Ozarks Transportation Organization (OTO) Safety Toolkit

Ways to reduce crashes and keep our communities safe

Sources: U.S. Department of Transportation Federal Highway Administration, National Highway Traffic Safety Administration, NACTO, Caltrans

Images: Wikipedia, Texas A&M Transportation Institute, LH6, City of Kirkwood, Nevada DOT, NACTO, Unsplash, Florin Roebig Trial Attorneys, WGI, Inclusivity City Maker, Street Light Data, Sagacom, ABC27, CDN, Wikimedia, CMT, Wired, Regina, NYC Street Design, PGA Design, Journal & Courier, Boston Globe, 1st State Bikes, Cuyahogacms, UT Dallas, EW Scripps, Vecteezy, Beta-Inc, Advanced Pavement Marking, Donegal Construction, Virginia DOT, FGBLawfirm, CNU, Wallpapers, Wikipedia

Introduction

Ensuring safety within local transportation systems is paramount for the well-being of all road users, including cyclists, drivers, pedestrians, and wheelchair users. The OTO Safety Toolkit provides crucial insights and actionable strategies to enhance transportation safety and accessibility. This guide highlights the importance of targeted interventions to address specific safety challenges and reduce risks effectively. Implementing evidence-based countermeasures can significantly improve the safety and inclusivity of transportation networks, fostering a more secure environment for everyone in the community.

Legend

TARGETED USER


Vehicle


Bicycle


Pedestrian


Wheelchair

COST

$$\$\$\$\$$$ Less than $100k

$$\$\$\$\$$$ $100k - $500k

$$\$\$\$\$$$ $500k - $1M

$$\$\$\$\$$$ $1M+

SYSTEMIC APPLICATIONS

Appropriate for Systemic Applications

Table of Contents

Automated Enforcement

PURPOSE

Agencies can use speed safety cameras (SSCs) as an effective and reliable technology to supplement more traditional methods of enforcement, engineering measures, and education to alter the social norms of speeding.

DESCRIPTION

SSCs use speed measurement devices to detect speeding and capture photographic or video evidence of vehicles that are violating a set speed threshold.

APPLICABLE LOCATIONS

Agencies should conduct a network analysis of speeding-related crashes to identify locations to implement SSCs. The analysis can include scope (e.g., widespread, localized), location types (e.g., urban/suburban/rural, work zones, residential, school zones), roadway types (e.g., expressways, arterials, local streets), times of day, and road users most affected by speed-related crashes (e.g., pedestrians, bicyclists).

The applicability of SSCs in Missouri is subject to local ordinance. For state owned roadways, guidance is found in the MoDOT Engineering Policy Guide (EPG) 950 Automated Traffic Enforcement.

SAFETY BENEFITS

Fixed units can reduce crashes on urban principal arterials up to 54% for all crashes and 47% for injury crashes.

Point-to-point (P2P) units can reduce crashes on urban expressways, freeways, and principal arterials up to 37% for fatal and injury crashes.

Mobile units can reduce crashes on urban principal arterials up to 20% for fatal and injury crashes.

In New York City, fixed units reduced speeding in school zones up to 63% during school hours.

SSCs can produce a crash reduction upstream and downstream, thus generating a spillover effect.

DESIGN CONSIDERATIONS

Public trust is essential for any type of enforcement. With proper controls in place, SSCs can offer fair and equitable enforcement of speeding, regardless of driver age, race, gender, or socio-economic status. SSCs should be planned with community input and equity impacts in mind.

Using both overt (i.e., highly visible) and covert (i.e., hidden) enforcement may encourage drivers to comply with limits everywhere, not only at sites they are aware are enforced.

MORE INFORMATION

Bicycle Lanes

PURPOSE

Aligns with the Safe Systems Approach principle of recognizing human vulnerability and separates users in space.

DESCRIPTION

Bicycle facilities can mitigate or prevent interactions, conflicts, and crashes between bicyclists and motor vehicles, and create a network of safer roadways for bicycling.

APPLICABLE LOCATIONS

New roads/existing roads through modifications. Bicycle facilities can be appropriate within various roadway contexts however, roadway context determines the appropriate facility type and design.

SAFETY BENEFITS

Converting traditional or flush buffered bicycle lanes to a separated bicycle lane with flexible delineator posts can reduce crashes up to 53% for bicycle/vehicle crashes

Bicycle lane additions can reduce crashes up to 49% for total crashes on urban 4-lane undivided collectors and local roads

30% reduction for total crashes on urban 2-lane undivided collectors and local roads

DESIGN GUIDANCE CONSIDERATIONS

In order to maximize a roadway's suitability for riders of all ages and abilities, bicycle lane design should vary according to roadway characteristics (number of lanes, motor vehicle and truck volumes, speed, presence of transit), user needs (current and forecasted ridership, types of bicycles and micromobility devices in use within the community, role within the bicycling network), and land-use context (adjacent land uses, types and intensity of conflicting uses, demands from other users for curbside access). Separated bicycle lanes are recommended on roadways with higher vehicle volumes and speeds, such as arterials.

City and State policies may require minimum bicycle lane widths, although desirable bicycle lane widths can differ by agency and functional classification of the road, current and forecasted bicycle volumes, and contextual attributes such as topography. Studies have found that roadways did not experience an increase in crashes or congestion when travel lane widths were decreased to add a bicycle lane.

Studies and experience in U.S. cities show that bicycle lanes increase ridership and may help jurisdictions better manage roadway capacity.

In rural areas, rumble strips can negatively impact bicyclists' ability to ride if not properly installed. Agencies should consider the dimensions, placement, and offset of rumble strips when adding a bicycle lane.

Bicycle lanes should be considered on roadways where adjacent land use suggests that trips could be served by varied modes, particularly to meet the safety and travel needs of low-income populations likely to use bicycles to reach essential destinations.

MORE INFORMATION

Corridor Access Management

PURPOSE

Thoughtful access management along a corridor can simultaneously enhance safety for all modes, facilitate walking and biking, and reduce trip delay and congestion.

DESCRIPTION

Access management refers to the design, application, and control of entry and exit points along a roadway. This includes intersections with other roads and driveways that serve adjacent properties.
The following access management strategies can be used individually or in combination with one another:

- Reduce density through driveway closure, consolidation, or relocation.
- Manage spacing of intersection and access points.
- Limit allowable movements at driveways (such as right-in/right-out only).
- Place driveways on an intersection approach corner rather than a receiving corner, which is expected to have fewer total crashes.
- Implement raised medians that preclude across-roadway movements.
- Utilize designs such as roundabouts or reduced left-turn conflicts (such as restricted crossing U-turn, median U-turns, etc.).
- Provide turn lanes (i.e., left-only, right-only, or interior two-way left).
- Use lower speed one-way or two-way off-arterial circulation roads.

APPLICABLE LOCATIONS

Every intersection, from a signalized intersection to an unpaved driveway, has the potential for conflicts between vehicles, pedestrians, and bicyclists. The number and types of conflict points—locations where the travel paths of two users intersect—influence the safety performance of the intersection or driveway.

SAFETY BENEFITS

Reducing driveway density 5-23% reduction in total crashes along 2-lane rural roads

25-31% reduction in fatal and injury crashes along urban/suburban arterials.

