Safe Routes PARTNERSHIP
Active Paths for Equity & Health

ENGINEERING SOLUTIONS GUIDE

for Safe Routes to School

List of Acronyms

AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
CDC	Centers for Disease Control and Prevention
CMAQ	Congestion Mitigation and Air Quality
DOT	Department of Transportation
EMS	Emergency Medical Services
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
GIS	Geographic Information Systems
HSIP	Highway Safety Improvement Program
ITE	Institute of Transportation Engineers
LPI	Leading Pedestrian Interval
MPH	Miles per Hour
MUTCD	Manual on Uniform Traffic Control Devices
NCHRP	National Cooperative Highway Research Program
PBOT	Portland Bureau of Transportation
SRTS	Safe Routes to School
STBG	Surface Transportation Block Grant
TAP	Transportation Alternatives Program
USDA	United States Department of Agriculture

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INTRODUCTION

Road traffic has become the leading cause of death for children young people 5–29 years of age (World Health Organization, 2018). Pedestrian fatalities are at their highest level in 30 years, with over 6,000 Americans dying in traffic while walking according to the Governors Highway Safety Association's 2018 Spotlight on Safety report.

Children's access to safe places to walk, bike, and play over the past four decades has coincided with these troubling trends:

1. Less than one-quarter of children 6 to 17 years of age participate in 60 minutes of physical activity every day according to the 2016 National Survey of Children's Health. Physical inactivity is a significant contributor to obesity, which increases the risk of heart disease, diabetes, and other dangerous health conditions. Almost 19 percent of youth in the United States ages 2 to 19 years are obese (National Obesity Monitor, State of Obesity).

2. Air pollution causes the deaths of 127,000 children under age five annually, according to the FIA Foundation's 2018 *Unfinished Journey* report.

3. Social isolation is on the rise and safer streets would create informal spaces for children and caregivers to build social bonds which can prevent mental health stresses, according to the 2020 Designing Streets for Kids report.

Lack of safe places for walking and bicycling is markedly higher for Black, Indigenous, and people of color (BIPOC) and in low income neighborhoods. In these communities, without sidewalks or bike lanes, people are forced to walk in the streets or ride on the sidewalks, putting them at risk of increased enforcement and racial profiling.

Open Streets Collaborative | Burlington, VT

Featured Resource:

The Safe Routes Partnership has fact sheets, case studies and toolkits to help you engage students in the design and implementation of transportation safety measures.

ABOUT THIS GUIDE

Street design is one significant factor that influences whether children and adults are able to, and choose to, walk or bicycle. The way our streets are designed can support or hinder active transportation. The Engineering Solutions Guide for Safe Routes to School covers street design strategies to address traffic safety concerns commonly identified in school areas and along the routes to school. The guide includes evidence-based strategies that work to keep kids safe by constructing streets, sidewalks, and paths that inherently reduce or eliminate unsafe behaviors and conflicts between drivers and people walking or biking.

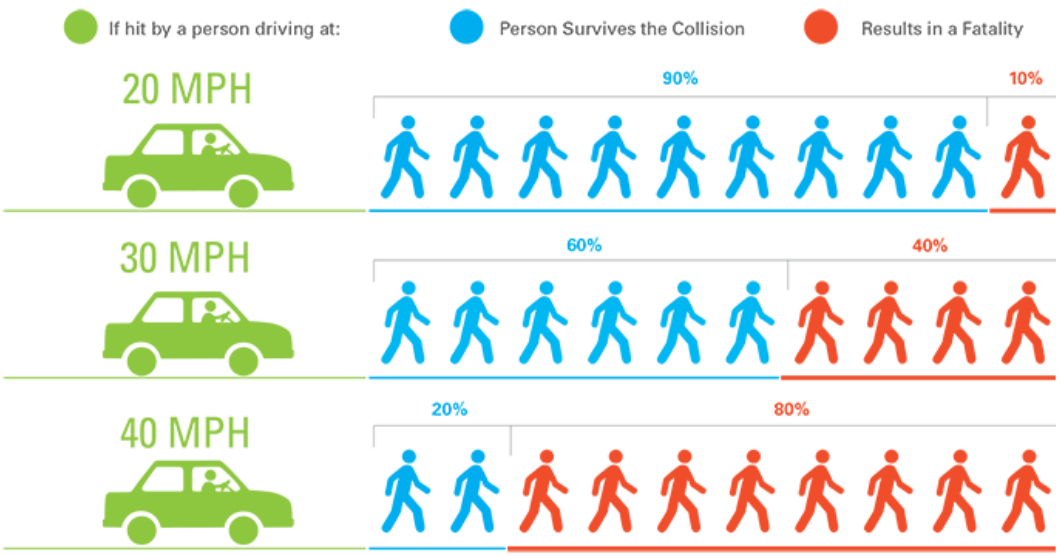
The guide is intended to help Safe Routes to School advocates, families, students, and community members understand the range of street design strategies that can be employed, and to de-mystify some of the technical aspects of street design. Use this guide to help identify potential strategies to discuss with your local transportation department or to understand the solutions that are being proposed in your neighborhood.

The guide features 17 fact sheets on engineering solutions' key features, estimated costs, safety considerations, safety outcomes and opportunities for public art in rural, suburban and urban routes to school. The engineering solutions are presented in four categories which address aspects of street design important for Safe Routes to School:

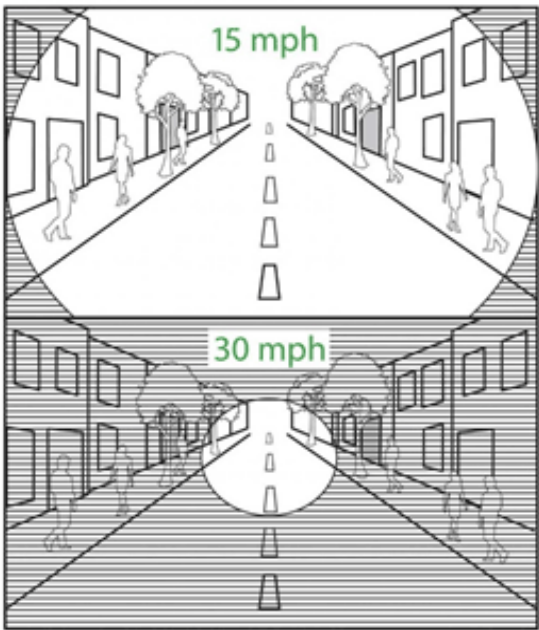
- **Reducing Vehicle Speeds** - In 2018, 26 percent of transportation fatalities in the U.S. were speed-related (NHTSA, 2020). As drivers increase their speed, their field of vision significantly narrows, making drivers less likely to see vulnerable road users on their periphery. For these resasons, speed is a major factor in the cause and severity of crashes.
- **Pedestrian Crossings** – In 2018, 74 percent of pedestrian fatalities in the U.S. occurred outside of intersections, including locations in the middle of the block (NHTSA, 2020). For that reason, it is important to create safe and predictable crosswalks between destinations.
- **Bicycle Connectivity** – In 2018, an estimated 47,000 bicycle riders were injured and 857 bicycle riders were killed in traffic collisions (NHTSA, 2020). Bicycle infrastructure that is physically separated from traffic increases the safety and comfort of using bicycles, scooters, skateboards and other mobility devices.
- **Intersection Safety** -- In 2018, almost one-fifth (18 percent) of pedestrians killed and 30 percent of bicyclists killed were struck in intersections (NHTSA, 2019). Traffic signals at intersections can be timed to reduce points of conflict between cars and vulnerable road users that could result in serious injury or fatalities.

