



Designing for Bicyclist Safety
Module B

DESIGNING ON-ROAD BIKEWAYS

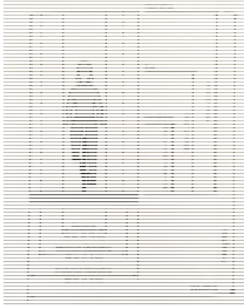
LEARNING OUTCOMES

- ✘ Describe features of on-road bikeways
- ✘ Select design criteria for on-road bikeways in various contexts

BICYCLE CHARACTERISTICS



BICYCLE CHARACTERISTICS



- ✘ Height
 - + Handlebar - 36-44 in
 - + Eye - 60 in
 - + Operating - 100 in
- ✘ Width
 - + Physical - 30 in
 - + Minimum operating - 48 in
 - + Preferred operating - 60 in

OLDER BIKEWAY TYPES

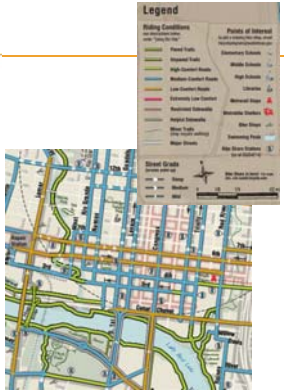
- ✘ “Bike Route”
- ✘ “Bike Path”

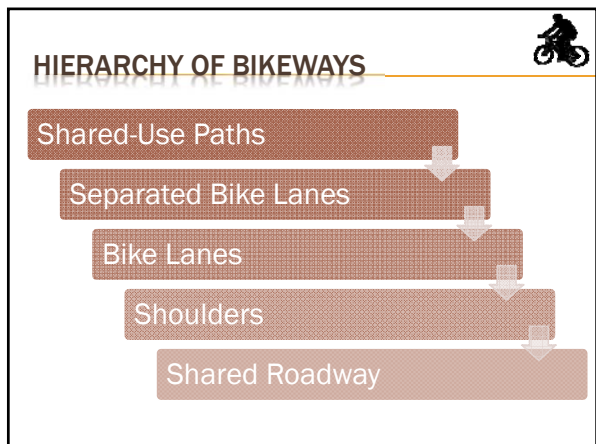
Neither term is clear

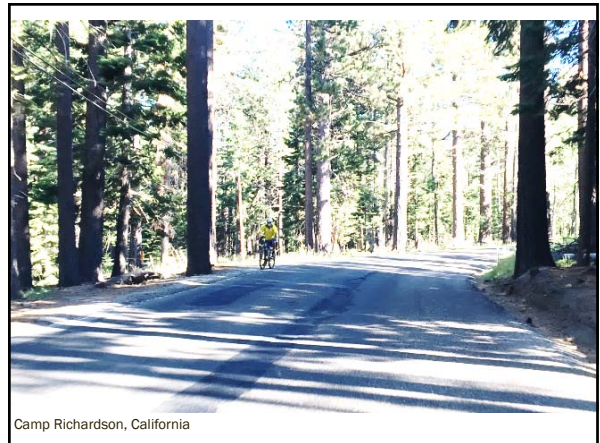
They are all *bikeways*

BIKEWAY NETWORK

- ✘ Just like roads and sidewalks, bikeways need to be part of an connected network
- ✘ Combine various types, including on and off-street facilities

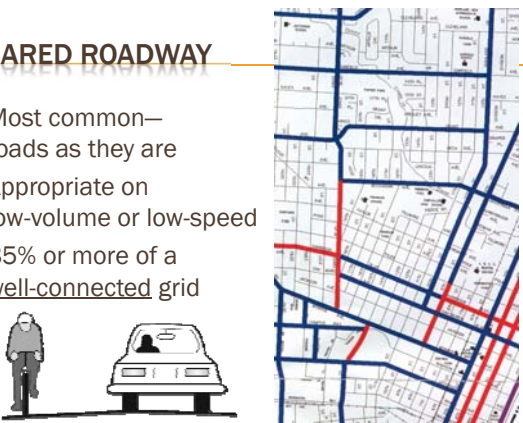







SHARED ROADWAY

- ✘ Most common—roads as they are
- ✘ Appropriate on low-volume or low-speed
- ✘ 85% or more of a well-connected grid




SHARED LANES

- ✘ Unless prohibited, all roads have shared lanes
- ✘ No special features for:
 - + Minor roads
 - + Low volumes (< 1000 vpd)
 - + Speeds vary (urban v. rural)




SHARED LANES

- ✘ Supplemental features
 - + Pavement markings or “sharrows”
 - + Detectors & signal timing



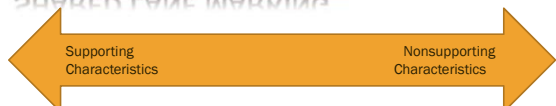
SHARED LANE MARKING

- ✘ Lateral position
- ✘ Connect gaps in bike lanes
- ✘ Roadway too narrow for passing
- ✘ Position in intersections & transitions

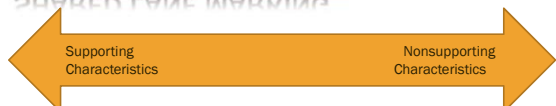


SHARED LANE MARKING

Supporting Characteristics



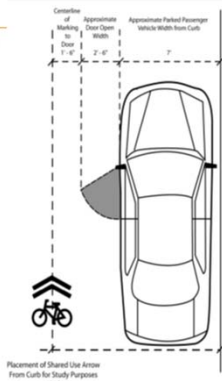
Nonsupporting Characteristics



- ✘ More than 1 lane
- ✘ Downhill or level
- ✘ Short segment to fill gap in bikeway
- ✘ Speed < 30 mph
- ✘ High bicycle use
- ✘ Single lane
- ✘ Uphill
- ✘ Parallel route option
- ✘ Long segment
- ✘ Speed > 40 mph
- ✘ Low bicycle use

SHARED LANE MARKING

- ✘ Center in lane
 - + Prevent “dooring”
 - + Prevent passing too closely
 - + Keep bicyclist visible





SHARED ROAD SIGNS

- ✗ Ride side-by-side?
- ✗ Chase bicyclist?
- ✗ Warning or regulation?
- ✗ Opposite forces?

...and who "shares"?