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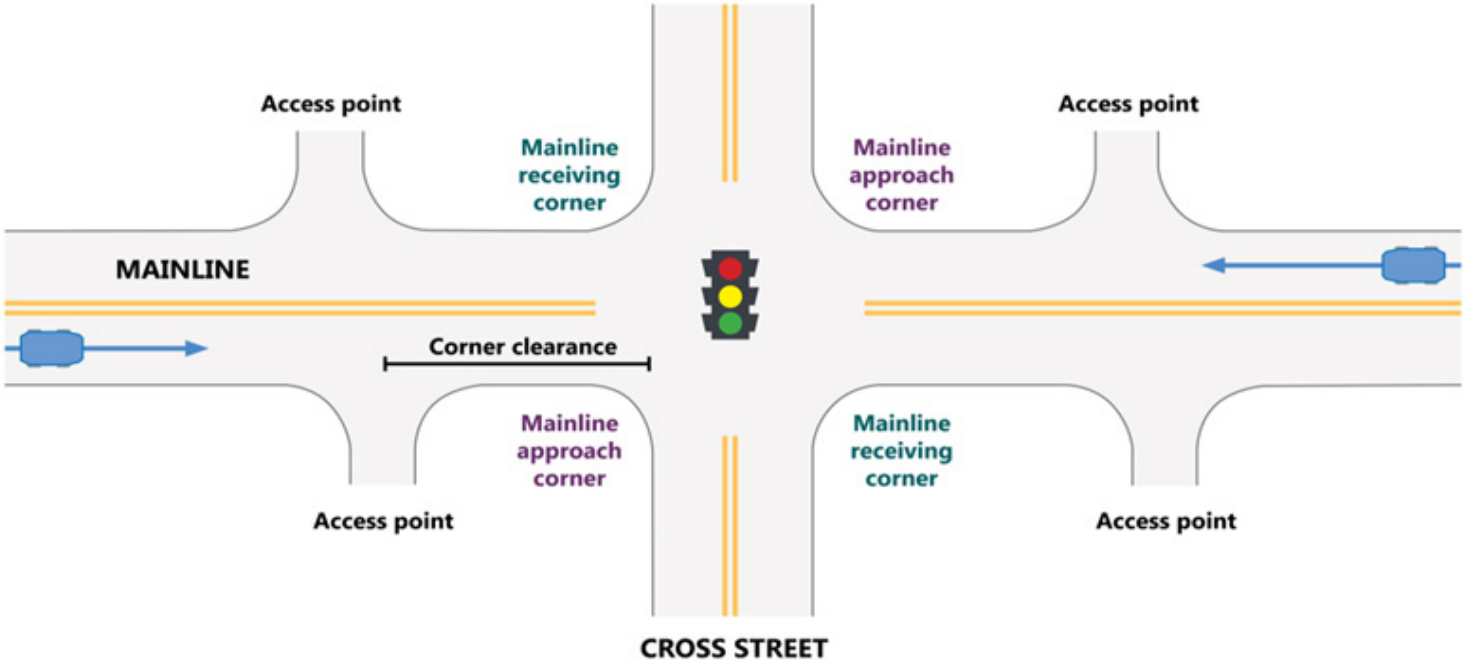
MORE INFORMATION


Access point
Mainline receiving corner
Mainline approach corner
Access point
MAINLINE
Corner clearance
Mainline approach corner
Mainline receiving corner
Access point
Access point
CROSS STREET

Crosswalk Enhancements

DESCRIPTION

Poor lighting conditions, obstructions such as parked cars, and horizontal or vertical roadway curvature can reduce visibility at crosswalks, contributing to safety issues. For multilane roadway crossings where vehicle volumes are in excess of 10,000 Average Annual Daily Traffic (AADT), a marked crosswalk alone is typically not sufficient. Under such conditions, more substantial crossing improvements could prevent an increase in pedestrian crash potential.

APPLICABLE LOCATIONS

Mid-block crossings and intersections.

DESIGN CONSIDERATIONS

High-visibility crosswalks use patterns (i.e., bar pairs, continental, ladder) that are visible to both the driver and pedestrian from farther away compared to traditional transverse line crosswalks. Agencies should use materials such as inlay or thermoplastic tape, instead of paint or brick, for high reflectivity and durability. High visibility crosswalks should be considered at all midblock pedestrian crossings and uncontrolled intersections. These improvements can reduce pedestrian injury crashes up to 40%.

IMPROVED LIGHTING

The goal of crosswalk lighting should be to illuminate with positive contrast to make it easier for a driver to visually identify the pedestrian. This involves carefully placing the luminaires in forward locations to avoid a silhouette effect of the pedestrian.

76% of pedestrians were killed in collisions that occurred when it was dark, with another 4% occurring during dusk or dawn (Schneider, 2020). Retting (2021) notes that during the years 2010-2019 —a time when pedestrian fatalities have been increasing—the number of pedestrian fatalities that occurred in the dark increased by 58%, while daylight fatalities increased by 16%.

ENHANCED SIGNING AND PAVEMENT MARKINGS

On multilane roadways, agencies can use "YIELD Here to Pedestrians" or "STOP Here for Pedestrians" signs 20 to 50 feet in advance of a marked crosswalk to indicate where a driver should stop or yield to pedestrians. To supplement the signing, agencies can also install a STOP or YIELD bar pavement markings. In-street signing, such as "STOP Here for Pedestrians" or "YIELD Here to Pedestrians" may be appropriate on roads with two- or three-lane roads where speed limits are 30 miles per hour or less.

MORE INFORMATION

Curb Extensions

PURPOSE

Curb extensions visually and physically narrow the roadway, creating safer and shorter crossings for pedestrians while increasing the available space for street furniture, benches, plantings, and street trees

DESCRIPTION

Curb extensions involves extending the curb into the street, decreasing roadway space and increasing pedestrian space.

APPLICABLE LOCATIONS

Curb extensions may be implemented on downtown, neighborhood, and residential streets, large and small.

Mid-block curb extensions, known as pinchpoints or chokers, which may include cut-throughs for bicyclists.

Curb extensions used as gateways to minor streets known as neckdowns.

Offset curb extensions that force vehicles to move laterally, known as chicanes.

Curb extensions at bus (or transit) stops, also known as bus bulbs.

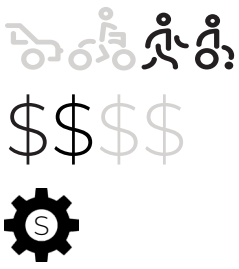
SAFETY BENEFITS

Curb extensions decrease the overall width of the roadway and can serve as a visual cue to drivers that they are entering a neighborhood street or area.

Curb extensions increase the overall visibility of pedestrians by aligning them with the parking lane and reducing the crossing distance for pedestrians, creating more time for preferential treatments such as leading pedestrian interval and transit signal priority.

Used as a bus bulb, curb extensions may improve bus travel times by reducing the amount of time a bus takes to merge with traffic after boarding. Bus bulbs also help to prevent motorists from double parking in the bus stop.

Curb extensions tighten intersection curb radii and encourage slower turning speeds.



DESIGN CONSIDERATIONS

Where application of a curb extension adversely impacts drainage, curb extensions may be designed as edge islands with a 1–2-foot gap from the curb or a trench drain.

