Pedestrian Safety

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I. Introduction

A. Pedestrian Safety Problem Background

This document can be used as a reference for improving pedestrian safety through street redesign and the use of engineering countermeasures was well as other safety-related treatments and programs that involve the whole community.

In 2015, 5,376 pedestrians were killed in traffic crashes, representing 14 percent of all roadway-related fatalities (National Highway Traffic Safety Administration, 2016). On average, a pedestrian was killed every 2 hours and injured every 7 minutes. While reducing pedestrian crashes has recently gained increasing priority among some state and local agencies as well as the U.S. Department of Transportation (DOT), more efforts and programs are needed to develop and implement effective strategies to reduce pedestrian-related injuries and deaths.

The safety literature reveals a variety of risk factors that influence pedestrian crashes and severity. For example, pedestrian crash risk increases on wide roads (four lanes or more) with high motor vehicle speeds and/or volumes. Intersections are more difficult to cross when pedestrians encounter wide crossing distances, wide turning radii or multiple turn lanes. Other high-risk factors include drug/alcohol use by motorists and pedestrians, lack of nighttime roadway lighting and the lack of walkways along roads. Older pedestrians are much more susceptible to serious or fatal injuries because of their frailty, while young children are more likely to be struck by a motor vehicle after darting into the street.

Many pedestrian crashes are the result of unsafe motor vehicle driver and pedestrian behaviors. Certain roadway designs features can contribute to unsafe behaviors by pedestrians and motorists. For example, excessively wide streets encourage higher motorist speeds. High-volume multilane roads with a lack of safe crossings at regular intervals can contribute to pedestrians crossing streets at unsafe locations, particularly those who cannot or will not walk great distances to signalized locations. Land use decisions can also result in areas that are unsafe for pedestrians. For example, separating residential areas from shopping areas with high-volume multilane roads forces some pedestrians to cross streets in places that may not be safe. These types of issues must also be addressed in long-term solutions for pedestrian safety.

The American Association of State Highway and Transportation Officials' (AASHTO) 'A Policy on Geometric Design of Highways and Streets' (Green Book) states:

"*Pedestrians are a part of every roadway environment, and attention should be paid to their presence in rural as well as urban areas… pedestrians are the lifeblood of our urban areas, especially in the downtown and other retail areas*" (AASHTO, 2016)

The National Cooperative Highway Research Program (NCHRP) Report 500, Volume 10, 'A Guide for Reducing Collisions Involving Pedestrians' states:

"*Walking is a basic human activity, and almost everyone is a pedestrian at one time or another… Even though pedestrians are legitimate roadway users, they are frequently overlooked in the quest to build more sophisticated transportation systems. Whether building new infrastructure or renovating existing facilities, it should be assumed that people will walk, and plans should be made to accommodate pedestrians.*"

Unfortunately, many of our nation's streets and highways were primarily built to facilitate the smooth flow of motor vehicles. Yet, walking is the fundamental mode of human mobility; everyone is a pedestrian at some point in every journey that they take. This includes walking to a bus or walking to a parking lot. It includes people of all ages from children to older adults as well as pedestrians with visual and mobility impairments.

It is important to recognize that although many people choose to walk instead of drive as their only or primary mode of transportation, many others do not have the choice of driving. According to 2015 Census figures, nearly 10 percent of U.S. households do not own a vehicle. Also, 13 percent of U.S. citizens do not have a valid driver's license. This includes children under age 16, as well as many older and physically-impaired adults. This portion of our population should not be prevented from safe and reasonable opportunities to walk.

In a society that values choice and freedom, people should be able to walk safely, whether for fun and recreation, errands, getting to work or school, shopping, or other reasons. Many Americans want to be able to walk more if given the opportunity to do so. Yet, many street environments are often inhospitable or unsafe for walking.

Pedestrian safety and mobility must be elevated to a top priority for the situation to improve substantially. The engineers, planners, and other public officials in state and local agencies can leave an important legacy of improved walking conditions and fewer pedestrian crashes and injuries for future generations.

There are several objectives that transportation professionals should address to improve pedestrian safety and mobility.

- Reduce the speed of motor vehicles
- Reduce pedestrian risks at street crossing locations
- Provide sidewalks and walkways separate from motor vehicle traffic
- Improve awareness of and visibility between motor vehicles and pedestrians
- Improve pedestrian and motorist behaviors

A variety of strategies are available to improve pedestrian safety. A comprehensive approach involving the "three E's" (Engineering, Education, and Enforcement), as well as making pedestrian conscious land use decisions, is recommended. Engineers, educators, planners, and enforcement officials all play a role in helping to identify and implement effective safety improvements.

II. Planning and Designing for Pedestrian Safety

A. Understanding Pedestrian Characteristics

Good pedestrian safety planning must include an understanding of the characteristics of pedestrians. With an understanding of pedestrian needs and characteristics, those involved in pedestrian safety planning can more effectively understand how new and existing facilities must operate, as well as how pedestrians will act when faced with certain conditions. Applying a practical understanding of pedestrian characteristics will provide insights when considering appropriate safety solutions and will particularly help ensure that facilities are inviting to pedestrians.

Important characteristics include understanding why and where pedestrians walk, what types of design features create a safer pedestrian environment, and what types of behavioral decisions pedestrians are likely to make. In addition, pedestrians also consist of specific populations with difference characteristics, including children (who may be impulsive or unpredictable), persons with mobility impairments (who may require specific visibility devices or facility features) and senior citizens (who may require additional time for roadway crossings).

B. Transportation Design and Policy Elements that Impact Pedestrian Safety

Several design practices and policies conceived to improve motor vehicle mobility are now recognized as barriers to a safe pedestrian environment. There are many factors that affect the safety and mobility of the pedestrian transportation network. The major planning, design and policy elements that impact pedestrian safety include:

1. Street design
2. Street connectivity
3. Site design
4. Land use
5. Access management

C. Street Design

The traditional street system is based on a simple hierarchy: most trips originate on local streets; travelers are then ferried via collector streets to arterials, which are intended to carry large amounts of motor vehicle traffic long distances at higher speeds. This system is based on the

assumption that most trips occur by motor vehicle, so most of the facilities are designed primarily for motor vehicle travel. The system results in street designs that do not serve pedestrians well for several reasons:

1. They lack pedestrian facilities: Some collector and arterial streets are built with inadequate or no sidewalks or walkways, discouraging or limiting safe pedestrian movement along streets. Continuous lighting may not exist to provide adequate nighttime pedestrian conditions.

2. They are wide or have multiple lanes that are difficult to cross: Since arterial are designed to facilitate smooth and efficient motor vehicle flow, they often have multiple lanes in each direction to accommodate high motor vehicle traffic volume and also multiple turn lanes. The number of lanes a pedestrian must cross has a direct effect on the complexity of the crossing task and the pedestrians crash risk. The pedestrian must find an adequate gap in motor vehicle traffic, a task that increases exponentially with the number of lanes.

3. They have high speeds: Wide streets encourage and allow higher vehicle speeds, which relate directly to more severe injuries (to motorists and pedestrians) when a crash occurs; the majority of pedestrian crashes and most fatalities occur on higher speed arterials.

4. They have complex intersections: Typically, wide arterial streets have intersections that are even wider due to the addition of multiple turn lanes. They also often have large turning radii to allow larger vehicles such as trucks and busses, to make turns easily and quickly. This requires pedestrians to cross longer distances and watch for more cars in more lanes, often a challenging and dangerous task. Skewed intersection designs and high vehicle right and left turn volumes at an intersection can also add complexity to the crossing task. Left turn arrows can also be confusing to pedestrians.

5. They create long delays for pedestrians at intersections: Wide intersections are those with multiple turn lanes create a long wait for pedestrians. At times, crossing prohibitions may be designated for one or more crosswalks to facilitate turning movements. If a crosswalk is closed, the pedestrian is left with three choices: cross illegally with no signal protection, walk a long distance around the intersection, or walk to another location to cross.

6. They provide little "friction" to protect pedestrians: Much of the traffic engineering philosophy of the last few decades has been aimed at stripping roads of "friction" (for example, removing trees, etc.) in order to facilitate motor vehicle traffic flow. This creates a barren, unsafe and unattractive environment for pedestrians, often with high vehicle speeds.

D. Street Design Policies that have Affected Pedestrians

Achieving a Desired Level of Service

Level of Service (LOS) for motor vehicle traffic is usually measure in letter grades A through F. LOS A describes free-flowing unimpeded motor vehicle traffic; LOS F is near gridlock. LOS D is typical of congested urban areas where streets are full and motor vehicle traffic is moving relatively slowly. It is not uncommon for intersections to operate at LOS F during the peak periods of traffic.

The measurements and calculations needed to predict or determine LOS are quantitative. However, the desired LOS is often a political decision (or policy), based on how much congestion decision-makers assume the public will tolerate. Those communities that have sought to have motor vehicle traffic flow smoothly often have characteristically wide roads with minimal pedestrian accommodations. Consequently, they often experience higher crash rates for all roadway users, as both motorists and pedestrians suffer from the less safe conditions created to achieve these higher levels of vehicle mobility.

Accommodating Special Vehicles

Roadway design is usually predicated on the concept of the "design vehicle." The design vehicle is the largest vehicle that can be expected to used the road often enough to justify designing the roadway to accommodate that vehicle. Large design vehicles are commonly trucks and busses, include trash collection trucks, moving vans, school busses, and fire trucks. A typical design vehicle for local streets is known as a SU (Single Unit delivery truck), such as those used by UPS.

The most critical application of this concept is at intersections, where the radius is made large enough so the design vehicle can make a right turn without encroaching into the opposing lane. This can have a major negative effect on pedestrian safety and comfort, because a large radius allows passenger vehicle to make right turns at higher speeds and requires pedestrians to cross longer distances. Large radii at intersections can contribute to a higher pedestrian crash risk as pedestrians are often hit by turning vehicles.

E. Street Connectivity

Within the context of the previously described street hierarchy, local streets typically do not connect well to each other, arterial streets, or destinations such as transit stops or stores. This leads to larger collector and arterial streets that convey heavy motor vehicle traffic. This discontinuous pattern of local streets limits travel choices for pedestrians to higher-risk arterial streets that reduce both comfort and safety. A lack of street connectivity leads to intersections that are few in number – but often large in size- that are more difficult for pedestrians to navigate. Many local streets have curvilinear or cul-de-sac designs that:

1. Limit pedestrians' ability to travel in the most direct path
2. May be disorienting
3. Increase the distance to destinations
4. Increase pedestrian exposure time to other vehicles on the road
5. Discourage walking because of the added travel distance to destinations

Fewer people walking reduces the motorist's expectation of seeing pedestrians along and crossing streets

These street designs have some negative impacts on motorists as well, increasing driving distance and time, and affecting the response time for emergency vehicles.

