Pedestrian Safety

Report to Congress

Federal Highway Administration
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GLOSSARY OF TERMS

Concept validation – Following the identification of an idea for a new technology, this is the first phase in the actual development of a new technology. In this phase, the developer determines on paper that the concept does indeed have the potential to resolve the problem. The developer then develops and tests a prototype to demonstrate that implementing the technology is feasible and that the concept works.

Deployment phase – This is the final phase of a technology's development process. A technology is in the deployment phase when it has been validated, prototyped, tested successfully, has had all major implementation issues resolved, and is ready to be deployed in a real-world setting to solve the problem for which it was designed.

Developmental phase – This is the second stage in the technology development cycle. Once the concept validation phase has been completed, a critical assessment of the technology is performed on a prototype or experimental system and a demonstration of the technology is performed to identify and resolve problems.

Global technical regulation (GTR) – A global technical regulation is an international agreement on automobile safety standards that is used by vehicle manufacturers throughout the world. The agreement is founded on a 1988 legal framework to facilitate the adoption of uniform conditions for the manufacturing and approval of motor vehicles, their equipment, and parts. Twenty-one countries, including the United States, Canada, Japan, China, Korea, Australia, New Zealand, South Africa and many European countries, as well as the European Community, have ratified the 1988 Agreement, and vehicle manufacturers in these countries are required to meet the automobile safety standards set forth under the regulation.

Intersection-related pedestrian fatality – A death that occurs on an approach to an intersection and results from an activity, behavior, or a traffic control device – such as a signal or a stop sign – related to movements of traffic through the intersection.

Mid-block crossing – A pedestrian crosswalk that is located between signalized or stop-controlled intersections.

Multilane crossings – A pedestrian crosswalk that spans two or more lanes of traffic.

Pedestrian-vehicle conflict – This occurs when a vehicle is attempting to cross a roadway when pedestrians are present. The conflict may be as minor as the vehicle stopping short to avoid a pedestrian or as significant as a pedestrian being struck by a vehicle while walking in the crosswalk.

Pre-deployment phase – This stage of the technology development cycle follows the developmental phase and involves evaluating and validating the effectiveness of the technology for its intended application. During this phase, issues and barriers associated with reliability, costs, competitiveness, liability, specifications, and maintenance requirements are identified and addressed.

Signalized intersections – An intersection that depends on traffic signals, usually electric, to indicate which traffic has the right-of-way at any particular time.

Stop-controlled intersection – An intersection with one or more stop signs. Two-way and four-way stops are common.

Traffic control device – Signs, signals, pavement markings and other devices placed along highways and streets to control the movement of vehicles and pedestrians safely and efficiently. These devices are placed in key locations to guide traffic movement, control vehicle speeds and warn of potentially hazardous conditions.

EXECUTIVE SUMMARY

This report was prepared in response to the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), Public Law 109-59, Section 2003(e), which requires the Secretary of Transportation to produce a comprehensive report on pedestrian safety. It builds on the current level of knowledge of pedestrian safety countermeasures by identifying the most effective advanced technology and intelligent transportation systems, such as automated pedestrian detection and warning systems (infrastructure-based and vehicle-based), road design, and vehicle structural design improvements, that could potentially mitigate the crash forces on pedestrians in the event of a crash. Pursuant to Section 2003(e), the report also includes recommendations on how new technological developments could be incorporated into educational and enforcement efforts and how they could be integrated into national design guidelines developed by the American Association of State Highway and Transportation Officials and the Federal Highway Administration.

Pedestrian injury and fatality statistics from the Fatality Analysis Reporting System (FARS), a database maintained and updated annually by the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA), can be used to illustrate the extent of the problem. These data indicate that of the 42,642 total highway deaths that occurred on U.S. highways in 2006, 4,784 were pedestrian deaths.

The report found that nearly all of the technologies and improvements assessed are in some stage of development and are not yet market ready. They almost universally require additional research and extensive field testing to demonstrate and evaluate the benefits and feasibility of deploying the systems in a live environment. These research and test results are essential in order to accurately identify the most effective advanced technologies and intelligent transportation systems to prevent or mitigate pedestrian crashes. Further research is also necessary to determine the most appropriate locations where each type of technology should be deployed to maximize a technology's potential for improving pedestrian safety. States and localities need this information to match the proper corrective technology to the specific pedestrian crash problems they face to assure the greatest safety impact in the most cost-efficient manner.

Once proven, these technologies may be incorporated into education and enforcement efforts, including outreach programs needed to increase public awareness of how the technologies work and how they are used to improve pedestrian safety. Law enforcement officials will also need to be educated as to how the technologies tie into enforcement efforts, and enforcement of the pedestrian right-of-way within the context of these new technologies should be encouraged to reinforce proper motorist and pedestrian behavior.

In the area of advanced vehicle design, NHTSA has been working with the international community to develop a global technical regulation (GTR) on pedestrian safety that is designed to reduce head and leg injuries when a pedestrian is hit by the front of a vehicle. NHTSA has concluded the technical work to develop the GTR and is preparing to establish the regulation by November of 2008 by consensus voting of the contracting parties to the 1998 Agreement under WP.29 (the forum under which NHTSA has been developing the regulation). A Notice of Proposed Rulemaking (NPRM) will be initiated within a few month of the November vote.

The integration of advanced pedestrian safety technologies into national design standards will require successful completion of the field tests and research needed to validate their benefits and feasibility. Therefore, efforts to integrate the advanced technologies to improve pedestrian safety discussed in this report into national design guidelines should await the completion of field tests and research that clearly establish the benefits and feasibility of each technology.

1. BACKGROUND

In 2005, Congress passed in law a new authorization of surface transportation programs, the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), Public Law 109-59. Section 2003(e) of this legislation reads as follows:

SEC. 2003. HIGHWAY SAFETY RESEARCH AND OUTREACH PROGRAMS

(e) PEDESTRIAN SAFETY.—

(1) IN GENERAL.—The Secretary shall—

(A) produce a comprehensive report on pedestrian safety that builds on the current level of knowledge of pedestrian safety countermeasures by identifying the most effective advanced technology and intelligent transportation systems, such as automated pedestrian detection and warning systems (infrastructure-based and vehicle-based), road design, and vehicle structural design that could potentially mitigate the crash forces on pedestrians in the event of a crash; and

(B) include in the report recommendations on how new technological developments could be incorporated into educational and enforcement efforts and how they could be integrated into national design guidelines developed by the American Association of State Highway and Transportation Officials.

(2) DUE DATE.—The Secretary shall complete the report under this subsection not less than 2 years after the date of enactment of this Act and submit a copy of the report to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Transportation and Infrastructure of the House of Representatives.[1]

This report is designed to satisfy the stated legislative requirement.

The contents of this document are largely derived from a more extensive Federal Highway Adminstration (FHWA) technical report whose purpose was to identify the most promising advanced technologies being developed to improve pedestrian safety. In developing that technical report, information was obtained from three sources: 1) a literature search to identify and secure information on advanced technologies that may improve pedestrian safety, 2) structured interviews with FHWA personnel who have pedestrian safety responsibilities, and 3) the FHWA's Highway Safety Information System (HSIS) and the National Highway Traffic Safety Administration's (NHTSA) Fatality Analysis Reporting System (FARS) databases. Information from the databases served to define crash characteristics and estimates associated with the potential technologies. A meeting was held with select FHWA personnel to gain their input on the initial draft plan. After updating the initial draft plan to include the input, the plan was shared with a select group of stakeholders outside of FHWA to gain their input, and the final draft plan incorporates the input received from those stakeholders. This document includes that input.

[1] Public Law 109-59: Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy For Users, August 10, 2005.

Defining the Problem

As a starting point, a basic understanding of the characteristics of the problem is important. Data from the FARS database show that of the 42,642 total highway deaths that occurred on U.S. highways in 2006, 4,784 were pedestrian deaths.

To provide a frame of reference for the issue of pedestrian safety in its entirety, some key statistics from the 2006 FARS database associated with these 4,784 pedestrian deaths are as follows[2]:

- 1,145 pedestrian deaths occurred at intersections, were intersection-related, or were intersection/intersection-related and occurred within interchanges. This number is broken down as follows:
    - 542 pedestrians died at signalized intersections.[3]
        - Of these, 164 died while attempting to cross four or more lanes of traffic.
        - Of these, 395 died on urban arterials and 61 died on urban local roads.
    - 135 pedestrians died at stop-controlled intersections (i.e., intersections with one or more STOP signs).[4]
    - 468 pedestrians died at intersections with neither signs nor signals, with traffic control devices that did not influence the crash, with unknown traffic control devices, or in circumstances where the relationship between the crash and the intersection was not known.
- 3,388 pedestrians died at mid-block locations (i.e., between intersections).
    - 1,422 pedestrians died trying to cross 2 to 3 lanes of traffic.
    - 1,966 pedestrians died trying to cross 4 or more lanes of traffic.
- 275 pedestrians died at other locations such as driveways and entrance/exit ramps of interchanges.

While the actual speeds in each individual crash are not known from the crash data, the speed limit may be considered an indicator of the prevailing speeds on the highway. As speeds increase, the severity of pedestrian crashes generally increases: 2,770 of the 4,784 pedestrian deaths occurred at locations where the speed limit was equal to or greater than 40 mph. However, special pedestrian crash studies conducted by NHTSA and other countries in support of a United Nations global technical regulation (i.e., an international agreement on automobile safety standards) show that about 50 percent of all child and about 40 percent of all adult head and leg injuries were sustained at crash velocities at or below 40k/hr (25 mph).[5]

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[2] Data in this section were derived from the "Fatality Analysis Reporting System Encyclopedia," maintained by the National Highway Traffic Safety Administration, and contains data from 2006, the most recent year available to the public at the writing of this report.
[3] There are probably additional pedestrian fatalities that occurred at signalized and stop controlled intersections, but determining these numbers is not possible due to insufficient data.
[4] Ibid.
[5] PS-131, "Analysis of Pedestrian Accident Situation and Portion Addressed by this GTR - 8th GRSP Ad Hoc Meeting, Brussels, Belgium, July 11 – 14, 2005." http://www.unece.org/trans/main/wp29/wp29wgs/wp29grsp/pedestrian_8.html

Time of day also plays a role in pedestrian fatality levels. The distribution of pedestrian deaths by known light conditions[6] is as follows:

- 1,224 pedestrian deaths during daylight hours.
- 3,290 pedestrian deaths during the night, with 1,623 on highway sections which were lighted.
- 210 pedestrian deaths during dusk or dawn, as described by police reports.

