APPENDIX G

Active Transportation Toolbox

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Facility Type Toolbox

The Toolbox describes each suggested pedestrian and bicycle facility improvement, clearly outlines each facility's merits and provides design guidelines.

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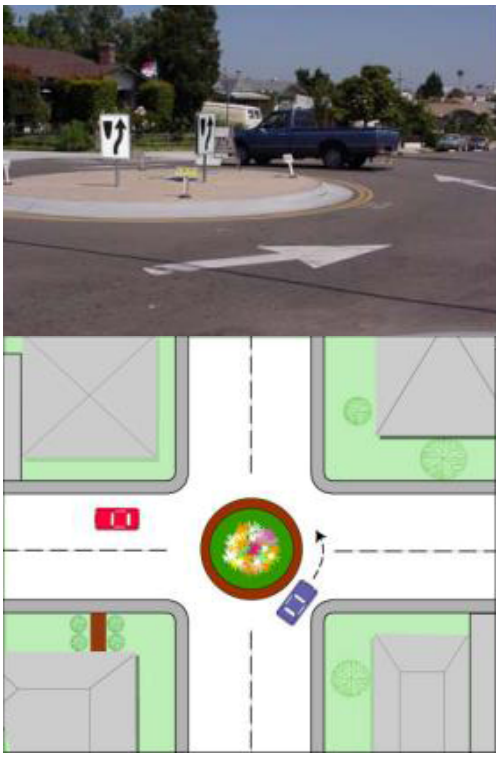
Intersection Treatments

Neighborhood Traffic Circles



Primary Purpose:	**Speed Reduction** *on Residential Streets*
Other Potential Results:	Volume Reduction
	Pedestrian Safety
	Collision Reduction

Neighborhood traffic circles are circular medians placed in the middle of the intersection, motorists travel counter-clockwise through the intersection. Drivers yield to vehicles already circulating within the intersection. Due to the horizontal deflection, vehicles must slow to maneuver around the device. The circular median can be landscaped to help beautify the neighborhood. These devices may reduce speeds through neighborhoods.

Depending on right-of-way and budget constraints, either a traffic circle or roundabout can be installed. Unlike roundabouts, traffic circles do not have splitter islands on each approach to help guide traffic around due to their smaller size. Large emergency vehicles like fire trucks are permitted to turn left in front of the circle.

MEASURED EFFECTIVENESS	
Speed Reduction[1]	-11%
Volume Reduction[2]	-5%
Collision Reduction[3]	-71%
Source: Traffic Calming – State of the Practice 2000	
[1]Reduction in 85th Percentile Speeds between slow points	
[2]Reduction in Vehicles per Day	
[3]Reduction in Average Annual Collisions	
[4]ID = Insufficient Data to predict reduction effect	

Advantages

- Speed reduction
- Possible opportunity for landscaping
- Possible decrease in intersection accidents compared with stop-controlled intersections

Disadvantages

- Potential loss of parking
- Restricts turning movements by larger vehicles
- Increased EMS/Fire response

Neighborhood Traffic Circles Design Guidelines

Traffic Circle Center Island Profile

Traffic circles should be designed with both a vertical inner curb and a mountable apron. The vertical inner curb prevents vehicles from driving over the circle. The apron is a shallow sloped curb extending out from the bottom of a vertical curb; the apron has a low lip at its pavement-side edge. This mountable apron facilitates easier turns for large vehicles. The lip at the apron's edge discourages vehicles from using it unnecessarily.

Traffic Circle Turn Operations

All vehicles should circulate around the center island counter-clockwise. However, an exception can be made for large vehicles (i.e., trucks and buses) in some cases if geometric constraints require it. If a specific intersection has a high proportion of truck and/or bus traffic, alternative treatments may provide similar results without the impact to trucks or buses. All traffic circles should be designed using AutoCAD/AutoTurn software or using appropriate truck turning templates as specified in *A Policy on Geometric Design of Highways and Streets* (FHWA, 2001) to identify whether emergency response vehicles and buses can turn left around the circle.

Traffic Circles at T-Intersections

Traffic circles should have deflection on all approaches if implemented at a T-intersection. This can be implemented in both existing neighborhoods in retrofit situations and in new neighborhoods. First, a raised island can be placed at the right side of the un-deflected approach to the traffic circle to artificially introduce deflection. In new neighborhoods the street curbs can be modified to allow the center island to be located at the center of the intersection.

Signage

Traffic circle center islands will include signage symbolically indicating the permitted travel paths around the center island, yield control signs, “Share the Road” signs, and pedestrian crossing signs.

Source: City of San Diego, *Traffic Calming Program Handbook*¸2006.

Protected Intersections

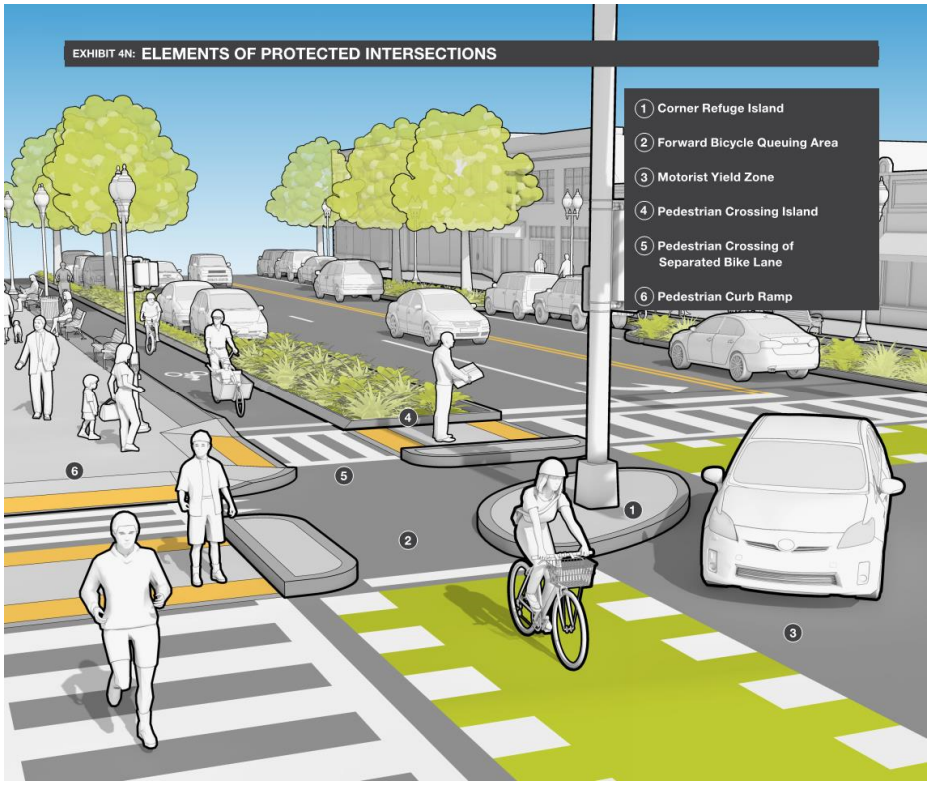
Primary Purpose:	**Bicyclist Safety** *on Major and Collector Streets*
Other Potential Results:	Collision Reduction
	Pedestrian Safety

Protected Intersections physically separate people walking, people biking, and motor vehicles. These facilities provide a continuation of a physically separated bicycle facility through an intersection by placing bicycle facilities within the curb and providing opportunities for all bicycle turning movements. Protected intersections reduce conflicts between vehicles and people biking and eliminate the need for people biking to use the crosswalk. Conflicts between people biking and vehicles may be eliminated if a bicycle signal is also installed. Turning vehicle speeds may be reduced as a result of an increased curb radius. Refer to Improvement Area E in Chapter 5 of the Linda Vista Comprehensive Active Transportation Strategy for an example of a plan of the entire intersection.

Design Guidelines

- Reduce speeds at conflict points
- Minimize curb radius
- Provide adequate sight distance
- Provide clearly marked separate facilities for pedestrians and bicyclists.
- Provide appropriate lighting for all approaches
- If deemed necessary, provide a bicycle signal

Protected Intersection Elements



1. Corner Refuge Island

The corner refuge island allows the bike lane to be physically separated up to the intersection crossing point where potential conflicts with turning motorists can be controlled more easily. It serves an important purpose in protecting the bicyclist from right-turning motor vehicle traffic. The corner island also provides the following benefits:

- Creates space for a forward bicycle queuing area.
- Creates additional space for vehicles to wait while yielding to bicyclists and pedestrians who are crossing the road.
- Reduces crossing distances.
- Controls motorist turning speeds.

The corner island geometry will vary greatly depending upon available space, location and width of buffers, and the corner radius. The corner island should be constructed with a standard vertical curb to discourage motor vehicle encroachment. Where the design vehicle exceeds an SU-30, a mountable truck apron should be considered to supplement the corner refuge island.

