

Safe Routes to School Guide

Engineering



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Overview

Engineering is one of the complementary strategies that Safe Routes to School (SRTS) programs use to enable more children to walk and bicycle to school safely. Communities tailor a combination of engineering, education, encouragement and enforcement strategies to address the specific needs of their schools.

Engineering approaches can improve children’s safety to enable more bicycling and walking. Engineering is a broad concept used to describe the design, implementation, operation and maintenance of traffic control devices or physical measures, including low-cost as well as high-cost capital measures.

This chapter serves as a toolbox of various engineering techniques aimed at creating safe routes to school. It focuses on tools that work to create safe routes by improving paths, creating safer crossings and slowing down traffic. At the same time, it recognizes the importance of a balanced roadway environment that can accommodate the needs of all modes of transportation, be it foot, bicycle or motor vehicle. In this chapter, there are examples of urban, suburban and rural school locations, which will provide various perspectives on engineering challenges and solutions.

Engineering strategies are best used in conjunction with education, encouragement and enforcement activities. The Education chapter describes the pedestrian and bicycle safety messages and how to deliver the messages to children, parents and others. Driver, bicyclist and pedestrian behavior changes, such as those discussed in the Enforcement and Encouragement chapters, complement the engineering strategies described in this chapter.



Kentfield, California.

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“Engineering” is a broad concept used to describe the design, implementation, operation and maintenance of traffic control devices or physical measures.
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Guiding Principles for Applying Safe Routes to School Engineering Solutions

Several principles guide this discussion of Safe Routes to School (SRTS) engineering solutions as well as the design of a built environment that provides safe routes for children as they walk and bicycle to school. The following list states and briefly describes some of the principles:

Infrastructure within the school zone and beyond is a prerequisite for walking and bicycling.

The physical environment often determines whether many children walk or bicycle to school. To safely walk or bicycle to school along a street or separate path, or to cross a street along the way, children need well-designed, well-built and well-maintained facilities.

SRTS programs address infrastructure needs at schools as well as along a child's route to school. Children walk and bicycle to school from locations outside the immediate school zone and often from beyond the school's designated walk zone. SAFETEA-LU, the federal transportation legislation, provides funding for SRTS activities within approximately a two-mile radius of a school.

Accessibility Required

SAFETEA-LU specifies that a key purpose of the Safe Routes to School program is "to enable and encourage children, including those with disabilities, to walk and bicycle to school." An important aspect of enabling children with disabilities to walk and bicycle to school is provision of accessible infrastructure. Guidelines for making schools sites and routes to school accessible for children with disabilities can be found in the Americans with Disabilities Act Accessibility Guidelines (ADAAG) and the Public Rights-of-Way Accessibility Guidelines (PROWAG). Throughout this guide, the term "pedestrian" should be understood to include students using assistive devices such as wheelchairs.



Peter Lagerwey

The relationship between the crossing, the building and the sidewalk are important elements in developing a safe route to school. Mary Scroggs Elementary School, Chapel Hill, North Carolina.

Relationships are everything.

The relationship of school buildings to sidewalks and street crossings can determine the level of comfort and safety a pedestrian or bicyclist experiences. All elements are interconnected; the street is connected to the sidewalk and the sidewalk is connected to the building. Getting this relationship right is critical. One important point: do not put motor vehicles between sidewalks and schools. Such obstructions add a conflict point on a child's walking route. Another relationship to consider is the school's location relative to its students' homes. A child's route to school should have a minimal number of busy street crossings, and school attendance boundaries should be drawn with this principle in mind.

Easy-to-implement and low-cost solutions are focused on first, while longer-term improvement needs are identified and the implementation process is begun.

Effective improvements do not always require substantial funds. For example, signs and paint are relatively inexpensive and can make a big difference. Completion of these projects can build momentum and community interest in making other improve-

ments. Smaller cost-effective projects, when concurrently implemented with larger more expensive projects are likely to have lasting impacts on the built environment and garner interest and support from the community.

Some engineering improvements will require substantial time and financial commitment. Projects such as new sidewalks and bridges or the reconstruction of a street crossing should be identified early and advanced through the various stages required to complete them. As these longer-term improvements are developed, smaller projects can be implemented to build momentum and maintain community interest in creating safe routes to school.

Engineering treatments are matched to the type of problem.

As communities consider improvements for the routes to school, care should be taken to identify problems or obstacles and to provide appropriate solutions to alleviate these specific problems.

Collectively, these principles guide the decisions that local professionals and members of the school community make as they begin to address issues that will improve the built environment for children to safely walk and bicycle to school. These principles will help guide decisions as communities:

- Create school walking and bicycling route maps using a variety of assessment tools and exercises.
- Identify and regulate the school zone.
- Provide and maintain bicycle and pedestrian facilities along the school route including sidewalks, on-street bicycle facilities, paths, bridges and tunnels.
- Provide safe street crossings for bicyclists and pedestrians.
- Slow down traffic.



Peter Lagerwey

Crosswalks are an effective, low-cost, and easy-to-implement engineering treatment. It is important, however, to be aware of guidelines for appropriate placement and use of crosswalks. Guidelines can be found at www.walkinginfo.org/engineering/crossings-crosswalks.cfm

What's Wrong With This Picture?

Following are a number of photographs to help identify the types of problems that children may encounter on the trip to or from school. These examples focus on some of the most common problems, many of which are easy to correct. If these problems are addressed and obstacles to safe walking and bicycling routes are eliminated, more parents will allow their children to walk and bicycle to school and children will be safer doing so.

what's wrong with this picture?



David Parisi

Tree root damage has pushed the sidewalk up. The sidewalk is angled greater than the 2-percent Americans with Disabilities Act requirement, and the lifted section presents a tripping condition.

what's wrong with this picture?



David Parisi

There is no paved sidewalk for these students to use, and the rolling terrain can “hide” children walking in the street.

what's wrong with this picture?



David Parisi

Motor vehicle is stopped in the crosswalk and in the red (no parking/stopping) zone. The red curb paint is faded. In addition, most states require all crosswalks to be white. This picture was taken in California, where yellow is used for pavement markings in school zones.

what's wrong with this picture?



David Parisi

This picture was taken one block from school. The sidewalk abruptly ends, forcing children to walk in the street; visibility is obscured at the corner by the bushes and fence. In addition, most states require all crosswalks to be white. This picture was taken in California, where yellow is used for pavement markings in school zones.

• what's wrong with this picture?



Bushes are growing over the sidewalk.

• what's wrong with this picture?



This motor vehicle is parked on the sidewalk. Not only does this cause pedestrians to walk in the street, it will damage the sidewalk.

• what's wrong with this picture?



This is a damaged multi-use pathway with cracks in the surface and debris on the trail. The cracks are an obstacle for walkers, bicyclists and particularly people in wheelchairs.

• what's wrong with this picture?



The driver entering this street, just before the school crosswalk, is likely looking left for oncoming motor vehicles and may not see the pedestrian or the crosswalk to the right. The amount of traffic on this busy street is prompting this child to dart across. In addition, most states require all crosswalks to be white. This picture was taken in California, where yellow is used for pavement markings in school zones.

• what's wrong with this picture?



This empty bicycle rack is broken and is not a recommended design. It is difficult to lock bicycles to this rack and keep them in an upright position. It is also not a well-placed rack; only one side is useable.

• what's wrong with this picture?



Hedges block access to the sidewalk at the end of this school crosswalk. There is no curb ramp, and the bushes block access to pedestrians in wheelchairs and any other students attempting to cross. In addition, most states require all crosswalks to be white. This picture was taken in California, where yellow is used for pavement markings in school zones.

• what's wrong with this picture?



This gate and lock were recently installed by neighbors to block access to their private road. The locked fence also blocks access to the sidewalk that leads to the school.

• what's wrong with this picture?



This is a pathway off a sidewalk at a school. The pathway ends at a parking lot and is blocked by parked motor vehicles. There is no sidewalk for students to cross the parking lot and walk to the school buildings. The bicycle rack is poorly placed and inaccessible.

• what's wrong with this picture?



This is a well-marked school crosswalk with advanced warning signs. (Note the back of the sign in the middle of the image.) However, school children must walk 10 to 12 feet into the travel lane, while in the crosswalk, before they can see approaching traffic. In addition, most states require all crosswalks to be white. This picture was taken in California, where yellow is used for pavement markings in school zones.

• what's wrong with this picture?



This well-marked school crosswalk has good signage, but there is a discontinuous sidewalk on the right side and no curb ramps.

• what's wrong with this picture?



This is a long line of motor vehicle traffic for drop-off and pick-up of school children. The sidewalk on the left side of the street is narrow and almost entirely blocked by overgrown bushes.

Putting It Into Practice: Developing a Safe Routes to School Walking Route Map

Roadrunner Elementary School, Phoenix, AZ

Phoenix, like many other communities, is working with school officials and parents to develop walking route maps to provide young students guidance on the safest routes to walk to and from school. The program not only makes the school trip safer by identifying the safest routes, but it also involves a comprehensive review of the walking routes by school officials and parents to identify problem areas. The walking route plan helps to identify where improvements are needed and where to place crosswalks, STOP signs and adult school crossing guards. The ultimate purpose of the walking routes is to encourage more children to walk to school and discourage parents from driving their children to school.

The school provides the walking attendance boundary map and parent volunteers to work on reviewing and developing the walking routes. The city provides aerial photographs, quarter-section maps and guidelines for parents and school officials on how to conduct their reviews. The process requires parent volunteers or school officials to review the entire walking route and to identify the most desirable walking route to serve each household within the walking attendance boundary. This exercise may also involve a revision of the walking attendance boundary if safe routes can be identified or created to serve more students.

Once the walking route maps are completed, traffic officials review the areas of concern and work with school officials to ensure the right number and placement of adult school crossing guards. The city provides final versions of the maps and maintains the computer files for the walking routes. It is the responsibility of the school officials to distribute the walking route plans to the parents at the start of the school year and when new students are enrolled at the school. School walking route maps are reviewed annually to identify if there are any changes to or within the school walking attendance boundary.

For another example of mapping safe routes to school visit the 2004 PEDSAFE "Safe School Route Mapping" Rochester, New York, case study at www.walkinginfo.org/pedsafe/casestudy.cfm?CS_NUM=33.

Neighborhood Walk-about and Bike-about

Neighborhood walk-about and bike-about are environment analysis exercises used in many Safe Routes to School (SRTS) programs to raise awareness of the issues and conditions facing walking and bicycling, to garner support for needed changes and to gather information needed to help create school route maps. The walk-about and bike-about seek to identify and document the traffic and safety issues near schools and identify potential short- and long-term solutions to deal with these safety issues.

The neighborhood walk-about and bike-about are organized by the community or school and may involve local policymakers, traffic engineers and planners, law enforcement, safety professionals, school district



Participants of a neighborhood walk-about familiarize themselves with the school zone.

personnel, school nurses, parents, students, school principals and local media. The group typically meets at the school, observes the school activities during drop-off and pick-up time, and tours the school zone and walking and bicycling routes to the school. Along the way, safety concerns are documented and photographed for later discussion. Active & Safe Routes to School (www.saferoutestoschool.ca) offers a list of items to consider during a walk-about. Participants also can complete easy-to-use checklists, such as the Walkability Checklist (www.walkinginfo.org/library/details.cfm?id=12) and Bikeability Checklist (www.bicyclinginfo.org/library/details.cfm?id=3) while conducting the walk-about or bike-about.

After the tour, the group reconvenes at the school to discuss their findings and potential short- and long-term solutions to address the problems they encountered. Participants leave the meeting with a clear plan of action that includes responsibilities for each person and follow-up dates. Results of the walk-about and bike-about are communicated to the school community through newsletters or other channels. A walk-about and bike-about can also be conducted by teachers with students as a hands-on learning experience about their community.

Walking and Bicycling Audits

Walking and bicycling audits, sometimes called assessments, are processes that involve the systematic gathering of data about environmental conditions (social, built and natural) that affect walking and bicycling. Audits are typically performed by personnel with experience in pedestrian and bicycle issues or training on the specific audit tool used. One objective of the audits is to document factors that help or hinder safe walking and bicycling. These factors include, but are not limited to, street lighting, sidewalk width and condition, traffic volume, presence of bicycle lanes, topography, and presence of dogs, trash and debris.

Audits might focus on a school site, a corridor popular for bicycling or an intersection that residents find daunting. Walking and bicycling audits are tools that provide community stakeholders (parents, children, school staff, public works or traffic department staff, local engineers or planners, and law enforcement officers) with the

information they need to effectively analyze the design and condition of the transportation network. This information can help identify areas conducive to walking and bicycling, identify areas where changes are needed and inform the solutions chosen to create change. For engineers and planners, audits provide useful feedback to help them incorporate these ideas into their work.

Numerous walking and bicycling audit tools exist, and they can vary in the scope and scale of data they collect. Some audits focus broadly on the network or route level, while others hone in on details of the individual street segments that comprise a route or network. Determining which type of audit tool is most appropriate will depend on the audit participants, data needs and available resources. Collecting information on every street segment will provide a detailed and comprehensive assessment, but it may require data collection training and labor intensive data collection and analysis. Audit information collected at the neighborhood level can provide an overview of the walkability and bikeability along routes to school, but it may not allow for pin-pointing a specific area along the route that is a trouble spot.

In addition to assessing infrastructure and conditions currently in place, audits can be used to analyze proposed development construction plans or other projects that will introduce change into a neighborhood. Audits are useful for analyzing proposals to ensure that the needs of bicyclists and pedestrians are accommodated in all stages of a project.

Results from the walking and bicycling audits combined with the walk-about and bike-about activities and parent and student surveys form the basis of the design of a Safe Routes to School program. This information can also be used in the development of school traffic control plans.

For audit tool information, see the following:

- School Site Assessment Form and Neighborhood Assessment Form in the Maryland Safe Routes to School Guidebook at <http://www.saferoutesinfo.org/program-tools/neighborhood-site-assessment>.

- School Site Assessment and the Neighborhood Site Assessment in the Safe Ways to School “Toolkit” from the Florida Traffic and Bicycle Safety Education Program. at www.saferoutesinfo.org/program-tools/safe-ways-school-tool-kit
- A host of audit tools developed by health professional and planners, which consider the built environment from a walking, bicycling and health standpoint, are available at the Active Living

Research Web site at www.activelivingresearch.org/index.php/Tools_and_Measures/312.

- Walking and Bicycling Suitability Assessment at www.unc.edu/~jemery/WABSA.
- Cycle Audit and Review from the UK Department of Transportation at www.bicyclinginfo.org/library/details.cfm?id=2064.

Putting It Into Practice: School Walking Routes Pilot Project Ontario, Canada

Research suggests that if there were safe routes for children to walk or bicycle to school more families would choose this form of transportation. The School Walking Routes pilot project of Green Communities’ Active & Safe Routes to School (ASRTS) set out to test this.

The School Walking Routes pilot project was implemented in four steps:

1. Mapping

Students in participating schools were asked to draw their routes to school on maps of their school’s catchment area. Maps were sorted by grade and by street and one master map was created of the most popular routes.

2. Observing

Municipal transportation staff collected baseline data for each mapped route at each school site.

3. Analyzing traffic

Municipal transportation staff coordinated traffic counts at each of the four schools before, during and after the pilot project.

4. Surveying

Parents, children and community members were surveyed at the start and end of the project.

Families who chose to participate in walking school buses were encouraged to walk along the designated routes, which were selected by local municipal and police staff as the best route from the perspective of traffic safety and pedestrian controls. SCHOOL ROUTE signs placed along the route provide the following benefits:

- Notification to drivers that they are on a designated walking route to a school and need to use extra caution.
- Encouragement for parents to walk their children along the designated walking route, thus creating more eyes on the street. This is critical in the establishment and sustainability of walking school buses.
- Encouragement for pedestrians and bicyclists to cross only at the designated intersections.
- Promote the culture of child safety in general.

Project organizers found that collecting data through observations is labor-intensive, not cost-effective and there are many factors contributing to transportation choices of families from one day to the next. Also, signs coupled with other ASRTS initiatives can change behaviors of drivers and encourage more people to walk their children to school.

Phase One of the School Walking Routes pilot project was implemented in Toronto in April 2002. During 2004, Phase Two of the School Walking Routes pilot project was expanded from the City of Toronto to three other Ontario municipalities: London, Brantford and Brampton.

For more information visit Active & Safe Routes to School at www.saferoutestoschool.ca.

School Traffic Control Plans

A comprehensive traffic control plan can help create a balanced roadway environment to accommodate the needs of all modes of transportation, be it by foot, bicycle or motor vehicle. A traffic control plan is a map of a school campus and the adjacent street system marked with proposed engineering improvements to increase the safety of bicyclists and pedestrians.

Putting It Into Practice: Traffic Control Plan Park Elementary School, Marin County, CA

Schools in two communities in Marin County, California, developed comprehensive traffic control plans to increase the safety of bicyclists and pedestrians traveling to school.

The schools mapped typical routes that students used to walk and bicycle to school and proposed safety improvements along those routes. The schools used this analysis to apply for and receive funding to complete suggested improvements. One map proposed a new signing and striping plan for a local elementary school. It lays out proposed signing and pavement marking measures, taking into account many streets surrounding the school.

The traffic control improvements in Marin County, in conjunction with Safe Routes to School encouragement activities, have led to an increase in the number of students walking and bicycling to school, as well as an increase in carpooling.

For more information about this story visit the 2004 PEDSAFE "Safe Routes to School Program" Marin County, California, case study at www.walkinginfo.org/pedsafe/casestudy.cfm?CS_NUM=9.



David Parisi

Park Elementary, Marin County, California.

Around The School

Ideally, the school zone starts at the front door and encompasses the campus and as many blocks as possible that surround the school and have a high concentration of school-generated traffic. Often the school zone includes the streets along the school and usually the area one to two blocks around it. The school zone should be marked with special signing to alert drivers of the high concentration of children. School crossing signs, speed signs, school zone pavement markings and other traffic calming devices remind drivers to treat the area with special care and attention.

Understanding The School Environment

There are generally three zones around the school that you need to think about when doing a Safe Routes to School project: the school enrollment boundary, the school walk zone, and the school zone.

School Enrollment Boundary

The school enrollment boundary is the entire zone around the school from which students are drawn.

School Walk Zone

The school walk zone is typically a subset of the enrollment zone. School walk zones may be defined by State or Local policy, but if not, a general rule of thumb is that the walking boundary is $\frac{1}{2}$ mile or 1-mile out from an elementary school, sometimes further for middle and high schools. The shaded circle on the map above is intended to provide a visual of a “walk zone”, but rarely is the walk zone an exact circle. Some students will live too far away from the school to reasonably be expected to walk, and they are typically provided with bus service. Walk zones defined by policy typically indicate



School enrollment boundary. Image provided by Dave Parisi.



