



Advancing Pedestrian and Bicyclist Safety

A Primer for Highway Safety Professionals



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16. Abstract: Communities across the county are encouraging walking and biking to meet safety, health, livability, equity, and mobility goals. This primer is intended for highway safety professionals, including State Highway Safety Officials, as well as their partners and grantees, as a reference for an integrated and comprehensive effort to improve pedestrian and bicycle safety and support broader transportation-related goals. The primer summarizes the most promising infrastructure treatments and behavioral programs available for addressing specific safety problems and highlights how these approaches can be combined and implemented. It identifies opportunities for various agencies to collaborate and combine their respective approaches and funding for a more comprehensive program. It also offers real-world examples of what States and local jurisdictions are doing to address pedestrian and bicycle issues in a comprehensive manner. Finally, the primer includes descriptions of key concepts and definitions of common terms and acronyms to help readers understand the essentials of pedestrian and bicycle safety issues when discussing and collaborating with diverse partners to develop comprehensive programs.					
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SECTION 1: INTRODUCTION

Purpose of This Primer

Communities across the country are encouraging walking and biking to meet safety, health, mobility, and other goals. Pedestrian- and bicycle-friendly environments support health goals by offering opportunities for residents to incorporate more active transportation and may support economic goals, such as increasing local retail sales. Such streets are also associated with safer conditions, fewer injuries, and fewer deaths than streets designed primarily for motorized travel. These active transportation modes are increasingly recognized as fundamental to equitable transportation systems that afford all residents access to destinations without requiring the use of a private automobile.

This primer is intended for highway safety professionals, including State Highway Safety Offices, as well as their partners and grantees, as a reference for an integrated and comprehensive effort to improve pedestrian and bicycle safety. This type of approach is referred to as “comprehensive” given that it brings to bear all relevant types of resources, including a variety of strategies and safety measures. The goal of this primer is to:

- Summarize the most promising infrastructure treatments and behavioral programs available for addressing specific safety problems and highlight how these approaches can be combined and implemented.
- Offer real-world examples of what States and local jurisdictions are doing to address pedestrian and bicycle issues in a comprehensive manner.
- Identify opportunities for agencies with differing missions to collaborate and combine their respective approaches for a more comprehensive program.
- Include descriptions of key concepts and definitions of common terms and acronyms to help readers understand the essentials of pedestrian and bicycle safety issues.

The primer is organized into the following sections:

- **Section 1: Introduction** — Briefly describes national initiatives related to non-motorized travel and provides an overview of how States and municipalities are planning more multimodal facilities while working to improve safety for pedestrians and bicyclists.
- **Section 2: Understanding and Identifying Pedestrian and Bicycle Safety Concerns** — Describes safety trends and issues for people who walk and bike and summarizes ways to better understand and identify concerns when developing and supporting comprehensive pedestrian and bicycle safety programs.
- **Section 3: Addressing Pedestrian and Bicycle Safety Concerns** — Provides an overview of evidence-based engineering, education, and enforcement treatments or programs that, when properly implemented, can improve conditions for pedestrians and bicyclists. The section also discusses a number of factors that may limit or enhance the effectiveness of treatments or programs.

- **Section 4: Implementing Treatments and Programs in a Partner-Driven Approach** — Highlights potential partners for bicycle/pedestrian safety efforts and opportunities for collaboration.
- **Section 5: Glossary and Additional Resources** — Includes brief descriptions of resources that provide additional information about treatments and programs described in Section 3. The glossary includes key terms, acronyms, and concepts that are mentioned in this primer, or that one may come across in the field of transportation safety. Throughout the text, key terms found in the glossary will be *bolded and italicized*.

Emerging Trends in Advancing Pedestrian and Bicycle Safety

Across the Nation, there are many initiatives taking place to address and improve pedestrian and bicycle safety and mobility. For instance, the U.S. Department of Transportation’s Safer People, Safer Streets initiative encourages communities to create safe and *connected networks* of biking and walking facilities by providing data, resources, and examples of best practices.¹ It also aims to create *ladders of opportunity*, helping increase travel options so more communities can access essential services such as employment, education, and healthcare. At the local level, the concept of traffic calming—slowing driver speeds or reducing traffic volumes through the use of physical features in the roadway—has been a popular and often-used approach to improve the safety of all roadway users, particularly on residential streets. Traffic calming and other roadway design approaches are one way to create *self-enforcing roadways*, whereby the design of the road encourages safe and appropriate user behaviors, rather than relying on law enforcement measures to ensure compliance. For example, raised medians and crossing islands are roadway design elements that may be used to slow traffic speeds by visually narrowing the roadway, as well as facilitate pedestrian crossings at desired locations; these and other approaches are described in detail in Section 3.

One symbol of the movement toward advancing pedestrian and bicycle safety is the rapid rise in the number of cities and States that are taking a *Complete Streets* approach to transportation projects (Figure 1). This type of approach starts with a policy commitment to design and operate roads that provide safe access for all users—pedestrians, bicyclists, transit riders, and motorists—and is intended to lead to roadway designs that provide for the needs of all roadway users. To date, over 850 local or regional jurisdictions and 30 States have adopted some form of Complete Streets policy.²

¹ U.S. Department of Transportation. *Safer People, Safer Streets: Pedestrian and bicycle safety initiative*. Retrieved from www.transportation.gov/policy-initiatives/ped-bike-safety/safer-people-safer-streets-pedestrian-and-bicycle-safety

² Smart Growth America. *Policy atlas*. National Complete Streets Coalition. Retrieved from www.smartgrowthamerica.org/complete-streets/changing-policy/complete-streets-atlas



Figure 1. New York City streets accommodate many different modes of travel to support health, mobility, and accessibility goals. (Source: pedbikeimages.org / Laura Sandt).

A growing number of U.S. cities and regions—over 30 since 2007—and many cities in Europe and Asia are also successfully offering *bike sharing* systems (see Figure 2), which facilitate short distance point-to-point trips by providing users the ability to pick up a bicycle at any self-serve station and return it to any other station in the service area.³ As reported by Reuters in 2014, after 23 million bike share rides in 7 years across 36 cities, no fatalities associated with the bike share programs have been reported.⁴ This has largely been attributed to the concept of *safety in numbers*, whereby the more pedestrians and bicyclists that are present, the more drivers will expect to see pedestrians or bicyclists, and thus the lower the individual crash risk.⁵

As part of providing multimodal facilities and encouraging people to walk and bike, communities are becoming increasingly aware of the need to improve safety in order to reduce total crashes. More people walking and biking means more exposure to traffic and a potential for a greater number of conflicts, even though individual risks may decrease with the safety in numbers phenomenon. While serious injuries and fatalities from traffic collisions have been decreasing nationally over the past decade or more, pedestrians and bicyclists still account for a disproportionate number of traffic fatalities. To address this problem, cities and States have been

³ Pedestrian and Bicycle Information Center. *Bike sharing*. Retrieved from www.pedbikeinfo.org/programs/promote_bikeshare.cfm

⁴ Goldberg, B. (2014, August 12). After 23 million rides, no deaths in U.S. bike share programs. *Reuters*. Retrieved from <http://www.reuters.com/article/2014/08/12/us-usa-transportation-bikes-idUSKBN0GC10T20140812>

⁵ Jacobsen, P. L. (2003). Safety in numbers: More walkers and bicyclists, safer walking and bicycling. *Injury Prevention*, 9(3), 205-209. doi:10.1136/ip.9.3.205



Figure 2. Bike share stations such as this one in San Antonio, Texas, are being installed in more and more locations across the U.S. (Source: pedbikeimages.org / Greg Griffin).

adopting a *Vision Zero* or *Toward Zero Deaths* approach to reducing traffic fatalities and serious injuries. These policies or planning frameworks set a goal to reduce fatal and serious injuries due to traffic crashes as close to zero as possible. For example, the Washington State Traffic Safety Commission has a Target Zero initiative to eliminate serious injuries and fatalities by 2030, and the City of Seattle has a Vision Zero plan that is a joint effort of the city’s police department and the transportation department. Vision Zero approaches acknowledge that there is not a singular strategy that will eliminate traffic fatalities, so agencies employ a combination of strategies, such as public education campaigns, enhanced enforcement, legislation, and prioritizing roadway designs that reduce speeds and provide space for all roadway users.

For approaches such as Toward Zero Deaths and similar highway safety initiatives to be effective in reducing crashes and injuries, a comprehensive, integrated approach using all of the traditional “E’s”—Engineering, Education, Enforcement, and possibly others, as discussed later—is needed. While State Highway Safety Offices (SHSOs) traditionally focus on selecting and funding outreach, education, and enforcement programs to change road user behavior, there is a growing recognition that the most effective programs integrate environmental (engineering-based) improvements with behavior-change programs while building broader social or policy supports for transportation safety.⁶ Since SHSO grant funds generally cannot be used to support infrastructure changes, accomplishing a more comprehensive approach requires establishing coordination among numerous groups with different approaches but share a common mission—to improve safety.

⁶ Sallis, J. F., Cervero, R. B., Ascher, W., Henderson, K. A., Kraft, M. K., & Kerr, J. (2006). An ecological approach to creating active living communities. *Annual Review of Public Health, 27*, 297-322. Retrieved from www.annualreviews.org/doi/abs/10.1146/annurev.publhealth.27.021405.102100

SECTION 2: UNDERSTANDING AND IDENTIFYING PEDESTRIAN AND BICYCLE SAFETY CONCERNS

In order for highway safety professionals, including State Highway Safety Offices and other agencies and organizations responsible for addressing traffic safety issues, to develop effective pedestrian and bicycle injury prevention programs, it is important to have an understanding of the nature of pedestrian and bicycle crashes and prevailing crash trends. This section provides a brief background on relevant pedestrian and bicycle safety issues and basic information on how agencies can approach identifying State and local safety problems to help drive the decision-making process regarding program development.

Pedestrian and Bicycle Crash Trends and Indicators

Pedestrian and bicyclist crash and injury frequencies (sometimes called crash/injury counts or numbers) and crash rates (per population or unit time or distance) are measures used by many agencies to monitor pedestrian and bicyclist safety over time.

Nationwide in 2013, there were 4,590 pedestrians and 711 bicyclists killed in collisions with motor vehicles.⁷ Although the total number of traffic fatalities has declined substantially in recent decades, there has not been an equivalent decrease in the numbers of pedestrians and bicyclists killed in traffic collisions. Consequently, pedestrians and bicyclists make up a growing percentage of traffic fatalities—about 16% in 2013. Many pedestrians and bicyclists also sustain serious injuries in traffic crashes—the numbers of bicycle and pedestrian injuries captured in national and State crash databases are typically only a fraction of those that actually occur, so the actual extent of the safety problem is likely much larger than what published statistics portray.⁸ For more information on pedestrian and bicyclist fatalities and injuries, see the Fatality Analysis Reporting System (FARS) crash data website or the National Highway Traffic Safety Administration's (NHTSA) [Traffic Safety Facts Annual Reports](#) and [Traffic Safety Fact Sheets](#).

Growing pedestrian and bicyclist fatality and injury counts may reflect population growth and people making more trips by walking and bicycling therefore increasing *exposure* to traffic.⁹ Thus, it may be helpful to also consider pedestrian and bicyclist crash rates, which takes into account some measure of exposure. Unfortunately, relative to other modes of travel, there is

⁷ National Highway Traffic Safety Administration. (2015). Traffic safety facts 2013 (Report No. DOT HS 812 139). Retrieved from www-nrd.nhtsa.dot.gov/Pubs/812139.pdf

⁸ Stutts, J. C., & Hunter, W. W. (1999). *Injuries to pedestrians and bicyclists: An analysis based on hospital emergency department data*. Retrieved from the FHWA website: www.fhwa.dot.gov/publications/research/safety/pedbike/99078/ ;

Stutts, J. C., & Hunter, W. W. (1999). Motor vehicle and roadway factors in pedestrian and bicyclist injuries: An examination based on emergency department data. *Accident Analysis and Prevention*, 31, 505-514.

⁹ Centers for Disease Control and Prevention. (2012). Vital Signs: Walking among adults — United States, 2005 and 2010. *Morbidity and Mortality Weekly Report*, 61, 595-601.;

Pucher, J., Buehler, R. Merom, D., & Bauman, A. (2011). Walking and cycling in the United States, 2001–2009: Evidence from the National Household Travel Surveys. *American Journal of Public Health*, 101, S310-S317.;

Santos, A., McGuckin, N., Nakamoto, H. Y., Gray, D., & Liss, S. (2011). *Summary of travel trends: 2009 National Household Travel Survey* (Report No. FHWA-PL-11-022). Retrieved from the FHWA website:

nhts.ornl.gov/2009/pub/stt.pdf

often limited information available regarding changes in pedestrian and bicyclist travel patterns and exposure (such as number, length, and nature of biking and walking trips, where these trips are taking place, and amount of time spent walking and biking). This lack of data tends to limit our understanding of the seriousness of pedestrian and bicyclist crash risks and where problems exist. For example, two intersections may have the same number of pedestrian crashes in a given year, but one site may have double or triple the number of pedestrians crossing, making it potentially a safer site. Without knowing the details of the pedestrian volumes at each site, an agency could wrongly conclude that both sites warranted the same amount of attention.

To help understand and deal with safety problems, jurisdictions are developing more sophisticated ways to measure the safety performance of transportation facilities, which often involves monitoring both changes in pedestrian and bicycle crash frequencies and exposure. For example, if crashes go down while exposure also decreases, it may indicate that people are not walking or biking because they feel unsafe. Likewise, if exposure goes up and crashes go down, it is a likely sign that efforts, such as Toward Zero Deaths (or Vision Zero) safety initiatives, have been effective. Efforts that encourage people to bicycle and walk while simultaneously implementing initiatives to reduce crashes require State and local agencies to take a cooperative approach to identify risks and the most effective ways to create a safer environment for walking and biking.

Common Factors Contributing to Crashes

While crash frequencies and rates can provide a sense of the magnitude of the issue and changes that occur over time, they do not give any insights into the underlying causes of the crashes or how to address them. A thorough understanding of the factors that contribute to pedestrian and bicyclist crashes and injuries is necessary for developing and applying the most cost-effective and appropriate combinations of *countermeasures*. In highway safety, the term countermeasure is generally used to describe a safety treatment, a safety program, or a safety program approach focused on a particular type of crash problem. In this primer, the terms countermeasure, treatment, intervention, and program are used interchangeably to describe approaches focused on preventing or mitigating pedestrian and/or bicyclist crashes and injuries. For example, a community facing a problem with pedestrian crashes at intersections may apply several countermeasures, such as new signal enhancements, a “look before you cross” education campaign, and enforcement targeting drivers running red lights or failing to yield to pedestrians at intersections.

Many studies have examined pedestrian and bicycle crashes including pre-crash events and any role that location or environment may have played in the crash.¹⁰ Common problems associated with a higher risk of collision and/or severe injury include:

¹⁰ National Cooperative Highway Research Program. (2004). *Report 500, Volume 10: A guide for reducing collisions involving pedestrians*. Transportation Research Board: Washington, DC.; National Cooperative Highway Research Program. (2008). *Report 500, Volume 18: A guide for reducing collisions involving bicyclists*. Transportation Research Board: Washington, DC.

- **Excessive motor vehicle speed**—Speeding drivers or those who drive too fast for conditions increase their risk of a collision with a pedestrian or bicyclist. A number of studies have examined the impact of speed on pedestrian fatalities; all find similar relationships. As motor vehicle impact speeds increase, the risk of pedestrian death increases. One study estimated that the risk of a pedestrian dying from a collision with a motor vehicle increases from 8% at 50 km/h (about 31 mph) to 50% at 75 km/h (about 47 mph).¹¹
- **Conflicts at crossing locations**— When the design of an intersection or other crossing location puts different types of road users in conflict, the risk of a crash may increase. In general, the likelihood of a crash increases when pedestrians and bicyclists opt to cross at locations not properly designed for crossing because motorists do not expect pedestrians there. In the United States, approximately 20% of pedestrians killed and an estimated 45% of those injured were struck in collisions at intersections. For bicyclists, 33% of those killed and 56% of those injured were involved in intersection collisions.¹² These figures may be greater in urban settings, where the density of crossings is high.
- **Inadequate conspicuity**—When pedestrians and bicyclists are not conspicuous, whether in light or dark conditions, it is difficult for drivers to notice them and crash risk increases. Nationwide in 2013, 70% of pedestrians killed and 43% of bicyclists killed were struck in dark conditions.¹³ Empirical evidence also suggests that many bicyclists are not aware of or compliant with laws requiring bicyclists to use lights and/or reflectors when traveling at night.
- **Poor compliance with traffic laws and proper use of facilities**—Drivers, pedestrians, or bicyclists who do not comply with traffic laws and rules of the road, impact the safety of all road users. Examples include drivers failing to yield to pedestrians at crosswalks, and pedestrians and bicyclists walking/riding on the wrong side of the road and/or failing to follow traffic signs and signals. Sometimes poor compliance may result from other problems, such as non-existent or poorly designed facilities and crossings, or misunderstanding of how certain designs or traffic control devices are intended to work. For example, a pedestrian might press a pushbutton and when he or she does not receive a “WALK” indication in a relatively short period of time, he or she may try to judge gaps in traffic and cross on their own.
- **Inadequate separation**—The safety of pedestrians and bicyclists who are not adequately separated from high-speed and high-volume traffic is affected in a number of ways.

¹¹ Rosén, E., & Sander, U. (2009). Pedestrian fatality risk as a function of car impact speed. *Accident Analysis & Prevention*, 41, 536–542.

¹² National Highway Traffic Safety Administration. (2015). *Traffic safety facts 2013* (Report No. DOT HS 812 139). Retrieved from www-nrd.nhtsa.dot.gov/Pubs/812139.pdf

¹³ Statistics from FARS data query. “Dark conditions” variable includes dark with no supplemental roadway lighting, dark with supplemental roadway lighting, and dark with unknown roadway lighting. The query did not include “low lighting” conditions like dusk and dawn. Retrieved from www-fars.nhtsa.dot.gov/QueryTool/querysection/selectyear.aspx

Pedestrians may have to walk on the roadway and may not be seen by drivers in time to avoid a crash. Dense traffic, large-vehicle traffic, darkness, and limited sight distance may also affect the safety of bicyclists sharing motor vehicle lanes under these conditions. If they do not feel safe, bicyclists may resort to riding on sidewalks (when available), often against the direction of traffic, which can increase the risk of crashes at intersections and driveways and create potential conflicts with pedestrians.

The risk factors above can be greatly exacerbated by alcohol or drug use, as well as inattention and distraction by drivers, pedestrians, or bicyclists. These impairments can cause a driver, pedestrian, or bicyclist to lose control of their vehicle or their actions entirely. Non-behavioral factors such as weather, visibility, road condition, can also greatly influence crash risk.

Given the complexity of factors that can contribute to a crash, many risks are challenging for safety practitioners to address using just one countermeasure. For example, law enforcement alone may be insufficient to reduce driver speeding in areas where pedestrian and bicycle activity and the potential for conflicts with vehicles is high, particularly if the roadway is designed for higher-speed traffic. Changes in road design, such as traffic calming measures and roundabout intersection designs, can provide self-enforcement of lower speeds, especially needed as an additional countermeasures since law enforcement personnel cannot be present at all times. Section 3 of this primer helps provide links between key safety issues and a range of countermeasures that can be part of a comprehensive solution that includes a multiple “E” approach. Table 1 in Section 3 provides a matrix of 29 potential countermeasures in relation to these five key safety concerns.

Identifying Key Trends and Issues

While the risks described in the previous section are likely to be overarching concerns, it is helpful for State and local agencies to spend more time learning about crash patterns and potential underlying factors that are occurring in their area. This can help lead to a more informed and targeted strategy to address crashes and injuries. The following section outlines two methods agencies can utilize to assess their key pedestrian and bicycle safety issues and needs – 1) analyzing and mapping crash data, and 2) performing road safety audits.