2. Forward Bicycle Queuing Area

The forward bicycle queuing area provides an area for stopped bicyclists to wait that is fully within the view of motorists who are waiting at the stop bar, thus improving bicyclist visibility. This design enables bicyclists to enter the intersection prior to turning motorists, allowing them to establish the right-of-way in a similar manner as a leading bicycle interval. Ideally, the bicycle queuing area should be at least 6 ft. long to accommodate a typical bicycle length. The opening at the entrance and exit of the crossing to the street should typically be the same width as the bike zone, but no less than 6 ft. wide. Where stops are required, a stop line should be placed near the edge of the crossing roadway. Where feasible, the designer should consider providing additional queuing space on streets with high volumes of bicyclists.

3. Motorist Yield Zone

Bicycle and pedestrian crossings set back from the intersection create space for turning motorists to yield to bicyclists and pedestrians.

4. Pedestrian Crossing Island

The pedestrian crossing island is a space within the street buffer where pedestrians may wait between the street and the separated bike lane. It should be a minimum of 6 ft. wide and should include detectable warning panels. Pedestrian islands provide the following benefits:

- Enables pedestrians to negotiate potential bicycle and motor vehicle conflicts separately.
- Shortens pedestrian crossing distance of the street.
- Reduces the likelihood that pedestrians will block the bike lane while waiting for the walk signal.

The crossing island path may be directly adjacent to the forward bicycle queuing area, but these spaces should not overlap unless the facility is a shared use path. Separation via a raised median improves comfort and compliance among pedestrians and bicyclists (pedestrians are less likely to wander into the bike lane zone, and vice versa). The opening in the crossing island should match the width of the pedestrian crosswalk.

5. **Pedestrian Crossing of Separated Bike Lane**

   Pedestrian crossings should be provided to indicate a preferred crossing of the separated bike lane and to communicate a clear message to bicyclists that pedestrians have the right-of-way. The crossing should typically align with crosswalks in the street. Yield lines in the bike lane in advance of the pedestrian crosswalk are typically used to emphasize pedestrian priority. It is also important to provide clear and direct paths for pedestrians to reduce the likelihood that they will step into or walk within the bike lane except at designated crossings.

6. **Pedestrian Curb Ramp**

   Pedestrian curb ramps may be required to transition pedestrians from the sidewalk to the street where there is a change in elevation between the two. It is preferable to use perpendicular or parallel curb ramps. The ramp must comply with ADA. Detectable warning panels must be provided at the edges of all street and bike zone crossings.

Protected intersections fully comply with MUTCD and other existing design standards.

Source: Massachusetts DOT, *Separated Bike Lane Planning & Design Guide*, 2015.

Bicycle Facilities

Bike Lanes

Primary Purpose:	**Bicyclist Safety** *on arterials, collectors, and residential streets*
Other Potential Results:	Speed Reduction (with lane diet)
	Collision Reduction

Bike lanes designate an exclusive space for bicyclists through the use of pavement markings and signage. The bike lane is located adjacent to motor vehicle travel lanes and flows in the same direction as motor vehicle traffic. Bike lanes are typically on the right side of the street, between the adjacent travel lane and curb, road edge, or parking lane. This facility type may be located on the left side when installed on one-way streets, or may be buffered if space permits. See contra-flow bike lanes for a discussion of alternate direction flow.

Bike lanes enable bicyclists to ride at their preferred speed without interference from prevailing traffic conditions. Bike lanes also facilitate predictable behavior and movements between bicyclists and motorists. Bicyclists may leave the bike lane to pass other bicyclists, make left turns, avoid obstacles or debris, and avoid other conflicts with other users of the street.

Advantages

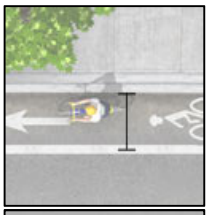
- Increases bicyclist comfort and confidence on busy streets.
- Creates separation between bicyclists and automobiles.
- Increases predictability of bicyclist and motorist positioning and interaction.
- Increases total capacities of streets carrying mixed bicycle and motor vehicle traffic.
- Visually reminds motorists of bicyclists' right to the street.

Typical Applications

- Bike lanes are most helpful on streets with ≥ 3,000 motor vehicle average daily traffic.
- Bike lanes are most helpful on streets with a posted speed ≥ 25 mph.
- On streets with high transit vehicle volume.
- On streets with high traffic volume, regular truck traffic, high parking turnover, or speed limit > 35 mph, consider treatments that provide greater separation between bicycles and motor traffic such as:
    - Left-side bike lanes
    - Buffered bike lanes
    - Cycle tracks

Bike Lane Design Guidance

Required Features



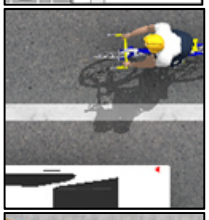
The desirable bike lane width adjacent to a curbface is 6 feet. The desired ridable surface adjacent to a street edge or longitudinal joint is 4 feet, with a minimum width of 3 feet. In cities where illegal parking in bike lanes is a concern, 5 foot wide bike lanes may be preferred.

When placed adjacent to a parking lane, the desirable reach from the curb face to the edge of the bike lane (including the parking lane, bike lane, and optional buffer between them) is 14.5 feet; the absolute minimum reach is 12 feet. A bike lane next to a parking lane shall be at least 5 feet wide, unless there is a marked buffer between them. Wherever possible, minimize parking lane width in favor of increased bike lane width.

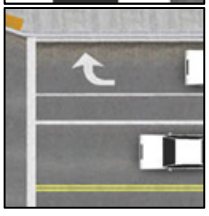
The desirable bike lane width adjacent to a guardrail or other physical barrier is 2 feet wider than otherwise in order to provide a minimum distance from the barrier.

Bike lane wording and/or symbol and arrow markings (MUTCD Figure 9C-3) shall be used to define the bike lane and designate that portion of the street for preferential use by bicyclists.

Bike lane word, symbol, and/or arrow markings (MUTCD Figure 9C-3) shall be placed outside of the motor vehicle tread path at intersections, driveways, and merging areas in order to minimize wear from the motor vehicle path.



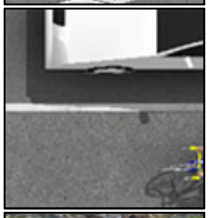
A solid white lane line marking shall be used to separate motor vehicle travel lanes from the bike lane. California Manual on Uniform Traffic Control Devices (MUTCD) recommends the use of a 6 inch line.



A through bike lane shall not be positioned to the right of a right turn only lane or to the left of a left turn only lane (MUTCD 9C.04). A bike lane may be positioned to the right of a right turn only lane if split-phase signal timing is used.

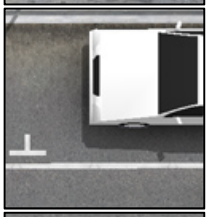
Recommended Features

Bike lanes should be made wider than minimum widths wherever possible to provide space for bicyclists to ride side-by-side and in comfort. If sufficient space exists to exceed desirable widths, see buffered bike lanes. Very wide bike lanes may encourage illegal parking or motor vehicle use of the bike lane.

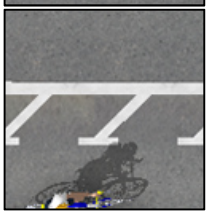


When placed adjacent to parking, a solid white line marking of 4 inch width should be used between the parking lane and the bike lane to minimize encroachment of parked cars into the bike lane.

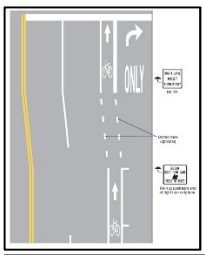
Gutter seams, drainage inlets, and utility covers should be flush with the ground and oriented to prevent conflicts with bicycle tires.



If sufficient space exists, separation should be provided between bike lane striping and parking boundary markings to reduce door zone conflicts. Providing a wide parking lane may offer similar benefits. Refer to buffered bike lanes for additional strategies.



If sufficient space exists and increased separation from motor vehicle travel is desired, a travel side buffer should be used. Refer to buffered bike lanes for additional details.



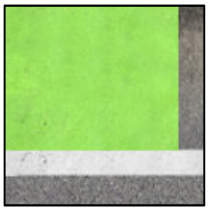
Lane striping should be dashed through high traffic merging areas.

In San Diego, where local vehicle codes require motor vehicles to merge into the bike lane in advance of a turn movement, lane striping should be dashed from 50 to 200 feet in advance of intersections to the intersection.

Optional Features

"Bike lane" signs (CA MUTCD R 81(CA)) may be located prior to the beginning of a marked bike lane to designate that portion of the street for preferential use by bicyclists. The CA MUTCD lists bike lane signs as optional.

On bike lanes adjacent to a curb, "No Parking" signs (CA MUTCDR7-9/R7-9a) may be used to discourage parking within the bike lane.



Color may be used to enhance visibility of a bike lane, especially in conflict areas.

Maintenance

- Lane lines and stencil markings should be maintained to clear and legible standards.
- Bike lanes should be maintained to be free of potholes, broken glass, and other debris.
- Utility cuts should be back-filled to the same degree of smoothness as the original surface. Take care not to leave ridges or other surface irregularities in the area where bicyclists ride.
- If chip sealing, consider providing new surfacing only to the edge of the bike lane. This results in a smoother surface for bicyclists with less debris. Sweep bike lanes clear of loose chip in the weeks following chip sealing.
- If trenching is to be done in the bike lane, the entire bike lane should be trenched so that there is not an uneven surface or longitudinal joints.