New Orleans, LA Philadelphia, PA California

SHARED ROAD SIGNS

- ✗ Reminder for motorists

On Roadway

MAY USE FULL LANE

PASSING SIGNS

- ✗ TCD's not meant to be educational
- ✗ Limit to areas with identified problem

Corvallis, Oregon

- ✗ Low speed/low volume
- ✗ Up to 25 mph for LTS 1

Corvallis, Oregon

- ✗ Low speed/low volume
- ✗ Up to 30 mph for LTS 2



✘ Low speed street



Bend, Oregon

✘ Increased speed or volume, increased LTS
✘ LTS 3



Salem, Oregon

✘ Increased speed or volume, increased LTS
✘ LTS 4



✘ Rural back roads




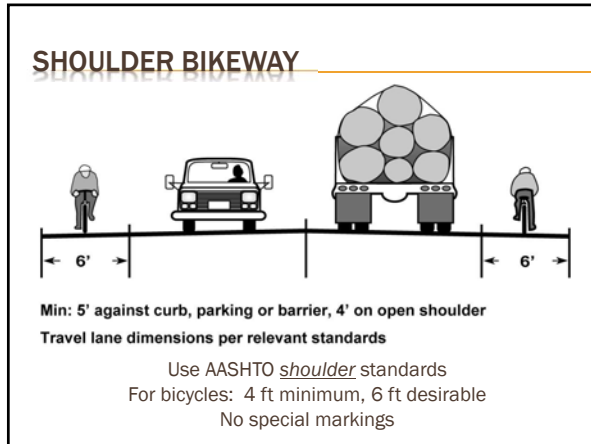
Designing On-Road Bikeways

PAVED SHOULDERS

PAVED SHOULDERS

- ✘ Useful for higher traffic volume and/or speed
- ✘ Frequently used for rural
- ✘ Uphill direction
- ✘ Not a travel lane – intersection conflicts
- ✘ Rumble strips
- ✘ Maintenance





SHOULDER BIKEWAY

Functional classification	Volume (AADT)	Speed (Mi/h)	Recommended Minimum Paved Shoulder Width
Minor Collector	up to 1,100	35 (55 km/h)	5 ft (1.5 m)
Major Collector	up to 2,600	45 (70 km/h)	6.5 ft (2.0 m)
Minor Arterial	up to 6,000	55 (90 km/h)	7 ft (2.1 m)
Principal Arterial	up to 8,500	65 (100 km/h)	8 ft (2.4 m)

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RUMBLE STRIPS

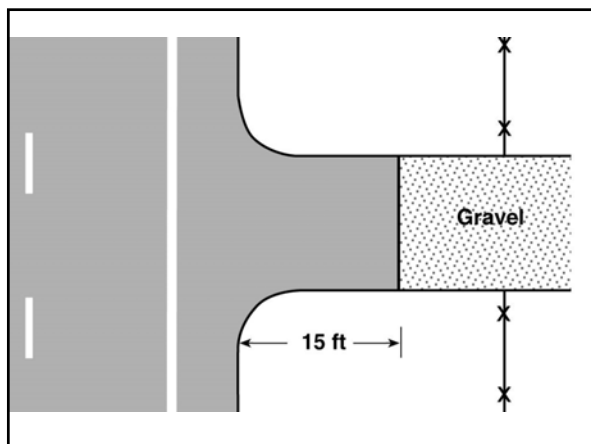
- ✘ Safety countermeasure for motor vehicle ROTR crashes
- ✘ Can render shoulder unrideable

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RUMBLE STRIPS

- ✘ Minimum clear path
 - + 4 feet
 - + 5 feet adjacent to curb
- ✘ Periodic gaps
 - + Minimum length 12 feet
 - + Interval 40 - 60 feet
- ✘ Gaps at intersections
 - + 10 - 20 feet prior to cross-street or driveway
- ✘ Bicycle tolerable (?) rumble strips

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BIKE LANE DEFINED

Portion of the roadway or shoulder designated for exclusive or preferential use by people riding bicycles

ADVANTAGES

- ✘ Low stress on wide/low speed streets
- ✘ Access to major destinations
- ✘ Mobility on arterials
- ✘ Guide bicyclist behavior
- ✘ Improve visibility

ADVANTAGES

- ✘ Travel at bicyclist's pace

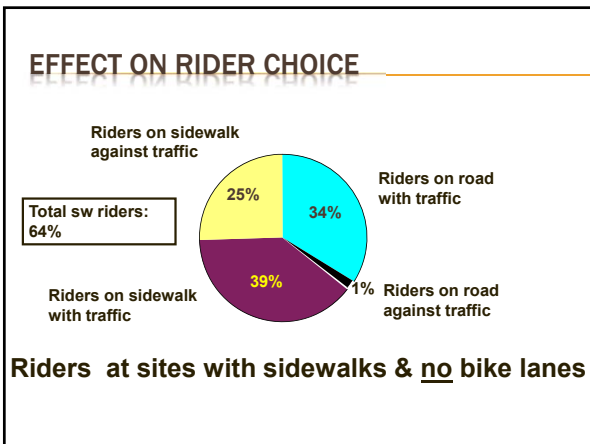
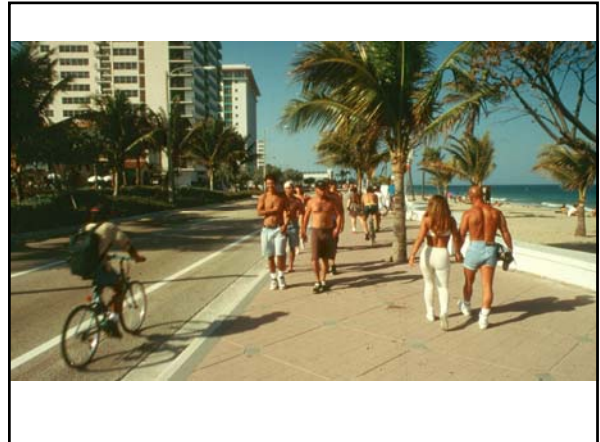
Geneva, Switzerland

ADVANTAGES

- ✘ Guide cyclists behavior
 - + Visible
 - + Predictable

ADVANTAGES

- ✘ Reduce pedestrian conflicts
- ✘ Improve visibility at driveway conflicts



RELATIVE DANGER INDEX


Facility	Relative Danger Index
Major Streets w/out bike lanes	1.28
Minor Streets w/out bike lanes	1.04
Streets with bike lanes	0.5
Mixed-use paths	0.67
Sidewalks	5.32

1.00 = median

* Typical shared roadway


DISADVANTAGES

- ✗ LTS 3 or 4 on arterials
- ✗ Often too narrow
- ✗ Removal of parking




BIKE LANES

- ✗ Urban thoroughfares
- ✗ Efficient cross-town travel
- ✗ Stop or signal control
- ✗ Little point on local streets