F. Site Design

Many existing developments do not provide direct, clear and convenient access for pedestrians. Pedestrians wishing to access a site may have to determine their own path and navigate through driveways, parking lots, landscaping, and other buildings in order to reach the destination. This often leads to confusion and conflicts between pedestrians and motorists, resulting in more pedestrian crashes.

G. Land Use

Land use practices that took shape after World War II have typically favored the segregation of land uses (i.e., commercial and employment areas, schools and residences) and the concentration of commercial activities along auto-dominated arterial corridors. This has produced the following unintended consequences:

1. Trip origins and destinations are often far apart.
2. Longer travel distances lead to fewer people walking and more driving.
3. More people driving creates more hectic motor vehicle traffic conditions not conducive to safe pedestrian environments – those who do walk are exposed to long distances and high levels of risk when they walk along or try to cross busy high-speed arterial streets.
4. The premise that most trips will be made by automobile leads to streets designed to accommodate only the automobile, built to handle large volumes of motor vehicle traffic. When this occurs, pedestrians are often minimally accommodated only as an afterthought, if at all.
5. Many of the destinations and commercial activities along a roadway corridor are also design to serve motorists, fostering strip development with ample parking to capture passing motorists. As most of these destinations are located on arterials, they are hard for pedestrians to access.

The typical land use pattern of concentrating commercial activities along auto-dominated corridors creates generic-looking roads that are hard for pedestrians to cross. The safety consequences are evident when one analyzes crash data and sees that many pedestrian crashes occur along higher speed suburban corridors with few or no pedestrian facilities and very separated land uses.

H. Access Management

According to AASHTO, access management "involves providing (or managing) access to land development while simultaneously preserving the flow of traffic on the surrounding roadway system in terms of safety, capacity, and speed" (AASHTO, 2001). It has widely been used to improve the efficiency and flow of motor vehicle traffic by limiting the number of driveways and intersections on arterials and highways. In some cases this has improved safety for pedestrians and motorists alike, but in other instances it has had the unintended consequence of facilitating the design of larger intersections spaced farther apart. These intersections are often difficult and unsafe for pedestrians to cross due to their size and large numbers of turning vehicles. Pedestrians wishing to cross at an intersection may have to walk long distances out of their way.

For communities that do not limit the number of driveway and intersections, the issue of intersection size and spacing may not be a problem, but an excessive number of driveways can create another problem. For pedestrians, every driveway is a potential conflict point. Vehicles pull in and out of commercial driveway continuously, and when driveways are designed like street intersections, turning speeds can be quite high. Too many driveways along a street without proper driveway design can also create a challenging walking environment for people with disabilities.

The following illustration shows how poorly designed driveways can become conflict points for pedestrians and motorists.

I. Methods to Improve Pedestrian Safety

In addition to improving the compliance of all roadway users with traffic controls and laws, there are several measures that can be taken to improve conditions for pedestrians within these transportation conventions previously discussed. Improved pedestrian safety can be achieved in a variety of ways, including:

Street Design Improvements

Can be made safer for pedestrians if planners, designers, engineers and officials focus on:

- Slowing vehicle speeds
- Reducing street crossing distances for pedestrians
- Improving the visibility of pedestrians and motorists
- Increasing the level of caution taken by pedestrians and motorists
- Providing pedestrian facilities (sidewalks, crossing islands, etc.) where the potential crash reductions are the greatest by establishing a routine system to identify gaps in the network, along streets and highways, particularly in urban and suburban areas.

Achieving one or more of these objectives not only reduces the risk of pedestrian crashes, but also usually improves safety for motor vehicle drivers and passengers. Sometimes a design issue may result in a complication or delay to other roadway users, and transportation officials will have to make a choice to balance the competing interests. Officials may perceive these choices to be unpopular or difficult to make, especially for those whose job has been to move motor vehicle traffic and who may not be aware of values held by the community. However, most often a community will be supportive of improved pedestrian safety; it is important to educate and inform people about how and why certain choices are made.

To achieve these objectives, some policies may require rethinking or reprioritization. These include:

Achieving a Desired Level of Service

Some effective pedestrian safety measures may increase motor vehicle travel time and have a slight negative impact on motor vehicle LOS. A rebalancing of the transportation system where pedestrian LOS and safety are included may sometimes mean a change in expectations about the priority that motor vehicle LOS is given in design and decision-making. If serious safety measures are to be achieved, the particular LOS may be lower for motor vehicles than if those measures were not taken. Improvements in capacity can be achieved in other ways: by expanding the capacity of other transportation options, re-thinking land use strategies, or determining where important destinations – such as schools – are to be located.

Accommodating Special Vehicles

The conflict between vehicle accommodation and pedestrian safety is usually considered a design decision, but it is also a values (policy) decision. An intersection can be designed with a smaller radius than is typically used for a particular design vehicle, thereby increasing pedestrian safety by reducing crossing distance/exposure. The motor vehicle driver can still make the turn, but the truck will have to maneuver into the inside lane to complete the turn. Communities with streets designed around the concept of "bigger is better" are communities that often provide poor pedestrian service and typically have poor pedestrian safety records. Conversely, communities that place a high priority on pedestrian safety and convenience do more to balance the needs of large vehicles with the needs of pedestrians in their street designs. This does not mean trucks, school buses, and fire trucks cannot use the streets – they are accommodated; they just usually need to travel at a lower speed and take care in making turns. Transportation professionals are asked to carefully weigh these factors when making street design decisions.

Street Connectivity Improvements

Increasing street connectivity creates a safer, more pedestrian-friendly street system by:

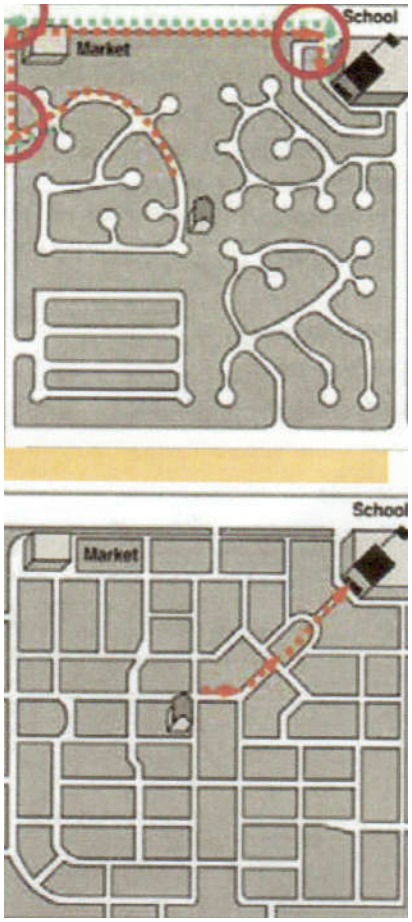
- Reducing walking distances
- Offering more route choices along quiet local streets
- Dispersing motor vehicle traffic with more two-lane, neighborhood commercial streets, which relieves motor vehicle traffic from arterials to make streets safer for pedestrians to walk along
- Reducing the need for wide, difficult to cross streets and intersections by providing more connections

Street connectivity with the transit network is very important. If people are to use transit, then their role as pedestrians on both ends of their trip is important and should be accommodated on well-connected streets.

Street connections are vital to pedestrians, and there are many things that can be done to improve the connectivity of existing street networks and plans for the connectivity of future developments. Here are a few potential solutions:

- Improve existing local street connectivity and circulation by adding sidewalks, paths, stairs/ramps, gates, etc. to link dead-end streets and cul-de-sacs to other parts of the street network.
- Maintain a pedestrian connection (e.g., provide a path in the right-of-way or sidewalk easement) when a street is being severed (it is more difficult to purchase an easement for a connection later).
- Increase the number of access points to and from neighborhoods and other destinations, so not all trips are funneled through one or two large intersections or access points. More neighborhood travel options means less motor vehicle traffic on any given street.
- Design future developments with improved circulation patterns within neighborhoods so more neighborhood automobile trips can be taken on local streets, reducing the need to widen arterials.

The following illustration shows that residential streets that are well connected provide a more direct route to destinations.



Site Design Improvements

Both small-scale and large-scale developments should be directly accessible from the sidewalk through a safe and convenient sidewalk or pathway. Many communities are achieving better pedestrian safety records by requiring businesses and developments to locate close to the street (with parking provided in the back) in more pedestrian-oriented site developments that balance auto access with pedestrian needs and facilities. This does not mean that auto access is denied; it is just managed more appropriately.

These site design goals are achieved by enacting local zoning ordinances, which must be enforced. These principles contribute greatly to the safety, comfort and aesthetics of the walking experience.

Land Use Improvements

Land use planning has often been considered a discipline separate from transportation planning, street design and traffic engineering and insufficient emphasis has been placed on the coordination of the two planning processes. However, the relationship between land use and transportation is evident and the responsibility to coordinate between the two is imperative. Some changes to land use patterns that may positively influence pedestrian safety include:

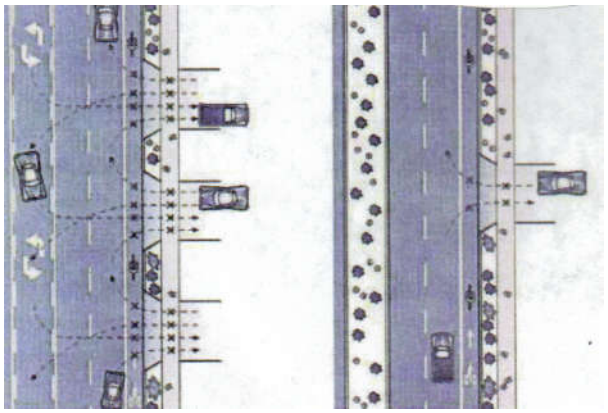
- Encouraging mixed-use development (such as allowing small-scale retail in neighborhoods or placing schools in the center of neighborhoods) to help create destinations within walking distance of where people live and work.
- Designing new neighborhoods in a cluster pattern with many destinations accessible on foot to residents.

Access Management Improvements

One of the most important access management techniques includes reducing conflicts at driveway to improve the walking environment. Some driveways can be closed – increasing the safety of both pedestrians and motorists - without impeding access to local businesses. Access management tools should not be used to reduce public street connections, especially pedestrian connections to the transportation network. Other access management goals can work in favor of pedestrians within the context of other important planning and policy issues, including:

- Constructing medians to control turning movements.
- Encouraging clustered development and mixed land uses.
- Improving street and neighborhood connectivity.
- Converting auto-oriented strip development into more accessible land use patterns more suitable for pedestrians.

The following illustration shows how proper access management can control turning movements to reduce conflict points. The use of a two-way left turn lane results in multiple conflict points while the median design reduces the number of conflict points.



Reviewing Pedestrian Policies and Design Guidelines to Improve Pedestrian Safety

A multimodal approach to policy-making is needed. Agencies need to review their design guidelines and policies to ensure that quality facilities are provided with both developer-built and new agency-built roadway projects. New facilities must be fully accessible to all pedestrians. The following is a list of effective practices that may serve as a template for review of the current status of agency policies and guidelines:

1. Improvements along the road (on sidewalks, at driveways, etc.)
2. Improvements for crossing the road (at midblock locations and signalized/unsignalized intersections).
3. Speed control measures.
4. Land use and site design.

