actions. Vehicle manufacturers have improved designs and added airbags to make vehicles safer. States have enacted laws requiring the use of safety belts and child restrain, and usage of both has increased dramatically. City planning departments and MPOs have worked together to program funds for bicycle and pedestrian-friendly roadways and paths. Transit agencies have started to aggressively collect data to analyze frequent accident locations and develop countermeasures. States and local governments have improved unsafe roadways. The result of these and other countermeasures, such as legislative improvements, public information, education and training, has been an improvement in the general safety of the transportation system.

Why Safety is Important for Transportation Planning

Although the public demands a safe transportation system, safety historically has not been an explicit part of transportation planning. A clear need has developed for safety to be considered as part of the planning process instead of as a reactionary consideration as it has been. To be adequately addressed, safety must be a key goal within the process. This is a critical time to formally increase safety's role in the planning process. The 1990s showed a leveling off of fatalities, and it is important for planners to remain aggressive in developing even more strategies and countermeasures to improve system safety.

A systematic method for including safety in the planning process has not yet been identified. A discussion of the planning process, and potential spots for systematically including safety, is presented later in this chapter.

Legislative Background

Until the enactment of the Transportation Equity Act for the 21st Century (TEA-21), federal laws have separately addressed transportation system safety and security and required transportation planning processes. Federal law requires that the road system be kept safe and that road safety improvements be continuous. Federal law also requires that federally funded highway and transit projects in urbanized areas be based on a transportation planning process. These historic laws are discussed in the following sections.

Federal-Aid Highway Act of 1962

The Federal-Aid Highway Act of 1962 created the federal requirement for urban transportation planning. As a condition for federal funding, transportation projects in urbanized areas with populations of more than 50,000 must be based on a continuing, comprehensive, urban transportation planning process undertaken in a cooperative manner between states and local governments. This was the beginning of the "3C" planning process—continuing, comprehensive, and cooperative. This requirement led to the creation of the MPO because a need clearly existed for one agency capable of carrying out the planning process.

State Highway Safety Program

The Highway Safety Act of 1966 (23 USC Chapter 4, Section 402) requires each state to have a highway safety program, approved by the Secretary of Transportation, to reduce traffic accidents and deaths, injuries, and property damage. The Section 402 Highway Safety Program is administered jointly by NHTSA and FHWA. In its current form, the program sets forth the minimum requirements for state highway safety programs and provides funds for non-construction projects aimed at reducing injuries, deaths, and property damage from motor vehicle crashes. These requirements include developing or upgrading traffic record systems; collecting crash data; conducting traffic engineering studies; developing technical guides for state and local highway agencies; developing work zone safety projects; encouraging the use of safety belts and child safety seats; conducting roadway safety public outreach campaigns; and developing enforcement programs to reduce impaired driving, combat drivers who speed or drive impaired, and reduce aggressive driving. The Section 402 program is primarily oriented toward improving crash information systems and modifying driver behavior to reduce crashes, although the program will fund safety tool development and some engineering work. This legislation was landmark in providing direction and funding for making highway safety improvements.

Hazard Elimination Program

The Highway Safety Act of 1973 introduced a federal mandate for roadway safety, requiring each state to conduct and systematically maintain a survey of all highways to identify high-hazard locations that may constitute a danger to vehicles and pedestrians. States must assign priorities for correcting identified hazards and develop a schedule of projects for their improvement. The law establishes a benefit-cost methodology for identifying safety project locations and establishes a means for assigning priorities. Like the Highway Safety Act of 1966, the 1973 act provides mandates for states, a systematic approach to safety improvements, and an earmarked funding source for the improvements.

The initial legislation, Section 152 Hazard Elimination Program (HEP), made construction funds available for roads on the federal-aid system other than a highway on the interstate system, which was covered under other legislation. The 1973 act also created a separate Railway/Highway Crossings Program, Section 130. The legislation earmarked funds for each program.

In 1982, the legislation was amended to extend Section 152 authorization to all public roads, except the Interstate Highway System, which had its own authorization (Highway Improvement Act of 1982). The current law (23 USC, October 1983) essentially unifies this principle, stating:

> *Each State shall conduct and systematically maintain an engineering survey for all public roads to identify hazardous locations, sections and elements, including roadside obstacles and unmarked or poorly marked roads, which may constitute a danger to motorists and pedestrians, assign priorities for the correction of such locations, sections and elements, and establish and implement a schedule of projects for their improvement.*
>
> *(Section 152 Hazard Elimination Program; II–91-II–92)*

Intermodal Surface Transportation Efficiency Act

The Intermodal Surface Transportation Equity Act of 1991 (ISTEA) combined the separate funds for Section 152 Hazard Elimination Program and Section 130 Railway/Highway Crossings Program. Section 133 (d) (1) of Title 23 USC of the Highway Safety Act establishes a Surface Transportation Program (STP) and states that 10 percent of the funds apportioned to a state for STP *"shall only be available for carrying out sections 130 and 152 of this title."* The amount of funds in each category (Section 152 or 130) could not be less than the amount that was allocated in 1991. ISTEA further noted that the 10 percent safety set-aside funds were to be the minimum amount for use in safety improvements. States could allocate additional funds to improve the safety of entire public transportation system.

Transportation Equity Act for the 21st Century

TEA-21, enacted in 1998, expanded the safety programs of ISTEA. TEA-21, for the first time, brought in safety and security as a planning factor, particularly to be considered when preparing plans/transportation improvement programs (TIP):

> *It is in the national interest to encourage and promote the safe and efficient management, operation, and development of surface transportation systems that will serve the mobility needs of people and freight and foster economic growth and development within and through urbanized areas while minimizing transportation-related fuel consumption and air pollution.*

The regulations required safety (along with security) to be a stand-alone planning factor for the first time, by defining the scope of the planning process to *"provide for consideration of projects and strategies that will…increase the safety and security of the transportation system for motorized and nonmotorized users."*

In addition, TEA-21 extended HEP to all public roads, including the Interstate Highway System, and provided for funding of safety improvements along the interstates. TEA-21 further expanded transportation safety efforts to allow:

- HEP funds to be used for bicycle and off-road improvements on publicly owned routes as well as traffic-calming devices
- Railway/highway crossing programs to include bicycle safety
- Increased motor carrier safety inspection efforts
- A railway/highway hazard elimination program in high-speed rail corridors
- A Safe Communities Program that allows cities so designated to fund safety programs from a variety of categories within Title 23

Enabling Regulations

Parallel to this legislation, FHWA issued a series of regulations in 1979 that came to be known as the Highway Safety Improvement Program.[b] These regulations were modified in 1991 and 1998.[c] The regulations establish three components of the program:

- **Planning**—a process for collecting and maintaining a record of accident, traffic, and highway data; analyzing available data to identify highway locations that are hazardous; conducting engineering studies of hazardous locations; prioritizing implementations; conducting an expected benefit-cost analysis; and paying special attention to railway/highway grade crossings
- **Implementation**—a process for scheduling and implementing safety improvement projects and allocating funds according to the priorities developed in the planning phase
- **Evaluation**—a process for evaluating the effects of highway improvements on safety including the cost of the safety benefits derived from the improvements, the accident experience before and after the implementation, and a comparison of the pre- and post-project accident numbers, rates, and severity

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[b] Federal-aid Highway Program Manual, Volume 8 - Highway Safety, Chapter 2 - Safety Program Implementation, Section 3 - Highway Safety Improvement Program; Transmittal 298, HHS-11, March 5, 1979.

[c] Subchapter J - Highway Safety, Part 924 - Highway Safety Improvement Program; 23 CFR Part 924.

In short, federal legislation has created a mandate for highway and transit safety on all public systems. States and, by implication, local jurisdictions are required to monitor their transportation networks for safety problems and to develop mitigation strategies for each high-hazard location. They are required to conduct a benefit-cost analysis and to prioritize projects on the basis of the benefit-cost analysis. The legislation creates a strategy for safety planning and a required minimum level of funding.

The consideration of safety in the transportation planning process is a new concept. States, MPOs, transit agencies, and local governments clearly have varying mechanisms for identifying areas with safety concerns and procedures to address these areas. These agencies have also implemented the required transportation planning processes. For the first time, TEA-21 introduced safety as a component in the transportation planning process. This will require a new level of coordination between the groups responsible for these efforts as they now have common objectives to meet, and must work collaboratively to meet them. New processes must be developed to ensure that the safety component becomes a permanent and critical part of the planning process.

Agencies Involved in Safety and Transportation Planning

A wide variety of agencies and organizations have activities and programs closely related to safety and transportation planning. These include federal, state, regional, and local agencies as well as national non-profit and for-profit organizations and interest groups (see Exhibit 1-1). These agencies and organizations can serve as valuable resources to state and MPO transportation planners in understanding the efforts, funding sources, and expertise available. These agencies have their own specific goals for safety and their own methods for considering safety. Each of the agencies and organizations involved in transportation safety operates on a different timeframe. Some focus on short-term safety improvements, others on analyzing methods for longer range projects. The differing goals of these agencies can cause additional challenges to planners because they must consider the varying modes, nomenclatures, and goals of these organizations. A detailed description of these agencies is included in Chapter 5, in addition to examples of ways in which the agencies form partnerships to meet common objectives. This not a comprehensive list of all safety partners, just an overview of several key players.

Exhibit 1-1

Partners in Safety Planning

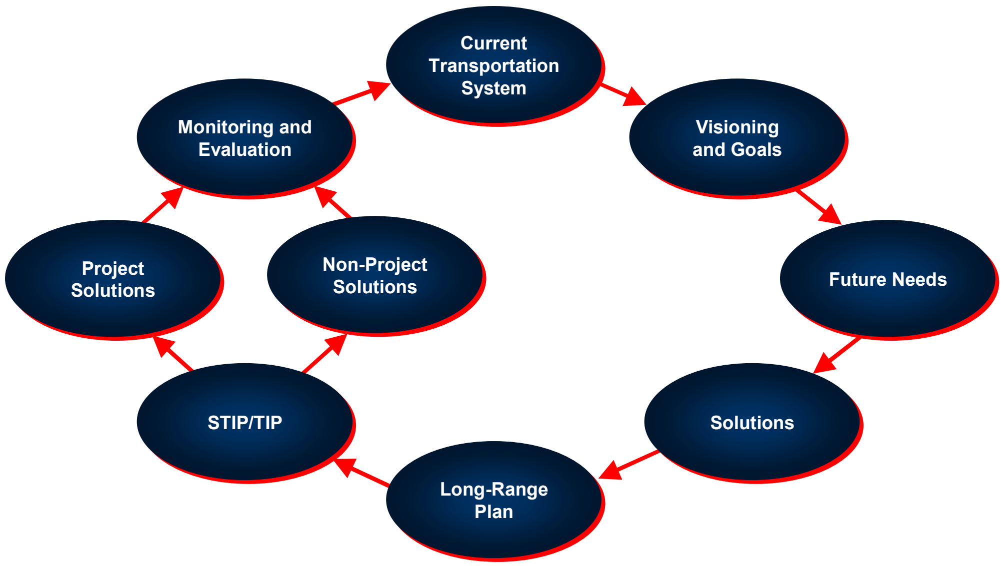
Federal	State
Federal Highway Administration National Highway Traffic Safety Administration Federal Motor Carrier Safety Administration Federal Transit Administration	State Departments of Transportation State Departments of Public Safety State Departments of Emergency Management

Regional	National
Metropolitan Planning Organizations Local Departments of Transportation Transit Agencies City Planning Agencies Local Governments	Transportation Research Board National Association of Governors' Highway Safety Representatives Roadway Safety Foundation Association of Metropolitan Planning Organizations Institute of Transportation Engineers American Association of State Highway and Transportation Officials American Automobile Association

Considering Safety as Part of the Transportation Planning Process

Safety can be incorporated into the transportation planning process in a variety of ways. In traditional transportation planning, safety can be accomplished through both long-range and short-range planning activities. A simplified overview of the traditional transportation planning process is depicted in Exhibit 1-2.

Exhibit 1-2
FHWA's Representation of the Transportation Planning Process



Source: A Citizen's Guide to Transportation Planning, Federal Highway Administration

Transportation planning is a cyclical process that continually improves the current transportation system through planning and programming both project and non-project solutions to the needs of the system. A project solution is a physical improvement to the system infrastructure; a non-project solution is a management-operation such as a program improvement to the system (for example, a dial-a-ride or van pool program). Planners develop long-range plans for the transportation system based on the goals for the system, the identified future needs, and solutions to address those needs. The long-range plan is carried out through short-range planning activities, most of which are programmed through the transportation improvement program (TIP) or the statewide transportation improvement program (STIP). The TIP is a multi-modal programming document for defined projects. Through the programming process, transportation planners evaluate projects for funding and inclusion in the TIP. The STIP is the collaboration of the state's transportation systems and is the defining vision for the transportation system and services. In metropolitan areas, the plan notes all of the transportation improvements scheduled for funding during the next 20 years. After both project and non-project solutions are implemented in these plans, they are monitored and evaluated with performance measures to determine how well the needs of the transportation system are being met.

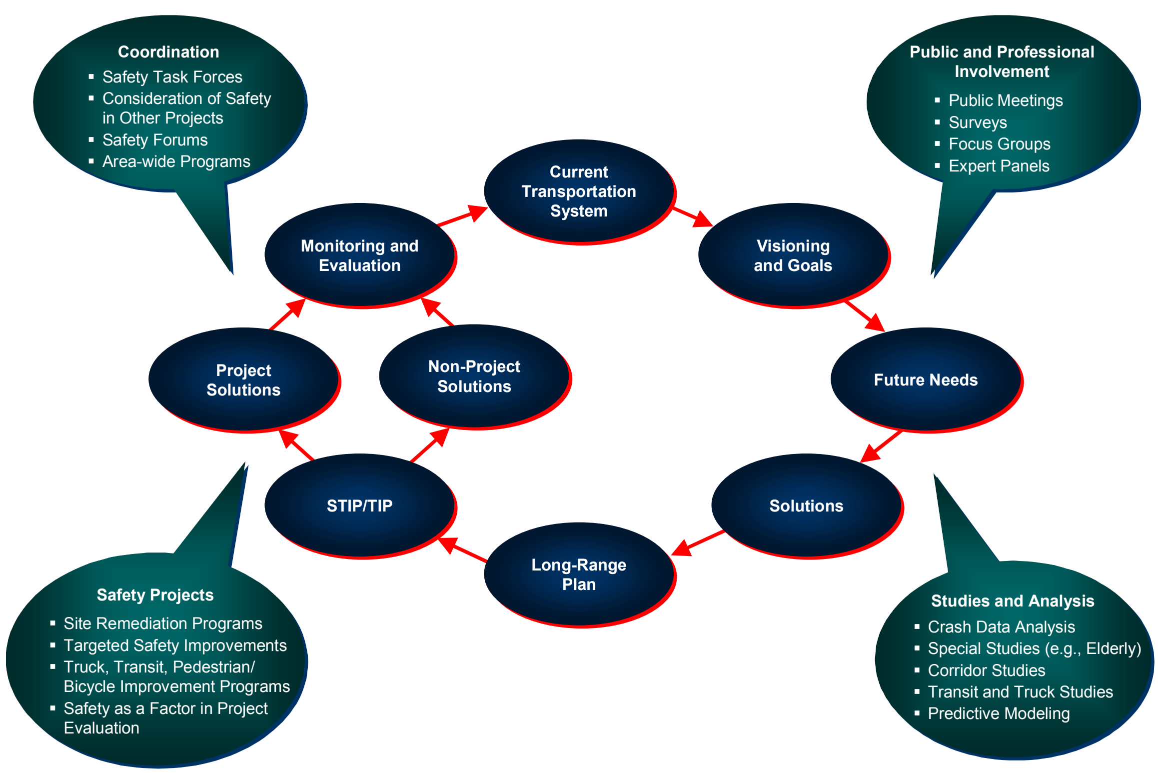
Planning activities carried out by the MPO area are specified in the Unified Planning Work Program (UPWP). The UPWP is the statement of work, budget, and schedule for federally funded planning activities in the area. It may include provisions for activities such as special studies to identify system needs and solutions and to pursue innovative data collection and analysis needs. State planners have a similar unified planning document. Funding for the projects is available from the federal government, state government, and local sources. The funding available depends on the type of project.

The graphic above is shown in the beginning of the following three chapters, highlighting which areas are addressed in that chapter.

How Safety Fits in the Transportation Planning Process

Safety can be incorporated into the traditional transportation planning process in many areas. Exhibit 1-3 depicts the simplified cyclical transportation planning process in the context of safety. Safety is incorporated through the involvement of the public and professional safety community, special studies and data analysis, various dedicated safety projects, and as an element of other transportation projects. Public and professional involvement figures prominently in incorporating safety into the transportation planning process. The involvement is beneficial throughout the various stages of planning especially in developing safety goals and identifying future safety needs. Public and professional involvement is also important for implementing non-project solutions to address the safety needs of the transportation system. MPOs and DOTs can fill the coordination role, which is necessary throughout the planning process to facilitate the inclusion of safety. Special studies and crash data analysis are useful in various stages of the process including identifying future safety needs and potential solutions. Within each chapter, this report identifies how safety can be considered in the transportation planning process.

Exhibit 1-3
Overview of Transportation Planning Process in Context of Safety



Safety and Long-Range Planning Activities

State DOTs are responsible for establishing long-range goals and objectives for their transportation systems. MPOs develop long-range goals and objectives for the metropolitan areas. The safety of the transportation system is almost always one of those goals. These goals should not be limited to highway safety, but should also address the safety of other modes, including transit, pedestrian, bicycle, and heavy vehicle safety. States and MPOs should coordinate with their planning partners to develop the appropriate safety goals, objectives, and measures of effectiveness for the transportation system. This coordination should also extend beyond planning partners to include other groups interested in the safety of the transportation system such as law enforcement, emergency management, community groups, and safety advocates.

The safety goals and objectives are considered in the context of the future needs of the transportation system. Crash data analysis, special studies, and corridor studies can identify additional measures and projects that will be needed in the future to provide a safe transportation system. Similar to developing the goals and objectives, the planning partners and other stakeholders can help identify future safety needs. On the basis of the goals and objectives, both the state and the MPO can develop a long-range plan to address the future needs of the system.

Long-range planning activities for safety may also include incorporating safety into long-range facility planning through techniques such as predictive modeling or expert review. Safety could also be considered in long-range land-use planning and access management decisions. These issues are further discussed in Chapter 2.

Safety and Short-Range Planning Activities

The safety goals and objectives of the long-range plan are carried out through short-range planning activities. MPOs mainly program those activities through the TIP, and Statewide planners through the STIP. Safety can be incorporated in a variety of ways in the TIP or STIP programming process. Targeted long-range safety programs are often implemented project by project through short-range programming. Safety can also be one of the criteria used to evaluate and prioritize projects submitted for inclusion in the TIP or STIP. Safety projects can be submitted directly as a result of hazard identification programs, truck or freight safety programs, pedestrian or bicycle safety programs, or transit safety programs. Planners can encourage the consideration of safety improvements to all projects submitted for inclusion.

MPOs can use their roles as regional coordinators to incorporate safety into the transportation system. MPOs can serve as forums for various safety issues facing the transportation system, particularly those safety issues that are interjurisdictional. MPOs can also bolster support, both with the public and professional communities, for safety initiatives and consideration in all aspects of the transportation system.

Funding Sources for Safety and Transportation Planning Activities and Projects

Federal legislation provides several funding sources for a variety of safety improvements. TEA-21 reflected an unprecedented commitment to improve transportation safety. USC 23 makes funding available for safety improvements through several programs.

The Highway Safety Program (Section 402), administered jointly by NHTSA and FHWA, provides funds for state and community highway safety grants. These grants to states are available for enforcement, crash record systems, training, public education, and safety tool development. Typically, Section 402 funds are distributed by an office of safety planning, which is most often found in the Department of Transportation, the Department of Motor Vehicles or the Department of Public Safety. The governor of the state is responsible for administration of the program through a state highway safety agency, and the person responsible for the program administration is called the governor's representative for highway safety. At least 40 percent of Section 402 funds must be expended for local traffic safety problems by political subdivisions of the state. The federal share is 100 percent of the cost of projects. Funding for Section 402 was about $146 million for fiscal year 2001.

The Hazard Elimination Program (Section 152) provides funds for safety improvements involving construction at hazardous locations and segments. The program can fund a variety of projects such as the installation of traffic signals and the construction of divided medians, or sidewalks. The expenditures can be made on any public road, any public surface transportation facility, any publicly owned bicycle or pedestrian pathway, or any traffic-calming measure. The federal share is 90 percent of the cost of projects.

The Railway/Highway Crossings Program (Section 130) provides funds for improvements at railway/highway crossings. Projects funded under this program include the installation of signs and markings, flashing light signals, automatic gates, and crossing surface improvements. Bicycle facilities also can be funded under this program if they improve safety at crossings. The federal share is 90 percent of the cost of projects.

The Surface Transportation Program provides for an optional safety set-aside within the 10 percent STP allocation, above and beyond the specific funds allocated to Section 130 or 152. This optional amount may be used at the discretion of the state and may be allocated to either the Section 152 or 130 programs. The federal share is the same as the program to which the funds are allocated—100 percent for the Hazard Elimination Program and 90 percent for the Railway/Highway Crossing Program. The combined funding for STP safety was about $546 million for fiscal year 2001.

Southeast Michigan Council of Governments (SEMCOG) is the MPO for the Detroit metropolitan area. It has been able to finance its safety efforts through multiple funding sources. SEMCOG receives safety funds from both from the Office Highway Safety Planning (OHSP) of the Michigan State Police and the Michigan Department of Transportation (MDOT) through TEA-21. OHSP receives Section 402 and other monies from NHTSA, as well as funds from FHWA. SEMCOG has received funds from OHSP for both engineering activity and other driver behavior programs, such as the establishment of the statewide elderly mobility task force. Thus, SEMCOG receives funding from U.S. DOT through two different state agencies.

Institutional Issues to Safety Planning

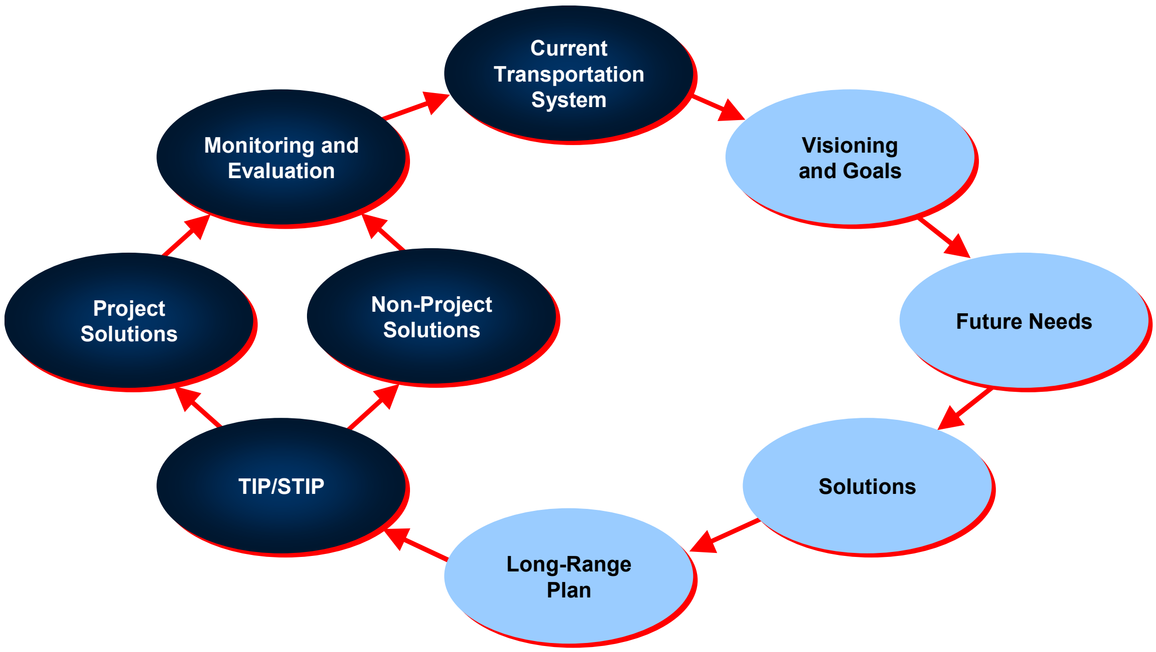
A variety of institutional issues exist that make integration of safety into transportation planning difficult. It is important to understand these barriers in order to take proactive steps to overcome them.

- **Project Funding.** Transportation funding is always in demand, as many key decision-makers would prioritize projects that accomplish other goals, such as congestion mitigation, before they would consider safety within the planning process. Planners must incorporate safety as a primary goal for it to be properly weighted by decision-makers and must encourage safety to be considered as a primary evaluation measure.
- **The time horizon for long-range transportation planning compared to the short-term focus of safety activities.** Safety issues have to be addressed immediately and cannot be forestalled. Part of this problem stems from the short-range perspective of constituents within a community. For example, if a community views an intersection as unsafe, this places pressures on transportation agencies to create short-term improvements to that intersection and distracts from the development of longer range safety planning focus.
- **Institutional battles over control and responsibilities, such as between a state DOT and a local government.** The case studies showed that within a given state, the roles and responsibilities for safety and transportation planning are not clearly defined. States, MPOs, transit agencies, and local governments should strive to understand each other's goals and projects in order to work together effectively.
- **Split responsibility for safety in a metropolitan area between multiple agencies.** In many cases, within one region, several entities are responsible for the safety of the transportation system. A city, an MPO, and a state DOT may be responsible for varying parts of an area. Coordination among these agencies is crucial to implement their multi-modal plans.
- **Lack of crash information that could allow safety issues to be identified.** Another ongoing concern is the quality and consistency of the data collection activities within an area. Transportation planners need reliable safety data to demonstrate where the problem areas exist and to develop countermeasures.
- **Liability concerns over data sharing.** In many states, access to the crash data remains an issue. Agencies responsible for collecting and maintaining data are often reluctant to share data freely, but local agencies may need it to accurately conduct short-range planning. Planners should work with the state and local safety professional to gain access to safety data.

- **Need for more technically trained personnel in local governments, MPOs, and state DOT planning offices.** Agencies need to make available the appropriate resources to effectively develop safety goals, understand future safety needs, develop solutions, consider safety goals and projects in the long- and short-range plans, and monitor and evaluate the projects. These trained personnel must also understand the key players for this process within a state and how to effectively coordinate among various agencies.
- **New partnerships among organizations (public and private) not traditionally involved in the planning process.** The incorporation of safety into the planning process is a new concept, and will include players not previously involved in transportation planning. These agencies must collaborate with the more traditionally involved players to understand the role they could provide. Some examples of non-traditional partners include state highway police departments and insurance companies.

Understanding these challenges can assist agencies in considering safety in the transportation planning process. The goal of this report is to address these challenges and provide solutions and real-world examples.

Chapter 2
Safety as Part of Long-Range Transportation Planning Process



Long-range transportation planning is a process by which states and MPOs determine their desired transportation system and then work toward achieving it. Transportation planners examine demographic characteristics and travel patterns for a given area to predict the future needs of the transportation system. Planners analyze alternatives for the area's transportation system. This is provided to the decision makers who evaluate the alternatives to determine the most expeditious use of local, state, and federal transportation funding to provide a system to meet those future needs.

The result of the long-range transportation planning process is a document, the adopted long-range transportation plan. Both the regional and statewide processes result in a long-range transportation plan. The document is a collaboration of the region's or state's transportation systems and is the defining vision for the transportation system and services. In metropolitan areas, the plan notes all of the transportation improvements scheduled for funding during the next 20 years.

Long-range planning is typically done over a 20-year or more period. Long-range planning provides input for short-range programming of specific projects, which usually covers a 3-to-5-year period.

The Transportation Equity Act for the 21st Century (TEA-21) specified that both the statewide and metropolitan transportation planning processes *"shall provide for the consideration of projects and* *strategies that will increase the safety and security of the transportation system for motorized and non-motorized users."*

State and metropolitan transportation planners can facilitate the incorporation of safety into the transportation planning process by providing a forum for safety and encouraging the consideration of safety in long-range transportation strategies. Safety can formally be incorporated into the long-range transportation planning process by developing long-range safety goals, objectives, and performance measures and evaluating progress toward those goals, whether the progress is regionwide or through individual projects. Long-range approaches, such as predictive modeling, can help guide transportation decisions to accomplish the safety goals and objectives of the long-range plan.

Transportation planners will most likely experience some challenges when incorporating safety into the long-range transportation planning process. However, some state and metropolitan planners are finding methods through which safety can be incorporated. This chapter provides transportation planners with guidance on how safety has been incorporated into the long-range transportation planning process. Potential challenges are also identified and discussed.

Providing a Forum for Safety

State and metropolitan transportation planners can facilitate the incorporation of safety into the long-range transportation planning process by providing a forum, such as a safety conference or a formal meeting, for safety partner involvement. Providing this forum could help to enhance communication and understanding among transportation planners and safety practitioners about the respective planning processes that exist and the opportunities for safety to be included in long-range planning. For example, the transportation planner could organize a conference on pedestrian safety in the region. In addition to all involved transportation planning agencies and safety practitioners, forums could include representatives from various aspects of the transportation system including:

- Local planning organizations
- Public and private safety-related organizations and associations
- Neighborhood and community groups (including groups of senior citizens, persons with disabilities, mothers of small children, etc.)
- Enforcement personnel
- Land use policy and development groups
- School district representatives
- Motor vehicle safety and operations professionals
- Elected officials

- Bicycle and pedestrian advocacy organizations
- Members of the media

Long-range transportation planning must be multi-modal in nature. It should consider the safety of all users in the transportation system including pedestrians, bicyclists, motorists, transit riders, and heavy vehicles. Providing a forum for safety can facilitate the consideration of the needs of all system users in the long-range transportation planning process. However, long-range transportation strategies employed to increase the safety of one user may decrease the safety of another. The balance between the needs of these users and their effects on one another must be considered. Members of the forum could identify these issues and develop strategies to provide this balance.

