

# DESIGNING URBAN BIKEWAYS

**BICYCLE FACILITY DESIGN WORKSHOP  
CHAMPAIGN, ILLINOIS  
OCTOBER 29, 2015**

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**T. Y. LIN INTERNATIONAL**

# AGENDA

1. Bikeway Principles
2. Bike Lanes
3. Cycle Tracks
4. Intersections
5. Signals
6. Bike Ride
7. Lunch
8. Signs and Markings
9. Bike Boulevards
10. Design Exercise



Chicago, IL

# HOUSEKEEPING

- **Informal Lecture/Discussion Format**
- **Get Familiar with the UBDG**
- **Restrooms, Water Fountains, etc.**
- **Professional Development / Continuing Education**



# BIKEWAY PRINCIPLES





# STATE OF THE PRACTICE SOLUTIONS

1. It's been done
  - List of US Cities currently using a given treatment. Nothing in the NACTO Guide is new/untested.
  
2. Research, Design and Performance
  - Existing design guidelines, academic research, Federal RFE reporting, other studies.
  
3. Works with – not against – MUTCD



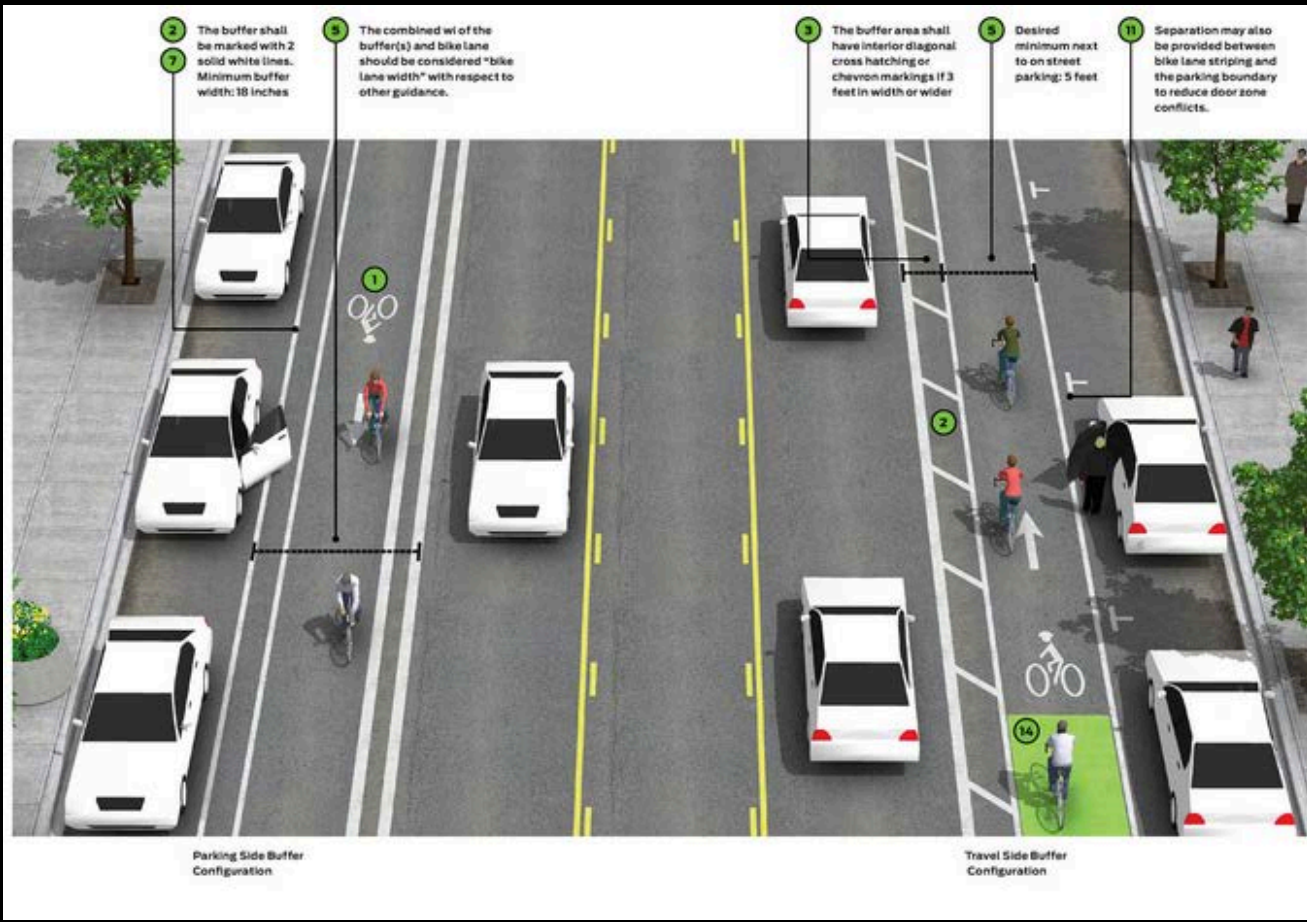
# GUIDANCE STRUCTURE

## Echoes MUTCD:

**Required**  
(Shall)

**Recommended**  
(Should)

*Optional*  
(May)





# BETTER BIKE NETWORK ESSENTIALS

## Low-Stress & Comfortable

Physical Separation is Key

## Attractive & Accessible

To Users of All Ages and Abilities

## Cohesive & Connected

Bike Lanes should *go* Somewhere

## Intuitive & Direct

Avoid Circuitous Routing and Multiple Turns







# DESIGN FOR ALL MODES

Complete Street networks accommodate all users



# AVOID CLUTTER

Be clear, be sure you know what problem you're trying to fix







# DESIGN FOR LOADING, MAINTENANCE & EMERGENCY RESPONSE



Chicago, IL



Chicago, IL





# PRIORITIZE BIKES AT INTERSECTIONS



# CONTEXT MATTERS

Choose the Appropriate Design Based on your Environment

Vehicle Speed →

Greater Separation

Neighborhood Greenways



Bike Lanes



Buffered Bike Lanes



Protected Bike Lanes

Shared Space



Shared Lane Markings

Vehicle Volume →





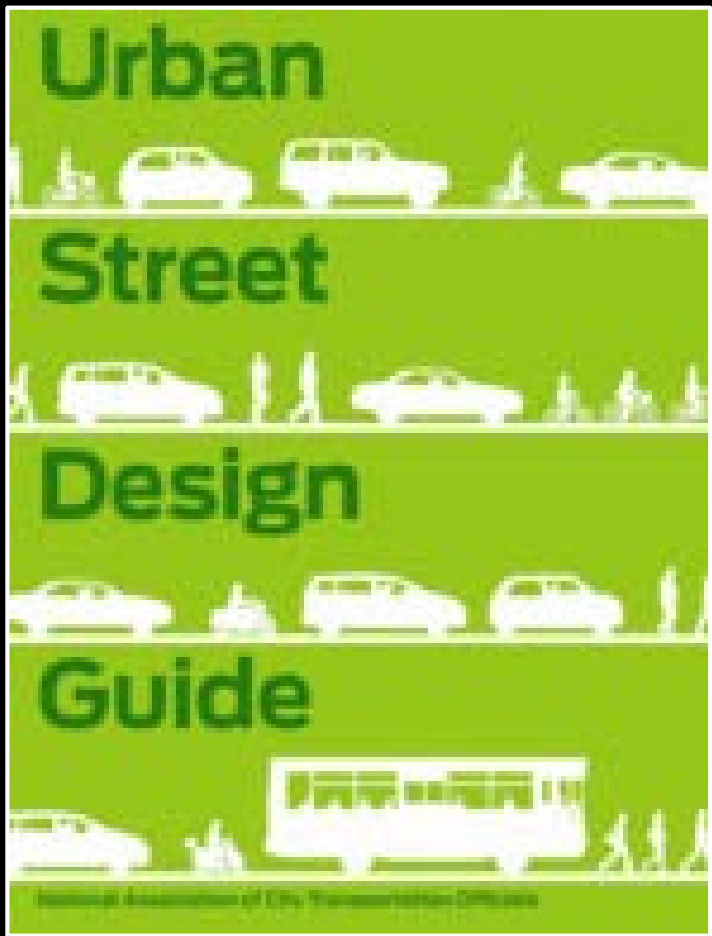
# CYCLE TRACK INTERSECTION DESIGN CONSIDERATIONS

Intersection Characteristics	Intersection Treatment
Major Intersection with high turning volumes	Bicycle Signal (Full Separation) or Bikes with Pedestrians
Medium volume intersections	Bicycle Signal, Mixing Zone, or other treatment
Minor Intersections and Driveways	Highlight conflict zone and ensure good sightlines