Source: NACTO, *Urban Bikeway Design Guide*, 2013.

Buffered Bike Lanes

Primary Purpose:	**Bicyclist Safety** *on arterials, collectors, and residential streets*
Other Potential Results:	Speed Reduction (with lane diet)
	Collision Reduction

Buffered bike lanes are conventional bicycle lanes paired with a designated buffer space separating the bicycle lane from the adjacent motor vehicle travel lane and/or parking lane. A buffered bike lane is allowed as per CA MUTCD (9C.04) guidelines for buffered preferential lanes.

Typical Applications

- Anywhere a standard bike lane is being considered.
- On streets with high travel speeds, high travel volumes, and/or high amounts of truck traffic.
- On streets with extra lanes or extra lane width.
- Special consideration should be given at transit stops to manage bicycle & pedestrian interactions.

Advantages

- Provides greater distance between motor vehicles and bicyclists.
- Provides space for bicyclists to pass another bicyclist without encroaching into the adjacent motor vehicle travel lane.
- Encourages bicyclists to ride outside of the door zone when buffer is between parked cars and bike lane.
- Provides a greater space for bicycling without making the bike lane appear so wide that it might be mistaken for a travel lane or a parking lane.
- Appeals to a wider cross-section of bicycle users.
- Encourages bicycling by contributing to the perception of safety among users of the bicycle network.

Buffered Bike Lane Design Guidance

Required Features

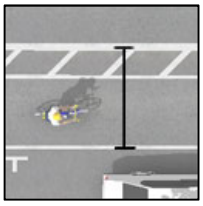
Bicycle lane word and/or symbol and arrow markings (CA MUTCD 9C.04) shall be used to define the bike lane and designate that portion of the street for preferential use by bicyclists.

The buffer shall be marked with 2 solid white lines. White lines on both edges of the buffer space indicate lanes where crossing is discouraged, though not prohibited. For clarity, consider dashing the buffer boundary where cars are expected to cross at driveways.

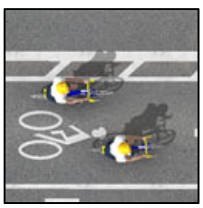
Recommended Features

The use of interior diagonal cross hatching or chevron markings should be considered. These markings should not be used if the buffer is less than 4' in width (CA MUTCD 9C.04).

If used, interior diagonal cross hatching should consist of 6" lines angled at 45 degrees and striped at intervals of 10 to 40 feet. Increased striping frequency may increase motorist compliance.

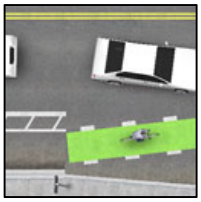


The combined width of the buffer(s) and bike lane should be considered "bike lane width" with respect to guidance given in other documents that don't recognize the existence of buffers. Where buffers are used, bike lanes can be narrower because the shy distance function is assumed by the buffer. For example, a 3 foot buffer and 4 foot bike lane next to a curb can be considered a 7 foot bike lane. For travel side buffered lanes next to on street parking, a 5 foot minimum width is recommended to encourage bicyclists to ride outside of the door zone.



Where bicyclist volumes are high, bicyclist speed differentials are significant, or where side-by-side riding is desired, the desired bicycle travel area width is 7 feet.

Buffers should be at least 18 inches wide because it is impractical to mark a zone narrower than that.

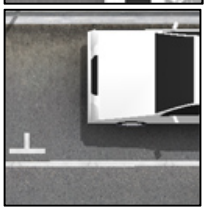


On intersection approaches with right turn only lanes, the bike lane should be transitioned to a through bike lane to the left of the right turn only lane, or a combined bike lane/turn lane should be used if available road space does not permit a dedicated bike lane.

On intersection approaches with no dedicated right turn only lane the buffer markings should transition to a conventional dashed line. Refer to Figure 9C-104CA in CA MUTCD.

Optional Features

Like a conventional bike lane, a wide (4 inch, as per CA MUTCD Figure 9C-104CA) solid white line may be used to mark the edge adjacent to a motor vehicle travel lane. For a parking side buffer, parking T's or a solid line are acceptable to mark between a parking lane and the buffer.



For travel lane buffer configurations, separation may also be provided between bike lane striping and the parking boundary to reduce door zone conflicts. This creates a type of parking-side buffer.

On wide one-way streets with buffered bike lanes, consider adding a buffer to the opposite side parking lane if the roadway appears too wide. This will further narrow the motor vehicle lanes and encourage drivers to maintain lower speeds.

The interior of the buffer area may use different paving materials to separate it from the bike lane. Textured surface materials may cause difficulties for bicyclists as surfaces may be rough. Increased maintenance requirements are likely.

Color may be used at the beginning of each block to discourage motorists from entering the buffered lane. For other uses of color in buffered bike lanes see colored bike facilities.

Maintenance

- Buffer striping may require additional maintenance when compared to a conventional bicycle lane.
- Buffered bike lanes should be maintained free of potholes, broken glass, and other debris.
- If trenching is to be done in the bicycle lane, the entire bicycle lane should be trenched so that there is not an uneven surface or longitudinal joints.

Source: NACTO, Urban Bikeway Design Guide, 2013.

Cycle Tracks (and Separated Bike Lanes)

Primary Purpose:	**Bicyclist Safety** *on arterial and collector streets*
Other Potential Results:	Speed Reduction
	Collision Reduction

A **cycle track** is an exclusive bike facility that combines the user experience of a separated path with the on-street infrastructure of a conventional bike lane. A cycle track is physically separated from motor traffic and distinct from the sidewalk. Cycle tracks have different forms but all share common elements—they provide space that is intended to be exclusively or primarily used for bicycles, and are separated from motor vehicle travel lanes, parking lanes, and sidewalks. In situations where on-street parking is allowed cycle tracks are located to the curb-side of the parking (in contrast to bike lanes).

Cycle tracks may be one-way or two-way, and may be at street level, at sidewalk level, or at an intermediate level. If at sidewalk level, a curb or median separates them from motor traffic, while different pavement color/texture separates the cycle track from the sidewalk. If at street level, they can be separated from motor traffic by raised medians, on-street parking, or bollards. By separating cyclists from motor traffic, cycle tracks can offer a higher level of security than bike lanes and are attractive to a wider spectrum of the public.

All Cycle Tracks Advantages

- Dedicates and protects space for bicyclists in order to improve perceived comfort and safety.
- Eliminates risk and fear of collisions with over-taking vehicles.
- Reduces risk of 'dooring' (when a vehicle door is opened into the bike lane and creates an unexpected hazard for bicyclists, which often results in collision) compared to a bike lane and eliminates the risk of a doored bicyclist being run over by a motor vehicle.
- Low implementation cost by making use of existing pavement and drainage and by using parking lane as a barrier.
- More attractive for bicyclists of all levels and ages

All Cycle Tracks Typical Application

- Streets on which bike lanes may cause many bicyclists to feel stress because of factors such as multiple lanes, high traffic volumes, high speed traffic, high demand for double parking, and high parking turnover.
- Streets for which conflicts at intersections can be effectively mitigated using parking lane setbacks, bicycle markings through the intersection, and other signalized intersection treatments.
- Along streets with high bicycle volumes.

- Along streets with high motor vehicle volumes and/or speeds or streets with heavy truck traffic.
- Special consideration should be given at transit stops to manage bicycle & pedestrian interactions.

One Way Separated Cycle Track (also known as a Separated Bike Lane)

One-way separated cycle tracks are bikeways that are at street level and use a variety of methods for physical protection from passing traffic. A one-way separated cycle track may be combined with a parking lane or other barrier between the cycle track and the motor vehicle travel lane.

Advantages

- Prevents double-parking, unlike a bike lane. As well as general cycle track advantage (see above).

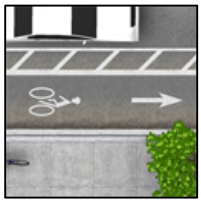
Typical Applications

- Streets with parking lanes, as well as, general cycle track typical applications (see above).

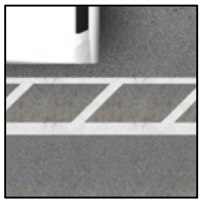
One-Way Separated Cycle Track Design Guidance

Required Features

A cycle track, like a bike lane, is a type of preferential lane as defined by the CA MUTCD.

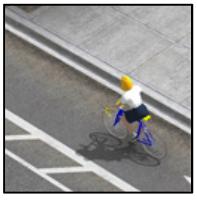


Bike lane wording, symbol, and/or arrow markings (CA MUTCD Section 9C-3) shall be placed at the beginning of a cycle track and at periodic intervals along the facility based on engineering judgment.

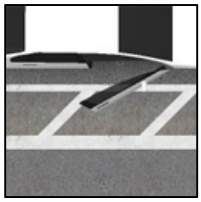


If pavement markings are used to separate motor vehicle parking lanes from the preferential bicycle lane, solid white lane line markings shall be used. Diagonal crosshatch markings may be placed in the neutral area for special emphasis. See CA MUTCD Section 9C.04. Raised medians or other barriers can also provide physical separation to the cycle track.