Installation of curb extensions may require moving a fire hydrant to maintain adequate curbside access in case of a fire. In such cases, a curb extension may incur additional expense or be reoriented to avoid conflict with the hydrant.

Generally, curb extensions should be designed to be 1-2 feet less than the space provided by the adjacent parking lane.

MORE INFORMATION

Curve Improvements

PURPOSE

Curve improvements aim to enhance road safety by addressing issues that can lead to crashes on curved road segments. Improving the design and visibility of curves helps drivers navigate them more safely, reducing the risk of run-off-road crashes, head-on collisions, and other curve-related crashes.

DESCRIPTION

Curve improvements encompass various measures, including geometric design enhancements, increased signage, improved pavement markings, and the addition of safety features like guardrails and rumble strips. Geometric enhancements might involve adjusting the curve radius, superelevation, and widening the lanes or shoulders to provide more room for maneuvering. Increased signage and pavement markings make curves more visible and provide advance warning to drivers, while guardrails and rumble strips help prevent vehicles from leaving the roadway.

APPLICABLE LOCATIONS

Curve improvements are particularly beneficial on rural roads with sharp or poorly visible curves, urban areas with high traffic volumes, and roadways with a history of curve-related crashes. They are also effective in areas with challenging weather conditions that can reduce visibility and traction, making curves more dangerous.

SAFETY BENEFITS

Curve improvements can significantly reduce the incidence and severity of crashes. Enhancements such as better signage and markings can decrease crash rates by up to 30%, while geometric improvements can lead to a reduction in crashes by up to 50%. Implementing these measures improves overall road safety by ensuring drivers can navigate curves more safely and effectively.

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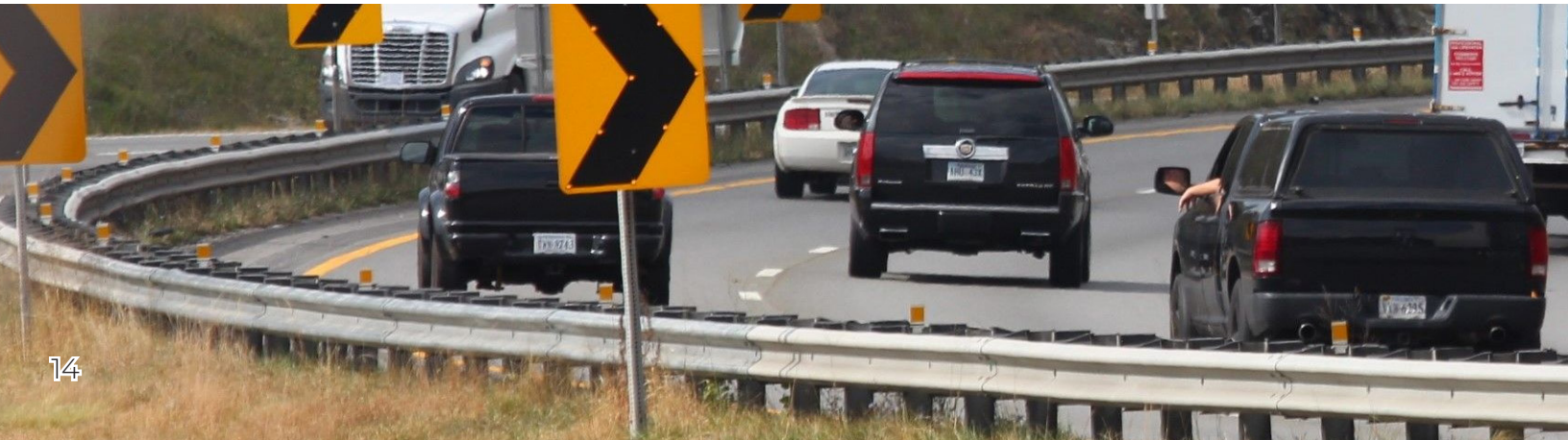
MORE INFORMATION



Dedicated Left- and Right-Turn Lanes at Intersections

PURPOSE

Turn lanes can be designed to provide for deceleration prior to a turn, as well as for storage of vehicles that are stopped and waiting for the opportunity to complete a turn.

DESCRIPTION

Auxiliary turn lanes—either for left turns or right turns—provide physical separation between turning traffic that is slowing or stopped and adjacent through traffic at approaches to intersections.

APPLICABLE LOCATIONS

While turn lanes provide measurable safety and operational benefits at many types of intersections, they are particularly helpful at two-way stop-controlled intersections. Crashes occurring at these intersections are often related to turning maneuvers .

Installing left-turn lanes and/or right-turn lanes should be considered for the major road approaches for improving safety at both three- and four-leg intersections with stop control on the minor road, where significant turning volumes exist, or where there is a history of turn-related crashes. Pedestrian and bicyclist safety and convenience should also be considered when adding turn lanes at an intersection. Specifically, offset left- and right-turn lanes will lengthen crossing distances for pedestrians.

SAFETY BENEFITS

Left-Turn Lanes saw a 28-48% reduction in total crashes. Right-Turn Lanes saw a 14-26% reduction in total crashes.

MORE INFORMATION

Dilemma Zone Detection

PURPOSE

The dilemma zone, where drivers may be unsure whether to stop or proceed during a yellow traffic signal, can significantly increase the risk of accidents at signalized intersections. This uncertainty can lead to rear-end collisions, red-light running, and other types of intersection-related crashes.

Dilemma Zone Detection systems are designed to enhance driver decision-making and improve safety by detecting vehicles approaching an intersection and adjusting the signal timing to mitigate the risks associated with the dilemma zone.

DESCRIPTION

Dilemma Zone Detection systems use advanced sensor technology, such as radar or inductive loop detectors, to monitor vehicle speed and location as they approach an intersection. When a vehicle is detected within the dilemma zone, the system can extend the green signal phase or provide an early warning to drivers about an impending signal change.

This proactive approach helps reduce the occurrence of abrupt stops or dangerous accelerations.

APPLICABLE LOCATIONS

Dilemma Zone Detection systems are particularly effective at intersections with high-speed approaches, typically where speed limits exceed 35 miles per hour.

They are also useful in areas with a high incidence of red-light running or where the timing of traffic signals has been identified as a contributing factor to crashes. Transportation agencies should assess the specific traffic conditions and crash history at each intersection to determine the suitability of Dilemma Zone Detection systems.

SAFETY BENEFITS

Dilemma Zone Detection systems can reduce red-light running and rear-end collisions by up to 39%. They also improve overall intersection safety by optimizing signal timing to account for the varying speeds and behaviors of approaching vehicles.

MORE INFORMATION

Dynamic Speed Monitoring Display

PURPOSE

Dynamic Speed Monitoring Display (DSMD) signs actively manage vehicle speeds through real-time feedback to drivers. By measuring the speed of approaching vehicles and displaying this information on dynamic message displays, DSMD signs encourage drivers to adjust their speed to comply with posted speed limits, ultimately reducing the risk of accidents and improving overall traffic safety.

