NACTO

Urban Bikeway Design Guide

April 2011 Edition

Contents

Introduction

The purpose of the NACTO Urban Bikeway Design Guide (part of the Cities for Cycling initiative) is to provide cities with state-of-the-practice solutions that can help create complete streets that are safe and enjoyable for bicyclists.

The NACTO Urban Bikeway Design Guide is based on the experience of the best cycling cities in the world. The designs in this document were developed by cities for cities, since unique urban streets require innovative solutions. Most of these treatments are not directly referenced in the current versions of the AASHTO Guide to Bikeway Facilities or the Manual on Uniform Traffic Control Devices (MUTCD), although many of the elements are found within these documents. The Federal Highway Administration has recently posted information regarding approval status of various bicycle related treatments not covered in the MUTCD, including many of the treatments provided in the NACTO Urban Bikeway Design Guide. All of the NACTO Urban Bikeway Design Guide treatments are in use internationally and in many cities around the US.

To create the Guide, the authors have conducted an extensive worldwide literature search from design guidelines and real-life experience. They have worked closely with a panel of urban bikeway planning professionals from NACTO member cities, as well as traffic engineers, planners, and academics with deep experience in urban bikeway applications. A complete list of participating professionals is included here. Additional information has been gathered from numerous other cities worldwide.

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NACTO encourages the exchange of transportation ideas, insights, and practices among large central cities while fostering a cooperative approach to key national transportation issues. We do this by:

- Sharing data and best practices, through research projects and peer-to-peer sessions
- Communicating regularly, through conference calls with the Cities and via an annual meeting with the USDOT Secretary and other federal agencies
- Advocating change in transportation laws, regulations, and financing to enable large cities to better provide the integrated transportation services envisioned by Federal transportation law.

The intent of the Guide is to offer substantive guidance for cities seeking to improve bicycle transportation in places where competing demands for the use of the right of way present unique challenges. Each of the treatments addressed in the Guide offers three levels of guidance:

- **Required:** elements for which there is a strong consensus that the treatment cannot be implemented without.
- **Recommended:** elements for which there is a strong consensus of added value.
- **Optional:** elements that vary across cities and may add value depending on the situation.
- In all cases, we encourage engineering judgment to ensure that the application makes sense for the context of each treatment, given the many complexities of urban streets.

Guide Status

This Guide has been created by a panel of professionals from NACTO member cities and a consulting team consisting of international experts in bikeway design along with the support of the NACTO Board of Directors. The NACTO Guide can be adopted by individual cities, counties, or states as either a stand-alone document or as a supplement to other guidance documents. The NACTO Guide will be updated regularly and have an extensive website that will include engineering drawings, three dimensional renderings and images of the various design treatments, as well as a discussion area where professionals can exchange information and ideas on bikeway design.

How to Use the Guide

First and foremost, the NACTO Urban Bikeway Design Guide is intended to help practitioners make good decisions about urban bikeway design. The treatments outlined in the Guide are based on real-life experience in the world's most bicycle friendly cities and have been selected because of their utility in helping cities meet their goals related to bicycle transportation. Step one for most cities will be to start using the Guide in their daily transportation design work.

It is important to note that many urban situations are complex; treatments must be tailored to the individual situation. Good engineering judgment based on deep knowledge of bicycle transportation should be a part of bikeway design. Decisions should be thoroughly documented. To assist with this, the NACTO Urban Bikeway Design Guide links to companion reference material and studies.

View more online:

For more details, information, resources, case studies, and photographs, please visit www.c4cguide.org. The online platform of the NACTO Urban Bikeway Design Guide reflects the most current, up-to-date, available design guidance. It will be frequently revised, updated, and expanded to reflect the state of the practice in bicycle facility design.

IN THIS SECTION:

- Conventional Bike Lanes
- Buffered Bike Lanes
- Contra-Flow Bike Lanes
- Left-Side Bike Lanes

BIKE LANES

A Bike Lane is defined as a portion of the roadway that has been designated by striping, signage, and pavement markings for the preferential or exclusive use of bicyclists.

Bike lanes enable bicyclists to ride at their preferred speed without interference from prevailing traffic conditions and facilitate predictable behavior and movements between bicyclists and motorists. A bike lane is distinguished from a cycle track in that it has no physical barrier (bollards, medians, raised curbs, etc.) that restricts the encroachment of motorized traffic. Conventional bike lanes run curbside when no parking is present, adjacent to parked cars on the right-hand side of the street or on the left-hand side of the street in specific situations. Bike lanes typically run in the same direction of traffic, though they may be configured in the contra-flow direction on low-traffic corridors necessary for the connectivity of a particular bicycle route.

The configuration of a bike lane requires a thorough consideration of existing traffic levels and behaviors, adequate safety buffers to protect bicyclists from parked and moving vehicles, and enforcement to prohibit motorized vehicle encroachment and double-parking. Bike Lanes may be distinguished using color, lane markings, signage, and intersection treatments.

Conventional Bike Lanes

Description

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.

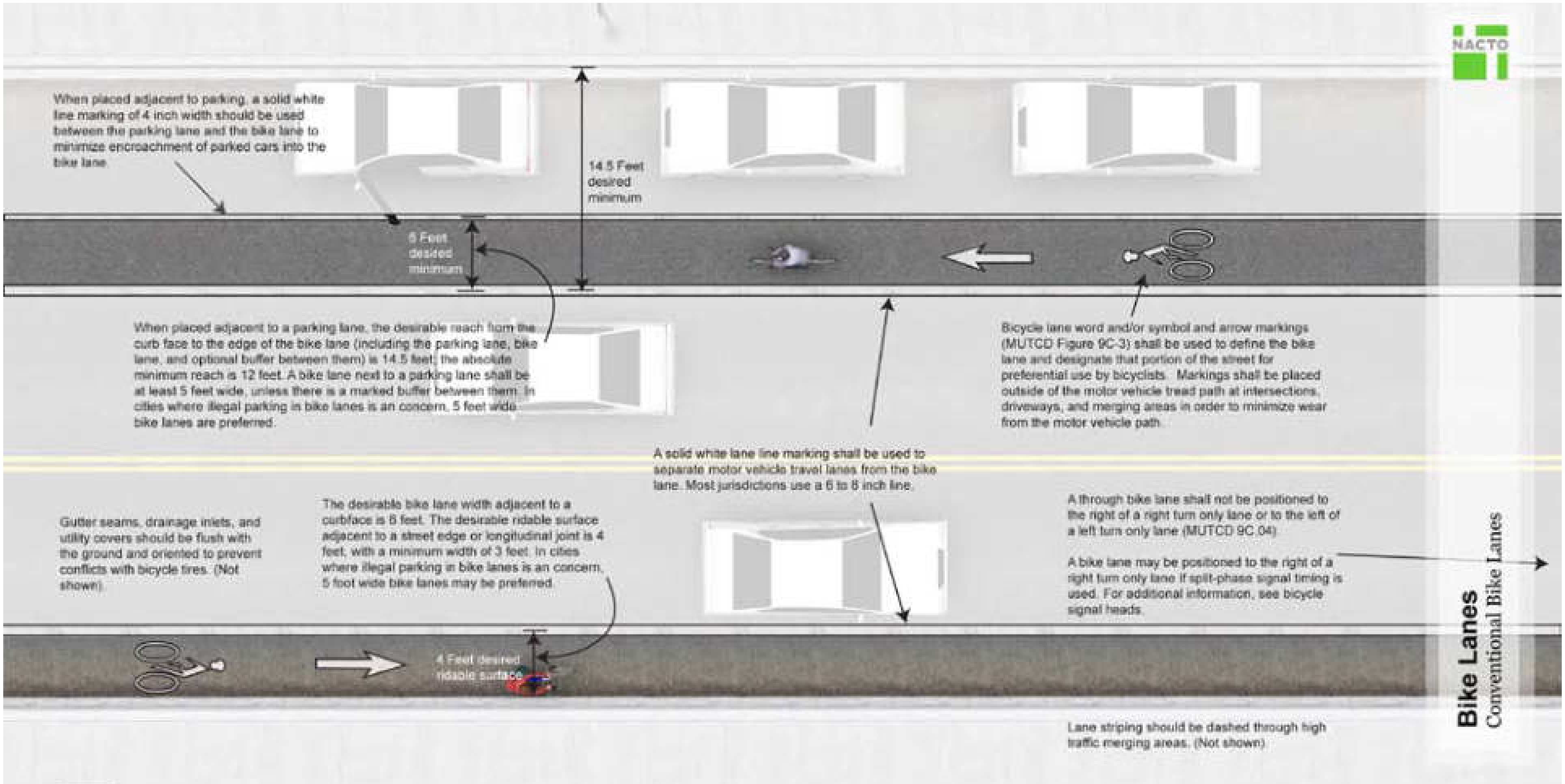
Conventional Bike Lane Benefits

- 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

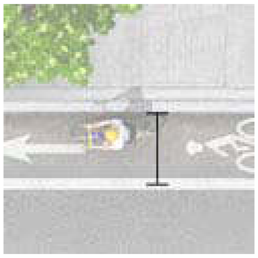
- Bike lanes are most helpful on streets with ≥ 3,000 motor vehicle average daily traffic.
- Bike lanes are most helpful on streets with a posted speed ≥ 25 mph.
- On streets with high transit vehicle volume.
- On streets with high traffic volume, regular truck traffic, high parking turnover, or speed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

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/Conventional-Bike-Lanes_Annotation.jpg

REQUIRED



The desirable bike lane width adjacent to a curbface is 6 feet. The desirable 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 an concern, 5 foot wide bike lanes may be preferred.

> *The recommended width of a bike lane is 1.5m(5 feet) from the face of a curb or guardrail to the bike lane stripe.*

> *If the [longitudinal] joint is not smooth, 1.2m(4 feet) of ridable surface should be provided.*

AASHTO. (1999). Guide for the Development of Bicycle Facilities.

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. In cities where illegal parking in bike lanes is an concern, 5 feet wide bike lanes are preferred.

> *If parking is permitted, … the bike lane should be placed between the parking area and the travel lane and have a minimum width of 1.5 m (5 feet).*

> *Where parking is permitted but a parking stripe or stalls are not utilized, the shared area should be a minimum 3.6 m (12 feet) adjacent to a curb face … If the parking volume is substantial or turnover is high, an additional 0.3 to 0.6 m (1 to 2 feet) of width is desirable.*

AASHTO. (1999). Guide for the Development of Bicycle Facilities.

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 shy distance from the barrier.

> *On new structures [with railings], the minimum clear width should be the same as the approach paved shared use path, plus the minimum 0.6-m (2-foot) wide clear areas.*

AASHTO. (1999). Guide for the Development of Bicycle Facilities.

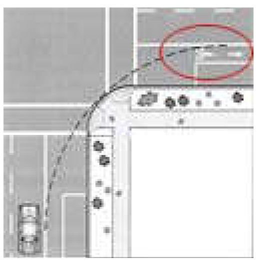
REQUIRED (CONTINUED)

Bicycle lane word 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.

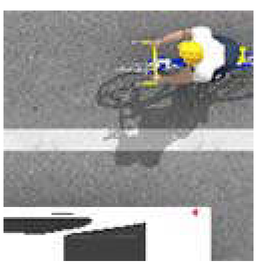
Markings shall be placed:

- *At the beginning of bike lane*
- *At the far side of all bike path crossings*
- *At approaches and at far side of all arterial crossings*
- *At major changes in direction*
- *At intervals not to exceed ½ mile*
- *At beginning and end of bike lane pockets at approach to intersection*

Los Angeles Bicycle Plan Update(2010). Chapter 5—Technical Design Handbook-DRAFT.



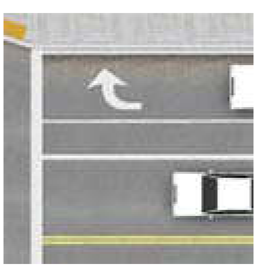
Bike lane word, symbol, and/or arrow markings (MUTCD Figure 9C-3) shall be placed outside of the motor vehicle tread path at intersections, driveways, and merging areas in order to minimize wear from the motor vehicle path.



A solid white lane line marking shall be used to separate motor vehicle travel lanes from the bike lane. Most jurisdictions use a 6 to 8 inch line.

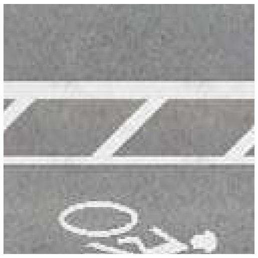
A bike lane should be delineated from the motor vehicle travel lanes with a 150-mm (6-inch) solid white line. Some jurisdictions have used a 200-mm (8-inch) line for added distinction.

AASHTO. (1999). Guide for the Development of Bicycle Facilities.

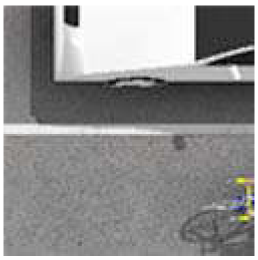


A through bike lane shall not be positioned to the right of a right turn only lane or to the left of a left turn only lane (MUTCD 9C.04). A bike lane may be positioned to the right of a right turn only lane if split-phase signal timing is used. For additional information, see bicycle signal heads. For additional strategies for managing bikeways and right turn lanes, see through bike lanes in this guide.

RECOMMENDED



Bike lanes should be made wider than minimum widths wherever possible to provide space for bicyclists to ride side-by-side and in comfort. Reduce bike lane width only after other street elements (e.g., travel lanes, medians, median offsets) have been reduced to their minimum dimensions. 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.

> *An additional 100-mm (4-inch) solid white line can be placed between the parking lane and the bike lane. This second line will encourage parking closer to the curb, providing added separation from motor vehicles, and where parking is light it can discourage motorists from using the bike lane as a through travel lane.*

AASHTO. (1999). Guide for the Development of Bicycle Facilities.

> *In a case study looking at the influence of pavement markings and bicyclist positioning, researchers found that, "the bicycle lane [with an edge line demarcating the parking lane] was the most effective at keeping cars parked closer to the curb and encouraging cyclists to ride in a consistent position at intersections.*

Pedestrian and Bicycle Information Center. (2006). BIKESAFE: Bicycle Countermeasure Selection System. Publication No. FHWA-SA-05-006, Federal Highway Administration, Washington, DC.

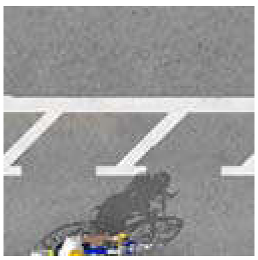
Gutter seams, drainage inlets, and utility covers should be flush with the ground and oriented to prevent conflicts with bicycle tires.

> *Since bicyclists usually tend to ride a distance of 0.8-1.0 m (32-40 inches) from a curb face, it is very important that the pavement surface in this zone be smooth and free of structures. Drain inlets and utility covers that extend into this area may cause bicyclists to swerve, and have the effect of reducing the usable width of the lane. Where these structures exist, the bike lane width may need to be adjusted accordingly.*

AASHTO. (1999). Guide for the Development of Bicycle Facilities.

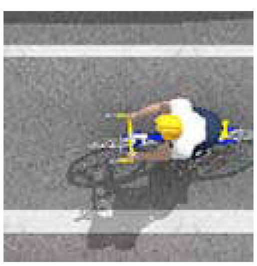
RECOMMENDED (CONTINUED)

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. See through bike lanes for more information.



The desirable dimensions should be used unless other street elements (e.g., travel lanes, medians, median offsets) have been reduced to their minimum dimensions.

In cities 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. Different states have varying requirements.

OPTIONAL

"Bike lane" signs (MUTCD R3-17) 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 2009 MUTCD lists bike lane signs as optional; however, some states still require their use.

> *If the word, symbol, and/or arrow pavement markings shown in Figure 9C-3 are used, Bike Lane signs (see Section 9B.04) may also be used, but to avoid overuse of the signs not necessarily adjacent to every set of pavement markings.*
>
> Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices.

On bike lanes adjacent to a curb, "No Parking" signs (MUTCD R8-3) may be used to discourage parking within the bike lane.

Color may be used to enhance visibility of a bike lane.

South Huntington Avenue Bike Lanes

Boston, MA

The South Huntington Avenue Bike Lanes, installed by the city of Boston in 2010, create a safe, designated route for cyclists along a problematic traffic corridor and a main bicycle route leading to and from the Jamaica Plain neighborhood of Boston. Before construction of the bike lane, the roadway had been difficult for cyclists to navigate for a number of reasons, including a set of trolley tracks in the middle of the street and a troublesome intersection where Heath St. meets South Huntington Ave. The bike lane was designed 6' wide and rests between a 12' travel lane and 8' and 9' parking lanes. At the intersection of Heath St. and South Huntington Ave., 20-30 parking spaces were removed and additional pavement markings added to channel cars into the proper area and avoid collisions. Where the bike lane crosses the trolley track, it has been painted green to ensure a safe, right-angle crossing of the tracks, and as a sign for cars to yield. Green paint has also been employed at several other points along the bike lane to create greater distinction from motorists. Further along Huntington Ave., a bus stop had to be relocated, parking removed, and an asphalt ramp created for bicyclists to wait safely on the curb to cross the tracks. In this area, the bike lane is indicated by sharrows in the right travel lane. As part of the city of Boston's bike network, the bike lane establishes connectivity between Hyde Square in Jamaica Plain, another bike route leading south towards the Arborway, and the Southwest Corridor off road path.

Maintenance

- Lane lines and stencil markings should be maintained to clear and legible standards.
- Bike lanes should be plowed clear of snow by crews.
- 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.

Treatment Adoption and Professional Consensus

Bicycle lanes are the most common bicycle facility in use in the US, and most jurisdictions are familiar with their design and application as described in the MUTCD and AASHTO Guide for the Development of Bicycle Facilities. To offer increased levels of comfort and security to bicyclists, some cities have exceeded the minimum dimensions required in these guides.

Bike Lane and Sharrows on 27th Avenue SE

Minneapolis, MN

The 27th Ave SE bike lane in Southeast Minneapolis provides a key north-south connection between two major bicycle trails: East River Road and the University of Minnesota Transitway. The lane serves as a major corridor for bicyclists leading through several densely populated neighborhoods and affordable housing areas in SE Minneapolis. Before installation of the bike lanes, 27th Ave. SE, a truck route and County State Aid Highway, was a four lane roadway with a 30 mph speed limit and 3,600 vehicles per day. The road also crosses a railroad track at a 45-degree angle dangerous for cyclists. To create a safer roadway for cyclists, the city added bike lanes and/or sharrows at all points along the route and reduced 27th Ave. SE from four lanes to two at certain points. A gutter pan at the roadside curb was paved to create a smooth surface for cyclists. Extra pavement was also added to the railroad track area to ensure a right angle crossing for cyclists and avoid the risk of catching a tire in the tracks. The lanes were created using permanent tape striping with a layer of seal coating in most places, though portions of the lane were milled and overlaid to create a single-surface bike lane. Bicycle route and way-finding signage, as well as bicycle racks and intersection treatments, were included as part of the project.

The 27th Ave. SE bike lane and sharrows project was funded by a $100,000 federal grant from the Non-motorized Transportation Pilot Program (Bike Walk Twin Cities). The project was completed in August 2010.

Renderings

The following images are 3D concepts of conventional bike lanes.


NACTO
Bike Lanes
Conventional Bike Lanes


NACTO
Bike Lanes
Conventional Bike Lanes


BIKE LANE
NACTO
Bike Lanes
Conventional Bike Lanes

Image Gallery

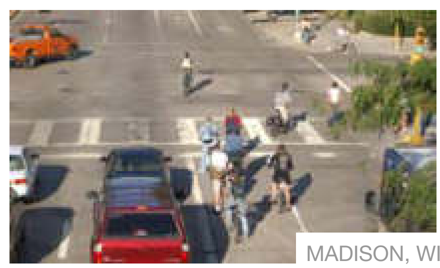
BALDWIN PARK, CA

WASHINGTON, DC

OLYMPIA, WA

KANSAS CITY, KS

SAN MARCOS, TX



MADISON, WI

CHAPEL HILL, NC

AUSTIN, TX

AUSTIN, TX

DEL MAR, CA

AUSTIN, TX

Buffered Bike Lanes

Description

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 MUTCD guidelines for buffered preferential lanes (section 3D-01).

Buffered Bike Lane Benefits

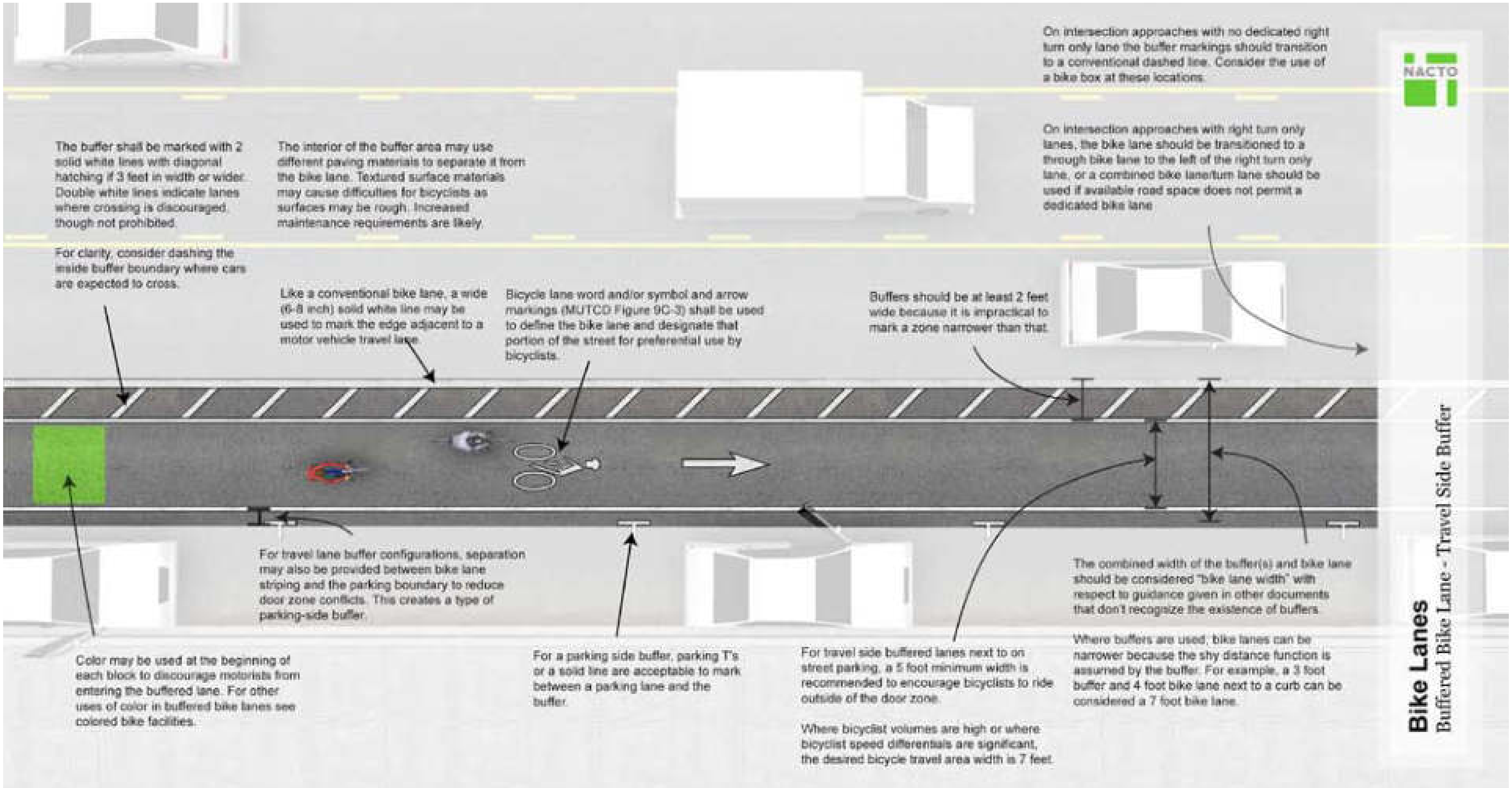
- Provides greater shy distance between motor vehicles and bicyclists.
- Provides space for bicyclists to pass another bicyclist without encroaching into the adjacent motor vehicle travel lane.
- Encourages bicyclists to ride outside of the door zone when buffer is between parked cars and bike lane.
- 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.

> *Cyclists indicated they feel lower risk of being 'doored' in the buffered bike lanes and nearly nine in 10 cyclists preferred a buffered bike lane to a standard lane. Seven in 10 cyclists indicated they would go out of their way to ride on a buffered bike lane over a standard bike lane...*
>
> Portland State University, Center for Transportation Studies. (2011). Evaluation of Innovative Bicycle Facilities: SW Broadway Cycle Track & SW Stark/Oak Street Buffered Bike Lanes FINAL REPORT. Portland Bureau of Transportation, Portland, OR.

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 and pedestrian interactions.

Design Guidance

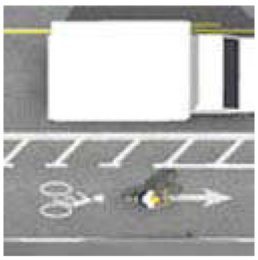


View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/Buffered-Bike-Lane_Annotation1.jpg

REQUIRED

Bicycle lane word 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.

> *Bicycle lane—the preferential lane-use marking for a bicycle lane shall consist of a bicycle symbol or the word marking BIKE LANE.*
>
> Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices. Section 3D.01.



The buffer shall be marked with 2 solid white lines with diagonal hatching if 3 feet in width or wider. Double white lines indicate lanes where crossing is discouraged, though not prohibited. For clarity, consider dashing the inside buffer boundary where cars are expected to cross.

> *Standard guidance for Buffer-separated right-hand side preferential lane buffer configurations (MUTCD 3D.02 03-D):*
>
> 1. A wide solid double white line along both edges of the buffer space where crossing the buffer space is prohibited.
>
> 2. A wide solid single white line along both edges of the buffer space where crossing of the buffer space is discouraged.
>
> Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices. Section 3D.02.

Division Street Buffered Bike Lane San Francisco, CA

Division Street is a wide, high-volume, multi-lane arterial that runs under Highway 101 in central San Francisco. It connects two bike routes (along 14th St. and 11th St.) with Townsend Street, a street with a bike lane used by many cyclists to reach the Caltrain (commuter rail) station. Prior to implementation of the buffered bike lane, this stretch of Division Street had shared road-way markings, or "sharrows."

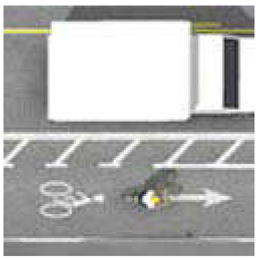
In November of 2010, the SFMTA striped a buffered bicycle lane and added channelizers, or "safe-hit posts," on Division Street between 9th Street and 11th Street. The physical separation from vehicular traffic fills an important gap in the route to and from the Caltrain (commuter rail) station.

This stretch of Division Street, partially covered by Highway 101, had on-street parking and several driveways to commuter parking lots or industrial fa-cilities. Removal of parking elicited some opposition. Additionally, while the driveways along Division Street receive relatively infrequent use, access must be maintained. Maintaining access to these driveways created some difficulties for barrier placement and staff will monitor potential vehicle/bicycle conflicts in the future.

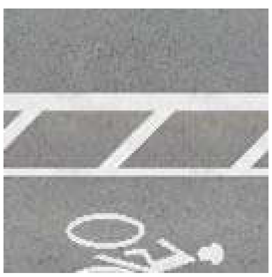
RECOMMENDED

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.

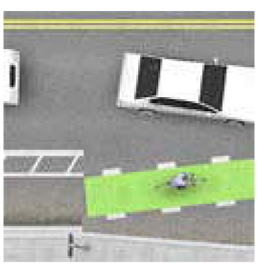
For travel side buffered lanes next to on street parking, a 5 foot minimum width is recommended to encourage bicyclists to ride outside of the door zone.



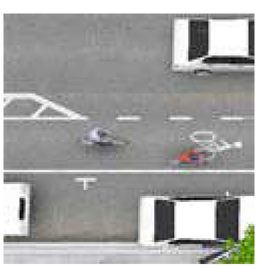
Where bicyclist volumes are high or where bicyclist speed differentials are significant, the desired bicycle travel area width is 7 feet.



Buffers should be at least 2 feet wide because it is impractical to mark a zone narrower than that.

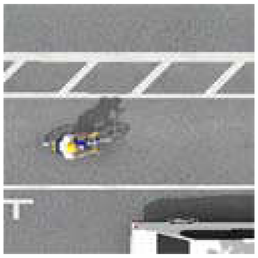


On intersection approaches with right turn only lanes, the bike lane should be transitioned to a through bike lane to the left of the right turn only lane, or a combined bike lane/turn lane should be used if available road space does not permit a dedicated bike lane.



On intersection approaches with no dedicated right turn only lane the buffer markings should transition to a conventional dashed line. Consider the use of a bike box at these locations.

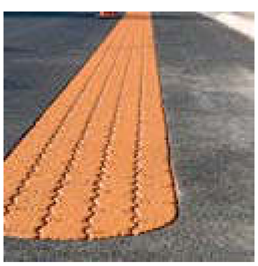
OPTIONAL



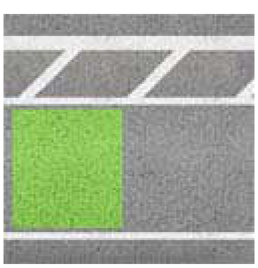
Like a conventional bike lane, a wide (6-8 inch) solid white line may be used to mark the edge adjacent to a motor vehicle travel lane. For a parking side buffer, parking T's or a solid line are acceptable to mark between a parking lane and the buffer.

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.



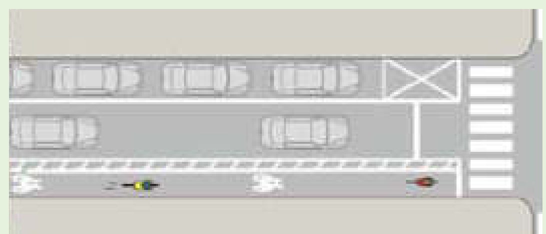
The interior of the buffer area may use different paving materials to separate it from the bike lane. Textured surface materials may cause difficulties for bicyclists as surfaces may be rough. Increased maintenance requirements are likely.



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.

Pine and Spruce Streets Philadelphia, PA

In 2009, the Mayor's Office of Transportation in Philadelphia undertook a pilot project to evaluate the impact of a buffered crosstown bike lane on Spruce and Pine Streets running through the center city of Philadelphia. The project creates a buffer protected east-west bike route and provides a direct connection between paths on the Schuylkill and Delaware Rivers. The buffered bike lane is 6' with a 2' buffer at most points along the route. The bike lane required the removal of a single traffic lane on both streets, which had low-traffic levels, and the retiming of a traffic signal at Broad Street. The pilot projects measured a 65-100% increase in bicycle traffic along the route and an 11% decrease in motor vehicle traffic. Following the pilot, the bike lane will be made permanent in coordination with a planned street resurfacing.



N 130th Street N 130th Street Buffered Bike Lanes

Seattle, WA

The N 130th Street Buffered Bike Lane in Seattle, completed in June 2010, runs along a 0.32 mile segment from Linden Ave. N to Greenwood Ave. N. The project grew out of a pedestrian project to improve a mid-block, uncontrolled marked crosswalk at North Park Avenue N. Before the reconfiguration, N 130th Street was a three-plus lane arterial street with a history of speeding. N 130th Street had an Average Daily Traffic (ADT) of 11,353 and a posted speed limit of 30 MPH. 85th percentile speeds along the corridor were 38 – 39 MPH before the re-channelization. The city wanted to reduce the number of lanes for pedestrians to cross at this location, which serves a Community Center and park on the north side of the street and apartments and single family homes on the south side. The neighborhood also has a high senior citizen population.

The reconfiguration of N 130th St. initially called only for the installation of a raised median midway through the pedestrian crossing. In coordination with these improvements and the Bicycle Master Plan, the city decided to implement buffered bike lanes as part of the re-design. The city first looked into creating one bike lane in each direction, but a center left turn lane did not leave enough room for installation. Left turn movements along the corridor were minimal since there are no intersecting streets on the north side of N 130th Street and all the intersecting streets on the south side are non-arterial. The city decided to reduce the number of travel lanes to one in each direction and to create a buffer that reduces the width of the vehicle travel lane to discourage speeding.

As part of the N 130th Street buffered bike lane project, video detection was installed for the westbound approach at Greenwood Ave N and N 130 St. After shifting the existing lane markings to add the bike lanes, existing detection loops on this approach were no longer in the correct locations. Video detection was chosen because it was cost-effective and cheaper to install than cutting loops for three vehicles lanes and one bike lane. The pavement was also in subpar condition for cutting new loop detectors. The other three sections of the intersection continue to function using loop detection.

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.
- See conventional bicycle lanes for additional maintenance issues that may apply.

Treatment Adoption and Professional Consensus

Buffered bike lanes are used in the following US cities and counties:

- Austin, TX
- Brooklyn, NY
- Cape Coral, FL
- Marin County, CA
- New York, NY
- Portland, OR
- San Francisco, CA
- Seattle, WA
- Tucson, AZ

Renderings

The following images are 3D concepts of conventional bike lanes. The configuration shown is based on Brooklyn, NY, and Portland, OR, examples.


Bike Lanes
Buffered Bike Lane - Parking Side Buffer


BEGIN
RIGHT TURN LANE
YIELD TO BIKES
Bike Lanes
Buffered Bike Lane - Travel Side Buffer and Merging Area


Bike Lanes
Buffered Bike Lane at Intersection Without Right Turn Only Lane


Bike Lanes
Buffered Bike Lane at Intersection Without Right Turn Only Lane

Image Gallery

SAN RAFAEL, CA

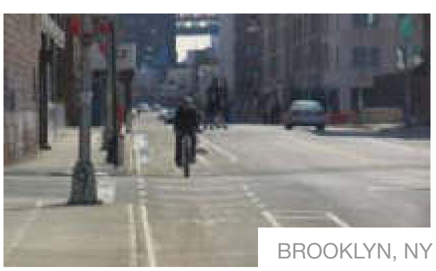

TUCSON, AZ


AUSTIN, TX


PORTLAND, OR


PORTLAND, OR


BROOKLYN, NY


BROOKLYN, NY


PORTLAND, OR

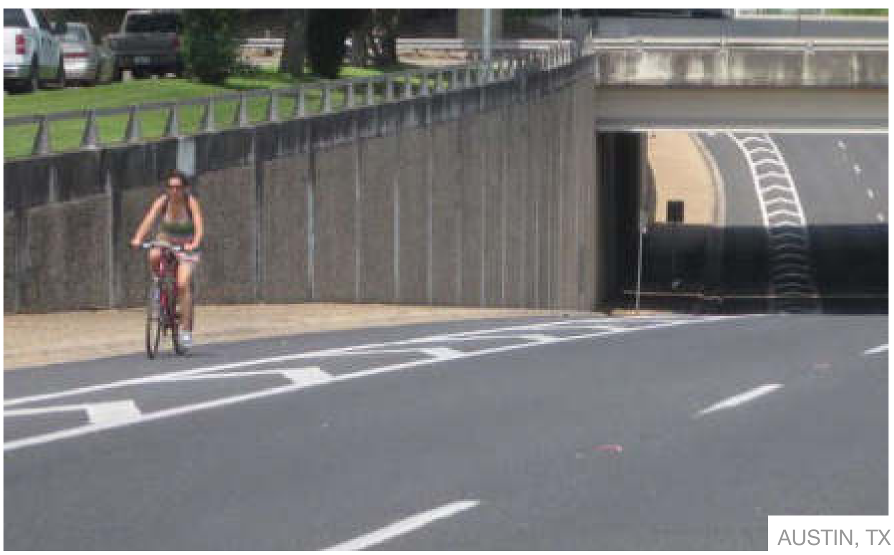

SEATTLE, WA

Image Gallery


NEW YORK, NY


AUSTIN, TX


NEW YORK, NY


AUSTIN, TX


AUSTIN, TX


CAPE CORAL, FL

Contra-Flow Bike Lanes

Description

Contra-flow bicycle lanes are bicycle lanes designed to allow bicyclists to ride in the opposite direction of motor vehicle traffic. They convert a one-way traffic street into a two-way street: one direction for motor vehicles and bikes, and the other for bikes only. Contra-flow lanes are separated with yellow center lane striping. Combining both direction bicycle travel on one side of the street to accommodate contra-flow movement results in a two-way cycle track.

The contra-flow design introduces new design challenges and may introduce additional conflict points as motorists may not expect on-coming bicyclists.

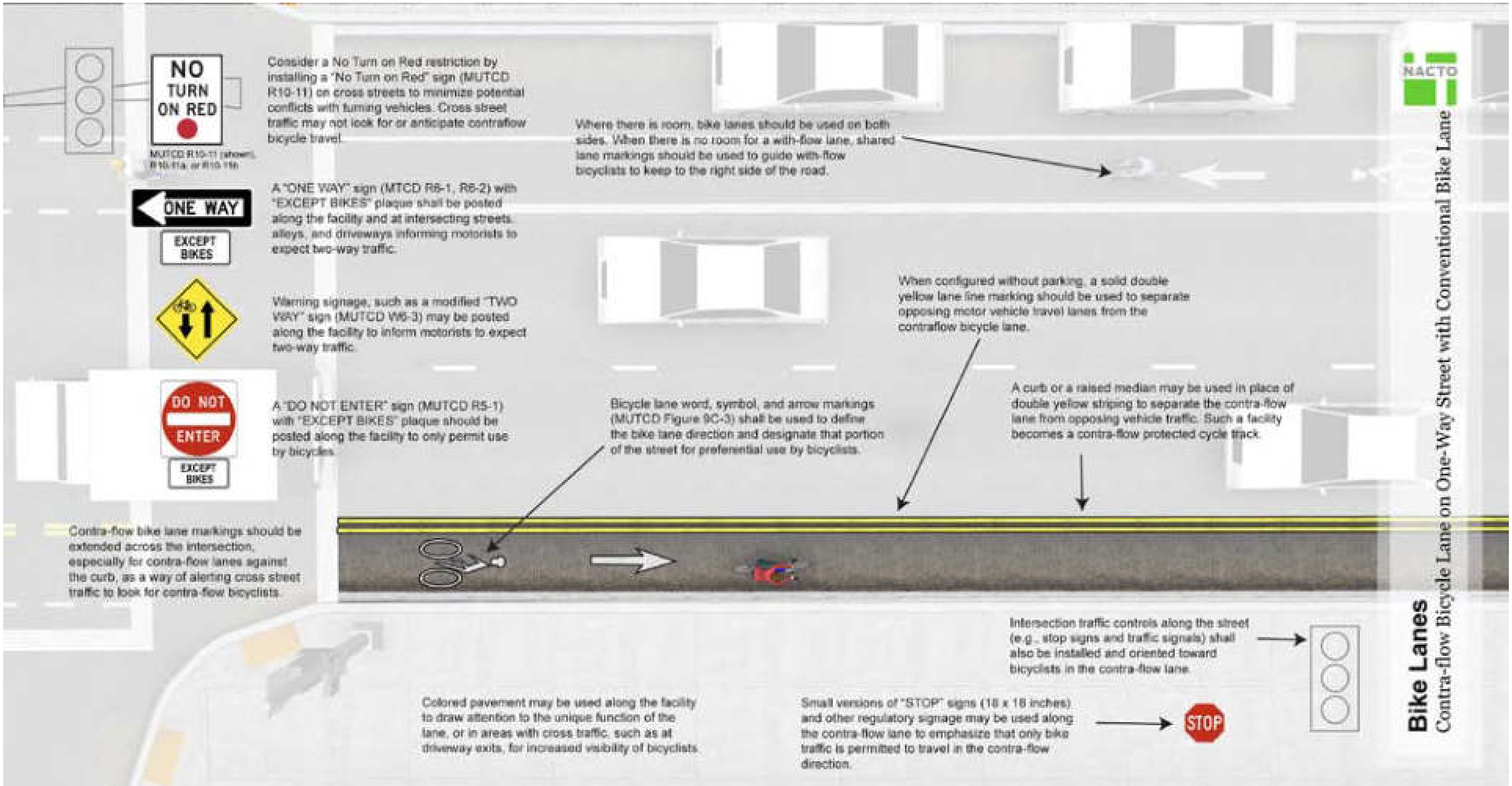
Contra-Flow Bike Lane Benefits

- Provides connectivity and access to bicyclists traveling in both directions.
- Reduces dangerous wrong-way riding.
- Decreases sidewalk riding.
- Influences motorist choice of routes without limiting bicycle traffic.
- Decreases trip distance, the number of intersections encountered, and travel times for bicyclists by eliminating out-of-direction travel.
- Allows bicyclists to use safer, less trafficked streets.

Typical Applications

- On streets where large numbers of bicyclists are already riding the wrong way.
- On corridors where alternate routes require excessive out-of-direction travel.
- On corridors where alternate routes include unsafe or uncomfortable streets with high traffic volumes and/or no bicycle facilities.
- On corridors where the contra-flow lane provides direct access to destinations on the street under consideration.
- Where two-way connections between bicycle facilities are needed along one-way streets.
- Works best on low-speed, low volume streets to minimize the risk of dangerous crashes.

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/ContraFlow_Annotated.jpg

REQUIRED

Bicycle lane word, symbol, and arrow markings (MUTCD Figure 9C-3) shall be used to define the bike lane direction and designate that portion of the street for preferential use by bicyclists.

A "ONE WAY" sign (MTCD R6-1, R6-2) with "EXCEPT BIKES" plaque shall be posted along the facility and at intersecting streets, alleys, and driveways informing motorists to expect two-way traffic.

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

Contra-Flow Bike Lane on Lanvale Street

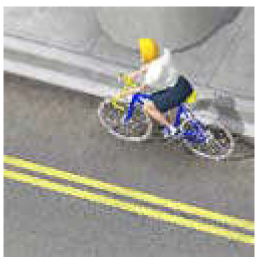
Baltimore, MD

In November 2001, the city of Baltimore Department of Transportation installed a contra-flow bike lane on Lanvale St. to facilitate access between a proposed bike boulevard project on Guilford Avenue, bicycle parking facilities at Baltimore Penn Station, two local bike shops, and the Jones Falls Trail. The contra-flow lane allows bicyclists to travel in both directions. It is distinguished by a 3' wide yellow striping buffer and pavement markings, as well as 'Two-way Bike Traffic' and 'Do Not Enter- Except for Bikes' signs. To divert traffic from using the bike lane as a turn lane, flex posts were installed at the intersection.

Existing signal heads, in place from when Lanvale St. was a two-way corridor, obviated the need to purchase and install new bicycle signals. Signage that had permitted illegal parking in the bike lane on the unit block of W. Lanvale St., had to be removed. The project was constructed in-house and installed at a cost of $5,000. Following the project's completion, the bike lane has been heavily used by cyclists and most motorists have been compliant.

RECOMMENDED

A "DO NOT ENTER" sign (MUTCD R5-1) with "EXCEPT BIKES" plaque should be posted along the facility to only permit use by bicycles.



When configured without parking, a solid double yellow lane line marking should be used to separate opposing motor vehicle travel lanes from the contraflow bicycle lane.

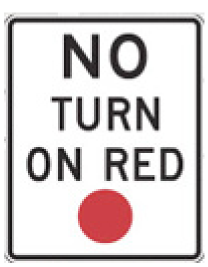
> *Center line pavement markings, when used, shall be the pavement markings used to delineate the separation of traffic lanes that have opposite directions of travel on a roadway and shall be yellow (3B.01 01).*

> *Two-direction no-passing zone markings consisting of two normal solid yellow lines where crossing the center line markings for passing is prohibited for traffic traveling in either direction (3B.01 04.C).*

Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices.

Consider a No Turn on Red restriction by installing a "No Turn on Red" sign (MUTCD R10-11) on cross streets to minimize potential conflicts with turning vehicles. Cross street traffic may not look for or anticipate contraflow bicycle travel.

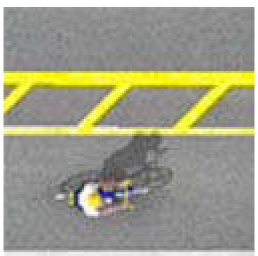
> *MUTCD R10-11, R10-11a, or R10-11b*



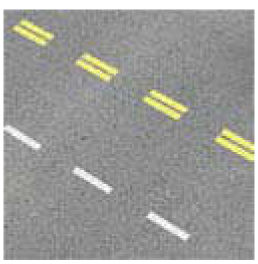
RECOMMENDED (CONTINUED)

Where there is room, bike lanes should be used on both sides. When there is no room for a with-flow lane, shared lane markings should be used to guide with-flow bicyclists to keep to the right side of the road.

> *Where there is room for bike lanes on both sides of the street, they should be included to clarify where bicyclists should travel. If there is no room for a full bike lane, other pavement markings or signs should be considered to clarify direction.*
>
> Pedestrian and Bicycle Information Center. (2006). BIKESAFE: Bicycle Countermeasure Selection System. Publication No. FHWA-SA-05-006, Federal Highway Administration, Washington, DC.



If sufficient space exists, a buffered bike lane design should be used.



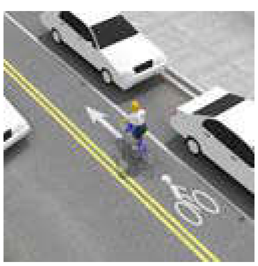
Contra-flow bike lane markings should be extended across the intersection, especially for contra-flow lanes against the curb, as a way of alerting cross street traffic to look for contra-flow bicyclists.

OPTIONAL

Warning signage, such as a modified "TWO WAY" sign (MUTCD W6-3) may be posted along the facility to inform motorists to expect two-way traffic.

Colored pavement may be used along the facility to draw attention to the unique function of the lane, or in areas with cross traffic, such as at driveway exits, for increased visibility of bicyclists.

Small versions of "STOP" signs (18 x 18 inches) and other regulatory signage may be used along the contra-flow lane to emphasize that only bike traffic is permitted to travel in the contra-flow direction.



Contra-flow lanes may be installed where there is parking on the contra-flow side. Most existing installations use a double yellow line to separate the contra-flow bicycle lane, however local ordinance may prohibit parking in the opposite direction of the contra-flow travel lane. A dashed yellow line, or dashed white line may also used to separate the contra-flow bicycle lane.

Local urban practitioners should use best engineering judgment to determine which strategy to implement.

A curb or a raised median may be used in place of double yellow striping to separate the contra-flow lane from opposing vehicle traffic. Such a facility becomes a contra-flow protected cycle track.

Contra-Flow Bike Lane on New Hampshire Avenue

Washington, D.C.

In July 2010, the city of Washington, D.C. (DDOT) installed a contra-flow bike lane along New Hampshire Ave. leading towards the intersection of U and 16th streets. The purpose of the project was to facilitate a popular diagonal movement for cyclists heading southwest by reconfiguring a street with excess capacity and low traffic levels. The contra-flow bicycle lane, which is separated from oncoming traffic by double-yellow striping, allows cyclists to ride against traffic along New Hampshire Ave. in a diagonal direction and then safely turn into a bike box across 16th St. DDOT placed several plastic pylons to distinguish cyclists from oncoming traffic at the intersection and a bicycle overhead signal with a bicycle detector to ensure an efficient crossing. Dashed shared lane markings guide cyclists into a bike box at 16th St., from which cyclists may continue through the intersection onto New Hampshire Ave. or take a right onto U Street.

West Ardmore Avenue

Chicago, IL

The low-traffic, one-block corridor of W. Ardmore Ave. between N. Sheridan Road and N. Kenmore Ave. in Chicago serves as a strategic connection between the north end of the Chicago Lakefront Trail and bikes lanes to the west of the trail. In 2001, a contra-flow bike lane was installed to allow cyclists emerging from the popular Lakefront Trail to have more direct westbound access. The neighborhood, which has a high senior citizen population, had been inclined to riding on the sidewalk or against traffic on W. Ardmore Ave. The contra-flow bike lane facilitates this movement along a safe, designated bikeway. The lane was installed without shifting the placement of parked cars and is marked by double-yellow striping as well as prominent bike & chevron shared lane markings through the intersection. The project was augmented by way-finding signage at the intersection and the revision of an existing 'Do Not Enter' sign to read 'Do Not Enter- Except Bikes.'

This project was designed and implemented by the Chicago Department of Transportation in May 2001, on W. Ardmore Ave. at the north end of the Lakefront Trail between N. Sheridan Road and N. Kenmore Ave in Chicago IL.

Maintenance

- Like all bicycle lanes, contra-flow bike lanes should be maintained to be 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.
- Please see guidance for conventional bike lanes.

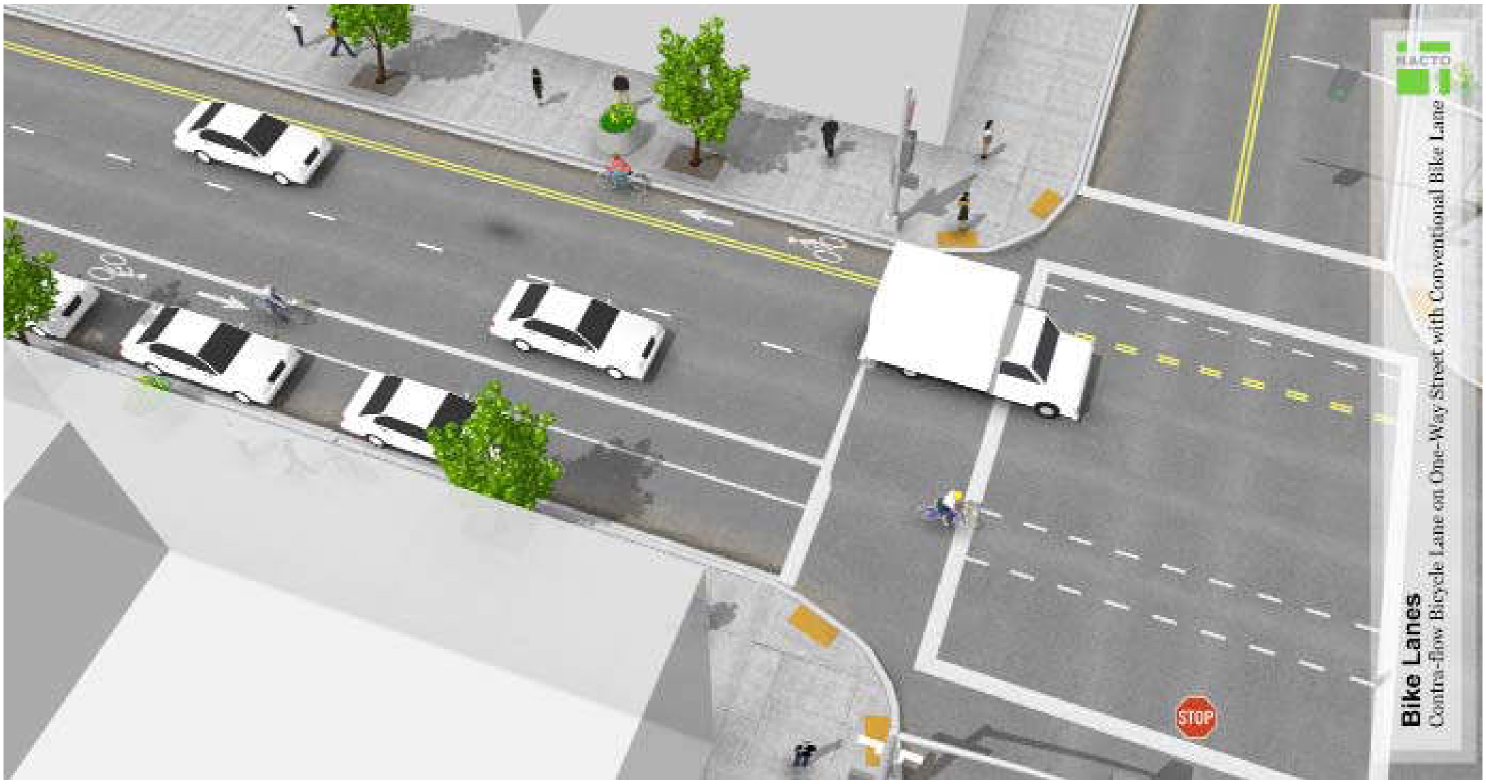
Treatment Adoption and Professional Consensus

Contra-flow bike lanes are used in the following US cities:

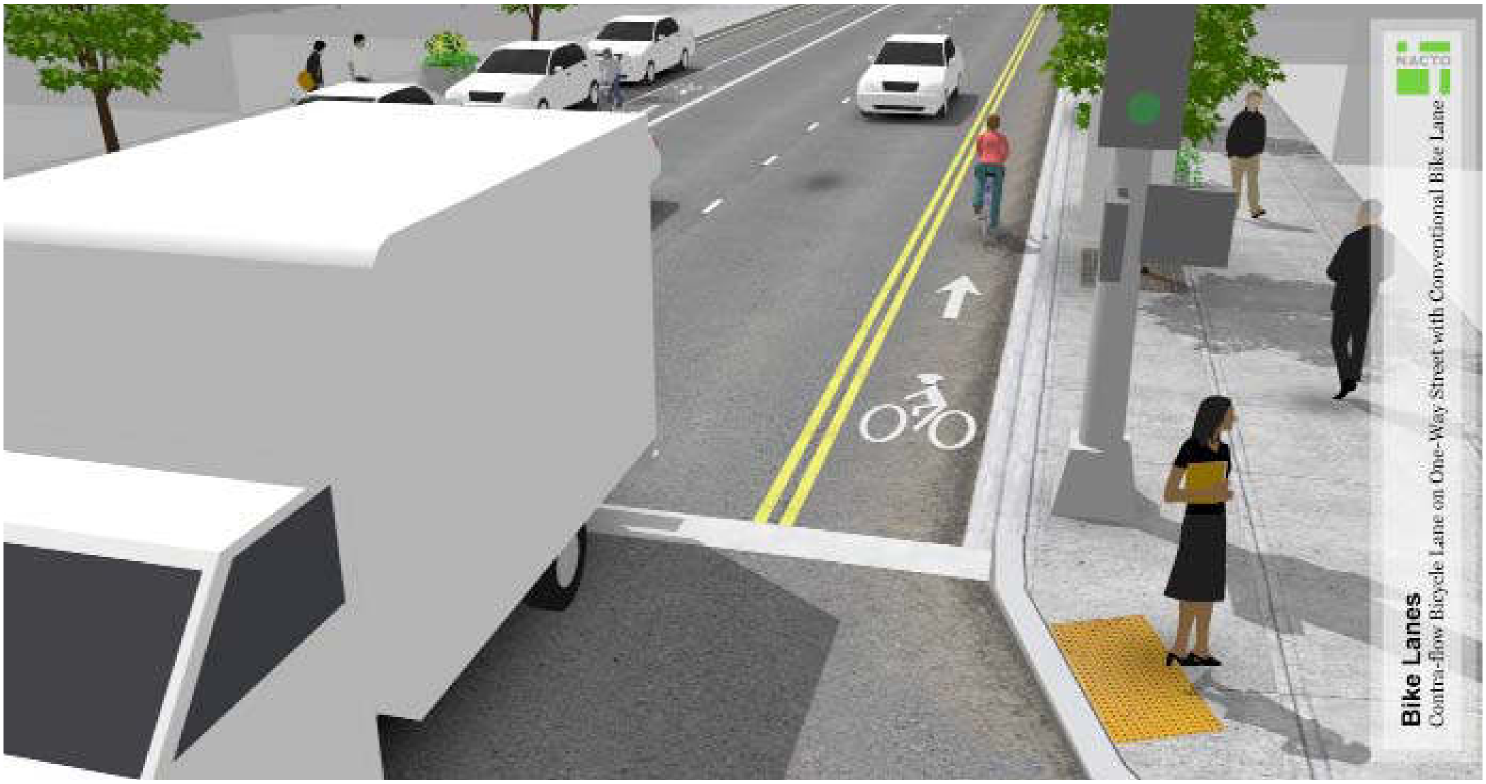
- Austin, TX
- Boise, ID
- Boulder, CO
- Cambridge, MA
- Brookline, MA
- Baltimore, MD
- Chicago, IL
- Eugene, OR
- Madison, WI
- Minneapolis, MN
- Portland, OR
- San Francisco, CA
- Seattle, WA
- Washington, DC

Renderings

The following images are 3D concepts of contra-flow bike lanes. The configuration shown is based on a Seattle, WA, example.


NACTO
Bike Lanes
Contra-flow Bicycle Lane on One-Way Street with Conventional Bike Lane
STOP


NACTO
Bike Lanes
Contra-flow Bicycle Lane on One-Way Street with Conventional Bike Lane


Bike Lanes
Contra-flow Bicycle Lane on One-Way Street with Conventional Bike Lane


Bike Lanes
Contra-flow Bicycle Lane on One-Way Street with Shared Lane Markings

Image Gallery


CHICAGO, IL


CHICAGO, IL


CHICAGO, IL

WASHINGTON, DC


WASHINGTON, DC

Image Gallery


PORTLAND, OR


SAN FRANCISCO, CA

SAN FRANCISCO, CA


PORTLAND, OR


SAN FRANCISCO, CA


PORTLAND, OR

Left-Side Bike Lanes

Left-side bike lanes are conventional bike lanes placed on the left side of one-way streets or two-way median divided streets.

Left-side bike lanes offer advantages along streets with heavy delivery or transit use, frequent parking turnover on the right side, or other potential conflicts that could be associated with right-side bicycle lanes.