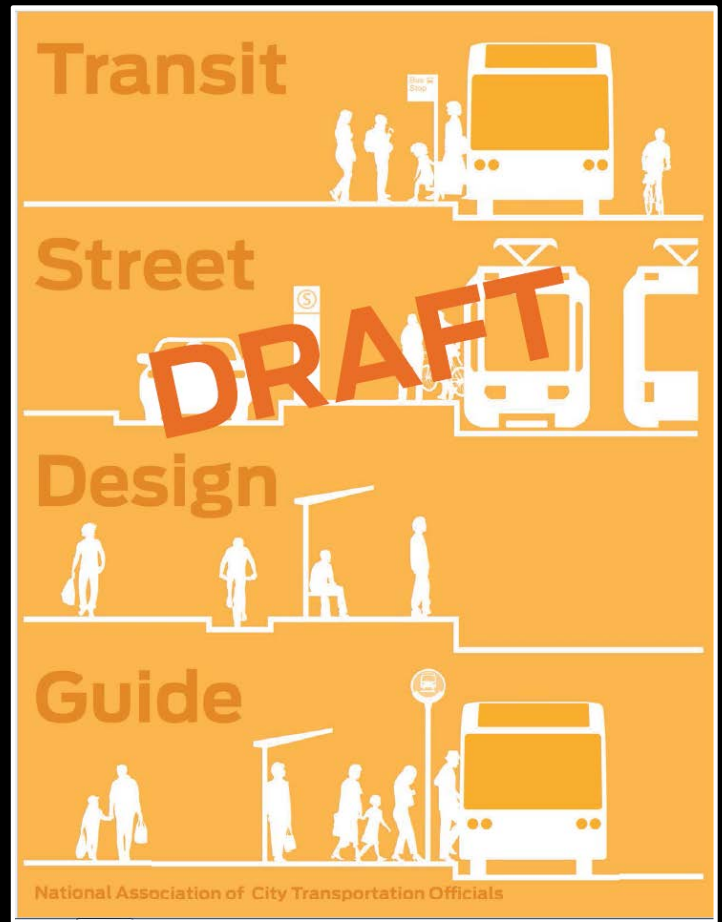
# CYCLICAL, INFORMED PROCESS



# OTHER NACTO GUIDANCE



Released 2013



Coming later 2015















# FHWA STATUS OF BICYCLE FACILITY TREATMENTS

Description of Bicycle Facilities	Status in the FHWA's Manual on Uniform Traffic Control Devices (MUTCD)	Are <b>FHWA Experiments</b> in Progress?
<b>Signs and Markings</b>		
<b>Bike Lanes</b>		
<b>Conventional bike lanes</b>	Can be implemented at present time	
<b>Continuation of bike lanes up to intersections</b>	Can be implemented at present time	
<b>Dashed bike lanes through intersections</b>	Can be implemented at present time	
<b>Use of green pavement markings for bike lanes and cycle tracks within intersections</b>	Interim approval has been granted. Requests to use green colored pavement need to comply with the provisions of Paragraphs 14 through 22 of Section 1A.10	Yes
<b>Green bike lanes at conflict points such as heavy turning and merging locations</b>	Interim approval has been granted. Requests to use green colored pavement need to comply with the provisions of Paragraphs 14 through 22 of Section 1A.10	Yes



# FHWA STATUS OF BICYCLE FACILITY TREATMENTS

Subject to <u>Experimentation</u>	Available through <u>Interim Approval</u>	<u>Interpretations</u>
 <p><u>Two-Stage Turn Box</u></p>	 <p><u>Green-Colored Pavement</u></p>	 <p><u>Use of R4-11 Sign on Roads with Speed Limits Above 35mph</u></p>
 <p><u>Bicycle Box</u></p>	 <p><u>Alternate Design for the U.S. Bicycle Route (M1-9) Sign</u></p>	 <p><u>Modified Bicycle Destination Sign</u></p>
 <p><u>Dashed Bicycle Lanes</u></p>	 <p><u>Bicycle Signal Faces</u></p>	 <p><u>Installation of Advance Turn and Directional Assemblies for Bike Route Signs</u></p>
 <p><u>Destination Guide Signs for Shared-Use Paths</u></p>		 <p><u>Pavement Markings for Designated Bicycle Routes</u></p>
 <p><u>Green-Colored Pavement for Use with the Shared-Lane Marking</u></p>		
<b>Additional Resources</b>		
<p><b>Allowable through the 2009 MUTCD</b></p>	<ul style="list-style-type: none"> <li>• Continuation of Bicycle Lanes up to Intersections</li> <li>• Extensions of Bicycle Lanes through Intersections</li> <li>• Counter-flow Bicycle Lanes</li> <li>• Buffer-Separated Bicycle Lanes</li> <li>• Bicycle Lanes on the Left-Hand Side of One-Way Streets</li> <li>• Two-stage turn box Jughandle movement at a T-Intersection</li> <li>• Shared-Lane Markings</li> <li>• Shared-lane markings in exclusive turn lanes</li> <li>• Reversed bicycle symbols in bicycle lanes or separated bikeways at intersections and driveways oriented towards turning or entering motorists</li> </ul>	



**Where does the MUTCD address this? Protected cycle tracks, both one-way and two-way bicycle facilities are a preferential lane, not a traffic control device, so there is no MUTCD restriction on its use.**

Cycle Tracks	
Protected cycle tracks, both one-way and two-way bicycle facilities	Not a traffic control device, so no MUTCD restriction on its use
Raised cycle tracks, both one-way and two-way bicycle facilities	Not a traffic control device, so no MUTCD restriction on its use
Merging cycle track users with turn lanes in advance of high volume turn locations, allowing bicyclists to make a through movement at the intersection in order to reduce conflicts with the turning traffic	Can be implemented at present time if signs and pavement markings that are compliant with the MUTCD are used

[www.fhwa.dot.gov/environment/bicycle\\_pedestrian/guidance/design\\_guidance/mutcd\\_bike.cfm](http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_guidance/mutcd_bike.cfm)



## FHWA Status of Existing Bikeway Treatments

<p><b>Allowable through the 2009 MUTCD</b></p>	<ul style="list-style-type: none"> <li>• Continuation of Bicycle Lanes up to Intersections</li> <li>• Extensions of Bicycle Lanes through Intersections</li> <li>• Counter-flow Bicycle Lanes</li> <li>• Buffer-Separated Bicycle Lanes</li> <li>• Bicycle Lanes on the Left-Hand Side of One-Way Streets</li> <li>• Two-stage turn box Jughandle movement at a T-intersection</li> <li>• Shared-Lane Markings</li> <li>• Shared-lane markings in exclusive turn lanes</li> <li>• Rotated bicycle symbols in bicycle lanes or separated bikeways at intersections and driveways oriented towards turning or entering motorists</li> </ul>	
<p><b>Disallowed</b></p>	<ul style="list-style-type: none"> <li>• Combined bicycle lane/turn lane where the lane attempts to establish a bike lane</li> <li>• Green channelizing devices, delineators, posts, or retroreflective elements thereof</li> <li>• Yield bar pavement markings without a standard, regulatory yield sign</li> </ul>	
<p><b>Other Treatments</b></p>	<ul style="list-style-type: none"> <li>• Separated bikeways</li> <li>• Convex mirrors at conflict points to improve visibility</li> <li>• Bicycle networks</li> <li>• Median or refuge island for bikeway crossings</li> </ul>	<ul style="list-style-type: none"> <li>• Not a traffic control device, so no MUTCD restriction on its use</li> </ul>