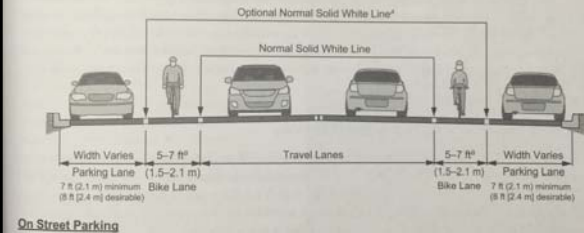


BIKE LANES

- ✗ Preferred in urban/suburban
- ✗ Rural for high demand for bicycle travel
- ✗ Preferential space for bicyclists delineated
- ✗ Bicyclists may leave lane
 - + Passing
 - + Turning
 - + Avoid debris
 - + Avoid buses
- ✗ Priority for uphill

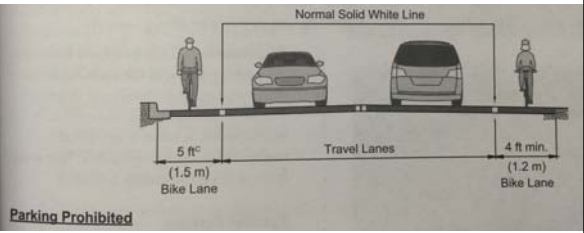


BIKE LANE WIDTH

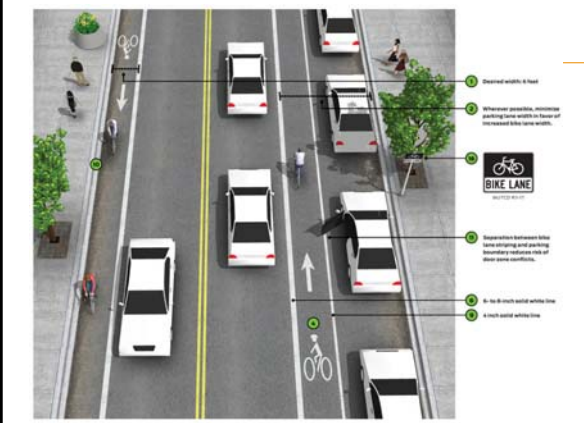


Desirable: 7 feet
AASHTO Guide minimum: 5 Feet

BIKE LANE WIDTH



Parking Prohibited



BIKE LANE SURFACE

- ✘ Cross slope
 - + 2% preferred
 - + 8% allowable when constrained
- ✘ Pavement
 - + Asphalt
 - + Concrete joints
 - + Avoid pavers



SHY DISTANCE

- ✘ Lateral offset
 - + Height < 36" no offset
 - + Height > 36" 6" offset
- ✘ Vertical clearance
 - + 100"



GUTTER PAN

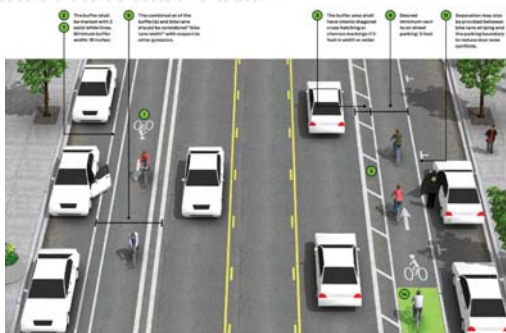


BUFFERED BIKE LANE

- ✘ Shy distance
- ✘ Bike passing
- ✘ Door zone
- ✘ Wider w/out confusing motorists
- ✘ More comfortable



BUFFERED BIKE LANE



WIDE BIKE LANE/LOW SPEED



LTS 1

BUFFERED BIKE LANE



LTS 1

5 FT BIKE LANE/30 MPH



LTS 2

5 FT BIKE LANE/35 MPH



LTS 3

5 FT BIKE LANE/40 MPH



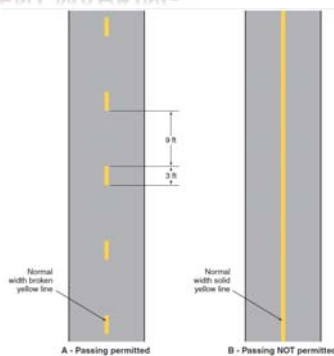
LTS 4

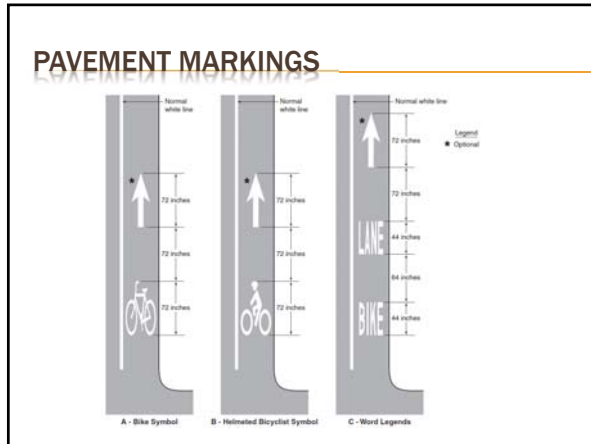
PAVEMENT MARKING & SIGNING

- ✘ Longitudinal marking required
 - + Solid white line between bikes & motor vehicles
 - + Line recommended between bikes & parking
- ✘ Symbols at beginning & interval
- ✘ Signs



PAVEMENT MARKING





Section 3B.24 Chevron and Diagonal Crosshatch Markings

Option:

01 Chevron and diagonal crosshatch markings may be used to discourage travel on certain paved areas, such as shoulders, gore areas, flush median areas between solid double yellow center line markings or between white channelizing lines approaching obstructions in the roadway (see Section 3B.10 and Figure 3B-15), between solid double yellow center line markings forming flush medians or channelized travel paths at intersections (see Figures 3B-2 and 3B-5), buffer spaces between preferential lanes and general-purpose lanes (see Figures 3D-2 and 3D-4), and at grade crossings (see Part 8).

