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

Designing for Bicyclist Safety

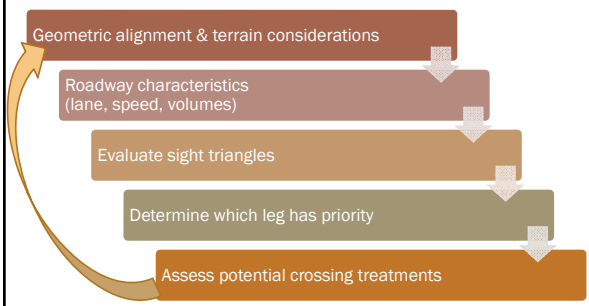
SHARED-USE PATH CROSSINGS

SIDE-STREET CROSSINGS

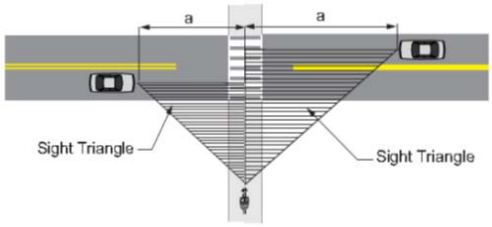
Adjacent Road Speed Limit (Mi/h)	Recommended Sidepath Separation Distance at Crossings
< 25 mi/h	6.5 ft (2.0 m)
35–45 mi/h	6.5–16.5 ft (2.0–5.0 m)
≥ 55 mi/h	16.5–24 ft (5.0–7.0 m)

*Separation distance may vary in response to available right of way, visibility constraints and the provision of a right turn deceleration lane.

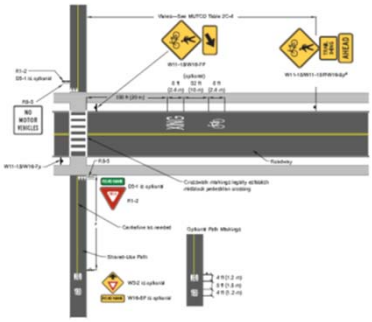
MID-BLOCK CROSSING DESIGN PROCESS



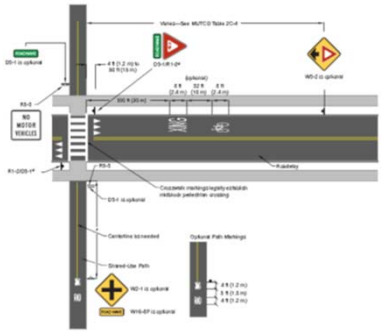
SIGHT TRIANGLES

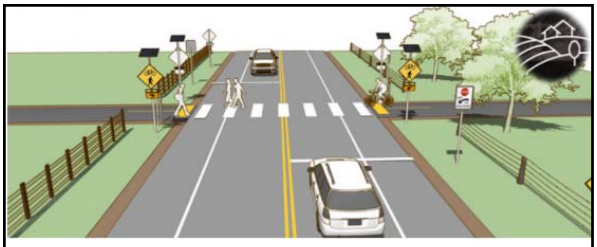


PATH YIELDS TO ROADWAY



ROAD YIELDS TO PATHWAY



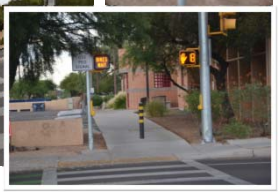


Crossing Countermeasures

- Advance warning signs
- Advance yield/stop line
- Raised island/crossing
- RRFB/PHB

BIKE "HAWK" PHB

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



BIKEHAWK AT PHB CROSSINGS

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

BIKE TOUR

- Where were you comfortable?
- What made you uncomfortable?
- What bikeway features worked?
- What bikeway features could be improved?