# BIKE LANES

CONVENTIONAL  
BUFFERED  
CONTRAFLOW  
LEFT SIDE





## Conventional Bike Lanes

- Wider is better
- 6' preferred
- Mark through the intersection
- Typically

# CONVENTIONAL BIKE LANE



Champaign, IL





# BIKE LANE DESIGN CHECKLIST

## REQUIRED

- 4-5 foot min width
- 5 foot adjacent to parking (7-9 foot)
- Delineate between travel lane and bike lane
- Bike lane symbol
- Surface condition

## Recommended

- Additional width whenever available
- Delineate the Parking line
- Flush seams at gutters, drainage inlets, utility covers
- Dashed lines through merge / conflict / transition zones

## *Optional*

- Bike lane signs
- “No Parking” signs



# Buffered Bike Lanes

- 2' minimum buffer
- Can buffer both sides of bike lane
- Add buffer if you have the width







Chicago, IL





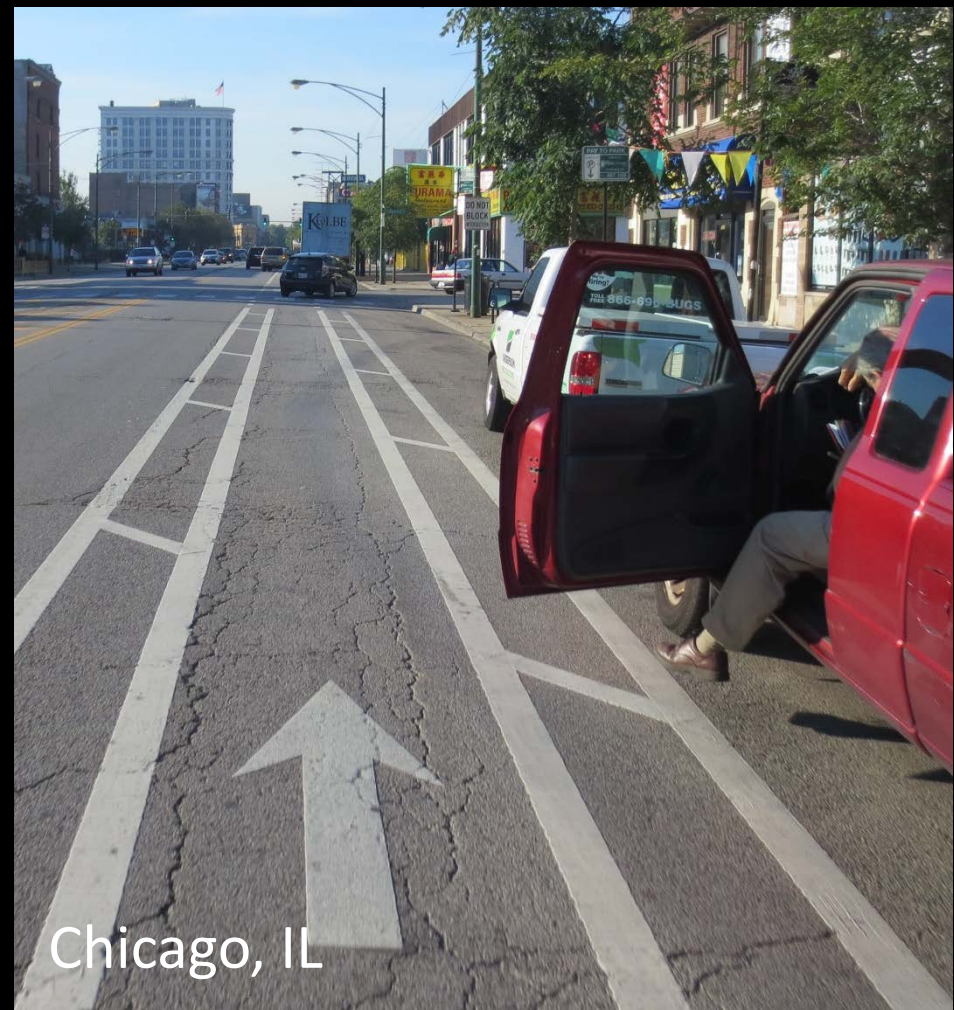
Chicago, IL



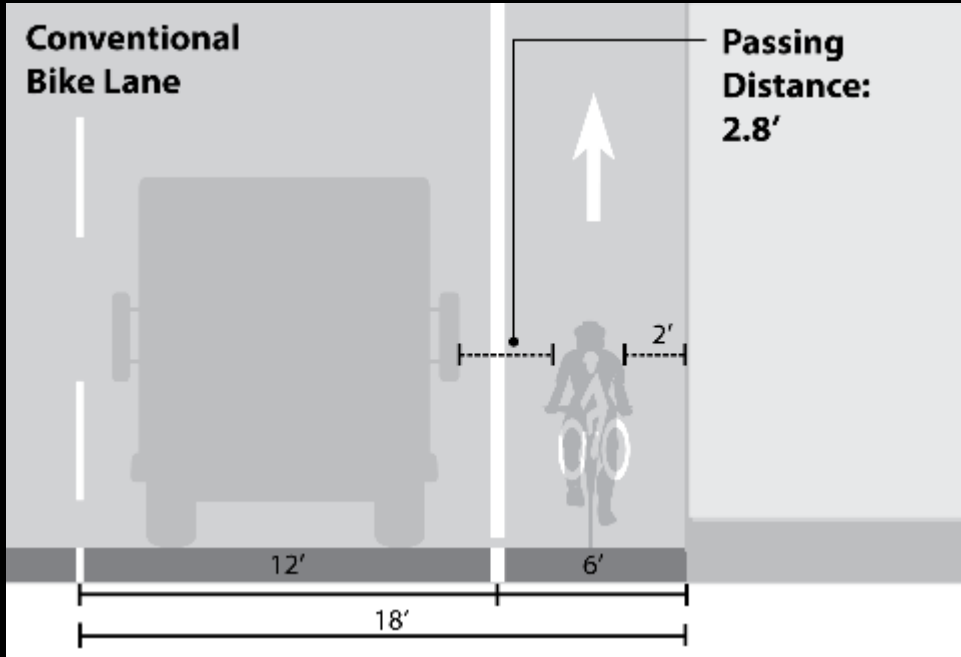
Chicago, IL



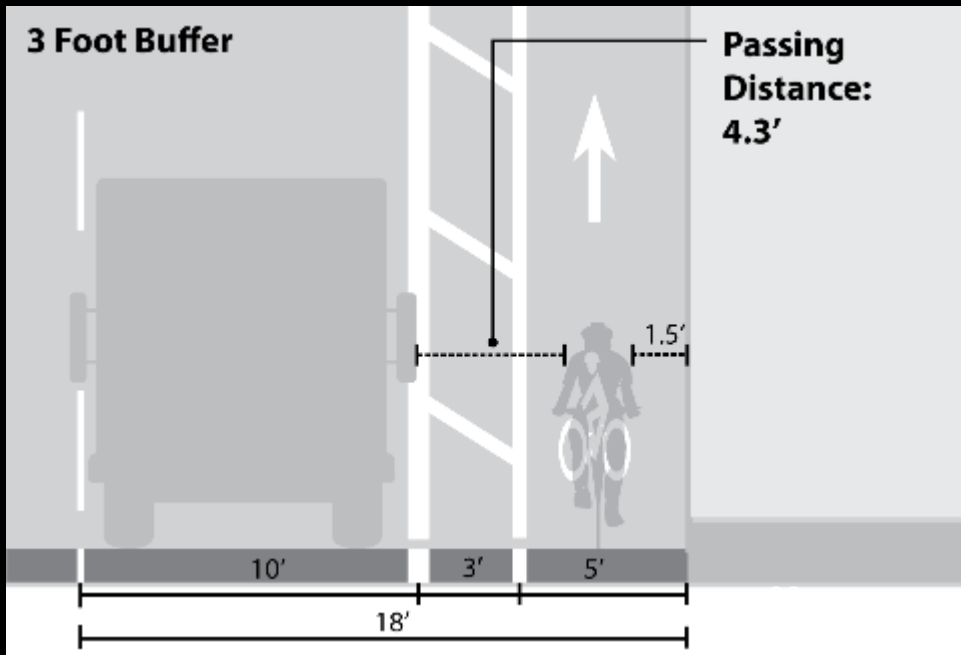
# IF YOU CAN, ADD BUFFERS (NCHRP REPORT 766)



# Conventional Bike Lanes



# Buffered Bike Lanes





# BUFFERED BIKE LANE DESIGN CHECKLIST

## REQUIRED

- Required bike lane elements PLUS:
- 2 solid white line buffer (18" min)

## Recommended

- 30 or 45-degree hatching at 10'-40' spacing
- 7-foot width whenever possible (lane + buffer = 7)
- Transition to dashed lane at intersections, or the left side of right-turn lanes

## *Optional*

- Parking lane "T" markings
- Use wider buffers to narrow travel lanes and reduce speeds
- Use different pavement or color in the bike lane or at start of each block



# Contra-Flow Bike Lanes

- Short connections ideal
- Combine with bike signals
- Use physical barrier where appropriate