Standard:

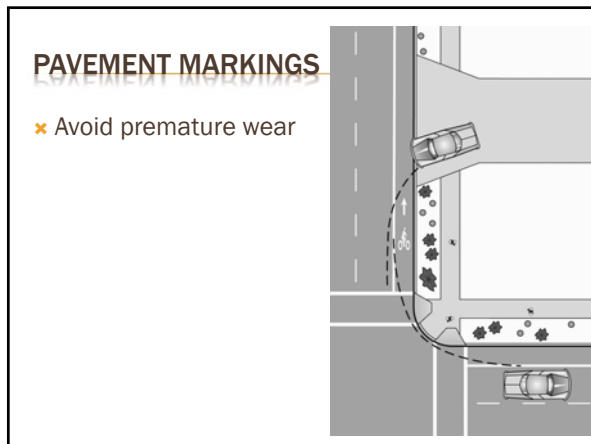
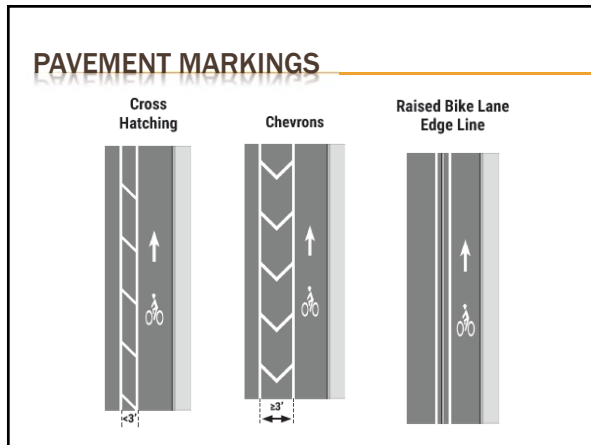
02 When crosshatch markings are used in paved areas that separate traffic flows in the same general direction, they shall be white and they shall be shaped as chevron markings, with the point of each chevron facing toward approaching traffic, as shown in Figure 3B-8, Drawing A of Figure 3B-9, Figure 3B-10, and Drawing C of Figure 3B-15.

03 When crosshatch markings are used in paved areas that separate opposing directions of traffic, they shall be yellow diagonal markings that slant away from traffic in the adjacent travel lanes, as shown in Figures 3B-2 and 3B-5 and Drawings A and B of Figure 3B-15.

04 When crosshatch markings are used on paved shoulders, they shall be diagonal markings that slant away from traffic in the adjacent travel lane. The diagonal markings shall be yellow when used on the left-hand shoulders of the roadways of divided highways and on the left-hand shoulders of one-way streets or ramps. The diagonal markings shall be white when used on right-hand shoulders.

Guidance:

05 The chevrons and diagonal lines used for crosshatch markings should be at least 12 inches wide for roadway having a posted or statutory speed limit of 45 mph or greater, and at least 8 inches wide for roadways having posted or statutory speed limit of less than 45 mph. The longitudinal spacing of the chevrons or diagonal lines should be determined by engineering judgment considering factors such as speeds and desired visual impacts. The chevrons and diagonal lines should form an angle of approximately 30 to 45 degrees with the longitudinal lines that they intersect.





PAVEMENT MARKINGS

- ✦ Add green pavement marking – bike lanes & sharrows

PAVEMENT MARKINGS

- ✦ Add green pavement marking – bike lanes & sharrows

SIGNING

- ✦ Beginning, end, & interval
- ✦ Optional

SIGNING

SIGNING

CONTRA-FLOW BIKE LANE

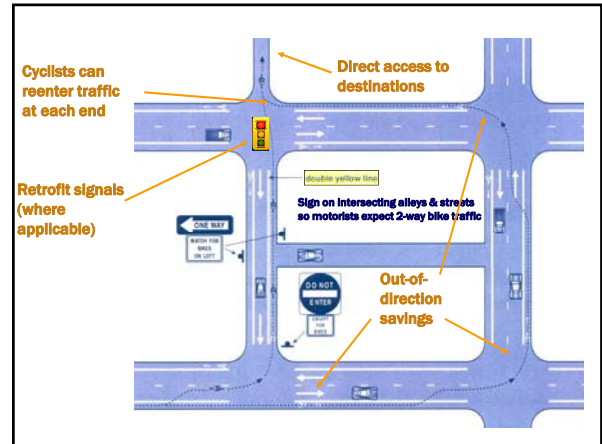
Reasons for:

- ✘ Continuity on one-way
- ✘ Avoid conflicts
- ✘ Maximize space



Considerations:

- ✘ Markings
- ✘ Signing
- ✘ Intersections



Double yellow line creates 2-way street
With-flow cyclists ride in "normal" bike lane...



...or in a shared travel lane without bike lane



Madison, Wisconsin

BIKE LANE PLACEMENT

- ✘ Both sides of two-way streets



BIKE LANE PLACEMENT

- ✘ Exception - may omit on downhill



BIKE LANE PLACEMENT

- ✘ Add shared-lane for uphill - discourage wrong-way



BIKE LANE PLACEMENT

- ✘ Between parking and travel lane



BIKE LANE PLACEMENT

- ✘ Right side of one-way



BIKE LANE PLACEMENT

- ✘ Exception—left side to avoid conflicts



BIKE LANE PLACEMENT

- ✘ Exception—left side to avoid conflicts



BIKE LANE PLACEMENT

- ✘ Exception – two-way to avoid conflicts



San Juan, PR

BIKE LANES & ON-STREET PARKING

- ✘ Use wider bike lane with
 - + High turnover parking
 - + Narrow parking lane



Is diagonal parking compatible with bicycling?

BACK-IN DIAGONAL PARKING

- ✘ Back-in diagonal parking
 - + Improve sight distance
 - + No door conflicts
 - + Easier trunk access
 - + Passengers channeled to curb



Designing On-Road Bikeways

SEPARATED BIKE LANES

SEPARATED BIKE LANES

- ✘ Exclusive bike facility
- ✘ Adjacent to or on roadway
- ✘ One-way or contra-flow
- ✘ Separated from traffic by vertical element



SEPARATED BIKE LANES



Mid-block (LTS 1)

SEPARATED BIKE LANES



Mid-block (LTS 1)

SEPARATED BIKE LANES



Minneapolis, Minnesota

Mid-block (LTS 2)

SEPARATED BIKE LANES



Mid-block (LTS 1 - except at intersection)

SEPARATED BIKE LANES



Mid-block (LTS 1 - except at driveways)

SEPARATED BIKE LANES

Advantages

- ✘ Very low stress midblock
- ✘ Encourages bike riding
- ✘ More conspicuous
- ✘ Crash rate reductions

SEPARATED BIKE LANES

Disadvantages

- ✘ Special intersection treatments
- ✘ Special driveway treatments
- ✘ Additional space needed
- ✘ More costly than bike lanes
- ✘ More to learn

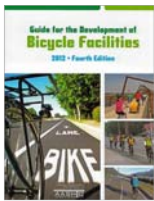
SEPARATED BIKE LANES

- ✘ Exclusive bike facility
- ✘ Adjacent to or on roadway
- ✘ One-way or contra-flow
- ✘ Separated from traffic by vertical element

- + Delineators
- + Bollards
- + Barrier
- + Median
- + Raised bike lane
- + Planters
- + Wheel stops
- + Parked cars



DESIGN GUIDANCE



- ✘ Primarily a geometric design feature
- ✘ Follow combination of shared use path & bike lane guidance
 - + Dimensions
 - + Horizontal
 - + Signal timing
 - + Design controls (speed, braking)