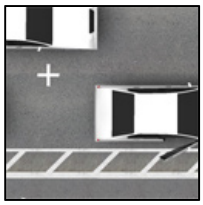
Recommended Features



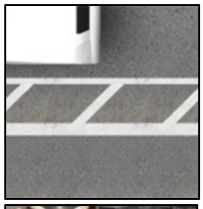
The minimum desired width for a cycle track should be 5 feet. In areas with high bicyclist volumes or uphill sections, the minimum desired width should be 7 feet to allow for bicyclists passing each other.



Three feet is the desired width for a parking buffer to allow for passenger loading and to prevent door collisions.



When using a parking separated pavement marking buffer, desired parking lane and buffer combined width is 11 feet to discourage motor vehicle encroachment into the cycle track.



In the absence of a raised median or curb, the minimum desired width of the painted buffer is 3 ft. The buffer space should be used to locate bollards, planters, signs or other forms of physical protection.

Driveways and minor street crossings are a unique challenge to cycle track design. A review of existing facilities and design practice has shown that the following guidance may improve safety at crossings of driveways and minor intersections:

If the cycle track is parking separated, parking should be prohibited near the intersection to improve visibility. The desirable no-parking area is 30 feet from each side of the crossing.

For motor vehicles attempting to cross the cycle track from the side street or driveway, street and sidewalk furnishings and/or other features should accommodated a sight triangle of 20 feet to the cycle track from minor street crossings and from driveway crossings.

Color, yield lines, and “Yield to Bikes” signage should be used to identify the conflict area and make it clear that the cycle track has priority over entering and exiting traffic.

Motor vehicle traffic crossing the cycle track should be constrained or channelized to make turns at sharp angles to reduce travel speed prior to the crossing.

Gutter seams, drainage inlets, and utility covers should be configured so as not to impede bicycle travel and to facilitate run-off.

Sidewalk curbs and furnishings should be used to prevent pedestrian use of the cycle zone.

Cycle track width should be larger in locations where the gutter seam extends more than 12 inches from the curb (NACTO, Urban Bikeway Design Guide, 2013.).

Optional Features

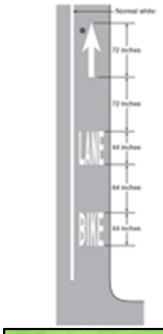
Tubular markers (also known as delineators) may be used to protect the cycle track from the adjacent travel lane. The color of the tubular markers shall be the same color as the pavement marking they supplement.

Cycle tracks may be shifted more closely to the travel lanes on minor intersection approaches to put bicyclists clearly in the field of view of motorists

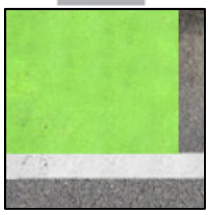
A raised median, bus bulb, or curb extension may be configured in the cycle track buffer area to accommodate transit stops. Bicyclists should yield to pedestrians crossing the roadway at these points to reach the transit stop.

At transit stops, consider wrapping the cycle track behind the transit stop zone to reduce conflicts with transit vehicles and passengers. Bicyclists should yield to pedestrians in these areas. At intersection bus stops, an extended mixing zone may be provided with signage directing bicyclists to yield to buses and loading passengers. Cycle tracks may be configured on the left side of a one-way street to avoid conflicts at transit stops.

A BIKE LANE sign (CA MUTCD R3-17) may be used to designate the portion of the street for preferential use by bicyclists. A supplemental “No Motor Vehicles” selective exclusion sign (CA MUTCD R5-3) may be added for further clarification.



A BIKE LANE legend (CA MUTCD Figure 9C-3) may be used to supplement the preferential lane wording or symbol marking.



Colored pavement may be used to further define the bicycle space.

Two-Way Cycle Tracks

Two-way cycle tracks (also known as separated bike lanes, separated bikeways, and on-street bike paths) are physically separated cycle tracks that allow bicycle movement in both directions on one side of the road. Two-way cycle tracks share some of the same design characteristics as one-way tracks, but may require additional considerations at driveway and side-street crossings.

A two-way cycle track may be configured as a separated cycle track—at street level with a parking lane or other barrier between the cycle track and the motor vehicle travel lane—and/or as a raised cycle track to provide vertical separation from the adjacent motor vehicle lane.

Advantages

- On one-way streets, reduces out of direction travel by providing contra-flow movement and typical requires less street width than separate bike facilities, as well as, general cycle track advantages (see above).

Typical Applications

- On streets with few conflicts such as driveways or cross-streets on one side of the street.
- On streets where there is not enough room for a one-way cycle track on both sides of the street.
- On one-way streets where contra-flow bicycle travel is desired.
- On streets where more destinations are on one side thereby reducing the need to cross the street.
- On streets with extra right-of-way on one side.
- To connect with another bicycle facility, such as a second cycle track on one side of the street.

Two-Way Cycle Track Design Guidance

Required Features

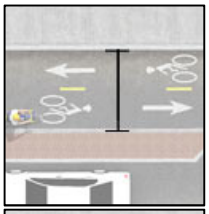
Bike lane wording, symbol, and/or arrow markings (CA MUTCD Figure 9C-3) shall be placed at the beginning of a cycle track and at periodic intervals along the facility to define the bike lane direction and designate that portion of the street for preferential use by bicyclists.

If configured on a one-way street, a "ONE WAY" sign (CA MUTCD Figure 2B-13) with "EXCEPT BIKES" plaque (MUTCD R6-2) shall be posted along the facility and at intersecting streets, alleys, and driveways informing motorists to expect two-way traffic.

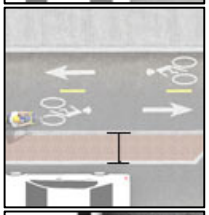
A "DO NOT ENTER" sign (CA MUTCD Figure 2B-09) with "EXCEPT BIKES" plaque shall be posted along the facility to only permit use by bicycles.

Intersection traffic controls along the street (e.g., stop signs and traffic signals) shall also be installed and oriented toward bicyclists traveling in the contra-flow direction.

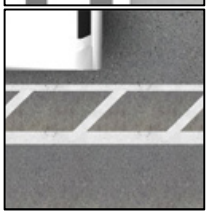
Recommended Features



The desirable two-way cycle track width is 12 feet. Minimum width in constrained locations is 8 feet.



When separated by a parking lane, 3 feet is the desired width for a parking buffer to allow for passenger loading and to prevent dooring collisions.



In the absence of a raised median or curb, the desired with of the painted buffer is 3 ft. The buffer space should be used to locate bollards, planters, signs or other forms of physical protection.

A dashed yellow line should be used to separate two-way bicycle traffic and to help distinguish the cycle track from any adjacent pedestrian area.

Driveways and minor street crossings are a unique challenge to cycle track design. A review of existing facilities and design practice has shown that the following guidance may improve safety at crossings of driveways and minor intersections:

If the cycle track is parking separated, parking should be prohibited near the intersection to improve visibility. The desirable no-parking area is 30 feet from each side of the crossing.

- For motor vehicles attempting to cross the cycle track from a side street or driveway, street and sidewalk furnishings and/or other features should accommodate a sight triangle of 20 feet to the cycle track from minor street crossings and from driveway crossing.
- Color, yield lines, and “Yield to Bikes” signage should be used to identify the conflict area and make it clear that the cycle track has priority over entering and exiting traffic.
- Motor vehicle traffic crossing the cycle track should be constrained or channelized to make turns at sharp angles to reduce travel speed prior to the crossing.
- If configured as a raised cycle track, the crossing should be raised, in which the sidewalk and cycle track maintain their elevation through the crossing. Sharp inclines on either side from road to sidewalk level serve as a speed hump for motor vehicles.

Two-stage turn queue boxes should be provided to assist in making turns from the cycle track facility.

Optional Features

Same as One-Way separated Cycle Track (refer to page 19).

ADA/PROWAG Considerations

When providing accessible parking spaces alongside cycle tracks, the following general considerations are recommended to accommodate persons with disabilities in the design of one-way and two-way separated cycle tracks. Local parking regulations and roadway context may vary considerably.

- A widened buffer space may be used to accommodate a side mounted vehicle ramp or lift so that it will not protrude into the cycle track and become a hazard to bicyclists. Additional buffer space may be challenging to achieve with limited right-of-way.
- Mid-block curb ramps may be provided near marked accessible parking spaces, or curb ramps may be provided at a consistent interval along the cycle track to provide additional egress points

for wheelchair users to gain access to the sidewalk. Mid-block curb ramps may also offset inconveniences in curbside freight delivery crossing the cycle track.

- Roadway cross-slopes should be considered across the cycle track during design as slopes exceeding two percent will create difficulty for bicyclists and some disabled users.
- If significant Taxi or Paratransit service exists along the cycle track, consider providing periodic loading zones to allow the vehicles to pull out of the travel lane.
- If used, consider placement of bollards in the buffer area so as not to impede access by disabled users. Individuals with sight-impairments may lack familiarity with this roadway configuration. Outreach and education for sight-impaired individuals is advised to ensure that these individuals have a better understanding of changes to the roadway alignment. Select design elements, such as tactile surfaces may help reinforce these measures.