Chicago, IL





# CONTRAFLOW BIKE LANE DESIGN CHECKLIST

## REQUIRED

- Required bike lane elements PLUS:
- ONE WAY Except Bikes sign
- Appropriate traffic control for contraflow movement

## Recommended

- DO NOT ENTER Except Bikes sign
- Double yellow line for opposing directions
- No Turn on Red signs
- Provide buffer
- Extend contraflow markings through intersections
- Provide sharrows or a lane for the opposing direction

## *Optional*

- Modified Two-Way sign showing bike symbol
- Colored pavement
- Smaller stop signs for bike-only direction of travel
- Avoid placing contraflow lanes adjacent to parking
- Use curb or median for added buffer



# Left-side Bike Lanes

- Great for transit routes
- Use two-stage turns or bike boxes to facilitate transition from left to right





7

Desired width: 6 feet

1



3



2



BUS ONLY

# LEFT SIDE BIKE LANE DESIGN CHECKLIST

## REQUIRED

- Required bike lane elements PLUS:
- Only place on left side of one-way or median-divided two-way streets

## Recommended

- Left side signage
- Additional buffer
- Bike boxes and signals at intersections
- “Yield to Bikes” sign at left-turn lanes

## *Optional*

- Colored pavement

# PROTECTED BIKE LANES (a.k.a.) CYCLE TRACKS

ONE-WAY  
RAISED  
TWO-WAY



# Variation on a Theme

**1/2**  
use parked cars



**1/3**  
use plastic posts



**1/4**  
use curbs



**a few**  
use planters



**2/3**  
are one-way



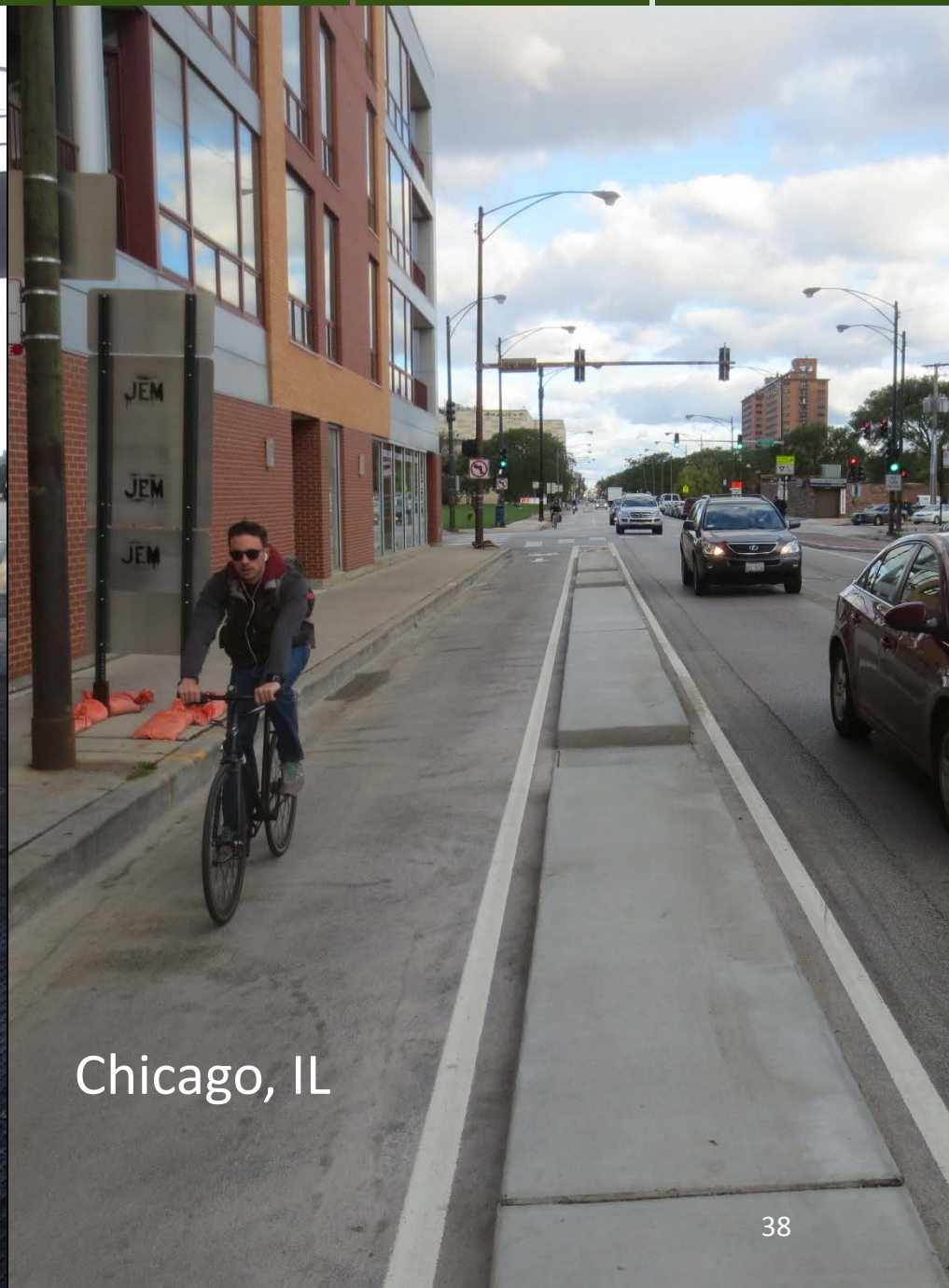
**1/3**  
are two-way



Source: The Green Lane Project



Chicago, IL



Chicago, IL





# One-way Cycle Track

- Separate using striped buffer, planters, or curbs
- Stakeholder outreach critical
- Pay attention to road's crown





