

# Intersection Safety Needs Identification Report

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16. Abstract The National Agenda for Intersection Safety was developed as a result of the information, data and discussions that occurred at the National Intersection Safety Workshop held in Milwaukee, WI on November 14-16, 2001. The Agenda includes 62 strategies and 41 issues intended to assist road jurisdictions in improving safety at intersections throughout the nation. The National Agenda for Intersection Safety (Publication No. FHWA-SA-02-007) was published by the Federal Highway Administration in 2002. The Agenda was intended to be a "living document", and capable of being modified periodically based on comments received and actions implemented by transportation and safety agencies. This document has not been revised since the publication in 2002.  The Needs Identification Report documents the investigation of the current accuracy, relevance and implementation of the strategies contained in the Agenda. The report reflects the findings from the study that reviewed the progress that has been made on intersection safety in the U.S. since the National Agenda for Intersection Safety was published in 2002. This report can help guide decision makers in any highway agency, or organizations such as industry and academia, in their investment in reducing crashes and their impacts in and related to intersections, with emphasis on reducing fatalities and serious injuries.			
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## Executive Summary

The National Agenda for Intersection Safety (Agenda), published in 2002, was intended to be a living document. This Intersection Safety Needs Identification Report reflects the progress that has been made in improving intersection safety since then. Intersections are recognized as an important safety emphasis area. AASHTO and 41 of the states have specifically included intersections in their strategic highway safety plans.

### Objective

The Objective of this report is to identify needs in developing and achieving safety performance through enhanced activities that can reduce crashes and their impacts – specifically the fatalities and serious injuries associated with intersection safety within their jurisdictions.

## 1. Intersection Design Options

### 1.1 Access Management

- Continue research on the safety and cost benefits of access management techniques.
- Conduct outreach and education on the safety and cost benefits of access management techniques.
- Increase implementation of access management techniques.

### 1.2 Roundabouts

- Consider roundabouts as viable alternatives for new and redesigned intersections.
- Conduct outreach to overcome opposition by state and local officials who are unfamiliar with the safety and operational benefits of roundabouts.
- Educate engineers on how to properly plan and design roundabouts, including avoiding past design and construction errors.
- Educate and familiarize road users about roundabout usage and benefits.

### 1.3 Alternative Intersection Designs

- Consider alternative designs at intersections with safety and/or operational problems.
- Perform outreach to inform transportation agencies and the public of the benefits of alternative intersection designs.
- Provide education on the selection, evaluation, and design of alternative intersections.
- Continue to evaluate the safety implications of alternative intersection designs.

### 1.4 Rural Intersection Safety

- Promote programs and action plans that encourage proactive, systematic application of low-cost treatments rather than focusing only on the locations where high numbers of severe crashes have occurred.

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- Develop a best-practice guide for rural, low-volume intersection improvements, for use by local county engineers and managers of tribal lands, national parks, and others who implement safety improvements.
  - Promote the continued funding of high-risk rural roads, including rural intersection treatments, into future reauthorization legislation.

## **2. Traffic Control**

### **2.1 Signal Timing**

- Develop best practices and policies and procedures for calculating, installing, verifying, and updating signal phasing and timings that enhance safety.
- Increase research to identify the safety aspects of operational improvements.
- Perform regular maintenance and assessments of signal timings.
- Develop a regular maintenance program for traffic signal equipment.
- Develop best practices for implementation of emergency vehicle pre-emption.

### **2.2 Red-Light Running**

- Identify and mitigate the number of correctable red-light running (RLR) intersection problems based on unintentional red-light runners.
- Consult stakeholders early in the process to obtain acceptance in the decision to use red-light cameras.
- Provide state and local jurisdictions with up-to-date information on the issues of deploying a red-light camera program.

### **2.3 Advanced Technologies**

- Continue to support collision-avoidance programs, including establishing a gap acceptance countermeasure and developing the violation countermeasure.
- Convene a panel to identify additional needs for these technologies.
- Continue public-private partnerships to develop the systems for communication between the roadway infrastructure and the vehicles, and conduct field testing.

## **3. Intersection User Issues**

### **3.1 Pedestrians and Bicyclists**

- Increase the use of pedestrian and bicycle design guides, such as the *Guide for the Development of Bicycle Facilities* and the *Guide for the Planning, Design, and Operation of Pedestrian Facilities*, as well as the NCHRP Report 500 volumes that address pedestrian (Volume 10) and bicycle (Volume 18) safety.

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- Train designers to advance their knowledge, skills, and abilities regarding intersection accessibility and safety, especially the accessibility needs of the elderly, blind, and disabled. Current resources may include *Special Report: Accessible Public Rights-of-Way Planning and Design for Alterations*, prepared by the Public Rights-of-Way Access Advisory Committee and the *Accessible Sidewalk* Video series from the U.S. Access Board.
  - Conduct pedestrian mobility and safety audits for all users at intersections, similar to the AARP audits conducted in 2008. Encourage local agencies to share with lay volunteers and the general public safety resources such as the *Pedestrian Mobility and Safety Audit Guide* (from AARP-ITE) or the *Walkability and Bikeability Checklists* (from the Pedestrian and Bicycle Information Center [PBIC]), to perform safety scans of local streets and neighborhoods.
  - Implement public information and education campaigns for pedestrians and bicyclists on how to safely cross intersections.
  - Implement public information and education campaigns for motorists on how to drive safely around pedestrians and bicyclists, including intersections that have bike lanes.
  - Use walking speeds appropriate for the local population when timing traffic signals.

### **3.2 Motorcyclists**

- Implement design and maintenance practices to address road surface conditions and road debris (e.g., reduce uneven road surfaces, avoid materials that create slippery surfaces for motorcycles, patch potholes promptly, remove debris and clean fluid spills promptly, etc.).
- Establish a working group to review design and signing guidelines to identify any appropriate changes that would better accommodate motorcycles. This may include signage to communicate hazardous road and construction conditions.
- Review motorcycle crash data to identify any high-incident intersections, roadway hazards for motorcyclists, patterns in primary contributing factors, and a 4E (Engineering, Education, Enforcement, and Emergency Medical Services) action plan with priority safety countermeasures.
- Continue driver training and testing for motorcyclists, but ensure adequate coverage of issues related to intersection safety, especially watchfulness for vehicles at intersections and evasive maneuvers if a vehicle pulls in front of a motorcyclist's path.
- Implement public information and education campaigns regarding motorcycle safety, targeting motorcycle drivers on key topics (e.g., helmets, speeding, alcohol, clothing that increases conspicuity, etc.) as well as reminding drivers of other vehicles how difficult it can be to see a motorcycle.