A forum for safety can provide a good starting point for incorporating safety into transportation planning activities. The collaboration of all interested parties can strengthen the incorporation of safety into the long-range transportation planning process and can help to overcome some of the current challenges.

Goals and Objectives in Long-Range Transportation Planning

The development of long-range transportation planning goals is essential to the incorporation of safety into the long-range transportation planning process. Including safety as a goal in the long-range plan helps to establish the importance of safety among various interests in the competition for limited financial resources. It identifies safety as a priority. Most MPOs and DOTs have safety goals, although many do not have performance measures. However, there has been an increasing trend in the past several years to incorporate performance measures in state and metropolitan plans.

Several issues must be considered when developing safety goals. Safety goals represent broad targets. Goals are typically somewhat vague and general although they should be within the sphere of the transportation system and obtainable. Developed through citizen input, the goals represent the general themes and overall direction envisioned for the transportation system, which in turn is carried out through tangible objectives. Objectives are more precise and measurable; they provide specificity and focus for the goals. Together, goals and objectives provide a policy framework to develop and implement the long-range plan. For example, a safety goal may be to improve pedestrian safety. This goal would be translated into objectives such as "reduce pedestrian fatalities at intersections." Safety objectives should be well defined, obtainable, and measurable.

Often, there is a delicate balance between goals. Achieving one goal can often mean that another goal will not be achieved. For example, the goals of increased mobility and increased safety can often conflict. A project that increases the mobility of an area may decrease the safety. Transportation planning agencies should attempt to find a balance between the goals.

Planning agencies should consider the following when developing safety goals and objectives:

- **Reasonable and Obtainable**: Safety goals should be carefully chosen so that they can be reasonably accomplished through investment in the transportation system. Those goals should be translated into obtainable safety objectives.
- **Multi-Modal**: Safety is important to users of all transportation modes. Safety goals and objectives should be multi-modal and include highway, transit, freight, pedestrian, and bicycle considerations.
- **Public Involvement**: As with all goals and objectives in the planning process, the formation of safety goals and objectives can be greatly facilitated with public involvement and support. Public support or "buy-in" of the safety goals and objectives demonstrates support of the community's own safety.
- **Assessment of Safety**: Because resources are usually limited and the need for them is competitive, current transportation system safety needs to be assessed and prioritized.
- **Timeframe**: It is also beneficial in developing objectives to include target completion dates.

Once safety goals and objectives are established, they can be used to formulate transportation strategies including policies and initiatives. They can also be used in selecting projects and in evaluating alternatives at the project-planning level. This is discussed further in Chapter 3.

Performance Measures and Monitoring Progress

Performance measures monitor progress toward the established safety goals and objectives. Performance measures, or measures of effectiveness (MOEs), are used in the planning process to report on how well goals and objectives are being achieved. Performance measures are used to answer the question: "Are we achieving what we set out to accomplish?"

The selection of appropriate performance measures is essential. Performance measures should be quantifiable so that progress toward goals and objectives can be practically and objectively measured or monitored. A performance measure must provide timely and accurate assessment of progress.

Monitoring Performance in the Delaware Valley Region

The Delaware Valley Regional Planning Commission (DVRPC) published a report on the region's progress toward meeting the goals and policies set forth in the 2020 long-range plan *(1)*. The report was part of a 2-year effort to update the long-range regional plan and produce *Horizons, The Year 2025 Plan for the Delaware Valley*. The 2020 plan had developed goals, policies, and recommended actions in specific areas for improvements in future development and transportation. Mobility was one of eight specific areas. The mobility goal was to *"improve access to and efficiency of the region's transportation network, and ensure the **safety** and security of the system's user."* [Emphasis added.]

The safety of the transportation system, road conditions, and reliability of public transit were identified as indicators of the progress toward the mobility goal. Improving these three indicators was the unstated objective of the plan. The combined numbers of fatal crashes, injury crashes, and property-damage-only crashes were used to measure the performance toward the long-range goal of improving mobility. DVRPC used crash data from 1988 through 1995 from New Jersey and Pennsylvania to determine that, region-wide, total crashes decreased by 17.7 percent. Data was presented individually for each of the nine counties in the region. Between 1995 and 1998, crashes in the Pennsylvania side of the region increased by 3.3 percent. (Data from New Jersey was not available beyond 1995 to be included in the report.)

For a long-range plan, progress toward each of the objectives should be evaluated regularly (for example, annually) using the performance measures. The progress evaluation can be used to revise or refine the goals or objectives for inclusion in subsequent plans. The evaluation should alert the planning agency if the transportation investment allocation needs to be adjusted to achieve the goals and objectives. In addition, the performance measures need to be evaluated to determine if they are accurately monitoring progress toward achieving the goals and objectives.

Examples of Safety Goals, Objectives, and Performance Measures

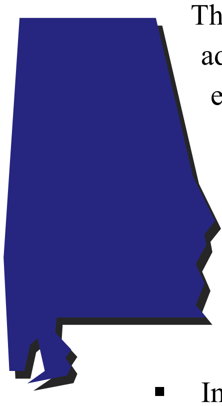
Exhibit 2-1 presents examples of safety goals with accompanying objectives and performance measures for highway, pedestrian, heavy vehicle, and transit safety. Each goal provides potential objectives and performance measures that could be incorporated into long-range planning to increase safety.

Exhibit 2-1
Examples of Safety Goals, Objectives, and Performance Measures

Goals	Objectives	Performance Measures
Increase highway safety	Reduce highway fatalities 10 percent by 2020	Number of fatal highway crashes
		Rate of fatal highway crashes
		Total number of people fatally injured in highway crashes
	Reduce highway crashes 10 percent by 2020	Number of motor vehicle highway crashes
		Rate of motor vehicle highway crashes
Increase pedestrian safety	Reduce pedestrian crashes	Number of pedestrian crashes
		Number of pedestrian fatalities
		Number of pedestrian crashes resulting in an incapacitating injury or a fatality
Increase heavy vehicle transportation safety	Improve heavy vehicle safety on the highway	Number of highway crashes involving a heavy vehicle
		Percentage of highway crashes involving a heavy vehicle
		Number of fatal and incapacitating injury crashes involving a heavy vehicle
		Percentage of fatal and incapacitating injury crashes involving a heavy vehicle
		Rate of heavy vehicle crashes on the highway (using heavy vehicle miles travels as exposure)
Improve transit system safety	Reduce incidence of transit vehicle crashes	Number of transit vehicle crashes
		Rate of transit vehicle crashes (with transit miles traveled used as exposure)
	Increase safety of transit riders before and after boarding transit vehicle	Number of pedestrian crashes within 250 feet of transit stops
		Number of pedestrian crashes involving transit vehicles
		Number of midblock transit stops
		Number of midblock transit stops with positive barrier systems to discourage pedestrians from crossing at non-designated pedestrian crossing points

Many state DOT planning agencies address long-range transportation safety in the goals or mission statements of their long-range plans. Some of these long-range plans are briefly described in the following paragraphs.

Alabama Department of Transportation



The Alabama Statewide Transportation Plan has four long-range goals, the first of which addresses safety *(2)*. This goal is addressed through five objectives. Measures of effectiveness are not presented in the plan.

Goal 1: Provide safe and efficient transportation for people and goods

Objectives

- Monitor and reduce, where possible, the rate of motor vehicle, bicycle and pedestrian accidents, injuries and fatalities on the state's roadways.
- Improve the safety of commercial vehicles, rail facilities, airports, and public transit vehicles and facilities.
- Improve the safety of intermodal connections and crossings, such as highway and railroad bridges over waterways, railway/highway crossings, and intermodal terminals.
- Improve transportation facilities for emergency management, including natural disasters, hazardous materials emergencies, and other public emergencies.
- Address safety issues in the design of facilities, establishment of programs, construction, operations, maintenance, and all phases of development and use of transportation.

Pennsylvania Department of Transportation

In 1998, the Pennsylvania Department of Transportation (PennDOT) conducted a statewide customer survey to understand the degree of importance and the levels of concern about a variety of safety and traffic topics. Safety was identified by 42 percent of the respondents as more important to them than smooth pavement, reduced congestion**,** and increased capacity. The results of the survey established a framework for the statewide long-range transportation plan, *PennPlan Moves!* The plan presents 10 goals that were identified by soliciting input from the public and professional communities. The first of these 10 goals is **to promote the safety of the transportation system**. Thirty objectives were drafted to address these 10 goals. Many of those objectives addressed multiple goals. According to the plan, 18 of the objectives correspond to the safety goal. A performance measure and target level of that measure is presented for each objective. One objective is to reduce the number of fatalities and severity of crashes on the state's highways. For that objective, the performance measure is overall injuries and overall fatalities. Thirteen types of fatalities are specifically identified including fatalities of 16- and 17-year-old drivers/passengers and 65-and-older drivers/passengers; fatalities involving drivers with revoked/suspended licenses, heavy trucks, and buses; fatalities involving alcohol; fatalities involving failure to use seat belts; fatalities involving pedestrians and bicyclists, and motorcyclists; and fatalities in collisions with fixed objects, in head-on collisions, at stop-controlled and signalized intersections, and on curves. The target, or MOE, is to reduce fatalities across all categories 10 percent by 2002, 15 percent by 2004, 20 percent by 2008, and 40 percent by 2020 *(3)*.

Pennsylvania DOT's Statewide Progress

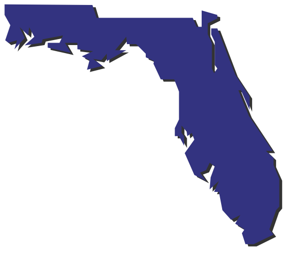
In June 2001, PennDOT published the first long-range plan progress report, *PennPlan 2000 Achievement Report (4)*. The report outlines the first-year progress toward the objectives of *PennPlan Moves!* The report was distributed to all planning partners so they could see how projects and programs across the state were helping to fulfill the long-range goals of the state, including the long-range safety goals.

The report describes the progress made toward each of the 30 statewide objectives outlined in the long-range plan. Progress is reported in terms of the performance measures defined for each objective. Many of the targets for the first year were met. The fourth objective was to reduce the number of fatalities and severity of crashes on the state's highways. Originally, the target was to reduce fatalities across all of the identified categories 10 percent by 2002, 15 percent by 2004, 20 percent by 2008, and 40 percent by 2020. However, after the publication of the long-range plan, these targets were modified to reflect goals in the Commonwealth's new strategic plan for transportation, *Moving Pennsylvania Forward: A Transportation Strategy.* The modified targets were to reduce fatalities across all categories of 5 percent by 2002 and 10 percent by 2005. The achievement report conveys that the state is progressing toward the new targets. Statewide, fatalities have been reduced by 2 percent since 1999.

The long-range plan also identified 28 corridors of statewide significance, each with its own objectives. The achievement report describes the progress toward the objectives of each corridor. In 15 of the corridors, at least one objective involves a safety improvement for a portion of the corridor. According to the achievement report, in all but one of the corridors, progress was made in the last year toward improving safety. In some corridors, safety improvements were being designed or constructed. In other corridors, safety improvements had been completed.

The achievement report illustrates that, overall, Pennsylvania is on its way toward achieving *PennPlan's* goals. Achievement reports will be published annually to continue tracking this progress.

Florida



Florida Transportation Mission:
Florida will provide and manage a ***safe*** *transportation system that ensures the mobility of people and goods, while enhancing economic competitiveness and the quality of our environment and communities.* [Emphasis added.]

The Florida long-range transportation plan has four goals: safety, system management, economic competitiveness, and quality of life *(5)*. The safety goal will be accomplished through the following long-range objectives:

- Reduce the rates of motor vehicle, bicycle and pedestrian fatalities.
- Improve the safety of highway/railroad crossings and other locations where modes intersect.
- Improve the safety of commercial vehicle operations.
- Improve the safety of seaport, rail, and public airport facilities.
- Improve the safety of services, vehicles, and facilities for transit and for the transportation disadvantaged.
- Minimize response times of each entity responsible for responding to crashes and other incidents.
- Implement hurricane response and evacuation plans in cooperation with emergency management agencies.

The Florida transportation plan addresses safety in the goals and objectives, but like many state long-range plans, has no corresponding measures of effectiveness for each of the objectives.

Applying Goals, Objectives, and Performance Measures

Long-Range Corridor Planning

Most of the discussion about the identification of goals, objectives, and performance measures has been in the context of long-range plans; however, the same procedures can also be applied to evaluating transportation project alternatives. Transportation planners could use the safety goals and objectives as a measure to evaluate future alternatives for both short-range and long-range project planning. A systematic process of alternative evaluation, which could be used by transportation planners, follows:

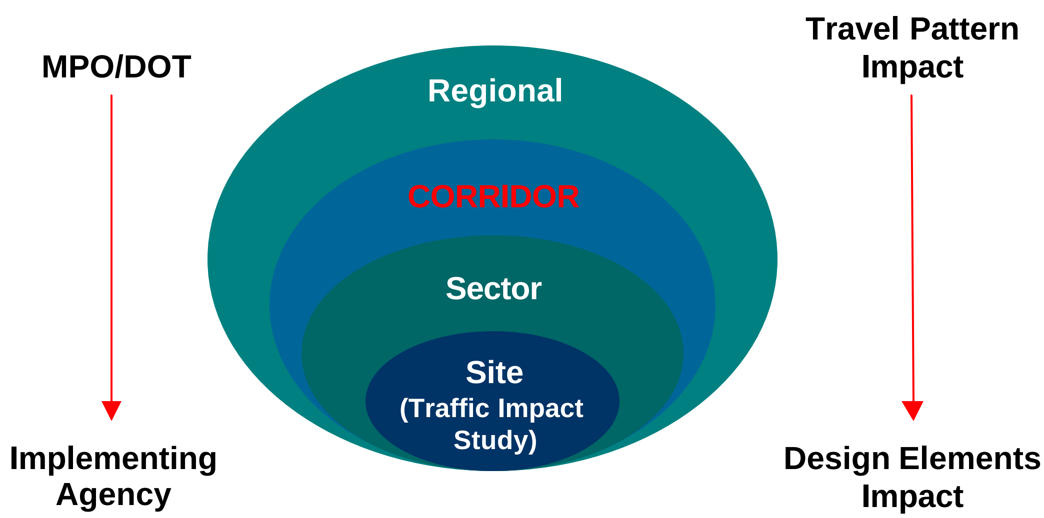
1. Define goals, objectives, and performance measures.
2. Identify problems and needs.
3. Generate alternatives.
4. Quantify performance measures.
5. Conduct tradeoff analysis of costs (political, social, and economic).
6. Identify best alternatives.

Although the actual process of evaluating alternatives takes place in steps 4 and 5, steps 1, 2, and 3 provide the means by which to evaluate. The evaluation process should be able to describe how well each alternative performs as measured by the goals and objectives and should be sufficiently well-structured to identify commonalities, differences, and tradeoffs that exist among the alternatives with respect to the various goals and objectives. Well-constructed safety objectives and measures of effectiveness should allow the decision-maker to compare alternatives.

This alternative evaluation process can be used in long-range corridor planning projects Exhibit 2-2 illustrates the levels of transportation planning. MPOs and DOTs planning offices are more involved with the broader levels of planning. As the levels become more site specific, MPO and DOT planning office involvement decreases while the implementing agency involvement increases. The corridor level of planning, a broad level below regional planning, may encompass multiple routes and various modes of transportation between two major destinations or urban areas. Corridor-level planning may be composed of multiple smaller projects within the corridor on major arterials, minor arterials, transit routes, and multi-use trails.

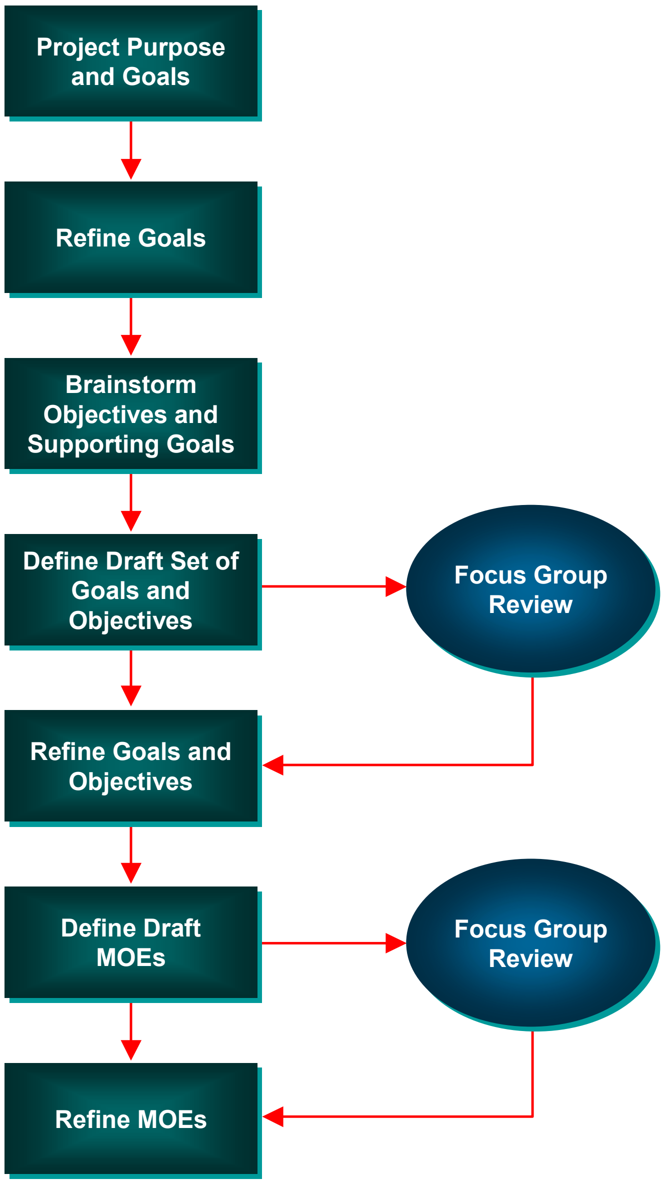
Exhibit 2-2

Levels of Transportation Planning



Corridor level planning can be both short-range planning and long-range planning depending on the time horizon of the project. Short-range corridor planning is addressed in Chapter 3. An excellent example of using safety goals and objectives to evaluate transportation system alternatives in corridor project planning is in the Maryland I-270/U.S. 15 project.

Planning for the I-270 Multi-Modal Corridor in 2025



The I-270/U.S. 15 multi-modal corridor provides a link between the Washington, D.C., metropolitan area and central and western Maryland. It carries both local and long-distance trips. Because of its current condition and projected growth, the multi-modal corridor is being studied to investigate highway and transit options that will relieve congestion and improve safety conditions along the corridor. The project horizon for the long-range study is 2025.

Because the corridor is multi-modal, no single transportation strategy alone will solve the its transportation needs. Therefore, several transportation strategies are being considered in the alternatives analysis including a "no-build" alternative. The proposed alternatives and strategies will all have different effects on the transportation, environmental, and economic systems throughout the corridor and in the region. For prudent evaluation, the project team needed to develop a system for comparing the alternatives being considered. Using input from focus groups, the project team translated the purpose of the project into goals and objectives. Five goals were identified, and multiple objectives were discussed to address each of the goals. For each objective, the project team identified a MOE for the various aspects of each alternative. The process of defining MOEs is explained in the adjacent flowchart.

For the second goal, enhance mobility, 12 objectives were suggested. After discussion within the project team, six objectives were recommended. The fourth objective addressed the stated goal of improving the safety of the transportation system.

The safety performance of future highway, transit ways, and corridors is difficult to predict. However, some safety generalities can be applied. Higher functional class roadways (for example, controlled access freeways) have lower crash rates by VMT than lower functional class roadways (for example, undivided highways). Alternatives that reduced VMT on lower functional class roadways accomplish this objective better. Additionally, general safety performance of various transit modes (for example, light rail versus bus) can be compared using local safety data.

For the third goal, improve goods movement, the safety of truck travel was a concern. The project team decided that the safety of truck travel must be one of the objectives that the project addresses.

The project team considered ways to differentiate the safety of truck travel from the safety of general vehicle travel within the types of build alternatives that were being analyzed. The team discussed ways to improve the safety of truck travel such as separating trucks from general-use lanes, moving truck travel into non-peak periods, and/or moving trucks to higher order facilities. Finally, the team decided on simply comparing the percentage of trucks on the highway during the peak periods for each of the alternatives.

Using Safety Goals in Municipal Planning: West Pikeland, Pennsylvania

The County Planning Commission in Chester County, Pennsylvania, assists county municipalities in developing comprehensive long-range plans. Safety is one of the goals of the long-range plan that the planning commission helped the municipality of West Pikeland to develop *(6)*. The township is concerned with balancing its scenic character and aesthetic value with its safety and mobility needs. According to the plan, safety and traffic congestion are two key factors that determine road network effectiveness. The following goal and objective were developed:

- **Safety Goal:** Provide for a safe and effective circulation system that minimally impacts the township's rural character, open space, and scenic roadways.
- **Accompanying Objectives:**
  - Facilitate road safety improvements that comply with the township's functional classification system.
  - Identify and improve circulation system deficiencies on an ongoing basis and coordinate road improvements with new development.
  - Develop an access management program to reduce roadway conflicts and provide safe and efficient access to the road network.
  - Identify and improve non-vehicular circulation networks.

To develop the safety goal and accompanying objectives, the County Planning Commission assisted the municipality in reviewing and analyzing traffic volumes, intersection levels of service, anticipated traffic growth, and 5 years of crash data. The crashes were roughly summarized by junction location, injury severity, and some causes. The analysis identified roadway features within the municipality, such as steep grades and sharp curves, that can negatively affect transportation safety. The features of the plan are summarized in the following paragraphs.

The plan identifies a list of road segments and conditions on those sections that can adversely affect transportation safety. The plan also suggests a list of projects for the PennDOT 12-year program update. Leading the list of projects are two safety improvements at intersections within the township. Strategies and techniques are recommended based on the safety goal to address the identified transportation planning implications. The plan recommends giving the utmost importance to safety improvements throughout the township.

Three specific areas in the township are identified including two intersections and one route. The first intersection is already included in the 12-year program to receive channelization and traffic signal updates. The second intersection also includes a bridge update on an approach to the signal. After the bridge is updated, the plan suggests improving signage, adding left turn lanes, implementing access management strategies, and considerations for pedestrians. The suggested safety improvement to the identified routes is the addition of left turn lanes at all major intersections along the route.

Long-Range Planning Approaches

Including transportation safety as one of the goals of the transportation system is the first step in incorporating safety into the transportation planning process. However, for this goal to be realized, transportation policies and strategies must also consider safety. Many of the efforts to increase the safety of the transportation system will be carried out through short-range planning activities. However, long-range transportation planning approaches also hold some promise for improving the safety of the transportation system.

Risk and Exposure

The risk that a crash will occur is based on many variables. Crash risk varies widely by facility, mode traveled within a facility, and temporally. Many of the approaches to improving the safety of the transportation system focus on improving existing facilities where demand exists. However, transportation crash occurrences are a function of exposure; that is, generally the more miles traveled within a system, the more crashes are expected to occur. This is true for motor vehicle, pedestrian, bicycle, transit, and heavy vehicle crashes. Transportation planners can also influence the safety of the transportation system through long-range transportation strategies that affect this exposure. Transportation planners can improve the safety of the transportation system through reducing exposure, modifying exposure, and reducing exposure to conflicts. These three approaches are explained in the following paragraphs.

Reducing Exposure

Exposure for most forms of transportation can be expressed as vehicle miles traveled. As mentioned in the preceding section, transportation crashes are a function of exposure. One of the areas in which transportation planners, especially metropolitan transportation planners, can affect the safety of the transportation system is through reducing the miles traveled within the system (that is, reducing exposure). Transportation planners are responsible for coordinating long-range land-use decisions. The total VMT in a state or metropolitan area is influenced by transportation planning especially in relation to land use and transit options. Long-range transportation strategies that decrease the total VMT in an area will likely produce a corresponding decrease in the frequency of transportation crashes.

In the interest of pedestrians and bicyclists, this may involve long-range land-use decisions that allow for densely spaced development. The resulting environment would shorten the distance of pedestrian and bicycle trips and therefore reduce the users' overall exposure. For motor vehicles, this may involve planning highways that are the most direct link between activity generators. Direct trips would reduce the overall highway miles traveled and therefore reduce exposure.

Modifying Exposure

The state and metropolitan transportation planning process has the ability to direct the transportation system to help divert traffic volumes from less safe modes or functional classes to safer modes or functional classes; that is, they have the ability to manipulate the exposure. This is especially true in long-range transportation planning. As the long-range strategy is being formulated in the long-range plan, the transportation process can help to guide the future of the system to help reduce the exposure of unsafe modes or divert the traffic (exposure) to safer modes. However, changes in trip patterns will have system level impacts on the function of the transportation system. Those impacts could cause negative safety impacts elsewhere in the network. Those impacts would need to be evaluated and the trade offs would have to be analyzed. Additionally, methods to modify exposure (such as adding a lane on the freeway) can be more cost intensive than other solutions.

Highway Functional Class

As explained in the preceding section, traffic crashes are a function of exposure. The general risk for traffic crashes varies by highway functional class. Long-range transportation strategy can divert traffic volumes from the higher risk functional classes to the lower risk functional classes to increase transportation safety.

Exhibit 2-3 presents motor vehicle fatality rates by highway functional system calculated by the Bureau of Transportation Statistics. The rates, which are from 1998 fatality data from the 50 states and the District of Columbia, are represented as fatalities per 100 million vehicle miles. The fatality rate on rural highways is much greater than on urban highways. For rural highways, as the functional class of the roadways decrease, the fatality rate increases. This is generally true of urban highways, except for the "Other Arterial" functional class.

Exhibit 2-3
Motor Vehicle Fatality Rates by Highway Functional System for 1998

Highway Functional System	Fatality Rate (per 100 million vehicle miles)
Rural	**2.39**
Interstate	1.23
Other Arterial	2.38
Collector	2.94
Local	3.70
Urban	**1.01**
Interstate	0.61
Other Arterial	1.15
Collector	0.79
Local	1.28

Nationwide, highway crash rates by functional highway system are only available for fatal crashes. However, similar fatality rates, injury rates, and total crash rates could be calculated for a jurisdiction and then used in long-range transportation planning. Transportation planners could use these rates to evaluate the safety of various transportation strategies. Planners could promote and support transportation strategies that decrease VMT on the lower functional classes such as local roads and, instead, divert those vehicle miles that are traveled on the higher functional class highways such as arterials. For example, a proposed transportation alternative that reduced the amount of vehicle miles driven on rural collectors and instead diverted those miles driven to rural interstate or rural arterials would be expected to increase the overall highway safety of the jurisdiction. This may be accomplished through improving access to rural interstates or expanding the rural arterial system.

Transit Alternatives

Transportation planners must prepare for future transit needs of transportation systems during the long-range transportation planning process. This may involve expanding the service of an existing transit system or introducing new transit service to an area. Various modes of transit are available including bus service, light rail, heavy rail, commuter rail, demand-responsive transit, and van pools. Each of the transit modes has different operating characteristics. One of those operating characteristics is the relative safety performance of each. When considering the future transit needs of the transportation system, the transportation planner must assess each transit mode available and determine which will best meet the needs of the area. Planners can incorporate safety into the long-range transportation planning process by considering the relative safety performance of each of the proposed transit modes as one of the aspects that is analyzed. If the proposed transit modes are already in operation in the region or in the state, planners could use the past safety performance of that mode's operation. Planners could also determine which transit modes operate the safest under different conditions. For example, they may find that bus service performs better in suburban areas than in urban areas. For future transit needs, planners may consider substituting urban bus service with a safer transit mode.

Exhibit 2-4 displays the transit crash rates based on total incidents occurring in 1999 on direct-operated urban transit systems. The number of fatalities, injured persons, and total incidents is represented by the number of vehicle miles for each transit mode. The rates were calculated by Federal Transit Administration (FTA).

Exhibit 2-4
Transit Fatality, Injury, and Accident Rates by Transit Mode for 1999

Transit Crash Rates for 1999			
Transit Mode	**Fatalities per 100 Million Vehicle Miles**	**Injured Persons per 100 Million Vehicle Miles**	**Accidents per 100 Million Vehicle Miles**
Motor Bus	5.0	1,106	1,166
Light Rail	27.1	889	624
Heavy Rail	3.6	50	69
Commuter Rail	24.9	22	86
Demand Responsive	0.6	379	516
Van Pool	0	75	263

Because the rates are based on vehicle miles, the transportation planner must consider the relative occupancy of each mode in the analysis of safety. For example, van pools have a relatively low accident rate compared to light rail. However, light rail generally moves more passengers per vehicle mile than van pools because the vehicles have a higher passenger capacity. Although not presented here, national transit crash rates per passenger mile are available from FTA as reported in the National Transit Database. However, similar to highway rates, a state or metropolitan planning agency could calculate its own passenger-mile-based transit-crash rates by using the vehicle miles, total crashes, and average occupancy of each transit mode. Planners could use the resulting rates to evaluate the relative safety of the existing system and to predict the future performance of the transit system. For example, a transportation planner may use the rates to decide between extending a light-rail transit line to more stations or to increase motor-bus routes in those areas. The relative safety performance of each transit mode would be considered in the alternative evaluation. However, the relative safety performance would only be one of the considerations. There are other safety and passenger security issues, such as access, that would be considered in long-range planning transit alternative evaluation.