Designing for Bicyclist Safety

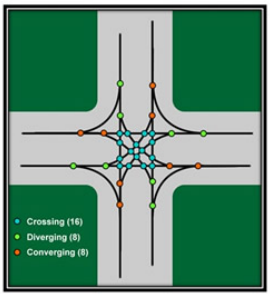
INTERSECTION DESIGN

INTERSECTION DESIGN PRINCIPLES

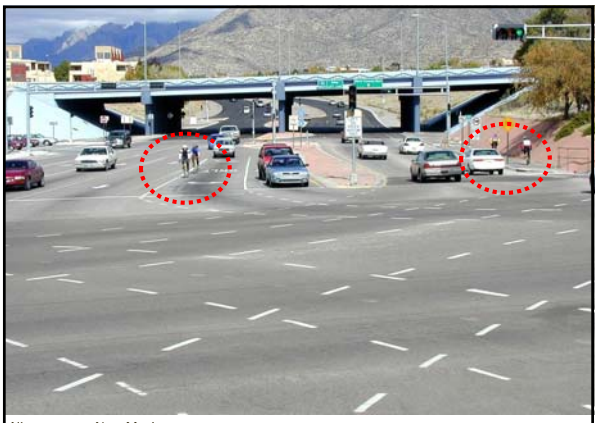
- Reduce speed
- Minimize exposure to conflicts
- Communicate right-of-way priority
- Provide adequate sight distance

INTERSECTION CONFLICTS

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

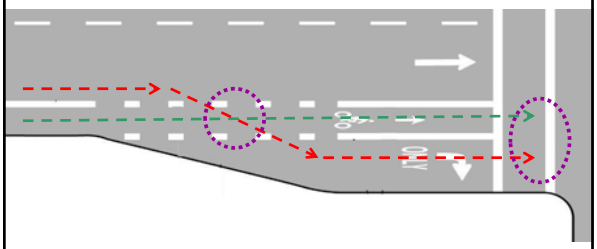


Albuquerque, New Mexico



Albuquerque, New Mexico

RIGHT-TURN/THRU CONFLICT



LEFT-TURN CONFLICT

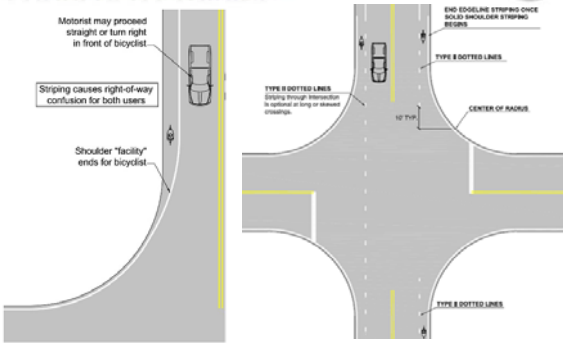
Madison, Wisconsin

RIGHT-TURN COUNTERMEASURES

SHOULDER RIDING AT INTERSECTION

- Shoulder not a travel lane
- Modify shoulder striping
- Opportunity to switch to shared lanes **OR**
- Add bike lane thru intersection