From the above information some of the major concerns are as follows:

- Intersections, particularly those that are signalized and involve multilane crossings.
- Mid-block crossings, which account for over 70 percent of the fatalities.
- Multilane crossings, both mid-block and at intersections.
- High-speed approaches to pedestrian crossings.
- Night pedestrian fatalities.

Select demographic information from the FARS data system and NHTSA publications are as follows:

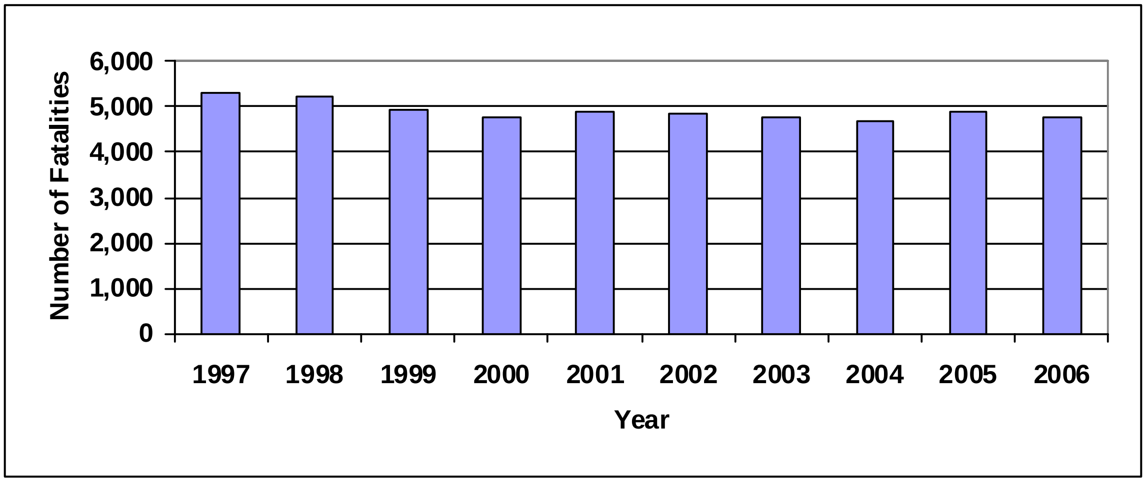
- More than two-thirds of pedestrian deaths were males.
- Approximately half of pedestrian fatalities occurred on the weekend.
- Approximately 40 percent of pedestrian fatalities occurred between 6:00 p.m. and 11:00 p.m.
- Nearly 20 percent of pedestrian fatalities were the result of hit and run crashes.
- Nearly 75 percent of pedestrian fatalities occurred in urban areas.
- The number of traffic fatalities and the population-based fatality rate for 2006 were as follows:

Age Range	Number of Fatalities*	Population (thousands)	Fatality Rate**
0-15	369	60,754	0.60
16-34	1,179	82,851	1.42
35-54	1,703	86,945	1.96
55-74	941	50,504	1.86
75+	530	18,344	2.89

* There were 62 pedestrian fatalities in which the age of the victim was unknown or not reported.
**Deaths per 100,000 people.
Source: U.S. Census Bureau, "2006 Population Estimates," DP.1 General Population Characteristics, and the National Highway Traffic Safety Administration, Fatality Analysis and Reporting System, "Persons Killed, by Age – State: USA, Year: 2006."

In sum, over the past 10 years, approximately 50,000 pedestrians have died and over a half million have been injured, illustrating the significance of the pedestrian crash problem over time. This is shown in the chart on the next page.

[6] There were 4,724 pedestrian deaths in which the light conditions were recorded, but 70 deaths occurred in light conditions that were unknown or not reported.



Pedestrian Fatalities by Year

The following section identifies some major concerns associated with pedestrian fatalities and serious injuries that may be influencing these numbers.

Primary Concerns

Pedestrian crashes involve a number of factors or conditions that increase the potential for a crash. Some of the primary concerns assembled from the literature and crash data are as follows:

Drivers

- Drivers in situations of increased driving tasks, particularly on multilane highways in urban areas, where the ability to recognize and react to a pedestrian can be compromised. This risk can be heightened if the driver's cognitive abilities are reduced due to age, alcohol or drug impairment, sickness, fatigue, inattentiveness, drowsiness, and/or distractions.
- Drivers who become increased risks to themselves and other people on the highway due to aggressive driving and speeding.
- Drivers who cannot readily see pedestrians at night in sufficient time to reduce potential collisions due to combinations of poor visibility, atmospheric conditions, and headlight limitations. Combinations of these factors can result in drivers overdriving their headlights in terms of being capable of seeing and stopping before striking poorly visible pedestrians at speeds of 35 mph or less.

Pedestrians

- Pedestrians who disobey traffic control devices such as "walk/don't walk" signals, do not use established cross walks, or are not vigilant as they cross the roadway.
- Pedestrians who are in a reduced cognitive state due to alcohol or other drug impairment.
- Pedestrians who, as a matter of need, must cross a major, high-speed roadway.
- Pedestrians who perceive that oncoming drivers will see them at night because they see the headlights of oncoming vehicles.

- Pedestrians who are less mobile and more prone to sustain life-threatening injuries due to age, disabilities, or other physical conditions.

Infrastructure

- Sections of roadway that have increased potential for pedestrian fatalities and serious injuries due to combinations of pedestrian volumes, high approach speeds and traffic volumes, and the number of lanes that pedestrians must cross.
- High volume signalized intersections where pedestrians must compete with vehicles even during the pedestrian phase to safely cross the highway.
- Intersections that provide inadequate pedestrian separation from vehicles by means of refuge islands at the halfway point in multi lane crossings.
- The pedestrian's perception that the wait will be too long or that the signal call buttons are ineffective, leading to attempted pedestrian crossings against oncoming full-speed traffic.

Environment and Unforeseen Events

- Sections of roadway that may have frequent, but unpredictable surges of pedestrian activity that are a surprise to oncoming motorists, particularly if they occur at night.
- Inclement weather or decreased visibility due to time of day or other environmental factors can affect drivers' ability to see and stop for pedestrians.

Vehicles

- Vehicle front-end designs that can intensify the extent of the injury and increase the potential for a pedestrian fatality.
- Pedestrians and children who walk behind large vehicles such as SUVs may be injured by vehicles that are backing up.

Interactions and Data Issues

- Combinations that involve two or more of the above factors may substantially increase the potential for a severe crash. As an example, a combination of a drowsy driver entering a signalized intersection with a green indication at night with a pedestrian crossing against the signal increases the probability that a pedestrian crash will occur.
- Pedestrian crash data to base countermeasure evaluations on, including exposure levels, is limited at best.

2. The Role of Advanced Technologies

In this report, the term “advanced technology” refers to new technologies that are infrastructure-based (existing exclusively as part of the roadway) or vehicle-based. Their purpose is to warn drivers about the presence of pedestrians and enable pedestrians to walk more safely in areas that may or may not be designated specifically for pedestrian use. If properly integrated, these technologies can complement traditional safety strategies and help reduce pedestrian fatalities and incapacitating injuries. Tables 1 and 2 provide summaries of pedestrian crash problems and advanced technology strategies for each of the scenarios as well as the technology’s stage of development.

The development of highway-based technologies is led by government (predominantly Federal and State) organizations. Vehicle-based technologies are developed by the private sector with government (predominantly Federal) involvement in coordination, basic research, and standards development. Many of the infrastructure-based and vehicle-based advanced technologies have the potential to undergo deployment within the next 10 years.

Technologies must progress through several stages between conceptualization and deployment. The first of these steps is **concept validation**, in which it is determined that a concept has the potential to resolve the problem. Once this is determined, the technology enters the **developmental** phase, in which a critical assessment of the technology is performed on a prototype or experimental system. The developmental phase is followed by the **pre-deployment** phase, which involves evaluating and validating the effectiveness of the technology. Once the pre-deployment stage proves that the technology is valid and effective, the technology is then ready for the full **deployment** phase.

Most of the potentially successful advanced technology strategies identified in tables 1 and 2 are in the pre-deployment or the developmental stages and require additional technological analyses and advances before widespread deployment can occur.

Table 1: Infrastructure-Based Advanced Technology

Pedestrian Crash Problem	Advanced Technology Strategy	Stage of Development
Pedestrian crossing intersection or roadway – General	Passive sensors to recognize pedestrians and activate pedestrian assistance and/or warning systems	Pre-Deployment Phase Developmental Phase
Signalized intersection crossing	Pedestrian countdown signal	Deployment Phase
Signalized intersection crossing – Pedestrian struck by through vehicles	Automatic extension of the walk signal	Pre-Deployment Phase
Signalized intersection crossing – Pedestrians struck by turning vehicles	Pedestrian scramble activation, pedestrian head start phasing	Pre-Deployment Phase
Signalized intersection crossing – Right turn on red collisions	Pedestrian-activated no right turn on red LED signs or red light arrow	Developmental Phase
Mid-block crossing and unsignalized intersection crossings.	Automated detection and activation of in-pavement crosswalk lighting, overhead lighting, LED warning signs for oncoming drivers, variable speed limit signs, and high-intensity crosswalk signals.	Pre-Deployment Phase Deployment Phase
Pedestrian crashes on Interstates and freeways	Night pedestrian recognition systems	Concept Validation Phase

Table 2: Vehicle-Based Advanced Technology

Pedestrian Crash Problem	Advanced Technology Strategy	Stage of Development
Pedestrian injury severity	Vehicle front-end design to reduce pedestrian injuries in crashes, vehicle parking aids, in-vehicle pedestrian sensors	Pre-Deployment Phase*
Pedestrian night crashes	Night vision in vehicles capable of identifying pedestrians on the road	Pre-Deployment and Deployment Phase

*Note: Two automobile manufacturers (Honda and Mazda) have deployed vehicles with bumpers and hoods designed to reduce pedestrian injury severity, but this is not yet a widespread industry practice.

3. Assessment of Developmental and Pre-deployment Advanced Technologies

The advanced technologies identified in tables 1 and 2 (page 9) will be described and assessed below by crash problem addressed. For each technology identified, this chapter will provide:

1. A brief description.
2. Considerations, including a description of the technology's perceived benefits, continuing concerns that need to be resolved, and a discussion of the potential safety impacts.
3. Where the technology stands in the development process and what needs to be done to advance it to the point it is ready for widespread deployment.