Pedestrians and Bicyclists

Transportation planners should consider the needs of all users in the long-range transportation planning process. Many state and metropolitan transportation planning agencies are developing long-range plans to protect pedestrians and bicyclist, who are especially vulnerable users. Planners can increase safety by using transportation strategies and investments to modify pedestrians' and bicyclists' exposure. Similar to highway users, the safety of these users can be increased by shifting trips traveled on less safe facilities to safer facilities.

To accomplish this, transportation planners must first identify which types of facilities are unsafe and which are safer. For example, planners may want to compare bicycle lanes, shared facilities, and paved shoulders. Planners equipped with this data could then plan and encourage the use of facilities that reduce pedestrian and bicycle crashes. The rate of pedestrian and bicyclist crashes by functional class or facility type is not readily available nationwide. Calculating pedestrian crash rates in relation to pedestrian exposure is difficult because adequate pedestrian activity data is generally lacking. This is also true of bicycle crash rates and exposure. However, pedestrian and bicyclist crash data may be more applicable if the numbers were developed individually for a state or an MPO region. State or metropolitan transportation planners could develop their own estimates of pedestrian or bicycle crash risk by facility type or functional class from the crash data within the jurisdiction. Transportation planners could coordinate with community members who are frequent pedestrians or bicyclists to identify where these trips are occurring. This could be facilitated through a safety forum.

When the safety of various pedestrian and bicycle facilities has been determined, transportation planners can use long-range transportation strategy to increase the safety of these users. This may be accomplished by replacing unsafe facilities with safer ones. Transportation planners may also identify access limitations to safer pedestrians and bicycle facilities and direct long-range transportation investment to providing access to safe facilities, thus shifting these users to the safer ones.

In the absence of data on pedestrian and bicycle crash risks by facility type, transportation planners could also use the operating speeds of facilities to quantify the general crash risk. Transportation research has identified the strongly associated relationship to higher vehicle speeds and the greater likelihood of pedestrian crashes and more serious resulting pedestrian injury *(7)*. Long-range transportation strategies that divert pedestrian and bicyclists from high-speed roadways to lower speed roadways or lower vehicular speeds could be promoted to increase the safety of the transportation system.

Reducing Exposure to Conflicts

Transportation planners can use long-range transportation strategy and investment to increase the safety of the transportation system by reducing system users' exposure to conflicts with other system users. One of the foremost methods of reducing conflicts is through access management.

Highways and Access Management

For motor vehicle transportation, one of the most widely accepted method of reducing motor vehicle traffic exposure to conflicts is through access management. FHWA defines access management as *"the process that provides access to land development while simultaneously preserving the flow of traffic on the surrounding system in terms of safety, capacity, and speed."* Access management is the prudent control and planning of the location, design, and operation of driveways and street connections (that is, access) to a roadway. Access management has many goals. One of its foremost goals is to improve safety networkwide by decreasing crash rates. Transportation planners can incorporate safety into the long-range transportation planning process by promoting access management as a long-range transportation strategy.

The Minnesota DOT's Office of Access Management is responsible for the state's access management. The goal of the program is to use access management to reduce congestion and crashes on the existing road system. The office develops recommendations for land use planning and for engineering and legal practices that affect the operational efficiency and safety of the roadways by functional class. To support its study, the office also analyzed the safety effects of access management.

The Minnesota DOT developed a variety of publications for planners on the consideration and use of access management strategies. Although the publications were developed for planners in the state of Minnesota, the principles are applicable for all planners interested in using access management to increase the safety of the transportation system. The publications are available on the Minnesota DOT's web site.

The goals of access management are achieved through controlling and regulating direct access to roadways based on their functional class. In this way, roadways can operate better at their originally intended speed and capacity with the benefit of smoother vehicle flow, reduced delay, and reduced crashes. Every access point onto a roadway is a potential conflict point for vehicular movements. As the access points become more complex, the potential for crashes increase.

For the roadway system to operate effectively at its intended functional class, transportation planners must coordinate the system with the land use surrounding it. However, the relationship between the road's functional class and the land use is often dynamic. As a transportation system grows, it may stimulate growth and changes in land use. For example, transportation planners may decide to widen and repave a highway that bypasses a town in order to move traffic around the town more effectively. However, open space and traffic generated by the improved highway may attract shopping complexes and other developments to the outskirts of town also. The developments' needs for multiple driveways into their parking lots would produce access control issues. The increased access onto the improved highway would eventually increase the number of crashes and reduce the capacity of the roadway. Planners would need to integrate corridor, land use, and access management into the area's long-range plans to avoid this cycle.

Heavy Vehicles

Crashes between heavy vehicles and lighter passenger cars are more likely to result in severe injuries or fatalities. One method of increasing transportation safety is by reducing conflicts and thereby severe crashes between passenger vehicles and heavy vehicles. Heavy vehicles are often restricted to specific routes (such as truck routes) that are more capable of handling their operating characteristics (turning radii, weight, deceleration ability). On some controlled access facilities, heavy vehicles are restricted from traveling in certain lanes. For example, on portions of Interstate 40 through North Carolina, heavy vehicles are restricted from traveling in the innermost lanes.

Some consideration has been given to providing either exclusive lanes for trucks and passenger vehicles on interstate highways or completely exclusive facilities. FHWA developed the Exclusive Vehicle Facilities (EVFS) computer program to determine the economic feasibility of separating light vehicles from heavy vehicles by designating existing lanes or constructing new exclusive lanes on sections of controlled-access highways. EVFS calculates the benefits and costs associated with separating light and heavy vehicles. Accident cost savings because of less severe accidents is one of the benefits considered. The program is for site-specific analyses only and not for regional, statewide, or national network analyses *(8)*. The State of Virginia used EVFS to determine the economic feasibility of providing exclusive lanes for trucks and passenger vehicles on a segment of Interstate 81. The analysis revealed that many of the exclusive lane strategies would produce a positive benefit *(9)*.

The Southern California Association of Governments (SCAG) approved the provision of a four-lane dedicated truck facility on a 37-mile stretch of State Route 60. SCAG is the MPO for the Los Angeles metropolitan area *(10)*. The Association conducted a study on the feasibility of having dedicated truck facilities along State Route 60 partially because of concerns for safety, but predominantly because of significant truck volumes that were expected to increase by more than 60 percent by the year 2025. The facility has been approved for consideration in the long-range plan; however, financing is still needed for the estimated $4.3 billion project. The MPO is coordinating this project with the California DOT, the 3 area county transportation commissions, and the 30 municipalities that will be affected by this facility. Preliminary engineering studies and environmental impact statements are expected to be conducted in the next 2 to 3 years. If the project is funded and approved, construction is targeted to begin in 2010 *(11)*.

Predicting the Safety Performance of the Transportation System

Transportation planners have fairly reliable tools and methods for evaluating alternatives to predict mobility-related performance measures such as levels of highway and transit use, delay, and overall system performance. However, for many safety MOEs, transportation planners may not have the necessary tools. When evaluating the future safety of an existing or planned project as an MOE, transportation planners must predict the project's future safety performance. The lack of a reliable method for estimating the safety performance of an existing or planned transportation facility has been identified as one of the most critical gaps in the management of highway safety. Potential methods to predict the long-range safety performance are discussed in the following sections.

Expert Judgment

Transportation planners can employ the expert judgment of transportation safety professionals in reliably assessing highway safety or predicting the future safety performance of transportation alternatives. Years of experience can help traffic safety professionals to assess the relative safety when choosing between alternative projects, strategies, and programs. Transportation planners could encourage the cooperation of safety experts through panels, consultations, and reviews and could draw on the experience of transportation safety experts to review strategies and investments in the long-range plan. These experts could also be used in evaluating alternatives for long-range project planning. Employing their assistance in the alternative design evaluation stage of project planning would be similar to conducting an informal safety audit. Safety experts may be able to identify unforeseen safety impacts of proposed transportation alternatives. They may also be able to identify the unforeseen impacts of improving the safety of one user group at the expense of another.

Predictive Modeling and the Interactive Highway Safety Design Model

Predictive modeling uses crash, traffic, and geometric data to develop a model to predict future crashes based on past performance. Transportation engineers and safety analysts develop the models by applying statistical techniques to the data. Most use a form of regression analysis to draw statistical correlations between roadway characteristics and crashes. The value of the dependent variable, crashes, is predicted as a function of a set of independent variables such as traffic volume, functional class, and roadway width. Existing crash prediction models are used for a variety of applications including identifying factors affecting transportation safety, evaluating safety at specified locations, identifying locations with higher than expected crash rates or frequencies, ranking the identified crash locations, and evaluating the application of safety countermeasures at a location.

Transportation planners and decision-makers do not commonly use crash prediction models to predict the safety performance of a project because most models are applicable only at the design level, not at the broader planning level. FHWA is currently developing the Interactive Highway Safety Design Model (IHSDM) software at the Turner-Fairbank Highway Research Center (TFHRC). The software will enable planners and highway designers to incorporate explicit consideration of safety into the highway design process. Although this model is intended for planners and highway design engineers, it extends beyond the project level, allowing them to evaluate the safety of designs under consideration. IHSDM will be a system of interactive computer modules integrated into a roadway design program. It will provide a systematic approach that will enable roadway designers and design reviewers to assess the potential safety effects of specific geometric design decisions. IHSDM will facilitate decision-making from the planning process through final design stages for both new construction and reconstruction projects. The software has a roadside safety module that will perform benefit-cost analyses of roadside design alternatives.

Rural Two-Lane Highways

An algorithm for predicting the safety performance of a rural two-lane highway was developed for incorporation into IHSDM *(12)*. The method predicts the frequency of crashes annually on rural roadway segments and at-grade intersections on rural two-lane highways. It was developed for application by highway agencies to estimate the safety performance of an existing or proposed roadway and can be used to compare proposed geometric alternatives for a highway. The algorithm is project specific. Planners could use this model, or assist others in using this design model, to address project-specific safety considerations.

The transportation decision-maker would select a proposed roadway segment or intersection. Separate algorithms were developed for roadway segments and for three types of at-grade intersections: three-leg intersections with STOP control, four-leg intersections with STOP control, and four-leg signalized intersections. All four of the algorithms can be combined to predict the total crash experience for an entire highway corridor.

The algorithms are composed of base models and accident modification factors (AMFs). The base model is used to estimate the expected accident frequency for a specified set of nominal base conditions at a particular intersection or roadway segment. The base estimate is then adjusted with the accident modification factors that represent the safety effects of individual geometric design and traffic elements of the at-grade intersection or roadway segment. Because accident frequencies vary widely by agency, the AMFs account for differences in roadway alignment, cross section, and intersection design between sites. State or regionwide differences in climate, animal population, driver populations, accident reporting thresholds, and accident reporting practices are accounted for with a calibration procedure. After the calibration procedure is applied, the predicted crash frequency is known. For entire roadways, the predicted crash frequencies of the roadway segments and at-grade intersections that make up the roadway are summed. For planned roadways not yet constructed, the predictive process would conclude at this point. The remaining steps in the process are for existing sites when the site-specific accident history is available. For these sites, an Empirical Bayes procedure is applied to the accident-prediction algorithm and site-specific accident history.

The model was developed by combining historical accident data, regression analysis, before-and-after studies, and expert judgement to make safety predictions. This is a new approach that could potentially be adapted for similar predictive models for other roadway types.

The accident prediction algorithm could assist transportation planners in predicting the safety performance of rural two-lane highways. Incorporating the algorithm into IHSDM will increase the ease of applying the algorithm. Currently, a 13-step process for the applying the model to planned facilities is explained in the report documenting the algorithm.

Forecasting Safety: Applying Predictive Modeling to Travel Forecasting

One of the long-range responsibilities of transportation planners is travel forecasting. Travel forecasting is the process of predicting future travel demand to analyze long-range transportation alternatives. Travel demand is predicted, or forecasted, to estimate the likely transportation consequences of several transportation alternatives being considered for implementation. These alternatives could also include a “do-nothing” option.

Travel forecasting is a multi-modal process that typically consists of four-steps: trip generation, trip distribution, modal choice, and network assignment. The process uses land use and socioeconomic projections for an area as inputs to develop the impacts of the future transportation system. The outputs of travel forecasting are projected volumes, speed, origins and destinations, and mode split. The level of service can be calculated for the various modes and facilities within the transportation network based on these outputs. The level-of-service results can help planners to identify future system deficiencies and to plan and schedule capacity improvements accordingly. The process is also used to identify the environmental impacts of future transportation alternatives.

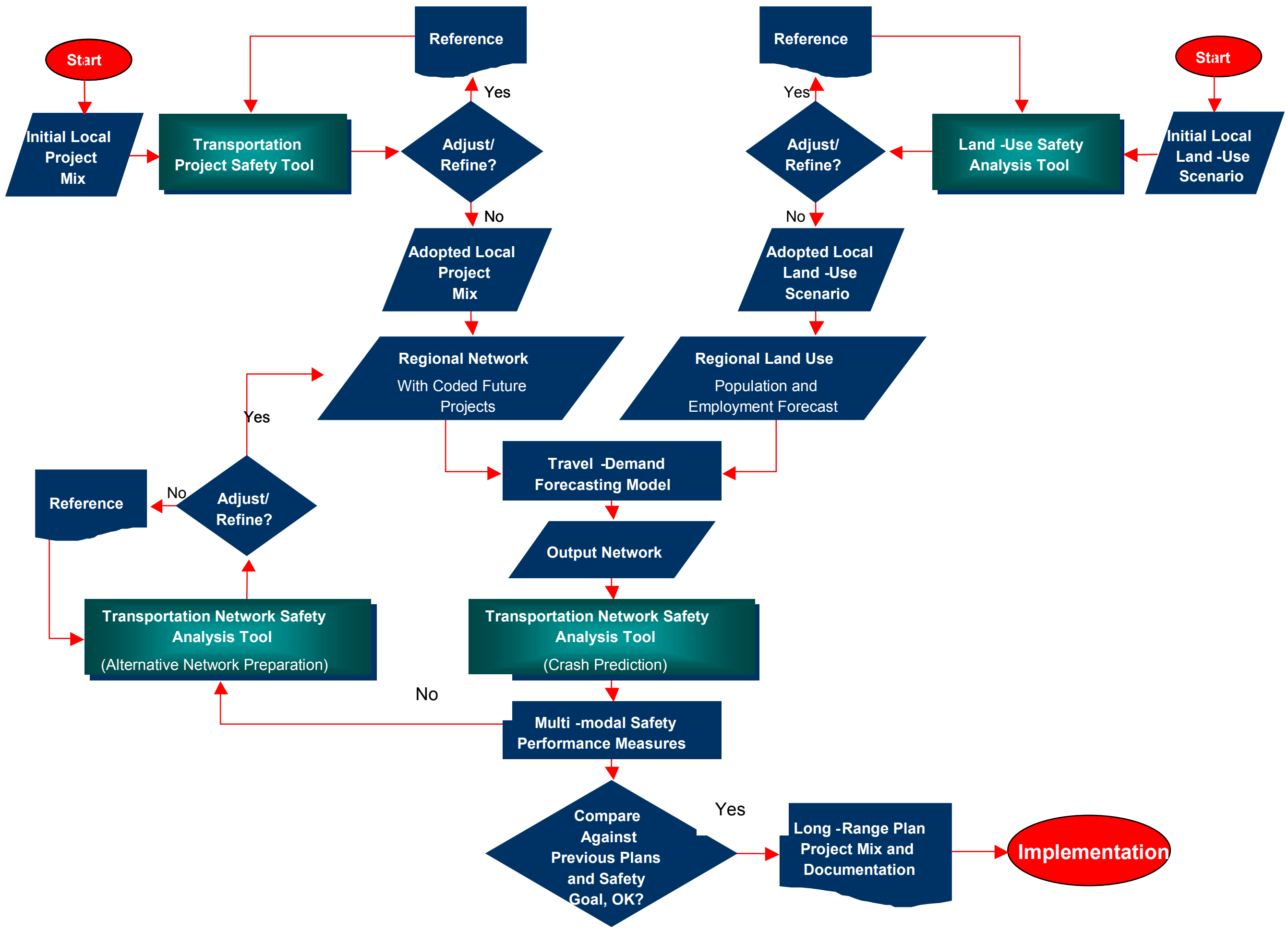
Together, travel forecasting and safety predictive modeling can be used to forecast future operational characteristics and environmental impacts of the transportation network, as well as future safety of the network. Currently, the predictive modeling tools to accomplish this kind of analysis are not available. The lack of a reliable method for estimating the safety performance of an existing or planned roadway has been identified as one of the most critical gaps in the management of highway safety. Research is focusing on creating predictive modeling tools for this purpose.

Although not available, the analysis tools and their use in travel forecasting can be envisioned. A typical long-range technical analysis process incorporating potential safety analysis tools is envisioned in Exhibit 2-4. This technical analysis could evaluate how well transportation improvements achieve the goals for an area.

Long-term analysis tools would enable planners to be proactive in formulating solutions to safety problems. The long-term analysis would be primarily a forecast of crash levels based on exposure, speed, and operating condition of the multi-modal network. This effort will therefore focus on creating a safer transportation environment through land use, transportation projects, and network planning.

To accomplish this, the associated tools should work within the current analysis process used by most planning agencies. The proposed safety tools are incorporated and are discussed in the following sections. The analysis process should evaluate and optimize both land use and proposed transportation network to achieve not only mobility and/or air-quality goals, but safety goals as well.

Exhibit 2-4
Overview of Envisioned Long-Term Technical Analysis Process Incorporating Safety



Project tool

The project tool would help planners to evaluate and formulate projects for improving the safety of system users. Considered both a long-range tool and a short-range tool, it would include a “hot-spot” evaluation component. The tool would also help planners formulate solutions by providing a reference of potential improvements to enhance safety. The output of the project-level tool would be a mix of transportation projects that could then be integrated into the TIP, and, for use in the long term, into the transportation network for metropolitan transportation plan (MTP) analysis purposes. The project-level tool would be highly useful to local jurisdictions and other implementing agencies usually charged with proposing projects to be included in the TIP or MTP. Currently, planning agencies such as SEMCOG and the Arizona DOT have developed project tools that can perform this evaluation. They are discussed in Chapter 3, Incorporating Safety Into Short-Range Planning.

Land-use tool

The land-use tool would assist planners in creating a land-use scenario for improving the safety of transportation system users. It would be most useful in long-term analysis, providing the planner with ideas about the safety benefits of different land-use scenarios. The tool should also include a reference, providing potential alternatives to enhance safety. The result of this module would be a land-use scenario to be used in the regional land-use scenario for MTP testing.

Network tool

The network tool is the most complex of the safety analysis tools represented in this report and should incorporate all users including transit, motorized and non-motorized users. The envisioned tool would have two components: the crash prediction and alternative network preparation modules.

The crash prediction tool would provide planners with the ability to take assigned transportation networks with traditional output (volume, speed, delay, volume/capacity ratios, and the level of usage by facility type) and, by using the relationships between these data elements and crashes, develop a forecasted crash level. This would provide a metric for planners to evaluate the level to which the network tested helps them achieve their safety goal.

If the network requires additional modification to optimize the safety benefits, the alternative network preparation tool should be used. This tool would include a reference providing planners with ideas to enhance the safety of the network. If changes are made, the network would need to be “fed-back” to the travel model, to re-estimate the travel demand, distribution, mode usage, and level of use on the network.

Although these planning analysis tools are not available, FHWA and other agencies are exploring their development or conducting research that will make these tools possible in the future. Recent research has focused on forming models for predicting the effects of highway design, traffic density, and land use on highway safety by studying the historical effects of various conditions on crash occurrence. The following section discusses research that eventually will lead to the development of an analysis method for forecasting the safety effects of transportation alternatives as part of the travel forecasting process.

The Relationship Between Volume and Safety

One of the main outputs of the travel forecasting process is the distribution of transportation volumes by mode. These volumes are available for all facilities modeled (for example, highways and transit lines). An analysis tool that predicts the future safety performance of a transportation network could use these volumes in the prediction.

Zhou and Sisiopiku *(13)* studied the relationship between volume-to-capacity (V/C) ratios and safety. The correlation between V/C ratios and crash rates follows a general U-shaped distribution; that is, crash rates are highest for low hourly volumes with a low corresponding V/C ratio. The crash rates decrease with increasing V/C ratios but then increase again as the V/C ratios increase. The researchers' findings were based on local data. Much more research is needed before the results can be generalized and applied in transportation planning.

Frantzeskakis and Iordanis *(14)* also studied the relationship between traffic accident rates and the V/C ratio. These researchers used 89 months of crash data from an 18 km section of interurban, four-lane undivided national highway in Greece. They found that the rates for traffic accidents were almost constant for level of service A, B, and C at non-hazardous locations for a V/C ratio of up to 0.65. The crash rates increased considerably for ratios higher than 0.65 and more than doubled when the V/C ratio was greater than 1.0. This same pattern was also observed for accident rates and V/C ratios at locations considered hazardous by the quality control technique, and when specific categories of accidents are analyzed, such as day and night, or dry and wet pavement conditions. The study was intended to explore the use of V/C ratios in traffic analysis as an alternative to volume as a measure of exposure in accident analysis. However, the findings are valuable in understanding the relationship between V/C ratio and safety.

The University of Tennessee is also involved in testing relationships between V/C ratios for differing levels of facilities and crash or accident potential. These relationships were developed in the 1970s in North Carolina and have not been tested for transferability to other areas of the United States. This effort promises to be a first step in working on the relationships needed to improve predictive safety modeling.

Challenges to Incorporating Safety Into Long-Range Planning

Planners may experience some challenges when incorporating safety into the long-range transportation planning process. Accomplishing many of the steps needed in the process is difficult. However, progress is being made. States such as Pennsylvania and Michigan are meeting these challenges to improve the safety of the transportation system. The following sections describe some of the challenges and methods for overcoming those challenges.

Balancing Safety Goals with Other Goals

Achieving the goal of improved safety may mean that another goal will not be achieved. For example, the goals of increased mobility and increased safety can often conflict. A project that increases the mobility of an area may decrease the safety. Transportation planning agencies should attempt to find a balance between the goals.

Turning Safety Goals Into Safety Actions

Although safety is often included as a goal of a long-range transportation plan, it is often not actively incorporating into long-range planning. As described previously, specifying objectives and performance measures can help to achieve the safety goal. The safety objectives aid in translating the safety goals into actions, and the performance measures ensure accountability of the process.

Competition for Limited Funding

The lack of funding can be a challenge to incorporating safety into long-range planning. Often, transportation planners must allocate limited funding between competing priorities. If safety is not identified as a priority, funds may not be allocated for it, especially for long-range projects and planning. Planners can overcome this by bolstering public support for safety. The public must be involved in the long-range planning process to understand the importance of safety in long-range planning.

Competing Needs of Users

Transportation planners must consider the safety needs of all user groups including motor vehicles, pedestrians, bicyclists, transit, and heavy vehicles. However, the safety needs of one user group may conflict with the needs of others. For example, modern roundabouts have been an increasingly popular intersection design in the United States. Research indicates that this design can reduce motor vehicle crashes and injuries at an intersection compared to a conventional signalized or stop-controlled intersection *(15, 16)*. However, because roundabouts allow for continuous traffic movement at the intersection, this design can decrease the safety of pedestrians and bicyclists, especially for pedestrians with disabilities. In considering how various aspects of the transportation system will affect different user groups, the transportation planner could employ a citizen safety advisory committee, representative of the various transportation system users, to help account for the safety needs and identify their potential effect on one another. Transportation safety experts are another potential resource for planners.

Availability of Pedestrian and Bicycle Data

One of the challenges that transportation planners may encounter when incorporating the safety of pedestrians and bicyclists into the long-range transportation planning process is the availability of data on pedestrian and bicycle crashes, demand, and exposure. A number of studies have shown that official crash records significantly underestimate the numbers of pedestrians and bicyclists *(17)*. In addition, reliable data on the number of pedestrians and bicycle trips is not available because of the difficulty in collecting the data. FHWA has developed a guidebook to assist planners in estimating non-motorized (pedestrians and bicyclists) travel *(18)*.

Limitations of Predictive Modeling

Transportation engineers have developed many models to predict the occurrence of crashes. However, most of the models are not readily applicable to transportation planning. Some only predict the occurrence of crashes from existing conditions. Others models require inputs that are too detailed to be identified during the planning phase.

When used, predictive models have inherent limitations. Because the models are based on the past data, they may not be applicable outside of the jurisdiction from which they were created. Even the best predictive models may not yield accurate estimates of crash frequency, especially if some of the parameters of the input variables are outside the range of data from which the model was created. Planners would likely only use predictive models based on roadway, traffic, geometric, and land-use data. However, planners must keep in mind when applying these models that crash frequency depends on many factors—all of which may not be accounted for in the predictive model.

Long-Range Methodologies: Research on the Horizon

One of the challenges in integrating safety into the long-range planning process is the lack of accepted methodologies to predict the long-range safety performance of a facility or proposed facility. The National Cooperative Highway Research Program (NCHRP) anticipates undertaking a study to develop better predictive tools for identifying safety deficiencies and methods to address those deficiencies. The research will review existing methods of predicting future safety deficiencies as part of the long-range transportation planning processes, at both the state and MPO levels. Based on the findings, alternative methods will be evaluated. Another part of the research will evaluate land-use decisions and development patterns to enhance pedestrian safety, reduce conflicts between bicycles and other travel modes, and enhance transit rider safety. The final product of the research will be a guide to transportation planners. The guide will provide methods to predict long-range safety deficiencies of the transportation system and provide advice on the most effective countermeasures and their expected performance to incorporate into the long-range plan recommendations.

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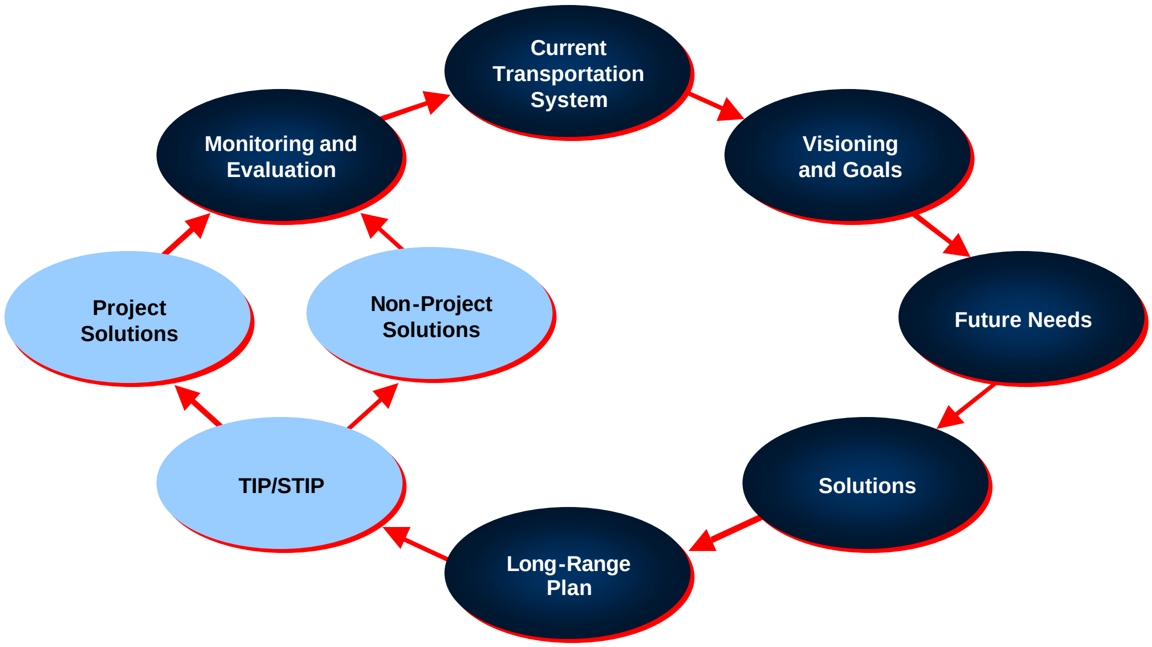
Chapter 3
Incorporating Safety Into Short-Range Planning



The long-range transportation plan is multi-modal and fiscally constrained. It has at least a 20-year horizon and is updated every 3 years in air-quality non-attainment areas and every 5 years in other areas. The long-range plan includes financially constrained, practical projects to achieve the needs of the transportation system. The plan is carried out through the transportation improvement program (TIP) for metropolitan areas and through the statewide transportation improvement program (STIP) for all other areas. The TIP and STIP are the primary programming documents for a region or state. They must cover at least 3 years and be updated at least every 2 years. Similar to the long-range plan, these short-range plans are multi-modal and financially constrained.

Programming Process

The TIP is a multi-modal programming document for defined projects. Through the programming process, transportation planners evaluate projects for funding and inclusion in the TIP. Projects are chosen on the basis of selection criteria. After the TIP or STIP is approved, projects advance to the project development stage.

Transportation planners can incorporate safety into the programming process by empowering their member agencies, identifying safety as a priority in the selection of projects for the TIP or STIP, and advocating the consideration of safety elements in proposed projects.

Empowering Agencies and Jurisdictions

Transportation planners can improve transportation system safety by assisting their member agencies, districts, and jurisdictions as follows:

Provide Data: Transportation planners can provide their member agencies with safety data, primarily crash data. Because planning agencies are traditionally not keepers of crash data, the planning agency would only facilitate agencies in obtaining the data. However, transportation planners work with the agencies that maintain the data and can distribute the data to the member agencies or jurisdictions or facilitate their obtaining the data. The actual arrangement varies by agency.

