



Bicycle and Pedestrian Design Guidelines

Presented to: City of Lawrence

Prepared by: TREKK Design Group

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1. Introduction and Objective

Through stakeholder and community engagement processes, the City of Lawrence, Kansas, identified the need to improve pedestrian and bicycle crossings within the City. The transportation planning process developed the [Lawrence Pedestrian Plan](#) and the [Lawrence Bike Plan](#) that supports the ultimate vision outlined for the region in the [Transportation 2040](#) plan. This Bicycle and Pedestrian Design Policy and Guidelines document will build on the existing City of Lawrence Plans and City design standards.

2. Pedestrian and Shared-Use Path Crossings

Pedestrian crossings are often considered the most dangerous movement for the streets' most vulnerable user. The safety of these crossings is impacted by street width, corner radius, sight lines, vehicle volume and speed, lighting, and familiarity of the design. Consistency in design concepts and locations are important to manage expectations for drivers and pedestrians.

In urban settings, crossings should be available every 400 – 600 feet to discourage jaywalking along collector and arterial routes. On local urban streets and rural roads, crosswalks should be placed based on context of the land use. Some specific cases for local streets include small retail centers, schools, and parks.

All pedestrian facilities must comply with the American Disabilities Act (ADA) to ensure all users are able to move safely within the public right-of-way. The ADA Accessibility Guidelines (ADAAG) has been the main tool for state and local governments to ensure compliance. This was supplemented by the Proposed Public Right Of Way Accessibility Guidelines in 2011 to improve ADAAG's guidance for streets, but has never been fully adopted at the federal level. The Kansas Department of Transportation (KDOT) fully adopted PROWAG in 2018 updating all relevant design standards. Municipalities develop transition plans to show a level of investment to comply with ADA requirements over a reasonable period of time.

Shared-use paths function as higher volume pedestrian facilities. The paths must be wide enough to accommodate pedestrians and bicyclists traveling at variable speeds in both directions. This is especially important at street crossings. Each shared-use path crossing should follow pedestrian crossing guidelines for a facility with a higher volume of travel. This includes all recommendations for curb extensions, median refuges, curb ramp widths, signalization, markings, and signage. The high-visibility continental crosswalks on shared use paths are recommended to be a minimum of 12 feet wide to accommodate speedy crossings without conflict in opposing direction.

Signage and markings for pedestrian crossings are governed by the Manual of Uniform Control Devices (MUTCD).

2.1. Pavement Markings

The City of Lawrence uses continental and parallel line style crosswalk markings. All crosswalks must be a minimum of 6 feet wide and the stop bar at least 4 feet from the crossing. Crosswalks should be wider in areas with higher volumes of pedestrian traffic. Standard details for Crosswalks are shown in Figure 2.1.

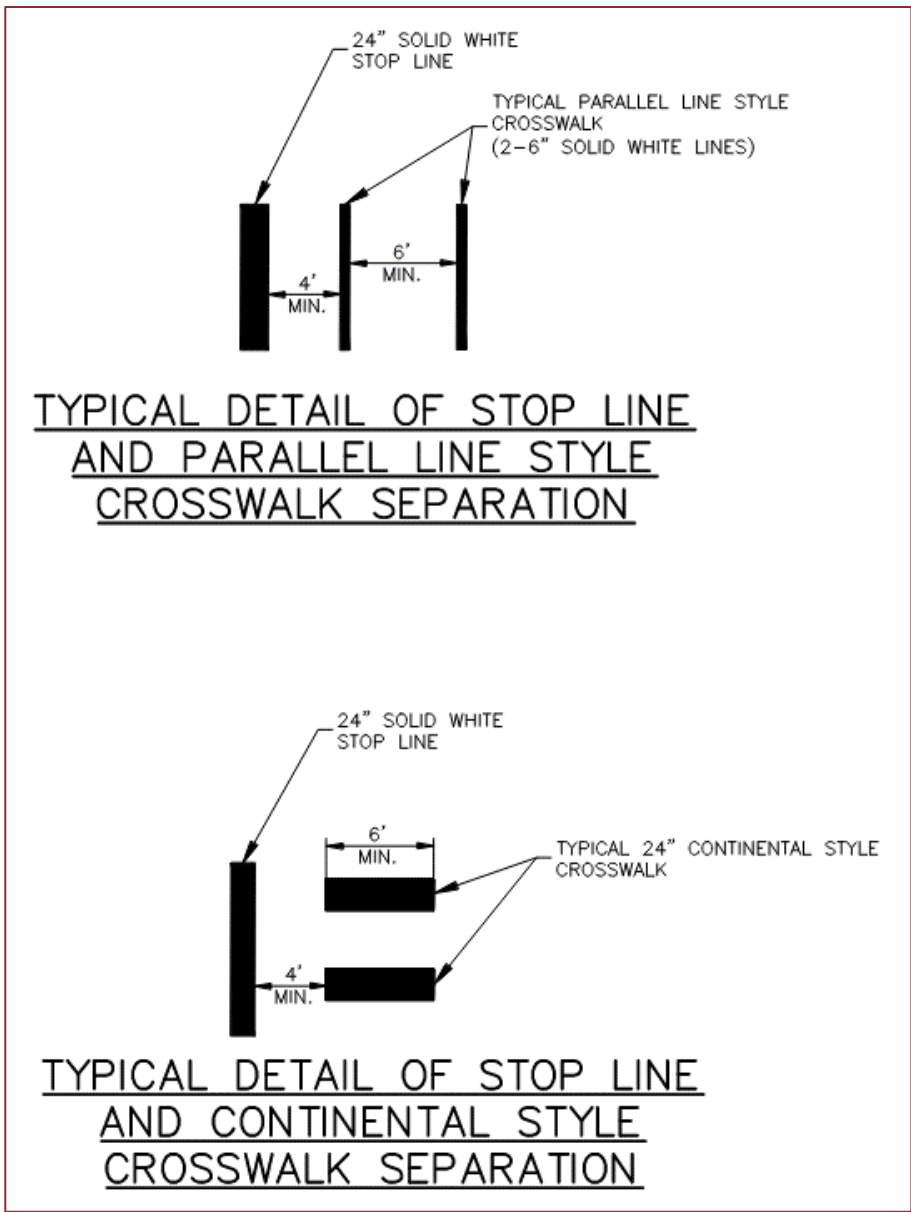


Figure 2-1: Lawrence Crosswalk Standard Details

2.1.1. Intersections

Pedestrian crossings at intersections on high volume roads controlled by stop/yield signs or signal devices should be marked with standard crosswalks. Low volume residential stop/yield control intersections do not require marked crosswalks. The exception to this recommendation is school crosswalks, or other crossings with vulnerable users, where enhanced visibility should be considered by using continental style markings.

The high-visibility continental crosswalks are appropriate for arterial/arterial, arterial/collector, and collector/collector intersections. Arterial/collector corridors with high volumes of turning vehicles to/from local residential streets may be marked with parallel crosswalks to improve visibility. Local intersecting streets operating with signed or signalized control should use parallel crosswalks. The parallel markings should also be used to outline artistic crosswalks. These crossings may be further enhanced with curb extensions and pedestrian refuge islands.

2.1.2. Midblock Crossings

Midblock crossings should be marked with high-visibility continental crosswalks. These crossings are inherently not at expected locations requiring improvements to visibility. Additional improvements which may include signal devices, curb extensions, median refuge islands, and/or raised crosswalks may be applicable based on the street type and volume of vehicles and pedestrians. Guidance on the selection of these treatments is provided in section 2.3 Application of Crossing Treatments.

Stop bars should be placed 4 feet in advance of the mid-block crosswalks for streets that include only one travel lane in each direction. Mid-block crossings for streets with 2 or more travel lanes in each direction should place the stop bar 20 – 50 feet from the crosswalk, and prohibit parking between stop bar and crosswalk, to allow visibility of the pedestrian in both travel lanes.

2.2. Signage

Signage is an important piece of design that helps raise awareness of shifts in roadway functionality and locations of possible conflict. The consistent placement of signage and the frequency of use improves reaction responsiveness of road users. Overuse of signage reduces compliance with signs as roadway users can no longer distinguish the signs at travel speed and the repetitive nature allows the signs to transition to background noise within the visual streetscape.

2.2.1. Intersections

Pedestrian signage for controlled intersections should follow standard recommendations and guidelines included in the MUTCD.

2.2.2. Midblock Crossings

At midblock crossings, pedestrian signage requirements increase based on the speed of vehicular traffic and size of the roadway. All crosswalks at uncontrolled midblock crossings should be marked with a Pedestrian Crossing sign (W11-2) and Diagonal Arrow (W16-7p) at the edge of crosswalk nearest oncoming traffic. A Stop Here for Pedestrians sign (R1-5c) is placed at the stop bar. On streets with higher speeds, greater widths, or poor sight visibility an additional Pedestrian Crossing sign with an Ahead plaque (W16-9P) should be placed to notify oncoming drivers.

2.3. Application of Crossing Treatments

Street crossing designs are impacted by numerous factors. Each crossing is affected by its locations, the surrounding land uses, area context, traffic volumes, vehicular speeds, modal interactions, geometric design, and access control. This section will provide an overview of four tools to determine the appropriate crossing treatments for Pedestrian and Shared-Use Path Crossings.

Guidance on the selection of crossing treatments is currently provided on the Pedestrian Crossing Contextual Guidance table (Figure 2-2) in Appendix A: Bikeway Design Guide (pg. 93) of the Lawrence Bike Plan.