SHOULDER STRIPING

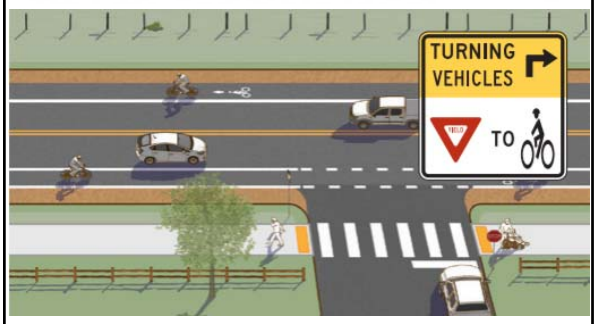


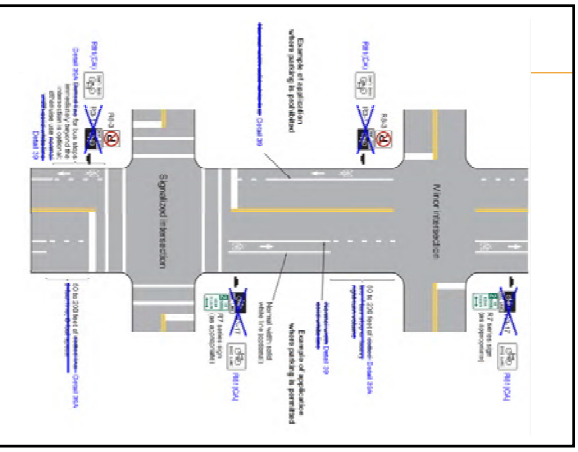
INTERSECTION WITH SHARED LANES

- Additional/all lanes are shared at intersection

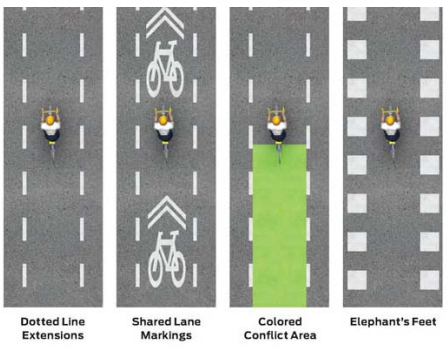
BIKE LANE THRU INTERSECTION

BIKE LANE THRU INTERSECTION





HIGHLIGHT CONFLICT ZONE



HIGHLIGHT CONFLICT ZONE

BIKE LANE THRU INTERSECTION

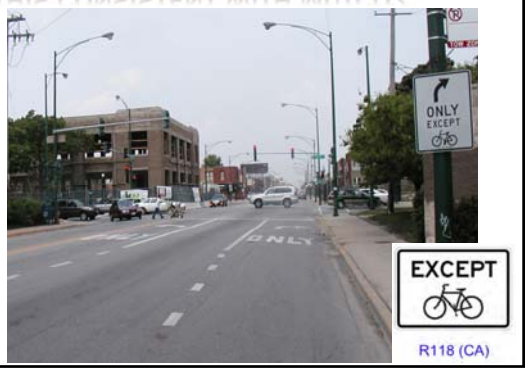
BIKE LANE THRU INTERSECTION

BIKE LANE THRU INTERSECTION

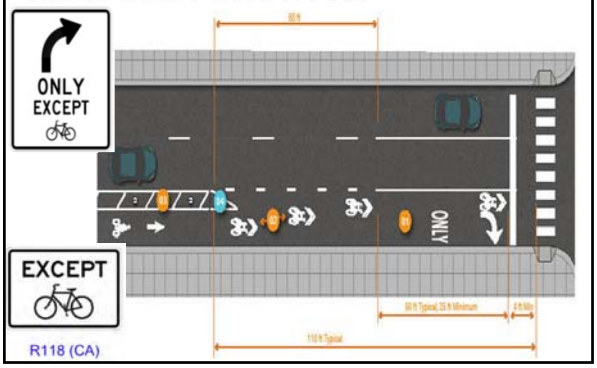
SHARROW W/ GREEN BACKGROUND

IS THIS CONSISTENT WITH MUTCD?

IS THIS CONSISTENT WITH MUTCD?

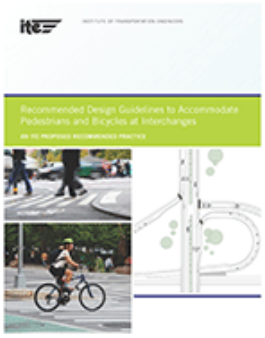


RIGHT TURN SHARED LANE



RIGHT-TURN SHARED LANE

INTERCHANGE RAMPS

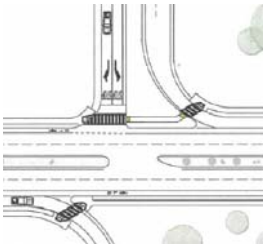


Recommended Design Guidelines to Accommodate Pedestrians and Bicycles at Interchanges

ITE 2016

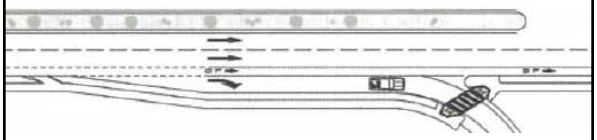
GUIDING PRINCIPLES FOR PEDESTRIANS

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



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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LEFT-TURN COUNTERMEASURES

TWO-STAGE LEFT TURN 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

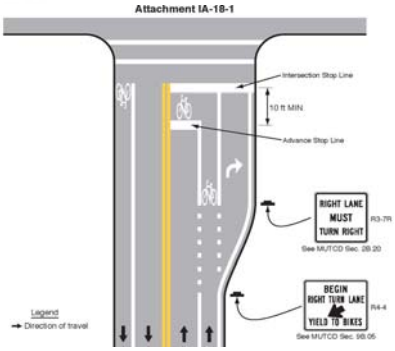
BIKE BOX

- Reduced conflicts between bicyclists and turning vehicles
- Reduced avoidance maneuvers
- Reduced encroachment into crosswalks
- Use clearly understood by motorists and bicyclists