Conduct Crash Analysis: Many member agencies lack the resources (such as tools, staff, and expertise) to analyze crash data. State transportation planners and MPOs, which have tools such as GIS that facilitate crash data analyses, could provide crash analysis as a service to member agencies or jurisdictions. State transportation planners and MPOs could also work cooperatively with member agencies or jurisdictions and assist them in conducting the analysis.

Provide Crash Analysis Tools: Transportation planners can empower agencies to identify safety projects by providing the tools necessary to analyze crash data. These tools may range from comprehensive crash analysis software to simple maps of high crash locations.

Identify Target Areas: Transportation planners can identify target areas or systemwide safety problems (such as red signal violations) that need to be addressed. Most likely, these areas or problems would be identified through special studies. On the basis of the special studies findings, the transportation planner could educate their member agencies and jurisdictions on the importance of the issue and suggest transportation strategies and investments to mitigate the problem.

By empowering the member agencies and jurisdictions, transportation planners can increase the consideration of safety in projects proposed for the TIP or STIP. The quality of the projects proposed may also be increased.

Safety in the Project Selection Criteria for the TIP or STIP

The project evaluation and selection process varies according to the MPO or state planning office and the project funding category (for example, congestion mitigation and air quality, bridge, and STP). The TIP or STIP should outline the process for selecting projects for the financially constrained program. Project selection can be both quantitative and qualitative and should be based on screening, scoring, and programming criteria. Candidate projects are drawn from the conforming, fiscally constrained transportation plan. The TIP or STIP must be consistent with the long-range plan and, as such, the TIP or STIP projects must meet the goals set forth for the transportation system through the long-range plan. As described in the previous chapter, including safety as one of the transportation system's goals is vital to incorporating safety into the transportation planning process. Once safety is identified as a goal of the transportation system through the long-range plan, the safety goal can be used to select and prioritize projects for the TIP or STIP.

In most jurisdictions, the process of selecting projects is highly competitive. The available resources to fund the TIP or STIP often are not enough to meet all the identified needs of a jurisdiction. Planning agencies are faced with the delicate task of allocating the resources among competing priorities within their jurisdictions. If safety is not clearly defined as a priority, safety projects may not be funded.

Even when long-range safety goals are included in the plan and validate safety as a priority, safety projects may not be selected for the TIP or STIP if the process is not objective. If the projects will bring improvements in safety only in the long term, they may be excluded to accommodate projects that will bring near-term improvements and address other objectives such as reducing congestion.

An objective selection process can help to secure funds for safety projects in the TIP or STIP. Planning agencies can accomplish this by including safety goals and objectives in the long-range plan and then constructing a project scoring system to evaluate projects based on the goals and objectives of the long-range plan. A properly devised scoring system evaluates the level to which each proposed project advances the transportation system toward the goals and objectives of the long-range plan, including the safety goals and objectives. Selecting projects under this method should facilitate the attainment of long-range goals, project by project.

The Delaware Valley Regional Planning Commission (DVRPPC) TIP Project Scoring

DVRPC developed a process for ranking projects proposed for inclusion in the TIP based on a series of questions that are integrated with the goals, policies, and actions of the MPO's long-range plan. There are seven goals in the long-range plan. The importance or priority of each goal is expressed with a weight. The goals and weights are as follows:

- Preserve and modernize key elements of the existing system: weight = 20
- **Improve safety and security:** weight = 15
- Mitigate congestion: weight = 15
- Protect and improve the environment: weight = 10
- Support economic activity: weight = 15
- Improve the mobility of people and goods: weight = 15
- Support land use plans and goals: weight =10

Each goal has an objective, referred to as a process. The objective of the safety and security goal is to improve the safety and security of the transportation system's user/customer through programs or improvements that eliminate or lessen safety hazards. Each process also has a series of "yes" or "no" questions. Five or ten points are allocated for each question. Questions answered "no" receive zero points. Questions answered "yes" receive the maximum number of points. The questions in the safety and security process are as follows:

- Will the project directly reduce the number and severity of accidents that occur on highways or transit systems?
- Will the project reduce system-related crimes or violations?
- Will the project increase public awareness of safety and security programs?
- Will the project remove barriers to system use (ADA, posted bridges)?

The points are totaled for each question in the process and multiplied by the weighting factor. All of the processes are totaled together to obtain the project score. These project scores are then considered in the selection of projects.

Many MPOs and state planning agencies use safety as a criterion by which to prioritize TIP or STIP projects. Safety can be assessed quantitatively (for example, based on the number of fatal and injury crashes the project prevents) or qualitatively. For qualitative safety assessments, expert judgment can be used to determine how safety will be changed by the proposed project.

Including Safety as a Priority in Project Selection for the TIP in Urban Areas

A survey of MPOs and their practices in scoring projects for the TIP found that many included safety as one of the scoring criteria *(1)*. Some of these MPOs are highlighted in the following examples.

SANDAG, the MPO for the San Diego, California, metropolitan area uses safety as 10 percent of the TIP selection criteria for state highway projects based on the project's highway accident rate. Safety is 19 percent of the selection criteria for Regional Arterial System projects.

Scoring is based on a subjective description of the project's accident problems and project safety features.

OKI, the MPO for the Cincinnati, Ohio, metropolitan area uses safety as 10 percent of the TIP selection criteria for highway projects. Scoring is based on a subjective rating of the project's accident history. It is similarly used as 5 percent of the project selection criteria for highway projects in the flexible funding criteria.

Metroplan, the MPO for the Little Rock and North Little Rock, Arkansas urban area uses safety as a criterion in the selection of transit projects; roadway, bridge, and intersection improvement projects; and enhancement projects. Safety is 12 percent of the project score for each of the three project categories. The safety measure used for each is a subjective assessment of the project's ability to eliminate hazards.

Bi-State Regional Commission is the MPO for the Quad City metropolitan area of Illinois and Iowa. The regional planning agency uses safety as 20 percent of the project score for highway projects. The scoring is based on the project's past accident history, severity of those accidents, and accident rate.

Mid-America Regional Council (MARC) is the MPO for the bi-state Kansas City region. Safety is considered in the TIP project score for both highway and enhancement projects. Safety is 20 percent of the project score for Missouri roadway projects, 10 percent of the project score for Kansas bridge projects, 30 percent of the project score for Kansas roadway projects, and 15 percent of the project score for enhancement projects.

The Denver Regional Council of Governments (DRCOG) uses safety as part of their project evaluation scoring for the TIP. There are 8 project categories evaluated by DRCOG including:

- Maintenance projects such as highway reconstruction and resurfacing projects,
- Safety projects,
- Management projects such as operational projects,
- Transit projects such as transit operations or passenger facilities projects,
- Highway projects such as widening projects,
- Bicycle and pedestrian projects,

- Elderly and disabled and non-urbanized transit projects, and
- Other projects such as special studies.

Projects that are defined as safety projects are selected by the Colorado Department of Transportation (CDOT) based on their benefit/cost ratio. However, other projects can also have safety impacts including operation improvement projects, roadway widening projects, interchange reconstruction projects, and bicycle and pedestrian projects. The consideration of safety in these projects varies depending on the type of project. For example, in operational improvement projects, the safety evaluation represents 10 of the 126 points available. Points are awarded based on the estimated reduction in crashes that project is expected to bring about and the project's weighted crash rate compared to the statewide average.

Encouraging the Consideration of Safety in Proposed and Planned Projects

Transportation planners can improve the safety of the system by advocating safety consideration. Projects programmed through the TIP or STIP do not have to be expressly identified as safety projects to improve transportation system safety. Safety improvements can also be accomplished as add-on items to proposed projects. For example, a highway-widening project could also include a provision for new sidewalks and improved pedestrian crossings and pavement markings. Often, it is cost effective to make safety improvements while other improvements are being made. The same is true of operations and management projects. These projects often consume large amounts of an agencies budget and have a large potential for including safety improvements.

Transportation planners can suggest to member agencies and jurisdictions that they include safety elements in all projects recommended for inclusion in the TIP or STIP. The transportation planner may need to examine aspects of the proposed projects and identify elements where safety can be improved.

Dedicated Safety Programs Implemented Through the TIP or STIP

Some transportation safety projects are part of a dedicated safety program implemented through the TIP or STIP. These programs usually involve the identification of hazardous sites in need of safety remediation. Projects can be selected by crash data analysis and from citizen complaints, professional input (such as police officers), and road or neighborhood safety audits. They may also be incident motivated or part of a targeted, systemwide improvement such as increasing the clear zones on all rural highways in the jurisdiction.

Crash Data Analysis

Transportation planners or their member agencies and jurisdictions can use past crash histories to identify locations needing safety improvements. Ideally, this analysis should identify not only those sites with safety deficiencies, but also those sites that can be reasonably improved through transportation investment. This method of identifying safety projects is described in detail in Chapter 4.

Citizen Input through Public Involvement Process

Users of the transportation system are often aware of site safety deficiencies before the sites are identified through crash data analysis. Transportation planners can use citizen input to identify sites in need of safety improvements. This can be accomplished informally through the receipt of complaints or formally through a formal public involvement process or citizen committees.

Incident Motivated

Highly publicized traffic incidents can result in public outcry for safety remediation. Although reactive activities are not usually associated with planners, highly publicized incidents can help to identify potential safety projects. Incident-motivated projects also provide an opportunity for planners to increase awareness of the importance of safety in their jurisdictions. Highly publicized crashes often bolster public support for safety, at least in the short term. Unfortunately, the importance of incorporating safety into the planning process is often not fully realized until such incidents occur. Planners can use the safety awareness that incidents generate to increase public support for safety as a long-range goal. Planners can also use this awareness to identify safety projects that should also be selected for the TIP or STIP in the short term.

Road Safety Audits

All the methods described so far to identify potential safety projects for the TIP or STIP have been mainly reactive to safety deficiencies. Road safety audits (RSAs) are a potential tool for assessing safety deficiencies proactively. FHWA describes an RSA as an assessment of the crash potential and safety performance of an existing road or proposed project. An RSA consists of a formal examination of an existing or future roadway by an independent team of qualified engineering, enforcement, and human factors professionals. It is a formal and independent review for assessing the multi-modal safety performance of the roadway. An RSA results in a brief report identifying the safety problems and potential solutions.

Road Safety Audits in the United States

An FHWA initiative introduced the concept to the United States in the late 1990s. Both Pennsylvania and Minnesota were selected to conduct pilot studies of RSAs in the United States to determine if the safety audit process is a valuable tool, and if so, how to expand its use to additional areas. Both states found that the process was beneficial as a tool for improving safety. On the basis of the pilot program, PennDOT decided to expand the program within its organization *(2)*. The safety audit process has now been expanded to all Pennsylvania districts. Currently, the safety audits are only being used to review preliminary designs for construction projects and not for assessing how safety for existing facilities can be improved.

Other states have been involved in the FHWA safety audit initiative including California, Kentucky, Missouri, Montana, Ohio, New York, Rhode Island, Texas, Utah, Vermont, and Wyoming. FHWA will continue to partner with states and local jurisdictions to assess the feasibility of integrating the RSA system into all phases of roadway planning, preliminary design, final design, construction, and operations *(3)*.

Currently, the role of transportation planners in the RSA process is largely undefined. Because of their emphasis on design, RSAs are fairly inconsistent with the structure of transportation planning. However, because of the desire to use RSA as a tool to proactively increase safety, there is potential for collaboration between transportation planning and RSA.

One way that transportation planners could be involved in RSAs is through the role as a facilitator. Transportation planners can help assemble the RSA team. The team should consist of experts from all disciplines of highway engineering, including traffic engineers, design engineers, and safety engineers, and should be supported by human factors experts, law enforcement experts, and risk management experts. Team roles could be adapted depending on project needs or agency resources. The audit team members should be independent from those involved in designing or constructing the project.

Additional Information

The Institute of Transportation Engineers (ITE) with financial support from FHWA has developed a Road Safety Audits web site. The site has a variety of resources related to safety audits, links to other web sites, and a discussion forum for safety professionals. The web site can be accessed at: http://www.roadwaysafetyaudits.org

Targeted Safety Improvements

Dedicated safety improvements identified for implementation through the TIP or STIP may be part of a targeted safety improvement program (for example, one that increases the clear zone on rural highways). Sites for the targeted improvement program may be identified through crash data analysis or simply based on the characteristics of the site. Using the clear-zone improvement example, a roadway segment may be identified for improvement through the program because of past run-off-the-road crashes or because the site has a narrow shoulder and hazards (such as utility poles) close to the roadway.

Targeting Low-Cost Improvements: PennDOT's Approach

PennDOT has developed a targeted program to implement low-cost improvements to reduce the number of fatalities statewide. The low-cost improvements are being implemented by district safety engineers through the Safer Travel Strategic Focus Area (SFA) program at high crash segments and spots.

The program concentrates on the following 12 crash categories:

- Signalized intersections
- Stop-controlled intersections
- Guiderails
- Utility poles
- Trees
- Curves
- Head-on/sideswipe crashes
- Pedestrians—midblock
- Pedestrians—intersection
- Safety belts
- Aggressive driving
- DUI

The Bureau of Highway Safety and Traffic Engineering (BHSTE) developed a toolbox of low-cost highway safety improvements to address these 12 categories. The improvements were developed based on analyses of collision data for the state. The following are examples:

- Centerline rumble strips to reduce centerline crossings
- Consolidation of pole utilities to one side of the roadway (PennDOT pays 50 percent of the costs) to reduce impacts by errant vehicles
- Use of reflective tape on utility poles to delineate poles and reduce the possibility of impacts by errant vehicles
- Increasing clear zone through tree removal to reduce fixed object impacts by errant vehicles
- Guardrail upgrades
- Innovative pavement markings such as "curve ahead" to warn motorists of curves
- Epoxy dots in the center of lanes to guide motorists in maintaining a safe vehicle headway
- Warning signs for special enforcement activities such as aggressive driving and DUI enforcement
- Durable crosswalks and pedestrian crossing sign stands to increase the conspicuity of crosswalks
- Truck rollover warning systems

District engineers are asked to include a plan and approach to meet their target fatality reduction goal as part of their District Business Plan. The progress of each area is reported quarterly. The primary measure of progress is the number of lives saved annually. A secondary measurement is the number of low cost improvements implemented.

Each category has minimum criteria for the number of clustered collisions deemed necessary for a segment to be considered for low-cost improvements. Improvements have been developed for each category. Crash-reduction factors are given for each category by improvement type. To meet its goal for reductions in fatalities, each district must implement low-cost improvements at locations with the highest potential for a reduction in crashes based on the crash data. Each district must maximize its resources to meet its targets *(4)*.

Tools for Transportation Programming

Tools are available to help transportation planners incorporate safety into the transportation programming process. These tools include benefit-cost analysis methods, crash reduction factors, and project analysis software that also performs benefit-cost analysis.

Benefit-Cost Analysis

When transportation planners are evaluating whether to proceed with a transportation investment, they analyze the benefits and costs of transportation projects or policies. A benefit-cost analysis usually compares alternatives although it can be used to decide whether to proceed on a specific project. Because of the limited funds available for transportation projects, benefit-cost analysis helps transportation planners allocate limited funds to maximize societal benefits.

The benefits and costs of a project or policy usually extend beyond the direct costs (that is, capital costs, operating costs, and revenue). Transportation planners must also consider benefits and costs that do not have a dollar value attached to them. Using a technique called monetization, the planner can assign a dollar value to indirect benefits and costs of a project. This allows both the direct and indirect costs and benefits of a project to be considered systematically in the analysis.

The safety benefits of a project are usually considered as reductions in crashes. When monetizing the benefits of reduction in crashes, the crash severity is important; that is, reducing the number of fatal crashes has a greater benefit than reducing the amount of property-damage-only crashes.

Estimating Project Benefits: Crash-Reduction Factors

When considering the safety benefits of a project, transportation planners first estimate the projected reductions in crashes that the project will bring about. To optimize the use of available funds, many agencies employ crash reduction factors, also called accident reduction factors or accident modification factors, to estimate the safety benefits of highway improvements or design alternatives. A crash-reduction factor is a measure of the effectiveness of a specific transportation improvement. It quantifies the effectiveness of the improvement designed to reduce the frequency and/or the severity of crashes at a location.

Crash-reduction factors are usually expressed as a percent reduction in the number of crashes attributed to the specific transportation improvement. The percent reduction is multiplied by the expected crash frequency without the improvement. This calculates the reduction in crashes that the improvement is estimated to bring about. Often, this reduction is just applied to the crash frequency from the previous year or from an average of the last 3 years. However, to account for the effect of an unusually hazardous year (regression to the mean), the estimate of the expected number of crashes without the improvement may be more appropriately derived from a predictive model if available *(5)*.

The crash-reduction benefits of a highway improvement or design alternative are sensitive to the unique characteristics of the transportation environment. High-quality crash-reduction factors are necessary to provide a reliable estimate of safety benefits. FHWA has encouraged states to produce their own crash-reduction factors. States such as California, Indiana, South Dakota, and Florida have done so and have published the resulting factors. The published factors could be used prudently by other agencies to conduct benefit-cost analysis, especially because developing crash-reduction factors requires a large amount of effort. However, crash reduction factors are highly sensitive to the locality of the data that produced the factor. If jurisdictions use crash-reduction factors developed by other jurisdictions, they should evaluate the transferability of such factors. In addition, agencies should understand the data used to create the factors so that the factors can be appropriately applied to the crashes at the location of the proposed improvement. For example, should crashes involving alcohol be included in the calculation? Some crash-reduction factors are developed only from the number of crashes that relate to the proposed improvement. Crashes that were the result of impaired drivers may have been excluded from the calculation of the crash-reduction factor and therefore should be excluded from the calculation of the estimated reduction in crashes.

Developing Crash Reduction Factors for an MPO Area

SEMCOG developed a set of crash-reduction factors for use in estimating the benefits of safety projects and improvements in its MPO area. The MPO developed the set of crash-reduction factors by researching several data sources including the Kentucky Transportation Research Program, the Kentucky Transportation Center, Texas DOT, and MDOT. They synthesized the results and decided on a default crash-reduction factor for a group of countermeasures. These factors are given to local jurisdictions to be used as default crash-reduction factors. In their benefit-cost analyses submitted for each safety project, local communities can use different values if supporting documents are provided. Jurisdictions are encouraged to use their own data to develop factors and then provide copies of such new information to the SEMCOG Transportation Department for use in subsequent development/ refinement of crash-reduction factors *(6)*.

Methods to Develop Crash-Reduction Factors

The two predominant methods for developing crash-reduction factors are before-and-after studies and cross-sectional analysis. Before-and-after studies determine the safety effect of an improvement by comparing the number of crashes occurring before and after a transportation improvement. Cross-sectional analysis compares the differences in safety across locations. The differences in the relative safety of the various locations are attributed to disparate aspects of the location environments. The results of either of the two study methodologies are then analyzed using regression, confidence intervals, likelihood functions, and others to develop crash-reduction factors.

The potential drawbacks (threats to the validity) of before-and-after studies are well known (regression to the mean, history, maturation). Some of these drawbacks can be overcome with a well-designed study although the data requirements may become restrictive. The drawback of using the cross-sectional analysis method to develop crash-reduction factors is that it is difficult to attribute the variation in safety between locations to particular transportation improvements. When developing crash-reduction factors, the study should be carefully designed and the findings should be interpreted with care.

Applying Multiple Crash-Reduction Interventions

Crash-reduction factors estimate the reduction in crashes from an individual transportation improvement such as adding a signal, widening the travel lane, or increasing the shoulder width. However, proposed transportation projects will often involve more than one of these improvements. Unfortunately, the crash-reduction potential of these improvements is not additive; that is, if increasing travel lane width has a crash reduction factor of 30 percent and increasing shoulder width of the travelway has a crash reduction factor of 40 percent, both improvements together should not be expected to result in a 70 percent reduction in crashes.

The generalized formula *(7)* for estimating the combined effect of implementing a number (*n*) of transportation improvements is:

$$\Delta F = F * \left(1 - \frac{100 - CRF_1}{100} \times \frac{100 - CRF_2}{100} \times .... \times \frac{100 - CRF_n}{100}\right) \qquad [3\text{-}1]$$

where,

$?F$ = estimated annual reduction in crash frequency,

F = estimated annual crash frequency without improvement,

n = the number of improvements,

CRF_1 = crash reduction factor (expressed as a percent) for the first improvement, and

CRF_2 = crash reduction factor (expressed as a percent) for the second improvement, etc. to the nth improvement.

Monetizing Estimated Benefits

After the reduction in total crashes, injury crashes, or fatal crashes are estimated for a proposed project, the reduction must be translated into a benefit that can be systematically evaluated in relation to the costs. The translation of the benefit into monetary units is the process of monetization. To monetize crash-reduction benefits correctly, the analyst needs cost estimates for motor vehicle crashes.

In a 1994 report, FHWA estimated the costs of a fatal crash to be $2,600,000, an incapacitating injury (type A) to be $180,000, an evidential injury (type B) to be $36,000, and a possible injury (type C) to be $19,000; property-damage-only crashes were priced at $2,000 *(8)*. The methodology suggests annually increasing the costs by the gross domestic product (GDP) implicit price deflator. Thus, in 2002, these costs are approximately $2,981,000 for a fatality, $206,000 for an incapacitating injury, $41,000 for an evidential injury, $22,000 for a possible injury, and $2,300 for a property-damage-only crash.

Additional Information on Benefit-Cost Analysis

There are several approaches to benefit-cost analysis. In its Toolbox for Regional Policy Analysis, FHWA presents various methodologies and programs that can assist planners in conducting benefit-cost analysis. The toolbox is available on the Internet at http://wwwcf.fhwa.dot.gov/planning/toolbox.

ITE publishes the *Transportation Planning Handbook* . It provides information on the state-of-the-art of established practice in transportation planning. The handbook includes guidance for transportation planners conducting a benefit-cost analysis and a discussion on monetizing the benefits of crash-reduction measures.

The American Society of Civil Engineers (ASCE) is developing guidance for the application of benefit-cost analysis in transportation planning. The guidance is being developed through ASCE's Committee on Urban Transport Economics and Policy. The objective of the project is to help broaden the extent to which benefit-cost analysis is used for transportation policy and investment decision-making and to help improve the quality of analysis. The final product will be a web site devoted to benefit-cost analysis in transportation planning. The web site, currently available as a work in progress, can be accessed at:

http://ceenve.calpoly.edu/sullivan/cutep/cutep_bc_ outline_main.htm

Project Analysis Software

TELUS Software

The Transportation, Economic, and Land-Use System, or TELUS, is a data-management and decision-support program created to assist transportation agency planning. The thrust of the system's development was to help transportation agencies meet the transportation planning and programming requirements of TEA-21. TELUS helps planners meet the safety and security goal as well as the other six goals in the TIP or STIP scoring process. The system has a scoring module for prioritizing TIP or STIP projects. TELUS allocates 100 points for each of the 7 TEA-21 objectives. Concerning the safety objective, points are allocated for reducing personal injury, fatalities, and property damage; denying unauthorized access to the system; assisting the monitoring or patrolling of the system; increasing access to accident incidences and/or disabled motorists; enhancing or adding to the system of bike lanes and sidewalks; enhancing the movement of pedestrians across intersections and the public safety of pedestrians; and contributing to a reduced number of elderly drivers.

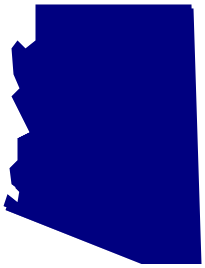
Additional Information

More information and the software are available to transportation planners at:

http://kimon.njit.edu/TELUS/

The first version of the system also contains a planning analysis module that calculates the degree to which the resulting TIP or STIP meets the seven TEA-21 planning objectives. Future versions will include economic and land-use components, providing further assistance for incorporating safety in the planning process.

Arizona Local Government Safety Project Model



Often, local governments lack the resources for conducting in-depth analysis of highway safety needs to identify potential safety projects in their jurisdictions. In response to this lack of resources, the Arizona DOT developed the Local Government Safety Project (LGSP) analysis model. The model is intended to help identify sites and implement strategies for local safety projects. It provides local governments with an efficient and justifiable means of assigning priority to potential projects in a local safety program so that resources can be appropriately allocated among traffic safety alternatives. It is focused on the development of implementation strategies for local safety projects through the synthesis of data such as traffic volume, average speed, and type and design of the roadway.

The LGSP model was incorporated in a Microsoft Access program for users. The model consists of two parts. The first part selects a subset of locations within the area of concern based on user-defined parameters such as the weighting method for injuries sustained. On the basis of the user parameters, the model generates reports that identify hazardous sites. The reports include information on crash frequency, severity, and costs of the crashes for each location. It also provides specific details about each of the sites (such as roadway type) and details about the crashes that occurred at those sites (such as weather). The model does not select treatments for the user because it is assumed that no one can understand the unique needs of each site better than local engineers. Safety treatments are selected by the local engineer on the basis of a traditional engineering safety analysis. The model output is only one of many data sources that the engineer considers in the site analysis.

The model also generates a list of similar sites for each of the hazardous sites. This comparative list can be useful to the engineer for before-and-after evaluations of the selected countermeasures once they are implemented.

In the second part of the model, the user inputs the possible safety treatments for each of the sites. Each treatment is assigned an effectiveness value. The user can input the projected effectiveness of the treatment or use default values included in the model. From the input of possible safety treatments and effectiveness values, the model calculates an expected benefit for each project and returns a benefit-cost analysis, the results of which are used to prioritize projects in the area *(8)*.

Decision Support System

The computer software program Decision Support System (DSS) was developed for U.S. DOT to assist planners' decisions about investments in highway transportation infrastructure. The program aids planners in performing an economic evaluation of proposed reinvestments and/or modest new highway investment projects. Predicted reductions in accidents are one of the project benefits evaluated.

Safety Resource Allocation Program

The Safety Resource Allocation Program (SRAP) is a software package that contains three computerized methodologies developed by FHWA to aid highway safety planning decisions by prioritizing projects on the basis of their benefits and costs. The methodologies include an incremental benefit-cost analysis, integer programming, and dynamic programming. Using the software, a transportation planner can maximize the total net accident savings within the available budget by selecting the optimal mix of accident locations and the preferred countermeasure at those locations. A user's manual was also developed and is available from FHWA *(9)*.

> DSS, SRAP, and other applicable software can be ordered through the FHWA-designated software distribution center, PC-TRANS. PCTRANS can be accessed on the Internet at:
>
> http://www.kutc.ku.edu/pctrans/

Safety Analysis for Railroad/Highway Grade Crossings

The Federal Railroad Administration (FRA) requires a benefit-cost analysis as a condition for receiving funds for railroad/highway grade crossing improvements (Section 130 funds). These funds are for the elimination of hazards associated with railway/highway crossings including the separation or protection of grades at crossings, the reconstruction of existing railroad-grade crossing structures, and the relocation of highways to eliminate grade crossings.

FRA requires that the benefit-cost analysis follow the Administration's definition of benefits and costs *(10)*. Benefits include safety benefits (savings in lives, injuries, and crashes), travel time savings by highway vehicles, environmental benefits (in reducing vehicle emission due to idle time at grade crossings), vehicle operating cost savings (for both motor vehicles and rail cars), network benefits (on average queue lengths for vehicles approaching highway segments), and local benefits (grade crossing improvements to the local community).

Costs include the capital outlays involved in the construction, the annual operating and maintenance costs, and other life cycle costs (for example, the need to hire specialists to change particular components). FRA has produced a software package for conducting benefit-cost analysis at railroad/highway crossings *(11)***.** The package, called GradeDec 2000, can be downloaded from the FRA web site.

Incident Management

Incident management is the process of managing multi-agency, multi-jurisdictional responses to highway traffic incidents. Traffic incidents, if not properly managed, can greatly affect transportation system performance. Not only do traffic incidents increase congestion and reduce capacity, they also decrease the safety of the entire system. In addition, rescue personnel response may be slowed by the congestion caused by the incident, further endangering the safety of the motoring public.

Transportation planners can facilitate incident management programs by acting as coordinators, increasing the awareness of the need for an incident management system, or strengthening the support and cooperation between member agencies.

The goal of an incident management system is to coordinate the response to the incident efficiently so that the impact on public safety, traffic conditions, and the local economy is lessened. States and metropolitan areas implementing incident management systems experience a marked decrease in secondary crashes, a decrease in incident response times, increased delay savings due to reduced congestion, reduced emissions, and increased throughput.

MPO Facilitation of an Award Winning Incident Management Program

The Ohio-Kentucky-Indiana Regional Council of Governments (OKI) is a pioneering MPO in incident management. The Cincinnati region MPO facilitated the bi-state "buy-in" of the region's incident management system by completing both the feasibility study for the incident management system and the preliminary engineering design study. Because of OKI's work, the resulting system, the Advanced Regional Traffic Interactive Management and Information System (ARTIMIS), now serves 51 jurisdictions in Ohio and 20 in Kentucky. ARTIMIS covers 88 miles of the region's busiest highways.

Although the lead role for the project implementation was transferred from OKI to the State of Kentucky, the MPO continued to play a facilitating role throughout the ARTIMIS implementation. The MPO also facilitated the operation of the system by establishing a partnership of incident management agencies in the region *(12)*.

Incident management systems use intelligent transportation systems such as closed circuit televisions, vehicle detectors, signal timings, and variable message boards to detect, verify, respond to, and clear incidents faster. The systems require coordination between many diverse agencies, especially in metropolitan areas that span multiple jurisdictions. MPOs can coordinate the incident management system across jurisdictional boundaries.