PEDESTRIAN CROSSING CONTEXTUAL GUIDANCE

At Unsignalized Intersections

| FACILITY TYPE | Local Streets 15-25 mph | | Collector Streets 25-30 mph | | | Arterial Streets 30-45 mph | | | | | | | |
|---|----------------------------------|--------|--------------------------------|---------------------------|--------|-------------------------------|---------------------------|--------|--------|---------------------------|--------|--------|---------------------------|
| | 2 lane | 3 lane | 2 lane | 2 lane with median refuge | 3 lane | 2 lane | 2 lane with median refuge | 3 lane | 4 lane | 4 lane with median refuge | 5 lane | 6 lane | 6 lane with median refuge |
| | Crosswalk Only (high visibility) | ✓ | ✓ | EJ | EJ | X | EJ | EJ | X | X | X | X | X |
| Crosswalk with warning signage and yield line | EJ | ✓ | ✓ | ✓ | ✓ | EJ | EJ | EJ | X | X | X | X | X |
| Active Warning Beacon (RRFB) | X | EJ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X | ✓ | X | X | X |
| Hybrid Beacon | X | X | EJ | EJ | EJ | EJ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Full Traffic Signal | X | X | EJ | EJ | EJ | EJ | EJ | EJ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Grade Separation | X | X | EJ | EJ | EJ | X | EJ | EJ | ✓ | ✓ | ✓ | ✓ | ✓ |

| Legend | |
|-----------------------|----|
| Most Desirable | ✓ |
| Engineering Judgement | EJ |
| Not Recommended | X |

Figure 2-2: Lawrence Pedestrian Crossing Contextual Guidance

This table provides open and flexible guidance focusing on how to apply improvements based on facility type and lane configuration. Most situations have multiple possible solutions that would be chosen based on engineering judgment. The adaptability of this table provides a first step during conceptual planning to narrow down the selection of treatments.

The FHWA Safe Transportation for Every Pedestrian (STEP) program includes guides, countermeasure tech sheets, training, and educational tools. The Guide for Improving Pedestrian Safety at Uncontrolled Intersection Crossing Locations provides guidance on the evaluation and application of safety countermeasures to improve pedestrian safety. The guide includes a similar tool to Lawrence’s Contextual Guidance table to help with the selection of the appropriate countermeasures (Figure 2-2).

| Roadway Configuration | Posted Speed Limit and AADT | | | | | | | | |
|--|-----------------------------|---------------------|-------------------|---------------------------|---|-------------------|----------------------|-------------------|-------------------|
| | Vehicle AADT <9,000 | | | Vehicle AADT 9,000–15,000 | | | Vehicle AADT >15,000 | | |
| | ≤30 mph | 35 mph | ≥40 mph | ≤30 mph | 35 mph | ≥40 mph | ≤30 mph | 35 mph | ≥40 mph |
| 2 lanes (1 lane in each direction) | ① 2 4 5 6 | ① 5 6 7 9 | ① 5 6 ⑦ ⑨ | ① 4 5 6 7 9 | ① 5 6 7 9 | ① 5 6 ⑦ ⑨ | ① 4 5 6 7 9 | ① 5 6 7 9 | ① 5 6 ⑨ |
| 3 lanes with raised median (1 lane in each direction) | ① 2 3 4 5 | ① ③ 5 7 9 | ① ③ 5 ⑦ ⑨ | ① 3 4 5 7 9 | ① ③ 5 ⑦ ⑨ | ① ③ 5 ⑦ ⑨ | ① ③ 4 5 7 9 | ① ③ 5 ⑦ ⑨ | ① ③ 5 ⑨ |
| 3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane) | ① 2 3 4 5 6 7 9 | ① ③ 5 6 7 9 | ① ③ 5 6 ⑨ | ① 3 4 5 6 7 9 | ① ③ 5 6 ⑦ ⑨ | ① ③ 5 6 ⑨ | ① ③ 4 5 6 7 9 | ① ③ 5 6 ⑨ | ① ③ 5 6 ⑨ |
| 4+ lanes with raised median (2 or more lanes in each direction) | ① ③ 5 7 8 9 | ① ③ 5 7 8 9 | ① ③ 5 8 9 | ① ③ 5 7 8 9 | ① ③ 5 ⑦ 8 9 | ① ③ 5 8 9 | ① ③ 5 ⑦ 8 9 | ① ③ 5 8 9 | ① ③ 5 8 9 |
| 4+ lanes w/o raised median (2 or more lanes in each direction) | ① ③ 5 6 7 8 9 | ① ③ 5 ⑥ 7 8 9 | ① ③ 5 ⑥ 8 9 | ① ③ 5 ⑥ 7 8 9 | ① ③ 5 ⑥ ⑦ 8 9 | ① ③ 5 ⑥ 8 9 | ① ③ 5 ⑥ ⑦ 8 9 | ① ③ 5 ⑥ 8 9 | ① ③ 5 ⑥ 8 9 |
| <p>Given the set of conditions in a cell,</p> <ul style="list-style-type: none"> # Signifies that the countermeasure is a candidate treatment at a marked uncontrolled crossing location. ● Signifies that the countermeasure should always be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location. ○ Signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.* <p>The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgment.</p> | | | | | <ol style="list-style-type: none"> 1 High-visibility crosswalk markings, parking restrictions on crosswalk approach, adequate nighttime lighting levels, and crossing warning signs 2 Raised crosswalk 3 Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line 4 In-Street Pedestrian Crossing sign 5 Curb extension 6 Pedestrian refuge island 7 Rectangular Rapid-Flashing Beacon (RRFB)** 8 Road Diet 9 Pedestrian Hybrid Beacon (PHB)** | | | | |

Figure 2-3: FHWA Application of Pedestrian Crash Countermeasures by Roadway Feature

This table focuses on the 9 treatments that have shown improvements to pedestrian safety through FHWA research studies. High visibility crosswalks are the only countermeasure that reaches the recommendation level of always being used in certain conditions. The 9 countermeasures are arranged based on Average Annual Daily Traffic (AADT), posted speed limit, and roadway configuration. To further narrow down the selection FHWA also provides Safety Issues Addressed by Countermeasure (Figure 2-4).






































| Pedestrian Crash Countermeasure for Uncontrolled Crossings | Safety Issue Addressed | | | | |
|---|---|---|---|---|---|
| | Conflicts at crossing locations | Excessive vehicle speed | Inadequate conspicuity/visibility | Drivers not yielding to pedestrians in crosswalks | Insufficient separation from traffic |
| Crosswalk visibility enhancement |  |  |  |  |  |
| High-visibility crosswalk markings* |  | |  |  | |
| Parking restriction on crosswalk approach* |  | |  |  | |
| Improved nighttime lighting* |  | |  | | |
| Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line* |  | |  |  |  |
| In-Street Pedestrian Crossing sign* |  |  |  |  | |
| Curb extension* |  |  |  | |  |
| Raised crosswalk |  |  |  |  | |
| Pedestrian refuge island |  |  |  | |  |
| Pedestrian Hybrid Beacon |  |  |  |  | |
| Road Diet |  |  |  | |  |
| Rectangular Rapid-Flashing Beacon |  | |  |  |  |

Figure 2-4: FHWA Safety Issues Addressed by Countermeasure

This table provides additional insight on what safety issues may be addressed by certain countermeasures. When used in conjunction with the previous table the appropriate countermeasure becomes clearer for each location. A specific case would be the decision between a RRFB and PHB on a 3-lane roadway with a median. If there is a history of reported incidents between vehicles and pedestrians and/or bicycles due to excessive speeding at this location the choice would be a PHB. This is backed by research that shows side of the road mounted signage/signal devices do not affect safety outcomes involving high speed driving. This is also true for sight distance improvements, which may encourage a driver to increase their speed. The only effective methods that have been shown to reduce speeding incidents are techniques that require drivers to interact along their path of travel.

To further refine the selection process Figure 2-5 provides technical guidance for the selection of pedestrian signal devices. This tool was developed by the City of Boulder by updating information provided by the MUTCD with observational research findings. The application of this table with the previous tools will provide a uniform and consistent methodology for design for safe crossings at midblock locations.