5 to 7 Feet

ONLY BIKE





3' Minimum





Austin, TX

# One-way Cycle Track

- Take advantage of pedestrian benefits
- Wrap around transit stops



# ONE-WAY CYCLE TRACK DESIGN CHECKLIST

## REQUIRED

- Required bike lane elements PLUS:
- Raised median, curb, or barrier
- 5-foot minimum width

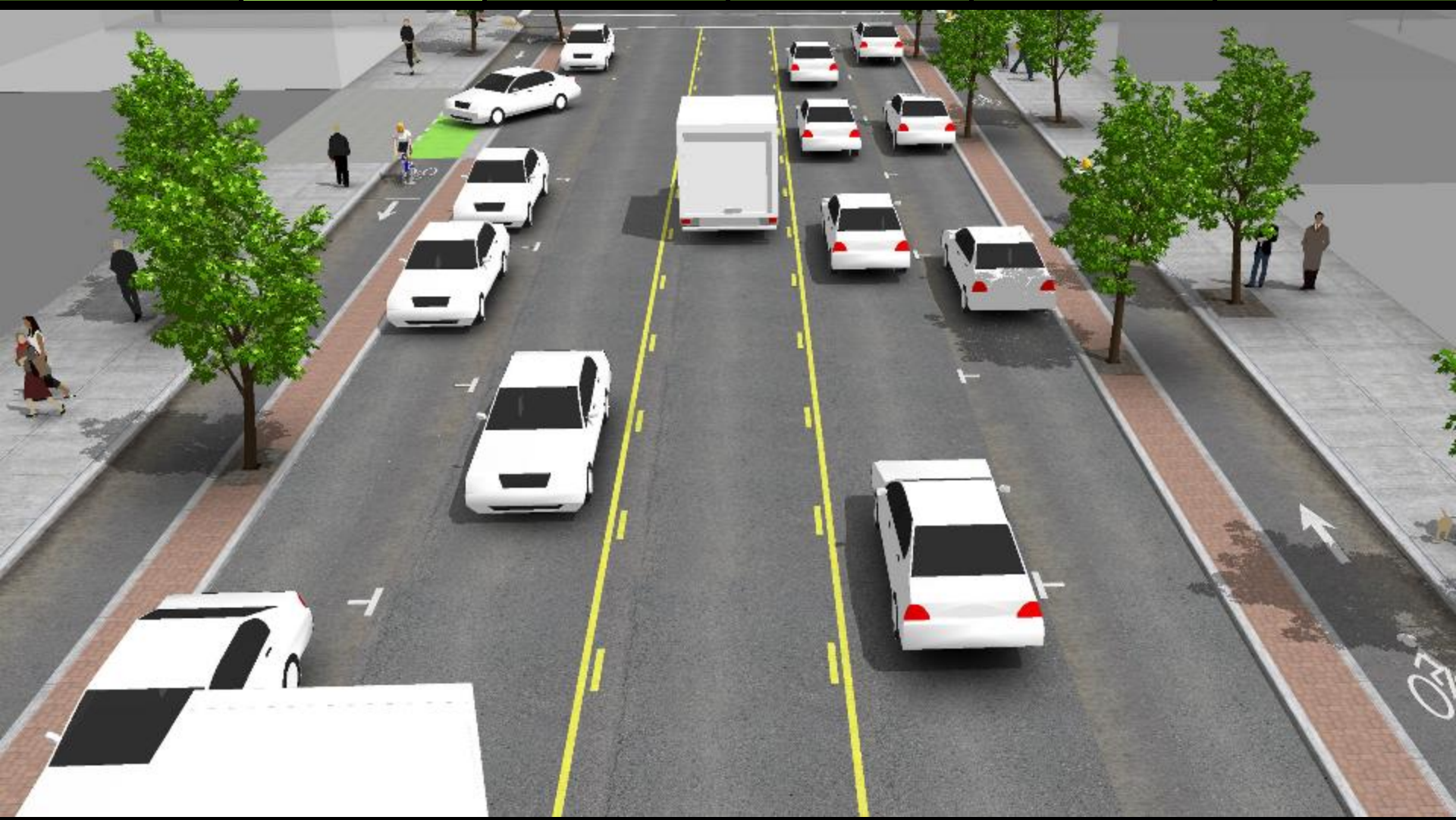
## Recommended

- 7-foot width for high bike volumes, steep grades, etc.
- 3-foot parking lane buffer
- Maximum parking lane plus buffer width = 11 feet
- Use planters, bollards, other barrier if no curb or parking lane is present
- Highlight driveway crossings and conflict zones
- Be aware of drainage impacts

## *Optional*

- Flex posts
- Lateral shift at minor intersections
- Separate bus stops and cycle tracks with transit boarding islands
- Colored pavement





# Raised Cycle Track

- Should feel like part of the sidewalk
- Asphalt overlay can be cheaper
- Consider mountable curb





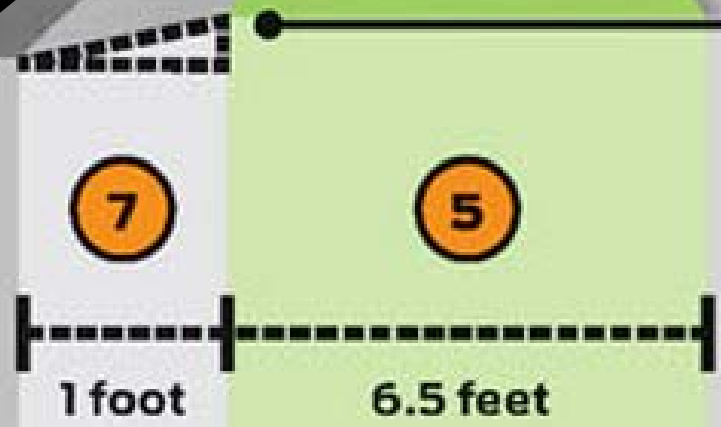
# Design Guidance

## Raised Cycle Track with Mountable Curb



16

When placed adjacent to a travel lane, one-way raised cycle tracks may be configured with a mountable curb.



4

If used, the mountable curb should have 4:1 slope edge.



# Design Guidance

## Raised Cycle Track with Parking Buffer



3

Protection strategies may include a curb, furnishings, vegetation or a parking lane.

6

3 feet

5

6.5 feet

8

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

# RAISED CYCLE TRACK DESIGN CHECKLIST

## REQUIRED

- Required cycle track elements PLUS:
- Raised above street level to at or near sidewalk level
- Barrier or curb separation from automobile traffic
- If curb is used it must be mountable (4:1 slope)

## Recommended

- Minimum 5 feet, 7 feet desired
- 3-foot buffer next to parking
- 1-foot mountable curb
- 6 inches to 1 foot higher than travel lane
- 0 to 5 inches lower than sidewalk
- Extra visibility needed at driveways & minor intersections
- Drain toward street
- Two-stage turn queue boxes at intersections

## *Optional*

- Lateral shift at minor intersections
- Can be placed on left side
- Can be contraflow
- Colored pavement