Maintenance

- Cycle tracks should be maintained in order to be free of potholes, broken glass, and other debris.
- Street sweeping may have to be done more frequently than on streets, especially during the fall, because the lack of the sweeping effect of motor traffic, together with the canyon profile of a cycle track, tends to hold leaves and other debris.
- Snow removal procedures should minimize the creation of snow banks in the buffer zone, because snow melt flowing across the cycle track can freeze at night, requiring frequent salting in order to avoid hazardous conditions.
- Consider restricting parking at a regularly scheduled time of the week or day to facilitate snow removal and street cleaning.
- If trenching is to be done in the cycle track, the entire facility should be trenched so that there is not an uneven surface or latitudinal joints.

Source: NACTO, Urban Bikeway Design Guide, 2013.

Bicycle Boulevard

Primary Purpose:	**Bicyclist Safety** *on local streets*
Other Potential Results:	Speed Reduction
	Collision Reduction

Bicycle boulevards are streets with low motorized traffic volumes and speeds, designated and designed to give bicycle travel priority. Bicycle boulevards use signs, pavement markings, and speed and volume management measures to discourage through trips by motor vehicles and create safe, convenient bicycle crossings of busy arterial streets.

Signs and Pavement Markings

Signs and pavement markings create the basic elements of a bicycle boulevard. They indicate that a roadway is intended as a shared, slow street, and reinforce the intention of priority for bicyclists along a given route. Signs and pavement markings alone do not create a safe and effective bicycle boulevard, but act as reinforcements to other traffic calming and operational changes made to the roadway.

There are three applications for signing and markings on bicycle boulevards:

- Modified street signs identify and brand the route without introducing a new sign. A bicycle symbol can be placed on a standard road sign, along with the coloration associated with the bicycle boulevard network. These are commonly used in tandem with pavement markings.
- Pavement markings identify the route as a bicycle boulevard and can guide users through jogs. These vary throughout North America from small dots about a foot across to stencils that take up nearly a full lane at 30 feet by 6 feet. Several jurisdictions are using MUTCD-approved shared lane markings on bicycle boulevards for consistency with the rest of the bicycle network and because they are visible and proven to impact desired lane positioning by bicyclists.
- Wayfinding signs also guide users through jogs, help brand the network, and include information about the route by identifying intersecting bikeways and providing distance/time information to nearby or popular destinations. Since few businesses or services are typically located along local streets, wayfinding signs inform users of the direction and distance to key destinations, including neighborhoods, commercial districts, transit hubs, schools and universities, and connecting bikeways.

Advantages

- Signs and pavement markings help users remain on the designated route as it turns.
- Signs and markings differentiate bicycle boulevards from other local streets, indicating good routes for people bicycling and reminding people driving to watch for bicyclists.
- Signs and markings brand the bicycle boulevard to raise awareness of the designated routes and to encourage new users.
- Pavement markings encourage people on bicycles to properly position themselves in the roadway and reinforce to all users where bicyclists should be riding, promoting a more comfortable shared use environment for all users.

- Wayfinding signs provide information about nearby destinations and route finding, improving confidence for people bicycling in a new area.

Required Features

Bicycle wayfinding signage and pavement markings shall be included on bicycle boulevards. Pavement markings and identification/wayfinding signs provide a strong visual identity for the street and designate the corridor as a bicycle route.

Where the bicycle boulevard turns or jogs onto another street, signs and/or markings shall be provided to indicate how users can remain on the route.

Center line stripes (if present) shall be removed or not repainted, except for short sections on intersection approaches that have a stop line or traffic circle. Drivers have an easier time passing bicyclists on roads that do not have centerline stripes. If vehicles cannot easily pass each other using the full width of the street, it is likely that there is too much traffic for the street to be a successful bicycle boulevard.

Recommended Features

Pavement markings should be large enough to be visible to all road users; 112 inches by 40 inches (the standard size of a shared lane marking) is the minimum recommended size.

Decision and turn signs should include destinations with arrows and distance and/or bicycling times. Bicycling time should assume a typical speed of 10 mph.

Advanced crossing warning signs such as CA MUTCD sign W11-15 (combination bicycle and pedestrian crossing; may be supplemented with AHEAD plaque) should be placed on intersecting streets with more than 5,000 vpd. A non-standard sign using the coloration and style of other bicycle boulevard signs may be used with an arrow showing bi-directional cross traffic.

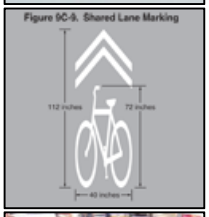
On narrow local streets where it can be difficult for cars traveling in opposite directions to pass, pavement markings should be applied in closer intervals near the center of the travel lane.

Optional Features

Signs may differ from those outlined in the CA MUTCD to highlight or brand the bicycle boulevard network. If used, signs shall be consistent in content, design, and intent; colors reserved by the CA MUTCD Section 1A.12 for regulatory and warning road signs (red, yellow, orange, etc.) are not recommended. Green, blue and purple are commonly used.

Confirmation signs may include destinations and distance and/or bicycling times.

To minimize sign clutter, a bicycle symbol may be placed on a standard street name sign, along with distinctive coloration.



Either shared lane markings or non-standard markings may be used along bicycle boulevards.

On particularly narrow streets (approximately 25 feet wide with parking), shared lane marking stencils may be placed either in the center of the lane facing each other, or with the bicycle marking in the center of the roadway and two sets of chevrons offset 1 foot in each direction or travel.

For wayfinding purposes, the orientation of the chevron marking at offset intersections may be adjusted to direct bicyclists along discontinuous routes. Alternately, an arrow may be used with the chevrons to indicate the direction of the turn.

On-street parking spaces may be delineated with paint or other materials to clearly indicate where a vehicle should be parked and to discourage motorists from parking their vehicles too far into the adjacent travel lane.

Maintenance

- Maintenance needs for bicycle signs are similar to other signs. Signs will need periodic replacement due to wear.

- The shared lane marking may be placed in the center of the lane between wheel treads to minimize wear.

Bicycle Signals

Primary Purpose:	**Bicyclist Safety** *on arterial and collector streets*
Other Potential Results:	Collision Reduction

Bicycle signals facilitate bicyclist crossings of roadways. Bicycle signals make crossing intersections safer for bicyclists by clarifying when to enter an intersection and by restricting conflicting vehicle movements. Bicycle signals are traditional three lens signal heads with green-yellow and red bicycle stenciled lenses that can be employed at standard signalized intersections. Push buttons, signage, and pavement markings may be used to highlight these facilities for both bicyclists and motorists.

Bicycle detection can be used at actuated signals to alert the signal controller of bicycle crossing demand on a particular approach. Bicycle detection occurs either through the use of push-buttons or by automated means (e.g., in-pavement loops, video, microwave, etc). Inductive loop vehicle detection at many signalized intersections is calibrated to the size or metallic mass of a vehicle. For bicycles to be detected, the loop must be adjusted for bicycle metallic mass. Otherwise, undetected bicyclists must either wait for a vehicle to arrive, dismount and push the pedestrian button (if available), or cross illegally.

Bicycle Signal Benefits

- Separates bicycle movements from conflicting motor vehicle, streetcar, light rail, or pedestrian movements.
- Provides priority to bicycle movements at intersections (e.g., a leading bicycle interval).
- Accommodates of bicycle-only movements within signalized intersections (e.g., providing a phase for a contra-flow bike lane that otherwise would not have a phase). Through bicycle travel may also occur simultaneously with parallel auto movement if conflicting automobile turns are restricted.
- Improves operation and provides appropriate information for bicyclists (as compared to pedestrian signals).
- Helps to simplify bicycle movements through complex intersections and potentially improve operations or reduce conflicts for all modes.

Typical Applications

- Where a stand-alone bike path or multi-use path crosses a street, especially where the needed bicycle clearance time differs substantially from the needed pedestrian clearance time.
- To split signal phases at intersections where a predominant bicycle movement conflicts with a main motor vehicle movement during the same green phase.
- At intersections where a bicycle facility transitions from a cycle track to a bicycle lane, if turning movements are significant.

- At intersections with contra-flow bicycle movements that otherwise would have no signal indication and where a normal traffic signal head may encourage wrong-way driving by motorists.
- To give bicyclists an advanced green (like a leading pedestrian interval), or to indicate an "all-bike" phase where bicyclist turning movements are high.
- At complex intersections that may otherwise be difficult for bicyclists to navigate.
- At intersections with high numbers of bicycle and motor vehicle crashes.
- At intersections near schools (primary, secondary, and university).

Bicycle Signal Head Required Features

The bicycle signal head shall be placed in a location clearly visible to oncoming bicycles.

If the bicycle phase is not set to recall each cycle, bicycle signals shall be installed with appropriate detection and actuation. See "Detection and Actuation Required Features" below.

An adequate clearance interval (i.e., the movement's combined time for the yellow and all-red phases) shall be provided to ensure that bicyclists entering the intersection during the green phase have sufficient time to safely clear the intersection before conflicting movements receive a green indication.