### **3.3 Motorists**

- Encourage young driver training programs and older driver safety courses to include lessons on intersection safety. Course material should reflect factors that contribute to the age group's increased risk and what drivers can do to counteract these factors, and should include testing driving skills and safety knowledge at intersections.

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- Perform public information and education campaigns for young and older driver groups on their risks at intersections and changes they can make to minimize their potential to be involved in a collision.
  - Increase use of the *Design Handbook for Older Drivers and Pedestrians* (FHWA, 2001), which is currently being updated and should be available in 2009. This handbook contains numerous design recommendations by intersection design elements (e.g., curb radius and channelization) specifically regarding older drivers and older pedestrians. After the release of the updated handbook:
    - Widely disseminate the handbook among state and local street and highway agencies, especially since the original handbook was underutilized by the transportation engineering profession.
    - Support the professional development and training of transportation engineers in the knowledge, skills, and abilities presented in the handbook.
    - Work with and educate elected officials on the value of key laws and programs that address young and older driving populations. This may include graduated driver licensing for young drivers and minimum vision, physical, and cognitive skills for older drivers.

## **4. Intersection Program Issues**

### **4.1 Road Safety Audits at Intersections**

- Review current road safety audit material to evaluate whether the information is appropriate for intersections.
- Review existing NHI and FHWA road safety audit training courses to evaluate whether adequate coverage is given to the topic of intersections. Create a renewed focus in promoting and providing intersection safety audit courses.
- Promote the use of intersection safety audits by publishing success stories where implemented recommendations had an immediate and noticeable reduction in crashes. Include a safety audit category as part of the National Roadway Safety Awards.

### **4.2 Crash Data and Reporting**

- Continue the dialogue and collaboration between users and collectors of crash data to better integrate the needs of each onto crash report forms.
- Maintain strong funding and support for the state Traffic Record Coordinating Committees.
- Develop outreach and education between traffic engineers and police officers to further communicate the necessity for accurate, timely, complete, consistent, accessible, and linked crash data.
- Encourage state and local jurisdictions to standardize their crash data collection based on ANSI D16.1 Standard, the Model Minimum Uniform Crash Criteria (MMUCC).

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- States and local jurisdictions should standardize the collection of roadway inventory and traffic elements critical to safety management based on the Model Minimum Inventory of Roadway Elements (MMIRE).

### **4.3 Intersection Design Standards, Guidelines, Policies, and Practices**

- Utilize NCRHP Report 500 guides (especially Volumes 5 and 12, which are specific to intersections), the Intersection Safety Strategy brochures, and FHWA's *Desktop Reference for Crash Reduction Factors* to select cost-effective countermeasures that can be incorporated into the intersection design process early to avoid later expensive retrofits.
- At the release of the *Highway Safety Manual*, convene a panel to review national design and signing guidelines for potential revisions to incorporate the latest intersection safety information in the manual, NCHRP Report 500 guides, and FHWA's *Desktop Reference for Crash Reduction Factors*.
- Develop and package training that emphasizes new design standards, guidelines, policies, and practices that have been established nationally and internationally in the past few years.
- Identify and promote key personnel to assist agencies (e.g., peer-to-peer) in reviewing and updating intersection design standards, guidelines, policies, and practices to incorporate current knowledge on safety performance.

### **4.4 Multidisciplinary Nature of Intersection Safety**

- Organize a national 4E coalition to establish a multidisciplinary discourse to monitor the progress on intersection safety and identify programs that organizations are willing to collaborate on. Participating agencies should represent not only federal agencies but also national organizations representing cities, counties, police and sheriff departments, emergency medical services providers, etc.
- Develop and implement multi-disciplinary intersection safety action plans.
- Develop a startup kit and program materials for state and local agencies. Material should help in the organization and structure of multidisciplinary teams that address local intersection issues.
- Contact existing state and local 4E teams that address intersection safety within their communities to learn if the teams are meeting objectives. This can include existing NHTSA Safe Community Programs or SHSP implementation teams. Possible team objectives to assess include:
  - Sharing information during meetings, via an email list serve, or on a web page regarding project and program implementation to encourage agencies to coordinate resources.
  - Discussing observations, findings, and patterns of circumstances and contributing factors that lead to severe intersection crashes, allowing agencies to develop response plans.



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- Sharing crash information about problem locations (e.g., locations with high total crash frequency, severe crash frequency, crash rates, etc.) to develop a coordinated response.
  - Discussing agencies' needs (e.g., selection of corridors where emergency vehicle preemption is added, locations to focus RLR enforcement, etc.).

#### **4.5 Marketing Intersection Safety**

- Create a 5-year plan to develop and broadcast education messages. This should include working with Congress to identify dedicated funding in the next transportation reauthorization.
- Establish a coalition of safety partners to create and maintain an on-line clearinghouse of intersection safety education materials.
  - The clearinghouse should be easy to locate, accessible, and maintained with current information. Material in the clearinghouse should address multiple audiences, including the public, and specific audiences such as elected officials, high-risk drivers, and young or aging drivers. The material should also consider the unique needs of different locations (urban versus rural) and types of traffic control (i.e., signalized, unsignalized, and roundabout).
  - To use available resources effectively, work with the PBIC and others in the FHWA Office of Safety to jointly market intersection safety educational materials along with pedestrian safety intersection materials.
- Create new or enhance existing NHTSA Safe Community Programs to address local intersection safety problems. Provide support and information to elected officials, agencies, and the general public.
- Fund local agencies for intersection safety marketing to develop grass-roots support for intersection programs and raise awareness.
- Identify an "intersection safety champion" to promote intersection safety programs and countermeasures and raise safety awareness.
- At statewide, regional, and national meetings and conferences, provide an intersection safety message.

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## Introduction

### Purpose & Scope

This *Needs Identification Report* reflects the findings from the preliminary study that reviewed the progress that has been made on intersection safety in the U.S. since the *National Agenda for Intersection Safety* was published in 2002. This report can help decision makers in any highway agency, or organizations such as industry and academia, in their investment in reducing crashes and their impacts related to intersections, with emphasis on reducing fatalities and serious injuries.

The strategies presented were developed with a consensus of national experts. They specifically focus on filling needed key program and technology gaps, emphasizing activities that can enhance improvement efforts for intersection safety. These strategies consider the Four E's—Engineering, Education, Enforcement, and Emergency Medical Services (EMS)—because attaining the desired increase in safety improvement at intersections will require increased awareness, communication, and coordination for transportation industry stakeholders.