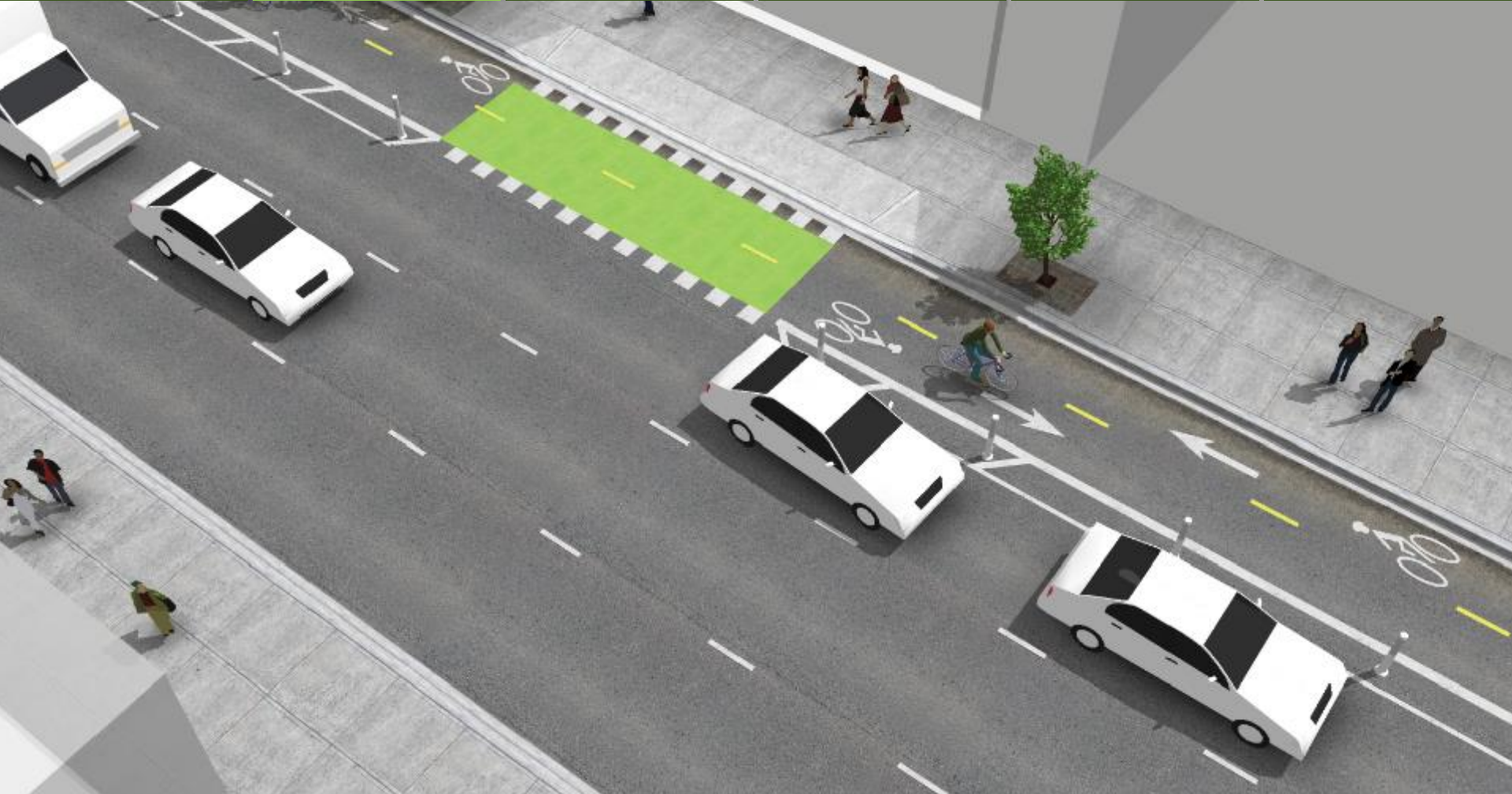




Indianapolis, IN

# Raised Cycle Track (two-way)





## Two-way Cycle Track

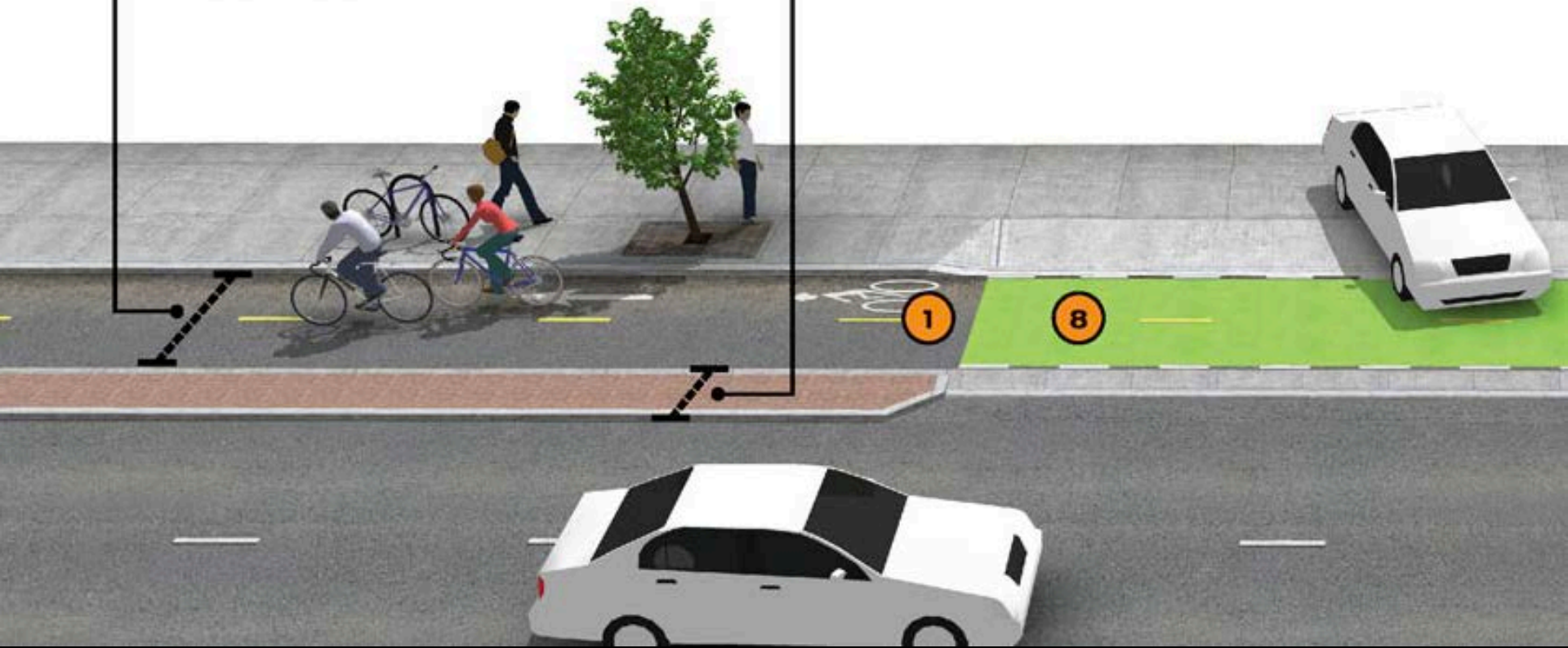
- Left side of one-way streets
- Similar to design of paths





**5** Desired minimum:  
 12 feet (in constrained  
 conditions: 8 feet)

**6** Desired minimum:  
 3 feet











Austin, TX



Indianapolis, IN





Chicago, IL





Chicago, IL (in progress)



# TWO-WAY CYCLE TRACK DESIGN CHECKLIST

## REQUIRED

- Required cycle track elements PLUS:
- ONE WAY Except Bikes for one-way streets
- DO NOT ENTER Except Bikes for two-way streets
- Appropriate traffic controls at intersections

## Recommended

- 12-foot width (8-foot minimum for constrained locations)
- 3-foot buffer from parking
- Dashed yellow line for cycle track centerline
- Extra visibility needed at driveways and minor intersections
- Two-stage turn queue boxes
- Channelize/constrain automobile turns across cycle track

## *Optional*

- Flex posts
- Lateral shift at intersections for improved bicyclist/motorist visibility
- Transit boarding island
- Can be a raised cycle track