DESCRIPTION

DSMD signs are advanced traffic control devices that utilize Intelligent Transportation System (ITS) technology. These signs incorporate radar sensors to measure the speed of oncoming vehicles and then relay this information to drivers via dynamic message displays. Positioned alongside standard static regulatory speed limit signs, DSMD signs provide drivers with real-time feedback about their current speed compared to the posted speed limit. This interactive approach aims to encourage drivers to adhere to speed limits and promote safer driving behavior, particularly in areas where speed limits change, such as speed reduction transition zones.Dynamic signs can be used to alert other street users of approaching transit vehicles, and to regulate turns and other movements that are prohibited when transit vehicles are approaching.

APPLICABLE LOCATIONS

DSMD signs are applicable in various locations where managing vehicle speeds is crucial for road safety. These signs are particularly effective in speed reduction transition zones, where speed limits change from higher to lower speeds, such as rural highways entering urbanized areas. Additionally, DSMD signs can be beneficial in residential neighborhoods, school zones, work zones, and areas with high pedestrian activity. They are also useful on roads with frequent speed limit changes, curves, or hazardous conditions, where maintaining appropriate speeds is essential for preventing accidents.

SAFETY BENEFITS

By providing real-time feedback to drivers about their vehicle's speed compared to the posted speed limit, DSMD signs encourage drivers to adjust their speed accordingly, promoting compliance with speed limits and reducing the risk of accidents. These signs are particularly effective in speed transition zones and areas with changing road conditions, where maintaining appropriate speeds is critical for road safety. Additionally, DSMD signs enhance driver awareness and promote safer driving behaviors, contributing to overall improvements in traffic safety on both rural and urban roads.

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MORE INFORMATION

Enhanced Delineation

PURPOSE

Enhanced delineation improves the visibility of road features and boundaries, especially under low visibility conditions such as nighttime, fog, or heavy rain. This can be achieved through various measures like wider edge lines, reflective markers, and improved signage to provide better guidance for drivers, reduce lane departure incidents, and enhance overall road safety.

DESCRIPTION

Enhanced delineation can include increasing the width of edge lines, using reflective pavement markers, installing larger and more reflective signs, and marking high-visibility crosswalks. Wider edge lines, for example, increase visibility and help drivers maintain lane discipline. Reflective pavement markers provide visual and tactile feedback, especially useful at night and in adverse weather conditions. Improved signage ensures critical warnings and guidance are visible from greater distances, while high-visibility crosswalks make pedestrian crossings more noticeable to drivers.

APPLICABLE LOCATIONS

These measures are particularly effective on rural roads where street lighting is minimal, curvy roads needing better navigation aids, high-speed roadways, and intersections or pedestrian crossings requiring enhanced visibility to protect pedestrians and reduce vehicle-pedestrian conflicts.

SAFETY BENEFITS

Enhanced delineation significantly improves road safety by providing clearer guidance and reducing lane departure incidents. For instance, wider edge lines can reduce total crashes by up to 15% and fatal or injury crashes by up to 30%. Reflective pavement markers can decrease nighttime crashes by up to 40%, while improved signage and delineators enhance driver awareness and reaction times, leading to fewer crashes.

MORE INFORMATION

High Friction Surface Treatments

PURPOSE

High Friction Surface Treatments (HFST) are applied to road surfaces to significantly improve pavement friction and enhance vehicle traction, especially in areas prone to skidding and slipping. These treatments are designed to reduce crashes, particularly on curves, ramps, intersections, and areas with steep grades.

DESCRIPTION

HFST involves applying a layer of high-quality, durable aggregate to the road surface using a strong polymer binder. This creates a textured surface with significantly higher friction than standard pavement. The treatment is particularly effective in locations where vehicles are prone to losing control due to sharp turns, wet conditions, or high traffic volumes.

APPLICABLE LOCATIONS

Curves: Where vehicles are more likely to skid due to the change in direction.

Intersections: Where stopping distances are crucial, and vehicles often need to brake suddenly.

Steep grades: Where vehicles can lose control due to gravity and wet conditions.

Pedestrian crossings: To enhance safety for pedestrians by ensuring vehicles can stop more quickly.

SAFETY BENEFITS

Studies have shown that HFST can reduce total crashes by up to 52% and wet weather crashes by up to 83%. By providing enhanced friction, these treatments help reduce the risk of run-off-road incidents, rear-end collisions, and intersection-related crashes.

MORE INFORMATION

Improved Right Turn Angle

PURPOSE

Improving the right turn angle at intersections aims to enhance safety and efficiency for vehicles making right turns. By optimizing the turn angle, drivers can maintain better control and visibility, reducing the likelihood of collisions and near-misses with other vehicles, pedestrians, and cyclists.

DESCRIPTION

Improving the right turn angle involves redesigning the intersection geometry to create a sharper, more perpendicular right turn rather than a sweeping, high-speed turn. This can be achieved by adjusting the curb radius, implementing curb extensions, or adding channelization islands. The goal is to reduce the speed of turning vehicles, improve sightlines, and encourage drivers to make safer, more deliberate turns.

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APPLICABLE LOCATIONS

Enhanced right turn angles are beneficial at:

- Urban intersections: Where pedestrian and bicycle activity is high, and slower vehicle speeds improve safety.
- Suburban and rural intersections: Where right turn speeds are typically higher, increasing the risk of run-off-road crashes.
- High-crash intersections: Locations with a history of right-turn-related collisions.

SAFETY BENEFITS

Improving the right turn angle can significantly reduce crash rates at intersections. Sharper turn angles force drivers to slow down, improving reaction times and reducing the severity of collisions. Enhanced turn geometry also improves sightlines, making it easier for drivers to see oncoming traffic, pedestrians, and cyclists. Research indicates that improving the right turn angle can reduce right-turn-related crashes by up to 50%.

MORE INFORMATION

Intersection Conflict Warning System

PURPOSE

An Intersection Conflict Warning System (ICWS) enhances intersection safety by providing real-time alerts to drivers about potential conflicts with other vehicles. These systems are particularly useful in reducing crashes at intersections, especially where visibility is limited or where high-speed approaches are common.

DESCRIPTION

ICWS uses a combination of sensors, signs, and communication technology to monitor traffic movements and alert drivers to potential conflicts. The system detects vehicles approaching or within the intersection and activates warning signs to alert drivers of cross-traffic. The alerts can be visual (flashing lights or digital message signs) and sometimes auditory, depending on the system design. This increased awareness helps drivers make safer decisions when approaching or navigating intersections.

APPLICABLE LOCATIONS

ICWS is particularly effective at rural intersections with limited visibility, intersections with high-speed approaches, and locations with a history of angle or side-impact collisions. They are also beneficial in areas where traffic volumes are unpredictable or where traditional traffic control measures (like traffic signals) may not be feasible or sufficient.

SAFETY BENEFITS

ICWS can significantly reduce the incidence of intersection-related crashes by improving driver awareness and reaction times. Studies have shown that these systems can reduce total crashes at treated intersections by up to 30%, with notable decreases in severe crashes, such as right-angle collisions. By alerting drivers to potential conflicts, ICWS enhances decision-making and reduces the likelihood of crashes.

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MORE INFORMATION

Leading Pedestrian Interval

PURPOSE

Leading pedestrian intervals (LPI) allow pedestrians to better establish their presence in the crosswalk before vehicles have priority to turn right or left.

