BIKEWAY FACILITY DESIGN:
SURVEY OF BEST PRACTICES

Appendix D

PORTLAND BICYCLE PLAN FOR 2030

CITY OF PORTLAND BUREAU OF TRANSPORTATION

BIKEWAY DESIGN – best practices

This report was developed as an element of the Portland Bicycle Plan for 2030.

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INTRODUCTION – SURVEY OF BEST PRACTICES

The unprecedented numbers of people bicycling in Portland has necessitated expansion of the bikeway design tools available to the city's traffic engineers. Portland is looking to world leaders in bicycle transportation to meet this growing demand. Many cities from across the globe have long recognized the merits of bicycling as an important means of transportation and have led the way in facilitating bicycle traffic through innovation and adaptation of bicycle-friendly infrastructure.

This report documents an extensive review of best practices from world-class bicycling cities where the most innovative technology advances in designing for bicycle traffic have been proven effective. The purpose of the report is to create a guide for traffic engineers, designers and planners detailing tried-and-tested bicycle facility designs along with essential considerations for their implementation.

Portland aims to help lead a national effort to develop standards and guidelines for designing bikeways that meet the wide ranging needs of the cycling public for safe, comfortable and attractive conditions. Currently, the City's Bikeway Design and Engineering Guidelines established as Appendix A of the 1996 Bicycle Master Plan serve as the local manual for the design, construction and maintenance of the city's bikeway network. Formation of the *Portland Bicycle Plan for 2030* presented the opportunity to revisit these guidelines, make enhancements to approved designs and integrate new designs into a revised manual that will meet the bicycling demands projected in coming decades.

Current State of the Practice

In 1996 when the city's original bikeway design guidelines were adopted the bicycle mode share in Portland was roughly two percent for commute trips. Today, eight percent of Portlanders reported bicycling as their primary commute mode and 10 percent of those who sometimes used a different mode reported bicycling as their secondary commute mode. Nationally, only 0.5 percent of trips to work are made by bicycle according to the 2007 American Community Survey.

Standard guidance on bikeway design outlined in national manuals, namely the American Association of State and Highway Transportation Officials (AASHTO) "Guide for the Development of Bicycle Facilities" and the Manual on Uniform Traffic Control Devices (MUTCD), has proven insufficient to address the levels of bicycling experienced in Portland. The intense influx of bicyclists using the city's transportation system has begun to exceed the capacity of developed facilities. If Portland is successful in realizing more than one quarter of all trips made by bicycle as envisioned in this 2030 plan, current practices will not suffice. Thus, new design guidelines and standards need to be adopted to ensure safe traffic conditions in the future for all travel modes.

Bikeways for Portland's Future

Portland has a reputation for implementing innovative designs that are not found in any domestic traffic design manual. Demonstration projects implemented by the Portland Bureau of Transportation, such as bicycle boxes at several high-risk intersections, have been lauded by the cycling public. Still, the city's existing bikeway network has primarily appealed to those residents who are already confident in their cycling abilities and enthusiastic riding on major streets alongside motor vehicles.

Moving forward, Portland is committed to developing better designs for bikeways that will have greater appeal to the average citizen who is interested in bicycling but concerned about their safety. A key recommendation of the *Portland Bicycle Plan for 2030* is to expand the palette of bikeway designs to facilitate creating conditions that make bicycling more attractive than driving for short trips. Separation from high volumes of high-speed traffic is an essential element of the Plan's approach, as it is in the world's most bicycle-friendly cities.

Next Steps

Most of the facilities contained within this report are considered nonstandard or experimental in the United States. Some treatments will require enabling legislation to permit their usage. In addition, transfer of any appropriate engineering technologies from other countries will require context-sensitive translation to fit local conditions.

The bikeway designs collected and published as part of this report will be further evaluated and considered for potential inclusion in revisions to the City's Bikeway Design and Engineering Guidelines that will direct future bikeway improvements within the City of Portland.

PORTLAND BICYCLE PLAN FOR 2030

BIKEWAY FACILITY DESIGN: SURVEY OF BEST PRACTICES

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Bike Lanes

Description/Purpose
Marked space along length of roadway for exclusive use of cyclists. Bike lanes create separation between cyclists and automobiles.

Advantages
- Provides bicycle access on major through street
- Clarifies lane use for motorists and cyclists
- Increases cyclist's comfort through visual separation.

Disadvantages
- Space requirements can preclude other possible uses like parking or excess travel lane

Application
- On roadways with ≥3,000 motor vehicle tripss per day
- Any street with excessive curb to curb space where bike lanes could help reduce vehicle lane widths

Source: City of Portland (PBOT)

Design/Maintenance Considerations
- Bike lane width
- Frequency of bike symbol
- Keep bike symbols out of the path of turning vehicles
- Typically placed on right side of roadway
- Vehicle door zone clearance when bike lanes are adjacent to parked vehicles

Maintenance Level – Medium

Design Guidance
- Recommended width
  - 6.5-8.2 ft (CROW)
- Should comfortably accommodate two cyclists riding side by side with sufficient shy distance from both travel lane and on-street parking.

Implementation Obstacles
n/a

Example Cities/Countries
- CROW Design Manual for Bicycle Traffic - Netherlands
- Chicago, IL
- Portland, OR
- Seattle, WA

Bike Passing Lane

Description/Purpose
Adding a second bike lane adjacent to a first to provide space for passing

Advantages
- Reduces the length of bicycle platoons
- Reduce number of faster bicyclists that merge with auto traffic to pass slower cyclists.

Disadvantages
- Space requirements can preclude other possible uses like parking or excess travel lane

Application
- Large number of cyclists
- Wide range of travel speeds
- Typically on an uphill roadway

Source: BikePortland.org
Portland, OR

Design/Maintenance Considerations
- Adequate space for two bicyclists to pass without encroaching into travel lane.

Maintenance Level – Medium

Design Guidance
- Commute routes
  - Uphill sections
  - After forced stops (signals) where platoons form
- Recreational paths
  - Uphill sections
- PBOT guidance
  - Minimum passing lane width of 5 ft adjacent to a 5-ft bike lane
  - Skip striping between the two bike lanes and double bike symbols mitigates concerns of motorists mistaking the area for a travel lane.
  - Bike lanes in same direction separated by 4-in wide (100 mm) skip stripe, 1 ft long (300 mm) skip stripe with 3 ft (1 m) skip.

Implementation Obstacles
- Space requirements may reallocate uses from parking or driving lane

Example Cities/Countries
- Portland, Oregon

Buffered Bike Lane

Description/Purpose
Bicycle lane with a buffer to increase the space between bicycle lane and travel lane or parked cars.

Advantages
- Provides cushion of space to mitigates friction with motor vehicles on streets with narrow bike lanes.
- Provides space for cyclists to pass without encroaching into the travel lane.
- Mitigate for obstacles in the bike lane, e.g. drainage inlets, manholes.
- Parking side buffer: provides cyclists with space to avoid the "dooring zone" of parked cars.
- Provides motorists (particularly drivers of large vehicles) greater shy distance from cyclists in the bike lane.

Disadvantages
- Additional space requirements
- Added maintenance required for the buffer striping

Application
- Bike lanes with high automobile traffic speeds and volumes
- Bikeways with bike lanes adjacent to on-street parking
- Bike lanes with high volume of truck/oversized vehicle traffic

Source: Greg Raisman
Bruges, Belgium

Design/Maintenance Considerations
- Determine which side of the bike lane the buffer is needed, adjacent to parking or the travel lane.
  - Frequency of parking turnover
- Determine buffer width needed to avoid door zone of parked cars
- Major intersection approaches
  - Frequency of motor vehicle right turns
  - Design of conflict areas where cars and bike weave
  - Continuous or truncated buffer striping approaching intersection

Maintenance Level – Medium

Design Guidance
- Buffer Width
  - Minimum 32 in (London)
  - 32 in (Brussels)
  - 20-30 in (CROW)
- Diagonal Buffer Stripe Details
  - 6 ft spacing (Portland - Holgate)

Implementation Obstacles
- Space requirements may reallocate uses from parking or driving lane

Example Cities/Countries
- Brussels & Bruges, Belgium
- London, UK
- San Francisco, CA
- New York, NY
- Portland, OR (NW 10th)

Contraflow Bike Lane

Description/Purpose
A one-way street for motor vehicles that includes an opposite-direction bicycle only lane.

Advantages
- Provides direct access and connectivity for bicycles traveling in both directions.
- Influences motorist choice of routes without limiting bicycle traffic.
- Cyclists do not have to make detours as a result of one-way traffic.