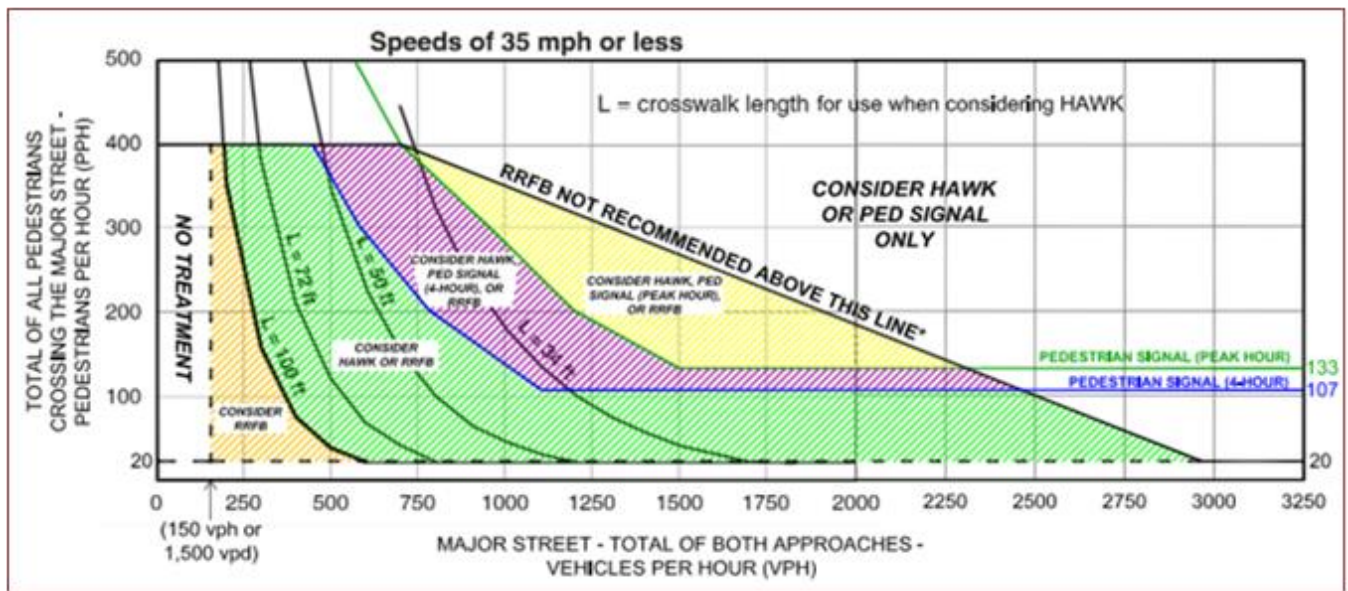


Figure 2-5: Guidelines for the Installation of Pedestrian Signalization Devices

3. On-street Bicycle Facility Crossings

With the growth of bicycling and bicycle infrastructure over the past decade the design of the intersection has become the focus regarding safety. Following this trend, recommended guidelines have been published including Don't Give Up at the Intersection (NACTO), Recommended Design Guidelines to Accommodate Pedestrians and Bicycles at Interchanges (ITE), Guidance to Improve Pedestrian and Bicyclist Safety at Intersections (NHCRP 926), and countless other documents from AASHTO, FHWA, state, and local governments. The main objective of each of these documents is to reduce the speed of all modal interactions, improve sight distance and visibility, and increase awareness of the location of conflict points.

The approach to each intersection varies in design to accommodate the multimodal needs, context, type of bike facility, and availability of space on the street. Most early guidance recommended moving bicyclists to the left of the right turning vehicles using transitions or mixing zones. Bike boxes are another method that places bicyclist in front of vehicles giving them a small head start. Over the past 5 years, cities have begun adopting Dutch cycling principles of offsetting the bicycles to the right of the travel lanes at the intersection. This concept is most prevalent in protected intersection designs that provide a queuing space for turning vehicles to wait for crossing bicyclists and pedestrians and remain out of through traffic.

3.1. On-Street Pavement Markings

On-street Bicycle Pavement markings are an important part of the bike crossing design. Best practice requires the selection of several types of marking to differentiate the volume/risk associated with each crossing. Varying the treatments keeps drivers and bicyclists from becoming complacent seeing the same markings crossing every street. Table 3-1 provides the street markings recommended for Lawrence's bicycle crossings for on-street facilities. Shared use paths should follow the recommendations for pedestrian crossings.

Table 3-1. On-Street Bicycle Crossing Marking Recommendations

| | Arterial | Collector | Major Driveway | Minor Driveway | Local > 40 ft | Local ≤ 40 ft |
|-----------|----------|-----------|----------------|----------------|---------------|---------------|
| Arterial | Green | Green | Green | Chevron | Chevron | None |
| Collector | Green | Chevron | Chevron | None | None | None |
| Local | Green | Dashes | None | None | None | None |

Green: Dashed 2-ft green markings with 6-ft spacing

Chevron: Double chevron at 4-ft width

Dashes: Edge Markings including 2-ft x 4-in white stripes placed every 6-ft

None: Markings are not necessary, due to low volume of conflicting movements and operating speeds

The green bicycle markings will focus along arterial streets concentrating in areas where bicycles interact with a higher volume of motor vehicles. This includes the intersections of two arterials or an arterial with a collector or major driveway. Major driveways will be high trip generators like large box stores, high density shopping centers, and some fast-food chains. Local streets with bike lanes crossing an arterial would also be green, but only local streets, greater than 40-ft wide, will be marked with chevrons on the bike lane along an arterial.

Green markings should also be used in bike boxes and two-stage turn queue boxes on all streets. Bike lanes and cycle tracks, along arterials, should include green paint in shared right turn lanes and mixing zones approaching the intersection. Chevrons or sharrows are suitable for these applications on collector streets.

In shared street configurations bicycle sharrows should be placed in the center of the outside travel lane. For streets with wide outside lanes that allow parking, the sharrow should be placed 12 feet from the curb to allow parking and reduce the possibility of dooring incidents. It is recommended that Streets including sharrows are designed and signed for an operating speed of 25 mph or less.

Reverse angle parking should be placed on any street that includes bike facilities separating the parking from the travel lane. The conventional front-in angled parking reduces sight visibility for the vehicle driver attempting to back out of the parking space. Reorienting the parking allows the driver to see bicyclists in bike lanes and shared lanes that would have been behind the vehicle. Cities across the nation have shown a decrease in overall crashes and almost no pedestrian/bicycle crashes in locations with reverse angle parking.

3.2. Signage

Most bike signs consist of Bike Lane (R3-17) and Bike Route (D11-1) signs which mainly serve as directional guidance to bicyclists and to raise the awareness of vehicle drivers. The MUTCD and numerous supplementary manuals from FHWA, AASHTO, and NACTO provide very clear guidance on the use and placement of signage relating the bicycle facilities.

Shared lanes have two common recommendations for signage; Share the Road (W16-1) and Bikes May Use Full Lane (R4-11). The Share the Road sign is used more frequently but has been attributed to driver misunderstanding and encouragement of unsafe riding practices by bicyclists. Surveys revealed that many drivers thought the Share the Road signs were telling bicyclists to share the road with cars and move to the far right. In some cases, the bicyclist traveling on the right edge of a lane forces them into the gutter pan, dooring zones, or uneven pavement when a car passes too close. The Bikes May Use Full Lane has now become the preferred sign of the bicycle community, informing the driver that bicyclists may ride anywhere in the lane providing them the opportunity to move around obstacles. It is recommended to use the Bikes May Use Full Lane sign on streets with sharrows or residential streets functioning as bicycle boulevards. Share the Road signs are still appropriate for locations that require the mixing of bicycles with automobiles, such as a shared right turn lane approaching an intersection.

The State of Kansas passed a law (House Bill 2192) in 2011 requiring passing vehicles to maintain a minimum 3-foot passing distance. The City of Lawrence may use the KDOT approved sign to raise awareness of the law. These may be placed temporarily along new on-street facilities and permanently at entry points into the city. These signs should be used as an educational tool and not be overused which may detract from the effectiveness of warning and regulatory signage.

4. Signalization Devices and Lighting

There has been a proliferation of signal and detection devices, communication systems, and new operating methodology with the growth of bicycle facilities and refocusing cities on pedestrian travel. To determine the appropriate device for each location it is important to consider the number of crossing pedestrians, length of the crossing, and the speed and volume of vehicles at the crossing. This section provides an overview of accepted signal devices and recommendations for their operation.

4.1. Traffic Signals

4.1.1. Signal Timing

a. Cycle Lengths

A short signal cycle length is preferred in areas with pedestrian traffic and short block lengths. A cycle length of 60 – 90 seconds will reduce pedestrian delays at signals based on typical walking speeds.

b. Pedestrian Crossing Time

The MUTCD recommends a walking speed of 3.5 feet per second to safely cross the street. This is the amount of time assigned to the red flashing hand. In areas with a higher density of older pedestrians, pedestrians with disabilities, and/or small children, the walking speed may need to be lowered to 3 feet per second. A field survey should be conducted of the area to determine the appropriate application.

4.1.2. Pedestrian Signals

Pedestrian countdown timers and audible beacons should be used at all intersections to support crossing compliance and the visually impaired.

4.1.3. Pedestrian Actuation

At wider crossings, pedestrian FLASHING WALK time when added to the 4 – 7 second WALK time, and 3 seconds solid red hand may control the signal phasing. To keep from having long delays with vehicular traffic, non-actuated pedestrian phases are only appropriate for areas with shorter crossing and consistent pedestrian traffic. Several manufacturers are testing devices to automate pedestrian detection, similar to vehicles, but most are still working on determining the pedestrian's path as they reach the intersection.

4.1.4. Leading Pedestrian Intervals (LPI)

The use of LPI provides a safer crossing for pedestrians by providing them 3 – 10 seconds to establish themselves in the intersection before right turn or permissive left turn movements begin. This technique works well at locations with high volumes of right turns and permissive left turns. Having appropriate gap spacing to allow affective permissive left turns allows the time that may have been attributed to a protected left phase to be shifted to the LPI balance the overall cycle length.

4.1.5. Left Turn Signal Phasing

Protected left turn movements at signalized intersections provide the safest crossing movement for pedestrians. Permissive left turns are the most dangerous for pedestrian crossings because the driver is focused on finding a gap in on-coming traffic and not focused on the crosswalk. Protected-Permissive Left Turns (PPLT) allow most queued vehicles to turn before changing to a yellow flashing arrow. This method provides a higher level of safety for pedestrians while improving operational capacity but should not be used in areas with poor sight visibility or high-volume pedestrian traffic.