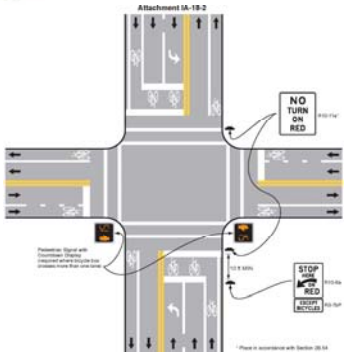
BIKE BOX

- Required elements:
  - Advance stop line at 10'
  - Bike symbol in the box
  - RTOR prohibited
  - Setback from crosswalk
  - 50 feet of bike lane on approach
  - STOP HERE ON RED (R10-6/R10-6a) with EXCEPT BICYCLE text plaque
  - Countdown ped signal if box crosses multiple lanes
  - Yellow change & red clearance
- Green pavement is optional

BIKE BOX



BIKE BOX



Designing for Bicyclist Safety

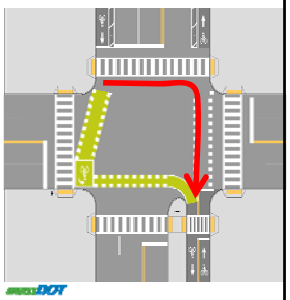
TRANSITIONS

CONSIDERATIONS

- What happens at termini?
- What happens when bicycle facility type changes?
- Have you stranded or created a barrier to the less confident user?
- How many stops will bicyclist have to make to traverse transition?

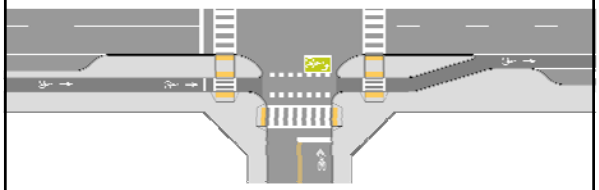
EXAMPLE TRANSITIONS

into a two-way separated bike lane



EXAMPLE TRANSITIONS

into a conventional bike lane



TRANSITION AT TERMINI

San Juan, PR

SHARED-USE CROSSING

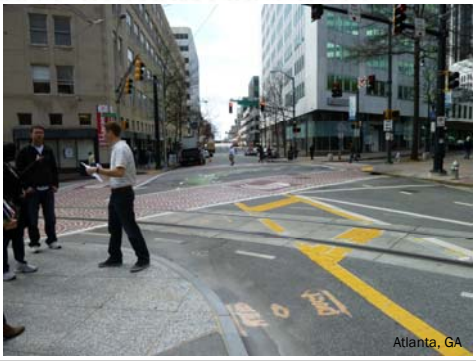
San Juan, PR

ACCESS TO/FROM SIDE STREET

ACCESS TO/FROM SIDE STREET

Atlanta, GA

ACCESS TO/FROM SIDE STREET



Atlanta, GA

ACCESS TO/FROM SIDE STREET

Atlanta, GA

STEEP GRADE TO INTERSECTION

Atlanta, GA

STEEP GRADE TO INTERSECTION

Atlanta, GA

Designing for Bicyclist Safety

SIGNALIZED INTERSECTIONS

SAFER SIGNALS FOR BICYCLISTS

- Bikes start-up and travel slower than cars
  - Differentiating bike detection to optimize signals
  - Set initial and gap times to accommodate bikes
- Leading Bike Interval
- Segregate Conflicting Movements

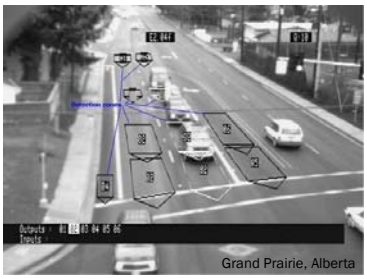
BICYCLE SIGNAL FACE

Application for:

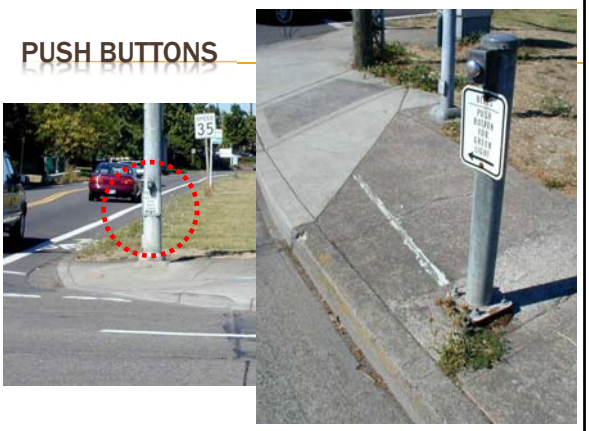
- Bicyclist non-compliance
- Provide a leading or lagging bicycle interval
- Continue the bicycle lane on the right-hand side of an exclusive turn lane
- Augment the design of a segregated counter-flow
- Unusual or unexpected arrangements of the bicycle movement through complex intersections, conflict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

BICYCLE DETECTION

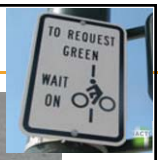
- Buttons
- Loops
- Video
- Microwave
- Radar
- Infrared

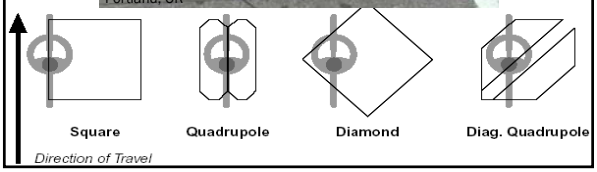


PUSH BUTTONS

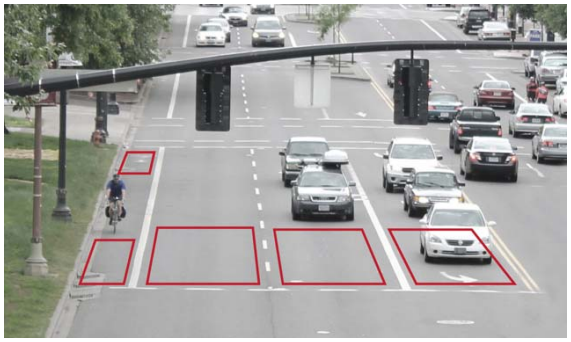


LOOP DETECTION

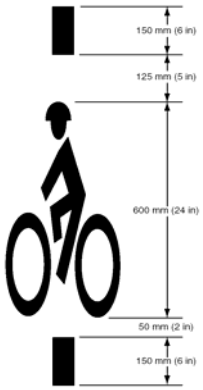




PASSIVE DETECTION



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



Designing for Bicyclist Safety

BICYCLISTS AT ROUNDABOUTS

MAKING ROUNDABOUTS WORK

- Slow speeds
  - Deflection
  - Truck apron
  - NO BIKE LANES
- Simple
  - Single lane
  - NO BIKE LANES
- Splitter islands
- Escape ramps