III. Collecting Data to Identify Pedestrian Safety Problems

It is important to know where pedestrian safety deficiencies exist, how extensive the safety problems are and what new projects, programs, and policies can provide the biggest safety benefit, including those related to engineering, education and enforcement. This process occurs before an action plan can be formulated. While collecting and analyzing data are crucial, an agency should not spend excessive resources on this task to the point where there are no resources available for implementing safety improvements. It is important to know how much data and what types of data are needed to identify, prioritize and implement safety projects as well as evaluate the effectiveness of completed safety improvements.

A. Types of Safety Projects

Projects can be identified and prioritized for pedestrian safety improvements by the following types:

1. Spot locations: individual intersections and non-intersections.
2. Corridors: may be roadway sections of 0.5 miles to 5 miles or more in length.
3. Targeted areas: may be as small as a single neighborhood or business district to a large area where pedestrian crashes are disproportionately high.
4. Entire jurisdictions: Some types of crashes are frequent but are scattered throughout an entire jurisdiction (i.e., they are not spot location or area specific). The must be addressed through system-wide changes, such as making it a policy to install pedestrian WALK/DON'T WALK signals at all traffic signals.

Some safety improvements can be made immediately and do not need to wait for all data collection efforts to be completed. Very little data are needed to make simple, low-cost improvements such as the installation of advanced stop bars on multilane roads, or the upgrade or installation of warning signs where high number of pedestrians cross busy streets.

B. Information Needed to Identify and Quantify Pedestrian Safety Deficiencies

Crashes, roadway, traffic and other data are essential to identify pedestrian safety deficiencies and to select the appropriate improvements to make conditions safer for pedestrians and other roadway users. More data and higher quality data will typically offer more tools to identify and address safety problems. Engineers cannot collect everything; they will have to prioritize data needs. In some instances, improvements in databases or more accurate or timely data will enhance the ability to identify pedestrian deficiencies.

The following is a list of data that can be helpful in identifying and prioritizing pedestrian safety deficiencies.

Crash Data

The most important data are pedestrian crash records. State and local agencies should collect and maintain crash data, and every effort should be made to include all pedestrian crashes. In some cases, pedestrian crash data collection efforts may be linked with data collection on bicycle crashes, because both are often not included in highway safety data. There are limitations to computerized crash databases; most only include crashes with motorized vehicles, and many

non-injury pedestrian crashes or those involving minor injuries are unreported. Statewide crash data needs to be timely and accurate so an engineer can properly identify and respond to a crash problem and monitor trends. Having to wait several months for state computerized data can severely hamper an engineer's ability to respond to a crash location, especially in rapidly developing areas. Collaboration between state and local agencies assures that all involved parties have access to current data.

Police Reports

Individual police reports are essential in documenting precisely where, how and why each crash occurred. The most important part of the police crash report is the officer's narrative and the police should thoroughly and precisely document crash details. Care should be taken with some of the information included in a police report. Some investigating police officers are not aware of the legal definition of an unmarked crosswalk, and sometimes a pedestrian in an unmarked crosswalk will incorrectly be listed "at fault" for not using a crosswalk. Educating officers in proper terminology and police training on pedestrian legislation can help reduce such errors. Rather than assign fault, it is better for police crash reports to simply list actions in a neutral manner, such as "failed to yield while turning." This makes it easier for analysis to classify and sort the data. Another common error in crash data is that the nearest intersection is coded when the crash really occurred at a midblock location.

Some information may require follow-up investigation such as issuing citations or BAC/drug testing, which may not be recorded on the original police report. For serious injury or fatal crash reports there is often a supplemental police investigation that can provide considerably more details on the crash, including witness statements and a thorough investigation of roadway, motorist and pedestrian conditions at the time of the crash.

System-wide crash data is needed to efficiently identify high crash corridors or areas, in addition to high crash locations. To identify high crash corridors or areas, three years of crash data is ideal, but as little as one year of crash data may be sufficient. Agencies should also review the types of information available in their computerized crash database so they have ready access to information such as the age of the pedestrians, physical condition of the pedestrian or motorist, behaviors of the pedestrian and motorist prior to the crash, direction of travel and other detail that can be used in identifying safety problems.

Pedestrian Counts Studies

Ideally, collecting pedestrian counts can be useful in understanding the pedestrian activity and in considering needs for facilities. Pedestrian crash data can be used to identify high crash

locations, corridors, areas, and jurisdictions; supplemental pedestrian volume. Count studies are best employed when there is a decision (design or operational) to be made that the information can influence (i.e., is a traffic signal warranted?). However, low pedestrian counts should not be used as a justification to not take any action. If there is a clear indication that pedestrians need access to a destination, but roadway conditions are so intimidating that few people are seen walking, then a safety improvement can open up new opportunities for pedestrians.

High pedestrian volumes do not necessarily result in high number of pedestrian crashes. In many downtown areas, pedestrian crashes are relatively low despite the high pedestrian and motor vehicle traffic volumes. This results from lower motor vehicle traffic speeds, short blocks and a greater motorist expectation and awareness of pedestrians. Conversely, pedestrians can often be at greater risk in areas with low pedestrians use due to lower motorist expectation and awareness of pedestrians. But high pedestrian volumes can be used to justify a higher priority for pedestrian facility or traffic control improvements.

Roadway/Sidewalk Inventories

Not all pedestrian deficiencies can be identified by crash data. Since pedestrian crashes at particular locations are relatively rare and random events in general, roadway infrastructure can be used to identify locations needing pedestrian facility improvements. While most pedestrians are not hit while walking along a road, the presence or absence of a sidewalk often determines when and where a pedestrian will cross a street. It can be difficult or expensive to create and maintain a database of roadway, sidewalk, and traffic characteristics for an entire city, county, state, agency, or system. In working to create such a database, an agency should begin by collecting data for arterial or major streets and then phase in data collection on collector streets. Data collection for local streets may be limited to school walking routes or walkways near major pedestrian destinations, such as parks, churches, community centers, senior centers, and medical facilities.

Inventories should include the presence (one side or both sides) and quality of sidewalks (width, surface condition, separation from traffic, accessibility, etc.) Roadway characteristics include street classifications; posted speed limits; school zones; number of lanes; width of lanes' the presence of medians, traffic signs, or marked crosswalks; curb ramps; pedestrians regulatory, warning and wayfinding signs; streetlights; and bike lanes. Inventories can also include other features such as school sites, major school crossings, walking routes or school-specific signs and marking. Since transit stops are associated with high pedestrian activity, an inventory of transit stops is also useful. Other facilities that generate high levels of foot-traffic include parks, libraries, churches, community centers, and medical facilities. These inventories can help identify and prioritize where pedestrian improvements should be implemented.

Traffic Counts and Characteristics

This data includes Average Daily Traffic (ADT), peak hour motor vehicle traffic and the percentage of trucks in the traffic mix. Many agencies maintain motor vehicle traffic count maps showing flows on all arterial and most collector streets, and this information is generally updated every three to five years. Also, some agencies post the motor vehicle traffic volume maps on their web sites and continuously update the ADTs when new counts are made. Speed limit data files or maps are also maintained and updated by many agencies. Ideally these databases should be geo-coded and combined with roadway/sidewalk inventories; they can be used to help prioritize pedestrian improvements or to assess a location, corridor, or area for safety improvements. Jurisdictions can conduct pedestrian volume counts at intersections the same time as they perform vehicle turning movement counts. This data is relevant to pedestrian safety as most severe injury pedestrian crashes typically occur in areas with high motor vehicle traffic speeds and on wide roadways which often have high motor vehicle traffic volumes.

Other inventories that can be compiled to assist agencies in keeping track of where pedestrian improvements are or should be made include:

- Street light inventories – single versus double sided lighting, spacing of lights, and the size of lights (level of illumination).
- Crosswalk inventories – location and type of crosswalk markings (especially helpful for maintenance activities).
- Inventories of school locations, crosswalk locations, and school-related signs.
- Inventories of pedestrian warning signs, and the last dates when the signs were replaced (to ensure reflective signs are in place).
- Inventories of pedestrian generators such as parks, libraries, medical facilities, senior citizen homes, etc.

IV. Analyzing Information and Prioritizing Concerns

Improving pedestrian safety in a community or region is typically the result of implementing different safety treatments and changing agency design policies. Crash countermeasure or treatments intended to address pedestrian safety concerns, can take several different forms: operational and construction projects intended to fix specific problems; changes in design guidelines to help improve streets and intersections in future projects; and education and enforcement programs aimed at achieving changes in motorist and pedestrian behavior or attitude.

Projects involving pedestrian crash countermeasures can be further subdivided into:

1. Countermeasures for spot locations.
2. Countermeasures for corridors
3. Countermeasures for targeted areas (including neighborhoods).
4. Countermeasures for general problems common to an entire jurisdiction.

Categorizing Concerns for Pedestrian Safety

A systematic procedure is needed to identify what (and where) countermeasures should be implemented to provide for a safe walking environment. There will always be more improvements to be made than can be accommodated. Thus, a prioritization system needs to be developed to rank the various competing projects. Typically, the severity of pedestrian crashes is so disproportionately high compared to other motor vehicle crashes that the elimination of a few pedestrian crashes will result in a high safety dividend and high benefit/cost ratios.

Unlike vehicle crashes, crash rates for pedestrians are typically not used, since pedestrian volumes are usually not known. The crash to volume relationship for pedestrians is different than for vehicles. A single pedestrian crash at a low volume location will result in a high rate, while several crashes at a major downtown crossing may correspond to a low rate. Additionally, it is uncommon for agencies to invest extensive manpower to collect the system-wide pedestrian counts that are needed to develop rates; pedestrian crash rates would also need to account for motor vehicle volumes.

Instead, high pedestrian crash locations, corridors and targeted areas should be initially identified by comparing the total number of pedestrian crashes. System-wide concerns for a jurisdiction can be inferred from the sum of all data.

Another method of identifying and prioritizing high crash locations is by using weighted pedestrian crash data, giving more weight to severe or fatal pedestrian crashes. When identifying and prioritizing high crash locations, three to five years of computerized crash data should be used. For prioritizing corridors or other targeted area, one to three years of pedestrian data are acceptable.

The first step in determining the right countermeasure is to look at the problem and determine whether the problem is a spot problem, a problem evident in a targeted area or along a corridor, or a broader and more general problem that affects an entire jurisdiction.