Disadvantages
- Limits on parking might be needed on side with contraflow lane.
- Possibility of illegal loading or parking in contraflow lane.

Application
- One-way auto traffic streets
- Narrow streets where on-street parking and bicycle accessibility are give priority over traffic accessibility

Source: Denver Igarta
Amsterdam, Netherlands

Design/Maintenance Considerations
- Accompanying signage needed.
- Contraflow lane separated from motor vehicle lane by a solid double yellow line.
- Ensure contraflow lane is exclusively for bicycles by using bike lane striping with legal status.
- Clearly distinguish contraflow lane with markings.
- Consider use of color on bike lane.
- Consider physical separation between bike lane and travel lane.
- Determine modifications needed to existing traffic signals.

Maintenance Level – Medium

Design Guidance
- Contraflow lane width
  - 5.0 to 6.5 ft (CROW)
  - Minimum 5.0 ft (London)

Implementation Obstacles
- Outreach to stakeholders, adjacent businesses and neighbors
- Conversion from 2-way requires elimination of one direction of auto travel.

Example Cities/Countries
- Madison, WI
- Cambridge, MA
- San Francisco, CA
- Netherlands
- Germany
- Portland (23rd Pl, Weidler Ct)

Floating Bike Lane

Description/Purpose

A single lane functions as a parking lane or an exclusive bike lane:

- During peak hours, parking is not allowed and cyclists use a curbside bike lane.
- During off-peak hours, cyclists travel in the space between the motorized traffic lane and parked cars.

This treatment retains the bicycle facility when an extra travel lane (for automobiles) is added during peak hours.

Advantages

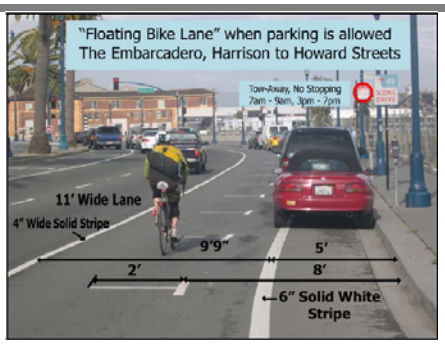
- Accommodates bicycles at all times, even when parking is permitted.
- Provides bicycle facilities on streets with constrained rights-of-way.

Disadvantages

- Unorthodox design can be confusing.
- Enforcement required

Application

- Primary bicycle routes during peak hours
- Streets warranting bike lanes with high parking demand where there is not enough space to provide both standard bike lane and parking.



Source: sfmta.org
San Francisco, CA

Design/Maintenance Considerations

- Provide adequate space to minimize the risk of "doorings" when parking is permitted
- Consider using bicycle symbol curbside
- Minimal use of signage required.
- Consider using sharrow markings in lieu of bike lane striping. (San Francisco)
- Time of day vehicle use communication

Maintenance Level – Medium

Design Guidance

- Peak hour (SF)
  - 7 am - 9 am / 3 pm - 7 pm
- Parking permitted during off-peak (SF)
  - 9 am - 3 pm / 7 pm - 7 am

Implementation Obstacles

- Typically requires removal of travel lane to add parking

Example Cities/Countries

- San Francisco (SF), CA

Colored Bike Lanes

Description/Purpose
Color is applied to the bike lanes to distinguish the bike lane, alert roadway users at high conflict areas and to clearly assign right-of-way to cyclists. Motorists are expected to yield to cyclists in these areas.

Advantages
- Provides a continuous facility for cyclists.
- Mitigates high conflict areas.
- Provides for safer merging of bicycles with motor vehicle traffic.
- Increases awareness and safe behaviors by both cyclists and motorists

Disadvantages
- Maintenance requirements.

Application
- Heavy auto traffic streets with bike lanes
- At dangerous intersection or where cyclists and motorists must weave with one another.
- Conflict area with a record of crashes

Source: BikePortland.org
Portland, OR

Design/Maintenance Considerations
- Provide appropriate signs.
- Use marking and sign configurations that encourage the weaving of bicycles and motor vehicles in advance of the intersection proper.
- Use thermoplastic rather than paint

Maintenance Level – High

Design Guidance
- Provide ample bike lane width
- Provide color through the conflict area
- PBOT guidance
  - ***Green Color:*** Bright green color was adopted in 2008 replacing the blue color used prior. Typically blue color is used to indicate disabled parking.
  - Limit use to conflict areas

Implementation Obstacles
- Not part of the Manual on Uniform Traffic Control Devices (MUTCD)

Example Cities/Countries
- New York City, NY
- Cambridge, MA
- Portland, OR
- Cologne, Germany

Advisory Bike Lanes

Description/Purpose
Dotted white lines on both sides of a narrow roadway delineate bicycle areas. The automobile zone is not wide enough for two cars to pass in both directions creating a queuing situation. Motorists may enter the bicycle zone when no bicycles are present. Motorists must overtake with caution due to traffic traveling in the opposite direction.

Advantages
- A viable option when cross-section is too narrow for mandatory bike lanes
- Striping offers visual separation on a low-traffic roadway
- Motorist tend to travel slower due to friction created with oncoming vehicles.

Disadvantages
- Motor vehicle encroachment into the bike lane permitted
- If vehicles are parked in the bike lane cyclists must position themselves further into the roadway to pass safely
- Less protection for cyclists than a conventional bike lane

Application
- Low motor vehicle traffic volumes and speeds
- Straight segments with few bends, inclines or sightline obstructions
- Two-way streets
- No centerline on roadway

Source: Roger Geller
IJsselstein, Netherlands

Design/Maintenance Considerations
- No continuous centerline should separate opposing directions of auto travel
- Colored pavement on the edges to discourage encroachment by motorists or parked vehicles.
- Assess potential hazards and conflict points
- Minimum bike lane width 5 ft (London)
- Two-direction travel lane not wide enough for two cars to pass in opposite directions
- Consider maximum volume and speed (London: 3000 adt / 30 mph[1]/ 37 mph[2])
- Continue across minor street intersection

Maintenance Level – Medium

Implementation Obstacles
- Not in MUTCD
- May require enabling legislation
- Standard need for striping

Design Guidance
- Advisory bike lane width:
  - 5 ft -6.5 ft (CROW)
  - Min. 5 ft (London)
  - 4.1 ft -5.25 ft (FGSV)
- 2-way motor vehicle lane:
  - 15 ft - 18 ft (FGSV)
  - Min. 13 ft (London)
- Curb-to-Curb:
  - 23 ft -28 ft (London)
- Parking dimensions:
  - 7.5 ft -8.2 ft (FGSV)
- Line dimensions (CROW):
  - Width: 4 in -6 in
  - Spacing: 3.28 ft

Example Cities/Countries
(1) Dutch CROW Manual
(2) German FGSV
(3) London, England

[1] Transport London - London Cycling Design Standards
[2] Zeeland, Netherlands

Cycle Track

Description/Purpose
Exclusive bicycle facility adjacent to - but separated from - the roadway by a physical barrier. Combines the user experience of a separated path with the on-street infrastructure of a bike lane.

Advantages
- Direct access to main street commercial areas
- Significant separation from automobile traffic in busiest parts of town

Disadvantages
- Amount of right-of-way required
- May require removal of travel lane or on-street parking
- Left-turns must be made in non-standard manner, potentially resulting in delay
- Expensive

Application
- Arterial roadways with higher motor vehicle speeds and volumes.
- Roads with fewer cross-streets and longer blocks.

Source: Denver Igarta
Amsterdam, NL

Design/Maintenance Considerations
- Separation – channelized (elevated or at-grade), mountable curb, or bollards/markings
- Cycle track width
  - Based on bicycle volumes, design speed, and passing opportunities.
- Crossing driveways & low-volume streets
  - Continue the cycle track through the driveway crossing
  - Use pavement markings and grade separation to indicate cycle track has the right-of-way
- Signalized intersections
  - Drop down to bike lane
  - Forward stop bar
  - Crossbike marking through the intersection
  - Exclusive bike signal phase
- Other considerations: maintenance, bike symbol, interactions with transit, ADA requirements, and two-way cycle tracks.
- Adequate sidewalks to reduce likelihood of cycle track use by pedestrians.
- Difficult to implement where intersections are closely spaced.