How to Get Involved in the Safe Routes to School Engineering Process: A Case Study from Santa Ana, California

While engineering can seem highly technical, there are many ways for children, caregivers, and advocates to get involved in making streets and sidewalks easier and more welcoming places to walk and bike. The Federal Highway Administration's Safe Transportation for Every Pedestrian program outlines six steps to create safer streets for all road users. Children, caregivers, and parents can use the tools below to proactively identify their community transportation safety concerns and any underlying issues, including gentrification, displacement, social equity, and environmental justice. These community discussions give context to the transportation safety issues, help prioritize recommendations, and can inform community engagement strategies. Here is an example from Santa Ana, CA where students were engaged in similar steps to kickstart the City's Safe Routes to School efforts. The students' work resulted in $2.4 million in grant funding to make infrastructure improvements.



Institute of Transportation Engineers



Step 1: Collect Data and Engage the Public

Students training to survey safety hazards using video, field observations, and GIS computer mapping. Santa Ana, CA.

Students and staff kickstarted Safe Routes to School improvements in Santa Ana, California.

After receiving a letter from students involved with the KidWorks, a local nonprofit, the City of Santa Ana set up training sessions and regular meetings for the group to learn about the planning and engineering process.

After their training, students surveyed nearly 200 bicyclists, used geographic information systems (GIS) to digitally map Santa Ana's bikeways and demographics, and recorded road safety hazards with video.

Step 2: Inventory Conditions and Prioritize Locations

Activity to identify school safety needs and concerns. Santa Ana, CA

Using these data, students and staff ranked and prioritized Safe Routes to School improvements.

Working with city staff, the students found that 20 people walking and biking had been injured on one 1.7 mile road segment between 2011 and 2015. In response, the students selected three pedestrian and cycling routes to prioritize for safety improvements. These three routes lead to eight public schools.

In addition to the data from their training and surveying, students were motivated by stories of classmates and family members involved in collisions, including a 13-year-old cyclist killed by a Santa Ana Unified School District employee driving a work truck in July 2015.

Step 3: Analyze Crash Types and Safety Issues

Completing walk audits and student travel tallies to verify and add to public records of collisions and environmental hazards. Santa Ana, CA

Students and staff analyzed crash types and safety issues using a variety of methodologies:

Travel tallies representing 28,000 students were collected using forms from the National Center for Safe Routes to School to understand travel patterns.

Safety concerns along these routes were identified through the Transportation Injury Mapping System (TIMS) database of collisions.

Environmental hazards were identified along school routes using CalEnviroScreen, California's environmental justice screening tool.

Step 4: Select Countermeasures

Students help mark advance yield signs. Santa Ana, CA

Students and staff selected safety countermeasures according to roadway features and safety issues. Roadway features included the average daily traffic counts (AADT), the number of lanes, the presence of a median, and the speed limit. Safety issues included visibility issues, near-misses at road crossings, and speeding traffic.

Improved sidewalks and a protected bike lane with a raised physical barrier separating the bike and car lanes were chosen by Santa Ana youth. The physical barrier also incorporates street parking as an added barrier providing more visible protection for bicyclists.

Step 5: Consult Design and Installation Resources

Pop-up crosswalk with planters and crossing guards at a temporary installation. Santa Ana, CA

As with the design of any roadway improvement, engineers consulted federal and local guidelines and plans including the:

- **American Association of State Highway and Transportation Officials** Guide for the Design of Pedestrian Facilities
- **Manual on Uniform Traffic Control Devices (MUTCD)** for traffic control measures, including signs, signals and roadway markings to be used during construction projects, temporary projects or roadway closures.

Step 6: Identify opportunities and monitor outcomes

Students and staff write grants to secure millions in federal funding. Santa Ana, CA

Working with KidWorks and city staff, students helped develop a proposal to the California Active Transportation Program that secured $2.4 million for the desired Safe Routes to School improvements. Students supported the development of:

- Cost estimates
- Measurements for three proposed sites
- Grant proposal narrative and conceptual framework

The students' work ranked among Orange County's highest-scoring grant proposals for that year.

In addition to the infrastructure improvements, the work resulted in engaging additional community members to support future Safe Routes to School programming.

COMMUNITY ENGAGEMENT FOR ALL AGES AND ABILITIES

An important component of the process of designing streets that support kids, families, and community members walking and biking is to engage the community in identifying local needs and challenges, as well as potential solutions. Without community engagement throughout the process, engineering solutions run the risk of not addressing underlying community concerns, creating streets that people do not use, or exacerbating inequities. Here are some strategies to engage community members around street design and engineering.

Talk to Your Neighbors

Use kitchen table talks, collaborative storytelling, drama and art-making activities to understand your neighbors' unique needs, concerns and visions for Safe Routes to School.

Use Arts-based Engagement to Solicit Input

Arts and humanities based engagement activities can cross barriers of language, age, and experience. Here are two examples:

- **Conduct Art Workshops:** James Rojas' Place It! workshops use recycled objects and zero Powerpoint presentations to build consensus around transportation planning projects.
- **Conduct Drama Workshops:** The Theater of the Oppressed, a curriculum of drama-based games and activities inspired by the Brazilian pedagogy studies of Paolo Freire, has been used by community groups in Los Angeles, New York and beyond to process, discuss and present issues of tenant rights, affordable housing and displacement.

Visualize Your Needs and Assets

Use free online and pen-and-paper tools with students, parents, staff, and neighbors to diagram and quantify assets and gaps in your community.

Growing up Boulder

Create Interactive Maps

- **National Trends**: The Centers for Disease Control and Prevention (CDC)'s Social Vulnerability Index, the United States Department of Agriculture (USDA)'s Food Environmental Atlas, and the Enviromental Protection Agency (EPA)'s Environmental Justice Screen can be used to explore physical activity rates, food costs, food availability, disease rates, healthcare coverage, English proficiency, dwelling conditions, transportation use, and environmental hazards in your community and national wide. Use the maps and reports to see differences across age groups, income levels, ethnic groups and people of differing physical/mental abilities. Available online or for download.
- **Gentrification and Displacement**: Explore online maps and charts to understand the key drivers of gentrification and displacement in the US and abroad through Harvard University and the California Air Resources Board.