It is important to note that most of the pre-deployment technologies discussed will require additional study of their potential to improve safety as a pre-requisite to deployment. Such study is necessary to establish the benefits, costs, and performance characteristics of the systems so that localities that are seeking solutions to their pedestrian crash problems will be able to identify the technology that is most likely to resolve their problem. Such guidance will both identify the appropriate technology to improve pedestrian safety in locations with specific crash characteristics and will also help budget-conscious localities determine where the technology can be most cost-effectively deployed.

Pedestrians Crossing Intersections or Roadways in General

Passive Pedestrian Sensors

Passive Pedestrian Sensors detect pedestrians passively. The pedestrian does not have to push a button to be recognized; sensors detect the pedestrian and activate a traffic control device to improve pedestrian protection as the pedestrian crosses the street or highway. The principal benefit of a passive pedestrian sensor is that 100 percent of the pedestrians who are detected by the sensor activate the pedestrian traffic control device, not just those pedestrians who would manually push the call button. The level of non-activation of a pedestrian device by pedestrians at signalized intersections and mid-block crossings is variable depending on the age and type of pedestrian, cycle length and pedestrian wait time, traffic flow level and vehicle speeds, number of travel lanes to cross, crossing difficulty, and other factors, including whether the pedestrian is physically impaired to the point that he or she is unable to push the call button.

Passive pedestrian sensors are an advanced technology that may be used or are a prerequisite for use in several of the systems that are described in this chapter. Their use may improve overall pedestrian safety in a variety of settings due to the 100 percent detection rate and the activation of the pedestrian phase regardless of the type of crossing.

A number of commercially available passive detection systems exist that use technologies that are sometimes combined so that one system will detect pedestrians on the curbside and another will detect pedestrians in the crosswalk. Each of the systems has issues of costs and reliability in terms of capability to detect 100 percent of the pedestrians. Additional advances in these technologies and the potential to use video imaging processing to detect pedestrians are underway by the private sector.

Considerations

Benefits

1. Existing installations indicate that there are a variety of technologies available to detect pedestrians. A number of these technologies have been deployed at select sites throughout the United States, including Portland, Oregon, Los Angeles, California, Phoenix, Arizona, and Rochester, New York.
2. The multistate database that records crash, roadway inventory, and traffic data for selected States, called the Highway Safety Information System (HSIS), suggests that pedestrian crashes both at intersections and mid-block. About 25 to 35 percent of the total crashes are limited to a relatively small number of locations where advanced technologies can probably be deployed to impact the problem cost effectively.
3. While no crash evaluation data can be found, passive pedestrian sensors should create higher compliance with pedestrian devices since close to 100 percent of the pedestrians will activate the system, not just those who push the button. Therefore, the number of pedestrian-vehicle conflicts should be reduced.
4. Passive pedestrian sensors at **signalized intersections** can:
    a. Be used in combination with LED signs or traffic signal control processes that prohibit turns across crosswalks when pedestrians are present.
    b. Activate lighting to increase pedestrian visibility at night.
    c. Confine the pedestrian phase to the time that pedestrians are in the crosswalk.
5. Passive pedestrian sensors at **mid-block locations** can:
    a. Activate lighting to make the pedestrian more visible.
    b. Activate LED pedestrian warning signs until the pedestrian clears the crosswalk.
6. When combined with other technologies, such as those described in items 4a-4c and 5a-5b above, this technology has the potential to substantially improve pedestrian safety.

Concerns

1. The current average installation cost range of installed, pedestrian passive sensors systems ($15,000 to $20,000) may make it difficult to address a large number of pedestrian crossings.
2. The safety effectiveness of the passive pedestrian systems, particularly in comparison to pedestrian activated (e.g., call button) systems, is unknown.
3. New, in-vehicle technologies may supplant the infrastructure-based technologies at some time in the future, creating redundancies.
4. Hardware standards and specifications along with algorithms to detect a pedestrian do not exist for some technologies.
5. Pedestrian sensor systems are in a state of evolution, with no technologies that are clearly superior to others. During this developmental stage it would be imprudent to undertake massive deployment of a technology that could be obsolete a few years from now.

Potential Safety Impacts

One early study conducted by FHWA on the safety impact of pedestrian sensors assessed reductions in vehicle and pedestrian conflicts at intersections between push-button activated crosswalk signals and push-button activated signals with automated detection. The study found that there was an 81 percent decrease in the number of pedestrians crossing during the “Don’t

Walk" phase with the addition of automated detection to intersections with operational push buttons. The study found that during the first half of the crossing, pedestrian-vehicle conflicts were reduced by 89 percent, while conflicts for the second half were reduced by 42 percent. Pedestrian-vehicle conflicts associated with right turning vehicles were reduced by 40 percent.[7]

However, it should be noted that the number of sites upon which these results are based is small (only three locations), and pedestrian performance can vary widely across sites. The study also did not assess any links between increased compliance and decreased pedestrian crashes. Additional studies, at a wider variety of sites, need to be conducted to assess these and other operational and safety variables.

Advancing and Deploying Passive Pedestrian Sensor Technology

In order for the technology to be advanced toward deployment, a major demonstration and validation effort must be undertaken to evaluate the benefits, reliability, costs, and performance of passive pedestrian sensors. Following the validation process, enhancements leading to improved sensor reliability should lead to wider deployment and reduced costs.

Implementation of the system would be facilitated by the development of guidance to identify pedestrian crossings where the technology can be cost effectively deployed and by determining typical contract specifications that a designer could use.

As part of the eventual deployment process, it would be advisable to develop a marketing campaign designed to promote the deployment of passive pedestrian identification systems by State and local governments, primarily at pedestrian crossings with a high potential for pedestrian crashes. Once deployed, pedestrian and driver education about these sensor systems and how they are used alone or in conjunction with other technologies will be necessary to achieve the full safety benefit. Law enforcement support for the pedestrian right-of-way should also be secured to reinforce proper motorist behavior.

Signalized Intersection Crossings

Pedestrian Countdown Signals

These systems provide pedestrians with the remaining seconds available before the pedestrian phase ends. They can function with passive or pedestrian activated pedestrian sensors or fixed time signals. Pedestrian countdown signals are in the deployment stage, have been widely but sporadically deployed in a number of States and municipalities, and are accepted by both pedestrians and motorists who can see how much pedestrian crossing time remains.

[7] Hughes, Ronald, et al., *Evaluation of Automated Pedestrian Detection at Signalized Intersections*, prepared by the University of North Carolina (Highway Safety Research Center) for DOT, Report No. FHWA-RD-00-097. Washington, DC: August 2001.

Considerations

Benefits

1. San Francisco's pedestrian countdown signals have been associated with a 52 percent reduction in pedestrian injury collisions at pilot locations; in addition, about 92 percent of post-installation interviewees explicitly said the countdown signals were "more helpful" than conventional pedestrian signals, primarily because they showed the time remaining to cross.[8] This is consistent with recent FHWA research that showed that a pedestrian sample strongly preferred the countdown signal to actual and theoretical versions of pedestrian signals, and that the countdown version was "most easily understood."[9]

Pedestrian Countdown Signal

2. Existing installations indicate that the technology is relatively straightforward and easy to apply.
3. Initial before and after observations for communities or highways where pedestrian countdown signals are installed indicate generally mixed results regarding compliance with walk signals; however, there were fewer observations of pedestrians having to run once in the crosswalk.[10] [11] [12]

Concerns

1. Only one limited evaluation was found that assessed the effectiveness of countdown signals to reduce pedestrian crashes.[13] Conducting a crash-based analysis of a countdown signal would require hundreds or thousands of test sites in order to have an adequate sample of pedestrian crashes.
2. It is possible that the use of pedestrian countdown signals may increase some types of pedestrian crashes. Some drivers, who can see the device counting down, may use it as an indicator, independent of the stoplight, to step on the accelerator as soon as the countdown displays zero seconds. In such a case, a pedestrian who is still in the process of crossing the street may be struck by this motorist.

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[8] Markowitz, F., S. Sciortino, J.L. Fleck, and B. M. Yee, "Pedestrian Countdown Signals: Experience with an Extensive Pilot Installation," *ITE Journal*, 76, no. 1 (2006).

[9] Pedestrian Safety Guide and Countermeasure Selection System Web site, "Pedestrian Countdown Signals" (case study 2), http://www.walkinginfo.org/pedsafe/case_studies2.cfm?op=C&subop=f&CM_NUM=38

[10] J. L. Botha, "Pedestrian Countdown Signals: An Experimental Evaluation," City of San Jose Department of Transportation, May 2002. http://www.sanjoseca.gov/transportation/forms/report_pedcountdown.pdf

[11] H. Huang and C. Zegeer, *The Effects of Pedestrian Countdown Signals in Lake Buena Vista*, Florida Department of Transportation, November 2000. http://www.dot.state.fl.us/Safety/ped_bike/handbooks_and_research/research/CNT-REPT.pdf

[12] PHA Consultants, "Pedestrian Countdown Signal Evaluation – City of Berkeley," City of Berkely, CA, July 2005. http://209.232.44.21/transportation/Reports/PedestrianCountdownSignalReport2_July%202005.pdf

[13] F. Markowitz, S. Sciortino, "Pedestrian Countdown Signals: Experience with an Extensive Pilot Evaluation," *ITE Journal*, 76, no. 1 (2006).

Potential Safety Impacts

The impact of pedestrian countdown signals on pedestrian safety, including pedestrian-vehicle conflicts resulting in pedestrian fatality or injury, has not been widely studied in part due to the small number of intersections where the technology has been deployed and the nature of the limited studies that have been conducted to date.

In a San Francisco deployment study, only 17 percent of pedestrians interviewed after deployment of the pedestrian countdown signals understood that it is a pedestrian violation to start crossing during the countdown, when the red hand is flashing. This compares to 40 percent in the pre-installation study.[14] These numbers suggest that pedestrians are using the countdown signals to decide when to begin crossing the street. Perhaps more significantly, it underscores that a substantial proportion of pedestrians do not understand pedestrian signals, and that a greater emphasis on educating the public on how to cross streets at pedestrian crossings is appropriate.

Advancing and Deploying Pedestrian Countdown Signals

Although limited deployment of this technology has already taken place, there are several steps that need to be taken to promote wide-scale deployment. The first step would be to establish a plan to validate the effectiveness of the countdown signals in terms of reducing non-compliance with pedestrian signals (i.e., pedestrians walking against the don’t walk signal). Next steps include improving public understanding of the pedestrian phase designations, validating the actual effectiveness of countdown signals to reduce pedestrian crashes, and reducing pedestrian-vehicle conflicts in crosswalks. Such a validation evaluation could be undertaken using existing and planned installations.