School walk zone. Image provided by Dave Parisi.

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Since school zones are locations frequented by children, making the area safe for children at any time of day is a sound investment for the community.
.....

the area within which students are NOT provided with bus service (note that some schools may define this as the no-transport zone, not the walk zone). Determining walk zones, whether policy based or through the general rule-of-thumb, can be helpful in focusing your efforts in identifying engineering problems and solutions.

School Zone

The school zone is the roadway (or roadways) immediately adjacent to the school (shown in yellow on the map to the right), usually extending one to two blocks in each direction. Speed limits are often reduced in the school zone during morning and afternoon hours. Special signing is used – crossing signs, speed signs, school zone pavement markings – so that motorists know to treat the area with special care and attention.

School Zone Signing and Marking

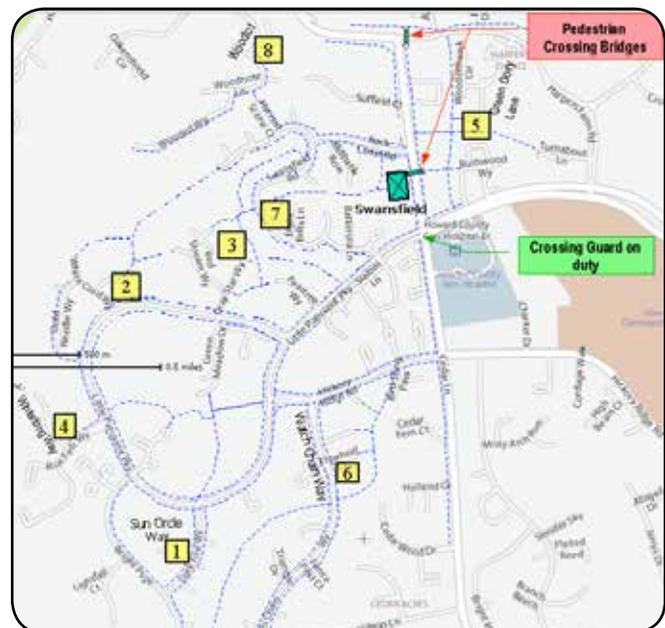
School zone signs and pavement markings provide important information to drivers to improve safety within the school zone. The 2009 Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD), Part 7 sets forth principles and standards for controlling traffic in school areas, although many states and local jurisdictions provide additional guidance. The principles and standards in the MUTCD provide information on appropriate design, application, and maintenance of all traffic control devices (including signs, signals, and markings) and other controls (including adult school crossing guards, student patrols, and grade-separated crossings) required for the special pedestrian conditions in school areas (MUTCD, Ch. 7).

Some jurisdictions recommend or require school signs that are larger than the sizes of signs recommended by the MUTCD or may allow different types of pavement markings. School zone signs and markings on public streets must comply with the MUTCD as well as consider any relevant local or state guidelines that are themselves consistent with the MUTCD. Signs should be used judiciously, as overuse may lead to driver noncompliance and excessive signs may create visual clutter.

Guidelines for making schools accessible to children with disabilities can be found in the Americans with



School zone. Image provided by David Parisi.



Swansfield Elementary School, Howard County, MD. Image provided by Jennifer Toole.

Disabilities Act Accessibility Guidelines (ADAAG) and the Public Rights-of-Way Accessibility Guidelines (PROWAG). ADAAG applies to the school site itself whereas PROWAG addresses the route to school. The Department of Justice established the 1991 ADAAG as a standard, which means that compliance is required for all newly constructed or altered school facilities.

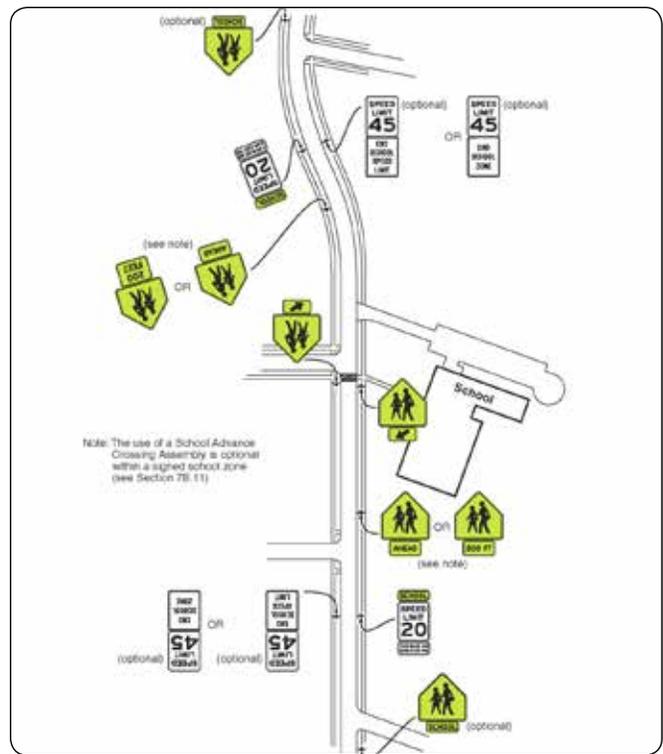
Properly designed and applied traffic calming devices encourage good motorist and pedestrian behavior in the school zone. Traffic calming measures such as high visibility crosswalks, street narrowing and signage can be in place all the time. Since school zones are locations frequented by children, making the area safe and accessible for children anytime of day is a sound investment for the community.

Properly designed and applied accessibility improvements, such as curb ramps, accessible pedestrian signals, and accessible sidewalks and pathways are also sound community investments. They benefit not only children with disabilities but also parents with strollers, senior citizens, and others with permanent or temporary mobility impairments.

Methods for addressing bicyclist and pedestrian safety and accessibility within the school zone will be discussed in this section. Topics include:

- School Speed Limit Sign
- Overhead School Flasher Speed Limit Sign
- Changeable Message Sign
- Portable Speed Feedback Sign
- School Advance Warning and Crosswalk Signs
- Pavement Markings
- Parking Restrictions

For more info on traffic calming in school zones visit the 2004 PEDSAFE “School Zone Traffic Calming” Portland, Oregon, case study at www.walkinginfo.org/pedsafe/casestudy.cfm?CS_NUM=38



This diagram from the MUTCD shows typical placement of SCHOOL advance warning signs, SCHOOL SPEED LIMIT signs, SCHOOL CROSSING signs and END SCHOOL ZONE signs.

Treatment: Signing and Marking the School Zone

Description/Purpose

Signs and pavement markings provide important information to drivers to improve road safety. Examples include retroreflective yellow-green SCHOOL advance warning signs and SPEED LIMIT 25 MPH WHEN FLASHING signs.

Marked crosswalks help guide children to the best routes to school.

Expected Effectiveness

The limited empirical evidence suggests that signs and pavement markings help educate drivers and improve driving behaviors in school zones.

Costs

Costs depend on the school zone treatment selected and the intensity of application. The cost for signs generally ranges from \$50 to \$150 per sign, plus installation costs.³ Pavement marking costs vary by type of paint and marking design.

Keys to Success

- Schools should develop Safe Routes to School traffic control plans that include sign and marking recommendations.
- Traffic signs and pavement markings used on public streets and property must comply with the Manual on Uniform Traffic Control Devices (MUTCD). See Chapter 7 of the MUTCD for traffic control used in school areas.

Key Factors to Consider

Signs should be used judiciously; overuse may breed driver noncompliance and excessive signs may create visual clutter.

Evaluation Measures

- Pedestrian and bicyclist conflicts in the school zone.

School Speed Limit Sign

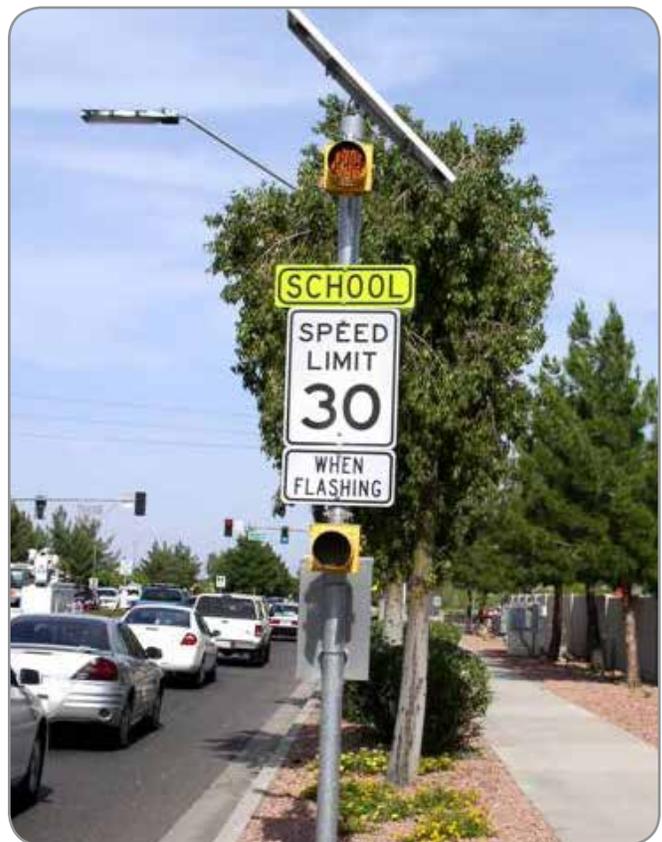
School speed limit signs vary among states, but their main objective is to alert drivers that they are entering a school zone and they need to slow down for school children. The MUTCD (<http://mutcd.fhwa.dot.gov/pdfs/2009/part7.pdf>) provides guidance for installing school area speed limit signs in school zones at a specified distance from marked school crosswalks or a certain distance from the edge of school property. The school speed limits typically range from 15 to 25 mph. These devices are important but should not be overused. Excessive and unreasonable use may lead drivers to ignore the devices.

School speed limit signs alert drivers that they are entering a school zone and they need to slow down for school children. The MUTCD provides guidance for installing school area speed limit signs in school zones at a specified distance from marked school crosswalks or a certain distance from the edge of school property. School speed limits vary based on state law and typically range from 15 to 25 mph. These devices are important but should not be overused. Excessive and unreasonable use may lead drivers to ignore the devices. Occasional police enforcement is also needed at these signs.

School flasher speed limit signs are sometimes used on busy streets, where they can help attract drivers' attention to the school speed limit. School flasher speed limit signs that are activated only during school hours are probably more effective at drawing a driver's attention compared to school flasher speed limit signs that flash throughout the day (AASHTO, 2004, Sec. 2.5.4).



School speed limit sign at Diggs-Latham Elementary School in Winston-Salem, NC. Image provided by Mike Cynecki.



School flasher speed limit sign at Arrowhead Elementary School in Glendale, AZ. Image provided by Mike Cynecki.

Overhead School Flasher Speed Limit Sign

School flasher speed limit signs can be installed overhead for even better driver visibility than side mounted school flasher speed limit signs. The best uses for overhead signs and beacons are at locations where drivers cannot see the marked crosswalk due to topography or other unusual barriers, such as on the crest of a hill or around a curve.

Changeable Message Sign

Permanently mounted changeable message signs are illuminated with messages or speed limits and are used to heighten awareness of speed limits in the school zone or to establish a lower speed during school crossing times. Solar units are available for under \$10,000 per sign and non-solar units are sold for under \$8,000. While the non-solar equipment is less expensive to purchase, it requires a hard wire connection to a power source, which can be much more expensive.

Speed Feedback Sign

One type of changeable message sign is a speed feedback sign which shows “Your Speed” and the “Speed Limit” to alert drivers to their actual speed and the posted speed limit. Speed feedback signs can record traffic counts and are programmed via a Personal Digital Assistant. They work best if they flash or provide a SLOW DOWN message if drivers exceed a preset speed threshold. Speed feedback signs still need to be used with other standard speed limit signs, which should be placed in advance of or next to speed feedback signs.

Portable Speed Limit Signs and Radar Speed Trailers

Portable speed limit signs are movable signs that remind drivers of the posted speed limit. Radar speed trailers alert each passing driver to their traveling speed. These machines are used in some jurisdictions along with law enforcement. For example, the signs are put in place, parents are notified that law enforcement officers will be present, and then officers show up to ticket speeders and drivers who fail to stop for children in marked crosswalks. In other locations, signs are used with no further enforcement activity. Portable speed limit signs are discussed further in the Enforcement chapter.



Overhead school flasher speed limit sign at Second Street School in Frankfort, KY. Image provided by Mike Cynecki.



This solar-powered changeable message sign used in Mill Valley, CA is adjacent to a school and is only operational during the school commute periods. Image provided by David Parisi.



Typical portable radar speed trailer.

School Advance Warning and Crosswalk Signs

School advance warning and school crosswalk signs are important elements of a safe route to school. Chapter 7 in the 2009 edition of the MUTCD designates these signs to be used in advance of and at school crossings, and mandates use of fluorescent yellow green color sheeting for all new school warning signs. The MUTCD and local and state regulations should be followed when considering installation in any area. Traffic signs, as well as pavement markings, which are symbols, stencils or legends applied to the surface of a roadway or a curb along public streets, must be installed or authorized by the local traffic authority, such as the city, county or state traffic engineering department. Signs should not be overused or underused, and when installed, they need to be maintained and kept clear of tree branches and other visual obstructions.

Post-covering

Retroreflective yellow-green post covers can be bolted onto sign-posts to draw additional motorist attention to school warning signs. This treatment is permitted in the MUTCD.

Pavement Markings

Pavement markings, or stencils, are an effective way to enhance driver awareness near schools. They can be used to supplement regulations and warnings provided by traffic signs and signals, or they can convey regulations, guidance, and warnings independently.

The use of pavement markings is governed by the MUTCD and by state regulations and guidance. In some cases, state regulations and guidance may differ from the MUTCD. For example, while the MUTCD requires white crosswalks and stencils, California calls for yellow crosswalks and stencils in school zones. Examples of stencils commonly used in school zones include SCHOOL, SLOW SCHOOL X-ING, STOP, and 25 MPH. Check with your local jurisdiction for guidance.



Austin Brown

Example of a school advance warning sign.



Austin Brown

Example of a school crosswalk sign.



School warning sign with retroreflective yellow-green post covering in Phoenix, AZ. Image provided by Mike Cynecki.



Pavement markings at Morey Middle School in Denver, CO. Image provided by Mike Cynecki.

Stencils should be checked annually. Installing stencils with thermoplastic or other plastic materials may cost more initially, but these materials will last longer than paint and reduce long-term maintenance costs. In areas that receive snow, consideration must be given to the fact that stencils may be obscured by snow during the winter months, and that regular plowing may shorten the lifespan of the marking.

Parking Restrictions

Parking restrictions are needed to regulate parent parking, but care must be taken not to push motorists into adjacent neighborhoods or deny parents appropriate and adequate space for parking and drop-off activities. Curb paint and signs can be used individually or together to help convey messages regarding parking restrictions. For additional information, see Part 7 of the MUTCD.



Parking restriction sign at Latham Elementary School in Winston-Salem, NC. Image provide by Mike Cynecki.

Along the School Route

Children that walk or bicycle to school need safe and well-designed facilities between their home and school. This section describes the types of infrastructure found along the school route that improve the conditions for walking and bicycling, including:

- Sidewalks
- Bikeways
- Paths
- Connectivity



Sidewalks

Sidewalks, specifically paved sidewalks, are an important piece of a walking route to school. Paved sidewalks are “pedestrian lanes” that provide people with space to travel within the public right-of-way separated from motor vehicles and on-road bicycles. They should have a level, hard surface and be separated from motor vehicle traffic by a curb, buffer or curb with buffer. Sidewalks provide places for children to walk, run, skate and play, and are often used by young bicyclists. Continuous and accessible sidewalk networks improve mobility for all pedestrians and are particularly important for pedestrians with disabilities. They provide access for all types of pedestrian travel to schools as well as work, parks, shopping areas, transit stops and other destinations

Many roads around schools are not equipped with sidewalks and can be unsafe for walking. According to a study by the UNC Highway Safety Research Center conducted for the Federal Highway Administration, the likelihood of a site with a paved sidewalk being a crash site is 88.2 percent lower than a site without a sidewalk after accounting for traffic volume and speed limits (McMahon et al., 2002). A study of the California SRTS program has shown that providing sidewalks is one of the most effective engineering measures in encouraging children to walk to school (Boarnet et al., 2005).

Sidewalks should be part of all new and renovated development. Streets that do not have sidewalks, particularly those on routes where children walk or bicycle to school, should be identified and assessed to determine if retrofitting these streets with sidewalks is appropriate. Where feasible, sidewalks should be provided on both sides of the street. A sidewalk on only one side forces pedestrians to either walk in the street or cross the street twice to get to the side with a sidewalk and back again.

Design and Strategy

Sidewalk Surface Types

Sidewalks can be surfaced with a variety of materials to accommodate varying budgets and contexts. While urban, suburban and heavily used sidewalks are typically made of concrete, less expensive walkways may be constructed of asphalt, crushed stone, or other materials



Peter Lagerwey



Peter Lagerwey

Many parents are not willing to allow their children to walk to school if there is no place for them to walk.



While concrete is the most common sidewalk material, other construction materials may be acceptable, but may require more maintenance.

if they are properly maintained and accessible. In more rural areas, a “side path” made of a material other than concrete may be suitable and be a better fit with a rural environment.

Concrete is more expensive than asphalt to install, but it lasts longer and requires less maintenance, which may make it a better value in the long run. Although brick pavers may appeal to some designers, they can require more maintenance and create a tripping condition. Pavers may also pose a problem to pedestrians in wheelchairs if the bricks settle or become lifted. Safe sidewalk surfaces are firm, stable, and slip-resistant.

Sidewalk Placement

Sidewalk placement, or setback, along streets should take into account worn paths and buffer zones, and provide room for snow storage where snowfall is prevalent. The worn path that pedestrians create when there is not a sidewalk demonstrates where people naturally want to walk. The area between the street and the worn path or sidewalk is a “buffer zone” which provides space between pedestrians and motor vehicles. Unfortunately, when sidewalks are built along major arterial streets many tend to not include a buffer zone, thus placing pedestrians uncomfortably close to high-speed traffic. Sidewalks also need to provide a continuous path. Just as streets are designed and built to provide a continuous network, sidewalks also should provide users with a continuous path.

Sidewalk Width

The preferred minimum sidewalk width recommended for safe routes to schools is five to six feet. Walking can be a social activity; facilities are needed to accommodate social walking. The six-foot width allows for two people to walk comfortably side by side and provides sufficient space for pedestrians crossing in the opposite direction. Sidewalks with a width of eight to ten feet or more should be built where there is no sidewalk buffer along an arterial street and along roads adjacent to school grounds where large numbers of walkers are expected.



