Designing for Bicyclist Safety
Module C

INTERSECTION DESIGN TREATMENTS

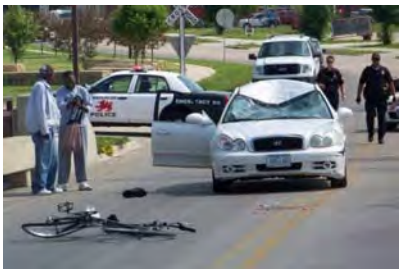
LEARNING OUTCOMES

- Understand intersection design options and features
- Select appropriate design feature for a bikeway in a given context

KEY SAFETY FACTORS

Important Message

- Speed
- Number of lanes
- Visibility
- Traffic volume & composition
- Conflict points
- Proximity
- Bike control
- Connectivity

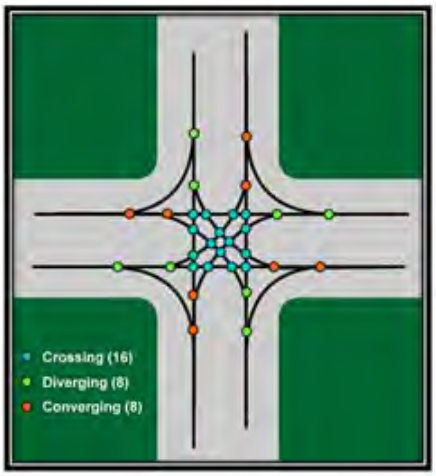


INTERSECTION DESIGN PRINCIPLES

- Reduce speed
- Minimize exposure to conflicts
- Communicate right-of-way priority
- Provide adequate sight distance

INTERSECTION CONFLICTS

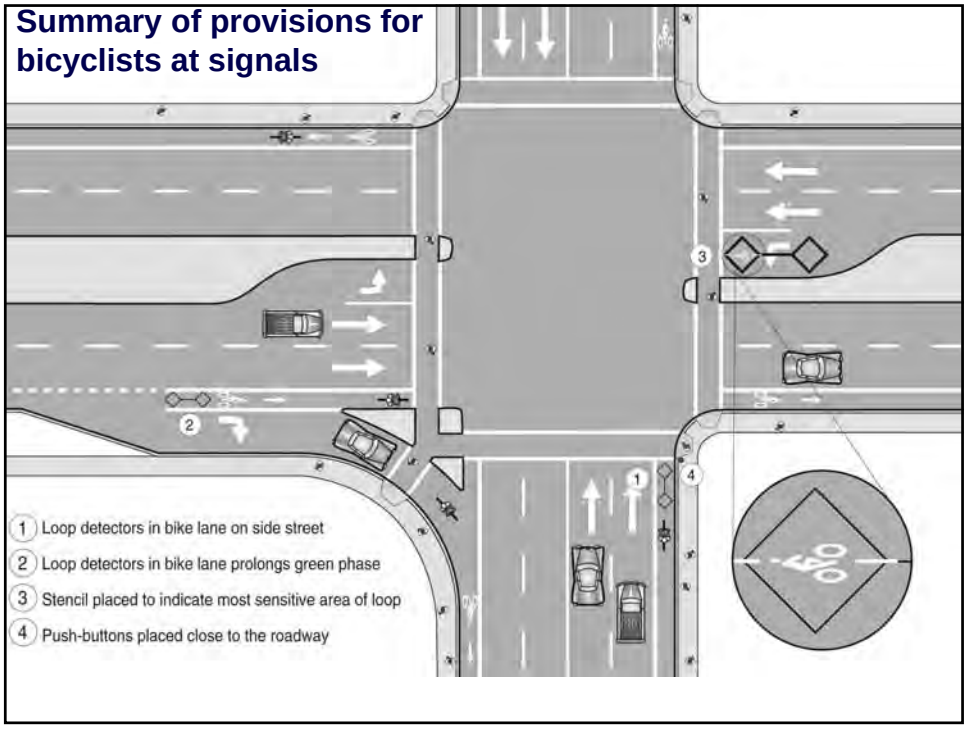
- Typical conflicts for both pedestrians and motorists, plus:
  - Right-turn/thru movement
  - Weaving to left turn



Designing for Bicyclist Safety

PLACEMENT OF BIKEWAY THRU INTERSECTION

Summary of provisions for bicyclists at signals



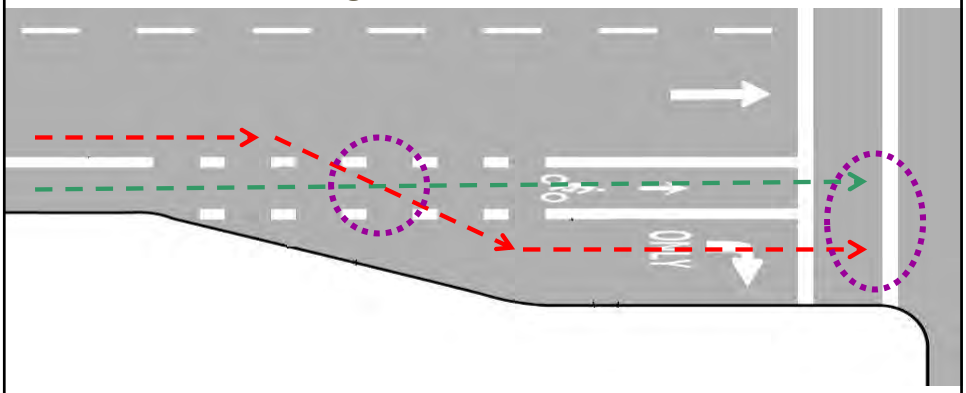
INTERSECTION WITH SHARED LANES

- Additional/all lanes are shared at intersection

INTERSECTION WITH BICYCLES ON SHOULDER

- Shoulder not a travel lane
- Opportunity to switch to shared lanes

Bike Lane & Right-turn Lane Channelization

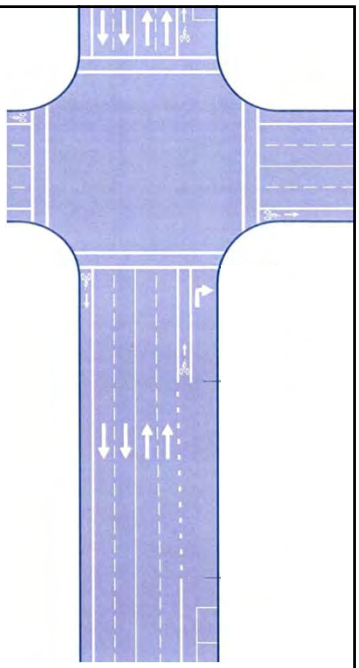


Always place bike lane to left of RTL to

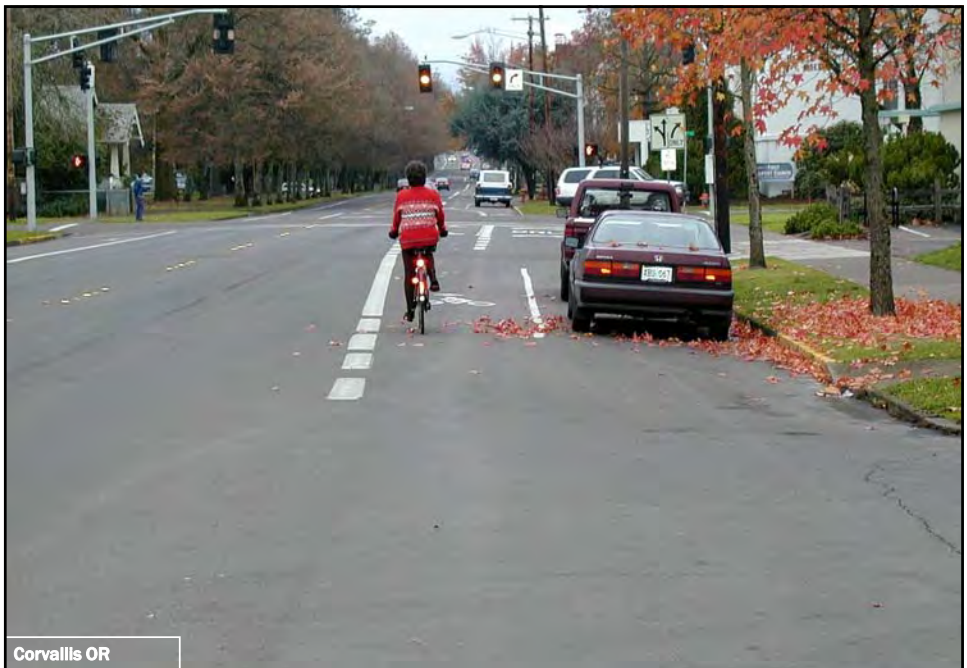
- Separate conflicts
- Make bicyclists' movements more predictable
- Take advantage of speed difference