After validation, a study to determine the characteristics of those signalized intersections where it would be beneficial to install pedestrian countdown signals would be advisable. Additionally, as with the pedestrian sensor technology, typical contract specifications, including hardware, software, and algorithm/operational requirements that a public body could use to deploy the technology must be developed. Another action that would lead to effective deployment would be to establish a guidance document, including a model training program, for both operators and end users to ensure proper maintenance and operation of the system.

Finally, to reap the full safety benefit from deploying pedestrian countdown signals, localities that install these systems should be encouraged to undertake public education campaigns to inform pedestrians about how the technology works and advise them of when it is and when it is not safe to cross an intersection based on the phases displayed by the countdown signal.

Signalized Intersection Crossing – Pedestrians Struck by Through Vehicles

Automatic Extension of the Pedestrian Signal

This technology incorporates a passive pedestrian detection system that senses pedestrians who enter the crosswalk at the end of the pedestrian phase and extends it for a period of time that will allow the pedestrian to reach the end of the crosswalk. This system may be particularly

[14] Ibid.

beneficial at signalized intersections where there is a wide range of walking speeds among pedestrians, such as those with concentrations of older pedestrians, disabled pedestrians, or very young pedestrians.

Although automatic detection and extension of the walk signal for pedestrians have been used successfully in Europe and Australia for many years, such applications are still in the pre-deployment stages in the United States. To date, the system has been deployed at two intersections in Los Angeles and was recently installed in San Francisco, Las Vegas, and Miami. Preliminary results from studies of these installations are expected in spring of 2008, but no evaluation of the system is currently available.

Considerations

Benefits

1. Intersections where this technology is appropriate to consider include crosswalks with pedestrians who have less mobility and crosswalks that have high peaking volumes of pedestrians where some pedestrians occasionally get trapped in the crosswalk.
2. Once passive pedestrian sensors are more fully developed, this technology can be readily considered at many intersections.
3. The system will have the ability to cancel or shorten the call for the pedestrian signal if the pedestrian leaves the area, or if the pedestrian completes the crossing in a speedy manner. This can help prevent congestion caused by extended walk signal times.

Concerns

1. No data systems were identified that could either determine the level of pedestrian crashes at signalized intersections where a vehicle turning to the right in the crosswalk struck the pedestrian after the signal changed, or help identify intersections where it would be cost beneficial to consider this type of installation.
2. In coordinated systems, signal coordination will be more difficult to achieve.
3. In congested urban areas with heavy pedestrian traffic, a constant flow of pedestrians activating extended walk phases may contribute to congestion.

Potential Safety Impacts

This technology would be particularly advantageous for individuals who are disabled, elderly, very young, or unable to cross the street during the entire pedestrian phase.[15] However, no studies examining the safety benefits of the technology have been identified to date.

Advancing and Deploying Automatically Extended Walk Signals

As with the other technologies previously discussed, further assessments need to be made to determine the conditions where application of this technology would be appropriate, although it appears to have the most potential for reducing pedestrian-vehicle conflicts at intersections where there are a large number of elderly, disabled, or very young pedestrians who are unable to cross the street within the time normally allotted for the pedestrian phase. To this end, an evaluation of the costs and benefits of the automatic extension of the walk phase technology compared to the pedestrian

[15] Federal Highway Administration, *Manual on Uniform Traffic Control Devices*, 2003 Edition, Revision 1, Chapter 4E. Pedestrian Control Features, Section 4E.10, http://mutcd.fhwa.dot.gov/HTM/2003r1/part4/part4e.htm.

countdown signal technology needs to be made to identify the types of intersections and conditions where use of the automatic extension of the walk phase is preferable, where it could be used in conjunction with pedestrian countdown signals,[16] or where pedestrian countdown signals alone are adequate.

Assuming that a reasonable number of signalized intersections where this technology (or where this technology is in conjunction with pedestrian countdown signals) is preferable and cost effective to install are identified, and also assuming that further maturing of pedestrian passive sensors occurs, a technology demonstration should be considered to evaluate the costs and performance of the system to determine its effectiveness at reducing trapped pedestrians.

Signalized Intersection Crossing – Pedestrians Struck by Turning Vehicles

Exclusive Pedestrian Phasing

Exclusive pedestrian phasing, also called "pedestrian scramble," has been generally used in a number of downtown areas with large concentrations of pedestrians using a manual call button. The exclusive pedestrian phase stops all vehicular movement and allows pedestrians access to cross in any direction at the intersection, including diagonally. An exclusive pedestrian phase that incorporates advanced technology would be able to recognize the conditions under which the pedestrian phase would be appropriate based on such factors as time of day, vehicle volume, pedestrian presence, etc. The system would activate when the pedestrian phase is activated, either by pedestrians pushing a button or by being passively detected by sensors, and during conditions that would not create or contribute to congestion. Pedestrian phase activation could be further refined to prohibit pedestrian-vehicle conflicts in crosswalks (e.g., prohibiting all turns) and allowing other non-conflicting vehicle movements to occur or continue in tandem with the activation. Although exclusive pedestrian phasing has been widely deployed, the advanced technology aspect of this system is in the concept development phase and needs further conceptual evaluation before moving forward.

An alternative to the exclusive pedestrian phase concept is to prohibit left and right turning vehicles moving in parallel to the crosswalk from turning when a pedestrian is detected in the crosswalk by a passive pedestrian sensor. This system activates LED turn prohibition signs when pedestrians are detected.

Considerations

Benefits

1. The technology to apply exclusive pedestrian phases has been widely used and is readily available for installation.
2. Prohibiting turning vehicles from moving across the crosswalks when pedestrians are detected using passive pedestrian sensors would decrease the impact on congestion (no queued cars

[16] It is envisioned that, with this combination, once the pedestrian countdown reached zero and a pedestrian was still detected in the crosswalk, the countdown signal would hold at zero to keep additional pedestrians from entering the crosswalk, and the signal for oncoming vehicles would be held at red, allowing the pedestrian a few extra seconds to reach the safety of the curb.

waiting for an opportunity to turn) and eliminate the pedestrian-vehicle conflict that may occur during pedestrian non-scramble phases.

Concerns

1. The exclusive pedestrian phase takes away from available green time for vehicle movement. If the intersection is operating close to capacity and a scramble phase is introduced, significant congestion will likely occur.
2. This system is inadvisable for use at intersections that have low to moderate levels of pedestrian crossings during peak vehicle hours because it will lengthen the signal cycle, increasing wait times for pedestrians, delays for motorists, and heightening the potential for pedestrians to cross against the signal.
3. The exclusive pedestrian phase should only be activated when a pedestrian activates a pedestrian push button or when passive sensors detect a pedestrian. However, it is inadvisable to provide exclusive pedestrian phases when the impact on congestion is minimal, but then to allow turning vehicles to cross pedestrian walkways when traffic volumes increase. This may confuse pedestrians, making them unclear about when or whether vehicles are allowed to turn across their path. This could create potentially unsafe conditions.
4. At this time, there are no studies that establish improved pedestrian safety through the use of exclusive pedestrian phasing, and, therefore, there is no way to compare safety benefits to probable delay costs to motorists as a means of determining when it is and is not advisable to provide exclusive pedestrian phases.
5. Because these intersections are complicated for pedestrians and expectations for walk signals are violated, extra educational efforts would be required for areas where this system is deployed, including permanent signage.
6. Concerns also exist for visually impaired pedestrians who rely on traffic sounds to decide when and where to cross.

Potential Safety Impacts

Because exclusive pedestrian phasing causes all traffic to stop, the safety benefit to pedestrians from this technology could be significant due to the virtual elimination of pedestrian-vehicle conflicts. However, a rigorous comparison of the pedestrian crash experience between exclusive pedestrian phases and systems that permit parallel traffic to turn across crosswalks during the walk phase of the pedestrian signal could not be found.

Advancing and Deploying Exclusive Pedestrian Phasing

The first step toward effectively advancing and deploying this technology is to perform studies of the technology to determine the safety benefits to pedestrians, the potential costs to motorists in terms of vehicle delay, and the locations where exclusive pedestrian phasing or the prohibition on vehicles turning across an active crosswalk would be most effective to improve pedestrian safety without substantially increasing congestion.

If a positive safety benefit to providing either exclusive pedestrian phases or the prevention of parallel moving vehicles turning across a pedestrian crossing can be determined without substantial adverse impacts on congestion, further examinations should be conducted to evaluate effectiveness in terms of pedestrian compliance.

Pedestrian Head-Start Phasing

Pedestrian head-start phasing, also known as pedestrian lead-in phasing, provides a walk phase to pedestrians prior to providing parallel vehicle traffic with a green light. All directions of traffic see a brief all red phase during this time. Head start phasing is most appropriate to consider in intersections with heavy combinations of pedestrian traffic and right and left turning vehicles across the crosswalk. Pedestrian push button or passive sensors can activate it, and it can be traffic-flow dependent (i.e., not activated during periods of light traffic flow when the frequency of turning vehicles is low). The advanced technology aspect involves the incorporation of passive sensors to activate the system only when a pedestrian is at curbside.

Considerations

Benefits

1. For those signalized intersections where pedestrians frequently cannot get out onto the crosswalk due to heavy, aggressive right turning traffic, the head start allows pedestrians to establish themselves in the crosswalk before right turning traffic can begin moving.
2. This technology can be installed at most intersections without advanced technologies. The use of passive sensors with this technology would mean the pedestrian phase is only activated when pedestrians are present and would provide nearly 100 percent pedestrian detection. In addition, the amount of pedestrian phase time is limited to the amount necessary for pedestrians to cross, which may contribute to reduced congestion.

Concerns

1. Older traffic signals, particularly fixed time signals in cities, may require new controllers at substantial increases in cost to accommodate this technology.

Potential Safety Benefits

This technology is principally beneficial in decreasing pedestrian-vehicle conflicts by allowing pedestrians to establish themselves in the crosswalk before vehicles are shown a green light. The addition of a passive pedestrian sensor to such systems may serve primarily to prolong a green phase in the absence of pedestrians, but the likelihood of the technology improving the safety of pedestrians cannot be known until further studies are conducted.