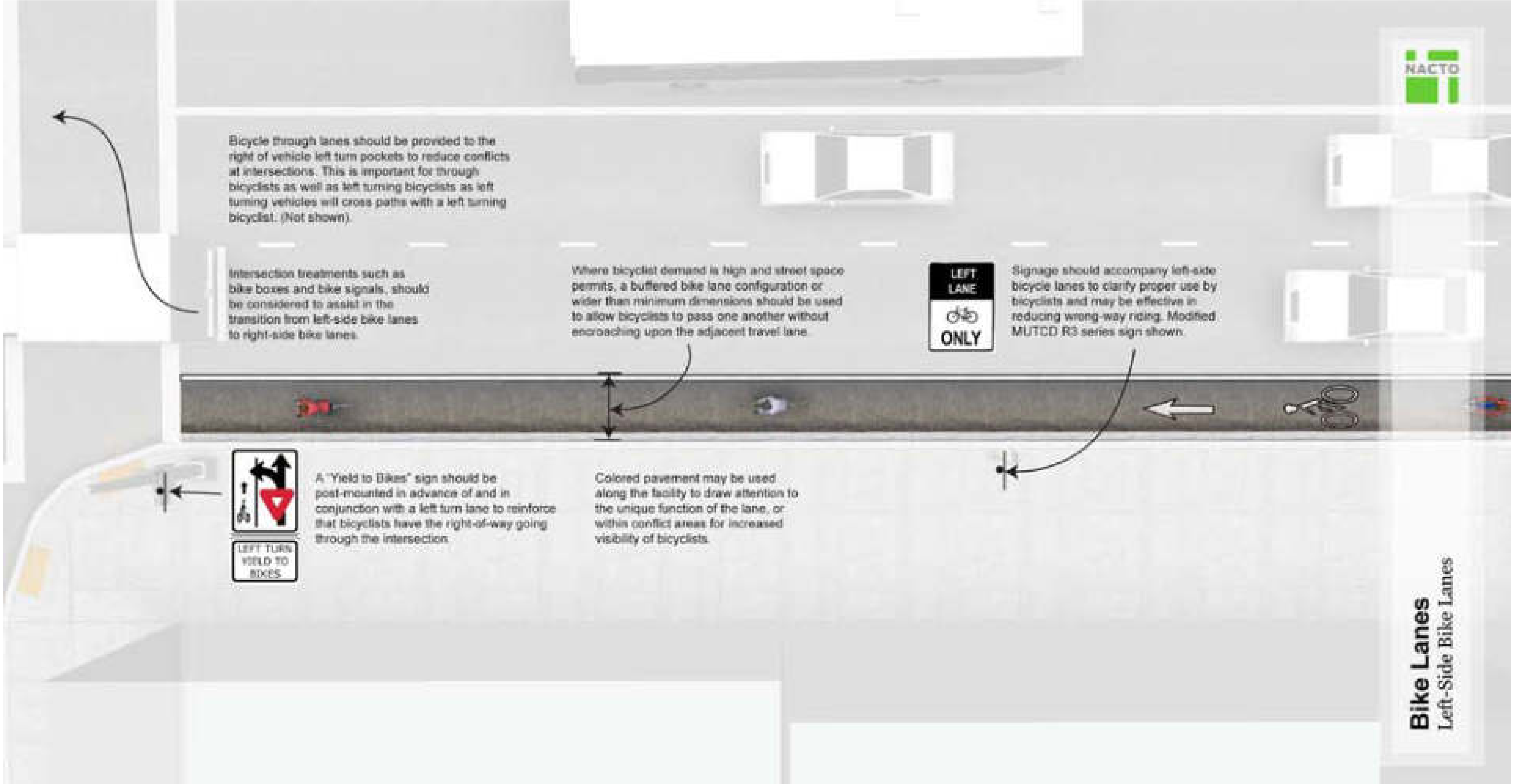
Left-Side Bike Lane Benefits

- Avoids potential right-side bike lane conflicts on streets.
- Improves bicyclist visibility by motorists by having the bike lane on the driver's side.
- Provides consistent facility configuration in locations where right-side travel lanes are subject to rush hour parking restrictions and other flexible uses.
- Minimizes door zone conflicts next to parking because of fewer door openings on the passenger side of vehicles.
- Fewer bus and truck conflicts as most bus stops and loading zones are on the right side of the street.

Typical Applications

- On one-way streets or median divided streets with frequent bus stops or truck loading zones on the right side of the street.
- On streets with high parking turnover.
- On streets with rush hour parking restrictions.
- On streets with high volumes of right turn movements by motor vehicles.
- On streets with a significant number of left-turning bicyclists.
- On streets where traffic enters into an add lane on the right-hand side, as from a freeway off-ramp.
- For favorable alignment to connect to a path, two-way cycle track, or other bicycle facility.

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/LeftSideBikeLanes_Annotated.jpg

REQUIRED

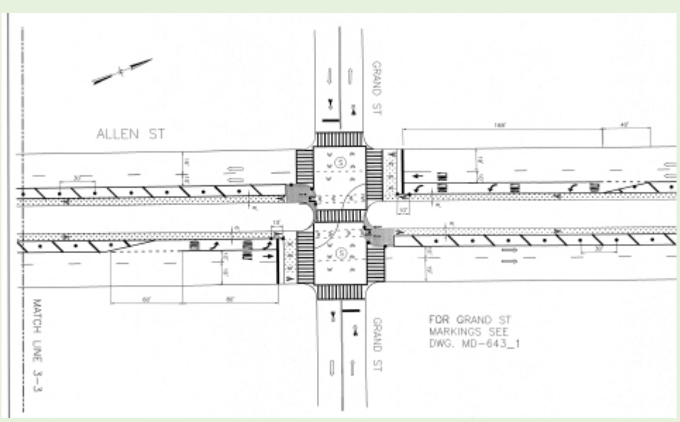
Design guidance for conventional bike lanes applies to this treatment.

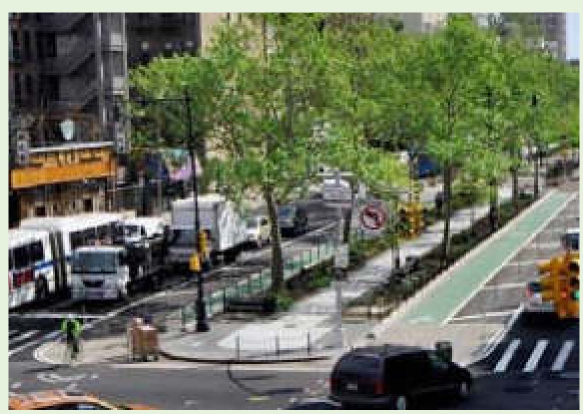
Allen and Pike Streets Pedestrian and Bicycle Improvement Project New York, NY

In 2009, the New York City Department of Transportation undertook a bicycle, pedestrian, and traffic safety improvement project along the Allen and Pike Street Malls between Delancey Street and the East River Waterfront. The project rectified frequent turning conflicts between cars, buses, delivery trucks, bicyclists, and pedestrians by creating four pedestrian connections between landscaped malls, new signal installation at nine intersections, pedestrian refuge islands, bicycle paths separated from traffic, and planters.

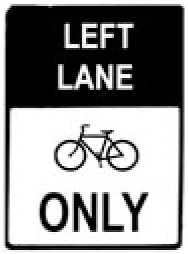
Previous to the improvement of the mall, a bike lane had run along the right side of Allen St., but was often obstructed by delivery trucks, double-parking, and aggravated by turning conflicts at busy intersections.

Shifting the bike lane to the left side, and installing flexible bollards and planters to protect cyclists from traffic, diminished many of the conflicts cyclists encountered, while providing a more attractive riding space along the planted median. The bike lane has colored asphalt to distinguish it from the street, as well as shared lane markings through the intersections. The conversion of several cross streets along the mall to pedestrian plazas vastly improved the connectivity of the bikeway and diminished the number of turning conflicts. Data compiled following the installation of the protected bike paths and pedestrian improvements showed a decrease in injuries for pedestrian, cyclists, and motorists at several busy traffic junctions.

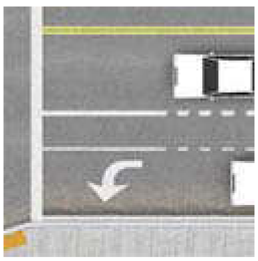




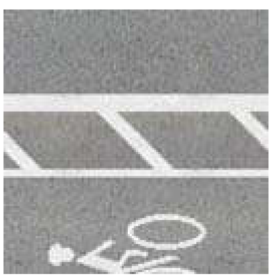
RECOMMENDED



Signage should accompany left-side bicycle lanes to clarify proper use by bicyclists and may be effective in reducing wrong-way riding. Modified MUTCD R3 series sign shown.



Bicycle through lanes should be provided to the right of vehicle left turn pockets to reduce conflicts at intersections. This is important for through bicyclists as well as left turning bicyclists as left turning vehicles will cross paths with a left turning bicyclist. Additional guidance can be found in through bicycle lanes in this guide.



Where bicyclist demand is high and street space permits, a buffered bike lane configuration or wider than minimum dimensions should be used to allow bicyclists to pass one another without encroaching upon the adjacent travel lane.

Intersection treatments such as bike boxes and bike signals, should be considered to assist in the transition from left-side bike lanes to right-side bike lanes.

RECOMMENDED (CONTINUED)

A “Yield to Bikes” sign should be post-mounted in advance of and in conjunction with a left turn lane to reinforce that bicyclists have the right-of-way going through the intersection.

Fig. A Variant of MUTCD R10-15 to include helmeted bicycle rider symbol (MUTCD figure 9C-3 B).

Fig. B Similar sign in common use, similar to MUTCD R1-5, 1-5a.

A

B

OPTIONAL

Colored pavement may be used along the facility to draw attention to the unique function of the lane, or within conflict areas for increased visibility of bicyclists.

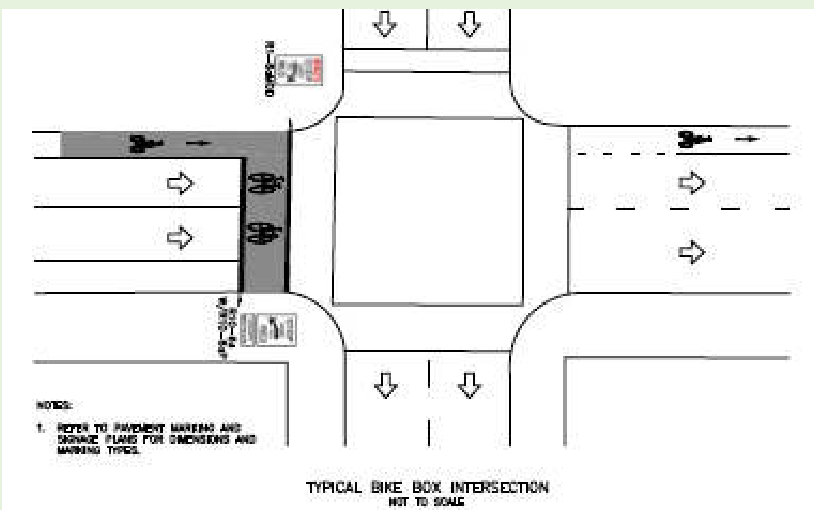
Left-side Bike Lanes on Commonwealth Avenue

Boston, MA

In 2009, Commonwealth Avenue in Boston had the second highest bicyclist crash rate in the city of Boston. As part of continued efforts by the city to create continuous, safe bicycle facilities leading west of the city and to connect cyclists to a number of dedicated off-road paths, in 2010, the city of Boston installed a left-side bike lane on Commonwealth Avenue between Kenmore and Arlington Streets.

A left-side bike lane was selected over a right-side lane for several reasons. Commonwealth Avenue has problems with double parking which would have undermined the effectiveness of a right side bike lane. The left side lane decreases the risks of "dooring" and takes advantage of an underpass that averts a busy intersection at Massachusetts Ave. Conditions for the intersection at Arlington favored the construction of a left-side lane. The lane also runs alongside the historic Commonwealth Avenue Mall, which is a positive environment for cyclists and discourages cycling inside the park.

The facility required several modifications to the roadway. The number of vehicle lanes was reduced from three to two in both the underpass, and from Kenmore St. to Charlesgate West. A buffer was created between the roadway and the bicycle lane leading into and out of the underpass. The project included the creation of five bike boxes at access points to the Charles River Pass, as well as a designated waiting area for cyclists who failed to shift from the right to the left side lane.



Maintenance

- Like all bicycle lanes, left-side bike lanes should be maintained to be free of potholes, broken glass, and other debris.
- If trenching is to be done in the bicycle lane, the entire lane should be trenched so that there is not an uneven surface or longitudinal joints.
- Please see guidance for conventional bike lanes.

Treatment Adoption and Professional Consensus

Left-side bike lanes are used in the following US cities:

- Berkeley, CA
- Boston, MA
- Eugene, OR
- Madison, WI
- Minneapolis, MN
- Naples, FL
- New York City, NY
- Portland, OR
- San Francisco, CA
- Washington, DC

Renderings

The following images are 3D concepts of left-side bike lanes. The configuration shown is based on a Minneapolis, MN example.


NACTO
Bike Lanes
Left-Side Bike Lanes


NACTO
Bike Lanes
Left-Side Bike Lanes


Bike Lanes
Left-Side Bike Lanes

Image Gallery

NEW YORK, NY


BOSTON, MA


BOSTON, MA


PORTLAND, OR


BOSTON, MA


NAPLES, FL


PORTLAND, OR


NEW YORK, NY

IN THIS SECTION:

- One-Way Protected Cycle Tracks
- Raised Cycle Tracks
- Two-Way Cycle Tracks

CYCLE TRACKS

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.

One-Way Protected Cycle Tracks

This treatment covers one-way cycle tracks that are at street level and use a variety of methods for physical protection from passing traffic. See raised cycle track for information on alternative cycle track designs. Street level cycle tracks are also known as “on-street bike paths” in New York City.

One-Way Protected Cycle Track Benefits

- Dedicates and protects space for bicyclists in order to improve perceived comfort and safety.

"Compared with bicycling on a reference street…these cycle tracks had a 28% lower injury rate."

Lusk, A., Furth, P., Morency, P., Miranda-Moreno, L., Willett, W., Dennerlein, J. (2010). Risk of injury for bicycling on cycle tracks versus in the street. Injury Prevention.

"Cyclists feel most secure on roads with cycle tracks and most at risk on roads with mixed traffic."

Jensen, S. U., Rosenkilde, C., and Jensen, N. (2007). Road safety and perceived risk of cycle facilities in Copenhagen. Copenhagen: Trafitec Research Center

- Eliminates risk and fear of collisions with over-taking vehicles.
- Reduces risk of 'dooring' compared to a bike lane and eliminates the risk of a doored bicyclist being run over by a motor vehicle.

"The construction of [raised] cycle tracks has resulted in a slight drop in the total number of accidents and injuries on the road sections between junctions of 10% and 4% respectively.

Jensen, S. U., Rosenkilde, C., and Jensen, N. (2007). Road safety and perceived risk of cycle facilities in Copenhagen. Copenhagen: Trafitec Research Center.

- Prevents double-parking, unlike a bike lane.
- 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.

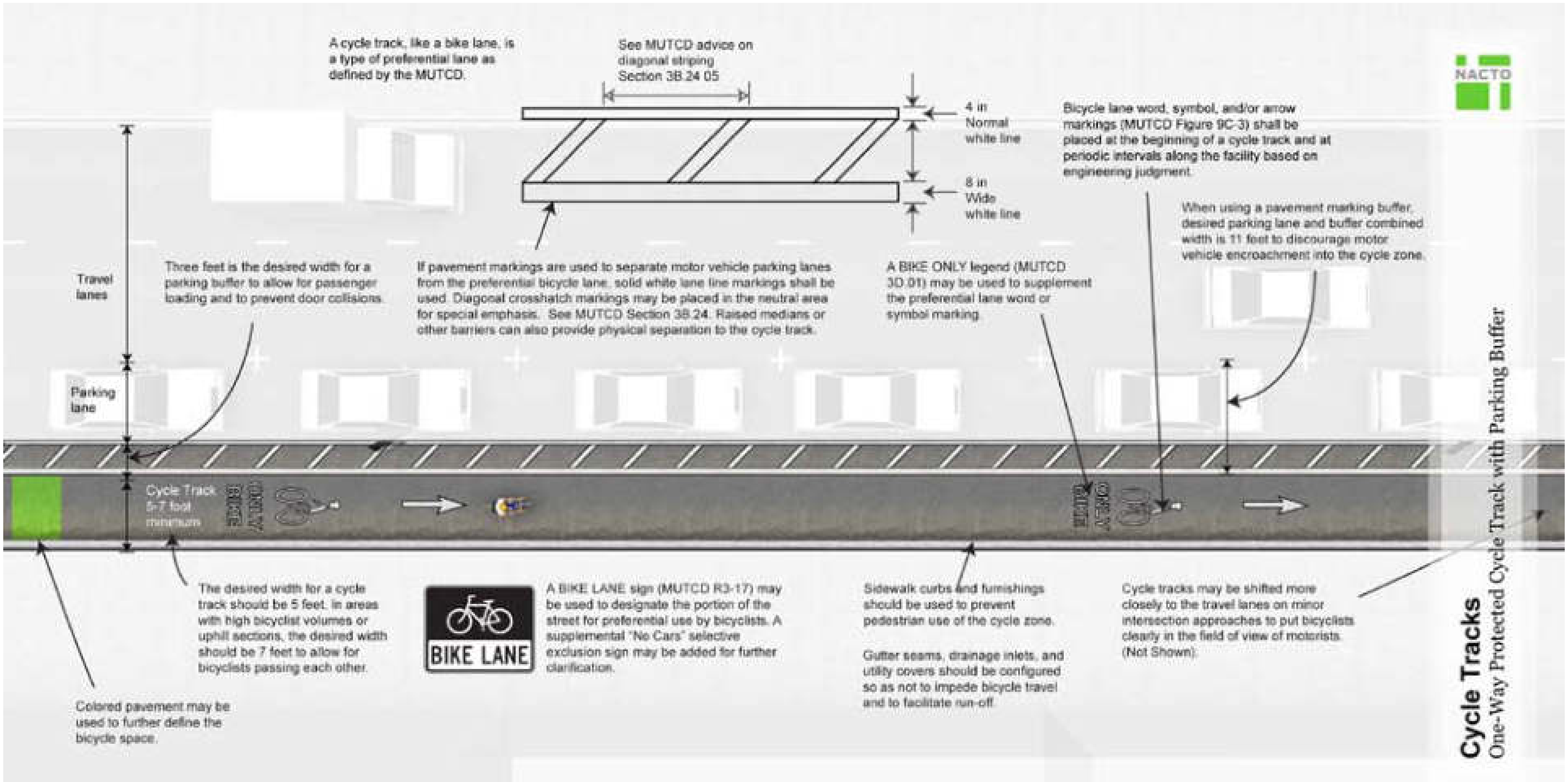
"Overall, 2.5 times as many cyclists used the cycle tracks compared with the reference streets."

Lusk, A., Furth, P., Morency, P., Miranda-Moreno, L., Willett, W., Dennerlein, J. (2010). Risk of injury for bicycling on cycle tracks versus in the street. Injury Prevention.

Typical Applications

- Streets with parking lanes.
- Streets on which bike lanes would 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. While there are no US standards for the bicyclist and motor vehicle volumes that warrant cycle tracks, several international documents provide basic guidance (see references below).
- 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.
- Special consideration should be given at transit stops to manage bicycle & pedestrian interactions.

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/CycleTrack_Segment_Annotated.jpg

REQUIRED

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

> *Preferential lanes are lanes designated for special traffic uses such as high-occupancy vehicles (HOVs), light rail, buses, taxis, or bicycles*

Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices. Section 2G.01.

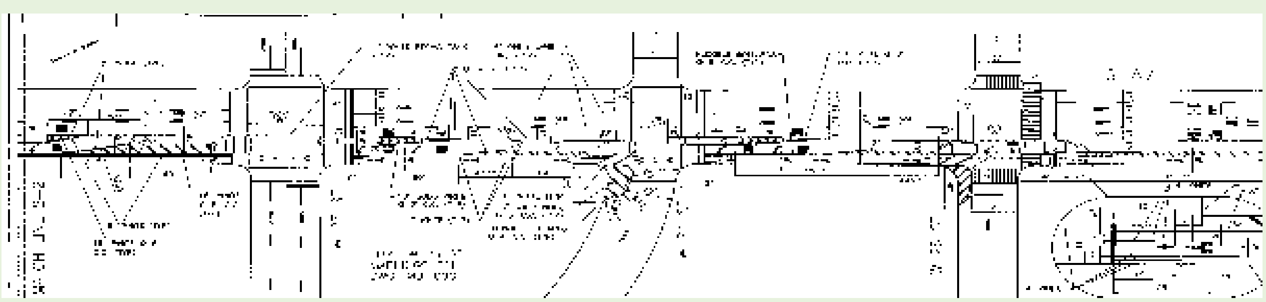
Bicycle lane word, symbol, and/or arrow markings (MUTCD Figure 9C-3) shall be placed at the beginning of a cycle track and at periodic intervals along the facility based on engineering judgment.

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 MUTCD Section 3B.24. Raised medians or other barriers can also provide physical separation to the cycle track.

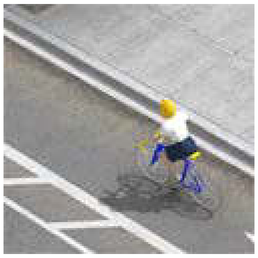
9th Avenue On-street Protected Bike Path New York City

In the fall of 2007, the New York City Department of Transportation built the first on-street parking and signal protected bicycle facility in the United States on Ninth Avenue between 23rd Street and 16th Street in Manhattan. Ninth Avenue, a 70 ft.-wide avenue formerly dominated by motorists, was reduced from four unassigned traffic lanes to three through traffic lanes (a 30 ft. reduction) with dedicated turn bays, shorter pedestrian crossings, and southbound bicycle facilities protected by an eight-foot buffer/parking lane. Turning conflicts for cyclists were resolved by creating left turn bays adjacent to the bicycle path with protected left-turn phases to separate conflicting through cyclists and left-turning vehicles. Bicycle signal lenses regulate movement on the bicycle path. The project included the construction of pedestrian refuge islands with planting beds and turn bays, pavement markings, signs, traffic signals, and raised concrete islands. Dedicated commercial loading space was created for businesses on Ninth Avenue using multi-space parking meters.

The Ninth Avenue project was achieved using operating instead of capital revenues under the purview of the NYCDOT, allowing for swifter implementation procedures. NYCDOT maintained an open dialogue with all stakeholders from early on in the project and included a variety of specialists and city departments in the design process. Parking regulations were modified several times following the installation of the facility to meet the needs of residents, business owners, and customers.



RECOMMENDED



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

Cycle Track Width Guidelines in the Netherlands

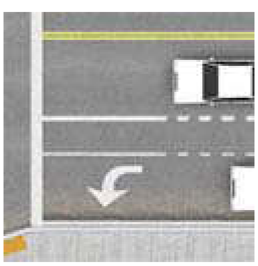
Rush hour intensities (two directions, bikes per hour)	Cycle Track Width (feet)
0 - 150	6.5
150 - 750	10
> 750	13

CROW. (2006). Record 25: Design Manual for Bicycle Traffic. CROW, The Netherlands.

	Desirable minimum width (m) (see note 1)	Absolute minimum width (m) (see note 1)	Safety strip to carriageway kerb edge minimum width (m) (see note 2)
One Way	2.0	1.5	0.5
Two Way	3.0	2.0	0.5

Notes:
1. 0.5m should be added for each side of the track that is bounded (e.g. by a wall, railings fence or hedge)
2. Safety strip to carriageway kerb edge minimum width should be 1.0m adjacent to frequently accessed parked cars

Transport for London. (2005). London Cycling Design Standards.



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

> *Safety strip to carriageway kerb edge minimum width should be 1.0m adjacent to frequently accessed parked cars.*

Transport for London. (2005). London Cycling Design Standards.

> *Width of critical reaction strip is .50 to .75 m.*

CROW. (2007). Design Manual for Bicycle Traffic.

RECOMMENDED (CONTINUED)

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

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

> *Parking must be banned along the street with the bike path for a distance long enough to ensure adequate stopping sign distances for motorists crossing the path.*
>
> Velo Quebec. (2003). Technical handbook of bikeway design. 2nd ed. Quebec: Ministere des Transport du Quebec and the Secretariat au Loisir et au Sport.

- For motor vehicles attempting to cross the cycle track from the 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 10 feet 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.

> *Variant of MUTCD R10-15 to include helmeted bicycle rider symbol (MUTCD figure 9C-3 B).*

> *Alternate sign in common use, similar to MUTCD R1-5, 1-5a.*

- 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.

RECOMMENDED (CONTINUED)

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.

In these situations, recommended minimum widths should be increased using the following calculation:

- [Distance from curb to edge of gutter seam] – 18 inches (if the value is positive)
- For example, if the gutter seam is 24 inches from the curb, add 6 inches to the recommended dimension for a one-way cycle track that serves single-file cycling.

Market Street Protected, Buffered Bicycle Lane

San Francisco, CA

Market Street is a busy commercial corridor that is vital to multiple modes of surface transportation. Diesel buses, trolley coaches, and light rail vehicles share the roadway with delivery trucks, taxis, private automobiles, and bicycles. While competing demands for roadway use have been addressed by providing transit only lanes and bike lanes, commercial vehicles, taxis, and private motorists regularly use the side-walk or bike lane for loading and unloading. Vehicles that encroach into or stop within the bike lane create a safety hazard, forcing cyclists to swerve out into the travel lane to avoid the obstructing vehicle and thereby contributing to unnecessary delay on already-busy Market Street and endangering cyclists.

In response to these issues, as part of a pilot project in May 2010, the San Francisco Municipal Transportation Agency installed traffic channelizers, or "safe-hit posts," along Market Street between Gough and 8th Streets where a painted buffer already existed in the space between the bike lane and travel lane. These surface-mounted, retroreflective traffic control devices discourage motorists from crossing into the bicycle lane. In addition to channelizers, parts of Market Street's bicycle lanes were painted green to "brand" the lanes and further increase their visibility. Because Market Street is particularly complex and home to so many different modes of transportation, there is no consistent bicycle treatment along its length. While green buffered lanes are lauded by San Francisco cyclists, there remain stretches with shared lanes rather than dedicated bike lanes.

Until Fall 2010, San Francisco was subject to a court-ordered injunction prohibiting the implementation of new bicycle-related improvements. While the Bicycle Plan Injunction was partially lifted prior to this project, the number and type of projects permitted was still limited. Additionally, the use of colored pavement as a traffic control device is not officially sanctioned by the Federal Highway Administration. Therefore, the Market Street colored bike lanes have not been made retroreflective, and the SFMTA's official position is that the color is not serving as a traffic control device; it is serving merely an aesthetic "branding" function.

Before-and-after observations of bike and vehicle traffic were conducted in January 2010 (before the channelizers and green paint) and in October 2010 (after the treatments) along one westbound segment and four eastbound segments. These observations show an 84 percent reduction in the number of vehicles encroaching in the bike lane. Intercept surveys conducted in May 2010 (before the green paint) and October 2010 (after the green paint) showed mixed results in perception of the green lanes, with a 9 percent increase in safety ratings among eastbound travelers but no change observed by travelers intercepted as they were headed westbound.

OPTIONAL

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.

> *It is recommended that on roads within built-up areas … cycle tracks are bent in 20-30 meters before and intersecting road (bending-in is defined as bending a separate cycle track toward the carriageway, with the distance between the cycle track and the side of the main carriageway measuring between 0 and 2 m).*

> *Function of Bending Cycle Track In:*
>
> - Improving conspicuity of cyclists
> - improving visibility of cyclists
> - clarifying right of way situations

CROW. (2007). Design Manual for Bicycle Traffic.

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

A BIKE ONLY legend (MUTCD 3D.01) may be used to supplement the preferential lane word or symbol marking.

> *The ONLY word marking (see MUTCD Figure 3B-23) may be used … to supplement a preferential lane word or symbol marking.*

Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices. Section 3B.20.

OPTIONAL

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

Where the combined width of the cycle track and buffer is less than 8 feet, parking places next to the cycle track will not be accessible for disabled persons using vans or taxis (though they may be accessible to car users, for whom a 5 foot level landing area is needed). Consider local needs for van-accessible spaces and how best to meet those needs.

Maintenance

- Cycle tracks should be maintained in order to be free of potholes, broken glass, and other debris.
- Snow removal and street sweeping may require special equipment. This is the case if the combined width of cycle track and buffer, or the cycle track width inside of the raised curb is too narrow for existing street maintenance equipment.
- 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.
- Snow removal may be simplified by putting the cycle track at sidewalk level or by constructing a raised median between the parking lane and the cycle track. Care should be taken to make physically separated cycle tracks accessible by street sweeping equipment, otherwise snow removal will need to be done by hand.
- 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.

Treatment Adoption and Professional Consensus

- Commonly used in dozens of European bicycle friendly cities.
- Currently used in the following US cities:
  - Boulder, CO
  - Cambridge, MA
  - Missoula, MT
  - New York, NY
  - Portland, OR
  - San Francisco, CA
  - St. Petersburg, FL
  - Washington, DC

Renderings

The following images are 3D concepts of a protected cycle track. The configurations shown are based on a Portland, OR, cycle track.


ONLY BIKE
ONLY BIKE
NACTO
Cycle Tracks
One-Way Protected Cycle Track with Parking Buffer


ONLY
NACTO
Cycle Tracks
One-Way Protected Cycle Track with Parking Buffer


Cycle Tracks
One-Way Protected Cycle Track with Planters and Parking Buffer
ONLY


Cycle Tracks
One-Way Protected Cycle Track with Raised Curb and Parking Buffer
ONLY

Image Gallery

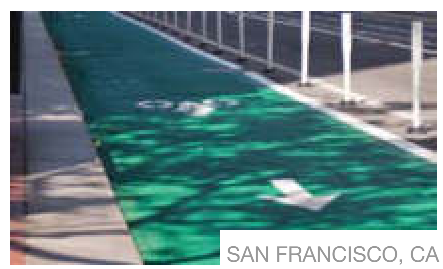

NEW YORK, NY


NEW YORK, NY


NEW YORK, NY


SAN FRANCISCO, CA

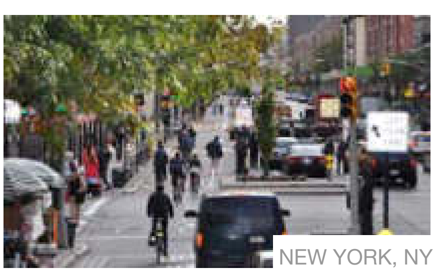

SAN FRANCISCO, CA


SAN FRANCISCO, CA


BOULDER, CO


PORTLAND, OR


NEW YORK, NY


NEW YORK, NY


NEW YORK, NY


NEW YORK, NY

Raised Cycle Tracks

Raised cycle tracks are bicycle facilities that are vertically separated from motor vehicle traffic. Many are paired with a furnishing zone between the cycle track and motor vehicle travel lane and/or pedestrian area. A raised cycle track may allow for one-way or two-way travel by bicyclists. Two-way cycle tracks have some different operational characteristics that merit additional consideration.

Raised cycle tracks may be at the level of the adjacent sidewalk, or set at an intermediate level between the roadway and sidewalk to segregate the cycle track from the pedestrian area. A raised cycle track may be combined with a parking lane or other barrier between the cycle track and the motor vehicle travel lane (refer to protected cycle tracks for additional guidance). At intersections, the raised cycle track can be dropped and merged onto the street (see cycle track intersection approach), or it can be maintained at sidewalk level, where bicyclists cross with pedestrians, possibly with a dedicated bicycle signal.

When placed adjacent to a travel lane, one-way raised cycle tracks may be configured with a mountable curb to allow entry and exit from the bicycle lane for passing other bicyclists or to access vehicular turn lanes. This configuration has also been known as a 'raised bike lane.'

One-Way Protected Cycle Track Benefits

- Dedicates and protects space for bicyclists in order to improve perceived comfort and safety.

> *Compared with bicycling on a reference street…these cycle tracks had a 28% lower injury rate.*
>
> Lusk, A., Furth, P., Morency, P., Miranda-Moreno, L., Willett, W., Dennerlein, J. (2010). Risk of injury for bicycling on cycle tracks versus in the street. Injury Prevention.

> *Cyclists feel most secure on roads with cycle tracks and most at risk on roads with mixed traffic.*
>
> Jensen, S. U., Rosenkilde, C., and Jensen, N. (2007). Road safety and perceived risk of cycle facilities in Copenhagen. Copenhagen: Trafitec Research Center.

- More attractive to a wider range of bicyclists at all levels and ages than less separated facilities.

> *Overall, 2.5 times as many cyclists used the cycle tracks compared with the reference streets."*
>
> Lusk, A., Furth, P., Morency, P., Miranda-Moreno, L., Willett, W., Dennerlein, J. (2010). Risk of injury for bicycling on cycle tracks versus in the street. Injury Prevention.

- Keeps motorists from easily entering the cycle track.
- Encourages bicyclists to ride in the bikeway rather than on the sidewalk.
- Can visually reduce the width of the street when provided adjacent to a travel lane.

> *Since the raised bicycle lane is constructed of concrete and has a left edge that is beveled up to a height of half the normal curb height, it adds a very visible edge to the travel lane that a normal, striped bike lane does not provide. The 4:1 slope of the left edge is very forgiving for both bicyclists and motorists who get too close to the edge, but is visually nearly as powerful as a vertical curb."*
>
> Pedestrian and Bicycle Information Center. (2006.) BIKESAFE: Bicycle Countermeasure Selection System. Publication No. FHWA-SA-05-006, Federal Highway Administration, Washington, DC.

- Minimizes maintenance costs due to limited motor vehicle wear.
- With new roadway construction a raised cycle track can be less expensive to construct than a standard bicycle lane.

Typical Applications

Raised cycle tracks can be considered wherever a bicycle lane would be the standard recommendation. They may be most beneficial:

- Along higher speed streets with few driveways and cross streets.
- Along streets on which bike lanes would 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.
- On streets for which conflicts at intersections can be effectively mitigated using parking lane setbacks, bicycle markings through the intersection, and other signalized intersection treatments.
- On streets with numerous curves where vehicle encroachment into bike lanes may be a concern.
- Along streets with high bicycle volumes.

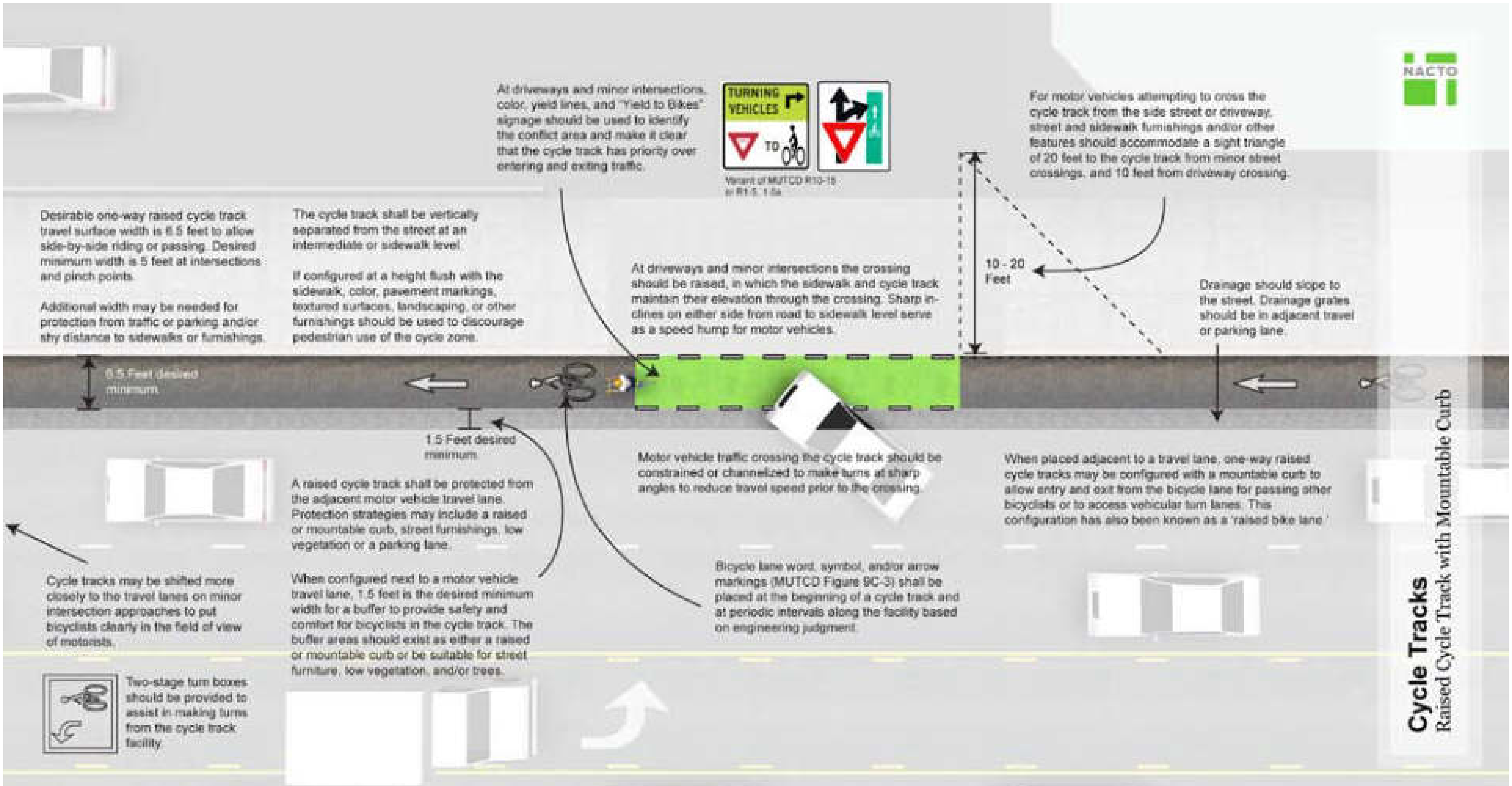
Special consideration should be given at transit stops to manage bicycle & pedestrian interactions. See cycle track intersection approach for transitioning strategies.

Vassar Street Raised Cycle Track Cambridge, MA

In 2003, Vassar Street in Cambridge, MA underwent a full reconstruction as part of a large scale building project undertaken by the Massachusetts Institute of Technology (MIT). As part of the development, the city redesigned a one mile stretch of Vassar Street from Main St. to Audrey St. with east and westbound raised cycle tracks at sidewalk grade level. The cycle tracks, which are each 5' wide with 5' landscaped buffers separating the bikeway from parked cars, serve as a primary east-west route across the MIT campus for cyclists and as a connector to the Kendall Square area and the riverfront.

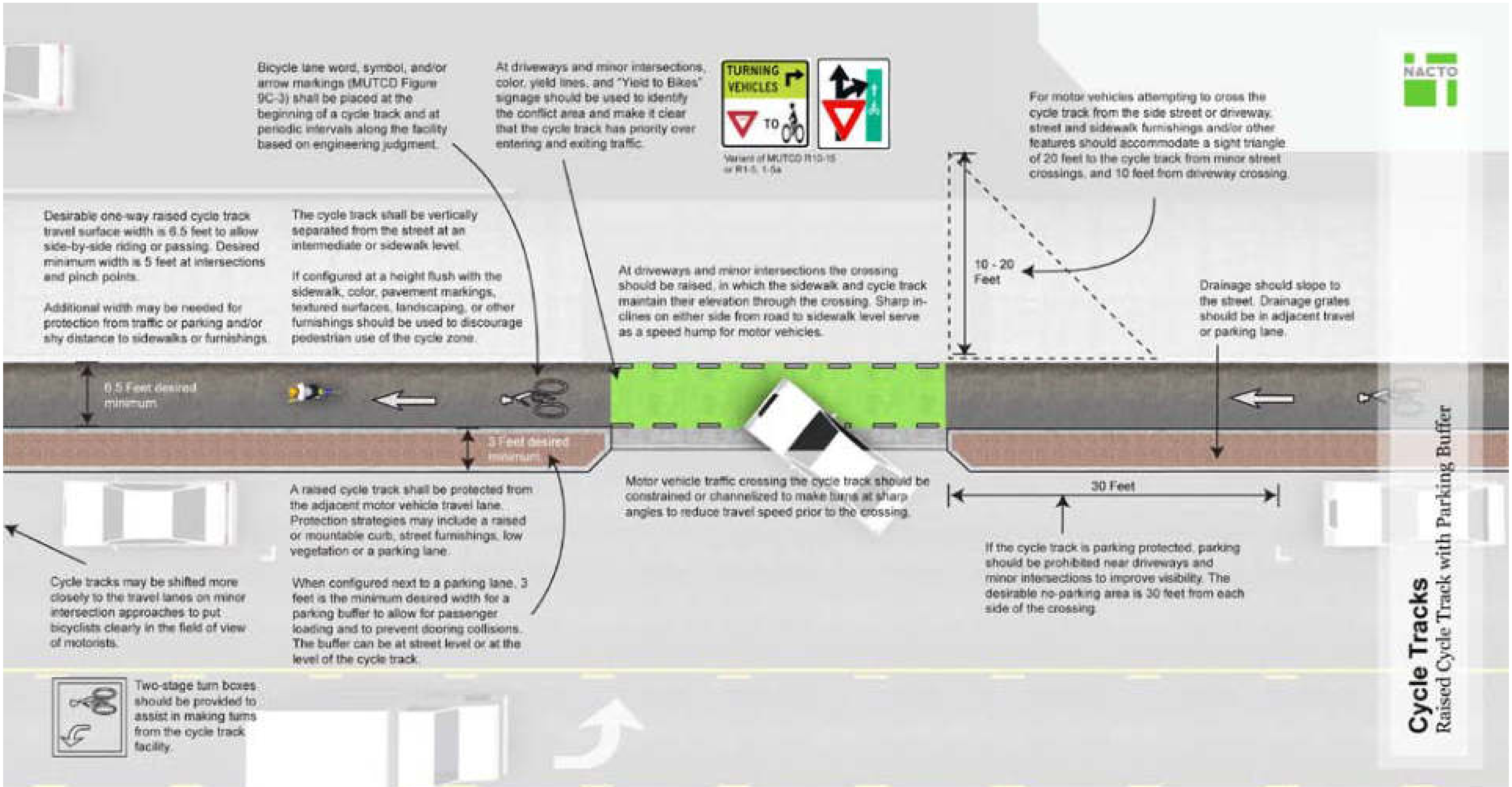
The configuration of the bikeway took into account a number of site constraints and employed many innovative treatments. The bikeway sits at grade with the sidewalk due to the prohibitive costs of reconfiguring existing underground utilities. The cycle track is primarily differentiated from the sidewalk by its material- a hot mix asphalt edged with grey concrete pavers. In addition to these features, the track has prominent "bicycle-only" pavement markers, blue paint at points of conflict, bulb-outs at crosswalks to shorten crossing distances, and other traffic calming devices such as shoulder-less vehicle lanes, raised crosswalks, and prominent signage warning motorists to watch for cyclists. The city of Cambridge constructed the Vassar Street cycle track in two phases. The eastern portion was completed in 2004 and the western portion in 2008. The design of future cycle tracks in Cambridge has been revised to more adequately separate bicyclists from pedestrians by placing street furniture in between the two modes.

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/Raised_Mountable_CycleTracks_Annotation.jpg

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/Raised_Separated_CycleTracks_Annotation.jpg

REQUIRED

The cycle track shall be vertically separated from the street at an intermediate or sidewalk level.

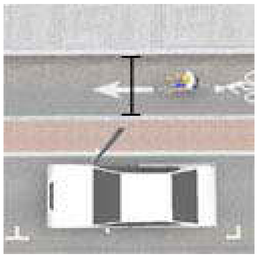
Bicycle lane word, symbol, and/or arrow markings (MUTCD Figure 9C-3) shall be placed at the beginning of a cycle track and at periodic intervals along the facility based on engineering judgment.

A raised cycle track shall be protected from the adjacent motor vehicle travel lane. Protection strategies may include a raised or mountable curb, street furnishings, low vegetation or a parking lane.

If used, the mountable curb should have 4:1 slope edge without any seams or lips to interfere with bike tires to allow for safe entry and exit of the roadway. This curb should not be considered a ridable surface when determining cycle track width.

> *Mountable Curb Design: Mountable curb should have a 4:1 or flatter slope and have no lip that could catch bicycle tires.*
>
> Los Angeles Bicycle Plan Update. (2010). Chapter 5—Technical Design Handbook-DRAFT, 122.

RECOMMENDED



Desirable one-way raised cycle track travel surface width is 6.5 feet to allow side-by-side riding or passing. Desired minimum width is 5 feet at intersections and pinch points. Additional width may be needed for protection from traffic or parking and/or shy distance to sidewalks or furnishings.

	Desirable minimum width (m) (see note 1)	Absolute minimum width (m) (see note 1)	Safety strip to carriageway kerb edge minimum width (m) (see note 2)
One Way	2.0	1.5	0.5
Two Way	3.0	2.0	0.5

Notes:
1. 0.5m should be added for each side of the track that is bounded (e.g. by a wall, railings fence or hedge)
2. Safety strip to carriageway kerb edge minimum width should be 1.0m adjacent to frequently accessed parked cars

Transport for London. (2005). London Cycling Design Standards.

When configured next to a parking lane, 3 feet is the minimum desired width for a parking buffer to allow for passenger loading and to prevent dooring collisions. The buffer can be at street level or at the level of the cycle track.

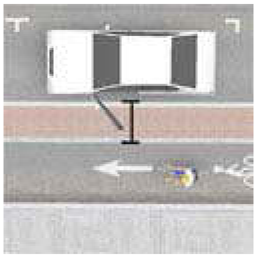
> *Safety strip to carriageway kerb edge minimum width should be 1.0m adjacent to frequently accessed parked cars.*

Transport for London. (2005). London Cycling Design Standards.

> *Width of critical reaction strip is .50 to .75 m*

CROW. (2007). Design Manual for Bicycle Traffic. p159

RECOMMENDED (CONTINUED)



When configured next to a motor vehicle travel lane, 1.5 feet is the desired minimum width for a buffer to provide safety and comfort for bicyclists in the cycle track. The buffer areas should exist as either a raised or mountable curb or be suitable for street furniture, low vegetation, and/or trees.

	Desirable minimum width (m) (see note 1)	Absolute minimum width (m) (see note 1)	Safety strip to carriageway kerb edge minimum width (m) (see note 2)
One Way	2.0	1.5	0.5
Two Way	3.0	2.0	0.5

Notes:
1. 0.5m should be added for each side of the track that is bounded (e.g. by a wall, railings fence or hedge)
2. Safety strip to carriageway kerb edge minimum width should be 1.0m adjacent to frequently accessed parked cars

Transport for London. (2005). London Cycling Design Standards.

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

> *Parking must be banned along the street with the bike path for a distance long enough to ensure adequate stopping sign distances for motorists crossing the path.*
>
> Velo Quebec. (2003). Technical handbook of bikeway design. 2nd ed. Quebec: Ministere des Transport du Quebec and the Secretariat au Loisir et au Sport.

- For motor vehicles attempting to cross the cycle track from the 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 10 feet from driveway crossing.

RECOMMENDED (CONTINUED)

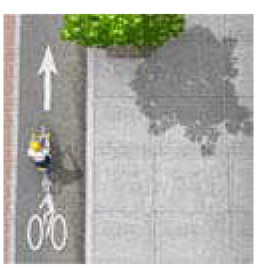
- Color, yield lines, and "Yield to Bikes" signage should be used to identify the conflict area and make it clear that the cycle track has priority over entering and exiting traffic.

Variant of MUTCD R10-15 to include helmeted bicycle rider symbol (MUTCD figure 9C-3 B).Alternate sign in common use, similar to MUTCD R1-5, 1-5a.

- 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.
- 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.

The results show that the paths with raised crossings attracted more than 50 percent more bicyclists and that the safety per bicyclist was improved by approximately 20 percent due to the increase in bicycle flow, and with an additional 10 to 50 percent due to the improved layout.

Garder, P., Leden, L., Pulkkinen, U. (1998). Measuring the Safety Effect of Raised Bicycle Crossings Using a New Research Methodology. Transportation Research Record, 1636.



If configured at a height flush with the sidewalk, color, pavement markings, textured surfaces, landscaping, or other furnishings should be used to discourage pedestrian use of the cycle zone.

RECOMMENDED (CONTINUED)

Drainage should slope to the street. Drainage grates should be in adjacent travel or parking lane.

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

Raised Cycle Track on Cully Boulevard Portland, OR

Once completed, the one-way cycle track on Cully Boulevard between Prescott Ave. and Killingsworth Ave. in Portland, OR, will represent the city's most comprehensive traffic-protected bicycle facility. Previous to its reconstruction, Cully Blvd. was an unimproved street with center strip asphalt paving and no sidewalk or other amenities. The Cully Blvd. project involves a total reconstruction of the street, including a raised cycle track on both sides of the street, "green street" and storm-water treatment features, and curb extensions. To decrease the risk of bicyclist and right-turning motorist collisions, parking was pushed back at the intersection. The raised cycle track gradually transitions to street grade (with a continuation of the concrete material) and moves closer towards traffic to increase visibility at the intersection. Design of storm-water treatment features, which stretch the width of the parking lane, carefully analyzed the water flow as a result of the change in grade between the sidewalk, cycle track, and the street.

This project was designed and implemented by the Portland Bureau of Transportation. It is slated for completion in late summer 2011.

OPTIONAL

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.

> *It is recommended that on roads within built-up areas … cycle tracks are bent in 20-30 meters before and intersecting road (bending-in is defined as bending a separate cycle track toward the carriageway, with the distance between the cycle track and the side of the main carriageway measuring between 0 and 2 m).*

> *Function of Bending Cycle Track In:*
>
> - *Improving conspicuity of cyclists*
> - *Improving visibility of cyclists*
> - *Clarifying right of way situations"*

CROW. (2007). Design Manual for Bicycle Traffic.

When placed adjacent to a travel lane, one-way raised cycle tracks may be configured with a mountable curb to allow entry and exit from the bicycle lane for passing other bicyclists or to access vehicular turn lanes. This configuration has also been known as a 'raised bike lane.'

Color may be used to contrast with the adjacent pedestrian area or to increase the visibility of the cycle track in conflict areas.

Maintenance

- Cycle tracks should be maintained to be free of potholes, broken glass, and other debris.
- Cycle tracks may be incompatible with conventional street sweeping equipment and snow plow equipment, depending on their configuration.
- Cycle tracks receive less wear and tear than travel lanes.

Treatment Adoption and Professional Consensus

- Commonly used in dozens of European bicycle friendly cities.
- Currently used in the following US cities:
  - Bend, OR
  - Brooklyn, NY
  - Cambridge, MA
  - Denton, TX
  - Missoula, MT
  - Portland, OR
  - Other cities in Oregon

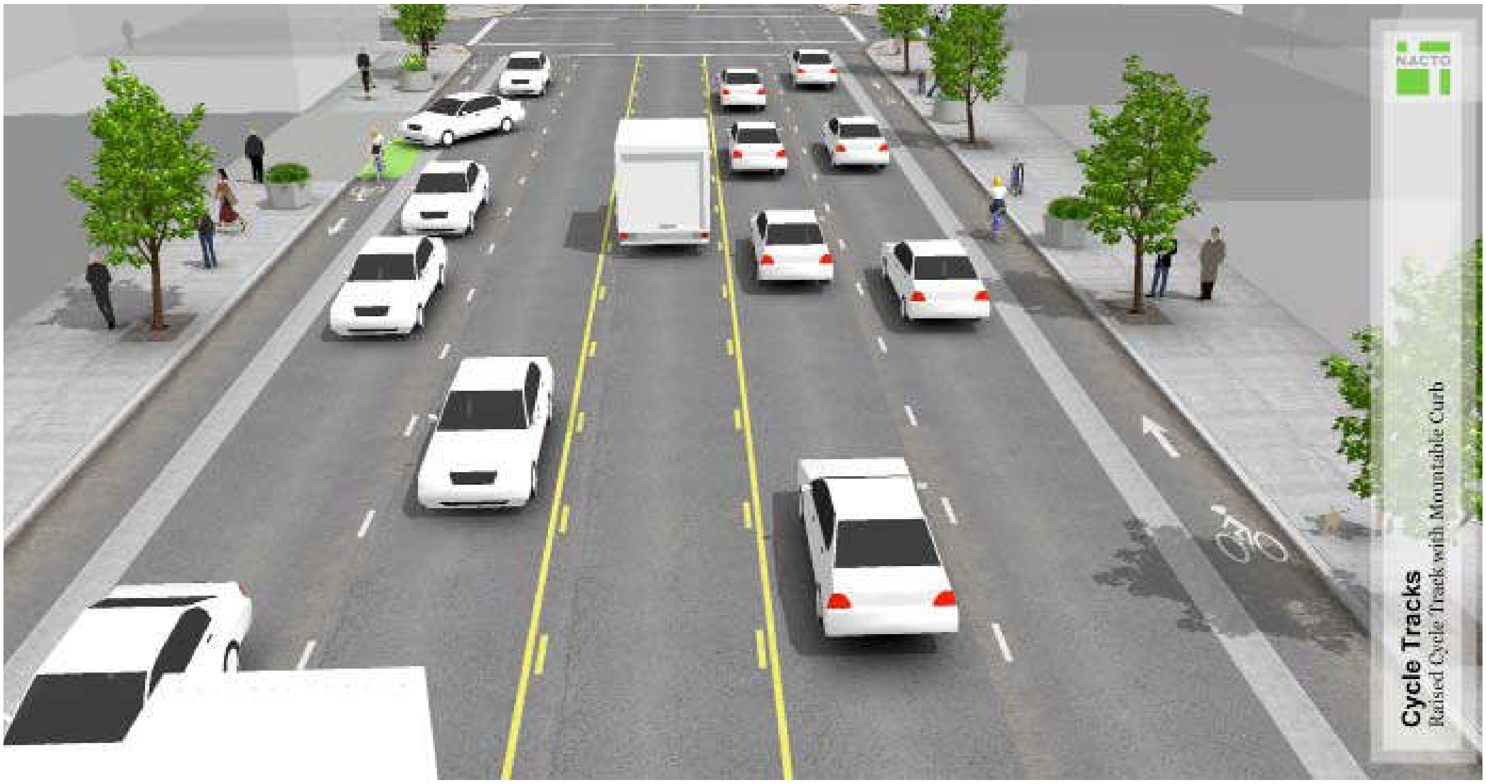
North Higgins Avenue Raised Cycle Track Missoula, MT

The North Higgins Avenue Raised Cycle Track was completed in October 2010 as part of a coordinated effort by the Missoula Downtown Association and Business Improvement District to create protected bicycle facilities running through downtown Missoula. North Higgins Avenue, a retail corridor with two traffic lanes running north and south through Downtown Missoula, is bound to the north by Interstate Route 90, a railroad yard, and the mountains, and to the south by a State Highway along Broadway Street and the River. North of Broadway Street, the state highway turns and Higgins Avenue has lower traffic levels which can support a narrower road profile. The raised cycle track was incorporated into a master plan created for the downtown association by the Portland-based firm Crandall Arambula. The 8' wide cycle track is a raised facility with a 2' yellow painted buffer to separate cyclists from parked cars. It was determined to place parking meters at the edge of the cycle track adjacent to parking in order to narrow the visual field and encourage cyclists to ride closer to the sidewalk. Green colored markings and signage help indicate the cycle track to motor vehicles at intersections. The city had to apply to MUTCD for permission to experiment with this treatment. The design of the cycle track avoids potentially hazardous collisions resulting from a lack of visibility. Parking was moved back at the intersections. The city considered prohibiting a right-turn for motorists at a red signal. In coordination with a planned street resurfacing, bike lanes were also installed on the southern half of Higgins Avenue which is a state highway.

The North Higgins Avenue raised cycle track was designed and implemented by the city of Missoula and the urban revitalization firm Crandall Arambula. The project was funded by the Missoula Downtown Association and Business Improvement District, with a Federal Stimulus Grant through the American Recovery and Reinvestment Act (ARRA).

Renderings

The following images are 3D concepts of a raised cycle track. The configurations shown are based on Bend, OR, examples.


NACTO
Cycle Tracks
Raised Cycle Track with Mountable Curb


NACTO
Cycle Tracks
Raised Cycle Track with Mountable Curb


NACTO
Cycle Tracks
Raised Cycle Track with Parking Buffer


NACTO
Cycle Tracks
Raised Cycle Track with Parking Buffer

Image Gallery


BEND, OR


MISSOULA, MT


PORTLAND, OR


INDIANAPOLIS, IN


CORVALLIS, OR


CAMBRIDGE, MA


PORTLAND, OR


PORTLAND, OR


PORTLAND, OR

Two-Way Cycle Tracks

Two-way cycle tracks 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 protected 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. Street level cycle tracks are also known as “on-street bike paths” in New York City.

One-Way Protected Cycle Track Benefits

- Dedicates and protects space for bicyclists by improving perceived comfort and safety. Eliminates risk and fear of collisions with over-taking vehicles.

> *Compared with bicycling on a reference street…these cycle tracks had a 28% lower injury rate.*
>
> Lusk, A., Furth, P., Morency, P., Miranda-Moreno, L., Willett, W., Dennerlein, J. (2010). Risk of injury for bicycling on cycle tracks versus in the street. Injury Prevention.

> *Cyclists feel most secure on roads with cycle tracks and most at risk on roads with mixed traffic.*
>
> Jensen, S. U., Rosenkilde, C., and Jensen, N. (2007). Road safety and perceived risk of cycle facilities in Copenhagen. Copenhagen: Trafitec Research Center.