### Background

The Agenda, published in 2002, was originated to record the findings of the National Intersection Safety Workshop of November 2001 that focused on improving and increasing intersection safety. One of the goals was to have the state representatives go back to their states and develop a plan of action to address intersection safety.

As the Agenda did previously, this report lists only major program gaps and activities, rather than all ongoing programs, which can enhance the outcomes of intersection safety. This report provides recommendations to help intersection safety professionals fill gaps in current and future planned activities and programs. It is important to realize that this report does not list all the ongoing programs and activities that continue to be needed for providing intersection safety. The consensus of needs and associated strategies herein involved the assessment of the adequacy of the Agenda, as well as the adequacy of updated information regarding gaps, emphasis areas, and needs in technology and programs for intersection safety.

### Current State of Intersection Safety

Intersection fatalities declined from 8,922 in 2001 to 8,657 in 2007. However, during the time period needed for implementing the Agenda's activities, intersection fatalities continued increasing to 9,273 and 9,362 in 2002 and 2003, respectively, until a steady reduction began in 2004.

Exhibit I shows that in 2007, approximately 2.4 million intersection-related crashes occurred, representing approximately 40 percent of total reported crashes. This caused an annual cost to society for intersection crashes of approximately \$83 billion.

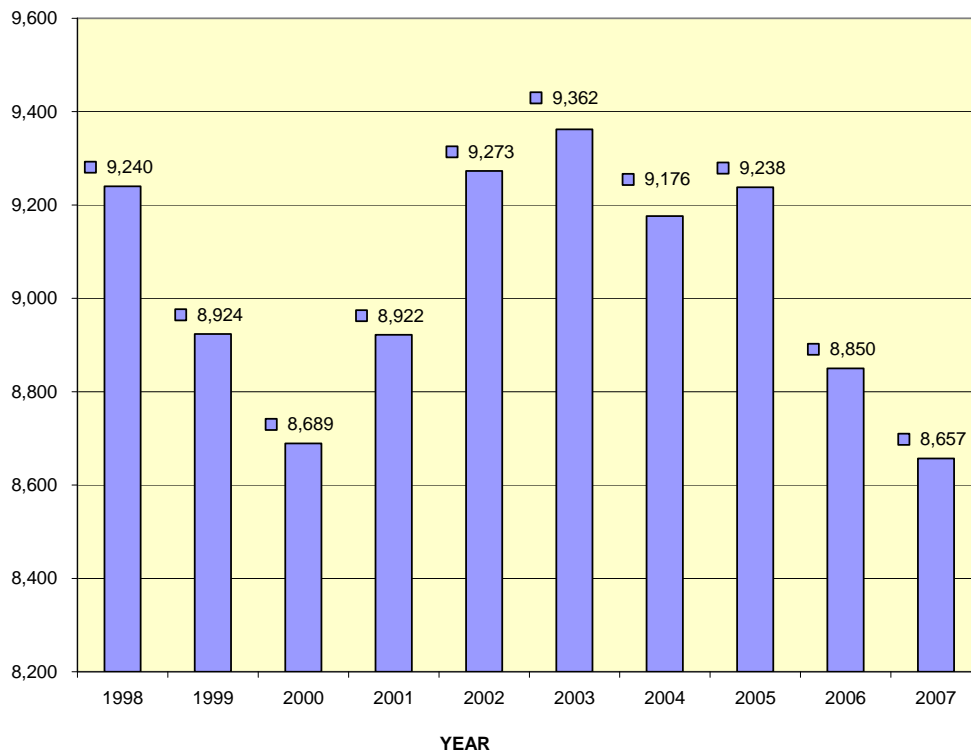
**EXHIBIT I**

2007 Intersection Crashes as Related to Societal Cost

	Number	Percentage	Societal Cost (Billion \$)
Total Fatal Crashes	37,248		\$126.3
Total Intersection-Related Fatal Crashes	8,202	22.0%	\$27.8
Total Injury Crashes	1,711,000		\$68.7
Total Intersection-Related Injury Crashes	767,000	44.8%	\$51.3
Total Property Damage Only (PDO) Crashes	4,275,000		\$11.2
Total Intersection-Related PDO Crashes	1,617,000	37.8%	\$4.2
All Crashes	6,024,000		\$206.2
Total Intersection-Related Crashes	2,393,000	39.7%	\$83.3

There was a 6.3 percent reduction in intersection fatalities between 1998 and 2007 (9,240 to 8,657). In 2007, 8,657 fatalities (21 percent of the traffic fatalities) occurred at or within the influence areas of intersections. As shown in Exhibit II, between 1998 and 2007, the minimum and maximum number of intersection fatalities was 8,657 and 9,362, respectively. The average number of intersection fatalities for this 10-year period was 9,033.

**EXHIBIT II**  
Intersection Fatalities: 1998 to 2007



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## Objective

The Objective of this report is to identify needs in developing and achieving safety performance through enhanced activities that can reduce crashes and their impacts – specifically the fatalities and serious injuries associated with intersection safety within their jurisdictions.

The areas of need identified during this study fall into the following categories:

- Design Options;
- Traffic Control;
- Intersection Users; and
- Intersection Programs.

The remaining section of this report covers these categories. Each of the categories contains subcategories discussing the issues and providing a list of recommendations for improving safety within intersections.

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# Intersection Safety Categories and Associated Strategies

## 1. Intersection Design Options

### 1.1 Access Management

#### EXHIBIT III

Intersection and Access Fatalities, 1998 - 2007

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Intersection <sup>1</sup> Fatalities	9,240	8,924	8,689	8,922	9,273	9,362	9,176	9,238	8,850	8,657
Access <sup>2</sup> Fatalities	820	932	774	837	874	1,105	1,208	1,263	1,317	1,397

Access fatalities in the vicinity of intersections have increased by more than 41 percent in the last 10 years, from 820 in 1998 to 1,397 in 2007 (Exhibit III).

Access fatalities are those that occur at driveways, alley accesses, entrance or exit ramps, and crossovers.

#### Facts<sup>3</sup>

- Access-related crashes occur at conflict points.
- Up to half of all crashes in urban areas are related to issues of access (minor public road intersections, traffic signal spacing, and driveways).
- Left-turn exiting movements generate 75 percent of all crashes at driveways.
- Left-turn entering movements generate almost 50 percent of all crashes at driveways.

A number of tools and techniques can be used as part of an access management plan. They include physical design as well as policy-related techniques that address land development and roadway design standards.

Implementing access management tools and techniques can be difficult. They are not always initially understood or acceptable to residents, road users, and businesses, often due to concerns about impeded mobility, access, or safety. Governments must do their part to educate and demonstrate to the affected citizenry the potential positive impacts of access management techniques – for both individuals and the collective community.