Analyzing and Mapping Crash Data

A review of pedestrian and bicycle crash data can help identify trends and specific issues that may be addressed in a targeted or comprehensive manner. These data are typically collected by law enforcement officers responding to a reported crash and housed in a database maintained by the Department of Transportation (DOT) or Department of Motor Vehicles (DMV) and are available to SHSOs and other agencies to support planning efforts. Since pedestrian and bicycle crash data is more limited than overall vehicular crash data, multiple years of data should be reviewed to arrive at a stable estimate of the safety situation and to identify any trends. When possible, a review of individual crash reports can provide insights into specific problems that can be addressed.

- Crash data trends based on crash locations: Geo-coded crashes (i.e., coded with geographic location such as latitude and longitude) can be presented in map format

and/or spatially analyzed in relation to factors of interest such as roadway types, destinations (such as schools), and socio-demographic information (see Figures 3 and 4).

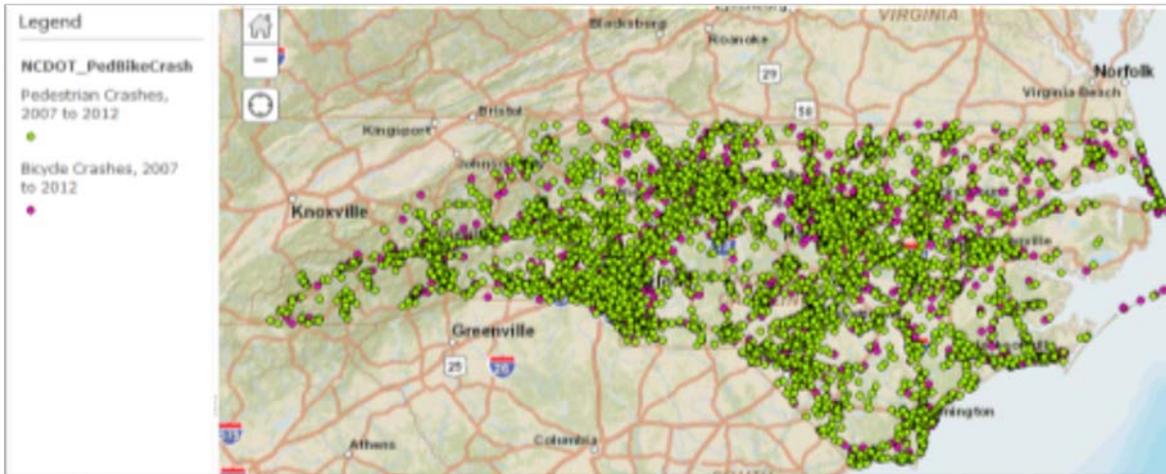


Figure 3. North Carolina DOT's web-based mapping tool displays geocoded pedestrian and bicycle collisions. (Source: ncdot.maps.arcgis.com/home/index.html).

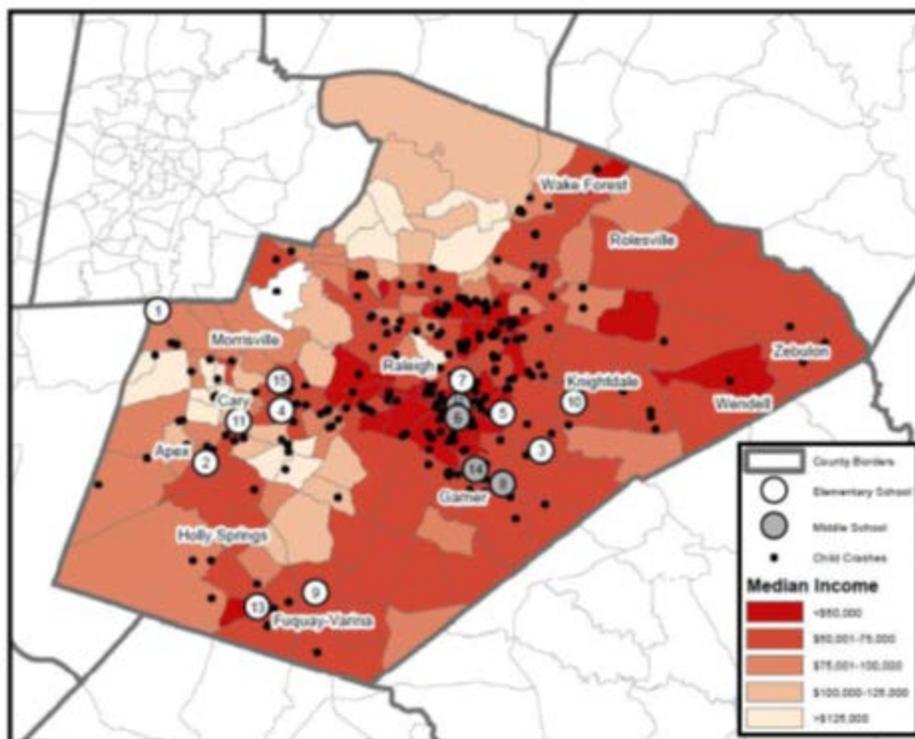


Figure 4. An example spatial analysis of Wake County, NC, child pedestrian crashes in relation to low-income areas to identify high-priority schools. (Source: Jesse Cohn, HSRC).

- Crash data trends based on crash types: *Crash types* are classifications of pedestrian and bicycle crashes based on research into the pre-crash actions taken and errors made by the driver, pedestrian, or bicyclist and the circumstances under which the crash occurs (e.g., walking along road, midblock dart/dash, turn/merge). Countermeasures have already been developed and tested for many of the defined crash types. Identifying a prevailing crash type and the frequency of crash types in a community can provide important guidance for developing a comprehensive program to reduce crashes. Unfortunately, pedestrian and bicycle crash type information is often lacking in State and local crash databases. Crash types can, however, be determined from a review of hard copy crash reports using the [Pedestrian and Bicycle Crash Analysis Tool \(PBCAT\)](#) developed to help code the crash type information.¹⁴

As one example of the use of crash-typed data, the North Carolina Department of Transportation (NCDOT) Division of Bicycle and Pedestrian Transportation provides a [suite of tools](#) to help practitioners in the State understand pedestrian and bicycle crash issues. These include a database of crash-typed data that can be queried, an interactive map (separate from the one displayed in Figure 3), and [detailed summary reports](#) on pedestrian and bicyclist crash trends and common crash types. The database is regularly updated when new crash data become available. These tools, developed with support from the North Carolina Governor’s Highway Safety Program in coordination with the NCDOT, are used to inform decision-making when developing the State Highway Safety Improvement plan and by local agencies receiving planning grants. More examples of communities that are effectively using crash data to identify pedestrian and bicycle safety concerns to help tailor a response include:

Example: Oregon’s Use of Crash Data to Systemically Identify High Risk Locations

Pedestrian and bicyclist fatalities comprise more than 15% of all traffic deaths in the State of Oregon, so the State DOT has identified bicycle and pedestrian crashes as a primary focus for infrastructure funding. Since pedestrian and bicycle crashes are still infrequent enough to make it difficult to predict where they will occur next, the ODOT Traffic-Roadway Section decided to focus limited resources on locations that have the greatest potential for crash reductions. In 2013, ODOT set out to match effective safety systemic infrastructure countermeasures with potential locations for improvements by identifying a few key patterns of behavior and roadway conditions that cause locations to be high-risk. This approach is promising, but ODOT expressed that the analysis was constrained by the limited availability of roadway information such as bicyclist and pedestrian volumes, the presence of a crossing treatment, presence of a turn lane, driveway activity, and sight distances. Missing data should not prevent an agency from undertaking this type of analysis, but more detailed inventories could help agencies identify important risk factors with more certainty. Also, conducting an analysis can help identify data deficiencies and prompt additional data collection.

¹⁴ The PBCAT software is available for free download from the site link in the main text. Potential users should be aware that they may have to install and operate the software in “compatibility” mode since the software may not be fully compatible with current computer operating systems.

Example: San Francisco's Use of Data to Prioritize Its Investment Strategy

San Francisco's [WalkFirst Strategy](#) aims to develop a framework for how the city would prioritize future pedestrian improvements. *WalkFirst* is a data-driven approach for prioritizing investments within San Francisco and for making progress towards achieving San Francisco's overall *Vision Zero* goals. The first phase included identifying both high-demand and high-risk corridors and intersections based a history of severe or fatal injuries (Figure 5). The data fed directly into Phase 2, the city's safety project prioritization list for implementing improvements along these corridors. This phase considered project costs and effectiveness as well as the location type such as "complex intersections," areas with many alcohol-related crashes, corridors with several midblock collisions, and locations with poor night visibility. Finally, the Phase 3 streetscape prioritization for *WalkFirst* addresses priority corridors to further enhance them beyond what was done for safety in Phase 2. The city is now ready to leverage \$17 million over the next five years to improve pedestrian safety at 170 high-priority locations identified in the *WalkFirst* Strategy.

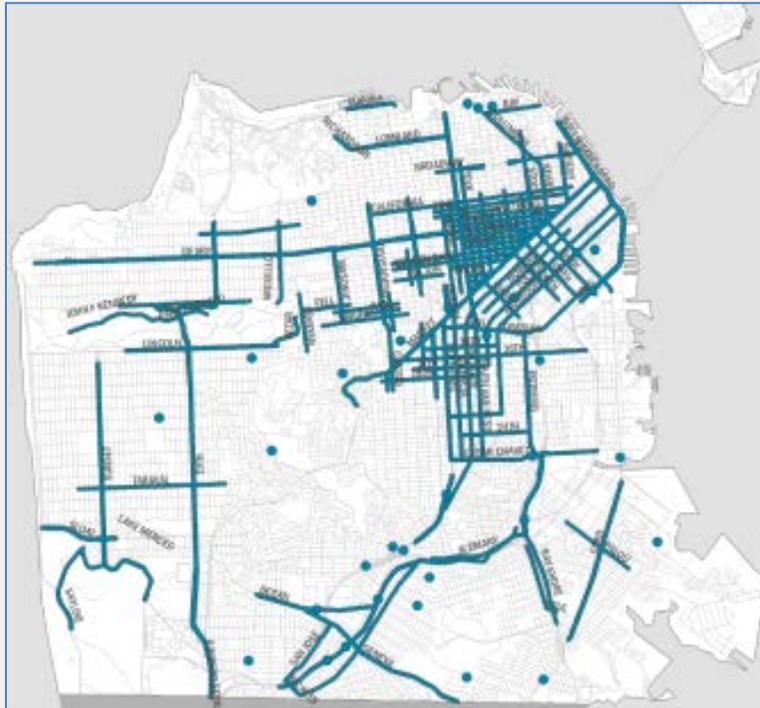


Figure 5. A crash analysis found that just 12% of San Francisco streets account for over 70% of all severe and fatal crashes. This map shows streets and intersections with a high density of collisions. (Source: San Francisco Department of Public Health, 2014).

Example: Chicago’s Use of Injury Severity Data to Benchmark Safety Goals and Progress

Chicago conducted a [comprehensive pedestrian crash analysis](#) in 2006 and again in 2011, feeding into the citywide *Chicago Pedestrian Plan*. These analyses were conducted using crash data files from the Illinois Department of Transportation, and included several descriptive and spatial analyses. The city evaluated injury frequency and severity for different age groups (such as children and seniors), as well as for various crash types and contributing environmental factors. The spatial analysis presented crash density citywide, by ward, as well as near schools. This data highlighted key crash conditions and served as a benchmark for measuring the City of Chicago’s goals set forth in the *Chicago Pedestrian Plan*, as well as informing the city’s upcoming pedestrian safety public awareness campaign.

Performing Road Safety Audits or Other Assessments

Road safety audits (RSAs) of pedestrian and bicycle networks, corridors, or intersections represent another method that can be used to complement crash data analysis and proactively identify safety concerns. Road safety audits rely on independent, interdisciplinary teams to conduct a formal, qualitative safety assessment, and include observing road user interactions with the infrastructure and with each other. RSAs are therefore inherently comprehensive in considering the problems and potential solutions, which primarily involve design but can also include enforcement or educational measures. Less formal versions of RSAs, often referred to as assessments, walkabouts, or field reviews, may not have as much “official” weight but can accomplish many of the the same goals as an RSA (Figure 6). RSAs or other roadway assessments can be particularly useful when agencies are concerned with missing or poor quality crash reports and need additional information about a specific site, or one that represents a common roadway design. A recent U.S. Department of Transportation initiative to improve pedestrian and bicycle safety involved conducting road safety assessments in every State. State Highway Safety Offices, in addition to local and State DOT personnel, are key participants in such initiatives.



Figure 6. The roadway assessment process can involve many partners, including transportation planners and engineers, law enforcement, and members of the disability community. (Source: Michele McKinley, *Advocates for Health in Action*).

Many tools are available to those seeking to organize or participate in RSAs or assessments. The [Bicycle Road Safety Audit Guidelines and Prompt Lists](#) and [Pedestrian Road Safety Audit Guidelines and Prompt Lists](#) are examples of documents that provide a comprehensive guide for conducting RSAs. The [Bikeability Checklist](#) and [Walkability Checklist](#) are less formal but very user-friendly tools that can also be used to guide an assessment process.

SECTION 3: ADDRESSING PEDESTRIAN AND BICYCLE SAFETY CONCERNS

The “3 E” Approach

Transportation practitioners commonly refer to the “3 E” model when seeking to address pedestrian and bicyclist safety concerns. The primary “Es” most often refer to:

1. **Engineering (and related policy changes)** — Changes to the roadway environment or operations (e.g., provision of sidewalks, bike facilities, traffic signals) that affect the movement of pedestrians, bicyclists, and other road users. The roadway design and changes to the roadway environment often reflect or result from the policies, plans, or design guidelines that are in place.
2. **Education** — Efforts made to educate pedestrians, bicyclists, drivers, or other groups in order to raise awareness of a particular law, safety issue, or behavior and motivate a change in attitude or behavior that will have a positive effect on safety.
3. **Enforcement** — Law enforcement agency efforts to promote compliance with laws, ordinances, and regulations (e.g., speed limits, failure to yield, use of crosswalks, use of bicycle facilities) related to pedestrian and bicycle safety.

Additionally, there may be other important “E’s” to consider. These may include the role of “Emergency Response” in managing injuries after a crash occurs, “Emerging Technologies” including the use of V2P (vehicle to pedestrian) collision warning applications, or the need for “Encouragement” and “Engagement” to promote walking and biking and engage the public regarding the other “E’s.” Some practitioners view the “E’s” through a framework of “Evaluation”—acknowledging the importance of understanding the effects of a safety treatment or program—and also “Equity,” seeking to justly balance how investments are distributed across a community. There is much evidence to show that a combination of the “E’s” (e.g., making engineering changes along with education and enforcement efforts) applied together will be more effective than using only one approach.

This section provides an overview of 29 evidence-based engineering, education, and enforcement treatments or programs that, when properly implemented, can improve safety and provide a better environment for pedestrians and bicyclists. Treatments selected for inclusion in this primer were based on:

1. Accumulated evidence regarding effectiveness; and
2. Their relation to safety concerns faced by highway safety officials (safety concerns are described in Section 2).

Table 1 provides an overview of the treatments and programs that are covered. Following the table, for each treatment there is a description of what it is or how it works, a discussion of the appropriate context for the treatment, details on how it works with other treatments, and additional resources. Under “Relation to other treatments,” a term that is in **bold** represents another countermeasure that has an entry in this section.

These treatments by no means represent all of the potential countermeasures that are available to address pedestrian and bicycle concerns; rather, this section is intended to help SHSOs and other

readers to better understand the basics of core treatments commonly used and accepted by the U.S. and State Departments of Transportation. It is also important to note that this primer includes some treatments and programs that an SHSO may not have the full authority or funding mechanisms to implement on its own. For example, SHSO funding generally cannot be used to implement engineering improvements. However, each *countermeasure* presented in the following sections can be successfully implemented or enhanced if there is effective collaboration between agencies and community partners (for more on partnerships, see Section 4). For more on the research related to pedestrian and bicycle countermeasures and resources to support countermeasure selection, see Section 5.

Table 1. Summary of Key Pedestrian and Bicycle Safety Concerns and Related Treatments and Programs.

Treatment or Program	Primary Mode Affected	Relation to Safety Concern*				
		Excessive vehicle speed	Conflicts at crossing locations	Inadequate conspicuity/visibility	Poor compliance with laws/proper facility use	Insufficient separation from traffic
Engineering Treatments						
1. Access management	All	•	•	maybe		
2. Advance yield/stop lines	Pedestrians/Drivers		•	•	•	
3. Bicycle detection at signals	Bicyclists		•		•	
4. Bike lanes	Bicyclists				•	•
5. Bicycle pavement marking improvements	Bicyclists		•	•	•	•
6. Bicycle-tolerable rumble strips	Bicyclists/Drivers					•
7. Crossing islands and raised medians	Pedestrians/Drivers	•	•	•		•
8. Interchange design	Pedestrians/ Bicyclists	•	•			
9. Intersection geometric design	Pedestrians/Drivers	•	•	•		
10. Lighting and illumination	All		•	•		

Treatment or Program	Primary Mode Affected	Relation to Safety Concern*				
		Excessive vehicle speed	Conflicts at crossing locations	Inadequate conspicuity/visibility	Poor compliance with laws/proper facility use	Insufficient separation from traffic
11. Marked crosswalks	Pedestrians		•	•	•	
12. Pedestrian and bicycle overpasses/underpasses	Pedestrians/ Bicyclists		•			•
13. Pedestrian hybrid beacons	Pedestrians (and potentially Bicyclists)		•		•	
14. Pedestrian signals and push buttons	Pedestrians		•		•	
15. Rectangular rapid flashing beacons	Pedestrians		•	•	•	
16. Road diets	All	•	•	•		•
17. Roundabouts	All	•	•		•	
18. Separated bike lanes	Bicyclists	•			•	•
19. Sidewalk buffers and landscaping	Pedestrians	•	maybe	•	maybe	•
20. Sidewalks and curb ramps	Pedestrians				•	•
21. Traffic signal phasing	All		•	•	•	•

Treatment or Program	Primary Mode Affected	Relation to Safety Concern*				
		Excessive vehicle speed	Conflicts at crossing locations	Inadequate conspicuity/visibility	Poor compliance with laws/proper facility use	Insufficient separation from traffic
22. Traffic calming and management	All	•				
Education and Awareness Programs						
23. Child training and skills practice	Pedestrians/ Bicyclists		•	•	•	
24. General pedestrian/bicycle safety communication and outreach	All	maybe	maybe	•	•	
25. Safe routes to school	Pedestrians/ Bicyclists		maybe	maybe	•	
Enforcement Programs						
26. Adult school crossing guards	Pedestrians/ Bicyclists	•	•	•	•	
27. Automated enforcement	All	•	maybe		•	
28. Speed display devices	All	•			•	
29. Targeted law enforcement	All	•	•	•	•	

* Safety concerns are explained in Section 2 under “Common Factors Contributing to Crashes” (pages 6 through 8).

Engineering Treatments

1. Access management

Description

Access management is a set of roadway design techniques used to improve the safety for all street users by reducing the number of conflicts at driveways and side streets. Most often, access management is accomplished through medians or islands located on the main road or driveway to prohibit vehicles from turning left to or from the main road. This reduces many of the common motor vehicle crashes including rear-end, right-angle, head-on, and left-turn crashes and improves the predictability of vehicle movements. Once the left-turn movement is disallowed, drivers may focus more on persons on the sidewalks or bike lanes rather than looking for gaps in two-way traffic.

Since each entrance or exit point (driveway) is a potential conflict point between motorists, pedestrians, and bicyclists, driveway consolidation is another access management method used to improve safety. Where possible, closely spaced driveways should be combined and vehicle circulation should be provided off the main roadway. An example of how this is done is shown in the before/after illustration in Figure 7.