Create Cognitive Maps

This psychological technique has participants draw from memory local landmarks, routes, nodes, edges, and zones in their neighborhood, starting at their place of residence or work. Gaps in the drawn map represent the gaps in our understanding of economic, social, and recreational opportunities in our communities.

A NOTE ABOUT PUBLIC ART IN THE RIGHT OF WAY

As community members get involved in traffic safety planning, there is often an interest in adding public art as a strategy to improve safety. It is important to know that the MUTCD provides guidance on public art in crosswalks. Here are some key tips and examples of how cities have responded to the MUTCD's guidance.

> The MUTCD regulates traffic control devices, defined as all signs, signals, and markings used to regulate, warn, or guide traffic, placed on, over, or adjacent to a street, highway, pedestrian facility, bikeway, or private road open to public travel.

Public Art in Crosswalks

Federal standards for traffic control devices, defined in the MUTCD, allow paint/colored pavement applied as a "purely aesthetic treatment" which are **not "intended to communicate a regulatory, warning, or guidance** message to road users" (Interpretation Letter 3(09)-8 (I)). Generally, if the colored pavement is non-retroreflective, it is considered an aesthetic treatment. Specifically, in 2013, the FHWA's Associate Administrator for Operations issued Interpretation Letter 3(09)-24(I) – Application of Colored Pavement, which states:

"Examples of acceptable treatments include brick lattice patterns, paving bricks, paving stones, setts, cobbles, or other resources designed to simulate such paving. Acceptable colors for these materials would be red, rust, brown, burgundy, clay, tan or similar earth tone equivalents. All elements of pattern and color for these treatments are to be **uniform, consistent, repetitive, and expected so as not to be a source of distraction**. No element of the aesthetic interior treatment is to be random or unsystematic. No element of the aesthetic interior treatment can implement pictographs, symbols, multiple color arrangements, etc., or can otherwise attempt to communicate with any roadway user."

Cities across the United States have responded with a degree of subjectivity in determining what is and is not technically compliant within the above federal guidance.

Greg Raisman via Flickr

- **Austin, Texas's Creative Crosswalks program** allows community groups to submit designs for the space between the crosswalk bars for a nominal fee. Octagons, triangles, text, and logos are prohibited, but there is no mention of restricting the color palette or pattern.
- **Seattle, Washington's Community Crosswalks program** has lead to the creation of over 40 creative crosswalks, with the city's lead engineer, Dongho Chang, serving as an active committee member of the federal MUTCD. The program prohibits images that create a distraction for drivers or could be confused with traffic signs or traffic pavement legends. Participants are directed to "consider using a limited palette" of colors and simple graphic images to avoid visual clutter and keep costs down.

Public Art in Intersections

The FHWA's MUTCD FAQ site states:

"Exclusive of a crosswalk that may be present, intersection murals and street artwork are not traffic control devices and the MUTCD most likely does not directly apply."

An example of how a city has allowed for public art in intersections is Portland, Oregon's Block Party Street Closure Permit, which has allowed the creation of over 70 street murals at intersections and midblock locations since 1996. The design must be approved by all adjacent residents and 80% of residents within 400 feet of each art project.

Ontario Promenade, Montréal
Photo + Art by: Roadsworth

ENGINEERING SOLUTIONS

Use the following 17 fact sheets to understand each engineering solution's key features, estimated costs, safety considerations, safety outcomes, and opportunities for public art in rural, suburban and urban routes to school.

HOW TO USE THIS GUIDE

The engineering solutions fact sheets are divided into four categories:

- Reducing Vehicle Speeds
- Pedestrian Crossings
- Bicycle Connectivity
- Intersection Safety

Each fact sheet includes:

- A Description
- Treatment Types - ideas for how the solution might be implemented with high-, medium-, and low-cost treatments. This section also includes ideas for temporary solutions using low-cost materials.
- Safety Considerations – context or other considerations for implementing the solution. If the solution is a traffic control device and subject to the MUTCD, the status and MUTCD section reference is provided. Also, studies or statistics on the solution's effectiveness are referenced here.
- Urban/Suburban/Rural icons – indications of the settings where it would be appropriate to consider the solution.
- Cost Range – what the anticipated cost range is for the solution, corresponding to the cost range key below.
- Opportunities for Art icon – identifying which treatments provide an opportunity to incorporate public art.

The following table summarizes the estimated costs and safety and design contexts of each engineering solution, formally known as a safety countermeasure, in this guide. The research in this report follows the latest guidance from the 2020 National Cooperative Highway Research Program (NCHRP) Report #926: "Guidance to Improve Pedestrian and Bicyclist Safety at Intersections," which is available at https://www.nap.edu/read/25808/chapter/13#111.

Page	Safety Countermeasure	Where Should the Countermeasure be Considered?	Requires a Traffic Signal?	Cost:
REDUCING VEHICLE SPEEDS				
21	Narrowing Lanes	• Urban and rural multi-lane roads • Priority bicycle and pedestrian routes	Either with or without signals	$$
22	On-Street Parking	• High volume of pedestrians, bicyclists and/or collisions • Parking or loading zones with multiple or confusing signs • Areas where parking and loading traffic violations are common	Either with or without signals	$
23	Speed Humps and Speed Tables	• Crossings at school zones or shared-use paths • Crossings where motorists fail to yield to pedestrians	Either with or without signals	$$
24	Curb Extensions	• On-street parking is present	Either with or without signals	$$
25	Mini Traffic Circles	• 30 mph or lower roads, especially in residential areas	Without signals	$$
PEDESTRIAN CROSSINGS				
27	Raised Crosswalks	• Crossings at school zones or shared-use paths • Crossings where motorists fail to yield to pedestrians	Either with or without signals	$$$
28	Ladder Crosswalks	• All crossing locations	Either with or without signals	$
29	Raised Medians and Crossing Islands	• Two or more lanes of traffic and vehicle speeds of 30 mph or more	Either with or without signals	$$

Page	Safety Countermeasure	Where Should the Countermeasure be Considered?	Requires a Traffic Signal?	Cost:
30	Flashing Beacons or HAWK Signals	• High volume of pedestrians and vehicles on high speed roads (at or above 35 mph) for HAWK Signals • Low-to-medium vehicle volumes on low speed roads (less than 35 mph) for Rectangular Rapid Flashing Beacons	Without signals	$$$
BICYCLE CONNECTIVITY				
32	Bicycle Lanes	• Bicycle routes that are a minimum of 5 ft wide, or 4 ft when not adjacent to on-street parking • Wider bike lanes (6 to 7 ft) should be considered in locations with high volumes of bicyclists, heavy parking turnover, higher vehicle speeds, higher traffic volumes, or a higher percentage of heavy trucks or buses.	Either with or without signals	$$
33	Bicycle Boxes	• Medium-to-high volume of bicyclists and vehicles • Intersections where large vehicles are common • Intersections with high volumes of turning vehicles and bicyclists going straight	With signals	$
34	Bicycle Boulevards	• 30 mph or lower roads, especially in residential areas	Without signals	$$