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<sup>1</sup> Source: Preliminary 2007 FARS data.

<sup>2</sup> Intersection and Junction Fatalities in the Context of Access Management, Edward R. Stollof, Prepared for: TRB 8th National Conference on Access Management, July 2008.

<sup>3</sup> FHWA. Presented at TRB Access Management Conference. Baltimore, MD, 2009.

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## Recommendations

- Continue research on the safety and cost benefits of access management techniques.
- Conduct outreach and education on the safety and cost benefits of access management techniques.
- Increase implementation of access management techniques.

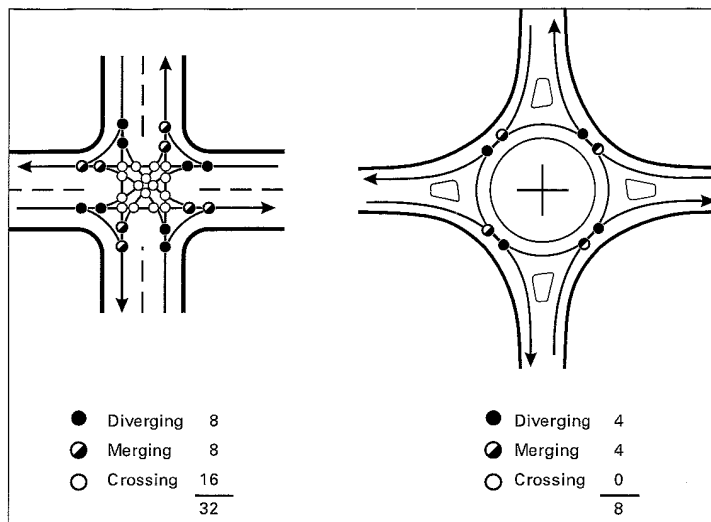
## 1.2 Roundabouts

### Issues

Roundabouts have been shown to improve safety by slowing traffic and reducing the number and severity of the conflicts between the different movements. The National Cooperative Highway Research Program found that the installation of roundabouts led to a 35 percent reduction in total crashes and a 76 percent reduction in crashes causing injuries or fatalities.

#### EXHIBIT IV

Intersection Conflicts: Roundabout vs. Conventional Intersection



Because traffic enters and exits the roundabout using only right turns, the number and types of hazardous traffic conflicts are lessened, as illustrated in Exhibit IV. The exposure for severe angle crashes is substantially reduced or eliminated. All approaching vehicles are required to yield to vehicles already in the circulatory roadway, so rear-end crashes from vehicles stopping suddenly are much less common.

However, pedestrian crossings are potentially more challenging because entering traffic does not have to stop if there are sufficient gaps. On the other hand, pedestrians have a lower risk of being

involved in a severe crash because of the lower vehicle speeds and having to cross only one roadway at a time.

The use of roundabouts is common in other countries and is gaining momentum in the U.S. The safety benefits are well-documented. The reluctance to move toward more widespread construction of roundabouts in this country is based primarily on unfamiliarity and tradition, which is slowly being overcome as more of them are built and the many benefits become obvious. The upcoming *Highway Safety Manual* has a section on the safety effectiveness of roundabouts. Increasing the number of roundabout installations would not only improve users' familiarization and expectations, but would also significantly reduce the numbers of serious injuries and fatalities at U.S. intersections.

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## Recommendations

- Consider roundabouts as viable alternatives for new and redesigned intersections.
- Conduct outreach to overcome opposition by state and local officials who are unfamiliar with the safety and operational benefits of roundabouts.
- Educate engineers on how to properly plan and design roundabouts, including avoiding past design and construction errors.
- Educate and familiarize road users about roundabout usage and benefits.

## 1.3 Alternative Intersection Designs

### Issues

The most common severe crashes at intersections are angle crashes. The typical traffic control devices (stop sign or traffic signal) require drivers on one path to yield or stop for those on the conflicting path through the intersection. Some alternative designs remove these conflicts (angle crossings) replacing them with less-severe conflict types (merge/diverge). These types of intersections can address the safety problems and still maintain the mobility of the higher-speed, high-volume routes. They can be more cost-effective than grade-separated interchanges, especially for lower-volume routes crossing the major routes. A few of these alternative intersection designs are shown in Exhibit V. For additional information, see FHWA publication *Alternative Intersections / Interchanges: Informational Report*.

### EXHIBIT V

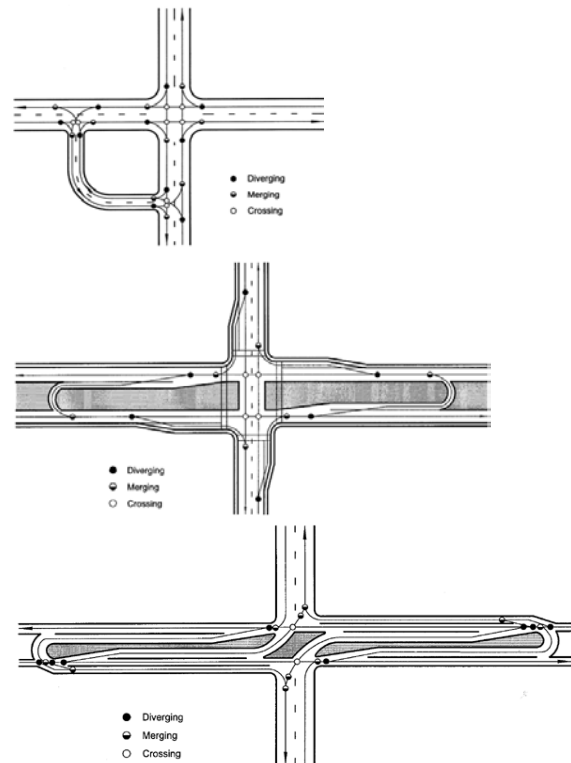
#### Alternative Intersection Designs

Quadrant roadways remove the left-turning traffic from the large intersections, replacing the movement with multiple right turns or a left turn at a T intersection. This configuration reduces the number of left-turn crossing conflicts from 12 to 4, providing potential for a major reduction in left-turn crashes.

Median U-turn intersections replace the left turns with right turns and U-turns on the major and minor approaches. Median crossovers are very common in Michigan. The collision rate along road sections utilizing the median crossovers was 49 to 52 percent less for signalized corridors having more than one traffic signal per mile.

Restricted crossing U-turn intersections are similar to median U-turn crossovers, but allow left turns from the major street only. This design is appropriate where there are high volumes on the major route and relatively small volumes on the minor route.

Pedestrian safety may be increased because there are medians between the different channelized movements that provide refuge.