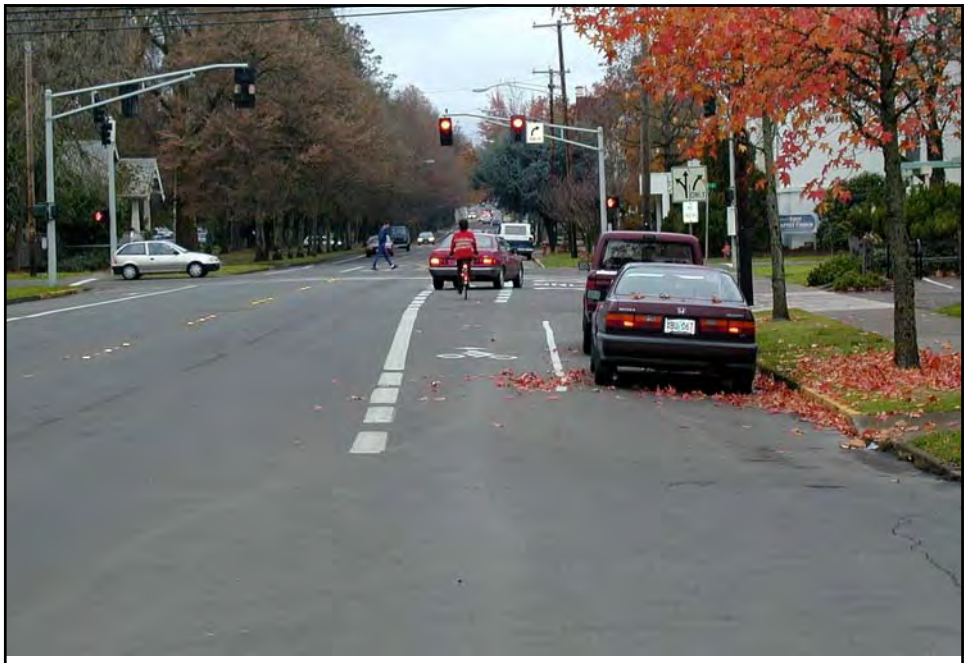
Other Scenario

1. RTL created by dropping parking




Corvallis OR

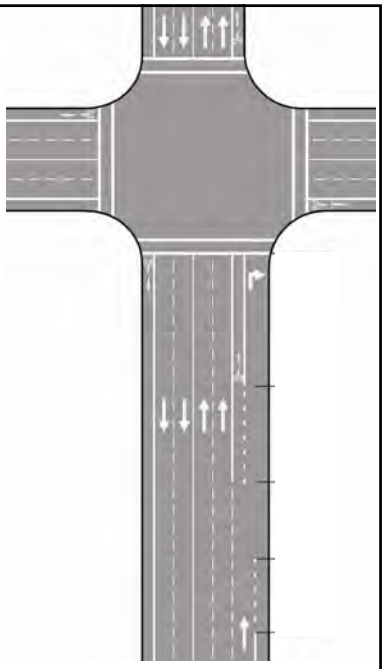

Corvallis OR



Other Scenario

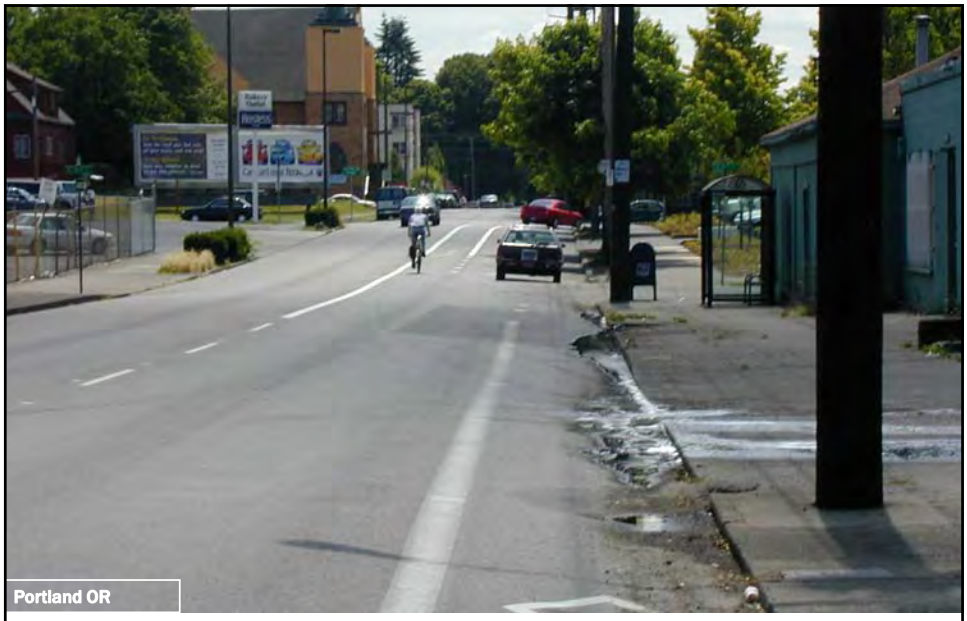
2. RTL created by dropping through lane

In this case, bicyclists must move over across a lane to reach through bike lane



Bicyclists must cross a lane to reach through bike lane

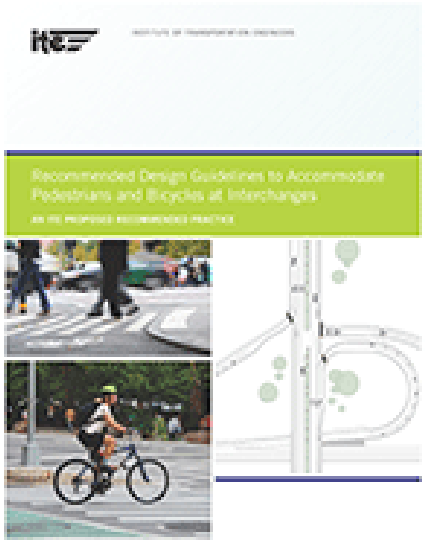
Bicyclists must cross a lane to reach through bike lane



Seek opportunities for minor improvements

Place bike lane correctly even if it ends past intersection

Apply same principles at other intersections



Recommended Design Guidelines to Accommodate Pedestrians and Bicycles at Interchanges

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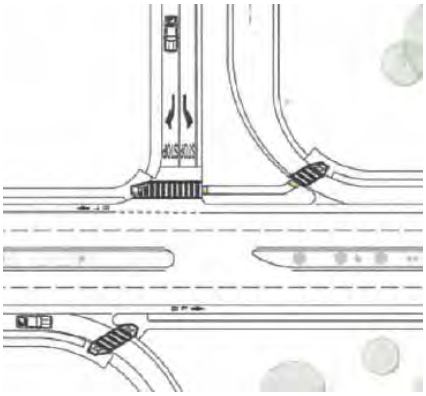
GUIDING PRINCIPLES FOR PEDESTRIANS

- Ramp geometry
- Locate crosswalk
  - Best visibility
  - Before accelerate
- Crosswalk short w/out excessive deviation
- Widen sidewalks shared with bicyclists



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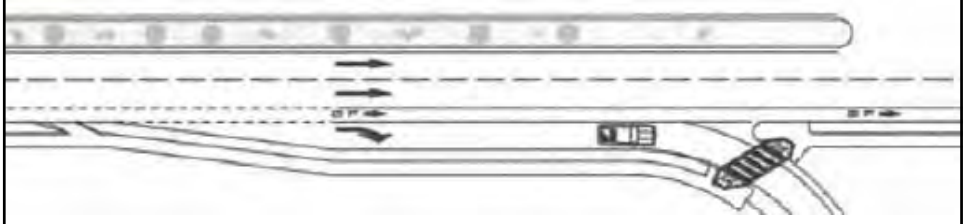
GUIDING PRINCIPLES FOR BICYCLISTS

- Buffer where bicyclists are between moving vehicles more than 200 ft
- Provide bike “exit” option ahead of on-ramps
- Define a weaving area



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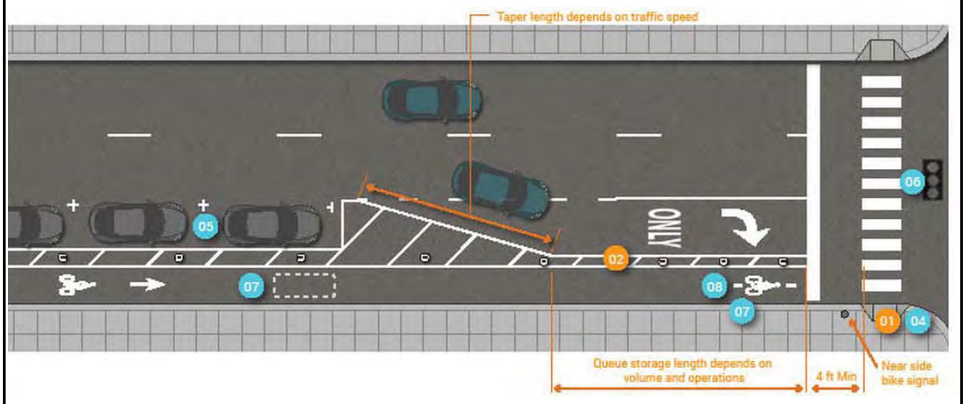
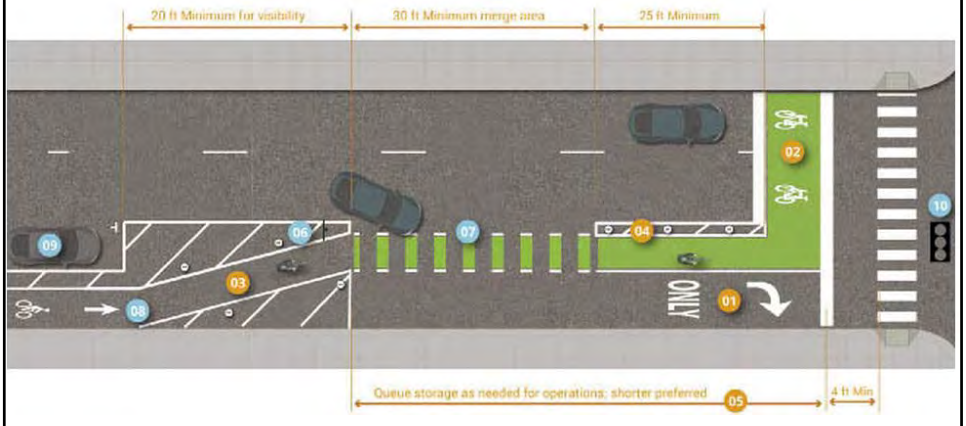
INTERSECTIONS WITH SEPARATED BIKE LANES