Context

Access management techniques are most often used on suburban corridors, particularly those with center turn lanes. They may also be useful in more urbanized environments to improve safety and vehicle flow.

Relation to other treatments

Road diets are often a great candidate for access management techniques, particularly in cases where a center turn lanes are added as this space can also be used for periodic median islands to prohibit left turns onto the main road.

Further resources

1. Federal Highway Administration. (2014). *Bicycle safety guide and countermeasure selection system (BIKESAFE)*. Retrieved from pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=7
2. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=20
3. Federal Highway Administration, Office of Safety. (2012). *Proven Safety Countermeasures: Corridor Access Management*. Retrieved from safety.fhwa.dot.gov/provencountermeasures/fhwa_sa_12_006.cfm

Image

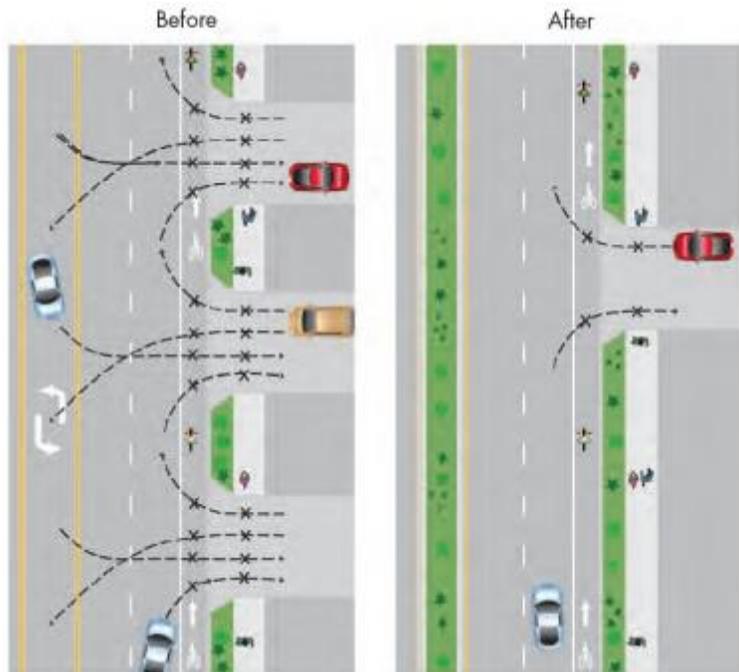


Figure 7. Illustration of adding medians and consolidating driveways to manage access and reduce potential points of conflict.
(Source: Michele Weisbart for the Model Design Manual for Living Streets).

2. Advance Yield/Stop Lines

Description

At locations where a marked crosswalk is placed on multilane roads, a driver yielding to a crossing pedestrian may block the view of that pedestrian to drivers in the adjacent lane and the view of the vehicle to the pedestrian. This can lead to a crash when the pedestrian proceeds into the path of the driver in the adjacent lane who cannot see the pedestrian and therefore does not slow or stop to yield.

Advance stop/yield lines can be placed prior to the intersection to help improve the visibility of pedestrians in the crosswalk and the pedestrians' ability to see drivers. By placing this line 20 to 50 feet in advance of the crosswalk, drivers are encouraged to stop far enough back to allow for better visibility and also give drivers in the adjacent lane enough time to recognize the conditions and safely stop before reaching the crosswalk. This line should be supplemented with a "Stop (or Yield) Here For Pedestrians" sign to alert drivers of the crossing. Whether the line is an advance stop or advance yield line depends on whether State law requires drivers to stop or yield for pedestrians.

Context

Advance yield/stop lines are used in locations where pedestrians must cross two or more lanes of traffic in a given direction.

Relation to other treatments

Depending on traffic speeds, number of travel lanes, and volumes, additional crossing treatments including **Pedestrian Hybrid Beacons**, and **Rectangular Rapid Flashing Beacons**, may also be needed to improve pedestrian safety at these crossing locations.

Additional roadway design features such as **crossing islands** are also frequently used to shorten the pedestrian crossing distance and simplify the crossing.

Providing adequate **lighting** will also improve the visibility of pedestrians using the crossing at night.

Further resources

1. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=13
2. Federal Highway Administration. (2012, May). *Manual on uniform traffic control devices for streets and highways* (2009 ed.). Retrieved from mutcd.fhwa.dot.gov/kno_2009r1r2.htm

Images



Figure 8. The white triangle pavement markings shown here represent the advance yield line. Some states use a solid white line, as shown in Figure 9.
(Source: Toole Design Group).

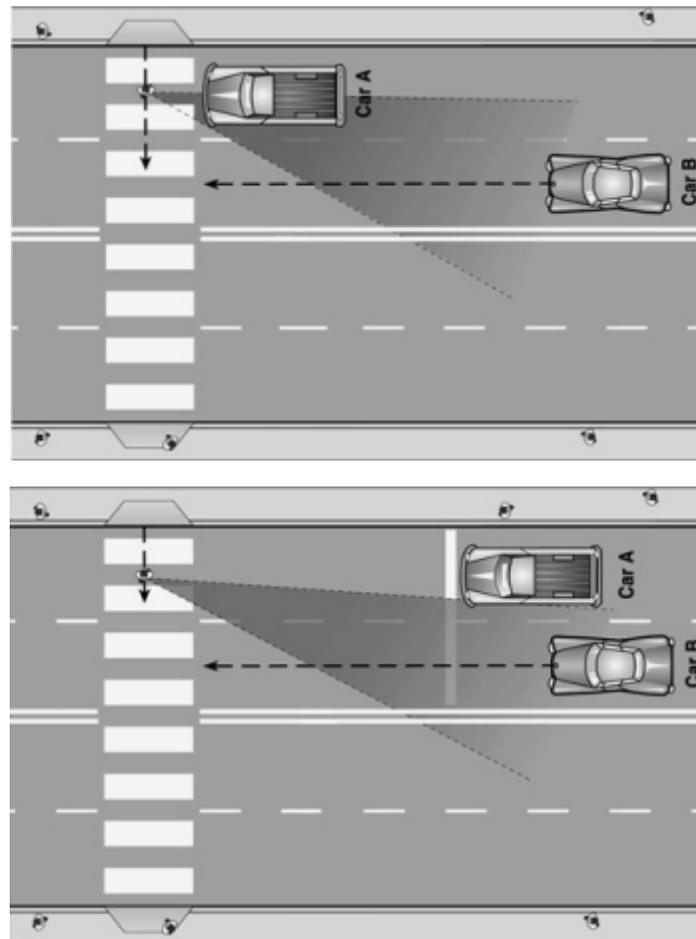


Figure 9. Before and after illustrations show how compliance with an advance stop/yield line can improve the view for pedestrians and drivers.
(Source: National Center for Safe Routes to School Guide).

3. *Bicycle Detection at Signals*

Description

At many traffic signals, a detector is used to “call” a green light. Typically, these detectors are designed to detect motor vehicles, but may not be located correctly or be sensitive enough for the small amount of metal in bicycles. As a consequence, bicyclists are often not detected and given a green light resulting in unsafe bicyclist behaviors such as red light running or simply undue intersection delay. Detection devices need to be placed in the path of a bicyclist (whether in a motor vehicle lane or bike lane) and be designed/calibrated to pick up the small amount of metal in bicycles. In some cases a push button can be used, but it must be placed so that bicyclists do not have to dismount or ride onto the sidewalk to activate.

Context

Providing an accurate detection of bicycles is important at all signalized intersections that use any sort of detectors. The exception is fixed-time signals (where a detector is not needed), which are most common in highly urbanized areas such as downtown cores.

Relation to other treatments

To provide sufficient time for bicyclists or provide bicycle-specific movements, **traffic signal phasing** modifications may also be required.

Bicycle pavement markings can assist bicyclists with locating the optimal place in the lane to be detected by the signal and be used to improve awareness of bicycle movements through the intersection.

Both **bicycle skills practice** and **general bicycle safety education** will help bicyclists and motorists better understand how traffic signals function and may increase the confidence bicyclists have in receiving a green light, thus reducing the chance of running a red light.

Further resources

1. American Association of State Highway and Transportation Officials (AASHTO). (2012). *Guide for the development of bicycle facilities* (4th ed.). Retrieved from bookstore.transportation.org/collection_detail.aspx?ID=116
2. Federal Highway Administration. (2014). *Bicycle safety guide and countermeasure selection system (BIKESAFE)*. Retrieved from pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=36
3. Federal Highway Administration. (2012, May). *Manual on uniform traffic control devices for streets and highways* (2009 ed.). Retrieved from mutcd.fhwa.dot.gov/kno_2009r1r2.htm
4. National Association of City Transportation Officials. (2012). *Urban bikeway design guide* (2nd ed.). Retrieved from nacto.org/cities-for-cycling/design-guide/

Image



Figure 10: Example of pavement marking at traffic signal that shows bicyclists where to stop to activate the signal. (Source: *pedbikeimages.org* / Marie Stake).

4. Bike Lanes

Description

Bike lanes are dedicated marked roadway space for bicyclists traffic and are typically four to six feet wide. This dedicated space allows for a more comfortable ride and often a greater amount of separation from passing motorists. If conditions allow, they may be added to existing streets through the removal of a travel or parking lane or through the narrowing of travel lanes. When bike lanes are adjacent to parking, a greater width should be used to allow for the safe operation of bicycles outside the range of opening car doors. To increase comfort and safety, a painted buffer may also be used to provide additional space between parked cars or travel lanes. Bike lanes need to be clearly marked at intersections and driveways to reduce conflicts with turning vehicles through increased awareness and to identify expected movements.

Context

Bike lanes are typically used in suburban and urban environments where higher speeds or traffic volumes may create hazardous or uncomfortable conditions for bicyclists.

Relation to other treatments

To ensure that bicyclists are detected by traffic signals and visible through intersections, bike lanes are often combined with **bicycle detection at signals** and **pavement marking improvements** through the intersection area.

A **separated bicycle lane** (also known as a cycle track) may be appropriate in locations with high bicycle traffic or locations of high bicyclist stress from motor vehicle speeds or volumes.

Road diets are frequently used as a method of retrofitting bike lanes onto existing roadways by reallocating street space for bicyclists through restriping.

Both bicycle skills practice and **general bicycle safety education** are key components to developing safe and courteous behaviors between all street users.

Further resources

1. American Association of State Highway and Transportation Officials (AASHTO). (2012). *Guide for the development of bicycle facilities* (4th ed.). Retrieved from bookstore.transportation.org/collection_detail.aspx?ID=116
2. Federal Highway Administration. (2014). *Bicycle safety guide and countermeasure selection system (BIKESAFE)*. Retrieved from pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=11
3. National Association of City Transportation Officials. (2012). *Urban bikeway design guide* (2nd ed.). Retrieved from nacto.org/cities-for-cycling/design-guide/
4. Los Angeles County, California. (2011). Chapter 8 bikeway design. In *Model design manual for living streets*. Retrieved from www.modelstreetdesignmanual.com/index.html
5. Federal Highway Administration. (2015). *Separated bike lane planning and design guide* (Report No. FHWA-HEP-15-025). Retrieved from www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/page00.cfm

Image



Figure 11. Bike lane. (Source: *pedbikeimages.org* / Dan Burden).

5. Bicycle Pavement Marking Improvements

Description

Different pavement markings like stripes, symbols, and color can be used to provide information to road users on where bicyclists can be expected. Examples include green lanes or boxes, striping bike lanes, and providing shared lane markings along roadways that guide bicyclists to where they should typically ride. At intersections, pavement markings can be used to provide guidance to bicyclists on the correct path through an intersection, where and how they may safely turn, and to reinforce driver awareness of the bicyclist's presence and expected behaviors at these locations where their movements may cause a conflict. In areas with a high potential for conflict, such as interchanges with many turning vehicles and bicyclists traveling straight through, non-skid green pavement markings may be used to further improve conditions and awareness for bicyclists.

Context

Pavement markings are a versatile tool that can be used in a range of suburban and urban contexts.

Relation to other treatments

Certain pavement markings, such as shared lane markings, work well with **traffic calming** devices, as they increase the expectation of bicyclists in the roadway and may even provide wayfinding guidance for bicyclists on routes along local streets.

Due to the width of the buffer along **separated bike lanes**, pavement markings through an intersection can help call attention to the presence of bicyclists and their expected through and turning movements.

Road diets are often used to create space for **bike lanes**. Where bike lanes cannot be continued due to volume and space constraints, additional types of pavement markings should be added to continue providing bicycle guidance.

Further resources

1. Federal Highway Administration. (2014). *Bicycle safety guide and countermeasure selection system (BIKESAFE)*. Retrieved from pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=38 and pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=18
2. National Association of City Transportation Officials. (2012). *Urban bikeway design guide* (2nd ed.). Retrieved from nacto.org/cities-for-cycling/design-guide/

Images



Figure 12. Dashed lines and green paint are used at this complex intersection in Portland, Oregon. (Source: *pedbikeimages.org* / Shawn Turner).



Figure 13. Shared lane marking on a residential street in Asheville, North Carolina. (Source: *pedbikeimages.org* / Lyubov Zuyeva).

6. Bicycle-Tolerable Rumble Strips

Description

Shoulder-running rumble strips are often used by agencies as an effective countermeasure in reducing motor vehicle run-off-road crashes. However, this treatment can cause safety concerns for bicyclists due to the effective narrowing of the shoulder, which may cause bicyclists to ride in the travel lane. In addition, where the shoulder is wide enough to still safely allow bicyclists to maneuver, bicyclists may have trouble traversing or riding over rumble strips when they need to enter the travel lanes to make a turn or avoid an obstacle on the shoulder. Thus, it is suggested that where rumble strips are recommended for installation, at least four feet of traversable shoulder space remain and that periodic gaps in rumble strips are included. Other options include a reduced depth or width of rumble strips or placing them under the white edge line that marks the extent of the outside travel lane (see Figure 14).

Context

Rumble strips are most frequently used as a safety countermeasure on rural roads.

Relation to other treatments

N/A

Further resources

1. American Association of State Highway and Transportation Officials (AASHTO). (2012). *Guide for the development of bicycle facilities* (4th ed.). Retrieved from bookstore.transportation.org/collection_detail.aspx?ID=116
2. Federal Highway Administration. (2014). *Bicycle safety guide and countermeasure selection system (BIKESAFE)*. Retrieved from pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=13
3. Federal Highway Administration. Rumble Strips and Rumble Stripes. Retrieved from safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips/accommodating-all-users.cfm

Image



Figure 14. Bicycle-tolerable rumble strip. (Source: pedbikeimages.org / Bob Boyce).

7. Crossing Islands and Raised Medians

Description

Crossing islands are raised, paved areas that are used to facilitate safe road crossing for pedestrians and bicyclists and to create a safe place to wait while crossing multiple lanes of traffic. They allow for the crossing to be performed in two-stages, one for each direction of traffic, and shorten the time and distance pedestrians and bicyclists are exposed to moving traffic. Raised medians and crossing islands may also slow traffic speeds by visually narrowing the roadway. Landscaping may enhance this traffic calming effect and provide an aesthetic treatment; however, landscaping should not be permitted to obstruct the visibility of the pedestrians, bicyclists, or approaching motorists. In order to provide a safe refuge that accommodates the length of a bicycle or several pedestrians, a crossing island should be designed with a preferred width of eight feet. Narrower designs may be considered depending on site use and physical conditions.

Context

Crossing islands are typically used where pedestrians are expected to cross the street and are most effective on multilane roads with higher speeds or volumes of traffic.

Relation to other treatments

To shorten the crossing distance for pedestrians (and bicyclists acting as pedestrians when walking their bikes) further and improve their visibility, crossing islands may be used in conjunction with curb extensions (see **intersection geometric design**).

Strategically placed islands and medians may also assist with **access management** goals by prohibiting left-turns to reduce conflicts and improve driver looking behavior.

Many additional crossing enhancements including **advance yield/stop lines, lighting, Pedestrian Hybrid Beacons, and Rectangular Rapid Flashing Beacons** can further improve pedestrian safety at these crossing locations.

Further resources

1. American Association of State Highway and Transportation Officials (AASHTO). (2004). *Guide for the planning, design, and operation of facilities*.
2. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=6 and pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=22
3. Federal Highway Administration. (2014). *Bicycle safety guide and countermeasure selection system (BIKESAFE)*. Retrieved from pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=6
4. Federal Highway Administration, Office of Safety. (2012). *Proven safety countermeasures: Medians and pedestrian crossing islands in urban and suburban areas*. Retrieved from safety.fhwa.dot.gov/provencountermeasures/fhwa_sa_12_011.cfm

Image



Figure 15. Crossing island with high visibility crosswalk. (Source: *pedbikeimages.org / Lyubov Zuyeva*).

8. Interchange Design

Description

Barriers created by freeways often provide pedestrians and bicyclists little choice but to cross this barrier at an interchange. Safely doing so can be a challenge due to the frequent high volumes of traffic at these locations and the high speeds at which drivers enter and depart freeway entrances. Interchanges can be designed (or redesigned) to better accommodate all roadway users safely by designing the location where freeway ramps meet the street as intersections rather than free-flow ramps. This can considerably slow vehicle speeds, improve driver searching and behavior, and significantly reduce the distance required for pedestrians and bicyclists to cross entrance and exit ramps.

Context

To improve safety, in urban and suburban locations, interchange ramps should be designed to reduce speeds and shorten crossing distances for pedestrians and bicyclists. On the surface streets, traffic signals, including **pedestrian signals**, may also be used to facilitate pedestrian and bicyclist crossings.

Relation to other treatments

Pavement markings and **advance yield/stop lines** may be used to further highlight bicycle and pedestrian movements through the conflict areas with motor vehicles.

At freeway ramp entrances and exits, **roundabouts** may be considered as an alternative to traditional intersections to improve safety and efficiency.

Further resources

1. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=30
2. Federal Highway Administration. (2014). *Bicycle safety guide and countermeasure selection system (BIKESAFE)*. Retrieved from pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=21
3. Mitman, M. F., & Ridgway, M. D. (2014). *Recommended design guidelines to accommodate pedestrians and bicycles at interchanges*. Retrieved from the Institute of Transportation Engineers website: ecommerce.ite.org/IMIS/ItemDetail?iProductCode=RP-039

Image

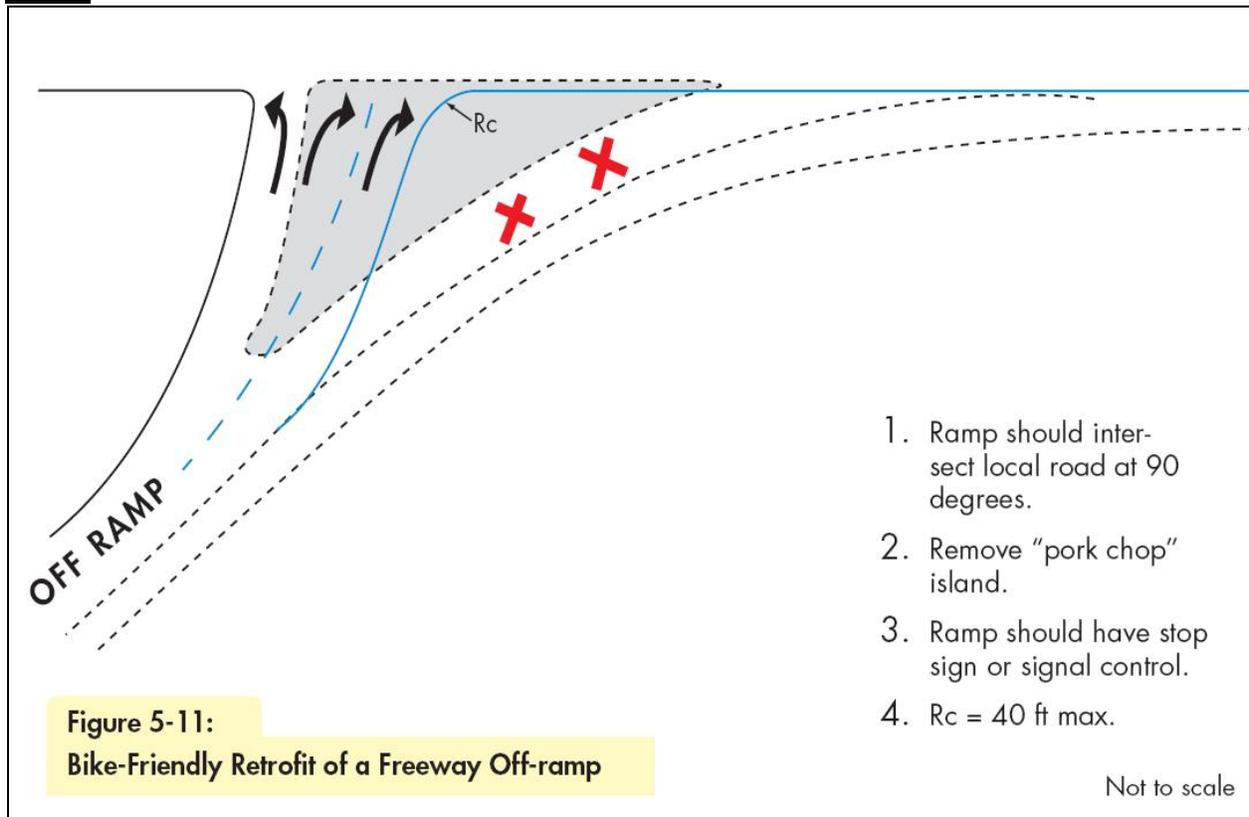


Figure 5-11:
Bike-Friendly Retrofit of a Freeway Off-ramp

Figure 16. Modified intersection ramp to improve safety with slower speeds and shortened crossing pedestrian distances.
(Source: Oregon Department of Transportation).