Advancing and Deploying Pedestrian Head-Start Phasing

At this time, no data systems have been identified that are able either to determine the level of pedestrian crashes at signalized intersections where the pedestrian was struck by a right turning vehicle in the crosswalk at the onset of the pedestrian phase, or to identify intersections where it would be cost beneficial to consider this type of installation.

A critical assessment of the benefits of applying advanced technologies to head-start phasing needs to be made if this concept is to be further pursued. Unless such an assessment yields substantive benefits of applying advanced technologies for a given set of intersections, further efforts to implement this concept with advanced technologies should be deferred. If this assessment indicates substantive benefits, then a demonstration of the concept should be undertaken to evaluate and verify the benefits predicted.

Signalized Intersection Crossing – Right Turn on Red Collisions

Pedestrian-Activated No Turn on Red LED Sign or Red Light Arrow

This system, upon detection of a crossing pedestrian either by push button or passively, would activate a "no turn on red" LED sign or a red light turn arrow signal lens to eliminate the conflict of a stopped right turning vehicle from crossing the crosswalk when a pedestrian is recognized by push button activation or passive pedestrian sensor. This system can be programmed to come on automatically at certain times of the day and be turned off the rest of the time. It can also be incorporated with the exclusive pedestrian phase concept described above by prohibiting vehicles from turning right across crosswalks during the pedestrian phase.

Considerations

Benefits

1. For those signalized intersections where significant conflicts exist with right turning vehicles moving across active crosswalks, the pedestrian activation of a no turn on red LED sign for turning vehicles can eliminate the conflict.
2. The concept can be demonstrated now with pedestrian push button activation.
3. Once the technology's technical issues have been addressed (see section 3.5.1.2 below), it may be possible to extend the concept of restricting right turns across active pedestrian crosswalks to include prohibitions on left turning vehicles across active pedestrian crosswalks.

Concerns

1. If pedestrian activation occurs throughout the pedestrian phase, vehicles will have no time to turn right. This could have a negative impact on traffic flow.
2. An assessment is needed to determine the impacts of a "no turn on red" sign on traffic flow. This assessment should examine the congestion implications for vehicles that are traveling through the intersection as well as vehicles that are turning right at the intersection.

Potential Safety Impacts

Although detailed data on the number of pedestrian injuries and fatalities that occur due to vehicles turning right across crosswalks is not collected by NHTSA's FARS database, that information is collected on a limited basis in the multistate HSIS database, maintained by the FHWA. Data from the State of Illinois, for example, indicate that between 1999 and 2003, 529 pedestrians were struck at urban signalized intersections by right or left turning vehicles.[17] This accounts for about a quarter of pedestrian crashes at urban signalized intersections in that State.

As with exclusive pedestrian phasing, eliminating turning traffic could significantly improve pedestrian safety by reducing pedestrian-vehicle conflicts among vehicles turning right or left across crosswalks. However, no studies could be identified that show a positive safety impact at signalized intersections where traffic is not permitted to turn across crosswalks when compared to intersections where traffic is permitted to turn across crosswalks.

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[17] Highway Safety Information System database, maintained by the Federal Highway Administration. http://www.hsisinfo.org/

Advancing and Deploying Pedestrian-Activated No Turn on Red LED Signs or Red Light Arrows

While the basic advanced technologies are available to implement this concept, there are a number of technical issues that need to be addressed beforehand, including developing algorithms to activate and terminate the "no turn on red" sign, evaluating the impacts to right turning vehicles, and determining the characteristics of intersections where this technology would be most appropriate.

Upon satisfactory resolution of the operational concerns related to the flow of right turning traffic and the impact of the system on both through and right turning traffic, an assessment of passive sensors versus the pedestrian-activated push button should be made to determine if the use of the more advanced technology is beneficial considering the added cost. Once these assessments and evaluations are complete, a field evaluation of the concept should be pursued to demonstrate benefits to pedestrians and resolution of turning traffic operational concerns.

Mid-Block Crossing

For mid-block locations between signalized intersections with significant pedestrian crossings, a mid-block traffic signal or other warning system to provide protection for crossing pedestrians is desirable. There are a variety of advanced technologies that may by themselves and in combination with other advanced technologies substantially improve pedestrian safety between signalized intersections. Some, such as passive pedestrian sensors, pedestrian countdown signals, and automatic extension of the walk signal duration have already been discussed. Other technologies also applicable to mid-block crossings are described below.

Activation of In-Pavement Crosswalk Lighting

These systems are roadway-based and can be activated by either passive pedestrian sensors or push buttons. In-pavement lights are being used at mid-block crosswalks or crosswalks at intersections without stop control devices. Their purpose is to alert motorists to the presence of a pedestrian crossing or preparing to cross the street by using amber lights that are embedded in the pavement on both sides of the crosswalk and are oriented to face oncoming traffic. Once activated, in-pavement lights begin to flash at a constant rate, warning the motorist that a pedestrian is in the vicinity of the crosswalk ahead.

In-Pavement Crosswalk Lighting

Activation of Overhead Lighting

These systems, upon detection or activation by a pedestrian, provide overhead lighting for the crosswalk during the time that the pedestrian is crossing the roadway.

Activation of LED Warning Signs

These systems operate similar to the overhead lighting systems and activate an LED sign warning approaching drivers that a pedestrian is crossing the roadway. They have been demonstrated in Clearwater, Florida, and have resulted in increased driver yielding behavior of

30 to 40 percent during the day and 8 percent at night.[18] Activated LED warning may be combined with activated overhead lighting to provide improved night driver yielding.

Activation of Variable Speed Limit Signs

These systems would automatically reduce the speed limit using variable LED speed limit signs when a pedestrian is detected approaching the crosswalk. This initiative is in the concept validation phase and needs additional development on paper to demonstrate feasibility and validation before a prototype can be built.

Activation of High-Intensity Activated Crosswalk Signals

The high-intensity activated crosswalk (HAWK) signal uses traditional traffic and pedestrian signal heads but in a different configuration. It includes a sign instructing motorists to "stop on red" and a "pedestrian crossing" overhead sign.

Example of a High-Intensity Activated Crosswalk (HAWK) Signal

When not activated, the signal is blanked out. The HAWK signal is activated by a pedestrian push button or passive pedestrian sensor. The overhead signal begins flashing yellow and then solid yellow, advising drivers to prepare to stop. The signal then displays a solid red and shows the pedestrian a "Walk" indication. Finally, an alternating flashing red signal indicates that motorists may proceed when safe, after coming to a full stop. The pedestrian is shown a flashing "Don't Walk" with a countdown indicating the time left to cross.

Benefits

1. There are a considerable number of highway segments that have concentrations of pedestrian crashes within relatively close distances where these technologies can be cost effectively applied.
2. Many of the potential advanced technologies have been demonstrated and performed well.

Concerns

1. A number of the promising technologies are in varying stages of development, making comparisons difficult. As an example, the comparisons between the in-pavement lighting systems and variable message signs activated by passive pedestrian sensors to reduce pedestrian-vehicle conflicts and lower speeds across crosswalks cannot be made directly

[18] U.S. Department of Transportation, Federal Highway Administration, *An Evaluation of High Visibility Crosswalk Treatments – Clearwater, Florida*, FHWA-RD-00-105 (Washington, DC: August 2000).

at this time because the system using variable speed limits is only in the concept validation stage whereas the in-pavement lighting systems have been deployed in a number of locations.
2. New in-vehicle technologies such as the night visibility enhancement systems based upon in-vehicle infra-red technology will create some redundancies and provide in-vehicle warning to drivers regardless of whether a pedestrian is in a crosswalk or whether infrastructure warning systems are activated.

Potential Safety Impacts

With the several potential advanced technologies available, and numerous combinations of these technologies possible, it would be difficult to assess the potential safety impacts of all possible combinations. However, the set of attributes that a combined set of technologies should possess to improve pedestrian safety include:

1. The frequency of crosswalks and attractiveness to pedestrians is such that the vast majority of pedestrians within the vicinity of the crosswalks will use them.
2. The technologies that enhance pedestrian safety are activated for all pedestrians using the crosswalk.
3. The technologies significantly reduce pedestrian-vehicle conflicts.
4. The technologies significantly reduce the level of higher speed pedestrian-vehicle conflicts.

Advancing and Deploying Advanced Technologies for Mid-block Pedestrian Crossings

There are a number of steps that need to be taken to advance the promising technologies discussed above to the point where they can be fully deployed. The first step is for industry to resolve or address the technical issues associated with prototype deployment of candidate technologies, such as determining the optimal level of illumination to light the crosswalk. Once this is done, the next step is to mature the technology such that at least a major comparative demonstration can occur to determine optimum combinations from both a safety and cost perspective. This involves establishing and implementing a comprehensive demonstration plan to compare and validate the effectiveness of candidate systems in terms of reducing pedestrian crash injuries and deaths, pedestrian-vehicle conflicts, and pedestrian activation of the systems. Comparisons between alternate technologies that yield similar types of outcomes will then need to be made to determine the optimum combinations that can improve pedestrian safety cost effectively.

At this point, implementation of the systems will be facilitated by developing guidance to identify highway segments where the technology can be cost-effectively deployed; establishing typical contract specifications including hardware, software, and algorithm requirements that a designer could use to easily develop a design for the system; and establishing a guidance document for end users to ensure proper maintenance and operation of the system.

Once these efforts are complete, a marketing campaign should be undertaken that is designed to promote the deployment of the advanced technologies that State and local governments can use at mid-block pedestrian crossings to improve pedestrian safety. This may serve to increase implementation of the most effective technologies.

Pedestrian Crashes on Freeways

Night Pedestrian Recognition and Warning System

Infrastructure-based night pedestrian recognition systems are in the early stages of conceptualization. Infrastructure-based systems that detect and recognize deer and other large animals have been previously developed and demonstrated in the United States and Europe. These systems use passive or active infrared signals, lasers, or microwaves to activate warning signs that urge drivers to slow down, be more alert, or both, when large animals are on, or near, the road ahead. Such infrastructure systems may be modified to detect pedestrians on the roadway and shoulders of freeways and activate notification systems to reduce the potential for a crash.

Considerations

Benefits

1. One Swiss study showed an 82 percent reduction in collisions with large animals in locations with infrastructure-based, animal-detection systems.[19] If such a system could be modified to detect pedestrians on the roadway and shoulders of freeways and activate notification systems to reduce the potential for a crash, the safety benefit to pedestrians could be significant.
2. The detection of pedestrians on freeways can potentially be woven into strategies developed for incident management.