- No dedicated right turn
- Bicyclists may use crosswalk
- RTOR Prohibited

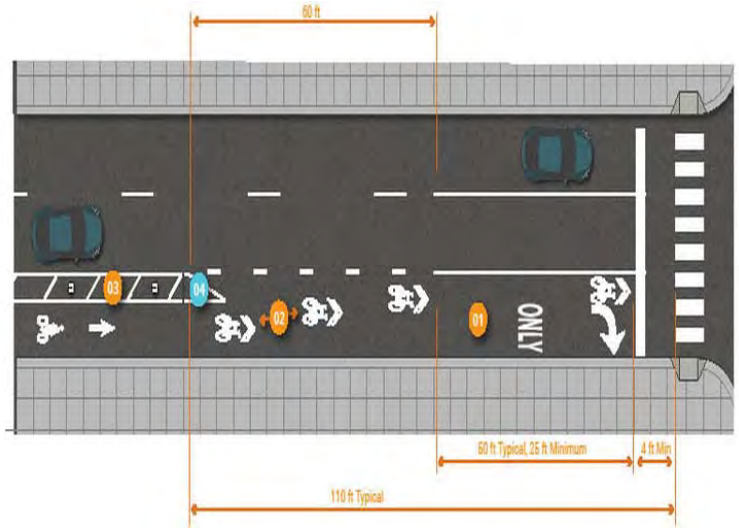
INTERSECTIONS WITH SEPARATED BIKE LANES



INTERSECTIONS WITH SEPARATED BIKE LANES



INTERSECTIONS WITH SEPARATED BIKE LANES



INTERSECTIONS WITH SEPARATED BIKE LANES

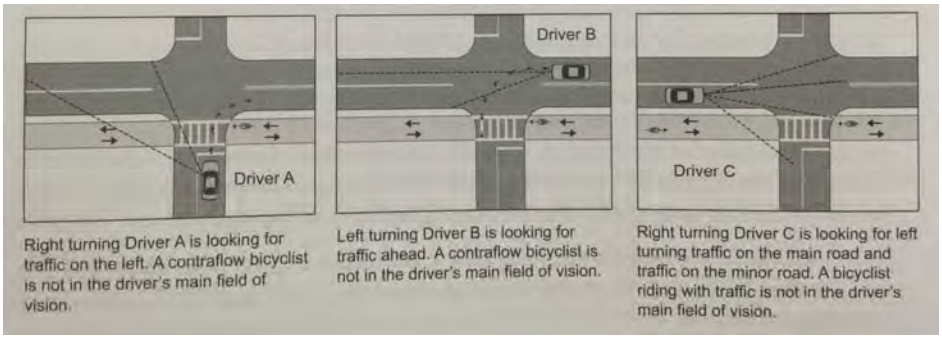
Intersection Configuration Alternatives

See the Cycle Track Intersection Approach and Bicycle Signals sections for details on design strategies at intersections.

Bicycle Signal Phase
A dedicated bicycle signal phase can eliminate conflict between turning automobiles and bicyclists.

"Bend In" Crossing
Using a curb extension or painted buffer, the cycle track may be bent-in to promote visibility of bicyclists in advance of the intersection.

INTERSECTIONS WITH SHARED USE PATHS



Right turning Driver A is looking for traffic on the left. A contraflow bicyclist is not in the driver's main field of vision.

Left turning Driver B is looking for traffic ahead. A contraflow bicyclist is not in the driver's main field of vision.

Right turning Driver C is looking for left turning traffic on the main road and traffic on the minor road. A bicyclist riding with traffic is not in the driver's main field of vision.

BICYCLISTS AT ROUNDABOUTS

A roundabout is a type of intersection control

Why roundabouts are safer for all users:

Slow speed:

Deflection, truck apron, splitter islands, "reverse super"

Reduced conflicts

No left turns

Yield on entry

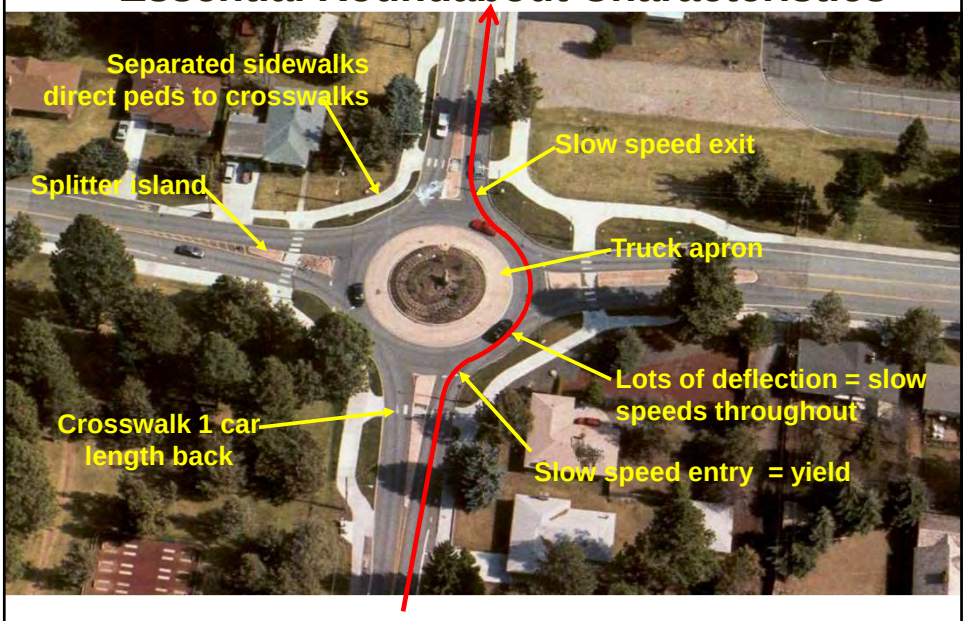
CRF (all users):

About 54% overall

27% pedestrian crashes

Up to 76% fatals and serious injuries

Essential Roundabout Characteristics



WHAT DOES IT TAKE TO MAKE ROUNDABOUTS WORK FOR BICYCLISTS?

- Slow speeds – lots of deflection; truck apron
- Simple, single lane, throughout
- Splitter islands
- "Escape ramps" for multi-lane roundabouts

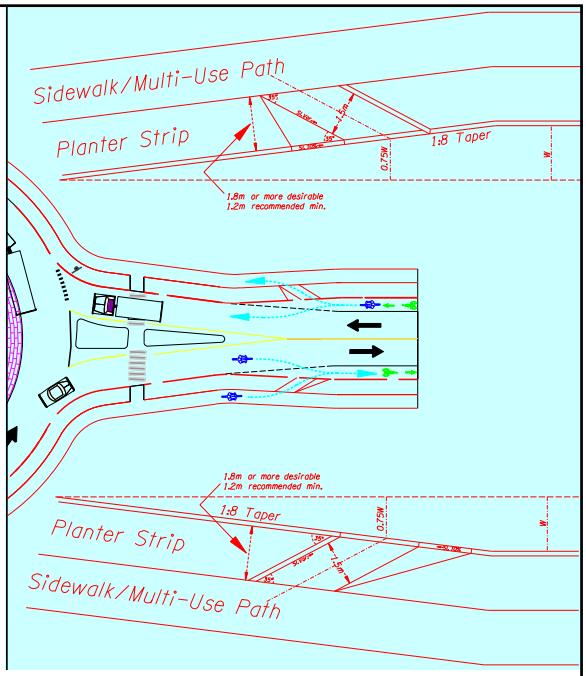
End bike lane to encourage cyclist to enter roadway

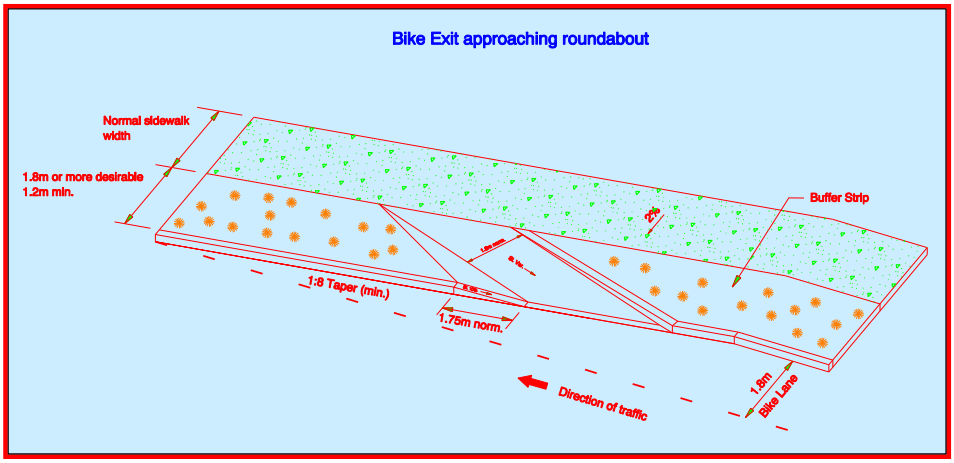
End bike lane to encourage cyclist to enter roadway

Slow speed allows cyclists to share roadway


147TH ST
CENTURY RD

Bike ramps at roundabouts for sidewalk use





Bike Design Detail: Exit ramp to sidewalk

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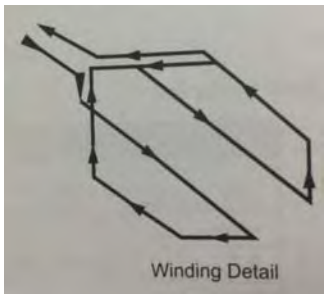
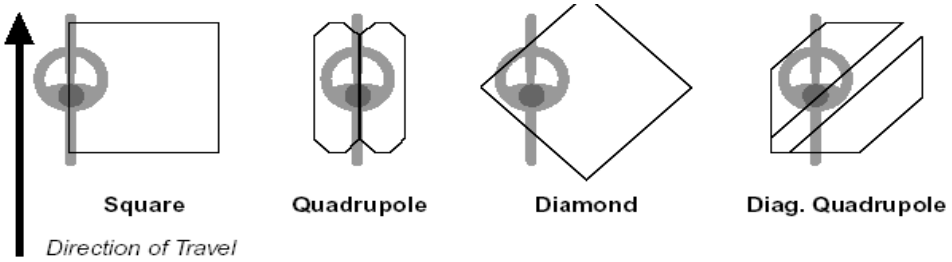
BICYCLE DETECTION

BICYCLE DETECTION AT SIGNALS

- Induction loops

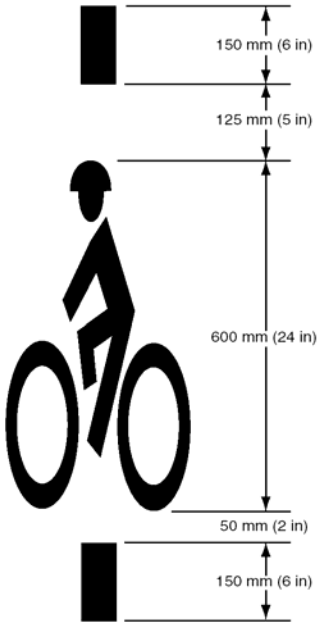


BICYCLE DETECTION AT SIGNALS



This figure indicates where cyclists should wait in order to actuate the signal

MUTCD standard for signal loop marking for bicyclists
(Section 9C.05)