In metropolitan areas where it is not the coordinating body of the incident management program, the MPO can be effective in other areas. In Milwaukee, Wisconsin, an incident management system was put into place after a joint study by the regional planning committee and the state DOT found that an incident management system would improve the safety and the flow of the city's transportation system. The MPO can also provide useful information to other jurisdictions coordinating an incident management program. Several MPOs already coordinate incident management in their metropolitan areas including Johnson City Metropolitan Transportation Planning Organization, Tennessee; Ohio-Kentucky-Indiana Regional Council of Governments (OKI); Atlanta Regional Commission (ARC), Georgia; and Puget Sound Regional Council (PSRC), Washington.

Incident management systems require funding. Identifying incident management as one of the goals and objective of the planning jurisdiction can help to secure funding and potentially increase transportation system safety.

Additional Information

More information is available tc transportation planners on incident management and other ITS measures that can increase safety through U.S. DOT's web site on ITS:

http://www.its.dot.gov

Special Studies

> **Balancing the Needs of Heavy Vehicles and Safety Concerns**
>
> In Syracuse, New York, residents were concerned about the effect of truck traffic on the safety of city streets. Citizen complaints prompted truck restrictions to be arbitrarily placed throughout the city without any concern for the needs of the trucking industry or the effect of individual restrictions on surrounding routes. The maze of restrictions and lack of guidance often led trucking companies onto routes that could not safely accommodate the vehicles. Citizen concerns prompted a study by the MPO, the Syracuse Metropolitan Transportation Council (SMTC). SMTC conducted a comprehensive review and analysis of truck routes, related signage, and constraints on those routes within the city. SMTC reached out to members of the trucking industry and the community and assembled a combined Study Advisory Committee (SAC) and Stakeholders group to provide guidance and review during the study. The group included six interested public agencies and six private companies. Other private companies provided input through written correspondence. By facilitating the involvement of all interested parties, SMTC was able to develop a designated truck route that satisfied the needs of the city and the trucking industry. The systematic approach resulted in a new recommended truck route system with fewer through truck routes within city limits *(13)*.

Transportation planners conduct a range of special studies to accommodate and understand the needs of transportation system users. Special studies that target or have elements that target the safety of the transportation system may include the aging population and its changing mobility needs, needs of pedestrians and bicyclists, transit access, and systemwide safety problems such as speeding. Transportation planners' roles as coordinators can increase the safety of transportation systems through these special studies.

Initiating Special Studies

Planning activities for an MPO or at state planning office are specified in the work program and may include provisions for special studies to identify system needs and solutions. A special study may be initiated in various ways. The transportation planner may have to promote the need for the special study so that funds are available and so that the study is included in the work program. For studies on increasing the safety of the transportation system, the transportation planner would serve as an advocate for safety.

A special study also can be initiated through public support. Highly publicized traffic incidents can result in public outcry for safety remediation. Although reactive activities are not usually associated with planners, incident motivation studies can offer planners the opportunity to increase safety in their jurisdictions.

Examples of Special Studies Conducted by Planning Agencies

Planners can perform various specialized, short-range studies to increase the safety of the transportation system. The findings of the studies may be implemented through short- or long-range planning activities. Examples of special studies that incorporate safety into transportation planning are described in the following sections.

Delaware Valley Elderly Study

DVRPC, the MPO for the Delaware Valley region, studied the mobility needs of older drivers. The study of older travelers reviewed the location and scale of the region's current and forecasted elderly population and identified alternatives to the private automobile including rides from family and friends, walking, public transit, demand-responsive paratransit services, taxis, and public and private senior transportation services.

On the basis of the study findings, the MPO developed transportation and non-transportation recommendations to improve the mobility and quality of life of older residents in the metropolitan area. Recommendations included revising plans and zoning regulations in suburban municipalities to encourage increased densities, mixed-use communities, and service clustering to provide walkable access to services. Although this recommendation is intended to plan a change in land use, the net effect is to improve transportation system safety because fewer older drivers will be on the area's highways. A similar recommendation called for increased access to regionwide transit and a marketing campaign to encourage older drivers to use transit. The MPO also recommended that pedestrian facilities be improved to increase the safety of the transportation system for pedestrians and encourage older citizens to forgo private automobile use *(14)*.

Two School Safety Studies

The Tri-County Regional Planning Commission (TCRCP), the MPO for the counties around Lansing, Michigan, introduced the "Bike and Walk" program to bolster support for pedestrian and bicycle safety. The increased support and awareness resulted in the creation of bicycle lanes and the rebuilding of alleys. TCRCP also conducted a community walkability audit (CWA).

The "Safe Ways to School" program was initiated in the State of Florida. It is a joint effort of the state's DOT, Department of Education, community traffic safety teams, and school safety teams. The program brings together state, county, and local policy-makers, planners, and school officials to increase the number of children who walk and bicycle to school by designating and improving safe routes. The pilot program was initiated at 10 elementary schools. In three of the pilot schools, regional planners or MPO planning staff served as members of the school safety teams. Many of the improvements recommended through the program were funded through the transportation improvement programming process *(15)*.

Making Secane a Walkable Community

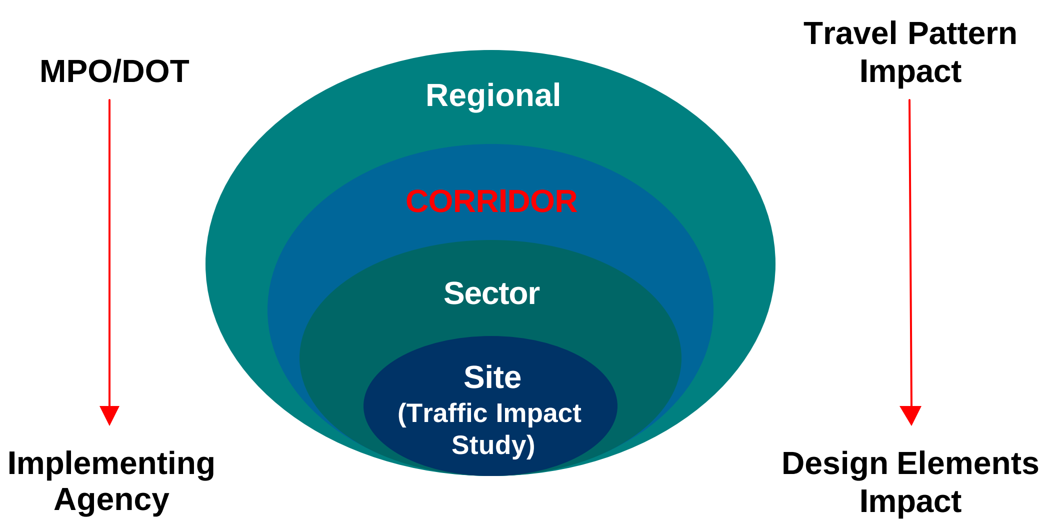
Secane is a suburban neighborhood that surrounds a commuter rail station in the Delaware County of Pennsylvania. DVRPC, the MPO for the Delaware Valley region, conducted a study of pedestrian travel and transit access in the area. From the study findings, it produced a report proposing a program of capital improvements to make pedestrian travel in Secane safer and more appealing.

County planners nominated Secane for the study because the community's residential density and mixed land uses were conducive to high walking rates, but also because its walking environment needed improvement. The study analyzed the history of motor vehicle crashes with pedestrians; design issues that may have contributed to those crashes; existing pedestrian facilities; elements of the environment that are inhospitable to pedestrian traffic; and deficiencies and shortages in crosswalks, bus stops, and transit amenities.

Incorporating Safety Into Corridor Planning

Corridor planning is an important tool for improving the safety of the transportation system. It provides the opportunity to incorporate safety at the broader planning level analysis. Exhibit 3-1 illustrates the levels of transportation planning. MPOs and DOTs planning offices are more involved with the broader levels of planning. As the levels become more site specific, MPO and DOT planning office involvement decreases while implementing agency involvement increases. The corridor level of planning, a broad level below regional planning, may encompass multiple routes and various modes of transportation between two major destinations or urban areas. Corridor-level planning may be composed of multiple smaller projects within the corridor on major arterials, minor arterials, transit routes, and multi-use trails. Through corridor planning, safety issues can be considered and addressed earlier in the process.

Exhibit 3-1
Levels of Transportation Planning



Corridor planning explores transportation safety beyond a single intersection, transit stop, crosswalk, or segment of highway. Many corridor studies are motivated by safety concerns or by a combination of safety concerns and congestion. These studies help to identify safety deficiencies that result in projects for the TIP or STIP. Projects along corridors can be coordinated to achieve the safest system of transportation within the corridor across multiple modes and routes. Corridor studies can also identify deficiencies in the junctions between modes.

Transportation planners have an important role in corridor studies. They are often the coordinating body for the multiple agencies needed to conduct a corridor study. These agencies include local and state highway agencies, transit agencies, railway agencies, port authorities, business owners, law enforcement, citizens, and community groups. Transportation planners can assure that adequate representation is provided in the corridor planning committee for all users including transit riders, pedestrians, and bicyclists. This helps to ensure that the safety needs of all transportation system users are considered in the corridor study.

MPO's Role in Corridor Planning in the Delaware Valley Region

DVRPC, the Delaware Valley MPO, assembles a committee for each corridor being studied. All interested bodies are represented on the committees, including municipalities, transit agencies, and community groups. After DVRPC receives data on the corridor from the PennDOT it superimposes the data on a map of the corridor. The superimposed data contains information on pavement, crashes, bridges, and so forth. On the basis of the data, the committee develops a characterization of how it would like the corridor to move forward. The committee must decide on the balance between corridor needs (for example, safety and capacity). Programming improvements along the corridor are then suggested globally.

Various types of data are needed for corridor safety studies including volume, land use, and crash data. Transportation planners can provide or assist the committee in obtaining the safety data needed for the corridor study.

Incorporating Safety Into Transit Planning

Transit agencies have a primary concern with safety and security. Because they are responsible for transporting passengers, they have extraordinary liability concerns. In metropolitan areas, transit agencies and MPOs jointly decide how to address TIP transit projects.

Transit agencies vary widely in size and service, and each has a unique method for management and operation. However, for the most part, these agencies lack a structured approach for integrating safety and planning. Transit agencies address safety and typically consider it a top priority, but have no formal method for safety planning. In a broad sense, transit agencies approach safety planning in two ways: on a specified project level and in response to an identified safety issue. On the project level, agencies consider all aspects of safety once the project has begun. Safety is a fundamental part of project planning, design, and implementation. For example, if a transit system is planning to construct a new transit center, careful consideration will be given to factors such as (1) the layout, to minimize pedestrian crashes, and (2) the security design, to include lighting and possible police patrolling. New projects are developed with safety in mind, not with safety as the sole purpose.

There is one exception to this "project level" approach where safety is considered as a result of the project. This occurs when agencies design a project in response to identified safety concerns including high-incident locations, unsafe pedestrian facilities, or dangerous driver behavior. For example, the Three County Transportation Authority (Tri-Met), the transit provider for the Portland, Oregon, area, has identified certain bus stops as high-incident locations and is mapping the city's pedestrian environment to transit accessibility. Tri-Met's goal is to reduce incidents at these bus stops, thereby enhancing the safety of the bus system. Most agencies maintain some mechanism for recording crash information, some more formal than others. The larger agencies have elaborate systems for tracking accidents of all scales, from broken mirrors to crashes resulting in fatalities. Agencies with the resources to do so will analyze crash data to identify consistent incident locations and trends, and use this information to develop countermeasures and fund projects based on these safety improvements.

Aside from these two distinct methods, transit agencies address safety and security through indirect measures such as driver training, designation of a safety officer, and implementation of bus transit system safety program plans. Transit agencies must consider safety and security concerns beyond transit vehicle crashes. They must also consider access issues that affect transit safety such as safe pedestrian crossings and transit stop locations. They must also address security issues such as security cameras in transit vehicles and at transit stations, traveler information, and emergency activations. The American Public Transportation Association (APTA) has created a manual for the development of a Bus Transit System Safety Program Plan. These plans address items such as accident response and review, management safety roles and responsibilities, and emergency management procedures. APTA has implemented a Safety Management Audit Program to assist transit agencies in developing system safety programs and to evaluate the program's effectiveness. Further, transit agencies are expected either to use 1 percent of urbanized area formula grant funds on transit security or to document why the funds were not used. Transit security includes agency fencing, lighting, bus and facility cameras, and transit police.

Safety Problems Unique to a Transit Agency

Particular crash problems are unique to a transit agency. Transit officials frequently mention the following incidents:

- Crash fraud: A private driver encourages an accident with a bus.
- Driver crash fraud: A few drivers have too many crashes, usually in order to gain access to worker's compensation.
- Jumper's claims: People who never were on a vehicle involved in a crash (the term comes from people who jumped on the bus after a crash).
- Malingering, symptom magnification, and enabling by doctors and attorneys.

Most transit agencies will aggressively fight such claims and have in-house legal representation, as well as external legal services under contract. Unfortunately, it is a dimension that most large transit agencies have to confront periodically.

Design Issues in Transit Safety

Transit agencies run bus systems and, for some, rail systems, where numerous design issues affect safety. Bus stop locations can improve or decrease safety and security, and care must be taken to ensure safety at these locations *(16)*. Many transit agencies devote extensive resources to improving safety and security at these locations.

For example, Tri-Met of Portland has a top-down approach to bus stop design. It conducts a macro approach to determine the existing routes and transfer points, and then maps the bus stop locations and evaluates them for Americans with Disability Act standards. Typically, bus stop placement is project driven. Tri-Met's principal concerns are:

- Safety
- Accessibility
- Comfort
- Efficiency
- Obtaining right of way

Some stops are placed in unsafe locations, such as along a stretch of highway without control devices or on a traffic island. The transit agency has created several partnerships with local governments and businesses to improve the bus stop environment. Currently, with support from other jurisdictions and the MPO, Tri-Met is leading the effort to map the pedestrian environment, including all sidewalk and pedestrian access points in proximity to Tri-Met stops.

Problems have arisen in placing stops in the jurisdictions outside of city of Portland. Although bus stop information has not been linked to crash incidents, Tri-Met is trying to improve the visibility of stops by adopting consistent signage and placement. It is also trying to improve lighting at stops. Currently, the transit agency is working on the external lighting and is creating partnerships with businesses to provide internal lighting. An experiment is being conducted to put user-initiated strobe lights to inform drivers when passengers are waiting at a stop. Tri-Met is also trying to improve consistency in the layout of bus stops. Shelters sometimes vary by size and design/aesthetics.

Tri-Met places a high priority on pedestrian safety, and the approaches taken by traffic engineers cause conflicts. For example, Tri-Met may want to move a bus stop 15 feet from a crosswalk while the engineers want the bus stop to be as close to the crosswalk as possible to avoid traffic backup. Trade-offs and compromises must be negotiated.

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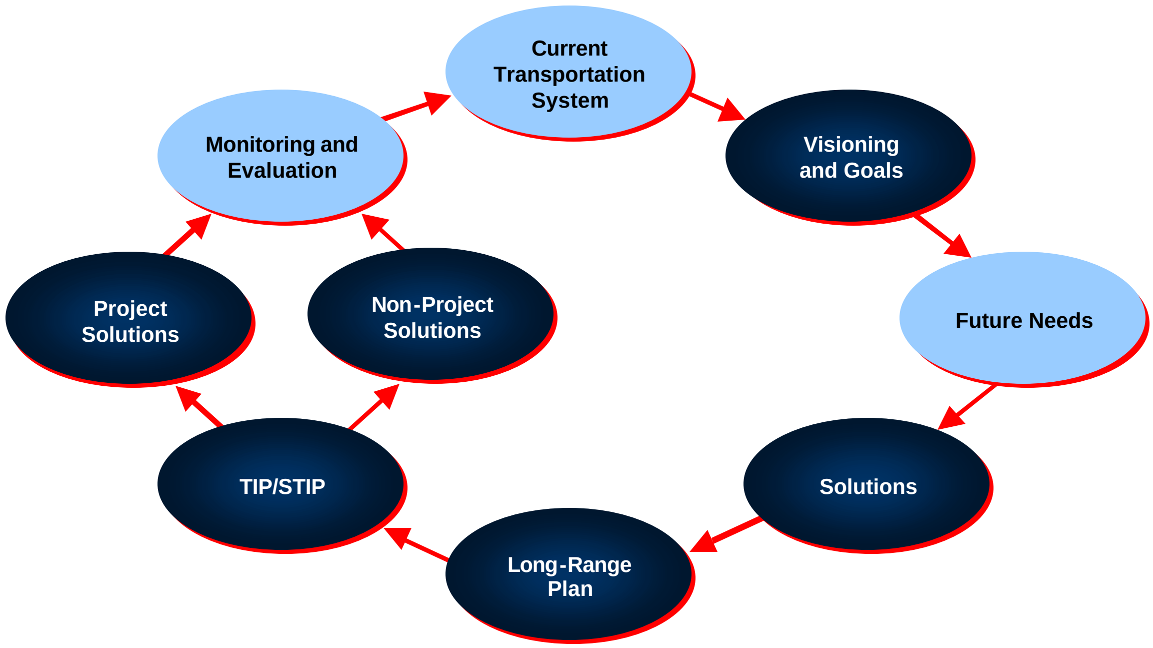
Chapter 4
Data and Information for Considering Safety in the Transportation Planning Process



Many transportation planning activities require large quantities of data, such as land-use, demographic, and traffic data. Timely and accurate crash data, when combined with other system data such as traffic volumes, can help transportation planners incorporate safety into the transportation planning process. This combined data, referred to as a crash information system, can be analyzed to provide useful information for transportation planning.

This chapter contains two parts. Part one addresses the fundamentals of crash data and presents information on obtaining and collecting crash data and organizing it into crash information systems. Part two describes the analysis of crash data and presents information on the tools, methodology, and application of the results of crash data analysis.

Part One: Fundamentals of Crash Data

Most metropolitan and state transportation planners are not involved in collecting or maintaining crash data, although some planners use crash data or the end products of crash data analysis (for example, location reports). However, understanding the process of crash data collection and maintenance can increase planners' awareness of and appreciation for transportation safety.

The Crash Reporting Process

The starting point for crash data is the initial crash. The law enforcement agency in the jurisdiction where the crash occurs is usually called to the scene to investigate. Depending on the severity of the crash, the reporting officer may fill out a report detailing the particulars of the crash. Almost all states report crashes resulting in fatalities or injuries. In addition, property-damage-only crashes are also reported if they exceed a legally defined reporting threshold. In most states, the property damage threshold is between $500 and $1,000.

For crashes meeting the reporting threshold, the responding officer conducts an investigation which varies depending on the severity of the crash. On a standard form, the officer records information on the circumstances, including drivers and vehicles involved and environmental and roadway conditions. In addition, information on the location and any traffic control in effect at the time of the crash is recorded.

The reporting officer may also try to ascertain and record the cause or contributing factors of the crash such as failure to observe traffic control, vehicle defects, or impairment. However, crashes may have multiple causes, all of which may not be apparent to the reporting officer. Depending on the reporting requirements of the jurisdiction, the crash report may also contain statements of witnesses and involved parties.

The reporting officer also records any injuries, usually making this assessment visually. Jurisdictions use various types of scales to describe injuries. A commonly used injury scale is the KABCO scale. Using this scale, the reporting officer assesses the injuries by using one of the following five designations: fatally injured (K); incapacitating injury (A); injury, not incapacitating (B); possible injury (C); and property damage only (O). Another common injury scale is the Maximum Abbreviated Injury Scale (MAIS). Using this scale, the reporting officer rates the injuries from one to six. One is for a minor injury, while five is for a critical injury and six is for an immediate fatality.

Crash Reporting

The organizational arrangements and crash-reporting thresholds are different for each state.

- In Michigan, all crashes involving a fatality, an injury, or property damage in excess of $400 are reported by the local governments to the Criminal Justice Information Center (CJIC) of the Michigan State Police in Lansing. The crashes are reported by local police officers and the forms are sent to CJIC for processing.
- In Texas, crashes are reported by local police officers and are sent to the Accident Record Bureau of the Department of Public Safety for all crashes involving fatalities, injuries, or property damage in excess of $500 in which at least one vehicle was towed away.
- In Oregon, the Transportation Data Section, within the Transportation Development Division of the Oregon DOT, maintain statewide crash data. The police are not required to report injury/fatality crashes, though they typically do. The police reports cover only about 33 percent of all crashes. Instead, state law requires that drivers submit a report to the DMV within 3 days of all fatal or injury crashes, or crashes resulting in more than $1,000 in property damage.

For crashes resulting in fatalities and injuries or when malfeasance is suspected, additional investigation may be required. Usually, special crashes such as heavy vehicle, transit, or hazardous material crashes also require additional information.

Crash Databases

Federal law requires each state to maintain a crash database for monitoring the safety of the transportation system. Once the crash report is filed, most enforcement agencies send a copy of the report to the state agency responsible for compiling the state's crash database, which varies by state but may be the department of motor vehicles (DMV), state police, or DOT. Most enforcement agencies also retain a copy of the crash report and maintain their own file or crash database. For example, the Honolulu Police Department maintains its own crash database in addition to sending the crash reports to the Hawaii DOT.

When the central state office receives crash reports from enforcement agencies, it compiles the information into a database. In some states, this may involve additional coding of the crash report. For example, in the State of Michigan, the central office instead of the reporting officer codes the crash type on the basis of the crash narrative and diagram.

A more precise location may also be assigned to the crash. For some states, this may mean assigning a map coordinate system to the crash. For other states, it may involve simply converting the transportation names into appropriate route numbers. The method of location assignment depends on the highway location reference system used by the state.

All statewide data is maintained on computer database systems, which usually requires the central office to perform some form of data entry, and data is often subjected to quality control and error checking procedures. These centralized databases are paid for, in part, by federal funding, and the federal government provides guidance for collecting and maintaining the data. For example, states are required to send data on all fatalities to the National Highway Traffic Safety Administration (NHTSA) for inclusion in the Fatality Analysis Reporting System (FARS), a national fatal crash database. Similarly, each state is required to report commercial heavy vehicle and bus crashes to the Federal Motor Carrier Safety Administration (FMCSA) through the SAFETYNET computer reporting system.

Sharing Data with Planning Partners

If data is needed from the centralized database, it is the responsibility of the state to determine if and how the data will be disseminated to planning partners. Many states are concerned about liability problems with crash data, and as such are reluctant to share the data with the planning partners. Some states accommodate for this by conducting crash data analysis for the planning partners so that they do not have to release the data. Other states, such as Connecticut, share the data freely with all planning partners. This is discussed further at the end of this chapter.

Potential Problems in Crash Data

Once crash data is received from the managing agency, users must consider the limitations of the dataset before conducting a crash analysis. The scope of data collected (reporting thresholds, jurisdictional boundaries, years of available data) should be understood. In addition, crash data is subject to errors from numerous sources of potential errors in the crash reporting process. These dataset errors and limitations in scope must be assessed in the context of crash-analysis needs. The following paragraphs describe some potential sources of errors and aspects of a crash dataset that must be considered.

Coding Errors

Even though police officers are trained in collecting crash data, they can make recording errors at the crash scene because of additional crash-site demands or time pressures to respond to other events. In addition, most crash reports are collected on paper forms and must be coded and digitizing for entry into the crash database. During the coding and digitizing stages, data entry specialists can make errors.

Underreporting

Not all transportation crashes within a jurisdiction are reported; that is, not all crashes are recorded on a crash report form and entered in the database of the jurisdiction. This is called underreporting. Drivers involved in single vehicle crashes are less likely to report the crashes. Elvik and Mysen compared 49 studies in 13 countries and showed that the reporting of injuries in official accident statistics was incomplete at all levels of injury severity (1). The mean reporting level of crashes in all countries was found to be 95 percent for fatalities, 70 percent for serious injuries requiring hospitalization, 25 percent for injuries in which the patient was treated as an outpatient, and 10 percent for very slight injuries.

Crashes involving some transportation system users are less likely to be reported than others. Underreporting is especially a problem for motor vehicle crashes involving pedestrian and bicycle crashes. Elvik and Mysen found that crash reporting was lowest for crashes involving cyclists. This is especially a problem when the crashes occur away from intersections at locations such as at driveways and across sidewalks. These crashes may result in very severe injuries to the pedestrian or bicyclist, but possibly because there is often minimal damage to the motor vehicle, the crash will go unreported.

Incorrect Assessment of Variables

Other common reporting errors on motor vehicle crash forms occur in the reporting officer's assessment of variables; the officer may incorrectly assess a condition such as the weather or simply fill in the wrong value for the field. For example, in a study of Honolulu motor vehicle crashes, the weather conditions recorded in crash reports were compared with actual National Weather Service data on rainfall (2). Only about a third of all wet days as defined by the National Weather Service were recorded in the weather conditions of the crash reports. Although analysts could obtain the necessary information from the

National Weather Service data instead, it indicates that other variables not as easily verified may be reported incorrectly.

Location Accuracy

The actual location of a crash is, itself, prone to numerous reporting errors. Police officers are trained to record the name of the street on which the crash occurred and the intersecting street or the nearest cross street that can be used for reference. However, in a study of Honolulu crashes, a variety of geographical errors were found that cut across different data elements (3, 4). These included differences in the way primary and reference streets were identified or in the direction of the crash (north, south, east, west) from the reference intersection. The errors involved using non-standard terminology, misspelling street names, abbreviating street types (for example, listing “5th” when the street could be “5th Street” or “5th Avenue”), using place names for locations, using local slang for locations, and miscoding names during digitizing (5). Differences were also found between the use of common street names and state route names with mileposts (mile markers); many police officers will use common street names rather than standardized state route names. A standardized state route name will allow crashes sites to be identified precisely, to a hundredth or even a thousandth of a mile (if the officer records that level of detail). On the other hand, if common street names are used, typically crashes have to be allocated to the nearest intersection.

In addition, locating crashes requires that street names in crash reports be matched against a base map with standardized street names. In a geographic information system (GIS), this process is called geocoding (or geo-referencing). Because necessary geographical information is missing from the motor vehicle crash reports, numerous errors are introduced during the geocoding process. For example, in the Honolulu study, crashes were identified by the nearest intersection because common street names (e.g. Chain Bridge Road) rather than standardized names (e.g. Route 123) were predominately used for the primary sites in the crash reports. The geocoding process involves matching as many crashes as possible including as much information as possible. Additional matching is obtained by ignoring (relaxing) certain information. Thus, when full street names (number, direction, street name, and street type) were required for both the primary and the reference streets, only 46.1 percent of all crashes were matched; however, the accuracy of these matches was 100 percent (5). When the street type (or suffix) was relaxed (that is, “avenue”, “street”, “drive” and so forth were ignored), an additional 37.5 percent of the crashes were matched, but the accuracy of the additional matches dropped to 96.5 percent. Further, when the direction of the street (North, South, East, West) was ignored, an additional 2.5 percent of the cases were matched but the accuracy of the additional matches dropped to 90.5 percent. Finally, when the street name and number were relaxed, an additional 7.8 percent of the cases were matched but the accuracy of the additional matches dropped to 52.5 percent.

Timeliness

The time from the actual crash until the crash report's full inclusion in the state-maintained crash database may range from a few months to a year or more. The actual time until inclusion varies by agency and depends on the agency's process. In addition, users of the data may receive a set of crash data only once a year from the maintaining agency. Meanwhile, conditions at some of the locations in the analysis may have changed since the crashes occurred. For example, in a study to determine countermeasures for run-off-the-road crashes in Maryland, the study team found that shoulder rumble strips had been installed at almost all the freeway locations after the crashes had occurred. Therefore, the study team concluded that it was inappropriate to consider other countermeasures until a further analysis of the crash data was performed for a period following the rumble strip installation.

Uniformity

Unfortunately, crash data lacks uniformity among the states and potentially within a state or urban area. Police departments may use different crash reporting forms or procedures. For planning agencies such as an MPO that spans multiple states, merging the various state databases may provide many challenges. These agencies may find more advantages in keeping the databases separate and conducting an individual analysis for each state.

Crash Information Systems: Linking Crash Data With Other Transportation Data

Crash data analysts often require additional information for more in-depth studies. For example, to calculate crash rates, analysts also need traffic volume data. When crash data is combined with other useful data for safety analysis, the result is a crash information system that can combine or link crash data with traffic volume, roadway inventory, and land-use data. This system allows crashes and locations to be analyzed in the context of the surrounding environment.

Different units and agencies collect traffic volume, roadway inventory, and land-use data. City, county, and state governments and MPOs collect traffic volumes. Road inventory items are collected and managed by multiple state and local agencies including local government and state DOTs, local government public works and planning departments, or a number of different state agencies. Similarly, land-use information may be collected from different sources such as local or state county tax assessment reports (for parcels), local zoning data, local building and demolition permits, local land-use plans, state data sources for areas under state jurisdiction, and even aerial and satellite photography (for land density and coverage maps, for example). The multiple data sources pose numerous consistency and currency problems. Assembling all this information for the planning area may be difficult but would add to the quality and depth of crash analysis. In Southern California, for example, SCAG is the MPO for the region; the planning area covers five counties with more than 170 separate jurisdictions. Because the data of any one jurisdiction represents only a piece of the larger picture, the data must be merged to provide a coherent multi-jurisdiction perspective.

In southeast Michigan, an integrated crash information system is maintained by SEMCOG. SEMCOG's system uses a GIS program to integrate data sources as diverse as road inventory characteristics, traffic counts, and land use. These data sources all provide information that can help to analyze particular crashes. For example, SEMCOG used the land use inventory data in GIS to conduct a spatial analysis on deer crash occurrences and the surrounding land use attributes (for example, forest, commercial, residential). Where possible, standardized data is used in the GIS program. There are some standardization issues, however. For example, traffic counts conducted by local governments have wide differences in the way they are implemented.