Maintenance Level – Medium

Design Guidance
- Cycle track width
  - 6.5 ft minmum, 7 ft typical, 8 ft desirable for new construction, Up to 10 ft for additional capacity (CPH)
  - 6.5 ft to 13.1 ft depending on rush hour bicycle intensity (CROW)
  - 2 ft buffer on vehicle side is desirable, required if cycle track width is less than 7 ft (CPH)
  - 5.5 ft absolute minimum for cycle tracks (CPH)
- Curb separating the bike and pedestrian facilities (CPH)
- Make the intersection look more dangerous than it actually is (CPH)
- On-street parking: place cycle track adjacent to the sidewalk with 2 ft clear space to prevent "doorings" (ALTA)
- Remove parking directly in advance of the intersection

Implementation Obstacles
- Separation from pedestrian realm
- ADA access to sidewalks from on street parking
- Design standards required

Example Cities/Countries
- Copenhagen Traffic Department (CPH)
- Netherlands (CROW Manual)
- Cambridge, MA
- St. Petersburg, FL
- New York, NY

Bicycle Street - *"Fahrradstrassen"/ "Fietsstraten"*

Description/Purpose

A street within a residential area that acts as a major bicycle route and where the position of the car is subordinate to that of the bicycle. Bicycle streets offer safe passage for large numbers of cyclists, mainly between and through districts. The intent of this treatment is to provide direct, safe, comfortable and attractive routes to promote bicycle use.

Provisions for *Fahrradstrassen* are outlined in German traffic law (Straßen-Verkehrs Ordnung – StVO) requiring:

- All vehicles are required to travel at moderate speeds
- Allowing cyclists to ride side-by-side

Advantages

- Achieve objectives of safety, comfort and attractiveness on low-traffic direct through streets.
- Provide cyclists an alternative to bicycling on an arterial street.
- Local streets typically have fewer modal conflicts.

Disadvantages

- Residential streets do not typically provide direct access to commercial destinations.
- Local residents may object to improvements or alterations on their street.

Application

- Low traffic residential street with a shared space for bicycle and motor vehicle traffic.
- Streets parallel to a nearby arterial.
- Direct routes across districts.

Source: Fietsberaad
Oss, Netherlands

Design Maintenance Considerations

- Bicycles are permitted to use the entire width of the roadway.
- Bicycle boulevard toolbox
  - Signage and pavement markings
  - Traffic calming
  - Diversion techniques
- Speed limits
  - 30 km/h or 18.6 mph (Germany)
- Preserve emergency access and occasion access for large vehicles.

Maintenance Level – Low

Design Guidance

- Design should consider neighborhood aesthetics.

Implementation Obstacles

- Enabling legislation may be required to reduce speed limits

Example Cities/Countries

- Muenster, Germany
- Essen, Germany
- Oss, Netherlands

Pinch Point (or Queuing Street/Neckdown/Choker)

Description/Purpose
This is a residential traffic calming treatment that narrows the travel lane for motorists by installing curb extensions or islands to create a narrow channel. A separated bicycle travel-way segregates bicycles and motor vehicles as they travel through the device. This design slows automotive traffic while retaining priority movement for bicycles. The intent is to calm and discourage non-local traffic on bicycle boulevards.

Advantages
- Slows speed of motor vehicles
- Provides mode separation between bicycles and motor vehicles passing through concurrently
- Discourages cut-through traffic
- Acts as horizontal deflection to reduce speed, and is more comfortable than a speed bump
- Some designs may allow for green treatments and that improve attractiveness.

Disadvantages
- Reduces on-street parking capacity
- Cost

Application
- Soft diversion – use in location where reduced volume is desired, but hard diversion is not possible
- Use as gateway treatment
- Speed reduction
- Hard diversion at T-intersection

Source: Greg Raisman
Utrecht, The Netherlands

Design/Maintenance Considerations
- Ensure adequate pass through
- Provide good visibility between modes.
- Provide good visibility and adequate warning of floating islands.
- Potential to add speed cushion in center of device for additional speed reduction
- Oppositional flow of traffic improves speed reduction benefit
- Auto speed through pinch point and cyclist merge point.

Maintenance Level – Low

Design Guidance
- Must accommodate turn movements at intersections
- Width of extension/islands can be increased for wider streets

Implementation Obstacles
- Not part of the Manual on Uniform Traffic Control Devices (MUTCD)

Example Cities/Countries
- Utrecht, The Netherlands

Chicanes

Description/Purpose
Alternating curb extensions or islands installed to create horizontal (serpentine) shifts of the travel lane thus reducing traffic speeds.

Advantages
- Narrow circuitous lanes that limit the clear path of vision and encourage slow auto speeds.
- Narrow travel lanes provide opportunities for on-street parking

Disadvantages
- Placement of curb extensions/islands may eliminate on-street parking

Application
- Bicycle boulevards
- Low traffic residential street with shared space for bicycle and motor vehicle traffic.

Source: Denver Igarta
Victoria, BC, Canada

Design/Maintenance Considerations
- Allow pedestrian and bicycle pass through
- Avoid disrupting drainage
- Median islands may be installed to eliminate the opportunity for drivers to avoid travel lanes shifts by driving down the centerline.
- Opportunities to enhance aesthetics with landscaping and streetscape design.

Maintenance Level – Low

Design Guidance
- *Refer to other design sheets*
  - *Narrow width roadway*
  - *Pass-through curb extensions*

Implementation Obstacles
n/a

Example Cities/Countries
- Seattle, Washington
- Tallahassee, FL
- Victoria, BC, Canada

Narrow Width Shared Roadway

Description/Purpose
A bikeway on a local street with a narrow width to reduce motor vehicle speeds and enhance safety for cyclists and pedestrians.

Advantages
- Achieve objectives of safety, comfort and attractiveness on shared local streets.
- Local streets typically have fewer modal conflicts.
- Provide more space for pedestrian realm (sidewalks, landscaping, etc.).
- Potential for less impervious surface.

Disadvantages
- Local residents may object to improvements or alterations on their street.
- Cost

Application
- Low traffic residential street with a mixed profile for bicycle and motor vehicle traffic.

Source: Denver Igarta
Vancouver, BC, Canada

Design/Maintenance Considerations
- Complementary speed limits
- Consider ways to preserve access for emergency vehicles, buses and/or delivery trucks.
- Bicycles are permitted to use the entire width of the roadway.
- Consider possible diversion impacts on adjacent streets.

Maintenance Level – Low

Design Guidance
- Roadway width (curb-to-curb)
  - 12.5 ft: extremely low volumes (CROW)
  - 16 ft: based on bicycle/car/bicycle combination (CROW)
- Design should consider neighborhood aesthetics.

Implementation Obstacles
- Requires enabling legislation to sufficiently reduce speed limits

Example Cities/Countries
- Muenster, Germany
- Berlin, Germany
- Netherlands (CROW)

Residential Speed Limit (Zone 30/Tempo 30/20 mph Zone)

Description/Purpose
Discourage motorists from cutting through residential areas by setting a speed limit of 20 mph and implementing necessary traffic calming measures.

Advantages
- Improves road safety by reducing the number of crash-related injuries
- Relatively inexpensive to implement
- Concentrates through traffic on streets designated as arterials
- Enhances neighborhood livability (noise levels, air quality, other traffic nuisances)
- Enables cyclists to more comfortably share the road with motorists

Disadvantages
- Enforcement requirements

Application
- Local service traffic streets in residential areas.
- Apply to an area consisting of several streets rather than an individual streets (UK)
- Bicycle routes off the main arterial streets.

Source: Denver Igarta
Vancouver, BC, Canada

Design/Maintenance Considerations
- If zone is too large (>250 acres or a square km), it may divert too much traffic onto arterials. (SWOV)
- Determine need for traffic calming measures to accompany speed limit signs.
- Traffic calming devices must be bicycle-friendly.
- Gateway treatments (signs, pinch points and other calming measures) at neighborhood entry points have been shown to be very effective in reducing speeds. (UK)
- Consider speed limit pavement markings (aka roundel marking)

Maintenance Level – Low

Design Guidance
- *Refer to other traffic calming related design sheets*

Implementation Obstacles
- Requires enabling legislation to sufficiently reduce speed limits

Example Cities/Countries
- New York City, NY[1]
- Graz, Austria
- Netherlands (SWOV)
- UK Dept of Transport

[1] New York STATE Vehicle & Traffic Law §1643
II. In cities with a population >1 million, speed limits <25 mph but in no case <15 mph may be established along designated highways for the "purpose of implementing traffic calming measures." However, no such speed limit can be established where such measure consists only of traffic control signs. The term "traffic calming measures" means "any physical engineering measure or measures that reduce the negative effects of motor vehicle use, alter driver behavior and improve conditions for non-motorized street users such as pedestrians and bicyclists." V & T Law §1642(26)

Speed Bumps

Description
Speed bumps are short sections of roadway that have been vertically raised to cause a reduction in automobile speed. (Also known as Speed Humps (14') or Speed Tables (22'))