Bike lane ends at splitter island

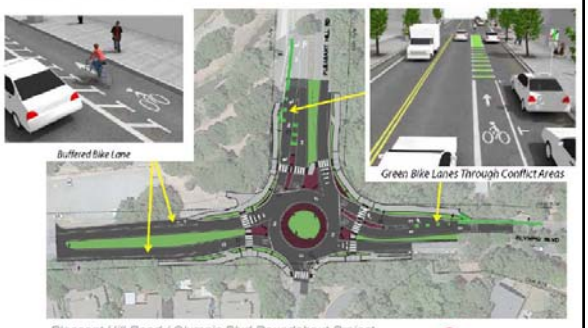
Slower speeds and fewer conflict points

Slower speeds and fewer conflict points

Bike lane begins

Escape ramp

BIKEWAY MARKINGS AT ROUNDABOUTS



Pleasant Hill Road / Olympic Blvd Roundabout Project
Lafayette, CA

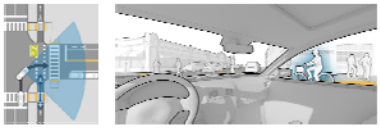
"PROTECTED" INTERSECTIONS

"PROTECTED" INTERSECTIONS

VISIBILITY AT CONFLICT POINTS

motorist's view at conventional bike lane

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



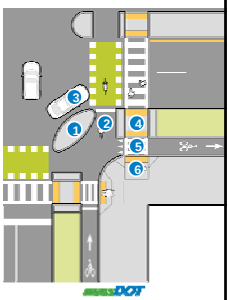
VISIBILITY AT CONFLICT POINTS


protected intersection


conventional bike lane

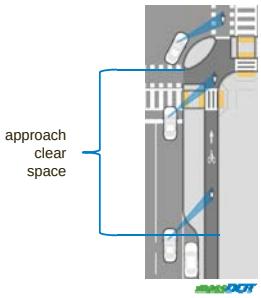
PROTECTED INTERSECTIONS

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



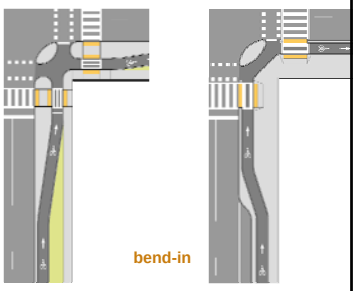
APPROACH CLEAR SPACE

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



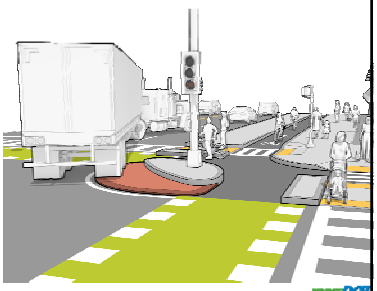
DEFLECTION

- 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



SLOW RIGHT TURNING SPEEDS

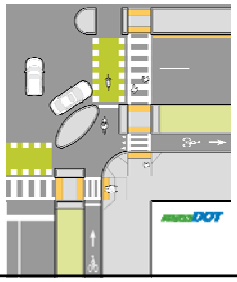
- Design for ≤**10 mph** vehicle turns
- Mountable truck apron
  - 3” max.
  - Visually distinct
- Large radii reduces bicycle, pedestrian queuing areas



ADA ISSUES

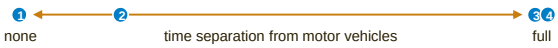
- PROWAG was written over 15 years ago
- Still a “draft” but widely used and enforceable
- Did not consider SBL’s
- Must be interpreted

NO EASY ANSWERS

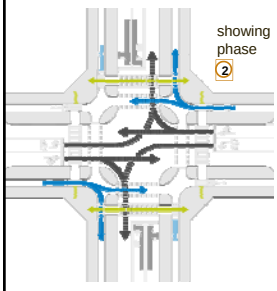


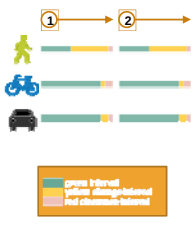
Signal Phasing Overview

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

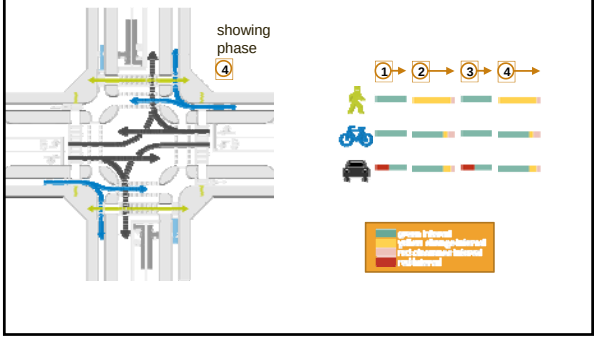


Concurrent Bike Phase with Concurrent Permissive Vehicle Turns

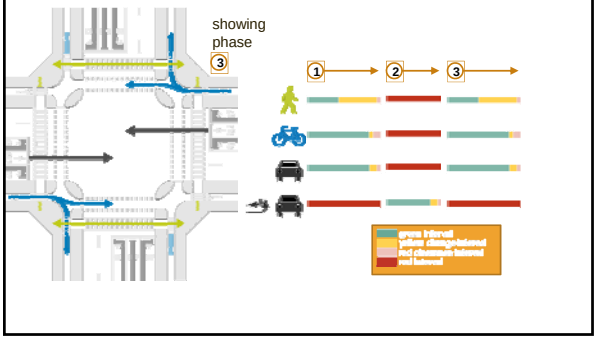




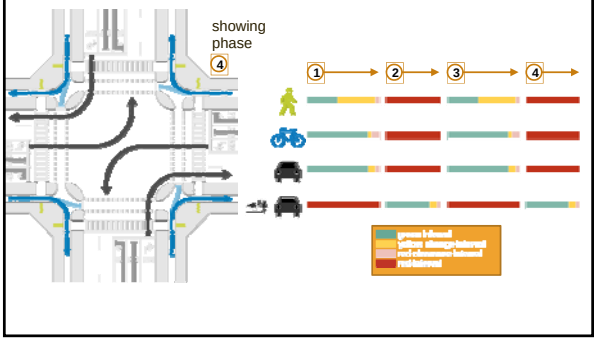
Concurrent Bike Phase with Leading Interval