Loop detector in bike lane detects cyclists

Advance loop detector extends green time for cyclists

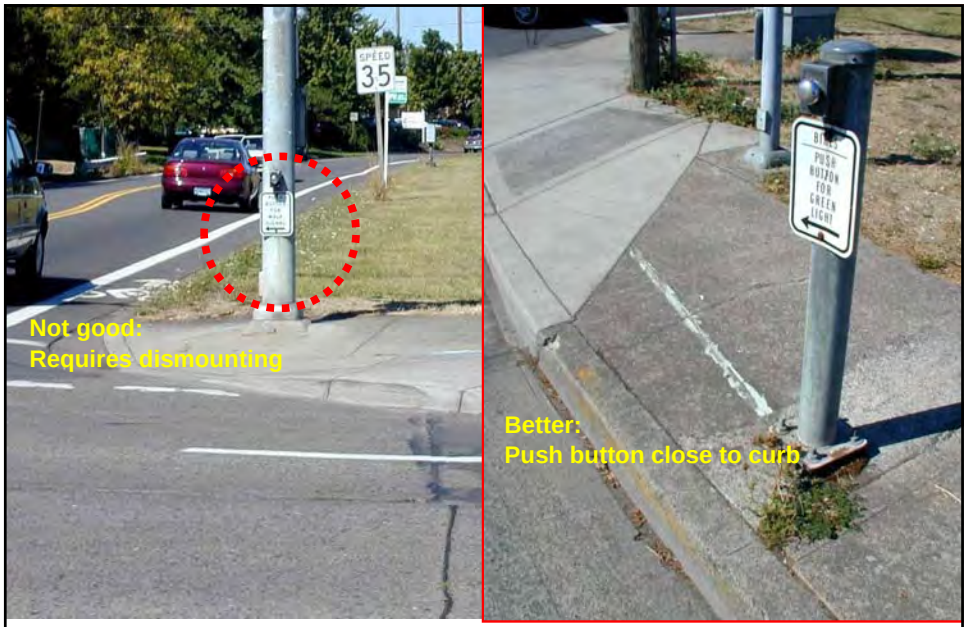
Loop detector in travel lane with cyclist stencil

Loop detector sensitive to cyclists: It works!

Good advice:

“Lean for the green”

Lean your bike to trigger light



What about ped-style push buttons for cyclists?

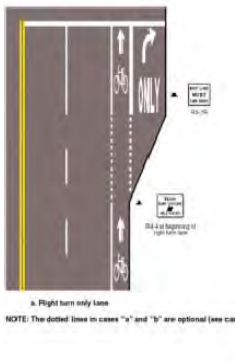
Designing for Bicyclist Safety

INTERSECTION TRAFFIC CONTROL

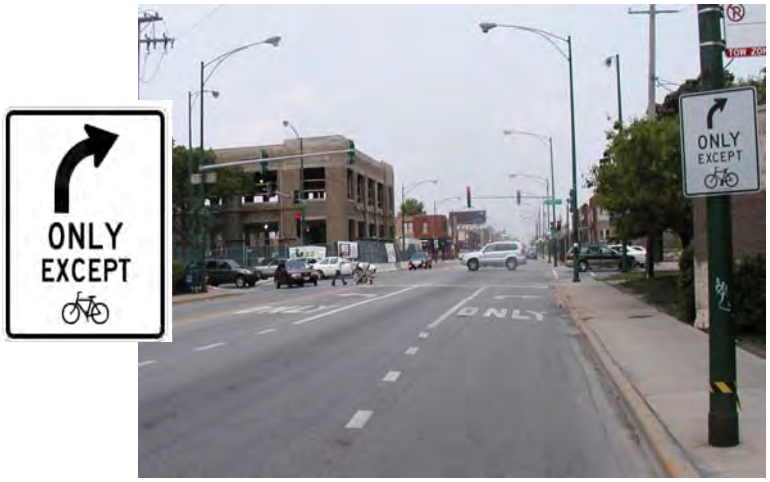
GOALS

- Awareness of conflicts
- Reduce encroachments
- Reinforces right-of-way
- Guide thru intersection
- Predictable
- Visible

Merging Bicyclists & Right Turners



Merging Bicyclists & Right Turners



Merging Bicyclists & Right Turners

A combined right turn lane and through bike lane is a reasonable compromise in constrained conditions

BICYCLE SIGNAL FACE

- MUTCD Interim Approval IA-16
- Experiments used for:
  - Bicyclist non-compliance
  - Provide a leading or lagging bicycle interval
  - Continue the bicycle lane on the right-hand side of an exclusive turn lane
  - Augment the design of a segregated counter-flow
  - Unusual or unexpected arrangements of the bicycle movement through complex intersections, conflict areas, or signal control.

TWO-STAGE LEFT-TURN QUEUE BOX

TWO-STAGE LEFT-TURN QUEUE BOX

- Required design elements include:
  - Bicycle symbol
  - Turn or through arrow
  - Turn on red prohibition
  - Passive detection of bicycles
- Size to prevent conflicts

SALT LAKE CITY, UT (PHOTO: SALT LAKE CITY PUBLIC WORKS)

BIKE BOX

- Increase visibility
- Reduce signal delay for bikes
- Positioning for left-turn
- Prevent “right-hook”
- Groups bikes

BIKE BOX

- Required elements:
  - Advance stop bar
  - Bike symbol
  - RTOR prohibited
  - Setback from crosswalk
  - Countdown ped signal
  - Yellow change & red clearance

Bike Box

COLORED BIKE LANE & BIKE BOX

Advantages of Bike Boxes

- Allows bicyclists to go before motor vehicles at signalized intersections
- More visible bicyclists improves motorist behaviors
- Bicyclists think they are wonderful

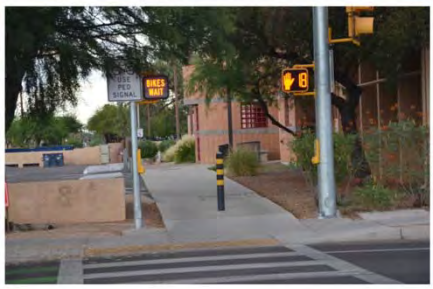
Disadvantages of Bike Boxes

- Requires lots of bicycles to gain motorist compliance
- Onset of green can lead to blind right turn hooks of bicyclists approaching from behind
- Crash record is mixed, no good data available as of this time
- Experimental traffic control device

PHB BIKE APPLICATION (BIKE HAWK)

BIKE "HAWK" PHB

- First installation Tucson, AZ
- "BIKES WAIT"/"BIKES OK"



PHB AS BIKE CROSSING

- Design matches how cyclists actually currently use the PHB crossing

BIKEHAWK AT PHB CROSSINGS

Normal PHB with Bike Facilities and R9-5 for cyclists to use pedestrian signals

PHB AT BIKE CROSSINGS

Provide actuation devices that are accessible to bicyclists with R9-5 sign

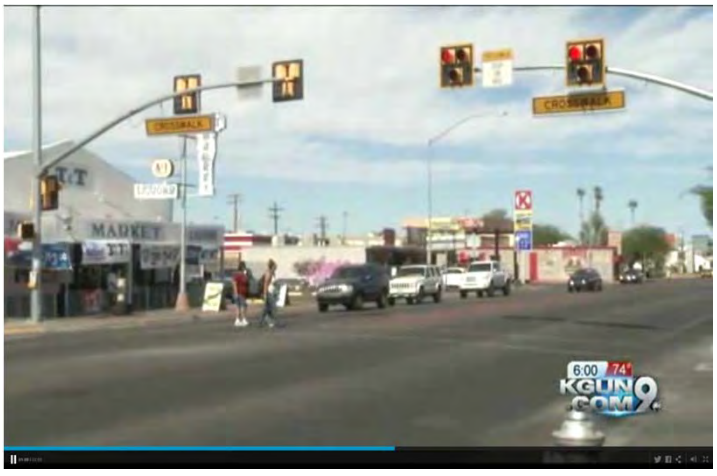
Compliance is in the 90% range & near 100% with families and children

PHBs SERVE THE COMMUNITY

- Balance of needs between the various modes of travel and neighborhoods
- High compliance rates
- Support from the community
- Can be designed to serve "special service" needs
- Gets everyone home safe and sound

Positive News Coverage

"



"I feel safer now that they have put these lights in"
Jocellyn Mora – KGUN 9 On Your Side

PHBs HELP GET EVERYONE HOME SAFE AND SOUND

The Living Streets Alliance, Tucson's bicycle and pedestrian advocacy organization has indicated that:

"The BikeHAWK helps unite neighborhoods and connect destinations for all modes of safe travel. Already, we've seen families and younger riders, both escorted and unescorted, using the BikeHAWK. This use emphasizes the safe connectivity of all levels of bicyclists across multi-lane, high speed roadways."