Peter Lagerwey

Common sense dictates that these two sidewalks should be connected.



Peter Lagerwey

The worn path in this picture clearly illustrates where pedestrians want to walk relative to traffic.



Dan Burden

This narrow four-foot wide sidewalk doesn't work very well for these two children.

The Americans with Disabilities Act (ADA) of 1990 mandates the establishment of minimum walkway clearance widths and there are variety of organizations that offer sidewalk width recommendations. Updated and revised in 2004, the ADA and the Architectural Barriers Act (ADA-ABA) Accessibility Guidelines for Buildings and Facilities state that walking surfaces should have a clear width minimum of 36 inches (ADA and ABA, Sec. 4.03). This clear width minimum is the minimum width for passage and not a sidewalk width recommendation (PROW Guide, Sec. 3.2.1). The clear width is the width of section of the walkway that is completely free of obstacles, vertical obstructions and protruding objects. The 36 inch width is the minimum width required to provide sufficient space for a person who uses mobility aids to travel within the restricted space (ADAAG, Sec. 4.3). However, restricting the pedestrian zone to 36 inches prevents passing and does not allow for two-way travel. The ADA-ABA guidelines state that where sidewalks are less than five feet in width, passing spaces sufficiently wide enough for wheelchair users to pass one another or to turn around shall be provided at intervals of 200 feet (ADA and ABA, Sec. 4.03).

The walkway width recommendations stated in several pedestrian facility guides exceed the 36-inch minimum needed for accessible travel as defined by the ADA-ABA Accessibility Guidelines for Buildings and Facilities.

- The Guide for the Planning Design and Operation of Pedestrian Facilities from the American Association of State Highway and Transportation Officials (AASHTO) recommends a minimum clear width for a sidewalk of four feet, and for sidewalks that are less than five feet in width passing space at least five feet in width should be provided at reasonable intervals (AASHTO, 2004, Sec. 3.2.3).
- The Design and Safety of Pedestrian Facilities from the Institute of Transportation Engineers (ITE) recommends different sidewalk width depending on the land uses and street type adjacent to the sidewalk. For residential areas, ITE recommends sidewalks widths ranging from four feet to five feet depending on housing density and for commercial areas a sidewalk width minimum of five feet. Sidewalks are required on a local street within two blocks of a school site that is on a walking route to school (ITE, 1998).
- Designing Sidewalks and Trails for Access: Best Practices and Design Guide Part 2 (www.fhwa.dot.gov/environment/sidewalk2) from the FHWA recommends a minimum width of five feet of sidewalk that is free of obstacles (FHWA, 2001, Ch.4).

Sidewalk Buffers

The space between the sidewalk and closest lane of moving vehicles is the sidewalk buffer. In general, there are four types of sidewalk buffers:

Planting strip of grass and trees

This is the preferred buffer as it provides a more pleasant, shaded environment to walk.

Bicycle lane

If a planting strip is not possible, a bicycle lane can provide an acceptable buffer between pedestrians and motor vehicles.

Parked cars

Parked motor vehicles can provide a buffer between pedestrians and moving vehicles, but can also create a visual screen for pedestrians as they cross at midblock.

Street furniture

Examples include benches, newspaper boxes, street lighting and public art.

If a sidewalk buffer does not exist, an effort should be made to provide a wider sidewalk. A wider sidewalk allows a pedestrian to avoid the splash zone (area adjacent to a motor vehicle travel lane into which water spray created by a motor vehicle traveling through water on the roadway enters) and provides a snow storage area and a more comfortable separation between moving vehicles and pedestrians. Guidelines for sidewalk buffers are available in the FHWA's *Designing Sidewalks and Trails for Access* (Section 4.1.2) at www.fhwa.dot.gov/environment/sidewalk2/sidewalks204.htm and AASHTO's *Guide for the Planning, Design, and Operation of Pedestrian Facilities* (Section 3.2.4).

Sidewalk and Landscaping Maintenance

Sidewalks and adjacent landscaping should be monitored for conditions that may impede safe pedestrian use. Sidewalks that have been damaged by tree roots, ground swelling or heat buckling present a tripping danger to pedestrians and can often be easily repaired. Sidewalks must be smooth and in good repair to accommodate wheelchairs. A smooth sidewalk is also safer for strollers, young bicyclists and skateboarders. A program to monitor sidewalks for repair should be instituted by local agencies. Parents, school officials and students are



Peter Lagerwey



Sidewalks should be monitored for repair.



Peter Lagerwey

These trees need trimming to provide clear access to this sidewalk, which is within 100 feet of an elementary school and along a major route to school.

an excellent source of feedback on sidewalk condition. This feedback provided to the agency can be used to list and prioritize sections of sidewalks that require maintenance.

Properly maintained landscaping along sidewalks helps maintain appropriate sight distances and makes it easier for pedestrians to use the sidewalks. Property owners are required to keep trees and bushes from blocking sidewalks and obstructing visibility at corners. If over-

growth is an issue, neighborhood “pruning parties” or friendly reminders from residents of the neighborhood can inform property owners about the need to maintain landscaping. Local public works or traffic departments can provide guidance on plantings, including the type of plants allowed along sidewalks, the distance from the sidewalk that plants can be installed and how often plants are to be maintained.

Treatment: Sidewalks

Description/Purpose

Paved walkways that clearly delineate that area of the public right-of-way for pedestrian use and typically separated from motor vehicles by a curb or buffer area.

Expected Effectiveness

Sidewalks reduce the likelihood of pedestrian crashes by more than half the likelihood in areas where sidewalks don't exist (Knoblauch et al., 1987). Another study found the likelihood of a site with a paved sidewalk being a crash site is 88.2 percent lower than a site without a sidewalk after accounting for traffic volume and speed limits (McMahon et al., 2002).

Costs

Costs vary depending on such factors as width and materials but are approximated at \$15 per linear foot (PEDSAFE, 2004).

Keys to Success

- Careful planning of the sidewalk design and network to ensure functionality and coverage.
- Inclusion of curb ramps for each crosswalk at an intersection.
- Providing an adequate buffer between the sidewalk and road, such as a planting strip, bicycle lane and/or on-street parking.

Key Factors to Consider

- Overcoming previous road construction projects that ignored the need for sidewalks.

Evaluation Measures

- Frequency and percent of “walking along roadway” crashes.
- Pedestrian volume.

Street Lighting

Street lighting improves pedestrian visibility and personal security. On streets with lots of trees, street lighting scaled to pedestrians (low lights) illuminates the sidewalk even after the trees grow big and tall. Street lighting improves safety by allowing pedestrians and motorists to see each other. It also adds to personal safety and aesthetics. Two-sided lighting should be considered along wide streets, and it is especially important to provide lighting at the crossings. Lighting can also be helpful along streets adjacent to the school grounds to minimize school vandalism and improve security. While most school walking activity occurs during daylight hours, the morning school trip in the middle of winter often occurs during hours of darkness, and many school activities occur during nighttime hours.



Peter Lagerwey

The image of a newly completed boulevard with lights.

Treatment: Street Lighting

Description/Purpose

Lighting along streets, especially at crosswalks, that more clearly illuminates areas of pedestrian activity to increase driver visibility and improve nighttime pedestrian security.

Expected Effectiveness

Better street lighting can reduce nighttime pedestrian crashes and increase the vision and awareness that drivers have relative to pedestrians (Pegrum, 1972; Freedman et al., 1975). Increases actual and perceived pedestrian safety and comfort.

Costs

Costs vary widely depending on materials used, lighting design, utility service agreements and other factors. However, a general cost estimate is \$2,000 to \$3,000 per streetlight (Safety Toolbox, Roadway Lighting).

Keys to Success

- Installing lighting on both sides of wide streets and avoiding “dark spots.”
- Using uniform lighting levels.

Key Factors to Consider

- Acquiring adequate funding.
- Design issues regarding height and existing objects, such as trees.

Evaluation Measures

- Number of nighttime pedestrian crashes.
- Percentage of all pedestrian crashes that occur at night.
- Increased pedestrian activity and reduction in crime.

ADA / Universal Design

The purpose of universal design is to provide an environment that is equally accessible and comfortable for users of all abilities and ages, including children. To help ensure access for all, the Americans with Disabilities Act (ADA) of 1990 prohibits discrimination on the basis of disability. Sidewalks and other pedestrian facilities in the public right-of-way are subject to the requirements of the ADA. In 2004 the U.S. Access Board released the Americans with Disabilities Act (ADA) and the Architectural Barriers Act (ABA) Accessibility Guidelines for Buildings and Facilities. These guidelines contain scoping and technical requirements for accessibility to sites, facilities and buildings by all users. Much of the information on walkway and street design contained in the ADA-ABA guidelines are contained in the 1999 Accessible Rights-of-Way: A Design Guide. The Federal Highway Administration (FHWA) document Designing Sidewalks and Trails for Access also provides detailed guidance on the design of pedestrian facilities that can be used as a supplement to the ADA-ABA guidelines.

Curb Ramp Design

According to ADA guidelines, curb ramps should be perpendicular wherever possible, where each corner has two ramps installed perpendicular to the face of the curb (vs. a single ramp facing diagonally into the intersection). A big advantage of having two ramps at the corner and small curb radii is that the curb ramps can lead directly along the line of travel, guiding pedestrians into the crosswalk rather than into the middle of the intersection. Two ramps that end at the crosswalk also provide directional guidance to pedestrians with vision impairments. When a corner is retrofit with new curb ramps, the crosswalk markings may have to be moved so that the curb ramp fully aligns within the crosswalk.

Warning Strips

Truncated domes are the standard design requirement for detectable warnings on curb ramps and at transitions from sidewalks to street crossings. These small, flattened domes provide a surface that is distinguishable underfoot and by cane. ADA guidelines require the use of a truncated dome warning strip at the bottom of every newly constructed curb ramp. These domes provide a



Peter Lagerwey

This sidewalk meets ADA requirements and is easy to maneuver by people in wheelchairs as well as other pedestrians.



Dan Burden

Each corner should have two curb ramps, one for each crossing.



Peter Lagerwey

The two-foot deep truncated dome tactile strip at the bottom of the curb ramp has a contrasting color to the rest of the sidewalk.

tactile warning to pedestrians with a visual impairment who would otherwise be given warning by the presence of a curb. The truncated dome tactile strip should be two feet deep for the entire width of the ramp and should have a contrasting color with the adjacent sidewalk. There are different materials and construction methods that can be used to provide the truncated dome tactile warning strip at the base of the curb ramp.

Driveways

Driveway Design

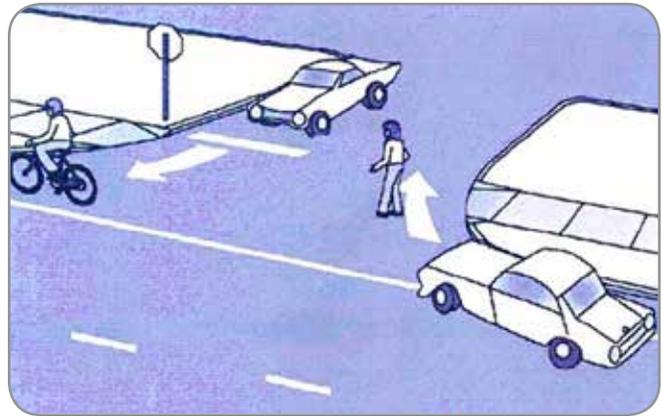
Properly designed driveways, as they cross sidewalks, can enhance pedestrian safety by providing a consistent surface and reminding drivers that they are crossing a sidewalk. The following principles should be applied to driveway design:

- The sidewalk continues across the driveway at the same elevation or level.
- The driveway apron does not go through the sidewalk.

Ramps may be necessary at intersections when pedestrians cross the street, but the rest of the sidewalk network should be continuous and at one level. At driveways, there is no need to break the sidewalk network. Driveways should not look like intersections. Radius driveway designs, like the one pictured on the right, encourage higher turning speeds and makes it less likely that the drivers will yield to pedestrians on the sidewalk.

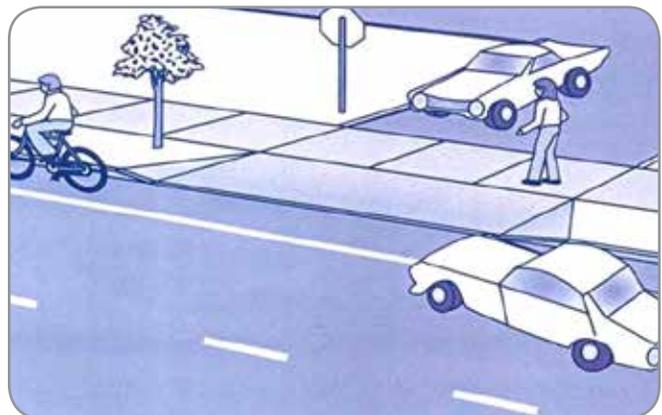
Providing a level, continuous sidewalk not only brings the sidewalk up to the standards of universal access for persons in wheelchairs, but also changes driver behavior. The driver exiting or entering the driveway is more aware that they are crossing a sidewalk, will proceed more slowly and is more likely to stop. Wing-type driveways (see illustration) also cause slower turning movements.

Alternative driveway designs for constrained spaces can be used. When there is not room for a full driveway apron, some alternative driveway designs can still comfortably maintain the level pedestrian pathway across the driveway. This will avoid cross-slope problems for wheelchair users.



Dan Burden

Radius-type driveways allow higher motor vehicle speeds. Driveways should not be designed like this.



Peter Lagerwey

Wing-type driveways provide the best pedestrian crossing as long as the driveway apron does not extend into the sidewalk area.



Peter Lagerwey

Sidewalks must allow a flat driveway crossing that is at least three feet wide with a side slope of less than 2 percent.

Fewer driveways and narrower driveway crossings will provide for improved pedestrian safety for children, especially for busy commercial zones. School walking routes should keep busy driveway crossings to a minimum. If young students are required to cross a busy school driveway, an adult should be assigned to monitor or direct the students at the driveway.

Treatment: Driveway Design and Location

Description/Purpose

Designing driveway crossings for pedestrians can improve the walking environment, improve visibility and reduce conflicts between drivers and pedestrians. Reducing the number of driveways can make it easier for people with disabilities to access and walk on the sidewalk.

Expected Effectiveness

Proper driveway design and placement can improve the safety of the pedestrian environment.

Costs

Costs will vary by project; no additional cost if part of original construction project (PEDSAFE, 2004).

Keys to Success

- For best results, driveways should be properly designed and consolidated at the outset. Local regulations can govern appropriate design when driveways are created.

Key Factors to Consider

- Projects that propose to retrofit or consolidate driveways after they are built should include an adequate level of public involvement and education to gain support from the community.

Evaluation Measures

- Reduced conflicts at driveways for pedestrians, bicyclists and drivers.

Corridor Access Management

Corridor access management is one of Federal Highway Administration's nine proven safety countermeasures. Corridor access management refers to the design, implementation, and control of entry and exit points, such as street intersections and driveways, along roads, streets and highways (Proven Safety Countermeasures, Corridor Access Management). Successful access management seeks to simultaneously provide for pedestrian and bicycle needs, preserve vehicle capacity and enhance safety of all users by managing the frequency and magnitude of conflict points (i.e., places where the travel paths of two different users may cross) along a corridor. Locations with higher densities of driveways, unsignalized crossroads, and median openings are associated with higher crash rates and injury severity (Mauga & Kaseko, 2010). Corridor access manage-

ment has been effective at reducing all crash types along multi-lane rural highways, and severe and fatal crashes along urban and suburban arterial roadways (Highway Safety Manual).

Driveways and minor uncontrolled intersections can be especially problematic locations for pedestrians and bicyclists (Proven Safety Countermeasures, Corridor Access Management).

Most safety related studies on access management have focused mainly on vehicular crashes, but given that children often travel on sidewalks by foot and bicycle, corridor access management will likely benefit this group by decreasing the conflict with turning traffic, in particular left turning traffic.

On-street Bicycle Facilities

Providing student travel facilities along the street is not just about walking, but about bicycling too. Bicycling is an important way for children to travel to and from school. Bicycling can help students who live too far from school to walk to participate in active transportation. Use of on-street facilities is more appropriate for upper elementary school and older children who have sufficient bicycle handling skills and knowledge of bicycle and traffic safety rules. See the Education chapter for more information. On-street bicycle facilities discussed in this section:

- Bicycle routes and maps designating streets for bicycling.
- Bicycle lanes.
- Shared lane markings.
- Paved shoulders.
- Bicycle boulevards.

Streets

Most bicycling occurs on neighborhood streets where children live and go to school. Trails and pathways can complement, but certainly are not a substitute for, the residential street network. A considerable amount of all bicycling occurs on the street system, and for children especially, most will occur in the streets near where they live. Some communities have designated special bicycle routes that are marked with guide signs. Other communities have provided maps showing streets that are ideal for bicycling.

Children of all ages, even high school students, will bicycle to school if given the opportunity. When designating bicycle routes to encourage bicycling to school, target all age groups, including elementary, middle, junior high and high school students.

Bicycle Lanes

Bicycle lanes provide a striped and stenciled lane for one-way bicycle travel on roadways. Bicycle lanes offer a comfortable space for older or more experienced children to ride. Bicycle lanes have been positively associated with an increase in the share of commuting by bicycle to work (Nelson & Allen, 1997; Dill & Carr, 2003).



Bicycle helmet use should be strongly encouraged and mandated where required by law.



Peter Lagerwey

Older students will ride if given the opportunity.



Dan Burden

Bicycle lanes should include the lane line and bicycle lane symbol.

Typically, bicycle lanes are installed on roadways with higher traffic speeds and volumes. However, where the lane is directly serving a school, communities may elect to stripe bicycle lanes on low-traffic residential streets in order to provide an additional level of visibility for younger bicyclists.

Bicycle lanes located next to motor vehicle parking should be at least five feet wide. The preferred width of bicycle lanes next to a curb is also five feet, although four feet, excluding the gutter pan, may be adequate. Bicycle lanes should not be wide enough to accommodate a motor vehicle as drivers may attempt to use a wide bicycle lane as a travel lane. Bicycle lanes should be designated through the use of signs or painted symbols and motor vehicle parking restrictions. Accommodating bicycle lanes within an existing roadway right-of-way may be a challenge.

Some communities have established school bicycle safety routes and bicycle lanes that are functional just during school commute hours. Because these installations can conflict with existing on-street parking, some cities have experimented with “time-of-day” bicycle lanes; the parking lane becomes a bicycle lane during school hours and then reverts to on-street parking for evening and overnight. One disadvantage to this concept is that overnight parking may block the bicycle lane during the start of the bicycle lane hours.