1. A spot location problem is unique to one location.
2. A corridor problem may be evident at several sequential intersections or along the roadside of a corridor; to successfully reduce crashes, countermeasures need to be applied throughout the corridor, not just at a single location; fixing one location may leave other similar areas untreated.
3. A targeted area problem may repeat itself is a neighborhood or other area where conditions are similar throughout. Similar to the corridor problem, the nature of the roadway is such that fixing a spot area may leave other potential areas untreated; the solutions are very likely to be the same all around the neighborhood. A neighborhood or targeted area problem may be common throughout a local area due to unique circumstances such as a large university, commercial or business district, or other neighborhood characteristic.
4. An entire jurisdiction problem is common to an entire city, county or state and is usually caused by an undesirable practice such as failing to routinely install sidewalks or paved shoulders for pedestrians or failing to provide streetlights.

Once it has been determined that a problem is one of these types, the next step is to determine whether the appropriate solution is an operations/construction, general design, or an education/enforcement countermeasure.

Identifying High Crash Locations, Corridors, Targeted Areas and Jurisdictions

Pedestrian safety problem locations, areas and jurisdictions are most readily identified using computerized crash information.

Spot Locations

For spot locations, countermeasures are most likely going to be operational/construction change, but they could occasionally be changes to education/enforcement programs. Operational/construction countermeasures include anything from a change in crosswalk striping or sign timing to construction projects such as curb extensions, realignment of an intersection approach, or building a pedestrian crossing island. Education/enforcement solutions include spot enforcement of drivers-yield-to-pedestrian laws or education materials aimed at well-defined user group. Three to five years of pedestrian crash data are typically beneficial in identifying and prioritizing high crash locations.

In the above illustration, a driveway near an intersection was closed to increase pedestrian safety.

Corridors

For problems that occur along corridors, an assessment of the entire corridor is necessary. For analysis purposes, study areas can be subdivided into roadway segments of 0.5 miles to 5 miles in length. Crashes at first may seem to occur in undefined, almost random locations. A more thorough analysis may reveal patterns such as crashes occurring primarily at transit stops or at night. What seems like an insurmountable project can be tackled systematically and comprehensively by focusing one or two countermeasures throughout the corridor. For example, in the case of a predominance of nighttime crashes, improved illumination throughout the corridor may solve many problems. In the case of transit-related crashes, working with the local transit provided to assess all bus stops may lead to simple solutions such as relocating, adding, or eliminating some stops, and implementing countermeasures to assist pedestrians in crossing the street at a limited number of critical locations. Two to three years of pedestrian crash data are typically sufficient for corridors.

In this corridor, pedestrian lights and planters have been added to buffer pedestrians from vehicle traffic.

Targeted Areas

When identifying high crash targeted areas within the agency, geographic information system (GIS) data are important. Small communities or jurisdictions may be able to manually map pedestrian crashes, but this task is difficult and time-consuming for larger cities with several hundred annual pedestrian crashes. It is important that statewide computerized crash data systems allow for geographically mapping crashes for analyses purposes. One to three years of pedestrian crash data are reasonable to identify area-wide problems.

For targeted area problem occurring throughout a neighborhood, a similar approach to that outline in corridor problems should be taken. Are there patterns, similarities, or a predominance of one crash type? Neighborhood problems may be more amenable to education/enforcement solutions, as the traffic that goes through a given neighborhood tends to be made up of the same travelers nearly every day. Engineering improvements can include area-wide traffic calming or the installation of sidewalks or streetlights.

Jurisdiction-Wide Problems

For a problem that is common throughout an entire jurisdiction, agencies should ensure that their policies, plans and engineering design guidelines adequately embrace the appropriate countermeasures. Problems in spot locations, targeted areas, corridors and jurisdictions can often reveal a fundamental design flaw in the roadway; solutions then include changes in design guidelines.

Traffic calming techniques, such as chicanes, were used in this targeted area to slow vehicle speeds on neighborhood streets.

An example of a jurisdictional change is a city-wide policy for the installation of ADA-compliant curb ramps.

High Pedestrian Crash Potential

A lack of pedestrian crashes does not mean that conditions are safe or ideal for pedestrians. Pedestrians may avoid certain areas because they perceive danger. Consequently, low pedestrian crash frequencies are not necessarily indicative of a safe facility, but may be a consequence low or zero pedestrian activity. A pedestrian safety analysis should therefore go beyond just looking at pedestrian crashes.

Methods to identify pedestrian deficiencies at low-crash or no-crash locations involve an analysis of the roadway, traffic and other agency databases. By looking at the deficiencies that occur at high crash locations, an agency should be able to identify other locations with similar deficiencies. Safety improvements that are successful at one location should be implemented at all similar locations. This requires an inventory of spot locations, corridors or areas to allow an agency to identify those places that have similar characteristics as the high pedestrian crash sites. Field review and public input through surveys or workshops can help identify these locations.

Analyzing High Crash Locations, Corridors or Areas

Field Reviews

Once high crash locations, corridors, or areas have been identified, individual crash reports, complete with the police narrative and other detailed information, should be used when conducting field reviews. The detailed crash information and field review can be used to identify how each pedestrian crash occurred, and what may be done to prevent future similar crashes. The outcome is a list of improvements that can be implemented to address those crashes and enhance safety. For crashes involving severe and fatal injuries, police investigations are available for in-depth and detailed review of how the crash occurred and may provide information on what may have prevented it. These typically include witness statements as well as more detailed investigations of motorists and pedestrian behavior and site conditions at the time of the crash.

Roadway Safety Audits and Reviews

Road Safety Audit Reviews (RSARs) involve the use of a multi-disciplinary team approach to review and evaluate a location, corridor or area after it is built or before it is open to the public. Audit review team participants should include a variety of transportation professionals such as a traffic engineering expert, a human factors expert and a police representative. This team is provided all of the crash history and other data for the crash location or study area such as pedestrian and motor vehicle traffic counts. In order to have the best chance of observing the pedestrian safety problems, the team should visit the site when the conditions best simulate the problems. For instance, if crashes are happening at night, the team should visit the site at night. The multi-disciplinary team members visit the location or corridor together with each member making their own observations of vehicle, traffic and environmental conditions. The observations and suggested solutions are summarized in a report once the team has a chance to compare notes. Pedestrian safety improvements implemented at one location can be implemented at other similar locations, even where no pedestrian crashes have occurred. Roadway Safety Audits (RSAs) are similar the RSARs except they are conducted before the system is built.

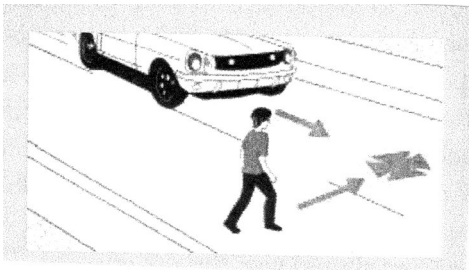
Pedestrian crashes may continue to occur at locations or along corridors or targeted areas where safety improvements have been implemented. The phenomenon may occur because more pedestrians are willing to cross at locations with one or more engineering enhancements, thereby increasing exposure. This may also be an indication that engineering solutions alone will not result in totally safe conditions. A proper before-and-after evaluation of any treatment is essential to determine how effective it has been.

The occurrence of a seemingly illogical pedestrian crash after the implementation of a safety measure has sometimes been attributed to a pedestrian's lack of understanding of the roadway environment. It can equally be attributed to the motorist's lack of understanding of the roadway environment. In many cases, therefore, education and enforcement programs may be necessary to achieve a true safety benefit. There are few engineering projects that can prevent motorists or pedestrians from choosing to travel intoxicated or that can stop motorist from willfully breaking the law. Education and enforcement programs addressing pedestrian safety programs should also be carefully implemented and evaluated.

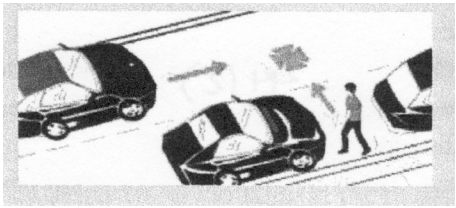
Crash Typing

A crash type describes the pre-crash actions of the parties involved. When crashes in a database are "crash typed," a pattern often emerges that helps safety officials identify what the problem is and what countermeasures are generally related to each crash type. The following six crash types are some of the most common pedestrian crash experiences:

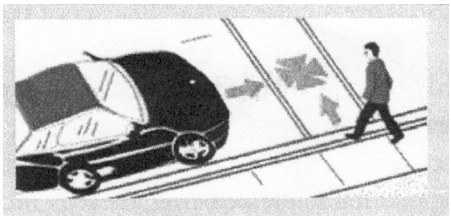
1. Dart/Dash – The pedestrian walked or ran into the roadway at an intersection or midblock location and was stuck by a vehicle. The motorist's view of the pedestrian may have been blocked until an instant before the impact.



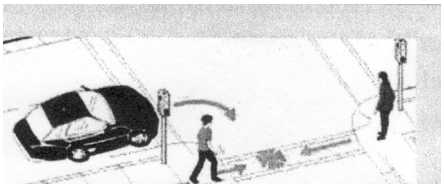
2. Multiple Threat/Trapped – The pedestrian entered the roadway in front of stopped or slowed traffic and was struck by a multiple-threat vehicle in an adjacent lane after becoming trapped in the middle of the roadway.



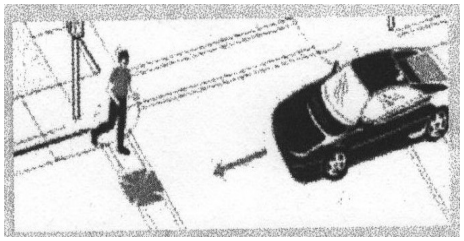
3. Through Vehicle at Unsignalized Location – The pedestrian was struck at unsignalized intersection or midblock location. Either the motorist or the pedestrian may have failed to yield.



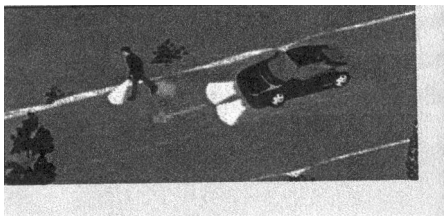
4. Turning Vehicle – The pedestrian was attempting to cross at an intersection, driveway, or alley and was struck by a vehicle that was turning right or left.



5. Through Vehicle at Signalized Location – The pedestrian was struck at a signalized intersection or midblock location by a vehicle that was traveling straight ahead.



6. Walking Along Roadway – The pedestrian was walking or running along the roadway and was stuck from the front or from behind by a vehicle.



Selecting the Appropriate Solutions

Once crash locations have been identified based on data analysis, crash patterns should be determined by narrowing in on specific crash types occurring at individual locations. If a pattern is observed, then it will be easier to select the solution that best applies to the crash type experienced.

Determining the Extent of Implementation

Once pedestrian safety solutions have been selected, the final decision is usually based on a combination of factors: is the project to be implemented in phases or all at once; is the project to be permanent or temporary; what are the cost constraints?

Phasing Projects

Phasing projects is most applicable to corridor or neighborhood/targeted problem areas. A desirable countermeasure may be very costly or politically challenging to implement all at once. Phasing allows certain elements to be implemented right away, as others await further funding. There are several ways projects can be phased: geographically, by urgency, by opportunity, or by type of treatment.