Emily Yetman, Executive Director, Living Streets Alliance

Designing for Bicyclist Safety

PROTECTED INTERSECTION

CONVENTIONAL BIKE LANES

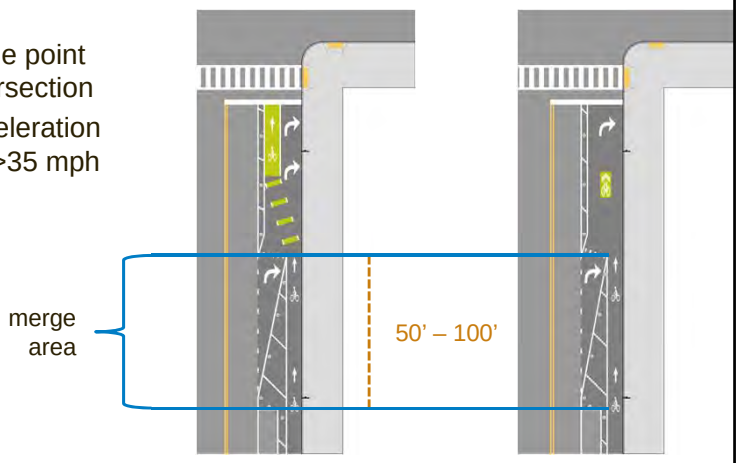
MIXING ZONES

- Physical separation removed where it's most needed
- Only as interim solutions or in severely constrained conditions

with shared lane | with shared lane | with bike lane

MIXING ZONES

- Locate merge point close to intersection
- Provide deceleration lane where >35 mph



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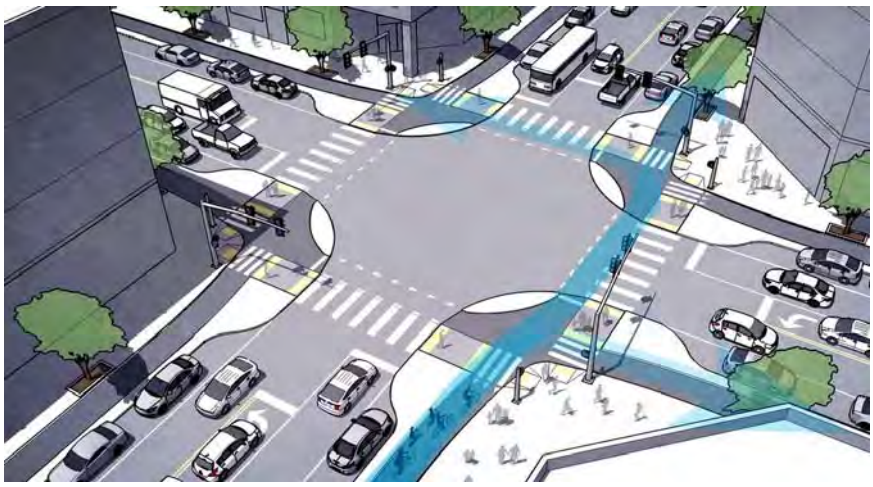
PROTECTED INTERSECTIONS

"Protected intersections maintain the physical separation through the intersection, thereby eliminating the merging and weaving movements inherent in conventional bike lane and shared lane designs."

"PROTECTED" INTERSECTION



motorist's view at conventional bike lane

motorist's view at **separated bike lane**

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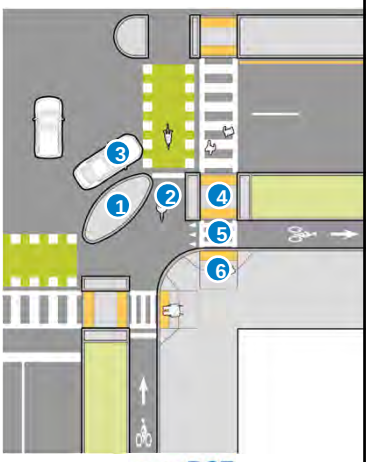
VISIBILITY AT CONFLICT POINTS

protected intersection

conventional bike lane

PROTECTED INTERSECTIONS

1. Corner refuge island
2. Forward bicycle queuing area
3. Motorist yield zone
4. Pedestrian crossing island
5. Pedestrian crossing of separated bike lane
6. Pedestrian curb ramp



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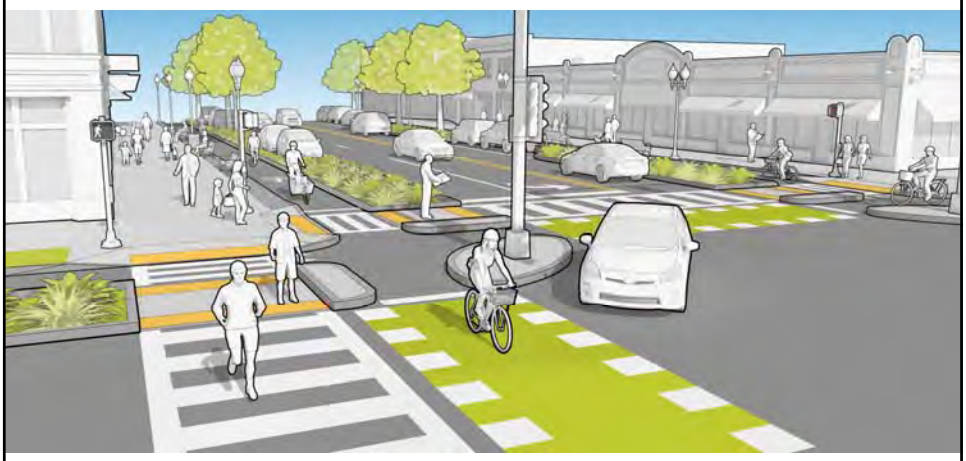
PROTECTED INTERSECTIONS



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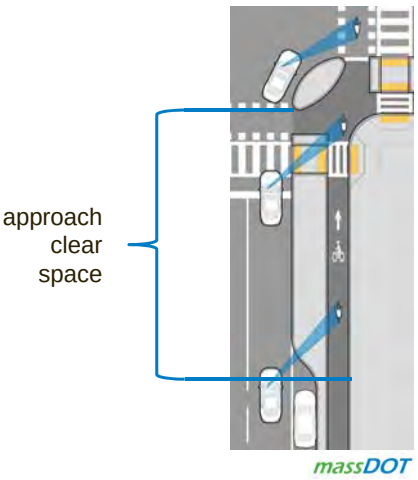
PROTECTED INTERSECTIONS IN THE US

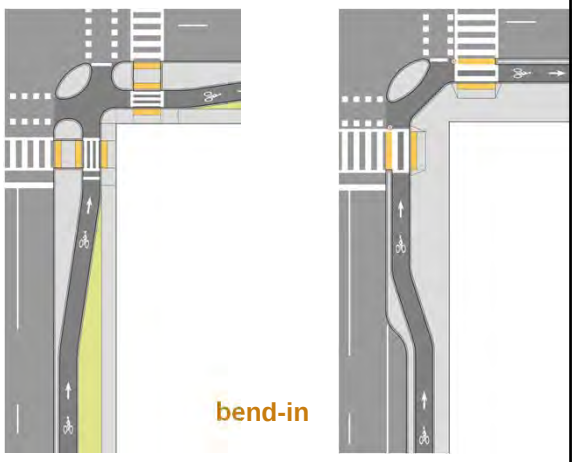
APPROACH CLEAR SPACE

Vehicular turning design speed	Minimum approach clear space
<10 mph	20’
10 mph	40’
15 mph	50’
20 mph	60’



DEFLECTION

- Maximum taper **3:1**
- Bend-out preferred (motorist yield zone, bus stops, pedestrian refuge area, loading and parking)
- Separation increases sight distance
- Corner island affects motorist yield zone



bend-out bend-in

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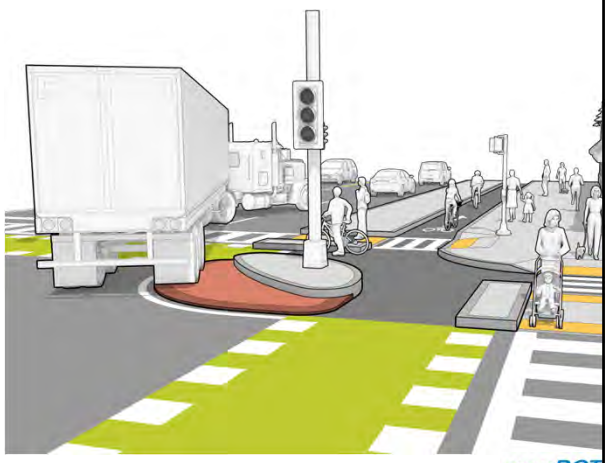
SLOW RIGHT TURNING SPEEDS

- Design for ≤**10 mph** vehicle turns
- Mountable truck apron
  - 3” max.
  - Visually distinct
- Large radii reduces bicycle, pedestrian queuing areas



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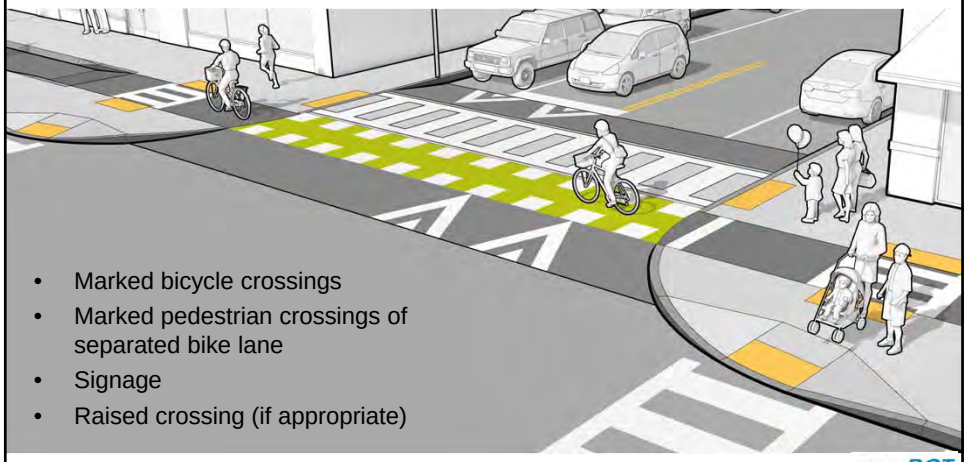
COMMUNICATING PRIORITY AT CROSSINGS



- Marked bicycle crossings
- Marked pedestrian crossings of separated bike lane
- Signage
- Raised crossing (if appropriate)

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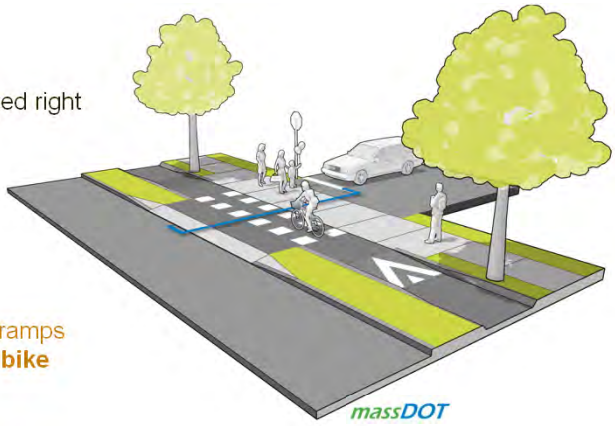
RAISED CROSSINGS