4.1.6. Right Turn on Red (RTOR)

Permission for drivers to make a right turn at a red light was originally granted to save fuel and reduce air quality impacts. The growth of bicycle and pedestrian traffic has begun a reevaluation of this application. To improve safety many municipalities are prohibiting RTOR in certain circumstances to reduce possible conflicts between motor vehicles and pedestrians/bicyclists.

a. MUTCD Section 2B.54 Prohibition Guidance

- i. Inadequate sight distance to vehicles approaching from the left (or right, if applicable)
- ii. Geometrics or operational characteristics of the intersection that might result in unexpected conflicts
- iii. An exclusive pedestrian phase
- iv. An unacceptable number of pedestrian conflicts with right-turn-on-red maneuvers, especially involving children, older pedestrians, or persons with disabilities
- v. More than three right-turn-or-red accidents reported in a 12-month period for the particular approach

- vi. The skew angle of the intersecting roadways creates difficulty for drivers to see traffic approaching from their left
- b. Additional Prohibition Guidance
 - i. High pedestrian and bicycle use areas
 - ii. Leading Pedestrian Interval
 - iii. Shared-use path or two-way cycle track crossing at a signalized intersection
 - iv. An exclusive bike only phase
 - v. Transit que jumps

4.2. Bike Signals

Bicycle signals should be evaluated for intersections along existing and planned bicycle facilities. They shall be placed in a visible location for on-coming bicyclists. At intersections with long crossings, a near-side signal can be used to support the far-side signal. The near side signal may include a countdown to green to assure cyclists that the actuation is working and give them an early start.

4.2.1. Recommended Locations

- a. Two-way Cycle Tracks
- b. Contra-flow Bike Lanes
- c. Intersections with high conflicting right/left turns
- d. Intersections with complex geometry

4.2.2. Bike Clearance Time

Bicyclists need longer minimum green times due to slower acceleration. NACTO provides this clearance time as:

$$C_i = 3 + \frac{W}{V}$$

Where: W = Intersection Width

V = Typical Bicyclists Speed

The extra time required for this crossing may coincide with the yellow phase if a bicycle signal is available.

4.2.3. Bicycle Actuation

Bicycle signals not set for full recall should be on passive actuation. There are many devices that can be used for detection including some cameras, pucks, infrared detection, and special design induction loops.

4.2.4. Needed Features

Locations with active bike signal phases must prohibit Right Turns on Red (RTOR) and only allow protected left turns.

4.3. Rapid Rectangular Flashing Beacons (RRFB)

RRFBs have become one of the most popular signal devices to heighten awareness at crossings. These are most feasible for crossings on 2 – 3 lane roads with lower volumes and speeds. As the street gets wider additional tools should supplement the RRFB including pedestrian refuge islands and curb extensions. The median provides a place to put signs on both sides of on-coming traffic improving visibility. In special circumstances, roads exceeding 4 lanes but not meeting the requirements to install a PHB may install RRFBs on overhead mast arms to improve visibility and compliance.

4.4. Pedestrian Hybrid Beacons (PHB)/HAWK

PHBs or HAWK signals provide phased movement structure. Vehicles slow on yellow, stop on all red, and may stop and proceed with caution on the wig-wag red (similar to a stop sign). The length of the all red and wig-wag phases are determined based on pedestrian crossing time and density of pedestrians crossing. These signal devices should only be installed at locations that meet the guidelines presented in the MUTCD.

4.5. Street Lighting for Crossings

Lighting at crossings is an important safety feature for pedestrians and bicyclists. National trends show high crash rates, with a higher percentage of sever crashes, at night and in other low light conditions. Streetlights should be installed in conjunction with signals to allow each crosswalk and their approach to be fully lit.

5. Road Diets and Road Reconfiguration

In built out cities the ability to reconfigure the roadway, often during annual resurfacing, provides one of the most cost-effective and quickest methods to build bicycle infrastructure and improve multimodal safety. These retrofits may include road diets to reuse under utilized space and improve safety by reducing travel speed, minimizing conflict points, and improving sight lines. Streetscape changes may also be made with full hardscaping, changes to pavement markings, artistic incremental design techniques, and/or green stormwater infrastructure installations. This section will provide a brief overview of these concepts and it is recommended that additional study move forward to fully develop the policies and tools to fit the City of Lawrence.

5.1. Road Diet Evaluation

The first step for any changes to the streetscape layout requires an analysis of existing conditions. The FHWA identifies 4-lane and 6-lane roadways as prime candidates for conversion to 3-lane and 5-lane configurations. Researchers have shown that the addition of a turn lane reduces the number of weaving movements on a roadway and decreases the number of sideswipe and rear end collisions. These configurations have also been shown to decrease operating speeds and nearly eliminate excessive speeding. Some of the benefits of road diets are highlighted on the FHWA table Safety Issues Addressed by Countermeasure (Figure 2-4).

Several communities and states across the nation have enacted road diet policies that include guidelines for the evaluation and delivery of these facilities. A widely accepted process includes a stepped base approach using increasing levels of evaluation based on Average Daily Traffic (ADT). The methodology to evaluate a 3 to 4 lane conversion is included in Figure 5-1.

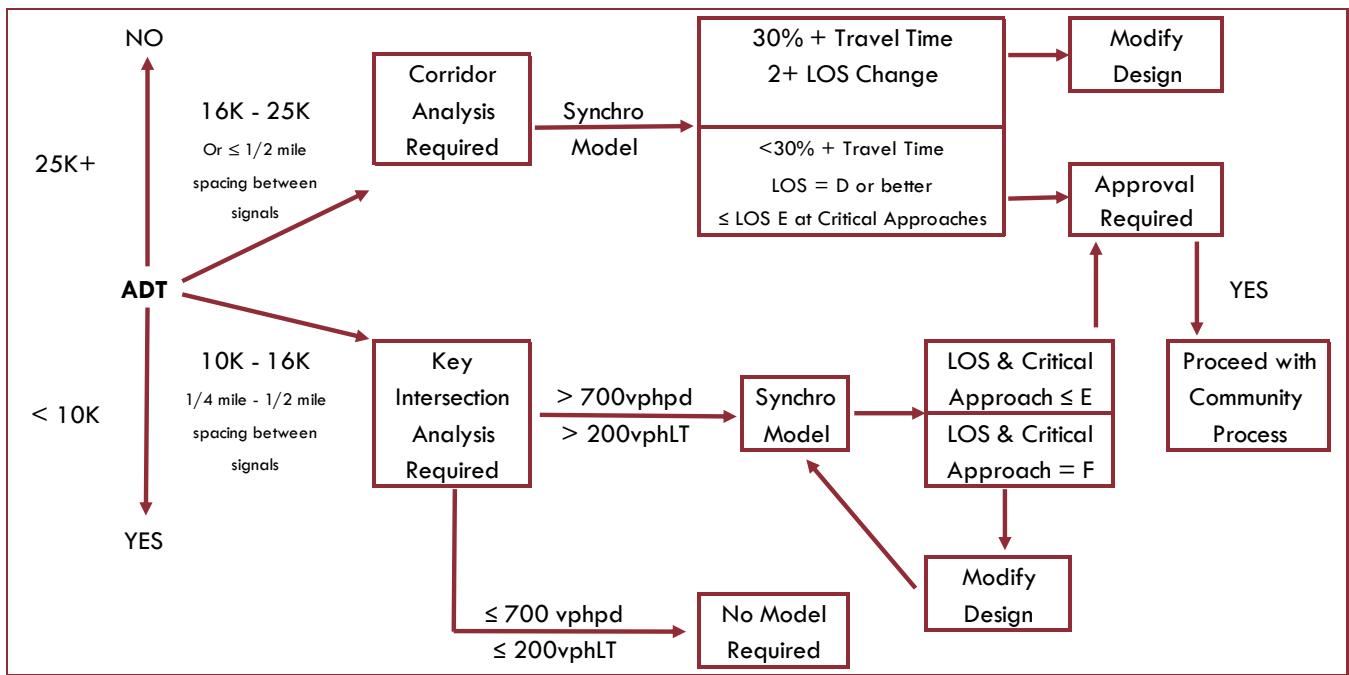


Figure 5-1: 4 to 3 Lane Road Diet Evaluation

This evaluation is often supplemented with an additional review to fit the contextual elements of the corridor. The following road diet questionnaire (Table 5-1), reproduced from the Tennessee Department of Transportation, identifies projects that will require contextual review by any answer being YES.

Table 5-1: Road Diet Questionnaire

| Question | YES | NO |
|---|-----|----|
| Is the current Average Daily Traffic (ADT) greater than 25,000? | | |
| Is the current posted speed limit greater than 45 mph? | | |
| Is the highway a diversionary route for an interstate highway? | | |
| Is the existing per hour/per lane peak hour volume greater than 1700? | | |
| Does the facility have a bus route with stops? (4 lanes to 3) | | |
| Are there more than 10 driveways per mile present? (4 lanes to 3) | | |
| Will the existing roadway pavement drainage be affected? | | |

Projects that require additional evaluation should be reviewed considering the following elements:

- a. Multimodal needs
- b. Project limits vs. corridor
- c. Crash frequency or severity linked to:
 - i. Lack of turn lanes
 - ii. Higher than desirable operational speeds
 - iii. Poor access management
 - iv. Bus stop locations (4 lanes to 3)

- v. Driveway density (4 lanes to 3)
- d. Increased presence of vulnerable users
- e. Community support for alternative modes of transportation accommodation
- f. Proximity to freeways
- g. Designation as an evacuation route or other emergency use
- h. Existing and future land use along the corridor

5.2. Road Reconfiguration

Road reconfiguration may include a road diet or a reallocation of existing space. Many cities have moved away from the standard interstate lane width of 12 feet for their roadways and have adopted standard 10 foot lanes for general traffic and 11 foot outside lanes for transit and freight corridors. Additionally, a nationwide discussion over on-street parking has lead many communities to reallocate this space to multimodal transportation, parklets, green infrastructure, and pedestrian plazas. The following table (Table 5-2) provides a simplified general layout for Lawrence’s streets based on roadway classification.