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## Recommendations

- Consider alternative designs at intersections with safety and/or operational problems.
- Perform outreach to inform transportation agencies and the public of the benefits of alternative intersection designs.
- Provide education on the selection, evaluation, and design of alternative intersections.
- Continue to evaluate the safety implications of alternative intersection designs.

## 1.4 Rural Intersection Safety

### Issues

Safety performance of conventional, two-way, stop-controlled intersections on rural highways declined as volumes on these minor roadways increased. Several strategies may be applied at rural areas to improve safety at problematic intersections.

Many fatalities occur at low-volume, stop-controlled intersections, but there are so many of these intersections that it is not practical to reconstruct all of them. Low-cost treatments that can be done on a widespread basis are needed.

Low-cost treatments that have been applied have included enhanced traffic signs and pavement markings, flashing beacons, turn lanes or bypass lanes, intersection lighting, rumble strips, and increased enforcement.

These treatments are effective in getting the driver's attention because they are enhancements at intersections that meet minimum requirements of the *Manual on Uniform Traffic Control Devices*.

Enhanced signing, such as larger signs, signs with LED lights, or sign-mounted flashers to get the driver's attention, help drivers to observe potentially unsafe conditions and react in time to take safe action.

Overhead flashing beacons call attention to the stop-controlled intersection.

Transverse or longitudinal rumble strips, pavement markings, lane narrowing, and splitter islands can reduce approach speeds and increase awareness of the intersections. Increased enforcement tends to reduce intentional violations of stop signs.

### Recommendations

- Promote programs and action plans that encourage proactive, systematic application of low-cost treatments rather than focusing only on the locations where high numbers of severe crashes have occurred.
- Develop a best practice guide for rural low-volume intersection improvements, for use by local county engineers and managers of tribal lands, national parks, and others who implement safety improvements.
- Promote the continued funding of high-risk rural roads, including rural intersection treatments, into future reauthorization legislation.



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## 2. Traffic Control

### 2.1 Signal Timing

#### Issues

Mobility or efficiency needs must be balanced with safety needs in the timing of traffic signals.

To increase safety at signalized intersections:

- Ensure that intersections' change and clearance intervals are adequate to clear the intersection prior to the green indication for the opposing phase.
- Provide protected or split phases where sight distance is limited or other conditions can cause safety problems.
- Evaluate signal timing regularly.
- Provide preemption on regular emergency vehicle routes.

There is currently no recommended practice for traffic signal change intervals. RLR is one of the most common causes of intersection crashes. The generally accepted definition of the yellow change interval is to warn motorists that the related green movement is being terminated and that a red signal indication will be exhibited immediately thereafter. Some jurisdictions supplement the yellow interval with an all-red interval to provide additional clearance time for vehicles within the intersection.

Traffic signal timing needs to address all users' needs, including pedestrians (and those with disabilities), bicyclists, and drivers of large trucks, transit vehicles, and emergency vehicles.

Increasing the number of phases to include protected left-turns reduces conflicts between opposing traffic movements. Protected left-turn phases significantly improve the safety for left-turn maneuvers by removing the conflicts with the opposing through vehicles.

Coordination of traffic signals along a route can generate safety benefits in two ways:

- Reducing the number of stops required
- Maintaining constant speeds

Traffic signal preemption allows emergency vehicles to disrupt a normal signal cycle in order to proceed through the intersection more safely, decreasing response times of emergency vehicles. Preemption systems can also be used for transit vehicles and for signalized intersections close to railroad at-grade crossings.

#### Recommendations

- Develop best practices and policies and procedures for calculation, installation, verification, and updating of signal phasing and timings that enhance safety.
- Increase research to identify the safety aspects of operational improvements.
- Perform regular maintenance and assessments of signal timings.
- Develop a regular maintenance program for traffic signal equipment.

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- Develop best practices for implementation of emergency vehicle pre-emption.

## 2.2 Red-Light Running

### Issues

According to 2007 data from NHTSA's Fatality Analysis Reporting System, crashes caused by RLR resulted in an estimated 785 fatalities. This represents 9 percent of all intersection crashes for that year.

Speeders and red light violators share many of the same characteristics. As a group, red light violators involved in crashes are more likely than non-violators to be young (under 26), to not wear seat belts, to have invalid driver's licenses, and to be alcohol-impaired. Speeders also tend to be young, drive newer vehicles, and have more speeding violations and other moving violations than slower drivers. They also have 60 percent more crashes.<sup>4</sup> A 2006 study by the National Safety Council and Elsevier Ltd. found that "their speeding behavior is not likely to be controlled without vigorous, consistent enforcement, including the use of automated technology."<sup>5</sup>

RLR crashes are much more likely to cause an injury or a fatality than other intersection crashes. About half of the deaths in RLR crashes are pedestrians and occupants in other vehicles who are hit by the red light runners.

Traffic engineers should ensure that the yellow interval is adequate for the conditions at the intersection and the expectations of the motorists.

An engineering study of locations with RLR collisions should be undertaken. A number of engineering countermeasures to reduce RLR should be tried before considering the placement of red-light enforcement cameras. If one or more these measures are tried and the RLR problem is not corrected, traffic engineers and law enforcement personnel should consider red-light cameras in accordance in the procedures found in *Red Light Camera Systems Operational Guidelines*<sup>6</sup> or a *Focus on Safety: A Practical Guide to Automated Traffic Enforcement* (see footnote 2).

### Recommendations

- Identify and mitigate the number of correctable RLR intersection problems based on unintentional red-light runners.

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<sup>4</sup> Focus on Safety: A Practical Guide to Automated Traffic Enforcement, National Campaign to Stop Red Light Running, 2007. Washington, D.C. [http://www.stopredlightrunning.com/pdfs/WEBONLY\\_Red%20Light%20Book.pdf](http://www.stopredlightrunning.com/pdfs/WEBONLY_Red%20Light%20Book.pdf).

<sup>5</sup> Reducing red light running through longer yellow signal timing and red light camera enforcement: Results of a field investigation. Richard A. Retting, Susan A. Ferguson, Charles M. Farmer Insurance Institute for Highway Safety, 1005 North Glebe Road, Arlington, VA 22201, United States b Ferguson International LLC, 1328 Lancia Drive, McLean, VA 22102, United States. © 2007 Elsevier Ltd.

<sup>6</sup> Red Light Camera Systems Operational Guidelines. Report # FHWA-SA-05-02. 2005. Federal Highway Administration.(Summary available at [http://safety.fhwa.dot.gov/intersection/docs/summaries/redlight\\_systems.doc](http://safety.fhwa.dot.gov/intersection/docs/summaries/redlight_systems.doc)).