If the bicycle signal is used to separate through bicycle movements from right turning vehicles, then right turn on red shall be prohibited when the bicycle signal is active. This can be accomplished with the provision of a traffic signal with red, yellow, and green arrow displays. An active display to help emphasize this restriction is recommended.

Bicycle signal heads are generally the preferred option over installing a sign instructing bicycles to use pedestrian signals. While instructing bicyclists to use pedestrian signals is a low-cost option, the length of the pedestrian clearance interval (typically timed at 3.5 feet per second) is usually inappropriate for bicyclists. The result is that approaching bicyclists have poor information about when it is safe and legal to enter the intersection.

Detection and Actuation Required Features

The sensitivity of standard video and in-pavement loop detectors shall be adjusted to ensure that they detect bicyclists.

Due to magnetic field symmetry, the center of inductive loops is the most sensitive location for detection for both diagonal slashed detectors and quadrupole loop detectors (above left). Square and unmodified circle detectors are most sensitive at their edge (left).

If not provided within a dedicated bike lane, shoulder, or cycle track, bicycle signal detection shall be visible to bicyclists through signs and/or stencils so that bicyclists know that the intersection has detection and where to position their bicycle to activate the signal.

If provided, push-button activation shall be located so bicyclists can activate the signal without dismounting. If used, push buttons should have a supplemental sign facing the bicyclist's approach to increase visibility.

On streets with bike lanes or bikeable shoulders, bicycle detectors shall be located in the bike lane or shoulder. Detection shall be located where bicycles are intended to travel and/or wait. If leading signal detection is provided, it shall be located along a bike lane or in the outside travel lane. Detection at signals shall be placed where bicyclists wait, either in the center of a bike box or immediately behind the stop bar in the bike lane.

Bicycle Signal Head Required Features

A supplemental "Bicycle Signal" sign plaque should be added below the bicycle signal head to increase comprehension.

Signal timing with bicycle-only indications should consider activating the signal with each cycle prior to implementation with detection. This will increase awareness of the interval for motorists and bicyclists. In a close network of signals, the timing should consider how often a bicyclist will be stopped in the system to insure that undue delay is not a result of the bicycle-only signal.

Intersection crossing markings should be used where the bicycle travel path through the intersection is unusual (e.g., diagonal crossing) or needed to separate conflicts.

Passive actuation of bicycle signals through loops or another detection method is preferred to the use of push-buttons for actuation where practical. Passive actuation is more convenient for bicyclists. If push buttons are used, they should be mounted such that bicyclists do not have to dismount to actuate the signal.

The primary factors in choosing an appropriate clearance interval are bicyclist travel speed and intersection width. At most signalized intersections, vehicular clearance intervals will likely function well for bicyclists. Exceptions requiring consideration include signals along cycle tracks or bicyclist facilities that may be likely to serve significant levels of novice cyclists.

Bicyclists typically need longer minimum green times than motor vehicles due to slower acceleration speeds. This time is usually more critical for bicyclists on minor-road approaches, since crossing distance of major roads is typically greater than that of minor roads, and crossings from minor roads are often subject to short green intervals. Bicycle minimum green time is determined using the bicycle crossing time for standing bicycles.

Maintenance

- Inductive loop detector sensitivity settings need to be monitored and adjusted over time.
- Bicycle signal heads require the same maintenance as standard traffic signal heads, such as replacing bulbs and responding to power outages.

Source: NACTO, *Urban Bikeway Design Guide*, 2013.

Pedestrian Facilities

Continental Crosswalks

Primary Purpose:	**Pedestrian Safety** *on arterial, collector, and residential streets*
Other Potential Results:	Collision Reduction

Crosswalks are marked crossings intended to indicate the preferred location for pedestrians to cross a roadway. **"Continental"** markings are crosswalk bars centered in the middle of the crossing and aligned parallel to the direction of vehicular travel. This treatment is used to offer as much comfort, visibility and protection to pedestrians as possible.

Continental crosswalks are preferable to standard parallel or dashed pavement markings. These are more visible to approaching vehicles and have been shown to improve yielding behavior. Continental striping facilitates eye contact by moving pedestrians directly into the driver's field of vision.

Design Guidelines

Critical Features

- Stripe all signalized crossings to reinforce yielding of vehicles turning during a green signal phase. The majority of vehicle-pedestrian incidents involve a driver who is turning.
- Stripe the crosswalk as wide as or wider than the walkway it connects to. This will ensure that when two groups of people meet in the crosswalk, they can comfortably pass one another. Crosswalks should be aligned as closely as possible with the pedestrian through zone. Inconvenient deviations create an unfriendly pedestrian environment.
- Street lighting should be provided at all intersections, with additional care and emphasis taken at and near crosswalks.
- Accessible curb ramps are required by the Americans with Disabilities Act (ADA) at all crosswalks.

Recommended Features

- Keep crossing distances as short as possible using tight corner radii, curb extensions, and medians. Interim curb extensions may be incorporated using flexible posts and epoxied gravel.
- An advanced stop bar should be located at least 4 feet in advance of the crosswalk to reinforce yielding to pedestrians.
- Stop bars should be perpendicular to the travel lane, not parallel to the adjacent street or crosswalk.

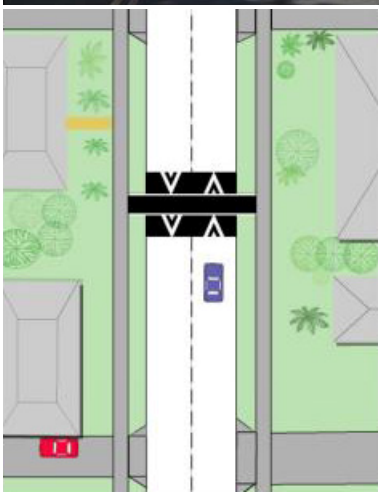
Optional Features

- Right-turn-on-red restrictions may be applied citywide or in special city districts and zones where vehicle pedestrian conflicts are frequent. Right-turn-on-red restrictions reduce conflicts between vehicles and pedestrians.

- Continental Crosswalk can also be used in conjunction with Raised Crosswalks, Pedestrian Refuge Islands, Staggered crosswalks, lighted crosswalks, and Rapid Rectangular Flashing Beacons (RRFB's). Refer to subsequent pages for more information about these facilities.

Source: NACTO, Urban Bikeway Design Guide, 2013.

Raised Crosswalks



Primary Purpose:	**Speed Reduction** *on Residential and Collector streets*
Other Potential Results:	Pedestrian Safety
	Speed Reduction

Raised Crosswalks are similar to speed tables; however, they provide a marked pedestrian crossing at a leveled pedestrian path and street crossing forcing vehicles to slow before passing the crosswalk. This device can be used at intersections or mid-block locations. Raised crosswalks are highly effective in areas with large volumes of pedestrian traffic, such as schools or downtown business districts. Raised crosswalks can be combined with bulb-outs to decrease the distance a pedestrian is in the vehicle travel way. They are also installed at alleyway and major driveway to improve the intersection of an alley/driveway with a major street.

MEASURED EFFECTIVENESS

Speed Reduction[1]	-18%
Volume Reduction[2]	-12%
Collision Reduction[3]	-45%

Source: Traffic Calming – State of the Practice 2000

[1]Reduction in 85th Percentile Speeds between slow points

[2]Reduction in Vehicles per Day

[3]Reduction in Average Annual Collisions

[4]ID = Insufficient Data to predict reduction effect

Advantages:

- Speed reduction
- Improves visibility of pedestrians and crossings
- Can provide pedestrian mid-block crossing

Disadvantages:

- Loss of parking
- EMS/Fire vehicles forced to almost stop at ramp
- May create more noise from decelerating and accelerating

Raised Crosswalk Design Guidelines

Raised Crosswalk Tapers

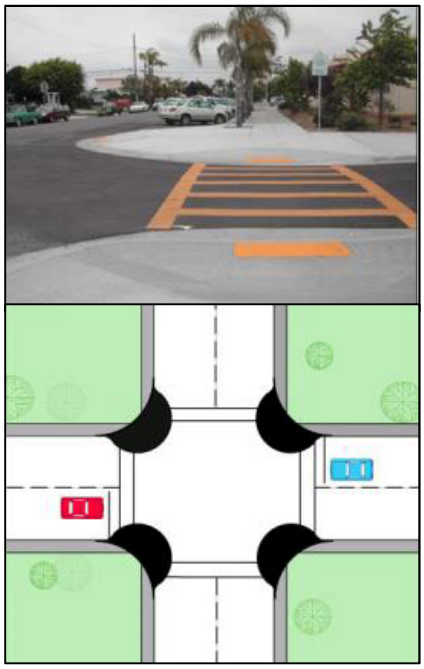
Raised crosswalks should always be designed to a height equal to the curb height, but not fully extended to the curb, as this will impede drainage. To bridge the gap between the sidewalk and raised crosswalk, a metal connector plate shall be used. The device should also include truncated domes to indicate the entrance to the crosswalk from the sidewalk. Raised crosswalks are not appropriate where curbs do not exist.

Signage

Raised crosswalks should always have pavement markings due to concerns about visibility of pedestrians to drivers.