9. Intersection Geometric Design

Description

Several roadway design improvements can increase pedestrian and bicycle safety at intersections by reducing speeds (particularly the speeds of turning vehicles), improving visibility, and shortening crossing distances. As long as they do not reduce bike lane width, curb extensions can be used at intersections and midblock crossings to achieve all of the previous objectives. Specifically, curb extensions limit parking near the crossings to improve sight lines, reduce the turning radius and thereby slow turning speeds, and shorten the amount of time pedestrians are in the roadway. A smaller radius at intersection corners requires motorists to further reduce their turning speed, making them more likely to yield to pedestrians. Where curb extensions are not feasible due to space limitations or other factors, the curb radius can still be reduced through reconstruction or less expensive measures such as paint and temporary posts. In addition, right turn lanes that are designed with a sweeping curve that does not force motorists to slow or stop should be redesigned with a reduced turning radius to slow turning speeds and increase driver awareness of the crosswalks. In general, intersection turn radii should be selected based on the design vehicle for that roadway (i.e., buses or fire trucks) and the roadway context.

Context

Focusing on reduced speeds and crossing distances at intersections is most important in urban and suburban locations where pedestrians and bicyclists are most frequently in conflict with motor vehicles.

Relation to other treatments

To further assist with safe crossings, **crossing islands** are often used to narrow the roadway.

Curb extensions provide additional space for **sidewalk buffers and landscaping**, which can improve aesthetics and may function as **traffic calming**.

In addition to these geometric design elements, **traffic signal phasing improvements** can provide further safety benefits.

Further resources

1. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=5, pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=26, pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=28, and pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=24
2. Institute of Transportation Engineers. (2010). Chapter 10 - Intersection design. In *Designing walkable urban thoroughfares: A context sensitive approach*. Retrieved from www.ite.org/css/RP-036A-E.pdf
3. Los Angeles County, California. (2011). Chapter 5 - Intersection design. In *Model design manual for living streets*. Retrieved from www.modelstreetdesignmanual.com/index.html

Image



Figure 17. Reduced corner radius at an intersection. Note the location of the previous curb which allowed for higher speed turns by vehicles and increased the crossing distance of the street for pedestrians.

(Source: pedbikeimages.org / Dan Burden).

10. Lighting and Illumination

Description

Appropriate lighting can improve the safety, security, and comfort for pedestrians and bicyclists traveling at night. Lighting serves to both enhance the visibility of pedestrians and bicyclists and to illuminate any hazards that may be on the roadway surface or sidewalk. Lighting should be properly located at crossings to increase pedestrian visibility to approaching drivers. This often requires placing luminaires on each side of the crosswalk rather than one overhead which does not adequately illuminate the pedestrian to make them visible to motorists. Ensuring that sidewalks and pathways, particularly in underpasses and along commercial corridors, are well lit helps increase safety, comfort, and use.

Context

Lighting is typically most important in urban and suburban locations but may also be appropriate in some rural locations such as trail crossings.

Relation to other treatments

Crossing islands, marked crosswalks, and underpasses should all be well lit. **General pedestrian/bicycle safety outreach programs** that seek to improve conspicuity of road users can be augmented by efforts to increase lighting at key locations so that pedestrians and bicyclists are as visible and conspicuous as possible whenever they are in the roadway.

Further resources

1. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=8
2. Federal Highway Administration. (2014). *Bicycle safety guide and countermeasure selection system (BIKESAFE)*. Retrieved from pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=4
3. Los Angeles County, California. (2011). *Model design manual for living streets*. Retrieved from www.modelstreetdesignmanual.com/index.html

Image



Figure 18. Proper placement of pedestrian-scale lamp posts provides illumination for the crosswalk. (Source: Michele Weisbart for the Model Design Manual for Living Streets).

11. Marked Crosswalks

Description

Marked crosswalks may be used at intersections and other crossing locations along a roadway to show pedestrians preferred crossing locations and indicate to drivers to expect pedestrians. In most locations, marked crosswalks alone may not provide full safety benefits for pedestrians due to traffic speeds, volumes, and number of lanes that need to be crossed. To maximize safety in these locations, marked crosswalks should be paired with additional crossing aids, such as raised median islands, improved lighting, and/or signalization.

Context

Marked crosswalks are typically placed at locations of expected pedestrian crossings, such as between transit stops, commercial areas, schools, parking lots, and offices.

Relation to other treatments

To improve safety, crosswalks should be used in conjunction with traffic signals, **crossing islands, advance yield/stop lines** (see **intersection geometric design**), **Rectangular Rapid Flashing Beacons**, or **Pedestrian Hybrid Beacons**.

All marked crosswalks should include **curb ramps** at each end to accommodate wheelchairs.

Motorist education and **targeted law enforcement** may be needed to ensure safe behaviors and driver yield for pedestrians in the crosswalk.

Further resources

1. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=4
2. Federal Highway Administration. (2014). *A resident's guide for creating safer communities for walking and biking*. Retrieved from safety.fhwa.dot.gov/ped_bike/ped_cmunity/ped_walkguide/residents_guide2014_final.pdf
3. Federal Highway Administration. (2012, May). *Manual on uniform traffic control devices for streets and highways* (2009 ed.). Retrieved from mutcd.fhwa.dot.gov/kno_2009r1r2.htm

Image



Figure 19. Marked crosswalk at a midblock location.
(Source: pedbikeimages.org / Carl Sundstrom).

12. Pedestrian and Bicycle Overpasses/Underpasses

Description

Pedestrian and bicycle overpasses and underpasses are used to provide conflict- and impediment-free travel across challenging environments and barriers such as freeways, railroads, and natural obstructions like streams. To be most effective, they should be designed in a convenient location to minimize out-of-the-way travel. If their design is perceived to be slower or has additional challenges like steep slopes, people may attempt to cross at street-level instead. Pedestrians and bicyclists express personal safety concerns when considering use of these facilities; therefore, design should include good lighting and visibility.

Context

Overpasses and underpasses should be used where it is necessary to completely separate pedestrians and bicyclists from motorized vehicular traffic because of a natural barrier or because of high bicycle, pedestrian, or motorized traffic volumes.

Relation to other treatments

Due to security concerns, proper **lighting** should also be provided along these facilities.

Further resources

1. American Association of State Highway and Transportation Officials (AASHTO). (2012). *Guide for the development of bicycle facilities* (4th ed.). Retrieved from bookstore.transportation.org/collection_detail.aspx?ID=116
2. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=10
3. Federal Highway Administration. (2014). *Bicycle safety guide and countermeasure selection system (BIKESAFE)*. Retrieved from pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=3

Image



Figure 20. Underpass for pedestrians and bicyclists.
(Source: pedbikeimages.org / Sree Gajula).

13. Pedestrian Hybrid Beacons

Description

A Pedestrian Hybrid Beacon (PHB) can be used at locations without a traffic signal where pedestrians still need a highly effective device to stop motor vehicle traffic and assist them with crossing the street safely. Typically, PHBs are used on multilane roads with higher speeds or volumes that require occasional pedestrian crossings. The installation of these devices is similar to traffic signals in that they require marked crosswalks, pedestrian signal heads, curb ramps, and push buttons. However, they are less expensive than full signals and are effective at reducing crashes as well as pedestrian wait times.

Context

Pedestrian Hybrid Beacons are often used at school crossings, near parks, transit stops, and trails.

Relation to other treatments

The design of a Pedestrian Hybrid Beacon includes **marked crosswalks, curb ramps, pedestrian signals and push buttons**. Proper **lighting** should also be provided at these locations.

At particularly wide streets, a **crossing island** may be considered such that the pedestrian crossing may be completed in two stages with a separate PHB for each direction of traffic.

Pedestrian and driver education may be needed when these devices are first installed to ensure proper use.

Further resources

1. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=53
2. Federal Highway Administration. (2012, May). *Manual on uniform traffic control devices for streets and highways* (2009 ed.) Retrieved from mutcd.fhwa.dot.gov/kno_2009r1r2.htm
3. Federal Highway Administration. (n.d.). *Pedestrian Hybrid Beacon Guide, Recommendations, and Case Study*. Retrieved from safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa14014/
4. Federal Highway Administration. (2014). *A Resident's Guide for Creating Safer Communities for Walking and Biking*. Retrieved from safety.fhwa.dot.gov/ped_bike/ped_cmunity/ped_walkguide/residents_guide2014_final.pdf

Image



Figure 21. PHB near a school. (Source: *pedbikeimages.org* / Mike Cynecki).

14. Pedestrian Signals and Push Buttons

Description

Pedestrian signals (i.e., WALK/DON'T WALK signals) should be placed at all signalized intersections to provide pedestrians with guidance on when to cross the street. Depending on pedestrian volumes and other factors, the pedestrian WALK signal should be displayed for each cycle, or a push button may be required to call the WALK interval. At all new installations, countdown timers are required on the pedestrian signal to provide further information on the amount of time remaining for the crossing. Accessible Pedestrian Signals (APS) are also recommended at many signalized locations to provide audible information to pedestrians who have vision impairments.

Context

Pedestrian signals should be provided at all signalized locations.

Relation to other treatments

Pedestrian signals are also required at locations with **Pedestrian Hybrid Beacons**.

Further resources

1. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=10
2. Federal Highway Administration. (2012, May). *Manual on uniform traffic control devices for streets and highways* (2009 ed.) Retrieved from mutcd.fhwa.dot.gov/kno_2009r1r2.htm
3. Accessible Pedestrian Signals Guide website. (2009). Developed from National Cooperative Highway Research Program Project 3-62. Retrieved from www.apsguide.org/chapter_overview.cfm

Image



Figure 22. Pedestrian countdown signal. (Source: *Resident's Guide for Creating Safer Communities for Walking and Biking*).

15. Rectangular Rapid Flashing Beacons

Description

A Rectangular Rapid Flashing Beacon (RRFB) is a sign with brightly lit strobe lights that flash irregularly when activated by a pedestrian or bicyclist. These signs are typically used at locations where additional assistance is needed to cross a street and bring attention to the crosswalk. RRFBs are placed in pairs on both sides of the roadway and, if applicable, the median. They can be designed to operate wirelessly through solar power for a simple installation. On multilane roadways they may be less effective unless a crossing island and advance yield/stop line are provided to reduce the crash risk.

Context

Rectangular Rapid Flashing Beacons are often installed at school crossings, or on streets near parks, transit stops, and trails.

Relation to other treatments

The design of an RRFB includes **marked crosswalks** and **curb ramps**. Proper **lighting** should also be provided at these locations.

On multilane roadways, it is recommended that they be used with a **crossing island** and **advance yield/stop line** to reduce the crash risk.

Pedestrian and driver education may be needed when these devices are first installed to ensure proper use.

Further resources

1. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=54
2. Federal Highway Administration. (2012, May). *Manual on uniform traffic control devices for streets and highways* (2009 ed.) Retrieved from mutcd.fhwa.dot.gov/kno_2009r1r2.htm
3. Federal Highway Administration. (2014). *A Resident's Guide for Creating Safer Communities for Walking and Biking*. Retrieved from safety.fhwa.dot.gov/ped_bike/ped_cmunity/ped_walkguide/residents_guide2014_final.pdf

Image



Figure 23. Rectangular Rapid Flashing Beacon. (Source: Carol Kachadorian).

16. Road Diets

Description

In some cases, roadways have more travel lanes than is necessary for the amount of traffic. These streets are often good candidates for road diets (also known as roadway reconfigurations) where these extra travel lanes can be eliminated to provide space for medians, turning lanes, bike lanes, or even sidewalks. The most common type of road diet involves converting a four-lane undivided road into a three-lane road that includes a center two-way left-turn lane and using the extra space to stripe in bike lanes. Other options instead of bike lanes include providing parking, extra sidewalk width, and/or transit lanes. These road diets help optimize the street space and are shown to increase the safety of all road users.

Context

Typically road diets are performed on multilane roads with excess capacity in suburban and urban environments. Road diets have also been used effectively in rural areas.

Relation to other treatments

Road diets are a great opportunity to install new facilities like **bike lanes** or **separated bike lanes**.

In a typical four-lane to three-lane conversion, the center turn lane space may also be used for periodic **median islands** to assist with pedestrian crossings and **access management**.

Further resources

1. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=19
2. Federal Highway Administration. (2014). *Bicycle safety guide and countermeasure selection system (BIKESAFE)*. Retrieved from pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=9
3. Federal Highway Administration. (2014). *Road Diet Informational Guide*. Retrieved from safety.fhwa.dot.gov/road_diets/info_guide/rdig.pdf
4. Federal Highway Administration, Office of Safety. (2012). *Proven Safety Countermeasures: Road Diet*. Retrieved from safety.fhwa.dot.gov/provencountermeasures/fhwa_sa_12_013.htm

Image



Figure 24. “Before” and "After" picture from a typical four-lane to three-lane conversion. (Source: Federal Highway Administration).

17. Roundabouts

Description

Single lane roundabouts have become an increasingly popular intersection design for both safety and efficiency reasons. Due to their design, roundabouts eliminate head-on and angle crashes that are most likely to cause serious injury. They are also designed to slow vehicles on approach and throughout the intersection, which increases safety and awareness. For pedestrians, each intersection approach to the roundabout should include a crosswalk and a splitter island that allows the crossing to be performed separately for each direction of traffic, offering a refuge for pedestrians (see Figure 25). Due to the slow traffic speeds, bicyclists typically have few challenges riding through a roundabout. However, dismounting the bicycle to walk around the roundabout is also an option. Multilane roundabouts are not recommended due to safety concerns for pedestrians and bicyclists.

Context

Roundabouts can work in most contexts, but are not appropriate for high-speed roads.

Relation to other treatments

If a multilane roundabout is used, **advance yield/stop lines** and **Pedestrian Hybrid Beacons** should be included at the pedestrian crossings.

Bike lanes should be discontinued prior to a roundabout with enough distance provided to allow a bicyclist to merge into traffic.

Roundabouts may be a good option for the design of **interchange** ramp terminals.

Driver education may be needed when these devices are first installed to better ensure proper use by all road users.

Further resources

1. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=25
2. Federal Highway Administration. (2014). *Bicycle safety guide and countermeasure selection system (BIKESAFE)*. Retrieved from pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=17
3. Rodegerdts, L., et. al. (2010). *Roundabouts: An Informational Guide* (2nd ed.). Retrieved from onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_672.pdf

Image



Figure 25. Modern roundabout. (Source: FHWA, *Designing for Pedestrian Safety*).

18. Separated Bike Lanes

Description

Separated bike lanes (SBLs), commonly known as cycle tracks or protected bike lanes, create a physical barrier to motorized traffic through the use of parked cars, posts, a landscaped buffer, or a raised curb. This separation creates a more comfortable and attractive bicycle lane for a wide range of abilities and moves bicyclists out of traffic and away from parked cars. Due to this separation from traffic, the design of SBLs at intersections and driveways requires good sight lines and clear markings to identify expected bicyclist movements.

Context

Separated bike lanes are most frequently installed in more urbanized areas with high bicycle and traffic volumes.

Relation to other treatments

Bicycle pavement markings and **traffic signal improvements** should be used at intersections and driveways to provide awareness and guidance of the facility.

Landscaping may be used in the buffer to improve aesthetics and calm traffic.

General safety and bicycle skills training may be required along with **communication and outreach** targeted toward all road users to ensure familiarity and safe behaviors with this newer facility type.

Further resources

1. Federal Highway Administration. (2015). *Separated Bike Lane Planning and Design Guide*. Retrieved from www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/page00.cfm
2. Federal Highway Administration. (2014). *Bicycle safety guide and countermeasure selection system (BIKESAFE)*. Retrieved from pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=52
3. National Association of City Transportation Officials. (2012). *Urban Bikeway Design Guide* (2nd ed.). Retrieved from nacto.org/cities-for-cycling/design-guide/

Image



Figure 26. Parked cars and flexible delineator posts on both sides of the street separate the bike lanes from traffic. (Source: City of Chicago).

19. Sidewalk Buffers and Landscaping

Description

Providing separation between traffic lanes and sidewalks provides several advantages. This buffer area, typically four to six feet wide, creates a place for landscaping that can provide a traffic calming benefit by visually narrowing the width of the roadway. It may also encourage more people to walk by providing shade and a comfortable distance from motorized traffic. In addition, this buffer zone provides space for a safe and level sidewalk at driveway locations.

Context

Sidewalk buffer widths may vary depending on the roadway speed and volume or the presence of parked cars. Higher speed roadways will typically require a larger buffer width.

Relation to other treatments

Driveway improvements can be aided by the use of a landscaping buffer to allow for continuous and level **sidewalk**.

Landscaping may also assist with **traffic calming** goals.

Due to the buffer between the travel lanes and sidewalks by **bike lanes** and **separated bike lanes**, an additional sidewalk buffer may not be needed. However, a buffer could still be beneficial to deter pedestrians from using the bike lane.

Further resources

1. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=1
2. Federal Highway Administration. (2014). *Bicycle safety guide and countermeasure selection system (BIKESAFE)*. Retrieved from pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=50

Image



Figure 27. Sidewalk with landscaped buffer and curb extension.
(Source: pedbikeimages.org / Dan Burden).

20. Sidewalks and Curb Ramps

Description

Good sidewalk design is fundamental to providing a safe environment for people walking along the road. These facilities allow people to safely access schools, work, and neighbors without walking in the roadway. Sidewalks should be included in almost all roadway projects and designed to be smooth and continuous. At intersections, curb ramps are required to provide access for those using wheelchairs or other devices from the sidewalk to the crosswalk. Curb ramps need to be designed with a tactile warning strip for visually impaired pedestrians.

Context

All roadways where pedestrians are allowed should provide sidewalks or paved shoulders.

Relation to other treatments

A **landscaping buffer** between the sidewalk and travel lanes allows for the sidewalk to remain straight and level across driveways, and it provides additional separation between pedestrians and motorists.

Further resources

1. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=1 and pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=3
2. United States Access Board. (2011). *Proposed guidelines for pedestrian facilities in the public right-of-way (PROWAG)*. Retrieved from www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/proposed-rights-of-way-guidelines

Image



Figure 28. Sidewalk with curb ramps. (Source: pedbikeimages.org / Dan Burden).