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- Consult stakeholders early in the process to obtain acceptance in the decision to use red-light cameras.
  - Provide state and local jurisdictions with up-to-date information on the issues of deploying a red light camera program.

## **2.3 Advanced Technologies**

### **Issues**

Intersection collision avoidance systems use both vehicle-based and infrastructure-based technologies to help drivers approaching an intersection understand the state of activities within that intersection.

Current research is focused on developing systems that can warn drivers of approaching vehicles. These systems can help with collision avoidance and selection of safe gaps in opposing traffic streams.

There are three types of collision avoidance systems:

- Vehicle-based autonomous systems, which have been developed mainly by private sector manufacturers;
- Infrastructure-based systems, where the warnings are located in the roadside infrastructure; and
- Systems that link vehicles to other vehicles or vehicles to infrastructure.

Intersection collision warning systems use sensors to monitor traffic approaching dangerous intersections and warn vehicles of approaching cross traffic. This technology warns drivers of potential collisions with vehicles not complying with stop signs or traffic signals.

Additional research is needed to develop and test the detection and communication systems to be installed in roadside infrastructure or in vehicles. Installation of equipment in vehicles will likely take a long time to reach a significant level because equipment is unlikely to be added to existing vehicles.

More research into human factors is also needed to develop a driver-vehicle interface that effectively communicates the information on potential hazards to drivers.

Cooperation is required between vehicle manufacturers and highway agencies to provide information to drivers from roadside infrastructure.

### **Recommendations**

- Continue to support the collision avoidance programs including establishing a gap acceptance countermeasure and developing the violation countermeasure.
- Convene a panel to identify additional needs for these technologies.
- Continue public-private partnerships to develop the systems for communication between the roadway infrastructure and the vehicles, and conduct field testing.

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### 3. Intersection User Issues

#### 3.1 Pedestrians and Bicyclists

##### EXHIBIT VI

Intersection and Pedestrian & Bike Fatalities, 1998-2007

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Intersection Fatalities	9,240	8,924	8,689	8,922	9,273	9,362	9,176	9,238	8,850	8,657
Ped & Bike Fatalities	1,400	1,334	1,320	1,466	1,407	1,390	1,350	1,409	1,390	1,394

##### Issues

In 2007, 13 percent of intersection fatalities were pedestrians, and bicyclists accounted for another 3 percent. Exhibit VI shows the preliminary 2007 FARS data. Pedestrians and bicyclists are a subset of intersection users, requiring special attention in the design, operation, and enforcement of intersections. Complicating the issue, pedestrians can have a wide variety of needs that require specialized solutions (e.g., elderly, blind, or persons in wheelchairs), and bicyclists have a wide variation in experience, skills, and knowledge on how to negotiate an intersection safely, with or without separate bike lanes, making it difficult to safely accommodate all users. The needs of some pedestrians may compete with what is best for motorists (e.g., increased crossing times for elderly pedestrians can affect intersection operations; blind individuals may have troubles negotiating a roundabout) and even other pedestrians (e.g., gently sloped curb ramps for elderly and persons in wheelchairs do not provide a distinct edge to help blind pedestrians identify the edge of a road).

##### Recommendations

- Increase the use of pedestrian and bicycle design guides, such as the *Guide for the Development of Bicycle Facilities* and the *Guide for the Planning, Design, and Operation of Pedestrian Facilities*, as well as the NCHRP Report 500 volumes that address pedestrian (Volume 10) and bicycle (Volume 18) safety.
- Train designers to advance their knowledge, skills, and abilities regarding intersection accessibility and safety, especially the accessibility needs of the elderly, blind, and disabled. Current resources may include *Special Report: Accessible Public Rights-of-Way Planning and Design for Alterations* prepared by the Public Rights-of-Way Access Advisory Committee and the *Accessible Sidewalk* Video series from the U.S. Access Board.
- Conduct pedestrian mobility and safety audits for all users at intersections, similar to the AARP audits conducted by ITE in 2008. Encourage local agencies to share with lay volunteers and the general public safety resources such as the *Pedestrian Mobility and Safety Audit Guide* (from AARP-ITE) or the *Walkability and Bikeability Checklists* (from PBIC) to perform safety scans of local streets and neighborhoods.
- Implement public information and education campaigns for pedestrians and bicyclists on how to safely cross intersections.

- Implement public information and education campaigns for motorists on how to drive safely around pedestrians and bicyclists, including intersections that have bike lanes.
- Use walking speeds appropriate for the local population when timing traffic signals.

### 3.2 Motorcyclists

#### EXHIBIT VII

Intersection and Motorcycle Fatalities, 1998-2007

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Intersection Fatalities	9,240	8,924	8,689	8,922	9,273	9,362	9,176	9,238	8,850	8,657
Motorcycle Fatalities	626	658	759	843	907	1,120	1,127	1,288	1,380	1,456

#### Issues

In 2007, motorcyclists accounted for nearly 17 percent of all intersection fatalities, up from 8 percent in 1998. Exhibit VII shows the preliminary 2007 FARS data. Of the fatal intersection crashes involving motorcycles, 46 percent of crashes were the right-angle crash type, and other turning-related crash types were also common. Although many factors contribute to right-angle and turning crashes, the conspicuity of the motorcyclists (or a driver's ability to see and recognize an approaching motorcycle) is known to be a significant contributing factor.

The second most common crash type was a "Not Collision with Motor Vehicle," which consists primarily of collision with a roadside fixed object, overturn, rollover, or fall off the motorcycle collision. These collisions can often be related to debris or road surface conditions that can cause a motorcyclist to lose control.

Regardless of the crash type, other common factors contributing to the frequency or severity of motorcycle crashes may include speeding, lack of helmet use, alcohol impairment, and motorcycle driver training/skills.

#### Recommendations

- Implement design and maintenance practices to address road surface conditions and road debris (e.g., reduce uneven road surfaces, avoid materials that create slippery surfaces for motorcycles, patch potholes promptly, remove debris and clean fluid spills promptly, etc.).
- Establish a working group to review design and signing guidelines to identify any appropriate changes that would better accommodate motorcycles. This may include signage to communicate hazardous road and construction conditions.
- Review motorcycle crash data to identify any high-incident intersections, roadway hazards for motorcyclists, patterns in primary contributing factors, and a 4E action plan with priority safety countermeasures.
- Continue driver training and testing for motorcyclists, but ensure adequate coverage of issues related to intersection safety, especially watchfulness for vehicles at intersections and evasive maneuvers if a vehicle pulls in front of a motorcyclist's path.