Geographically – starting at one end of a corridor and completing it in units. For example, a 5 mile corridor where a sidewalk is planned can be built in five 1 mile sections over five years. This is a practical method, but may not address the most urgent needs first. Conversely, safety projects may be disbursed equally in different regions of a state or city so that all areas can share an improved safety for pedestrians and no areas feel slighted.

By urgency – treating the areas with the highest crash numbers or highest pedestrian activity first. This may seem logical and politically acceptable, but in reality there may be constraints that make the most needed areas the hardest to address. Reasons may include lack of right-of-way or topographical constraints.

By opportunity – if a certain type of treatment is needed up and down a corridor and it can be piggybacked onto other planned projects in that corridor (such a maintenance or resurfacing projects), then it makes sense to implement the countermeasures along with the planned work.

By type of treatment – scheduling countermeasure by type of work. For example, illumination may come first, as an agreement with the utility company makes it easy to do so right away. A

more controversial countermeasure such as a traffic circle may have to wait until the political or design issues have been settled. Assuming both treatments will independently contribute to pedestrian safety, proceeding with one treatment while waiting for the other is acceptable.

Duration of Improvement

Projects can be further subdivided into temporary and permanent categories.

In most cases, a permanent solution should be sought. It will cost the most, but will last for the duration of the roadway. A good estimate for the life of a permanent treatment such as a sidewalk is 20 years or more, but in reality they typically last much longer. In some cases, a temporary solution is more appropriate. This is the obvious choice where it is known a road is to be rebuilt soon, but the pedestrian safety needs must be addressed right away. There are other reasons to consider a temporary installation: if the solution is new and untested in the community or if the design cannot be finalized based on local conditions. A temporary installation can be used to gauge public acceptance and can be modified when user observations demonstrate corrections that may be helpful. There are a variety of materials and designs that can be used for temporary solutions:

- Paint is the cheapest and can give an immediate impression of how the permanent solution will look and affect traffic operations; if simple lines are not enough to redirect traffic, hashing out areas with zebra stripes is often more effective at keeping cars out of certain areas; paint is very short term and should not be left in place for more that a few months, as it will wear out; nor should the experiment be considered a failure if motorists cross over the painted area, as there is really no physical barrier preventing them from doing so.
- Plastic posts or barrels provide more positive guidance and may last longer that paint.
- Plastic curbs offer a greater opportunity to create a picture of the proposed permanent solution, such as curb extensions or raised median islands.
- Concrete curbs can also be laid on the pavement; these are usually referred to as “wheel stops,” such as those found in parking lots. They are almost never used in the travel portion of the roadway but can be used as a substitute for a curb to protect a walkway. Wheel stops should be firmly anchored and supported with other measures. One potential disadvantage of wheel stops is that they may cause pedestrians to trip.

Temporary solutions should then be evaluated for their effectiveness. The techniques range from a full traffic study to observation and receiving public input. To warrant the time and expense of a traffic study, the temporary installation should closely resemble the final solution and therefore

be made to look substantial – evaluating the effect of paint will not predict how a raised curb would perform.

Prioritizing Pedestrian Improvements

Initial Factors to Consider

Pedestrian safety countermeasures can be prioritized taking into account the following factors:

Availability of Right-of-Way (ROW)

Most pedestrian safety countermeasures will not require additional ROW, as they usually involve road narrowing, striping, illumination, etc. Occasionally, additional ROW (or at least an easement) will be required, to create a sidewalk buffer for example. ROW negotiations can be lengthy, and it is best to start the process as soon as it is determined the improvement is needed so the project is not unduly held up. A conceptual design should be enough to determine how much ROW will be needed to help speed things along. Easements can often be obtained much quicker and at a much lower cost.

Federal and/or State Mandates

Certain countermeasures can be piggybacked to project scheduled to fulfill Federal or state requirements. ADA and curb ramp requirements are one example: if a safety countermeasure requires changing a corner radius, and the corner is slated for an ADA update (ramp installation), the two projects can be combined for efficiency. Some Federal or state requirements are safety-related, such as upgrading deficient bridge guardrails; these projects should also include pedestrian safety measures.

Public Support

The data collection methods will often make the most problematic areas rise to the surface. Yet there are some crashes that strike an emotional chord in the public, like when a child is hit while walking to school. This will create tremendous public support for a countermeasure that addresses this issue. The responsible agency should pursue a solution to this problem while not losing sight of the goal of making improvements where most crashes occur. Similarly, the solution should be one that improves pedestrian safety and is not a response that my make conditions less safe for motorists and pedestrians. However, responding positively to an emotionally charged situation is an opportunity for the agency to pursue funding for other needed

pedestrian crash countermeasure as well as gain acceptance of a fairly progressive countermeasure.

Travel Demand

Though pedestrian crashes do not always correlate to pedestrian use (pedestrians often get hit in areas where fewer people walk), countermeasures in an area where there are many pedestrians will be easier to justify.

Cost of Improvements

This is always an important factor in all decision-making: should an agency try to spread available funding to many low-cost countermeasures or target funds for a few high-profile projects? Some of the most expensive countermeasures are not necessarily the most effective. The best examples are pedestrian bridges and underpasses: they can cost millions of dollars but get little use because of inconvenience or security concerns. Several new pedestrian signals can be installed for the cost of one tunnel or bridge. Conversely, inexpensive measures, such as improved striping, can be quickly implemented over an entire corridor or neighborhood for comparatively little cost.

Funding

Some funding sources can only be used for limited applications. Many common funds can be used only for construction, only for education or only for enforcement. This is not necessarily a limitation, as a typical safety program will involve all three components. If a funding source becomes available, but has limitations, this should not be an impediment to implementation – every funding opportunity should be seized as it becomes available.

Safety Benefits

Decision-makers want to ensure the maximum cost-effectiveness, so the most effective countermeasures that offer the greatest safety benefits should be considered first. Some pedestrian safety countermeasure will have benefits for other road users, and some may have negative consequences for others. These issues need to be weighed against all other considerations. This highlights the need to develop a ranking system to prioritize projects.

Developing a Ranking System to Prioritize Projects

Transportation agencies often develop a ranking system for making improvement such as surface preservation, modernization or safety. Pedestrian safety countermeasures are no different. The

idea is to assign scoring to the various criteria, weighting each one according to the values of the community, available funding, political climate etc. Other scoring factors can be added, and each one needs to the weighted so it represents an agreed-upon value.

Pedestrians Needs Index

The primary input to a Pedestrian Needs Index is pedestrian crash data. In addition to crash data, inventories of missing sidewalks, lighting and other pedestrian facilities can be used to identify where upgrades are needed. Lists can be prioritized using pedestrian count data or proximity to schools or other pedestrian generators. Projects should be reassessed and reprioritized annually, funding should be assigned so that all regions within a state or an agency receive some level of pedestrian facility enhancements and all of the improvements are not concentrated in one area. Each agency should create its own Pedestrian Deficiency Index based on the resources available, and develop a point system to compare and assess various projects. Pedestrian crash history can be an input to this ranking system.

Any ranking system can be subject to personal bias if multiple observers or analysts contribute. A standardized form or checklist can enhance objectivity of the results. GIS methods can be used to automate the ranking process for large areas from a database. A scoring system where the total possible points add up to 100 makes it easier for the public to appreciate how a proposal fares; it also makes it easier to tweak individual weighted category scoring.

The first attempt at a scoring and weighting system is rarely perfect. A Pedestrian Advisory Board (PAB) can help develop the ranking system. It should then be field-tested on real-world problem areas so that the results appear rational and those projects that are obviously needed score highly. A potential downside is that a problem the public has identified as a major crisis may score low if it fails in several important categories. A scoring system created and backed by a PAB that represents the public's interests can help deflect criticism. It can also help ensure that projects that solve a real but ignored problem get the attention they deserve. However, if a scoring system is created and the high-scoring projects are not implemented, it may create a liability problem for the agency.

V. Selecting Safety Solutions

Jurisdictions should ensure that all of their policies, plans and engineering design guidelines include considerations for pedestrian safety.

A. Design Specifications and Guidelines

There are numerous policy, planning and design guidelines that transportation planners and engineers can use; however, only a few address pedestrian design thoroughly, AAHTO has published the 'Guide for the Planning, Design, and Operation of Pedestrian Facilities.' Most state and regional jurisdictions have their own guidelines. Additionally, FHWA has an excellent publication: 'PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System.' The "Manual on Uniform Traffic Control Devises" (MUTCD) should be used to select appropriate traffic controls: signs, traffic signals, marked crosswalks and other pavement markings.

Many of the above-mentioned pedestrian policy, planning and design guidelines were used to develop the following list of some of the more effective countermeasures in terms of improving pedestrian safety. They should also be used by jurisdictions for guidance to fix spot problems and to update and improve agency design manuals, practices and procedures.

B. Engineering Solutions

The countermeasures presented here are organized according to the type of pedestrian crash.

Walking Along the Road Crashes

Rural Environments

1. Paved shoulders – Paved shoulders provide room for pedestrians to walk separate from motor vehicle traffic in rural areas when providing sidewalks is not a feasible option. Paved shoulders also provide room for bicyclists. Paved shoulders have many safety and operational advantages for motor vehicle traffic as well. To be effective, paved shoulders should be 6 feet wide or more; 4 feet is considered the minimum acceptable width to accommodate pedestrians (AASHTO Green Book). Rural environments near large urban areas or those experiencing rapid growth should be considered suburban, where sidewalks are the preferred pedestrian accommodation. Newly-developed communities should provide sidewalks and other pedestrian features.

The following illustration shows a paved shoulder being utilized by a pedestrian.

Urban and Suburban Environments:

1. Sidewalks – Sidewalks can eliminate most walking-along-the-road pedestrian crashes by providing positive separation from motor vehicle traffic. Continuous and connected sidewalks are needed along both sides of streets to prevent unnecessary street crossings. Sidewalks generally should not be placed immediately adjacent to moving motor vehicle traffic. Whenever possible, they should be buffered with a planter strip, parking lanes, shoulders, or bike lane. This will increase pedestrian safety and comfort and can make it easier to meet the ADA requirement for a level passage through driveways and the requirement for a clear passage around utility poles, posts, fire hydrants, etc. (these can be placed in a landscaped buffer zone). Planter strips should be 5 feet wide or greater, 6 feet is the desirable minimum. Separate sidewalks should also be 5 feet wide or greater; 6 feet is a desirable minimum along arterial streets in non-commercial areas. Along arterials where there is no buffer, curbside sidewalks should be 10 feet wide or greater. Sidewalks should provide a continuous effective width to prevent choke points from being created by street furniture. In downtown areas, considerations must be made for outdoor seating for restaurants. Rolled (mountable) curbs are not recommended. Continuous and connected sidewalks are needed along both sides of streets to prevent unnecessary street crossings.