Shared Lane Markings

A Shared Lane Marking (SLM) is placed in a travel lane to indicate the lateral positioning of a bicyclist. Where parking is allowed, it may help reduce the chance of a



bicyclist impacting the door of a parked car. This marking may also help to increase the distance between a bicyclist and an overtaking motorist.

Shared Lane Markings are particularly useful when marked bike lanes are not an option due to street width or other factors, and can be used to link bicycle lanes within a comprehensive bicycle network.

Note that Shared Lane Markings should not be placed on roadways that have a speed limit above 35 mph and can not be placed on road shoulders or in designated bicycle lanes.

Information on Shared Lane Markings, including proper placement, can be found in Section 9C.07 of the 2009 MUTCD and in the UNC Highway Safety Center’s 2010 evaluation (<http://www.fhwa.dot.gov/publications/research/safety/pedbike/10041/10041.pdf>).

Shoulders

Paved shoulders benefit both bicyclists and drivers. They provide a place for bicyclists to ride that is removed from the motor vehicle travel lane and reduce the likelihood of crashes from motor vehicles drifting out of their travel lane (run off the road crash). Building shoulders on existing roadways or including them in new roadway projects can often be justified by the safety benefit provided to drivers. While pedestrians can walk along shoulders, shoulders should not be considered a good substitute for sidewalks in urban areas.



Wide shoulders can accommodate groups of bicyclists.

Paths

Separated multi-use paths (sometimes known as shared-use paths) are passageways that are used to increase the connectivity of the pedestrian and bicycle network. Paths can connect neighborhoods directly with schools and shorten the distance children must walk or bicycle. However, paths must be designed properly, especially where they intersect roadways, to minimize the risk of pedestrian and bicyclist crashes. Guidelines for designing paths are available in the Federal Highway Administration's *Designing Sidewalks and Trails for Access Part 2 Best Practices and Design Guide* and in the American Association of State Highway and Transportation Officials' *Guide for the Development of Bicycle Facilities*.

Guidelines for the width of a multi-use path can range from eight to 14 feet or more (AASHTO, 1999). Under most conditions, the recommended minimum width for a two-direction path designed for bicyclists and pedestrians is ten feet. However, when heavy traffic is expected, a path width of 12 to 14 feet is preferred. In some instances, a width of eight feet can be adequate, especially if the proportion of bicyclist or pedestrian travel is small and the overall number of users is not large (Turner et al., 2004).



Separate multi-use paths often provide a safe and more convenient alternative to riding or walking along a street and can be an integral part of the school walking and bicycling route plan.

Abandoned rail lines and utility corridors often make excellent corridors for multi-use paths. Pavement for multi-use paths can be asphalt or concrete. Measures should be taken to keep motor vehicles off of the path, yet allow maintenance vehicles to have access. This can be accomplished with removable posts (bollards) that lock into place. The space between posts should typically be about five feet wide to prevent motor vehicle access, but comfortably allow bicycle access. Agencies need to monitor conditions along the path for maintenance and repair. School officials, students and other path users can be a good source of information to alert the agency when bushes need trimming along the path or the surface is in need of debris removal or repair.

Treatment: Paths

Description/Purpose

Paths are passageways that are used to increase the connectivity of the pedestrian and bicycle network.

Expected Effectiveness

The presence of paths can increase the number of walking and bicycling trips made and decrease the time and distance it takes to travel from one point to another.

Costs

Costs vary by project conditions and scope. Availability of right-of-way can significantly change the total cost of projects.

Keys to Success

- Provide signs to show pedestrians and bicyclists how to access the path network and where it leads.
- Path designs should incorporate the appropriate width and/or number of lanes for the anticipated pedestrian and bicycle traffic.
- Paths should connect frequently visited origins and destinations.

Key Factors to Consider

- Considerations for lighting, maintenance and safety should be made.
- Acquiring easements can be a challenge.

Evaluation Measures

- Pedestrian and bicycle volume.

Connectivity

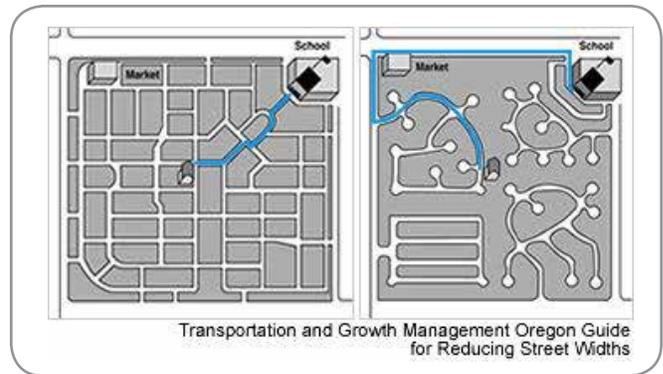
The connectivity of various bicycle and pedestrian facilities directly impacts the ability to walk or bicycle to school. Characteristics of a well-connected road or path network include short block lengths, numerous three and four-way intersections and minimal dead-ends (cul-de-sacs) (VTPI). As connectivity increases, travel distance decreases and route options increase. A network of streets, sidewalks, bicycle lanes and paths in which all parts are well-connected to each other reduces the distance children have to travel to get from home to school, allows for the use of more local streets rather than major roadways and provides a greater choice of routes to travel to and from school.



David Parisi

Paved paths connect cul-de-sacs in this community.

Street layout directly impacts the ability to walk or bicycle to school. Frequently, the layout of subdivision streets makes distances much longer than they need to be. Long neighborhood block lengths and cul-de-sacs contribute to this problem. Neighborhoods that are designed with long blocks and numerous cul-de-sacs are often barriers to walking and bicycling to school; they reduce connectivity and increase travel distance between the home and school.



The diagram on the left illustrates a street layout based on a grid system and the diagram on the right illustrates a layout which consists of many dead end streets with few exits or entrances. The diagram on the left provides a greater street connectivity than the diagram on the right. A trip from home to school for a child who lives in the neighborhood on the left is feasible on foot or by bicycle. It features a short distance using local streets, with no major streets to navigate. For the child who lives in the neighborhood on the right, the trip is longer and takes place mostly on busy streets. As a result, many parents will choose to drive their child to school which will overburden the arterial street system and create unnecessary traffic congestion at the school.

To help solve the cul-de-sac issue, connector paths between cul-de-sacs and other destinations can be constructed:

- At the time when the subdivision is first developed.
- As a voluntary retrofit.
- As a mandatory retrofit when the property is sold or redeveloped.



Peter Lagerwey

Connectivity is an important consideration when making a community walkable.

Treatment: Increasing Connectivity

Description/Purpose

Increasing connectivity of streets, paths and sidewalks reduces travel distances and makes it easier for pedestrians and bicyclists to access destinations.

Expected Effectiveness

The presence of paths, bridges or other neighborhood connectors can increase the number of walking and bicycling trips and decrease the time and distance it takes to travel from one point to another.

Costs

Costs vary by project conditions and scope; no additional costs are associated when connectivity is included in initial construction.

Keys to Success

- Sidewalk and roadway connectivity should be considered at the outset of design.
- Developments can be retrofitted for connectivity with the use of cut-throughs.

Key Factors to Consider

- Increasing roadway connectivity may sometimes cause an increase in unwanted through-vehicle traffic. Appropriate studies should be performed to estimate the effects of increasing roadway connectivity.
- It may be possible to retrofit existing, poorly connected street networks with a pedestrian path, bridge or sidewalk to increase connectivity.

Evaluation Measures

- Pedestrian and bicycle volume.

Bike Racks

Students must have a functional, secure place to park their bike once they reach school. Not having a well planned bicycle parking option can lead to several undesirable outcomes, such theft, damage and locked bikes in or on critical safety infrastructure like emergency exits, hand rails and fire hydrants.

According to the Association of Pedestrian and Bicycling Professionals Bicycle Parking Guidelines, there are four elements to a bicycle rack system:

1. The Rack Element

The rack element is the part of the bike rack that supports one bicycle. A good bike rack element holds the bike frame without bending the wheel and should have no moving parts. Rack elements are typically constructed of metal in an inverted u-shape, which allows for a variety of bicycle sizes and locks.

2. The Rack

A rack is one or more rack elements joined on any common base or arranged in a regular array and fastened to a common mounting surface. Anchor the rack so that it cannot be stolen with the bikes attached and provides easy, independent bike access. Inverted u-shaped rack elements mounted in a row should be placed on 30" centers, allowing two bicycles to be secured to each rack element.

3. The Rack Area

The rack area is a bicycle parking lot where racks are separated by aisles and may contain one or more racks. If possible, the rack area should be protected from the elements using any combination of structures, like a wall and awning. Try to avoid locating a bike rack area on grass or dirt as a rainy day can turn the bicycle parking lot into a mess. Instead, locate the bike rack area on a concrete pad.

4. The Rack Area Site

The rack area site is the relationship of the rack area to a building entrance and approach. Locate the bike rack area within visibility of the building

entrance it serves and consider the route cyclists' use to approach that entrance. Bike rack areas should be sited in a space that minimizes vandalism and maximizes use, while avoiding conflicts with driveways, buses, and large numbers of pedestrians.

Ideally, rack areas should be sited as close, or closer, than the nearest car parking space and provided near all high traffic building entrances. When choosing between a larger bicycle rack area or multiple smaller rack areas, it is preferred to choose multiple locations that are more convenient to users.



Crossing the Street

A child's journey to school on a bicycle or by foot will likely require crossing one or more streets. Many situations arise at street crossings that can impact the safety of the crossing for all pedestrians. Underlying good, safe design at pedestrian crossings is the need to keep the street crossing simple. The development of safe crossings for children is guided by several principles including the need to:

1. Establish or identify good crossing locations.
2. Reduce crossing distances.
3. Provide crossings that are direct, so that children with visual impairments can easily negotiate them,
4. Use appropriate traffic controls such as marked crosswalks, traffic signals and warning signs or flashers.
5. Slow motor vehicle speeds.

Engineering improvements recommended for creating safer routes to school are based on these principles. This section describes a variety of treatments that are used to create safer street crossings:

- Tools to reduce crossing distances for pedestrians.
- Marked crosswalks.
- Traffic signals.



Dan Burden

Street crossings are a vital part of the safe school route.

Putting It Into Practice: School Crossing Audit Procedure Phoenix, AZ

Phoenix, Arizona, has developed an audit procedure to evaluate individual school crossings to identify if any improvements can be made at the crossing and to identify locations where extra attention is needed. The audit procedure normally is conducted by a traffic engineer, a police representative and representatives from the school and school district. A separate audit form is completed for each individual crosswalk, and audits are performed on the major crossings. Audits are conducted when children are crossing, which allows for an evaluation of the crossing guard procedures. This also allows the guard to provide their input on traffic and other conditions at the crossing. A point system was developed for various conditions at the crossing; once the audit is completed, a letter summarizing findings and recommendations is sent to the principal and the district offices. Once the improvements are implemented, a follow-up audit is conducted to further monitor conditions. Over 200 audits have been completed and they have resulted in various improvements including new signs and crosswalks, street lights, curb ramps, larger waiting pads, stand-back lines, specialized crossing guard training, extra law enforcement and the installation of traffic signals.

See the City of Phoenix's School Crossing Safety Audit at www.saferoutesinfo.org/guide/engineering/phoenix_school_crossing_safety_audit.pdf

Putting It Into Practice: Swansfield Walk To School Day Swansfield Elementary School, Columbia, MD

Swansfield Elementary School in Columbia, MD held its first Walk to School Day in 2005. The event was so popular that the school launched a Safe Routes to School program soon afterwards. From the outset, Swansfield's program involved students with disabilities. During Walk-to-School days, the school designated an alternative bus drop-off location a short distance from the school (along a school walking route) so that children who could not walk to school would be able to participate — including students with disabilities who receive special busing services. Teachers and parent volunteers were posted at the alternative location to assist special education students so that they were fully involved in the event and were able to walk to school with their peers.



Jennifer Toole

In addition to ensuring that SRTS encouragement programs included students with disabilities, Swansfield used SRTS grant money (including federal and local funds) to improve accessibility to the campus, including eliminating key sidewalk gaps and installing ADA-compliant curb ramps.

Tools to Reduce Crossing Distances

Wide, multilane roads are barriers to walking and bicycling to school. If children cannot cross multilane roads then they are, in essence, trapped in their neighborhoods, unable to walk or bicycle to school or to play and explore outside of their immediate neighborhood.

School walking routes and big roads do not mix. High-speed, busy, multilane roads are a barrier to walking and bicycling. In an effort to provide safe routes for children, such roads should mark the boundary of a school walking zone. Ideally, school attendance boundaries should be designated along the major arterial streets to avoid the need for young children to cross them, and schools should be built within neighborhoods, not on the other side of busy streets from students' homes.

The distance required to cross a street and the length of time that a pedestrian is exposed to traffic can be shortened with curb extensions and crossing islands. Curb extensions, also known as curb bulbs or bulb-outs, reduce the distance pedestrians must walk in the street, while crossing islands also simplify a crossing by breaking it into two pieces.



Dan Burden

Wide crossings can be barriers to children.



Elementary school children should not have to walk across wide, complex intersections like these for their school commute.

Pedestrian and Bicycle Bridges and Underpasses

There are locations where a pedestrian bridge or underpass is the only way for pedestrians and bicyclists to cross the street, such as when children would otherwise be forced to cross freeways or major multi-lane arterial streets to get to or from school. However, the benefits of bridges and underpasses must be weighed against their substantial costs, which can be \$2 million or more. The convenience of bridges and underpasses should also be considered. If they require pedestrians and bicyclists to follow an indirect path, they are unlikely to be used. Some schools station adult crossing guards at nearby bridges to ensure that students use them.

Curb Extensions

Curb extensions narrow the roadway and reduce the crossing distance by providing an extension of the sidewalk area into the parking lane. This brings pedestrians out from behind parked motor vehicles and helps pedestrians and drivers to better see each other. This is especially important for smaller children who are often invisible behind parked motor vehicles and may take longer to cross the street. For main streets, reducing the crossing time permits the green-light time for the major street traffic to be increased proportionately (AASHTO, 2004). A curb extension also can slow turning vehicles and prevent drivers from parking on or near a crosswalk. Curb extensions must be designed to accommodate drainage. There are cases where curb extensions may not be needed or desirable on every leg of an intersection, such as when the street leg is narrow, parking is not permitted, or the curb would interfere with a bicycle lane or the ability of fire trucks or other large vehicles to negotiate a turn (AASHTO, 2004).



Pedestrian bridge at Isaac Middle School in Phoenix, AZ. Image provided by Mike Cynecki.



Curb extensions prevent motorists from parking too close to the intersection.

Treatment: Curb Extensions

Description/Purpose

The extension of the curb out from the sidewalk and into the street, typically at an intersection. Curb extensions increase pedestrian visibility and decrease pedestrian exposure distance in the street, crossing time and vehicle turn speeds.

Expected Effectiveness

- Better sight distances for pedestrians and drivers.
- Motor vehicles cannot park in, or too near, crosswalks if curb extensions are properly designed.
- Increases driver awareness of pedestrians.

Costs

Costs vary widely, ranging from \$2,000 to \$20,000, depending on details of design, drainage and movement or removal of utility poles or controller boxes (PEDSAFE, 2004).

Keys to Success

- Adequate lighting is needed to keep drivers from running into the curb extension.

Key Factors to Consider

- Curb extensions work best when installed on streets that have on-street parking (parallel, diagonal or perpendicular).
- Curb extensions should be designed to accommodate large vehicles and bicycles, as appropriate.
- Drainage issue must be addressed.

Evaluation Measures

- Number of crashes involving pedestrians.
- Severity of crashes.
- Speeds of through and right-turning motor vehicles.

Crossing Islands

The pedestrian crossing island, also known as a raised median or refuge island, is a raised island placed in the middle of the street at intersections or midblock locations. The island separates crossing pedestrians from motor vehicles and narrows the travel lanes at that location. By breaking the crossing into two phases, crossing islands decrease pedestrian wait time, reduce crossing distance and allow pedestrians to focus on one direction of traffic at a time. Raised medians and pedestrian crossing islands are one of Federal Highway Administration's nine proven safety countermeasures. Pedestrian crossing islands are effective techniques to reduce vehicle-pedestrian crash frequency and severity on multi-lane streets with both marked and unmarked crosswalks and on two-lane roads with and without a center left-turn

lane (Bowman & Vecellio, 1994; Zegeer et al., 2002; Harkey et al., 2008; Chen et al., 2012).

Overall, crossing islands simplify and reduce the pedestrian exposure time to approaching motor vehicles at a crossing. These benefits are especially important for children, who tend to cross intersections more slowly and have less experience with crossings than adults. Crossing islands are designed with an opening that is level with the street to allow wheelchairs and pedestrians to cross through the island. Crossing islands improve safety at signalized intersections, providing refuge for those who begin crossing too late or are too slow to cross the entire street in one signal cycle (AASHTO, 2004).

While the crash-reduction safety benefits of pedestrian

Treatment: Crossing Islands

Description/Purpose

Raised medians in the middle of a street at an intersection, midpoint of the block or continuously along street. They protect crossing pedestrians from oncoming traffic by serving as a barrier from motor vehicles, reduce crossing distance and allow pedestrians to focus on one direction of traffic at a time.

Expected Effectiveness

Significant reduction in pedestrian crashes on multi-lane streets and on multi-lane streets with marked and unmarked crosswalks at unsignalized crossing locations (Bowman & Vecellio, 1994; Zegeer et al., 2002).

Costs

- Costs vary widely depending on the length and type of individual crossing islands, ranging from \$6,000 to \$200,000 (Safety Toolbox, Pedestrian Refuge Island).
- Continuous raised medians cost \$15,000 to \$30,000 per 100 feet depending on conditions (PEDSAFE, 2004).

Keys to Success

- Most effective on high volume, multi-lane streets.
- Should be accessible to pedestrians with a visual impairment or in wheelchairs.
- Adequate lighting and markings can help to ensure driver awareness of crossing islands.
- Efforts should be made to slow traffic using advanced stop or yield lines and traffic calming measures for multi-lane pedestrian crossings (Leden, Garder, & Johansson, 2006).

Key Factors to Consider

- Landscaping, utilities and maintenance issues must be addressed in the overall design.
- Can benefit motor vehicle safety as well by reducing head-on vehicular crashes.
- Potential business opposition due to loss of left-hand turn ability.
- May conflict with right-hand turns for large vehicles.
- Must be Americans with Disabilities Act-compliant.

Evaluation Measures

- Number of pedestrian crashes.
- Number of vehicular crashes, especially left-hand-turn crashes, angle crashes at driveways and head-on vehicle-vehicle crashes.

crossing islands and raised medians are well documented, evaluations of the impacts of pedestrian crossing islands on child pedestrians, particularly near schools, is limited. Such evaluations require being able to discern the unique safety effects of pedestrian islands within school crossing environments. Often streets near schools where pedestrian crossing islands are present also have special school signs and markings and crossing guards. This combination makes it difficult to isolate their respective safety contributions at a particular location.