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- Implement public information and education campaigns regarding motorcycle safety, targeting motorcycle drivers on key topics (e.g., helmets, speeding, alcohol, clothing that increases conspicuity, etc.) as well as reminding drivers of other vehicles how difficult it can be to see a motorcycle.

### 3.3 Motorists

#### Issues

Younger (< 21) and older (> 64) drivers are overrepresented in fatal crashes, accounting for approximately 23 percent of all drivers involved in a 2007 fatal crash. Their involvement increases to more than 27 percent of all drivers involved in fatal intersection crashes, illustrating that safely navigating an intersection can be especially difficult for these two age groups.

Intersections tend to be one of the more-complex areas of the transportation system. Motorists may have to simultaneously process guide and warning signs as well as identify messages conveyed by traffic control, position their vehicles in the appropriate lane, and recognize and judge the speed and position of conflicting traffic. While this can be a difficult task for any motorist, it can be especially difficult for these two age groups. Young drivers' inexperience and risk-taking behavior, especially when combined with distractions such as peers riding in the vehicle or using cell phones, can lead to collisions and near-miss incidents at intersections. While drivers in the 64-and-above age group are more experienced and take fewer risks, changes in physical abilities (e.g., deteriorating eyesight, restricted range-of-motion, reaction time, etc.) and cognitive skills (e.g., recognition and decision making) increase their risk of being involved in a collision.

#### Recommendations

- Encourage young driver training programs and older driver safety courses to include lessons on intersection safety. Course material should reflect factors that contribute to the age group's increased risk, what drivers can do to counteract these factors, and should include testing driving skills and safety knowledge at intersections.
- Perform public information and education campaigns for young and older driver groups on their risks at intersections and changes they can make to minimize their potential to be involved in a collision.
- Increase use of the *Design Handbook for Older Drivers and Pedestrians* (FHWA, 2001), which is currently being updated and should be available in 2009. This handbook contains numerous design recommendations by intersection design element (e.g., curb radius and channelization) specifically regarding older drivers and older pedestrians. After the release of the updated handbook:
  - Widely disseminate the handbook among state and local street and highway agencies, especially since the original handbook was under utilized by the transportation engineering profession.
  - Support the professional development and training of transportation engineers in the knowledge, skills, and abilities presented in the handbook.

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- Work with and educate elected officials on the value of key laws and programs that address young and older driving populations. This may include graduated driver licensing for young drivers and minimum vision, physical, and cognitive skills for older drivers.

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## 4. Intersection Program Issues

### 4.1 Road Safety Audits at Intersections

#### Issues

A Road Safety Audit (RSA) is a formal safety performance examination of an existing or future road or intersection by an independent audit team. It qualitatively estimates and reports on potential road safety issues and identifies opportunities for improvements in safety for all road users. RSAs are an effective way to obtain an independent opinion about safety needs for an intersection, corridor, or network. Safety audits are often used in one of two ways—either to parallel the design process to suggest potential design revisions, or at a location with a safety concern to identify alternative solutions (before a design project is initiated).

Although RSAs have gained popularity in some regions, their acceptance varies and their use is still not uniform. Furthermore, some areas may lack personnel with the training or qualifications necessary to perform a safety audit. Another common problem with these audits is that suggested changes may or may not be implemented by the responsible agency.

Other perceived problems are that the specific safety effectiveness (crash reductions) of RSAs has not been defined and/or documented; FHWA has recently developed an RSA guidebook, online software, and a training course. However, having enough trained personnel to perform audits will be crucial, especially engineers who can identify creative low-cost solutions. And finally, the agency responsible for the intersection needs to have a plan for implementing the suggestions given by the intersection audit team.

#### Recommendations

- Review current road safety audit material to evaluate whether the information is appropriate for intersections.
- Review existing NHI and FHWA road safety audit training courses to evaluate whether adequate coverage is given to the topic of intersections. Create a renewed focus in promoting and providing intersection safety audit courses.
- Promote the use of intersection safety audits by publishing success stories where implemented recommendations had an immediate and noticeable reduction in crashes. Include a safety audit category as part of the National Roadway Safety Awards.



## 4.2 Crash Data and Reporting

The purpose of a comprehensive traffic records system is to ensure that complete, accurate, and timely traffic safety data are collected, analyzed, and made available for decision making at the national, state, and local levels to reduce crashes, deaths, and injuries on our nation's highways. NHTSA does this through its Section 408 program, which distributes grants to states through its Traffic Safety Information System Improvements Program.

### Issues

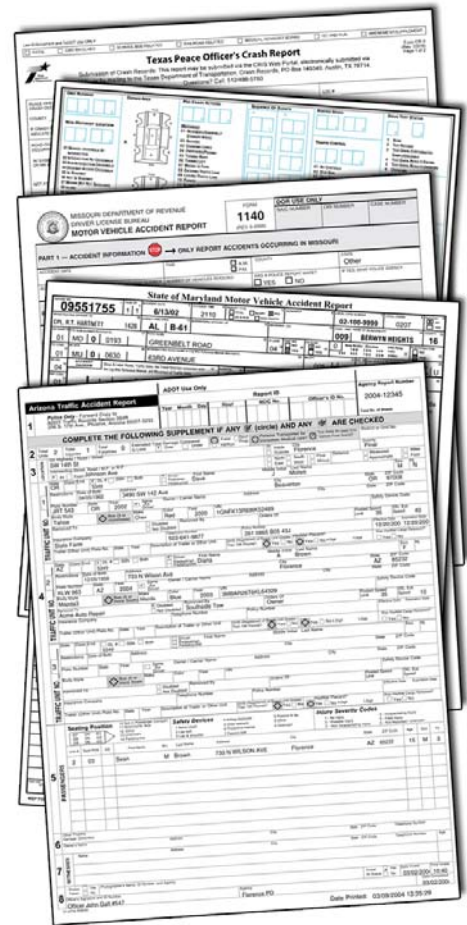
To identify areas that need improvement as well as to be able to measure improvement in safety, reliable crash data is necessary. Engineers need to have timely access to the crash data.

For traffic engineers to be able use data collected from a police crash report, the information must have six characteristics of "quality" attached to it, as follows:

- Timeliness;
- Accuracy;
- Completeness;
- Consistency ;
- Accessibility; and
- Linkage.

### Recommendations

- Continue the dialogue and collaboration between users and collectors of crash data to better integrate the needs of each onto crash report forms.
- Maintain strong funding and support for the state Traffic Record Coordinating Committees.
- Develop outreach and education between traffic engineers and police officers to further communicate the necessity for accurate, timely, complete, consistent, accessible, and linked crash data.
- Encourage state and local jurisdictions to standardize their crash data collection based on ANSI D16.1 Standard and the Model Minimum Uniform Crash Criteria (MMUCC).
- States and local jurisdictions should standardize the collection of roadway inventory and traffic elements critical to safety management based on the Model Minimum Inventory of Roadway Elements (MMIRE).