Linking data reported in different ways creates another problem. Traffic crash data is identified by specific locations, usually represented by points on GIS. Traffic volume data is usually measured over specific links of a highway network. On GIS, this data can be represented by line segments or, occasionally, by points (to measure, for example, the mid-point of a segment). Road inventory data (types of roads, lanes, bridges, rail lines) can be represented as lines or points. On the other hand, traffic analysis zones (TAZs), the basic analysis unit of travel-demand forecasting, are represented by zones or polygons on a map. Land-use data is frequently represented by zones but can also be represented by lines (block faces) or points (specific buildings). All data types that may be included in a crash information system can be measured in different ways and represented in different geometrical units. Added to this is the complexity involved in translating these data sources into the same geographic coordinate system (for example, state plane coordinates). Linking all this data requires a complicated set of programs and routines. In addition, other tools and programs must be linked to this data so that analysis can be performed.

Part Two: Crash Data Analysis, Tools, and Techniques

This section discusses crash data analysis in the transportation planning process. A brief overview describes how the analysis is conducted. Tools that are available to assist transportation planners in analyzing crash data are also identified, including GIS, which is highlighted, software, national databases, and useful reports.

Conducting Crash Data Analysis—A Brief Overview[1]

Safety improvement needs are addressed in two stages: identification and detailed safety analysis (6). One of the predominant uses of crash data is for the first stage—identification of hazardous locations. After locations are identified, a detailed safety analysis is conducted to determine if the sites can be improved by transportation investment and, if so, what improvements are needed. These hazardous locations, also referred to as "hot spots," "black spots," or "priority investigation locations," then become candidates for transportation programming.

[1] The primary reference for this section is the Manual of Transportation Engineering Studies (7). It is published by the Institute of Transportation Engineers, Washington, D.C., 1994.

Crash data analysis can also be used to identify region-wide safety programs that transcend one location or facility. For example, a region may be experiencing pedestrian crashes at multiple transit stops. Because the crashes are occurring at more than one transit stop, the problem may never appear in a hazardous location analysis. A planner may use crash analysis to identify the problem and develop a program to address the issue.

Classifying Locations

A location may be defined as a roadway segment or an intersection. It also may be defined as a single spot such as a curve or a transit stop. For state-level analysis, a location may be described broadly as a whole corridor or roadway. Generally, locations are defined as either spots or sections. A spot is a single location where many crashes occur, such as an intersection, an access driveway to a commercial center, or a railroad-highway grade crossing. A section is a length of highway, usually homogeneous, and can be as short as a half mile to several miles. When an aspect of the roadway changes, a new section or spot begins. For example, a new section begins when a lane is dropped, the shoulder width changes, or the type of pavement changes. Roadway inventory databases are used to parcel roadways into sections and spots. If a roadway inventory database is unavailable, uniform section lengths can be used in the analysis. (Most high crash location software systems can apply a "floating" section length to identify segments of roadway with high crash frequencies.)

Most state DOTs have defined state-maintained highways with a standard linear referencing system using control and section numbers. Each state highway is identified by one or more control numbers that, in turn, are subdivided into section numbers. The section numbers are then subdivided into mile points, usually to a hundredth or a thousandth of a mile. Crashes can then be allocated to small segments along a highway or grouped into larger segments (for example, tenths of a mile). In cities and counties, on the other hand, most local roads are known by their street names. Because most crashes are not identified by addresses, but by major streets and reference streets, many crashes in urban areas must be allocated to intersections (that is, the intersection of the main street where the crash occurred and the nearest reference street). This coding convention becomes important when interpreting the results, especially when using the crash data to identify hazardous locations.

Identifying and Ranking Hazardous Locations

Identifying hazardous locations requires that many different aspects of the location's crash history be considered including crash frequency, severity, rate, nature, and environment. Because available transportation funds are limited, hazardous locations must be ranked in order to identify those sites most in need of safety remediation. Intersections and sections are ranked separately. The importance and use of the different types of ranking are explained in the following paragraphs.

Frequency: A basic identification of a hazardous location is by the absolute frequency of crashes occurring. For example, an analyst may compare the total crashes occurring at each intersection in an area over a 3-year period. The intersections would be ranked according to crash frequency. The analyst may decide that the top 10 intersections need safety remediation. However, this will only identify the intersections where the most crashes are occurring. Potentially, one of these intersections is experiencing very minor crashes. Perhaps the intersection is heavily congested and rear-end crashes commonly occur, but the crashes result only in property damage or minor injuries.

Sites With Promise: A Change in Focus

A new school of thought has emerged in the safety analysis community that the emphasis should be shifted from hazardous location identification to locating sites that are in need of safety remediation and have the potential to be improved cost-effectively. These locations are referred to as "sites with promise." The basis of this idea is that a site does not have to be unduly hazardous for there to be the opportunity to prevent crashes cheaply. This is a shift in emphasis from only funding improvements at locations that are the most hazardous, to funding improvements at locations where crashes can be prevented in a cost-effective manner. A program for the identification of sites with promise would rank sites by at least five criteria in the interest of efficiency and fairness. A procedure is explained in Dr. Ezra Hauer's paper, "Identification of Sites with Promise," published in *Transportation Research Record 1542(6).*

Fatal and Injury Crash Frequency: It is more advantageous to try to prevent crashes that result in injuries or fatalities than it is to prevent crashes that result in property damage. A similar frequency analysis could be conducted in the context of injury to identify hazardous sites. For example, the transportation planner may want to compare intersections by the frequency of fatal crashes occurring at each. However, fatal crashes are relatively rare events.

Equivalent Property-Damage-Only Frequency: The analyst may want to consider using a weighting scheme to represent fatal crashes and injury crashes as their monetary equivalent in property-damage-only crashes; that is, an incapacitating injury crash may have the same negative impact on the safety of the intersection that 25 property-damage-only crashes would have. All crashes occurring at each intersection are converted to the equivalent property-damage-only (EPDO) crashes. The result is a weighted frequency of crashes at each intersection. The analyst would use this new weighted frequency to identify the top 10 intersections in need of safety remediation. However, this still may not identify those sites most in need of safety remediation. Potentially, although the equivalent crash frequency at an intersection is high, the traffic volume at the intersection may also be very high. Typically, locations or segments with the most crashes are those that also have high traffic volumes. Freeway segments, for example, will usually have among the highest numbers of crashes because of their very high volumes. An analysis of the 10 locations with the most crashes for Honolulu in 1990 showed that 8 of the 10 locations were on freeways. Because of the high volumes on the segments, inevitably a high number of crashes will occur even though the risk of crashes is much smaller than for other types of roads. Conversely, non-freeway highways and local roads in general will have much smaller crash totals because their traffic volumes are much lower.

Further Information

This section only provides a brief description some methods of crash data analysis used to identify hazardous sites. However, many publications are available for engineers and planners that describe the process. The following are some notable publications:

Manual of Transportation Engineering Studies, Institute of Transportation Engineers, Washington, D.C., 1994.

Highway Safety Engineering Studies Procedural Guide, USDOT, Washington, D.C., 1981.

Higle, J.L. and M.B. Hecht, A Comparison of Techniques for the Identification of Hazardous Locations, Transportation Research Record 1238, National Research Council, Washington, D.C., 1989.

Transportation Engineering: An Introduction. Khisty, C.J. and B.K. Lall, Prentice Hall, Upper Saddle River, New Jersey, 1990.

Crash Rates: Analyzing each location using a crash rate will take into account the traffic volume. The crash rate expresses the frequency of crashes at a location in the context of the exposure. For most crash analysis, the exposure will be some measure of the traffic volume at the location. Crash rates on highway segments are often expressed as the frequency of crashes per 100 million vehicle miles. Crash rates at intersections or other spots are often expressed as the frequency of crashes per million entering vehicles. Similar to crash frequency calculations, many different crash rates can be calculated including total crash rate, fatal crash rate, fatal and injury crash rate, and equivalent property damage crash rate.

Even ranking locations by crash rates can be problematic. A location on a low volume facility with only one crash could rank high because of the very low exposure. However, using limited funds to improve a location with only one crash may not be the most effective use of funds and may not prevent future crashes. Some agencies rank crashes by using a combination of frequency and crash rates.

Hazardous locations also can be identified using the classical statistical method, rate quality control method, and Empirical Bayes method, among others. These methods rank locations by applying statistical distributions.

Targeted Crash Types or Conditions

Another crash analysis method entails identifying certain crash types (such as run-off-the-road, heavy vehicle, or pedestrian crashes) or crash conditions (such as wet pavement and nighttime crashes) of interest. This method can be useful when funds are available for safety remediation in a targeted improvement type or when there is public support for reducing a certain crash type, such as a those involving pedestrians. To improve pedestrian safety, the analyst may identify locations (particular intersections, sections, or areas) where pedestrian crashes are occurring.

When analyzing targeted crash types or conditions, transportation planners may use specialized forms of exposure data. For example, for crash analysis of pedestrians at intersections, the crash rate may be calculated using the number of pedestrians crossing the intersection as exposure. For crash analysis of heavy vehicles on highway segments, the crash rate may be calculated based on truck VMT.

Over representation

Another variation on searching crash data for high crash locations is the identification of overrepresentation. An analyst can identify certain crash characteristics (nighttime, wet roadway, alcohol-involved) that are proportionally over represented at locations in a transportation network. This is a useful method for applying a targeted countermeasure. For example, if funds are available to install highway lighting, an analyst can identify locations where a large proportion of the crashes occur at night. The funds can be used to install lights where they would prevent the most crashes. In addition, this method may be useful in diagnosing crash causes. For example, an area that is experiencing a large proportion of wet roadway crashes may need improved pavement, an overlay, or milling.

Hot Spots Versus Hot Zones: The Problem of Spatial Autocorrelation

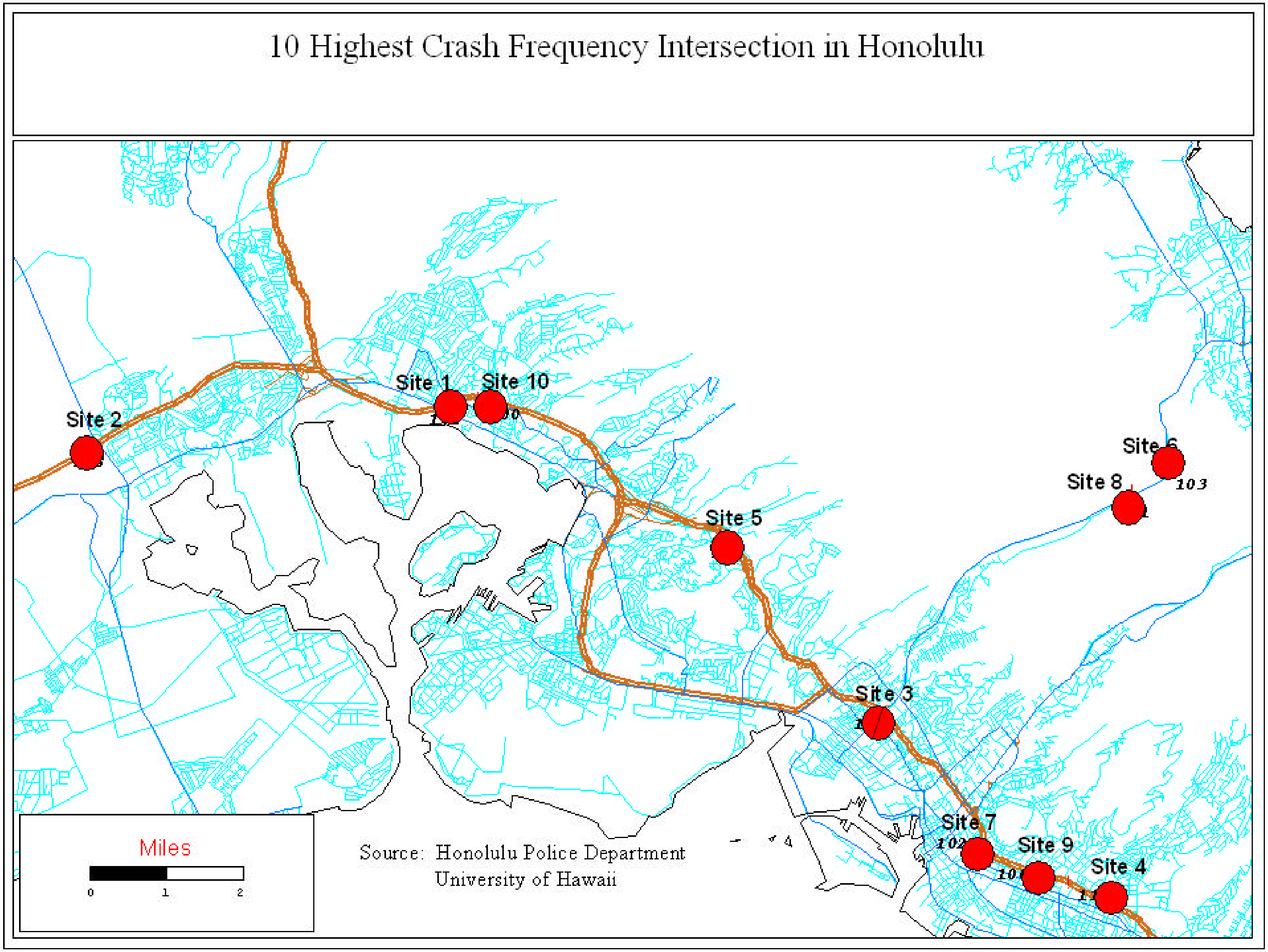
Problems with hot-spot analysis could occur when it is assumed that observed high crash locations are spatially independent. Often an isolated hot spot is more of a hot zone (a cluster of streets that have similar crash frequency).

For example, in 1990, approximately 19,000 crashes were reported on the island of Oahu (the City and County of Honolulu). Exhibit 4.1 identifies the 10 intersections with the most crashes. The crash frequency at these 10 locations varied from 100 to 191. The symbol size is not proportional to the number of crashes. While their crash frequency identifies these discrete locations high-incident hot spots, the map can be misleading. Inspecting the crash frequency in the vicinity of these locations revealed that there was also a high crash frequency on the roadways around these spots. Many of these high crash locations have crash frequencies that are not that much higher than the surrounding road segments.

This condition is statistically called spatial autocorrelation and indicates that geographic entities (in this case, intersections) located close to one another have similar crash levels. Spatial autocorrelation between the number of crashes (and presumably traffic volume) means that they are not really independent locations, but part of a larger complex. The similarities may be due to the similarities in traffic volume (that is, adjacent street segments carry the same traffic) as well as spillover of crashes from adjacent streets. (8, 9)

Shifting the analysis to highway segments does not solve the problem. The same problem of spatial autocorrelation would be true for highway segments with many crashes (hot links). Adjacent segments are liable to have similar characteristics, such as the numbers of crashes, traffic volume, number of lanes, bordering land uses, and even similar types of drivers (8). Without considering the crash experience of adjacent segments, any identification of a high accident segment is liable to be only part of the crash problem.

Exhibit 4.1


10 Highest Crash Frequency Intersection in Honolulu
Site 1
Site 10
Site 2
Site 6
Site 8
103
Site 5
Site 3
Site 7
Site 9
Site 4
Miles
0
1
2
Source: Honolulu Police Department
University of Hawaii

Another analysis plotted clusters of crashes in central Honolulu. Most of the clusters encompass several street segments; a couple fall along one single street, but others capture parallel streets. In other words, instead of isolated hot spots, the clusters show a collection of streets where there is a high concentration of crashes (hot zones).

GIS as a Tool for Crash Data Analysis

Many of the newer safety information systems use GIS software. GIS is a computerized mapping system that allows multiple data sources to be linked using a common coordinate system and to be displayed graphically. Information can be layered in GIS to produce detailed descriptions of conditions and to conduct analysis of relationships among variables. Most commercial GIS applications have associated database and analytical functions that can be linked to the graphic display of data.

Advantages of using a GIS-Based Crash System

A GIS-based crash system has many advantages over a traditional tabular database. The predominant advantage of a GIS-based system is the ability to visually represent crashes; that is, crashes can be represented geographically on a map, allowing the analyst to visually inspect roadway and roadway junctions. The geographic relationship between crashes can be seen. Other advantages of GIS include the ability to efficiently link crash data with other types of information and to easily manipulate spatially referenced information.

In GIS, crash data is maintained separately from roadway data (and from other data layers). The data is linked through a relational database system using the geographical coordinate system as the means of linking different variables. All types of information included in the database have their geographical coordinates encoded as a field and can be displayed as objects. Thus, a highway segment can be represented as a line in the database and a crash can be represented as a point. In turn, different types of highway segments can be displayed as separate databases (called layers), and different types of crashes can also be displayed as separate layers. For example, to display crashes on a highway, the crashes are drawn on the screen separately from the highway segments. By controlling the drawing order and color, the analyst can show a map of the crashes on the highways.

In GIS, high crash locations can be identified through coordinate analysis. Crashes are referenced in GIS by their X/Y coordinates, not by the highway on which they occurred. (Since crashes are usually references by the segment or intersection where they occurred, the crash data must usually be translated to get it into this form when it is input into the GIS program.) Using the coordinate system, the location can be defined narrowly (for example, exact X/Y coordinates) or more broadly (for example, all crashes within 100 yards of a particular X/Y coordinate).

Relationships between objects are developed in GIS by conducting spatial adjacency operations. For example, to link a crash to a particular highway segment, the analyst selects the highway segments and then selects crashes that have coordinates that fall along the highway. The GIS program will make the linkage by examining all crashes having coordinates that coincide with selected highway segments or that fall within a certain distance of the coordinates of the highway segments. Those crashes that fit the criteria are kept while those crashes that do not fit the condition are ignored. Because GIS is a visual representation of the database, the crashes are automatically identified on a map by the operation. (Example GIS output is provided in the previous section.)

Identifying particular types of roadway elements or subtypes of crashes is simplified with GIS. The roadway elements of interest are selected for display using GIS. The crashes occurring on roadways with those elements are also identified and displayed. For example, to identify the number of crashes occurring on two-lane rural highways, the analyst (1) selects all two-lane rural highways from the roadway inventory database and (2) uses the selected roadway segments within GIS to select crashes that occurred on these segments. The GIS operation can identify all crashes that occurred on roadways with those elements or within a specified distance of the highway segment.

Examples of Crash Analysis Operations Using GIS

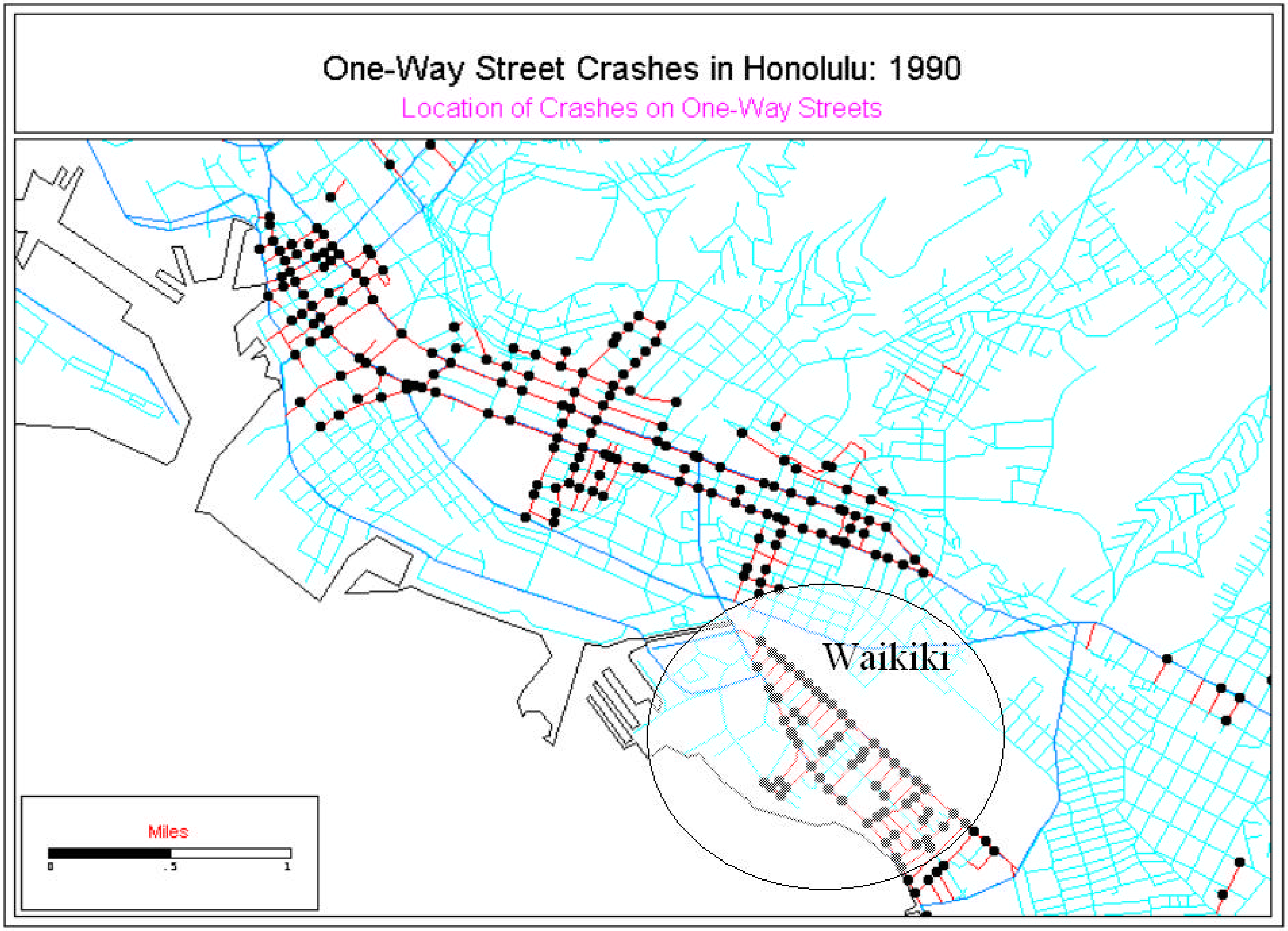
There are many examples of GIS use in crash data analysis. A few examples that illustrate GIS capabilities are discussed in the following paragraphs.

Analysis by Type of Roadway

Exhibit 4.2 displays the location of all crashes occurring on one-way streets in an area of Honolulu. The one-way streets are shown as red lines on the map, and the crashes occurring on the one-way streets are shown as black dots. The analysis revealed that, as expected, the crashes were concentrated in the most built-up part of Honolulu. In addition, the crashes occurred on streets that traverse commercial areas. While fewer crashes occur on some one-way streets in Honolulu (particularly downtown), other one-way streets have a high concentration of crashes (for example, in Waikiki at the bottom right). In short, a GIS-based crash system can facilitate identification of subsets of the data and can quickly display the data.

Although similar analyses could also be performed with a traditional crash database system, GIS allows the user to conduct this analysis quickly and with less effort. The analysis in the Honolulu example took approximately 15 minutes to prepare.

Exhibit 4.2


One-Way Street Crashes in Honolulu: 1990
Location of Crashes on One-Way Streets
Waikiki
Miles
0
.5
1

Analysis by Crash Characteristics

Using GIS, an analyst can identify certain characteristics of crashes (such as nighttime, wet roadway, and alcohol-involved crashes) that are proportionally overrepresented at locations on a roadway network. For example, Exhibit 4.3 displays locations where crashes occurred on wet days in Houston (red points). Of these crashes, the locations where proportionately more crashes occurred on wet days than on dry days are shown as green ellipses. This type of analysis can help to identify a possible deficiency in the roadway environment. For this example, a detailed review may be needed at those locations where proportionately more crashes occurred on wet pavement. The roadway at those locations may need drainage improvements or a friction overlay added to the pavement.

Density Analysis

Even more complicated spatial operations can be conducted with a GIS-based crash information system. Surface maps can be calculated that allow crash densities to be seen over an entire highway segment. For example, Exhibit 4.4 displays the distribution of crashes along Farm-to-Market Road (FM 1093) in Houston. The crashes are displayed as red points. FM 1093 is a major state-managed arterial running from the west loop of Interstate 610 to Fort Bend County. The heavy concentration of crashes in the eastern half of this arterial is mostly related to the much heavier volumes in the central part of Houston (to the right of the map). A density surface was created that overlays a fine grid on the arterial and calculates the density of crashes in each cell. The density of crashes is then related to a density surface of VMT. The result is crashes are reported in the context of their exposure. Exhibit 4.5 displays the relative density of crashes to VMT. As seen, the highest rate of crashes (crashes relative to VMT) is at the far eastern part of the arterial. Not only is the volume of crashes higher, but the crash rate is much higher as well.

Using GIS for Crash Data Analysis: An MPO's Experience

The Cheyenne Area Transportation Planning Process (ChATPP) is the MPO for the Cheyenne, Wyoming, metropolitan area. ChATPP was considering applying access management standards to its main arterials in the interest of increasing the safety of the transportation system. To determine if access management standards were needed, ChATPP conducted an in-depth analysis of crashes along arterial roadways to determine if access control could prevent the crashes. ChATPP employed GIS in the analysis. The State of Wyoming maintains a database of all crash reports statewide. ChATPP requested the subset of crashes occurring within the MPO area and requested only data on variables of interest including number of vehicles involved, number of injuries, number of fatalities, number of alcohol-involved crashes, violations issued, type and severity of injuries, type of accident, activity prior to accident, human contributing factors, and safety restraints. The data was contained in a common database program that was easily imported in GIS. The GIS platform allowed ChATPP to visually display the crashes and analyze the potential usefulness of access management. Maps and charts were easily created for use in the annual report production. ChATPP reports "no complications in the use of the data and the conversion to the GIS system." The GIS is shared with the City of Cheyenne and Laramie County. ChATPP plans to incorporate traffic volume information into the system in the near future so that accidents rates, not just frequencies, can be used in the analysis (10).