Crossing Islands for Offset or Two-Stage Crossings

Another innovation in crossing islands is to stagger or offset the two halves of the crosswalk at the island. This further reinforces the concept of a two-stage crossing and separates the crossing of each direction of traffic.



Michael Cynecki

Two-stage crossing island at Sunnyslope High School in Phoenix, Arizona.



Diagrammatic sign on a two-stage crossing island in Phoenix, AZ. Image provided by Mike Cynecki.

The median island is fenced and directs the pedestrian to face traffic once they reach the center island, before crossing the second half of the street. The median island must be fully wheelchair accessible.

A diagrammatic sign installed in a two-stage crossing island can be quite helpful in alerting pedestrians about possible dangers from moving vehicles when the closest lane of traffic stops.

For more information on staggered medians visit PedSafe “Staggered Median” case study Tucson, Arizona (http://www.walkinginfo.org/pedsafe/casestudy.cfm?CS_NUM=34).

Waiting Areas and Stand-back Lines

Larger waiting areas and stand-back lines are low cost measures to improve safety at busy crossings. Large groups of students should not be waiting to cross immediately next to high-speed moving traffic. Waiting areas at crosswalks can be provided along with stand-back lines painted to keep children further back from busy streets when waiting to cross.

When adequate waiting areas and stand-back lines are provided, the adult school crossing guard should be the only person between the curb and the stand-back line. The stand-back line gives the guard something to point at when telling children to stand back from the street.



Michael Cynecki

Waiting areas and stand-back lines keep students further back from busy streets when waiting to cross in Phoenix, Arizona.

Treatment: Waiting Areas

Description/Purpose

Extra paving at busy crossings where large numbers of pedestrians can congregate before crossing the street without having to stand on landscaping, dirt or mud.

Expected Effectiveness

Waiting areas provide a separation between moving traffic and students, bicyclists and parents with strollers waiting to cross.

Costs

Costs range from \$500 to \$1,500 depending on the size of the additional waiting area.

Keys to Success

- Working with schools to evaluate the crossing and making sure the waiting area is large enough to accommodate potential pedestrian volumes.

Key Factors to Consider

- Potential need for larger sidewalk easement.
- Potential relocation of landscaping and/or utilities.

Evaluation Measures

- Pedestrian capacity of waiting area.

Treatment: Stand-back Lines

Description/Purpose

A painted line on the sidewalk at a crossing, typically 5 to 10 feet from the back of the curb line, which pedestrians wait behind before crossing.

Expected Effectiveness

Increases pedestrian safety by increasing the distance between waiting pedestrians and vehicular traffic. The line also gives something for the crossing guard to point at when telling students where to wait before it is safe to cross the street.

Costs

Stand-back lines are extremely inexpensive, with an average cost of \$50; however, the lines may need repainting annually.

Keys to Success

- Ensuring a large enough waiting area, but stand back-lines can also be effective on narrow sidewalks.

Key Factors to Consider

- Ensuring the stand-back line is in good condition (visible) at the start of each school year. Colors for blue-stake markings should not be used.

Evaluation Measures

- Pedestrian-vehicle conflicts.

Putting It Into Practice: Student Waiting Pads and Stand Back Lines Phoenix, AZ

These images highlight the differences before and after a waiting area and stand-back line were installed at RE Miller Elementary School in Phoenix, AZ.

Unfortunately, many school crossings are at busy streets, and many of the sidewalks in Phoenix were built prior to the time when sidewalk buffer areas were required as a part of the design to separate pedestrians and motor vehicle traffic. It is important to provide a separation between moving vehicles and young children waiting to cross a busy street. This is not possible with a five-foot-wide sidewalk.

One such school crossing was identified by the Washington Elementary School District in northwest Phoenix. This is a crossing for RE Miller Elementary School for nearly 100 children over a busy five-lane street with nearly 40,000 motor vehicles per day. Despite the presence of two crossing guards and a 15 mph school zone, the school district expressed a concern about the large groups of children waiting on a five-foot wide sidewalk before crossing.

The school district, City, and property owners worked together on a solution to provide a safe area for students to wait. The property owner (church) provided an easement to build a 10 ft by 20 ft waiting area behind the sidewalk. The school district moved the existing wood fence behind the new student waiting pad, and the City modified the landscaping behind the sidewalk, poured a concrete pad for students, and placed a 'Stand-Back' line between the sidewalk and student waiting area. These low-cost and low-tech measures provided a considerable safety benefit at the crosswalk. Since then, Phoenix has built nearly 80 student waiting areas at major crossings where large numbers of students congregate before crossing. Even more of the painted 'stand-back' lines have been installed at numerous school crossings.

This example illustrates that you do not have to spend a lot of money to obtain a big safety dividend. Some of the least expensive measures can have a big impact on safety.



Before

Michael Cynecki



After

Michael Cynecki

Road Diets

A “road diet” occurs when one or more travel lanes or parking lanes which primarily serves motor vehicles is reallocated to serve another mode of travel. This most commonly involves converting an undivided four lane roadway into three lanes made up of two through lanes and a center two-way left turn lane with bicycle lanes added. The reduction of lanes allows the roadway to be reallocated for other uses such as bicycle lanes, pedestrian crossing islands, and/or parking (Proven Safety Countermeasures). The road diet is recognized as a proven safety countermeasure by the Federal Highway Administration. Studies demonstrate that road diets reduce vehicle-to-vehicle and pedestrian-to-vehicle crashes and lower vehicle speeds (Huang, Stewart, & Zegeer, 2002; Harkey et al., 2008; Chen et al., 2012; PEDSAFE, 2004 Ch. 5; Gates et al., 2007; Keuper, 2007). Street crossings are safer for pedestrians when there are fewer lanes to cross because a pedestrians’ exposure to traffic is reduced. Multiple-lane threat is a problem that arises when pedestrians have to cross more than one lane in each direction. A multiple-threat pedestrian crash is a crash type that occurs when a motor vehicle in one lane stops and provides a visual screen to the motorist in the adjacent lane. The motorist in the adjacent lane continues to move and hits the pedestrian. This type of collision, where the pedestrian is hit in the second, third or fourth lane is common on multilane roads and typically results in a serious injury or death producing collision due to a higher impact speed. Additionally, providing advance yield lines or stop lines as well as crossing islands also reduce the risk of a multiple threat crash, as discussed later in this chapter.

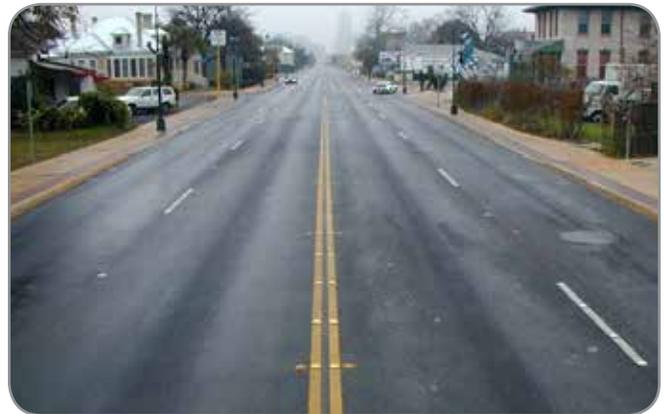
By decreasing the width of the road and number of travel lanes that pedestrians must cross, a road diet helps lower vehicle speed and reduces the multiple-lane threat to pedestrians. In settings with large numbers of children, speed management has great potential for injury prevention. Pedestrian crashes involving a child most often result from the child’s error, thus slower speeds give motorists more time to react and can lessen injuries when crashes do occur (Retting, Ferguson, & McCartt, 2003).

While road diets offer motorist and the general pedestrian population certain safety benefits, there is little



Peter Lagerwey

In this image, the pedestrians have crossed over the first of two lanes. The driver in the inside lane has stopped to let them cross. However, the driver in the outside lane has not seen the pedestrians and is still moving.



Dan Burden

This four-lane road is difficult for pedestrians to cross before the road diet.



Dan Burden

This shows the same road converted to three lanes plus bicycle lanes after the road diet.

research that has specifically examined the impact of road diets on children. Children face special challenges to safely cross a multi-lane street such as impulsiveness; slower walking speeds; small body size that limits their visibility; less experience with traffic and still-developing cognitive abilities that make it difficult to accurately judge vehicle speed and traffic stream gaps (Rodergerdts et al., 2010; Fitzpatrick et al., 2006). These factors lend support for considering the need for adult supervision such as parents, caregivers or crossing guards at street crossing locations near elementary schools during arrival and dismissal times.

Road diets can be low cost if planned in conjunction with reconstruction or pavement overlay projects, since a road diet mostly consists of reallocating roadway space with restriping. More capital-intensive conversions can include curb realignments or addition of center medians or median islands. If curbs are realigned, space can be allocated to green space or other buffers or to increase sidewalk width. Roadways with Average Daily Traffic (ADT) of 20,000 or less may be good candidates for a road diet and should be evaluated for feasibility (Proven Safety Countermeasures, Road Diet; HSIS, 2010). Most studies indicate that roadways were able to maintain vehicle capacity after the road diet was installed, (Harkey et al., 2008; Gates et al., 2007; Keuper, 2007), (ITE, 2010; HSIS, 2010), although one report found some delays during peak travel hours (Knapp & Giese, 2001). Three-lane roadways, like those created by road diets, can improve emergency response by creating space, via a two-way center turn lane, for emergency vehicles to bypass congestion (Daisa, 2010). Driveway density, transit routes, the frequency and design of intersections along the corridor, as well as operational characteristics are some considerations to be evaluated before deciding to implement a road diet (Proven Safety Countermeasures, Road Diet).

The next three images illustrate the “diet” applied to a four-lane roadway that is difficult to cross. Pedestrians must cross four travel lanes, there is no center pedestrian crossing island, no buffer between the road and sidewalk, and there is no designated space for bicyclists. Additionally, it is difficult for motorists to make left turns into the driveways and side streets along this road.



Dan Burden

Pedestrian crossing islands can be added in the center lane at select crossing locations.

Through the road diet, the roadway has now been reduced from four lanes to three lanes, one lane in each direction, plus a two-way center turn lane. There is now room to install bicycle lanes, and the bicycle lanes create a sidewalk buffer for pedestrians. This road diet was accomplished with paint, which has a relatively small cost and requires no construction.

A much better pedestrian connection along this roadway is now possible. The restriping of this roadway improves pedestrian crossings along the entire corridor since pedestrians only cross two through lanes, versus four lanes of travel. This roadway configuration also allows for the placement of crossing islands at some locations, which provide the pedestrian a refuge and allow the pedestrian to focus on traffic from one direction at a time. Adjacent residents and businesses also benefit from this change because left turns into and out of their property are now easier. Thus, road diets can benefit pedestrians, bicyclists, motorists, and adjacent businesses.

Treatment: Road Diet

Description/Purpose

Road diets are reductions of lanes on multilane roadways that can reduce crossing distances, as well as motor vehicle speeds, providing safety benefits to pedestrians, bicyclists and drivers. Road diets can also redistribute space to bicyclists and pedestrians by creating room for bicycle lanes and sidewalks.

Expected Effectiveness

Narrowing roadways and/or reducing the number of lanes that pedestrians are required to cross can result in slower motor vehicle speeds and reduced crossing exposure time, corresponding to a reduction in pedestrian crashes.

Costs

Costs vary depending on the scope and scale of the road diet.

- The cost of restriping a four-lane street to one lane in each direction, a two-way left-turn lane and bicycle lanes is about \$5,000 to \$20,000 per mile, depending on the number of lane-lines that must be repainted.
- Net costs may be lower for road diets when restriping a roadway after a resurfacing project.
- The cost of adding sidewalks and raised medians is much higher, estimated at \$100,000 per mile or more (PEDSAFE, 2004).

Keys to Success

- Considerations must be made for overall safety and roadway capacity operation.
- It is also desirable to include the entire affected area in the decision-making process.

Key Factors to Consider

- Reducing the number of lanes may result in lower motor vehicle capacity and increased delay for drivers in some situations.
- A level-of-service analysis should be conducted to determine whether the number of lanes on a roadway is appropriate and how alternative routes will be impacted by a road diet.

Evaluation Measures

- Reduction in motor vehicle speed or reduction in crashes and/or crash severity involving crossing pedestrians or bicyclists.

Marking Crosswalks

A marked crosswalk can benefit pedestrians by directing them to cross at locations where appropriate traffic control, including traffic signals or adult school crossing guards, either currently exist or can be provided. However, marked pedestrian crosswalks in and of themselves do not slow traffic or reduce pedestrian crashes.

It may be helpful to install marked crosswalks at signalized intersections or locations where crosswalks are typically marked, at key crossings in neighborhoods with designated school walking routes, and at uncontrolled crossings.

There are several reasons to install marked crosswalks, a few being:

- To indicate a preferred pedestrian crossing location.
- To alert drivers to an often used pedestrian crossing.
- To indicate school walking routes.

Marked Crosswalks at Uncontrolled Crossings

Marked crosswalks at uncontrolled intersections must be carefully designed to ensure that they enhance, rather than reduce, pedestrian safety. In some circumstances marked crosswalks should not be installed unless measures are taken to reduce traffic speeds, shorten crossing distances, enhance driver awareness, and/or provide an active warning of pedestrian presence.

Marked crosswalks alone (without other substantial treatments) should not be installed across uncontrolled roadways where the speed limit exceeds 40 mph or either:

- The roadway has four or more lanes of travel without a raised median or pedestrian refuge island and an ADT of 12,000 vehicles per day or greater; or
- The roadway has four or more lanes of travel with a raised median or pedestrian refuge island and an ADT of 15,000 vehicles per day or greater.

Note: The wording above complies with the 2001 Traffic Control Device Handbook, Chapter 13. The exact wording in the 2009 MUTCD on this issue is currently worded slightly differently and is being considered for revision by FHWA.



IWALK 2005

A marked crosswalk guides students along the school walking route to Ocoee Elementary School in Orlando, Florida.

.....

*It is important that both
drivers and pedestrians
clearly see the crossings.*

.....

Marked crosswalks should be designed to minimize crossing distances and should be straight, to make them easier for children with visual impairments to navigate. In many cases, crosswalk enhancements including raised median islands, traffic and pedestrian signals, or street lighting may also be needed. More substantial improvements are typically needed on high-volume multilane roads.

Treatment: Marked Crosswalks

Description/Purpose

Marked crosswalks are painted pedestrian crossings that specify proper locations for pedestrians to cross the street.

Expected Effectiveness

Properly placed marked crosswalks can encourage pedestrians to walk at preferred crossing locations while increasing the visibility of a pedestrian crossing and driver awareness. There is no proven reduction in pedestrian crashes resulting from marking crosswalks without adding other more substantial crossing treatments such as raised medians, traffic and pedestrian signals or improved nighttime lighting.

Costs

Costs range from \$100 for a regular striped crosswalk to \$300 for a ladder crosswalk to \$3,000 for a patterned concrete crosswalk (PEDSAFE, 2004). Maintenance costs should also be considered based on the paint material used.

Keys to Success

- Locations chosen to have marked crosswalks should be convenient, accessible and in the direct pedestrian route (AAS-HTO, 2004). For more information see the Institute of Transportation Engineers' Traffic Control Devices Handbook, 2001 and Zegeer, 2002.

Key Factors to Consider

- On multilane, high volume roads, substantial treatments, including raised medians, are also needed so pedestrian crash risks do not increase.
- Crosswalk markings must be placed so that the curb ramp is within the crosswalk.

Evaluation Measures

- Reduction in motor vehicle conflicts and increase in pedestrian activity within the crosswalk.

High-Visibility Crosswalks

Marked crosswalks guide pedestrians and alert drivers to a crossing location, so it is important that both drivers and pedestrians clearly see the crossings. Crosswalks can be marked in paint or a longer lasting plastic or epoxy material embedded with reflective glass beads. Although more expensive, longer-lasting crosswalk marking materials are a better value over time as they require less maintenance.

The minimum crosswalk width is six feet wide, but school-related crosswalks should be 10 to 15 feet wide or wider at crossings with high numbers of students. School-related crosswalks should be checked annually before the start of the school year. If necessary, fresh paint should be applied and other improvements made to keep the crosswalks in good condition.

The MUTCD allows for two high-visibility crosswalk designs, ladder and diagonal markings.



Crosswalk A is a traditional parallel line crosswalk. Crosswalk B is high-visibility crosswalk with a ladder design

Signing Crosswalks

In-street signs

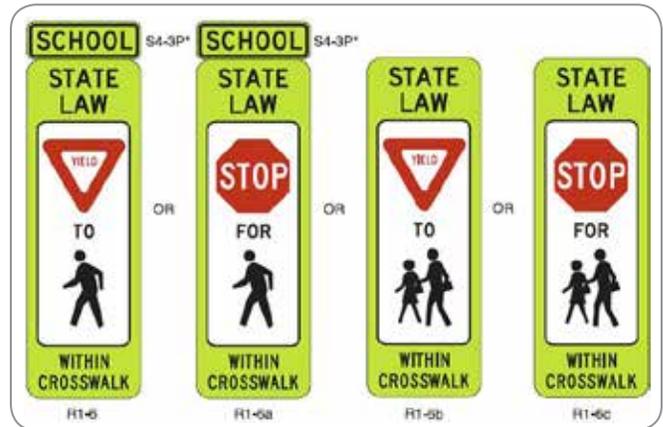
In-street crosswalk signs can be installed at unsignalized pedestrian crossings to make the crosswalk more visible and increase driver yielding. They are more effective on two-lane, low-speed streets than on multi-lane, high-speed streets, and are prohibited by the 2009 MUTCD at signalized intersections. They can be easily damaged and need to be reset or replaced when struck.

In-street pedestrian crossing signs should be placed at the crosswalk in the street or on a median, but should not obstruct the pedestrian path of travel. In-street signs can be permanently installed in the roadway or mounted on a portable base to allow them to be taken in and out of the street during the school day. When portable in-street signs are used for school crossings, they should be monitored by a school official or adult school crossing guard.

The MUTCD allows for two high-visibility crosswalk designs, ladder and diagonal markings.

Overhead signs and flashing beacons

School crosswalks with overhead signs (and sometimes flashing beacons) may be helpful in alerting drivers of a busy crossing at a wide or higher speed street. These are usually placed at mid-block crossings but can be used at intersections with uncontrolled crossings. Overhead signs are easier for drivers to see in cases where on-street parking, street trees, or other visual obstructions. Flashing beacons at a marked crosswalk may draw additional attention to the crosswalk. In a busy urban environment, flashing beacons may not provide much benefit, while on a rural road, they may increase driver awareness of the crosswalk. In other locations the beacons are set with a timer to flash only during crossing times, or are pedestrian-activated by an automatic detector or push button and only flash when pedestrians are present.