Concerns

1. To date, the reliability and robustness of experimental, infrastructure-based, animal detection systems tested in the United States has not been high.[20]
2. A false negative or a failed detection reading in an infrastructure-based system that leads to a pedestrian crash could result in liability.

Potential Safety Impacts

Because 3,290 pedestrian deaths in 2006 occurred on highways at night,[21] a technology that can identify pedestrians at night and warn drivers as to their presence, or even provide their location, has the potential to bring about a significant decrease in pedestrian fatalities. However, because these systems are almost all in the concept, validation, or demonstration phase and face many technical hurdles before they can move forward, such potential benefits are unlikely to be realized quickly.

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[19] Kistler, R. 1998. Wissenschaftliche Begleitung der Wildwarnanlagen Calstrom WWA-12-S. Juli 1995 - November 1997. Schlussbericht. Infodienst Wildbiologie and Oekologie. Zürich, Switzerland. Cited in *Animal Vehicle Crash Mitigation Using Advanced Technology Phase I: Review, Design and Implementation*, Huijser, M.P., et al., SPR 3(076). FHWA-OR-TPF-07-01. http://www.oregon.gov/ODOT/TD/TP_RES/docs/Reports/AnimalVehicle.pdf

[20] Huijser, M.P., et al., *Animal Vehicle Crash Mitigation Using Advanced Technology Phase I: Review, Design and Implementation*, SPR 3(076). FHWA-OR-TPF-07-01. http://www.oregon.gov/ODOT/TD/TP_RES/docs/Reports/AnimalVehicle.pdf

[21] "Fatality Analysis Reporting System Encyclopedia," National Highway Traffic Safety Administration, 2006 crash statistics database.

Advancing and Deploying Night Pedestrian Recognition and Warning Systems

Because most of these technologies are still in the early stages of the development process, there are challenges that must be overcome in the process of advancing toward widespread deployment, not least of which is creating a detection system with sufficient sensitivity and reliability to be able to recognize pedestrians under a variety of conditions and environments. For example, a human body's thermal signature may be difficult to differentiate from heat reflected off the road surface or heat emitted by vehicle engines. Other environmental factors, such as snowfall or ice covering roadway sensor equipment, may also impact the effectiveness of infrastructure-based detection systems.

It will be necessary, as a first step, to develop a concept-validation document showing that a technology for detecting pedestrians on freeways and providing relevant information to approaching motorists, emergency responders, and enforcement personnel has the potential to address a niche of the pedestrian crash universe better or more effectively than traditional countermeasures. The document should also demonstrate that the concept probably will not be overtaken by other advanced-concept technologies before its safety benefits have been realized and investments recouped, that the concept itself will be cost effective, and that critical concerns and issues associated with the technology and its deployment have been identified and a strategy to address them has been developed.

Assuming that the technology proceeds successfully through the concept validation stage, it will be necessary to select a number of urban freeway sections that have a considerable number of pedestrian crashes and deploy the technology as a demonstration.

Pedestrian Injury Severity

Over the next 10 years, defined as near term, there are a few key Intelligent Transportation System safety initiatives beginning to transition into the new vehicle fleet that have the potential to measurably reduce pedestrian fatalities. These include improved vehicle design and vehicle parking aids, which can help drivers identify pedestrians, especially small children, behind their vehicle.

Improved Vehicle Design

Improved vehicle design is currently being addressed by both the U.S. automobile manufacturing industry and the international community, which has recognized that pedestrian crash severity, to some degree, is dependent on the design of the vehicle. Vehicles that are not equipped with energy dissipating bumpers, that have sharp edges on the front end, or that have rigid vehicle hoods can contribute to injury severity, particularly related to the leg and head.

Potential Safety Impacts

According to the International Harmonised Research Agenda Pedestrian Safety Working Group, which compiled pedestrian injury data from Australia, Germany, Japan and the United States, road accident statistics unsurprisingly indicate that a significant proportion of road casualties are the result of contact with a moving vehicle.

The group found that, within the countries studied, pedestrian-vehicle impacts at 40 km/h (24.85 mph) or less accounted for 58 percent of child head-to-hood contacts, 40 percent of adult head-to-hood contacts, 19 percent of adult head-to-windshield contacts and 50 percent of adult leg-to-bumper contacts. Furthermore, hood impacts account for 41 percent of child head injuries and 19 percent of adult head injuries, windshield impacts represent 49 percent of adult head injuries, and bumper impacts account for 64 percent of adult leg injuries.[22]

As a result, improvements to front-end vehicle design can lead to significant global reductions in pedestrian fatality and serious injury, particularly in populous, industrialized countries with significant numbers of pedestrian-vehicle conflicts.

Advancing and Deploying Vehicles with Improved Design

In an attempt to respond to these safety concerns, U.S. manufacturers have developed vehicles that are designed to decrease the severity of pedestrian crashes. For example, the 2001 Honda Civic was designed with a three-inch gap between the hood and engine block to cushion impact and bendable hinges that allow the hood to collapse more easily. Similarly, Mazda redesigned the hood of its RX-8 model using an aluminum hood with a deeply dimpled structure underneath that is specifically designed to provide extra cushion in the event of a pedestrian collision.

This year, the European Union will require European vehicle manufacturers to meet pedestrian safety standards on all new models of vehicles, with stricter requirements beginning in 2010. These systems will primarily improve the bumper, the leading edge of the hood panel, and hood top in terms of providing increased crushability for pedestrian crashes and removal of sharp edges to reduce the severity of injury.[23]

NHTSA has been working with the international community, through the United Nations Working Party for the Harmonization of Vehicle Regulations (WP.29), to develop a GTR on pedestrian safety that is designed to reduce head and leg injuries when a pedestrian is hit by the front of a vehicle. An analysis of the benefits of the leg impact requirement is ongoing and will be released in FY 2008.

To meet the GTR requirement, vehicle manufacturers would need to make changes to their current vehicle designs, including redesigning hood hinges and latches to be deformable, which could occur quickly. Other changes are more involved and would require the hood and engine to be redesigned to protect the head from impacting hard engine and structural components. To protect for leg injuries, available countermeasures include deformable bumper fascia (i.e., the outer surface of the bumper), adding foam to the bumper, and deformable bumper elements.

The technical development of this GTR has been concluded and the formal discussions leading up to the GTR adoption will begin in November 2007. This GTR is expected to be adopted in November 2008. Once adopted, NHTSA expects to initiate its internal rulemaking process.

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[22] Proposed Amendment to the Pedestrian Safety Global Technical Regulation Preamble, Document No. INF GR / PS / 170, http://unece.org/trans/doc/2005/wp29grsp/ps-170e.pdf.

[23] Directive 2003/102/EC of the European Parliament and of the Council of 17 November 2003 Relating to the Protection of Pedestrians and Other Vulnerable Road Users Before and in the Event of a Collision with a Motor Vehicle and Amending Council Directive 70/156/EEC. http://eur-lex.europa.eu/LexUriServ/site/en/oj/2003/l_321/l_32120031206en00150025.pdf

In-Vehicle Pedestrian Avoidance Systems: Vehicle Parking Aids

In the case of in-vehicle technologies, the automotive industry has typically placed innovative high-tech safety equipment as optional equipment on high-end vehicles and models as a first step. As the equipment matures and gains acceptability, and as costs decrease, it progresses to be standard on some high-end models and optional on mid-level vehicles. This evolutionary process continues downward to lower priced vehicles until the market determines a level where the added cost of the equipment negatively impacts the sale of the vehicle. Further penetration into the market usually terminates unless rulemaking is passed that mandates inclusion of the equipment.

There are a number of systems marketed as "parking aids" that are designed to help drivers avoid backing into objects at the rear of their vehicles. There are several types of technology currently deployed on a limited but expanding scale, including sensor-based systems, which use ultrasonic and radar devices to determine the presence of objects, as well as camera-based systems, which are offered as options by a variety of vehicle manufacturers. NHTSA is conducting research to determine whether drivers would use the system to help prevent backovers. The currently available technology, however, is unlikely to be effective in reducing pedestrian collisions in many cases.[24]

Considerations

Benefits

1. NHTSA determined that camera-based systems may have the greatest potential to provide drivers with reliable assistance in identifying people in the path of the vehicle when backing.

Concerns

1. Testing by NHTSA showed that the performance of sensor-based (ultrasonic and radar) parking aids in detecting child pedestrians behind the vehicle was typically poor, sporadic, and limited in range.[25] Based on calculations of the distance required to stop from a typical backing speed, detection ranges exhibited by the systems tested were not sufficient to prevent collisions with pedestrians or other objects.

Potential Safety Impacts

Many backover crashes with pedestrians occur on private property and are not recorded in State or Federal crash databases, which focus on crashes that occur on public roadways. According to NHTSA, however, backover crashes involving all vehicle types are estimated to cause at least 183 pedestrian fatalities and between 6,700 and 7,419 injuries every year.[26] An effective vehicle-mounted advanced technology solution, therefore, could significantly reduce the number of pedestrian fatalities and injuries due to vehicle backovers.

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[24] National Highway Traffic Safety Administration, *Vehicle Backover Avoidance Study*, November 2006. http://www.nhtsa.dot.gov/staticfiles/DOT/NHTSA/Vehicle%20Safety/Studies%20&%20Reports/Associated%20Files/BackoverAvoidanceTechStudy.pdf
[25] Ibid.
[26] Ibid.

Advancing and Deploying Backover Avoidance Technologies

NHTSA intends to continue its work to address pedestrian backover incidents by conducting research aimed at analyzing the safety problem more thoroughly, developing an understanding of the scenarios under which such crashes occur, and determining whether technology-based countermeasures can be more effective. Its activities to this end will include:

1. Conducting additional research to estimate the potential effectiveness and performance variations of camera-based systems.
2. Sponsoring meetings and discussions with stakeholders to share research findings, identify advances in technology and identify additional research needs relating to pedestrian backover crashes.
3. Encouraging the industry to continue research and development of vehicle-based systems that can address the backover hazard.
4. Developing specifications for the performance of systems intended to prevent backover crashes through consultation with the industry and other interested organizations.
5. Sponsoring meetings and discussions with stakeholders to share research findings, identify advances in technology, and identify additional research needs relating to pedestrian backover incidents.

In-Vehicle Pedestrian Sensing System

In October 2007, FHWA executed a cooperative agreement through its Exploratory Advanced Research Program to explore a proposed in-vehicle pedestrian sensing system. This technology will use a camera system installed on the front end of a vehicle to detect moving objects (pedestrians, animals, etc.) about 30 meters (100 feet) in front of the vehicle. Once detected, the system would then alert the driver to drive carefully.