- Collectors, local streets
- Driveways, alleys
- Roundabouts, channelized right turn lanes
- Large corner radii to accommodate heavy vehicles



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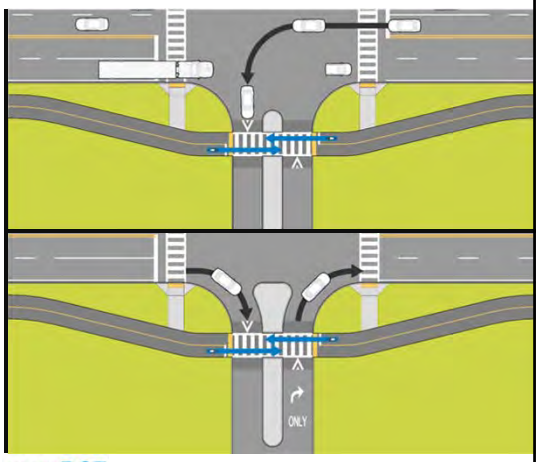
Too many bicycle transition ramps in quick succession? **Raise bike lane to sidewalk level**

RECESSED CROSSINGS

Crash reduction benefits when crossing set back **6' – 16.5'** from the roadway

recessed crossing

recessed crossing with access management



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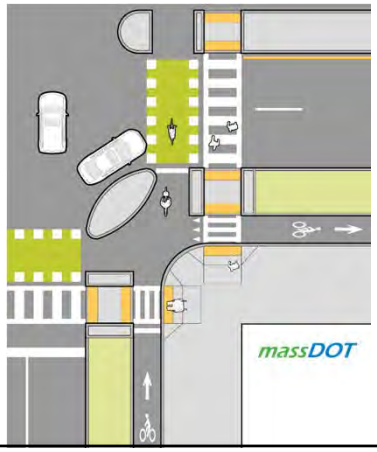
ADA ISSUES RELATED TO SBL'S

- PROWAG was written over 15 years ago
- Still a "draft" but widely used and enforceable
- Did not consider SBL's
- Must be interpreted

NO EASY ANSWERS



MAIN AREAS OF DESIGN IMPACTED BY THE ADA

- Placement of detectable warnings along SBLs
  - Intersections
  - Transit stops
- Placement of pedestrian signal heads and push buttons at protected intersections
- Accessible on-street parking

DETECTABLE WARNING SURFACES

Shall* be placed at:

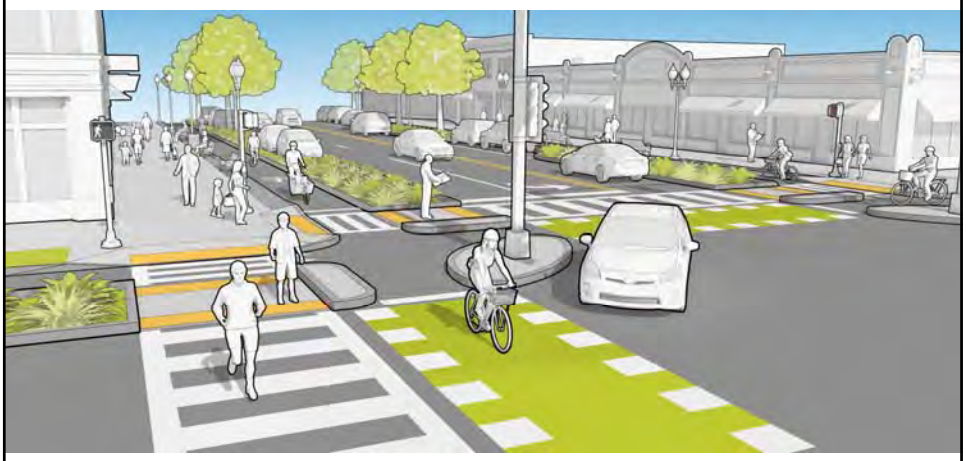
- Curb ramps (at the back of curb)
- RR crossings
- Edges of cut-throughs at pedestrian refuge islands
- Boarding and alighting edge of transit platforms

*Section R305, Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way (2011)

CURB RAMPS

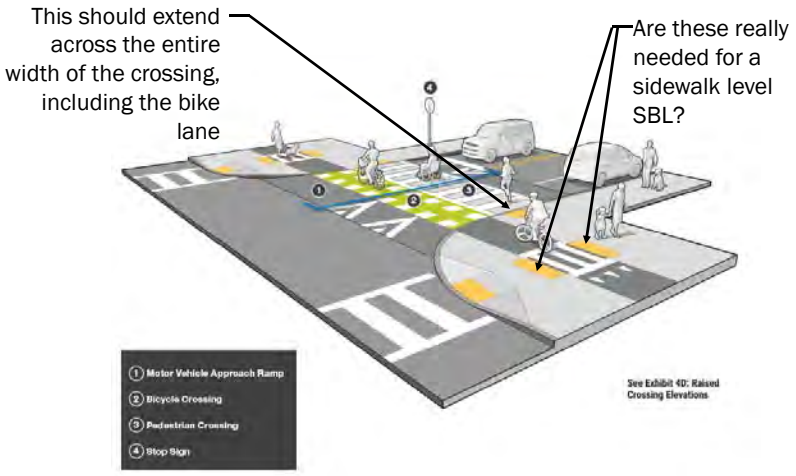
- Guidelines say that detectable warning surfaces should be provided at the transition between the street and the sidewalk.
- At curb ramps and blended transitions, detectable warning surfaces shall extend the full width of the ramp run (excluding any flared sides), blended transition, or turning space.

STREET LEVEL PROTECTED INTERSECTIONS



massDOT

SIDEWALK-LEVEL SEPARATED BIKE LANES



DETECTABLE WARNINGS

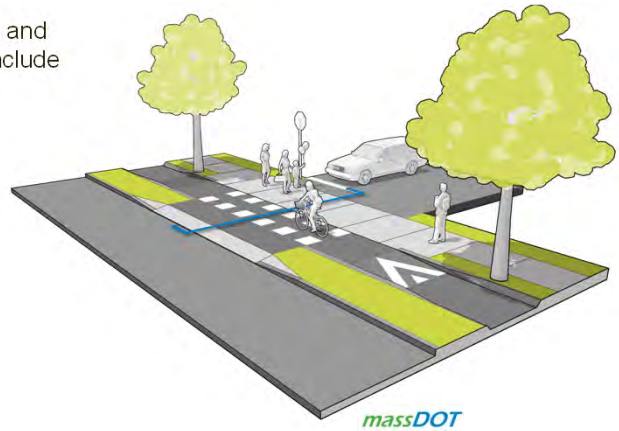
It is not common practice to put detectable warnings at flush transitions along sidewalks where curb ramps aren't used, such as:

HOWEVER:

- Driveways
- Alleys
- Entrances/exits to parking garages

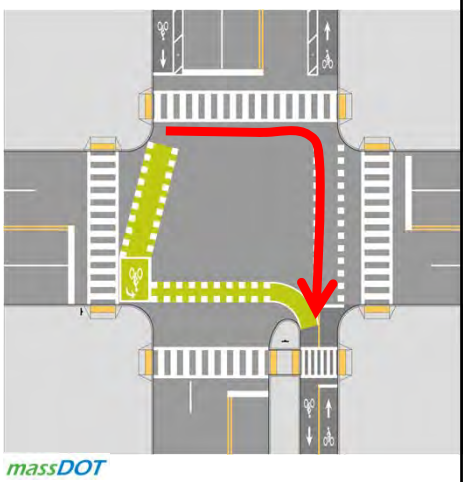
RAISED CROSSINGS

- As with other driveways and alleys, this should not include detectable warnings



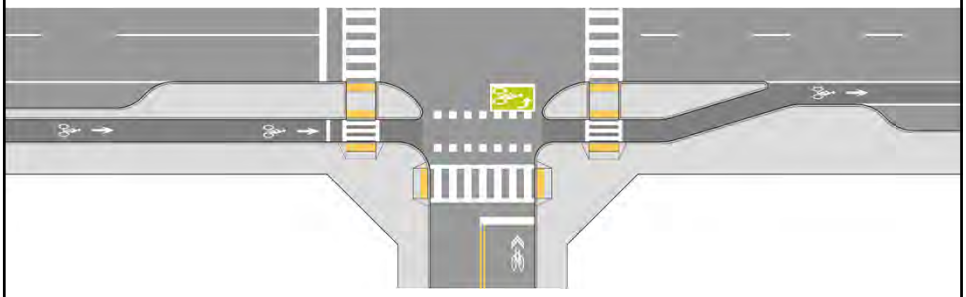
EXAMPLE TRANSITIONS

into a two-way separated bike lane



EXAMPLE TRANSITIONS

into a conventional bike lane



Designing for Bicyclist Safety

SIGNALS

SIGNAL GUIDANCE

Traffic signal warrant:

- Future bike volumes
- Counting bikes as pedestrians

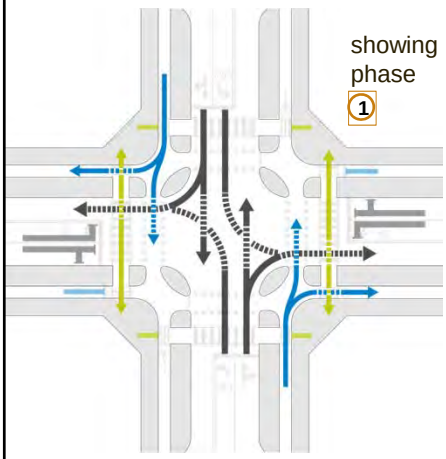
Bike signal head warrant:

- Leading or protected phasing
- Contra-flow movements
- Signal heads beyond cone of vision