DESIGN GUIDANCE



- ✘ Follow combination of shared use path & bike lane guidance (chapter 9)
 - + Bike lane signs
 - + Bike lane and path markings
 - + Bike lane extensions
 - + Signal placement
 - + Contra-flow

Look beyond current MUTCD

DESIGN GUIDANCE

- ✘ Not addressed in AASHTO
- ✘ Emerging need for design guidance
- ✘ Evolving knowledge with increasing experience



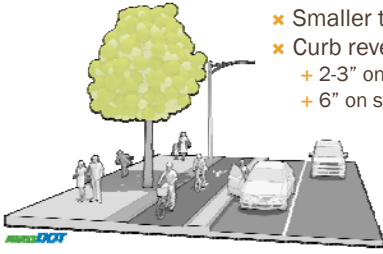
DESIGN GUIDANCE

- ✘ Conflicting definitions
- ✘ Basic dimensions
- ✘ Intersection considerations
- ✘ Goes beyond MUTCD
- ✘ Some contradictions



INTERMEDIATE LEVEL

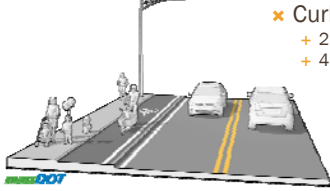
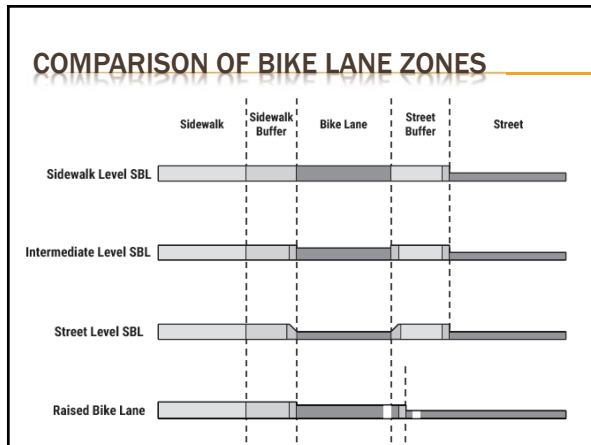
- ✗ Curb & drainage flexibility
- ✗ Smaller transitions
- ✗ Curb reveal:
 - + 2-3" on bike lane
 - + 6" on street



RAISED BIKE LANE

bike lane + buffer < 7 ft

- ✗ One-way
- ✗ No parking for two-way
- ✗ No protected intersection
- ✗ Curb reveal
 - + 2" on bike lane
 - + 4" on street

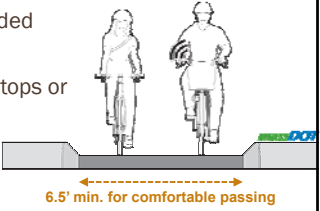
BIKE LANE WIDTH

Same Direction Bicyclists/ Peak Hour	Bike Lane Width (ft.)	
	Rec.	Min.*
<150	6.5	5.0
150-750	8.0	6.5
>750	10.0	8.0

- ✗ One-way

Widths vary by peak hour volume

- + 6.5-10 ft recommended
- + 5-8 ft minimum
- + 4' allowable at bus stops or accessible parking




BIKE LANE WIDTH

Bidirectional Bicyclists/ Peak Hour	Bike Lane Width (ft.)	
	Rec.	Min.*
<150	10.0	8.0
150-400	11.0	10.0
>400	14.0	11.0

- × Two-way

Widths vary by peak hour volume

- + 10-14 ft recommended
- + 8-11 ft minimum

≥ 10' min. for comfortable passing



BIKE LANE WIDTH

- × Maintenance
 - + Sweeping
 - + Snow removal

STREET BUFFER WIDTH

- × 6' preferred
- × 2' when constrained
- × 1' along raised SBL
- × 6-16.5' optimum for intersections

VERTICAL ELEMENTS

Vertical

Beveled
1V:1H

Mountable
1V:4H

Curb angle & height influence:

- + Wheel & pedal strike hazard
- + Bicycle access to sidewalk
- + Motor vehicle encroachment
- + Cross section width



BEVELED CURB



MOUNTABLE CURB



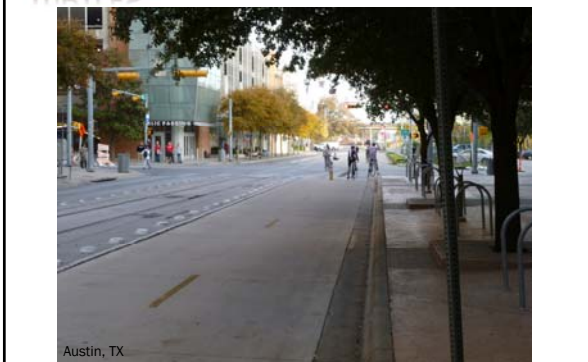
VERTICAL ELEMENTS

- ✗ Painted median
- ✗ Parking
- ✗ Lower cost
- ✗ Considerations
 - + Shy distance
 - + Spacing
 - + Durability
 - + Clear zone

FLEXIBLE DELINEATORS



TURTLES



ARMADILLOS



PARKING STOPS



RIGID BOLLARDS



PLANTERS



CONCRETE BARRIER



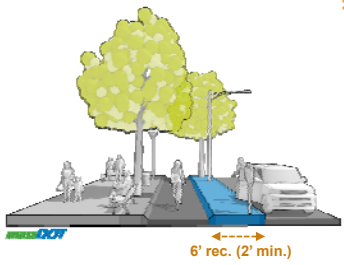
LOCAL BRANDING



INTERIM CONNECTIONS



VERTICAL ELEMENTS




- ✗ Raised median
 - + Any bike lane elevation
 - + Higher cost
 - + Considerations
 - ✗ Streetscape
 - ✗ Landscaping
 - ✗ Drainage

6' rec. (2' min.)