Table 5-2: Conceptual Roadway Configuration Cross Sections

| Classification | Pedestrian Realm | | Gutter Pan | Travel Way | | | | | | | | | |
|--------------------|------------------|---------|-------------|--------------|-------------|-------|-------------|-----------|-------------|--------------|------------|--------------------|-------------|
| | Pedestrian | Utility | | Parking Lane | | | Bikeway | | Buffer | Vehicle Lane | | Median / Turn Lane | |
| | | | | Requirement | Width | Count | Width | Type | | Width | Count | | |
| Min. (feet) | Min. (feet) | (feet) | Min. (feet) | | Min. (feet) | | Min. (feet) | | Min. (feet) | Min. (feet) | Max (feet) | | Min. (feet) |
| Principal Arterial | 6 | 4.5 | 2 | NO | NA | NA | 5 | Protected | 2 | 10 | 11 | 4 | 10 |
| Minor Arterial | 6 | 4.5 | 2 | Optional | 7 | 2 | 5 | Buffered | 2 | 10 | 11 | 2 | 10 |
| Collector | 5 | 4.5 | 2 | Optional | 7 | 2 | 6 | Standard | NA | 10 | 11 | 2 | Optional |
| Local | 5 | 4.5 | 2 | Optional | 7 | 2 | NA | Optional | NA | 9 | 10 | 2 | NA |

To fully apply this process TREKK’s recommendation is to build upon this concept to account for land use, area context, street typology, development density, street width, design speeds, and multimodal network plans. Additionally, the City of Lawrence should develop and adopt a parking modification process that meets the community’s needs.

6. Minimizing Turning Radii

Corner radii are a major influence on the speed of right turning vehicles at intersections. Smaller turning radii require vehicles to turn at a slower speed improving the ability of a driver to interact with pedestrians and bicyclists crossing the adjoining street. In urban settings, smaller corner radii are preferred and actual corner radii exceeding 15 feet should be the exception (NACTO Urban Design Guide). This section will focus on the decision factors for determining curb radii and methods to reduce the radii to improve safety for crossing pedestrians and bicyclists.

6.1. Design, Control, and Managed Vehicles

A critical element in the determination of curb radius is the design vehicle. The 2019 NACTO published Don’t Give Up at the Intersection, focusing on how to improve bicycle and pedestrian safety at urban intersections. One of the recommendations included the addition of two new vehicle types for design consideration the Control Vehicle and the Managed Vehicle.

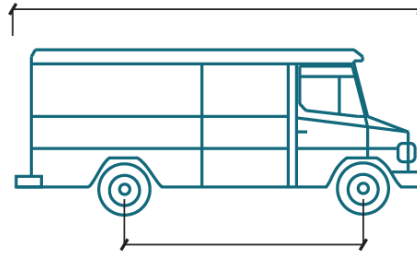
Design vehicles should be the largest vehicle that frequently accesses the street and fits the context. The following design vehicles (Figure 6-1) are recommended by the National Association of City Transportation Officials (NACTO) and have been adopted by many of the member cities.

Street Type

Design Vehicle

DL-23

22.6'

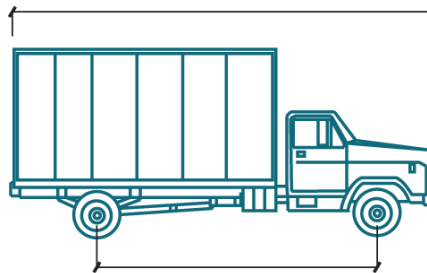


Neighborhood and Residential Streets

12.96'

SU-30

30'

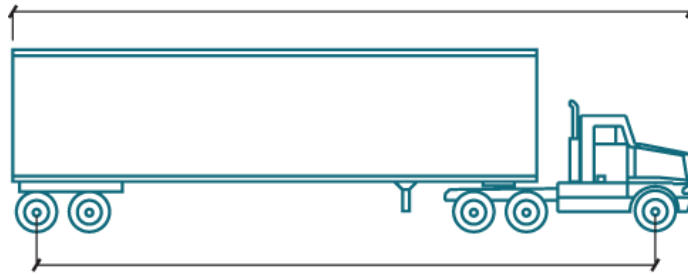


Downtown and Commercial Streets

20'

WB-50

55.5'

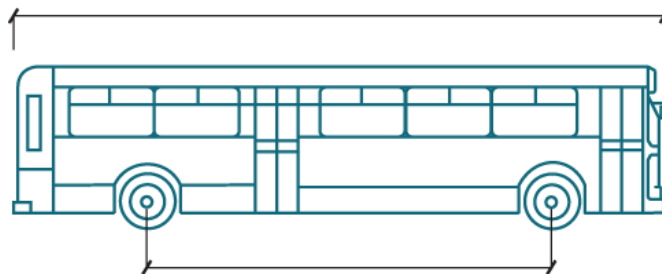


Designated Truck Routes

50'

BU-40

40'



Designated Bus Routes

25'

Figure 6-1: Recommended Design Vehicles (NACTO)

At the intersection of different street types, the minor receiving street will take precedence. Following this practice, the corner radius of a local residential street intersecting a freight route will be designed for a DL-23. The design vehicles' turn speed should be evaluated around 5-8 mph to help ensure all vehicles make slow turns.

A control vehicle is the largest non-frequent turning vehicle that needs to be accommodated at an intersection. For most streets this will be a large fire truck. To accommodate these vehicles while encouraging slower turning movements from more frequent smaller vehicles, techniques such as mountable curbs, offset stop bars, and parking prohibitions should be reviewed. The turning movements for these vehicles should be evaluated at less than 5 mph and may require additional field review to confirm software analysis.

Managed vehicles are the most common vehicle to use a street and often smaller than the design vehicle. This will typically be a standard passenger vehicle. The design should encourage a managed vehicle operator to travel at 10 mph, or less, when making a turn. In some cases, this may require mountable curbs for the design vehicle.

6.2. Effective Radius

The effective radius accounts for the offset of a turning vehicle from the roadway curb. On a street with bike lanes and on-street parking the travel lane is 12 to 14 feet from the curb. This increases the turning radius of the vehicle (Figure 6-2), allowing it to travel at a higher speed.

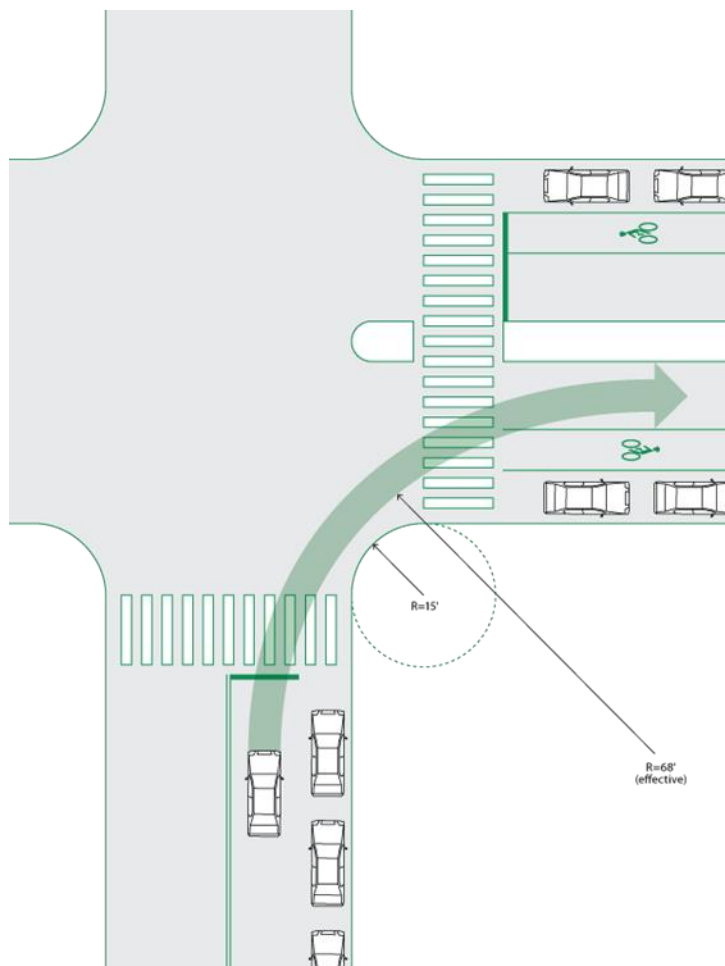


Figure 6-2: Effective Radius Example (NACTO)

Designing for turns using the effective radius provides additional space for curb extensions and minimizing the built radius. It is important to reduce the effective radius to minimize vehicle turning speeds. Alternate methods include placing small speed humps at the corner, vertical deflection devices at the end of lanes, mountable curbs, and textured pavement.