Advantages
- Full-time speed reduction
- Low cost relative to enforcement
- Quick to install

Disadvantages
- Fire vehicle response delay
- Potential to generate noise

Application
- Local Service or Neighborhood Collector streets that are not Major Emergency Response Routes

Source: Greg Raisman
Portland, OR

Design Considerations
- Adequate markings
- Adequate warning signs
- Distance from utility access points and intersecting streets
- Distance from driveways

Maintenance Level – Low

Design Guidance
- Bump Spacing
  - Ranges from 300-500 ft but is typically near 400 ft.
- Bump Size
  - Speed Bump (14 ft) on Local Service streets
  - Speed Tables (22 ft) on bus routes and Neighborhood Collector streets
  - Offset Speed Tables on Major Emergency Response Routes

Implementation Obstacles
n/a

Example Cities/Countries
- Portland, OR

Home Zone/Woonerf

Description/Purpose
Home Zones are residential streets in which the road space is shared between drivers of motor vehicles and other road users, with the wider needs of residents (including pedestrians, bicyclists, and children) in mind. (UK DfT)

Advantages
- Improves neighborhood livability and traffic safety by making streets places for people, not only traffic.
- Changes the layout of the street so that motorists perceive that they should give informal priority to other road users.
- Reduces cut-through traffic and speeding by motorists
- Prioritizes pedestrian and bicycle travel on residential streets

Disadvantages
- Can reduce connectivity for motor vehicle congestion relief
- Impacts convenience of residents and visitors who drive to the neighborhood

Application
Home Zones can be established in areas that are primarily residential. This traffic management system is particularly beneficial in areas with schools, parks, and other public spaces.

Source: Denver Igarta
Amsterdam, NL

Design/Maintenance Considerations
- Motorists should feel like "guests" on the street. (UK)
- Street design must be legible to visually impaired.
- Preserve two-way connectivity on all streets for bicycles and pedestrians
- Ensure acceptable levels of diversion on adjacent streets
- Retain emergency response access
- Focus on operational and area-wide strategies
- Utilize capital projects strategically
- Retain access for street sweeping
- Retain access for deliveries and basic municipal services such as garbage removal.
- Accommodate occasional use by large vehicles (UK)

Maintenance Level – Low

Design Guidance
- Travel lane should be as narrow as practicable – minimum 10 ft (UK)
- Design for 20 mph travel speed
- Traffic flows of < 100 vehicles in afternoon peak hour. (UK)
- Vehicles should not have to travel more than .25 miles along home zone street. (UK)
- Provide adequate guidance for bicyclists and pedestrians
- Utilize non-intuitive one-way systems or traffic diversion techniques to reduce non-resident cut-through traffic

Implementation Obstacles
- Oregon law: may require statutory change to establish slower travel speeds in Home Zones
- Area-wide planning requires very high level of community process

Example Cities/Countries
- Utrecht, Netherlands
- Groningen, Netherlands
- Copenhagen, Denmark
- Bonn, Germany
- Malmo, Sweden
- UK Institute of Highway Incorp. Engineers (homezones.org.uk)

Traffic Volume Control Measures

Description/Purpose

Volume control measures cover all techniques which utilize a physical barrier to restrict the flow of motor vehicles.

Treatments to control auto volumes include:

- Semi- (Partial-) diverter
- Median barrier
- Diagonal diverter
- Cul-de-sac/Full-street closure
- Forced turn island

Advantages

- Reduce potential conflicts between motor vehicles and bicyclists/pedestrians
- Increase comfort and attractiveness of route for bicyclists
- Enhance neighborhood livability

Disadvantages

- Creates some access restrictions for local residents
- Traffic may be diverted to an adjacent local street
- Enforcement may be required for partial diverters

Application

- Bicycle boulevards
- Local service streets in residential areas
- Streets with a documented cut-through traffic problem
- Not transit or major emergency response route

Source: Denver Igarta
Portland, OR

Design/Maintenance Considerations

- Consider designs that preserve necessary access for emergency vehicles or occasional truck deliveries
- Make passable for pedestrians and bicyclists
- Provide adequate alternative exit/entry routes for automobiles
- Consider trial treatment period
- Enhance visibility with signs, delineations, painted curbs, etc.
- Consider use in sets to make through traffic possible but less attractive
- Consider integrating stormwater, utilities and other functions

Maintenance Level – Low

Implementation Obstacles

- Defining a neighborhood outreach process

Design Guidance

Example Cities/Countries

- Berkeley, CA
- Boulder, CO
- Eugene, OR
- Portland, OR
- Seattle, WA

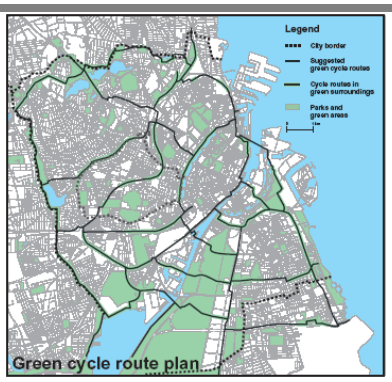
Copenhagen Green Cycle Routes

Description/Purpose
Green cycle routes serve a bicycle mobility function on quiet routes separated from heavy traffic. These routes serve both a transportation and recreation function passing through neighborhoods, parks, greenways and natural spaces. Green cycle routes are long (1-5 mi) continuous routes that form a citywide network complementing the city bikeway network.

Advantages
- Offers routes with minimal motor vehicle conflicts
- Provides the highest standard of bikeway design

Disadvantages
- Challenge of connecting green spaces to form a network

Application
- Green areas and low traffic roadways



Source: City of Copenhagen

Design/Maintenance Considerations
- Wide bicycle pathway and separated walkway the preferred treatment
- Minimize out of direction travel
- Minimize stops (delays) for cyclists

Maintenance Level – Low

Design Guidance
- *Refer to other design sheets:*
  - *Off-Street and Shared-Use Path Sections*
  - *Bicycle streets*

Implementation Obstacles
n/a

Example Cities/Countries
- Copenhagen, Denmark

Trails/Off-Street or Shared-Use Path Sections

Description/Purpose
Minimum and standard dimensions for off-street exclusive bike paths and shared-use pathways.

Advantages
- Uniformity of expectations for users and developers

Disadvantages

Application
- Off-street bike paths or shared-use bike and pedestrian pathways.

Design/Maintenance Considerations
- Travel speed of bicyclists
- Grade
- Pedestrian volumes
- Security issues – night time illumination
- No curbing
- Signing, including route signing
- Markings

Maintenance Level – Low

Implemenation Obstacles
- Right of way acquisition

Source: Denver Igarta
Munich, Germany

Example Cities/Countries
- Burke-Gilman Trail, Seattle, WA
- Springwater Corridor, Portland
- South Waterfront Trail, Portland
- Netherlands (CROW manual)

Design Guidance
- Horizontal separation of modes, particularly on commute routes
- Vegetation adjacent to catch run-off
- Ideally, pedestrians and bicyclists should be separated, especially in areas with high expected use.
- Bike & ped traffic can be combined if < 200 peds/hr/meter of profile width (CROW)
- Full combination – 100 peds/hr/meter of profile width (CROW)
- Visual separation (simple marking) – up to 160 peds per hr per meter of width (CROW)
- "Soft separation"- separate bicycle travel path using different paving material 160-200 peds/hr/meter of width (CROW)
- PBOT guidance (Portland)
  - Minimum path, exclusive or shared, is 12 ft (4 m), standard is 16 ft (5 m).
  - Preferred width for a shared-use pathway is a 16 ft bike lane, centered in the right of way, with pedestrian paths on each side (6 ft min, 8 ft standard width) and vegetated separation between bike & ped pathways (2-4 ft wide).

Trail Design Guidelines for Portland's Park System, Portland Parks & Recreation, May 2009, available online at http://www.portlandonline.com/parks/index.cfm?a=250105&c=38306

Car-Free Street/Zone

Description/Purpose
Streets or areas with a concentration of destinations where motor vehicles have been excluded from the public right-of-way. Combine pedestrian and bicycle traffic (modes with minimal nuisance) to provide for an attractive car-free experience.

Advantages
- Achieves safety, comfort and attractiveness on car-free streets.
- Provides bicyclists an alternative to busy arterial streets.
- Bicyclists can remain close to their bicycle to reduce theft and facilitate transport of purchased goods.
- Allowing bicycling (as opposed to prohibiting it) in pedestrian districts:
  - Offers access to the destinations clustered in the area
  - Eliminates what may form as a barrier in the bicycle network
  - Enables bicyclists to avoid busy streets that often encircle pedestrian districts

Disadvantages
- Possible conflicts with pedestrians

Application
- Streets in the central business district or regional/town center with high numbers of pedestrians and bicyclists.