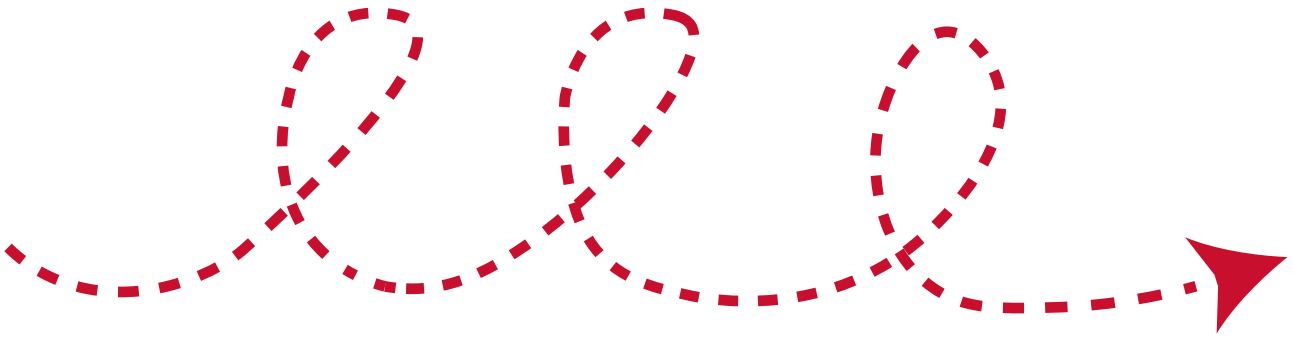
Page	Safety Countermeasure	Where Should the Countermeasure be Considered?	Requires a Traffic Signal?	Cost:
35	Protected Bicycle Lanes	• Medium-to-high volume of bicyclists and vehicles • Intersections where large vehicles are common • High volume of bicyclist collisions	Either with or without signals	$$$
36	Multi-Use Pathways	• Higher speed or high volume roads • Roads with a limited frequency of intersections or driveways	Either with or without signals	$$$
INTERSECTION SAFETY				
38	No Right Turn on Red	• High volume of right-turning vehicles • High volume of pedestrians and/or bicyclists	With signals	$
39	Signal Timing Modifications	• Turning vehicle crashes common • High volume of turning vehicles • Medium-to-high volumes of pedestrians • Wide streets with longer crossing distances	With signals	$$$

$ Low cost range - Under $2,000 on average

$$ Medium cost range - $2,000 - $15,000 on average

$$$ High cost range - $15,000 or more on average

REDUCING VEHICLE SPEEDS



NARROWING LANES

Description: Signaling drivers to slow down by reducing the width and/or number of existing travel lanes. Travel lanes are re-striped (painted over) in order to:

- Reduce lane widths (to 9, 10, or 11 feet) and paint a bicycle lane or paved shoulders on the remaining asphalt
- Remove travel lanes (often reducing from 4 to 3 lanes)
- Physically narrow the street by extending sidewalks, landscaped areas, or by adding on-street parking

Pictured Above: *Narrowing lane widths in New York City's Central Business District has created room for parking-protected bicycle lanes, pedestrian crossing islands, red bus-only lanes and 110 new street trees. Total traffic injuries have dropped by 20%, the average number of bicyclists on the road has increased by 59%, and travel speeds have remained steady since the project was completed (NYC, 2014).*

Treatment Types

High-End Treatments: Re-striping lane markings, adding raised medians, widening sidewalks, adding landscaping, and/or curb extensions

Medium Treatments: Re-striping lane markings

Low-Cost Treatments: Flexible delineator posts (flexiposts)

Temporary Solutions: Traffic cones, drums, planter boxes, or other barricades

Safety Considerations

Bike lanes may be needed if motor vehicle volumes and/or speeds are high.

School bus, emergency service access, and truck volumes generally require 11-foot lanes for urban areas, 10- to 11-foot lanes for suburban areas, and 9-foot lanes for rural areas.

47% reduction in collisions after one travel lane was removed in rural Iowa (FHWA, 2010). **Three to five mph reduction in vehicle speeds** after four lanes were reduced to three lanes in Minnesota and California (FHWA, 2014).

Urban Suburban Rural

Opportunities for art

$$ **Medium cost range**

ON-STREET PARKING

Description: On-street parking can help:

- Narrow the crossing width of a street
- Improve air quality by reducing the time cars' engines idle while looking for parking
- Provide a physical buffer between pedestrians, bicyclists and moving traffic

Parking, as well as pick-up and drop-off areas, should have easy-to-read signs and pavement markings.

Pictured Above: *New parking sign to consolidate poles with 4 or more signs in Los Angeles, CA | NPR Since 2015, these parking signs have been piloted in Los Angeles, CA, Oak Park, Illinois, Fargo, North Dakota, and other cities with templates available online.*

Treatment Types

High-End Treatments: Parking spaces delineated with thermoplastic paint and consolidated signs for clear pick-up, drop-off, loading, and parking.

Medium to Low-Cost Treatments: Parking spaces delineated with oil or water based paint and consolidated signs for clear pick-up, drop-off, loading, and parking.

Temporary Solutions: Parking spaces delineated with foil-backed traffic tape or paint made of chalk, tempera, acrylic, or cornstarch. Spray chalk and spray paint can also be used with stencils. Consolidated coroplast or homemade signs for clear pick-up, drop-off, loading, and parking.

Safety Considerations

At least 20 feet of parking should be removed on either side of a crosswalk, and curb extensions should be built (see page 24) to remove any blind spots, especially where children cross.

A 63% decrease in crashes resulting in injuries and a 54% decrease in the number of speeding vehicles was reported in New York City's Prospect Park West after on-street parking was added to protect a two-way bicycle lane. (FHWA, 2018 and NYC DOT, 2020)

Urban Suburban Rural

Opportunities for art

$ **Low cost range**

SPEED HUMPS + SPEED TABLES

Description: Mountable physical barriers in the roadway that can reduce speeding. Specifically:

- Speed humps are mountable obstructions installed on the pavement surface across travel lanes, intended to cause vehicles to reduce speed.
- Speed tables are wider flat-top speed humps and are gentler on vehicles. They have a lower slope that can handle relatively higher traffic volumes and speeds.

Pictured Above: *A speed bump in Brentwood, TN | NATCO. This speed hump from Brentwood, Tennessee is featured along with other design guidance in the NACTO Urban Street Design Guide online.*

Treatment Types

High-End Treatments: Brickwork, stamped asphalt, concrete ramps, and other enhancements sometimes used at pedestrian crossings in combination with curb extensions (see page 24).