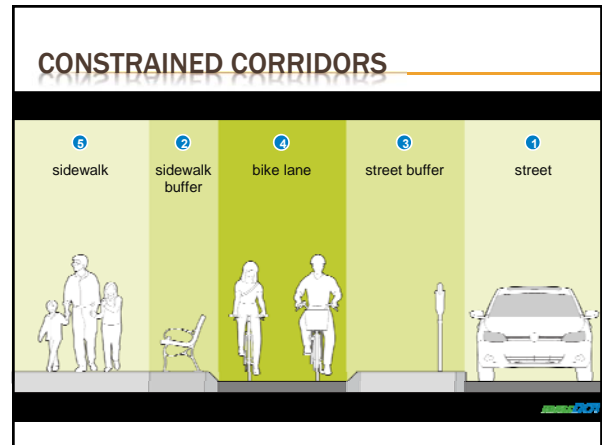


SIDEWALK BUFFER

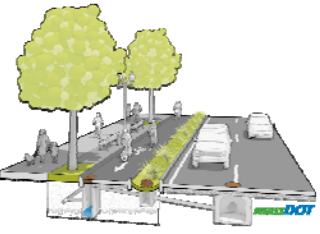
- ✗ Width considerations
 - + Minimum continuous sidewalk width 4'
 - + Minimum sidewalk for passing 5'
 - + Wider in commercial centers
 - + Shy distance
 - + Visual contrast



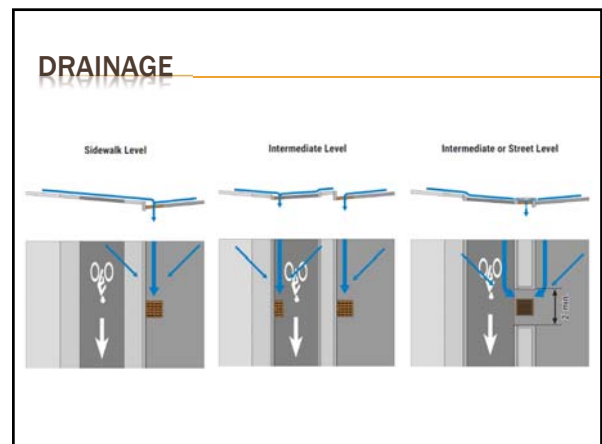
Philadelphia, PA (concept)

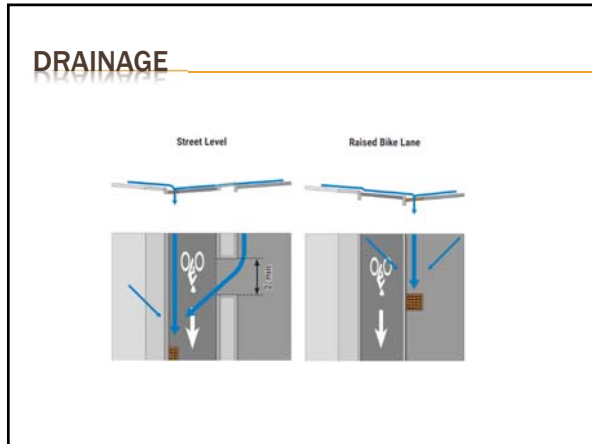


DRAINAGE



- ✗ Grates
- ✗ Stormwater management
 - + Bike lane elevation
 - + Roadway crown
 - + Existing catch basins
 - + Existing utilities
 - + Median openings

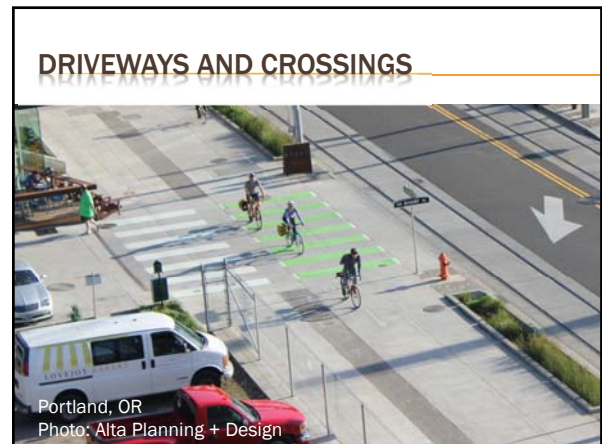


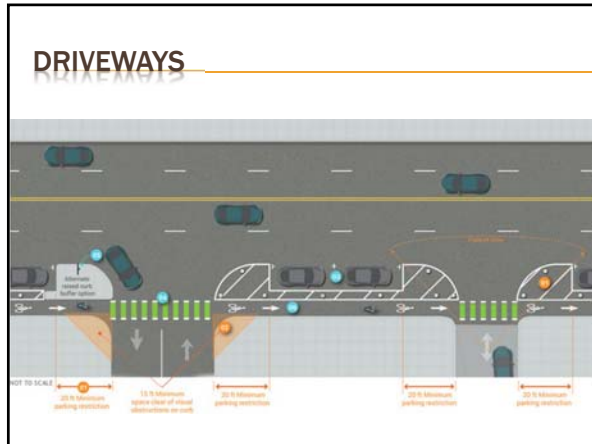


LANDSCAPING

- ✘ Considerations
 - + Clear zone
 - + Usable sidewalk width
 - + Tree clutter
 - + Lateral offset
 - + Vertical clearance
 - + Sight distance

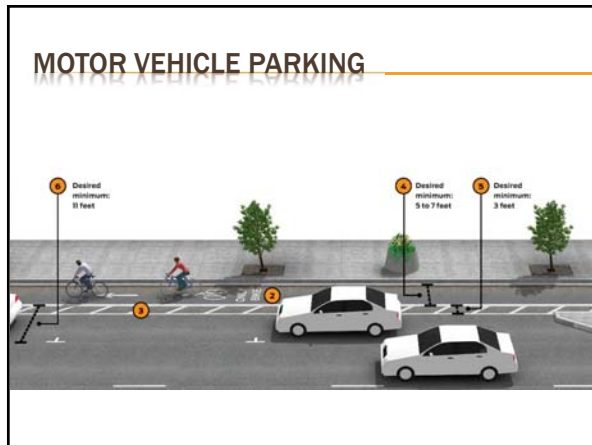
A 3D perspective rendering of a street scene. It shows a sidewalk with several trees, a raised bike lane, and a road with a car. The trees are green and have a rounded canopy. The bike lane is marked with a bicycle symbol. The road has a white arrow pointing forward.