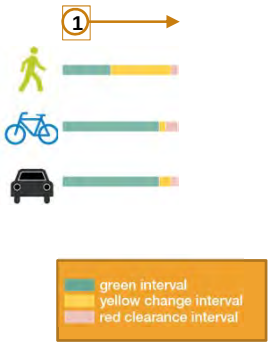
SIGNAL PHASING OVERVIEW

1. Concurrent bike phase with concurrent permissive vehicle turns

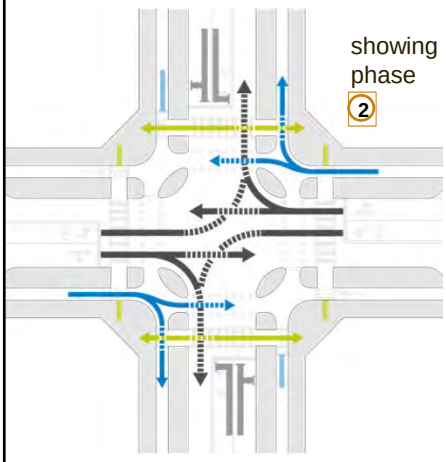
Concurrent Bike Phase with Concurrent Permissive Vehicle Turns

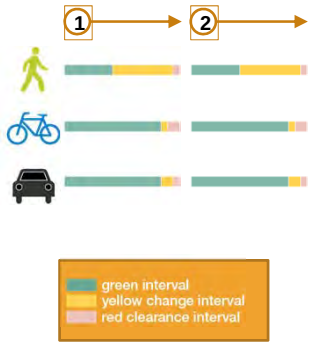


showing phase 1



Concurrent Bike Phase with Concurrent Permissive Vehicle Turns

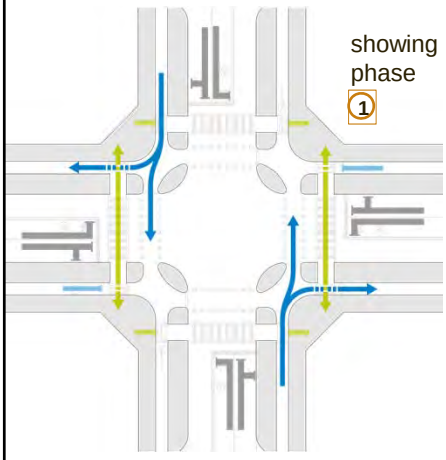


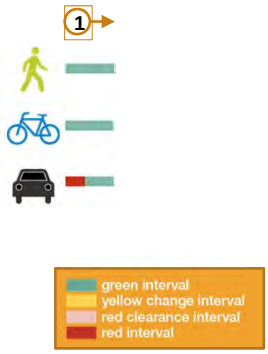


Signal Phasing Overview

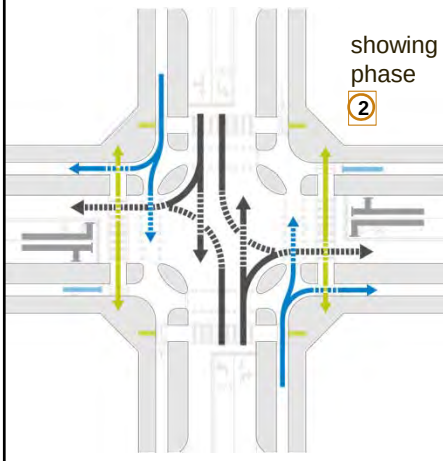
1. Concurrent bike phase with concurrent permissive vehicle turns
2. Concurrent bike phase with leading interval

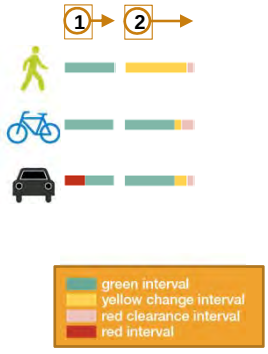
Concurrent Bike Phase with Leading Interval



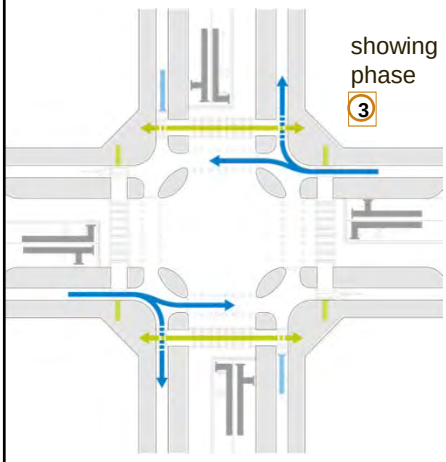


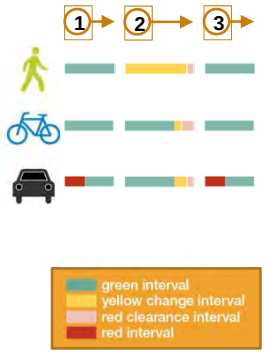
Concurrent Bike Phase with Leading Interval



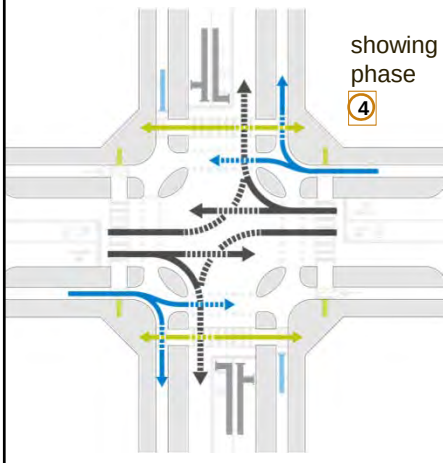


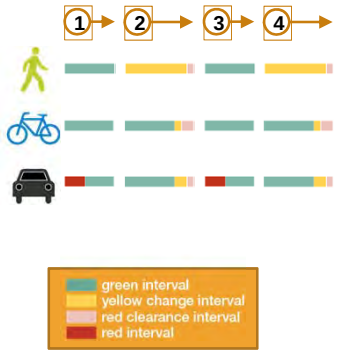
Concurrent Bike Phase with Leading Interval





Concurrent Bike Phase with Leading Interval



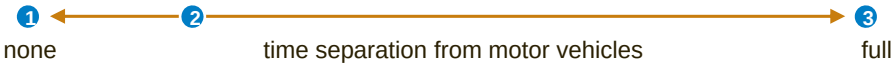


Allowing Motor Vehicle Turns Across Bike Lanes

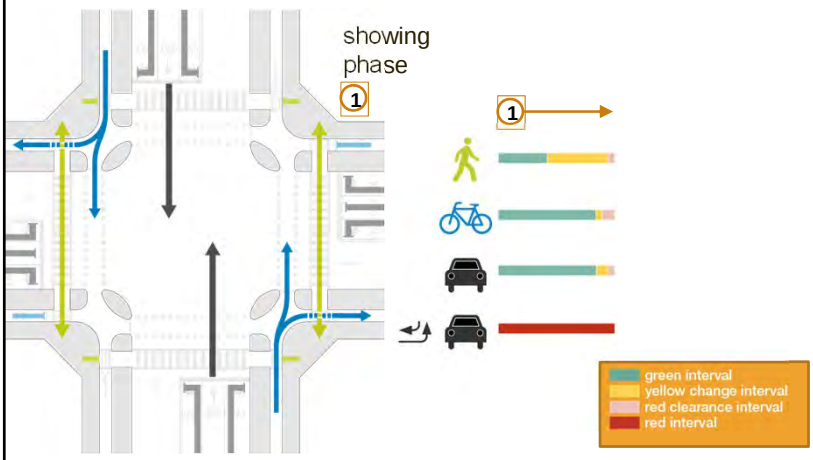
Separated Bike Lane Operation	Motor Vehicles per Hour Turning across Separated Bike Lane			
	Two-way Street			One-way Street
	Right Turn	Left Turn across One Lane	Left Turn across Two Lanes	Right or Left Turn
One-way	150	100	50	150
Two-way	100	50	0	100

Signal Phasing Overview

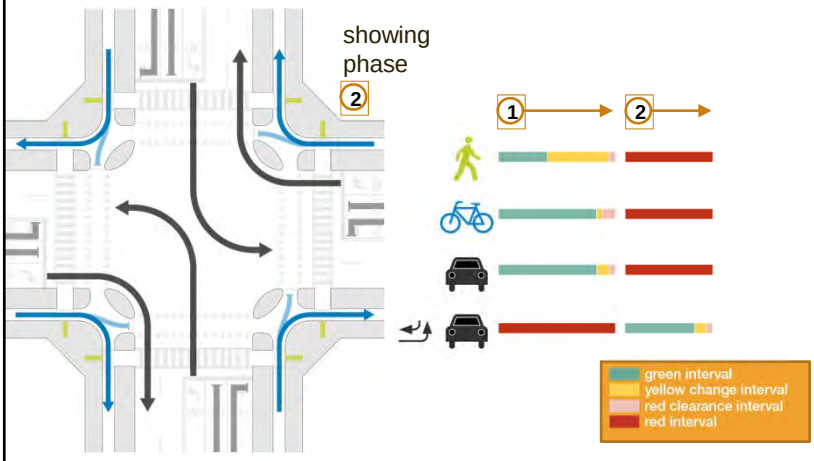
1. Concurrent bike phase with concurrent permissive vehicle turns
2. Concurrent bike phase with leading interval
3. Concurrent protected bike phase