Medium Treatments: Asphalt

Low-Cost Treatments: Rubber or plastic

Temporary Solutions: Rubber or plastic

Safety Considerations

If the street is a bus route or primary emergency route, design must be coordinated with operators.

Speed bumps, which are more abrupt mountable barriers, typically 3 to 6 inches in height, are not recommended due to the discomfort caused to emergency vehicles, cargo vehicles, and bus passengers.

Noise may increase, particularly if trucks use the route regularly. **Stormwater drainage problems** may occur on some streets. Do not use if sight distance is limited and/or if the street is on a steep grade.

After 16 speed humps were installed in five residential neighborhoods in Bellevue, WA, traffic speeds were reduced by 12 mph. (FHWA, 2014)

Urban Suburban Rural

$$ **Medium cost range**

CURB EXTENSIONS + CHICANES + CHOKEPOINTS

Description: Narrowing the roadway for safer crossing distances and speeds with:

- Curb Extensions: An extension of the curb or sidewalk into the street in the form of a bulb.
- Chicanes: Creating a zigzag or serpentine path to slow vehicles, usually with curb extensions or by alternating on-street parking between two sides of the street.
- Chokepoints: Narrowing of a street, often at mid-block location, through curb extensions, landscaping, or edge islands.

Pictured Above: A curb extension with a bioswale in King County, WA | MIG, 2015. Together, these 93 curb extensions with bioswales function as roadside rain gardens, featuring native and drought-tolerant plants, are estimated to divert six million gallons of stormwater annually from entering the combined sewer overflow.

Treatment Types

High-End Treatments: Native plants in rain gardens and bioswales to manage stormwater and drought, permeable pavers, curb extensions with street furniture, decorative low fencing, seating, and/or lighting

Medium Treatments: Concrete or brick

Low-Cost Treatments: Flexible delineator posts (flexiposts) and paint

Temporary Solutions: Traffic cones, drums, or other plastic barricades. Paint made of chalk, tempera, acrylic, or cornstarch. Spray chalk and spray paint can also be used with stencils.

Safety Considerations

Emergency access is often improved through the use of curb extensions, as intersections are kept clear of parked cars. Fire engines and other emergency vehicles can climb a curb where they would not be able to move a parked car. In addition, at mid-block locations, curb extensions can keep fire hydrants clear of parked cars and make them more accessible.

A 23-48% reduction in crashes and 2.6 mph reduction in speed is estimated through these measures, based on reviews of residential areas and in areas where high-speed rural highways transition into rural communities. (FHWA, 2018 and ITE, 1999)

Urban Suburban Rural

Opportunities for art

$$ **Medium cost range**

MINI-TRAFFIC CIRCLES

Description: A small circular island used in the middle of an intersection and intended to force vehicular traffic to slow and negotiate around it. When used in a residential area, it can be landscaped for aesthetic or barrier purposes, and may have mountable curbs to facilitate movement of emergency vehicles.

Mini-traffic circles are distinct from roundabouts in that they are designed for low-speed residential streets with one lane of travel.

Pictured Above: *A mini-traffic circle with street furniture in Seattle, WA | Streetsblog. 80% to 90% of Seattle residents feel their traffic circles have been effective and want to keep them permanently. These 1,200 traffic circles can feature bird houses, benches, signs, and landscaping.*

Treatment Types

High-End Treatments: Native plants in rain gardens and bioswales to manage stormwater and drought, permeable pavers, street furniture, decorative low fencing, and/or lighting

Medium Treatments: Flexible delineator posts (flexiposts), paint, and lighting

Low-Cost Treatments: Flexible delineator posts (flexiposts) and paint

Temporary Solutions: Traffic cones, drums, or other plastic barricades. Paint made of chalk, tempera, acrylic, or cornstarch. Spray chalk and spray paint can also be used with stencils.

Safety Considerations

A network of traffic circles at every intersection of a route is most effective.

A two-foot wide mountable curb allows fire trucks or larger vehicles, such as moving vans, to run over the curb without damaging either the vehicle or the circle.

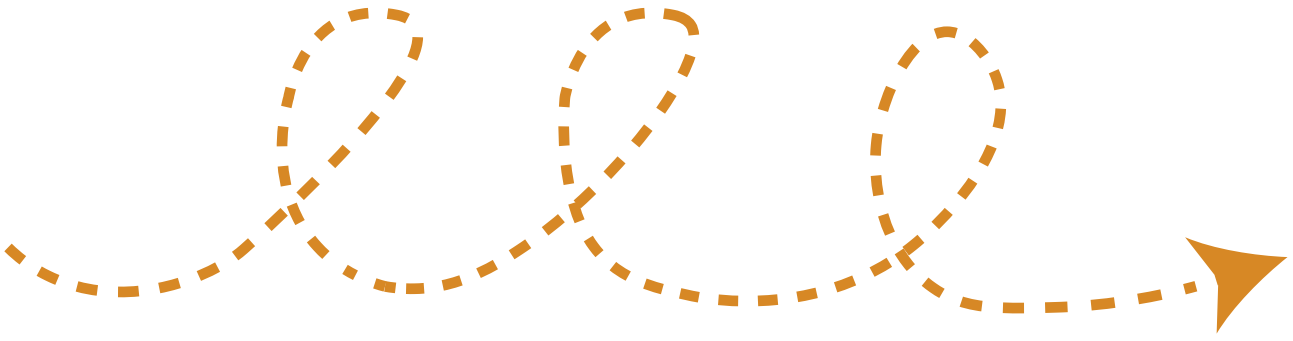
A 94% reduction in all types of crashes was found in the City of Seattle through repeated studies of mini-traffic circles since the 1990s. Over the last 50 years, only 2 of more than 1,200 traffic circles have been removed due to residents' concerns in the City of Seattle. (FHWA, 2014)

Urban Suburban Rural

Opportunities for art

$$ **Medium cost range**

PEDESTRIAN CROSSINGS



RAISED CROSSWALKS + INTERSECTIONS

Description: Elevating pedestrian crossing areas to reduce vehicle speeds and provide a better view of pedestrians and motorists in the intersection and/or crossing area. Specifically:

- Raised Intersections: the entire intersection is raised above normal pavement surface level.
- Raised Crosswalks: the pedestrian crossing area is raised above normal pavement surface level.

Pictured Above: *A raised intersection in West Palm Beach, FL | Dan Burden. Learn more about raised intersections and other traffic safety measures from an engineer's perspective through the Institute for Traffic Engineers (ITE) traffic calming fact sheets.*

Treatment Types

High-End Treatments: Permeable pavers, public art with thermoplastic paint, rapid flashing beacons, native plants in bioswales or rain gardens, human-scale lighting

Medium Treatments: Concrete, stamped concrete, stamped asphalt, paint

Low-Cost Treatments: Asphalt, paint

Safety Considerations

Fire departments typically prefer raised crosswalks over speed humps. There is typically less than three seconds of delay for fire trucks per raised crosswalk.