CURBSIDE ACTIVITY

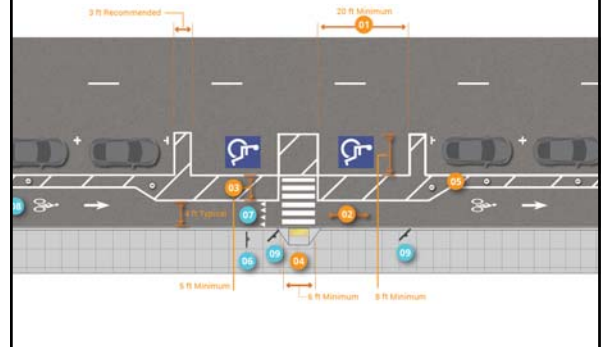
- ✘ Motor vehicle parking
- ✘ Bike parking
- ✘ Loading zones
- ✘ Bus stops



BIKE PARKING



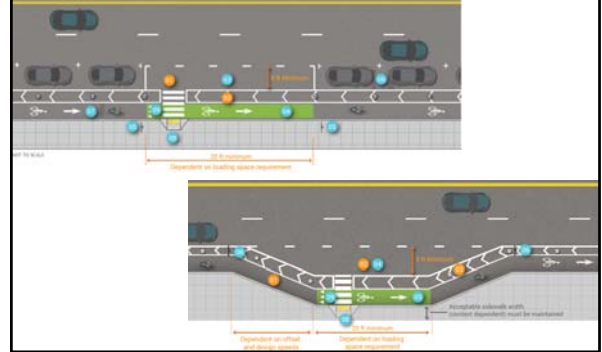
ACCESSIBLE PARKING



ACCESSIBLE PARKING



LOADING ZONES

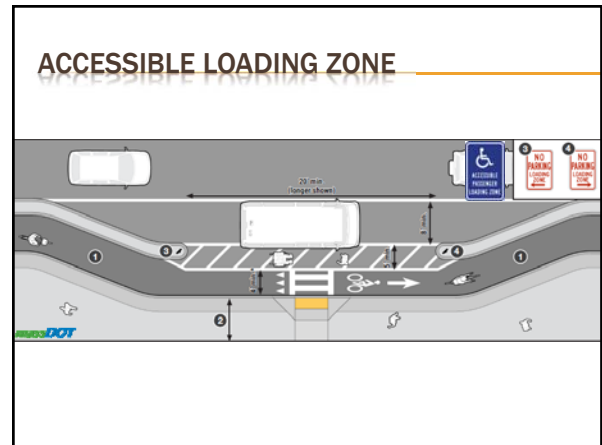
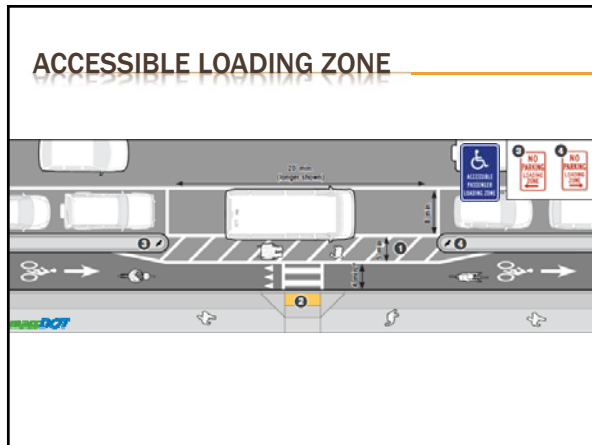
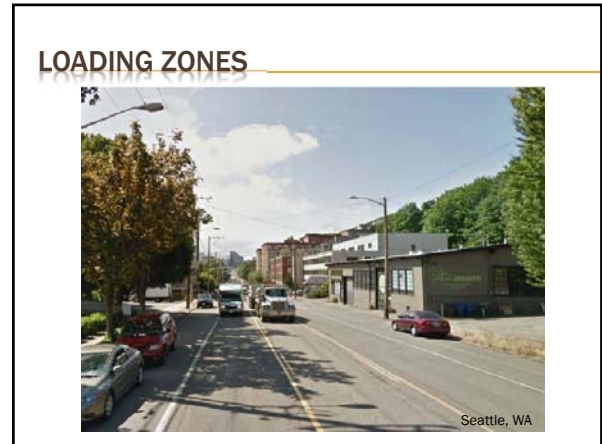


LOADING ZONES



LOADING ZONES





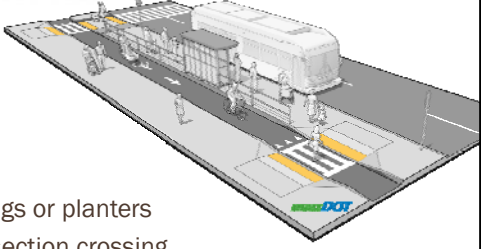
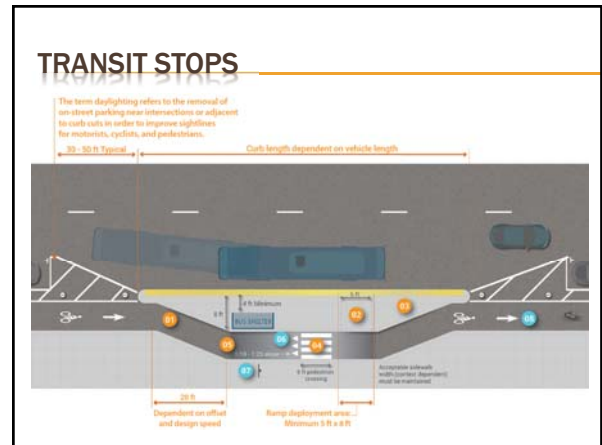
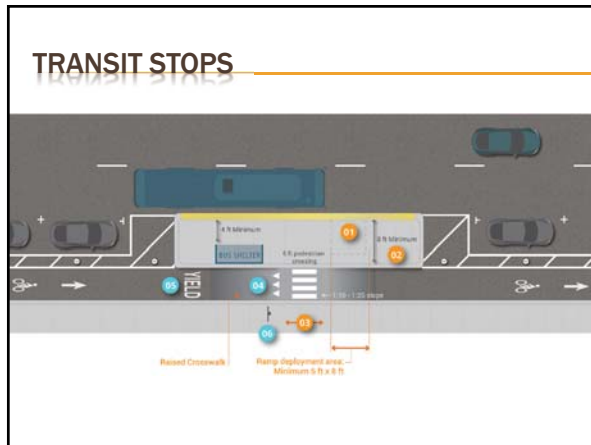
TRANSIT STOPS