DESCRIPTION

A leading pedestrian interval gives pedestrians the opportunity to enter the crosswalk at an intersection 3-7 seconds before vehicles are given a green indication.

For more information: https://highways.dot.gov/sites/fhwa.dot.gov/files/2022-06/fhwasa19040.pdf

APPLICABLE LOCATIONS

Several cities across the U.S. have decided to install LPIs across systems of signalized intersections to improve pedestrian safety.

Agencies prioritize the intersections in places where there are lots of crashes, high pedestrian crossing volumes, and vulnerable populations.

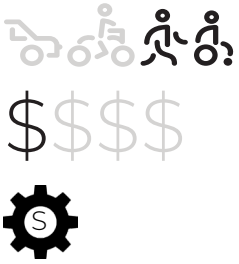
They may be especially useful at one-way streets or at T-intersections.

SAFETY BENEFITS

LPIs provide the following benefits:

- Increased visibility of crossing pedestrians.
- Reduced conflicts between pedestrians and vehicles.
- Increased likelihood of motorists yielding to pedestrians.
- Enhanced safety for pedestrians who may be slower to start into the intersection

Leading pedestrian intervals can create a 13% reduction in pedestrian-vehicle crashes at intersections



MORE INFORMATION


BEER WINE
Norwood
MARKET
5070
ATM
Little Armenia
Hollywood

Median

PURPOSE

Provides separation between opposing vehicle travel lanes, supports improved safety and traffic flow, and creates space for landscaping or visual enhancements.

DESCRIPTION

Area between opposing lanes of traffic, excluding turn lanes. Can be defined by pavement markings, raised medians, or islands.

APPLICABLE LOCATIONS

Mid-block crossings, multilane intersections, and areas near transit stops or other pedestrian-focused sites

SAFETY BENEFITS

46% reduction in pedestrian crashes (median with marked crosswalk)

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MORE INFORMATION

Pedestrian Hybrid Beacon

PURPOSE

The pedestrian hybrid beacon (PHB) is a traffic control device designed to help pedestrians safely cross higher-speed roadways at midblock crossings and uncontrolled intersections.

DESCRIPTION

The beacon head consists of two red lenses above a single yellow lens. The lenses remain ”dark“ until a pedestrian desiring to cross the street pushes the call button to activate the beacon, which then initiates a yellow to red lighting sequence consisting of flashing and steady lights that directs motorists to slow and come to a stop, and provides the right-of-way to the pedestrian to safely cross the roadway before going dark again.

APPLICABLE LOCATIONS

New Roads/Existing roads through modifications

SAFETY BENEFITS

Nearly 74% of pedestrian fatalities occur at non-intersection locations, and vehicle speeds are often a major contributing factor. Pedestrian hybrid beacons also allow motorists to proceed once the pedestrian has cleared their side of the travel lane(s), reducing vehicle delay. 55% reduction in pedestrian crashes, 29% reduction in total crashes, and 15% reduction in serious injury and fatal crashes.

DESIGN GUIDANCE CONSIDERATIONS

In general, PHBs are used where it is difficult for pedestrians to cross a roadway, such as when gaps in traffic are not sufficient or speed limits exceed 35 miles per hour. They are very effective at locations where three or more lanes will be crossed or traffic volumes are above 9,000 annual average daily traffic. Installation of a PHB must also include a marked crosswalk and pedestrian countdown signal. If PHBs are not already familiar to a community, agencies should conduct appropriate education and outreach as part of implementation. If PHBs are not already familiar to a community, agencies should conduct appropriate education and outreach as part of implementation.

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MORE INFORMATION

Pedestrian Refuge Island

PURPOSE

Provides a protected area for pedestrians crossing a road.

DESCRIPTION

A raised median island with a refuge area intended for pedestrians.

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APPLICABLE LOCATIONS

Mid-block crossings, multilane intersections, and areas near transit stops or other pedestrian-focused sites.

SAFETY BENEFITS

56% reduction in pedestrian crashes (Median with Marked Crosswalk)

MORE INFORMATION

Permissive to Protected Left-Turn Signal Phase

PURPOSE

Permissive left turns, where drivers must yield to oncoming traffic and pedestrians, can create safety concerns due to the complexity and judgment required by drivers. Converting permissive left turns to protected left turns, where left-turn movements have a dedicated signal phase without conflicting traffic or pedestrian movements, can enhance safety and reduce collision risks.

DESCRIPTION

Protected left turn phases are implemented through dedicated signal displays, such as a green arrow, indicating that left-turning vehicles have the exclusive right of way. This approach eliminates conflicts with oncoming vehicles and crossing pedestrians during the left-turn movement, thereby reducing the likelihood of crashes.

APPLICABLE LOCATIONS

Protected left turns are particularly beneficial at intersections with high traffic volumes, frequent left-turning movements, or a history of left-turn-related collisions. They are also effective in areas with complex intersection geometries or significant pedestrian activity. Transportation agencies should evaluate traffic conditions, collision history, and intersection layout to determine the need for protected left-turn phases.

SAFETY BENEFITS

Protected left turn phases can significantly reduce the risk of collisions involving left-turning vehicles. Research indicates that converting permissive left turns to protected left turns can reduce left-turn crashes by approximately 50% and improve overall intersection safety.

MORE INFORMATION

Rectangular Rapid Flashing Beacon (RRFB)

PURPOSE

A marked crosswalk or pedestrian warning sign can improve safety for pedestrians crossing the road, but at times may not be sufficient for drivers to visibly locate crossing locations and yield to pedestrians. To enhance pedestrian conspicuity and increase driver awareness at uncontrolled, marked crosswalks, transportation agencies can install a pedestrian actuated Rectangular Rapid Flashing Beacon (RRFB) to accompany a pedestrian warning sign.

DESCRIPTION

RRFBs consist of two, rectangular-shaped yellow indications, each with a light-emitting diode (LED)-array-based light source. RRFBs flash with an alternating high frequency when activated to enhance conspicuity of pedestrians at the crossing to drivers.

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APPLICABLE LOCATIONS

The RRFB is applicable to many types of pedestrian crossings but is particularly effective at multi-lane crossings with speed limits less than 40 miles per hour. Research suggests RRFBs can result in motorist yielding rates as high at 98 percent at marked crosswalks, but varies depending on the location, posted speed limit, pedestrian crossing distance, one- versus two-way road, and the number of travel lanes. RRFBs can also accompany school or trail crossing warning signs. Agencies should consult the Manual on Uniform Traffic Control Devices (MUTCD) for more information.

SAFETY BENEFITS

RRFBs can reduce crashes up to 47% for pedestrian crashes. RRFBs can increase motorist yielding rates up to 98%.

MORE INFORMATION

Reduced Left-Turn Conflict Intersections

PURPOSE

These intersections simplify decision-making for drivers and minimize the potential for higher severity crash types, such as head-on and angle.

DESCRIPTION

Reduced left-turn conflict intersections are geometric designs that alter how left-turn movements occur.

The RCUT intersection, also known as a J-Turn, Superstreet, or Reduced Conflict Intersection, modifies the direct left-turn and through movements from cross-street approaches. Minor road traffic makes a right turn followed by a U-turn at a designated location—either signalized or unsignalized—to continue in the desired direction.