In-street yield and stop signs. The 2009 MUTCD added a new option to use the schoolchildren symbol rather than the pedestrian symbol when an in-street sign is used at a school crossing. Image from the 2009 MUTCD.



Overhead pedestrian crossing sign. The 2009 MUTCD allows the use of the schoolchildren symbol as shown in the modified image above. Image from the 2009 MUTCD.

Rectangular Rapid Flashing Beacon

Rectangular rapid flashing beacons (RRFBs) are active warning devices used to alert motorists of crossing pedestrians at uncontrolled crossings. They remain dark until activated by pedestrians, at which point they emit a bright, rapidly flashing yellow light, which signals drivers to stop.

Studies suggest that RRFBs can significantly increase yielding rates over standard pedestrian warning signs. Results have shown that motorist yielding can be increased from baselines averaging 5% to 20% with the standard pedestrian warning sign treatment to sustainable yielding rates of 80% with this device.

RRFBs should be installed on both the right and left sides of the crosswalk, or in a median if available. They are not currently included in the MUTCD, but jurisdictions can use them if they obtain approval from FHWA.

In-pavement Flashers

Crosswalks with in-pavement flashers, or ‘flashing crosswalks,’ consist of embedded lights that are activated when a pedestrian pushes a button or starts walking across the crosswalk. The 2009 MUTCD allows them at uncontrolled crossings to further alert drivers to crosswalks at night but does not allow them at crosswalks controlled by traffic signals, STOP signs or YIELD signs. Crosswalks with in-pavement flashers are expensive to install and maintain, and should not be selected without first considering other solutions.

A 2009 review of literature on in-pavement flashing lights may be found on the Pedestrian and Bicycle Information Center’s website. For more information on case studies related to in-roadway warning lights visit 2004 PEDSAFE “School Zone Improvements” (http://www.walkinginfo.org/pedsafe/casestudy.cfm?CS_NUM=27). Cupertino, California case study. Evaluations of use of in-roadway warning lights are available from Washington and Florida.



Image: Provided by PBIC Designing for Pedestrian Safety Course.



In-pavement flashers at crosswalks are also an option that can be considered.

Advance Stop/Yield Line

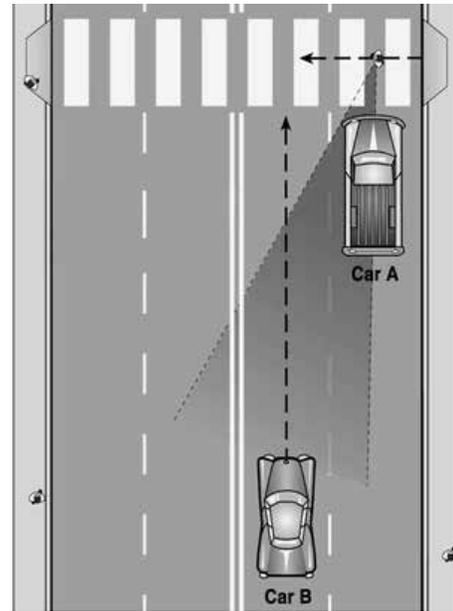
Advance stop or yield lines encourage drivers to stop further back from the crosswalk, promoting better visibility between pedestrians and motorists, and helping to prevent multiple-threat collisions particularly at mid-block or uncontrolled crossings.

A multiple-threat collision is a pedestrian crash type that occurs when pedestrians have to cross more than one lane in each direction. A motor vehicle in one lane stops and provides a visual screen to the motorist in the adjacent lane. The motorist in the adjacent lane continues to move and hits the pedestrian.

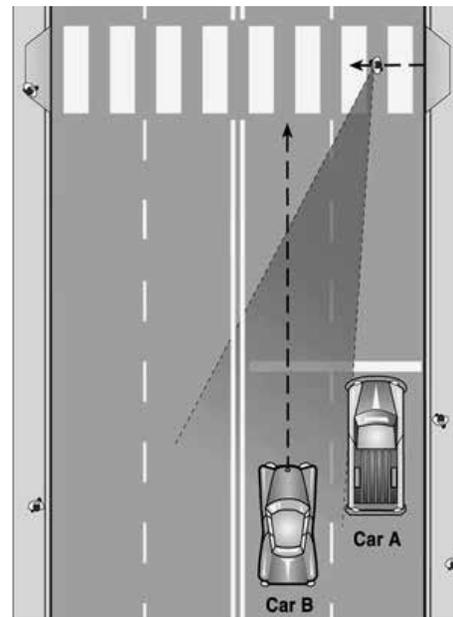
The 2009 MUTCD recommends that yield or stop lines used at uncontrolled multi-lane crossings be placed 20 to 50 feet in advance of the crosswalk; however, a distance of 30-50 feet is preferable. This distance is far enough away to provide for improved sight distance in the adjacent lanes. If the bars are placed more than 50 feet away, motorists are more likely to ignore the line and stop only a few feet prior to the crosswalk. At signalized midblock locations, the 2009 MUTCD recommends separation of at least 40 feet between the stop line and the nearest signal indication.



Painted triangles (shark's teeth) are used as the yield line at unsignalized locations.



Problem: Car 1 stops to let pedestrian cross; car 1 masks car 2, obstructing the pedestrian's and car 2's view of one another. Car 2 doesn't stop and may hit the pedestrian at a high rate of speed.



Solution: place advance stop/yield line so car 1 stops further back; car 1 no longer masks car 2, which can better see and be seen by the pedestrian.

The following signs can be used to reinforce advance stop or yield lines.



R1-5



R1-5a



R1-5b



R1-5c

Parking Restrictions

Restricting parking at corners will improve visibility of the crossing for both drivers and pedestrians. At a minimum, 30 feet should be kept clear in advance of marked crosswalks to help pedestrians and drivers see each other better. Distances greater than 30 feet are generally better, but parking restrictions have to be balanced with the need of the driver. For example, if parent parking is severely restricted or completely removed near schools, parents may ignore all parking restrictions.



Charlie Zegeer

Removing parking from corners can improve visibility between pedestrians and approaching drivers.

Treatment: Parking Restrictions at Corners

Description/Purpose

Restricting how close motor vehicles may park to a crosswalk (20-foot minimum per MUTCD) to improve pedestrian and driver sight distance.

Expected Effectiveness

Eliminating parking spaces too close to a crosswalk will improve pedestrian and motor vehicle visibility, which can reduce the likelihood of pedestrian-vehicle conflicts and collisions.

Costs

Costs involve new street markings, signs, enforcement and public education efforts. Roadway reconstruction issues may also affect the overall cost (Zegeer et al., 2004).

Keys to Success

- Accurately identifying problem locations and appropriate improvements.
- Educating the public about the purpose of proposed improvements.
- Enforcing parking restrictions.

Key Factors to Consider

- Potentially strong resistance to the loss of parking spaces by business owners and local residents, especially in areas with limited parking.

Evaluation Measures

- Number of crossing pedestrian crashes.
- Number of pedestrian-vehicle conflicts.

Traffic Signals

Signalizing busy intersections and providing signalized crosswalks help create safe routes to schools for children. New traffic signals are very expensive and must be warranted or they could cause more harm than good. Warrants for installing traffic signals are provided in the Manual on Uniform Traffic Control Devices (MUTCD) 2009 Edition Chapter 4C at <http://mutcd.fhwa.dot.gov/pdfs/2009/part4.pdf>.

Traffic signals are the highest form of traffic control. However, their benefit to the pedestrian network is contingent upon the application of several principles including:

Mark all legs of an intersection.

Pedestrian paths (marked crosswalks) should be provided on all sides of an intersection where pedestrian crossings are desired. A school walking route plan may limit crossings to three or fewer legs, but all options should be available for school officials to select the most desirable crosswalks to use.

Provide pedestrian signal heads in all directions.

Pedestrian signal indications (WALK, flashing DON'T WALK, DON'T WALK or walking man and raised hand symbols) should be provided at every signalized crossing.

Only use pedestrian pushbuttons if they are needed.

Push buttons are generally appropriate at locations with low or intermittent pedestrian activity. If used, they should be in clear view, wheelchair accessible and responsive to those who push the buttons.

Install landings on all corners.

Fully accessible landings should be in place on all corners to provide a safe place for people to wait.

Paint stop bars for motor vehicles on all approaches.

Stopping motor vehicles in advance of the marked crosswalk keeps the crosswalk clear for pedestrians and can reduce right-turn-on-red conflicts

Install curb ramps on each corner.

Two curb ramps per corner; eight per intersection is generally recommended, although there are situations where one diagonal ramp per corner is an acceptable option (e.g., where there is a wide turning radius and two ramps per corner is not feasible).

Provide streetlights on all four corners.

Proper illumination is critical at signalized intersections. Children are smaller and more difficult for motorists to see, especially in darker conditions, such as occur during arrival in the winter months.



Dan Burden

.....
Pedestrian signal indications (WALK, flashing DON'T WALK, DON'T WALK, or walking man and raised hand symbols) should be provided at every signalized crossing.
.....

Treatment: Traffic Signal Installation

Description/Purpose

Signals that control the flow of traffic and provide sufficient time for safe and efficient pedestrian crossings.

Expected Effectiveness

When signals are installed at appropriate locations (where warranted) they should improve pedestrian safety and also reduce the severity of motor vehicle crashes, even though total motor vehicle crashes (including rear-end collisions) may increase. Research is limited on the effect of traffic signals on pedestrian crashes, although some pedestrian signal timing schemes have been shown to significantly reduce pedestrian crash risk.

Costs

Costs range from \$30,000 to \$140,000 (PEDSAFE, 2004).

Keys to Success

- Signal cycles should be kept short.
- Marked crosswalks encourage pedestrians to cross at the signal.
- Pedestrian actuation (pushbuttons) should only be used if the pedestrian volume is low enough to support it and must be placed in accessible locations. Consider audible signals if students with visual impairments are present.

Key Factors to Consider

- Potential increase of vehicular crashes (especially rear-end collisions).
- Potential traffic diversion to adjacent streets.

Evaluation Measures

- Motor vehicle–pedestrian crashes.
- Pedestrian ability to complete their crossing before the steady DON'T WALK is displayed.
- Signal compliance of pedestrians.

Timing

The signal phasing and/or timing can be modified to increase the time available for pedestrians to cross, to give priority to the pedestrian at an intersection, and/or to provide a separation in time of motor vehicle and pedestrian crossings. The timing or phasing of traffic signals is a complex issue, impacted by the signal timing itself as well as other conditions at the crossing including pedestrian and driver behaviors. Factors that contribute to the complexity of traffic signal timing and phasing include:

- Duration of time pedestrians must wait for the WALK signal.
- Number of motor vehicle movements that conflict with the pedestrian WALK signal.
- Amount of time that is provided for people to cross the street.
- Speed at which people are walking.
- Presence or absence of a button people have to push to get a walk indicator and adequate time to cross the street.
- Presence or absence of one or more adult school crossing guards available to assist younger students while crossing the street. See Adult School Crossing Guard Guidelines for more information at www.saferoutesinfo.org/guide/crossing_guard/index.cfm.
- The potential for conflicts between pedestrians and right-turning motor vehicles.



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Treatment: Modified Traffic Signal Phasing and/or Timing

Description/Purpose

The signal phasing and/or timing can be modified to increase the time available for pedestrians to cross, to give priority to the pedestrian at an intersection and/or to provide a separation in time of motor vehicle and pedestrian crossings. Lead Pedestrian Interval is an example of modified signal phasing/timing treatment.

At signalized intersections, Leading Pedestrian Intervals allow the crosswalk/ pedestrian movement to begin crossing 3-6 seconds before the green light is given to motor vehicle traffic in the same direction. This gives pedestrians a head start, making it more likely that drivers will see them while turning. Leading Pedestrian Intervals are appropriate at signalized intersections where there is relatively heavy pedestrian volume or significant conflicts with turning vehicles. A “No Turn On Red” or “No Turn On Red When Pedestrians Are Present” sign should be considered in such situations, according to the 2009 MUTCD.

Expected Effectiveness

Studies of exclusive pedestrian timing have shown a reduction in pedestrian crashes by 50 percent in some downtown areas with high pedestrian volumes and low vehicle speeds and volumes. Other signal modifications have also resulted in a decrease in motor vehicle–pedestrian conflicts at intersections (e.g., leading pedestrian interval) (Zegeer, Opiela, & Cynecki, 1985).

Costs

The cost for adjusting signal timing is relatively low. The cost for installing new signals ranges from \$20,000 to \$140,000 (PEDSAFE, 2004).

Keys to Success

- Ensure that signals are placed so that they are visible to pedestrians and pushbuttons, if provided, are easy to reach.
- To ensure pedestrians gain the full benefit of the leading pedestrian interval, a “No Turn on Red” (R10-11) sign should be posted to prevent motorists from turning into crossing pedestrians. At locations where it is desirable to allow drivers to turn on red outside of school hours, a plaque (R10-20aP) can be placed beneath the “No Turn on Red” sign stating the hours during which the restriction is in effect.

Key Factors to Consider

- Signal cycles should be kept fairly short to minimize pedestrian delay, but wider intersections may require longer cycle lengths.
- The speed and volume of motor vehicles should also be considered in signal timing calculations and decisions.

Evaluation Measures

- Number of conflicts with motor vehicles (especially turning vehicles) and pedestrians at intersections.

Accessible Pedestrian Signals

Accessible pedestrian signals are audible signals that indicate when it is or is not appropriate to cross the street. Federal ADA guidelines encourage the use of accessible pedestrian signals where there is a need to accommodate pedestrians with visual impairments. Accessible signals come in a variety of designs but include an audible signal and tactile guidance for pedestrians. See the 2009 MUTCD for additional information on accessible signals.

Minimize Pedestrian Wait Time

The longer people must wait to cross the street, the more likely they will decide to cross against the signal. Pedestrian wait time can be reduced by shortening the overall signal cycle length or by providing an actuated demand-responsive pedestrian signal. Some pedestrians, especially large groups of children, may need more than the 4 feet per second standard that is used to calculate the time needed for the pedestrian clearance interval. However, longer pedestrian clearance intervals may result in longer signal cycle lengths, and thus longer wait times between ‘Walk’ signals.

Increase Pedestrian Clearance Intervals

The pedestrian clearance interval is the time remaining for pedestrians to cross the street once the flashing red hand indication is displayed on a pedestrian signal. The 2009 MUTCD requires this interval to be calculated based on a minimum walking speed of 3.5 feet per second. However, some pedestrians, especially large groups of children, may need additional time to cross. Consideration should be given to increasing the pedestrian clearance interval if a pedestrian signal must accommodate pedestrians that need more time to cross. However, these considerations should be balanced against the potential for increased wait times between ‘Walk’ signals.



This accessible pedestrian push button not only has an audible tone when the WALK signal comes on, but it also has a vibro-tactile signal. This is for a crosswalk at a midblock traffic signal.

Treatment: Accessible Pedestrian Signals

Description/Purpose

Audible signals for the visually impaired that indicate when it is or is not appropriate to cross the street.

Expected Effectiveness

- Audible signals increase awareness of all pedestrians, including those visually impaired, which can lead to fewer pedestrian crashes (Houten et al., 2000).
- Can decrease pedestrian cross time.

Costs

Costs range from \$400 to \$600 per signal (Safety Toolbox, Accessible Pedestrian Signals).

Keys to Success

- Locator tones should be used to help persons with visual impairment find pushbuttons.
- Appropriate sound levels should be used to limit audible intrusion into the surrounding neighborhood.

Key Factors to Consider:

- APS may be unclear as to which crosswalk it refers.
- Directional guidance may be needed at wide, skewed or angled intersections.

Evaluation Measures

- Motor vehicle–pedestrian crashes.
- Motor vehicle–pedestrian conflicts.
- Pedestrian crossing ability at current clearance interval.

Pedestrian Pushbuttons

Pedestrian pushbuttons are electronic buttons used by pedestrians to change traffic signal timing to accommodate pedestrian crossings. Pushbuttons may be needed at some crossings, but their use should be minimized. Signals can be put in pedestrian “recall” for key time periods of day such as school crossing times. During these periods the pedestrian WALK signal would be displayed every signal cycle. As traffic signals become more complex pedestrian pushbuttons are needed. If buttons exist, pedestrians must push them to get enough time to cross the street. Standard pushbuttons often result in longer waits to cross the street, especially if the pedestrian fails to push the button. Only about 50 percent of pedestrians actually push the buttons based on a FHWA research project (Zegeer, Opiela, & Cynecki, 1985). If used, they should be clearly visible and within easy reach for people in wheelchairs. Pushbuttons need to be checked periodically to assure that they are working and will place a call into the signal.



Studies show that 50 percent or fewer pedestrians use the push button to cross, yet if they do not use the button they may not get enough time to cross (Zegeer, Opiela, & Cynecki, 1985).

Treatment: Pedestrian Pushbuttons

Description/Purpose

Electronic buttons used by pedestrians to change traffic signal timing to accommodate pedestrian crossings.

Expected Effectiveness

- Improves pedestrian travel time and compliance.
- Reduces delay to vehicular traffic when pedestrians are not present.

Costs

Costs range from \$400 to \$1,000 per pushbutton (Safety Toolbox, Accessible Pedestrian Signals).

Keys to Success

- Must be well-signed, easily locatable and within reach of all pedestrians.
- Should not be used where pedestrian traffic is frequent, as the pedestrian phase should be built into the cycle.
- Buttons for neighboring crosswalks should be located at least 10 feet from each other.
- Locator tones can assist visually impaired pedestrians to find the pushbutton.

Key Factors to Consider

- Visually impaired pedestrians may have difficulty determining if a pushbutton is present.
- Accessible pedestrian signals may need to be considered at some locations.

Evaluation Measures

- Pedestrian volume.
- Pedestrian compliance to WALK/DON'T WALK signal.

No Turn on Red

Pedestrian and motor vehicle conflicts are a common occurrence when driver get a green light and pedestrians get a green light or a WALK signal at the same time. While drivers are required to stop for pedestrians, conflicts are likely to occur. One solution is to install a “leading pedestrian interval” (LPI) which illuminates the pedestrian WALK signal, while the motor vehicle signal remains red for the first few seconds of the cycle. The LPI gives pedestrians an opportunity to start walking and establish a presence in the crosswalk before drivers can begin their turn. The LPI is usually about three seconds or more.

For more information visit the 2004 PEDSAFE “Leading Pedestrian Interval (2 of 2)” St. Petersburg, Florida, case study at www.walkinginfo.org/pedsafe/casestudy.cfm?CS_NUM=66.