Exhibit 4.3

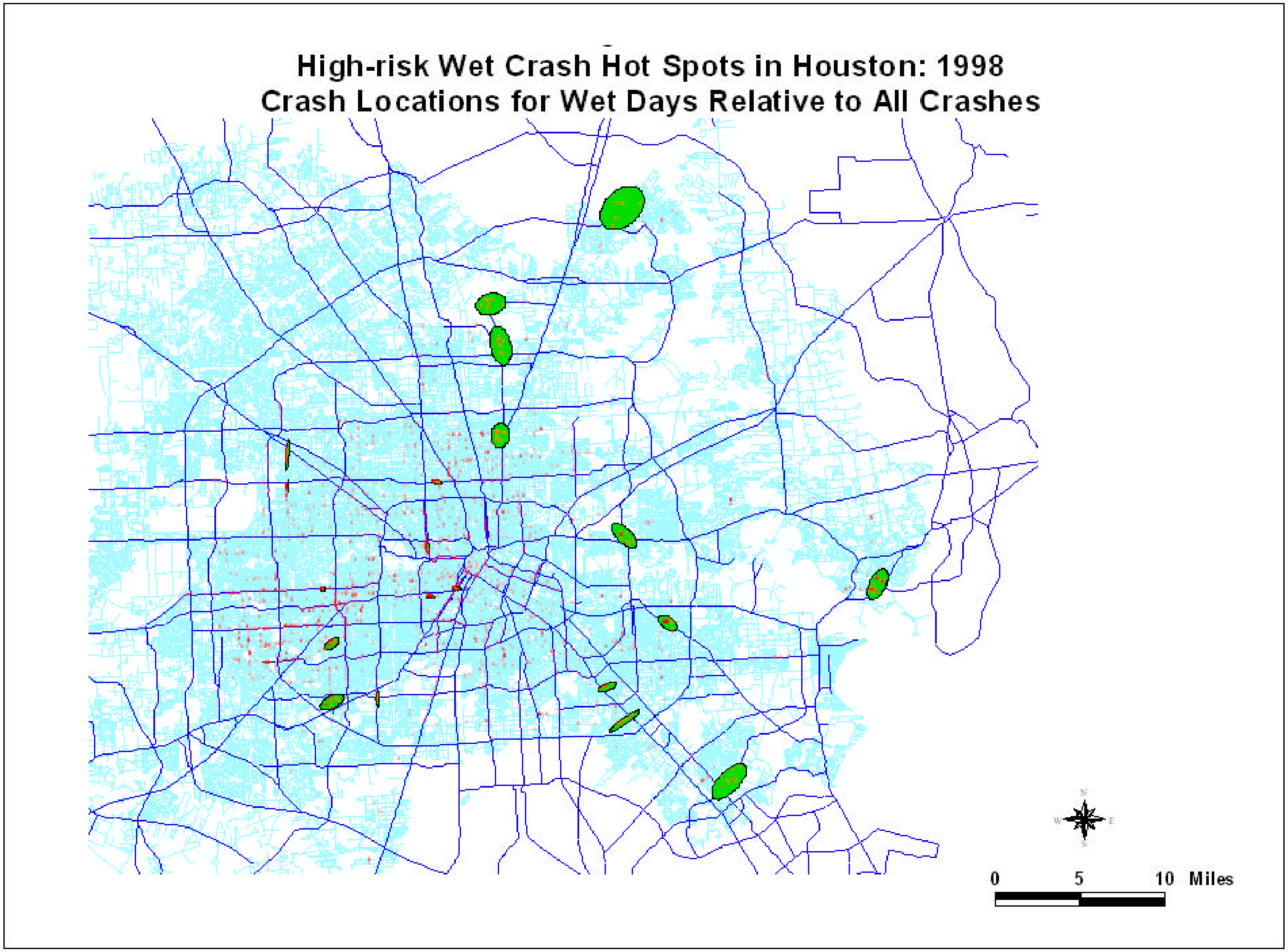

High-risk Wet Crash Hot Spots in Houston: 1998
Crash Locations for Wet Days Relative to All Crashes
0
5
10 Miles

Exhibit 4.4

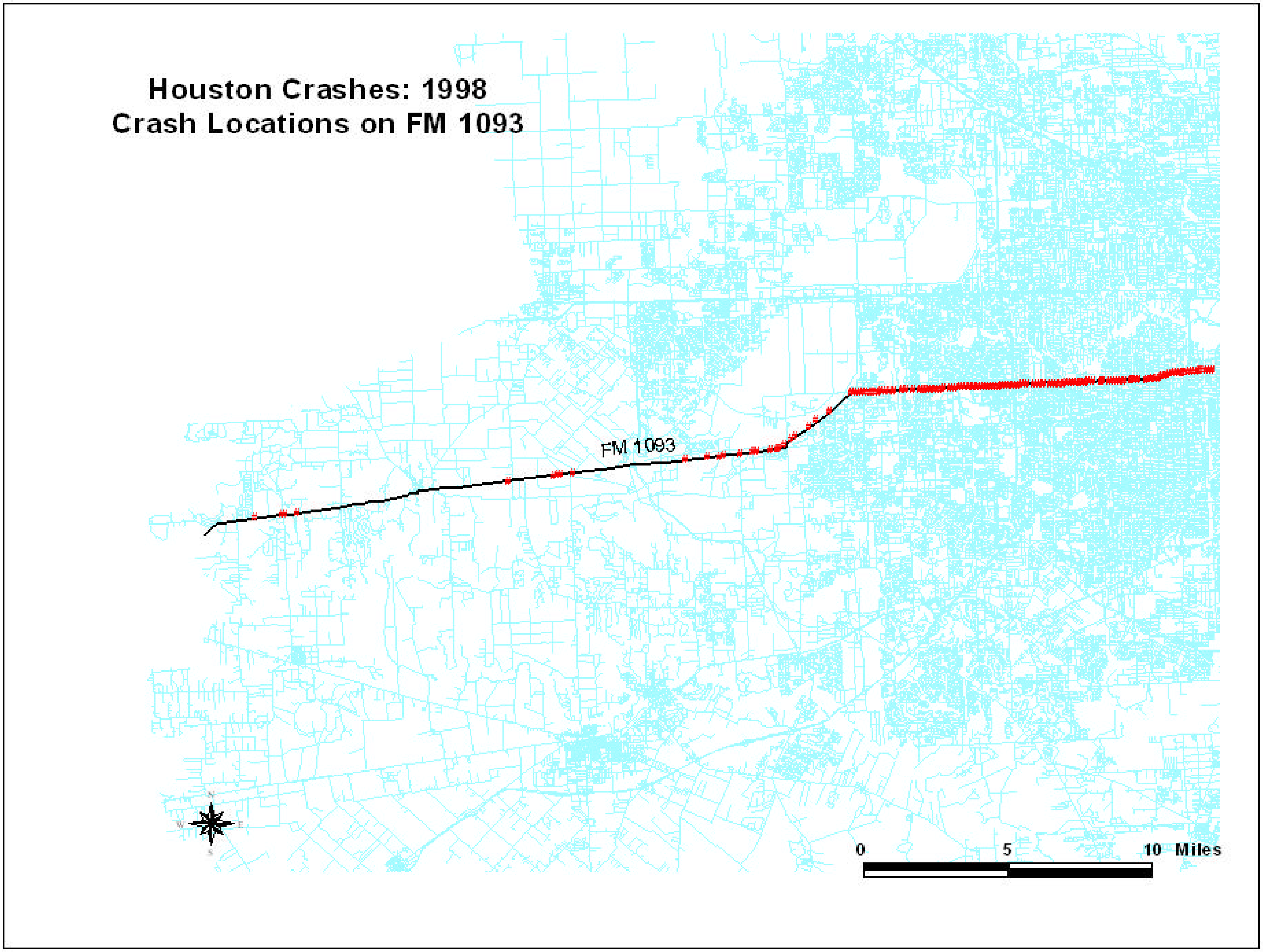
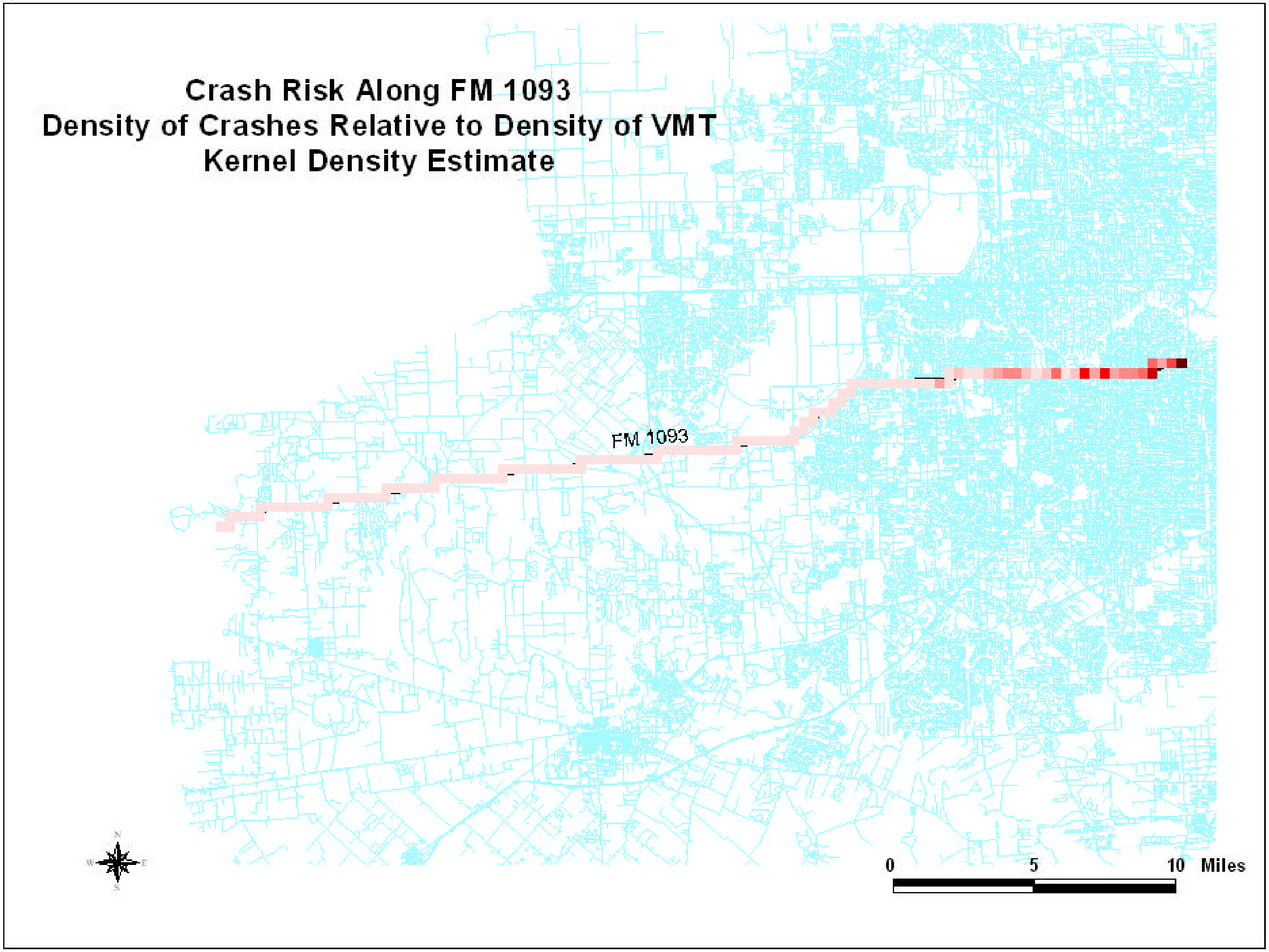

Houston Crashes: 1998
Crash Locations on FM 1093
FM 1093
0
5
10 Miles

Exhibit 4.5



Crash Risk Along FM 1093
Density of Crashes Relative to Density of VMT
Kernel Density Estimate
FM 1093
0
5
10
Miles

These examples illustrate the possibilities for crash analysis using a GIS-based system. Many other examples can be shown that link crashes to numerous factors that correlate with the crashes, such as crashes in commercial areas, temporal variations in the crash risk along particular highways, or crashes around particular venues such as stadiums. The ability to link diverse variables is one of the strengths of GIS. Analysts can use this powerful tool to easily identify factors involved in crashes as well as subsets of crashes and to link crash information to traffic volume, roadway inventory, land use, and many other characteristics. The ability to display the results of the analysis immediately make this tool particularly appealing because patterns can quickly be detected and unusual concentrations of crashes identified.

Software for Safety Analysis

GIS Safety Analysis Tools

FWHA developed a set of programs to perform spot/intersection analysis, cluster analysis, strip analysis, sliding-scale evaluations, and corridor analysis in GIS. Packaged together as GIS Safety Analysis Tools, the software is available free of charge from FHWA. One of the goals of distributing the software is to encourage safety engineers and others in state and municipal DOTs and MPOs to explore the capabilities of GIS-based highway safety analysis tools. The software also includes pedestrian and bicycle analysis tools to select safe routes to schools, assess the bicycle compatibility of roadways, and define high pedestrian crash zones (11).

GIS Software

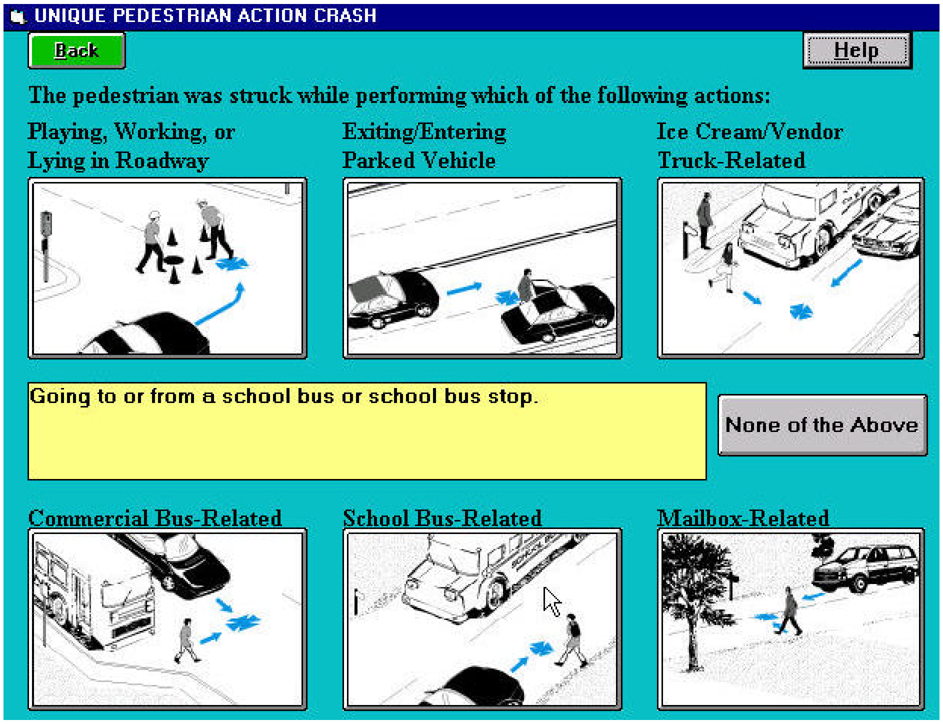
Many GIS software programs are commercially available. The appropriate software depends on the size and preference of the jurisdiction. Travel forecasting software used by transportation planners is often integrated with GIS programs.

PBCAT

PBCAT is the Pedestrian and Bicycle Crash Analysis Tool (see Exhibit 4.6). Developed by the Highway Safety Research Center for the FHWA, PBCAT software is intended to assist state and local planners and engineers in analyzing pedestrian and bicycle crashes. The software includes a database that analyzes pedestrian and bicycle crashes and helps the user to identify problems and potential countermeasures. The software also includes a user’s manual with examples.

Exhibit 4-6

Example of PBCAT Software Analysis Input Screen



PBCAT has the following capabilities:

- Quickly determines the crash type through a series of on-screen questions about the crash, crash location, and maneuvers of the parties involved.

> The PBCAT software and User's Manual are available free of charge from the FHWA. The software can be ordered online at the Pedestrian and Bicycle Information Center web site at:
>
> www.walkinginfo.org/pbcat

- Customizes the database in terms of units of measurement, variables, and location referencing as well as imports/exports data from and to other databases.
- Produces a series of tables and graphs defining various crash types and other factors associated with the crashes such as age, gender, and light conditions.
- Links recommended countermeasures to specific bicycle and pedestrian crash types and related resource and reference information.
- Provides user-friendly, online instructions and help features, including examples, along with a user's manual.

Highway Safety and Monitoring Software

Highway Safety and Monitoring Software (HISAM) is computer software developed under an FHWA research contract to assist local jurisdictions in developing, monitoring, and evaluating their highway safety programs. The software aids in database development and accident analysis. It also allows for integration between data files. Users can identify high accident locations based on accident frequencies, accident rates, or EPDO indexes and rates. The software provides the framework for a highway safety system for jurisdictions under 500,000 people (12).

> The HISAM software and other applicable software can be ordered through the McTrans, Center for Microcomputers in Transportation at the University of Florida. McTrans is a software distribution center originally established by FHWA and now independently operated. McTrans is available on the Internet at:
>
> http://mctrans.ce.ufl.edu/

Other Crash Analysis Software

Many commercial software programs are available that can assist traffic engineers, transportation planners, and traffic safety specialists in identifying high crash locations and crash patterns. These programs can rank high accident locations and analyze the locations for patterns that help in developing solutions. Some of the programs can also be integrated with GIS programs.

> Applicable software can be ordered through the FHWA-designated software distribution center, PC-TRANS. PCTRANS is available on the Internet at:
>
> http://www.kutc.ku.edu/pctrans/

CHSIM: Tools on the Horizon

The Comprehensive Highway Safety Improvement Model (CHSIM) is being developed for FHWA. CHSIM, which will consist of a set of software tools, will assist in identifying safety improvement needs and in developing a systemwide program of site-specific projects to maximize highway safety improvement. CHSIM will have five specific computerized analytical tools that will accomplish the following highway safety management steps:

- Network screening to identify sites with promise
- Diagnosis of safety problems at specific sites
- Selection of appropriate countermeasures
- Economic appraisal of candidate improvements
- Priority rankings for candidate improvements

The development of CHSIM began in April 2001. Interim tools are scheduled to be available in 2004 and final tools in 2006.

Useful National Databases

Nationally, many transportation agencies conduct analyses and produce reports on transportation safety that could be useful to transportation planners. In addition, national crash databases are available that can be used by planners either to acquire information about their own areas or state or to make comparisons.

National Center for Statistics and Analysis Databases

NHTSA's National Center for Statistics and Analysis (NCSA) provides both data and analysis on the nature, causes, and injury outcomes of crashes. NCSA data and reports are nationally representative. Two of NCSA's databases, the Fatality Analysis Reporting System (FARS) and the General Estimates System (GES), are useful to transportation planners.

Fatality Analysis Reporting System

FARS contains data on a census of fatal traffic crashes within the 50 states, the District of Columbia, and Puerto Rico. It includes all crashes involving motor vehicles traveling on a roadway customarily open to the public that result in the death of a person within 30 days of the crash, either an occupant of a vehicle or a non-occupant, such as a pedestrian.

NHTSA has a cooperative agreement with an agency in each state government to provide information in a standard format on fatal crashes. Data is collected on more than 100 different data elements. The system has been operational since 1975 and has collected information on more than 989,451 motor vehicle fatalities. Much of this data is directly available on the Internet where NHTSA maintains a direct query database (13), at the following URL: http://www-fars.nhtsa.dot.gov/.

General Estimates System

GES is calculated from a nationally representative sample (called the National Automotive Sampling System [NASS]) of police-reported motor vehicle crashes of all types, from minor to fatal (14). NASS/GES, which began operation in 1988, was created to identify traffic safety problem areas, provide a basis for regulatory and consumer initiatives, and form the basis for cost and benefit analyses of traffic safety initiatives. The information is used to estimate how many different kinds of motor vehicle crashes take place and what happens when they occur.

To be eligible for the GES sample, a crash must be recorded on a police crash report; involve at least one motor vehicle traveling on a traffic way; and result in property damage, injury, or death. These accident reports are chosen from 60 areas that reflect the geography, roadway mileage, population, and traffic density of the United States. GES data collectors make weekly visits to approximately 400 police jurisdictions in the 60 areas across the United States, where they randomly sample about 50,000 reports each year.

Highway Safety Information System

FHWA developed and maintains the Highway Safety Information System (HSIS). HSIS is a roadway-based system used for the study of highway safety. It provides data on accident, roadway, and traffic variables from a group of select states and can be used to associate the risk of crashes with roadway and traffic variables. The data is already being collected by the states for the management of their highway systems. Currently, HSIS contains data from California, Illinois, Maine, Michigan, Minnesota, North Carolina, Utah, and Washington. The states send the data to the HSIS laboratory where the data is subjected to quality-control procedures.

HSIS is primarily used in support of the FHWA safety research program and as input to program and policy decisions, although it is also available to analysts conducting research for NCHRP, university researchers, and others involved in the study of highway safety. Researchers define specific requests for the data and extracts of files are developed by HSIS staff. Full state data files are not available from HSIS because of agreements with the states. Transportation planners could request extracts from the files if they are studying specific safety problems.

Federal Motor Carrier Safety Administration

The U.S. DOT provides motor carrier safety information online through the Analysis and Information Online web site. The web site provides access to three online databases: SafeStat, Crash Profiles, and Program Measures. It also provides useful analysis reports on motor carrier safety.

> The FMCSA Analysis and Information Online website can be accessed at:
>
> http://ai.volpe.dot.gov/mcspa.asp

The most applicable of the online databases to transportation planners is Crash Profiles. Crash Profiles summarizes crash statistics for large trucks and buses involved in fatal and non-fatal crashes. The database merges data on fatal crashes from the FARS database and information on non-fatal crashes from the Motor Carrier Management Information System (MCMIS) crash file. Each state is represented in the database with a profile that provides information on the vehicle, driver, environment, carrier, location and other circumstances of heavy vehicle crashes. The database can be used for an individual state or combined for the nation. Transportation planners can use the database to identify heavy vehicle safety problems in specific geographical areas. National statistics can also be used for comparison. Direct file extracts from the MCMIS crash file can also be requested from FMCSA.

National Transit Database

The Federal Transit Administration collects annual information from urbanized area recipients of federal funds in a wide number of areas, including safety and security. The 2002 report cycle introduces a new and heightened safety and security database, requiring agencies to report safety information on a monthly or quarterly basis,

> **Further Information**
>
> The National Transit Database is available through the FTA website
>
> http://www.fta.dot.gov

depending on their size. The new reports collect data on an incident level (over a certain threshold) requiring agencies to report all major events (fatalities and major injuries) as well as a wide variety of security related information. The new database will assist FTA and industry users in identifying safety and security trends, and finding solutions to recurrent issues.

Useful Publications

The following publications provide information on or examples of safety analysis.

SEMCOG Traffic Safety Manual

The MPO for southeast Michigan, SEMCOG, has developed a manual for planners, engineers, and other agencies involved with traffic safety (for example, law enforcement) that describes a comprehensive approach to traffic safety analysis. It includes information on collecting crash data, maintaining a crash database, identifying high crash locations, choosing appropriate solutions, and performing a benefit/cost analysis. Although the manual was developed for distribution to SEMCOG's planning partners, it should be a valuable resource for other transportation planners (15).

> **Further Information**
>
> Information on obtaining a copy of the SEMCOG manual is available through the following website:
>
> http://www.semcog.org

Implementation of GIS-Based Highway Safety Analyses: Bridging the Gap

FHWA has published a report that discusses the integration of GIS in safety analysis. The report is an educational document for safety engineers and GIS professionals that provides information on the following (16):

- The benefits that GIS technology offers in general analyses, including display, spatial, and network evaluations, as well as cell-based modeling. The applications from the already-developed GIS Safety Analysis Tools are discussed as examples.
- A description of how historical safety data (crashes and roadway inventory) is acquired, why such data is collected as linear referenced data, and how linear referenced data is different from spatial data. Definitions of common route systems are provided along with illustrations to show how each is different.
- General background information on Linear Location Referencing Systems (LLRS or LRS), which includes an explanation of routes and their measures, common types of LRS, how linear referencing methods (LRMs) are used to locate crashes and roadway inventory, and how GIS uses LRS to locate linear features.

> **Further Information**
>
> The report would be a useful resource to a state or metropolitan planning agency interested in using GIS as a tool to assist in highway safety analyses. The report is available from FHWA or on the Internet at:
>
> http://www.tfhrc.gov/safety/pubs/1039.pdf

- A general understanding of how GIS manages network data and how in GIS route data is different from roadway network data. The impact of resolution, scale, and route calibration is discussed as they relate to data accuracy.
- A detailed discussion of the process of integrating GIS and safety data, including the need to plan for the integration and development of the GIS network and route system, and the processing of LRS data within GIS.

NCHRP 295: Statistical Methods in Highway Safety Analysis

A synthesis of statistical methods used in highway safety analysis was conducted for NCHRP. The report summarizes the current practice and research on statistical methods in highway safety analysis, including statistical methods used for the identification of hazardous locations and the development and evaluation of countermeasures. The synthesis could be a useful resource to transportation planners and other transportation professionals interested in highway safety analysis (17).

> **Further Information**
>
> The synthesis report is available from the Transportation Research Board or on the Internet at:
>
> http://www.nationalacademies.org/trb

Institutional Issues

Reliability of Crash Data

This chapter highlights some of the known problems with police-reported crash data—problems that can reduce the reliability of safety analyses. Innovations in crash data reporting, location identification, and database management are improving the quality of crash data. As these innovations and improved technologies become more widely used, crash data quality will increase.

Combining Data from Multiple Sources

Many MPOs span more than one local or state jurisdiction, and they must combine data from multiple agencies to conduct crash analysis of the entire metropolitan area. Because the crash reporting process is not nationally uniform, the data may not be easily merged; it may be in different formats or contain different elements. In addition, the data needed for analysis may not cover the same timeframe because the timeliness of available data varies by jurisdiction. In these situations, it may be advantageous to conduct a separate analysis for each jurisdiction in the metropolitan area.

Liability

Many state DOTs are concerned about the tort liability implications of crash data and, therefore, may be reluctant to share crash data with their planning partners. However, many states such as Connecticut and North Carolina look past this concern. These states expect that as more professionals have access to crash data, more safety remediation measures can be taken.

Many state DOTs have developed operational procedures, referred to as risk management programs, to decrease their tort liability. Conducting routine identification and remediation of hazardous highway safety locations is a component of a risk management program (18).

Personnel Resources

Software such as GIS programs can enhance capabilities and decrease the time needed to conduct safety analysis. Most traditional databases can be downloaded to commercially available database or spreadsheet software. However, staff must be trained (1) in using the programs to their full capability and (2) in basic safety analysis methodologies. Transportation planning personnel must balance the time needed to train for and conduct the analysis with their other responsibilities.

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Chapter 5
Partners in Safety Planning

In this chapter, the discussion of additional safety efforts and programs relating to this guidebook does not cover all national programs, but summarizes many of the most relevant ones. Substantial coordination occurs between many of the agencies on federal, state, and local levels, and many projects are a joint effort between one or more of these agencies, as discussed in the Safety Partnerships section.

Federal Agencies

Federal Highway Administration

The goal of the Federal Highway Administration (FHWA) is to create the best transportation system in the world through proactive leadership, innovation, and excellence in service. FHWA also provides expertise, resources, and information to continually improve the quality of our nation's highway system and its intermodal connections. FHWA is a part of U.S. DOT and is headquartered in Washington, D.C., with field offices across the United States. FHWA conducts and manages a comprehensive research, development, and technology program and provides technical expertise to its partners and customers in various areas, one of which is safety.

FHWA is organized by a matrix of core business units (CBUs) and service business units (SBUs), including the Safety CBU and the Planning and Environment CBU. The Safety CBU was created to provide national leadership and advocacy in the development and implementation of strategies and programs to reduce the number and severity of highway crashes on the nation's highways, streets, facilities, and intermodal connections.

The Safety CBU acts as a voice and liaison for highway safety within FHWA, U.S. DOT, and external organizations. It coordinates with other offices in FHWA to integrate safety improvements, goals, and activities in all FHWA business functions including planning, environment, design, engineering, management systems, and operations. It also coordinates FHWA safety strategies and initiatives with other U.S. DOT agencies[*] and the Office of Secretary. The Safety CBU works closely with FHWA partners, such as the states, American Association of State Highway and Transportation Officials (AASHTO), and National Association of Governors' Highway Safety Representatives (NAGHSR), the Local Technical Assistance Program, and with other external safety advocacy groups. The key functions of the Safety CBU include:

- Advocacy
- Safety information and analysis

[*] NHTSA, FTA, and FMCSA

- Strategic planning and quality
- Legislation, regulations, policy, and guidance
- Safety programs
- Safety council
- Technology delivery
- Advance product development, testing, and demonstration
- Monitoring and evaluation
- Outreach and consultation
- Communications and marketing assistance

The Planning and Environment CBU provides policy and direction in three major areas including statewide and metropolitan transportation planning, human and natural environment, and real estate services. The planning offices within this CBU support MPOs in meeting planning requirements and in collaborating effectively with their partners to maximize the success of the transportation planning process.

FHWA is also the administering agency for the Surface Transportation Program (STP), Safety Set Aside. STP provides flexible funding that may be used by states and localities for projects on any federal-aid highway, including NHS, bridge projects on any public road, transit capital projects, and intracity and intercity bus terminals and facilities. STP retains 10 percent set aside for safety improvement projects including railway/highway crossings and the Hazard Elimination Program. STP safety set-aside eligibilities are as follows:

- Hazard Elimination Program:
- – Opened to interstates and public transportation surface facilities, and any public or pedestrian pathway or trail.
- – Explicitly mentions traffic calming as an eligible activity.
- State Programs (at its own discretion):
- – Conduct surveys by identifying hazards to motorists, bicyclists, pedestrians, and users of highway facilities.
- – Develop and implement projects and programs to address the hazards.

Reference: www.fhwa.dot.gov

National Highway Traffic Safety Administration

The National Highway Traffic Safety Administration (NHTSA), under the US DOT, was established by the Highway Safety Act of 1970, to carry out safety programs under the National Traffic and Motor Vehicle Safety Act of 1966 and the Highway Safety Act of 1966. NHTSA's primary responsibility is to reduce deaths, injuries and economic losses resulting from motor vehicle crashes. This is accomplished by setting and enforcing safety performance standards for motor vehicles and motor vehicle equipment, and through grants to state and local governments to enable them to conduct effective local highway safety programs.

NHTSA also investigates safety defects in motor vehicles, sets and enforces fuel economy standards, helps states and local communities reduce the threat of drunk drivers, promotes the use of safety belts, child safety seats and air bags, investigates odometer fraud, establishes and enforces vehicle anti-theft regulations and provides consumer information on motor vehicle safety topics. Additionally, NHTSA conducts research on driver behavior and traffic safety to develop the most efficient and effective means of bringing about safety improvements as well as collecting and maintaining valuable information about general public safety interests, such as air bags, child passenger safety, crash tests, recalls, school bus safety, and disability information.

NHTSA is the administering agency for highway safety grant programs (totaling approximately $2.3 billion from FY 1998-2003) and two transfer programs, authorized by the Transportation Equity Act for the 21st Century (TEA-21). These programs are discussed below.

State and Community Grants

The Section 402 formula grant program provides funds to all States, territories, the District of Columbia, Puerto Rico, and the Indian Nations for performance-based highway safety programs. The grants support planning to identify highway safety problems, set goals and performance measures for highway safety improvements, provide start-up money for new programs, give new direction and support to existing safety programs, and fund analyses to determine progress in improving safety. At least 40 percent of these funds are to be used by States and communities to address local traffic safety problems.

Seat Belt and Occupant Protection Programs

Seat belt incentive grants. Section 157 incentive grants are designed to encourage States to increase seat belt use rates. A State may qualify for a grant (1) if its seat belt use rate exceeds the national average for the previous two calendar years; or (2) if the State does not meet the first criterion, if its seat belt use rate for the previous calendar year exceeds its highest seat belt use rate since 1996. The amount of funds States receive will be based on calculations by the Secretary of the annual savings to the Federal Government in medical costs, which result from the State's improvement its seat belt use rate. A State may use these awards for highway safety and highway construction programs.

Seat belt use innovative grants. Section 157 funds not allocated to incentive grants in a fiscal year are allocated to the States to carry out innovative projects to promote increased seat belt use rates. NHTSA must establish criteria for the selection of State plans to receive allocations, ensuring, to the maximum extent practicable, demographic and geographic diversity and a diversity of seat belt use rates among the States selected for allocations. Subject to the availability of funds, TEA-21 provides that the minimum grant amount for each State plan is $100,000.

Occupant protection incentive grants. The Section 405 occupant protection incentive grant program encourages States to implement specific laws and programs that will help increase seat belt and child safety seat use. Under this program, grants are awarded to States that adopt or demonstrate specific programs, such as primary safety belt use laws and special traffic enforcement programs. Grant funds may be used only to implement and enforce occupant protection programs.

Child passenger protection education grants. The Section 2003(b) grant program provides funding to States to implement child passenger protection programs designed to prevent deaths and injuries to children, educate the public concerning the proper installation of child restraints, and train child passenger safety personnel concerning child restraint use.