Raised crosswalks are essentially speed tables marked and signed for pedestrian crossings (see page 23).

45% average decrease in crashes at 27 speed table locations in Georgia and Maryland, which can also be painted as raised crosswalks. (FHWA, 2014)

Urban Suburban Rural

Opportunities for art

$$$ **Medium to high cost range**

LADDER CROSSWALKS

Description: Clear, high-visibility roadway markings and accompanying devices at intersections and priority pedestrian links, located where motorists should expect pedestrians with sufficient sight distance and reaction time.

Since 2017, crosswalks painted to appear hree-dimensional have been officially approved in school zones of Medford, Massachusettes, Little Rock, Arkansas and abroad in Iceland, India, and Thailand. Legal disputes in Ames, Iowa and elsewhere contest that public art treatments have increased safety, however, federally, they are not MUTCD-compliant.

Pictured Above: The Safe Routes to School program in Marin County, CA has implemented high-visibility crosswalks with crossing guards. In 2019, 25% of trips to Marin County school were made by bicycling or walking (TAM, 2019).

Treatment Types

High-End Treatments: Thermoplastic based paint

Medium to Low-Cost Treatments: Oil or water based paint, reflective inlay tape

Temporary Solutions: Paint made of chalk, tempera, acrylic, or cornstarch. Spray chalk and spray paint can also be used with stencils.

Safety Considerations

Crosswalks should be completed in conjunction with other measures, such as curb extensions, to improve the safety of a pedestrian crossing.

Crosswalks should be visible to motorists, particularly at night, should not be slippery, and should not create trip hazards.

MUTCD Status: High-visability crosswalks are allowed, as detailed in Report No. FHWA-HRT-10-068 and also Section 3B.18 of the MUTCD.

School sites with ladder crosswalks in San Francisco, CA experienced a 37% reduction in crashes. (FHWA, 2014)

Urban Suburban Rural

Opportunities for art

$ **Low cost range**

RAISED MEDIANS + CROSSING ISLANDS

Description: Raised medians to protect pedestrians include these two types:

- Median Barriers: A raised area constructed between travel lanes through an intersection to block movements.
- Pedestrian Refuge Islands: A raised area in the middle of a crosswalk for pedestrians to stop while crossing street.

Pictured Above: *A pedestrian refuge island in New York City | NACTO. Learn more about pedestrian refuge islands, median barriers and 67 other measures from the federal safety perspective through the FHWA Pedestrian Safety Guide and Countermeasure Selection System.*

Treatment Types

High-End Treatments: Native plants in rain gardens to manage stormwater and drought, raised concrete median, low fencing, lighting, permeable pavers

Medium Treatments: Raised concrete median

Low-Cost Treatments: Oil or water based paint, reflective inlay tape, flexible delineator posts (flexiposts)

Temporary Solutions: Traffic cones, drums, planter boxes, or other barricades

Safety Considerations

Median barriers are intended to prevent left turns from the major street and through movements along the minor street, while allowing pedestrian and bike access.

Ensure that there is enough room for wider sidewalks, bike lanes, and planting strips before proceeding with construction of raised medians.

A 5 mph reduction in vehicle speeds as part of a traffic calming project that included raised medians in rural Grand Junction, Colorado. (FHWA, 2014)

Urban Suburban Rural

Opportunities for art

$$ **Medium cost range**

FLASHING BEACONS + HAWK SIGNALS

Pictured Above: A HAWK Signal in Tucson, AZ | FHWA

Description: Signals that increase the visibility of pedestrians at mid-block crosswalks include:

- Rectangular Rapid Flashing Beacons (RRFBs): Pedestrian activated signal with a strobe-light flashing pattern.
- HAWK Signals: Pedestrian activated signal, dark when not in use, which begins with a flashing yellow light alerting drivers to slow, and then a solid red light requires drivers to stop while pedestrians have the right-of-way to cross the street.

Treatment Types

High-End Treatments: HAWK Signals

Medium Treatments: Rectangular Rapid Flashing Beacons with solar-powered lighting optional

Low-Cost Treatments: Barricades with flashing lights

Temporary Solutions: Planter boxes, plastic drums, painted jersey barriers, or other barricades with flashing lights

Safety Considerations

Overhead Pedestrian Crossing Signs mounted to masts over the roadway are permitted in MUTCD Section 2B.12 and can inform drivers farther in advance of a crosswalk of their legal obligation to stop for pedestrians.

Flashing beacons should be installed in the median rather than the far-side of the roadway if there is a pedestrian refuge island or other type of median.

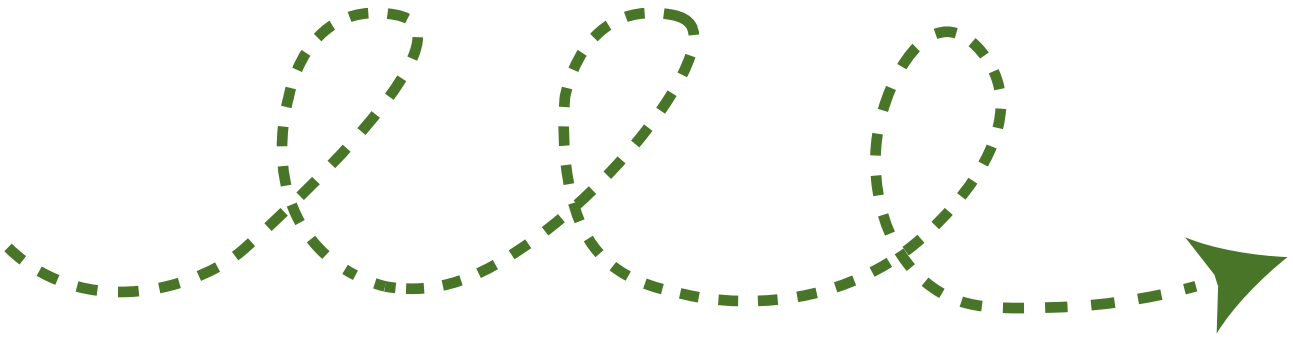
A 47% average reduction in crashes involving pedestrians after installing RRFB signals in Chicago, Eugene, Miami, Phoenix, Portland, and St. Petersburg (FHWA, 2014)

Urban Suburban Rural

Opportunities for art

$$$ **High cost range**

BICYCLE CONNECTIVITY



BICYCLE LANES

Description: The area of roadway designated for non-motorized bicycle use, separated from vehicles by pavement markings.

MUTCD Section 9C.04 specifies as technical guidance that the bicycle lane symbol must be painted white. Since 1999, however, the City of Portland, OR has been decorating bicycle lanes with recycled thermoplastic and paint. The public library and the Portland Bureau of Transportation (PBOT)'s Bike to Books program involves students in bicycle lane design through an art competition, books, and songs.