The MUT intersection modifies direct left turns from the major approaches. Vehicles proceed through the main intersection, make a U-turn a short distance downstream, followed by a right turn at the main intersection.

APPLICABLE LOCATIONS

The RCUT is suitable for and adaptable to a wide variety of circumstances, ranging from isolated rural, high-speed locations to urban and suburban high-volume, multimodal corridors. It is a competitive and less costly alternative to constructing an interchange. RCUTs work well when consistently used along a corridor, but also can be used effectively at individual intersections.

The MUT is an excellent choice for intersections with heavy through traffic and moderate left-turn volumes.

SAFETY BENEFITS

Studies have shown that installing an RCUT can result in a 30% increase in throughput and a 40% reduction in network intersection travel time.

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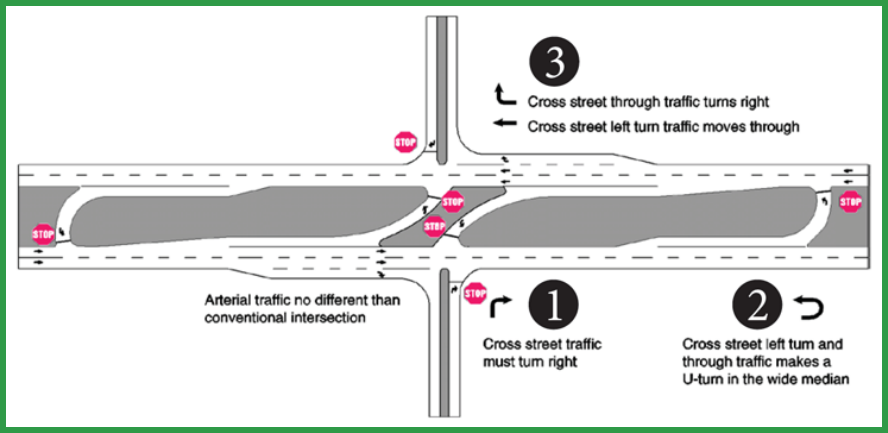
MORE INFORMATION



Retroreflective Backplates

PURPOSE

Backplates with retroreflective borders improve the visibility of the illuminated face of the signal. Signal heads that have backplates equipped with retroreflective borders are more visible and conspicuous in both daytime and nighttime conditions.

This treatment is recognized as a human factors enhancement of traffic signal visibility, conspicuity, and orientation for both older and color vision deficient drivers. This countermeasure is also advantageous during periods of power outages when the signals would otherwise be dark, providing a visible cue for motorists to stop at the intersection ahead.

DESCRIPTION

Backplates added to a traffic signal head introduce a controlled-contrast background. The improved visibility of a signal head with a backplate is made even more conspicuous by framing it with a 1- to 3-inch yellow retroreflective border.

APPLICABLE LOCATIONS

The most efficient means of implementing this proven safety countermeasure is to adopt it as a standard treatment for signalized intersections across a jurisdiction or State.

SAFETY BENEFITS

15% reduction in total crashes

MORE INFORMATION

Road Diet

PURPOSE

A Road Diet, or roadway reconfiguration, can improve safety, calm traffic, provide better mobility and access for all road users, and enhance overall quality of life. They may be a low-cost way to reduce an overbuilt street that suggests high speeds to drivers and provide more space for walking, bicycling, and for drivers who need to park their vehicles.

DESCRIPTION

A Road Diet typically involves decreasing the number of lanes in a roadway. This can be achieved by adding sidewalks, cycle lanes, center turn lanes, or otherwise decreasing the number of car lanes.

APPLICABLE LOCATIONS

A Road Diet can be a low-cost safety solution when planned in conjunction with a simple pavement overlay, and the reconfiguration can be accomplished at no additional cost. Typically, a Road Diet is implemented on a roadway with a current and future average daily traffic of 25,000 or less.

SAFETY BENEFITS

4-lane to 3-lane road diet conversions can have a 19-47% reduction in total crashes. Benefits of Road Diet installations may include:

- Reduction of rear-end and left-turn crashes due to the dedicated left-turn lane.
- Reduced right-angle crashes as side street motorists cross three versus four travel lanes.
- Fewer lanes for pedestrians to cross.
- Opportunity to install pedestrian refuge islands, bicycle lanes, on-street parking, or transit stops.
- Traffic calming and more consistent speeds.

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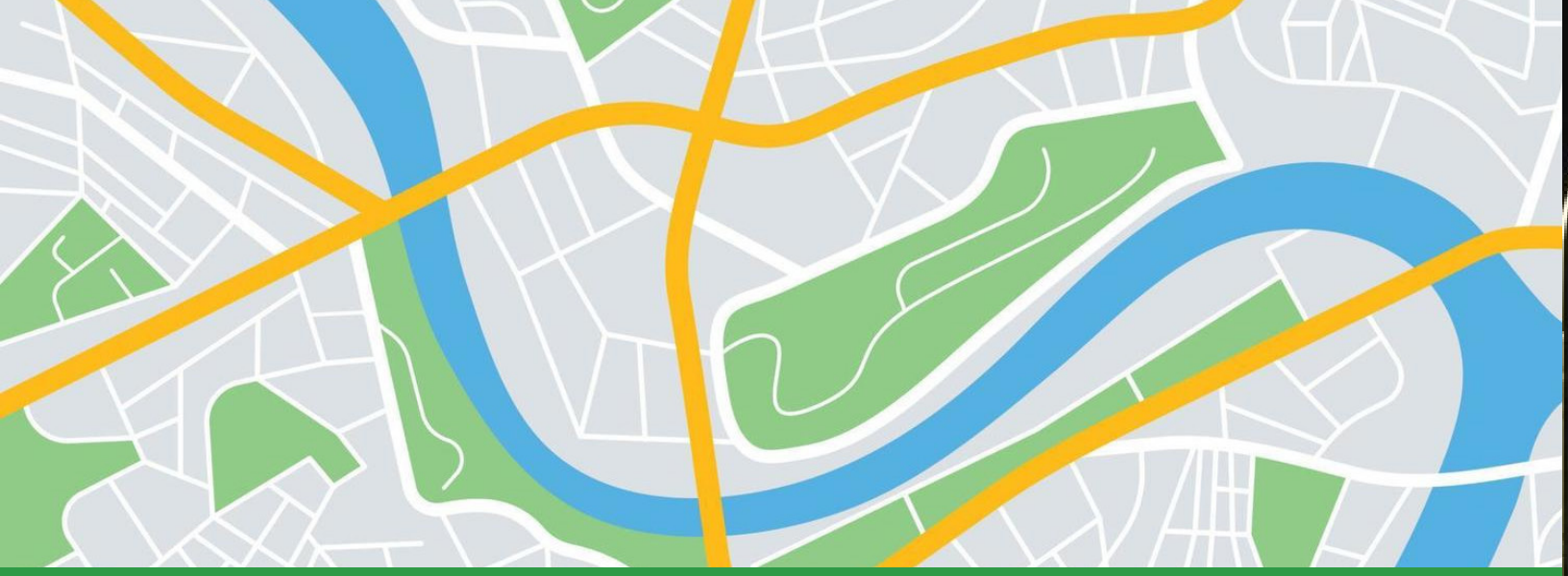
MORE INFORMATION



Road Safety Audit

PURPOSE

A Road Safety Audit (RSA) is a proactive safety management tool designed to identify and address potential road safety issues in existing or planned road projects. Conducted by an independent, multidisciplinary team, RSAs aim to enhance road safety by providing recommendations for improvements before crashes occur.