6.3. Accommodating Large Vehicles



Figure 6-3: Corner Extension using Speed Humps (Source: Google)

Heavy trucks and buses may use the full intersection to make turns when these movements are not frequent. These movements may require a 3-point turn or an external helper to complete the turn.

Transit routes with headways of 30 minutes or less should be designed with a receiving lane width to accommodate the vehicle's turning movement without encroaching into the oncoming lane. The transit frequency and on time performance is important for the overall operation of the transit system and passenger experience. As the most efficient form of travel design should always take into consideration transit operations.

The following section will provide some possible techniques to accommodate large vehicles without affecting their operation but keeping turning speed low.

6.3.1. Mountable Curb/Curb Apron

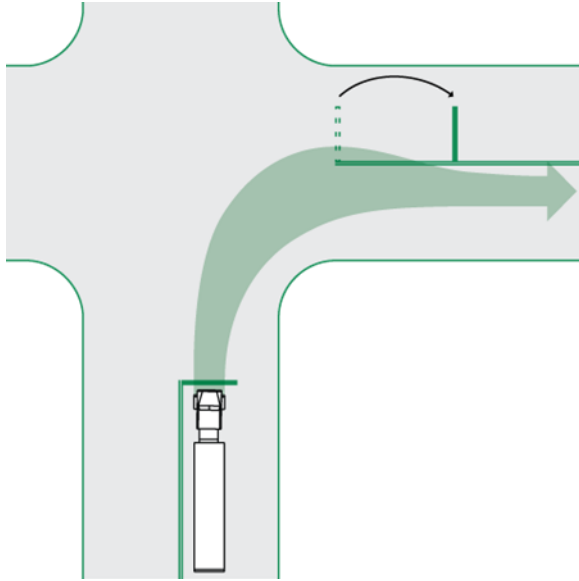
The smaller corner radii required to keep passenger vehicles operating at slow speeds while turning, the corner will prevent most large vehicles. Using a mountable curb provides the additional needed space for the large vehicle while still restricting the speed of smaller passenger vehicles. The rear wheels of the large vehicle will roll over the mountable curb allowing the turn at a lower speed. This same technique has been used in the US on roundabouts and is consistently used in European countries. Figure 6-4 is an example of this technique.



Figure 6-4: Cement Pillow, Portland (NACTO)

6.3.2. Stop Bar Location

To accommodate large vehicle turning movements that will encroach on the opposing travel lane at controlled intersections the stop bar should be moved away from the intersection as seen in Figure 6-5. Stop bars set back 20 feet or more from an intersection should include Stop Here on Red (MUTCD R10-6) for signalized control or a Stop Here (R1-5b) for stop sign control and STOP pavement markings.



6.3.3. Parking Set Back

Parking should be set back at least 20 feet from each crosswalk to allow visibility for pedestrians entering the street. A larger offset (Figure 6-6) may be needed to accommodate the control vehicle at each intersection. Turning analysis should be evaluated to determine the appropriate location to begin parking. This space would need to be maintained through parking enforcement and/or the installation of small vertical deflection devices to encourage compliance.

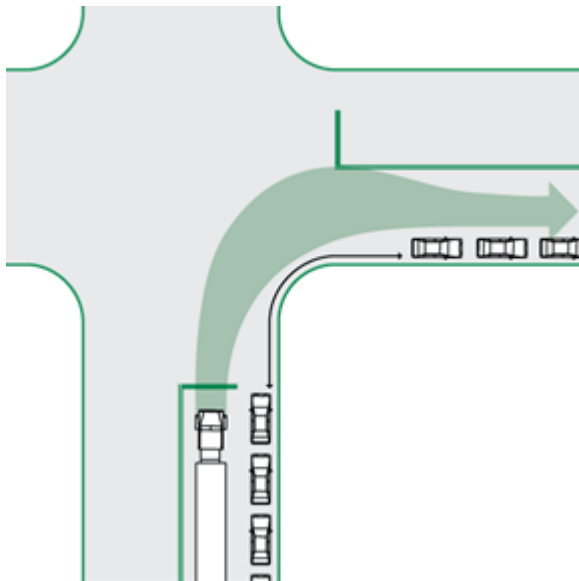


Figure 6-6: Parking Set Back (NACTO)

6.4. Channelized Turn Lanes

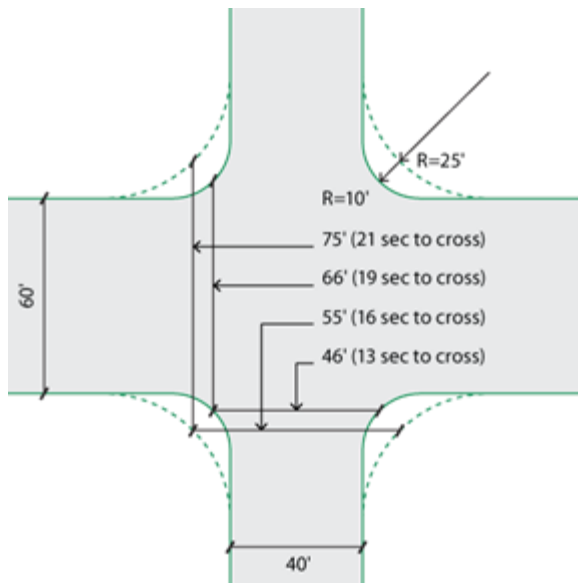
Channelized right turn lanes should be designed for slow speeds (5-10mph). Crossings should be marked with high-visibility continental crosswalks, a stop bar, standard pedestrian crossing assembly, and Stop Here for Pedestrian (R1-5c) signage. For high volume crossings or locations with documented safety issues some cities have begun using mountable curbs, raised crosswalks, and/or signalization devices. Often the curb apron takes the place of the area gored around the island. For channelized turn lanes for interstate access the City of Lawrence will need an agreement with KDOT.



Figure 6-7: Mountable Apron and Raised Crosswalk (Source: Google)

6.5. Benefits of Smaller Curb Radii

- Improved pedestrian ramp alignment
- Slower turning movements
- Reduced pedestrian crossing distances
- Additional space for traffic signal equipment
- Reduction of needed right-of-way
- Improved multimodal intersection safety



6.6. Slowing Left Hand Turns

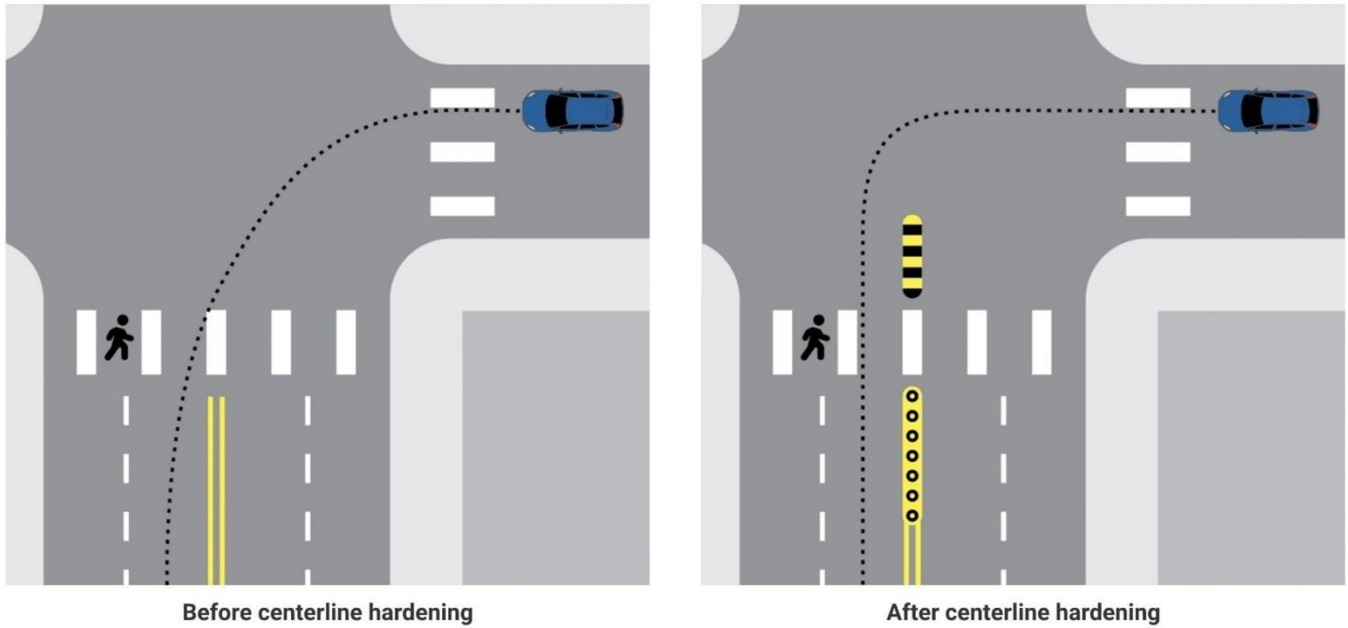
Left hand turns have not received the same focus in the past as right turns. New guidance has begun to encourage methods to slow vehicles making left hand turns. Wider left-hand turns decrease the turning radius, slowing speeds and improving visibility of the crosswalk.

6.6.1. Medians

The placement of medians with a pedestrian refuge improves the safety of pedestrians crossing an intersection. The ability for a pedestrian to stop in the median provides them the ability to react to each direction of travel independently. The curbed median being placed on both sides of the crosswalk also requires left turning vehicles to make wider turns to avoid the structure.