Source: City of San Diego, *Traffic Calming Program Handbook*¸ 2006.

Bulb-Outs/Curb Extensions



Primary Purpose:	**Improve Pedestrian Safety** *on Residential, Collector, and Major streets*
Other Potential Results:	Volume Reduction
	Speed Reduction
	Collision Reduction

Bulb-outs, also known as Pop-outs and Curb Extensions, narrow the width of a street at intersection and mid-block locations by extending the curb into the parking lanes. This creates a shorter crossing distance, reducing a pedestrian's exposure time to oncoming vehicles. Bulb-outs also may slow vehicles making right turns, as the potential turning radius is greatly reduced. By placing the pedestrian at the edge of the travel lane, both the pedestrian and driver have a better view of each other. Bulb-outs are best used in locations with high pedestrian volumes and locations in need of improved visibility, such as downtown areas and near schools.

MEASURED EFFECTIVENESS	
Speed Reduction[1]	-7%
Volume Reduction[2]	-10%
Collision Reduction[3]	I/D[4]
Source: Traffic Calming – State of the Practice 2000	
[1]Reduction in 85th Percentile Speeds between slow points	
[2]Reduction in Vehicles per Day	
[3]Reduction in Average Annual Collisions	
[4]ID = Insufficient Data to predict reduction effect	

Advantages

- Creates shorter crossing distances
- Increase the visibility of pedestrians
- Speed reduction for through traffic and right turning vehicles

Disadvantages

- Difficult for emergency vehicles and larger vehicles to turn

Bulb-out Design Guidance

Drainage

Bulb-outs should be constructed to minimize or avoid blocking the flow of the gutter to reduce cost and maintenance.

Width

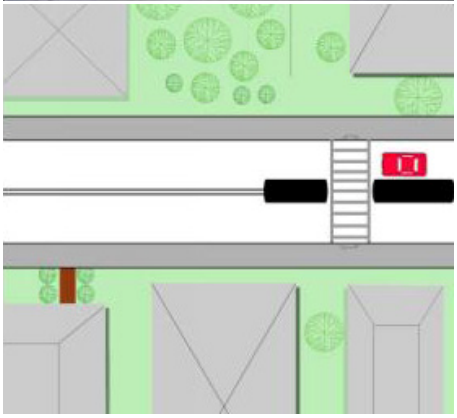
Bulb-outs should not be constructed wider than the approximate width of a parked vehicle. Extension of these devices any further than the width of a parked vehicle (or the length of a vehicle in the case of diagonal parking) could present potential safety issues to other drivers and bicyclists.

Landscaping

Aesthetic upgrades not only improve the aesthetic quality of the device but also increase the visual presence by extending the device's vertical size and introducing more varied colors. Landscaping should be low laying shrubs and plants.

Source: City of San Diego, *Traffic Calming Program Handbook*, 2006

Pedestrian Refuges



Primary Purpose:	**Pedestrian Safety** *on Residential, Collector, and Major streets*
Other Potential Results:	Collision Reduction
	Speed Reduction

Pedestrian Refuges, also known as Pedestrian Crossing islands, are raised median islands paced on a street (typically midblock) to separate crossing pedestrians from motor vehicles. They are used on wide streets to shorten a pedestrian's crossing distance and provide pedestrians with a refuge. To provide refuge, the median should have a minimum width of 6'. This also allows the pedestrian to cross one direction of traffic at a time. After a pedestrian crosses one lane of traffic, they may wait in the median area before finding a gap in traffic to safely cross to the other side of the street. These median refuges can be staggered and/or landscaped to break up the sight line of the drive and enhance the aesthetics of the neighborhood. Landscaping also increases the visibility of the tool.

MEASURED EFFECTIVENESS

Pedestrian Safety[1]	Reduce pedestrian collisions by 46%

[1]Source: Federal Highway Administration, *Medians and Pedestrian Crossing Islands in Urban and Suburban Areas* http://safety.fhwa.dot.gov/provencountermeasures/fhwa_sa_12_011.cfm

Advantages

- Provides ability for a safer pedestrian crossing
- Possible opportunity for landscaping
- Provide pedestrians a safe place to stop mid-point of the roadway to find a gap in traffic before crossing the remaining distance
- Can be used for access management for vehicles (creating right-in/right-out turning movements
- May reduce speeds of vehicles approaching the crossing
- May restrict access to driveways in vicinity of device

Disadvantages

- Potential loss of parking
- May restrict access to driveways in vicinity of device

Source: City of San Diego, *Traffic Calming Program Handbook*¸ 2006.

Rectangular Rapid Flashing Beacons (RRFB's)

Primary Purpose:	**Pedestrian Safety** *on Residential, Collector, and Major streets*
Other Potential Results:	Collision Reduction
	Speed Reduction

Rectangular Rapid Flash Beacons (RRFBs) are a type of active warning beacon that supplement warning signs at unsignalized intersections or mid-block crosswalks. RRFB's use an irregular flash pattern similar to emergency flashers on police vehicles and can be installed on either two-lane or multi-lane roadways. Active warning beacons should be used to alert drivers to yield where pedestrians and bicyclists have the right-of-way crossing a road.

Advantages

- Offers lower cost alternative to traffic signals and Hybrid Beacons.
- Significantly increases driver yielding behavior at crossings when supplementing standard crossing warning signs and markings.
- The unique nature of the stutter flash (RRFBs) elicits a greater response from drivers than traditional methods.

Typical Applications

- On multi-lane roads, where pedestrians have a longer distance to cross
- On roads where the volume of vehicles and speeds along a roadway may be a concern for pedestrians to find an adequate gap in traffic to safely cross
- Usually implemented at high-volume pedestrian crossings
- At locations where bike facilities cross roads at mid-block locations or at intersections where signals are not warranted or desired.
- At locations where driver compliance at crossings is low.

RRFB Design Guidelines

Required Features

Active warning beacons shall be installed on the side of the road. If center islands or medians exist, providing secondary installations in these locations marginally improves driver yielding behavior.

Beacons shall be unlit when not activated.

Refer to CA MUTCD for additional guidance on the use of RRFBs.

Maintenance

Depending on power supply, maintenance can be minimal. If solar power is used, RRFBs should run for years without issue.

Source: NACTO, *Urban Bikeway Design Guide*, 2013.

Pedestrian Hybrid Beacons (HAWK) Signals

Primary Purpose:	**Pedestrian Safety** *on Residential, Collector, and Major streets*
Other Potential Results:	Collision Reduction
	Speed Reduction

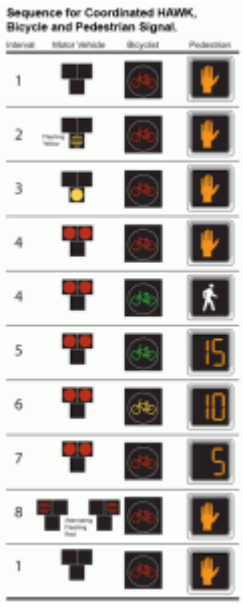
Officially known as a Pedestrian Hybrid Beacon, a **HAWK (High-Intensity Activated crossWalK)** beacon is a traffic control device used to stop traffic and allow pedestrians and cyclists to cross safely. It consists of a signal-head with two red lenses over a single yellow lens on the major street, and pedestrian and/or bicycle signal heads for the minor street. There are no signal indications for motor vehicles on the minor street approaches. Hybrid beacons were developed specifically to enhance pedestrian crossings of major streets. However, several cities have installed modified hybrid beacons that explicitly incorporate bicycle movements.

Hybrid beacons are used to improve non-motorized crossings of major streets in locations where side-street volumes do not support installation of a conventional traffic signal (or where there are concerns that a conventional signal will encourage additional motor vehicle traffic on the minor street). Hybrid beacons may also be used at mid-block crossing locations (e.g., trail crossings).

MEASURED EFFECTIVENESS

Pedestrian Safety[1]	Reduce pedestrian collisions up to 69%
	Reduce total roadway crashes up to 29%

[1]Source: Federal Highway Administration, *Pedestrian Hybrid Beacon* http://safety.fhwa.dot.gov/provencountermeasures/fhwa_sa_12_012.cfm



Operations

Hybrid beacon operations are significantly different from the operations of standard traffic control signals. The figure below illustrates the general sequence of phases for a hybrid beacon as applied for pedestrian crossings. The primary difference compared to a standard signal is that a hybrid beacon displays no indication (i.e., it is dark) when it is not actuated. Upon actuation (by a pedestrian or bicyclist on the minor street), the beacon begins flashing yellow, changes to steady yellow, then displays a solid red indication with both red lenses. During the solid red phase, drivers must stop and remain stopped, as with a standard traffic signal.

Prior to returning to no indication, the beacon displays an alternating flashing "wig-wag" red that allows drivers to stop and proceed when clear, as they would with a stop sign.

Advantages

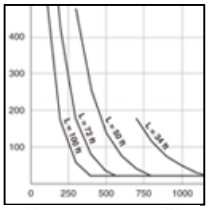
- Can be implemented when a conventional signal warrant is not met or where a conventional traffic signal is not desired due to the potential to increase traffic volumes on minor street approaches.
- Creates spaces for pedestrians and bicyclists to cross multi-lane, high volume, higher speed roads to cross busy streets.
- Is more flexible for bicyclists than a full signal as bicyclists do not have to actuate it if they find ample crossing opportunities during off-peak conditions.
- Associated with very high driver compliance (studies show greater than 95% driver compliance with red indications).
- Improves street crossing safety.