Advancing and Deploying Pedestrian Sensing Systems

This technology is in the prototype development stage, and there is no information at present on perceived technical hurdles or performance issues.

The current FHWA project is intended to validate the concept for the technology and move the technology toward a prototype. The project involves assembling a set of sensors on a frame that can be installed in test vehicles and developing specialized software to process the information collected by the sensors. Once an experimental design is achieved, the possibilities for commercialization will be further explored. The project is intended to last through 2009.

Pedestrian Night Crashes

Night Vision Enhancement Systems

In-vehicle, night vision enhancement systems (NVES) use either an active or a passive detection system to create an image on a dashboard display. Passive systems, known as far infrared (FIR), create pictures based on heat energy emitted by objects in the viewed scene. Active systems, also called near infrared (NIR), produce images based on infrared radiation that is sent out by emitters on the vehicle and is then reflected back from objects in the forward view (in the same manner that visible light from vehicle headlights is reflected off objects, except in the infrared spectrum).

Both FIR and NIR systems use cameras to detect infrared radiation. The NIR system employs IR headlamps or emitters, whereas the FIR system detects the IR emissions from objects. But no matter the science, the goal is to help the driver see farther down the road and to spot people and animals in the path – even at up to 300 meters (984 feet) away. An image of the area forward of the vehicle is generated through a display, brightening the objects that are hard to see with the naked eye.

Considerations

Benefits

1. The heads up display allows drivers to see pedestrians or animals entering their path before their eyes can detect them in the dark, potentially providing the driver with increased reaction time to avoid a crash.
2. Due to the prevalence of pedestrian crash fatalities during the dusk, dawn, and night periods, even a modest 30 percent reduction in the fatalities that occur during low light conditions will result in more than 1,000 lives saved annually.[27]

Concerns

1. Drivers utilizing in-vehicle systems may have difficulty splitting their attention between the night vision display on the dashboard and the roadway in front of them.
2. Although a heads-up display provides an image of the forward scene, there is no warning mechanism to notify drivers that a person or animal is in their path.

Potential Safety Impacts

In 2006, some 3,290 pedestrian deaths occurred at night.[28]

Advancing and Deploying In-Vehicle Night Vision Enhancement Systems

General Motors became the first automaker to introduce night vision in the 2000 Cadillac deVille. In the Cadillac DeVille, the technology took the form of a heads-up display that projected onto the bottom of the windshield just above the dashboard. While the 2000 model Cadillac DeVille provided a night vision option, it was discontinued on later models.
More recently, in 2006, BMW began offering a night vision system on its 5 and 6 class vehicles that utilizes the passive FIR system. The system uses a thermal imaging camera that reaches an area up to 300 meters (984 feet) in front of the vehicle. The system is designed to detect pedestrians on the edge of the road and animals that may attempt to cross in front of the vehicle.

[27] The "Fatality Analysis Reporting System Encyclopedia," maintained by the National Highway Traffic Safety Administration, 2006 crash statistics database, indicates that 3,612 of the 5,158 pedestrian deaths occurred at night, dawn, or dusk. As a result, a 30 percent reduction in the 3,612 reported pedestrian fatalities would be 1,084 lives saved annually.
[28] "Fatality Analysis Reporting System Encyclopedia," National Highway Traffic Safety Administration, 2006 crash statistics database.

In FY 2008, NHTSA is initiating a simulator study to evaluate the effectiveness of various warning modes for an IR vision system in eliciting appropriate driver avoidance behaviors to pedestrians and other detected hazards. The results will provide data on the differential effects of various warning modes on drivers' performance. The findings will be used to develop human factors recommendations for NVES interface requirements to optimize safety effectiveness, driver acceptance and usability. The results should also prove invaluable to vehicle manufacturers who are currently working to develop IR NVES with automatic warnings.

4. Recommendations for Law Enforcement and Education

Law Enforcement

Traffic enforcement using traditional patrolling activities poses significant difficulties for police, who in most cases must pursue a vehicle, stop it, and issue a citation to the driver violating a motor vehicle law. In addition to exacerbating traffic congestion, this can endanger motorists, pedestrians, and police officers themselves. Advanced technologies that provide automated enforcement are one way to deter violations and improve public safety without increasing congestion.

There are several advanced automated enforcement technologies that are or will be available to assist police with law enforcement activities and that may improve pedestrian safety. These include automated red light enforcement, particularly at intersections with significant pedestrian activity; automated speed enforcement, particularly on approaches to mid-block pedestrian crosswalks traversing higher speed urban and suburban arterials; and automated crosswalk enforcement, particularly at crosswalks with considerable violations.

Automated Enforcement

Automated red light enforcement is currently deployed at a variety of locations and is authorized by law in about half of the States. This technology utilizes static cameras placed at various points at an intersection to identify vehicles that fail to stop at red signals. The technology uses cameras triggered by sensors that detect vehicles entering the intersection above a preset minimum speed and at a specified time after the signal has turned red. In addition to vehicle identification, the systems record the date, time of day, time elapsed since the beginning of the red signal, and vehicle speed. Tickets typically are sent by mail to owners of violating vehicles based on this photographic evidence.

Automated speed enforcement is used in approximately 20 communities in the United States. These systems use radar detectors at given multiple static or portable locations to identify vehicles that are exceeding an established threshold speed. Once a vehicle is detected above the threshold, a camera takes a frontal and possibly rear photograph of the vehicle, capturing the license plate and copying the recorded speed and time on the photo. The picture is then matched with the vehicle owner through motor vehicle registration files, and a specified fine is mailed to the owner.

Automated red light enforcement may be appropriate to consider at intersections with significant pedestrian activity or pedestrian crashes, and automated speed enforcement may be appropriate to consider in advance of mid-block crosswalks on multilane arterials with significant pedestrian activity or pedestrian crashes. In the case of both technologies, however, studies should be undertaken to determine safety benefits to pedestrians of these automated enforcement technologies.

Automated crosswalk enforcement is designed to detect, record, and issue citations for motorists who violate pedestrian rights in crosswalks. However, this technology is still in the concept validation phase and requires paper analysis and feasibility studies from a technical standpoint to validate the technical practicability of photographs that can encompass both pedestrians in crosswalks and a motorist violating the crosswalk. If it can be determined to be workable on paper, limited prototypes may be developed to demonstrate the concept and determine the technology's impact on reducing pedestrian-motorist conflicts.

Institutional issues that are limiting wider deployment of automated enforcement technologies need to be identified and addressed in a way that allows the safety effectiveness of the technology to be retained while still making it possible for the vast majority of the public to support automated enforcement. Institutional issues that have arisen to date in localities considering deployment of automated enforcement technologies include privacy issues, due process concerns, perceived fairness, legality, and ample advanced warning. There have also been assertions that the technologies are being used in some locations as a means for localities to issue fines and increase revenue rather than to improve safety.

Guidance needs to be available that provides information to public officials on means to effectively address these issues while building public support for the technology. It is also necessary to differentiate between those public bodies which have existing legal authority to apply the technology and those that require additional legislative authority. The U.S. Department of Transportation (DOT) has developed implementation guidance for both red light and automated speed enforcement systems.

In addition, a National Cooperative Highway Research Program project entitled "Automated Enforcement for Speeding and Red Light Running" (NCHRP 03-93) will commence in 2008.[29] This project will document existing laws and ordinances, identify ongoing automated enforcement activities in the United States, document best practices among State and local jurisdictions, research the effectiveness of automated enforcement, conduct surveys of public opinion, and examine public information, education, and legislative approaches. A final report documenting the research conducted and providing a set of stand-alone guidelines is expected to be published in 2009.

Education

Positive Feedback for Pedestrians

The purpose of educating pedestrians about the technologies they can interact with or that activate in response to their commands is not just to instruct them on how to use the technology, but also to influence their behaviors in ways that can improve their safety.

One way to do this is by providing pedestrians with positive feedback. When a pedestrian actively pushes a call button, positive feedback could be as simple as an indicator light activating to show the pedestrian that his call has been registered and the pedestrian cycle activated. More

[29] Transportation Research Board, "Automated Enforcement for Speeding and Red Light Running," NCHRP 03-93, http://www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=1613.

detailed positive feedback could be provided in the form of pedestrian countdown signals that indicate how long the pedestrian has to traverse the crossing before the pedestrian cycle ends.

By providing timely feedback, pedestrians are informed that wait times are tolerable, perhaps making them less likely to avoid the wait by crossing against the signal and potentially improving their safety.

Public Outreach at the Point of Readiness

When advanced technologies have matured enough to be widely deployed, localities should undertake education campaigns to introduce the new systems to the public, explaining what they are, how they work, how the public should react to them, and what the safety benefit of the technology is expected to be. This outreach is ideally performed in conjunction with other pedestrian education and enforcement efforts.

Some suggested methods of outreach and education about pedestrian safety that have been successful in various States and localities include:

- Preparing operations and procedures manuals for pedestrian safety programs.
- Educational efforts to businesses and residences within a quarter-mile radius surrounding busy or dangerous intersections.
- Conducting educational pedestrian safety presentations at schools, health clinics, day care centers, traffic safety events, planned special events, and senior centers.
- Hosting special events that target children and youths, such as a Community Science Day that includes a feature on pedestrian and traffic safety issues as well as the new technologies that are being used to improve safety.
- Encouraging partnerships between Federal, State, county, and city governments, and incorporating other partners to promote awareness and technology.
- Presenting radio, newspaper and television media campaigns each year that address relevant pedestrian and traffic safety issues.
- Developing a comprehensive pedestrian and traffic safety media kit for use in presentations.
- Implementing a targeted program to increase public awareness of unacceptable driving behaviors and of increased enforcement efforts to apprehend violators.

Educating Law Enforcement

Outreach and education for law enforcement agencies should also be provided as part of new technology implementation. In the case of automated enforcement technologies, these efforts should focus on how to use the technologies properly and within the framework of established State or local laws.

However, law enforcement officers should be aware of crosswalk areas where new technology is in use and how that technology works so officers can recognize when crosswalk violations occur. For example, if an officer is aware that a pedestrian scramble system is in use and that right turns are prohibited during the pedestrian phase, an illegal right turning vehicle may be more easily identified and cited.