# INTERSECTIONS

**BIKE BOXES**

**INTERSECTION CROSSING MARKINGS**

**TWO-STAGE TURN QUEUE BOXES**

**MEDIAN REFUGE ISLAND**

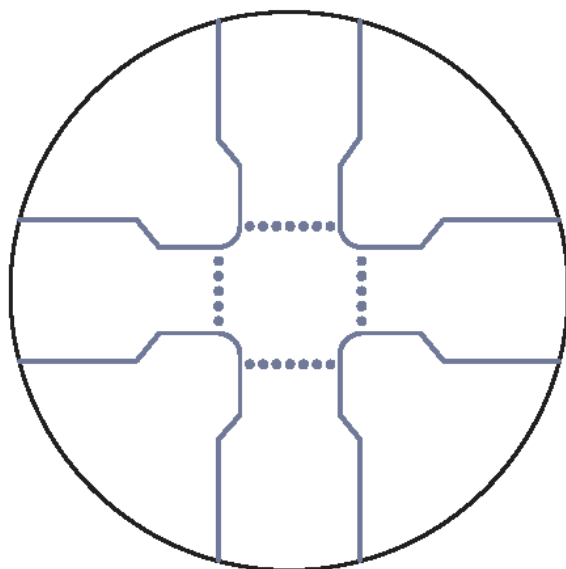
**THROUGH BIKE LANES**

**COMBINED BIKE LANE/TURN LANE**

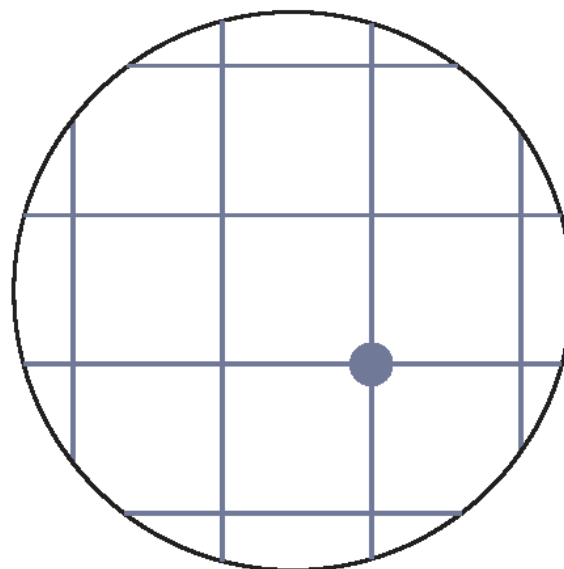
**CYCLE TRACK INT. APPROACH**



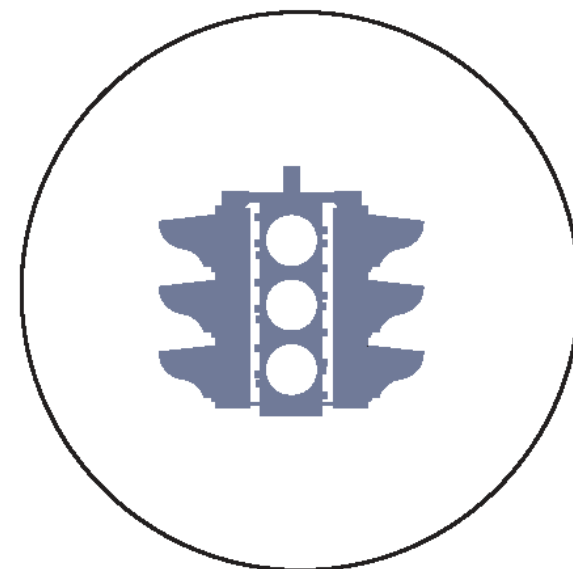
# INTERSECTION DESIGN GUIDANCE (USDG)



As compact  
as possible



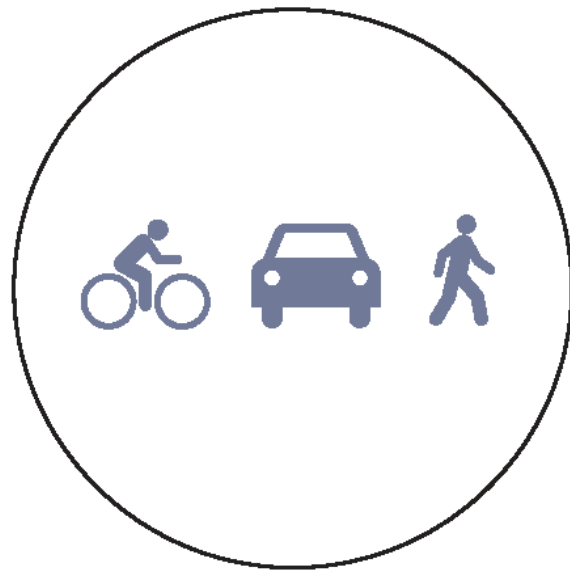
Analyze in network,  
not in isolation



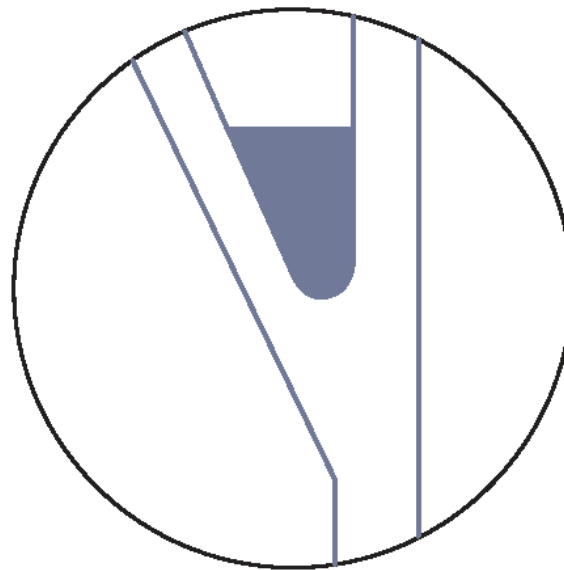
Integrate time  
and space



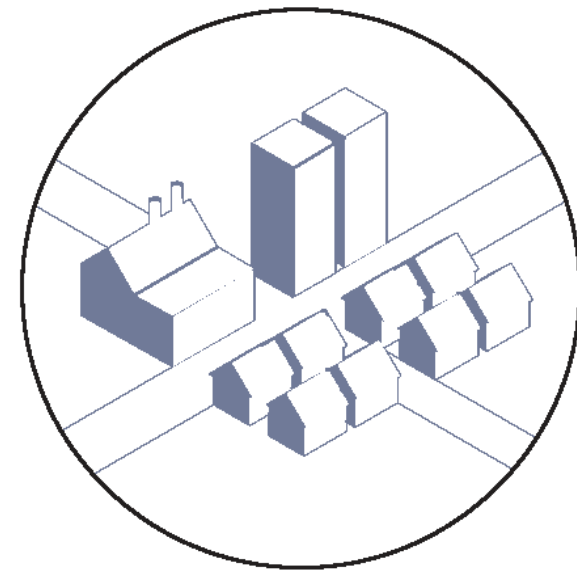
# INTERSECTION DESIGN GUIDANCE (USDG)



Shared by all modes



Excess space into public space



Design for the future



# INTERSECTION DESIGN **PARAPHRASED** CHECKLIST

## REQUIRED

- Mitigate/eliminate turning conflicts
- Facilitate turns for bikes
- Balance design for all modes

## Recommended

- Continue facility through intersections
- Provide intersection guidance for bicyclists
- Provide a modal hierarchy