Source: Denver Igarta
Düsseldorf, Germany

Design/Maintenance Considerations
- Volume of pedestrians/bicyclists
- Speed of bicyclists
- Pedestrian district streets limited to bus, taxi and service vehicle access should also be available to bicyclists
- Signing, including route signage
- Pavement markings

Maintenance Level – Low

Design Guidance
- Horizontal separation of modes
- Where volumes of pedestrians and bicyclists are high, designing for separation may be desirable.
- Bike & ped traffic can be combined if <200 peds/hr/meter of profile width (CROW)
- Full combination – 100 peds/hr/meter of profile width (CROW)
- Visual separation (simple marking) – up to 160 peds/hr/meter of width (CROW)
- "Soft separation"- separate bike travel path of different paving material 160-200 peds/hr/meter of width (CROW)

Implementation Obstacles
- Defining a business/neighborhood outreach process

Example Cities/Countries
- Boulder, CO
- Charlottesville, VA
- Düsseldorf, Germany
- Groningen, Netherlands

Trail/Off Street Path Transition

Description/Purpose
The concrete driveway ramp with bollard, signing and markings that delineate the beginning or end of a bicycle-only or shared-use pathway where it meets a standard public right-of-way.

Advantages
- Current driveway design is familiar to construct and not confused with pedestrian ramp
- Can double as access point for maintenance vehicles.
- Separates bicyclists from pedestrian crossing paths

Disadvantages
- Wider than standard ramp, so uses more space
- Added cost of construction

Application
- Any street where an off-street path or shared path enters or crosses a typical right of way.

Source: Denver Igarta
Vancouver, BC, Canada

Design/Maintenance Considerations
- Shared use paths may need added signing to communicate desired separation of modes.

Maintenance Level – Low

Design Guidance
- Standard 12 ft driveway with single, removable bollard centered in ramp.
- Pedestrian ramps adjacent to bicycle driveway on both sides with drop ramps at sidewalk.
- Use odd number of bollards only

Implementation Obstacles
n/a

Example Cities/Countries
- Portland, OR
- Copenhagen, DK
- Houton, NL

Bicycle Undercrossing (Tunnel)

Description/Purpose
Bicycle undercrossings, or tunnels, provide bicyclists grade-separated passage beneath major arterial streets. Tunnels eliminate the conflicts cyclists would encounter with motorized traffic if the crossing was at-grade.

Advantages
- Conflict-free crossing of bicycle and motorized traffic
- May offer shorter inclines than an overcrossing.

Disadvantages
- Susceptible to vandalism
- Security concerns
- Cost

Application
- Intersection between a main bikeway and a major arterial street.

Source: Denver Igarta
Vancouver, BC, Canada

Design/Maintenance Considerations
- Unobstructed views through tunnels (CROW)
- Good lighting situation for security. Maximize daylight. (CROW)
- Consider groundwater/drainage issues.
- Bicyclist preferably at ground level (CROW)
- Clear of vegetation. No corners or recesses. (CROW)
- Walls recede towards top (CROW)

Maintenance Level – Medium

Design Guidance
- Bicycle section
  - Separate footpath: 10 ft minimum (CROW).
  - Shared use: 11.5 ft minimum (CROW).
- Height: > 8.2 feet
- Incline < 1:20
- Tunnel floor: 2% (drainage)
- Approaches kept to no more than 5% grade (Davis)
- Illumination
- Adequate overhead clearance of at least 10 ft (Alta)
- Minimum width of 14 feet for several users to pass safely (Alta)

Implementation Obstacles
n/a

Example Cities/Countries
- Davis, CA
- San Diego, CA (ALTA)
- Boulder, Co
- Madison, Wi
- Netherlands (CROW)

Green Wave

Description/Purpose
Green waves are coordinated traffic signals that allow bicyclists to travel from intersection to intersection without stopping in one direction. Signs communicate to bicyclists the intended speed for the facility and how fast they need to ride to stay within the band. Green waves increase the efficiency of the bicycle and are a developing tool to address high demand bicycle corridors.

Advantages
- Reduces the number of stops for bicyclists along an arterial street.
- Makes cycling more competitive as compared to automobile travel.
- Reduces person delay, where bicycle and transit volumes exceed auto carrying capacity (or where policy dictates).
- Reduced noise due to lower speeds
- Increases safety for all roadway users (including pedestrians)

Disadvantages
- Potential to increase complaints from drivers about traffic signal timing and maintenance.
- Potential air quality impacts due to increased idling at traffic signals (not in all cases).
- More difficult to implement on two-way roadways.

Application
- Arterial and collector streets with groups of signalized intersections
- High bicycle volumes
- A high percentage of through movements for bicyclists

Source: City of Copenhagen

Design/Maintenance Considerations
- Identify effects to traffic (bicycle and automobile) in both directions
- Under congested conditions (automobile congestion), impacts to vehicles may be less significant

Maintenance Level – Low

Design Guidance
- Green wave speeds may be influenced by grade
- Operation may be limited to periods of peak bicyclist use
- Operation may be limited to periods when signal timing is operating at a given cycle length
- Signal cycle lengths may need to be revised, requiring comprehensive corridor evaluation.

Implementation Obstacles
- Auto traffic congestion resulting in complaints
- Increased road maintenance costs due to braking caused by heavy vehicles

Example Cities/Countries
- Copenhagen, DK
- Amsterdam, NL

Traffic Signal Operations for Bicycles

Description/Purpose

It is commonplace to have traffic signals designed primarily for automobiles. However, there are several techniques that can balance the usefulness of the traffic signal for bicyclists, including:

- Advanced signal detection in the bike lane
- Shorten delay for bike boulevard crossings
- Leading bicycle interval

Advantages

- Reduces bicycle delay (associated with advance bicycle detection and uncoordinated signals)
- Provides bicyclist priority over other users (leading bicycle interval)
- Increases bicyclist safety by allowing a head start through the intersection (leading bicycle interval)

Disadvantages

- Additional maintenance associated with advance bicycle detection
- Increased traffic congestion associated with additional green time used by bicyclists (advance detection, signal phasing, leading bicycle interval)

Application

- Signalized intersections where bicyclists travel at a high speeds
- Locations where intersection operation is not intuitive for crossing through the signal
- High volume of bicycle trips

Source: Denver Igarta
Amsterdam, NL

Design/Maintenance Considerations

- Identify effects to traffic (cyclists and auto) in both directions
- Identify mode of operation of signal (time of day for coordination) and determine whether it is necessary.

Maintenance Level – Low

Design Guidance

- Advance detection must account for signal timing parameters (gap timing), speed of bicyclists, and potential for automobiles to actuate the detector.
- Visibility of display for leading bicycle interval needs careful consideration.

Implementation Obstacles

- Exclusive signal displays for bicycles have not been reviewed by the Federal Highway Administration.

Example Cities/Countries

- Albany, OR (advance detection)
- Boulder, CO (scramble phase)
- Portland, OR (scramble)

Traffic Signal Crossings for Bicycles

Description/Purpose
Various types of traffic signal control provide opportunities for bicyclists to cross major streets in a safe and comfortable manner, include:

- Full traffic signals with detection/actuation for bikes
- Pedestrian Hybrid Signals (a.k.a. Hawk)
- Midblock signals for trails and pedestrian crossings

Advantages

- Reduces bicycle delay during periods of high vehicle traffic
- Provides a safer protected crossing
- Helps create an attractive and low-stress route for bicyclists

Disadvantages

- Power and maintenance costs for signal
- Increased stops and delay for automobile traffic
- Increased delay for bicyclists during periods when the major street traffic is low

Application

- Bicycle boulevard crossings of higher volume collector and arterial streets.
- Trail crossings of higher volume Collector and Arterial Streets

Source: City of Portland (PBOT)

Design/Maintenance Considerations

- Evaluate warrants to identify the need for a traffic signal and the type of signal.
- Placement of a new signal along a major street should consider signal spacing and progression.
- Identify mode of operation of signal (time of day for coordination).
- Design detectors so that they are easy for bicyclists to use.

Maintenance Level – Low

Design Guidance

Implementation Obstacles

- Pedestrian Hybrid Signals are not yet approved for general use.
- Exclusive signal displays for bicycles are not included in proposed design standards for Hybrid Signals.