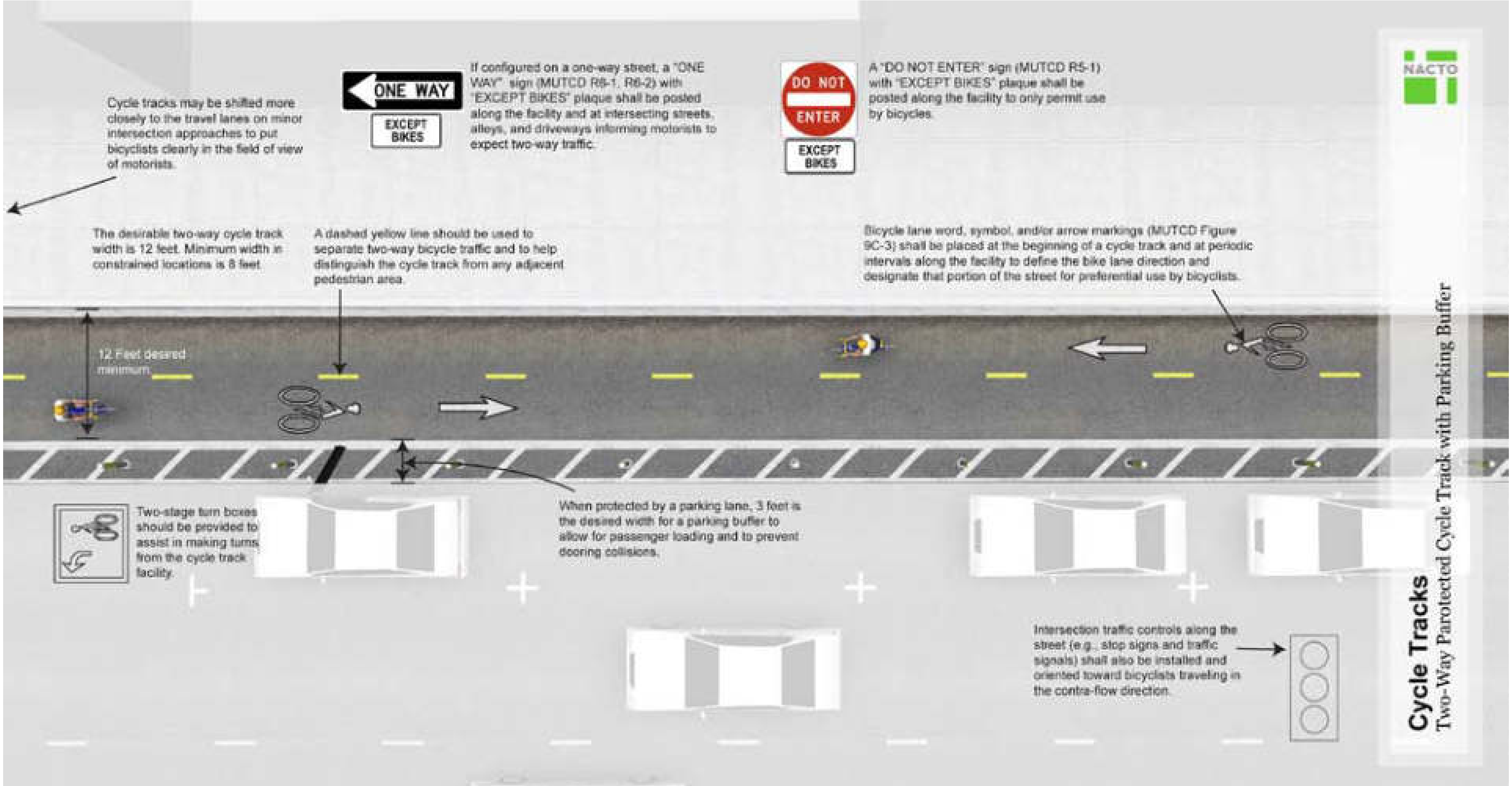
- Reduces risk of 'dooring' compared to a bike lane, and eliminates the risk of a doored bicyclist being run over by a motor vehicle.
- On one-way streets, reduces out of direction travel by providing contra-flow movement.
- Low implementation cost when making use of existing pavement and drainage and using parking lane or other barrier for protection from traffic.
- More attractive to a wide range of bicyclists at all levels and ages.

> *Overall, 2.5 times as many cyclists used the cycle tracks compared with the reference streets.*
>
> Lusk, A., Furth, P., Morency, P., Miranda-Moreno, L., Willett, W., Dennerlein, J. (2010). Risk of injury for bicycling on cycle tracks versus in the street. Injury Prevention.

Typical Applications

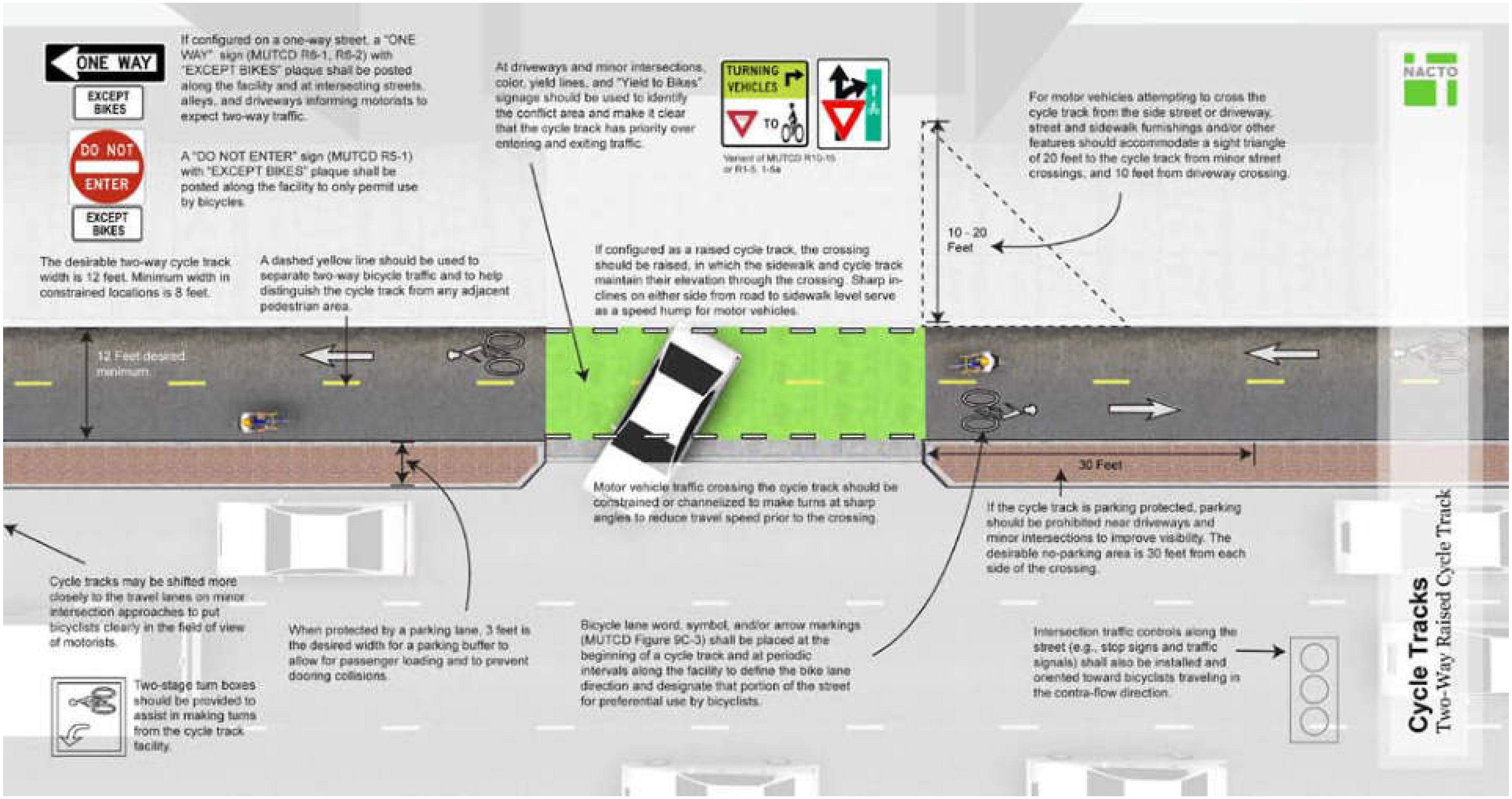
- On streets with few conflicts such as driveways or cross-streets on one side of the street.
- On streets where there is not enough room for a one-way cycle track on both sides of the street.
- On one-way streets where contra-flow bicycle travel is desired.
- On streets where more destinations are on 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.
- Along streets on which bike lanes would cause many bicyclists to feel stress because of factors such as multiple lanes, high traffic volumes, high speed traffic, high incidence of double parking, and high parking turnover.
- On 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.
- Special consideration should be given at transit stops to manage bicycle and pedestrian interactions.

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/CycleTrack_TwoWay_Protected_Plan_Annotation.jpg

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/CycleTrack_TwoWay_Raised_Plan_Annotation.jpg

REQUIRED

Bicycle lane word, symbol, and/or arrow markings (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 (MUTCD R6-1, R6-2) with "EXCEPT BIKES" plaque 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 (MUTCD R5-1) 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.

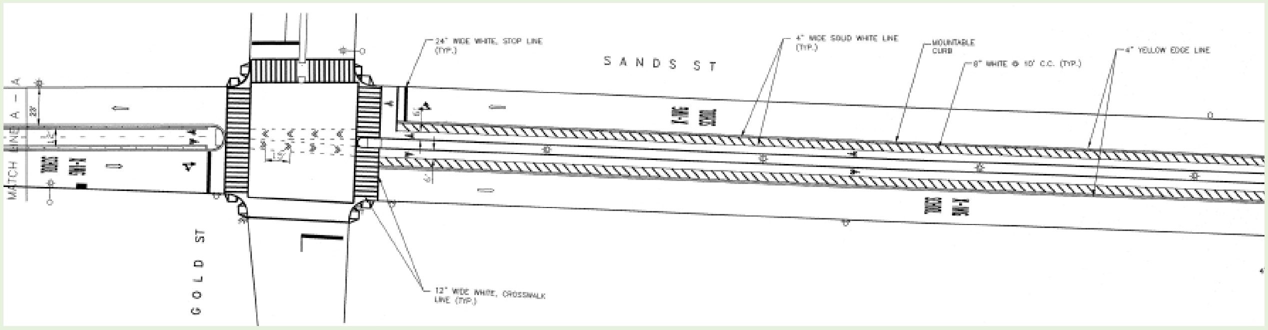
Sands Street Bicycle Path and Greenstreet

Brooklyn, NY

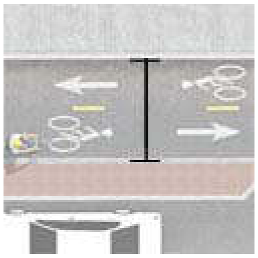
The Sands St. two-way raised cycle track in Brooklyn, NY was constructed to provide a safe, protected route for cyclists connecting to the Manhattan Bridge and the planned Brooklyn Waterfront Greenway. Following the re-opening of the Manhattan Bridge north path to bicycle traffic in 2004, the percentage of bicyclists using Sands St. as a connector to access the bridge increased heavily, rising from ten to forty percent.

The design of the Sands St. bikeway was formulated by observing of the behavior of cyclists along this street. Many cyclists had used the center line to negotiate high-speed traffic exiting and entering the on/off ramps to the Manhattan Bridge. The two-way cycle track, running a third of a mile between Navy Street and the Manhattan Bridge entrance, facilitates a safe and easy passage onto the Manhattan Bridge. It uses two treatments- a raised, mountable four-inch curb with a concrete center median separating two-way bicycle traffic, and a two-way combined track separated by concrete barriers. Where the cycle track meets the roadway, it tapers to street grade to ease merging maneuvers. The bikeway is 11' wide to allow snow-plowing and street-sweeping maintenance.

The project included the installation of a bicycle overhead signal and chevron markings at the intersection to guide the transition from a combined two-way cycle track to a median-separated raised bikeway. Dangerous and illegal left turns from westbound Sands Street to the westbound BQE on-ramp are blocked by the cycle track.



RECOMMENDED



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

Rush hour intensities (two directions, bikes per hour)	Cycle Track Width (feet)
0 - 150	6.5
150 - 750	10
> 750	13

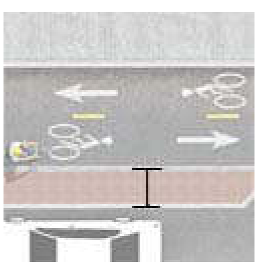
CROW. (2006). Record 25: Design Manual for Bicycle Traffic. CROW, The Netherlands.

	Desirable minimum width (m) (see note 1)	Absolute minimum width (m) (see note 1)	Safety strip to carriageway kerb edge minimum width (m) (see note 2)
One Way	2.0	1.5	0.5
Two Way	3.0	2.0	0.5

Notes:

1. 0.5m should be added for each side of the track that is bounded (e.g. by a wall, railings fence or hedge)
2. Safety strip to carriageway kerb edge minimum width should be 1.0m adjacent to frequently accessed parked cars

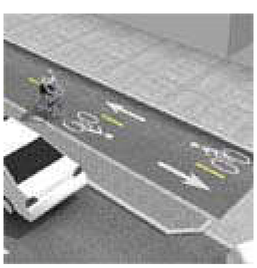
Transport for London. (2005). London Cycling Design Standards.



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

> *Safety strip to carriageway kerb edge minimum width should be 1.0m adjacent to frequently accessed parked cars.*

Transport for London. (2005). London Cycling Design Standards.



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.

RECOMMENDED (CONTINUED)

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

> *Parking must be banned along the street with the bike path for a distance long enough to ensure adequate stopping sign distances for motorists crossing the path.*
>
> Velo Quebec. (2003). Technical handbook of bikeway design. 2nd ed. Quebec: Ministere des Transport du Quebec and the Secretariat au Loisir et au Sport.

- For motor vehicles attempting to cross the cycle track from the 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 10 feet 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.

> *Variant of MUTCD R10-15 to include helmeted bicycle rider symbol (MUTCD figure 9C-3 B). Alternate sign in common use, similar to MUTCD R1-5, 1-5a.*

- 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.

> *The results show that the paths with raised crossings attracted more than 50 percent more bicyclists and that the safety per bicyclist was improved by approximately 20 percent due to the increase in bicycle flow, and with an additional 10 to 50 percent due to the improved layout.*
>
> Garder, P., Leden, L., Pulkkinen, U. (1998). Measuring the Safety Effect of Raised Bicycle Crossings Using a New Research Methodology. Transportation Research Record, 1636.

RECOMMENDED (CONTINUED)

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

OPTIONAL

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

> *It is recommended that on roads within built-up areas … cycle tracks are bent in 20-30 meters before and intersecting road (bending-in is defined as bending a separate cycle track toward the carriageway, with the distance between the cycle track and the side of the main carriageway measuring between 0 and 2 m).*

> *Function of Bending Cycle Track In:*

- Improving conspicuity of cyclists
- Improving visibility of cyclists
- Clarifying right of way situations

CROW. (2007). Design Manual for Bicycle Traffic.

May be configured as a raised cycle track.

Maintenance

- Cycle tracks should be maintained to be free of potholes, broken glass, and other debris.
- Two-way cycle tracks have similar maintenance requirements to one-way protected cycle tracks and raised cycle tracks depending on the configuration.

Treatment Adoption and Professional Consensus

- Commonly used in dozens of European bicycle friendly cities.
- Currently used in the following US cities:
  - New York City, NY
  - Portland, OR
  - Indianapolis, IN
  - Saint Petersburg, FL
  - Washington, DC

15th Street Two-way Cycle Track Washington, D.C.

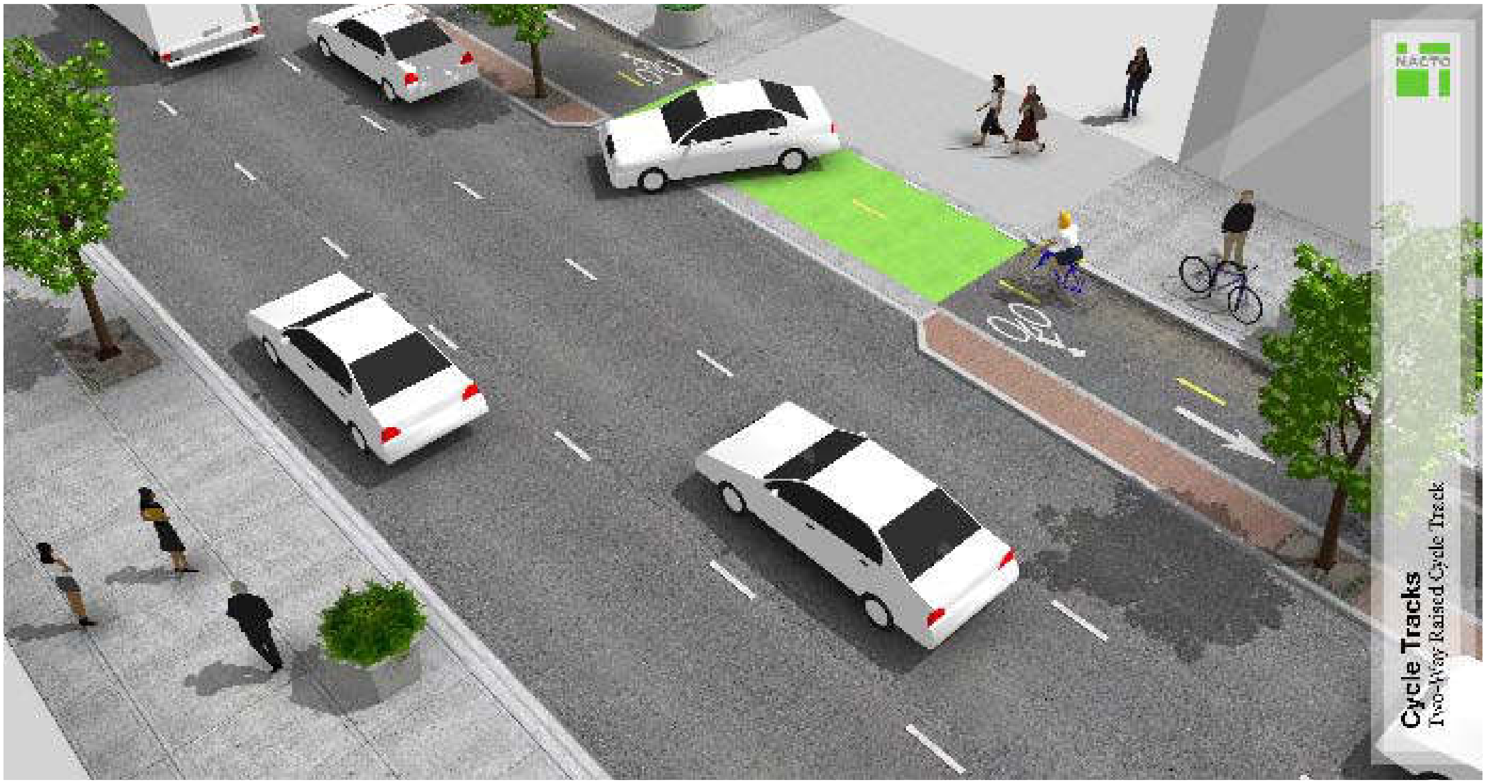
15th Street, running between Pennsylvania Ave. and V St., was selected as a suitable location to pioneer and experiment with the capital's first protected bike facility on account of its extra roadway capacity and central location. In 2010, the city installed a one-way, southbound, protected contra-flow cycle track. After observing cyclists using the protected facility in both directions, the route was converted to a two-way cycle track. The bikeway is separated from the road by a floating parking lane, buffer, and intermittent yellow plastic pylons. A bicycle signal was also put in place at the intersection with Pennsylvania Ave. to ease the passage ofcrossing cyclists. According to a 2010 follow-up study by the DDOT, the cycle track has increased levels of cycling, decreased riding on the sidewalk, and diminished the number of vehicles per day. At its full 2.1 mile length, the cycle track will cost an estimated $250,000.

This project was designed and implemented by the District of Columbia Department of Transportation along a 1.5 mile segment of 15th Street between Pennsylvania Ave. and V St. in Washington D.C.

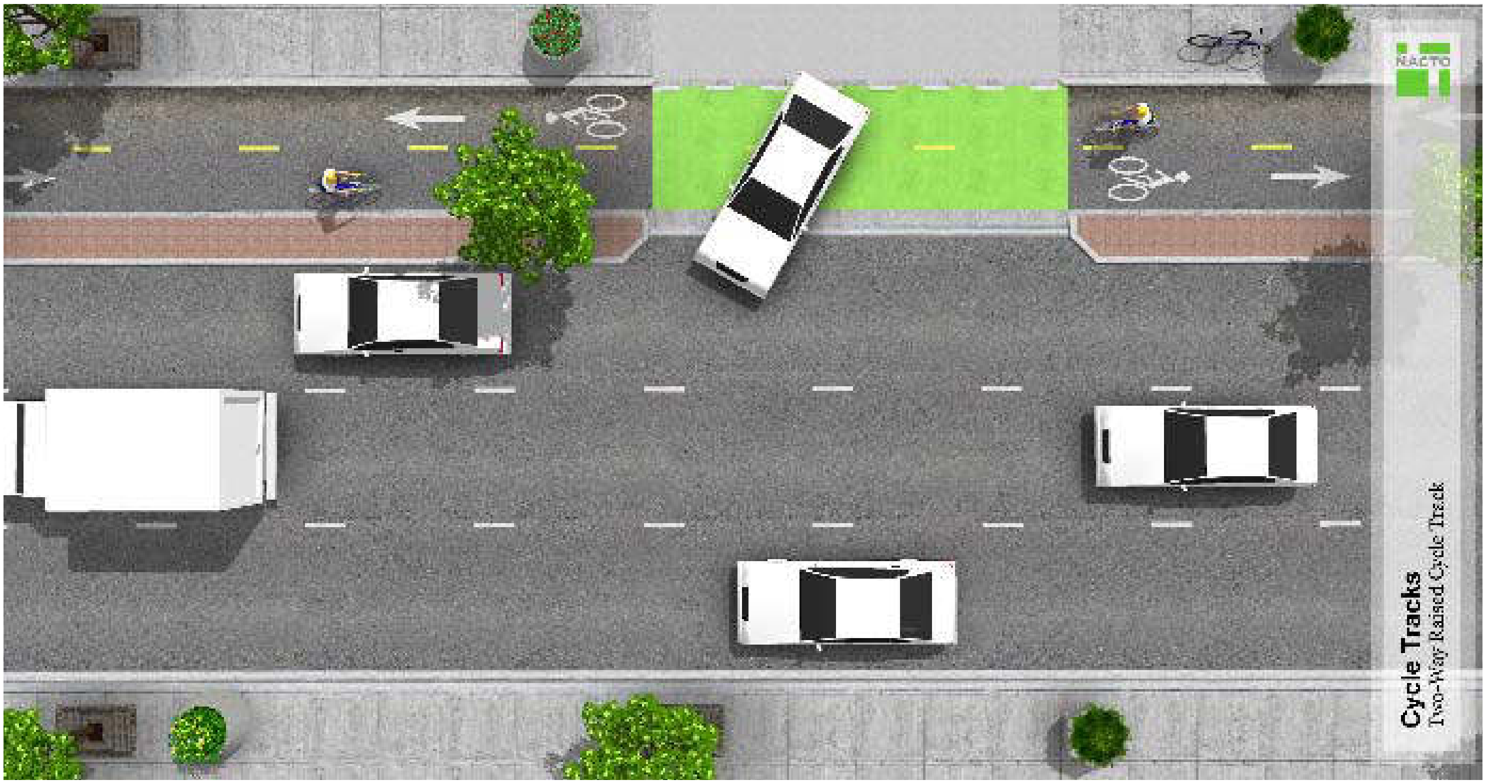
District Department of Transportation. (2010). 15th Street NW Separated Bike Lane Pilot Project – Interim Results and Next Steps.

Renderings

The following images are 3D concepts of a two-way cycle track. The configurations shown are based on Cambridge, MA and Washington DC, examples.


NACTO
Cycle Tracks
Two-Way Raised Cycle Track


NACTO
Cycle Tracks
Two-Way Protected Cycle Track with Parking Buffer


NACTO
Cycle Tracks
Two-Way Raised Cycle Track


NACTO
Cycle Tracks
Two-Way Protected Cycle Track with Parking Buffer

Image Gallery

PORTLAND, OR

PORTLAND, OR

WASHINGTON, DC

INDIANAPOLIS, IN

WASHINGTON, DC

IN THIS SECTION:

INTERSECTIONS

Intersections are junctions at which different modes of transportation meet and facilities overlap.

An intersection facilitates the interchange between bicyclists, motorists, pedestrians, and other competing modes in order to advance traffic flow in a safe and efficient manner. Designs for intersections with bicycle facilities should reduce conflict between bicyclists (and other vulnerable road users) and vehicles by heightening the level of visibility, denoting a clear right-of-way, and facilitating eye contact and awareness with competing modes. Intersection treatments can resolve both queuing and merging maneuvers for bicyclists, and are often coordinated with timed or specialized signals.

The configuration of a safe intersection for bicyclists may include elements such as color, signage, medians, signal detection, and pavement markings. Intersection design should take into consideration existing and anticipated bicyclist, pedestrian and motorist movements. In all cases, the degree of mixing or separation between bicyclists and other modes is intended to reduce the risk of crashes and increase bicyclist comfort. The level of treatment required for bicyclists at an intersection will depend on the bicycle facility type used, whether bicycle facilities are intersecting, the adjacent street function and land use.

Bike Boxes

A bike box is a designated area at the head of a traffic lane at a signalized intersection that provides bicyclists with a safe and visible way to get ahead of queuing traffic during the red signal phase.

Bike Box Benefits

- Increases visibility of bicyclists.

> *"Despite positioning themselves further from the intersection, motorists were observed to give bicyclists the right-of-way more often with the presence of the bicycle box."*
>
> Brady, J., Mills, A., Loskorn, J., Duthie, j., Machemehl, R., Center for Transportation Research. (2010). Effects of Bicycle Boxes on Bicyclist and Motorist Behavior at Intersections. The City of Austin.

- Reduces signal delay for bicyclists.
- Facilitates bicyclist left turn positioning at intersections during red signal indication. This only applies to bike boxes that extend across the entire intersection.
- Facilitates the transition from a right-side bike lane to a left-side bike lane during red signal indication. This only applies to bike boxes that extend across the entire intersection.
- Helps prevent 'right-hook' conflicts with turning vehicles at the start of the green indication.
- This is especially important in areas with high volumes of right-turning vehicles and/or trucks, whose high cabs make it difficult to see a bicyclist on the right, and who begin their turning maneuvers by going straight, which can deceive a bicyclist into thinking the truck is not turning.

> *Cyclists travelling straight ahead were found to be able to position themselves in front of the traffic thus reducing the risk of conflict with … turning vehicles.*
>
> Allen, D., S. Bygrave, and H. Harper. (2005). Behaviour at Cycle Advanced Stop Lines (Report No. PPR240). Transport for London, London Road Safety Unit.

- Provides priority for bicyclists at signalized bicycle boulevard crossings of major streets.
- Groups bicyclists together to clear an intersection quickly, minimizing impediment to transit or other traffic.
- Bicyclists can avoid breathing exhaust while queued at the signal.
- Contributes to the perception of safety among users of the bicycle network.

> *"77% of cyclists felt bicycling through the intersections was safer with the bike boxes"*
>
> Monsere, C., & Dill, J. (2010). Evaluation of Bike Boxes at Signalized Intersections. Final Draft. Oregon Transportation Research and Education Consortium.

- Pedestrians benefit from reduced vehicle encroachment into the crosswalk.

> *The video data showed that motorist encroachment into the pedestrian crosswalk fell significantly compared to the control intersection. … This reduction of motor vehicles entering the crosswalk area has the potential to improve pedestrian safety*
>
> Monsere, C., & Dill, J. (2010). Evaluation of Bike Boxes at Signalized Intersections. Final Draft. Oregon Transportation Research and Education Consortium.

> *All vehicles that encroached at control sites went into the pedestrian crossing, compared with 12% at [bike box] sites, indicating that [a bike box] can provide a buffer zone that discourages vehicles from blocking the pedestrian crossing.*
>
> Allen, D., S. Bygrave, and H. Harper. (2005). Behaviour at Cycle Advanced Stop Lines. Report No. PPR240. Transport for London, London Road Safety Unit.

Typical Applications

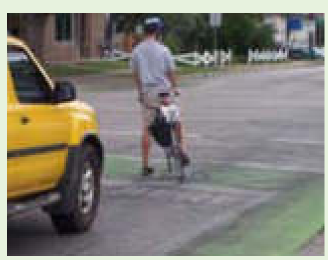
- At signalized intersections with high volumes of bicycles and/or motor vehicles, especially those with frequent bicyclist left-turns and/or motorist right-turns.
- Where there may be right or left-turning conflicts between bicyclists and motorists.
- Where there is a desire to better accommodate left turning bicycle traffic.
- Where a left turn is required to follow a designated bike route, access a shared-use path, or when the bicycle lane moves to the left side of the street.
- When the dominant motor vehicle traffic flows right and bicycle traffic continues through (such as a Y intersection or access ramp).

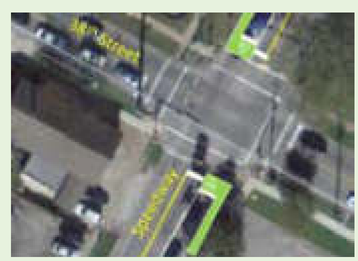
Evaluation of Bike Box at Speedway and 38th Street

Austin, TX

In 2009, as part of an experiment coordinated between the Austin Street Smarts Task Force and the University of Texas' Center for Transportation Research Center in 2010, the city of Austin installed bike boxes at two intersections on multi-lane roadways to study their effect on bicyclist and motorist behaviors. Three conditions were studied using before and after video footage: before the installation of the bike box, after the installation of a "skeleton" bike box, and after the introduction of color to the bike box.

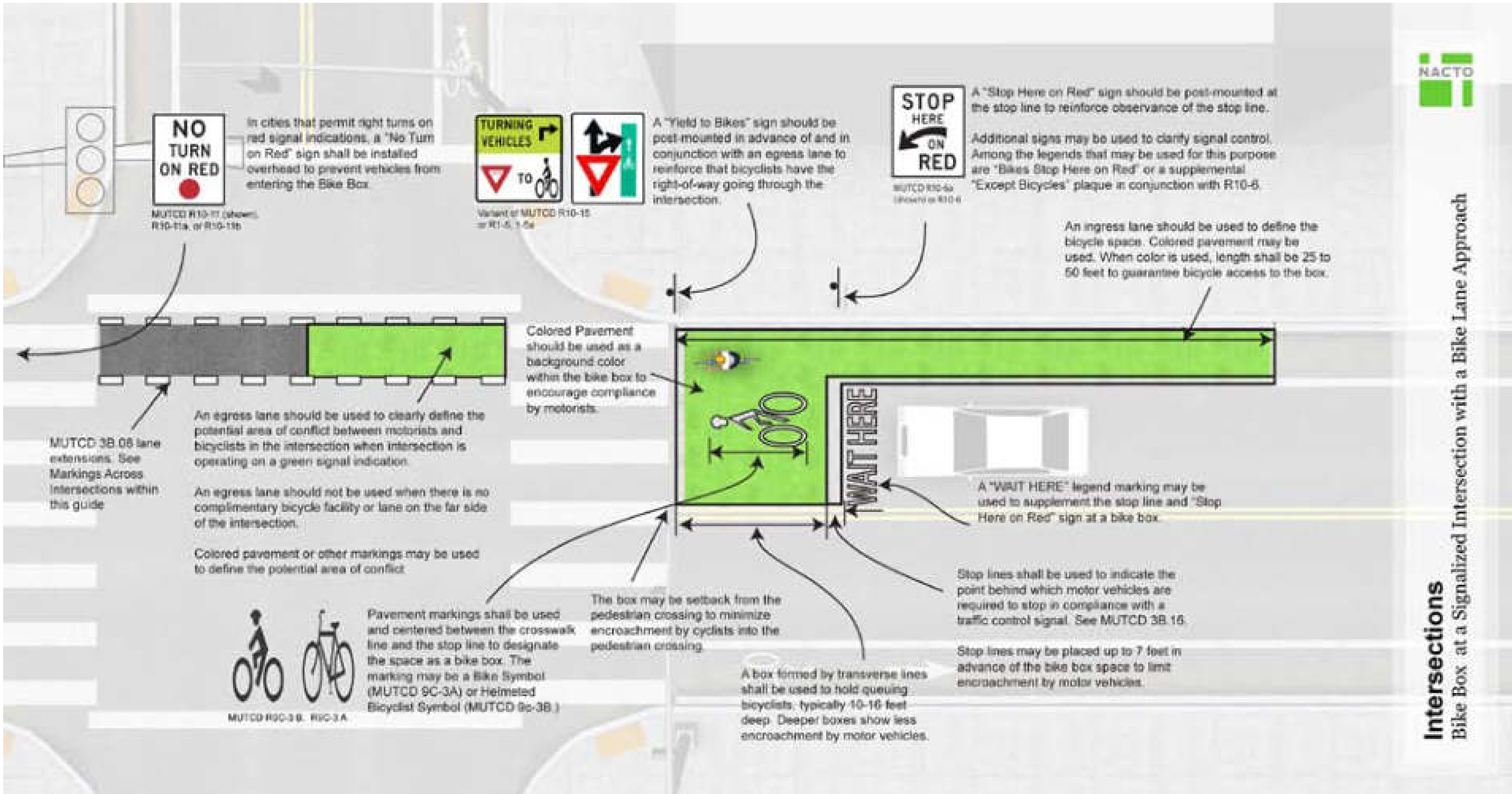
At the intersection of Speedway and 38th St., along a common commuter route for students to the University of Texas, bike boxes were installed on both sides of the intersection at 38th St. Speedway has a posted speed limit of 25 mph and hourly traffic volumes ranging from 150 to 250 vehicles. The results of the study showed a decrease in avoidance maneuvers, an increase in the percentage of cyclists that departed the intersection before a motorist, and an increase in the number of bicyclists that used the bicycle lane to approach the intersection. The addition of a chartreuse thermoplastic color to the bike box further deterred the encroachment of vehicles into the bike box and increased the use and visibility of the treatment. Overall, cyclists took a more predictable position at the intersection and were more likely to depart safely in front of motorists.





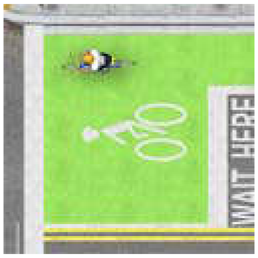
Images from: Brady, J., Mills, A., Loskorn, J., Duthie, j., Machemehl, R., Center for Transportation Research. (2010). Effects of Bicycle Boxes on Bicyclist and Motorist Behavior at Intersections. City of Austin.

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/BikeBox_Plan_Annotated.jpg

REQUIRED



A box formed by transverse lines shall be used to hold queuing bicyclists, typically 10-16 feet deep. Deeper boxes show less encroachment by motor vehicles.

> *Feedback from the public indicates that eight feet is not large enough to comfortably maneuver into the box.*

Brady, J., Mills, A., Loskorn, J., Duthie, j., Machemehl, R., Center for Transportation Research. (2010). Effects of Bicycle Boxes on Bicyclist and Motorist Behavior at Intersections. The City of Austin.

> *The two stop lines must be between 4 and 5m apart; the area between them across the full width of the approach is available for cyclists who wait at the rest light.*

Allen, D., S. Bygrave, and H. Harper. (2005). Behaviour at Cycle Advanced Stop Lines. Report No. PPR240. Transport for London, London Road Safety Unit.

Stop lines shall be used to indicate the point behind which motor vehicles are required to stop in compliance with a traffic control signal. See MUTCD 3B.16.

> *Use of bold demarcation of the box is vital. This could involve wider striping than the norm or perhaps painting the box a bright color.*

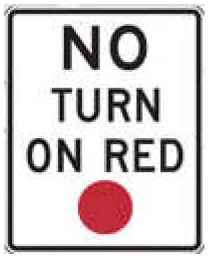
Hunter, W. W. (2000). Evaluation of Innovative Bike-Box Application in Eugene, Oregon. Transportation Research Record, 1705, 99-106.

Pavement markings shall be used and centered between the crosswalk line and the stop line to designate the space as a bike box. The marking may be a Bike Symbol (MUTCD 9C-3A) or Helmeted Bicyclist Symbol (MUTCD 9c-3B.)

REQUIRED (CONTINUED)

In cities that permit right turns on red signal indications, a "No Turn on Red" sign shall be installed overhead to prevent vehicles from entering the Bike Box.

MUTCD R10-11, R10-11a, or R10-11b



Crossing Bike Boxes at Three Locations on Jefferson and Washington Streets Phoenix, AZ

In 2009, the city of Phoenix installed bike boxes at three locations. These included the west side of Jefferson St. at 7th and 24th Streets and the east side of Washington St. at 24th Street. The use of the bike box at these sites is non-traditional, and is meant to facilitate a crossing movement from a right side bike lane to a left-hand lane across recently installed light-rail tracks on a one-way street. After the city completed a light rail line along Jefferson St. in 2008, because of limited right of way, the preexisting bike lane had to be shifted across the tracks to the left lane to preserve its continuity. Bike lane and double chevron markings, along with directional arrows, lead cyclists across the bike box in front of traffic. A sign indicates to cyclists and motorists the correct maneuver for bicyclists on the roadway and tells them to wait for the pedestrian walk signal to cross. The city of Phoenix applied for FHWA permission to experiment with this treatment, and compiled video and crash data of the three sites following their installation.

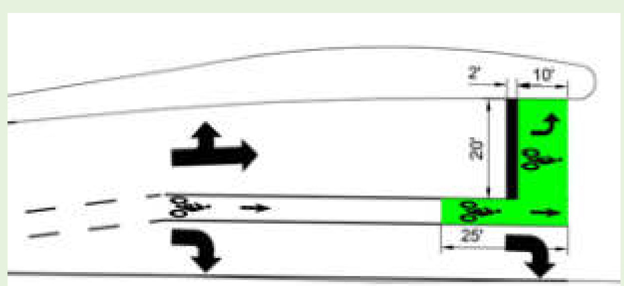
RECOMMENDED

A “Stop Here on Red” sign should be post-mounted at the stop line to reinforce observance of the stop line.

> *MUTCD R10-6a (shown) or R10-6. Additional signs may be used to clarify signal control. Among the legends that may be used for this purpose are “Bikes Stop Here on Red” or a supplemental “Except Bicycles” plaque in conjunction with R10-6 to indicate the bicyclist stop line.*

Wyman Park Bike Box Baltimore, MD

The Wyman Park Bike Box, at the intersection of Wyman Park Drive, Sission Street, and Keswick Drive in Baltimore, was installed to improve safety for bicyclists. Originally installed as a pocket lane with the Collegetown Bike Network from the Jones Falls Trail, the pocket lane created mid-intersection conflicts between cyclists and motorists. By providing the bike box, the city created a right turn only for vehicles and prioritized bicycle traffic going straight through the intersection on Wyman Park Drive or making a left onto Keswick Drive on the Hampden Bike Route. The opportunity to install the bike box came as a result of a planned street resufacing. The bike box will be painted green in Spring 2011.



RECOMMENDED (CONTINUED)

Colored pavement should be used as a background color within the bike box to encourage compliance by motorists.

“In regards to motorist stopping behavior, the percentage of motorists that encroached on the stop line decreased significantly with the implementation of the skeleton [uncolored] bicycle box.”

Brady, J., Mills, A., Loskorn, J., Duthie, j., Machemehl, R., Center for Transportation Research. (2010). Effects of Bicycle Boxes on Bicyclist and Motorist Behavior at Intersections. The City of Austin.

“The motorist survey revealed a strong preference for color. In addition, cyclists appear to use the box more as intended with the color, which should increase their visibility and improve safety.”

Monsere, C., & Dill, J. (2010). Evaluation of Bike Boxes at Signalized Intersections. Final Draft. Oregon Transportation Research and Education Consortium.

“Use of bold demarcation of the box is vital. This could involve wider striping than the norm or perhaps painting the box a bright color.”

Hunter, W. W. (2000). Evaluation of Innovative Bike-Box Application in Eugene, Oregon. Transportation Research Record, 1705, 99-106.

Support for Colored Pavement in Bike Lanes

“Significantly more motorists yielded to bicyclists after the blue pavement had been installed (92 percent in the after period versus 72 percent in the before period.”

Hunter, W.W. et al. (2000). Evaluation of Blue Bike-Lane Treatment in Portland, Oregon. Transportation Research Record, 1705, 107-115.

“Best estimates for safety effects of one blue cycle crossing in a junction are a reduction of 10% in accidents and 19% in injuries.”

Jensen, S. U. (2008). Safety effects of blue cycle crossings: A before-after study. Accident Analysis & Prevention, 40(2), 742-750.

RECOMMENDED (CONTINUED)

An ingress lane should be used to define the bicycle space. Colored pavement may be used. When color is used, length shall be 25 to 50 feet to guarantee bicycle access to the box.

> *It appears that [ingress lanes] provide cyclists with a considerable advantage in legally accessing [the bike box].” The site with no feeder lane “clearly showed that many cyclists were unable to reach the reservoir.*

Atkins Services. (2005). Advanced Stop Line Variations Research Study. Report No. 503 1271. Transport for London, London Road Safety Unit.

> *Two of the sites with distinctly coloured feeder lanes had lower levels of encroachment suggesting that colour differentiation may reduce levels of encroachment.*

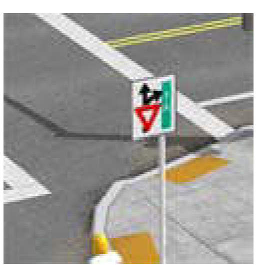
Allen, D., S. Bygrave, and H. Harper. (2005). Behaviour at Cycle Advanced Stop Lines. Report No. PPR240. Transport for London, London Road Safety Unit.

An egress lane should be used to clearly define the potential area of conflict between motorists and bicyclists in the intersection when intersection is operating on a green signal indication.

> *Where there was no cycle lane across the junction, cyclists were observed looking over their shoulders at the exit-arm pinch-point which is likely to impact on their level of comfort, and both perceived and actual safety.*

Atkins Services. (2005). Advanced Stop Line Variations Research Study. Report No. 503 1271. Transport for London, London Road Safety Unit. 8-2.

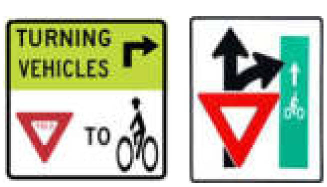
Refer to intersection crossing markings in this guide. Colored pavement or other markings may be used to define the potential area of conflict. An egress lane should not be used when there is no complimentary bicycle facility or lane on the far side of the intersection.



A “Yield to Bikes” sign should be post-mounted in advance of and in conjunction with an egress lane to reinforce that bicyclists have the right-of-way going through the intersection.

> *Variant of MUTCD R10-15 to include helmeted bicycle rider symbol (MUTCD figure 9C-3 B).*

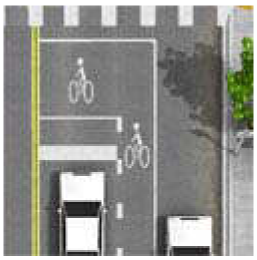
> *Alternate sign in common use, similar to MUTCD R1-5, 1-5a.*



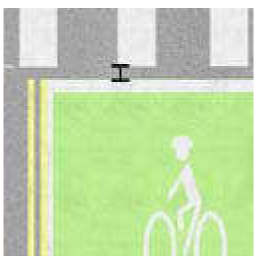
OPTIONAL

A “WAIT HERE” legend marking may be used to supplement the stop line and “Stop Here on Red” sign at a bike box.

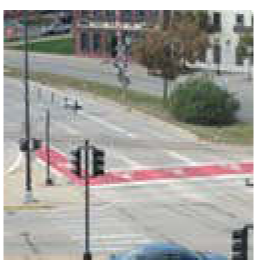
> *Use of bold demarcation of the box is vital. This could involve wider striping than the norm or perhaps painting the box a bright color.*
>
> Hunter, W. W. (2000). Evaluation of Innovative Bike-Box Application in Eugene, Oregon. Transportation Research Record, 1705, 99-106.



Stop lines may be placed up to 7 feet in advance of the bike box space to limit encroachment by motor vehicles.



The box may be setback from the pedestrian crossing to minimize encroachment by cyclists into the pedestrian crossing.



Bike boxes may extend across multiple travel lanes to facilitate bicyclist left turn positioning. A two-stage turn queue box may be an alternative approach to facilitating left turns where there are multiple vehicle through lanes.

> *To traverse a multi-lane bike box, significant lateral movement by the bicyclist is needed. This maneuver can take time and could potentially create conflicts by providing a green light for motorists while bicyclists are moving laterally through the bike box . For this reason, careful consideration should be given before applying.*

Bike boxes may be combined with an exclusive bicycle signal phase or leading bicycle interval through the use of bicycle signal heads to allow clearance of the bicycle queue prior to the green indication for motorists.

> *“Bicycle traffic signals are used to reduce turning conflicts at signalized intersections and often provide separate and sometimes exclusive phases for bicyclists.”*
>
> Federal Highway Administration. (2010). International Technology Scanning Program, Pedestrian and Bicycle Mobility and Safety in Europe. FHWA-PL-10-010.

Maintenance

- Colored pavement surface may be costly to maintain, especially in climates prone to snow/ice.
- Placement of markings between tire tracks will reduce wear.

Treatment Adoption and Professional Consensus

- Commonly used in dozens of European bicycle friendly cities.
- Currently used in the following US cities:
  - Austin, TX
  - Alexandria, VA
  - Boston, MA
  - Baltimore, MD
  - Boston, MA
  - Cambridge, MA
  - Columbus, OH
  - Madison, WI
  - Minneapolis, MN
  - New York, NY
  - Phoenix, AZ
  - Portland, OR
  - Roswell, GA
  - San Francisco, CA
  - San Luis Obispo, CA
  - Seattle, WA
  - Tucson, AZ
  - Washington, DC

Renderings

The following images are 3D concepts of a bike box. The configurations shown are based on Columbus, OH, Madison, WI, and Portland, OR, bike boxes.


WAIT HERE
NACTO
Intersections
Bike Box at a Signalized Intersection with a Bike Lane Approach


NACTO
Intersections
Bike Box at a Signalized Intersection with a Bike Lane Approach


NACTO
Intersections
Bike Box at a Signalized Intersection with a Bike Lane Approach

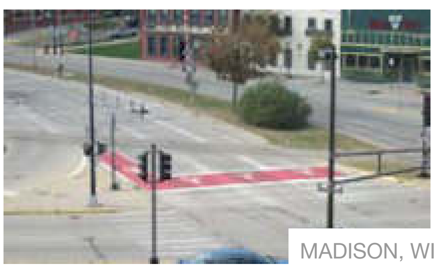

NACTO
Intersections
Bike Box at a Signalized Intersection with a Bike Lane Approach

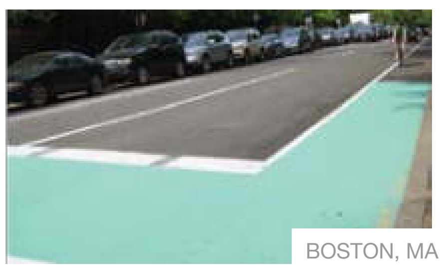
Image Gallery


SAN FRANCISCO, CA


SAN FRANCISCO, CA


VICTORIA, BC


MADISON, WI


BOSTON, MA


VANCOUVER, BC


MADISON, WI


VANCOUVER, BC


SAN FRANCISCO, CA

Image Gallery


SAN LUIS OBISPO, CA


AUSTIN, TX


AUSTIN, TX


NEW YORK, NY


PORTLAND, OR


TUCSON, AZ

Intersection Crossing Markings

Bicycle pavement markings through intersections indicate the intended path of bicyclists through an intersection or across a driveway or ramp. They guide bicyclists on a safe and direct path through the intersection, and provide a clear boundary between the paths of through bicyclists and either through or crossing motor vehicles in the adjacent lane.

This guidance covers a number of different marking strategies currently in use in the United States and Canada. Cities considering implementing markings through intersections should consider standardizing future designs to avoid confusion.

Intersection Crossing Marking Benefits

- Raises awareness for both bicyclists and motorists to potential conflict areas.

> *In areas where cyclists/motorist conflicts are not a major concern, white dashed markings are adequate since the comprehension is adequate and not adverse in nature, and minimizes undue materials and maintenance costs. For areas where conflicts may be of greater concern, the sharrow treatment is the preferred option (of the four testes) for raising awareness.*

Transportation Association of Canada. (2008). Coloured Bicycle Lanes Simulator Testing. File 785.

- Reinforces that through bicyclists have priority over turning vehicles or vehicles entering the roadway (from driveways or cross streets).

> *Significantly more motorists yielded to bicyclists after the blue pavement had been installed (92 percent in the after period versus 72 percent in the before period.*

Hunter, W.W. et al. (2000). Evaluation of Blue Bike-Lane Treatment in Portland, Oregon. Transportation Research Record, 1705, 107-115.

- Guides bicyclists through the intersection in a straight and direct path, reducing the likelihood of bicyclists veering right when entering the intersection and then back to the left at the far side.
- Reduces bicyclist stress by delineating the bicycling zone.

> *Significantly fewer bicyclists slowed or stopped when approaching the conflict areas in the after period.*

Hunter, W.W. et al. (2000). Evaluation of Blue Bike-Lane Treatment in Portland, Oregon. Transportation Research Record, 1705, 107-115.

- Makes bicycle movements more predictable.

Increases the visibility of bicyclists.

- Reduces conflicts between bicyclists and turning motorists.

> *Best estimates for safety effects of one blue cycle crossing in a junction are a reduction of 10% in accidents and 19% in injuries.*

Jensen, S. U. (2008). Safety effects of blue cycle crossings: A before-after study. Accident Analysis & Prevention, 40(2), 742-750.

- Promotes multi-modal nature of the corridor.

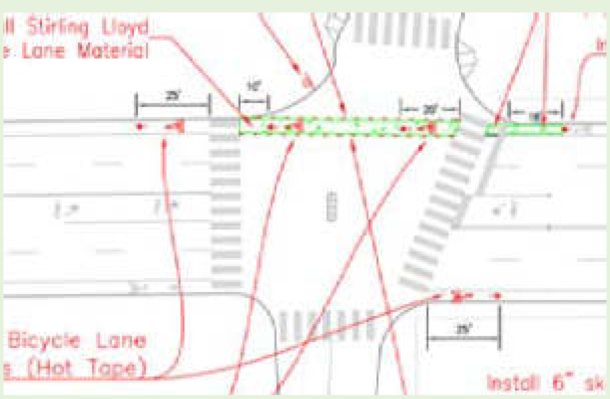
Typical Applications

- Across signalized intersections, particularly through wide or complex intersections where the bicycle path may be unclear.
- Along roadways with bike lanes or cycle tracks.
- Across driveways and Stop or Yield-controlled cross-streets.
- Where typical vehicle movements frequently encroach into bicycle space, such as across ramp-style exits and entries where the prevailing speed of ramp traffic at the conflict point is low enough that motorist yielding behavior can be expected.
- May not be applicable for crossings in which bicycles are expected to yield priority, such as when the street with the bicycle route has Stop or Yield control at an intersection.

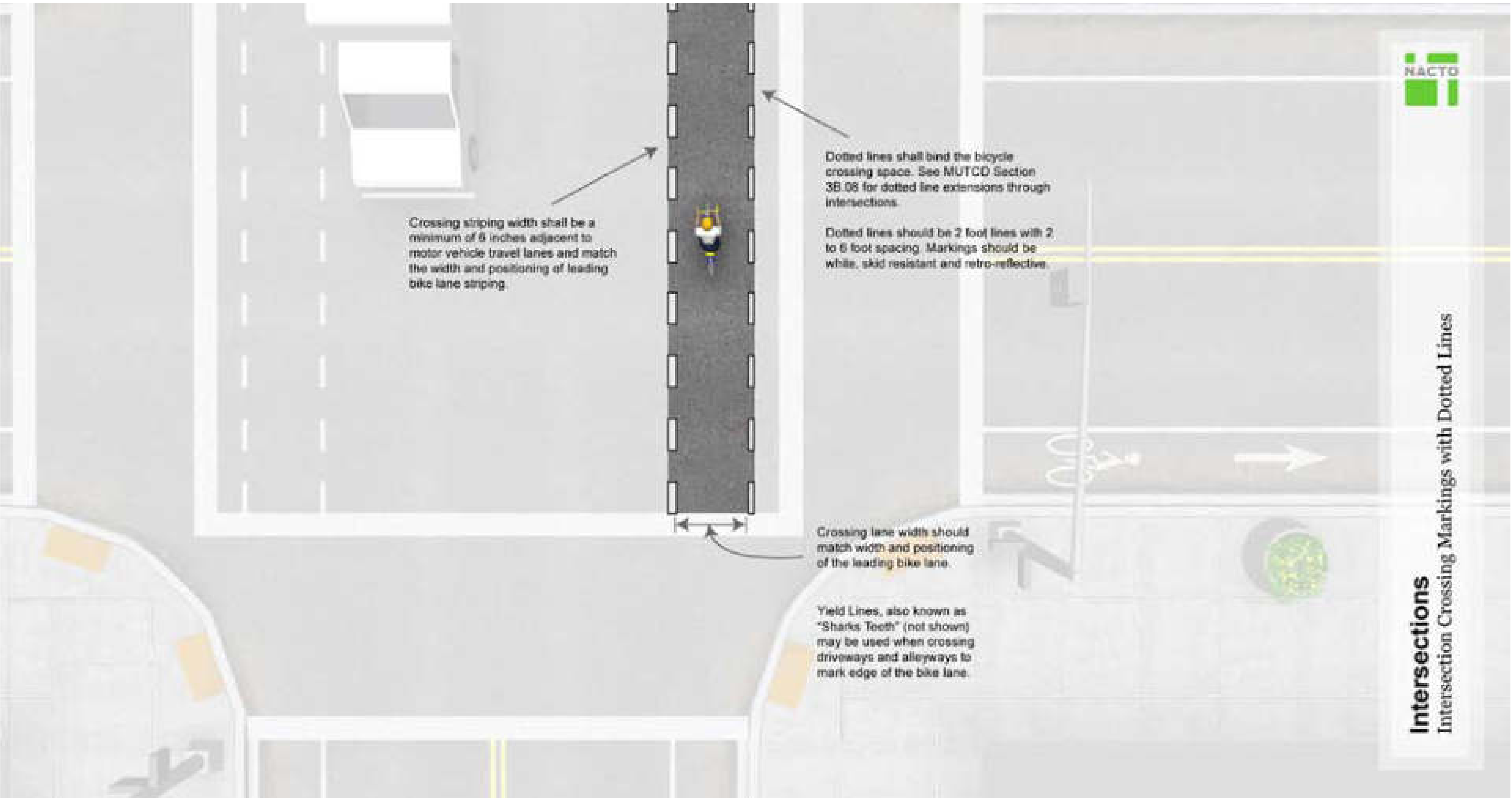
Green Bike Lane at Eastlake and Fuhrman Ave. East

Seattle, WA

Eastlake Avenue East is a busy route for bicyclists connecting Seattle's Downtown and Capitol Hill neighborhoods with the University District across the University Bridge. Several bicycle crashes occurred at this intersection over the course of four years, including one fatality involving a delivery truck making a right turn onto Fuhrman Avenue East. In order to bring more attention to the bike lane through the intersection, in August 2010, the Seattle Department of Transportation painted an existing bike lane green and added additional bike pavement legends. Signage was augmented to remind right-turning motorists to yield to bicyclists.