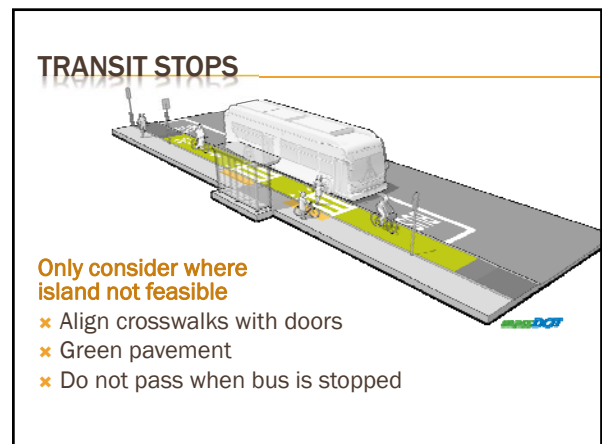
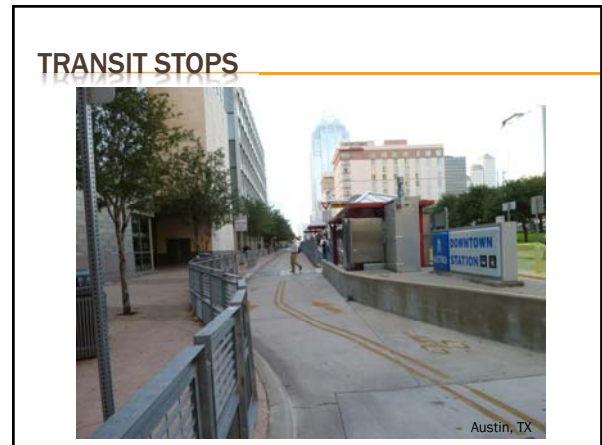
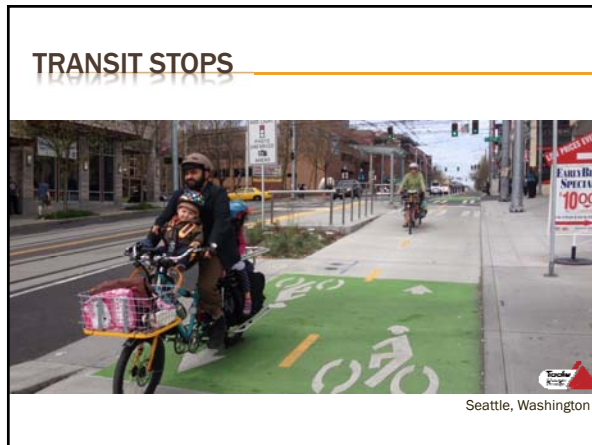
- ✗ Considerations
 - + Opposite side of street
 - + Guide passengers
 - + Two crossings
 - + Communicate to bicyclists
 - + Floating bus stop
 - + In-lane bus operation

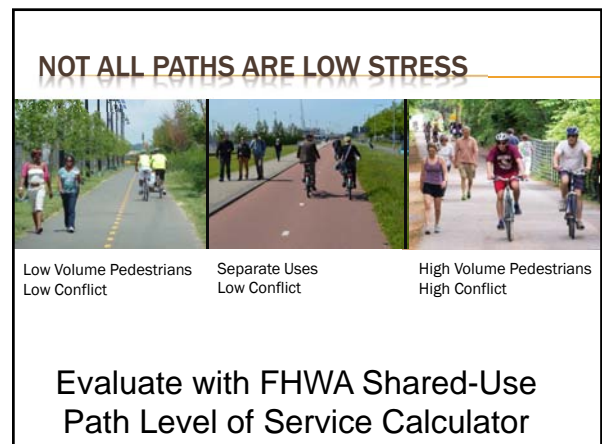
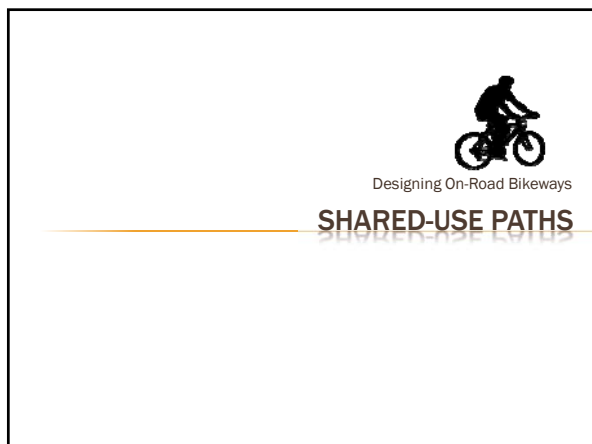
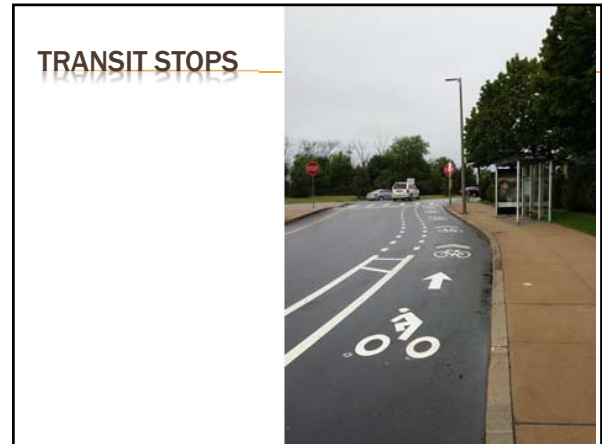
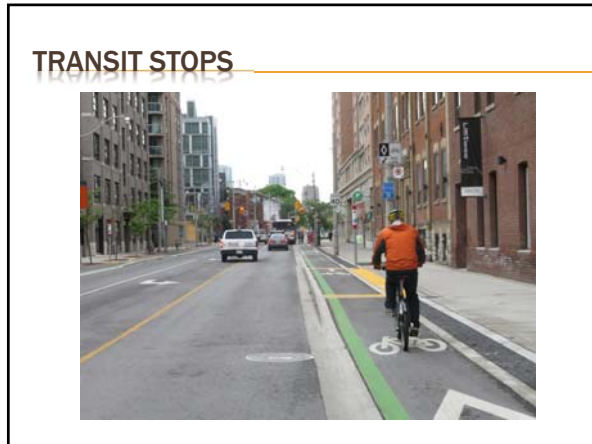


TRANSIT STOPS

- ✗ Railings or planters
- ✗ Intersection crossing
- ✗ Stop or yield markings







SHARED USE PATHS

Path width

Considerations:

- ✦ Based on anticipated user types, speeds, and volumes
- ✦ FHWA Shared Use Path Level of Service
- ✦ 10 ft minimum
- ✦ Research finds 11 feet best for overtaking (3 lanes)
- ✦ Wider in more populated areas
 - + 14 feet in urban areas desired

SHARED USE PATHS

Design strategies:

- ✦ Clearances/shoulders
- ✦ Separation
- ✦ Turning movements
- ✦ Intersections

SEPARATION OF USERS ALLOWED

- ✦ Bi-directional walking lane for pedestrians with directional lanes of travel for cyclists
 - + 5 ft min width for pedestrians
 - + At least 10 feet for bicyclists

SEPARATION OF USERS

- ✦ When pedestrians outnumber bicyclists, they are less likely to follow the rules.



SEPARATION OF USERS



ACCESSIBILITY CONSIDERATIONS



ACCESSIBILITY CONSIDERATIONS