Example Cities/Countries

- Portland, OR
- Phoenix, AZ
- Boulder, CO

Truncated Cycle Track - Ramp Down to Bike Lane

Description/Purpose
A cycle track that ramps down to the roadway in advance of the intersection to reduce conflicts with right turning motorists.

Advantages
- Bicyclists are more visible to motorists at intersections.
- Mitigates risk of "right-hook" crash with right turning motorists.
- Increases visibility of bicyclists in advance of the intersection.

Disadvantages
- Bicyclists may have a sense of perceived risk entering a travel lane with motor vehicles.

Application
- Cycle tracks situated behind on-street parking or otherwise removed from travel lane.
- Intersections with frequent right turning motor vehicles.

Source: City of Vancouver, BC

Design/Maintenance Considerations
- Bicyclists ramp down to a dedicated bike lane or mixed right-turn lane.
- Provide bike lane up to the intersection.
- Mark bicycle crossing through the intersection.
- May be combined with bicycle box treatment.
- Remove parking in advance of the intersection to increase visibility.

Maintenance Level – Low

Design Guidance
- Ramp down at least 70-100 ft before the intersection depending on the number of right turning motorists. (Denmark)
- If combined with right-turn lane must be about 13 ft wide to facilitate safe merging manoeuvres. (Denmark)

Implementation Obstacles
n/a

Example Cities/Countries
- Denmark – Collection of Concepts
- Muenster, Germany
- Amsterdam, Netherlands

Cycle Track Two-Stage Signalized Left Turn with Queuing Space

Description/Purpose
Two-stage left (aka Copenhagen-Left, Melbourne-Left, jug-handle turn) offers bicyclists a safe left-turn movement where there are physical/safety barriers to entering the roadway in advance of the intersection. Bicyclists proceed straight across the intersection to the far side and then queue in front of the cross-street traffic.

Advantages
- Reduces conflicts between motorists and bicyclists.
- Bicyclists can position themselves in front of traffic on cross street.
- Reduces complexity of left-turn for bicyclists.

Disadvantages
- Bicyclists must wait for two signals rather than one.
- Bicyclists may feel uncomfortable in the queuing area.

Application
- Cycle tracks or bike lanes with multiple motor vehicle travel lanes.
- Signalized intersections.

Source: City of Muenster, Germany

Design/Maintenance Considerations
- Use pavement markings to channelize bicycle movements and define queuing space.
- Consider a physical refuge (e.g. curb extension or jug-handle) for queuing bicyclists.
- Consider bicycle advanced signal.

Maintenance Level – Low

Design Guidance
- Markings separate left-turn and through movements of bicyclists.
- Adequate/marked queuing area.
  - Queuing area width > 4.0 ft (CROW).
- Motorists on cross street are not allowed to turn right on red.

Implementation Obstacles
n/a

Example Cities/Countries
- Netherlands, CROW Manual
- Copenhagen, Denmark
- Muenster, Germany

Forward Stop Bar

Description/Purpose
A second stop bar for bicyclists placed closer to the centerline of the cross-street than the first stop bar. Typically used with crossing treatment (i.e. curb extension) to encourage bicyclists to take full advantage of crossing design.

Advantages
- Bicyclists have better visibility of cross-street traffic.
- Bicyclists are more visible to adjacent motorists.
- Bicyclists are permitted to bypass queuing motorists.
- Shortens crossing distance for bicyclists.

Disadvantages
- Right-turn vehicle conflict if bicyclist arrives after motorist going in the same direction.
- Potential conflicts with pedestrians crossing the leg of the intersection with the forward stop bar.

Application
- Low-volume, stop-controlled intersections, preferably with curb extension
- Unsignalized bicycle boulevard crossing

Source: City of Portland (PBOT)

Design/Maintenance Considerations
- Low % right-turning motorists
- Moderate motor vehicle volumes
- High volumes of bicycle traffic
- Placement of the forward stop bar in relation to the crosswalk
- Adequate space for pedestrians
- Should be thermoplastic due to increased wear

Maintenance Level – Low

Design Guidance
- Consider other treatments if >25% motor vehicles turn right or >15% bikes (Portland)
  - Combined bike/right turn lane
  - Bike box in through lane
- Stop bar should be thermoplastic
- Stop sign permits bicyclists to move past the motorist stop bar without stopping.

Implementation Obstacles
n/a

Example Cities/Countries
- Portland, OR

Bicycle Box

Description/Purpose
Bicycle boxes are a traffic control device at signalized intersections that require motorists to stop a short distance before the crosswalk and allow bicyclists to stop in the area between the cars and the crosswalk. Bicycle boxes give bicyclists priority by allowing them to go to the head of the line.

Advantages
- Gives bicyclists priority and makes them more visible to mitigate "right-hook" threat.
- Gives bicyclists on bike boulevards priority when signal has a short green phase.
- Enables left-turning bicyclists to position themselves to the left prior to getting a green signal (works vise-versa if bicyclists turning right from left side bike lane).
- Lessens nuisance from exhaust.

Disadvantages
- Eliminates motorist right-on-red.
- Potential for unfamiliar drivers to be confused or to encroach into the bicycle box.
- Maintenance costs of colored surface.

Application
Signalized intersections:
- A high number of queuing bicyclists
- High automobile & bicycle volumes
- Frequent turning conflicts
- A high percentage of turning movements by both bicyclists and motorists.

Design Guidance
- Reservoir (box) depth
  - 13 ft -16.4 ft (CROW/London)
- Lead-in approach bike lane to allow bicycles to bypass queuing motor vehicles.
  - Minimum width: 5 ft (London)
  - As long as queue length
- Prominent bicycle symbol and bright color surfacing.
- Right-turn-on-red prohibited.
- Consider "head start" advanced signal.

Source: Denver Igarta
Portland, OR

Design/Maintenance Considerations
- Identify dimensions that work best for bicyclists (comfort/safety)
- Box may be disregarded by motorists if not commonly filled by bicyclists and properly signed.
- Consider surface color and markings to reduce vehicle encroachment

Maintenance Level – High

Implementation Obstacles
- Not part of the Manual on Uniform Traffic Control Devices (MUTCD)

Example Cities/Countries
- Cambridge, MA
- Portland, OR
- Vancouver, BC, CA
- Victoria, BC, CA
- Amsterdam, Netherlands
- Muenster, Germany

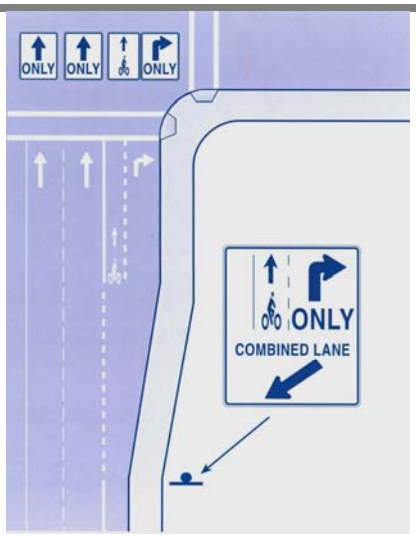
Combined Right-turn Bike Lane

Description/Purpose
A right-turn lane for automobiles that is also a through lane for bicyclists, marked or unmarked, but signed as such.

Advantages
- Identifies bicyclist location in a geometrically restricted intersection.
- Allows "dual use" of lane where there is insufficient space for both bicycle lane and dedicated right-turn lane.

Disadvantages
- Through-bicyclists may block right-turning motorists where turn capacity is needed.

Application
- Where a bike lane approaches a congested intersection that requires an exclusive right-turn lane for motorists.



Source: Oregon Department of Transportation

Design/Maintenance Considerations
- Advance warning is needed for bicyclists and motorists.
- Not appropriate at intersections with very high peak automobile turn demand or where automobile turn demand is consistently high throughout the day.
- Maintenance Level – Low or High. If the combined right-turn and bike lane includes markings for the cyclist space, those markings will be regularly driven over and suffer faster wear than a center of lane marking. Without markings the maintenance should be low and consist of only sign maintenance.

Design Guidance
- < 10% of auto traffic is right-turning
- If > 25% of auto traffic is right-turning, use bike box in adjacent through lane if bike demand is sufficient
- Use shared lane marking in right-turn lane to show through bicycle movement

Implementation Obstacles
n/a

Example Cities/Countries
Vancouver, Washington

Traffic Circles

Description
Traffic circles are raised circular islands at the center of the intersection of two or more streets.