21. Traffic Signal Phasing

Description

Signalized intersections provide an opportunity to improve safety for pedestrians and bicyclists with specific guidance and phasing. Minimizing and removing the conflicts between turning vehicles, pedestrians, and bicyclists traveling through the intersection is essential for improving safety at intersections. This can be accomplished through right-turn-on-red restrictions and protected left turn signal phases, which permit drivers to take left turns only when a green arrow signal is displayed and all other traffic movement is stopped. One of the most common types of pedestrian crashes in urban areas involves a motorist turning left and striking a pedestrian who is walking in the far crosswalk. A protected left-phase decreases this risk by providing separate phases for left turning vehicles and pedestrians.

Leading Pedestrian Intervals (LPI) can also be used to allow pedestrians to begin a crossing before stopped motor vehicles are released; thereby increasing their visibility and the likelihood that drivers will yield to them. Push buttons, bicycle detectors, and cycle lengths should all be provided and adjusted such that traffic signals do not provide undue delay for pedestrians and bicyclists.

Context

All signalized intersections should be designed for use by pedestrians and bicyclists.

Relation to other treatments

Bicycle detection at signals must have the correct sensitivity and be properly located for bicyclists to receive a green signal.

To provide further guidance and information on movements through an intersection, **bicycle pavement markings** and **marked crosswalks** may also be used at signalized intersections.

General pedestrian/bicycle safety communication and outreach should be performed to ensure that all road users understand how to properly and safely navigate the roadways.

Further resources

1. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=48, pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=47, pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=45, pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=46, pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=49, and pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=51
2. Federal Highway Administration. (2014). *Bicycle safety guide and countermeasure selection system (BIKESAFE)*. Retrieved from pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=35 and pedbikesafe.org/BIKESAFE/countermeasures_detail.cfm?CM_NUM=55
3. Federal Highway Administration. (2012, May). *Manual on uniform traffic control devices for streets and highways* (2009 ed.). Retrieved from mutcd.fhwa.dot.gov/kno_2009r1r2.htm

Image



Figure 29. This Leading Pedestrian Interval in Phoenix, Arizona, gives pedestrians a five second head-start before drivers get a green light. Note that the pedestrian WALK indication is on while the motorists are still briefly held with a red light. (Source: Federal Highway Administration, *Designing for Pedestrian Safety Course 201*).

22. Traffic Calming and Management

Description

Traffic calming is used to slow traffic speeds and/or reduce traffic volumes by using physical features in the roadway. These measures may require motorists to slightly shift their travel laterally, traverse raised elements such as bumps or humps, or divert their direction of travel altogether through roadway closures.

These different techniques can be generalized into three groups: horizontal deflection, vertical deflection, and roadway closures. Horizontal deflection includes measures such as chokers, chicanes, and mini-circles that require motorists to slow and move side-to-side. In some circumstances these techniques may be less effective at speed reduction than vertical devices, but they may be more aesthetically pleasing and reduce noise from passing motor vehicles.

Vertical deflection measures, such as speed humps and tables, can be extremely effective at reducing speeds and are less expensive to install compared with horizontal deflections; however, they may increase noise, create drainage issues, interfere with snow removal, and potentially cause physical discomfort to vehicle occupants.

Roadway closures or partial closures are used to prevent cut-through traffic on certain streets. These measures can have a great impact on the surrounding roadway network and neighborhood access, and should be designed to allow bicycle and pedestrian access. Impact evaluation and public outreach is encouraged.

Context

Traffic calming is most frequently used on local or neighborhood streets but can also be effective in a main street type environment. More subtle types of traffic calming through landscaping or visually narrowing the roadway may be used on higher volume and speed roadways.

Relation to other treatments

Many traffic calming measures allow for increased **landscaping** opportunities within the roadway that may further reduce speeds and can improve drainage efficiency.

Additional designs such as **roundabouts**, curb extensions (see **intersection geometric design**), and **raised medians** may help to reduce traffic speeds and create gateways to traffic calmed streets.

Traffic calming measures are often installed in coordination with **Safe Routes to Schools** programs due to the safety benefits of slowing traffic speeds and reducing traffic volumes on selected streets connecting to schools.

Further resources

1. Federal Highway Administration. (2013). *Pedestrian safety guide and countermeasure selection system (PEDSAFE)*. Retrieved from pedbikesafe.org/PEDSAFE/countermeasures.cfm
2. Federal Highway Administration. (2014). *Bicycle safety guide and countermeasure selection system (BIKESAFE)*. Retrieved from pedbikesafe.org/BIKESAFE/countermeasures.cfm

3. National Association of City Transportation Officials. (2013) *Urban street design guide*. Retrieved from nacto.org/usdg/
4. Los Angeles County, California. (2011). Chapter 10 - Traffic calming. In *Model design manual for living streets*. Retrieved from www.modelstreetdesignmanual.com/index.html

Images

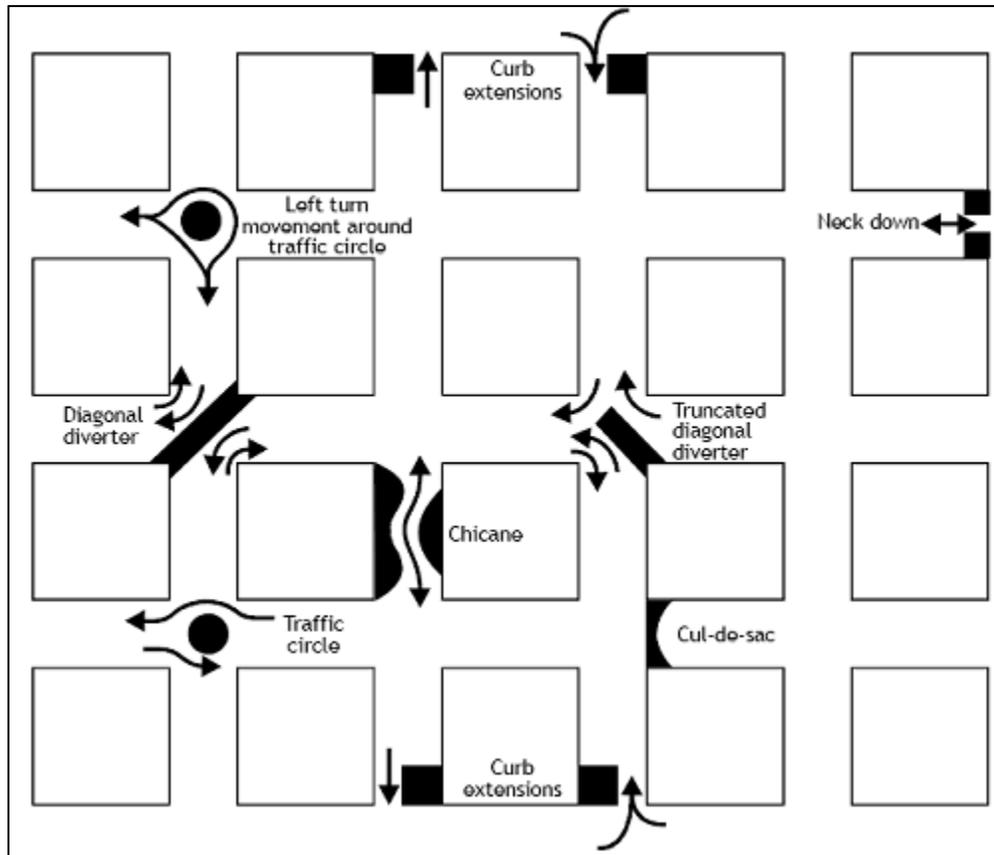


Figure 30. Visualization of various traffic calming devices. (Source: FHWA university course on bicycle and pedestrian transportation).



Figure 31. Mini-circle. (Source: *pedbikeimages.org* / Dan Burden).

Education and Awareness Programs

23. Child Training and Skills Practice

Description

The purpose of pedestrian, bicycle, and school bus safety training for children is to provide them with the knowledge and skills that are necessary to walk and bike safely. School and other community-based programs can help impart the knowledge and skills children need and can build on prior lessons to incorporate more critical thinking as children grow older. Research has shown that properly designed and delivered training programs can improve child behavior and result in safety benefits. Repeated chances to practice skills using interactive methods and “virtual” staging, or in well-supervised, real street environments, along with ongoing reinforcement of skills and safe behaviors are keys to helping children apply the knowledge and behaviors when they walk or bike on their own.

Parents and other caregivers play a vital role by teaching, demonstrating, and reinforcing safe behaviors as they accompany their children on walking or biking trips. Examples of teachable moments include demonstrating the use of lights and retroreflective clothing at night, wearing helmets on every bicycle ride, watching for cars at driveways, and even pointing out some safe and unsafe traffic behaviors when walking, biking, or driving. Caregivers also need to ensure proper supervision of younger children and teach children how to choose safe places to ride, walk, and play. This supervision should continue until they are capable of consistently making good decisions and can control impulsive behaviors. There is no magic age for this, as children vary in these attributes. Programs that help parents understand their child’s limits could complement child skills training programs. Even when children are perceived by parents to be ready for independent walking and biking, periodic reminders and assessments may be well worth the effort as children enter the preteen/teen years and use of electronics and peer influence become factors affecting behavior.

Certain populations such as recent immigrants and traditionally underserved communities are often at higher risk of traffic injuries because of language challenges and lack of experience with traffic laws. They may need additional support related to caregivers’ knowledge and skills, infrastructure improvements, and training programs.

Context

Most formal child training and skills practice programs occur within a school-based setting. However, after-school programs, weekend camps, community events such as bicycle rodeos, and others may also provide a venue or opportunity for training and skills practice. Involvement of parents and other caregivers is essential to assist in training delivery and provide needed reinforcement.

Relation to other treatments

General pedestrian/bicycle safety communication/outreach can be used to help reinforce key safety messages such as the need for caregivers to supervise their children around traffic or any location where vehicles are driven, how pedestrians and bicyclists can be more conspicuous and predictable at night and in the daytime, avoiding distractions while driving, walking, or biking, and watching out for and yielding to other road users.

Having **adult school crossing guards** is another way that communities can reinforce safe child pedestrian behaviors and provide additional safety at conflict areas/crossing locations.

Walking school buses (a group of children walking to school with one or more adults) and other **Safe Routes to School** activities can provide another avenue for daily lessons and reinforcement and can improve the walking environments near schools.

Partners such as faith-based groups, after school programs, and injury prevention partners may be able to expand the reach of child traffic safety training.

Traffic law enforcement can reinforce safe walking and biking behaviors during **targeted enforcement** efforts and at other times.

“Forgiving environments” that include lower speed limits, **traffic calming**, adequate **lighting**, and adequate separation of pedestrians and bicyclists from traffic (**sidewalks, separated bike lanes**, or shared use paths) are engineering measures that can be used to help protect children and others from severe injuries.

Further resources

1. Goodwin, A., Thomas, L., Kirley, B., Hall, W., O’Brien, N., & Hill, K. (2015). Chapter 8 - Pedestrians and Chapter 9 – Bicycles. In *Countermeasures that work: A highway safety countermeasure guide for State Highway Safety Offices* (8th ed., Report No. DOT HS 812 202). Retrieved from the NHTSA website: www.nhtsa.gov/staticfiles/nti/pdf/812202-CountermeasuresThatWork8th.pdf
2. National Highway Traffic Safety Administration. (n.d.). Child pedestrian safety curriculum. Retrieved from www.nhtsa.gov/ChildPedestrianSafetyCurriculum
3. Percer, J. (2009) *Child pedestrian safety education: Applying learning and developmental theories to develop safe street crossing behaviors* (Report No. DOT HS 811 190). Retrieved from the NHTSA website: www.nhtsa.gov/DOT/NHTSA/Traffic%20Injury%20Control/Articles/Associated%20Files/811190.pdf
4. Ellis, J. (2014). *Bicycle safety education for children from a developmental and learning perspective* (Report No. DOT HS 811 880). Retrieved from the NHTSA website: www.nhtsa.gov/staticfiles/nti/bicycles/pdf/Bicycle_Safety_Education_For_Children-811880.pdf

Image



Figure 32. Child bicycle skills training. (Source: *pedbikeimages.org* / Mike Cynecki).

24. General Pedestrian/Bicycle Safety Communications and Outreach

Description

General pedestrian/bicycle safety outreach can provide targeted safety messages to help the public better understand risky behavior likely to increase crashes and ways to prevent serious injuries and fatalities. Some of these risks include:

- Limited conspicuity, or pedestrians and bicyclists not being detected, especially at night;
- Drivers speeding;
- Drivers (or others) failing to yield because of not knowing or choosing not to follow traffic safety laws;
- Backovers and parking lot crashes that frequently involve children and older adults;
- Dash or dart-out crashes involving children in residential areas (including unexpected ride-outs on bikes); and
- Nonuse or misuse of bicycle helmets each ride.

Communications can be targeted to particular groups involved and in communities where a problem type is concentrated. The goal is to encourage adoption of safer behaviors such as using lights at night, or supervising children around cars and traffic.

Targeted messages can also be used to explain how and why to use new (or existing, but poorly understood) infrastructure, or to reinforce and publicize targeted enforcement campaigns.

Depending on the message and the intended audience, traffic safety communication and outreach could take a variety of forms: direct contact with individuals (such as through an intermediary such as a law enforcement officer, teacher, or health care provider), traditional mass media (such as radio, print, TV, billboards, transit ads), social media, or presentations to community groups, public events, etc.

Context

Communications and outreach programs should be tailored to meet the specific needs of the community. *Analysis* of crash data and other safety assessments will help to identify community and area specific problems and types of messages to help address the problems. Messages should be framed to provide a solution to the problem, repeated frequently enough over a long enough period of time, and sent via culturally relevant sources and in appropriate language and form to be received by the target audience. Local partnerships are important to gathering all of these types of expertise.

Relation to other treatments

Pedestrian and bicycle safety messages are dependent on the types of problems identified. Certain behaviors (crash types) or other safety issues (e.g., speeding) may be prevalent in a given location and may also require engineering and/or enforcement measures. Infrastructure improvements, such as changes to **traffic signal phasing**, or the installation of new treatments like **Pedestrian Hybrid Beacons** or **separated bike lanes** may require targeted communications with the general public, law enforcement, traffic schools, driver's education instructors, etc. to improve the correct use and effectiveness of these measures.

Roadway and pedestrian-level **lighting** is another measure that should be considered at certain types of locations, particularly, more urban or high pedestrian areas and busy roads, to enhance pedestrian and/or bicyclist visibility to drivers at night, and can complement programs encouraging pedestrians or bicyclists to use lights or other conspicuity aids.

Traffic calming, automated enforcement, or targeted speed enforcement may encourage motorists to comply with lower speed limits. Publicity and communications can be used in conjunction with a warning phase prior to initiating targeted enforcement action to increase general deterrence and encourage more drivers to comply with traffic laws, even if they are not ticketed themselves.

Communication and outreach efforts can also be conducted to help residents understand and know how to properly use a new or novel roadway treatment, such as a **roundabout** or **Pedestrian Hybrid Beacon**.

Further resources

1. Goodwin, A., Thomas, L., Kirley, B., Hall, W., O'Brien, N., & Hill, K. (2015). Chapter 8 - Pedestrians and Chapter 9 – Bicycles. In *Countermeasures that work: A highway safety countermeasure guide for State Highway Safety Offices* (8th ed., Report No. DOT HS 812 202). Retrieved from the NHTSA website: www.nhtsa.gov/staticfiles/nti/pdf/812202-CountermeasuresThatWork8th.pdf
2. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. (2010, March). *Adding power to our voices: A framing guide for communicating about injury*. Retrieved from the National Center for Injury Prevention and Control website: www.cdc.gov/injury/framing/CDCFramingGuide-a.pdf
3. National Highway Traffic Safety Administration. Traffic safety marketing website. Retrieved from www.trafficsafetymarketing.gov/

Image



Figure 33. As part of its outreach strategy, the *Watch for Me NC* program places safety messages on the backs of area buses, alerting drivers to the potential presence of pedestrians. (Source: Jennifer Baldwin, City of Raleigh).

25. Safe Routes to School

Description

Safe Routes to School (SRTS) programs are community-based, comprehensive programs that aim to encourage and enable children and their families to safely walk and bike to and from schools. School communities, including engineers, law enforcement, school officials, parents, and public health specialists work together to identify the safest routes, address roadway and traffic safety concerns such as gaps in facilities or hazardous crossing locations, address crime and personal safety issues, and deal with other community needs to enable children to be active during their daily school trips. For example, SRTS partners may help to organize walking school buses (a group of children walking to school with one or more adults), providing responsible adult volunteers to accompany a group of children walking to and from school. Such programs can help more children and their families reap the health and social benefits of walking and biking to school by helping to alleviate both traffic and personal safety concerns for families.

Context

SRTS programs can be implemented anywhere, but will have the most impact in urban and suburban areas where there is enough population density and basic infrastructure for students to walk or bike to a nearby school. However, a lack of adequate infrastructure could also be an impetus for organizing a SRTS program coordinated with a movement to improve infrastructure.

Relation to other treatments

SRTS programs may involve a wide variety of engineering, enforcement, educational, and outreach measures. They may be used to help organize an **adult crossing guard** program, seek **targeted law enforcement**, organize in-school **child education and skills training** such as bicycle rodeos or safety cities, perform walk/bike assessments or road safety audits, and identify engineering solutions such as sidewalks and walkways, crossing improvements, **traffic calming** measures, or a variety of other infrastructure needed to improve safety.

Further resources

1. Goodwin, A., Thomas, L., Kirley, B., Hall, W., O'Brien, N., & Hill, K. (2015). Chapter 8 - Pedestrians and Chapter 9 – Bicycles. In *Countermeasures that work: A highway safety countermeasure guide for State Highway Safety Offices* (8th ed., Report No. DOT HS 812 202). Retrieved from the NHTSA website: www.nhtsa.gov/staticfiles/nti/pdf/812202-CountermeasuresThatWork8th.pdf
2. National Center for Safe Routes to School website. Maintained by the University of North Carolina Highway Safety Research Center. Retrieved from <http://www.saferoutesinfo.org/>
3. Safe Routes to School National Partnership website. Retrieved from saferoutespartnership.org/

Image



Figure 34. Walking school bus. (Source: pedbikeimages.org / Dan Burden).

26. Adult School Crossing Guards

Description

Adult school crossing guards play a key role in the safety of children walking and bicycling to school. Responsible, trained, and well-equipped adults assist students in crossing at key locations on routes to school, providing an extra measure of safety and comfort to families. Crossing guards may use hand-held stop sign paddles or hand signals to create or extend gaps in traffic or to assist children crossing at signalized locations. At the same time, pedestrians retain some responsibility for crossing safely, and caregivers must determine when it is appropriate for their children to walk or bicycle to school unaccompanied by an adult.

Although some national guidance is available, it is largely up to local communities to determine locations where crossing guards are needed and other program criteria, including the number of guards needed and crossing procedures for different types of locations.

Context

School crossing guards are appropriate for schools in urban and suburban areas that have walkable zones around the schools. Some of the safety considerations include the speed and volumes of traffic to be crossed, and age of students served at the location. Crossing guards can also be used beyond the school campus, such as at busy urban intersections, university settings, and at major employment, sports, tourist, or entertainment centers.

Relation to other treatments

School communities, including engineers, law enforcement, school officials, and parents, should work together to identify **safer routes to school**, including where crossing guards are needed to address safety concerns.

Speed reductions near schools help decrease the likelihood and severity of crashes. School zone and other signs, **targeted law enforcement**, **traffic calming**, and other measures can be used to lower speeds, reduce crossing distances, and create safe crossing gaps to enhance safety of crossings for students.

Adult guards can be trained to observe and report unsafe driving such as speeding or failure to yield to pedestrians, or other potential safety hazards to the responsible agencies including law enforcement, engineering departments, and schools officials. An interagency task force might be charged with reviewing all such reports and working collaboratively to determine short- and long-term solutions.