DESCRIPTION

RSAs involve a systematic examination of road safety aspects, focusing on factors such as road design, traffic flow, signage, and environmental conditions. The process includes data collection, field reviews during different times and conditions, and analysis to pinpoint areas of concern. The findings are compiled into a report with recommendations for safety improvements. Follow-up actions involve implementing these recommendations and monitoring their effectiveness over time.

APPLICABLE LOCATIONS

RSAs can be conducted at any stage of a road project's lifecycle, including planning and design phases, during construction, or on existing roads. They are particularly useful for high-risk areas such as intersections, school zones, and locations with a history of frequent or severe crashes.

SAFETY BENEFITS

RSAs significantly improve road safety by proactively identifying and mitigating hazards. Implementing RSA recommendations can reduce crash rates by up to 60%, identifying cost-effective safety improvements that can be quickly implemented to prevent crashes and save lives.

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MORE INFORMATION

Roadway Lighting

PURPOSE

Roadway lighting improves visibility for drivers, pedestrians, and cyclists during nighttime and low-light conditions, reducing the likelihood of crashes and enhancing overall road safety. Proper illumination helps road users see obstacles, road geometry, signs, and each other more clearly, leading to safer navigation and decision-making.

DESCRIPTION

Roadway lighting involves installing lights along roadways, at intersections, pedestrian crossings, and other critical points to ensure adequate visibility. These installations can include streetlights, illuminated signs, and enhanced lighting at high-risk locations. The design of roadway lighting considers factors such as light intensity, placement, uniformity, and glare control to optimize visibility without causing visual discomfort to road users.

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APPLICABLE LOCATIONS

Urban and suburban areas: To enhance visibility in densely populated regions with high pedestrian and vehicular traffic.

Rural roads: Where natural light is minimal, and there are fewer ambient light sources.

Intersections and crosswalks: To improve safety where pedestrians and vehicles interact.

High-crash locations: Areas with a history of nighttime crashes benefit significantly from enhanced lighting.

Safety Benefits

Improved roadway lighting can lead to a substantial reduction in crashes. Studies have shown that roadway lighting can reduce nighttime crashes by 30% to 50%. Enhanced visibility helps drivers detect hazards sooner, improves reaction times, and reduces the likelihood of collisions. Effective lighting also improves pedestrian safety by making them more visible to drivers.

MORE INFORMATION

Roundabouts

PURPOSE

Roundabouts feature channelized, curved approaches that reduce vehicle speed, entry yield control that gives right-of-way to circulating traffic, and counterclockwise flow around a central island that minimizes conflict points. The net result of lower speeds and reduced conflicts at roundabouts is an environment where crashes that cause injury or fatality are substantially reduced.

DESCRIPTION

The modern roundabout is an intersection with a circular configuration that safely and efficiently moves traffic.

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APPLICABLE LOCATIONS

Roundabouts can be implemented in both urban and rural areas under a wide range of traffic conditions. They can replace signals, two-way stop controls, and all-way stop controls. Roundabouts are an effective option for managing speed and transitioning traffic from high-speed to low-speed environments, such as freeway interchange ramp terminals, and rural intersections along high-speed roads.

SAFETY BENEFITS

Roundabouts are not only a safer type of intersection; they are also efficient at keeping people moving. Even while calming traffic, they can reduce delay and queuing when compared to other intersection alternatives. Furthermore, the lower vehicular speeds and reduced conflict environment can create a more suitable environment for walking and bicycling.

MORE INFORMATION

Rumble Strips

PURPOSE

Rumble strips are designed to alert inattentive drivers through vibration and sound when they depart from their travel lane. These safety features can prevent roadway departure crashes, including run-off-road and head-on collisions. There are three main types of rumble strips: shoulder rumble strips, centerline rumble strips, and transverse rumble strips.

DESCRIPTION

Shoulder Rumble Strips: Installed on the shoulder of the roadway to alert drivers when they are leaving the travel lane. These are typically found on rural highways.

Centerline Rumble Strips: Placed along the centerline of two-lane roads to reduce head-on collisions and opposite-direction sideswipe crashes.

Transverse Rumble Strips: Installed across the travel lane to alert drivers of upcoming changes in the road, such as stop signs, toll booths, or sharp curves.

APPLICABLE LOCATIONS

Rumble strips are particularly effective in:

Rural highways: Where there is a higher risk of run-off-road crashes.

Two-lane roads: Where head-on collisions and opposite-direction sideswipe crashes are a concern.

Approaches to intersections: To alert drivers of an upcoming stop or change in road conditions.

High-speed roadways: Where driver inattention or drowsiness is a significant concern.

SAFETY BENEFITS

Shoulder Rumble Strips can reduce run-off-road crashes by 29-51%.
Centerline Rumble Strips: Can reduce head-on collisions and opposite-direction sideswipe crashes by 44-64%.
Transverse Rumble Strips: Effectively reduce vehicle speeds and improve driver awareness at critical points on the road.

MORE INFORMATION

Shared Use Path

PURPOSE

Shared use paths provide a safe, dedicated space for non-motorized users, such as pedestrians, cyclists, and other forms of micromobility. These paths are designed to separate non-motorized traffic from motor vehicle traffic, reducing conflicts and enhancing safety and accessibility for all users.

DESCRIPTION

A shared use path is a type of infrastructure that is physically separated from motor vehicle traffic by an open space or barrier. These paths are typically at least 10 feet wide to accommodate two-way travel and are used by a variety of non-motorized users, including pedestrians, bicyclists, and skaters. Shared use paths can be located along natural corridors, such as rivers and rail lines, or within urban areas to connect parks, schools, and neighborhoods.

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APPLICABLE LOCATIONS

Shared use paths are suitable for various locations, including urban, suburban, and rural areas. They are particularly effective in:

- Recreational areas, parks, and greenways.
- Corridors with limited space for separate pedestrian and bicycle facilities.
- Routes connecting key community destinations, such as schools, libraries, and shopping areas.
- Areas with high pedestrian and bicycle traffic.

SAFETY BENEFITS

Shared use paths can significantly improve safety by reducing the number of conflict points between motor vehicles and non-motorized users. Research indicates that shared use paths can reduce crashes involving non-motorized users by up to 60%. These paths also encourage active transportation, contributing to public health and reducing traffic congestion.

MORE INFORMATION

Sidewalks

PURPOSE

Defined space for pedestrians.

DESCRIPTION

A walkway is any type of defined space or pathway for use by a person traveling by foot or using a wheelchair. These may be pedestrian walkways, shared use paths, sidewalks, or roadway shoulders.

APPLICABLE LOCATIONS

Well-designed sidewalks improve the safety and mobility of pedestrians. Pedestrians should have direct and connected network of walking routes to desired destinations without gaps or abrupt changes.

Transportation agencies should work towards incorporating pedestrian facilities into all roadway projects unless exceptional circumstances exist. It is important to provide and maintain accessible walkways along both sides of the road in urban areas, particularly near school zones and transit locations, and where there is a large amount of pedestrian activity. Walkable shoulders should also be considered along both sides of rural highways when routinely used by pedestrians.