Pictured Above: Bicycle lane featuring a first grader's winning design | PBOT

Treatment Types

High-End Treatments: Narrowing lanes (see page 21) to accomodate bicycle lanes, thermoplastic paint, wayfinding signs with estimated miles and/or calories burned to destination, wayfinding signs with nearby bikeshare or scooter stations, native plants in rain gardens, and bioswales to manage stormwater and drought

Medium Treatments: Oil or water based paint and/or reflective inlay tape after narrowing lanes (see page 21), wayfinding signs with estimated miles to destination and with nearby bikeshare or scooter stations

Low-Cost Treatments: Oil or water based paint and/or reflective inlay tape within an existing roadway shoulder

Temporary Solutions: Coroplast or homemade wayfinding signs, paint made of chalk, tempera, acrylic or cornstarch. Spray chalk and spray paint can also be used with stencils.

Safety Considerations

Bicycle lanes provide a buffer and greater visibility between motor vehicles and pedestrians.

15% decrease in cars encroaching in adjacent lanes when passing bicyclists (FHWA, 2014)

Urban Suburban Rural

Opportunities for art

$$ **Medium to high cost range**

BICYCLE BOXES

Description: A marked area in front of the stop bar at a signalized intersection that allows bicyclists to correctly position themselves for making turns by pulling ahead of cars at a red signal.

Pictured Above: A bicycle lane in Vancouver, Canada | Safe Routes Partnership

Treatment Types

High-End Treatments: Thermoplastic paint with "wait here" lettering and a bicycle symbol across one or multiple travel lanes, stripe additional stop lines to protect pedestrians, exclusive bicycle traffic signal, no right turn on red signs, and traffic signal arrows

Medium to Low-Cost Treatments: Oil or water based paint, striping lanes at start and end of bicycle box, "stop here" sign, "warning yield" sign, no right turn on red signs

Temporary Solutions: Coroplast or homemade no right turn on red signs, paint made of chalk, tempera, acrylic or cornstarch. Spray chalk and spray paint can also be used with stencils

Safety Considerations

Bicycle boxes are intended to reduce car-bicycle conflicts, particularly involving right-turning movements across the path of a bicyclist and to increase bicyclist visibility.

MUTCD Status: Allowable through interim approval (IA-1819)

64.4% reduction in right turn near misses. (OTREC, 2011)

Urban Suburban

Opportunities for art

$ **Low cost range**

BICYCLE BOULEVARDS

Description: Low volume and low speed streets that have been optimized for bicycle travel through treatments such as traffic calming and traffic reduction, signage and pavement markings, and intersection crossing treatments.

Pictured Above: A bicycle boulevard in Berkeley, CA | Carrie Cizauskas via Flickr

Treatment Types

High-End Treatments: Thermoplastic paint for bicycle symbols and public art, landscaping barriers (self-watering planter boxes, rain gardens or bioswales), wayfinding signs with estimated miles and/or calories burned to destination, wayfinding signs with nearby bikeshare or scooter stations

Medium Treatments: Oil or water based paint and/or reflective inlay tape for bicycle symbol markings and public art, wayfinding signs with estimated miles to destination and with nearby bikeshare or scooter stations, flexible delineator posts (flexiposts)

Low-Cost Treatments: Oil or water based paint and/or reflective inlay tape

Temporary Solutions: Coroplast or homemade wayfinding signs, paint made of chalk, tempera, acrylic or cornstarch. Spray chalk and spray paint can also be used with stencils.

Safety Considerations

MUTCD Status: Allowable (Section 9C.07, Section 9B.20, and Section 9B.21)

50% to 88% fewer crashes on bicycle boulevards compared to parallel, adjacent arterial routes (Fehr and Peers, 2018)

Urban Suburban Rural

Opportunities for art

$$ **Medium cost range**

PROTECTED BICYCLE LANES

Description: An exclusive bike lane separated from vehicle travel lanes, parking lanes, and sidewalks. The bike lane is typically adjacent to the curb and is physically separated from adjacent parking and travel lanes. They can be one-way, two-way, at street level, at sidewalk level, or at an intermediate level.

Pictured Above: A pop-up protected bicycle lane in Minneapolis, MN | Kristina Perkins

Treatment Types

High-End Treatments: Narrowing lanes (see page 21) to accommodate one-way or two-way bicycle lanes, thermoplastic paint, wayfinding signs with estimated miles and/or calories burned to destination, wayfinding signs with nearby bikeshare or scooter stations, exclusive bicycle traffic signal, lane barriers made of concrete and/or native plants in rain gardens and bioswales to manage stormwater and drought.

Medium Treatments: Oil or water based paint and/or reflective inlay tape after narrowing lanes (see page 21), wayfinding signs with estimated miles to destination and with nearby bikeshare or scooter stations, rubber or concrete lane barriers.

Low-Cost Treatments: Oil or water based paint and/or reflective inlay tape within an existing shoulder of traffic, flexible delineator posts (flexiposts) as lane barriers.

Temporary Solutions: Paint made of chalk, tempera, acrylic or cornstarch, coroplast or homemade wayfinding signs, traffic cones, drums, planter boxes, rock quarry slabs, or other lane barriers.

Safety Considerations

MUTCD Status: Not a traffic control device, so no MUTCD restriction on its use

28% injury reduction compared with alternative bicycle routes in Montréal, Quebec. (FHWA, 2014)

Urban Suburban Rural

Opportunities for art

$$$ **Medium to high cost range**

MULTI-USE PATHWAYS

Description: Paved pathways away from the road and out of the path of turning vehicles designed with space adequate for safe use by both pedestrians and bicyclists.

The FHWA advises walkways and shoulders should be separated from traffic. A physical barrier or separation of at least two to three feet between the pathway and traffic helps prevent crashes involving pedestrians.