Well-trained crossing guards can also assist in reinforcing safe walking and bicycling behaviors, but a comprehensive child pedestrian traffic safety program and caregiver outreach provide the basic opportunity for children to learn and practice the skills they need to walk or bicycle safely on streets from home to school.

Further resources

1. National Center for Safe Routes to School. (n.d.). *Adult school crossing guard guidelines*. Retrieved from guide.saferoutesinfo.org/crossing_guard/index.cfm

2. Florida Department of Transportation. (n.d.). *School crossing guard training program*. Retrieved from www.dot.state.fl.us/safety/2A-Programs/SchoolCrossingGuard.shtm
3. Federal Highway Administration. (2012, May). *Manual on uniform traffic control devices for streets and highways* (2009 ed.). Retrieved from mutcd.fhwa.dot.gov/kno_2009r1r2.htm

Image



Figure 35. Adult school crossing guard assists a family crossing near a school. (Source: *pedbikeimages.org / Dan Burden*).

Enforcement Programs

27. Automated Enforcement

Description

Some communities use automated enforcement to reduce red-light running and speeding. Cameras take photographs of vehicles entering the intersection on a red light. Safety benefits for red-light running may be highest at signalized intersections with high traffic volumes and a higher percentage of angle type (typically more serious) crashes relative to rear-end types. Similarly, speed measuring equipment and technologies can be used to trigger cameras to photograph speeding vehicles at point locations or over a distance. Some communities, such as Washington, DC, are even exploring using automated enforcement to address problems such as failure to yield to pedestrians in crosswalks.

Cameras and automated systems can enforce traffic safety laws at times and locations that are unsafe or infeasible for officers to enforce by other means. Automated enforcement also tends to be a well-publicized, and often a highly visible means of enforcement, which can help to deter even unticketed drivers from speeding or other unlawful behaviors. This type of enforcement, therefore, complements traditional enforcement through both specific and general (population-wide) deterrence. The automated enforcement programs in most U.S. jurisdictions take photos of the vehicle license plates and send citations to the vehicle's registered owner. In most of these programs, tickets are civil infractions.

Context

Factors such as road design, limited enforcement resources, and low general deterrence due to lax enforcement often contribute to drivers selecting unsafe speeds and running red lights. Driver habits and cultural norms can also contribute. Automated enforcement can be used as a short-term treatment where engineering countermeasures cannot be implemented right away, or as part of a longer-term, comprehensive safety program to provide a safer environment for walking and biking.

A 2011 nationally-representative survey of drivers found that a majority thought automated speed cameras would be acceptable to enforce speed limits in school zones (86%), at high-crash locations (84%), in construction zones (74%), in areas that would be hazardous for law enforcement officers to stop vehicles (70%), or where traditional enforcement would contribute to congestion (63%).¹⁵ Local public input is important to develop a program with broad community support. State and local laws also affect the ability to use automated enforcement. State authorizing legislation or changes in authorization may be needed.

Relation to other treatments

In addition to supplementing traditional traffic enforcement, automated enforcement can be used to help maintain safer speeds until self-enforcing roadway designs can be put into place. It may

¹⁵ Schroeder, P., Kostyniuk, L., & Mack, M. (2013, December). *2011 National survey of speeding attitudes and behaviors* (Report No. DOT HS 811 865). Retrieved from the NHTSA website: www.nhtsa.gov/staticfiles/nti/pdf/2011_N_Survey_of_Speeding_Attitudes_and_Behaviors_811865.pdf

take some time to redesign and retrofit existing roads that send an incorrect message about safe speeds and other traffic behaviors. Examples of self-enforcing roadway features that take time to implement include **roundabouts** instead of signalized or stop-controlled intersections; **road diets**; progressive, coordinated **traffic signal phasing**; and other **traffic calming** measures.

Signals should be timed correctly before trying automated red light enforcement. For the short-term, a **road safety audit** can verify correct signal timing, and potentially identify other measures that might contribute to signal violations or inappropriate speeds.

Two-way communications, well-crafted public information, and education programs are also essential to build support and communicate the safety reasons for an automated enforcement program. These might be addressed through **Safe Routes to School** efforts to improve safety in school zones and neighborhoods, through letters to the editor, press releases, social media, chat rooms, community forums, or through **general pedestrian/bicycle safety communications and outreach** to address other types of concerns such as safety of transit corridors.

Further resources

1. Goodwin, A., Thomas, L., Kirley, B., Hall, W., O'Brien, N., & Hill, K. (2015). Chapter 8 - Pedestrians and Chapter 9 – Bicycles. In *Countermeasures that work: A highway safety countermeasure guide for State Highway Safety Offices* (8th ed., Report No. DOT HS 812 202). Retrieved from the NHTSA website: www.nhtsa.gov/staticfiles/nti/pdf/812202-CountermeasuresThatWork8th.pdf
2. Eccles, K., Fiedler, R., Persaud, B., Lyon, C., & Hansen, G. (2012). *Automated enforcement for speeding and red light running, NCHRP Report 729*. Retrieved from the Transportation Research Board website: onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_729.pdf
3. Federal Highway Administration. (2005). *Red-light camera systems operational guidelines* (Publication No. FHWA-SA-05-002). Retrieved from safety.fhwa.dot.gov/intersection/redlight/cameras/fhwasa05002/fhwasa05002.pdf
4. Poole, B. (2012). *An overview of automated enforcement systems and their potential for improving pedestrian and bicyclist safety*. Retrieved from the Pedestrian and Bicycle Information Center for the Federal Highway Administration website: www.pedbikeinfo.org/cms/downloads/WhitePaper_AutomatedSafetyEnforcement_P BIC.pdf
5. U.S. Department of Transportation. (2008). *Speed enforcement camera systems: Operational guidelines* (Report No. DOT HS 810 917). Retrieved from the NHTSA website: www.nhtsa.gov/DOT/NHTSA/Traffic%20Injury%20Control/Articles/Associated%20Files/810916.pdf

Image



Figure 36. Red light photo enforcement in Springfield, Ohio. (Source: Derek Jensen).

28. Speed Display Devices

Description

The aim of using unstaffed speed display devices, or speed trailers, is to provide feedback to passing drivers about their operating speeds to discourage unintentional speeding. Speed displays can be effective at reducing speeding while in place, but speeds tend to return to higher levels once the displays are removed. The devices may also be used to collect speed data to monitor speeds at a particular location. Speed data should be periodically checked, as the devices are sometimes associated with poorer speed compliance, at least by some drivers.

Context

Speed display devices have been used on approaches to school zones and midblock crosswalks (and many other types of locations) to slow speeds, and when used in the context of pedestrian safety, to help induce drivers to yield to pedestrians. They might be used on downgrades, where speeding can occur unintentionally, and where traffic calming measures are insufficient or unable to address the problems. They have also been used successfully in work zones, especially when accompanied by conspicuous law enforcement. The devices tend to function best on two-lane roads, and where traffic volumes are moderate. The use of radar to measure speeds may also persuade some drivers that enforcement is close by. Used alone, speed display devices are unlikely to solve the underlying problem but can have a short-term impact.

Relation to other treatments

Speed display devices could in fact be combined with law enforcement presence (as has been done in work zones to good effect), progressive **law enforcement**, or **automated enforcement** of speeding for a longer-term impact. Used on approaches to intersections or midblock crosswalks, they could also be combined with other types of enforcement such as **automated red light enforcement**, and **high visibility enforcement** of driver yielding at crosswalks.

Any number of engineering measures such as **traffic calming**, **intersection geometric design**, **crossing islands** or other **marked crosswalk** enhancements, **road diets**, and/or **bike lanes** may also be appropriate, depending on the particular safety issues and challenges to be addressed.

Again, targeted messages and outreach such as through **Safe Routes to School** or other means may enhance effectiveness.

Further resources

1. Goodwin, A., Thomas, L., Kirley, B., Hall, W., O'Brien, N., & Hill, K. (2015). Chapter 8 - Pedestrians and Chapter 9 – Bicycles. In *Countermeasures that work: A highway safety countermeasure guide for State Highway Safety Offices* (8th ed., Report No. DOT HS 812 202). Retrieved from the NHTSA website: www.nhtsa.gov/staticfiles/nti/pdf/812202-CountermeasuresThatWork8th.pdf
2. Mead, J., Zegeer, C., & Bushell, M. (2014). *Evaluation of pedestrian-related roadway measures: A summary of available research*. Retrieved from the Pedestrian and Bicycle Information Center for the Federal Highway Administration website: www.pedbikeinfo.org/cms/downloads/PedestrianLitReview_April2014.pdf

Image



Figure 37. Portable radar speed trailer in San Francisco, California. (Source: *Federal Highway Administration*).

29. Targeted Law Enforcement

Description

Targeted law enforcement is used to apply scarce resources toward the most critical problem types or locations in order to maximize safety benefits. Targeted enforcement can be used to help focus enforcement efforts toward a wide variety of traffic safety laws (e.g., compliance with speed limits or not driving while impaired) at locations with the greatest safety problems related to those laws. Targeted enforcement can also be used to enforce laws that strongly affect pedestrian or bicyclist safety such as motorist yielding or stopping for pedestrians in crosswalks. High visibility enforcement of driver yielding at targeted locations has been used in a number of jurisdictions to raise driver compliance and improve safety of pedestrians crossing the street at these locations.

Context

Analysis of crashes and crash types, and other data (driver yielding or conflicts at crosswalks, speed studies, alcohol establishment locations, etc.) may reveal the extent and location of unsafe behaviors that need to be addressed through a targeted enforcement program. Initial analyses might suggest that drivers are failing to yield to pedestrians when turning at intersections (whether or not crosswalks are marked), driving too fast and not stopping/yielding for people crossing the road at midblock crosswalks, or speeding and passing bicyclists before turning right across their path.

Road safety audits or similar assessments could be a good first step to ensure that collaborating agencies correctly identify problems and first address any deficiencies in crosswalk placement, road design, or signalization that might be contributing to illegal and unsafe behaviors. For example, there may be long road stretches between intersections or crosswalks requiring pedestrians to cross at uncontrolled locations to access transit or other destinations.

Relation to other treatments

Driving safely around pedestrians and bicyclists is typically not covered in depth during driver training programs or testing and licensing procedures. Even law enforcement officers may not be fully aware of right-of-way rules, and the importance of enforcing all traffic laws, including those that particularly affect pedestrians and bicyclists. As a result, **communication and outreach** to drivers and law enforcement training might be needed in conjunction with a high visibility enforcement campaign. Advance publicity and warnings are often used to develop a progressive enforcement program in which tickets are only issued as a last resort. In these programs, the focus is on educating drivers, pedestrians, and bicyclists, but enforcement is used to give teeth to the message. Effective court procedures and appropriate and swift penalties are also important for upholding enforcement campaigns. For example, a high rate of dismissed tickets will almost surely demoralize law enforcement officers and result in a reduced issuance of future citations.

The frequency, quality, and proper location of facilities such as **marked crosswalks, pedestrian signals, crossing islands, advanced yield/stop lines**, in-roadway yield/stop here for pedestrians signs, bicycle detection at signals, and **pavement marking improvements** through intersections are keys to encouraging pedestrians and bicyclists to cross at these locations and obey traffic laws. Drivers are also less likely to yield to pedestrians at crosswalks when they are traveling at higher speeds, so speed-lowering road designs can also help to achieve safer speeds and better

compliance by drivers. Once these other improvements are made to the roadway, however, targeted enforcement of yielding might be needed to “train” drivers to comply at busy midblock crosswalks where pedestrians may have difficulty asserting their right-of-way.

A number of State and local jurisdictions have enacted bicyclist “safe passing” laws requiring drivers to leave at least three feet of space when passing bicyclists on a shared roadway, but enforcement is a challenge, and driver compliance may be low.

Separated bike lanes, off-road paths, or other infrastructure can be used to provide bicyclist protection from passing motorists. On smaller, lower-speed roads, **traffic calming** can be used to reduce speeds and create a safer shared roadway environment. However, drivers may still need to be educated about safe passing behavior.

Stronger engineering measures may be needed to create safe gaps or require motorists to yield the right-of-way on busier, multilane, and higher speed roads, or at some intersections where motorists may not yield when turning. Examples of engineering treatments such as **Rectangular Rapid Flashing Beacons** and **Pedestrian Hybrid Beacons** can be used at midblock locations such as shared use paths, school crossings, or at transit stops. Traffic and **pedestrian signals** with Leading Pedestrian Intervals (LPI), protected signal phasing, or **turning restrictions** can be used at intersection locations where enforcement and other measures are insufficient to achieve respect of pedestrian or bicyclist rights-of-way.

If speeding is an issue, any number of other engineering measures such as **road diets**, **roundabouts**, other **traffic calming** measures, **intersection geometric design**, **crossing islands**, and/or **bike lanes** may also be appropriate, depending on the particular safety issues and challenges to be addressed. Again, targeted messages and outreach such as through **Safe Routes to School** or other means may enhance effectiveness of the targeted enforcement.

Further resources

1. Goodwin, A., Thomas, L., Kirley, B., Hall, W., O’Brien, N., & Hill, K. (2015). Chapter 8 - Pedestrians and Chapter 9 – Bicycles. In *Countermeasures that work: A highway safety countermeasure guide for State Highway Safety Offices* (8th ed., Report No. DOT HS 812 202). Retrieved from the NHTSA website: www.nhtsa.gov/staticfiles/nti/pdf/812202-CountermeasuresThatWork8th.pdf
2. Mead, J., Zegeer, C., and Bushell, M. (2014). *Evaluation of pedestrian-related roadway measures: A summary of available research*. Retrieved from the Pedestrian and Bicycle Information Center for the Federal Highway Administration website: www.pedbikeinfo.org/cms/downloads/PedestrianLitReview_April2014.pdf
3. NHTSA. (2014). *Pedestrian safety enforcement operations: A how-to guide* (Report No. DOT HS 812 059). Retrieved from www.nhtsa.gov/staticfiles/nti/pdf/812059-PedestrianSafetyEnforceOperaHowToGuide.pdf
4. Van Houten, R., Malenfant, L., Huiema, B., & Blomberg, R. (2013). The effects of high visibility enforcement on driver compliance to pedestrian yield right-of-way laws. *Transportation Research Record: Journal of the Transportation Research Board*, 2393, 41-49. doi: [10.3141/2393-05](https://doi.org/10.3141/2393-05)

Image



Figure 38. Police officers in Durham, North Carolina, use targeted enforcement at high-crash pedestrian crossings as an educational opportunity. (Source: James Gallagher, UNC Highway Safety Research Center).

Building a Comprehensive Approach

As previously mentioned, engineering, education, and enforcement programs and treatments can be combined to form more effective injury prevention programs. To do this requires an interdisciplinary approach involving many different partners; see Section 4 on ways to implement programs in a partner-driven approach.

Following are examples from several local and State programs that highlight the ways in which comprehensive programs can be developed.

Example: Florida's Comprehensive Pedestrian and Bicycle Safety Program

The State of Florida has one of the highest rates of pedestrian and bicyclist crashes and fatalities in the Nation. To address these issues, the Florida Department of Transportation developed a comprehensive safety program, led by a multi-disciplinary coalition of more than 23 agencies. Program emphasis areas include law enforcement, driver education and licensing, highway and traffic engineering, communications/outreach, legislation, regulation and policy, and program evaluation. Initially, Florida strategically focused on the 10 counties with the highest crash numbers.

- **Education:** The program consists of an ongoing, communication and outreach campaign, “Alert Today Alive Tomorrow,” comprised of TV, radio, social media, and transit ads as well as local events such as bike rides and other activities designed engage the community and the media. This campaign is complemented by high-visibility enforcement including 20 agencies across the State making contact with drivers, pedestrians, and bicyclists to deliver warnings and citations.
- **Enforcement:** Law enforcement officers viewed “roll call” training videos prior to enforcement to ensure their understanding of common pedestrian/bicycle - vehicle, behaviors to look for, and relevant statutes to enforce.
- **Engineering:** The program provides Roadway Safety Audit training for FDOT and local agency staff across the State, and involves coalition members in roadway assessments.
- **Policy:** All activities are coordinated within the framework of the State Strategic Highway Safety Plan and have supported the development and implementation of a Statewide Pedestrian/Bicycle Strategic Safety Plan. The program continues to evolve and track its progress in a variety of ways. Visit the program [website](http://www.alerttodayflorida.com) to learn more.

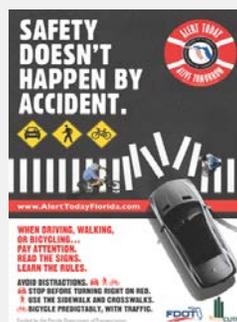


Figure 39. Example of communication material for Florida's “Alert Today Alive Tomorrow” campaign. (Source: alerttodayflorida.com/atat.html).

Example: Seattle’s Focus on Infrastructure and Enforcement to Improve Neighborhood Traffic Safety

The City of Seattle, Washington, takes a comprehensive approach to pedestrian and bicycle safety by incorporating enforcement and education programs alongside its infrastructure initiatives.

- Infrastructure projects: In the past 30 years, Seattle has installed over 1,030 traffic circles, or “mini-circles” to improve neighborhood traffic safety. A study of 32 previously signed intersections found a 90% reduction in crashes across a four-year period, and an even greater reduction in the number of injuries.
- Target issues: In 2007, Seattle’s Department of Transportation formed a special traffic unit called the Aggressive Driver Response Team (ADRT) to target aggressive and dangerous drivers and protect pedestrians. The team is extensively trained and targets areas that are known for aggressive driving and also works to address chronic community traffic complaints, pursue school zone violations, and conduct pedestrian emphasis operations.

Effective infrastructure and enforcement efforts like the neighborhood traffic calming program and the ADRT are now being planned, implemented, and evaluated together as part of Seattle’s *Vision Zero*. Even though there has been a 30% decline in traffic fatalities over the past decade, traffic collisions are the leading cause of death for Seattle residents ages 5-24. The city’s *Vision Zero* plan aims to approach the traffic safety problem from multiple angles—by combining the street design recommendations of the pedestrian, bicycle, transit, and freight *master plans* with data-driven enforcement and targeted education to address behavioral issues. The city plans to deploy quick, big impact improvements on arterial streets, where the majority of fatal crashes occur, and lower speed limits citywide. Corridor improvements will be coupled with enforcement to reduce speed, impairment, and distraction. Engineering work will also be supported by ongoing education programs like *Safe Routes to School*, *Be Super Safe*, and *Pedestrian Safety for Seniors*.

For more information:

Traffic circle study available: www.usroads.com/journals/rmej/9801/rm980102.htm

Vision Zero Plan: www.seattle.gov/visionzero

Important Considerations

In addition to understanding available treatments and programs and the importance of a comprehensive approach, traffic safety practitioners should take into consideration a number of factors that may limit or enhance the effectiveness of treatments intended to address an issue. These issues can influence the appropriateness of the treatments in different settings. Practitioners at the State and local levels should consider their:

Legal environment

Prior to or during efforts to build a comprehensive pedestrian and bicycle safety program, what legal implications may impact what you can or cannot do?