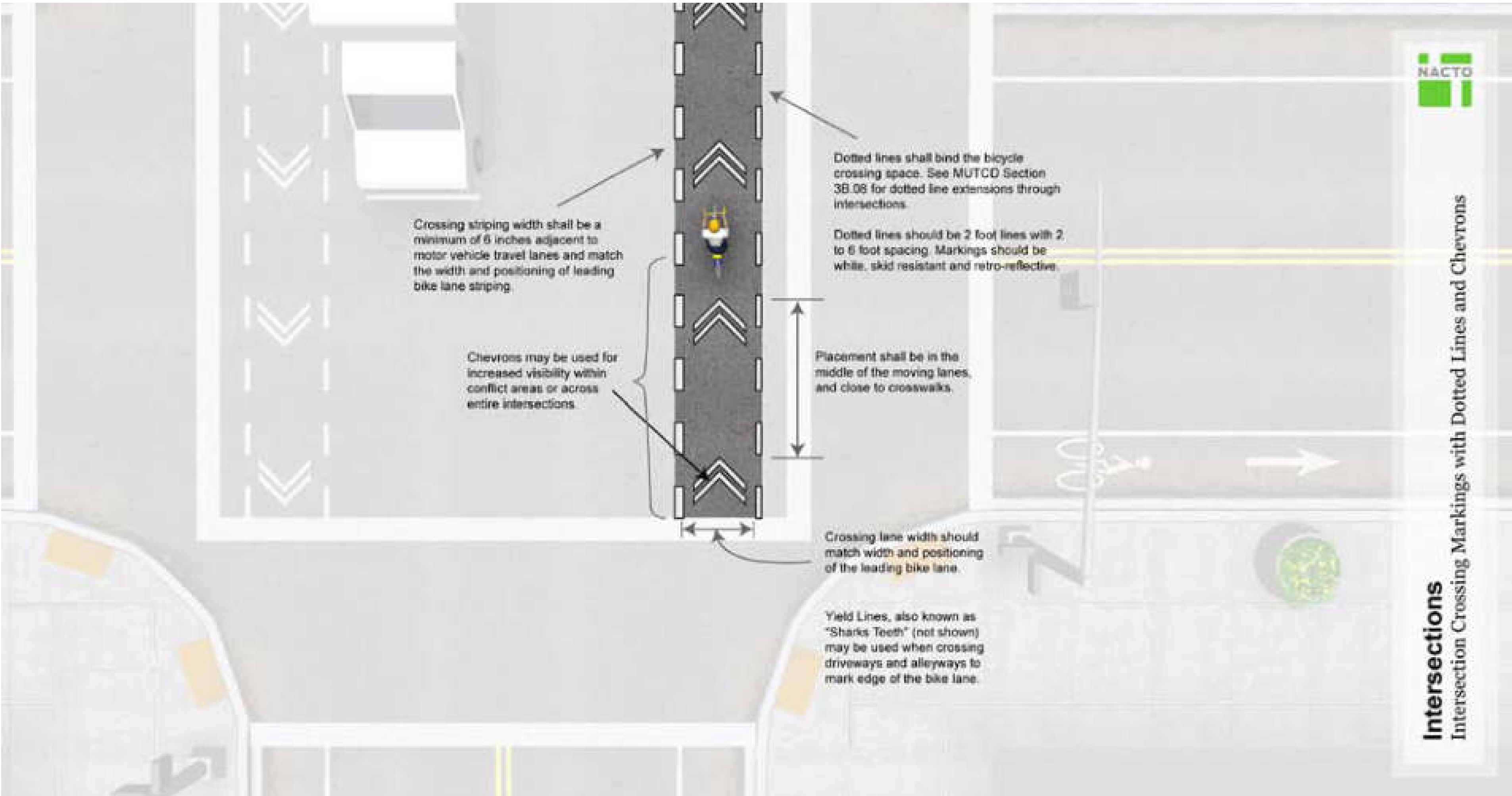


Design Guidance



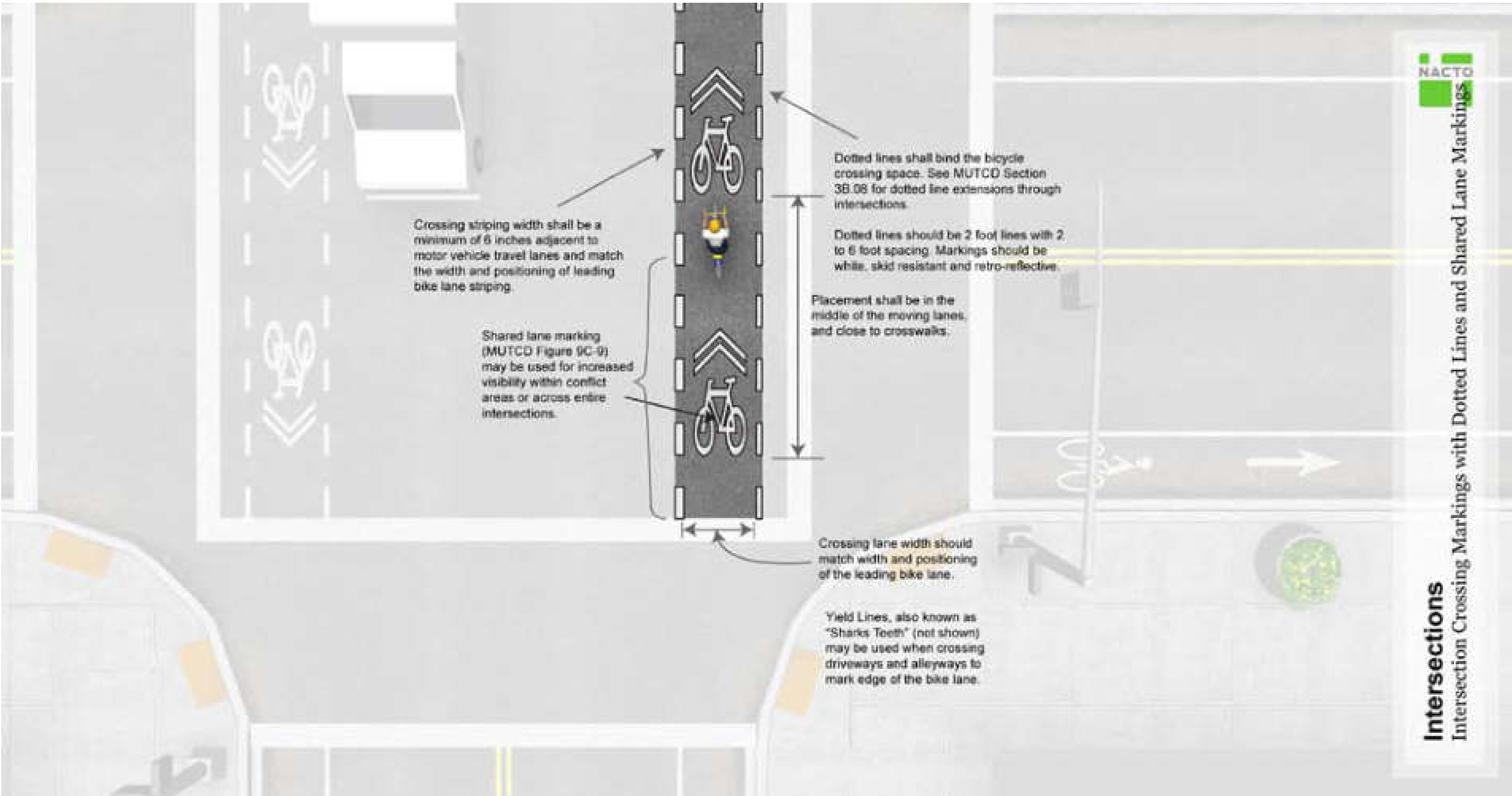
View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/IntersectionMarking_OptionA_Annotated.jpg

Design Guidance



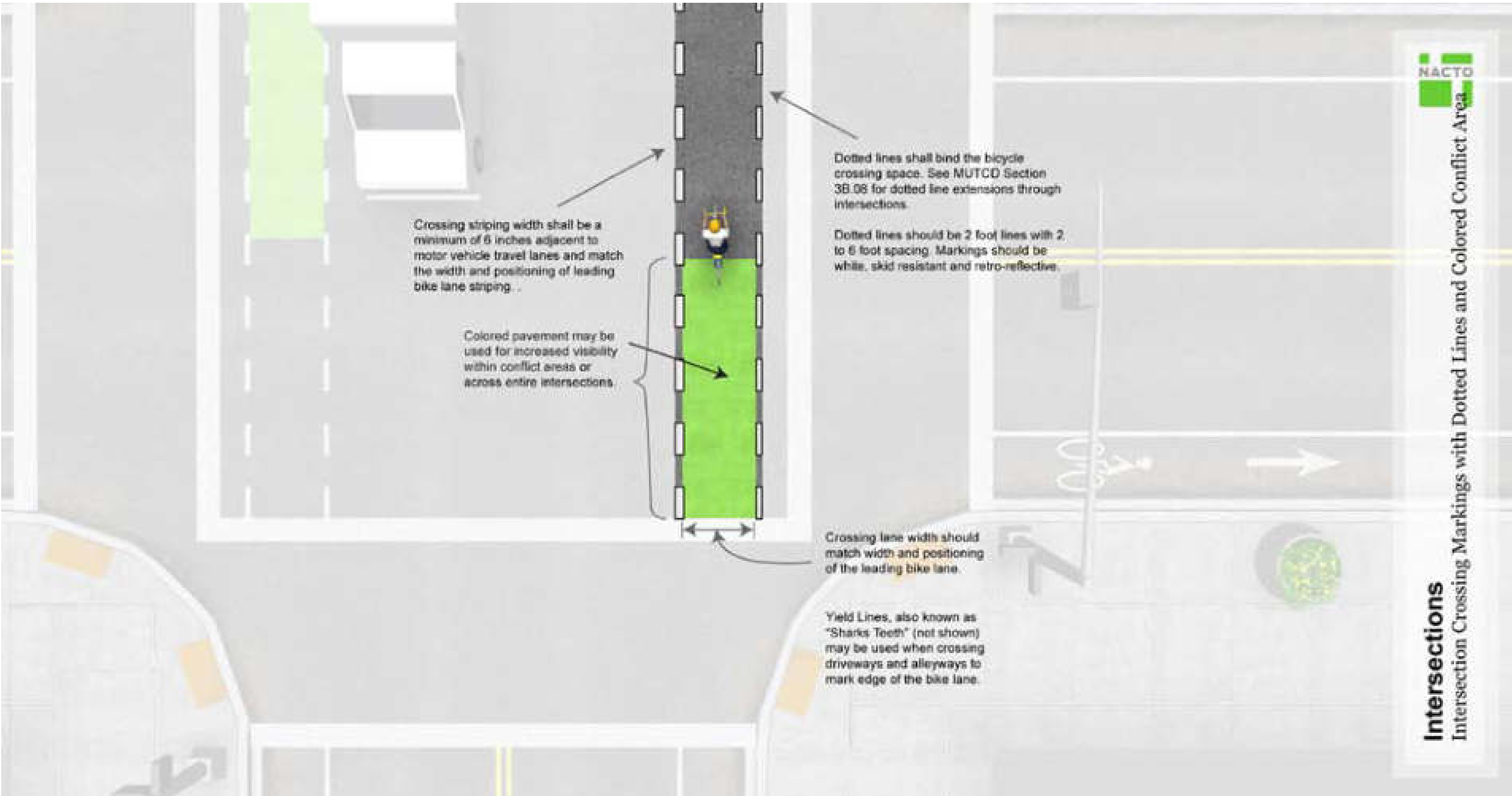
View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/IntersectionMarking_OptionB_Annotated.jpg

Design Guidance



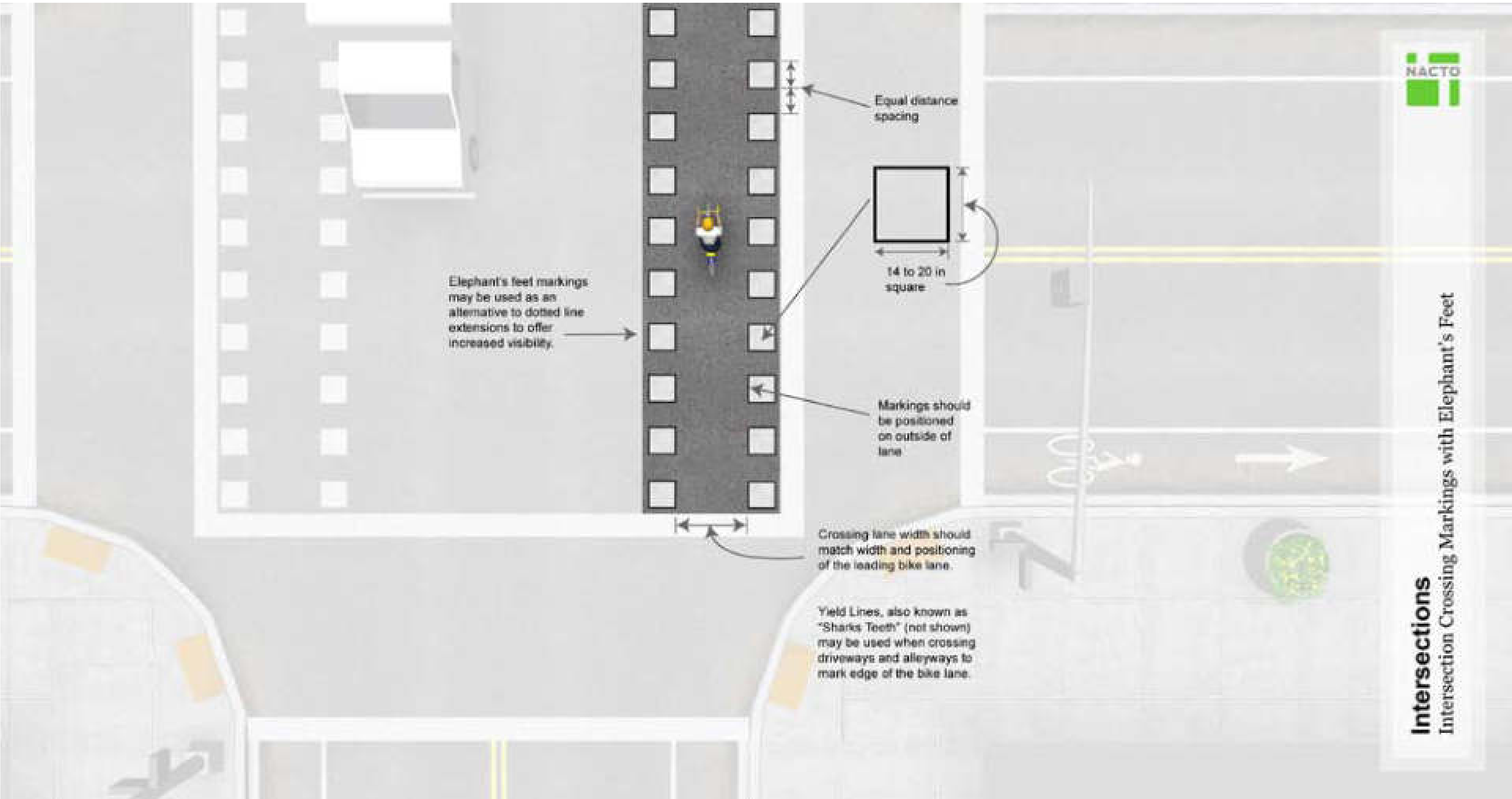
View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/IntersectionMarking_OptionC_Annotated.jpg

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/IntersectionMarking_OptionD_Annotated.jpg

Design Guidance



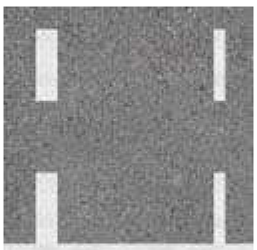
View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/IntersectionMarking_OptionE_Annotated.jpg

REQUIRED

Dotted lines shall bind the bicycle crossing space. See MUTCD Section 3B.08 for dotted line extensions through intersections.

> *Pavement markings extended into or continued through an intersection or interchange area shall be the same color and at least the same width as the line markings they extend.*

Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices. Section 3B.08.



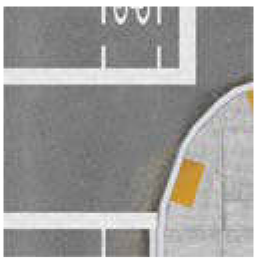
Crossing striping width shall be a minimum of 6 inches adjacent to motor vehicle travel lanes and match the width and positioning of leading bike lane striping.

> *A bike lane should be delineated from the motor vehicle travel lanes with a 150-mm (6-inch) solid white line. Some jurisdictions have used a 200-mm (8-inch) line for added distinction.*

AASHTO. (1999). Guide for the Development of Bicycle Facilities.

RECOMMENDED

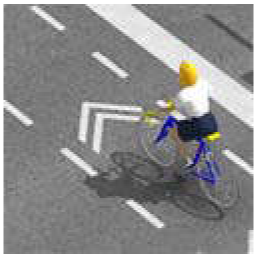
Dotted lines should be 2 foot lines with 2 to 6 foot spacing. Markings should be white, skid resistant and retro-reflective.



Crossing lane width should match width and positioning of the leading bike lane.

On crossings of two-way paths and cycle tracks, markings should indicate that there is two-way traffic either by marking the path center line through the intersection, or by marking bicycle silhouettes and / or chevrons in opposite directions in the two lanes.

OPTIONAL



Chevrons may be used for increased visibility within conflict areas or across entire intersections. Placement shall be in the middle of the moving lanes, and close to crosswalks.

Shared lane markings (MUTCD Figure 9C-9) may be used for increased visibility within conflict areas or across entire intersections. Placement shall be in the middle of the moving lanes, and close to crosswalks.

> *In areas where the practitioner deems that a bicycle lane carried through a conflict zone warrants increased visibility and/or demarcation, the following is recommended:*
>
> - *If there is a requirement for lane markings then a succession of bicycle stencils may optionally be placed between the dashed bicycle lane markings."*

Transportation Association of Canada. (2008). Coloured Bicycle Lanes Simulator Testing. File 785.

Colored pavement may be used for increased visibility within conflict areas or across entire intersections.

> *Significantly more motorists yielded to bicyclists after the blue pavement had been installed (92 percent in the after period versus 72 percent in the before period).*

Hunter, W.W. et al. (2000). Evaluation of Blue Bike-Lane Treatment in Portland, Oregon. Transportation Research Record, 1705, 107-115.

> *Best estimates for safety effects of one blue cycle crossing in a junction are a reduction of 10% in accidents and 19% in injuries.*

Jensen, S. U. (2008). Safety effects of blue cycle crossings: A before-after study. Accident Analysis & Prevention, 40(2), 742-750.

OPTIONAL (CONTINUED)

Elephant's feet markings may be used as an alternative to dotted line extensions to offer increased visibility. If used, the markings should be 14 to 20 inches square, with equal distance spacing between markings. Markings should be positioned on outside of lane.

> *Elephant's Feet Bicycle Crossing Markings are defined as 200-400 mm wide squares with equal distance spacing.*
>
> Transportation Association of Canada. (2008). Coloured Bicycle Lanes Simulator Testing. File 785.

Yield Lines, also known as "Sharks Teeth" may be used when crossing driveways and alleyways to mark the edge of the bike lane.

> *Yield lines (see Figure 3B-16) shall consist of a row of solid white isosceles triangles pointing toward approaching vehicles extending across approach lanes to indicate the point at which the yield is intended or required to be made.*
>
> Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices. Section 3B.16.

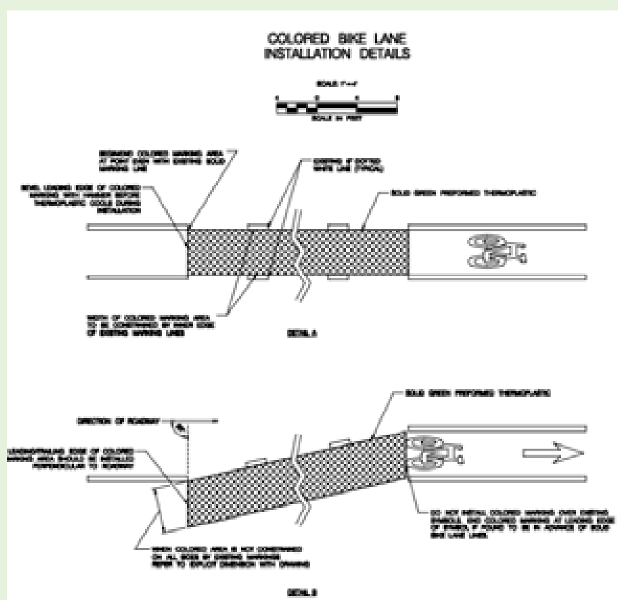
Green Colored Intersections at Nine Conflict Areas

Chicago, IL

In the Fall of 2007, nine problematic intersections throughout the city of Chicago were painted with a green preformed thermoplastic marking to test the effectiveness of the color in alleviating conflict between cyclists and motorists turning right at intersections. In most cases, color was applied between the thru lane and the weaving area, where cyclists most often experience obstruction and discomfort. Video of each intersection has been recorded, though it has yet to be heavily analyzed. Maintenance issues with the material have occurred, such as flaking of the markings following the winter months, though this may be attributed to poor installation.

This project was designed and implemented by the Chicago Department of Transportation in Fall 2007 at nine locations throughout Chicago, IL.

- Lincoln Ave. at Webster Ave. (Southbound)
- Elston Ave. at Division Ave. (Northbound & Southbound)
- Milwaukee Ave. at Augusta Ave. (Southbound)
- Dearborn Ave. at Chicago Ave. (Northbound)
- Warren Ave. at Ogden Ave. (Eastbound)
- Halsted Ave. at Roosevelt Ave. (Southbound)
- Roosevelt Ave. at Damen Ave. (Eastbound and Westbound)



Maintenance

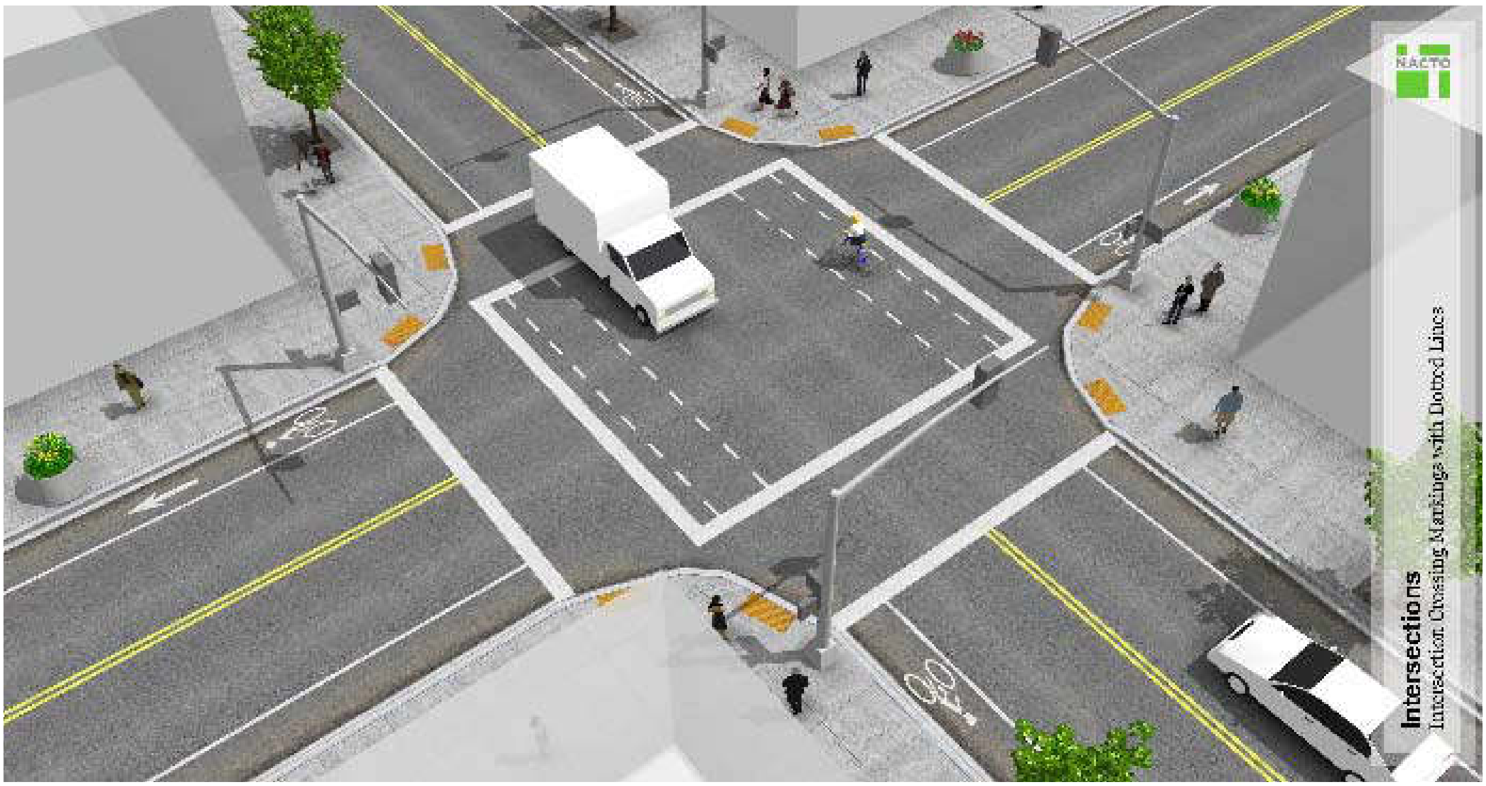
- Routine roadway/utility maintenance.
- Because the effectiveness of marked crossings depends entirely on their visibility, maintaining marked crossings should be a high priority.

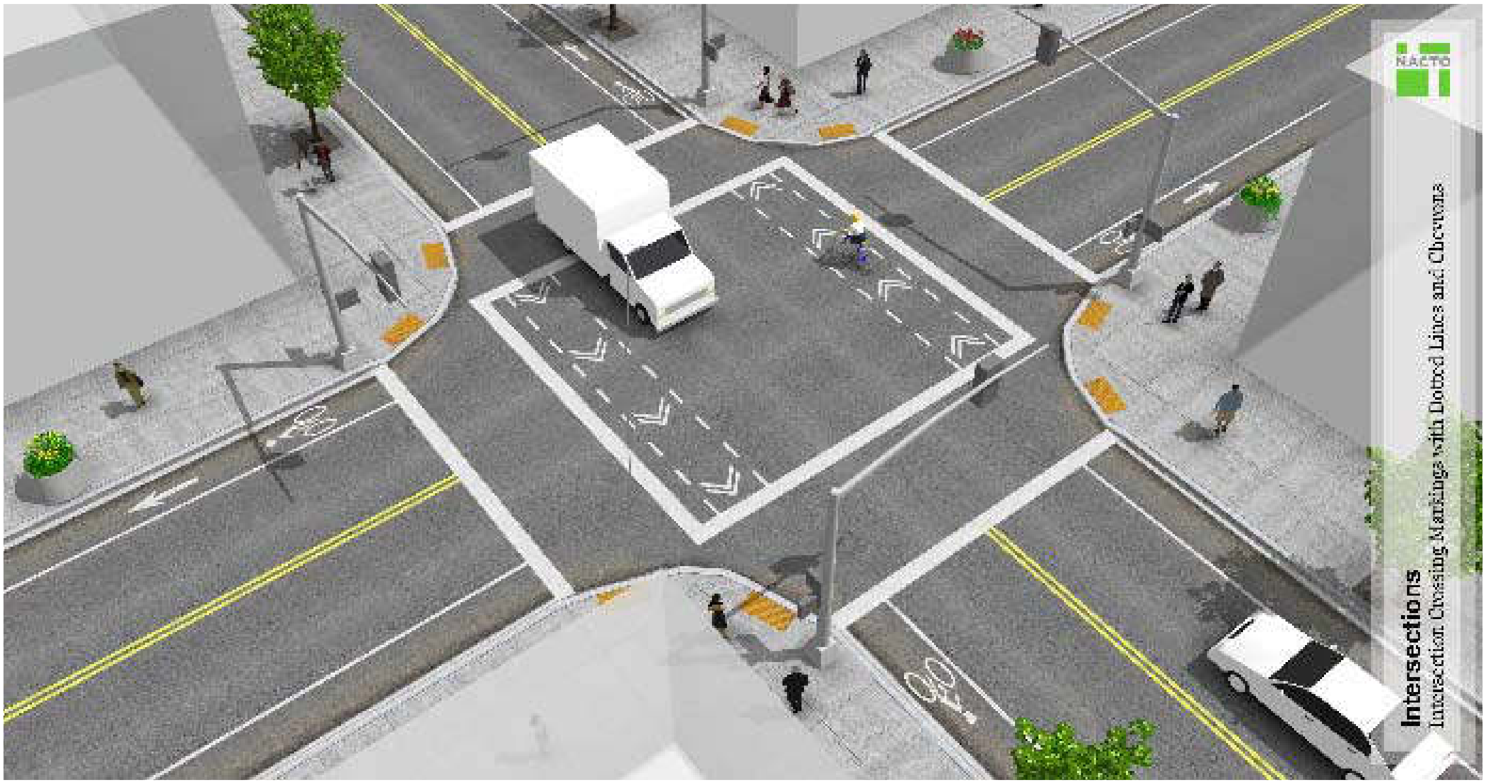
Treatment Adoption and Professional Consensus

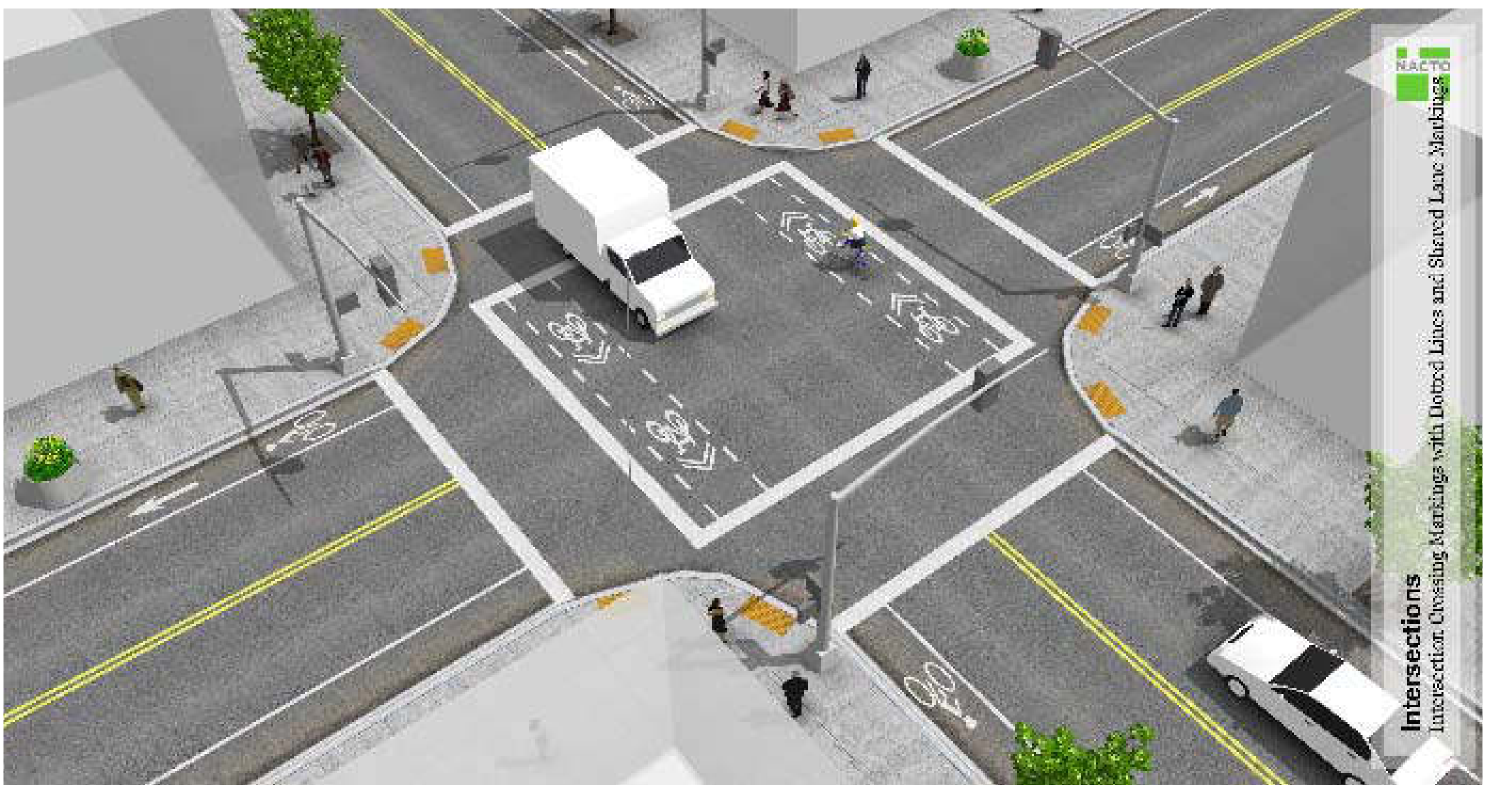
- Commonly used in dozens of European bicycle friendly cities.
- Seen in the form of dotted line extensions in most US bicycle-friendly cities. Innovative application of color and/or other intersection markings are at use in the following US cities:
- New York, NY
- Portland, OR
- San Francisco, CA
- Washington, DC

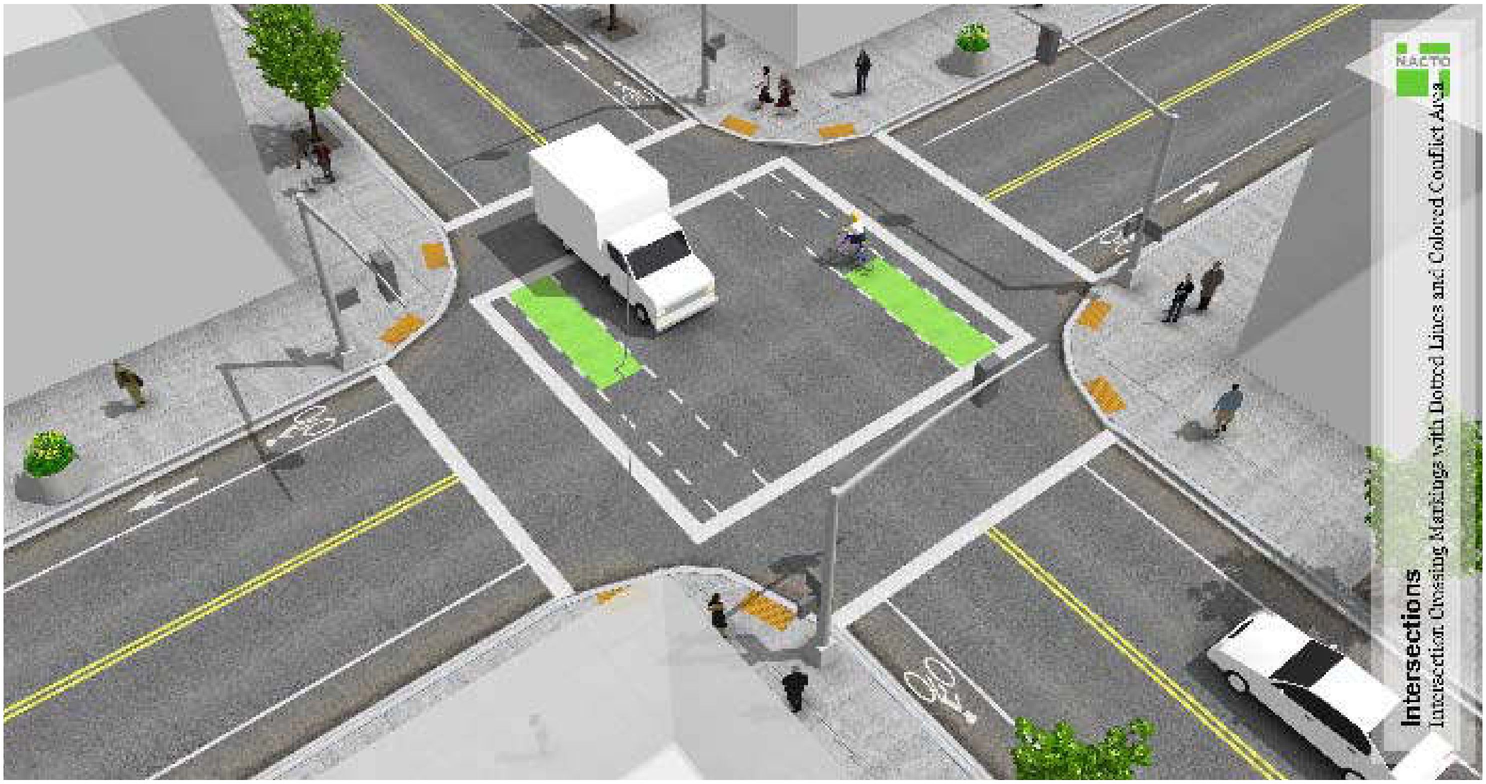
Renderings

The following images are 3D concepts of intersection crossing markings. The configurations shown are based on Portland, OR, and New York City examples.




NACTO
Intersections
Intersection Crossing Markings with Dotted Lines and Chevrons

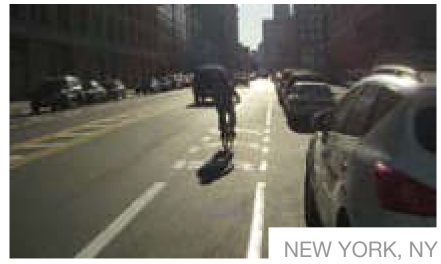

NACTO
Intersections
Intersection Crossing Markings with Dotted Lines and Shared Lane Markings


NACTO
Intersections
Intersection Crossing Markings with Dotted Lines and Colored Conflict Area


NACTO
Intersections
Intersection Crossing Markings with Elephant's Feet

Image Gallery


NEW YORK, NY


NEW YORK, NY


CHICAGO, IL


MISSOULA, MT


NEW YORK, NY


NEW YORK, NY

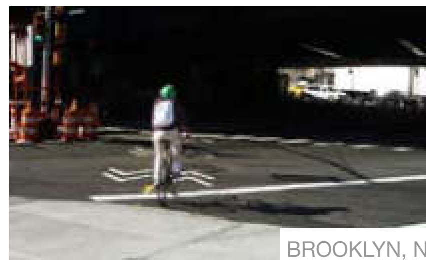

MISSOULA, MT


PORTLAND, OR

Image Gallery


BROOKLYN, NY


SEATTLE, WA


BROOKLYN, NY


SEATTLE, WA


NEW YORK, NY

Two-Stage Turn Queue Boxes

Two-stage turn queue boxes offer bicyclists a safe way make left turns at multi-lane signalized intersections from a right side cycle track or bike lane, or right turns from a left side cycle track or bike lane.

The typical international best practice is a two-stage turn (also referred to as a hook turn, box turn, or Copenhagen left). Two positions are available for queuing boxes, depending on intersection configuration.

On right side cycle tracks, bicyclists are often unable to merge into traffic to turn left due to physical separation, making the provision of two-stage left turns critical in making these facilities functional. The same principles for two-stage turns apply to both bike lanes and cycle tracks.

While two stage turns may increase bicyclist comfort in many locations, this configuration will typically result in higher average signal delay for bicyclists, due to the need to receive two separate green signal indications (one for the through street, followed by one for the cross street) before proceeding.

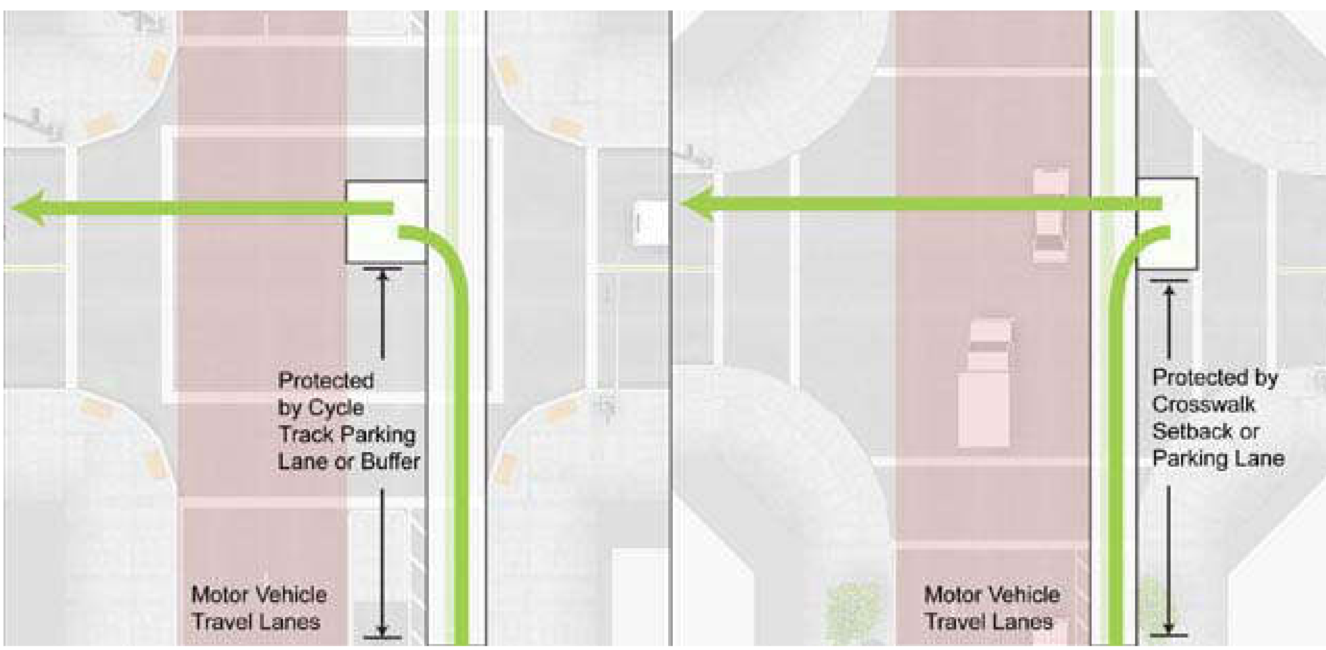
Two-stage Turn Queue Box Benefits

- Improves bicyclist ability to safely and comfortably make left turns.
- Provides a formal queuing space for bicyclists making a two-stage turn.
- Reduces turning conflicts between bicyclists and motor vehicles.
- Prevents conflicts arising from bicyclists queuing in a bike lane or crosswalk.

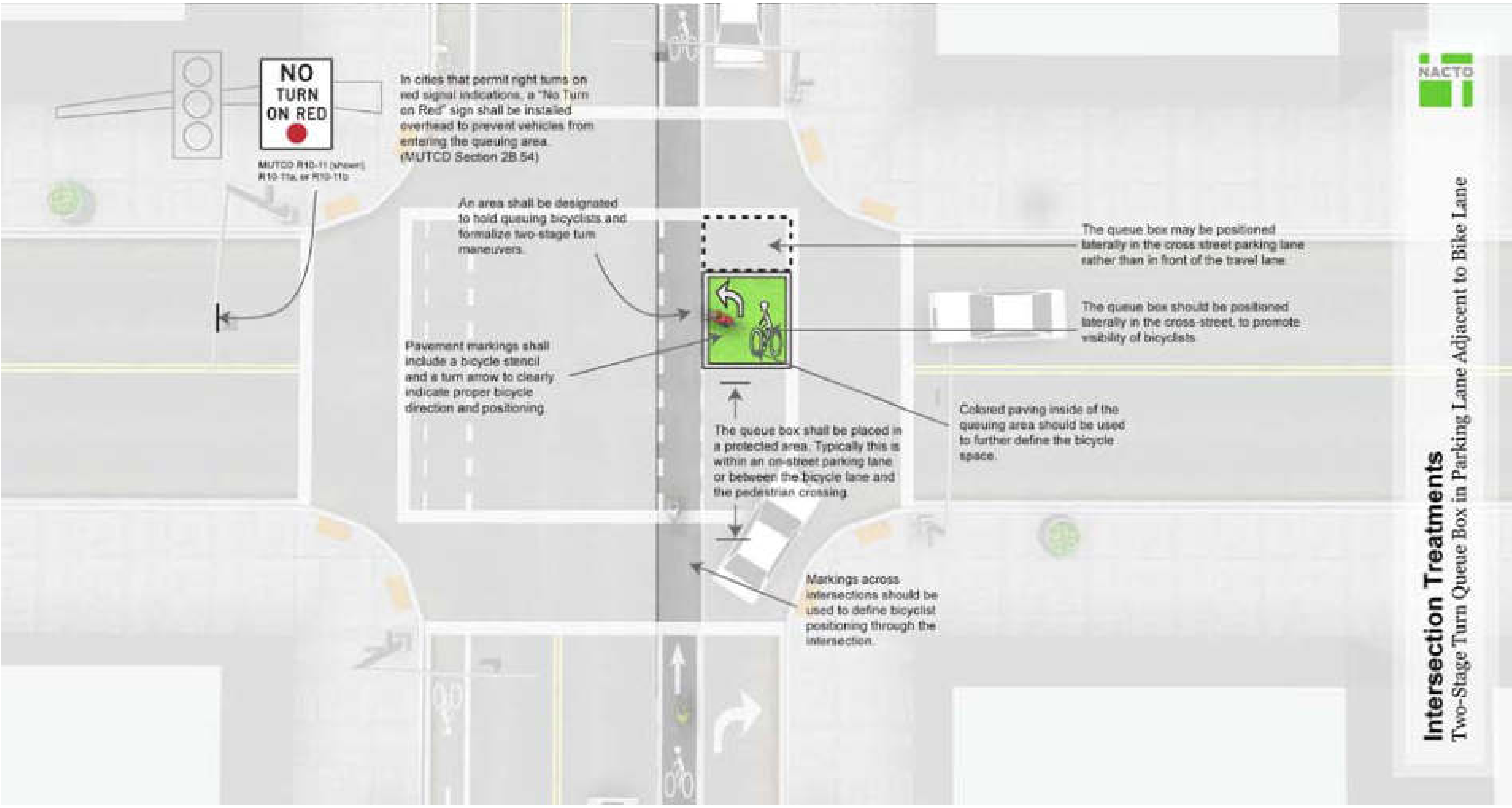
Typical Applications

- At signalized intersections.
- Along multi-lane roadways.
- Along roadways with high traffic speeds and/or traffic volumes.
- Where a significant number of bicyclists turn left from a right side facility.
- Along cycle track facilities.
- To assist bicyclists in navigating safely across streetcar tracks.

> *Other innovative bicycle treatments are starting to gain popularity that also encourage a safer crossing angle at tracks, including the two-stage turn for bicyclists.*
>
> Boorse, J., Hill, M., Danaher, A. (2011). General Design and Engineering Principles of Streetcar Transit. ITE Journal, 81(1), 38.

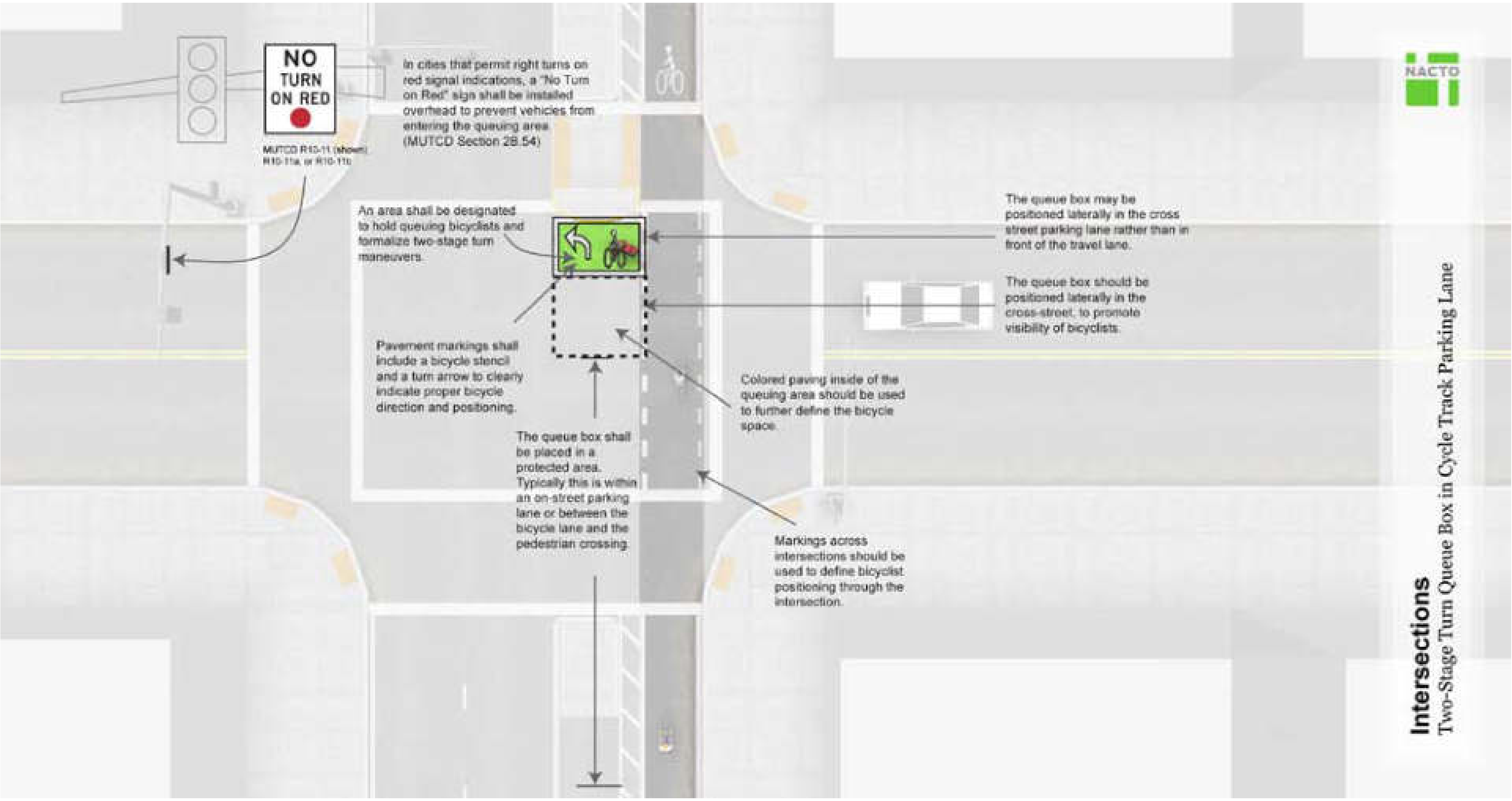


Design Guidance



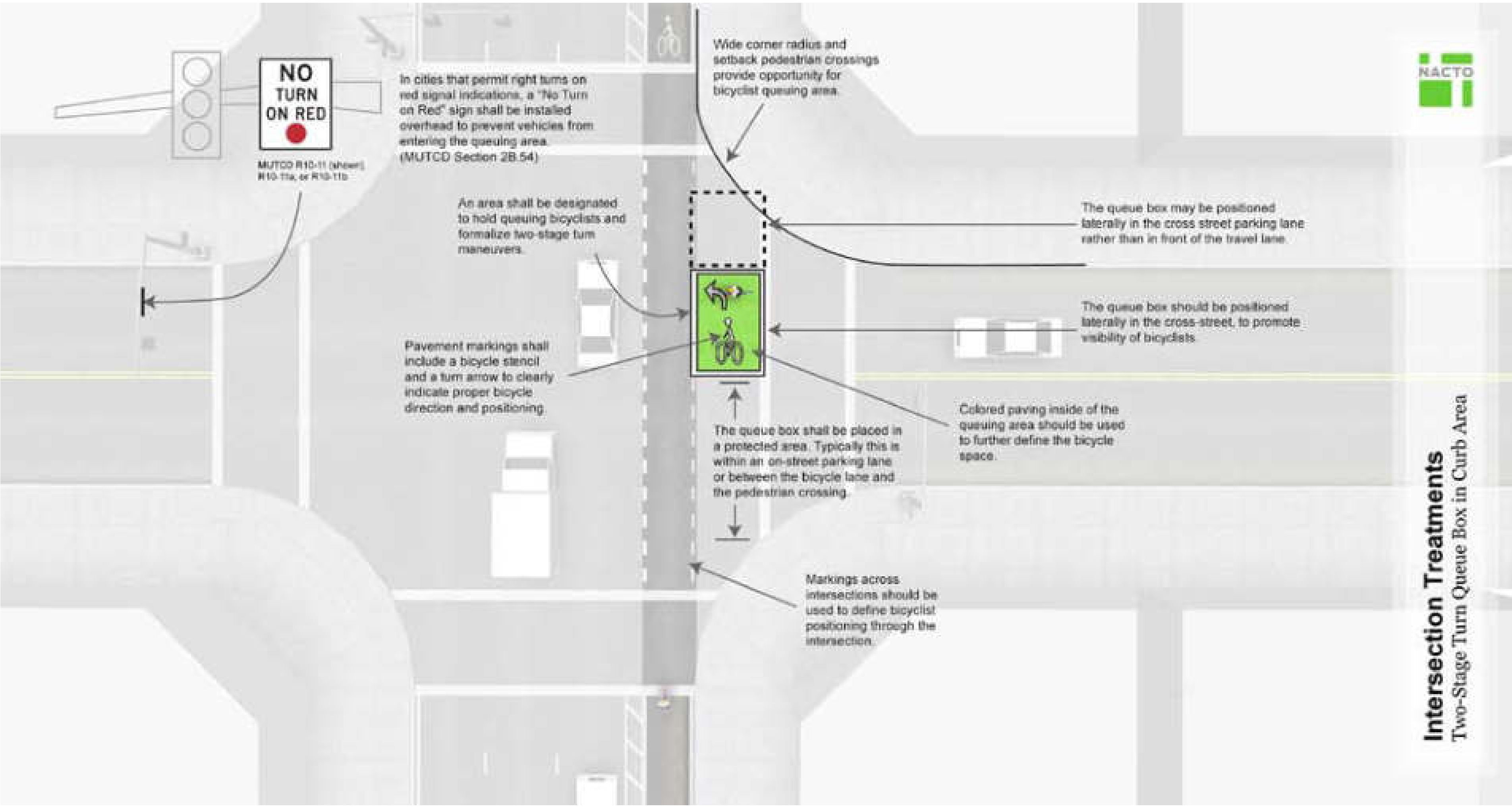
View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/TwoStageTurn_CycleTrackParking_Reference_Annotated.jpg

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/TwoStageTurn_Front_Reference_Annotated.jpg

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/TwoStageTurn_BikeLaneParking_Reference_Annotated.jpg

REQUIRED

An area shall be designated to hold queuing bicyclists and formalize two-stage turn maneuvers.

Bicycle Hook Turn Storage Areas should be up to 3.0 metres long and at least 1.0 metre wide.

RTA. (2009). Bicycle Storage Areas and Advanced Bicycle Stop Lines. Technical Direction.

Stacking facility for bicyclists turning left at traffic control system: "depending on intensity, width of stacking area > 1.2 m.

CROW. (2006). Record 25: Design Manual for Bicycle Traffic. CROW, The Netherlands.

Pavement markings shall include a bicycle stencil and a turn arrow to clearly indicate proper bicycle direction and positioning.

The queue box shall be placed in a protected area. Typically this is within an on-street parking lane or between the bicycle lane and the pedestrian crossing. A queue box placed behind the pedestrian crossing would also function as a bike box but should only be considered if pedestrian volumes are low.

In cities that permit right turns on red signal indications, a "No Turn on Red" sign shall be installed overhead to prevent vehicles from entering the queuing area. (MUTCD Section 2B.54)

MUTCD R10-11 (shown), R10-11a, or R10-11b

RECOMMENDED

The queue box should be positioned laterally in the cross-street, to promote visibility of bicyclists.

Colored paving inside of the queuing area should be used to further define the bicycle space.

Markings across intersections should be used to define bicyclist positioning through the intersection.

OPTIONAL

The queue box may be positioned laterally in the cross street parking lane rather than in front of the travel lane. This may require bicyclists to weave into the travel lane to resume through movement if no dedicated bicycle facility is present since the parking lane ahead will be occupied.

Signage may be used to define proper positioning and improve visibility of the queue box.

A bicycle signal, with leading bicycle interval, may be installed in conjunction with the two-stage turn queue box.

> *Bicycle traffic signals are used to reduce turning conflicts at signalized intersections and often provide separate and sometimes exclusive phases for bicyclists.*
>
> Federal Highway Administration. (2010). International technology Scanning Program, Pedestrian and Bicycle Mobility and Safety in Europe. FHWA-PL-10-010.

Guide lines, pavement symbols, and/or colored pavement may be used to lead bicyclists into the queue box. Guide lines, pavement symbols, and/or colored pavement may be used to lead bicyclists into the queue box.

Maintenance

- Colored pavement, if used, may be difficult to maintain in climates prone to snow and ice.