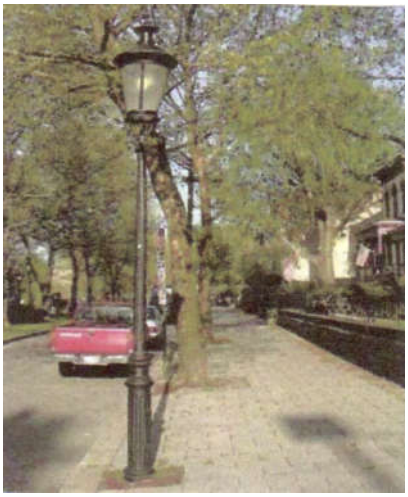
2. Driveways - Well-defined driveways clearly mark the area where motorists will be crossing the pedestrian's path. Non-defined vehicle access points with continuous access to parking create a long conflict area between pedestrians and motorists. This added area of ambiguity complicates the motorist's task of watching for pedestrians.

3. Driveway design and spacing – Driveways should be designed to look like driveways, not street intersections (sidewalks should continue through the driveway). Local policies should prohibit blocking the sidewalk at driveways and these policies should be enforced. Driveways should be kept as narrow as possible. The level of the sidewalk should be maintained, and the driveway should be sloped so that the motorist goes up and over the sidewalk. This will help with a number of goals: meeting ADA accessibility requirements will be easier, the fact that the

pedestrian has the right-of-way will be clear and motorists will need to slow down slightly to enter the driveway, which will help promote pedestrian safety. Driveways should be located away from intersections. The number of driveways should be minimized (consolidate whenever possible) to reduce the number of conflict points for pedestrians. This access management is also a safety advantage for motorists.

Driveways should be designed so the sidewalk continues through the driveway in a relatively flat and level alignment.

4. Illumination – Pedestrian crashes disproportionately occur at times of poor lighting (mostly dusk and nighttime). Illumination greatly increases the motorist's ability to see pedestrians walking along the road. Double-sided lighting should be provided along wide arterial streets to illuminate both sidewalks for the security and safety of the pedestrian. Light uniformity along a road is also important. Lights should be spaced to minimize or eliminate dark areas along the road and sidewalks. For midblock and intersection crossings, it may be helpful to provide extra lighting to crossings with high nighttime pedestrian use.



Pedestrians light fixtures increase pedestrian visibility at night and provide a better sense of security.

Crossing the Road Crashes

Midblock Crashes

1. Pedestrian crossing island – On two-way streets, a median island at uncontrolled locations can help reduce crashes by up to 40 percent. The benefits are greatest on busy multi lane streetswhere gaps are few and difficult to find. A pedestrian crossing island breaks an otherwise difficult crossing maneuver into two easier steps: instead of needing to find a gap long enough to cross all lanes at once, a pedestrian looks left, finds an acceptable gap in one direction only, crosses to the island, then looks right and fins a second gap.

The following illustration shows a pedestrian crossing through a raised median.

2. Two-stage crosswalk with median fencing – some agencies provide railings/fencing in the medians of multilane roads that channel pedestrians to the right, increasing the likelihood that the will look for vehicles coming from the right in the second half of the crossing. It should be mentioned, however, that these types of crossings can be problematic for pedestrians who are blind and for wheelchair users.

The following illustration shows a pedestrian crossing utilizing median fencing.

3. Curb extensions - On streets with on-street parking, curb extensions reduce the total crossing distance. Reducing the crossing distance help the pedestrians in two ways: it reduces the time they are exposed to moving traffic, and it makes it easier for pedestrians to assess and find an acceptable gap, as the time needed to cross is shorter. They also increase visibility: the waiting pedestrian can better see approaching motor vehicle traffic and motorists can between see pedestrians waiting to cross the road; their view is not longer blocked by parked cars. Curb extensions should be designed to accommodate stormwater drainage and should never extend more than 6 feet.

The following illustration shows a pedestrian crossing utilizing curb extensions.

4. Illumination - Illumination was discussed in the previous *Walking along the Road Crashes* section.

5. Crosswalks at uncontrolled locations with advance stop bar (or yield line) – On multilane streets a common and often fatal crash type is the "multiple-threat" crash, in which a motorist in one lane stops to let a pedestrian cross, but so close to the crosswalk as to mask a motorist in the adjacent lane who is not slowing down. The second motorist does not have time to react and the pedestrian is struck at a high speed. The advance stop bar or yield line requires all motorists to stop back (30 to 50 feet is desirable); when the first motorist stops at the stop bar, it allows the pedestrian to see if a motorist in the second lane is stopping. This enables the pedestrian to wait or step back if he or she has started to proceed into the second lane. While the advance stop bar with appropriate signing has the potential to reduce the probability of a multiple-threat crash, this is no guarantee that 1) all motorists will stop for pedestrians, and 2) all stopping vehicles will necessarily stop at the stop line, potentially on high-speed roads. Therefore, it is important to carefully select locations for unsignalized crossings, even if the advance stop bar and signing is used. Also, such sites should be monitored to ensure that pedestrians are able to cross safety and if not, then other treatments (e.g., traffic signals) should be considered.

6. Traffic signal with pedestrian signal displays – On busy multilane highways with significant volumes, a signal may be other only way to create a gap for pedestrians to cross. It is often difficult to meet the MUTCD warrants for a traffic signal based solely on existing pedestrian counts; it is often necessary to anticipate how many pedestrians might cross there once the signal is installed. All signals have associated operational and safety concerns. That must be addressed, including the distance to adjacent signals.

Nighttime Pedestrian Crashes:

Many nighttime crashes can be prevented through better lighting. Illumination was discussed in the previous *Walking along the Road Crashes* section.

Intersection Straight-Through Crashes:

Most of the techniques described under midblock crashes are applicable at intersections for straight-through crashes: pedestrians crossing islands, curb extensions, illumination and advance stop bars or yield lines.

Intersection Right Turn Crashes (Signalized or Unsignalized):

1. Tighter Radius – Tightening the intersection radius has many benefits for pedestrians: it shortens the crossing distance, brings the crosswalk closer to the intersection, increases visibility of the pedestrian or the approaching motor vehicle, slows right-turning vehicles and it makes it much easier to install two ADA compliant curb ramps at each corner. The choice of a curb radius is dependent on the design vehicle and whether the street is a local residential street, a neighborhood collector or a major arterial. This requires the designer to calculate the appropriate radius for each corner of an intersection and to accept occasional difficult turns for the rare event – for example a large moving truck turning onto a local street; this occurs seldom enough that there's little reason to provide large radii for turns onto local streets. The presence of on-street parking on both intersection streets can also result in the opportunity to tighten the curb radius.

The above illustrations shows how a curb extension can reduce the turning radius and vehicle turning speed.

2. Curb extensions – Curb extensions were discussed in the previous *Crossing the Road Crashes* section.

3. "Pork-chop" islands – while right-turn slip lanes (also called channelized right turn lanes) are often considered negative facilities for pedestrians (especially vision-impaired pedestrians) due to the emphasis on easy and fast motor vehicle travel, the can be designed to be less problematic. Where an exclusive right turn is provided, a pork-chop island between the right-turn lane and the through lanes can shorten the crossing, resulting in less pedestrian exposure and improve signal timing. The island also enables pedestrians and motorists to negotiate one conflict separately from the others. A properly designed pork-chop island has a longer tail point upstream to the approaching right-turn motorist; this channelization brings the approaching motorist as close to a 90 degree angle, so the motorist is looking forward at the crosswalk; the crosswalks is placed one car length back from the intersection proper. This enables the motorist to move forward once the pedestrian conflict has been resolved so the right-turning motorist can focus on traffic. The pedestrian then can cross to a shorter street crossing.

Intersection Left-Turn Crashes

1. Median islands – A median island helps channelize left-turning vehicles, slowing their speeds in the process. An island also gives pedestrians a refuge for long crossings or if a conflict cannot be avoided. However, signal phasing should ideally be designed to allow the pedestrian to cross the entire street during a single cycle.

2. Curb ramp placement and design – Poor ramp placement and design can make a street crossing more difficult and may lead to crashes. For example, poorly placed or oriented ramps

force wheelchair users to make long detours and they may not cross in the allotted time at a signalized intersections or they may force wheelchair users to cross outside the crosswalk lines at a location where motorists do not expect them. Proper ramp placement and design ensures that all users cross in crosswalks, close to the intersection, where motorists can see them and without undue delay. Ramps must be wholly contained within the marked crosswalk area. Usually, this can only be accomplished if the curve radius is 25 feet or less. Single ramps that direct the pedestrian into the middle of the intersection should be avoided (especially on arterial streets) but may be necessary where a large radius precludes the use of two ramps. Ramps must be designed to meet ADA Guidelines, and two ramps at a corner are generally preferred over single-ramp corners.

Signalized Intersection Crashes

All signalized intersections should have the following (unless no pedestrians are expected):

- Pedestrian signals are needed (pedestrian WALK/DON'T WALK signals) to ensure that a pedestrian knows when the signal phasing allows them to cross and when they should not be crossing. On one-way streets (or streets with unusual configuration) pedestrians approaching from the opposite direction may not realize an intersection is signalized and cannot see the vehicle signal heads to know when it is safe to cross if there is no pedestrian signal. The same is true for intersections with left turn arrows. Wide streets require more information on when to cross and when not to start crossing due to the long pedestrian clearance intervals that may exist.

- Marked crosswalks clearly indicate to the motorist where to expect pedestrians and help keep the crossing area clear of vehicles. It should be standard practice to mark all four legs of a signalized intersection unless unusual circumstances exist.

- A WALK signal (walking persons symbol) should be long enough to get pedestrians started and a clearance interval (flashing upraised had or DON'T WALK signal) long enough to ensure that a pedestrian can fully cross the entire street. While many agencies have traditionally used a 4 ft/s assumed walking speed, slower walking speeds of 3.5 ft/s or even 3 ft/s may be appropriate at locations that have a substantial number of older pedestrians. The 'Highway Capacity Manual' specifically recommended a slower walking speed when the percentage of walkers over the age of 65 represents 20 percent or more of the pedestrian population using that crossing. Another option is to consider the use of automatic pedestrian detectors, which can detect slower-moving pedestrians in a crosswalk and automatically extend the pedestrian clearance interval until the pedestrian is safely on the other side of the street. New detection methods such as video are being tested but some may still be expensive to implement.

- Push buttons, placed where a pedestrian who is in a wheelchair or is visually impaired can easily reach them, are often needed. They should be located so as to clearly indicate which crosswalk each button regulates for crossings in two different directions. The best practice is to provide push buttons mounted on two separate pedestals separated by at least 10 ft. Illuminated push buttons (that light up when activated) are used to notify the pedestrian that the actuated sign is working and/or connected. They increase the likelihood that the pedestrian will actuate the push button and comply with the pedestrian signal. Push buttons are not used in downtown/central business districts and other areas of high pedestrian use where pedestrian can be expected at every signal cycle. The pedestrian phase should be on recall at these locations. Push buttons should not be needed at fixed-time traffic signals where pedestrian crossings are reasonably expected on more than an occasional basis, and the crossings (WALK) interval should occur every signal cycle.