Advantages
- Requires motorists to slow down to drive around them
- Reduces the likelihood of right-angle collisions

Disadvantages
- High cost
- Delay to fire trucks
- Long vehicles cannot go around circle to make a left turn
- Where bike lanes do not exist, bicyclists and motorists are forced together

Application
- Local Service streets only

Source: Denver Igarta
Vancouver, BC

Design Considerations
- Proximity of circular roadway to pedestrian crossing path
- Emergency vehicle access
- On high volume roadways impact repairs may be more frequent, but are typically infrequent. Maintenance of vegetation for visibility issues may be required every five years.

Maintenance Level - Medium

Design Guidance

Design Obstacles/Challenges
n/a

Example Cities/Countries
- Seattle, Washington
- Portland, Oregon
- Vancouver, BC, Canada

Bicycle Boulevard Off-Set Intersection with Arterial Street

Description/Purpose
A variety of treatments to facilitate an off-set bicycle boulevard crossing of a major traffic street where the bicycle boulevard forms two closely spaced T-intersections.

Advantages
- Provides facilities for bicyclists to enabling them to cross one direction of traffic at once or using a dedicated signal.
- Facilitates bicycle mobility on bicycle boulevards.
- Provides safe crossings of high-volume roads.

Disadvantages
- Some designs may limit turning movements for motorists.
- Parking removal may be required for some designs.

Application
- Bicycle boulevards intersecting arterial streets at off-set locations.

Source: Roger Geller
Portland, OR

Design/Maintenance Considerations
- Designs for *RIGHT* off-set intersections include:
  - Bicycle-only center turn lane(s)
  - Median refuge island with integrated bike path
  - Right-running bike lane/cycle track with left-turn pockets
  - Two-way bicycle sidepath
- Designs for *LEFT* off-set intersections include:
  - Right-running bike lane/cycle track
  - Two-way bicycle sidepath
- Provide adequate bicycle turn lane width
- Consider median refuges or signals at intersections for right-running bike facilities
- Consider cross-bike to mark roadway crossings for bicyclists
- All designs may include a signal.

Maintenance Level – Medium

Design Guidance
- Bike lane width
  - 6 to 8 ft
- Use retroreflective materials on raised or painted center turn lanes.

Implementation Obstacles
n/a

Example Cities/Countries
- Portland, OR
- Seattle, WA
- Tucson, AZ
- De Bilt, Netherlands

Median Refuge

Description/Purpose
A short median of full-height curb constructed between automobile travel lanes where bicyclists (and pedestrians) can take refuge while crossing a multi-lane or high-volume arterial.

Advantages
- Calms traffic and provides space for safe bicycle and pedestrian crossing
- Allows bicyclists and pedestrian to cross while focusing on one direction of traffic at a time.

Disadvantages
- May restrict left-turn movements of automobiles
- Requires right-of-way that may result in loss of parking spaces or a travel lane
- Cost

Application
- Relatively wide roadways with multiple lanes and few gaps in traffic.
- May be used at signalized or un-signalized crossings.
- Can be effective when located at intersections between signalized intersections that create gaps

Source: Denver Igarta
Portland, OR

Design/Maintenance Considerations
- Adequate width to allow a bicyclist with a trailer to be protected from the travel lanes
- Angled refuge (45 degree) can be used to provide space and face bicyclist towards oncoming traffic
- If a crossing island is landscaped, it should not compromise visibility.
- Consider reflectors or lighting to enhance visibility at night
- Preferable at-grade passage through the island rather than ramps and landings.

Maintenance Level – Low

Design Guidance
- Median width: minimum width 8 ft, 10 ft preferred (BMP)
  - Should be at least 6.6 ft wide to provide sufficient waiting space. (MTC)
  - If 2 m is not available, the bicycle storage area may be angled across the median (MTC)

Implementation Obstacles
n/a

Example Cities/Countries
- Portland, OR (BMP)
- San Francisco, CA (MTC)

"Cross-bike" Markings

Description/Purpose
Pavement markings adjacent to the crosswalk indicating space for bicycles to cross major intersections. Increases visibility of bicycles at intersections and encourages motorists to yield right-of-way to bicyclists waiting to cross.

Advantages
- Provides greater visibility for bicyclists at intersections.
- Informs all roadway users of where bicyclists should cross.
- Separates modes to reduce conflicts.

Disadvantages
- Cross-bike will have higher than normal wear based on the level of crossing auto traffic.

Application
- Where main bicycle routes cross relatively minor collectors.
- Where cross traffic has to yield right-of-way to crossing bicyclists.
- Not appropriate where speeds exceed 30 mph unless signalized. (Sustrans)

Source: Denver Igarta Groningen, NL

Design/Maintenance Considerations
- Consider combining with yield (sharks teeth) marking.
- Use of color
  - Improves visibility
  - Increases maintenance cost
- Markings should not be confused with crosswalks
- Skid resistant markings for bicycles
- Physical measures to slow traffic.
- Civil crossing improvements should be introduced in conjunction.
- If signalized, prohibit right turns on red.
- Consider ladder-bar shape (aka Zebra) to reduce auto tire wear
- Consider marking adjacent crosswalk to distinguish two pathways

Maintenance Level – High

Design Guidance
- Minimum width of single lane crossing is 5 ft (London/CROW)
- Minimum width of two-way crossing is 10 ft (CROW)
- Elephant footprints. Block marking (CROW)
  - 20 in by 20 in meters
  - Spacing: 20 in

Implementation Obstacles
- Not in Manual on Uniform Traffic Control Devices (MUTCD)
- May require enabling legislation
- Standards for application needed

Example Cities/Countries
- London, England (Sustrans)
- Vancouver, BC (Keefer/Carrall)
- Vienna, Austria
- Netherlands (CROW)
- Paris, France
- Groningen, Netherlands

Pass-through Curb Extension

Description
A curb extension with a path for bicyclists that permits them to drive over the curb extension.

Advantages
- Eliminates conflict point where bicycles and automobiles share the same space

Disadvantages
- Potential for pedestrian-cyclist conflict
- Automobiles overtaking bicycles and conflicts after both pass curb extension

Application
- High-conflict point where frequently stopped transit vehicle may block bike lane
- Soft diversion location where road is narrowed to induce queuing for automobile traffic

Source: Denver Igarta
Vancouver, BC

Design Considerations
- Conspicuity of in-road features for roadway users
- Clearly communicate to cyclist and motorists the proper path to take
- Clearly designate right-of-way between opposing motorists

Maintenance Level – Low

Design Guidance
- Road narrowing to 16 ft does not require advance warning, below 16 ft provide advance warning of narrow road
- Mark bike path through curb extension to reduce conflict with pedestrians
- Provide truncated domes for pedestrians for crossing both bike path and entering roadway
- Bike lane width over curb extension to match bike lane standards

Design Obstacles/Challenges
n/a

Example Cities/Countries
- Vancouver, BC
- Portland, OR

Bicycle Roundabout

Description/Purpose
Use of a circular intersection conforming to modern roundabout standards to organize the interaction of bicycles(and automobiles) where bicycle boulevards or off street pathways intersect.

Advantages
- Familiar layout
- Reduces need to stop
- More predictable interactions
- Improves safety
- Educational benefit

Disadvantages
- Space needs
- Compliance uncertainty

Application
- Where two bike boulevards or shared use pathways cross.

Source: Greg Raisman
Utrecht, NL

Design/Maintenance Considerations
- Geometric layout on shared use paths should place bicyclists to center of pathway with pedestrians at sides (automobile bike analogy of roadways)
- Pedestrians should be guided to exit shared path and use concentric external pathway that crosses bikeways at splitter islands.
- Central island size and radii should encourage low-speed bicyclist interaction of 5-10 mph.

Maintenance Level - Medium

Design Guidance
- Center island diameter 20 ft minimum without visibility obstructions or truck apron.
- Target bicycle operational speed of 5-10 mph.
- Circular roadway width 8-ft minimum per lane
- Entry and exit lane widths, 6-ft minimum with flare
- Splitter island minimum 2-ft wide, offset left, with deflection toward circular roadway before entry.
- Consider raised pedestrian crossings.
- Standard roundabout signing and markings using bike-sized signs

Implementation Obstacles
n/a

Example Cities/Countries
- Utah
- Davis, California
- The Netherlands

Bicycle Boulevard Pavement Marking

Description/Purpose
Large pavement markings that identify bike boulevards. Intent of markings is to make these streets recognizable to all users as bicycle priority streets.

Advantages
- Guide bicyclists along the occasional jogs on boulevard routes.
- Reinforces proper bicycle position on a shared roadway.
- Makes bicycle boulevards as recognizable to roadway users as streets with bicycle lanes.

Disadvantages
- Maintenance costs.

Application
- Low-traffic shared roadways.