Typical Applications

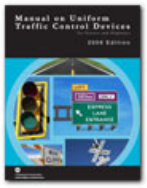
- Where bike paths intersect major streets without existing signalized crossings.
- At crossing locations that do not meet traffic signal warrants, or at locations that meet signal warrants but a decision is made not to install a traffic control signal.
- At mid-block crossings of major roadways with high bicycle or pedestrian volumes.
- At locations with inadequate gaps in traffic for pedestrians to safely cross, or higher speed roads, where pedestrian delay is excessive, at locations with long crossings.

Design Guidance

Required Features



The CA MUTCD provides warrants for the use of hybrid beacons based on motor vehicle speed, crossing length, motor vehicle volumes, and pedestrian volumes.



The MUTCD provides standards related to the design and location of hybrid beacons (e.g., mounting location, height, signal timing of phases, etc.).

Recommended Features

When hybrid beacons are installed to facilitate bicycle movements, a bicycle signal head should be installed in addition to pedestrian signal heads. This allows for safer and more efficient operations that effectively account for the different clearance requirements for pedestrians and bicycles. When used, a bicycle signal head should display a flashing red indication to bicyclists when the hybrid beacon is dark (i.e., the bicycle signal should not rest in dark). This allows bicyclists to treat the intersection as a "Stop" and proceed without the requirement of activating the hybrid beacon.

Should be installed at least 100 feet from side streets or driveways that are controlled by STOP or YIELD signs (CA MUTCD).

Parking and other sight obstructions should be prohibited for at least 100 feet in advance of and at least 20 feet beyond the marked crosswalk, or site accommodations should be made through curb extensions or other techniques to provide adequate sight distance.

The installation should include suitable standard signs and pavement markings.

If installed within a signal system, the HAWK Signal should be coordinated with other signals.

Optional Features

Due to the unique operational features of hybrid beacons, communities that are installing hybrid beacons for the first time may wish to coordinate installation with a public information campaign to educate roadway users on the operations and legal requirements associated with hybrid beacons.

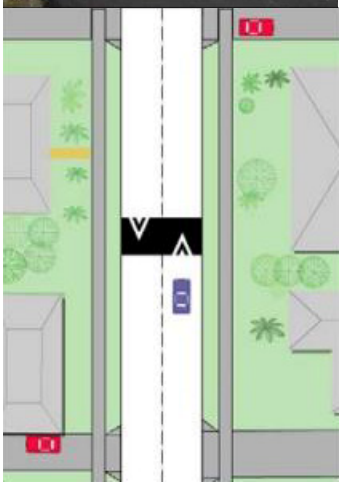
Maintenance

- Hybrid beacons are subject to the same maintenance needs and requirements as standard traffic signals.
- Signing and striping need to be maintained to help users understand the relatively unfamiliar traffic control.

Source: NACTO, *Urban Bikeway Design Guide*, 2013., California Department of Transportation, *California Manual on Uniform Traffic Control Devices,* 2015.

Traffic Calming Treatments

Speed Humps



Primary Purpose:	**Speed Reduction** *on Residential and Collector* streets*
Other Potential Results:	Collision Reduction
	Volume Reduction

Speed humps are devised to encourage drivers to travel at lower speeds over the device. They are approximately 3 ½" inches high, have a parabolic-shape surface, and span the width of the road. The height causes the driver to be jolted if traveling at too high of a speed. However, due to the advance in vehicle suspension system, this device may not affect all drivers. It must be cautioned that these devices do have a severe impact on emergency response services and can create an uncomfortable situation for all passengers including those in ambulances.

*May only be used on low ADT two-lane collectors that do not have two-way left-turn lanes or dedicated left-turn pockets.

MEASURED EFFECTIVENESS	
Speed Reduction[1]	-22%
Volume Reduction[2]	-18%
Collision Reduction[3]	-13%
Source: Traffic Calming – State of the Practice 2000	
[1]Reduction in 85th Percentile Speeds between slow points	
[2]Reduction in Vehicles per Day	
[3]Reduction in Average Annual Collisions	
[4]ID = Insufficient Data to predict reduction effect	

Advantages:

- Speed reduction
- May discourage cut-through traffic
- Relatively low cost (approximately $2,000 per hump)

Disadvantages:

- Uncomfortable for bicyclists and vehicle passengers
- Delay of emergency response vehicles of approximately 3-5 seconds per hump for fire trucks and up to 10 seconds for ambulance with patient source. (Source: Institute of Transportation Engineers, *Traffic Calming Measures – Speed Hump,* http://www.ite.org/traffic/hump.asp)

Variation of Speed Humps – Speed Lumps

Speed lumps are similar to road humps, however, speed lumps include cut out set at a distance to allow for emergency vehicles to pass without having to slow down. This allows lumps to address the concern for delayed emergency response. This feature can also cause motorists to try to "straddle" the cut outs to avoid driving over the lump.

Source: City of San Diego, *Traffic Calming Program Handbook*, 2006.

Full Street Closure/Cul-de-sac

Primary Purpose:	**Volume Reduction** *on Residential streets*
Other Potential Results:	Collision Reduction
	Speed Reduction

Full Street Closures/Cul-de-sacs are created by constructing a barrier across the entire street, closing the street to all through traffic. This measure will have a drastic effect on local traffic circulation. They are used to force changes in travel patterns – such as preventing cut-through traffic in residential neighborhoods or to eliminate dangerous or problematic intersections. Adjacent roadways will experience an increase in traffic due to the closure and local residents will have longer travel routes. Full street closures should be constructed in a manner which maintains pedestrian, bicycle and emergency vehicle access.

MEASURED EFFECTIVENESS

Speed Reduction[1]	6-20%[4]

Source:

[1]Minnesota Department of Transportation, *Investigating the Effectiveness of Traffic Calming Strategies on Driver Behavior, Traffic Flow, and Speed*, 2001, http://nacto.org/docs/usdg/investigating_effectiveness_of_traffic_calming_strategies_corkle.pdf.

Advantages

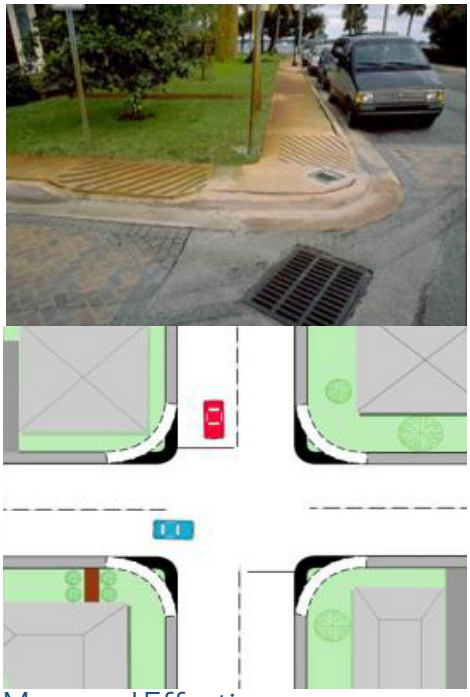
- Eliminate cut-through traffic
- Potential landscaping opportunity
- May reduce speeds

Disadvantages

- Limits access to the neighborhood
- Will change neighborhood traffic patterns
- Will increase trip length for many residents
- Will increase traffic on adjacent roadways
- Emergency response routes may lengthen

Source: City of San Diego, *Traffic Calming Program Handbook*, 2006.

Curb Radius Reduction



Primary Purpose:	**Speed Reduction** *on Residential, Collector, and Major streets*
Other Potential Results:	Collision Reduction
	Pedestrian Safety

Curb Radius Reductions provide tighter corner radii at intersections. This treatment may reduce the right-turn speed of vehicles. By reducing right-turn speeds, some drivers may be discouraged from cutting through the neighborhood. It also will increase the visibility of pedestrians to drivers and shorten the crossing distance for pedestrians.

This treatment may cause difficulty for large vehicles. Some larger vehicles may not be able to make the turn without crossing into the opposing travel lane. This treatment may not be appropriate in areas that experience high volumes of large vehicles.

Measured Effectiveness

Insufficient Data to predict reduction effect

Advantages

- Slows right turn speeds
- Increases the visibility of pedestrian to drivers
- Shorten pedestrian crossing distance

Disadvantages

- Difficult for large vehicles to make right-turn

Design Guidelines

- Design radius for a turning speed of 15 mph or less for pedestrian safety
- Design for the smallest possible design vehicle
- Accommodate trucks and buses on designated bus and truck routes
- Design for emergency vehicles

Drainage Improvements may be required for streets with unique roadway alignments or pre-existing drainage problems. If the proposed traffic calming feature would fundamentally alter the drainage patterns for a roadway, improvements would be required. The price of these improvements would be dependent on size and feasibility.

Source: City of San Diego, *Traffic Calming Program Handbook*, 2006.