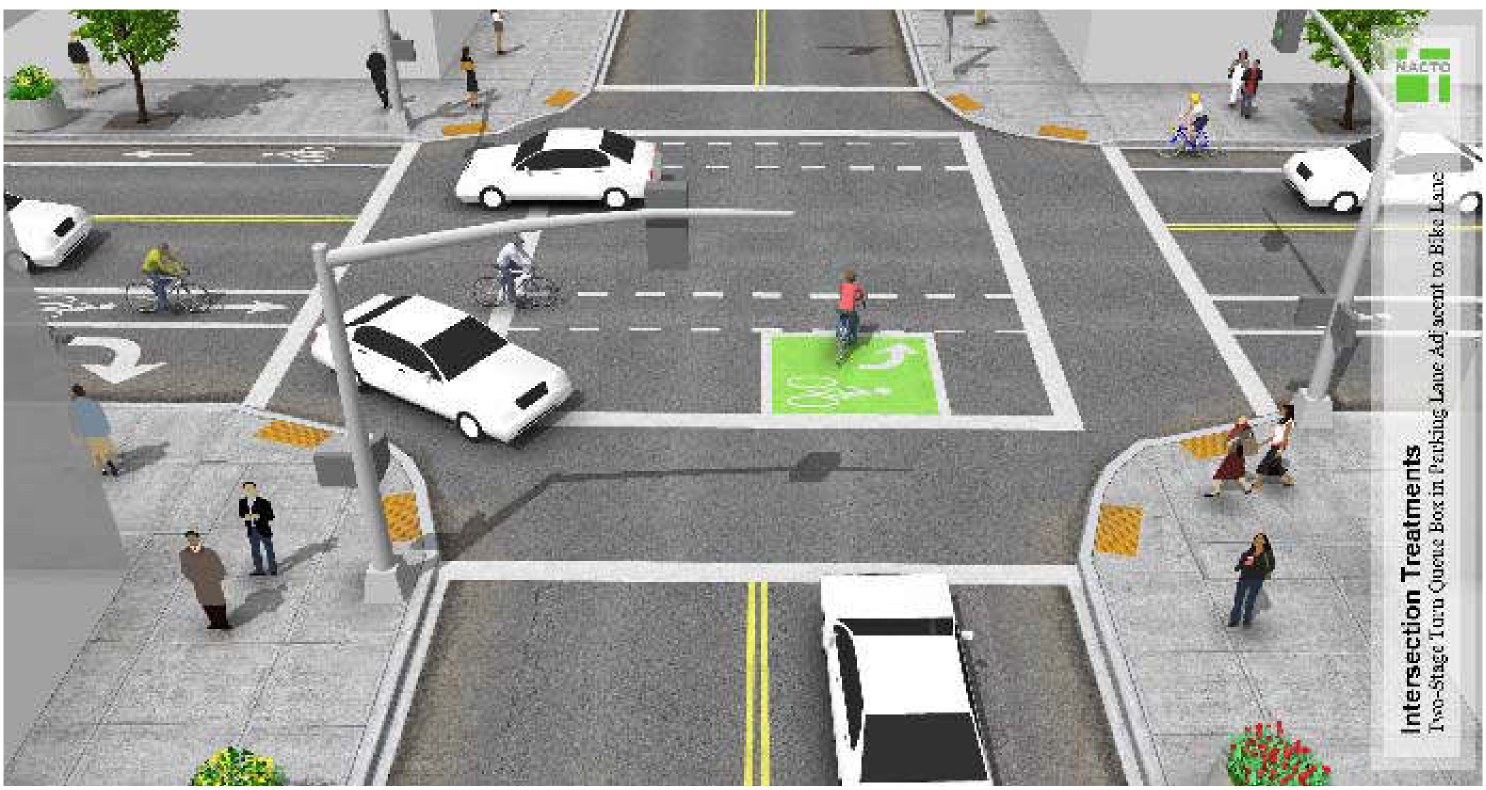
Treatment Adoption and Professional Consensus

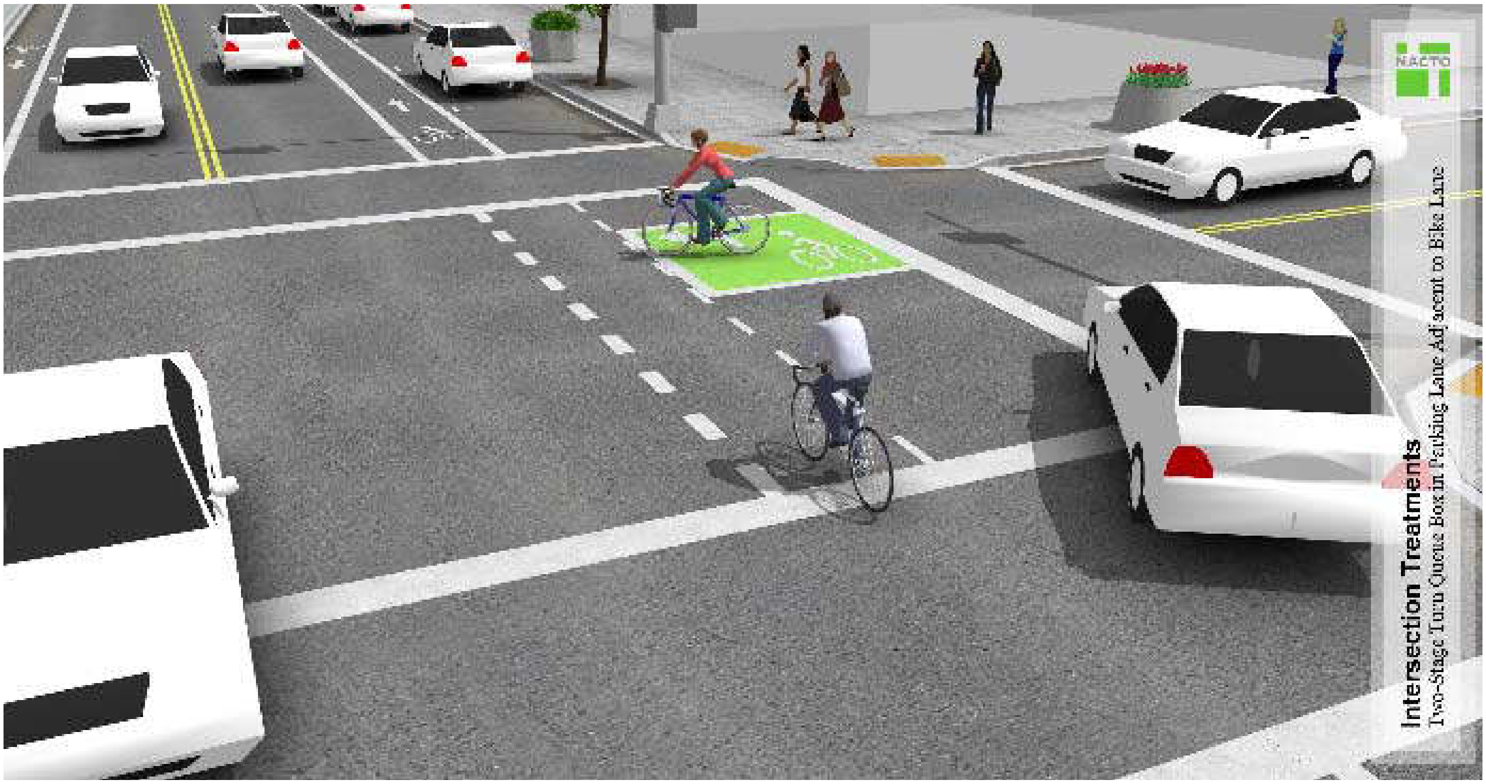
- Commonly used in dozens of European bicycle friendly cities.
- Currently used in the following US cities:
  - Portland, OR
  - New York, NY

Renderings

The following images are 3D concepts of two-stage turn markings. The configurations shown are based on Portland, OR, and Australian examples.


NACTO
Intersections
Two-Stage Turn Queue Box in Cycle Track Parking Lane


NACTO
Intersection Treatments
Two-Stage Turn Queue Box in Parking Lane Adjacent to Bike Lane


NACTO
Intersection Treatments
Two-Stage Turn Queue Box in Parking Lane Adjacent to Bike Lane


NACTO
Intersection Treatments
Two-Stage Turn Queue Box in Curb Area

Image Gallery


PORTLAND, OR


NEW YORK, NY


PORTLAND, OR

NEW YORK, NY


PORTLAND, OR

Median Refuge Island

Median refuge islands are protected spaces placed in the center of the street to facilitate bicycle and pedestrian crossings. On two-way streets, crossings are facilitated by splitting movements into two stages separated by the direction of approaching vehicle traffic. On streets with protected cycle tracks, medians can be provided at intersections to facilitate bicycle crossings that also function as two-stage turn queuing areas.

For bicycle facility crossings of higher volume or multi-lane streets, increased levels of treatment may be desired including bicycle signals, hybrid signals, or active warning beacons.

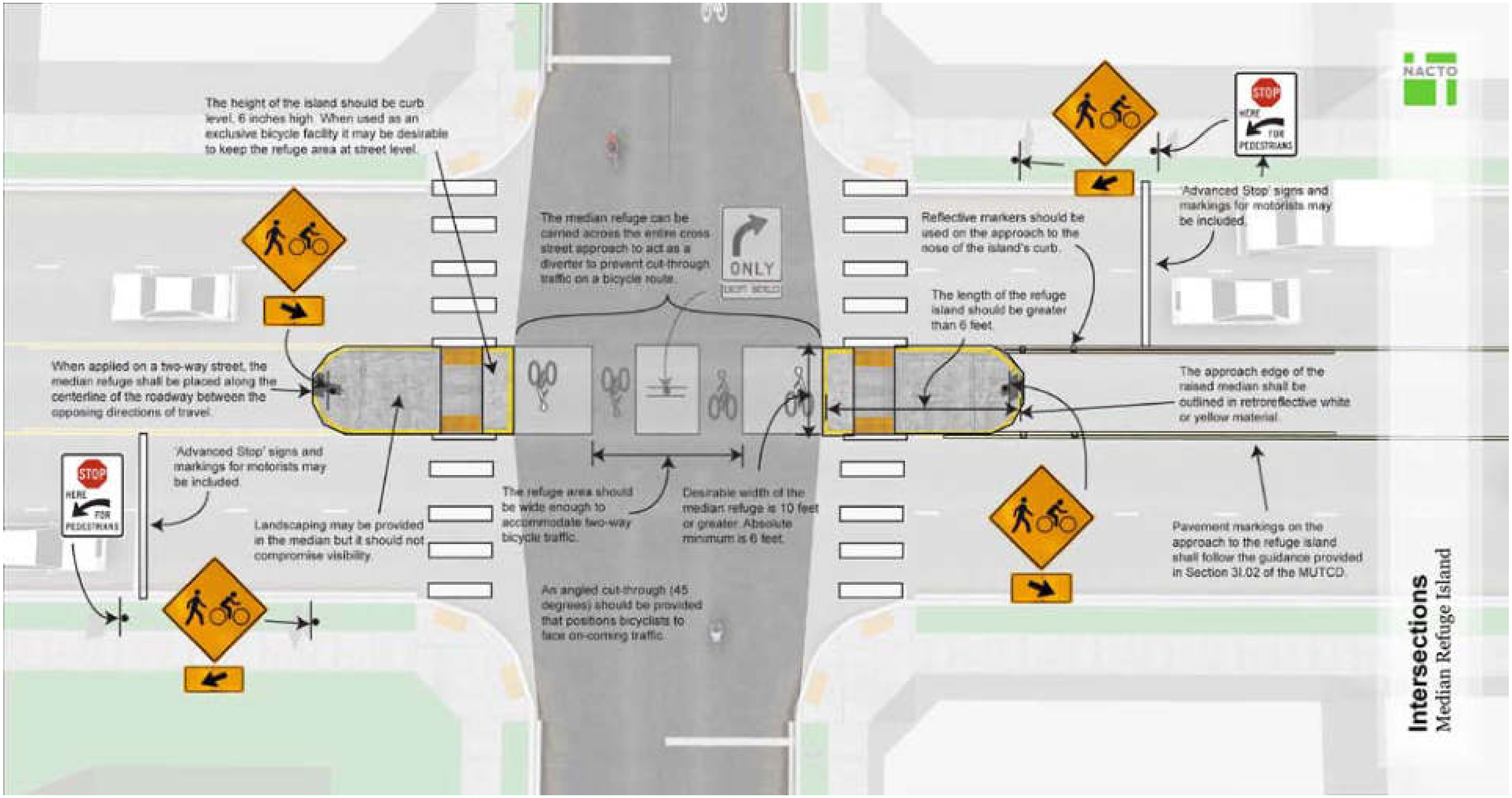
Median Refuge Island Benefits

- Allows bicyclists to more comfortably cross streets.
- Provides a protected space for bicyclists to wait for an acceptable gap in traffic.
- On two-way streets allows bicyclists to take advantage of gaps in one direction of traffic at a time.
- Reduces the overall crossing length and exposure to vehicle traffic for a bicyclist or pedestrian.
- Decreases the amount of delay that a bicyclist will experience to cross a street.
- Calms traffic on a street by physically narrowing the roadway and potentially restricts motor vehicle left turn movements.
- Establishes and reinforces bicycle priority on bicycle boulevards by restricting vehicle through movements.
- When used with a protected cycle track, raised medians can be installed at each side of the block to give structure to the floating parking lane.
- When used with a protected cycle track, raised medians can provide pedestrians with a place to pause before crossing a protected cycle track.
- When used with a protected cycle track, raised medians that extend into the intersection can also provide a shelter for a bicyclist making a two-stage turn across traffic.

Typical Applications

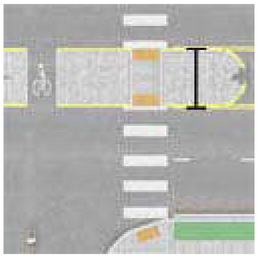
- Where a bikeway crosses a moderate to high volume or high speed street.
- Along streets with high bicycle and pedestrian volumes.
- Along streets with few acceptable gaps to cross both directions of traffic.
- At signalized or unsignalized intersections.
- Where it is desirable to restrict vehicle through movements, a median can double as a diverter to prevent cut-through traffic on a bicycle route.
- With protected cycle tracks.

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/MedianRefugeIsland_Diverter_Annotated.jpg

REQUIRED

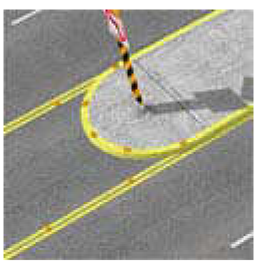


The desirable width of the median refuge is 10 feet or greater. The absolute minimum width is 6 feet.

> *Width of refuge:*
> - *2.0 m (6 ft) = poor*
> - *2.5 m (8 ft) = satisfactory*
> - *3.0 m (10 ft) = good*

AASHTO. (1999). Guide for the Development of Bicycle Facilities. p.51-52.

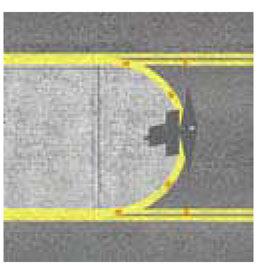
When applied on a two-way street, the median refuge shall be placed along the centerline of the roadway between the opposing directions of travel.



Pavement markings on the approach to the refuge island shall follow the guidance provided in Section 3I.02 of the MUTCD.

> *The ends of the islands first approached by traffic should be preceded by diverging longitudinal pavement markings on the roadway surface, to guide vehicles into desired paths of travel along the islands edge.*

Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices.



The approach edge of the raised median shall be outlined in retroreflective white or yellow material.

> *Retroreflective solid yellow markings should be placed on the approach ends of raised medians and curbs of islands that are located in the line of traffic flow where the curb serves to channel traffic to the right of the obstruction.*

> *Retroreflective solid white markings should be used when traffic is permitted to pass on either side of the island.*

Federal Highway Administration. (2009). Manual on Uniform Trafic Control Devices. Section 3B.23.

REQUIRED (CONTINUED)

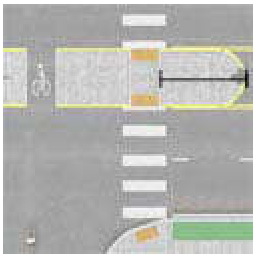
In areas with snow accumulation, reflective delineators shall be used to mark the island for increased visibility to snow plow crews.

Median Refuge Island at the crossing of Martin Luther King, Jr. Blvd. and Going Street Bicycle Blvd.

Portland, OR

At the intersection of the Going Street Bicycle Boulevard and Martin Luther King, Jr. Boulevard, the Portland Bureau of Transportation (PBOT) constructed a median refuge island to shorten the crossing distance for bicyclists. MLK Boulevard is a 58' four-lane arterial road and former state highway with a peak hour PM vpd of 2400. It is a major North-South traffic street built up with commercial storefronts. Immediately north of the intersection runs a pre-existing tree-lined median. The median refuge island constructed in 2010 effectively extends that median, blocking turning traffic and creating a cut through for cyclists using the Going Street Bicycle Boulevard. Because of the high level of motor vehicle traffic at the intersection, this reconfiguration boasts a significant amount of signage to warn motorists of crossing bicyclists and creates a barrier to east-west traffic and turning vehicles. The intersection includes an advanced stop bar, ladder-bar crossings for pedestrians, and a combined bicycle and pedestrian sign to alert motorists at the crossing. Users report that motorists yield to bicyclists at the same rate as pedestrians. Follow-up counts have measured PM peak cyclist counts of up to 83 cyclists per hour at the crossing.

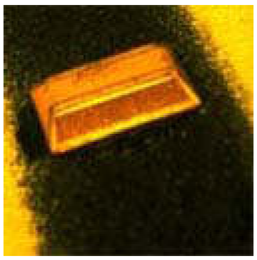
RECOMMENDED



The length of the refuge island should be greater than 6 feet.

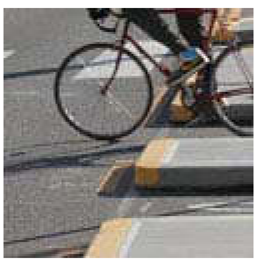
“ *Length of island should be 2 m (6 ft) or greater.*

AASHTO. (1999). Guide for the Development of Bicycle Facilities. p.51-52.



Reflective markers should be used on the approach to the nose of the island’s curb.

AASHTO. (2004). Geometric Design Guide of Highways and Streets.



The height of the island should be curb level, 6 inches high. When used as an exclusive bicycle facility it may be desirable to keep the refuge area at street level.

AASHTO. (2004). Geometric Design Guide of Highways and Streets.

An angled cut-through (45 degrees) should be provided to position bicyclists to face oncoming traffic.

If the cut-through is to be shared with pedestrians, the 45-degree angle of the curb should transition back to being perpendicular to the street to provide proper directional cues for the blind.

The refuge area should be wide enough to accommodate two-way bicycle traffic.

OPTIONAL

"Advanced Stop" signs and markings for motorists may be included.

Federal Highway Administration. (2009). Manual on Uniform Trafic Control Devices. Sections 3B.16, 2B.11, and 2B.12.

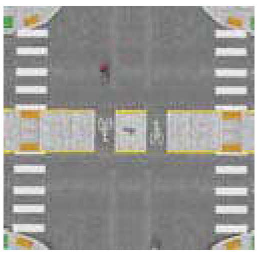
Landscaping may be provided in the median, but it should not compromise visibility.

> *Landscaping should not exceed 3 ft.*

City of Minneapolis. (2010). Bicycle Facility Manual. p.227.

Lighting may be installed for improving visibility of the facility at night.

At signalized intersections, push buttons or other detection methods may be provided to actuate the signal head.



The median refuge can be carried across the entire cross street approach to act as a diverter to prevent cut-through traffic on a bicycle route.

Maintenance

- Refuge islands may collect road debris and may require somewhat frequent maintenance.
- Refuge islands should be visible to snow plow crews and should be kept free of snow berms that block access.

Treatment Adoption and Professional Consensus

- Commonly used in dozens of European bicycle friendly cities.
- Currently used in the following US cities:
  - Austin, TX
  - Los Angeles, CA
  - Minneapolis, MN
  - Portland, OR
  - San Francisco, CA

Renderings

The following images are 3D concepts of median refuge islands. The configurations shown are based on San Luis Obispo, CA, Portland, OR, and New York, NY, examples.

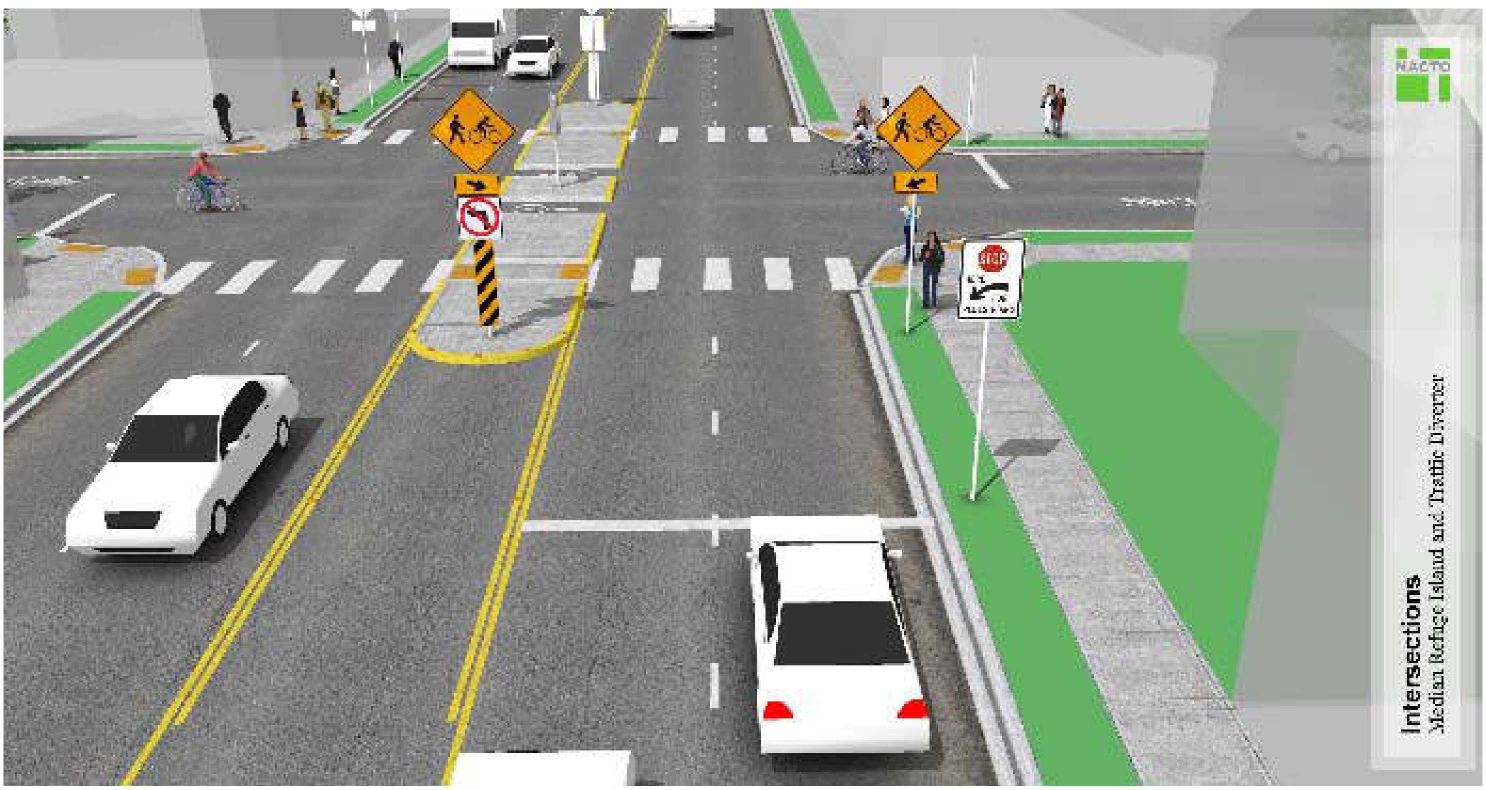

NACTO
Intersections
Median Refuge Island in Cycle Track Parking Buffer


NACTO
Intersections
Median Refuge Island


Intersections
Median Refuge Island in Cycle Track Parking Buffer


Intersections
Median Refuge Island and Traffic Diverter


Intersections
Median Refuge Island


Intersections
Median Refuge Island and Traffic Diverter


ONLY
STOP
NACTO
Intersections
Median Refuge Island and Traffic Diverter

Image Gallery


BELVUE, WA


SAN LUIS OBISPO, CA


NEW YORK, NY


NEW YORK, NY


NEW YORK, NY


SAN LUIS OBISPO, CA


SAN LUIS OBISPO, CA

Through Bike Lanes

For bicyclists traveling in a conventional bike lane or from a truncated cycle track, the approach to an intersection with vehicular turn lanes can present a significant challenge. For this reason it is vital that bicyclists are provided with an opportunity to correctly position themselves to avoid conflicts with turning vehicles. This treatment specifically covers the application of a through bicycle lane or 'bicycle pocket' at the intersection. For other potential approaches to provide accommodations for bicyclists at intersections with turn lanes, please see bike box, combined bike lane/turn lane, bicycle signals, and colored bike facilities.

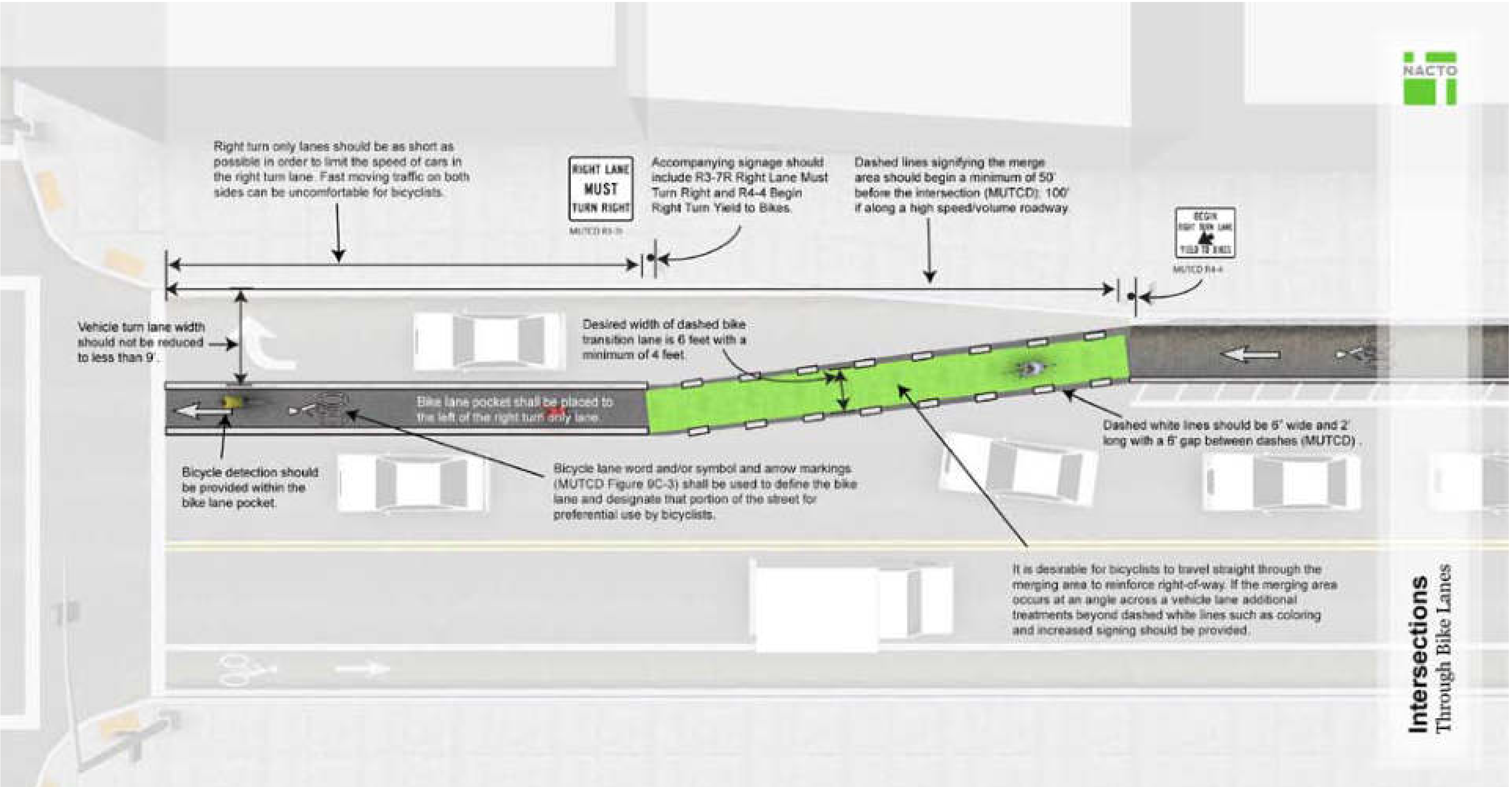
Through Bike Lane Benefits

- Enables bicyclists to correctly position themselves to the left of right turn lanes or to the right of left turn lanes.
- Reduces conflicts between turning motorists and bicycle through traffic.
- Provides bicyclists with guidance to follow the preferred travel path.
- Leads to more predictable bicyclist and motorist travel movements.
- Alerts motorists to expect and yield to merging bicycle traffic.
- Signifies an appropriate location for motorists to safely merge across the bike lane into the turn lane.

Typical Applications

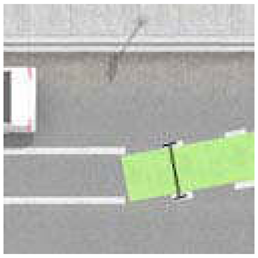
- On streets with right-side bike lanes and right-turn only lanes at intersections.
- On streets with left-side bike lanes and left-turn only lanes at intersections.
- On streets with bike lanes and where the right or left travel lane terminates in a turn lane.
- On streets with bike lanes and a parking lane that transition into a turn lane at intersections.

Design Guidance



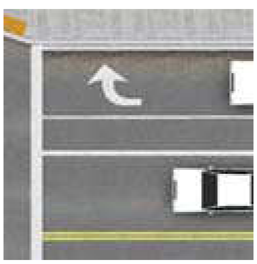
View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/ThroughBikeLanes_Annotated.jpg

REQUIRED



The desired width of a dashed bike transition lane and through bike lane is 6 feet with a minimum width of 4 feet.

Bicycle lane word 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.



The through bike lane shall be placed to the left of the right-turn only lane.

The through bike lane shall be placed to the left of the right-turn only lane.

Through bike lanes shall not be used on streets with double right turn lanes. Double right turn lanes are extremely difficult for bicyclists to negotiate. Shared lane markings may be used in the center of the outside turn lane to designate the preferred path of through bicycle travel.

Evaluation of a Green Bike Lane Weaving Area

St. Petersburg, FL

In September 2008, the University of North Carolina Highway Research Center, in coordination with the State of Florida Department of Transportation, released a study on the effects of green colored pavement in the weaving area between a through bike lane and a right-turn lane for motor vehicles. The green color was installed in the dashed striping area leading up to a pocket bike lane at the intersection of 1st Ave. N and 34th St in St. Petersburg, FL. First Avenue is a one-way street running east-west with five lanes, three through traffic lanes, a right turn-only lane, and a left turn only lane. The bike lane was positioned between the right turn lane and the through lane. Traffic counts on 1st Ave. showed close to 17,000 vehicles per day, with 17% of vehicles turning right.

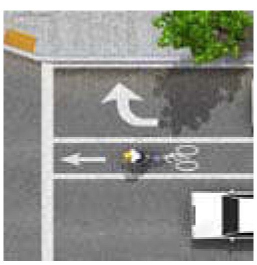
The study employed videotape data to study the before and after conditions of the green weaving area. A press-release was put out before the installation and reinforced by a “Right Turn Yield to Bikes” variable message board. In the first phase of the study, many motorists completely avoided the green lane. Following these early results, the city painted black mini-strips around the border of the weaving area, augmented by a “Cross in Green” variable message board sign. Overall, the study showed a higher percentage of motorists yielding to cyclists in the weaving area and a reduction in cyclist-motorist conflict.

RECOMMENDED

Accompanying signage should include R3-7R “Right Lane Must Turn Right” and R4-4 “Begin Right Turn Yield to Bikes” (MUTCD).

Dashed white lines should be 6 inches wide and 2 feet long with a 6 foot gap between dashes (MUTCD).

It is desirable for bicyclists to travel straight through the merging area to re-inforce right-of-way. If the merging area occurs at an angle across a vehicle lane additional treatments beyond dashed white lines, such as coloring and increased signing, should be provided.

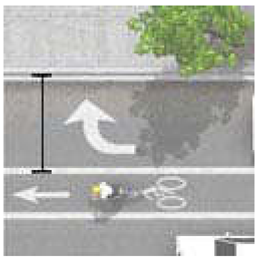


Right-turn only lanes should be as short as possible in order to limit the speed of cars in the right turn lane. Fast moving traffic on both sides can be uncomfortable for bicyclists.

Terminating the bike lane in advance of the intersection is discouraged.

RECOMMENDED

For intersections that lack the physical width to install a bicycle pocket, a combined bike/turn lane should be used.



Vehicle turn lane width should not be reduced to less than 9 feet.

Bicycle detection should be provided within the through bike lane.

Blue Bike Lane Weaving Area on Galileo Way

Cambridge, MA

Galileo Way in Cambridge, MA is a multi-lane roadway with a center median and a curbside bike lane. The street serves as a connector for both motorists and cyclists to the Massachusetts Institute of Technology Campus (M.I.T) and the Massachusetts Avenue Bridge crossing the Charles River into Boston. A bike lane runs southbound along Galileo Way and then transitions into a “pocket” bike lane where a right-turn bay for cars begins. During the construction of a new building at the Massachusetts Institute of Technology, the opportunity arose to reconfigure the intersection of Galileo Way and Main Street by improving crosswalks, signals, and better delineating the weaving area between the pocket bike lane and the right turn lane. Twenty feet from the stopline, dashed markings designate the weaving area, where an experimental blue color has been applied to reduce the risk of right-hook conflicts between cyclists and turning cars.

OPTIONAL

On streets with a combined turn and through lane, shared lane markings may be used in the center of the lane.

A bike box may be used in lieu of a designated through bike lane.

Bicycle warning signs or a "Share the Road" sign may be used in advance of the merge/transition area.

Maintenance

- Routine roadway maintenance is needed.
- Dashed lines should be installed with thermoplastic to increase durability and resist tire wear.
- Because the effectiveness of markings depends entirely on their visibility, maintaining markings should be a high priority.

Treatment Adoption and Professional Consensus

Bicycle lanes are the most common bicycle facility in use in the US, and most jurisdictions are familiar with their design and application as described in the MUTCD and AASHTO Guide for the Development of Bicycle Facilities. Many US cities offer through bicycle lanes at intersections; some offer increased levels of comfort and security to bicyclists through the application of some of the recommended and optional elements noted above.

Green Colored Intersections at Nine Conflict Areas

Chicago, IL

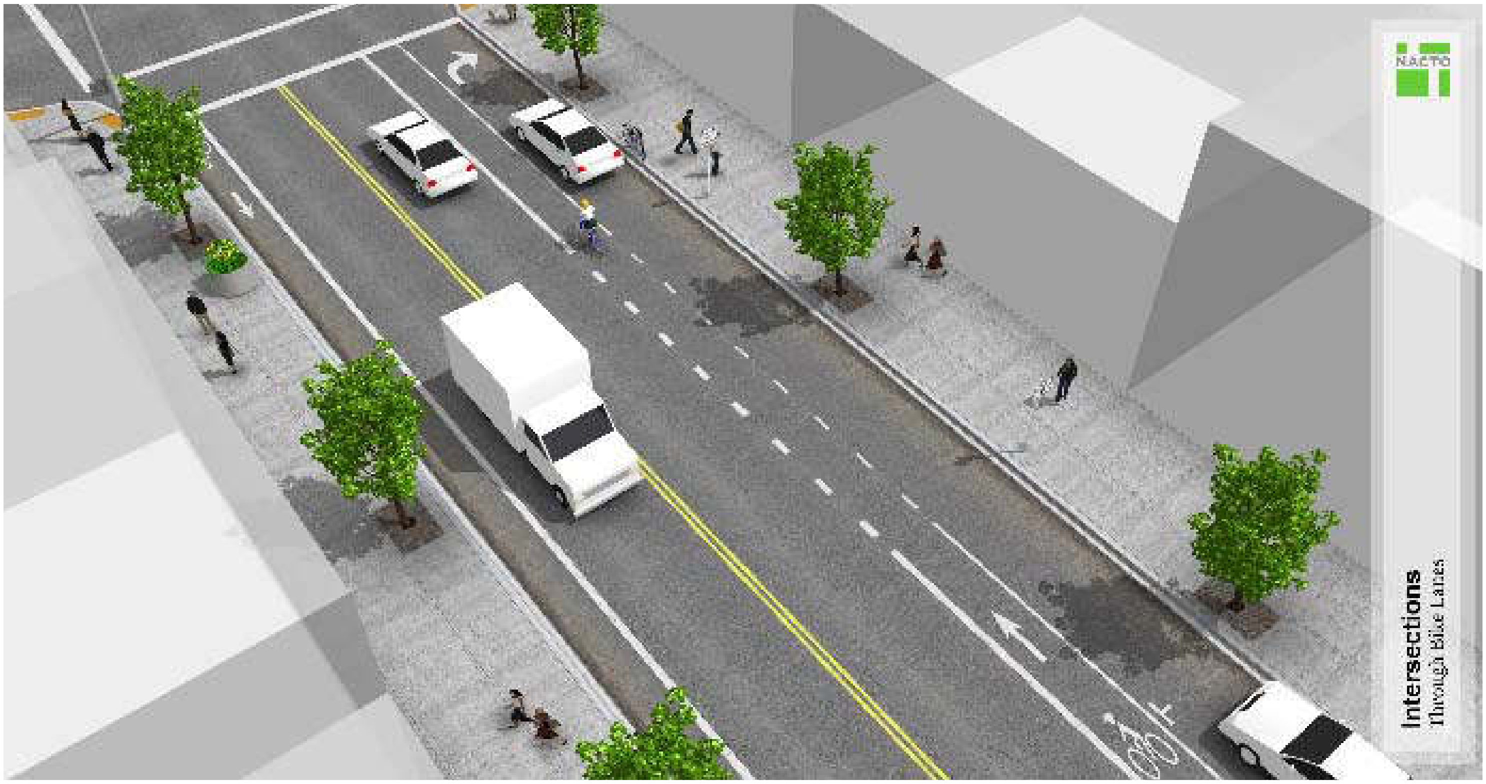
In the Fall of 2007, nine problematic intersections throughout the city of Chicago were painted with a green preformed thermoplastic marking to test the effectiveness of the color in alleviating conflict between cyclists and motorists turning right at intersections. In most cases, color was applied between the thru lane and the weaving area, where cyclists most often experience obstruction and discomfort. Video of each intersection has been recorded, though it has yet to be heavily analyzed. Maintenance issues with the material have occurred, such as flaking of the markings following the winter months, though this may be attributed to poor installation.

This project was designed and implemented by the Chicago Department of Transportation in Fall 2007 at nine Locations throughout Chicago, IL.

- Lincoln Ave. at Webster Ave. (Southbound)
- Elston Ave. at Division Ave. (North/Southbound)
- Milwaukee Ave. at Augusta Ave. (Southbound)
- Dearborn Ave. at Chicago Ave. (Northbound)
- Warren Ave. at Ogden Ave. (Eastbound)
- Halsted Ave. at Roosevelt Ave. (Southbound)
- Roosevelt Ave. at Damen Ave. (Eastbound and Westbound)

Renderings

The following images are 3D concepts of bikeways at intersections with turn lanes. The configurations shown are based on Seattle, WA, and Austin, TX, examples.


NACTO
Intersections
Through Bike Lanes


BEGIN
RIGHT TURN LANE
YIELD TO BIKES
NACTO
Intersections
Through Bike Lanes


NACTO
Intersections
Through Bike Lanes

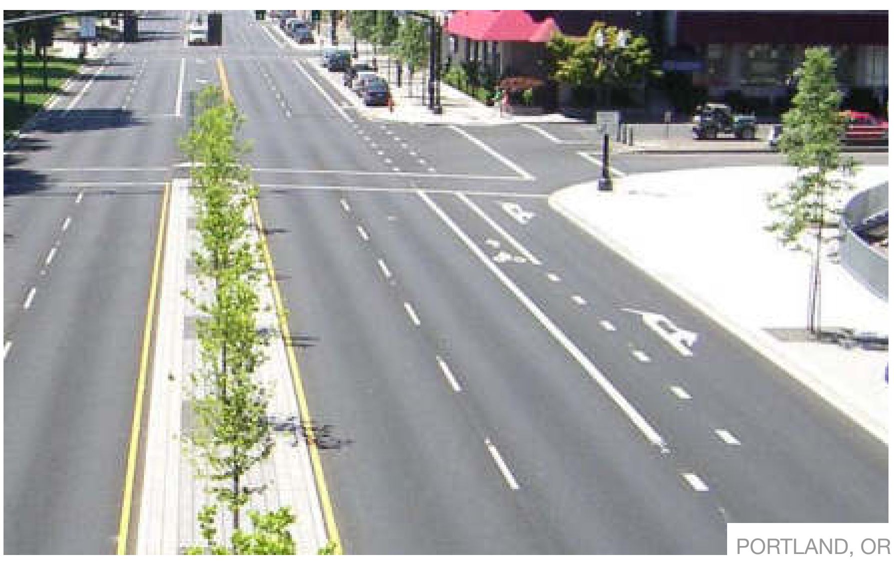

NACTO
Intersections
Through Bike Lanes

Image Gallery

LOS ANGELES, CA

EUGENE, OR

LANSING, MI



PORTLAND, OR

Combined Bike Lane/Turn Lane

A combined bicycle lane/turn lane places a suggested bike lane within the inside portion of a dedicated motor vehicle turn lane. A dashed line can either delineate the space for bicyclists and motorists within the shared lane or indicate the intended path for through bicyclists. This treatment includes signage advising motorists and bicyclists of proper positioning within the lane.

Benefits

- Preserves positive guidance for bicyclists in a situation where the bicycle lane would otherwise be dropped prior to an intersection.
- Maintains bicyclist comfort and priority in the absence of a dedicated bicycle through lane.

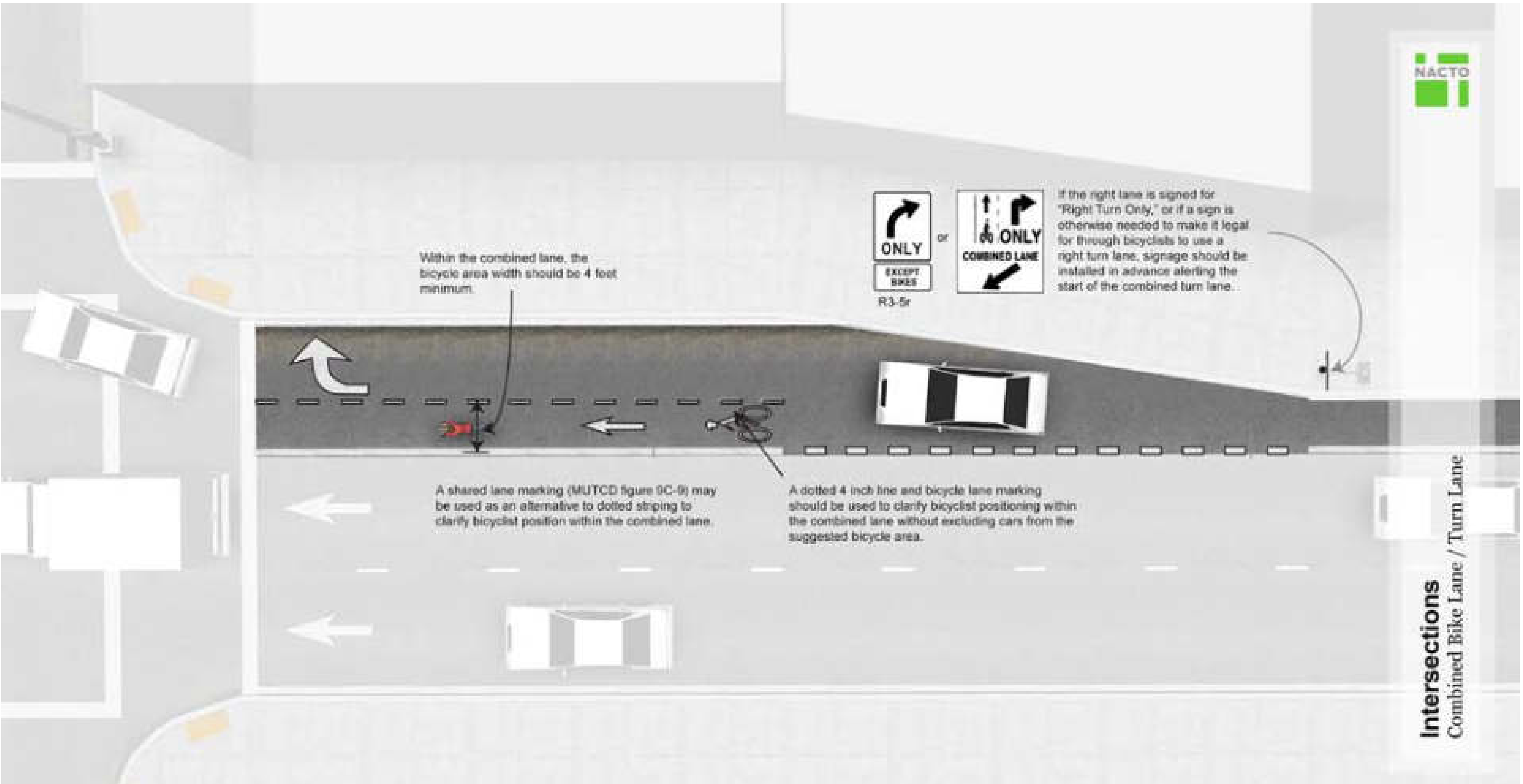
> *“More than 17 percent of the surveyed bicyclists using the narrow-lane intersection felt that it was safer than the comparison location with a standard-width right-turn lane, and another 55 percent felt that the narrow-lane site was no different safety-wise than the standard-width location.”*
>
> Hunter, W.W. (2000). Evaluation of a Combined Bicycle Lane/Right-Turn Lane in Eugene, Oregon. Publication No. FHWA-RD-00-151, Federal Highway Administration, Washington, DC.

- Guides bicyclists to ride in part of the turning lane, which tends to have lower speed traffic than the adjacent through lane, allowing higher speed through traffic to pass unimpeded.
- Encourages motorists to yield to bicyclists when crossing into the narrow right-turn lane.
- Reduces motor vehicle speed within the right turn lane.
- Reduces the risk of ‘right hook’ collisions at intersections.

Typical Applications

- On streets where there is a right turn lane but not enough space to maintain a standard-width bicycle lane at the intersection.
- On streets where there is no dedicated right turn lane, but on which high volumes of right turning traffic may cause conflicts between motorists and bicyclists.
- May not be appropriate at intersections with very high peak automobile right turn demand.

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/CombinedRightTurnLane_Plan_Annotated.jpg

REQUIRED

Some form of bicycle marking shall be used to clarify bicyclist positioning within the combined lane.

Evaluation of a Combined Bicycle Lane/Right Turn Lane Eugene, OR

In 1998, the city of Eugene, in coordination with the University of North Carolina Highway Safety Research Center, studied bicyclist and motorist interactions at two types of intersections- a standard right turn lane with a "pocket bike lane" at 13th Ave. and Willamette St., and a combined bike lane/turn lane at 13th Ave. and Patterson St. At the latter intersection, there was insufficient space to create the standard minimum 4' "pocket" lane and the potential for "right-hook" collisions between through cyclists and right turning vehicles. To resolve this conflict, the city installed a combined bike lane-right turn lane with dashed markings to distinguish bicyclists from right-turning motorists.

13th Ave. has a speed limit of 30 mph and carries 6,000-8,000 vehicles per day (vpd), in addition to significant bicycle traffic leading into the University of Oregon campus. Cyclists approach the intersection using a 5' wide bike lane, which is then combined into a 12' combined right turn lane, including the combined bike lane. This configuration compares favorably with the standard "pocket" lane, and many cyclists surveyed felt it was even safer than the standard model. The standard configuration (like that of 13th Ave. and Willamette St.) requires cyclists to shift to the left to reach the 5' pocket lane (with no adjacent bulb-out). The study recommends this design approach on local streets with speed limits of 30 mph and traffic volumes less than 10,000 vpd.

RECOMMENDED

Within the combined lane, the bicycle area width should be 4 feet minimum.

A dotted 4 inch line and bicycle lane marking should be used to clarify bicyclist positioning within the combined lane without excluding cars from the suggested bicycle area.

If the right lane is signed for "Right Turn Only," or if a sign is otherwise needed to make it legal for through bicyclists to use a right turn lane, signage should be installed in advance alerting the start of the combined turn lane.

This sign is used at a combined lane in Eugene, OR.

OPTIONAL

A shared lane marking (MUTCD figure 9C-9) may be used as an alternative to dotted striping to clarify bicyclist position within the combined lane.

Maintenance

Markings within the shared lane will require regular maintenance and marking repairs due to frequent wear from motor vehicle use. Inlaid thermoplastic application is recommended for increased durability.

Treatment Adoption and Professional Consensus

Currently used in the following US Cities:

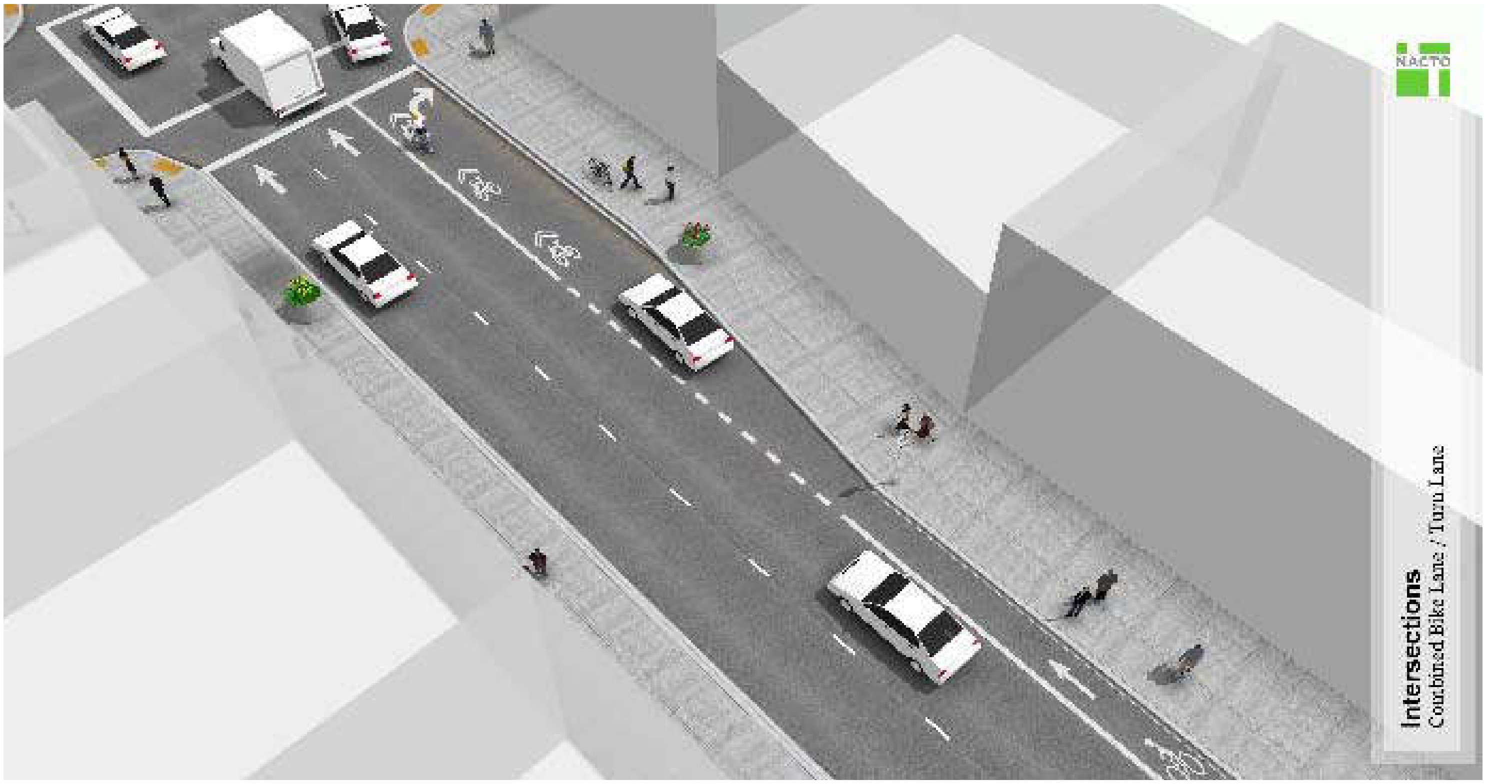
- Austin, TX
- Kona, HI
- New York, NY
- Oregon Cities
- San Francisco, CA
- Washington, DC

Renderings

The following images are 3D concepts of combined right-turn bike lanes. The configuration shown is based on a Eugene, OR, example.


ONLY
COMBINED LANE
NACTO
Intersections
Combined Bike Lane / Turn Lane


NACTO
Intersections
Combined Bike Lane / Turn Lane


NACTO
Intersections
Combined Bike Lane / Turn Lane

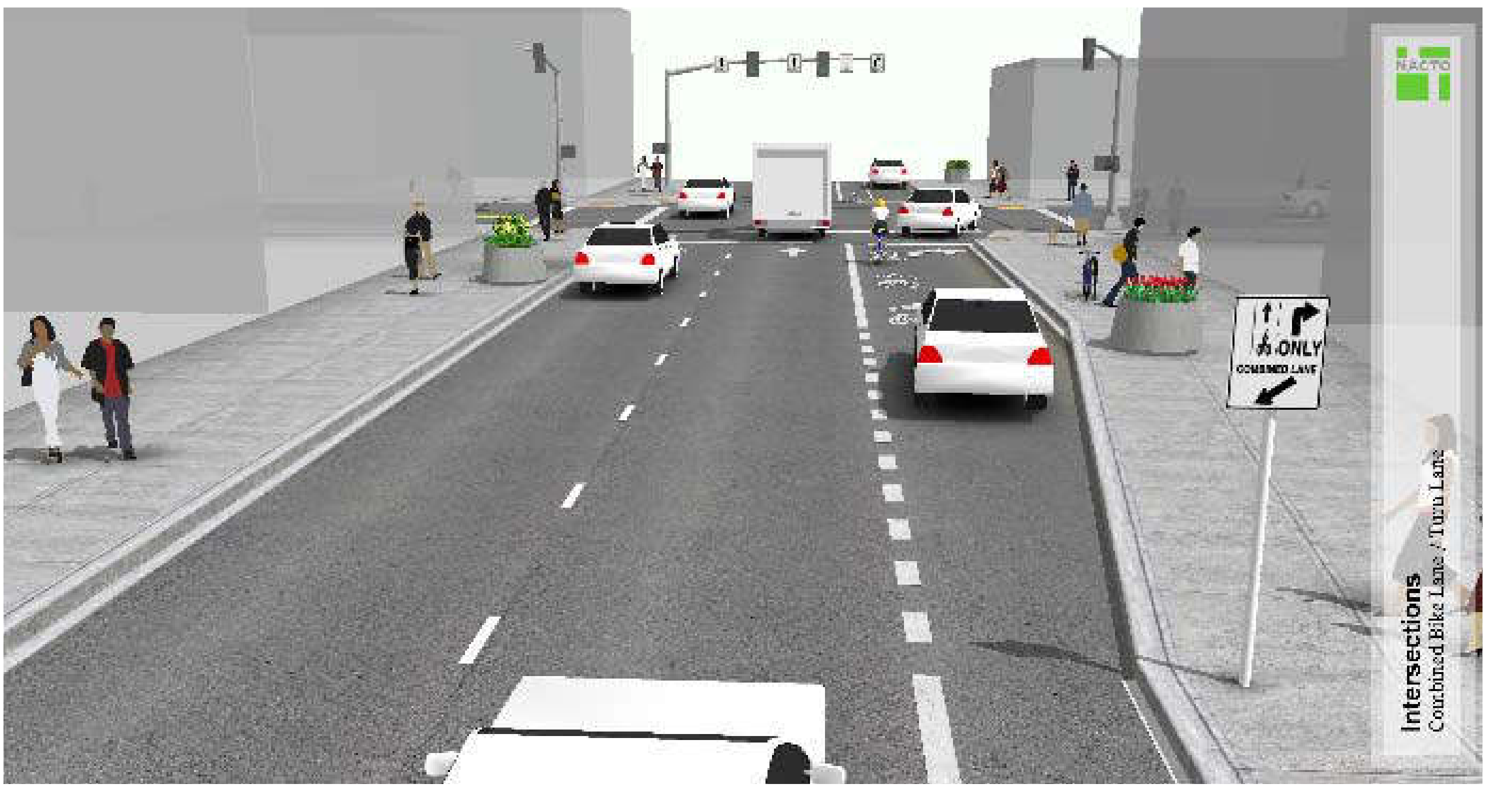

NACTO
ONLY
Intersections
Combined Bike Lane / Turn Lane

Image Gallery

AUSTIN, TX


AUSTIN, TX


MAUI, HI

EUGENE, OR


EUGENE, OR


NEW YORK, NY

Cycle Track Intersection Approach

This treatment covers guidance for cycle track design at intersection approaches with the purpose of the reducing turn conflicts for bicyclists or to provide connections to intersecting bicycle facility types.

This is typically achieved by removing the protected cycle track barrier or parking lane, lowering a raised cycle track to street level, and shifting the bicycle lane to be adjacent to or shared with motor vehicle travel. At these intersections, the experience is similar to a conventional bike lane and may involve similar applications of merging area treatments and markings across intersections. At the intersection, the cycle track may transition to a conventional bike lane or a combined bike lane/turn lane.

Cycle track crossings of signalized intersections can also be accomplished through the use of a bicycle signal phase (with or without use of bicycle signal heads) which reduce conflicts with motor vehicles by separating bicycle movements from any conflicting motor vehicle movements.