Source: vuz-essen.de
Essen, Germany

Design/Maintenance Considerations
- Supplemental arrows help direct bicyclists when boulevard route jogs.
- Fit the neighborhood aesthetic.
- Place near high-conflict areas (driveways).
- Apply markings with retroreflective paint or thermoplastic (Alta)
- Should be skid resistant.
- Consider the application of color and markings at major crossings.
- Consider wear/maintenance on roadways where motor vehicles travel.
- Potential neighbor concerns about aesthetic.

Maintenance Level – Low

Design Guidance
- Install markings at all intersections and at regular intervals:
  - 200 ft intervals (Alta)
- Symbol dimensions
  - Large bicycle symbol 5’ by 9’ (CROW)
  - 5.5’ by 9’ (London Cycle *symbol 1057*)

Implementation Obstacles
- Not in Manual on Uniform Traffic Control Devices (MUTCD)

Example Cities/Countries
- San Luis Obispo, CA
- Berkeley, CA
- Portland, OR
- Eugene, OR
- Essen, Germany
- Kiel, Germany

Shared Roadway Markings

Description/Purpose
Shared roadway pavement markings, or "sharrows", are markings used to indicate a shared lane environment for bicycles and automobiles. Sharrows increase the visibility of the roadway as a valid place for bicycle traffic and guide proper roadway positioning of bicyclists on streets where a separated facility is desired but not feasible.

Advantages
- Helps bicyclists position themselves in lanes too narrow for a motor vehicle and a bicycle to travel side by side within the same traffic lane.
- Mimics the effect of bicycle lanes on streets with constrained rights-of-way and alerts road users of the lateral location bicyclists may occupy.
- Moves bicyclists out of the "door zone" of parked cars.
- Encourages safe passing by motorists.

Disadvantages
- Maintenance requirements
- Less desirable than a separated bicycle facility.

Application
- Streets with moderate motor vehicle traffic volumes, but where bike lanes are precluded by constrained right-of-way.
- Short gaps between bike lanes.
- Streets without space for bike lanes in both directions.
- Low-traffic shared roadways to indicate presence of bikeway.
- To designate through-movement of bicycles through shared turn lane

Source: Denver Igarta
Portland, OR

Design/Maintenance Considerations
- Visible placement of markings.

Maintenance Level – Low

Design Guidance
- Design guidance for sharrows are provided in the Manual on Uniform Traffic Control Devices (MUTCD)
- Bike-and-chevron symbol dimensions 9 ft 3 in by 3 ft 3in.
- Marking placed minimum 11' from curb face.
- Symbol spacing should correspond to difficulty of bicyclists trying to take proper travel path.

Implementation Obstacles
n/a

Example Cities/Countries
- San Francisco, CA
- Portland, OR
- Montreal, Quebec, Canada
- Used by 76 jurisdictions in 26 states as of 2009

Bikeway Destination Signage

Description/Purpose
Guide signing for bicyclists along designated bike routes. Reinforce bikeway network by providing visual cues. Direct bicyclists to destinations via preferred routes.

Advantages
- Guides bicyclists to significant destinations
- Encourages potential riders

Disadvantages
- Size limits information
- Sign clutter

Application
- Bike route intersections
- At key decision points along bikeways

Design/Maintenance Considerations
- Current signs include direction, destination & distance (3D) – consider adding difficulty.
- Conspicuity
- Legend size
- Color code or route numbering

Maintenance Level - Low

Design Guidance
- Manual on Uniform Traffic Control Devices (MUTCD)
- Oregon Department of Transportation (ODOT) standard
- City of Portland standard sign

Source: City of Portland (PBOT)

Implementation Obstacles
- Federal Highway Administration and ODOT currently have standards that differ from the City of Portland.
- Maintaining and updating system with addition of new routes becomes increasingly complex.

Example Cities/Countries
- Portland, OR
- Berkeley, California
- Vancouver, BC, Canada
- Netherlands
- Denmark

Streetcar on Bikeways

(Center or left running streetcar tracks with bicycle lane or cycle track)

Description/Purpose

The street is designed to accommodate a center- or left-running streetcar track and platform. Bicyclists will either travel to the right of the streetcar in either a bike lane, cycle track or vehicle lane free of the streetcar tracks.

Advantages

- Bicyclists and streetcar are completely separated.
- Increases safety.
- The center platform eliminates the pinch point at curb extension platforms, and the lack of parked cars eliminates conflict with parking cars and doors.
- Center platforms eliminate curb extension platforms that force bicyclists to cross tracks at shallow angles.

Disadvantages

- Potential conflicts with pedestrians crossing the street to the center platform.

Application

- Where streetcar is planned on a one way or two-way street with a bicycle facility.

Source: Denver Igarta
Amsterdam, NL

Design/Maintenance Considerations

- Separate bicycle travel from streetcar tracks to the extent possible.
- Clearly mark where crosswalks meet with the bicycle facility (bike lane or cycle track)
- Way-finding signs and markings should be created for bicyclists to indicate turning opportunities
- Design should direct bicyclists to cross tracks at a right-angle.
- Crossing angles should be near-perpendicular.
- Mid-block or far-side streetcar stops may result in fewer conflicts than near-side corner stops.

Maintenance Level – Low

Design Guidance

- Track crossing angle for cyclists
  - Minimum 45 degree angle
  - Offer 90 degree whenever possible

Implementation Obstacles

n/a

Example Cities/Countries

- Melbourne, Australia (Swanston St.)
- Portland, OR (SW Bond/ SW Harrison)
- Amsterdam, Netherlands

Bicycle-Friendly Transit Stop Design

Description/Purpose
A boarding platform is placed at a transit stop between the bicycle facility and the roadway to eliminate the need for transit vehicles and bikes to merge.

Advantages
- Buses are not forced to merge into/across the bike lane.
- Bicyclists do not have to merge into automobile traffic or across rail tracks to overtake a stopped transit vehicle.

Disadvantages
- Pedestrians have to cross the bicycle facility.
- If in advance of an intersection, visibility of bicyclists may be obscured by platform/shelter.
- Potential ADA issues.

Application
- Bike lanes or cycle tracks on transit routes where buses merge with bicyclists to reach a passenger boarding area.

Source: Denver Igarta
Portland, OR

Design/Maintenance Considerations
- At intersections, visibility for motorists and bicyclists should not be blocked by the shelter.
- Communicate proper positioning for bicyclists, pedestrians and motorists.
- Consider markings or colored pavement in bicycle facility at conflict areas with pedestrians, including where pedestrians cross the bicycle facility.
- Consider maintenance – street sweeping

Maintenance Level – Low

Design Guidance
- Platform should be at least 6.56 ft wide. (CROW)
- Platform with shelter should be wider (8.2 ft) with the distance between the bicycle facility and the shelter being at least 2.1 ft apart.(CROW)
- Provide truncated domes and crosswalk markings for pedestrians crossing both the bicycle facility and the roadway
- Width of bicycle facility through the boarding area must match design standards

Implementation Obstacles
- Not part of the Manual on Uniform Traffic Control Devices (MUTCD)

Example Cities/Countries
- Netherlands (CROW)
- Copenhagen, Denmark
- Portland, OR

Bicycle Lift *(Trampe)*

Description/Purpose
The Bicycle Lift is a continuous collective transportation concept for assisting bicyclists up steep hills in urban areas.

Advantages
- Eliminates a severe topographical barrier
- Provides access for all bikeway users, not just the most fit.
- Provides a sweat-free option

Disadvantages
- Installation costs and maintenance
- May create a barrier for local auto access
- Right-of-way requirements

Application
- Relatively short bikeway segments with steep grades
- Important links in the network

Source: City of Trondheim, Norway

Design/Maintenance Considerations
- Semi-underground cableway
- Electric key card unit at base of hill (operation is unmanned)
- Trondheim prototype:
  - Operational since 1993
  - Served 145,000 trips in first 6 yrs
  - 4,500 keycard holders (approx. 150,000 residents)
  - Operates form 7 am to 10 pm
  - Safety: no injuries in 5 years. User safety rating of 4.7 out of 6 points
  - 70% of users were male

Maintenance Level - High

Design Guidance
- Maximum distance 656 ft
- Trondheim prototype:
  - Distance: 430 ft
  - Grade: up to 20%

Implementation Obstacles
- Not part of the Manual on Uniform Traffic Control Devices (MUTCD)

Example Cities/Countries
- Trondheim, Norway

PORTLAND BICYCLE PLAN FOR 2030

BIKEWAY FACILITY DESIGN: SURVEY OF BEST PRACTICES

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