Motorists making a right-turn on a red light are often looking left towards oncoming traffic and do not pay attention to pedestrians who may be approaching from the right. Restricting right-turn-on-red (RTOR) is another way to reduce conflicts between pedestrians and motorists at traffic signals. The RTOR restrictions can be limited to certain times of the day or can apply to all hours, prohibiting drivers from turning right without a green signal. The MUTCD identifies two conditions related to pedestrians when restricted RTOR may be most effective including:

- Where an exclusive pedestrian phase exists.
- Where an unacceptable number of pedestrian conflicts result from RTOR, especially conflicts involving children, older pedestrians or persons with disabilities (MUTCD).

When RTOR is prohibited, there may be more right-turn-on-green conflicts between motor vehicles and pedestrians when both the right turning drivers have a green light and the pedestrian has the WALK signal on the adjacent crosswalk. The use of leading pedestrian intervals can reduce this effect. Prior to deciding to restrict RTOR, the advantages and disadvantages must be carefully considered.



Dan Burden

Standard concurrent signal timing illustrates conflicts that can arise between crossing pedestrians and turning motor vehicles.

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Restricting right-turn-on-red is another way to reduce conflicts.
.....



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NO TURN ON RED sign may reduce some pedestrian conflicts in the near-side crosswalk, but may increase conflicts in the adjacent crosswalk.

Treatment: Right-turn-on-red Restrictions

Description/Purpose

Right-turn-on-red (RTOR) restrictions, which can be limited to certain times of the day or can apply to all hours, prohibit drivers from turning right without a green signal. Restricting this turning movement can reduce conflicts with pedestrians crossing at intersections.

Expected Effectiveness

Studies differ in terms of effectiveness, but the 2009 MUTCD identifies two conditions related to pedestrians when restricted RTOR may be most effective: 1) Where an exclusive pedestrian phase exists. 2) Where an unacceptable number of pedestrian conflicts result from RTOR, especially conflicts involving children, older pedestrians or persons with disabilities (Zegeer & Cynecki, 1985; MUTCD).

Costs

Costs associated with this treatment will vary widely based on conditions at the site, but are relatively low compared to other treatments. The average cost for a basic sign ranges from \$30 to \$150 plus installation costs of approximately \$200 per sign (PEDSAFE, 2004).

Keys to Success

- NO TURN ON RED signs should be installed adjacent to the signal on the right side of the street and clearly visible to right-turning drivers. Enforcement programs can help establish compliance with the law.

Key Factors to Consider

- RTOR restrictions may increase delay at intersections for motor vehicles and cause an increase in right-turn-on-green conflicts, but the use of leading pedestrian intervals can reduce this effect.

Evaluation Measures

- Number of crashes and conflicts.
- Pedestrian and driver compliance with intersection regulations.

Pedestrian Countdowns

Adequate time must be provided for pedestrians to cross the street safely. Countdown signals help by giving pedestrians information about how much crossing time remains. There is a good deal of confusion by most pedestrians on the meaning of the flashing DON'T WALK signal. While it technically means don't start walking if the pedestrian has not yet started to cross the street, some pedestrians and drivers think that they are supposed to see the WALK signal for the entire crossing and they will not have enough time to cross as soon as the flashing begins. The countdown signal shows the number of seconds remaining to cross the street. Some studies have shown that countdown signals reduce the number of stragglers in the street when the signal changes, although some people may still start late.



Michael Cynecki

Countdown pedestrian signals provide pedestrians with more information on how much time is left and are very well-received by pedestrians.

Treatment: Countdown Pedestrian Signals

Description/Purpose

A timer display that counts down the seconds remaining for a pedestrian crossing.

Expected Effectiveness

- Reduces the number of pedestrians caught in the crosswalk when the cycle ends.
- Increases pedestrians' perceived safety.

Costs

Costs range from \$300 to \$800 per signal (Safety Toolbox, Countdown Signals).

Keys to Success

- Should give WALK message with countdown indication each cycle in areas with sufficient pedestrian volume.
- Signals should be easily visible from both sides of crosswalks.
- The countdown signals are more applicable where pedestrians are crossing streets with multiple lanes in each direction.

Key Factors to Consider

- For wide streets, countdown pedestrian signals may be of particular benefit, especially if there are a substantial number of older pedestrians or persons with mobility disabilities who cross.

Evaluation Measures

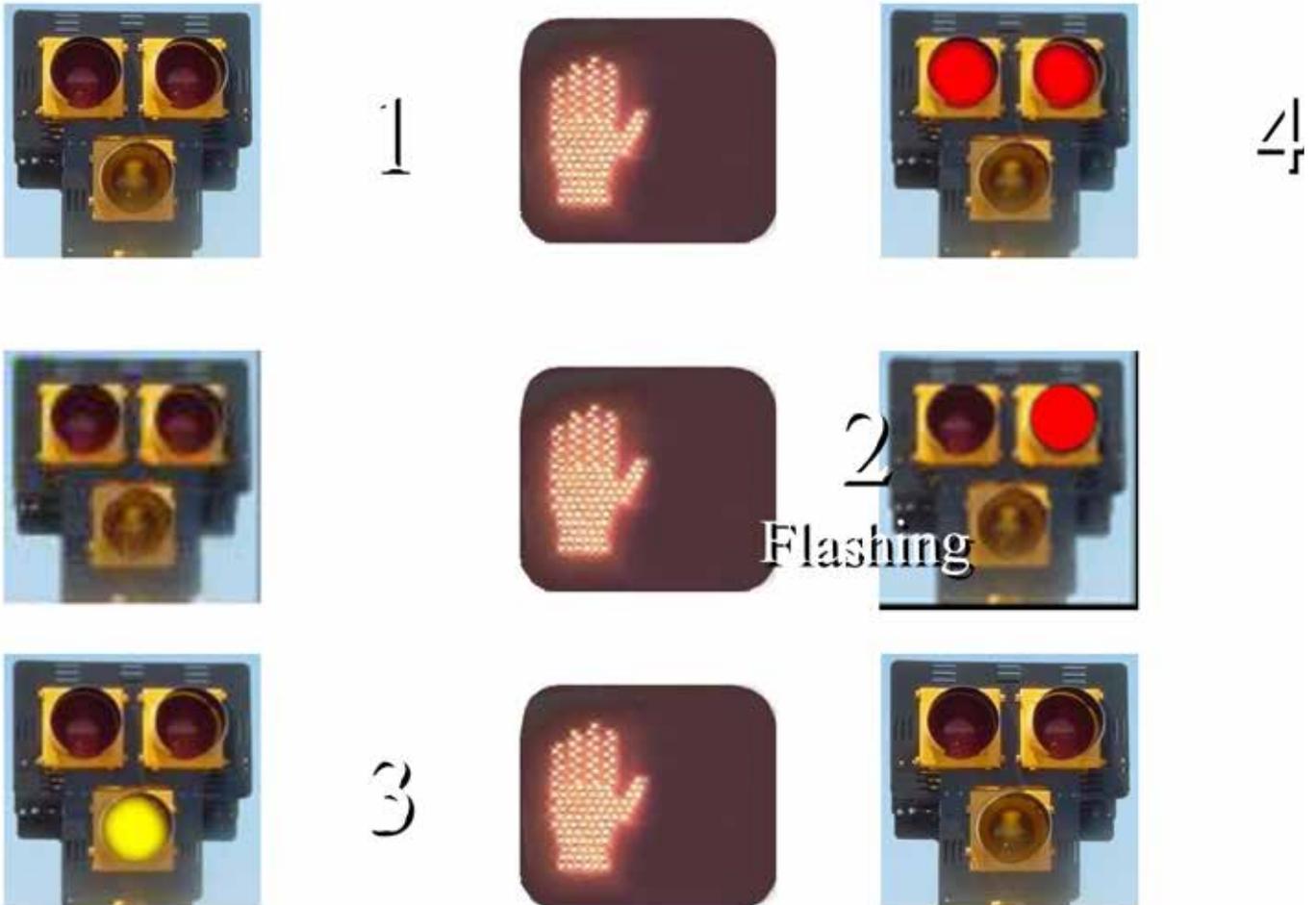
- Number of pedestrians caught in the crosswalk when the cycle ends.
- Perceived pedestrian safety.

Pedestrian Hybrid Beacon

The pedestrian hybrid beacon, also known as the High intensity Activated crossWalk (HAWK), is one of Federal Highway Administration's nine proven safety countermeasures. This designation is largely based on research that has shown pedestrian hybrid beacons to improve pedestrian safety at unsignalized intersections (Fitzpatrick & Park, 2010). The 2009 Manual on Uniform Traffic Control Devices (MUTCD) contains the basic principles that govern the design and use of traffic control devices in the United States. The MUTCD presently recommends when installation of a pedestrian hybrid beacon is justified, it should be used at midblock locations. However, the National Committee on Uniform Traffic Control Devices has a pending request to update the MUTCD to allow the pedestrian hybrid beacon also be allowed at intersection locations which is consistent with the researched locations which justified its inclusion into

the MUTCD. Use of a hybrid beacon at an intersection is thus, presently considered experimental until the MUTCD is updated to explicitly allow the hybrid beacon to be installed at an intersection.

The pedestrian hybrid beacon is a potential solution for midblock crossing locations where neighborhoods are located on the opposite side of a wide or busy street from a school. It is often difficult to get drivers to stop or yield to pedestrians at uncontrolled crossings on high volume, high speed, or multi-lane roadways, even if crosswalk markings and advance pedestrian warning signs are installed. At the same time, there may not be enough pedestrians crossing to warrant a full traffic signal. The warrants for the pedestrian hybrid beacon are much easier to meet, compared to the warrants of a full traffic signal.



The pedestrian hybrid beacon is an intermediate option between the operational requirements and effects of a rectangular rapid flash beacon and a full pedestrian signal (Fitzpatrick & Park, 2010). The signal phasing of this type of beacon provides a controlled crossing for pedestrians without delaying motorists unnecessarily (Shroeder et al., 2010). The pedestrian hybrid beacon signal head consists of two red lenses over a single yellow lens located on the roadside or on mast arms over midblock pedestrian crossings. Activating the beacon is typically done by push-button activation, which results in a sequence of a yellow traffic signal display, followed by dual red traffic signal display, which indicates to drivers when to stop for crossing pedestrians. After pedestrians have had time to cross the street on a steady red light, the red display begins flashing to indicate to driver that they should come to a complete stop. They can then proceed with caution after pedestrians have completed crossing the street (Shroeder et al., 2010; Proven Safety Countermeasures, Pedestrian Hybrid Beacons).

The pedestrian hybrid beacon should only be used in conjunction with marked crosswalks. As currently specified in the MUTCD, the pedestrian hybrid beacon, when used, should be installed at least 100 feet from side streets or driveways that are controlled by STOP or YIELD signs (Shroeder et al., 2010), unless installed with experimental approval at an intersection. Locations with vehicle speeds that are too high to permit pedestrians to cross safely, inadequate gaps in traffic to permit pedestrians to cross, or with excessive pedestrian delays may be good places to consider installing the pedestrian hybrid beacon (Proven Safety Countermeasures, Pedestrian Hybrid Beacons).

Since some pedestrians may be unfamiliar with pedestrian hybrid beacons, it is important to educate the public before implementation to minimize confusion about how the beacon operates and what drivers and pedestrians should do when encountering it (Shroeder et al., 2010).

While the pedestrian hybrid beacon has shown a significant reduction in crashes among the general pedestrian population (Fitzpatrick & Park, 2010), little is known about the beacon's safety impact on child pedestrians because few studies have specifically examined children using the beacon.

Children (particularly those under ten years of age) face special challenges to safely crossing a street including impulsiveness, slower walking speeds; small body size that limits their visibility; less experience with traffic; still-developing cognitive abilities that make it difficult to accurately judge vehicle speed and traffic stream gaps; and a general perception that drivers will be able to stop instantly (Fitzpatrick et al., 2006; Shroeder et al., 2010). These factors lend support for considering the need for adult supervision such as parents, caregivers or crossing guards at crossing locations near elementary schools during arrival and dismissal times.

Slowing Down Traffic

High-speed motor vehicles pose a serious threat to the safety of children who are crossing streets. One of the biggest challenges in providing children with safe walking and bicycling routes to school involves slowing down traffic.

Slower motor vehicle speeds allow drivers to stop in a shorter distance and reduce the chance of injuring a pedestrian or bicyclist. A motor vehicle traveling on a level surface at a rate of 40 mph will need nearly 300 feet between the vehicle and the child to stop in time to avoid a collision. This distance is reduced to approximately 197 feet for a vehicle traveling at 30 mph, 112 feet for a vehicle traveling at 20 mph and 77 feet for a vehicle traveling at 15 mph (AASHTO, 2001).

Pedestrian crash severity is also much lower at low motor vehicle speeds. If a pedestrian is struck by a motor vehicle traveling at 40 mph there is an 85 percent likelihood that the pedestrian will be killed. This percentage drops to 45 percent at 30 mph and 5 percent at 20 mph. Thus, slowing motor vehicle speeds not only reduces the chance of a crash due to the shorter stopping distance that is required, but it also reduces the chance of a pedestrian fatality or serious injury (UK DOT, 1987).

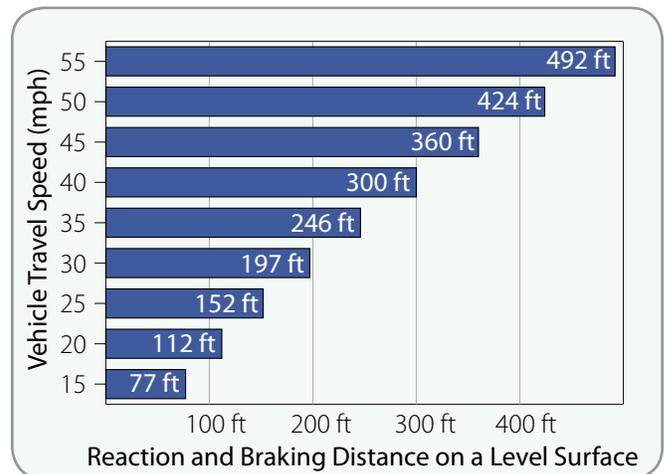
When slowing or “calming” traffic, the right design invites the right driver response. The guiding principle of traffic calming is to influence driver speed and behavior through good design whenever possible, rather than by traffic control measures such as traffic signals and STOP signs.

There are many design and engineering tools that can be used to slow down traffic and make it safer for children to walk and bicycle to school including:

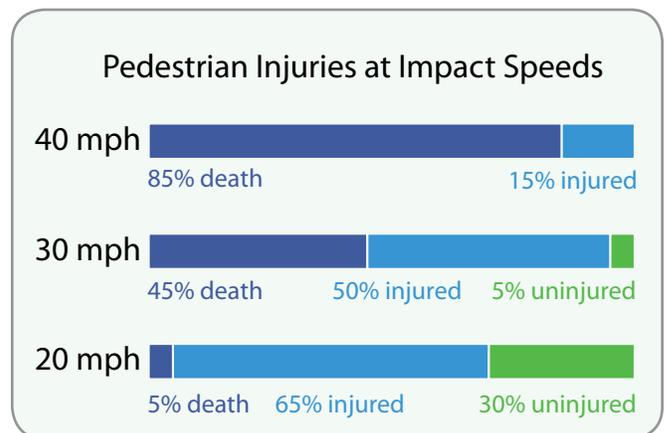
- Narrow lanes.
- Chokers and chicanes.
- Speed humps.
- Raised pedestrian crosswalks.
- Neighborhood traffic circles.
- Reduced corner radii.
- Speed sensitive signals.



Wide high-speed streets can create a barrier to walking to school. This is the type of condition that should not occur along a child’s route to school.



Relationship between motor vehicle speed and braking distance when traveling on a level surface.⁴¹



The relationship between pedestrian injury severity and motor vehicle impact speeds (UK DOT, 1987).



City of Auburn, Indiana

Which street has lower speeds? The street on the right with trees and a narrower pavement width will naturally result in slower driver speeds.

Narrow Lanes

There are several ways to narrow a street. Paint is a simple, low cost and easy way to narrow the street or travel lanes. If the narrower lanes can result in a striped shoulder, the shoulder will provide a buffer for pedestrians, a place for bicyclists to ride and a refuge for disabled motor vehicles. The shoulder stripe will also provide better driver guidance. Interior traffic lanes can be narrowed to 10 feet wide to encourage slower speeds. Narrow lanes can also result from road-diet projects which can include painted medians, center turn lanes, bicycle lanes or parking lanes.



Peter Lagerwey

As there is no sidewalk along this child's route, reducing the lane width works to slow motor vehicles and provide a place to walk.

Treatment: Narrow Lanes

Description/Purpose

The reduction of lane widths to increase pedestrian safety.

Expected Effectiveness

- The narrower lanes can reduce motor vehicle speed, which may reduce total pedestrian crashes.
- They also reduce lengths of pedestrian crossings.

Costs

Costs vary by technique.

- Reducing the width of lanes due to adding bicycle lanes costs approximately \$1,000 per mile.
- Completely restriping a street to reduce lanes, add bicycle lanes or add on-street parking costs approximately \$5,000 to \$10,000 per mile.
- Adding a raised median or widening a sidewalk is approximately \$100,000 or more per mile (PEDSAFE, 2004)

Keys to Success

- Adequate planning for large and emergency vehicles.
- Capacity and level of service should be analyzed to ensure appropriate design.
- Community involvement is needed to ensure balanced street safety throughout the area.

Key Factors to Consider

- Potential diversion of traffic onto neighboring streets.
- Potential adverse effects on large vehicles and bicycles.

Evaluation Measures

- Pedestrian crashes and severity.
- Reduction in motor vehicle speeds.

Chokers and Chicanes

Traffic calming can also result from narrowing the street through the use of chokers and chicanes. Chokers narrow both sides of the street to form a section of about 20 to 24 feet wide. Chicanes provide alternating narrow and wide sections, and a curved driving path similar to a slalom. Chicanes work best when supplemented with centerline striping and in some cases edgeline striping. Both chokers and chicanes need to have a vertical element in the narrowed section such as landscaping so the narrowed section can be seen easily by approaching drivers. Lighting at the narrowed section is also helpful. If drivers do not see and perceive the narrowing treatments, they may not slow down, and may even collide with the narrowed street section. Care must be used to accommodate storm water runoff when designing chokers and chicanes, and they should not be used if it will result in the loss of bicycle lanes or badly needed on-street parking.



Michael Cynecki

A choker has been installed on this street to calm traffic.

Treatment: Chokers and Chicanes

Description/Purpose

Parallel or offset curb extensions that effectively reduce road width for a specific distance are intended to reduce motor vehicle speeds and cut-through traffic, and make drivers aware of pedestrian activity.