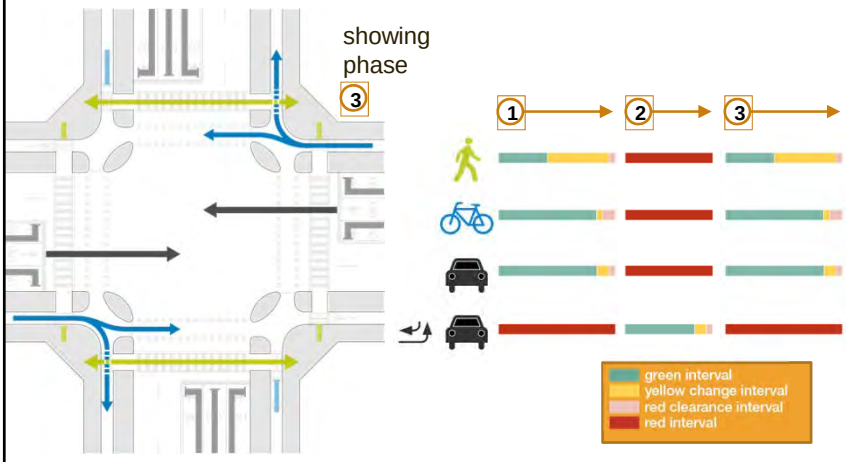
Concurrent Protected Bike Phase



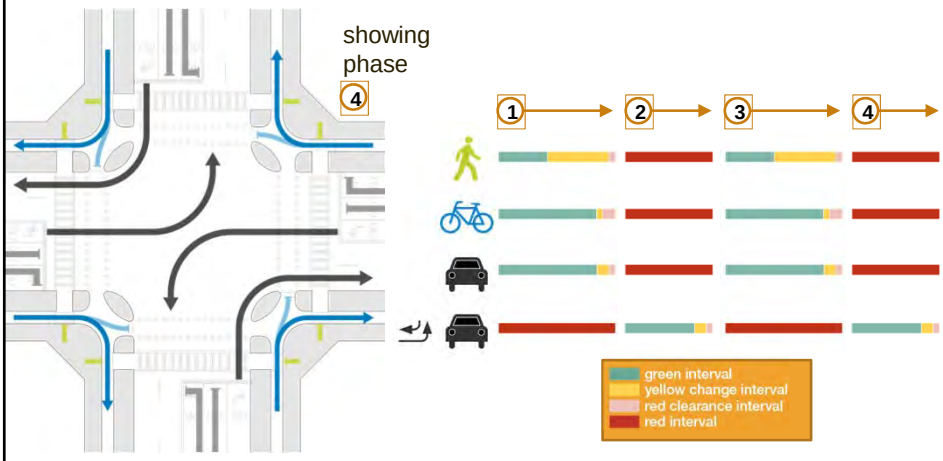
Concurrent Protected Bike Phase



Concurrent Protected Bike Phase



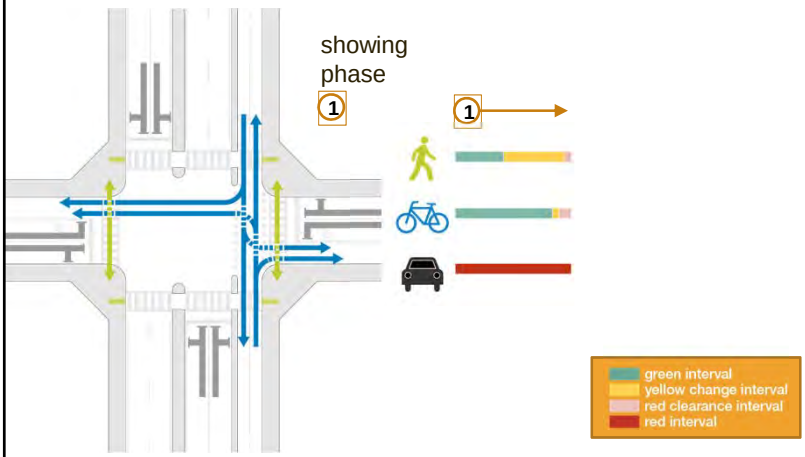
Concurrent Protected Bike Phase



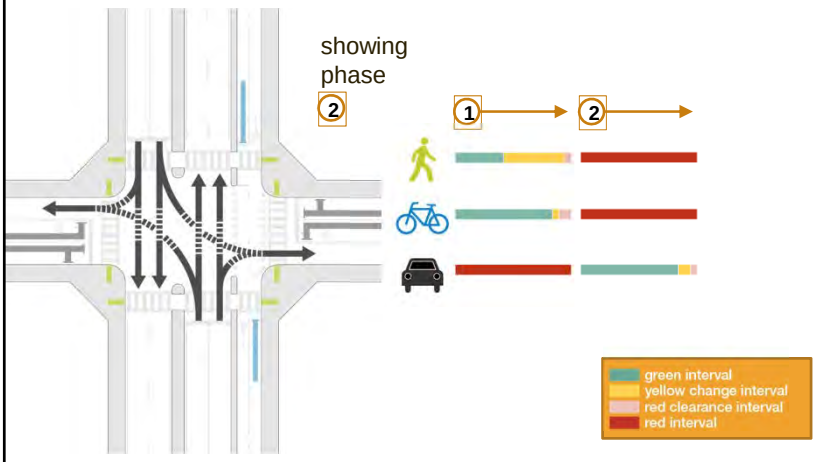
Signal Phasing Overview

1. Concurrent bike phase with concurrent permissive vehicle turns
2. Concurrent bike phase with leading interval
3. Concurrent protected bike phase
4. Protected bike phase

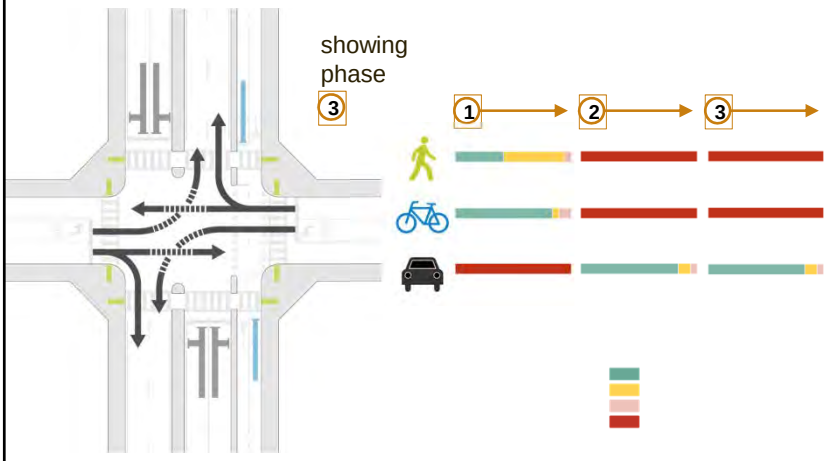
Protected Bike Phase



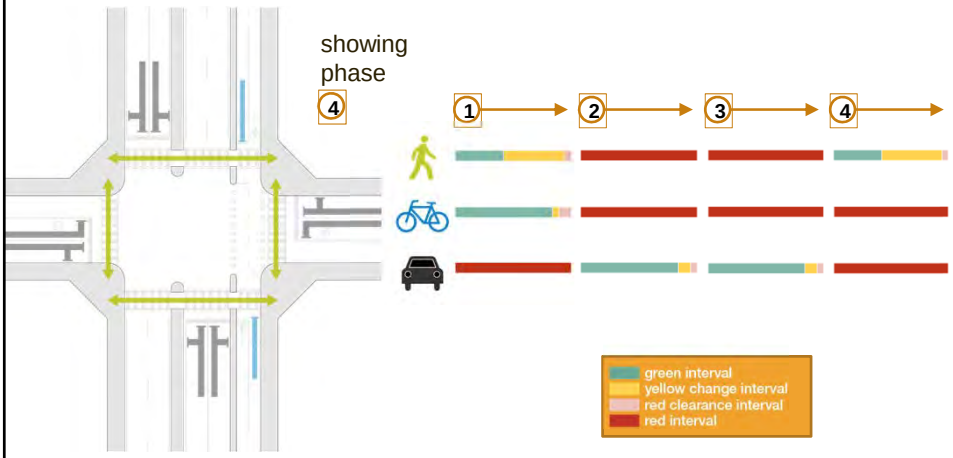
Protected Bike Phase



Protected Bike Phase



Protected Bike Phase



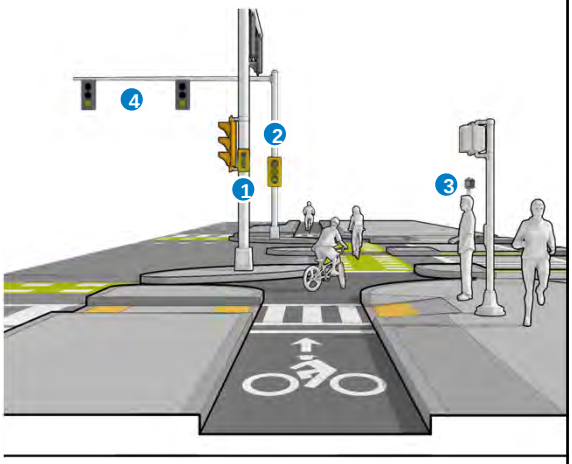
No Turn on Red Restrictions

Consider at:

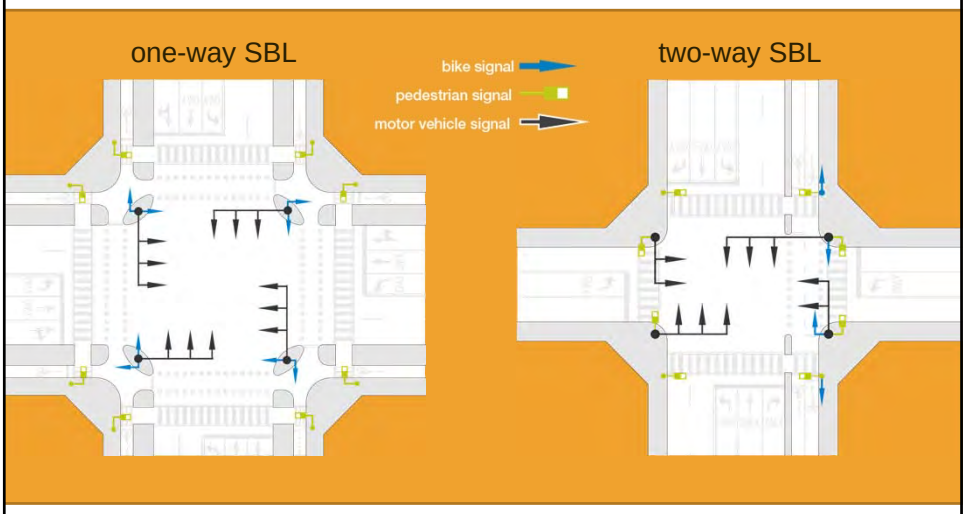
- Two-stage queue box
- Two-way SBL
- Contra-flow SBL
- Protected bike phase
- Protected right turn
- Leading bike phase

Signal Head Positioning

1. Bike signal (near side)
2. Bike signal (far side)
3. Pedestrian signal
4. Vehicle signal



Signal Positioning



Bicycle Detection

- Actuated signals
- Bicycle minimum green
- Protected bicycle phases