Law enforcement agencies should also be informed of the advantages of the new technology in helping them to identify traffic violators. For example, if a vehicle comes through an advanced mid-block crossing without yielding to the pedestrian, the presence of additional lighting can be used to support the citation and the education of the motorist on the importance of yielding to pedestrians.

5. Integration into National Design Guidelines

As technologies become more widely accepted and deployed, they need to be brought as close as possible to any existing applicable design guidelines. In cases where design standards do not exist for such technologies, however, national design guidelines will need to be expanded to accommodate them. The two principle owners of guidelines related to pedestrian safety are the American Association of State Highway and Transportation Officials (AASHTO) and FHWA.

American Association of State Highway and Transportation Officials

AASHTO is an independent transportation organization whose mission is to advocate transportation-related policies and provide technical services to support States in their efforts to provide transportation to the citizenry. As part of this mission, AASHTO provides technical guidance on a variety of transportation-related topics, including pedestrian facilities and geometric design of roadways. Within AASHTO, the Standing Committee on Highways' Subcommittee on Design has responsibility for maintaining and updating the *Guide for the Planning, Design, and Operation of Pedestrian Facilities,* which is the currently recommended minimum guideline for the construction and design of sidewalks and street crossings, and *A Policy on Geometric Design of Highways and Streets,* which provides guidance on the planning, design, and operation of pedestrian facilities along streets and highways.

In the case of incorporating newly developed advanced technologies into these guidelines, the specific technologies, after having undergone experimental deployment and study, can be brought to the attention of AASHTO by interested groups, such as professional transportation engineering organizations, State or local transportation agencies, or the FHWA. The Standing Committee on Highways, which has final approval authority for including new technologies into the established guidelines, can then opt to undertake consideration of the technologies as they emerge.

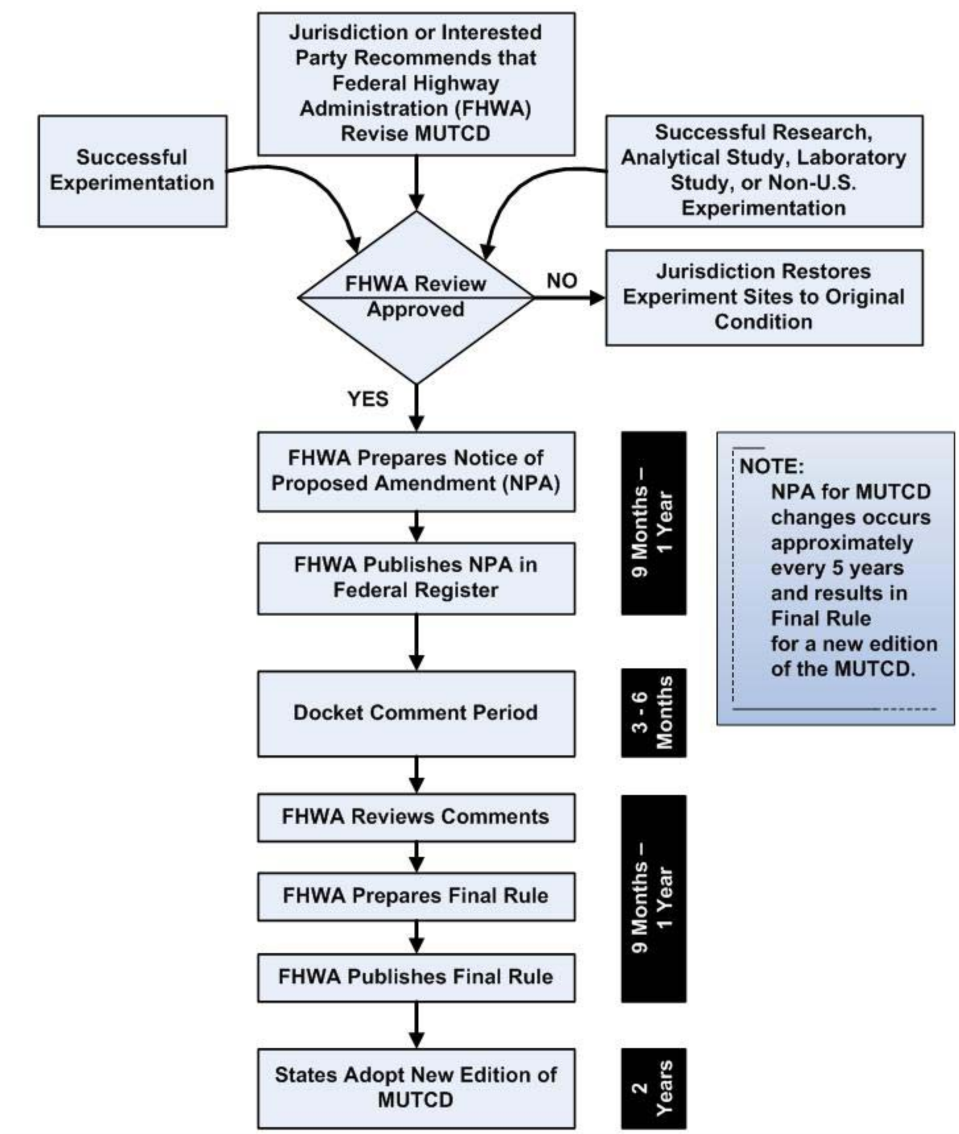
Once a new technology has been studied and the data analyzed, the draft guidelines for use are submitted for approval by the Standing Committee on Highways and then the Executive Committee. Standards and policies must be adopted by a two-thirds vote by the Member Departments (i.e., those departments or agencies of each of the States of the United States, Puerto Rico, and the District of Columbia in which the official transportation responsibility for that State or Territory is lodged) before publication. During the developmental process, comments are sought and considered from all the States, the Federal Highway Administration, and representatives of the American Public Works Association, the National Association of County Engineers, the National League of Cities, and other interested parties.

Federal Highway Administration

In the United States, national standards for the design, application and placement of traffic control devices are found in the *Manual on Uniform Traffic Control Devices* (MUTCD), which is published by the FHWA under 23 Code of Federal Regulations (CFR), Part 655, Subpart F. Some technologies discussed in this report are already included in the MUTCD and have been deployed on a limited basis, including pedestrian countdown signals. These technologies have already undergone rigorous experimentation and analysis for effectiveness and safety prior to being accepted for inclusion in the MUTCD.

This process begins when a State or locality interested in deploying a new technology applies to FHWA to have the technology designated as experimental. Once experimental status has been granted, the technology is then installed on a limited basis and the State or locality conducts an evaluation of the system to determine how effective it is and what, if any, its safety impacts are. Upon successful completion of the evaluation process, the technology may be considered for inclusion in the MUTCD following the process described below.

The FHWA Process for Amending the MUTCD



Note: The next Notice of Proposed Amendment (NPA) for the MUTCD is scheduled to occur in 2008.

If an interested party such as a State or local agency, the FHWA Office of Safety, or a professional transportation organization wishing to promote an advanced technology believes a change should be made to an existing provision in the MUTCD or that there should be a new provision added, a written request must be submitted to the Federal Highway Administration, Office of Transportation Operations (HOTO). The request should be sent electronically as an attachment (PDF or Word Document) to: MUTCDofficialrequest@dot.gov. Alternatively, a letter may be sent via postal mail or delivery service to FHWA at 1200 New Jersey Avenue, SE., HOTO-1, Washington, DC 20590.

If one or more of the advanced technologies designed to reduce pedestrian fatalities or injuries discussed in this report are considered and approved for inclusion into the AASHTO guidance or FHWA standards documents, the technology or technologies would effectively be integrated into national design guidelines.

6. Conclusions and Recommendations

Conclusions

Advanced technologies offer the potential to significantly improve pedestrian safety. However, additional research and extensive field demonstrations in real-world settings are needed to evaluate the benefits and effectiveness of deploying most of the advanced technologies described in this report. These research and demonstration results are essential for identifying the most effective advanced technologies and intelligent transportation systems to prevent or mitigate pedestrian crashes. It is also necessary to address any remaining substantive implementation barriers and determine the types of intersections or roadways where each technology can be best deployed to maximize the potential for improving pedestrian safety. States and localities will then be able to extensively deploy these technologies and reduce future pedestrian crash problems.

Improved vehicle design is currently being addressed both by the U.S. automobile manufacturing industry and by the international community, which has recognized that pedestrian crash severity, to some degree, is dependent on the design of the vehicle. NHTSA has been working with the international community to develop a GTR on pedestrian safety that is designed to reduce head and leg injuries when a pedestrian is hit by the front of a vehicle. This GTR is expected to be adopted in November 2008. Once adopted, NHTSA expects to initiate its internal rulemaking process.

Advanced automated technologies for red light and speed enforcement may be useful in improving pedestrian safety. However, institutional issues must be confronted before extensive deployment of these technologies can be pursued in many jurisdictions. Research reports have identified the following institutional issues including impacts on privacy, due process, perceived fairness of implementation, legality in terms of consistency with local and State laws, and providing ample advanced warning. These must be addressed in a way that is acceptable to the majority of the public in particular without a substantial reduction in the effectiveness of the technology. Guidance on how to overcome these issues has been developed and disseminated by DOT.

Educating law enforcement agencies as to the proper use of new technologies can also contribute to public outreach. Informed officers can participate in safety campaigns targeted at improving pedestrian safety, working to inform the public about how new technologies work and how to use them properly. In addition, law enforcement officers who are educated in the proper use of new technologies will therefore be able to identify violations, issue citations, and reinforce the pedestrian right-of-way.

The integration of advanced pedestrian safety technologies into national design standards will require successful completion of the field demonstrations and the research needed to validate their benefits and feasibility including the resolution of any remaining significant issues or barriers.

Recommendations

Future efforts should focus on the field demonstrations, research needed to prove the effectiveness and feasibility of implementing advanced pedestrian safety technologies, and resolution of any remaining issues or barriers to make the technology market ready. These efforts are critical to identifying the most effective advanced technology and intelligent transportation systems that could prevent and reduce pedestrian fatalities and injuries in the future. Available funding to support these activities at the national level is very limited.

Outreach and education for law enforcement agencies should be provided as an integral part of new technology implementation. Law enforcement agencies should be kept regularly informed of the advantages of new technology. Education efforts should focus on the proper use of the technologies and how to enforce proper use in compliance with the established framework of State and local laws.

Efforts to integrate the advanced pedestrian technologies in this report into national design guidelines, with the exception of the pedestrian countdown signal, should await the completion of field demonstrations and research that establish their benefits and feasibility for implementation and that resolve remaining issues and barriers.