- Are there laws or ordinances restricting your ability to deploy certain countermeasures? For example, some localities ban the use of automated enforcement measures, such as speed and red light cameras.
- Are there laws or ordinances that help support injury prevention efforts? For example, States with graduated driver license (GDL) programs, particularly those that enable new drivers to gain experience driving safely around pedestrians and bicyclists, and laws prohibiting texting/calling while driving may enhance local education programs addressed at reducing distraction and other unsafe behaviors.
- Does the language of your State or local ordinance laws affect how engineering treatments and educational messages are developed and enforcement is conducted? For example, whether a State is a “yield to pedestrians” State or a “stop for pedestrians” State will affect the type of signage or pavement markings that can be used in advance of crosswalks, and potentially the messaging to drivers and enforcement approach.
- Are there relevant ordinances, vehicle codes, and traffic laws—including bike helmet laws, safe passing laws, driver yielding and other right of way laws, and underlying definitions of pedestrians and bicyclists—to be sure that treatments and programs selected are compatible? When a law is incompatible or found to be insufficient regarding what is known to support pedestrian and bicycle safety, efforts may be needed to work with law makers to improve upon the law. For example, in North Carolina, legislators introduced a bill to “direct the department of transportation to study the bicycle safety laws in this State and make recommendations as to how the laws may be revised to better ensure the safety of bicyclists and motorists on the roadways.”¹⁶
- Can local authorities can implement ordinances to supplement State statutes and further ensure pedestrian and bicycle safety?
- How are the laws on the books interpreted, upheld, and enforced by members of the legal community? Partnership, coordination, and sometimes training and outreach with the legal community—including State highway patrols, local law enforcement agencies, district attorneys, court judges, and others—are essential to the success of a particular safety treatment or program. Learn more about partnership and collaboration opportunities in Section 4.

¹⁶ www.ncleg.net/Sessions/2015/Bills/House/PDF/H232v1.pdf

Roadway environment

Other factors related to the roadway environment impact the final selection and implementation of countermeasures, beyond which treatment may work best.

- Is the engineering or enforcement measure appropriate or likely to be effective? Consider the roadway's speed, volume of traffic, amount of different types of traffic (such as buses or other mass transit, large trucks, etc.), etc. For example, empirical evidence suggests that efforts to improve driver yielding to pedestrians in crosswalks through enforcement measures alone is less likely to be effective when driver speeds are high (e.g., 35 mph or above). In these instances, additional engineering measures—such as traffic calming or other design changes—may be needed to slow drivers before law enforcement or educational efforts can be effective.
- Are there factors that can limit or enhance the likely effectiveness of a treatment? Consider the area's land use (e.g., residential or commercial), site design, street connectivity, and underlying roadway design guidelines or policies, such as Complete Streets. For example, an agency seeking to improve pedestrian use of crosswalks may discover that the underlying condition contributing to unsafe pedestrian behaviors is a lack of street connectivity (or overly long street block length) and the absence of pedestrian crossing facilities at convenient locations. Communities experiencing high rates of cyclists violating traffic signals may find that a lack of bicycle facilities at intersections (such as sensors able to detect the presence of bicyclists to engage the traffic signal) is part of the problem, in addition to bicyclist ignorance or disregard of the laws. These examples further underscore the importance of a multidisciplinary, comprehensive approach to understanding and addressing pedestrian and bicycle concerns.

Agency factors

The agency responsible for implementing the treatment or program can affect the likelihood of effectiveness in addressing bicycle and pedestrian concerns. Address these factors during the development of a comprehensive program:

- Level of expertise of agency staff with pedestrian and bicycle issues and time available to explore and address concerns;
- Internal policies affecting funding and resources to invest in improvements;
- Ability to maintain facilities and sustain programs over time; and
- Training or other support potentially needed for agency staff in advance of *countermeasure* implementation.

Individual and community factors

The treatments and programs described above focused on some key safety issues experienced by States and localities—speeding, conflicts at crossings, inadequate conspicuity/visibility, poor compliance with laws/proper facility use, etc. However, all of these concerns may be compounded by additional factors or characteristics related to individual road users.

- Use of alcohol and drugs, age (both young and old), susceptibility to distraction (e.g., using a cell phone), a history of lax enforcement, and social and cultural norms can also affect the performance of a countermeasure in either direction. It is therefore important not only to understand the problem and the comprehensive treatment but also to have an

accurate picture of the community in which the countermeasure is being applied. “Will it be effective here?” is a vital question that must be asked and can only be answered with the help of knowledgeable local people.

- Your community’s “traffic culture” and perceptions about that traffic culture and the social norms of the road (such as, “everyone yields to pedestrians here” or “no one slows down in school zones” or “it’s OK to drive 10 mph over the speed limit”) can be influential. Legal and policy changes, along with education and enforcement efforts, may play a role in leveraging or countering these perceptions. This makes it all the more important for transportation and safety decision-makers to be cognizant of the characteristics of the individuals and communities they are seeking to reach in order to develop context-sensitive safety programs.

SECTION 4: IMPLEMENTING TREATMENTS AND PROGRAMS IN A PARTNER-DRIVEN APPROACH

The task of improving safety for pedestrians and bicyclists should not be the sole responsibility of one agency or department. To achieve maximum safety improvements, agencies need to partner with other entities that have a shared or complimentary focus on improving safety and comfort for pedestrians and bicyclists. A truly comprehensive approach to addressing pedestrian and bicycle safety requires cooperation and coordination among various partner groups at local, regional, and State levels. The following sections describe some potential partner groups and discuss opportunities for collaboration to achieve pedestrian and bicycle safety goals.

Potential Partners

State pedestrian and bicycle coordinators

Each State has a coordinator within its State Department of Transportation whose duties include planning and administering a bicycle/pedestrian program. Specific responsibilities may include developing facilities for the use of pedestrians and bicyclists and public educational, promotional, and safety programs for using such facilities. A [list of State coordinators](#) is available from the Pedestrian and Bicycle Information Center (PBIC).

States may also have a coordinator for their *Safe Routes to School* (SRTS) program or the State's projects that are funded through the Federal Transportation Alternatives (TAP) program. A [list of State SRTS coordinators](#) is available from the National Center for Safe Routes to School.

Law enforcement and public safety officers

People who enforce laws that impact pedestrians and bicyclists should be part of any comprehensive effort to improve conditions for those users. Beyond enforcing laws, law enforcement officers have high credibility with the public on safety topics and can be a key partner for crafting an education campaign or working with engineers to identify engineering countermeasures. Officers are also the ones who respond to and document crashes, so they need to understand the factors that lead to pedestrian and bicycle crashes, as well as how their crash reports will be used by law enforcement and transportation professionals to develop programs and/or make infrastructure improvements. NHTSA has more information about law enforcement training that focuses on [pedestrian](#) and [bicycle](#) safety. Many States are also creating their own training specific to their laws. Traffic court judges also play a role because their adjudication actions (e.g., imposing or dismissing fines, suspending or revoking licenses) can play a major role in establishing a community's safety and enforcement climates. Including judges in the development of a comprehensive program will help ensure their perspective is considered and they understand how certain behaviors on the roadway affect safety for pedestrians and bicyclists. The Pedestrian and Bicycle Information Center has more information about [working with law enforcement](#).

Transportation professionals, including engineers and planners

Local transportation agencies with responsibility for public roads, including pedestrian and bicycle facilities, may have department names such as Public Works, Streets, Transportation, or Community Development. Transit entities—responsible for transit planning, operation, and maintenance—may be independent (even private), or located within one of the previously

mentioned departments, but they should be involved in conversations about improving safety around transit facilities. Engineering components of a State or local pedestrian and bicycle program should be coordinated with enforcement and educational efforts for maximum effectiveness. Activities conducted by transportation engineers and planners affecting pedestrian and bicycle safety include:

- Development and enforcement of standards for street design (i.e., lane width, sidewalk installation).
- Development and implementation of projects to upgrade the existing street or multi-use trail network.
- Installation and maintenance of traffic signals, signs, and pavement markings (i.e., crosswalks, bike lanes).
- Development and implementation of programs or strategies to address speeding.
- Collaboration with other planning entities to forecast future traffic need and plan for future changes in the roadway network.
- Approval of development plans.

At the State level, the Department of Transportation (DOT) is responsible for integrating bicycle and pedestrian travel into planning and engineering efforts for State-owned roads. Their responsibility might also cover education and training programs. Many State DOTs have a pedestrian and/or bicycle plan that describes how the State will use transportation investments to improve conditions for walking and bicycling. Read Federal Highway Administration's (FHWA) [Statewide Pedestrian and Bicycle Planning Handbook](#) to learn more about the State-level pedestrian and bicycle planning process.

Public health educators and medical care providers

Hospitals, emergency rooms, trauma centers, clinics, and ambulance services are involved in the initial response to bicyclist and pedestrian injuries and are typically passionate about prevention because they see the consequences of a crash first hand. Care providers and practitioners (including doctors, nurses, medical assistants, social workers, community health advisors, etc.) can contribute another layer of understanding about a community, crash problems in a community, represent extremely credible sources for disseminating safety information, and provide educational information directly to individuals who were treated for injuries stemming from a collision or to those considered high risk. Supplementing crash data with hospital injury severity information can help estimate the cost of crashes. Injury prevention centers within hospitals have could be an important partner for developing and funding some types of countermeasures. County offices within public health agencies might partner to distribute safety messages and materials. The public health and medical community play an important role in identifying issues and administering interventions.

Driver education and licensing professionals

Driver education and licensing programs are sometimes under-utilized resources for coordinating pedestrian and bicycle education programs. There may be substantial opportunities to incorporate pedestrian and bicycle safety messages into driver training, materials, and licensing. Safety messages could be included as part of the education and training both in the classroom and behind the wheel. The State Department of Motor Vehicles plays a large role in training the next generation of drivers, consider including them on any steering committee for an education or

enforcement effort focused on traffic safety. A representative of the State’s driver education and licensing program could identify needs for policy change, enhancements to a curriculum, or methods for distributing safety messages.

Educators and school administrators

Education providers are important partners because they have “captive audiences” of students—and often parents and caregivers—and considerable influence in a community. Many local schools are involved in *Safe Routes to School* (SRTS) and may have detailed knowledge about the program needs and safety problems in their area. Community colleges and four-year universities are well-positioned to promote safe pedestrian and bicycle transportation because their students, faculty, and staff are likely among the most frequent pedestrians and bicyclists. University faculty members also teach planning and facility design to the next generation of transportation professionals. State and local school administrators—both at the elementary and higher education levels—can influence policy decisions that affect pedestrians and bicyclists, such as school or campus site selection and design, busing policies, crossing guard policies, driver education and safety curricula, and infrastructure upgrades.

Media and communications

Media coverage may be important for the success of a comprehensive safety program, and negative publicity can certainly undermine program efforts. Even when education or enforcement is only a minor part of a comprehensive program, positive media coverage can lend the program credibility and spread knowledge of its existence. Programs wishing to convey a strong safety message, pedestrian/bicycle safety campaign, or market an upcoming enforcement effort benefit from using a variety of forms of media materials. Partnering with local media can result in increased public outreach including earned media (i.e., free publicity for a promotional effort). Consider having a media and communications specialist on your local and State teams as part of a comprehensive pedestrian and bicycle safety program.

Community safety organizations

Community traffic safety coalitions share a vision of saving lives and preventing injuries caused by traffic-related issues and their associated costs to the community. Coalitions may include any of the stakeholders listed in this section, national safety organizations, injury prevention specialists, and members of the general public. Tailor the composition of your coalition to the community it represents. Community safety organizations may try to partner with their State Highway Safety Office and MPOs and DOTs to gain synergy and avoid duplication of effort. Safe Kids Worldwide is an example of a national organization with State coalitions throughout the country. These coalitions support such things as public policy change, research, and education and awareness programs to prevent roadway-related injuries to children. Visit the [Safe Kids website](#) to see a list of the coalitions in each State.

Advocacy groups

Advocacy groups devoted to walking and bicycling are particularly good at understanding the needs of pedestrians and bicyclists and organizing support for an improvement or program at the local-, regional-, State, or national levels. Examples of groups at the national level include: [The League of American Bicyclists](#), [People for Bikes](#), [America Walks](#), and the [Alliance for Biking and Walking](#). Groups that advocate for safer roadway design and a more pedestrian- and bicycle-friendly built environment include [Project for Public Spaces](#) and [Smart Growth America](#). Many

of these groups provide training and research for transportation professionals, and can help provide a connection to local groups and resources.

Opportunities for Collaboration

Forming and convening a standing pedestrian and bicycle safety focused committee

Addressing traffic safety is an interdisciplinary undertaking requiring communication among agencies and community groups. Efforts to address pedestrian and bicycle safety concerns and challenges will be more effective if a jurisdiction or region coordinates efforts by creating a focus group, executive review board, steering committee, or coalition of any other name. The concerns can take several forms: operational and construction projects intended to fix specific problems; changes in design guidelines to help improve streets and intersections in future projects; and education and enforcement programs aimed at achieving changes in pedestrian/bicyclist/driver behaviors or attitudes. SHSOs or other State or local entities including major local employers could provide leadership in establishing such a group, setting agendas, providing meeting space or administrative support, and following up on action items that result from the meetings. Here are some suggestions:

- This group should meet regularly, as defined by the group, to discuss pedestrian and bicycle safety needs.
- Members should include any of the potential partner groups mentioned in the previous section, as long as members have a sincere and continuing commitment to bicycle and pedestrian safety.
- Members should have defined duties or expectations, that might include:
 - Reviewing crash data,
 - Facilitating or participating in roadway audits/assessments,
 - Identifying and prioritizing appropriate countermeasures and discussing alternatives,
 - Providing input on strategic plans and projects as they relate to pedestrian and bicyclist issues, and
 - Promoting legislation and government decision-making to reflect the safety of all road users.

Sharing data

A variety of potential partners—including law enforcement, planners, engineers, and public health professionals—will have relevant insights regarding what data is available (e.g., crash data, volume or exposure data, roadway inventory data) and how it could be collected, analyzed, and presented. For example, an interdisciplinary standing meeting to review crash data and crash trend reports could be used to approach a safety problem from different viewpoints and target helpful countermeasures. This type of group could also develop recommendations for improving the way that data are collected and shared with other stakeholders to support decision-making. See Section 2 for more on data sources related to problem identification.

Participating in audits/assessments

As described in Section 2, an audit (or a less formal assessment) is an unbiased examination/evaluation of the walking and biking environment. The general purpose of an audit is to identify concerns for pedestrians and bicyclists related to the safety, access, comfort, and

convenience of the environment. In addition to identifying problem areas, an audit can be used to identify potential alternative solutions, such as engineering treatments, policy changes, or education and enforcement measures. An audit is best performed by a multidisciplinary team of trained professionals, including engineers, planners, transportation researchers, pedestrian and bicycle specialists, and others, and can take place before, during, or after the construction of a project. Including individuals with differing areas of expertise in the audit process ensures that problem identification and related solutions take into the account important interactions including the relationship between infrastructure and user behavior.

Developing the Highway Safety Plan

Each State Highway Safety Office is responsible for submitting an annual Highway Safety Plan (HSP) and annual reports to NHTSA. The HSP must be data-driven and set quantifiable, annual performance targets for 15 performance measures, at least three of which need to be coordinated with the SHSP (traffic fatalities, serious injuries in traffic crashes, and fatalities/vehicle miles traveled). The plan must include strategies that will allow the State to meet its performance targets and must describe its successes in meeting its performance targets in the previous fiscal year. Note: “Bicycle facilities” was added as a core outcome measure in the FY 2015 HSP. It is advisable to include the State Pedestrian and Bicycle Coordinator in developing the HSP since the coordinator will be involved in some aspect of plan implementation. In some States, the coordinator may submit an application for a highway safety grant or serve on the grant review committee. The HSP must include a statement that describes the outcomes of coordination of the HSP, data collection and information systems with the SHSP (see below).

Developing the Strategic Highway Safety Plan

The Strategic Highway Safety Plan (SHSP) is a statewide-coordinated plan providing comprehensive framework for reducing highway fatalities and serious injuries on all public roads. The lead agency is the State Department of Transportation, which works collaboratively with the SHSO and other local, State, Federal, Tribal, and private sector safety stakeholders. The SHSP establishes statewide goals, objectives, and key emphasis areas and integrates engineering, education, enforcement, and emergency medical services (EMS). A steering committee overseeing the development of the SHSP should include many of the partners listed above.

Co-funding and/or coordinating on existing programs

Seek opportunities to coordinate with partners on existing programs run by the DOT, SHSOs, Metropolitan Planning Organizations (MPOs), or their grantees, such as regular law enforcement efforts, graduated driver licensing, or efforts related to distracted or impaired driving. The knowledge of State Bicycle and Pedestrian Coordinators about how roadway design and engineering treatments in relation to bicycle and pedestrian safety, for example, could be a useful perspective for tailoring or improving ongoing programs not traditionally focused on bicycle and pedestrian safety. Separate agencies or departments may be able to jointly fund or to coordinate funding for specific elements of a program. For example, in a comprehensive pedestrian and bicycle safety outreach and education program, the SHSO could be responsible for providing funding and training for law enforcement staff and activities, while other departments could fund planning, infrastructure, or community engagement elements of the program.

Joint promotion of safety initiatives

Some State laws and local ordinances support injury prevention efforts (e.g., safe passing laws, bike helmet laws), while others restrict the ability to use certain countermeasures (e.g., speed and red light cameras). It may take a broad coalition of stakeholders, many of whom are listed under “Potential Partners,” to work with law makers and other elected officials to remove, revise, or add legal requirements to support bicycle and pedestrian safety.

“Focused Approach to Safety” initiative

The Federal Highway Administration’s [Focused Approach to Safety](#) initiative offers high-priority States and cities additional support to address three focus areas, including pedestrian/bicycle crashes. Eligible cities and States have access to technical assistance for data analysis, action plan development, and staff training. The Focused Approach calls for transportation professionals to consider low-cost, comprehensive, systematic safety solutions. While the initiative focuses on infrastructure improvements, specifically [FHWA’s nine proven safety countermeasures](#), the initiative also acknowledges that these safety measures may need to incorporate education and enforcement programs.

For more insight on comprehensive efforts to address safety, read the following examples.

Example: Washington’s comprehensive approach to improving safety along corridors

The Washington Traffic Safety Commission (Washington’s SHSO) and the Washington State DOT jointly run a Corridor Traffic Safety Program funding low-cost, short-term projects to address engineering, education, enforcement, and emergency medical service needs.

- The projects are locally led, with the aim to improve safety on short stretches of roadway with a higher than average number of serious injury and fatality crashes.
- Local coordination includes providing local leadership to develop an action plan and chair meetings of the steering committee.
- Active work on the projects usually last 18-24 months and all projects undergo a robust analysis to measure changes in road safety.

The program’s initial focus was on rural State routes but eventually started to include local projects. The State has completed over 36 projects since the program was started in the early 1990s and these project areas have seen a 30% overall reduction in fatal and serious injury collisions.



Figure 40. Road signs for the corridor project.
(Source: Washington Department of Transportation).

One of the first local projects was the Fourth Plain Corridor in the City of Vancouver.

- Fourth Plain has the highest transit use in the city and serves several low to moderate-income neighborhoods.
- The Steering Committee that was formed for the Fourth Plain project included city and county departments, the school district, neighborhood associations, State agencies, and the transit agency. This core group became one of the longest standing committees formed for a corridor project and went on to participate in two more projects in Vancouver that were outside the Fourth Plain neighborhood.
- Crash analyses showed:
 - Pedestrian/bicyclist crashes were 4.5 times more likely to occur on Fourth Plain than other similar roadways in the region. The area was branded as a Traffic Safety Project and all citations were stamped with “Traffic Safety Corridor.”
 - The leading contributing causes of collisions were inattention, disregarding signal, following too closely, and failure to yield to pedestrian or bicyclist.
- To address these problems, the city’s engineering improvements included upgrading crosswalk markings, installing pedestrian countdown signals and refuge islands, and improving traffic signal timing. The transit agency relocated bus stops closer to signalized intersections. There were also numerous education and enforcement efforts targeted toward drivers, pedestrians, and bicyclists.
- Comparing the three years before the project to two years after the project, the State found a 22% decrease in total crashes, a 38% decrease in fatal/serious crashes, and a 25% decrease in total injuries.