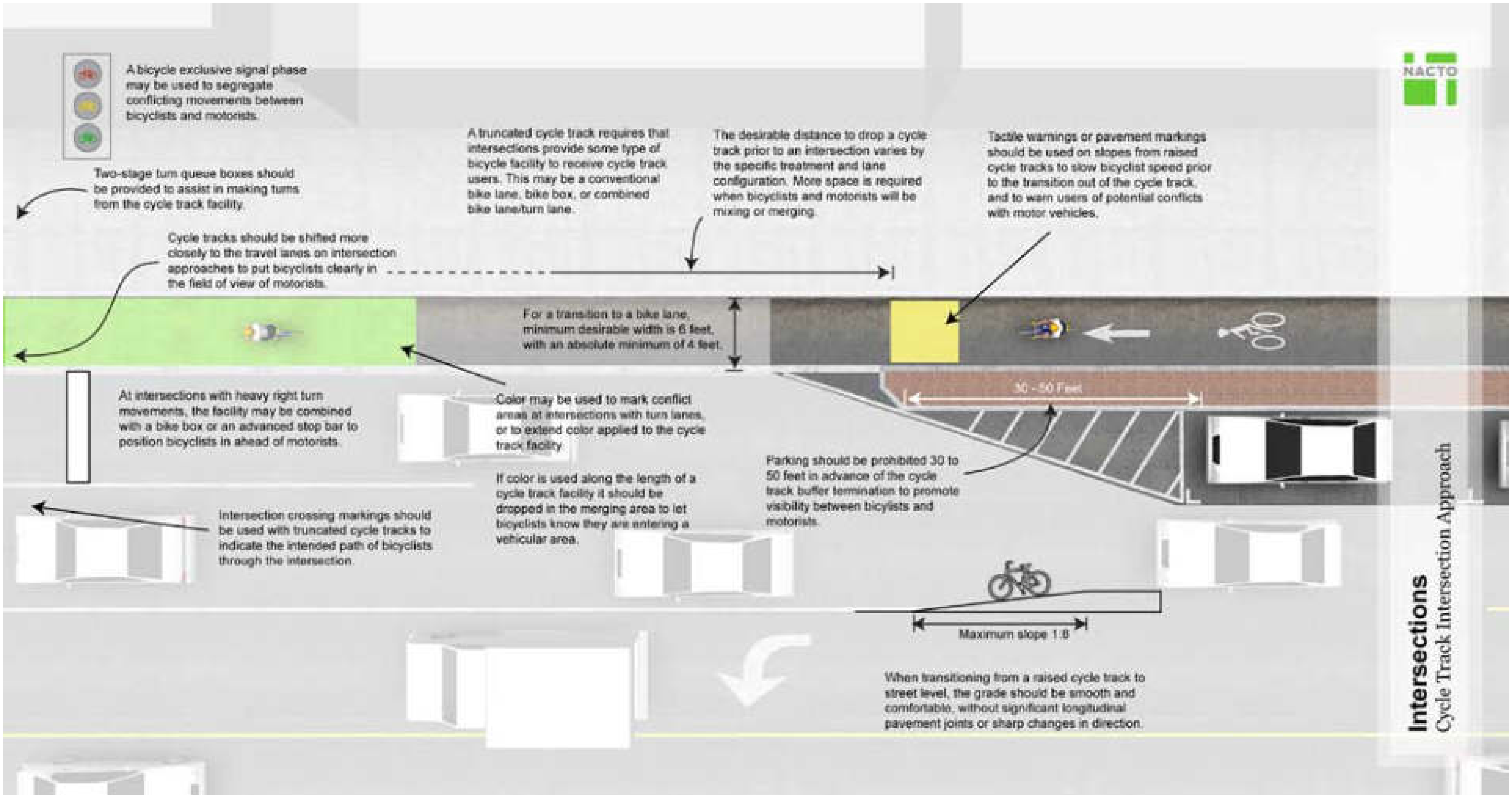
Cycle Track Intersection Approach Benefits

- Increases visibility of bicyclists and motorists in advance of the intersection.
- Mitigates the risk of “left or right-hook” crashes with turning motorists.
- May be less expensive than using full bicycle signals.

Typical Applications

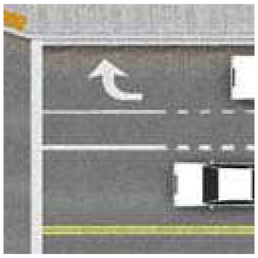
- Where cycle tracks approach intersections where turning movements across the path of the bicyclist (either left or right) is allowed.
- At intersections with a single dedicated right turn lane for motor vehicles.
- On cycle tracks protected by on street parking or otherwise removed from the travel lane.

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/Cycle-Track-Intersection-Approach_Plan_Annotation.jpg

REQUIRED



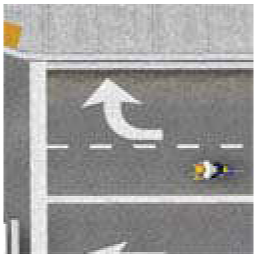
When the cycle track is dropped on an intersection approach, the intersection shall provide some type of bicycle facility to receive cycle track users. This may be a conventional bike lane, bike box, or combined bike lane/turn lane.

Truncated Cycle Track at 15th and O Streets

Washington, D.C.

Where the 15th St. two-way cycle track intersects with O St. in Washington, D.C., the DDOT altered the configuration of the bikeway to enhance the visibility of northbound cyclists for left turning cars. Buffered parking was removed near the intersection and the divided bike lane swung closer to motorists to bring cyclists closer to traffic at the unsignalized junction. White bollards maintain a degree of separation between the road and the cycle track. Shared lane markings with dashed lines lead cyclists through the intersection. To accommodate street cleaning and maintenance vehicles, the buffer dividing northbound and southbound cyclists has been painted rather than raised.

RECOMMENDED

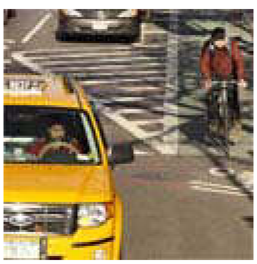


For a transition to a bike lane, minimum desirable width is 6 feet, with an absolute minimum of 4 feet. At constrained intersections with right turn lanes, consider transitioning to a combined bike lane/right turn lane.

The desirable distance to drop a cycle track prior to an intersection varies by the specific treatment and lane configuration. More space is required when bicyclists and motorists will be mixing or merging.

> *Another way [sic] improving interactions between vehicles turning right and cyclists is to truncate the cycle track. One way of doing it is by locating the cycle crossing at an intersection immediately next to the adjacent street and remove [sic] the curb stone at a distance of 20 – 30 meters.*

Leden, L., Gårder P., Johansson, C. (2005). Traffic environment for children and elderly as pedestrians and cyclists. 18th ICTCT workshop.



Parking should be prohibited 30 to 50 feet in advance of the cycle track buffer termination to promote visibility between bicyclists and motorists.

Tactile warnings or pavement markings should be used on slopes from raised cycle tracks to slow bicyclist speed prior to the transition out of the cycle track, and to warn users of potential conflicts with motor vehicles.

> *Where it is necessary to route bicyclists from a cycle track to a standard bike lane the transition should be "clear, smooth, safe and comfortable." Included in the design of the facility should be measures to slow bicyclists down to a safe speed prior to entering/exiting the cycle track. This may be accomplished through the use of 'Tramline & Ladder' tactile pavers at the ramps.*

> *On the bicyclist path these should run in the direction of travel ('tramline').*

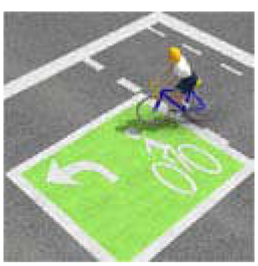
Transport For London. (2005). London Cycling Design Standards.

RECOMMENDED (CONTINUED)

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

When transitioning from a raised cycle track to street level, the grade should be smooth and comfortable, without significant longitudinal pavement joints or sharp changes in direction. Maximum slope should be 1:8.

Intersection crossing markings should be used with truncated cycle tracks to indicate the intended path of bicyclists through the intersection.t



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

OPTIONAL

Color may be used to mark conflict areas at intersections with turn lanes, or to extend color applied to the cycle track facility. If color is used along the length of a cycle track facility it should be dropped or dashed in the merging area to let bicyclists know they are entering a vehicular area.

At intersections with heavy right turn movements, the facility may be combined with a bike box or an advanced stop bar to position bicyclists ahead of motorists.

A bicycle exclusive signal phase may be used to segregate conflicting movements between bicyclists and motorists.

Maintenance

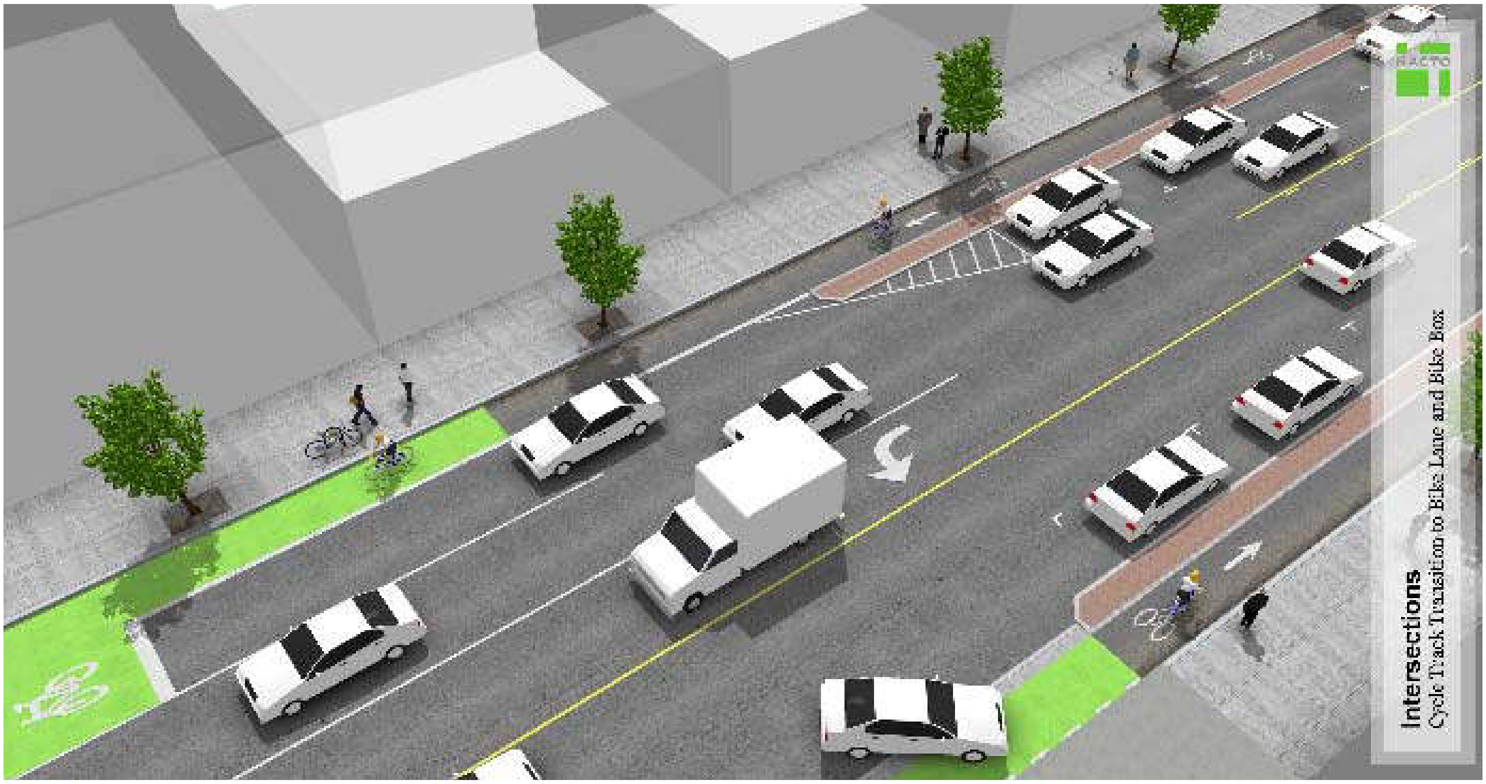
- Routine roadway/utility maintenance.
- Maintaining markings should be a high priority.

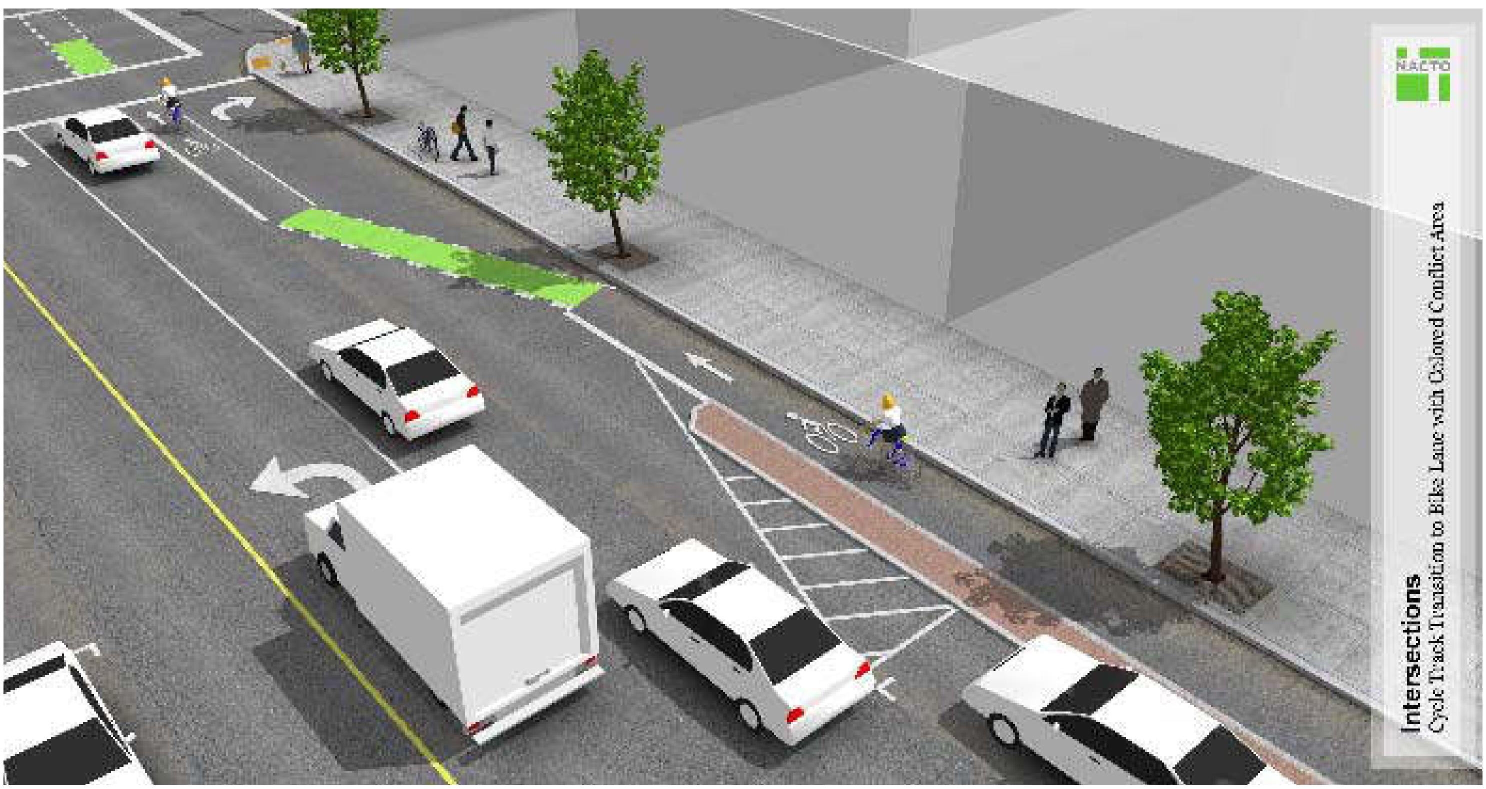
Treatment Adoption and Professional Consensus

- Commonly used in dozens of European bicycle friendly cities.
- Currently used in the following US cities:
  - Missoula, MT
  - Portland, OR
  - New York City, NY
  - Washington, DC
  - San Francisco, CA
  - Cambridge, MA

Renderings

The following images are 3D concepts of cycle track intersection approaches. The configuration shown is based on Washington, DC, and New York City examples.


NACTO
Intersections
Cycle Track Transition to Bike Lane and Bike Box


NACTO
Intersections
Cycle Track Transition to Bike Lane with Colored Conflict Area


NACTO
Intersections
Cycle Track Transition to Mixed Traffic Zone

Image Gallery


CAMBRIDGE, MA


WASHINGTON, DC


MISSOULA, MT


MISSOULA, MT


NEW YORK, NY


SAN FRANCISCO, CA

IN THIS SECTION:

- Bicycle Signal Heads
- Signal Detection and Actuation
- Active Warning Beacon for Bike Route at Unsignalized Intersection
- Hybrid Signal for Bike Route Crossing of Major Street

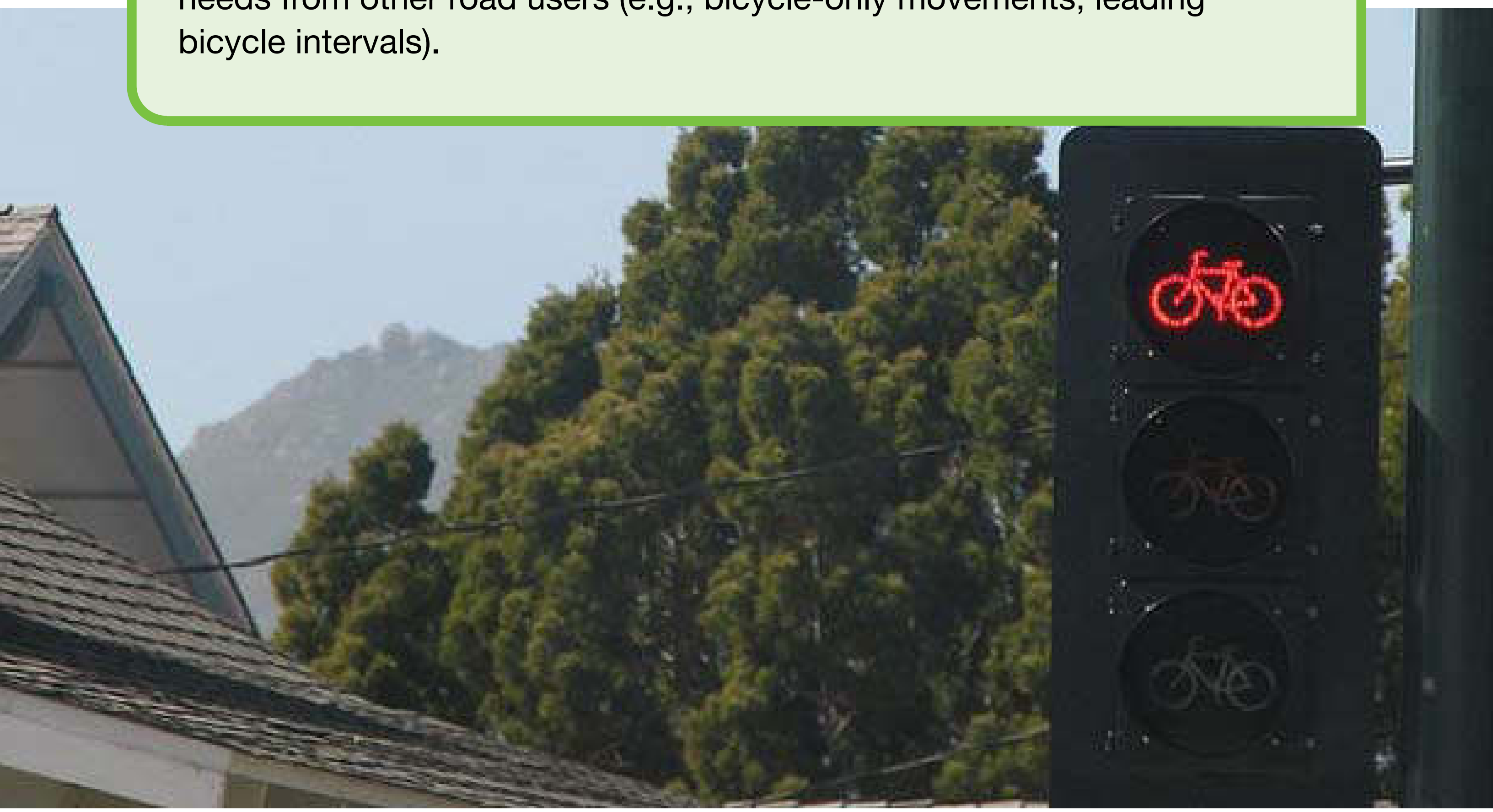
BICYCLE SIGNALS

Bicycle signals and beacons 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 and Hybrid Signal crossings. Flashing amber warning beacons are utilized at unsignalized intersection crossings. Push buttons, signage, and pavement markings may be used to highlight these facilities for both bicyclists and motorists.

Determining which type of signal or beacon to use for a particular intersection depends on a variety of factors. These include speed limits, average daily traffic (ADT), anticipated bicycle crossing traffic, and the configuration of planned or existing bicycle facilities. Signals may be required as part of the construction of a protected bicycle facility such as a cycle track with potential turning conflicts, or to decrease vehicle or pedestrian conflicts at major crossings. An intersection with bicycle signals may reduce stress and delays for a crossing bicyclist, and discourage illegal and unsafe crossing maneuvers.

Bicycle Signal Heads

A bicycle signal is an electrically powered traffic control device that should only be used in combination with an existing conventional or hybrid signal. Bicycle signals are typically used to improve identified safety or operational problems involving bicycle facilities. Bicycle signal heads may be installed at signalized intersections to indicate bicycle signal phases and other bicycle-specific timing strategies. In the United States, bicycle signal heads typically use standard three-lens signal heads in green, yellow, and red lenses. Bicycle signals are typically used to provide guidance for bicyclists at intersections where they may have different needs from other road users (e.g., bicycle-only movements, leading bicycle intervals).



Bicycle Signal Head Benefits

- Separates bicycle movements from conflicting motor vehicle, streetcar, light rail, or pedestrian movements.
- Provides priority to bicycle movements at an intersection (e.g., a leading bicycle interval).
- Allows for accommodation 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), though bicycle signals may also occur simultaneously with auto movement if combined with right turn on red restrictions.
- Protects bicyclists in the intersection, which may improve real and perceived safety at high-conflict areas.
- 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.

“*Concluding a case study of a bicycle signal head installation in Davis, CA: “Both motorists and bicyclists found the new signal heads to be effective in reducing conflicts between the various modes passing through the intersection. Evaluation of crash data seemed to reflect this as well. For the two-year period before the installation of bicycle signal heads at the intersection of Sycamore and Russell, there were about 16 bicycle and motor vehicle collisions. For the two-year period following the installation, there were only two collisions, neither of which involved bicycles.”*

Pedestrian and Bicycle Information Center. (2006.) BIKESAFE: Bicycle Countermeasure Selection System. Publication No. FHWA-SA-05-006, Federal Highway Administration, Washington, DC.

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.
- To make it legal for bicyclists to enter an intersection during an all-pedestrian phase (may not be appropriate in some cities).
- 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).

REQUIRED

The bicycle signal head shall be placed in a location clearly visible to on-coming bicycles

If the bicycle phase is not set to recall each cycle, bicycle signal heads shall be installed with appropriate detection and actuation.

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.

> *In Davis, the current signal phasing provides for a minimum bicycle green time of 12 seconds and a maximum green time of 25 seconds. Additionally, a two-second all red interval is provided at the end of this phase as opposed to only one second at the end of other phases.*

Metropolitan Transportation Commission. Safety Toolbox: Engineering. Bicycle Signals.

If the bicycle signal is used to separate through bicycle movements from right turning vehicles, then right turn on red shall be prohibited if it is normally allowed. 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.

REQUIRED (CONTINUED)

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.

TOUCAN Bicycle Signal at Third Street and Country Club Road Tucson, AZ

The Third Street Bicycle Boulevard in Tucson, AZ runs east of the University of Arizona and sees 3,000-plus cyclists and 500 motor vehicles per day. Where it intersects with Country Club Road, a busy four-lane arterial with a traffic volume of 30,000-plus vehicles per day, the Tucson Department of Transportation installed the city's first TOUCAN bicycle signal in 1998. A TOUCAN (TwO groUps CAN cross) signal provides a signal protected crossing for bicyclists and pedestrians on roads that prioritize non-motorized traffic.

Cyclists approaching the intersection are guided into an abbreviated two-way track/raised center median, where they push a button to indicate their arrival. Cars proceeding down Third Street are required to turn right at the junction, helping to protect cyclists from through traffic. A white lane was painted across the intersection to channelize bike traffic, but will be replaced by "dinner plate" bicycle markings.

The TOUCAN signal and center median were constructed at a cost of $400,000. Data collected since the signal's installation has shown a 100% increase in bicycle traffic on Third Street. This project was designed and implemented by the Tucson Department of Transportation in 1998 at East 3rd Street and North Country Club Road in Tucson, AZ. The city continues to install TOUCAN signals at intersections for cyclists, but uses a revised design with minimized capital construction costs.

RECOMMENDED

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 having the signal recall 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.

RECOMMENDED (CONTINUED)

There are currently no national standards for determining the appropriate clearance intervals for bicycle signals. However, the primary factors in choosing an appropriate clearance interval are bicyclist travel speed and intersection width. The following provides general guidance for selecting clearance intervals. This guidance should be tailored to local conditions using engineering judgment.

- At a minimum, the bicycle clearance interval should be sufficient to accommodate the 15th percentile biking speed (i.e., it should accommodate 85 percent of bicyclists at their normal travel speed). This is consistent with MUTCD guidance on pedestrian clearance intervals.
- Ideally, typical bicyclist speeds (V) should be measured in the field to determine a clearance interval appropriate for local conditions. However, at intersections with level approaches, 14 feet per second (9.5 miles per hour) may be used as a default speed in the absence of local data.

> *A research study collecting cyclist speeds on 15 trails throughout the United States found that the 15th percentile cycling speed is approximately 9.4 miles per hour.*
>
> Federal Highway Administration. (2006). Shared Use Path Level of Service Calculator. Publication: FHWA-HRT-05-138.

- Intersection width (W) should be calculated from the intersection entry (i.e., stop-line or crosswalk in the absence of a stop-line) to half-way across the last lane carrying through traffic.
- Calculate the total clearance interval (Ci) based on the following equation:

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

- Yellow intervals for automobiles will typically be shorter than those needed for bicycles, because of slower bicycle travel speeds. The intersection clearance time needed for bicyclists can be met partly through the automobile yellow interval, as well as through the all-red phase.
- The above guidance should be supplemented with engineering judgment as some wider intersections could be left with extremely long all-red signal phases.

Fell-Masonic Bicycle Signal San Francisco, CA

The intersection of Fell Street and Masonic Avenue had a history of collisions between automobiles and users of the Panhandle bicycle and pedestrian path, which runs parallel to Fell Street. During the five–year period from March 2003 through February 2008, there were 15 reported collisions involving a vehicle making a left turn from westbound Fell Street to southbound Masonic Avenue and a bicycle crossing Masonic Avenue; there were three reported collisions involving a vehicle turning left from westbound Fell Street and a pedestrian crossing Masonic Avenue.

The new signal, the first of its kind in the city and installed by the San Francisco Municipal Transportation Agency (SFMTA) in September 2008, provides an exclusive time interval for bicyclists and pedestrians to cross Masonic Avenue together, while automobiles intending to turn left onto Masonic from Fell Street are stopped at the traffic signal. The bicycle component of the new signal uses a bicycle symbol in the familiar green, yellow and red phases to indicate when a bicyclist can cross Masonic Avenue. The pedestrian signal continues to use the white walking figure and the orange hand to direct pedestrian traffic.

Several issues arose as a result of this project:

First, the addition of a bicycle phase was equivalent to separating the through and left phases for vehicles. A left-turn phase for vehicles required the creation of a left-turn lane with sufficient capacity. In this case, that lane required the removal of numerous on-street parking spaces.

Additionally, the phase sequence was an issue. Initially, vehicle left-turns were permitted before the through bike movement. This phasing was chosen because the actuation required for this permitted a longer green bicycle phase. Cyclists felt that this phasing was unfair. Furthermore, many vehicles arriving at the end of the left-turn phase and anxious to avoid waiting an entire cycle would try to pass at the end of the yellow and the beginning of the red, which created an additional conflict with cyclists. Switching the phase sequencing to permit bicycle movements before vehicle left-turns solved these problems. Despite the shorter bicycle green signal necessary because of the less-efficient lagging left-turn actuation, cyclists felt that they were prioritized and vehicles violated the left red arrow less frequently.

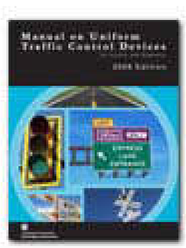
Lastly, the location of the signals provided a challenge. Having the through movements (e.g. green ball), turn movements (e.g. red arrow) and bike signal on one pole created an abundance of potential visual conflicts. Louvers have been used to retrofit the existing signal heads, but future upgrades should include separating the various signal faces onto separate poles, including a mast-arm for through movements.

Enforcement and education continue to be needed as vehicles occasionally violate the red arrow and turn into the crosswalk, endangering bicyclists and pedestrians during the protected bicycle/pedestrian phase. After the modifications mentioned above, all user groups seem to be happy with the new signal.

RECOMMENDED (CONTINUED)

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 minor-road crossing distance is typically greater than major-road crossing distance and minor-road crossings are often subject to short green intervals. Bicycle minimum green time is determined using the bicycle crossing time for standing bicycles.

Some controllers have built-in features to specify and program a bicycle minimum green based on bicycle detection. However, if this is not available, and bicycle minimum green time is greater than what would ordinarily be used, the green time should be increased.



Design and operation of bicycle signal heads should consider general MUTCD guidance on standards for traffic signals where applicable (e.g., positions of signal indications; visibility, aiming, and shielding of signal faces). Many of the MUTCD considerations for traffic signals will not apply to bicycle signals. Existing experience with bicycle signal installations in some cities has resulted in post mounted signals being utilized adjacent to the bikeway with a lower overall height. Such an installation functions more like a pedestrian signal than a vehicle signal. Some existing designs use shields and louvers to limit the driver's visibility of the bicycle signal to avoid any potential confusion. Engineering judgment should be used to ensure that the positioning of bicycle signal heads is optimal for each installation. It is recommended that bicycle signal heads be separated from motor vehicle signal heads by at least two feet to increase comprehension.

OPTIONAL

For improved visibility, near-sided bicycle signals may be used to supplement far-side signals.

Visual variation in signal head housing for the bicycle signal when compared to adjacent traffic signals may increase contrast and awareness.

Near-side bicycle signals may incorporate a 'countdown to green' display to provide information about when a green bicycle indication will be provided. This treatment has proved popular in Europe, but there are currently no known installations in the United States.

Maintenance

- Bicycle signal heads require the same maintenance as standard traffic signal heads, such as replacing bulbs and responding to power outages.

Treatment Adoption and Professional Consensus

Bicycle signal heads are widely used in Europe and China, as well as the following US cities:

- Davis, CA
- San Luis Obispo, CA
- San Francisco, CA
- Portland, OR
- New York, NY
- Alexandria, VA
- Washington, DC
- Austin, TX

Evaluation of Bicycle Signal Heads at Unsignalized Intersections Davis, CA

In 1996, the City of Davis installed bicycle signal heads at the intersection of Russell Boulevard and Sycamore Lane as part of a demonstration project submitted to the California Traffic Control Devices Committee (CTCDC) to study the impact of the bicycle signals on bicycle and pedestrian safety and traffic behavior at the intersection. The intersection, which abuts the University of California-Davis campus, sees peak hour volumes for bicycles around 1,100 bicycles per day (bpd) and 18,500 vehicles per day (vpd) for Russell Boulevard and 7,500 vpd for Sycamore Lane. Before signal installation, motor vehicle and bicycle traffic operated concurrently, resulting in discomfort and unsafe weaving maneuvers.

Before and after data gathered at the intersection showed a marked increase in bicyclist and pedestrian safety. Only two collisions occurred the sixteen month period after implementation (neither of which involved a cyclist or pedestrian), as compared to fourteen in the three years preceding the signal modification (over half of which involved a cyclist or pedestrian). Surveys distributed as part of the study showed a positive reception of the signal heads and a favorable impression of the intersection compared with other junctions in the area.

Pelz, D., Bustos, T., Flecker, J. (1996). The Use of Bicycle Signal Heads at Signalized Inersections. Davis California.

Image Gallery

PORTLAND, OR

SAN LUIS OBISPO, CA


SAN LUIS OBISPO, CA


PORTLAND, OR


WASHINGTON, DC


PORTLAND, OR


NEW YORK, NY

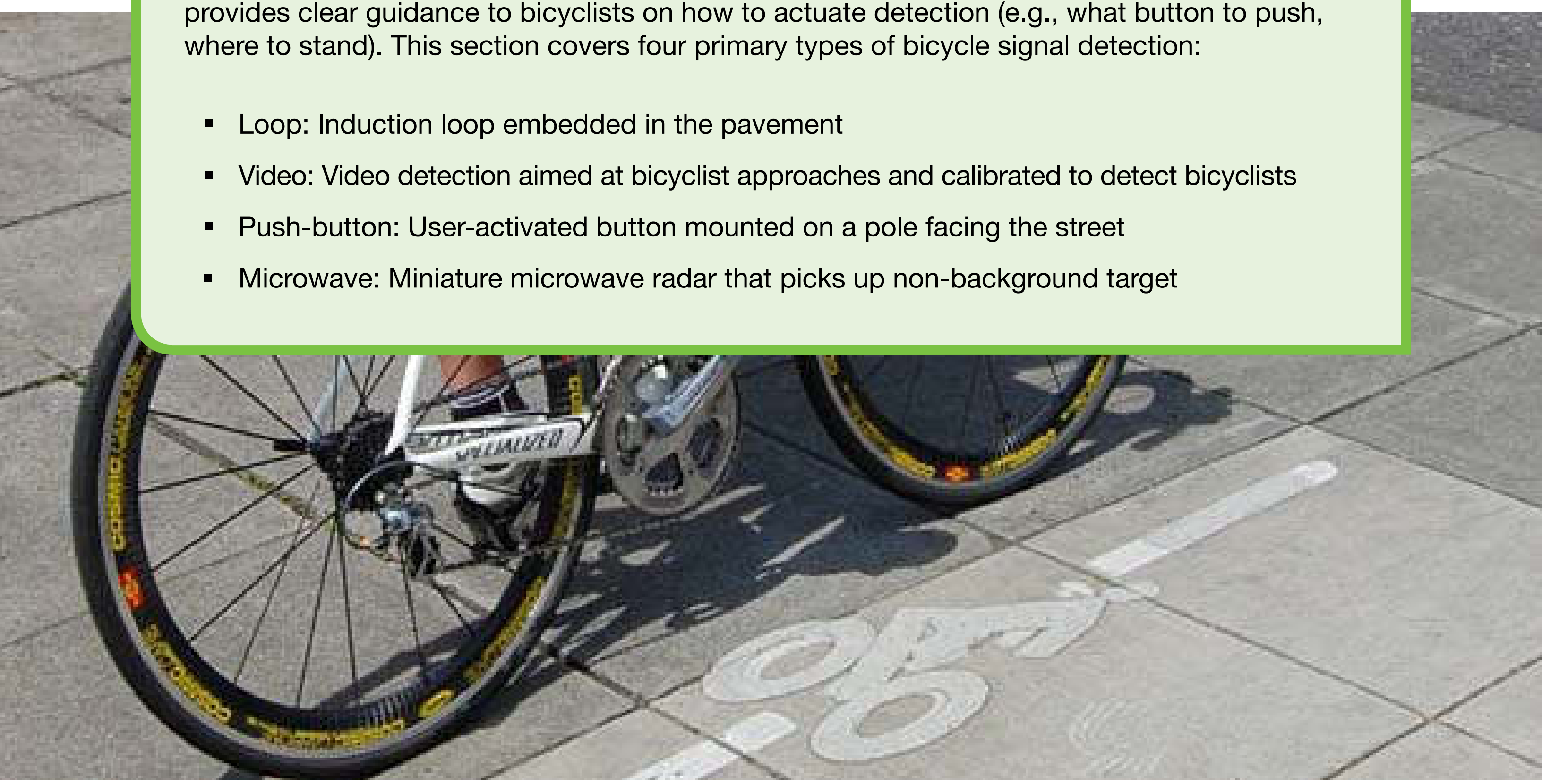
Signal Detection and Actuation

Bicycle detection at traffic signals is 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, meaning that bicycles may often go undetected. The result is that bicyclists must either wait for a vehicle to arrive, dismount and push the pedestrian button (if available), or cross illegally.

Proper bicycle detection meets two primary criteria: 1) accurately detects bicyclists; and 2) provides clear guidance to bicyclists on how to actuate detection (e.g., what button to push, where to stand). This section covers four primary types of bicycle signal detection:

- Loop: Induction loop embedded in the pavement
- Video: Video detection aimed at bicyclist approaches and calibrated to detect bicyclists
- Push-button: User-activated button mounted on a pole facing the street
- Microwave: Miniature microwave radar that picks up non-background target



Benefits

- Improves efficiency and reduces delay for bicycle travel.
- Increases convenience and safety of bicycling and helps establish bicycling as a legitimate mode of transportation on streets.
- Discourages red light running by bicyclists without causing excessive delay to motorists.
- Can be used to prolong the green phase to provide adequate time for bicyclists to clear the intersection.

Typical Applications

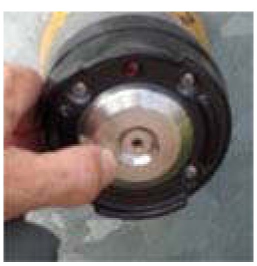
- In the travel lane on intersection approaches without bike lanes where actuation is required.
- At intersections with bicycle signal heads and/or bicycle-specific phasing that are actuated.
- In bike lanes on intersection approaches that are actuated.
- In left turn lanes with actuated left-turn signals where bicyclists may also turn left.
- To increase the green signal phase on intersection approaches whose combined minimum green plus yellow plus all-red is insufficient for bicyclists to clear the intersection when starting on a green signal. Advanced bicyclist detection can be applied to extend the green phase or to call the signal.
- At clearly marked locations to designate where a bicyclist should wait.

REQUIRED

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.

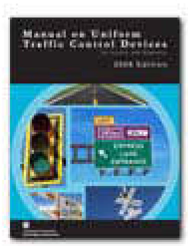


If provided, push-button activation shall be located so bicyclists can activate the signal without dismounting. If used, push buttons should have a supplemental sign facing the bicyclist's approach to increase visibility.

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.

Intersections without painted bicycle infrastructure shall provide detection in the center of the outside lane.

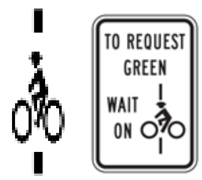
RECOMMENDED



The MUTCD provides guidance on stencil markings and signage related to signal detection.

> *Stencil for marking location of most sensitive portion of traffic sensor (MUTCD Figure 9C-7)*

> *Informational sign describing optimum use of traffic sensor (MUTCD Sign R10-22)*



Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices.

Bicycle Loop Detector at Channing Way and Martin Luther King, Jr. Boulevard Berkeley, CA

At the intersection of the Channing Way Bicycle Boulevard and Martin Luther King, Jr. Boulevard, in the late 1990s, the city of Berkeley installed one of the city's first bicycle loop detectors, as well as a legend with a right-in/right-out diverter. Thru-movement on the bicycle boulevard was banned as part of the project and left-turns for cars prohibited. By isolating the loop detector within small raised concrete curbs, the city avoided the issue of false detection and created a protected platform for cyclists to await the light change. The design deters cut-thru traffic and makes the bicycle boulevard safer for bicyclists. The use of the loop detectors has been a key facet of Berkeley's bicycle boulevard development over the past decade.

Maintenance

- Inductive loop detector sensitivity settings need to be monitored and adjusted over time.

Treatment Adoption and Professional Consensus

Bicycle signal detection is widely used in North American and European cities, both at standard signalized intersections and those with bicycle signal phases. Some US examples include:

- Austin, TX
- Berkeley, CA
- Marin County, CA
- Madison, WI
- Portland, OR
- San Luis Obispo, CA
- Santa Clara Valley, CA

Bicycle Signal Detector Loops Madison, WI

The city of Madison, WI utilizes bicycle signal detector loops to improve access and decrease wait times at signalized intersections for bicyclists. Two to four detector loops are installed along any approach where a local neighborhood road frequented by bicyclists meets a signalized intersection at an arterial road. Loops may also be installed on collector roads and bike lanes where they are deemed necessary. Detector loops are typically 6' by 6' and square or diamond shaped (as opposed to round). They are often installed during street resurfacings, and are placed between 3" and 9" below the surface. Shallow loops saw-cut into the pavement are most prone to damage. Approximately 80 percent of the city's 285 signalized intersections have bicycle signal detection loops in place. To help bicyclists identify the signal detectors, the city of Madison is considering using pavement markings or striping to identify the most sensitive parts of the loops.

Design and construction is performed in-house by the City of Madison. Loops cost approximately $500-600 per unit.

Image Gallery

SAN LUIS OBISPO, CA

PORTLAND, OR

PORTLAND, OR

SAN LUIS OBISPO, CA

PORTLAND, OR

Active Warning Beacon

for Bike Route at Unsignalized Intersection

Active warning beacons are user-actuated amber flashing lights that supplement warning signs at unsignalized intersections or mid-block crosswalks. Beacons can be actuated either manually by a push-button or passively through detection. Rectangular Rapid Flash Beacons (RRFBs), a type of active warning beacon, 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 bicyclists have the right-of-way crossing a road.

Benefits

- Offers lower cost alternative to traffic signals and hybrid signals.

> *"The RRFB offers significant potential safety and cost benefits, because it achieves very high rates of compliance at a very low relative cost in comparison to other more restrictive devices that provide comparable results, such as full midblock signalization."*
>
> Federal Highway Administration. (2008). Interim Approval for Optional Use of Rectangular Rapid Flashing Beacons (IA-11).

- Significantly increases driver yielding behavior at crossings when supplementing standard crossing warning signs and markings.

> *"Overall, motorist yielding increased from 2% before to 35% after. When the flasher was activated, motorist yielding was 54%.*
>
> Hunter, W. W., Srinivasan, R., Martell, C. (2009). Evaluation of the Rectangular Rapid Flash Beacon at a Pinellas Trail Crossing in St. Petersburg, Florida. Florida Department of Transportation.

- The unique nature of the stutter flash (RRFBs) elicits a greater response from drivers than traditional methods.

> *"With the introduction of a two- and four-beacon system came increases of 70.6% and 77.8% increases over baseline, respectively, and increases of 66% and 73.2% over the standard-beacon efficacy.*
>
> Houten, R. V., Malenfant, L. (Undated). Efficacy of Rectangular-shaped Rapid Flash LED Beacons.

Typical Applications

- Usually implemented at high-volume pedestrian crossings, but may also be considered for priority bicycle route 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 bicycle crossings is low.

REQUIRED

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.

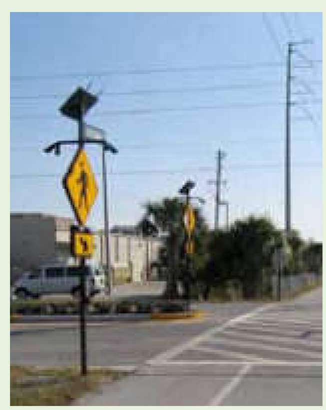
Due to magnetic fiel Beacons shall be unlit when not activated. d symmetry, the center of inductive loops is the most sensitive location for detection for both diagonal slashed detectors and quadrupole loop detectors (above left). Square and unmodified circle detectors are most sensitive at their edge (left).

Evaluation of the Rectangular Rapid Flash Beacon (RRFB) at the Pinellas Trail Crossing St. Petersburg, Florida

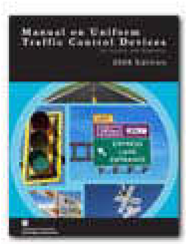
In August 2008, as part of a coordinated effort by the North Carolina Highway Safety Research Center and the Florida Department of Transportation to evaluate innovative bicycle and pedestrian improvements, a rectangular rapid flash beacon (RRFB) was installed at the intersection of the Pinellas Trail and 22nd Ave. in St. Petersburg, Florida. The beacon contains two rectangular yellow LED indicators, is solar-powered, and can be activated by bicyclists and pedestrians using a push button. 22nd Ave. N in St. Petersburg is a busy four-lane urban street with 15,000 vehicles per day and a speed limit of 40 mph. Where it intersects with the Pinellas Trail, which has 1,300-2,000 users per day, researchers wanted to study the effect of the RRFB on motorist and trail user yielding patterns. Videotape data was collected and analyzed. The results showed an increase in motorist yielding from 2% to 54% (with an activated flasher), an increase in the percentage of trail users able to cross the intersection, and a decrease in the percentage of trail users stopping in the middle of the road. According to the results of the study, overall safety increased for trail users as a result of the RRFB.

Information and Photographs were compiled from the following report:

Hunter, W. W., Srinivasan, R., Martell, C. (2009). Evaluation of the Rectangular Rapid Flash Beacon at a Pinellas Trail Crossing in St. Petersburg, Florida. Florida Department of Transportation.



RECOMMENDED



The MUTCD provides additional guidance on use of Rectangular Rapid Flash Beacons (RRFBs):

- RRFBs should be used to supplement standard pedestrian and bicycle crossing signs and markings.
- RRFBs should not be used where the crosswalk approach is controlled by a yield sign, stop sign, or traffic-control signal.
- RRFBs can be used at a crosswalk at a roundabout.

Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices.

Rapid Flash Beacons (RFB) for Pedestrian Crossings at Four Locations Alexandria, VA

As part of its 2008 Pedestrian and Bicycle Mobility Plan, the city of Alexandria, Virginia installed rapid flash beacons (RFB) at four intersection crossings in December 2009. The beacons were placed at unsignalized intersections with more than 25/pedestrians per hour (during peak hour) and usually near transit nodes or activity centers. Intersections were selected on the basis of community demands for safety improvement and at locations in need of additional reinforcement for a preexisting Yield sign.

Beacons were placed at the following locations, with brief descriptions of their traffic conditions following:

1. 201 Yoakum Parkway (between Edsall Road and Stevenson Avenue): Heavily-used transit stops are located on both sides of this four-lane roadway between multi-family housing units.
2. Duke Street at Telegraph Road: The sidewalk on the north side of Duke Street between West Taylor Run and Roberts Lane is heavily used by pedestrians headed to-and-from Old Town, Patent and Trademark Office (PTO) and the King Street Metro.
3. Braddock Road at Braddock Road Metro: This heavily-used mid-block location was previously delineated by in-pavement lights. By installing rapid-flash beacons and removing in-pavement lights, the City intends to improve visibility of the signals and compliance by motorists.
4. Mount Vernon Ave. at Kennedy Street: A developer contributed $16,000 toward installation as part of the Mount Vernon Commons development.

The effort was coordinated with the Police department to ensure enforcement at the crossing and paid for by the Department of Transportation and Environmental Services. The cost was $25,000 per beacon, not including labor and installation costs, and $91,000 for assembly and installation.

Maintenance

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

Treatment Adoption and Professional Consensus

Several municipalities and counties in the United States have experimented with and evaluated RRFBs for bicycles (as well as pedestrians), including the following:

- Boulder, CO
- Portland, OR
- St. Petersburg, FL
- Wilmington, NC
- Miami-Dade, FL
- Las Cruces, NM
- Click to see the complete reference material for this treatment.

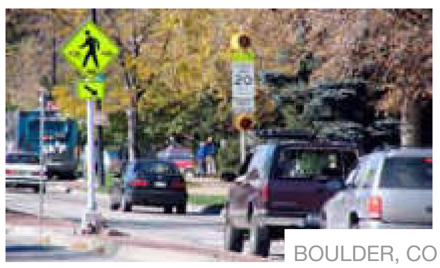
Image Gallery

PORTLAND, OR


ST. PETERSBURG, FL


ALEXANDRIA, VA

ST. PETERSBURG, FL


BOULDER, CO


ALEXANDRIA, VA


ST. PETERSBURG, FL


BOULDER, CO


ST. PETERSBURG, FL


ST. PETERSBURG, FL

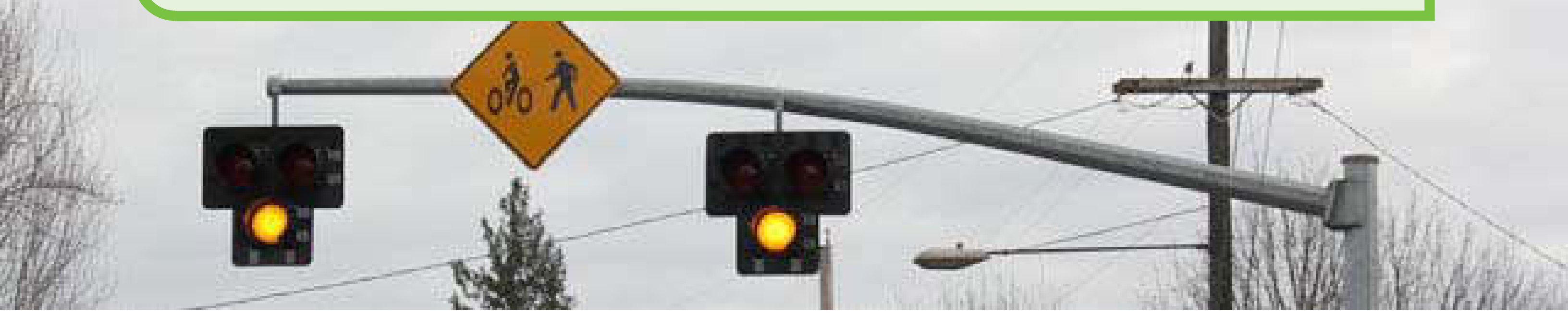
Hybrid Signal for Bike Route Crossing of Major Street

A hybrid beacon, also known as a High-intensity Activated CrosswalK (HAWK), 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 examples of hybrid beacons explicitly incorporating bicycle movements. The information provided here focuses on the application of hybrid beacons for bicyclists.

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).

The hybrid beacon can significantly improve the operations of a bicycle route, particularly along bicycle boulevards or neighborhood greenway corridors. Because of the low traffic volumes on these facilities, intersections with major roadways are often unsignalized, creating difficult and potentially unsafe crossing conditions for bicyclists. Hybrid beacons may be supplemented with a bike signal and signal detection for the minor street approaches to facilitate bicycle crossings.

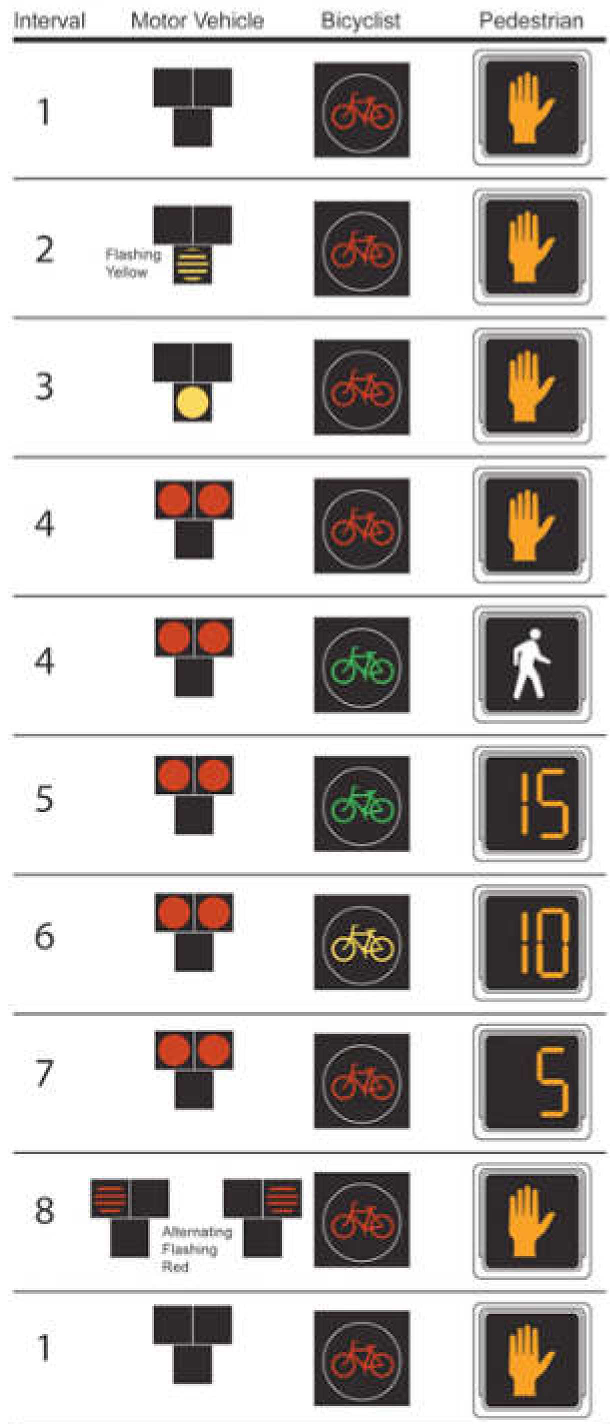


Operations

Hybrid beacon operations are significantly different from the operations of standard traffic control signals. The figure below (from the 2009 MUTCD) 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. To maximize safety when used for bicycle crossings, this phase should be very short and occur after the pedestrian signal head has changed to a solid "DON'T WALK" indication as bicyclists can enter an intersection quickly.

Sequence for Coordinated HAWK, Bicycle and Pedestrian Signal.



Benefits

- 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.

> *This application provides a pedestrian crossing without signal control for the side street because signal control on the side street can encourage unwanted additional traffic through the neighborhood.*
>
> Fitzpatrick, K. and Park, E.S. (2010). Safety Effectiveness of the HAWK Pedestrian Crossing Treatment. Federal Highway Administration. Publication No. FHWA-HRT-10-042.

- Creates gaps for bicyclists 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.
  - The need for a signalized crossing of a collector at a minor street if often limited to peak traffic times. A full signal would have the unintended consequence of unnecessarily delaying bicyclists wishing to cross the collector during off-peak conditions as well as motorists on the main street, who would have to wait through an otherwise unnecessary full signal cycle.
- Associated with very high driver compliance (studies show greater than 95% driver compliance with red indications).

> *The three devices designated as red signal or beacon had statistically similar mean compliance rates. These devices include the midblock signal, half signal, and HAWK signal beacon. All three devices had average compliance rates greater than 97 percent."*

> *A compliance rate above 94 percent exists, regardless of the number of lanes on the facility."*
>
> Fitzpatrick, K., Turner, S., Brewer, M., Carlson, P., Lalani, N., Ullman, B., Trout, N., Park, E.S., Lord, D., and Whitacre, J. (2006). Improving Pedestrian Safety at Unsignalized Crossings. TCRP/NCHRP Report 112/ 562, Transportation Research Board, Washington, DC.

- Improves street crossing safety.

> *A 29 percent reduction in total crashes was achieved, which was statistically significant at the 95 percent confidence level.*

> *A 69 percent reduction in pedestrian crashes was achieved, which was statistically significant at the 95 percent confidence level.*
>
> Fitzpatrick, K. and Park, E.S. (2010). Safety Effectiveness of the HAWK Pedestrian Crossing Treatment. Federal Highway Administration. Publication No. FHWA-HRT-10-042.

Typical Applications

- Where bike routes intersect major streets without existing signalized crossings.
- Where off-street bicycle or pedestrian facilities intersect major streets without existing signalized crossings.
- At mid-block crossings of major roadways with high bicycle or pedestrian volumes.

Design Guidance

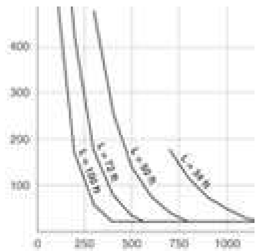
Chapter 4F of the 2009 MUTCD provides guidance and standards for hybrid beacons at unsignalized and mid-block pedestrian crossings, but does not consider hybrid beacons for bicyclist crossings. The guidance provided here is intended to supplement the MUTCD to cover the use of hybrid beacons specific to bicyclist crossings. Where hybrid beacons are installed as pedestrian crossing improvements only, practitioners are encouraged to follow 2009 MUTCD provisions.

High Intensity Activated Crosswalk (HAWK)

For pedestrian crossing of major streets, over 90 locations in Tucson, AZ

The High Intensity Activated Crosswalk (HAWK) beacon for bicyclist and pedestrian traffic was pioneered in Tucson, AZ and has been successfully installed at over ninety intersections throughout the city since 2004. Field studies conducted throughout the city have demonstrated improvements in safety and motorist behavior at intersections with HAWK signals and recently led MUTCD to incorporate these into their design manual. Signals have been prioritized at intersections with a high frequency of pedestrian crashes, including those near schools, shopping areas, and universities. While the HAWK has not been specifically tailored toward cyclists in Tucson, this signal is currently utilized for major bicycle crossings elsewhere in the country. The unit cost for each HAWK is $100,000, significantly cheaper than bicycle signal heads.

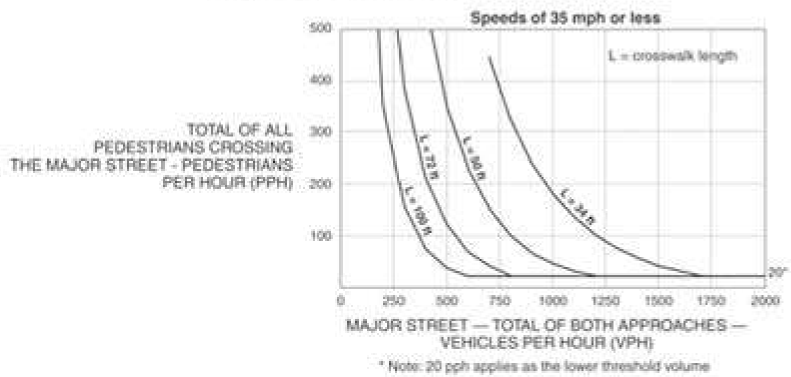
REQUIRED



The MUTCD provides warrants for the use of hybrid beacons based on motor vehicle speed, crossing length, motor vehicle volumes, and pedestrian volumes. These warrants do not explicitly consider bicyclists; however bicyclist crossing volumes may be added to pedestrian crossing volumes for the purposes of evaluating the warrant.

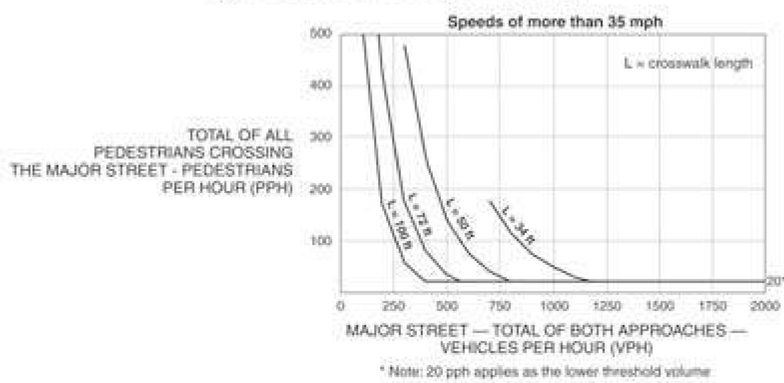
- For roads with speeds less than 35 miles per hour (MUTCD Figure 4F-1):

Figure 4F-1. Guidelines for the Installation of Pedestrian Hybrid Beacons on Low-Speed Roadways



- For roads with speeds greater than 35 miles per hour (MUTCD Figure 4F-2):

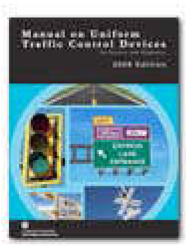
Figure 4F-2. Guidelines for the Installation of Pedestrian Hybrid Beacons on High-Speed Roadways



Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices.