Expected Effectiveness

Few formal evaluations have been performed, but these treatments are implemented based on the assumption that they do in fact benefit pedestrians by slowing motor vehicle traffic, reducing the number of severe crashes and increasing safety.

Costs

Costs for chokers range from \$5,000 to \$20,000, depending on site conditions and landscaping. Costs for landscaped chicanes range from \$10,000 (for a set of three chicanes) on an asphalt street to up to \$30,000 on a concrete street. Drainage and utility relocation often represent a significant portion of the cost for both chokers and chicanes (PEDSAFE, 2004).

Keys to Success

- For chokers to perform effectively, the street must be narrowed such that motor vehicles approaching from opposite directions do not have enough room to pass.

Key Factors to Consider

- Ensure that bicycle safety and mobility is not compromised and that streets are still wide enough to accommodate emergency motor vehicles.
- Chicanes may reduce the number of on-street parking spaces.

Evaluation Measures

- Motor vehicle speeds.

Speed Humps

Speed humps represent one type of traffic calming measure that has been used by many local agencies for slowing traffic. Modern speed humps are 12 to 14 feet wide and have a rounded appearance that is 2.5 to 4 inches high at the center. Longer and flatter speed humps are referred to as speed tables. Speed humps have been shown to reduce motor vehicle speeds on streets where they were installed (PEDSAFE, 2004). Despite their ability to reduce motor vehicle speeds, speed humps have certain disadvantages and are generally disliked by many drivers, fire departments and other emergency service providers. They often are not feasible on collector streets or arterial streets due to their impact on emergency response times. Other problems with speed humps include their impact on storm water runoff and snowplowing, and complaints about drivers driving onto the sidewalk to avoid the hump. The presence of speed humps also complicates street resurfacing.

While speed humps have been used extensively by some agencies, other traffic calming measures such as street-narrowing traffic circles or traffic diverters to eliminate cut-through traffic are often more effective and appropriate. Speed humps have been removed at some locations in the U.S., Europe and the Netherlands.

Treatment: Speed Humps

Description/Purpose

An elongated section of raised pavement designed to reduce motor vehicle speeds. Longer and flatter speed humps are referred to as speed tables.

Expected Effectiveness

An overall reduction of motor vehicle speeds. More specifically, 85th-percentile speeds reduced by 4 to 23 mph.

Costs

Speed humps cost approximately \$1,000 each. Speed tables range from \$2,000 to \$15,000 each (PEDSAFE, 2004).

Keys to Success

- Selection of appropriate areas, which are primarily low-volume residential streets.
- Complete coverage of lane width to ensure drivers do not veer into bicycle lane to avoid the hump.
- Should not be used on sharp curves.

Key Factors to Consider

- Potential increase in noise.
- Potential drainage issues on some streets.
- Increase in cost and complexity of resurfacing.
- Appropriate design important to prevent motor vehicle passenger discomfort.

Evaluation Measures

- Number of crashes and motor vehicle–pedestrian conflicts.
- Motor vehicle speed and driver delay.

Raised Pedestrian Crosswalks

Raised pedestrian crosswalks serve as traffic calming measures by extending the sidewalk across the road and bringing motor vehicles to the pedestrian level. The raised crosswalks allow the pedestrian to cross at nearly a constant grade without the need for a curb ramp and makes the pedestrian more visible to approaching drivers. They have a trapezoid-shaped cross-section to slow drivers at the pedestrian crossing where the slowing will be most effective. Speed tables outfitted with crosswalk markings are used on local streets, but they may not be

applicable for some collector streets due to an increase in emergency vehicle response time.

Roadways are not the only places traffic calming devices can be useful. Raised crosswalks can be used in school parking lots to slow traffic and more safely allow pedestrians to cross the parking lots. When used, care must be taken to accommodate drainage in the parking lot and to prevent water from pooling.

Treatment: Raised Pedestrian Crosswalks (Speed Tables)

Description/Purpose

A speed table the width of a typical crosswalk stretching across an entire intersection, slowing traffic and keeping the crossing at grade with the sidewalk.

Expected Effectiveness

- Decrease in motor vehicle speeds generally occurs.
- An increase of vehicular yield rate by as much as 45 percent due to adding speed tables (Hawkey et al., 1992).

Costs

Costs range from \$2,000 to \$15,000 (PEDSAFE, 2004).

Keys to Success

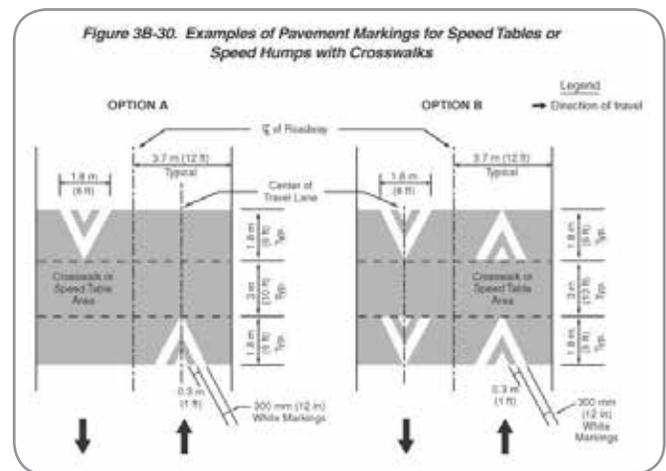
- Should not be used on sharp curves or steep grades.
- Visually impaired pedestrians need warning strips at edges to indicate the beginning of the crosswalk.
- Colors and special paving materials can be used for an urban design effect.

Key Factors to Consider

- May not be appropriate if the intersection is part of a bus or emergency route.
- Potential drainage issues.

Evaluation Measures

- Number of crashes.
- Severity of crashes.
- Motor vehicle speeds.
- Traffic volume.



At a speed table, a marked crosswalk provides a level area for pedestrians crossing the street. Traffic is slowed as drivers must go up and over the crosswalk.



The raised crosswalk in this picture slows traffic at the sidewalk crossing and draws more attention to the pedestrian crossing.

Roundabouts

The modern roundabout is one of Federal Highway Administration's nine proven safety countermeasures. This designation is based on research that has shown roundabouts to greatly improve safety compared to traditional intersections (Proven Safety Countermeasures). The frequency of crashes resulting in injury are lower at roundabouts compared to traditional intersections with the crash reductions being most pronounced for motor vehicles, less pronounced for pedestrians and the overall the same for bicyclists (Rodergerdts et al., 2010). When injuries do occur, they tend to be less severe than those sustained in crashes at traditional intersections.

The modern roundabout is a form of circular intersection in which traffic travels at low speeds counterclockwise around a central island. Vehicles entering a roundabout must yield, or stop if needed, to circulating traffic. Roundabouts allow for more continuous traffic flow compared to conventional stop or signalized intersections. Additionally, compared to conventional stop or signalized intersections, roundabouts reduce and simplify the number of places where motor vehicles would potentially conflict with other vehicles (cars and bicycles) and pedestrians. Roundabouts are designed to slow vehicles as they enter, travel through and exit the circular intersection. The lower design speed of roundabouts is likely to improve yielding, safety, and comfort for pedestrians and bicyclists. In settings with large numbers of children, lowering vehicle speed has great potential for injury prevention. Pedestrian crashes involving a child most often result from the child's error, thus slower speeds give motorists more time to react and can lessen injuries when crashes do occur (Retting, Ferguson, & McCartt, 2003). Roundabouts can be single-lane or multiple-lane. Near elementary and middle schools, single-lane roundabouts are generally preferable to multiple-lane roundabouts due to lower vehicle speeds, simpler crossings for children and the greater comparative crash safety benefit (Rodergerdts et al., 2010).

At locations where it is determined a multi-lane roundabout is necessary to accommodate traffic volumes, it should be anticipated that vehicle speeds through the roundabout may be higher during non-peak periods, motorists may be less likely to yield to pedestrians in crosswalks, and pedestrians are exposed to the multiple

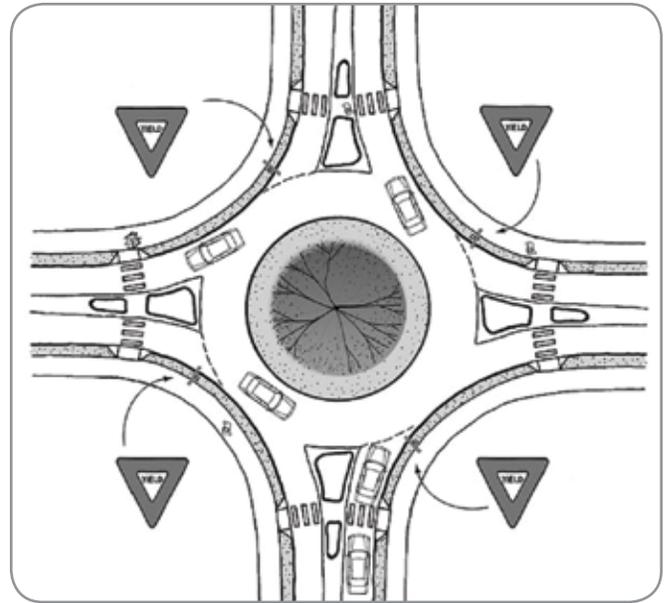


Image from ITE's Intersection Design Guidelines, Chapter 10. A typical single-lane modern roundabout design.



Image provided by Ron Reed and Creative Commons. Properly designed single-lane roundabout can accommodate all users including large trucks.

threat crash. To mitigate these challenges, consideration should be given to providing a pedestrian crossing island and/or an actuated rapid flashing beacon or pedestrian hybrid beacon (PHB) at each crossing.

Well-designed modern roundabouts that have replaced traditional two-way stop, all-way stop, and signal controlled intersections have reduced motor-vehicle crash frequencies and crash severity in urban, suburban, and rural settings (Shroeder et al., 2010). Vehicle collisions in modern roundabouts are typically less severe than those that occur at signalized intersections because the roundabout lowers vehicle speeds and helps prevent certain types of crashes such as 90 degree (“T-bone”) collisions and head-on crashes.

Compared to traditional intersections, single-lane roundabouts, typically offer the following safety benefits and features for pedestrians:

- Lower motor vehicle speeds and increased yielding behavior (Rodergerdts et al., 2010).
- Fewer conflict points (Rodergerdts et al., 2010).
- Higher visibility of pedestrians in the crosswalk (Rodergerdts et al., 2010).
- Shorter wait time for pedestrians to cross than at signalized intersections
- Lower exposure to motor vehicles because of the shortened crossing distance (Rodergerdts et al., 2010).
- Simpler crossing due to the splitter islands, which provide mid-crossing refuge and allow the pedestrian to focus on traffic from one direction at a time (Rodergerdts et al., 2010).

While roundabouts offer the general pedestrian population certain crossing and safety benefits, there is a dearth of research about the ability of child and elderly pedestrians, and those with mobility impairments to cross safely at roundabouts (Rodergerdts et al., 2010). Children face special challenges to safely crossing a street. Factors include: impulsiveness, slower walking speeds; small body size that limits their visibility; less experience with traffic; still-developing cognitive abilities that make it difficult to accurately judge vehicle speed and traffic stream gaps; and a general perception drivers will be able to stop instantly (Rodergerdts et al.,

2010; Fitpatrick et al., 2006). These factors lend support for considering the need for adult supervision such as parents, caregivers or crossing guards at roundabout and other street crossing locations near elementary schools during arrival and dismissal times.

Bicyclists face similar conflicts as motor vehicles at roundabouts. Additionally, bicyclists may experience uncomfortable passing or be cut off on roundabout entrances and exits if they ride on the right edge of a curb lane or in any lane of a multi-lane roundabout (Rodergerdts et al., 2010). As with conventional intersections, a bicyclist using a roundabout can proceed either as a motor vehicle or as a pedestrian using the sidewalk and marked crosswalks (PBIC). Given the varying cognitive abilities and bicycling skills of children, it is recommended that children dismount their bicycles and proceed through the roundabout as a pedestrian using the sidewalk and marked crosswalks. To allow bicyclists to operate as pedestrians through roundabouts, and in particular at locations near schools, consideration should be given to designing bicycle curb ramps and wider sidewalks to accommodate transitions for bicyclists between the roadway and sidewalk system (Rodergerdts et al., 2010). Wider sidewalks and crosswalks can help mitigate potential conflicts between pedestrians and bicyclists.

Neighborhood Traffic Circles

Traffic circles can help slow traffic on local and collector streets and calm traffic for pedestrians. While traffic circles are typically not ideal for use at a school crossing location, they can help calm traffic along a street, making the crossing locations on that street safer. Traffic circles typically have less of an impact on emergency vehicles than speed humps or speed tables, and can add to the aesthetics of the street. Neighborhood traffic circles on local streets do not need to have raised splitter islands, but they should be illuminated with streetlights. Landscaping also is important for aesthetics and making the islands visible to drivers. Provisions are needed for maintaining the landscaping and providing water to the landscaping.



Michael Cynecki

Example of a traffic circle used in a neighborhood.

Treatment: Neighborhood Traffic Circles

Description/Purpose

Neighborhood traffic circles are raised islands in residential intersections intended to reduce motor vehicle speeds.

Expected Effectiveness

In a study in Seattle, Washington, minicircles were found to reduce motor vehicle crashes by an average of 90 percent.⁴⁵ They also slowed motor vehicle speeds, reducing the likelihood and severity of pedestrian crashes.

Costs

The cost for a landscaped traffic circle on an asphalt street is about \$6,000 and ranges from \$8,000 to \$12,000 for a landscaped minicircle on a concrete street (PEDSAFE, 2004).

Keys to Success

- Keep turning radii tight to avoid compromising pedestrian and bicyclist safety.
- Accommodate larger motor vehicles by providing a mountable curb on the outer portion of the traffic circle.

Key Factors to Consider

- Landscaping in the circle should not block sight distance.
- The needs of blind pedestrians should be considered when determining the design and placement of neighborhood traffic circles.

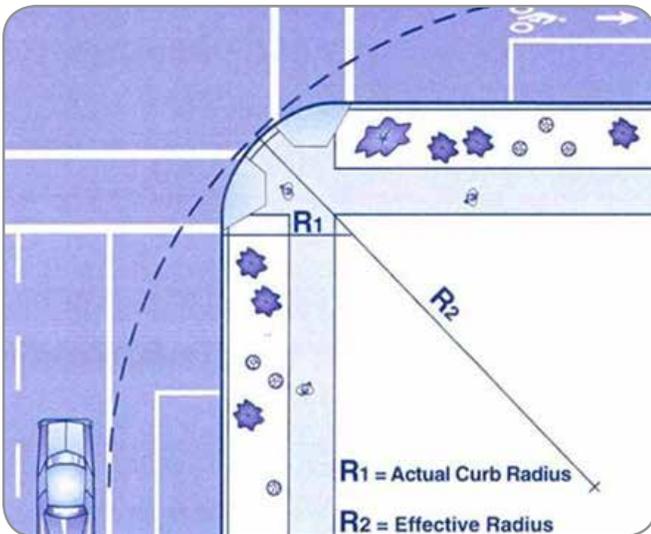
Evaluation Measures

- Crashes and injury severity.

Reduced Corner Radii

There is a direct relationship between the size of the curb radius and the speed of turning motor vehicles. A large radius may easily accommodate large fire trucks, other large trucks and school buses, but it also allows other drivers to make high speed turns, and it increases the crossing distance for pedestrians. Drivers who drive faster are less likely to stop for pedestrians. A larger radius will also result in a longer crossing distance for the pedestrian. The solution is to reduce the curb radius.

When designing curb radii, consider what motor vehicles actually need when turning. Instead of assuming that every corner needs to be cut back, look at other factors such as on-street parking and bicycle lanes to determine how much space a turning motor vehicle will need. The effective radius that exists should include the width of parking lanes and bicycle lanes on both streets. Large trucks do not need to stay on their half of the street when turning on local streets. There is not a need to design for the largest vehicle that may use a street, especially for streets inside neighborhoods.



The effective radius that exists should include the width of parking lanes and bicycle lanes on both streets.



A large turn radius allows drivers to make higher speed turns and increases the crossing distance.

.....
There is a direct relationship between the size of the curb radius and the speed of turning motor vehicles.
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PBIC Image Library

Treatment: Reduced Corner Radius

Description/Purpose

The reduction of a corner radius to produce a tighter turn results in decreases in turning speeds, improved motor vehicle and pedestrian site distances, and a shortened pedestrian crossing distance.

Expected Effectiveness

Reduces the most common type of pedestrian crash by decreasing right-turn motor vehicle speeds. Shortening of crossing distance can improve signal timing and reduces the exposure of pedestrians to motor vehicles.

Costs

Costs range from \$2,000 to \$20,000 depending on drainage, utilities and other site features (PEDSAFE, 2004).

Keys to Success

- The needs of all road users including pedestrians, bicyclists, buses, trucks and cars need to be considered in designing or retrofitting corner turn radii.
- Appropriate design based on street type, angle of intersection, land uses, etc. should also be considered.

Key Factors to Consider

- Designing for maintenance vehicles, emergency vehicles and school buses. Pedestrians are at risk if large vehicles ride over the curb.

Evaluation Measures

- Right-turning motor vehicle–pedestrian crashes.
- Total pedestrian crashes.

Speed Sensitive Signals

Some agencies have installed innovative traffic control measures, such as speed sensitive traffic signals, to reduce motor vehicle speeds. These devices involve using pavement loops to detect the speed of a motor vehicle. If the speed exceeds the speed limit, the traffic signal ahead will display a red light. Drivers learn that speeding on such streets will require them to stop at the traffic signal and be further delayed. This treatment is not applicable to local streets inside neighborhoods that do not have traffic signals, but can be applicable to collector and some arterial streets. Some communities are timing their traffic signals to a preset reasonable speed. Drivers who exceed the preset speed will be stopped at the next traffic signal. Signs with SIGNAL SET AT XX MPH can be installed along the street to alert drivers.



Peter Lagerwey

Boulder, Colorado.

Putting It Into Practice: Speed Sensitive Signals

Boulder, CO; Arlington, VA; and Washington, D.C.

High-speed motor vehicles pose a serious threat to the safety of children who are crossing arterial streets near schools and are one of the largest challenges in providing Safe Routes to School. Innovative measures have been used to reduce motor vehicle speeds such as the speed sensitive signals used in Boulder, Colorado; Arlington, Virginia; and Washington, D.C.

The signals use pavement loops to detect the speed of a motor vehicle. If the motor vehicle exceeds the speed limit, the traffic signal ahead displays a red light. Drivers learn that speeding on such streets will require them to stop at the light and be further delayed. The sign SPEED SENSITIVE SIGNAL conveys that message to drivers.

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