SAFETY BENEFITS

With more than 6,200 pedestrian fatalities and 75,000 pedestrian injuries occurring in roadway crashes annually, it is important for transportation agencies to improve conditions and safety for pedestrians and to integrate sidewalks more fully into the transportation system. Research shows people living in low-income communities are less likely to encounter sidewalks and other pedestrian-friendly features.

Sidewalks can lead to a 65-89% reduction in crashes involving pedestrians walking along roadways.

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MORE INFORMATION

Signage

PURPOSE

Signs serve a crucial purpose in ensuring the safe and efficient movement of people and vehicles. They provide vital information regarding directions, speed limits, hazards, and regulations, aiding navigation and decision-making for drivers, pedestrians, and cyclists alike. By communicating standardized symbols and messages, signs help to establish order and predictability on roads, highways, railways, and waterways, reducing the risk of accidents and promoting smoother traffic flow. Whether indicating a sharp curve ahead or directing travelers to the nearest exit, the purpose of signs in transportation is ultimately to foster a safer, more organized, and user-friendly environment.

DESCRIPTION

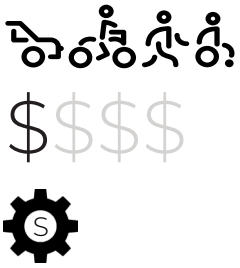
Regulatory signs include those used to communicate required or prohibited movements. Flashing beacons can be used to enhance overhead and other regulatory signage, indicating to drivers and other users when the transit lane is in force. Overhead signs above transit lanes and transitways alert drivers and other street users by placing critical information about lane use in a prominent location. Dynamic signs can be used to alert other street users of approaching transit vehicles, and to regulate turns and other movements that are prohibited when transit vehicles are approaching.

APPLICABLE LOCATIONS

Signage finds application in various settings including highways, roads, and streets. They are often particularly important near intersections and busy areas.

SAFETY BENEFITS

A number of types of signs have been shown to provide safety benefits. For instance, advance yield signs have been shown to be effective in decreasing rear end and sideswipe crashes. Fluorescent curve signs have been shown to reduce crashes during nighttime and at non-intersections.



MORE INFORMATION


Primary School
0.1 MI.
1 MIN.
City Park
2.0 MI.
15 MIN.
Rail Trail
3.0 MI.
20 MIN.

Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections

PURPOSE

This systemic approach to intersection safety involves deploying a package of multiple low-cost countermeasures, including enhanced signing and pavement markings, at a large number of stop-controlled intersections within a jurisdiction. These countermeasures increase driver awareness and recognition of the intersections and potential conflicts.

There are several benefits to systemically applying multiple low-cost countermeasures at stop-controlled intersections, including:

- Resources are maximized because the treatments are low cost.
- A high number of intersections can receive treatment.
- Improvements are highly cost-effective, with an average benefit-cost ratio of 12:1, even assuming a conservative 3-year service life.

DESCRIPTION

On the Through Approach:

- Doubled-up (left and right), oversized advance intersection warning signs, with supplemental street name plaques (can also include flashing beacon).
- Retroreflective sheeting on sign posts.
- Enhanced pavement markings that delineate through lane edge lines.

On the Stop Approach:

- Doubled-up (left and right), oversized advance "Stop Ahead" intersection warning signs (can also include flashing beacon).
- Doubled-up (left and right), oversized Stop signs.
- Retroreflective sheeting on sign posts.
- Properly placed stop bar.
- Removal of vegetation, parking, or obstructions that limit sight distance.
- Double arrow warning sign at stem of T-intersections.

APPLICABLE LOCATIONS

Stop-controlled intersections.

SAFETY BENEFITS

10% reduction of fatal and injury crashes at all locations/types/areas.

15% reduction of nighttime crashes at all locations/types/areas.

27% reduction of fatal and injury crashes at rural intersections.

19% reduction of fatal and injury crashes at 2-lane by 2-lane intersections.

MORE INFORMATION

Vertical Deflections

PURPOSE

Vertical deflections are traffic calming measures designed to reduce vehicle speeds and enhance safety for all road users. These measures include raised intersections, raised crosswalks, speed cushions, and speed tables. Vertical deflections force drivers to slow down, thereby reducing the likelihood and severity of crashes, especially in areas with high pedestrian activity.

DESCRIPTION

Raised Intersections: Entire intersections are elevated to the level of the sidewalk, creating a flat, raised surface that forces vehicles to slow down while also providing a safer crossing environment for pedestrians.

Raised Crosswalks: Pedestrian crossings are elevated above the roadway surface, making pedestrians more visible to drivers and encouraging vehicles to reduce speed as they approach.

Speed Cushions: Rounded, raised areas placed across the roadway, with cutouts for larger vehicles, that reduce vehicle speeds to around 15-20 mph.

Speed Tables: Longer and flatter than speed humps, speed tables can accommodate vehicles at slightly higher speeds (25-30 mph) and are often used in conjunction with pedestrian crossings.

APPLICABLE LOCATIONS

Residential areas: To control speeds and improve safety in neighborhoods.

School zones: To protect children by slowing down traffic near schools.

Urban areas with high pedestrian activity: To enhance pedestrian safety and comfort.

Roadways with documented speeding issues: To address and mitigate speed-related safety concerns.

SAFETY BENEFITS

Vertical deflections are effective in reducing vehicle speeds, which directly contributes to improved safety. Research shows that these measures can reduce crashes by 30-50%. Specifically, speed humps can reduce speeds by approximately 20-25%, and raised crosswalks and intersections can significantly improve pedestrian safety by increasing driver awareness and reducing speeds at critical crossing points.

MORE INFORMATION

Yellow Change Intervals

PURPOSE

Since red-light running is a leading cause of severe crashes at signalized intersections, it is imperative that the yellow change interval be appropriately timed. Too brief an interval may result in drivers being unable to stop safely and cause unintentional red-light running. Too long of an interval may result in drivers treating the yellow as an extension of the green phase and invite intentional red-light running. Factors such as the speed of approaching and turning vehicles, driver perception-reaction time, vehicle deceleration, and intersection geometry should all be considered in the timing calculation.

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DESCRIPTION

At a signalized intersection, the yellow change interval is the length of time that the yellow signal indication is displayed following a green signal indication. The yellow signal confirms to motorists that the green has ended and that a red will soon follow.

APPLICABLE LOCATIONS

Signalized intersections

SAFETY BENEFITS

36-50% reduction in red light running
8-14% reduction in total crashes
12% reduction in injury crashes

MORE INFORMATION

List of Acronyms

SSC	-Speed Safety Camera
P2P	-Point-to-Point type of speed safety camera
AADT	-Average Annual Daily Traffic
DSMD	-Dynamic speed Monitoring Display
HFST	-High Friction Surface Treatment
ICWS	-Intersection Conflict Warning System
LPI	-Leading Pedestrian Interval
PHB	-Pedestrian Hybrid Beacon
RRFB	-Rectangular Rapid Flashing Beacon
RCUT	-Restricted Crossing U-Turn
MUT	-Median U-Turn
RSA	-Road Safety Audit