6.6.2. Hardened Centerlines

In locations that do not provide the space for a center median, cities have begun using centerline hardening as a design method. A recommended practice is the use of mountable devices near the intersection and vertical delineators on the segment side of the crosswalk. These devices should include yellow retroreflective markings.



6.6.3. Application

While these techniques for slowing left hand turns may be installed at any intersection and city should evaluate the site to ensure that limited funding is allocated to the areas with the greatest need. It is important to factor in crash history, left turn operation, pedestrian volume, left turn volume, gap acceptance for permissive left turn movements, and sight distance. The following questionnaire (Table 6-1) indicates when further study for installation when any question receives a YES answer.

Table 6-1: Left Turn Hardening Questionnaire

| Question | YES | NO |
|---|-----|----|
| Is there record of 3 pedestrian crashes over the previous 3 years? | | |
| Is there record of a pedestrian fatality over the previous 5 years? | | |
| Are permissive left turns allowed at the intersection? | | |
| Do more than 150 vph make left turns? | | |
| Is this area considered a high pedestrian zone? | | |
| Is there a concentration of vulnerable users in the area? | | |
| Does vehicular speed exceed 30 mph? | | |

7. Roundabout

The FHWA's Roundabouts: An Informational Guide (NHRCP 672) addresses the planning, design, construction, maintenance, and operation of roundabouts. It also includes information that will be useful in explaining to the public the trade-offs associated with roundabouts. The City of Lawrence has adopted the Kansas Roundabout Guide, A Companion to NHCRP 672, as part of the local design criteria for roundabout design. Roadway intersections introduce potential conflict points with other

vehicles, but also raise a concern for non-motorized users, such as pedestrians and bicyclists. Residents of Lawrence have indicated that they feel most comfortable bicycling where there are buffered or designated bicycle lanes (source 2019 Lawrence Bikes report) that elevate the level of comfort for the rider. Navigating through an intersection safely and efficiently both motorized and non-motorized users can be addressed with varying accommodations and requires additional considerations. This section specifically covers how the roundabout, one of the safest intersection types for vehicles, can also function safely for non-motorized users when properly designed and constructed. The FHWA's *Roundabouts: An Informational Guide* should be referred to for more information and recommendations.

7.1. Bicyclists

7.1.1. In-roadway or Separated Pathway Considerations.

a. Entry Speeds.

Roundabouts are generally designed with an entry speed of 20-30mph where merging and diverging can be easily managed. Experienced, confident in-road bicyclists typically travel 12-20mph. Compatible speeds between users is a key factor in determining whether the bicyclists should be provided with an alternate pathway through the intersection. If travel speeds and confidence levels are not compatible, user separation is advisable.

b. Traffic Volumes.

The number of lanes in a roundabout is influenced by the amount of vehicular traffic traveling through the intersection. Multilane roundabouts increase the number of decisions to be made by drivers. Allowing low confident bicyclists to travel within the multilane roundabout, increases potential for collisions between users. When traffic volumes dictate more than a single lane roundabout, guiding the bicyclists through the intersection on a separated path is recommended.

Typically, vehicle volumes are greater than bicycles or pedestrians. In some cases, the reverse can be true. When there is a high disparity between the number of vehicles and the number of bicyclists navigating the roundabout, it is recommended to provide separation between users.

7.1.2. Design Criteria.

a. Bike Ramps to Separated Pathway (sidewalk).

The [FHWA's Roundabouts: An Informational Guide](#) recommends a 35% -45% angle on the ramp to discourage a high speed bicycle entry to the sidewalk. This is to decrease potential conflicts with pedestrians and other bicyclists on the sidewalk.

In order to not confuse visually impaired pedestrians on the sidewalks, the bicycle ramps are placed at least 50 ft prior to the crosswalk.

b. Pavement Markings and Signing.

If there is an existing bike lane designated on the roadway approaching the roundabout, the bike lane would terminate prior to entering the roundabout by providing a taper similar to what is shown in Figure 7-1. Bike Lanes are not marked in the roundabout and the bicyclists would travel through it the same as motorized vehicles. The bike lane would resume downstream from the roundabout. The ending and beginning of the bike lane is indicated by standard MUTCD Bike Lane Begins and Ends signing.

If there is an existing bike lane designated on the roadway approaching the roundabout and bicycles are to be separated, additional measures to navigate the bicyclists to the bike pathway would be taken. This includes the pavement markings and bike trail signs to guide bicycles to the designated pathway. The [Urban Bikeway Design Guide](#) provides solutions that can help create complete streets that are safe and enjoyable for bicyclists.

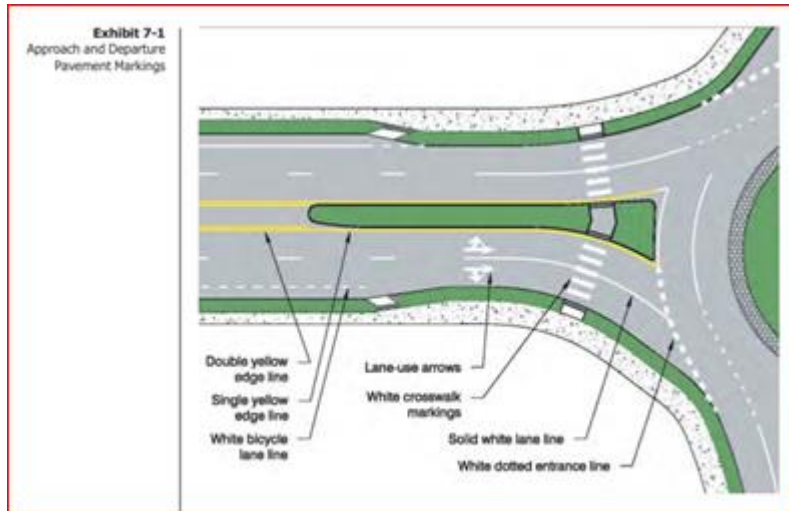


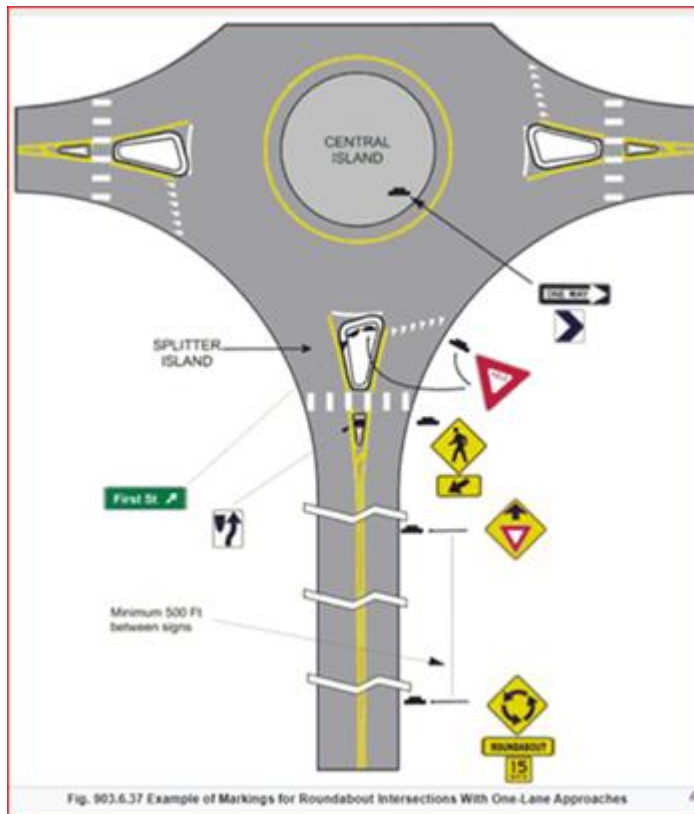
Figure 7-1: Sample Pavement Marking

c. Crossings In Roundabout.

Crossings within the roundabout are set back away from the circular pathway in order to not impede the movement through the roundabout.

Yield lines for vehicles entering the roundabout are generally placed on the outer edge of the circular pathway. The crosswalk should be located approximately 25 feet in advance of the Yield line. This provides space for a vehicle waiting to merge into the roundabout and not block the crossing.

Proper signing for approaching vehicles, bicyclists, and pedestrians, is applied using standard MUTCD guidelines and the NACTO report "[Don't Give Up at the Intersection](#)" report. Signing applications for vehicles approaching the roundabout provide include Circular Intersection warning, Yield, and Pedestrian Crossing warning. A sample signing layout is shown in Figure 7-2.



Not common, but in certain situations, more advanced traffic control features are necessary to enhance the warning for pedestrian and bicycle crossings at intersections, including roundabouts. When the vehicle volumes are high, multilane configurations are present, pedestrian and/or bicycle volumes are high, or the roundabout is complex in geometrics, crossing signals and Rectangular Rapid Flashing Beacons can be considered. This is outlined in the [FHWA's Roundabouts: An Informational Guide](#) and [MUTCD](#).

8. Transit and Railroad Crossings

8.1. Bicyclists

Transit and railroad conflicts may be addressed through designs that clearly delineate the pathway for each user, including bicyclists and pedestrians. Key guiding principles include safety, accommodation and comfort, coherence, predictability, context sensitivity, and experimentation. The FHWA report “[Achieving Multimodal Networks – Applying Design Flexibility and Reducing Conflicts](#)” provides details and criteria to reduce conflicts between modes of travelers.