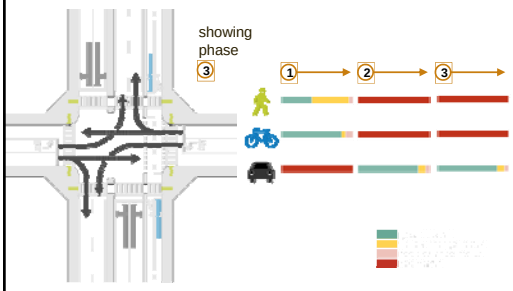
Concurrent Protected Bike Phase



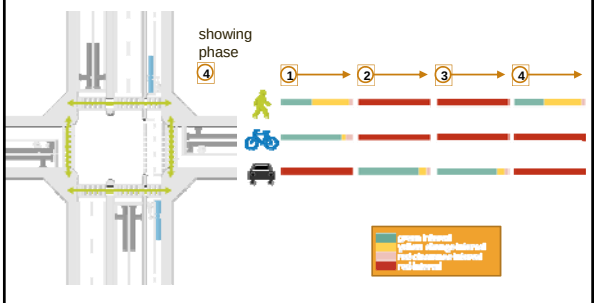
Concurrent Protected Bike Phase



Protected Bike Phase



Protected Bike Phase



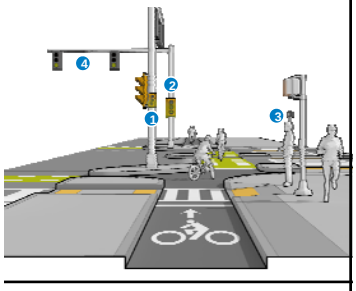
No Turn on Red Restrictions

Consider at:

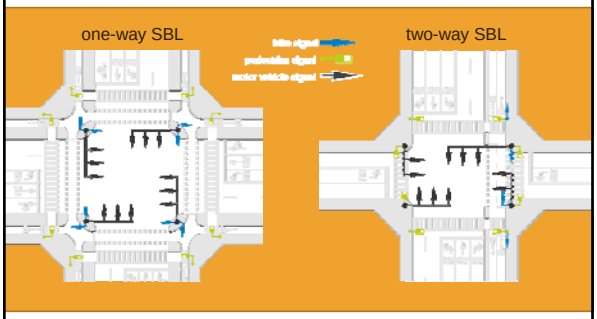
- Two-stage queue box
- Two-way SBL
- Contra-flow SBL
- Protected bike phase
- Protected right turn
- Leading bike phase
- Bike boxes

Signal Head Positioning

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

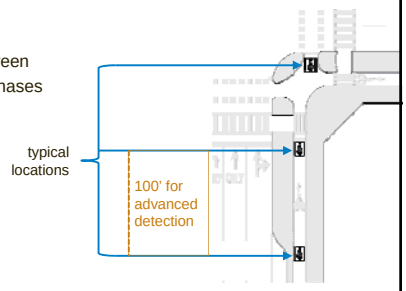


Signal Positioning



Bicycle Detection

- Actuated signals
- Bicycle minimum green
- Protected bicycle phases



Designing for Bicyclist Safety

SUMMARY THOUGHTS

CHICAGO, IL

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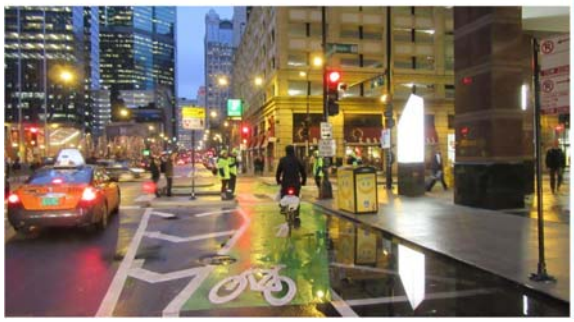

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