Many crashes occur while the pedestrian is crossing with the WALK signal, and some signal-timing techniques can help reduce the incidence of these crashes. Additional countermeasures at signalized locations may include:

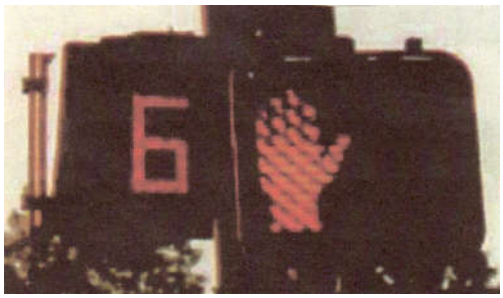
1. Protected left-turn phases - This allows left-turning vehicles to have their own separate interval, which can also separate vehicle left-turning movement from pedestrian crossing intervals. Thus, pedestrians can cross without interference from left-turning motorists. Red and green left turn arrows are used to make it clear to motorist they must wait before turning left.

2. All-red phase – A short (i.e., 2 second) all-red interval may help prevent a crash resulting from a high-speed red-light runner hitting a pedestrian who has begun crossing with the WALK signal or who may have a slower walking speed and did not clear the crosswalk.

3. Lead pedestrian interval (LPI) – The LPI can help reduce conflicts between turning vehicles and pedestrians when turning vehicle encroach onto the crosswalk before pedestrians leave the curb. The LPI releases pedestrians (WALK phase) 3 to 5 seconds prior to the green light for vehicles. This enables pedestrians to enter and occupy the crosswalk before the turning motorists enter it. This treatment is particularly effective where there is a double right or left turn movement.

4. Pedestrian countdown signal – this tells the pedestrian how much time is left in the pedestrian clearance interval (flashing DON'T WALK or upraised hand). This information encourages pedestrians to leave the crossing before the crossing time runs out and reduces the number of pedestrians who initiate a crossing too late in the cycle or who are still in the street at the end of

the crossing interval. The countdown signal should begin during the pedestrian clearance interval (flashing DON'T WALK) phase.



5. All-pedestrians phase (also know as scramble phase) – By stopping all vehicle movements and allowing pedestrians to cross in all directions (including diagonally), virtually all conflicts are eliminated. But pedestrians are not allowed to cross during the regular motor vehicle phase, so motorists can turn without needing to yield to pedestrians. This introduces a third signal phase that generally increases delay for motorists and pedestrians. This signal phasing technique has been removed from many intersections as both pedestrians and motorists do not typically tolerate the extra delay, and such phasing may only be appropriate for a few central city crossing locations with very high pedestrian traffic, relatively low vehicle volumes and a high number of turning conflicts. Also where intersecting streets are narrow and cycle lengths are short, such timing schemes may be more practical, since increased delay will be less of a problem. The all-pedestrians phase may also be better when applied at intersections where all street approaches have a similar cross-section and traffic flow.

The following illustration shows an intersection with an all pedestrian phase.

6. Prohibited right-turn-on-red at selected locations – Consideration should be made to prohibit right-turn-on-red (RTOR) at intersections where there are high volumes of pedestrians, particularly near schools and/or where older pedestrians cross regularly. Placing NO TURN ON

RED signs may also be appropriate at complex intersections (e.g., skewed intersections, intersections with more than four legs), and also where pedestrians are having trouble crossing on a WALK signal due to a high volume of right-turning motorists. It should be noted that at locations where RTOR is prohibited, right-turn-on-green collisions or conflicts with pedestrians may still occur.

Pedestrian Crashes on Road Sections

1. Road diets – Reducing travel speed and reducing the number of travel lanes a pedestrian has to cross are beneficial in all cases. One well-documented technique that accomplishes both goals is a "road diet" that takes a four-lane undivided street (two lanes in each direction) and reconfigures the lanes to two travel lanes, a center turn lane and two bike lanes. The benefits for pedestrians include a shorter effective crossing fewer lanes to cross and slightly slower motor vehicle traffic speeds. The addition of a center-turn lane also creates space for pedestrian crossing islands. All this is accomplished without having to change the curb lines. The bike lanes add a buffer for pedestrians as well as a place for bicyclists to ride. The key to a successful road dist is to ensure that all signals are set up to handle expected volumes of left-turn movements and to monitor adjacent streets to ensure that they are not overly impacted by higher speed or higher volume motor vehicle traffic.

There are many variations on this road diet, for example reducing a multilane one-way street by one lane. A more expensive road diet can involve moving the curbs to actually narrow the roadway surface. A simpler road diet can involve narrowing the travel lanes to 10 or 11 feet to slow motor vehicle travel speeds and create space for bike lanes that acts as a buffer for pedestrians.

A road diet, such as the one above, may decrease motor vehicle speed and reduce the number of lanes a pedestrian must cross.

2. Traffic calming – Within neighborhoods, traffic calming measures can be used to slow motor vehicle traffic (such as speed tables, speed humps, traffic circles, chokers and chicanes) or to break up long stretches of straight streets.

Traffic calming devices such as a raised crosswalk help illuminate the pedestrian crossings and slow motor vehicle traffic.

C. Enforcement and Education Solutions

Measures to improve pedestrian safety should not be limited to engineering treatments; education and enforcement are also important for pedestrians. If pedestrians and/or motorists do not know how to respond correctly to a safety device such as a traffic signal or flasher, it is not likely that the crossing will operation safely. Education and enforcement programs teach motorists and pedestrians about safe practices as well as the laws that govern them.

An important educational feature is how motorist come to think of pedestrians. Most motorists do not routinely look for pedestrians and this is, in part, a result of how transportation official educate them and enforce (or fail to enforce) certain behaviors. In pedestrian-vehicle crashes, the pedestrians are often blamed, even when the motorist was at fault for not looking for and yielding to the pedestrian, because of the underlying assumption that pedestrians should not be in the road. Educators and law enforcement officers need to work to change the views to ensure that pedestrians are accepted as legitimate users of the street network.

Safety education by itself may have limited effectiveness without also providing engineering and/or complementary enforcement measures. For example, to encourage increased motorist yielding to pedestrians in crosswalks, the roadway should be designed to carry motor vehicles at a lower speed, while police enforcement can give warning and tickets to violating motorists, and public education programs are used simultaneously to educate the public about the importance of motorist compliance to such laws (and the possible consequences of not doing so).

An adequate level of enforcement is needed to monitor motorist and pedestrian behavior, especially in school zones. Enforcement aimed at motorists is more effective than enforcement aimed at pedestrians: "anti-jaywalking" campaigns have proven ineffective and very unpopular. Police interaction with pedestrians should focus on education and warnings rather than giving citations. It is more effective to cite motorist for behavior violations. While the laws clearly explain the dual responsibility of motorists and pedestrians, the burden for safety is mostly on the motorist operating a heavy motor vehicle at relatively high speeds. Enforcement programs that involve frequent and reasonable motorist penalties are more effective than enforcement that is less frequent but imposes high penalties for a motorist violation.

Police resources should be used to enforce pedestrian crossing rights and to control motorist speeds. This requires speed limits to be established at reasonable and desirable levels. Police department should undertake training programs so that the police officers who are responsible for enforcement programs understand the laws and issues surrounding pedestrian safety.

Enforcement Programs

1. Radar speed trailers – Fixed motorist feedback signs or movable radar speed trailers can be use as part of a community education program. The more effective units have bright strobe lights that will flash like a photo-enforcement camera or display red and blue flashing lights when motorist exceed a preset speed. Radar trailers are moved to different locations and are occasionally supplemented with motor officer enforcement for those motorists who do not believe that there is any reason to pay attention to the speed trailers. Some radar trailers can record speed data and traffic counts by 15-minute or hourly intervals throughout the day, which will help in targeting future police enforcement. As with neighborhood speed watch programs, these have limited long-term effectiveness in changing the problem but can be useful in educating people and helping to boost support for long-term solutions.

2. Pedestrian Safety Enforcement Operations - These are well-prepared and coordinated operations designed to warn motorist that the yield-to-pedestrians laws will be enforced at target

locations. Officers prepare a site ahead of time by establishing the safe stopping distance to a crosswalk, with a 10 mi/h over the speed limit leeway. Cones are set out in that location. An officer in plain clothes steps into the crosswalk just before a vehicle passes the cone. This gives the motorist plenty of time to yield to the pedestrian. If the motorist doesn't yield, either a warning or a citation is given, based on the severity of the incident. The most effective campaigns have been accompanied by an extensive media blitz ahead of time; all the interactions recorded on video so if the motorists dispute a ticket, their behavior can be viewed by the courts. This usually leads to a guilty plea. These campaigns have proven to be very popular, as pedestrians are happy to see enforcement oriented at motorists, who often act aggressively towards pedestrians.

3. Photo Enforcement – In states where automated photo speed enforcement is permissible, it can be used to concentrate on areas with high concentrations of pedestrians crossing. Vans allow the enforcement cameras to rotate to various sites, and warning signs are use to give motorists advance notice of the camera enforcement. Some communities combine photo speed enforcement with red-light enforcement, which can be used at traffic signals with hi pedestrian exposure, such as school crossing or near parks or community centers.

4. Safe Routes to School Walking Plans – Safe Routes to School (SR2S) is a national program teaching Education, Enforcement, Engineering and Encouragement strategies to make walking to school safe. Although SR2S programs vary between communities, they often include exercises to map out the best and safest ways to walk to school and encourage students to walk. These walking plans help to identify where sidewalk and roadway improvements are needed and where crossing guards or police enforcement is needed. Parents and students should be involved in developing the plans, and part of the plan should focus on teaching children how to cross safely. Safe walking routes can also be developed for senior citizen homes to assist in finding the routes to walk to near by stores and medical centers and to target problem areas for improvements.

Educational Programs

Educational campaigns need to target both pedestrians and motorists to improve their behavior and compliance with laws and ordinances. Motorist education should include the added component of increasing the understanding that pedestrians are legitimate road users as well as provide practical strategies for motorist to look for and expect pedestrian activity.

Educations programs and campaigns are most effective if there is a clear understanding of the audience, the objective, the messages that need to be conveyed, and the funding. Such programs are also more effective when they are part of a long-term program and not just designed to

achieve short-term changes. There are three basic approaches for educational programs. These include:

Education campaigns can teach children about safe pedestrian practices.

1. Public awareness campaigns - These programs involve increasing knowledge and also motivating positive behavioral changes. They can sensitize motorists to their responsibilities concerning pedestrians. This can also include educating pedestrians about safety risks and explaining the meaning and proper use of crosswalks, pedestrian signals and other pedestrian facilities.