8.1.1. Railway Track Crossing.

Railway tracks can be a hazard for bicycle tires because of the gaps, known as flangeways, around the rails and during wet weather where the rails become slick. Certain countermeasures can help reduce the impact of these circumstances.

Alignment of the bike pathway to the tracks. It is recommended that the bike path cross the rails at a 60-90 degree angle or fill the flangeways with appropriate filler material. Additionally, advance warning signs for the bicyclists is advised. Figure 8-1 below from the FHWA report mentioned previously shows a typical layout for this situation.

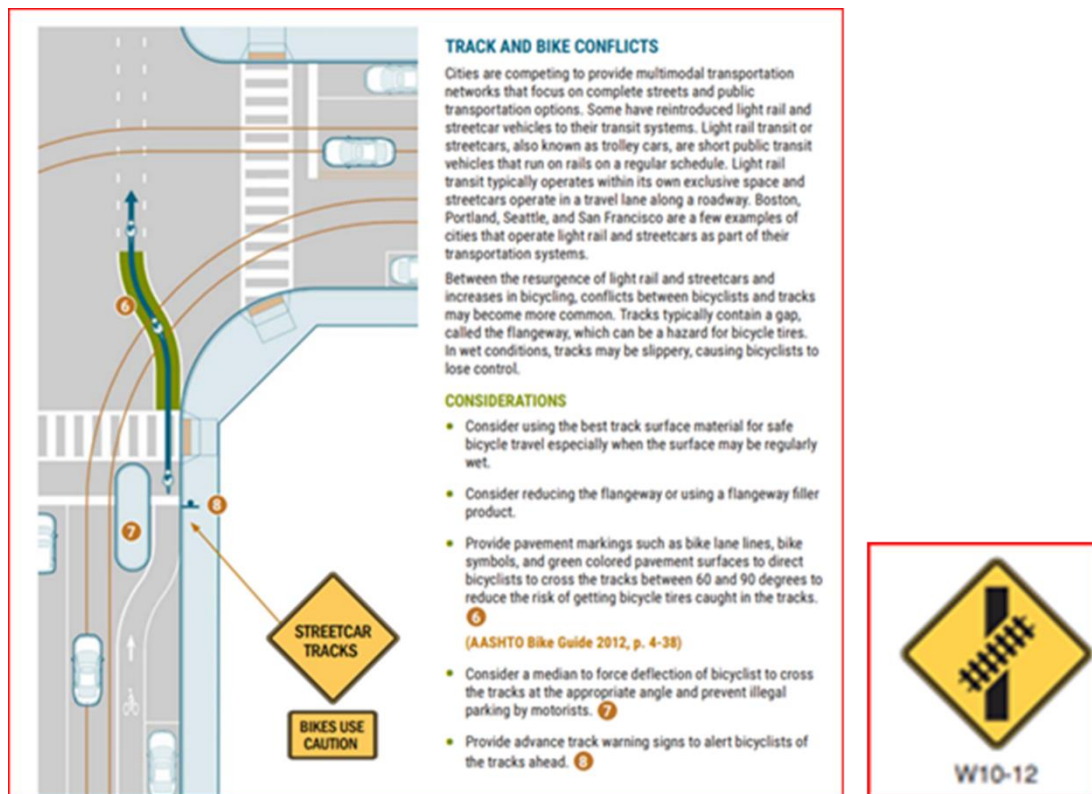


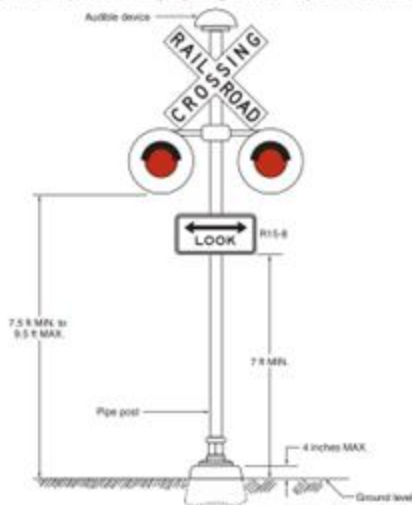
Figure 8-1: Sample Bike Path Alignment Across Rails

Pedestrian crossings over rails can be challenging for pedestrians as well. Recommendations include providing a suitable crossing plate or filler material to ensure a safe walking surface.



It may be necessary to install more advanced and active traffic control for pedestrians and bicyclists crossing rails, such as in high traffic, complex intersections, or areas of greater vulnerability. This includes providing gates and signals for pedestrian and bicycle movements. In some situations, a bridge or tunnel is recommended where more separation is warranted and eliminating the potential conflict is critical.

Figure 8C-4. Example of Flashing-Light Signal Assembly for Pedestrian Crossings

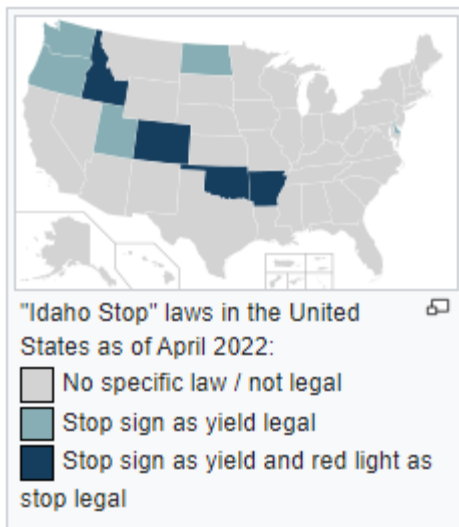


9. Idaho Stops

The Idaho stop is the common name for laws that allow cyclists to treat a stop sign as a yield sign, and a red light as a stop sign.[1] It first became law in Idaho in 1982, but was not adopted elsewhere until Delaware adopted a limited stop-as-yield law, the "Delaware Yield", in 2017.[2] Arkansas was the second state to legalize both stop-as-yield and red light-as-stop in April 2019. Studies in Delaware and Idaho have shown significant decreases in crashes at stop-controlled intersections. Additional historical information regarding this topic can be found at https://en.wikipedia.org/wiki/Idaho_stop

9.1. States with Idaho Stop

A limited number of states, counties, and cities across the nation have legalized this movement. Reasoning for this legalization varies. For example, Tennessee partially legalized this years ago because they allowed motorcycles to treat redlights as stop signs because the induction loops were not reading them at actuated signals. A group of cyclists sued the state to receive the same flexibility. Tennessee statute 55-8-110(8)(d) is only applicable to signals with actuation devices and the officer may issue a ticket if they believe the signal is functioning properly. The map below (Figure 9-1) shows the states that have passed specific “Idaho Stop” statutes.



In addition to the states identified on the map, an additional 9 states have passed laws similar to Tennessee requiring a belief that signal detection is malfunctioning to proceed.

1. Arizona
2. Illinois
3. Kansas
4. Minnesota
5. Missouri
6. South Carolina
7. Tennessee
8. Virginia
9. Wisconsin

Kansas statute 8-1508(c)(4) allows bicyclists to proceed through an inoperative and/or malfunctioning light after they have waited a reasonable period of time. These laws are typically passed at the state level with the exception of a few cities in Colorado. Standalone laws at the local level, with certain exceptions, can lead to confusion of how bicyclists or drivers will react at intersections throughout a region based on where they fall within a municipal boundary.

9.2. Pros and Cons of the Idaho Stop.

9.2.1. Pros

- Safety with regards to the odds of collisions involving a vehicle's blind spot
- More clear enforcement of unsafe drivers and riders
- Conservation of energy
- Vehicle detection limitations are minimized

9.2.2. Cons

- Inconsistent laws for all road users
- Less predictable behavior for cyclists
- Degraded safety
- Modern detection devices available

9.3. Recommendation for Idaho Stop

The City of Lawrence should continue to advocate for the full legalization of the Idaho Stop in the State of Kansas. The current law requires a subjective decision based on the signals functioning operation. Lawrence should not enact a law specific to their boundaries. A local law would place further uncertainty between the bicyclists and drivers on how the other party will act at signal devices. Each individual would need a clear understanding of the city's boundaries and extra educational programs would be needed for visitors.

References

Transportation 2040 Metropolitan Transportation Plan Lawrence – Douglas County
Approved on March 17, 2022 by MPO Policy Board

Lawrence Bikes Plan
Approved on August 15, 2019 by MPO Policy Board and Lawrence City Commission

Lawrence Pedestrian Plan
Adopted on June 12, 2022 by Lawrence City Commission and on May 12, 2022 by MPO Policy Board

Urban Street Design Guide (NACTO)

Transit Street Design Guide (NACTO)

Urban Bikeway Design Guide (NACTO)

Don't Give Up at the Intersection (NACTO)

Designing for All Ages & Abilities (NACTO)

Recommended Design Guidelines to Accommodate Pedestrians and Bicycles at Interchanges (ITE)

Prohibition of Turns on Red at Signalized Intersections (ITE)

Crosswalk Policy Guide (ITE)

Guidance to Improve Pedestrian and Bicyclist Safety at Intersections (NHCRP 926)

Guide for Improving Safety at Uncontrolled Crossing Locations (FHWA)

STEP: Improving Visibility At Trail Crossings (FHWA)

PEDSAFE – Pedestrian Safety Guide and Countermeasure Selection System (FHWA)

Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts (FHWA)

Small Town and Rural Multimodal Networks (FHWA)

Manual on Uniform Traffic Control Devices (AASHTO)