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## 4.3 Intersection Design Standards, Guidelines, Policies, and Practices

### Issues

Intersection design standards, guidelines, policies, and practices (e.g., signing, turn-lane lengths, lighting, etc.) may not adequately incorporate the current knowledge on the safety performance of different intersection designs, traffic control devices, and other countermeasures. Furthermore, design standards, guidelines, policies, and practices are likely based on safety, as well as cost, capacity, and driver comfort. This means that simply attaining minimum values do not guarantee a “safe” design. With growing information about transportation safety, including vehicle performance, driver behavior, access management, and countermeasure effectiveness, it is important to ensure that design standards, guidelines, policies, and practices accurately reflect the state of current knowledge.

Not only does this information need to be incorporated at the national level, but it must be shared with all levels of highway agencies if the resulting changes are to be effectively and widely implemented. This leads to a need for an education program to share updates with the engineering community.

### Recommendations

- Utilize NCRHP Report 500 guides (especially Volumes 5 and 12 which are specific to intersections), the intersection safety strategy brochures and FHWA’s *Desktop Reference for Crash Reduction Factors* to select cost-effective countermeasures that can be incorporated into the intersection design process early to avoid later expensive retrofits.
- At the release of the *Highway Safety Manual*, convene a panel to review national design and signing guidelines for potential revisions to incorporate the latest intersection safety information available in the manual, NCHRP Report 500 guides, and FHWA’s *Desktop Reference for Crash Reduction Factors*.
- Develop and package training that emphasizes new design standards, guidelines, policies, and practices that have been established nationally and internationally in the past few years.
- Identify and promote key personnel to assist agencies (e.g., peer-to-peer) in reviewing and updating intersection design standards, guidelines, policies, and practices to incorporate current knowledge on safety performance.

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## 4.4 Multidisciplinary Nature of Intersection Safety

### Issues

The safety issues faced at intersections are multi-faceted, with potential variations in the users (drivers, pedestrians, and bicyclists), traffic control type (signalized and unsignalized), location (rural or urban), jurisdiction (state or local) and functional class (high-volume arterial or low-volume local road). Furthermore, an equally wide variety in driver behavior (speeding, inattentiveness, failure to yield) and demographics (teen drivers, elderly drivers, children walking or biking to school) can be contributing factors to intersection crashes.

With all these factors, it is clear that no one agency, group, or countermeasure will be able to solve all intersection safety problems. This leads to the recognition that the multidisciplinary 4E approach is best able to address all aspects of the intersection safety problem.

The key to resolving the multifaceted intersection safety problem begins with an approach that encourages cooperation and coordination among the four Es – education, emergency medical services, enforcement, and engineering. Regular meetings involving all disciplines in traffic safety will encourage the sharing of information, plans, and possibly even resources. Ideally, this approach will occur at all levels of government—local, state, and national. While states used an integrated approach to develop their strategic highway safety plans, an important key is to continue the interaction through implementation and evaluation.

### Recommendations

- Organize a national 4E coalition to establish a multidisciplinary discourse to monitor the progress on intersection safety and identify programs that organizations are willing to collaborate on. Participating agencies should represent not only federal agencies but also national organizations representing cities, counties, police and sheriff departments, emergency medical services providers, etc.
- Develop and implement multi-disciplinary intersection safety action plans.
- Develop a startup kit and program materials for state and local agencies. Material should help in the organization and structure of multidisciplinary teams that address state and local intersection issues.
- Contact existing state and local 4E teams that address intersection safety within their communities to learn if and how the teams are meeting objectives. This can include existing NHTSA Safe Community Programs or SHSP implementation teams. Possible team objectives to assess include:
  - Sharing information during meetings, via an email list serve, or on a webpage regarding project and program implementation to encourage agencies to coordinate resources.
  - Discussing observations, findings, and patterns of circumstances and contributing factors that lead to severe intersection crashes, allowing agencies to develop response plans.
  - Sharing crash information about problem locations (e.g., locations with high total crash frequency, severe crash frequency, crash rates, etc.) to develop a coordinated response.

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- Discussing agencies' needs (e.g., selection of corridors where emergency vehicle preemption is added, locations to focus RLR enforcement, etc.)

## 4.5 Marketing Intersection Safety

### Issues

The 2007 FARS data reveal that 8,657 fatalities, out of the 41,059 total fatalities across the nation, occurred at intersections. Yet, there is a lack of awareness by the traveling public and elected officials regarding the actual risks that accompany negotiating intersections, which often represent the most complex areas in the transportation system. Redefining intersection safety as a public health problem and a quality of life issue is necessary to change the mindset of the public. In doing so, the public can help provide the grass-roots support needed to fund and implement intersection safety programs, especially programs that may be currently controversial in some communities.

Agencies should consider a variety of material and techniques to communicate the problem to the public and elected officials, with the objective of increasing their awareness and changing their perceptions about intersection safety. Educational messages may be provided in print, broadcast on radio or TV media, or through local presentations to community groups and schools. Marketing intersection safety should also extend to other road users, such as pedestrians and bicyclists. School children and the seniors should be targeted, because they may have higher risks when navigating an intersection as a pedestrian or bicyclist.

### Recommendations

- Create a 5-year plan to develop and broadcast education messages. This should include working with Congress to identify dedicated funding in the next transportation reauthorization.
- Establish a coalition of safety partners to create and maintain an on-line clearinghouse of intersection safety education materials.
  - The clearinghouse should be easy to locate, accessible, and maintained with current information. Material in the clearinghouse should address multiple audiences, including the public and specific audiences such as elected officials, high-risk drivers, and young or aging drivers. The material should also consider the unique needs of different locations (urban versus rural) and types of traffic control (i.e., signalized, unsignalized, and roundabout).
  - To use available resources effectively, work with the PBIC and others in the FHWA Office of Safety to jointly market intersection safety educational materials along with pedestrian safety intersection materials.
- Create new or enhance existing NHTSA Safe Community Programs to address local intersection safety problems. Provide support and information to elected officials, agencies, and the general public.
- Fund local agencies for intersection safety marketing to develop grass-roots support for intersection programs and raise awareness.

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- Identify an “intersection safety champion” to promote intersection safety programs and countermeasures and raise safety awareness.
  - At statewide, regional, and national meetings and conferences, include an intersection safety message.