Pictured Above: Charlotte Rail Trail | Xavier Wang for the Charlotte Observer

Treatment Types

High-End Treatments: A multi-use pathway (also known as a Class 1 Shared Use Trail) on both sides of the road and with unimpeded crossings using permeable pavers or boardwalk materials with human-scale lighting, bicycle fix-it stations and parking, water fountains, wayfinding signs, rain gardens, and/or bioswales

Medium Treatments: A multi-use pathway (also known as a Multi-Use Trail) with at grade (sidewalk level) crosswalks, human-scale lighting, wayfinding signs and concrete or asphalt pavement

Low-Cost Treatments: A multi-use pathway on a paved shoulder of an existing roadway with wayfinding signs

Safety Considerations

MUTCD Status: Not a traffic control device, so no MUTCD restriction on its use

Multi-use pathways can provide safe, alternative routes between cul-de-sacs, open space and roadways

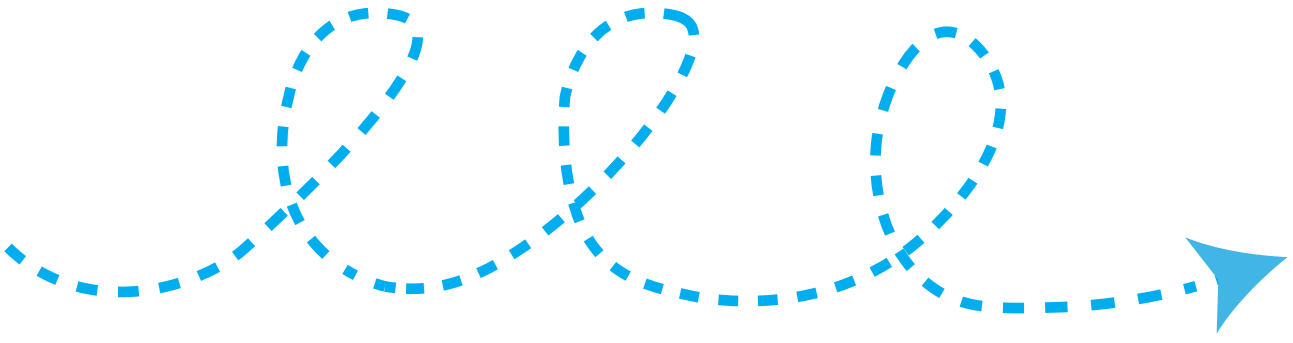
88.2% less likely to have pedestrian crashes on trails with a sidewalk or wide shoulder compared to trails without (FHWA, 2014)

Urban Suburban Rural

Opportunities for art

$$$ **Medium to high cost range**

INTERSECTION SAFETY



PROHIBITING RIGHT TURNS ON RED

Description: Mounted sign eliminates the right of drivers to make a right turn at a red light. Can be used full-time or under restricted time intervals.

Pictured Above: No Right Turn on Red sign and traffic signal arrow in Jacksonville, FL | News4Jax

Treatment Types

High-End Treatments: No right turn on red electronic and metal signs at all intersections

Medium to Low-Cost Treatments: No right turn on red metal signs at all intersections

Temporary Solutions: Coroplast or homemade no right turn on red signs

Safety Considerations

Together with a leading pedestrian interval, a clearly visible no right turn on red signal change can benefit pedestrians with minimal impacts on traffic.

Locations where children cross and that have substantial pedestrian volumes should have the no right turn on red signal.

44% of fatalities from right turns on red were pedestrians and 10% were bicyclists over an 11 year period in Indiana, Maryland, and Missouri. **Injuries occurred at 100 times the rate of fatalities** in those states between 1989 and 1992. (NHTSA, 1995)

Urban Suburban Rural

$ **Low cost range**

SIGNAL TIMING MODIFICATIONS

Description: Traffic signal timing modifications can either reduce pedestrians' waiting times at the crosswalk or extend the time they have to cross through:

- Timing Modifications: Adjustments of existing signal timings to more readily accommodate all modes and users of all ages and abilities.
- Leading Pedestrian Interval (LPI): Pedestrians' countdown signal begins a few seconds in advance of the light change for cars so that people walking are more visible to drivers making turns.
- Pedestrian Scramble: Pedestrians can cross the intersection diagonally or laterally while all cars are stopped.

Pictured Above: This hopscotch game was painted to make crossing times more interactive in Baltimore, MD. Leading pedestrian intervals give pedestrians an advanced countdown of the seconds they have to cross an intersection. | Graham Coreil-Allen

Treatment Types

High-End Treatments: Pedestrian Scramble (also known as the Barnes' Dance) with crossing guards, public art

Medium Treatments: Leading Pedestrian Interval

Low-Cost Treatments: Signal timing modifications

Temporary Solutions: Crossing guards and traffic control officers to direct pedestrian crossings

Safety Considerations

Ensure visibility of pedestrian countdown timers and signs.

Adjust signal countdown timers for children, elderly pedestrians, and persons with disabilities to account for slower walking speeds, estimated to be three feet per second or slower (MUTCD Section 4E.06).

50% average decrease in pedestrian crashes after pedestrian crossing times were increased in a study of 244 intersections in New York City. (FHWA, 2014)

Urban Suburban Rural

Opportunities for art

$$$ **Medium to high cost range**

REFERENCES

Portland, OR | Greg Raisman via Flickr

- **Bike to Books Bicycle Lane Design Contest in Portland, OR**: https://www.portland.gov/transportation/safe-routes-school/bike-books-digital-design-contest
- **Fehr and Peers on the efficacy of Safety Countermeasures**: https://www.fehrandpeers.com/wp-content/uploads/2020/03/NACTO_SafetyEfficacyGuide_2018.pdf
- **FHWA Guidance on MUTCD compliant crosswalk treatments**: https://mutcd.fhwa.dot.gov/resources/interim_approval/ia11/informationalbrief/informationalbrief.pdf
- **FHWA Guidance on Safety Countermeasures**: http://www.pedbikesafe.org/
- **FHWA Manual of Uniform Traffic Control Devices (MUTCD) FAQ page**: https//mutcd.fhwa.dot.gov/kno-faq.htm
- **FHWA Safe Transportation for Every Pedestrian (STEP) technical guidance**: https://safety.fhwa.dot.gov/ped_bike/step/resources/
- **Global Designing Cities Initiative, "Designing Streets for Kids"**: https://globaldesigningcities.org/wp-content/uploads/guides/designing-streets-for-kids-lowres.pdf
- **National Cooperative Highway Research Program (NCHRP) Report #926: "Guidance to Improve Pedestrian and Bicyclist Safety at Intersections"**: https://www.nap.edu/read/25808/chapter/13#111
- **People for Bikes Inventory of Protected Bike Lanes**: https://peopleforbikes.org/green-lane-project/inventory-protected-bike-lanes/
- **Seattle Community Crosswalks Program**: http://www.seattle.gov/transportation/projects-and-programs/programs/pedestrian-program/community-crosswalks
- **Street Plans Collaborative "Tactical Urbanist's Guide to Materials and Design"**: https://issuu.com/streetplanscollaborative/docs/tu-guide_to_materials_and_design_v1/40
- **Syracuse Metropolitan Transportation Council (SMTC) white paper on the MUTCD and public art**: https://smtcmpo.org/wp-content/uploads/2019/12/Community-Streets-White-Paper.pdf
- **Parking Sign design templates**: https://toparkornottopark.com/about
- **University of North Carolina (UNC) Chapel Hill's repository of transportation safety research and case studies**: http://www.pedbikeinfo.org/topics/designengineering.cfm
- **University of North Carolina (UNC) Chapel Hill's repository of policies supporting pedestrian and bicycle transportation during COVID-19**: http://pedbikeinfo.org/resources/resources_details.cfm?id=5209