Alcohol Programs

Incentives to prevent operation of motor vehicles by intoxicated persons. The Section 163 program provides incentive grants to States that have enacted and are enforcing a law providing that any person with a blood alcohol concentration of 0.08 or greater while operating a motor vehicle in the State shall be deemed to have committed a *per se* offense of driving while intoxicated. These Section 163 grants may be used for highway safety and highway construction programs.

Alcohol-impaired driving countermeasures. The Section 410 alcohol-impaired driving countermeasures incentive grant program rewards States that adopt and demonstrate specific programs, such as prompt suspension of the driver's license of alcohol-impaired drivers or graduated licensing systems for new drivers (Programmatic Basic Grant); or meet performance criteria showing reductions in fatalities among impaired drivers (Performance Basic Grant). States receiving basic grants may qualify for up to six supplemental grants. Grant funds may be used only to implement and enforce impaired driving programs.

Open containers and repeat offenders. The Section 154 and 164 transfer programs provide penalties for States that fail to enact laws that prohibits open alcoholic beverage containers in the passenger area of a motor vehicle and that establish minimum penalties for repeat drunk-driving offenders. Failure to enact each of the required laws results in the transfer of a portion of the State's Federal highway construction funds to its highway safety program beginning in October 2000. The funds transferred may be used for alcohol-impaired driving countermeasures or for hazard elimination programs.

State Highway Safety Data Improvement Incentive Grants

The Section 411 State highway safety data improvement incentive grant program encourages States to take effective actions to improve the timeliness, accuracy, completeness, uniformity, and accessibility of their highway safety data. Section 411 grant funds may be used only to implement data improvement programs.

NHTSA Training Programs

NHTSA provides intensive training programs through the Transportation Safety Institute in order to enable highway safety professionals to maximize the impact of their efforts to reduce motor vehicle crashes and the results of these crashes. NHTSA's training courses enable Federal, state, and local highway safety professionals to perform at state-of-the-art levels in the enforcement of drunk driving laws; the design and management of highway safety programs; the delivery of emergency medical services; encouraging the use of safety belts, child safety seats, motorcycle and bicycle helmets and other safety systems; and to assist in training of other highway safety professionals to these levels of capability.

The purpose of NHTSA's training programs is to: transfer important knowledge, skills, and expertise to police, prosecutors, judges, EMS professionals, and others; provide highway safety professionals with essential information and tools; promote the enforcement of occupant protection, impaired driving, and other traffic safety laws; facilitate communication and cooperation among diverse interests; support community efforts to make our streets and highways safer and; improve the quality and financial integrity of highway safety programs and projects.

Reference: www.nhtsa.dot.gov

Federal Motor Carrier Safety Administration

The Federal Motor Carrier Safety Administration (FMCSA), formerly a part of FHWA, has a primary mission to prevent commercial motor-vehicle-related fatalities and injuries. FMCSA activities contribute to improving highway safety through strong enforcement of motor carrier safety regulations, targeting high-risk carriers and commercial motor vehicle drivers; improving safety information systems and commercial motor vehicle technologies; strengthening commercial motor vehicle equipment and operating standards; and increasing safety awareness. To accomplish these activities, FMCSA works with other federal agencies, state and local enforcement agencies, the motor carrier industry, labor safety interest groups, and others.

FMCSA manages several relevant programs. The first is the Motor Carrier Safety Assistance Program, a federal grant program that provides states with financial assistance for driver and vehicle roadside inspections and other commercial motor vehicle safety programs. It promotes detection and correction of commercial motor vehicle safety defects, commercial motor vehicle driver deficiencies, and unsafe motor carrier practices before they become contributing factors to crashes and hazardous material incidents. The program also promotes the adoption and uniform enforcement by the states of safety rules, regulations, and standards compatible with the federal Motor Carrier Safety Regulations and Hazardous Materials Regulations.

Another key section of FMCSA is the Enforcement Program. The Administration's compliance reviews of motor carriers and enforcement activities and the states' roadside inspection activities involving vehicles and drivers are the principal means of ensuring that the federal Motor Carrier Safety Regulations and Hazardous Materials Regulations are enforced. Compliance and enforcement efforts are enhanced through the Performance and Registration Information Systems Management (PRISM) program, a federal and state partnership to improve safety performance or remove high-risk carriers from the nation's highways. The PRISM program ties state motor carrier vehicle registration to carrier safety performance. Habitually unsafe carriers can be denied the privilege of registering their vehicles.

In addition, FMCSA develops, issues, and evaluates standards for testing and licensing commercial motor vehicle drivers. These standards require states to issue commercial driver's licenses only after drivers pass knowledge and skill tests that pertain to the type of vehicle operated. States are audited every 3 years to monitor compliance with federal standards; noncompliance could result in loss of federal highway construction and/or safety grant funding.

FMCSA collects and disseminates safety data concerning motor carriers. Federal safety investigators and state partners collect carrier data from roadside inspections, crashes, compliance reviews, and enforcement activities. An algorithm assesses all this information and separates carriers by their safety performance. FMCSA focuses its enforcement resources on those carriers that pose the greatest safety risk. This information provides a national perspective on carrier performance and assists in determining FMCSA and state enforcement activities and priorities. Combined with information from other sources (including NHTSA), the data is extensively analyzed to determine trends in performance by carrier and other factors such as cargo, driver demographics, location, time, and type of incident. On the basis of identified trends, FMCSA directs resources in the most efficient and effective manner to improve motor carrier safety.

Finally, FMCSA identifies, coordinates, and administers research and technology development to enhance the safety of motor carrier operations, commercial motor vehicles, and commercial motor vehicle drivers. The Administration promotes the use of information systems and advanced technologies to improve commercial vehicle safety, simplify government administrative systems, and provide savings to states and the motor carrier industry.

Reference: www.fmcsa.dot.gov

Federal Transit Administration

The Federal Transit Administration (FTA) comprises nine offices, including the Office of Safety and Security and the Office of Planning. The Office of Safety and Security addresses issues for all modes of mass transit. The goal of the Office is to achieve the highest level of safety and security for all mass transit riders and employees. The Office of Safety and Security initiates these efforts by encouraging transit systems to develop and implement a system safety program plan. The Office has developed guidelines and best practices, in association with the American Public Transportation Association (APTA), to aid transit agency staff in developing the plans. In addition, FTA provides training and system safety analyses and reviews to ensure proper implementation. The Office of Safety and Security targets its efforts by dividing them between safety and security and by dividing the safety efforts by transit mode. FTA has initiated efforts to help transit agencies better equip themselves by planning for safety. In conjunction with APTA, FTA has recently published a variety of training tools and manuals for the use of transit agencies, including *Development of a Model Transit Bus Safety Program*, *Transit Security Handbook*, and *Safety Action Plan*. FTA works very closely with APTA to understand the needs of the changing industry needs with respect to safety, and provide the necessary materials to assist transit agencies.

FTA's *Safety Action Plan* was developed in 1999 after the FTA administrator determined the need to examine the federal role in transit safety. The plan defines six major areas to be addressed and set specific action plans. The six areas include:

- **Statistical Data.** FTA will enhance its data collection and analysis processes in order to guide future activities aimed at improving safety.
- **Human Factors.** Through the analysis of enhanced data, FTA will identify those human factors that most impact transit safety. This activity will assist FTA in focusing on safety program activities relating to human factors.
- **Design Standards.** FTA will work proactively with the industry in formulating and disseminating transit system design standards.
- **Revise State Safety Oversight Rule, Section 49 CFR Part 659.** FTA will propose revision of the safety oversight rule to integrate system safety concepts more effectively into the development phases of transit projects.
- **Activate Work With the Industry to Improve Bus Safety.** FTA will enhance the safe operations of the nation's transit bus systems by promoting the system safety concept.
- **Promote Safety.** FTA will actively promote innovative solutions to the provision of safe transportation in order to reduce deaths, injuries, and property damage.

The FTA *Safety Action Plan* can be viewed at http://transitsafety.volpe.dot.gov/publications/default.asp#Safety.

FTA is implementing changes to the safety and security information collected through the National Transit Database. The changes include monthly major incident reporting and significantly more detailed reports on fatalities, incidents, and injuries as well as major security information. FTA intends to use this new information to track and understand national trends, and for future planning purposes.

The National Transit Database is available at www.NTDprogram.com.

Additionally, FTA provides, through an interagency agreement with the Transportation Safety Institute (TSI) in Oklahoma City, training in transit safety and security. Transit professionals from around the country can be trained on subjects that include system safety, accident prevention and investigation, system security, emergency management, industrial safety, alternative fuels, bus operator safety, and fatigue awareness.

The FTA web site describes the Office of Planning as follows:

> *The Office of Planning administers a national program of planning assistance as the basis for capital and operating assistance grants. The office manages the financial and technical resources of the planning program and directs program implementation through the regional offices. The office provides expert support on the transportation planning process (transportation plans and program development) to regional offices, grantees, and the transit community. Areas supported include: safety, financial planning, public involvement, environmental impacts, air quality, new start criteria, and innovative planning methods through research, technical assistance, training and information dissemination.*

FTA also funds grants through the Rutger's University's National Transit Institute (NTI). NTI provides transit training based on identified industry needs. NTI's mission, as described on its web site, is to provide training, education, and clearinghouse services in support of public transportation and quality of life in the United States. NTI has specialized classes in a variety of both safety and planning-related areas relevant to transit agencies.

Reference: www.fta.dot.gov

State and Local Agencies

State Police

The responsibilities and organization of state police vary widely from state to state. Most state police maintain a separate highway patrol department, although in some cases highway patrols fall within a state department of public safety. In either case, it is the state agency responsible for enforcing traffic laws and investigating accidents on state and interstate highways. However, state police are also frequently called upon to assist other law enforcement agencies and to respond to emergencies. The Mississippi Department of Public Safety Highway Patrol lists the responsibilities of the patrol as follows:

1. Encourage and promote the safe operation of vehicles on Mississippi's state and federal highways.
2. Enforce traffic laws and other applicable laws in a fair, impartial and courteous manner.
3. Function as guardians of public safety in a professional capacity.
4. Assist in law enforcement and criminal justice agencies.
5. Enhance the public esteem for law enforcement by precept and example of each member of the department.

This list can be viewed at www.dps.state.ms.us/dps.nsf.

Mississippi's departmental goals are not unique. State troopers are responsible for law enforcement and safety education, as well as for upholding a strong public image. In some states, the scope of state trooper or highway patrol responsibilities is expanded to include issuing driver's licenses and vehicle titles, conducting bus inspections, investigating auto thefts, rendering first aid to injured motorists, and administering forfeitures in DUI and drug cases.

Another key responsibility of state police, city police, or highway patrols, is responding to accidents and conducting investigations. As previously discussed, police on the scene of an accident are the primary source for providing state DOTs and regional planners with useful, accurate crash data.

Communication between state police and planners is crucial because their relationship mutually benefits the goals of both parties. The information that the police departments provide to planning agencies, highway engineers, and state highway safety organizations allows these organizations to allocate funding and make the reasonable adjustments to reduce incidents. Without good information flow between police agencies, state DOTs, state highway safety agencies, and MPOs, these organizations cannot make informed resources allocation decisions. Enforcement resources cannot be effectively deployed unless the organizations understand where, when, how, and why crashes occur.

Transit Agencies

Like MPOs and state DOTs, the safety programs of transit agencies vary dramatically. As discussed earlier in the guidebook, transit agencies address safety in almost every aspect of their daily operations, but typically lack a systematic approach to incorporating safety in their long- and short-term planning. When planning for any new project, the element of safety will be considered at all levels, although projects are usually not selected with any weight placed on safety. The only exception to this occurs when transit agencies design a project as a countermeasure to an identified safety hazard.

Transit agencies typically conduct business with safety on the forefront of their operations. Larger agencies often have a dedicated safety officer, while smaller agencies have at least one employee whose responsibilities include safety. Agencies usually have created safety plans, addressing items such as accident review, response, and reporting; maintenance facility safety; driver training; and emergency management procedures. Agencies also conduct periodic drills to ensure that their procedures are in place. Transit agencies can review the FTA and APTA web sites for example safety plans and toolkits.

National Transportation/Safety Organizations

Transportation Research Board

The Transportation Research Board (TRB) is a nonprofit organization under the National Research Council. TRB's mission, as described on its web site, is to "*promote innovation and progress in transportation by stimulating and conducting research, facilitating the dissemination of information, and encouraging the implementation of research results.*" TRB fulfills this mission through the work of its standing technical committees and task forces addressing all modes and aspects of transportation; publication and dissemination of reports and peer-reviewed technical papers on research findings; administration of two contract research programs; conduct of special studies on transportation policy issues at the request of the U.S. Congress and government agencies; operation of an online computerized file of transportation research information; and hosting of an annual meeting that typically attracts 8,000 transportation professionals from throughout the United States and abroad.

Most notable to safety is the efforts and resources TRB has dedicated within the contract research programs. One significant research program, the National Cooperative Highway Research Program (NCHRP), has designated 25 special project areas, one of which is safety. Within the safety realm, NCHRP has sponsored countless safety projects including:

- Safety Impacts and Other Implications of Raised Speed Limits on High-Speed Roads
- Identification of Vehicular Impact Conditions Associated with Serious Ran-Off-Road Crashes
- Comprehensive Human Factors Guidelines for Road Systems
- AASHTO Strategic Highway Safety Plan—Technology Transfer Plan
- Integrated Management Process to Reduce Highway Injuries and Fatalities Statewide
- Highway Safety Manual
- AASHTO Strategic Highway Safety Plan Implementation Support
- Development of Guidelines for Nighttime Road Work to Improve Safety and Operations

Another significant research program is the Transit Cooperative Research Program (TCRP). Similar to NCHRP, TCRP designates research projects based on relevant issues facing transit agencies, including safety and security issues. A few of their recent studies include: *Guidelines for Collecting, Analyzing and Reporting Transit Crime Data, Light Rail Safety: Pedestrian and Vehicular Safety, and a Transit Manager Tool Kit for Rural and Small Urban Transportation Systems.*

TRB is also the joint sponsor of FHWA/TRB safety and planning forums. The forums seek to bring together safety professionals from different agencies within a state to meet, discuss their various safety initiatives, and brainstorm possibilities for collaboration. The forums are specifically designed to address the safety and planning requirements of TEA-21. The purpose of the forums is to initially bring together these professionals to establish an ongoing dialogue and to develop action plans for safety conscious planning implementation in a proactive, multi-modal, mutli-countermeasure manner. FHWA and TRB are continuing to hold forums around the country.

Reference: www.nationalacademies.org

American Public Transportation Association

The American Public Transportation Association (APTA) is a private non-profit trade association serving the needs and interests of the public transportation industry. The APTA membership includes over 1400 member organizations representing transit agencies, suppliers and manufacturers, consulting and management companies, academic institutions, state associations and public departments of transportation.

APTA is engaged in numerous safety activities to enhance the safety of transit operations. Among these activities, APTA has established international standards for system safety and safety auditing through its Rail Safety Audit Program, Commuter Rail Safety Management Program and Bus Safety Management Program. APTA also maintains standing safety committees for bus and rail operations to provide an on-going forum for the exchange and development of industry safety best practices and further advances these activities through sessions at its modal conferences. Included within these initiatives is a close working relationship with the administrations of the DOT, the NTSB and other transportation associations such as ASSHTO.

Reference: www.apta.com

Roadway Safety Foundation

The Roadway Safety Foundation (RSF), as described on its web site, is committed to *"reducing highway deaths and injuries by improving the physical characteristics of America's roadway—design and engineering, operating conditions, removal of roadside hazards, and the effective use of safety features."*

RSF is a membership-based non-profit organization created as a forum for public and private sector members to promote roadway improvements. Private sector members are from industries such as insurance, salt, automakers, and trucking, while public sector members are from agencies such as FHWA, NHTSA, TRB, AASHTO, NAGHSR, and several state DOTs.

RSF's mission, also described on its web site, is to *"build public awareness and support actions to assure that national, state, and local safety agendas recognize the role of the roadway in reducing the frequency and severity of traffic crashes."* The Foundation's major goals include educating the public on the importance of roadway safety improvements, supporting efforts to improve the quality of roadway safety data, and promoting roadway safety research and technology transfer.

Most notably, RSF has published a *Roadway Safety Guide* to provide local leaders with a hands-on, step-by-step approach to improving roadway safety. This guide highlights common practices for addressing roadway hazards in cost-effective ways. This guide is available at the RSF web site at www.roadwaysafety.org.

Reference: www.roadwaysafety.org

Association of Metropolitan Planning Organization

The Association of Metropolitan Planning Organizations (AMPO) is a membership-based non-profit organization created to identify the needs and interests of MPOs. AMPO provides services through several means including offering technical assistance, training, conferences and workshops, ongoing communications, and a forum for research and transportation policy development. AMPO has also created a list of MPO best practices by matching relevant issues with specific MPO efforts and related studies. This, combined with a directory of MPO contacts, fosters communication among MPO staffs and allows MPOs to benefit from the efforts of one another. The AMPO best-practices directory covers a wide variety of relevant MPO issues, including spotlighting MPO safety efforts. It also includes best-practice-type articles on issues related to public participation, project selection, state/MPO relations, management practices, flexible funds, and others.

Reference: www.AMPO.org

Institute for Transportation Engineers

The Institute for Transportation Engineers (ITE) is a professional association of transportation engineers, planners, and other interested professionals in the United States and abroad who are responsible for meeting the mobility and safety needs of society. The Institute facilitates the application of technology and scientific principles to research, planning, functional design, implementation, operation, policy development, and management for any mode of transportation. This is accomplished by promoting professional development of members, supporting and encouraging education, stimulating research, developing public awareness, and exchanging professional information. It provides support for its members in the form of professional publications, training courses, meetings, and seminars.

Specifically for transportation planners, ITE publishes the *Transportation Planning Handbook*. The handbook provides practicing professionals with guidelines and a source of reference on proven techniques. The fifth edition of the handbook was published in 1999. It identifies safety as a paramount issue in transportation planning. Another ITE publication, *The Traffic Safety Toolbox: A Primer on Traffic Safety*, provides guidance for transportation planners on improving safety. Some of the principles set forth in the publication are discussed elsewhere in this guidebook.

ITE has also published a paper on safety conscious planning entitled *Safety Conscious Planning, The Development of the Safer Transportation Network Planning Process.* This paper was written to stimulate discussion on the issue of road safety within transportation planning, and its relation to the overall transportation network including land use, bicycle, pedestrian, and transit.

Reference: www.ite.org

The American Association of State Highway and Transportation Officials

The American Association of State Highway and Transportation Officials (AASHTO) is a non-profit organization established to represent highway and transportation departments in the United States. AASHTO spans all modes; its primary goal, as described on its web site, is *"to foster the development, operation and maintenance of an integrated national transportation system."* The Association accomplishes its goal through a wide variety of programs, projects, conferences, and committees. AASHTO has historically dedicated resources to safety issues.

In 1996, AASHTO assembled a group of safety efforts from FHWA, NHTSA, and TRB to develop a strategic plan for highway safety with the primary goal to reduce vehicle-related death and injury. The document identifies cost-effective safety strategies based on programs already in existence. A few of the most relevant safety strategies include increasing driver safety awareness, making walking and street crossing easier, ensuring safer bicycle travel, making truck travel safer, reducing vehicle-train crashes, improving the design and operations of highway intersections, and improving information and decision support systems. Other AASHTO publications include a *Highway Safety Design and Operations Guide*, and a *Guide for Enhancement of Highway Safety Directed to Agencies, Programs, and Standards*, which aims to help transportation administrators in budgeting resources to meet safety objectives. These documents can be ordered through AASHTO.

Reference:www.aashto.org

National Association of Governors' Highway Safety Representatives

The National Association of Governors' Highway Safety Representatives (NAGHSR) represents the states on highway safety and administers the NHTSA Section 402 State and Community Safety Grant Program. NAGHSR is a non-profit association that promotes the varied highway safety programs of states and territories, focusing on the human behavioral aspects of highway safety. NAGHSR's mission, as described on its web site, *"is to provide leadership in the development of national policy to ensure the effective highway safety programs."*

NAGHSR addresses a wide variety of issues, including occupant protection; impaired driving and speed enforcement; and motor carrier, school bus, pedestrian, and bicycle safety. Membership in NAGHSR is open to highway safety program managers, appointed by the governors of the 50 states; the government of the District of Columbia; the Commonwealths of Puerto Rico and Northern Mariana Islands; and the territories of the Virgin Islands, Guam, American Samoa, and the Indian Nation. These members are responsible for developing and implementing their states' or territories' highway safety programs, maintaining fiscal oversight of the programs, and evaluating the programs' impacts on highway safety problems. Annual dues are based on a proportional formula which considers state size. Associate membership is also available to organizations, associations, and businesses whose interests are compatible with NAGHSR.

Reference: www.naghsr.org

American Automobile Association Foundation for Traffic Safety

The American Automobile Association Foundation for Traffic Safety (AAAFTS) mission statement as presented on its web site reads:

> *Our mission is to research why motor vehicle crashes happen and educate the public about how to avoid problems on the road. We offer useful information to everyone who uses the road—pedestrians, cyclists, children, drivers young and old, school bus passengers, school safety patrols, and more*.

The Foundation is funded through contributions from motor clubs associated with AAA and the Canadian Automobile Association, individual AAA club members, insurance companies, and other individuals or groups. It searches for research problems that are not only obvious safety problems, but also have more underlying causes. Recent AAAFTS research has investigated drowsy driving, road rage, and novice driver education, accident characteristics of large trucks on highway ramps, and driver aging.

Reference: www.aaa.com

Insurance Institute for Highway Safety

The Insurance Institute for Highway Safety (IIHS) helps to prevent motor vehicle crashes from occurring and to reduce the severity of the crashes that do occur. Research from the Institute covers three areas:

- **Human factors research,** which addresses problems associated with teen-age drivers, alcohol-impaired driving, truck driver fatigue, and safety belt use, among others.
- **Vehicle factors research,** which focuses on both crash avoidance and crashworthiness. Crash tests are central to performing crashworthiness research and to demonstrating the importance of seat belts and air bags.
- **Physical environment research,** which includes assessments of roadway designs to reduce run-off-the-road crashes and eliminate roadside hazards.

Institute research also addresses possible interventions that can occur before, during, and after crashes to reduce losses. IIHS also has a Vehicle Research Center, which includes a state-of-the-art crash test facility. The Institute is closely affiliated with the Highway Loss Data Institute, which gathers, processes, and publishes data on the way in which insurance losses vary among different kinds of vehicles.

Reference: www.hwysafety.org

Commercial Vehicle Safety Alliance

The Commercial Vehicle Safety Alliance's (CVSA) mission statement as presented on its web site reads:

> *To achieve uniformity and reciprocity of commercial vehicle inspections and enforcement activities throughout North America through effective motor carrier, driver, vehicle, and cargo safety standards, compliance, education and enforcement.*

CVSA is a non-profit organization comprised of Federal, state, and local government agencies, in addition to private sector representatives throughout North America. CVSA acts as a forum to public and private officials within the commercial vehicle industry in order to address the following goals as described on their web site:

- Reduce fatalities, injuries, and incidents by improving safety compliance of commercial vehicle operations through form and reciprocal standards, practices, and enforcement throughout North America.
  - Establish and maintain effective CV safety operational standards and practices, inspection procedures, out-of-service criteria, and enforcement practices and penalties that provide the basis for uniformity, compatibility and reciprocity among CVSA's member Jurisdictions and industry partners.

- Seek and establish partnerships with others with interests in CV safety that lead to greater influence, higher visibility, and more effectiveness in pursuing CVSA's mission.
  – Seek and establish understanding with the general public of North America by educating and informing them of CVSA's vision and mission.
- Maintain an efficient organizational structure that provides the leadership and guidance needed to focus on strategic priorities.
  – Improve processes and mechanisms for addressing CVSA goals and priorities effectively.
  – Prioritize actions and align resource bases (funding, facilities, staff and others) sufficient to support the mission of the Alliance.

Reference: www.cvsa.org

American Association of Motor Vehicle Administrators

The American Association of Motor Vehicle Administrators (AAMVA) is a non-profit educational organization representing state and local government officials in the United States and Canada who are responsible for the administration and enforcement of motor vehicle licensing and registration laws. The Association's goal is to develop industry-leading programs in the areas of motor vehicle administration, police traffic services, and highway safety.

Reference: www.aamva.org

Safety Partnerships

A number of different types of safety partnerships have been formed among states, MPOs, and other types of organizations. Some are formal, mandated by law or government regulations, while others are voluntary and depend on voluntary cooperation among its members. Some involve only public sector agencies and others include non-profit and for-profit organizations. The following sections describe safety partnerships and present examples.

Formal State Agency Partnerships

In some states, formal partnerships involve several agencies where participation is required by law. For example, in Oregon, the Safety Division of the Oregon Department of Transportation (ODOT) maintains an ongoing partnership with law enforcement through their cooperative policing agreement. The agreement allows the agencies to jointly sponsor relevant projects, such as a the "Gap Analysis" conducted by the Oregon State Police. In the Gap Analysis project, a study was organized in which local groups identified what level of police service the community felt should be provided. In recent years, this process identified the need for 100 new police officers in various jurisdictions throughout the state, although subsequent funding was not available.

Metropolitan and Local Partnerships

Local partnerships are critical to safety planning. As demonstrated, many different agencies within a region work with the common goal of reducing incidents on the transportation network. However, the areas of expertise vary between agencies, and alliances can allow jurisdictions with a common goal to draw upon the strengths of agencies to reach that goal. In addition, solid partnerships can reduce overlap between agencies with similar plans. Michigan and Oregon provide some examples of ongoing safety partnerships at the metropolitan and local levels.

In Oregon, Metro Regional Services of Portland is the MPO but is also a regional government for the greater Portland area. Metro participates in several partnerships relevant to its safety activities, notably the Intelligent Transportation System (ITS) Program, an advisory committee for the region's ITS projects. Metro participated in the Safety Management System (SMS) until 1995 when it was no longer required by FHWA. In addition, Metro lobbied the legislature for additional officers for the state police.

The City of Portland works closely with the ODOT regional office because ODOT provides funding for many of the city's safety projects. The city is also working to maintain a more consistent relationship with the city police department, particularly to improve crash information.

A unique example of an effective safety partnership is that of the Traffic Improvement Association (TIA) of Oakland County, Michigan. TIA is a public-private non-profit organization that helps broker safety projects within the county. The organization receives funding from multiple sources: about 30 percent from the private sector; 30 percent from county government and the Road Commission of Oakland County; 30 percent from local governments (cities, villages, and townships); and 10 percent from federal and state grants. The initial thrust of TIA was to compile traffic crash data and provide engineering assistance. The organization receives sanitized crash data on all crashes in Oakland County from the Michigan State Police. It uses the crash data for safety planning and acts as an "information broker" to cities within Oakland County. TIA provides preliminary engineering assistance, site analysis for jurisdictions (actual drawings), and suggested remedies. It helps in enforcement grants and provides supplementary information for grants. TIA also helps organize community-related concerns, such as alcohol enforcement, safety belt usage, and mature driver issues.

Federal Partnerships

States, MPOs, transit agencies, and state police also form close partnerships with federal agencies on a wide variety of programs. Not only are federal agencies often the greatest source of funding**,** they also provide ongoing support through smaller studies and programs. Through understanding the goals of the federal agencies and keeping up to date with the projects they sponsor, states and MPOs can become involved in projects and can benefit from the studies and reports. For example, FHWA, in coordination with TRB, is sponsoring state forums to encourage state agencies involved in safety and transportation planning to meet and discuss their current initiatives and identify ways in which they can work together. The forums are attended not only by the state agencies, but also by FHWA and TRB staff to administer and provide assistance.

Federal agencies are also available to provide technical assistance through their expertise on a wide variety of related subjects.

Safety Forums

Safety forums can act as beneficial vehicles to create partnerships on all levels. The goal of a safety forum is to provide agencies information on safety planning activities and to enable agencies to articulate their policy goals and programs. This provides a setting for areas to identify where cooperation is possible. By bringing together policy and decision-makers from different agencies, states can identify where goals overlap and how agencies can collaborate more effectively.

Training and Education

Safety training is an essential part of safety planning. A state, MPO, or local agency has a number of safety training needs. First, these organizations must train their staffs to fully understand safety planning (see Chapter 2). Second, MPOs often provide elected officials, judges, heads of government agencies, and police officers with training in various aspects of safety planning, such as crash record systems, hazard identification, targeting funds for safety improvements, bicycle safety, pedestrian safety, or alcohol enforcement. Third, information needs to be provided to the public to raise awareness of safety issues as well as solicit support for increased enforcement and funding support to make safety improvements.

In the greater Detroit region, SEMCOG has established a variety of training courses on safety. It has held several courses for local planners, law enforcement personnel, and engineers on its *Traffic Safety Manual* and associated Comprehensive Analysis Safety Tool (CAST) software. SEMCOG sees this training role as essential in getting its members to integrate safety into their policies and plans. More generally, SEMCOG tries to educate elected officials, engineers, planners, law enforcement personnel, private companies, and citizens about traffic safety and its importance to the overall community.

Another example is in Portland, Oregon, where Metro runs bicycle training courses with safety as a central topic. Metro works with the Bicycle Transportation Alliance (an advocacy group) on a school program for bicycle safety and provides the safety training. Metro has also produced a bicycle map showing congestion levels on roads.

Federal safety agencies offer significant highway safety training to state and local law enforcement and other safety professionals. For example, the FMCSA Training Center provides at least $1 million in annual training to state and local enforcement agencies.