For more, contact Angie Ward, Program Manager, 360-725-9898, award@wtsc.wa.gov

Example: Partnerships as an integral component of the Watch for Me NC program

The North Carolina Department of Transportation's (NCDOT's) Watch for Me NC (WFM) pedestrian and bicycle safety program is an example of a partner-driven approach to implement education and enforcement campaigns. The WFM program is a statewide initiative in which communities selected through a competitive application process receive training, media/materials for public outreach, and technical assistance from NCDOT in return for performing targeted enforcement and community-wide education and engagement regarding bicycle and pedestrian safety laws and issues. The WFM executive steering committee consists of various State agency representatives including NCDOT, the Governor's Highway Safety Program (GHSP), the Division of Motor Vehicles, the State Highway Patrol, Department of Health and Human Services, and others. These individuals meet quarterly to discuss the status of the program, coordinate activities, review and select new community applicants, and provide strategic support for the program goals. The WFM program is also jointly funded by the NCDOT Division of Bicycle and Pedestrian Transportation and GHSP.

In addition to State-level partnerships to support decision-making and funding, partnerships at the local level to implement the program are key. The competitive application process emphasizes the importance of coalitions to maximize the impact of the education and enforcement activities and requires that local law enforcement agencies, at a minimum, provide a letter of support. Participating communities also receive technical support designed to help them build and expand key partnerships. While each community's partners/coalition members can differ, typical partners include local law enforcement, municipal planning and public works, public information officers or public relations, parks and recreation departments, school administrators, Safe Kids, public health or injury prevention professionals, and local bicycle and pedestrian advocacy groups. Visit the program [website](#) to learn more and to see the pedestrian and bicycle education and enforcement [efforts conducted by the local partner groups](#).

Example: Michigan's Action Team to Address Pedestrian and Bicycle Safety

Michigan's Governor's Traffic Safety Advisory Commission (GTSAC) provides leadership for the development of the Strategic Highway Safety Plan. They have a multi-agency, multidisciplinary action team focused on Pedestrian and Bicycle Safety (PBSAT). The action team meets about bimonthly and is made up of representatives from law enforcement, State Police Office of Highway Safety Planning, Michigan DOT (MDOT), State Department of Education, Department of Community Health, Michigan Department of State, FHWA, Metropolitan Planning Organizations, the League of Michigan Bicyclists, advocacy groups, etc. The PBSAT regularly updates its Pedestrian and Bicycle Safety Action Plan and reports back on action plan accomplishments related to improving walking and bicycling facilities, educational and enforcement programs, and encouragement opportunities. The plan includes goals, objectives, and strategies and short-term, mid-term, and ongoing activities that are assigned a lead agency and a contact person. Michigan's Share MI Road campaign and law enforcement training efforts were borne out of discussion related to the action plan and are efforts led by the League of Michigan Bicyclists. A video was developed to support the campaign by MDOT and features the State DOT Director and Michigan's Secretary of State and has been shown in the Department of State's Motor Vehicle offices. In Michigan, there are also local and regional

working groups focused on bicycle and pedestrian issues that report back to the PBSAT, including representatives from MPOs, State DOT regions, and local jurisdictions.

For more, contact:

Carissa McQuiston, PBSAT co-chair, 517-335-2834, McQuistonC@michigan.gov, or
Brian Pawlik, PBSAT co-chair, 313-324-3426, pawlik@semcog.org

SECTION 5: ADDITIONAL RESOURCES AND GLOSSARY

Following is a description of useful resources and websites that relate to pedestrian and bicycle issues. Additionally, a glossary of key terms and common abbreviations is provided. For resources related to specific countermeasures, refer to the countermeasure descriptions in Section 3.

Key Resources

These resources are common tools for transportation practitioners working to identify pedestrian and bicycle safety issues and select appropriate, evidence-based countermeasures.

Costs for Pedestrian and Bicyclist Infrastructure Improvements

This [resource](#) provides estimates of infrastructure costs for pedestrian and bicycle treatments based on information reported from cities and States across the country. By sharing these nationwide costs, this database contains useful estimates for the funds required to implement different facility treatments.

Countermeasures That Work

Developed by NHTSA, this [guide](#) is a basic reference to assist State Highway Safety Offices in selecting effective, evidence-based countermeasures for traffic safety problem areas. Chapters Eight and Nine specifically address pedestrian and bicycle related countermeasures.

Crash Modification Factors Clearinghouse

The [Crash Modification Factors \(CMF\) Clearinghouse](#) includes a web-based database of CMFs and supporting documentation to help transportation engineers identify appropriate countermeasures for their safety needs. See the glossary for a definition of CMFs.

FHWA Proven Safety Countermeasures

This [website](#) highlights countermeasures that have demonstrated safety benefits shown through research, and also includes helpful links to case studies and design resources.

Pedestrian and Bicycle Crash Analysis Tool (PBCAT)

The [Pedestrian and Bicycle Crash Analysis Tool](#) (PBCAT) provides free software and a user manual to assist agencies in classifying crash data into common crash types (see definition in glossary) based on pre-crash actions and crash location attributes. Example images of common crash types are also available for download on the site.

Pedestrian and Bicycle Facility Design Resource Index

This [index](#) provides references to key information in national design manuals for several pedestrian and bicycle facility treatments. The resource consists of three indices, including on-street bicycle facilities, shared use paths, and pedestrian facilities.

Pedestrian and Bicycle Road Safety Audit Guidelines and Prompt Lists

The [Bicycle Road Safety Audit Guidelines and Prompt Lists](#) and [Pedestrian Road Safety Audit Guidelines and Prompt Lists](#) provide a comprehensive guide for conducting road safety audits.

PEDSAFE, BIKESAFE, and Summary of Available Research

The [PEDSAFE](#) and [BIKESAFE](#) Safety Guides and Countermeasure Selection Tools provide transportation practitioners with the latest information available for improving the safety and mobility of those who walk and bike. Both tools include safety-related performance objectives that may be used to help identify appropriate measures to proactively provide a safer network. These updated resources include a summary of the safety effectiveness research, primarily for engineering countermeasures relevant to [bicycle](#) and [pedestrian](#) travel.

Toolbox of Countermeasures and Their Potential Effectiveness for Pedestrian Crashes

This [toolbox](#) provides a sense of the crash reductions that could be expected if a specific pedestrian countermeasure or group of countermeasures is implemented.

Useful Websites

Bicycle Friendly America

The national advocacy organization [League of American Bicyclists](#) operates the [Bicycle Friendly America](#) program, which designates applicant communities, universities, and businesses as bronze, silver, gold, or platinum. The program provides technical assistance and recognition for entities that are working to make biking a safe, comfortable, and convenient transportation choice for people of all abilities.

Federal Highway Administration (FHWA)

The [Federal Highway Administration](#) administers Federal funds for transportation improvements, and providing technical assistance to localities implementing pedestrian and bicycle projects and programs. Three Offices in FHWA address pedestrian and bicyclist safety. The Office of Safety and the Office of Safety Research work together to develop tools and technologies to reduce the number of pedestrians and bicyclists killed and injured on our nation's roadways. The Pedestrian and Bicycle Program of FHWA's Office of Office of Planning, Environment, & Realty promotes bicycle and pedestrian transportation accessibility, use, and safety. The FHWA [Pedestrian and Bicycle Program](#) issues guidance and is responsible for overseeing that requirements in legislation are understood and met by the States and other implementing agencies.

Insurance Institute for Highway Safety (IIHS)

The IIHS is a nonprofit, independent, scientific, and educational organization dedicated to reducing deaths, injuries and property damage from crashes on the Nation's roads. The [Highway Loss Data Institute](#) (HLDI) within IIHS supports this mission through research on insurance data representing both the economic and human losses resulting from the ownership and operation of different types of vehicles and by publishing insurance loss results by vehicle make and model. The [IIHS Bicycle and Pedestrian website](#) provides information about bicycle and pedestrian safety.

National Highway Traffic Safety Administration (NHTSA)

The [National Highway Traffic Safety Administration](#)'s mission is to save lives, prevent injuries, and reduce economic costs due to road traffic crashes through education, research, safety standards, and enforcement activity. The agency collects and publishes State and national crash data, including data on pedestrian and bicycle crashes. NHTSA administers funding to support

programs developed and implemented by State highway safety offices. They also distribute to the general public free educational information and publications focused on many areas of traffic safety, including [bicycling](#) and [walking](#). NHTSA usually communicates through the highway safety offices rather than directly with neighborhood residents.

Pedestrian and Bicycle Information Center (PBIC)

The [Pedestrian and Bicycle Information Center](#) is funded by the Federal Highway Administration and housed within the [University of North Carolina Highway Safety Research Center](#). PBIC aims to improve the quality of life in communities by increasing opportunities for safe walking and bicycling as a viable means of transportation and physical activity. The [PBIC library](#) includes sample pedestrian and bicycle plans and planning tools, design guidelines, research and safety studies, articles and white papers, case studies, and links to presentations, videos, and other web resources.

National Center for Safe Routes to School (NCSRTS)

The [National Center for Safe Routes to School](#) is funded by FHWA and housed within the [University of North Carolina Highway Safety Research Center](#). The Center aims to assist communities in developing successful Safe Routes programs and strategies. The Center offers information on how to start and sustain a Safe Routes to School program, case studies of successful programs, as well as many other resources.

Walk Friendly Communities

This national recognition program, operated by the Pedestrian and Bicycle Information Center, encourages towns and cities across the United States to establish or recommit to a high priority for supporting safer walking environments. The [WFC](#) program recognizes communities that are working to improve a wide range of conditions related to walking, including safety, mobility, access, and comfort.

Glossary of Common Terms, Acronyms, and Concepts

Some of these terms, acronyms, or concepts were referenced in previous sections of this primer. Others are included here because they are commonly used by transportation professionals and are likely to come up in conversations with State Highway Safety Office representatives regarding pedestrian and bicycle issues. The terms are listed alphabetically for easy referencing.

AASHTO

The [American Association of State Highway and Transportation Officials](#) (AASHTO) is a nonprofit, nonpartisan association representing highway and transportation departments. Its primary goal is to foster the development, operation, and maintenance of an integrated national transportation system. AASHTO publishes *A Policy on Geometric Design of Highways and Streets*, which is commonly referred to as the “Green Book.” While this document touches on roadway design issues that affect pedestrians and bicyclists, more specific design guidance is included in AASHTO’s [Guide for the Development of Bicycle Facilities](#) and the [Guide for the Planning, Design, and Operation of Pedestrian Facilities](#).

ADA and U.S. Access Board

The Americans with Disabilities Act of 1990 (ADA) prohibits discrimination and ensures equal opportunity for persons with disabilities in employment, State and local government services,

public accommodations, commercial facilities, and transportation. The U.S. Access Board is an independent Federal agency that promotes equality for people with disabilities through leadership in accessible design and the development of accessibility guidelines and standards. The Board has developed [proposed rights-of-way guidelines](#), which address access to sidewalks, streets, and other pedestrian facilities, provide requirements for pedestrian access routes, including specifications for route width, grade, cross slope, surfaces, and other features. The Board is supplementing its rulemaking on public rights-of-way to also cover shared use paths.

Bike share

[Bike share](#) is a service in which bicycles are made available for shared use to individuals on a very short-term basis. Bike share schemes typically allow people to borrow a bike from one location and return it at another “station.” Many bike share systems offer subscriptions that make the first 30–45 minutes of use very inexpensive, encouraging their use as transportation. This allows each bike to serve several users per day.

Complete Streets

Complete Streets principles state that all people, regardless of age, ability, income, race, or ethnicity, should have safe, comfortable, and convenient access to community destinations and public places—whether walking, driving, bicycling, or taking public transportation. The [National Complete Streets Coalition](#) works to promote the adoption and implementation of Complete Streets policies—those that address the needs of all road users in transportation decisions—at the local, State, and Federal levels. Their website has information on model Complete Streets policies and resources for implementing such policies across the United States.

Connected networks

A connected pedestrian/bicycle network is a cohesive system of transportation facilities that provide multiple direct routes allowing people of all ages and abilities to safely, comfortably, and conveniently get where they need to go.

Conspicuity

Conspicuity is the ability of an object to be attention-getting. It combines the attributes of the object being viewed with the mental state of the viewer (when you are looking for something, you are more likely to see it) and the characteristics of the surrounding environment. A conspicuous object is defined as one that will be seen with certainty within a short observation time (i.e., without search) regardless of the location of the object in relation to line of sight. An object can be visible (return sufficient light to the viewer’s eyes to be potentially detectable) without being conspicuous (e.g., a white sheet against a snow bank).

Countermeasure

In highway safety, the term countermeasure is generally used to describe a safety program or program approach focused on a particular type of crash problem. In this primer, the terms countermeasure, treatment, intervention, and program are used interchangeably to describe approaches focused on preventing or mitigating pedestrian and/or bicyclist crashes and injuries.

Crash Modification Factor

A crash modification factor (CMF) is a factor used to calculate the expected number of crashes after implementing a given countermeasure at a specific location. As mentioned above, the [Crash](#)

[Modification Factors Clearinghouse](#) includes a web-based database of CMFs and supporting documentation.

Crash type

Crash types are classifications of pedestrian and bicycle crashes based on research into the pre-crash actions taken and errors made by the driver, walker, or bicyclist and the circumstances in which the crash occurs. Countermeasures have been developed and tested for many of the identified crash types, which include turning vehicle, overtaking, dart-out, bus-related, failure to yield, and many other crash types. The [Pedestrian and Bicycle Crash Analysis Tool](#) (PBCAT) provides additional information on crash types and how to classify crash data using the PBCAT approach.

Exposure

The period or point during which a pedestrian or bicyclist has the possibility of being involved in a crash with a motor vehicle. Road user exposure is often used as the denominator for calculating pedestrian or bicycle crash rates. Exposure data is often unavailable but there are various ways it can be measured, including counting people (on trails, at crossings, etc.) with manual or automated approaches, conducting surveys of person trips taken or miles or time spent walking, or using sophisticated models to predict walking and bicycling activity.

Greenways

This is another term for a shared-use or multi-use path that is separate from the roadway. Some cities the term “neighborhood greenway” to refer streets that are traffic calmed for bicycle use.

HSIP

The [Highway Safety Improvement Program](#) (HSIP) is a FHWA program that funds State safety projects that are administered by State DOTs. States may use HSIP funds for infrastructure improvements (e.g., intersection design, pedestrian crossings, etc.) and non-infrastructure improvements (e.g., safety planning, data collection, enforcement and emergency programs). The goal of this Federal-aid program is to achieve a significant reduction in traffic fatalities and serious injuries on all public roads, including non-State-owned public facilities and roads on tribal lands. The HSIP is associated with the State’s Strategic Highway Safety Plan (SHSP).

HSM

The [Highway Safety Manual](#) presents a variety of methods for quantitatively estimating crash frequency or severity at a variety of locations. For the first time, a complete collection of quantitative safety analysis methods are available. The manual is managed by AASHTO, FHWA Office of Safety, and the Transportation Research Board Highway Safety Performance Committee.

Ladders of Opportunity

As part of the White House’s focus on improving urban and economic mobility (i.e., creating “ladders of opportunity”), the U.S. Department of Transportation recognizes the importance of helping more Americans reach opportunity by ensuring that the Nation’s transportation system provides reliable, safe, and affordable ways to reach jobs, education and other essential services. This policy initiative focuses on creating jobs through transportation projects, using transportation infrastructure to revitalize neighborhoods and regions, and providing a multimodal transportation system that is low-cost and reliable (e.g., transit, pedestrian, and bicycle facilities).

Low-stress bicycle network

A bicycle network that attracts bicyclists of all ages and abilities by offering separated lanes and paths, as well as signed routes along low-volume roads.

Master plans (bicycle and/or pedestrian)

A master plan documents the vision and work plan for improving bicycling and/or walking over time, at a specified scale (i.e., community, region, State). A plan should include robust public participation and data collection, which then inform the development of goals, objectives, and actions. A plan should focus on infrastructure, policy, and programs, and have a clear relationship to other planning documents like a comprehensive plan or transportation master plan. The plan should specify measures and processes for implementation, evaluation, and monitoring.

MUTCD

Issued by FHWA, the [Manual on Uniform Traffic Control Devices](#) defines the standards used by road managers nationwide to design, install, and maintain traffic control devices (i.e., traffic signs, road surface markings, and signals) on all streets and highways. By providing for uniformity, the MUTCD promotes highway safety and efficiency on the Nation's streets and highways. Some State agencies have developed their own sets of standards, but these must conform to the Federal MUTCD.

NACTO

The [National Association of City Transportation Officials](#) (NACTO) association that represents large cities on transportation issues of local, regional, and national significance. NACTO views the transportation departments of major cities as effective partners in regional and national transportation efforts, promoting their interests in Federal decision-making. Its [Urban Street Design Guide](#) highlights design improvements that can improve pedestrian, bicycle, transit, and motor vehicle safety and mobility, along with case studies from communities around the United States. The accompanying [Urban Bikeway Design Guide](#) focuses on facility treatments that can improve safety and comfort for bicyclists, including some of the more innovative treatments found in the United States and abroad.

Road Safety Audit

A road safety audit (RSA) is the formal safety performance examination of an existing or future road or intersection by an independent, multidisciplinary team. It qualitatively estimates and reports on potential road safety issues and identifies opportunities for improvements in safety for all road users. RSAs aim to address what elements of the road may present a safety concern and what opportunities exist to eliminate or mitigate identified safety concerns.

Safety in numbers

Academics, advocacy groups, and individual municipalities have conducted research showing that there is an inverse relationship between biking and walking levels and fatality rates. Treatments that may encourage walking and biking (bike lanes, sidewalks, signed routes, etc.) also likely contribute to increased safety. Plus, as more pedestrians and bicyclists are present, motorists are more used to sharing the roadway.

Self-enforcing roadways

Self-explaining, self-enforcing roads are facilities that address safety in an efficient way, for all users, by implementing designs and operations that explain road function and enforce speeds close to limits (i.e., the roadway design should convey expected operating speeds to drivers) and reduce *opportunities* to speed or violate other safety rules.

SHSP

The [Strategic Highway Safety Plan](#) (SHSP) is a statewide-coordinated safety plan that provides a comprehensive framework for reducing highway fatalities and serious injuries on all public roads. An SHSP identifies a State's safety needs and guides investment decisions towards strategies and countermeasure with the most potential to save lives and prevent injuries.

Shared-use

A facility, typically a paved path, adjacent to the roadway or separate from the roadway that is designated for nonmotorized use. In general, this includes pedestrians and bicyclists, but some shared-use facilities are also designated for rollerbladers, skateboarders, and equestrians.

SRTS

Safe Routes to School programs examine conditions around schools and conduct projects and activities that work to improve safety and accessibility, and reduce traffic and air pollution in the vicinity of schools. As a result, these programs help make biking and walking to school safer and more appealing transportation choices thus encouraging a healthy and active lifestyle from an early age. These programs are sustained efforts by parents, schools, community leaders and local, State, and Federal governments to improve the health and well-being of children by enabling and encouraging them to walk and bicycle to school.

Toward Zero Deaths

The [Toward Zero Deaths](#) (TZD) vision succinctly describes how an organization can approach safety—in which even one death on our transportation system is unacceptable. Within FHWA, the Office of Safety, Office of Safety Research and Development, and the Resource Center Safety and Design Technical Services Team jointly established a [Safety Strategic Plan](#) to focus on a common safety vision. TZD uses a data-driven, interdisciplinary approach, integrating application of education, enforcement, engineering, and emergency medical and trauma services.

Vision Zero

Vision Zero, conceived in 1994, suggests that no one should die or suffer serious injury in traffic. The initiative places the main responsibility for safety on system design. A core principle of the vision is that human life and health cannot be exchanged for other benefits within the society (in contrast to the more conventional comparison between costs and benefits, where a monetary value is placed on life and health).

Walking school bus

A walking school bus is a group of children walking to school with one or more adults. It can be as informal as two families taking turns walking their children to school or as structured as a planned route with meeting points, a timetable and a schedule of trained volunteers. More information is available in the National Center for Safe Routes to School [Guide](#).



U.S. Department of Transportation
**National Highway Traffic Safety
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