REQUIRED (CONTINUED)

Engineering judgment and best practices should be used to ensure safe and appropriate signal timing for all phases. Appropriate yellow and red clearance intervals for bicycles should be calculated using the guidance provided for bike signals.



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

RECOMMENDED

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 solid red indication to bicyclists when the hybrid beacon is dark (i.e., the bicycle signal should not rest in dark). At locations where gaps are generally adequate outside of peak periods and passive signal detection is not used, a flashing red bicycle signal indication should be used when the hybrid signal is dark. This allows bicyclists to treat the intersection as a "Stop" and proceed without the requirement of activating the hybrid signal.

The 2009 MUTCD provides general guidance on establishing the length of flashing yellow and steady yellow phases; this guidance remains the same regardless of whether the hybrid beacon is used for a pedestrian crossing or bicycle crossing.

The operations associated with the clearance intervals for the minor street approaches differ considerably when a hybrid beacon is used to facilitate bicycle crossings as opposed to pedestrian crossings. The MUTCD specifies that the corresponding phase on the major street for the pedestrian clearance interval is alternating flashing red, which allows vehicle to stop and proceed if there is no pedestrian. In particular, because of the speed at which bicyclists can enter the intersection and because many bicyclists will actually speed up when presented with a flashing "DONT WALK" indication, hybrid beacons should maintain the solid red indication for motorists throughout the full bicycle clearance interval (yellow plus all-red).

See the Operations section (previous) for an example phasing diagram based on a Portland, Oregon, configuration, indicating how the solid red indication for drivers is maintained through bike clearance (phases 6 and 7).

The minimum length of the main street "rest in dark" interval should be set as short as possible to minimize bicyclist and pedestrian waiting time. Consider using a shorter minimum main street interval during off-peak periods than during peak periods.

RECOMMENDED (CONTINUED)

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.

Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices.

The installation should include suitable standard signs and pavement markings.

Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices.

If installed within a signal system, signal engineers should evaluate the need for the hybrid signal to be coordinated with other signals.

OPTIONAL

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.

> *The City of Madison published and distributed a brochure describing the function and operation of the Pedestrian Hybrid Beacon.*
>
> City of Madison, Wisconsin. Pedestrian & Bicyclist Hybrid Beacon.

H.A.W.K. Beacon at Burnside Street and 41st Avenue

Portland, OR

During the planning of the North-South Bikeway Project in Portland, OR, the city identified the need for signal modification at the intersection of Burnside St. and 41st Ave. Burnside St., which accommodates four lanes of traffic, had stood as a major barrier along one of the city's three planned continuous north-south bikeways, and extends to one of the only bicycle friendly crossings of the I-84 Freeway. The H.A.W.K (High intensity Activated crossWalK) beacon was pioneered by the Tucson, AZ Department of Transportation as a pedestrian crossing treatment, but in Portland is geared towards bicycle as well as pedestrian traffic. The beacon has a combined bicycle-pedestrian indication for crossing and provides no right turn signal protection on 41st Ave.

This project was designed and implemented by the Portland Bureau of Transportation in October 2006 at 41st Ave. and Burnside St. in Portland, Oregon. It was funded by a $140,000 Oregon Department of Transportation bike/ped grant.

Maintenance

- Hybrid signals 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.

Treatment Adoption and Professional Consensus

Hybrid signals have been implemented in several US cities, including the following:

- Tucson, AZ
- Phoenix, AZ
- Portland, OR
- Miami, FL
- Washington, DC

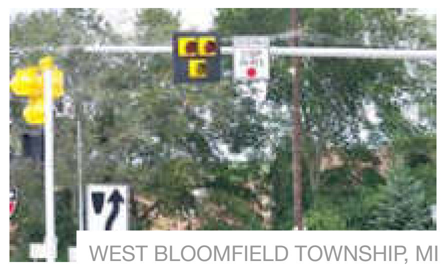
Image Gallery

PORTLAND, OR

PORTLAND, OR

PORTLAND, OR

PHOENIX, AZ



WEST BLOOMFIELD TOWNSHIP, MI

TUCSON, AZ

PHOENIX, AZ

PORTLAND, OR

IN THIS SECTION:

- Bike Route Wayfinding Signage and Markings System
- Colored Bike Facilities
- Shared Lane Markings

BIKEWAY SIGNING & MARKING

Bikeway Signing and Marking encompasses any treatment or piece of infrastructure whose primary purpose is either to indicate the presence of a bicycle facility or to distinguish that facility for bicyclists, motorists, and pedestrians. Bicycle signage includes several sub-categories. These include way-finding and route signage, regulatory signage, and warning signage. Some bicycle specific signage exists to provide motorized traffic with information and instruction.

Bikeway markings represent any device applied onto the pavement surface and intended to designate a specific right-of-way, direction, potential conflict area, or route option. These markings must take into consideration the use of particular colors, materials, and designs, as well as the legibility of these elements for motorists and pedestrians. Markings may be used to augment a particular lane, intersection, or signal treatment. In all cases, markings must strive for a high level of visibility, instant identification, and take into account both motorist and bicyclist movements in relation to the marking placement.

Bike Route Wayfinding

Signage and Markings System

A bicycle wayfinding system consists of comprehensive signing and/or pavement markings to guide bicyclists to their destinations along preferred bicycle routes. Signs are typically placed at decision points along bicycle routes – typically at the intersection of two or more bikeways and at other key locations leading to and along bicycle routes.

Types of Signs

There are three general types of wayfinding signs:

CONFIRMATION SIGNS

Berkeley, CA | Chicago, IL | Oakland, CA

PURPOSE

Indicate to bicyclists that they are on a designated bikeway. Make motorists aware of the bicycle route.

INFORMATION

Can include destinations and distance/time. Do not include arrows.

PLACEMENT

Every ¼ to ½ mile on off-street facilities and every 2 to 3 blocks along bicycle facilities, unless another type of sign is used (e.g., within 150 ft of a turn or decision sign). Should be placed soon after turns to confirm destination(s). Pavement markings can also act as confirmation that a bicyclist is on a preferred route.

TURN SIGNS

Concept | Chicago, IL | MUTCD

PURPOSE

Indicate where a bikeway turns from one street onto another street. Can be used with pavement markings.

INFORMATION

Include destinations and arrows.

PLACEMENT

Near-side of intersections where bike routes turn (e.g., where the street ceases to be a bicycle route or does not go through). Pavement markings can also indicate the need to turn to the bicyclist.

DECISION SIGNS

Oakland, CA

Concept

Portland Metro Cities, OR

PURPOSE

Mark the junction of two or more bikeways.
Inform bicyclists of the designated bike route to access key destinations.

INFORMATION

Destinations and arrows, distances, and travel times are optional but recommended.

PLACEMENT

Near-side of intersections in advance of a junction with another bicycle route.
Along a route to indicate a nearby destination.

Types of Destinations

Wayfinding signs can direct users to a number of different types of destinations, including the following:

- On-street bikeways
- Commercial centers
- Public transit centers and stations
- Schools
- Civic/community destinations
- Local or regional parks and trails
- Hospitals
- Bridges

Prior to developing the wayfinding signage, it can be useful to classify a list of destinations for inclusion on the signs based on their relative importance to users throughout the area. A particular destination's ranking in the hierarchy can be used to determine the physical distance from which the locations are signed. For example, primary destinations (such as the downtown area) may be included on signage up to five miles away. Secondary destinations (such as a transit station) may be included on signage up to two miles away. Tertiary destinations (such as a park) are more local in nature and may be included on signage up to one mile away.

Figure 1: Supported Destinations

Primary Destinations: distances up to five miles

7 destinations total (adjoining or en route jurisdictions, downtown)

Destination	Sign Content	Distance Measured From
Alameda	Alameda	city line
Berkeley	Berkeley	city line
Downtown	Downtown	Grand Ave, I-980, I-880, Oak/Lakeside/Harrison
Emeryville	Emeryville	city line
Moraga	Moraga	city line
Piedmont	Piedmont	city line
San Leandro	San Leandro	city line

Secondary Destinations: distances up to two miles

34 destinations total (10 BART stations, 4 other transit stations, 20 districts)

Destination	Sign Content	Distance Measured From
BART stations		
12th St BART	12th Street	12th St and Broadway
19th St BART	19th Street	19th St and Broadway
Ashby BART	Ashby	Adeline St and Woolsey St
Coliseum BART	Coliseum	San Leandro St and 73rd Ave
Fruitvale BART	Fruitvale	E 12th St and 34th Ave
Lake Merritt BART	Lake Merritt	Oak St and 9th St
MacArthur BART	MacArthur	40th St and Frontage Rd
Rockridge BART	Rockridge	College Ave and Shafter Ave
San Leandro BART	San Leandro	San Leandro St and Davis St
West Oakland BART	West Oakland	7th St and Center St
Other transit stations		
Alameda/Oakland Ferry	Oakland Ferry	Clay St and Water St
Coliseum Amtrak	Coliseum	73rd Ave and San Leandro St
Emeryville Amtrak	Emeryville	Horton St and 59th St
Jack London Amtrak	Jack London	2nd St and Alice St
Districts		
Chinatown	Chinatown	8th St and Webster St
Dimond	Dimond	MacArthur Blvd and Fruitvale Ave
Eastlake	Eastlake	E 12th St and 7th Ave
Eastmont	Eastmont	closest edge
Elmhurst	Elmhurst	94th Ave and Plymouth St
Fairfax	Fairfax	Bancroft Ave and Fairfax Ave
Glenview	Glenview	Park Blvd and Wellington St
Grand Lake	Grand Lake	Lake Park Ave and Walker Ave
Jack London Sq	Jack London Sq	Broadway and 2nd St
Laurel	Laurel	MacArthur Blvd and 38th Ave
Millsmont	Millsmont	MacArthur Blvd and Seminary Ave
Montclair	Montclair	Mountain Blvd and La Salle Ave
Oakmore	Oakmore	Leimert St and Oakmore Ave
Old Oakland	Old Oakland	9th St and Washington St
Park Street Business District (Alameda)	Park Street	Park St and Lincoln Ave
Piedmont Ave	Piedmont Ave	Piedmont Ave and 41st St
Rockridge	Rockridge	College Ave and Shafter Ave
Sobrante Park	Sobrante Park	105th Ave and Edes Ave
Temescal	Temescal	Telegraph Ave and 49th St
Woodminster	Woodminster	Mountain Blvd and Woodminster Ln

City of Oakland, California 9

City of Oakland. (2009). Design Guidelines for Bicycle Wayfinding Signage.

Pavement Markings

Pavement markings can be installed to help reinforce routes and directional signage and to provide bicyclist positioning and route branding benefits. Pavement markings may be useful where signs are difficult to see (due to vegetation or parked cars) and can help bicyclists navigate difficult turns and provide route reinforcement. In the United States, pavement markings have been experimented with in cities like Portland OR, and Berkeley, CA. Berkeley has applied a large stencil taking up nearly the entire travel lane designating the street as a 'bicycle boulevard.' In Portland, smaller stencils including a small circle and arrow system were initially used; however, since the adoption and wide spread use of the shared lane marking, most bicycle boulevards are being retrofitted with these larger markings. Portland has also applied the shared lane marking as a wayfinding device by turning the chevrons of the marking in the direction of intended travel.

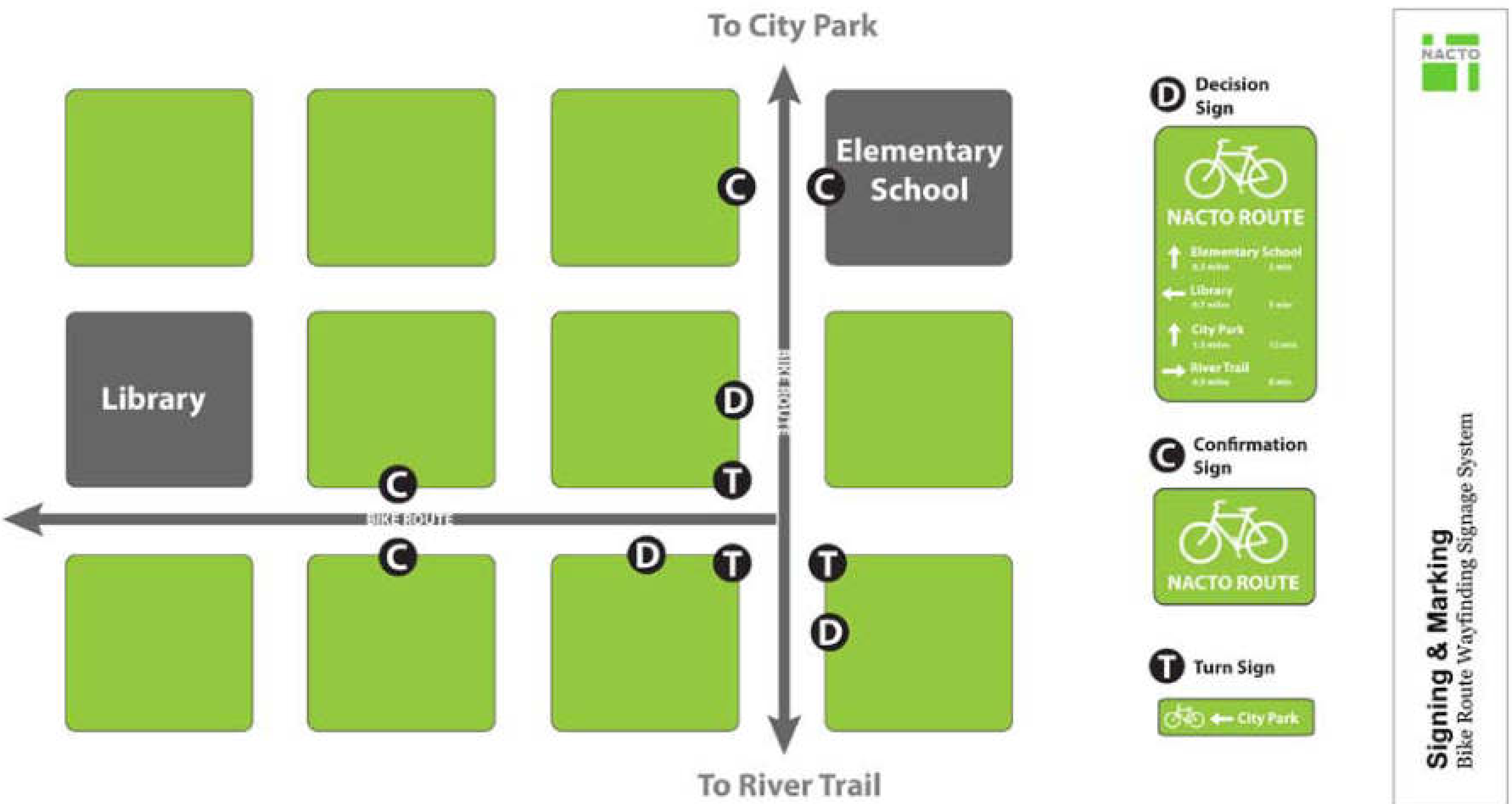
Wayfinding Signage Benefits

- Familiarizes users with the bicycle network.
- Identifys the best routes to destinations.
- Overcomes a "barrier to entry" for infrequent bicyclists.
- Signage that includes mileage and travel time to destinations may help minimize the tendency to overestimate the amount of time it takes to travel by bicycle.
- Visually indicates to motorists that they are driving along a bicycle route and should use caution.
- Passively markets the bicycle network by providing unique and consistent imagery throughout the jurisdiction.

Typical Applications

- Along all streets and/or bicycle facility types that are part of the bicycle network.
- Along corridors with circuitous bikeway facility routes to guide bicyclists to their intended destination.

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/WayfindingSignage_Plan1.jpg

REQUIRED

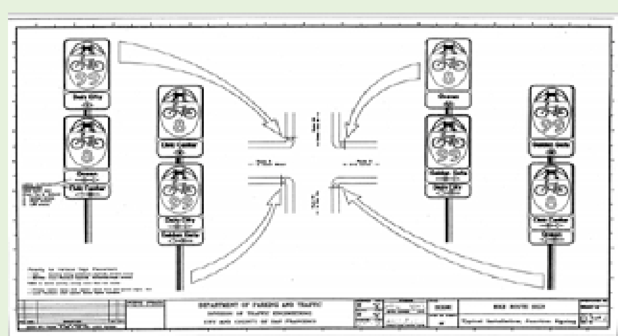
Follow MUTCD standards (Section 9B.01 – Application and Placement of Signs), including mounting height and lateral placement from edge of path or roadway. Additional standards and guidance are found in Section 9B.20 – Bicycle Guide Signs.

Bicycle Route and Sign System San Francisco, CA

In 1993, in response to growing interest in bicycling, the city of San Francisco, through its Bicycle Program within the Department of Parking and Traffic (DPT), designed a city-wide bicycle route network and comprehensive route signing system consisting of 3,100 new signs. The goal of the program was “to promote bicycle use by making the public more aware of the bicycle as a legitimate transportation mode” and to designate the safest, most direct, and flattest routes for bicyclists between major destinations. A customized bicycle route sign was designed and approved by the California Traffic Control Device Committee (CCTCDC). The signs include a white bicycle and route number on a green oval, and a graphic of the Golden Gate Bridge. The addition of color to the Bridge distinguishes “bicycle arterials” from local neighborhood routes. A route numbering system (with an included provision for anticipated network expansion) was based on the Federal Highway System . This system uses odd numbers for routes going in a north-south direction and even numbers for routes going east-west. Loops and spurs have three digit route numbers. Signs were placed in the sight line of the bicyclist at a standard height of seven feet whenever possible. An extension was created to attach bike route signage to existing STOP signs.

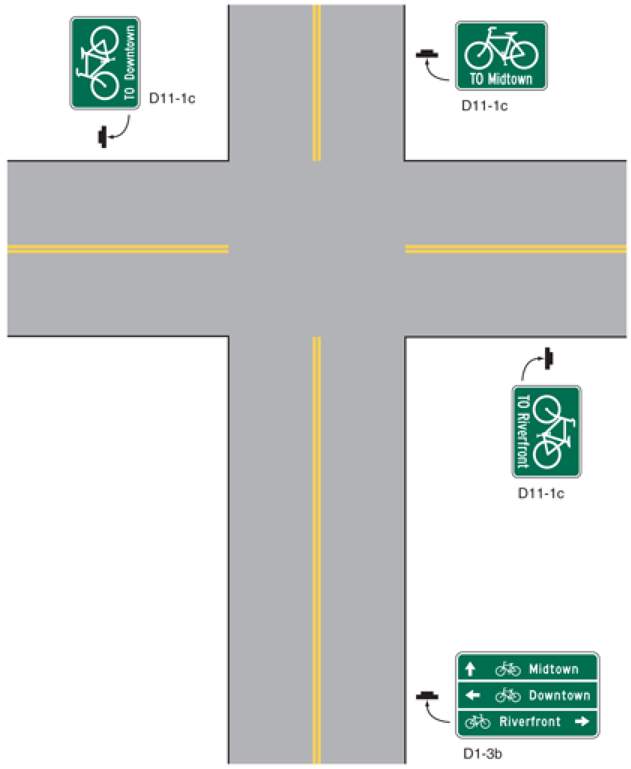
The project was originally estimated for completion within two years, but due to limited staffing at the Traffic Sign Division as well as other impediments, the city was unable to meet this goal. Following installation, the routes were surveyed to check that each made sense. Throughout the process, the city applied for a number of encroachment permits to install signs on State Highways and dealt with staff review and commission approval processes for internal jurisdictions, including Golden Gate Park, the Port of San Francisco, and the National Park Service.

The project was funded in part through an $85,000 state grant the city received in 1993. Installation of the 3,100 signs cost $24,000 with a unit price of $8.00 per three-color 12” x 18” sign. Each sign has a life expectancy of seven years. Yearly maintenance costs for the system are approximately $60,000.

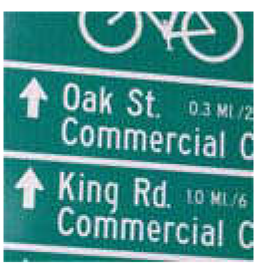


RECOMMENDED

Decision signs should be placed in advance of all turns (near side of the intersection) or decision points along the bicycle route.



Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices. Figure 9B-6.



Decision signs should include destinations, direction arrows, and distance. Travel time required to reach the destination provides bicyclists with additional information and may also be included. It is recommended that a 10 mph "urban average" bicycle speed be used for travel time calculations.

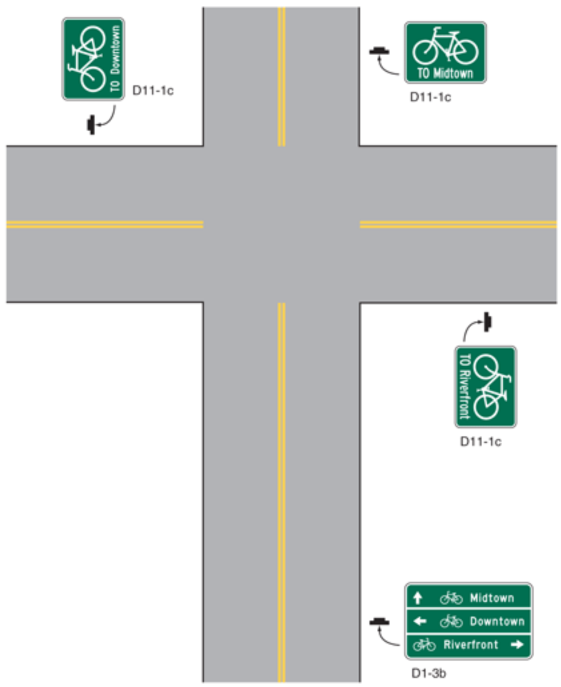
> *Bike Route Guide (D11-1) signs (see Figure 9B-4) may be provided along designated bicycle routes to inform bicyclists of bicycle route direction changes and to confirm route direction, distance, and destination.*

Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices. p. 798.

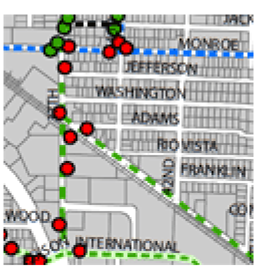
RECOMMENDED (CONTINUED)

Place the closest destination to each sign in the top slot. Destinations that are further away can be placed in slots two and three. This allows the nearest destination to “fall off” the sign and subsequent destinations to move up the sign as the bicyclist approaches. For longer routes, show intermediate destinations rather than include all destinations on a single sign.

Turn signs should be placed on the near-side of the intersection to indicate where the bike route turns.



Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices. Figure 9B-6.



Confirmation signs should be placed every ¼ to ½ mile along off-street bicycle routes or every 2 to 3 blocks along on-street routes, as well as on the far side of major street intersections.

RECOMMENDED (CONTINUED)

Clearview Hwy font is recommended, as it is commonly used for guide signs in the United States.

> *The Clearview Hwy typeface was granted interim approval by the FHWA for use on positive contrast road signs (light text on dark background) in September 2004 based on studies showing improved legibility.*
>
> Federal Highway Administration. (2004). Interim Approval for Use of Clearview Font for Positive Contrast Legends on Guide Signs.

Bicycle Route and Sign System Berkeley, CA

In 2002-03, the city of Berkeley undertook a comprehensive bicycle signage initiative to make way-finding easier on the city's new and existing bikeways and bicycle boulevards. Since many of the boulevards followed residential streets with few distinguishable landmarks or checkpoints, the city wanted to better distinguish these thoroughfares and provide more adequate guidance for bicyclists. The city opted to use a non-standard purple sign indicating key destinations and with a prominent and recognizable logo. Planning and placement was determined using four parameters—Destination, Direction, Distance, and Distinction—and signs were located at key decision points along the routes. In addition to these four parameters, the city used a "bread-crumb" approach to develop the system. Signage was painted on both sides, with one side offering directional assistance and the other a purple backdrop with a logo to reassure cyclists along the correct route.

Below is a basic synopsis of the Berkeley signage specifications and methodology:

SEVEN SIGN TYPES:

- Type 1A identifies route to motorists and cyclists
- Type 1B provides destinations, directions, distances, & route name
- Type 1C provides type 1B info plus intersecting route name(s)
- Type 1D provides direction when route changes
- Type 2 directs cyclists on parallel arterials to the bikeway
- Type 3 identifies the boulevard, replacing traditional street sign
- Type 4 notifies motorists that they are crossing a bicycle boulevard; placed in advance of intersection
- Destinations: various, including schools, shopping districts, BART stations & Amtrak, adjacent jurisdictions, trails & bikeways, parks, libraries, and post offices

SIGN LAYOUT & DESIGN

- Design Standard: Original design

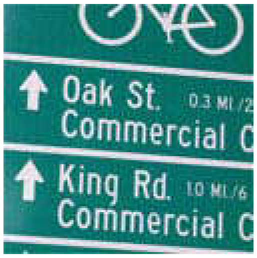
SIGN DIMENSIONS

- Types 1A-D: 20" wide x 30" high
- Type 2: 17" wide x 14" high
- Type 3: standard street sign sizes
- Type 4: 48" wide x 10" high
- Typeface: Helvetica Regular, mixed case
- Cap Height: 1.94" (140 points)
- Colors: White legend on Pantone Violet C background

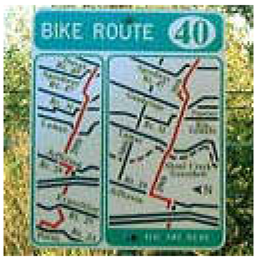
SIGN PLACEMENT

- Generally, Type 1A (Identity) Signs are placed on the bikeway at major street crossings, on the far-side of the intersection.
- Type 1B and 1C (Way_nding) Signs are placed at every midblock along the bikeway
- Type 3 (Street Identi_er) Signs are placed at every corner along the bikeway
- Types 1D and 2 are located as necessary.

OPTIONAL

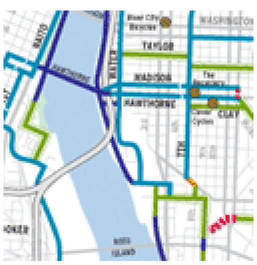


Signs may be placed on “feeder” streets between the bicycle route and nearby destinations.



Bicycle route map signs may be periodically placed along bike routes to provide additional wayfinding benefits to users.

Conventional street name signs along bicycle routes may be redesigned to incorporate the street’s identity as a bicycle route.



The placement of wayfinding signs may be limited specifically to the designated bicycle network, as other streets may be difficult or dangerous for bicyclists.

Pavement markings may be used to help reinforce routes and directional signage. Pavement markings may be useful where signs are difficult to see (due to vegetation or parked cars) and can help bicyclists navigate difficult turns and provide route reinforcement. Pavement markings may also be a standard component of bicycle routes.

OPTIONAL (CONTINUED)

Some wayfinding signage networks, such as those in San Francisco and Denver, utilize a route numbering system. Refer to MUTCD Section 9B.21 – Bicycle Route Signs for standards and options. Route numbering systems may not be intuitive for bicyclists without a map or directory.

There is no standard color for bicycle wayfinding signage. Section 1A.12 of the MUTCD establishes the general meaning for signage colors. Green is the color used for directional guidance and is the most common color of bicycle wayfinding signage in the US, including those included in the MUTCD.

> *The MUTCD defines the general meaning of 11 colors. Green is identified for use on direction guidance.*

Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices.

Signed bicycle routes may be partnered with a printed or on-line bicycle route map. Many online services,such as Google, now offer bicycle route mapping that may differ from signed routes. Cities may wish to consider such advancements in technology when planning wayfinding programs.

Maintenance

Maintenance needs for bicycle wayfinding signs are similar to other signs, and will need periodic replacement due to wear. Cities should maintain comprehensive inventories of the location and age of bicycle wayfinding signs to allow incorporation of bicycle wayfinding signs into any asset management activities. Maintenance for pavement markings are covered under shared lane markings.

Treatment Adoption and Professional Consensus

In the United States, the use of pavement markings to identify bikeways has been experimented with in Portland OR and Berkeley, CA. American cities with some implementation of advanced wayfinding and signing systems include the following:

- Albuquerque, NM
- Baltimore, MD
- Berkeley, CA
- Chicago, IL
- Davis, CA
- Emeryville, CA
- New York, NY
- Oakland, CA
- Portland, OR
- San Francisco, CA
- Seattle, WA
- Washington, DC
- Cambridge, MA
- Austin, TX

Bikeway Network Signage Portland, OR

The city of Portland, OR was awarded a federal grant to develop a comprehensive way-finding system for the Portland Bikeway Network. In April 2005, half of the planned 800 signs had been installed. The remainder of the project was funded using money from the Office of Transportation's Community and School Traffic Safety Program and a $1 million 2010 federal stimulus grant from the American Recovery and Reinvestment Act (ARRA).

The project identified over seventy destinations throughout the city of Portland, including districts, landmarks, the central library, colleges and universities, parks, and transit centers. Signage was placed at key intersections and decision points along the bike routes. Signs are 24" wide by 32" tall, with a similar width to MUTCD D11-1. They are green with white banners that indicate direction, destination, time, and distance. (Riding times on signs are based on a "no sweat" pace of 10 mph.) The signage is augmented by pavement markings that direct cyclists along the 60 miles of bicycle boulevards throughout Portland. Way-finding signage will help promote cycling in the city of Portland. In the future, signage may also include informational kiosks about cycling in and around Portland.

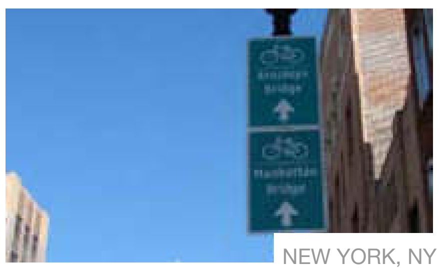
Image Gallery

PORTLAND, OR


PORTLAND, OR

SAN FRANCISCO, CA


NEW YORK, NY


NEW YORK, NY

SAN FRANCISCO, CA

SAN FRANCISCO, CA

BERKELEY, CA

BERKELEY, CA

BERKELEY, CA

Colored Bike Facilities

Colored pavement within a bicycle lane increases the visibility of the facility, identifies potential areas of conflict, and reinforces priority to bicyclists in conflict areas and in areas with pressure for illegal parking. Colored pavement is commonly applied at intersections, driveways, conflict areas, and along non-standard or enhanced facilities such as cycle tracks. Though rarely done in North America, color can be applied along the entire length of bicycle lanes to increase the overall visibility of the facility. Motorists are expected to yield right of way to bicyclists at these locations. Along bikeway corridors, color should be applied either in intersection conflict areas, or between conflict areas, or both; whichever approach is preferred, it is important to be consistent.

Colored Bike Facilities Benefits

- Promotes the multi-modal nature of a corridor.
- Increases the visibility of bicyclists.
- Discourages illegal parking in the bike lane.

> *Anecdotally, most cyclists like the green paint treatment and believe that it is more effective at keeping cars from parking in bike lanes than regular striping. In particular, cyclists cite the conspicuousness of cars parked in green painted lanes as a deterrent to drivers parking there.*

New York City Department of Transportation. (2011). Evaluation of Solid Green Bicycle Lanes, to Increase Compliance and Bicycle Safety.

- When used in conflict areas, raises motorist and bicyclist awareness to potential areas of conflict.

> *Bicyclists familiar with more traditional sharrows have noted that the additional emphasis resulting from the green pavement paint appears to be creating an heightened awareness by the motorists in the lane.*

City of Long Beach. (2010). Final Report: Second Street Sharrows and Green Lane in the City of Long Beach, California (RTE 9-113E).

- Increases bicyclist comfort though clearly delineated space.

> *Significantly fewer bicyclists slowed or stopped when approaching the conflict areas in the after period.*

Hunter, W.W. et al. (2000). Evaluation of Blue Bike-Lane Treatment in Portland, Oregon. Transportation Research Record, 1705, 107-115.

- Increases motorist yielding behavior.

> *"Significantly more motorists yielded to bicyclists after the blue pavement had been installed (92 percent in the after period versus 72 percent in the before period.*

Hunter, W.W. et al. (2000). Evaluation of Blue Bike-Lane Treatment in Portland, Oregon. Transportation Research Record, 1705, 107-115.

> *"A higher percentage of motorists yielded to bicycles in the after period (86.7% before versus 98.5% after). A chi-square test revealed the differences to be statistically significant at the 5% significance level ($p < 0.001$).*

William W. Hunter, W., Srinivasan, R., Martell, C. (2008). Evaluation of a Green Bike Lane Weaving Area in St. Petersburg, Florida. University of North Carolina Highway Safety Research Center.

> *The proportion of yielding events that were resolved by the motorist yielding to the bicyclist increased from 63% to 78% after the colored lane treatment was installed. Additionally, the proportion of motorists who used a turn signal before crossing the conflict zone when a bicyclist was present increased significantly from 38% to 74% after the colored lane treatment.*

Brady, J., Mills, A., Loskorn, J., Duthie, j., Machemehl, R., Center for Transportation Research. (2010). Effects of Colored Lane Markings on Bicyclist and Motorist Behavior at Conflict Areas. City of Austin, Texas.

- Helps reduce bicycle conflicts with turning motorists.

Best estimates for safety effects of one blue cycle crossing in a junction are a reduction of 10% in accidents and 19% in injuries.

Jensen, S. U. (2008). Safety effects of blue cycle crossings: A before-after study. Accident Analysis & Prevention, 40(2): 742-750.

Typical Applications

- Within bike lanes or cycle tracks.
- Across turning conflict areas such as vehicle right turn lanes.
- Across intersections, particularly through wide or complex intersections where the bicycle path may be unclear.

Overall, more cyclists followed the recommended path after the blue marking: 87 percent before versus 94 percent after.

Birk, M., Burchfield, R., Flecker, J., Hunter, W.W., Harkey, D.L., and Stewart, J.R. (1999). Portland's Blue Bike Lanes: Improved Safety Through Enhanced Visibility. City of Portland Office of Transportation.

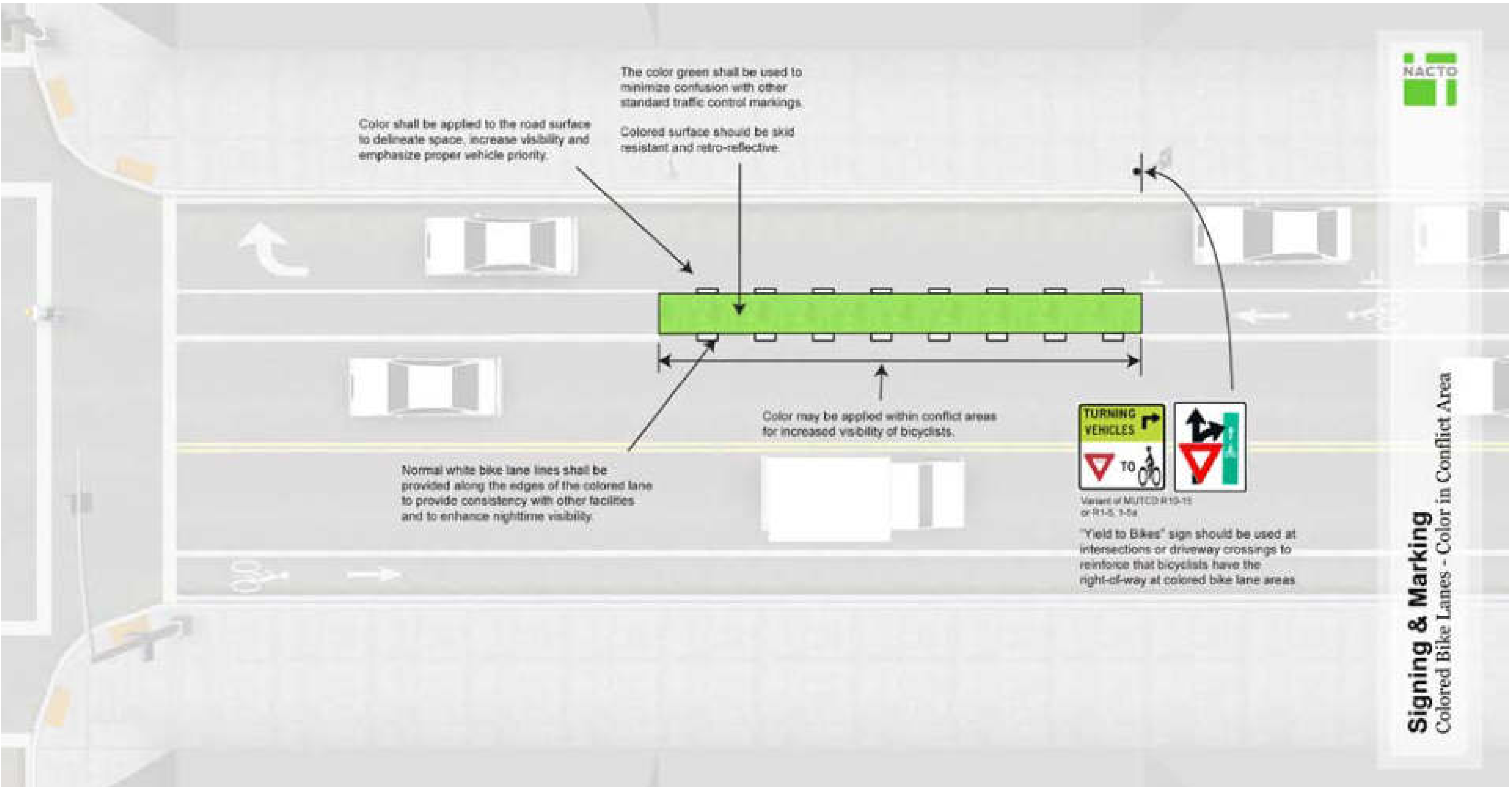
- Across driveways and Stop or Yield-controlled cross-streets.
- Where typical vehicle movements frequently encroach into bicycle space, such as across ramp-style exits and entries where the prevailing speed of turning traffic at the conflict point is low enough that motorist yielding behavior can be expected.
- Color may be applied along an entire corridor, with gaps in coloring to denote crossing areas.

"NYCDOT data indicates that the green paint treatment resulted in fewer instances of drivers encroaching on the bike lane by driving on the bike lane boundary line. Overall, 7% of drivers on the green paint treated streets drove on the bike lane boundary line as opposed to 16% of drivers on streets with the typical non-painted bike lane treatment. The data also showed fewer instances in driving in the bike lane; on average, 4% of drivers drove in the bike lane on green paint treated streets as opposed to 7% of typical streets.

New York City Department of Transportation. (2011). Evaluation of Solid Green Bicycle Lanes, to Increase Compliance and Bicycle Safety.

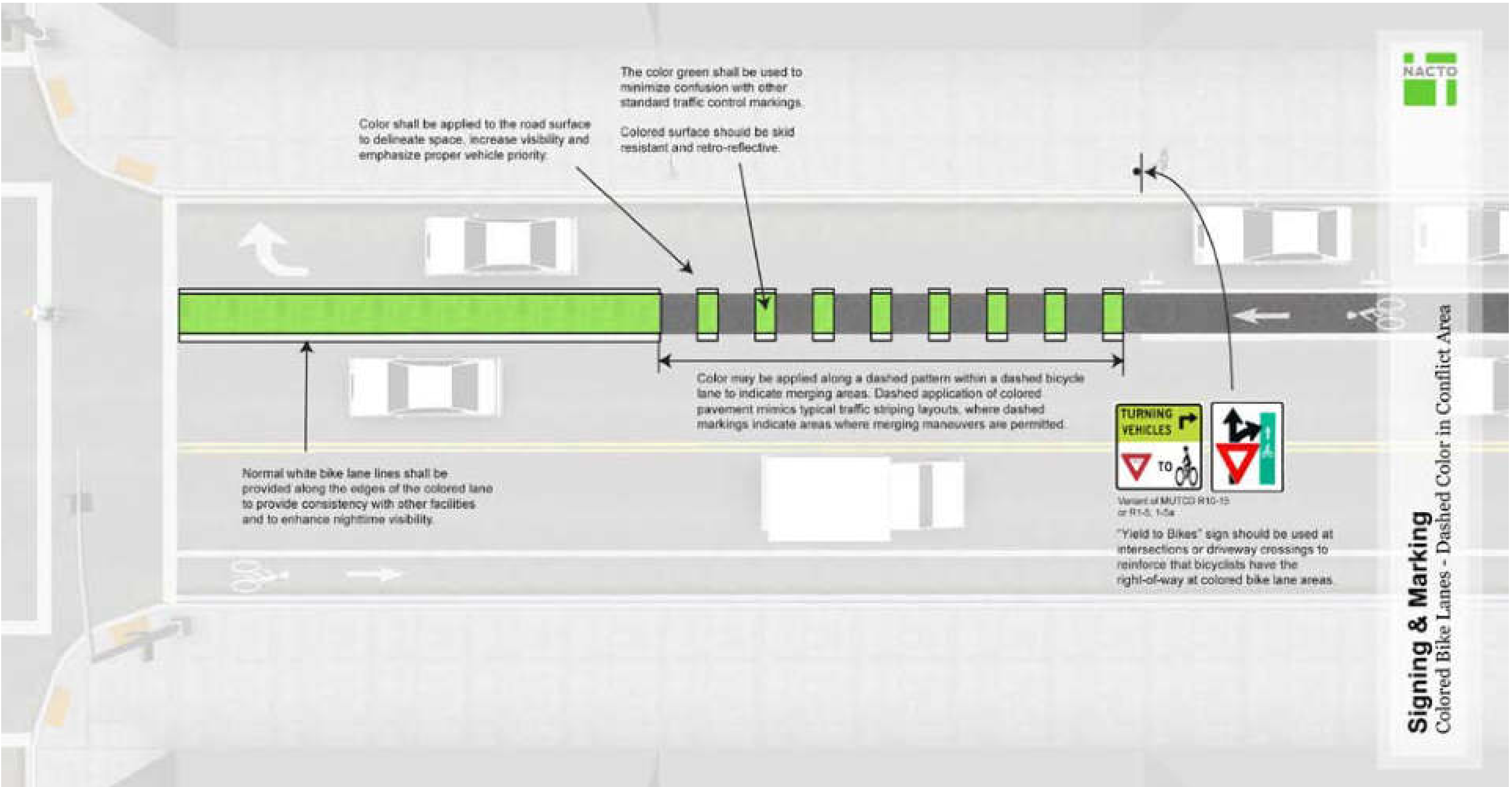
- Facility designers should match coloring strategy to desired design outcomes of projects.
- May not be applicable for crossings in which bicycles are expected to yield right of way, such as when the street with the bicycle route has Stop or Yield control at an intersection.

Design Guidance



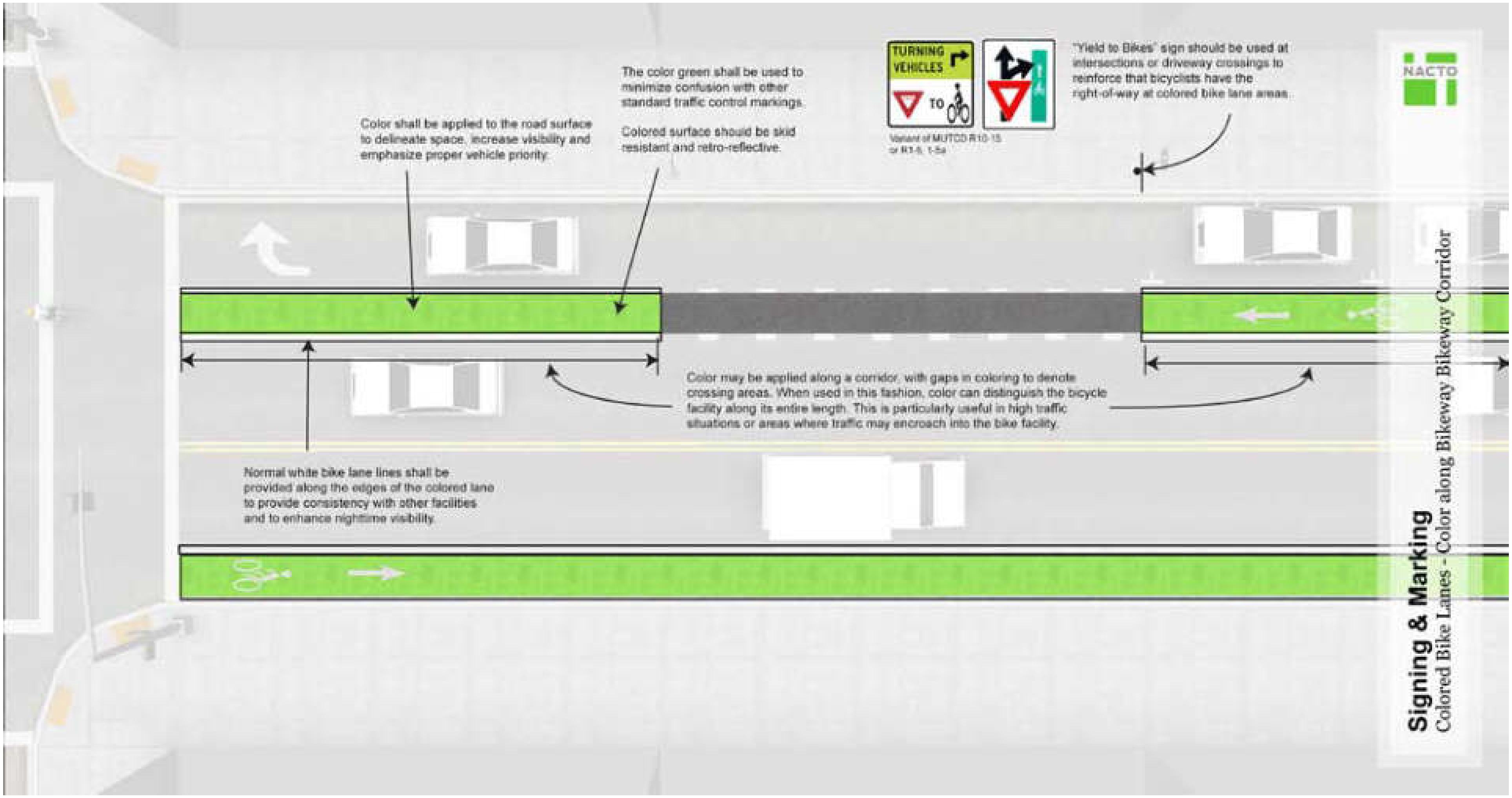
View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/ColoredBikeLanes_OptionA_Annotated.jpg

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/ColoredBikeLanes_OptionB_Annotated.jpg

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/ColoredBikeLanes_OptionC_Annotated.jpg

REQUIRED

The color green shall be used to minimize confusion with other standard traffic control markings.

> *Yellow, white, red, blue, and purple all have defined standard uses in the MUTCD.*

> *Blue is specifically discouraged for use on bicycle lanes to prevent confusion with parking for persons with disabilities.*

> *When used, blue markings shall supplement white markings for parking spaces for persons with disabilities.*

Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices. Section 3A.05.

Color shall be applied to the road surface to delineate space, increase visibility, and emphasize proper vehicle priority.

> *Significantly more motorists yielded to bicyclists after the blue pavement had been installed (92 percent in the after period versus 72 percent in the before period).*

Hunter, W.W. et al. (2000). Evaluation of Blue Bike-Lane Treatment in Portland, Oregon. Transportation Research Record, 1705, 107-115.

> *Best estimates for safety effects of one blue cycle crossing in a junction are a reduction of 10% in accidents and 19% in injuries.*

Jensen, S. U. (2008). Safety effects of blue cycle crossings: A before-after study. Accident Analysis & Prevention, 40(2): 742-750.

> *Bicyclists familiar with more traditional sharrows have noted that the additional emphasis resulting from the green pavement paint appears to be creating an heightened awareness by the motorists in the lane.*

City of Long Beach. (2010). Final Report: Second Street Sharrows and Green Lane in the City of Long Beach, California (RTE 9-113E).

Normal white bike lane lines shall be provided along the edges of the colored lane to provide consistency with other facilities and to enhance nighttime visibility.

Fell Street Queuing Lane and Green Bicycle Lanes

San Francisco, CA

Fell Street is a high-volume, three-lane, one-way arterial heading west. A Class II bike facility (bike lane) exists to the left of the left-most through vehicle lane on Fell Street. An Arco gas station popular for its low prices is located at the southeast intersection of Fell and Divisadero Streets and has two driveways on Fell Street. Queuing cars sometimes block the bike lane as they wait to enter the gas station, and cyclists are forced into the busy through lanes to the right of the bike lane. In addition to queues entering Arco, vehicles also cross the bike lane when turning onto Divisadero Street. In addition to the more important safety and circulation issues, queuing cars that blocked the bike lane forced cyclists into the vehicle lanes and around an in-pavement bicycle counter that had been installed in this block.

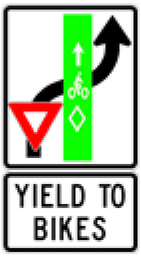
The San Francisco Municipal Transportation Agency (SFMTA) has made multiple attempts to discourage motorists from blocking the bike lane and to reduce the conflicts at this location. In late June 2010, the SFMTA removed parking to create a queuing lane for the gas station on the left of the bike lane. Additional outreach was done to motorists on site throughout July 2010. Finally, on August 3, 2010 the SFMTA painted the bike lane green (dashed where the solid white lines are dashed), in order to improve motorist awareness of the bicycle facility.

The results of the Fell Street treatment were positive. Observations of motorist behavior recorded during the evening peak period showed that cars queuing to enter the gas station were approximately 40% less likely to block the bike lane after the application of green paint.

A full description of the data collection process and results is detailed in SFMTA's evaluation: http://128.121.89.101/cms/rbikes/documents/Memo_2010-10-14_000.pdf

RECOMMENDED

The colored surface should be skid resistant and retro-reflective.



A "Yield to Bikes" sign should be used at intersections or driveway cross-ings to reinforce that bicyclists have the right-of-way at colored bike lane areas.

Variant of MUTCD R10-15 to include helmeted bicycle rider symbol (MUTCD figure 9C-3 B).

Alternate sign in common use, similar to MUTCD R1-5, 1-5a.

The configuration of color should be consistently applied throughout the corridor.

Green Shared Lane, 200 South Street

Salt Lake City, UT

The 200 South Street bike lanes in Salt Lake City extend a distance of approximately 3.9 miles from the University of Utah, through downtown, to the Jordan River Trail. The bike lanes are continuous except for a one block section downtown between Main St. and State St. A parking garage entrance/exit ramp on this block makes the street too narrow to add bike lanes. As a result, bicyclists must share the 12' outside lanes with automobiles while traversing the block. Since a 12' lane is too narrow for a motorist to pass a bicyclist within the lane while providing 3' of clearance as required by law, motorists should not attempt to pass bicyclists in the same travel lane on this block.

Salt Lake City has been working with the Federal Highway Administration (FHWA) to conduct a Shared Lane Markings experiment. The purpose of Shared Lane Markings is to remind motorists that bicyclists have the legal right to position themselves in the center of a travel lane when the lane is too narrow for a bicycle and automobile to safely travel side by side within the lane. The markings consist of a 4' wide green stripe in the center of the outside lane. White bike & chevron shared lane symbols have been painted at regular intervals on the top of the green stripe. The 4' width was chosen to keep the colored area inside of the wheel tracks and lessen the wear of car tires on the green apoxy paint.

Unlike other cities which have experimented with shared lane markings, Salt Lake City's experiment differs by the use of a green stripe centered in the travel lane instead of along the right edge of the lane. The city feels that the solid color stripe will further help to enforce the idea that bicyclists should lawfully ride in the center of the travel lane when conditions warrant. The green coloring is a highly durable, slip resistant coating specially developed for bicycle lanes. Data collected before and after the installation of the markings showed that bicyclists assumed a more central lateral position in the roadway. The city hopes to work with the FHWA to make the markings permanent and expand their use in the downtown area. Since the initial experiment on 200 South Street, Salt Lake City has done similar treatments on Main St. and South Temple St. in the downtown area.

OPTIONAL

Color may be applied within conflict areas for increased visibility of bicyclists.

Color may be applied along a dashed pattern within a dashed bicycle lane to indicate merging areas. Dashed application of colored pavement mimics typical traffic striping layouts, where dashed markings indicate areas where merging maneuvers are permitted.

> *The City of San Francisco is currently experimenting with dashed green bicycle lanes.*

The City and County of San Francisco. (2010). Evaluation of Solid and Dashed Green Pavement for Bicycle Lanes.

Color may be applied along a corridor, with gaps in coloring to denote crossing areas. When used in this fashion, color can distinguish the bicycle facility along its entire length. This is particularly useful in high traffic situations or areas where traffic may encroach into the bike facility.

> *NYCDOT data indicates that the green paint treatment resulted in fewer instances of drivers encroaching on the bike lane by driving on the bike lane boundary line. Overall, 7% of drivers on the green paint treated streets drove on the bike lane boundary line as opposed to 16% of drivers on streets with the typical non-painted bike lane treatment. The data also showed fewer instances in driving in the bike lane; on average, 4% of drivers drove in the bike lane on green paint treated streets as opposed to 7% of typical streets.*

New York City Department of Transportation. (2011). Evaluation of Solid Green Bicycle Lanes, to Increase Compliance and Bicycle Safety.

OPTIONAL (CONTINUED)

Color may be used to supplement shared lane markings for added visibility.

> *Salt Lake City, UT, and Long Beach, CA, have used a carpet of green coloring to create a lane-within-a-lane to indicate the priority area and preferred riding placement for bicyclists.*

> *The green lane facility has appeared to result in an approximate doubling of usage over the first 12 months of existence.*

> *Bicyclists familiar with more traditional sharrows have noted that the additional emphasis resulting from the green pavement paint appears to be creating an heightened awareness by the motorists in the lane.*

City of Long Beach. (2010). Final Report: Second Street Sharrows and Green Lane in the City of Long Beach, California (RTE 9-113E).

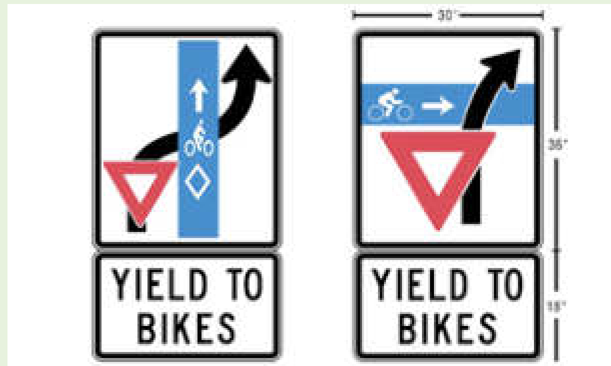
> *In an evaluation of a lane-within-a-lane treatment in Salt Lake City, researchers found that "eleven months after implementation, the fraction of in-street cyclists riding in the preferred zone, at least 4 ft from the curb, had risen from 17% to 92%.*

Furth, P., Dulaski, D. M., Bergenthal, D., Brown, S. (2011). More Than Sharrows: Lane-Within-A-Lane Bicycle Priority Treatments in Three U.S. Cities. Presented at the 2011 Annual Meeting of the Transportation Research Board.

Evaluation of Blue Bike Lanes

Portland, OR

In 1999, the city of Portland, in coordination with the University of North Carolina Highway Safety Research Center, released the results of a comprehensive study investigating the effectiveness of blue paint at enhancing safety and visibility at ten cyclist-motorist conflict intersections. The color blue was selected to avoid confusion with other colors which have significant meanings in traffic situations, such as yellow, red, and green. (Blue, it was noted, is also the color of disabled parking stalls.)



Sites selected each had a significant degree of interaction between bicyclists and motorists, and were grouped into three categories: Exit Ramps, Right Turn Lanes, Entrance Ramps. Color was subsequently applied in several phases to test the durability of different materials. Prominent 'Yield to Cyclists' signs were also installed at each intersection to warn motorists of oncoming bicycle traffic. Video data was recorded at each intersection and complemented by field and mail-in surveys of both cyclists and motorists.

The results of the study showed a significant, positive increase in the number of motorists yielding at the intersections (from 72 % to 92%), as well as increased comfort and perception of safety for cyclists at the intersection. Motorists acknowledged the signs and the blue color, and were, in the majority of cases, more likely to permit cyclists to safely pass.

Maintenance

- Colored pavement requires varying levels of maintenance depending on materials.
- Because the effectiveness of markings depends entirely on their visibility, maintaining markings should be a high priority.
- Colored facilities should be maintained to be free of potholes, broken glass, and other debris.