2. Campaigns to target groups and situations – These may include educational materials targeting groups such as older adults, children or motorists. They may also focus on specific settings such as crosswalks, school zones or crossing at signalized locations. To get the best results from such programs it is important for them to be institutionalized within an organization so they can be implemented on a long-term basis.

3. Individual campaigns – These are similar to targeted campaigns, except that the target audience is reached through an intermediary – such as a pediatrician, a parent, or a grandparent – on a one-on-one basis. For example, school crossing guards or classroom teachers may instruct students about safe behavior when getting on or off the school bus or how to cross streets safely.

Policy and Planning Solutions

Over and beyond incorporating feature designed specifically to improve pedestrian safety, there are many aspects of general street design that result in safer conditions for pedestrians:

General Street Design

1. Speed Control – For many pedestrian crashes, speed is an important factor; high speeds reduce the possibility of crash avoidance, and increase the likelihood of a severe injury or

fatality. Cities that have made concerted efforts to reduce pedestrian crashes use speed reduction as a primary tool. Speed reduction must be a matter of both policy (by setting lower speed limits) and design. However, simply lowering speed limits on streets where motorist can go fast is usually ineffective. Street must be redesigned to encourage lower speeds.

2. Traffic Calming – Local agencies often develop plans and policies for using a variety of traffic calming measure for reducing pedestrian and/or other crash types on local and neighborhood streets. Such measures include, speed tables, traffic circles, speed humps, chokers and chicanes to break up long straight stretches of straight streets and to reduce vehicle speeds and/or reduce cut-through motor vehicle traffic.

3. Residential Street Design - Many residential streets built in the last few decades have been built too wide and without interruptions for long distances, encouraging higher speed than appropriate for streets where children are frequently expected. Most small children who are involved in a crash are hit within a block of their homes. Features of residential streets that are safe for pedestrians include narrow width, on-street parking, tight curb radii, short block length, buffered sidewalks with street trees, short building setbacks and streetlights.

Land Use Design

Land use patterns can have an impact on pedestrian crashes. Many pedestrian crashes occur in suburban, auto-oriented locations. One reason is motorists simply do not expect pedestrians on some streets, but are much more highly aware of their presence on streets where pedestrian use is high. Other reasons include higher driving speeds in suburban areas and possibly diminished motorist reaction times or their willingness to slow and yield to crossing pedestrians. The following land use and site design techniques can help manage speed and therefore lower crash rates:

1. Buildings that Define Streets – Buildings located at the back of the sidewalk give the motorist sense of enclosure; buildings set far back, with large parking lots in front, create the illusion of a wide road with encourages higher speeds and discourages walking.

2. Mixed-Use Development – Buildings with retail on the bottom and housing on the top encourage pedestrian activity. This includes parking garages, office buildings and fast food restaurants.

3. Street Connectivity – Lack of street connectivity and pedestrian connections discourages walking because of the added travel distance to reach destinations. Long super blocks also reduce pedestrian crossing opportunities; midblock crossings should be provided about ever 300 feet – the length of a typical urban block.

4. Curb/Parking Management – Curb management practices (such as painted curbs) can be used to regulate parking. Parking should not be placed between the sidewalk and a building, as stated previously. The principles of access management should be extended to parking; single lots service multiple stores are preferred over single stores each with its own parking and driveway.

These site design practices need to be incorporated in city codes for future development. Also, many retail outlets such as fast food restaurants are remodeled or rebuilt about every ten years, with may present opportunities to implement new site design requirements to retrofit existing facilities, such as installing sidewalks with a planting strip.

Countermeasures to be used with Caution

Concerned citizens and elected officials often respond to a tragic pedestrian crash with a call for an immediate solution. Among the most commonly requested solutions are a traffic signal, flasher, pedestrian bridge or underpass or marked crosswalk. While these all can be an effective solution in certain places, in some instances they are not appropriate or effective.

Traffic Signals

The primary purpose of a traffic signal is to create gaps in motor vehicle traffic that otherwise would be hard to find. The MUTCD warns against the overuse of signals for a variety of reasons. Used inappropriately, traffic signals my increase crashes.

Traffic signals can range from $50,000 to $300,000 for one intersection, if no associated road widening is necessary. Furthermore, resources are need for annual maintenance of the signal.

In many cases, the only solution to crossing a busy, multilane arterial street is to install a pedestrian crossing signal. This is especially true in locations where there is not another signal for 0.25 miles or more in an area with heavy of pedestrian activity.

Traffic signals (with pedestrian displays) are one possible operation to be considered in helping to get pedestrians safety across busy streets. Adding a traffic signal, however, does not guarantee safety for a pedestrian, since some motorists run red lights and some turning motorists fail to yield to a pedestrian in a crosswalk during the WALK interval; also, some pedestrians will cross against the traffic signals.

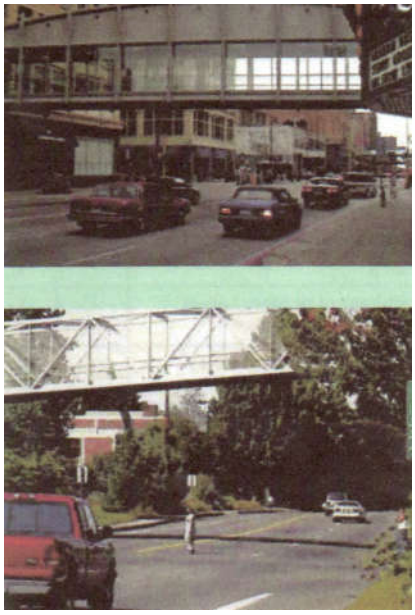
Pedestrian Bridge or Underpass

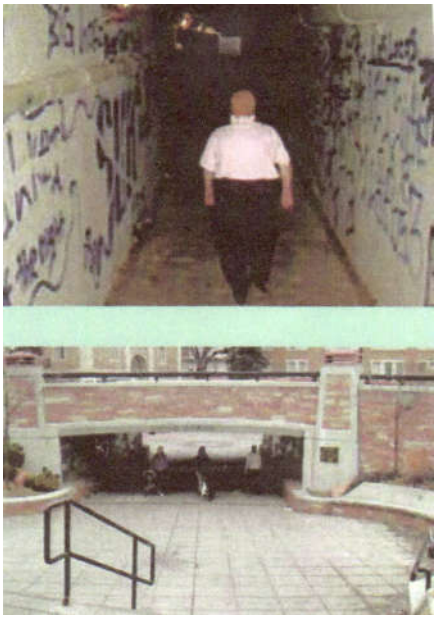
A popular but often ineffective countermeasure is to install a pedestrian bridge or underpass. These solutions are appealing because they give the impression of complete separation of pedestrians from motor vehicle traffic. In theory this is true, but in practice this rarely occurs for several reasons:

- Bridges and underpasses are so expensive, they cannot be provided at most locations where pedestrians may want to cross.
- Underpasses are often prone to security concerns due to low visibility.
- The inconvenience of out-of-distance travel is high, up to 1,000 feet or more, because of the need to provide accessible ramps; many pedestrians will not walk this extra distance and cross at-grade.
- To be effective, there has to be a self-enforcing feature that requires the pedestrian to use the bridge, such as topography, or fencing along one side of the street or in the median for several hundred feet on either side of the grade-separated crossing.

These reasons explain why pedestrian bridges or underpasses are under-used, and motorists are frustrated when they see pedestrians crossing in the vicinity of a bridge or underpass; this in turn increases the risk to pedestrians crossing at grade.

The high cost of a pedestrian bridge or underpass (from several hundred thousand to several million dollars) makes them impractical for all but a few locations. Many pedestrian crossing islands with illumination can be provided for the cost of one bridge. When a corridor has multiple crossing points, the crossing islands are a more effective use of resources.





Pedestrian bridges should be convenient for pedestrians; otherwise they will not be used (as in the bottom photo). The underpass in the top photo is not well-lit or secure. Underpasses should be designed so that they are safe for pedestrians to use.

Marked Crosswalks without Additional Treatments

Marked crosswalks tell the pedestrian where to cross. For example, where sight distance is compromised, it may be desirable to direct the pedestrian to the location where the site distance is best. Marked crosswalks also tell the motorist to expect pedestrians at a particular location, but motorists on higher-speed streets frequently cannot see them until it is too late to stop. Without other safety features mentioned thus far (islands, curb extensions, illumination, etc.), marked crosswalks on their own do not necessarily increase the security of a pedestrian crossing the street. In general, the following principles apply to the installation of marked crosswalks alone (i.e., without other substantial pedestrian treatments):

- On two-lane streets, a crosswalk can be marked without compromising pedestrian safety.
- On multilane streets with an average daily traffic (ADT) of up to 15,000 vehicles per day (VPD) and a median or island, a crosswalk can be marked without compromising pedestrian safety.
- On streets with an ADT over 12,000 (or 15,000 with a median) marked crosswalks on their own are not recommended. Other, more substantial, measures are needed to provide a safe pedestrian crossing.

At locations where crosswalks alone are not appropriate (e.g., on multilane roads with ADT's above about 12,000), consideration of more substantial pedestrian crossing treatments, such as enhanced nighttime lighting, traffic and pedestrian signals (if warranted), among others. Marked crosswalks should be given priority where there is an expectation of regular pedestrian activity such as near a school, park or other generator.

Textured and/or Colored Crosswalks

Textured or colored crosswalks are often requested based on the assumption that they stand out and are more visible by motorists. In many cases, the opposite is true: red or gray pavers are barely visible from afar, and they disappear from sight completely at dusk or at night. Textured crosswalks are difficult for pedestrians in wheelchairs or with walkers or canes. If a community decides to implement colored crosswalks, it is best to color the pavement around a conventional, high visibility white crosswalk; this way it really does stand out and is smooth.

VI. Summary

Pedestrian safety plays a key role in roadway design. In 2015, 5,376 pedestrians were killed in traffic crashes, representing 14 percent of all roadway-related fatalities. Many pedestrian crashes are the result of unsafe motor vehicle driver and pedestrian behaviors. Certain roadway design features can contribute to unsafe behaviors by pedestrians and motorists.

Good pedestrian safety planning must include an understanding of the characteristics of pedestrians. The major planning, design and policy elements that impact pedestrian safety include street design, street connectivity, site design, land use and access management.

It is important to know where pedestrian safety deficiencies exist, how extensive the safety problems are and what new projects, programs and policies can provide the biggest safety benefit, including those related to engineering, education and enforcement. This data collection must occur before an action plan can be formulated.

Improving pedestrian safety in a community or region is typically the result of implementing different safety treatments and changing agency design policies. Projects involving pedestrian countermeasures can be subdivided into spot locations, corridors, target areas, and jurisdictions.

Jurisdictions should ensure that all of their policies, plans and engineering design guidelines include considerations for pedestrian safety. The crash data should be analyzed so that the pedestrian improvement projects can be prioritized and selected for safety solutions.

Pedestrian safety should be monitored in the areas where countermeasures were implemented to ensure that the improvements have positive results.

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