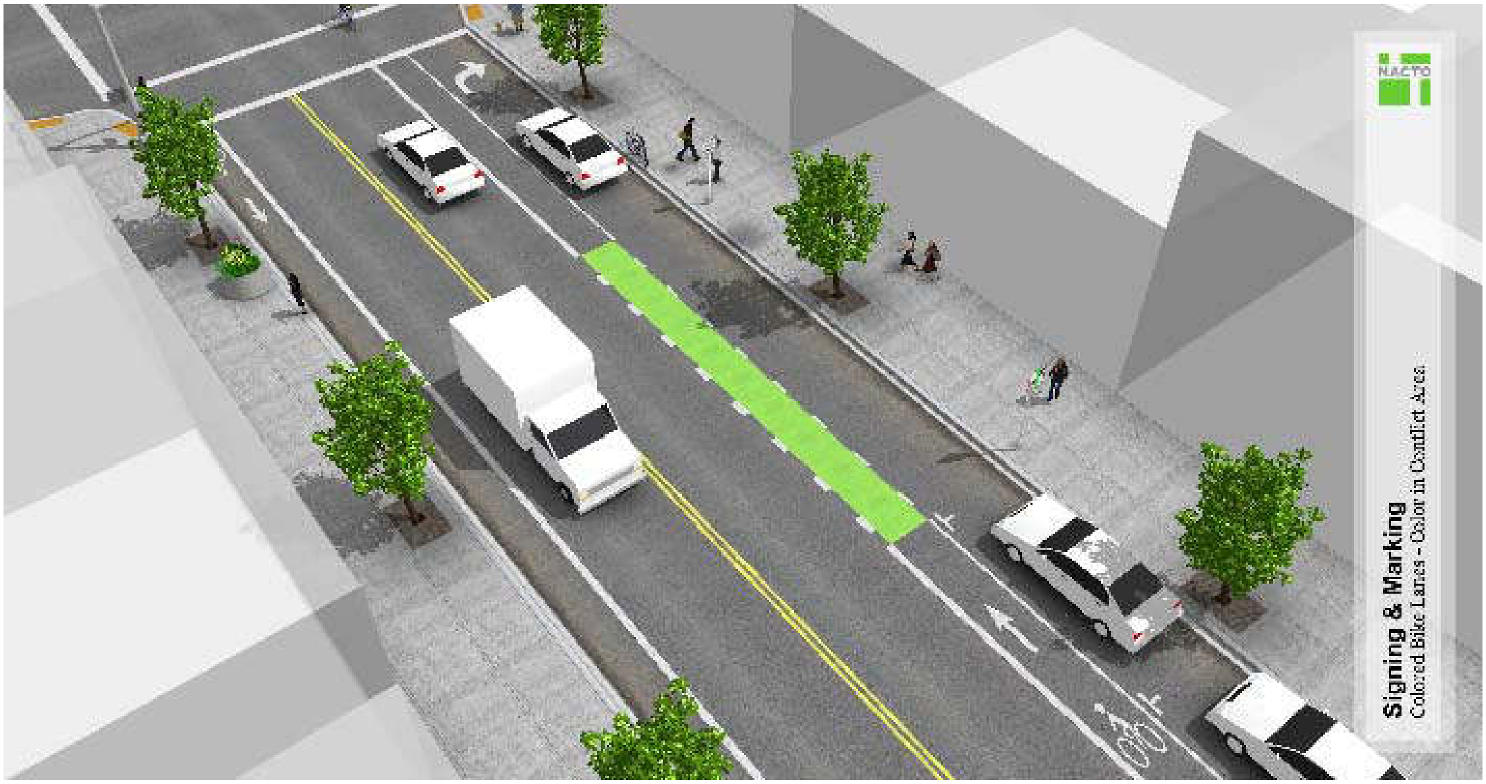
Treatment Adoption and Professional Consensus

Application of colored pavement is seen in the following US cities:

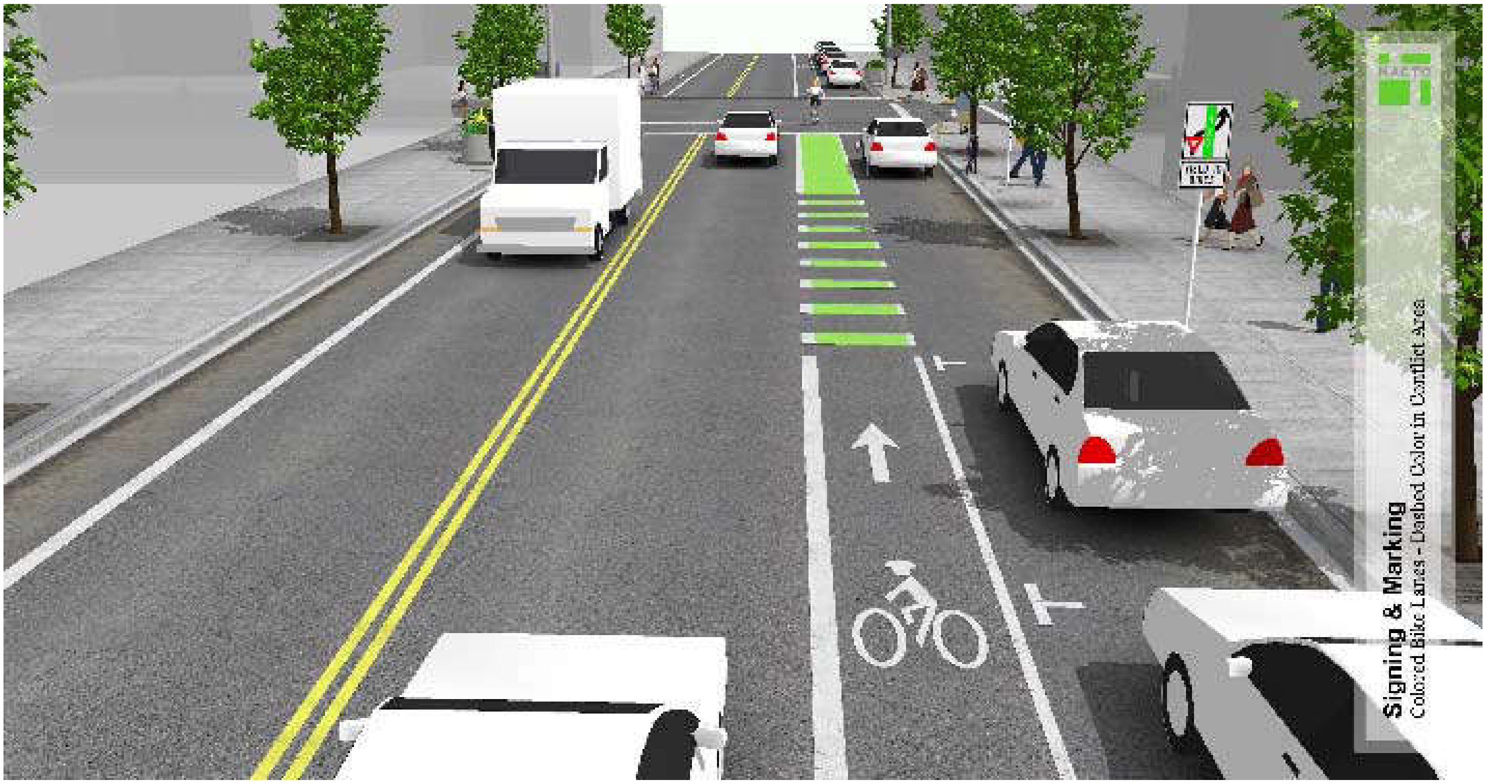
- Austin, TX
- Cambridge, MA
- Boston, MA
- Chicago, IL
- Columbia, MO
- Minneapolis, MN
- Missoula, MT
- New York, NY
- Portland, OR
- Salt Lake City, UT
- San Francisco, CA
- Seattle, WA
- Washington, DC

Renderings

The following images are 3D concepts of colored bicycle lanes. The configurations shown are based on San Francisco, CA, Portland, OR, and New York City examples.


Signing & Marking
Colored Bike Lanes - Color in Conflict Area


Signing & Marking
Colored Bike Lanes - Color along Bikeway Corridor


Signing & Marking
Colored Bike Lanes - Dashed Color in Conflict Area

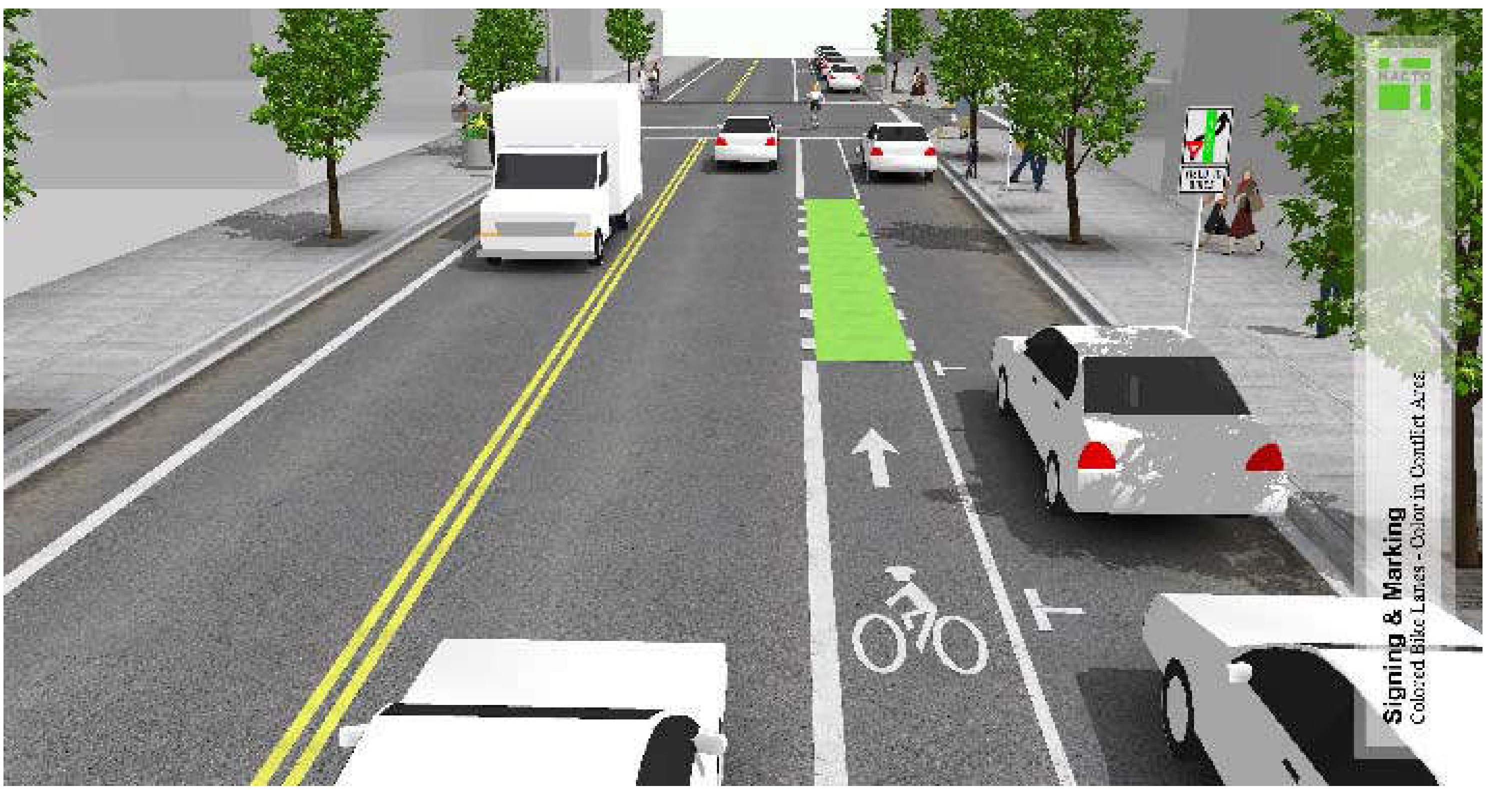

Signing & Marking
Colored Bike Lanes - Color in Conflict Area

Image Gallery


BOSTON, MA


SEATTLE, WA


CHICAGO, IL


NEW YORK, NY


PORTLAND, OR


NEW YORK, NY

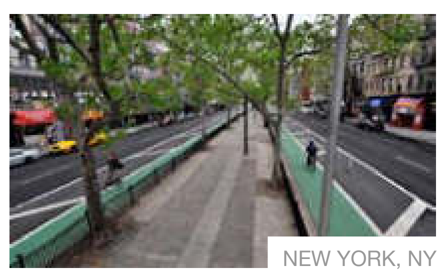

NEW YORK, NY

Image Gallery

SEATTLE, WA

AUSTIN, TX

AUSTIN, TX

SAN FRANCISCO, CA

AUSTIN, TX

NEW YORK, NY

Shared Lane Markings

Shared Lane Markings (SLMs), or "sharrows," are road markings used to indicate a shared lane environment for bicycles and automobiles. Among other benefits shared lane markings reinforce the legitimacy of bicycle traffic on the street and recommend proper bicyclist positioning. The shared lane marking is not a facility type, it is a pavement marking with a variety of uses to support a complete bikeway network. The MUTCD outlines guidance for shared lane markings in section 9C.07.

Shared Lane Marking Benefits

- Helps bicyclists position themselves safely in lanes too narrow for a motor vehicle and a bicycle to comfortably travel side by side within the same traffic lane.

> *"The average distance bicyclists rode from the edge of the lane (called lateral position) increased only marginally, usually between four and eight inches, but a large shift in the mode occurred along multiple sites—at least three feet in many cases."*
>
> The Center for Transportation Research, The University of Texas at Austin. (2010). Effects of Shared Lane Markings on Bicyclist and Motorist Behavior along Multi-Lane Facilities.

- Alerts motor vehicle drivers to the potential presence of bicyclists.
- Alerts road users of the lateral position bicyclists are likely to occupy within the street.
- Indicates a proper path for bicyclists through difficult or potentially hazardous situations such as railroad tracks.
- Advertises the presence of bikeway routes to all users.
- Provides a wayfinding element along bike routes.
- Increases the distance between bicyclists and parked cars, keeping bicyclists out of the "door zone."

> *Along Dean Keeton Street, where bicyclists rode alongside on-street parked vehicles, the marginal increase in lateral position resulted in a significant decrease in the percentage of bicyclists who rode within the range of an opening car door.*
>
> The Center for Transportation Research, The University of Texas at Austin. (2010). Effects of Shared Lane Markings on Bicyclist and Motorist Behavior along Multi-Lane Facilities.

> *Overall, the presence of a marking increased the distance of cyclists to parked cars by 8 inches.*

> *When passing vehicles were present, the markings caused an increase of 3 to 4 inches in the distance between cyclists and parked cars. In addition, the markings caused an increase of over 2 feet in the distance between cyclists and passing vehicles. The bike-and-chevron had a greater effect (by 3 inches) on the distance between cyclists and passing vehicles.*
>
> San Francisco Department of Parking and Traffic. (2004). San Francisco's Shared Lane Pavement Markings: Improving Bicycle Safety.

> *In the Cambridge, MA, study, the percentage of bicyclists who rode within 40 inches (i.e., near the door zone) of parked motor vehicles decreased.*
>
> Federal Highway Administration. (2010). Evaluation of Shared Lane Markings. FHWA-HRT-10-041.

- Encourages safe passing by motorists.

> *Regarding motorist behavior, motorists were more likely to change lanes when passing, less likely to pass, and less likely to encroach on the adjacent lane when passing, all of which indicate safer motorist behavior.*

The Center for Transportation Research, The University of Texas at Austin. (2010). Effects of Shared Lane Markings on Bicyclist and Motorist Behavior along Multi-Lane Facilities.

> *In the Chapel Hill, NC, experiment, motorists moved away from the markings, providing more operating space for bicyclists.*

Federal Highway Administration. (2010). Evaluation of Shared Lane Markings. FHWA-HRT-10-041.

- Requires no additional street space.
- Reduces the incidence of sidewalk riding.

> *Both the markings significantly reduced the number of sidewalk riders: the bike-and-chevron by 35% and the bike-in house by 25%.*

San Francisco Department of Parking and Traffic. (2004). San Francisco's Shared Lane Pavement Markings: Improving Bicycle Safety.

> *Before the arrow was placed, 39.3% of bicyclists rode in street, with traffic [versus on sidewalk.] After the arrow was placed, the proportion of bicyclists riding in street with traffic increased to 45.3%.*

Pein, W.E., Hunter, W.W., and Stewart, J.R. (1999). Evaluation of the Shared-Use Arrow. Florida Department of Transportation,Tallahassee, FL.

- Reduces the incidence of wrong-way bicycling.

> *The bike-and-chevron marking significantly reduced the number of wrong-way riders by 80%. The bike-in-house marking did not have any significant impact on the percentage of wrong-way riders.*

San Francisco Department of Parking and Traffic. (2004). San Francisco's Shared Lane Pavement Markings: Improving Bicycle Safety.

Typical Applications

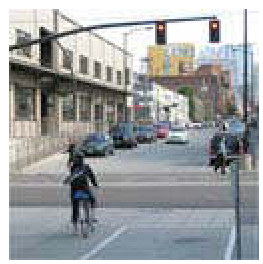
As shared lane markings are a relatively new bikeway marking in American cities, guidance on application will continue to evolve over time. Shared lane markings should not be considered a substitute for bike lanes, cycle tracks, or other separation treatments where these types of facilities are otherwise warranted or space permits. Shared lane markings can be used as a standard element in the development of bicycle boulevards to identify streets as bikeways and to provide wayfinding along the route.

DESIRABLE SHARED LANE MARKING APPLICATIONS

To indicate a shared lane situation where the speed differential between bicyclist and motorist travel speeds is very low, such as:

On bicycle boulevards or similar low volume, traffic calmed, shared streets with a designed speed of < 25 mph.

On downhill segments, preferably paired with an uphill bike lane. If space permits, consider a wide downhill bike lane.

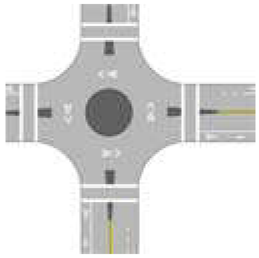


On streets where the traffic signals are timed for a bicycling travel speed of 12 to 15 miles per hour.

DESIRABLE SHARED LANE MARKING APPLICATIONS (CONTINUED)

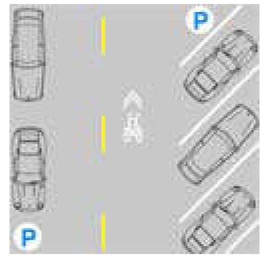
As a reasonable alternative to a bike lane:

Where street width can only accommodate a bicycle lane in one direction. On hills, lanes should be provided in the uphill direction.



Within single or multi-lane roundabouts.

> *"The complexity of vehicle interactions within a roundabout leaves a cyclist vulnerable, and for this reason, bike lanes within the circulatory roadway should never be used."*
>
> US Department of Transportation. (2000). Roundabouts: An Informational Guide. FHWA-RD-00-067.



Along front-in angled parking, where a bike lane is undesirable.

To strengthen connections in a bikeway network:

To fill a gap in an otherwise continuous bike path or bike lane, generally for a short distance.

To transition bicyclists from across traffic lanes or from conventional bike lanes or cycle tracks to a shared lane environment.

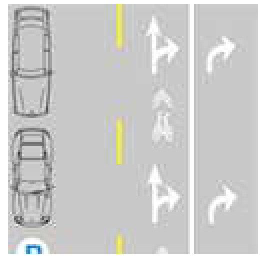
To direct bicyclists along circuitous routes.

DESIRABLE SHARED LANE MARKING APPLICATIONS (CONTINUED)

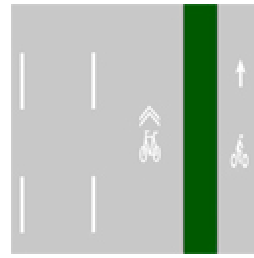
To clarify bicyclist movement and positioning in challenging environments:

To designate movement and positioning of bicycles through intersections.

To designate movement and positioning of bicyclists through a combined turn/ bike lane.



To assist bicyclists in taking the lane in the presence of a double turn lanes. Double turn lanes are undesirable for bicyclists.



In the street alongside separated bikeway facilities such as cycle tracks, to permit continued use of the street by confident bicyclists who prefer to ride in the street.

Generally, not appropriate on streets that have a speed limit above 35 mph.

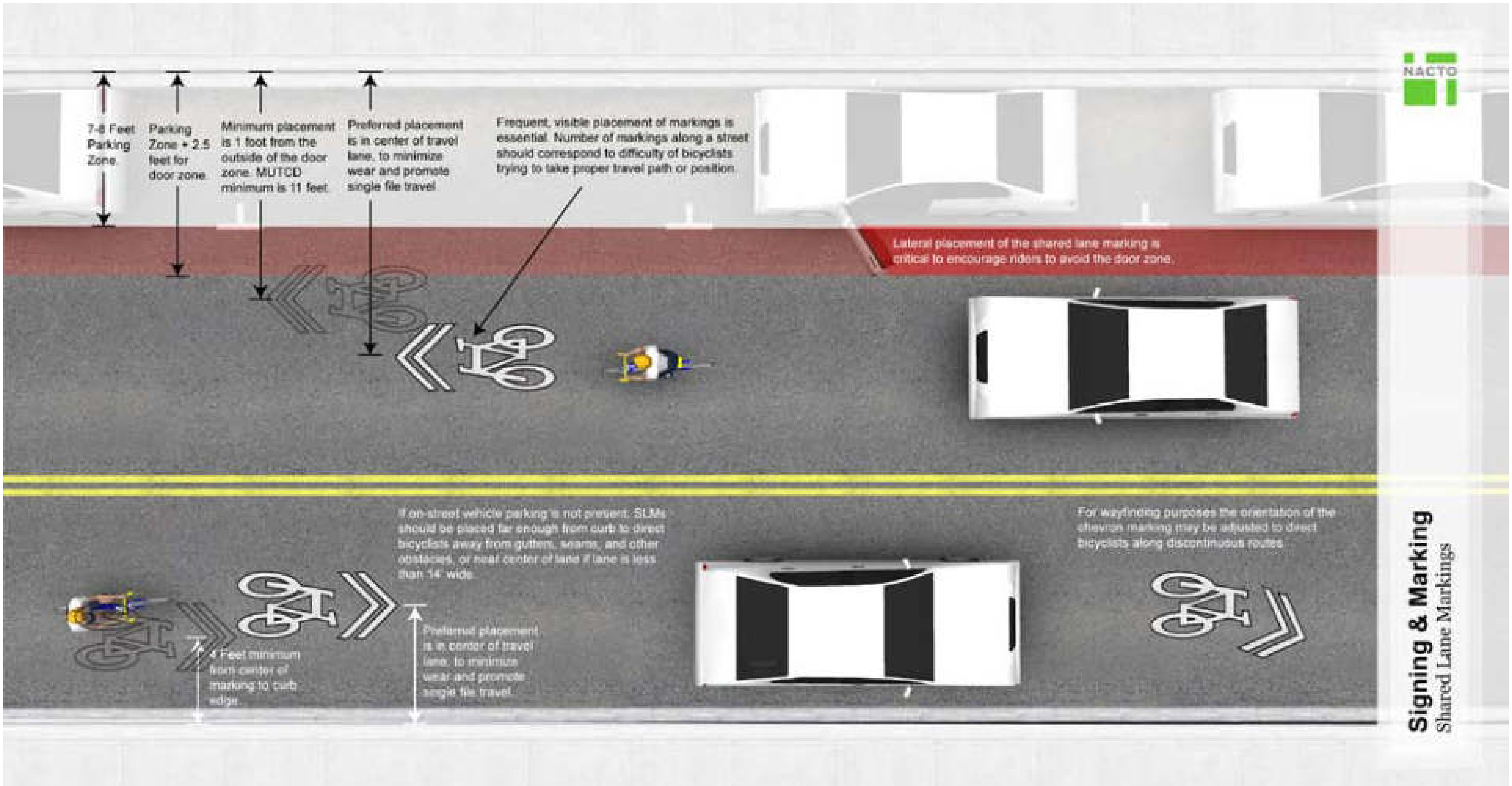
> *The Shared Lane Marking should not be placed on roadways that have a speed limit above 35 mph.*

Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices. Section 9C.07 02.

> *The Toronto Cycling Study (2010) found that while 72.5% of all existing bicyclists are comfortable riding on major roads with bike lanes, only 54% reported feeling comfortable on major roads with sharrow markings.*

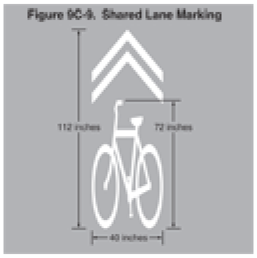
City of Toronto/Ipsos Reid. (2010). City of Toronto Cycling Study: Tracking Report (1999 and 2009).

Design Guidance



View a high resolution image here: http://nacto.org/wp-content/uploads/2010/08/Shared-Lane_Annotation.jpg

REQUIRED



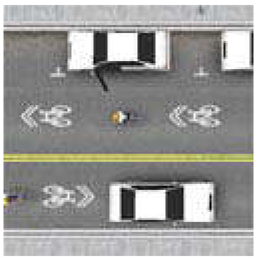
The Shared Lane Marking in use within the United States is the bike-and-chevron "sharrow," illustrated in MUTCD figure 9C-9.

Shared Lane Markings shall not be used on shoulders, in designated bicycle lanes, or to designate bicycle detection at signalized intersections. (MUTCD 9C.07 03)

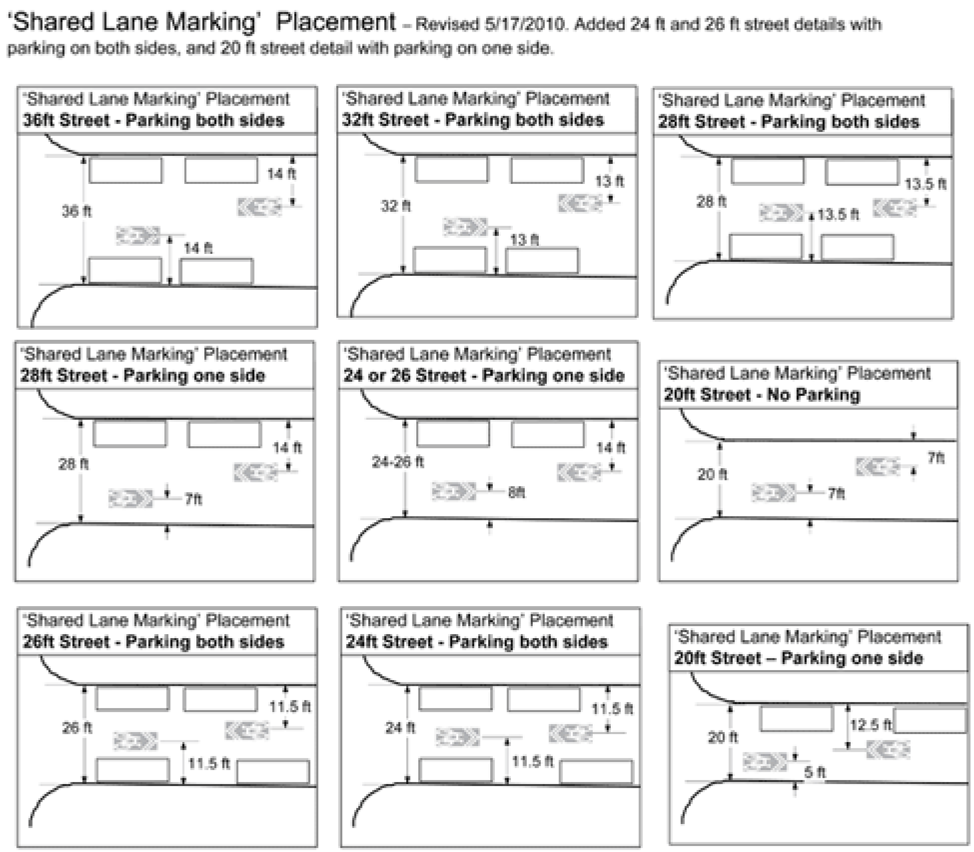
Second Street Sharrows and Green Lane Long Beach, CA

Second Street in the Belmont Shore area of Long Beach, California is a busy corridor which runs parallel to the beach. Many cyclists use the route as a connection between the beach, Orange County, and Ocean Boulevard. The street has significant motorized and pedestrian traffic, and bicyclists often choose to bicycle on the sidewalk rather than in the street. Since Second Street did not have sufficient room for a bike lane, in 2009, the city of Long Beach received FHWA and CTCDC approval to experiment with a shared lane marking that is set within a 5' green painted area at the midpoint of the roadway in the left-most and right-most lanes. A study conducted as part of the experiment measured an 100% increase in cyclists and an improvement in bicyclist lateral position in the roadway.

RECOMMENDED

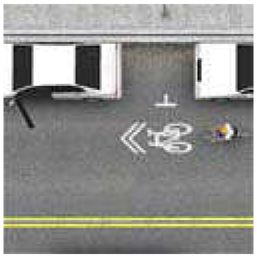


Frequent, visible placement of markings is essential. The number of markings along a street should correspond to the difficulty bicyclists experience taking the proper travel path or position. SLMs used to bridge discontinuous bicycle facilities or along busier streets should be placed more frequently (50 to 100 feet) than along low traffic bicycle routes (up to 250 feet or more). SLMs used along low volume routes can be staggered by direction to provide markings closer together.



Portland Bureau of Transportation. (2011). Wayfinding Sharrow Guidelines.

RECOMMENDED (CONTINUED)



Lateral placement is critical to encourage riders to avoid the "door zone." Preferred placement is in the center of the travel lane to minimize wear and promote single file travel. Minimum placement when the parking lane is present is 11 feet from the curb edge.

> *When sharrows were placed in the center of the lane, a significant change occurred in average bicyclist lateral position, away from the curb and towards the center of the lane. This result was significant both when bicyclists were being passed by motor vehicles and when no passing was occurring, but was more pronounced in the latter instance.*
>
> The Center for Transportation Research, The University of Texas at Austin. (2010). Effects of Shared Lane Markings on Bicyclist and Motorist Behavior along Multi-Lane Facilities.

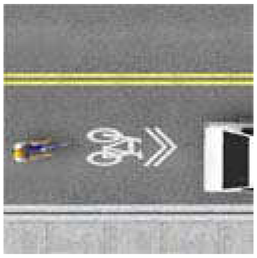
PLACEMENT GUIDELINES FOR SAN FRANCISCO

Laterally:

- 11' minimum with parking
- 11.5' general standard with parking
- May increase if higher cycling speeds are expected
- SFMTA. (2008). Shared Lane Markings: When and Where to Use Them. Presented at Pro Walk/Pro Bike 2008.

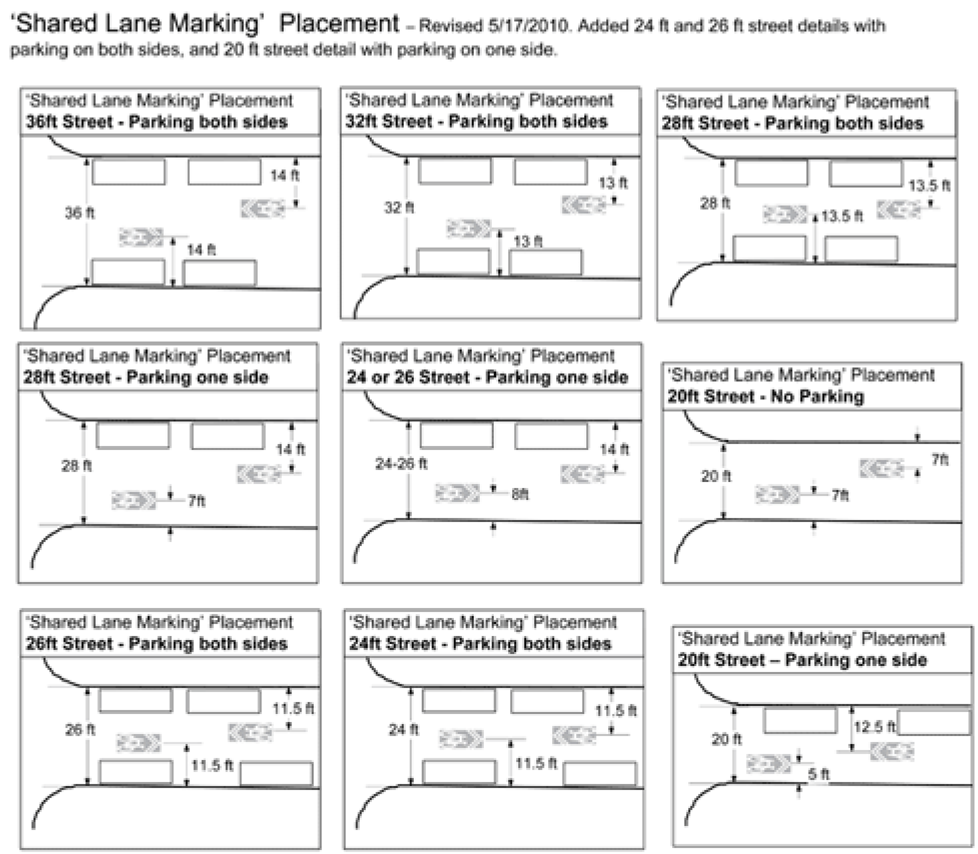
> *If used in a shared lane with on-street parallel parking, Shared Lane Markings should be placed so that the centers of the markings are at least 11 feet from the face of the curb or from the edge of the pavement where there is no curb.*
>
> Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices.

RECOMMENDED (CONTINUED)



If on-street vehicle parking is not present, SLMs should be placed far enough from the curb to direct bicyclists away from gutters, seams, and other obstacles, or near the center of the lane if the lane is less than 14 feet wide. Preferred placement is in the center of the travel lane to minimize wear and promote single file travel. Minimum distance from a curb is 4 feet.

SFMTA. (2008). Shared Lane Markings: When and Where to Use Them. Presented at Pro Walk/Pro Bike 2008.



Portland Bureau of Transportation. (2011). Wayfinding Sharrow Guidelines.

> *If used on a street without on-street parking that has an outside travel lane that is less than 14 feet wide, the centers of the Shared Lane Markings should be at least 4 feet from the face of the curb or from the edge of the pavement where there is no curb.*

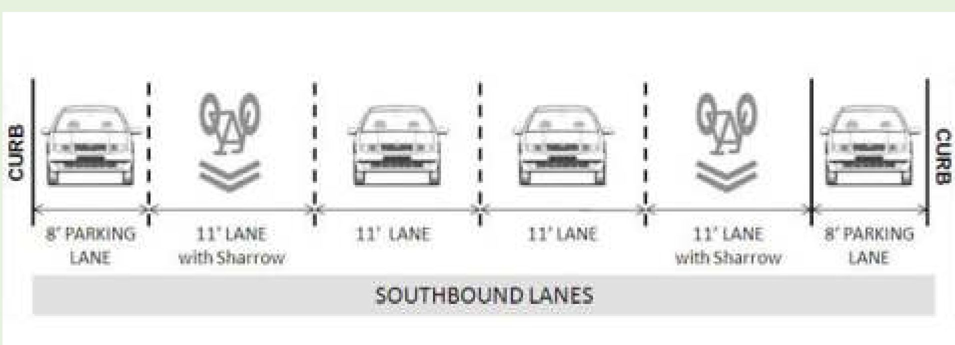
Federal Highway Administration. (2009). Manual on Uniform Traffic Control Devices.

Evaluation of Shared Lane Markings on Guadalupe Street Austin, TX

In 2009, as part of an experiment coordinated between the Austin Street Smarts Task Force and the University of Texas' Center for Transportation Research Center, the city of Austin installed shared lane markings on four multi-lane roadways to evaluate their impact on cyclist and motorist behaviors. Streets included in the study were all deemed too narrow to support bike lanes, which have been installed on many streets throughout Austin.

Guadalupe Street, between W 20th St. and W Cesar Chavez St., is a four lane, one-way southbound arterial extending from the southern edge of the University of Texas campus into downtown Austin. Before the study, the corridor was popular with cyclists despite its designation as a 'low ease-of-use street for bicyclists.' It has peak-hour traffic volumes of 1,650 vehicles and a 30 mph speed limit. Bike and chevron shared lane markings were installed in the center of the right-most and left-most vehicle lanes 5.5' from the parking lane to avoid the door zone at the center of each block. The results of the study demonstrated improved safety of the roadway, as well as a better bicyclist lateral position in the center of the lane instead of near the curb.

Images from:
Brady, J., Mills, A., Loskorn, J., Duthie, J., Machemehl, R., Center for Transportation Research. (2010). Effects of Shared Lane Markings on Bicyclist and Motorist Behavior along Multi-Lane Facilities. City of Austin.



OPTIONAL

For wayfinding purposes the orientation of the chevron marking may be adjusted to direct bicyclists along discontinuous routes.

Color may be used to enhance the visibility of the shared lane marking. Salt Lake City, UT, and Long Beach, CA, have used a carpet of green coloring to create a lane-within-a-lane to indicate the priority area and preferred riding placement for bicyclists.

> *The green lane facility has appeared to result in an approximate doubling of usage over the first 12 months of existence.*

> *Bicyclists familiar with more traditional sharrows have noted that the additional emphasis resulting from the green pavement paint appears to be creating an heightened awareness by the motorists in the lane.*

City of Long Beach. (2010). Final Report: Second Street Sharrows and Green Lane in the City of Long Beach, California. RTE 9-113E.

> *In an evaluation of a lane-within-a-lane treatment in Sald Lake City, researches found that "Eleven months after implementation, the fraction of in-street cyclists riding in the preferred zone, at least 4 ft from the curb, had risen from 17% to 92%."*

Furth, P., Dulaski, D. M., Bergenthal, D., Brown, S. (2011). More Than Sharrows: Lane-Within-A-Lane Bicycle Priority Treatments in Three U.S. Cities. Presented at the 2011 Annual Meeting of the Transportation Research Board.

Dotted line markings may accompany the shared lane marking to encourage bicyclists to ride in the center of the shared lane.

Configurations in Brookline, MA, have used dotted lines to create a lane-within-a-lane to indicate the priority area and preferred riding placement for bicyclists.

> *The lane-within-a-lane treatment appears to be effective in bringing about a shift in bicyclist position away from right-side hazards.*

Furth, P., Dulaski, D. M., Bergenthal, D., Brown, S. (2011). More Than Sharrows: Lane-Within-A-Lane Bicycle Priority Treatments in Three U.S. Cities. Presented at the 2011 Annual Meeting of the Transportation Research Board.

Maintenance

- Colored pavement requires varying levels of maintenance depending on materials.
- Because the effectiveness of markings depends entirely on their visibility, maintaining markings should be a high priority.
- Colored facilities should be maintained to be free of potholes, broken glass, and other debris.

Treatment Adoption and Professional Consensus

Application of colored pavement is seen in the following US cities:

- Austin, TX
- Cambridge, MA
- Boston, MA
- Chicago, IL
- Columbia, MO
- Minneapolis, MN
- Missoula, MT
- New York, NY
- Portland, OR
- Salt Lake City, UT
- San Francisco, CA
- Seattle, WA
- Washington, DC

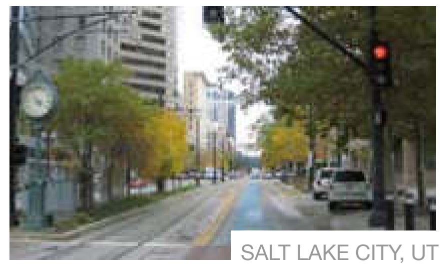
Evaluation of Shared Lane Pavement Markings San Francisco, CA

In 2004, the San Francisco Department of Parking and Traffic conducted a study on the effects of different types of shared lane markings on cyclist and motorist behavior. Using before and after videotape data, the city investigated the impact of three different markings- bike-in-house, bike & chevron, and bike & separate arrow- to evaluate how each effected a cyclist's lateral position in the roadway and motorist behaviors. The six sites included in the study were Polk St., 17th St., 2nd St., Market St., JFK Drive, and Stanyan St. Each of these roadways had a moderate-to-high Average Daily Traffic (ADT) level and was heavily used by recreational and utilitarian cyclists. The centerline of each marking was placed 11' from the curb and 4' from parked cars.

The study made several conclusions regarding the positive impacts of shared lane markings. On average, cyclists increased their riding distance to parked cars by 8", thus reducing the risks of dooring. In the presence of passing cars, this margin increased by 3 to 4". The bike and chevron symbol proved most successful in the study, though all of the markings increased motorists' awareness of cyclists.

Image Gallery


BROOKLINE, MA


SALT LAKE CITY, UT


PORTLAND, OR


PORTLAND, OR


SALT LAKE CITY, UT


LONG BEACH, CA


LONG BEACH, CA


NEW YORK, NY


PORTLAND, OR


PORTLAND, OR

MASTER REFERENCE MATRIX

	BIKE LANES	Conventional Bike Lane	Buffered Bike Lane	Contra-flow Bike Lane	Left-Side Bike Lane	CYCLE TRACKS	Protected Cycle Track	Raised Cycle Track	Two-way Cycle Tracks	INTERSECTION TREATMENTS	Bike Box	Intersection Crossing Markings	Two-stage Turn Queue Boxes	Median Refuge Island	Through Bike Lanes	Combined Bike/Turn Lane	Cycle Track Intersection Approach	BICYCLE SIGNALS	Bike Signal Heads	Signal Detection / Actuation	Active Warning Beacon	Hybrid Signal	SIGNING & MARKING	Bike Route Way-Finding	Colored Bike Facilities	Shared Lane Markings
NACTO MEMBER RESOURCES																										
Austin Street Smarts Task Force-Bicycle Facilities Toolbox		+	+								+				+				+	+					+	+
Baltimore Bicycle Facilities Toolkit		+	+	+							+									+				+		+
Chicago Bike Lane Design Guide		+													+											
District of Columbia Bicycle Master Plan		+									+				+											
District Department of Transportation Bicycle Facility Design Guide		+									+	+		+	+					+						+
City of Detroit Non-Motorized Transportation Plan		+																							+	
Los Angeles Bicycle Master Plan Technical Design Handbook		+	+	+	+		+	+			+			+	+				+	+				+	+	+
Minneapolis Bicycle Facility Manual Ch 9 Innovation		+	+	+	+		+	+	+		+	+		+		+			+	+				+	+	+
New York City Bicycle Master Plan		+		+				+							+				+						+	
Portland Bicycle Plan for 2030: Survey of Best Practices		+	+	+			+	+			+	+	+	+		+	+		+		+	+		+	+	+
San Francisco Supplemental Design Guidelines		+	+	+	+		+				+	+				+								+	+	+
Seattle Bicycle Master Plan			+												+											+
NATIONAL GUIDES																										
AASHTO Guide for the Development of Bicycle Facilities		+												+	+											
Manual on Uniform Traffic Control Devices		+													+									+		+

RESEARCH AND STUDIES	BIKE LANES	Conventional Bike Lane	Buffered Bike Lane	Contra-flow Bike Lane	Left-Side Bike Lane	CYCLE TRACKS	Protected Cycle Track	Raised Cycle Track	Two-way Cycle Tracks	INTERSECTION TREATMENTS	Bike Box	Intersection Crossing Markings	Two-stage Turn Queue Boxes	Median Refuge Island	Through Bike Lanes	Combined Bike/Turn Lane	Cycle Track Intersection Approach	BICYCLE SIGNALS	Bike Signal Heads	Signal Detection / Actuation	Active Warning Beacon	Hybrid Signal	SIGNING & MARKING	Bike Route Way-Finding	Colored Bike Facilities	Shared Lane Markings
Advanced Stop Line Variations Research Study, Report No. 503 1271. By Atkins Service.											+															
Behaviour at Cycle Advanced Stop Lines Report No. PPR240. By Allen, D., S. Bygrave, and H. Harper.											+															
Bicycle Storage Areas and Advanced Bicycle Stop Lines. By RTA.											+															
City of Toronto Cycling Study: Tracking Report (1999 and 2009). By Ipsos Reid.																										+
Coloured Bicycle Lanes Simulator Testing. File 785. By Transportation Association of Canada.												+													+	
Cycle Tracks: Lessons Learned. By Alta Planning & Design, Burchfield, R..							+	+	+								+									
Effects of Bicycle Boxes on Bicyclist and Motorist Behavior at Intersections. By Brady, J., Mills, A., Loskorn, J., Duthie, j., Machemehl, R., Center for Transportation Research.											+															
Effects of Colored Lane Markings on Bicyclist and Motorist Behavior at Conflict Areas. By Brady, J., Mills, A., Loskorn, J., Duthie, j., Machemehl, R., Center for Transportation Research.															+										+	

RESEARCH AND STUDIES (CONTINUED)	BIKE LANES	Conventional Bike Lane	Buffered Bike Lane	Contra-flow Bike Lane	Left-Side Bike Lane	CYCLE TRACKS	Protected Cycle Track	Raised Cycle Track	Two-way Cycle Tracks	INTERSECTION TREATMENTS	Bike Box	Intersection Crossing Markings	Two-stage Turn Queue Boxes	Median Refuge Island	Through Bike Lanes	Combined Bike/Turn Lane	Cycle Track Intersection Approach	BICYCLE SIGNALS	Bike Signal Heads	Signal Detection / Actuation	Active Warning Beacon	Hybrid Signal	SIGNING & MARKING	Bike Route Way-Finding	Colored Bike Facilities	Shared Lane Markings
Effects of Shared Lane Markings on Bicyclist and Motorist Behavior along Multi-Lane Facilities. By Brady, J., Mills, A., Loskorn, J., Duthie, j., Machemehl, R., Center for Transportation Research.																										+
Efficacy of Rectangular-shaped Rapid Flash LED Beacons. By Houten, R. V., Malenfant, L.																					+					
Evaluation of a Combined Bicycle Lane/Right-Turn Lane in Eugene, Oregon. By Hunter, W.W.																+										
Evaluation of Bike Boxes at Signalized Intersections. By Monsere, C., & Dill, J.											+															
Evaluation of Blue Bike-Lane Treatment in Portland, Oregon. By Hunter, W.W. et al.																									+	
Evaluation of Green Bike Lane Weaving Area in St Petersburgh, Florida. By Hunter, W., & Srinivasan, R.															+										+	
Evaluation of Innovative Bicycle Facilities: SW Broadway Cycle Track & SW Stark/ Oak Street Buffered Bike Lanes FINAL REPORT. By Monsere, C., McNeil, N., Dill, J., Center for Transportation Studies.			+				+																			

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Evaluation of Innovative Bike-Box Application in Eugene, Oregon. By Hunter, W. W.											+															
Evaluation of Solid and Dashed Green Pavement for Bicycle Lanes, (RTE). By SFMTA.															+										+	
Evaluation of Solid Green Bicycle Lanes, to Increase Compliance and Bicycle Safety. By New York City Department of Transportation.																									+	
Evaluation of the Rectangular Rapid Flash Beacon at a Pinellas Trail Crossing in St. Petersburg, Florida. By Hunter, W. W., Srinivasan, R., Martell, C. A.																					+					
Evaluation of the Shared-Use Arrow. By Pein, W.E., Hunter, W.W., and Stewart, J.R.																										+
Final Report: Second Street Sharrows and Green Lane in the City of Long Beach, California, (RTE 9-113E). By City of Long Beach.																									+	+
General Design and Engineering Principles of Streetcar Transit. By Boorse, J., Hill, M., Danaher, A.													+													
Infrastructure, Programs, and Policies to Increase Bicycling: An International Review. By Pucher, J., Dill, J., and Handy, S..		+		+	+		+	+	+		+	+							+					+	+	+

RESEARCH AND STUDIES (CONTINUED)	BIKE LANES	Conventional Bike Lane	Buffered Bike Lane	Contra-flow Bike Lane	Left-Side Bike Lane	CYCLE TRACKS	Protected Cycle Track	Raised Cycle Track	Two-way Cycle Tracks	INTERSECTION TREATMENTS	Bike Box	Intersection Crossing Markings	Two-stage Turn Queue Boxes	Median Refuge Island	Through Bike Lanes	Combined Bike/Turn Lane	Cycle Track Intersection Approach	BICYCLE SIGNALS	Bike Signal Heads	Signal Detection / Actuation	Active Warning Beacon	Hybrid Signal	SIGNING & MARKING	Bike Route Way-Finding	Colored Bike Facilities	Shared Lane Markings
Interim Approval for Optional Use of Rectangular Rapid Flashing Beacons (IA-11). By Federal Highway Administration.																					+					
International Technology Scanning Program, Pedestrian and Bicycle Mobility and Safety in Europe. FHWA-PL-10-010. By Federal Highway Administration.																										
Measuring the Safety Effect of Raised Bicycle Crossings Using a New Research Methodology. By Garder, P., Leden, L., Pulkkinen, U..								+																		
Modified HAWK Signal and Bike Signal – Draft Report – #4-298(E). By Portland Bureau of Transportation.																						+				
More Than Sharrows – Lane-Within-A-Lane Bicycle Priority Treatments in Three U.S. Cities. By Furth, P. G., Dulaski, D. M., Bergenthal, D., Brown S.																									+	+
NCHRP 562 – Improving Pedestrian Safety at Unsignalized Crossings. By Fitzpatrick, K., Turner, S., Brewer, M., Carlson, P., Ullman, B., Trout, N., Sug Park,E., Whitacres, J.																					+	+				

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RESEARCH AND STUDIES (CONTINUED)																										
Portland's Blue Bike Lanes: Improved Safety Through Enhanced Visibility. By M. Birk, R. Burchfield, J. Flecker, W.W. Hunter, D.L. Harkey, and J.R. Stewart.															+										+	
Risk of injury for bicycling on cycle tracks versus in the street. By Furth, P., Morency, P., Miranda-Moreno, L., Willett, W., Dennerlein J.							+	+	+																	
Road safety and perceived risk of cycle facilities in Copenhagen. By Jensen, S, Rosenkilde, C, and Jensen, N.							+	+	+																	
Safety effects of blue cycle crossings: A before-after study. . By Jensen, U.							+	+	+																	
San Francisco's Shared Lane Pavement Markings: Improving Bicycle Safety FINAL REPORT. By San Francisco Department of Parking & Traffic.																										+
Shared Lane Markings: When and Where to Use Them. By SFMTA.																										+
Traffic environment for children and elderly as pedestrians and cyclists. By Leden, L., Gårder P., Johansson, C.							+	+	+								+									

OTHER CITY RESOURCES	BIKE LANES	Conventional Bike Lane	Buffered Bike Lane	Contra-flow Bike Lane	Left-Side Bike Lane	CYCLE TRACKS	Protected Cycle Track	Raised Cycle Track	Two-way Cycle Tracks	INTERSECTION TREATMENTS	Bike Box	Intersection Crossing Markings	Two-stage Turn Queue Boxes	Median Refuge Island	Through Bike Lanes	Combined Bike/Turn Lane	Cycle Track Intersection Approach	BICYCLE SIGNALS	Bike Signal Heads	Signal Detection / Actuation	Active Warning Beacon	Hybrid Signal	SIGNING & MARKING	Bike Route Way-Finding	Colored Bike Facilities	Shared Lane Markings
Arizona Statewide Bicycle and Pedestrian Plan – Design Guide															+											
City of Columbus Bicentennial Bikeways Plan		+		+			+				+				+				+	+				+	+	+
City of Davis Comprehensive Bike Plan		+													+					+						
Denver Bicycle Master Plan		+																	+							
Long Beach Bicycle Master Plan		+													+					+					+	
Louisville Complete Streets Manual		+																								+
Maricopa County AZ Bicycle Transportation System Plan		+																								
City of Memphis Bicycle Design Manual		+	+								+								+	+				+	+	+
Nashville-Davidson County Strategic Plan for Sidewalks and Bikeways															+					+						+
NYDOT Street Design Manual			+				+																			+
Bicycle Facilities Design Manual for the City of Redmond															+	+				+				+		+
San Diego Bicycle Design Guidelines				+			+													+				+	+	+
Syracuse Bicycle and Pedestrian Plan											+								+	+				+		
Ohio Design Guide for Bicycle Facilities																										
Oregon Bicycle and Pedestrian Plan Facility Design Standards				+											+	+										

	BIKE LANES	Conventional Bike Lane	Buffered Bike Lane	Contra-flow Bike Lane	Left-Side Bike Lane	CYCLE TRACKS	Protected Cycle Track	Raised Cycle Track	Two-way Cycle Tracks	INTERSECTION TREATMENTS	Bike Box	Intersection Crossing Markings	Two-stage Turn Queue Boxes	Median Refuge Island	Through Bike Lanes	Combined Bike/Turn Lane	Cycle Track Intersection Approach	BICYCLE SIGNALS	Bike Signal Heads	Signal Detection / Actuation	Active Warning Beacon	Hybrid Signal	SIGNING & MARKING	Bike Route Way-Finding	Colored Bike Facilities	Shared Lane Markings
OTHER CITY RESOURCES (CONTINUED																										
Vermont Pedestrian and Bicycle Facility Planning and Design Manual – On Road Bicycle Facilities				+	+										+											
Wisconsin Bicycle Facility Design Handbook				+										+	+					+				+		
DESIGN GUIDES																										
Bikesafe Bicycle Countermeasure Selection System, Ch. 5		+						+																		
Bicycle Facility Selection: A Comparison of Approaches 2002																										
Walk, Bicycle, Skate, Jog Design Innovations for the Built Environment												+													+	
Pedestrian and Bicycle Safety and Mobility in Europe																										
Sacramento Best Practices for Bicycle Master Planning and Design				+	+						+				+				+	+					+	+
Transportation Planning Handbook: Bicycle and Pedestrian Facilities																										

INTERNATIONAL RESOURCES	BIKE LANES	Conventional Bike Lane	Buffered Bike Lane	Contra-flow Bike Lane	Left-Side Bike Lane	CYCLE TRACKS	Protected Cycle Track	Raised Cycle Track	Two-way Cycle Tracks	INTERSECTION TREATMENTS	Bike Box	Intersection Crossing Markings	Two-stage Turn Queue Boxes	Median Refuge Island	Through Bike Lanes	Combined Bike/Turn Lane	Cycle Track Intersection Approach	BICYCLE SIGNALS	Bike Signal Heads	Signal Detection / Actuation	Active Warning Beacon	Hybrid Signal	SIGNING & MARKING	Bike Route Way-Finding	Colored Bike Facilities	Shared Lane Markings
Road Directorate Collection of Cycle Concepts							+								+		+		+	+				+		
Sustrans Cycling Guidelines and Practical Details				+			+										+							+		
Department for Transport Cycle Infrastructure Design				+							+														+	
Ireland National Cycling Promotion Policy											+				+											
Langley Bicycle and Pedestrian Facility Design Guidelines														+	+					+				+		
London Cycling Design Standards							+		+		+			+			+					+			+	
Nottinghamshire Cycling Design Guide				+			+	+	+		+			+	+		+		+					+		
TransLink Regional Cycling Network Report				+	+		+	+			+	+	+	+	+	+					+			+	+	
Victoria vicroads Cycle Notes – No 9																										
Velo Quebec Technical Handbook of Bikeway Design							+		+		+	+														
CROW Design Manual for Bicycle Traffic							+				+	+	+													

PROJECT TEAMS

To create the Guide, the authors have conducted an extensive worldwide literature search from design guidelines and real-life experience. They have worked closely with a panel of urban bikeway planning professionals from NACTO member cities, as well as traffic engineers, planners, and academics with deep experience in urban bikeway applications. A complete list of participating professionals follows.w

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Bikes Belong
www.bikesbelong.org

SRAM Cycling Fund
www.sramcyclingfund.org

APPENDIX

Project Plan Drawings

BIKE LANES

- Conventional Bike Lane

  http://nacto.org/wp-content/uploads/2011/03/MichiganAveDetroit_BikeLane.pdf

  http://nacto.org/wp-content/uploads/2011/03/MichiganAveDetroit_BikeLane2.pdf

- Buffered Bike Lanes

  http://nacto.org/wp-content/uploads/2011/02/BufferedBikeLane_Seattle_Plans.pdf

  http://nacto.org/wp-content/uploads/2011/02/BufferedBikeLaneIntersection_Seattle_Plans.pdf

- Contra-Flow Bike Lane

  http://nacto.org/wp-content/uploads/2011/02/Chicago_Ardmore-Kenmore-to-Lakefront-Trail.pdf

- Left Side Bike Lane

  http://nacto.org/wp-content/uploads/2011/02/MD-600_Allen-Pike.pdf

CYCLE TRACKS

- One-way protected cycle track

  http://nacto.org/wp-content/uploads/2011/02/MD-762_1A_9th-Ave.pdf

  http://nacto.org/wp-content/uploads/2011/03/Market-st_Str-7635.1-Reservoir-St-to-Gough-St.pdf

  http://nacto.org/wp-content/uploads/2011/03/Market-st_Str-7694-12th-St-to-8th-St.pdf

- Raised Cycle Track

  http://nacto.org/wp-content/uploads/2011/02/Vassar_Street_West.pdf

- Two-way cycle track

  http://nacto.org/wp-content/uploads/2011/02/MD-627_Sands.pdf

  http://nacto.org/wp-content/uploads/2011/02/15th-Street-NW-Separated-Bike-Lane-Pilot-Project-Interim-Results-and-Next-Steps.pdf

INTERSECTIONS

- Bike Box

  http://nacto.org/wp-content/uploads/2011/02/WYMAN-PARK-BIKE-BOX.pdf

- Bike Box, Left Side-Bike Lane

  http://nacto.org/wp-content/uploads/2011/02/Project_LeftSideBoston_Plans.pdf

- Median Refuge Island

  http://nacto.org/wp-content/uploads/2011/02/MLK-CROSSING-ISLAND-167187.pdf

  http://nacto.org/wp-content/uploads/2011/02/MLK-CROSSING-MARKINGS-167189.pdf

  http://nacto.org/wp-content/uploads/2011/02/MLK-CROSSING-SIDE-SIGNS-167188.pdf

SIGNALS

- Bicycle Signal

  http://nacto.org/wp-content/uploads/2011/03/Fell_Masonic_Signal-Drawing.pdf

- Detection and Actuation

  http://nacto.org/wp-content/uploads/2011/02/Video-Detection_Seattle_Plans.pdf

SIGNING AND MARKING

- Intersection Markings

  http://nacto.org/wp-content/uploads/2011/02/Seattle-Eastlake-Fuhrman-Plans.pdf

- Colored Bike Facilities

  http://nacto.org/wp-content/uploads/2011/02/Chicago_Colored-Bike-Lanes-Plan-set.pdf