## *Optional*

- Colored pavement
- Restrict vehicle movements



# BIKE BOX





# BIKE BOX





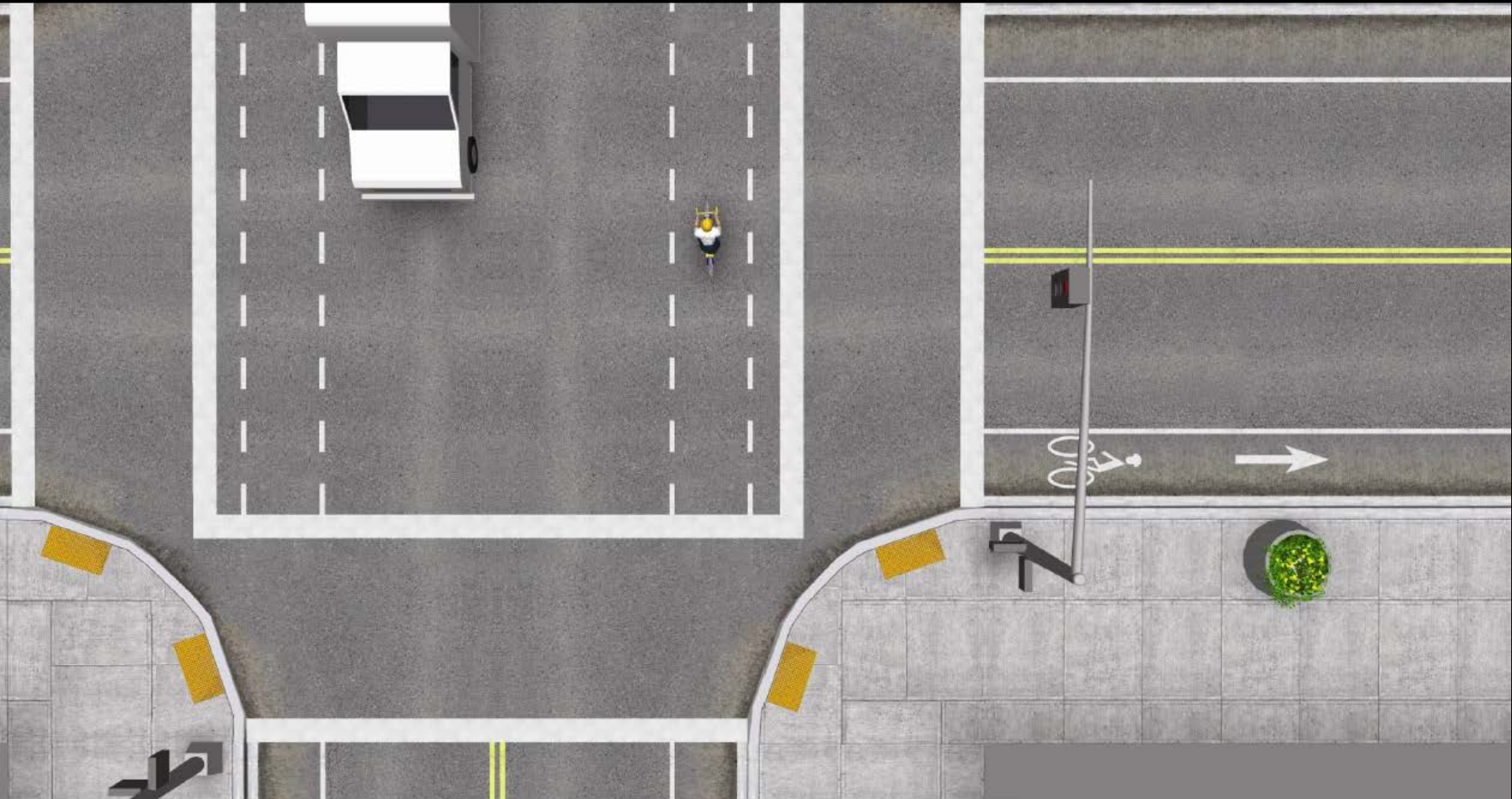
# INTERSECTION MARKINGS



© Jonathan.Maus/BikePortland



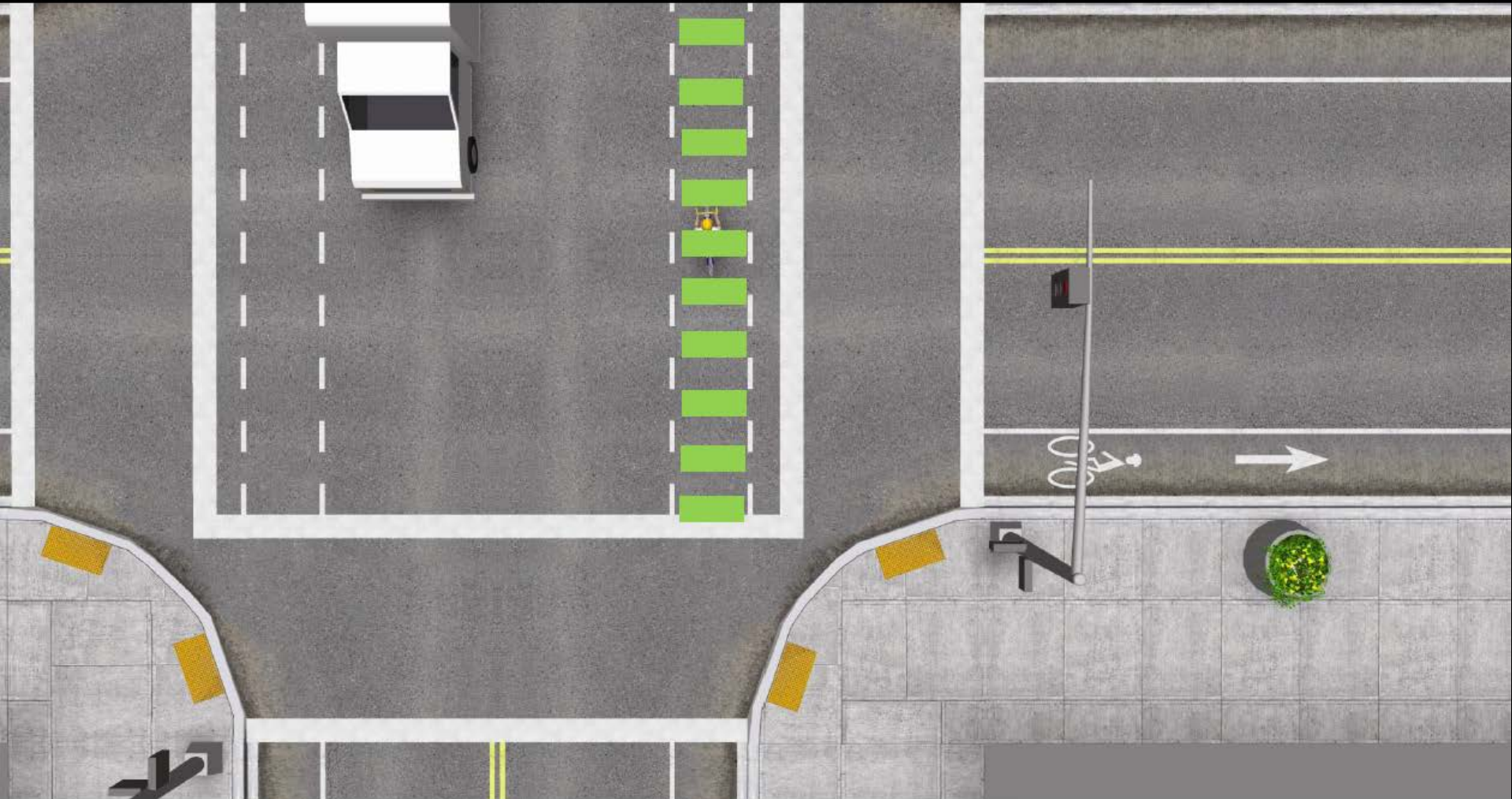
# Intersection Crossing Markings







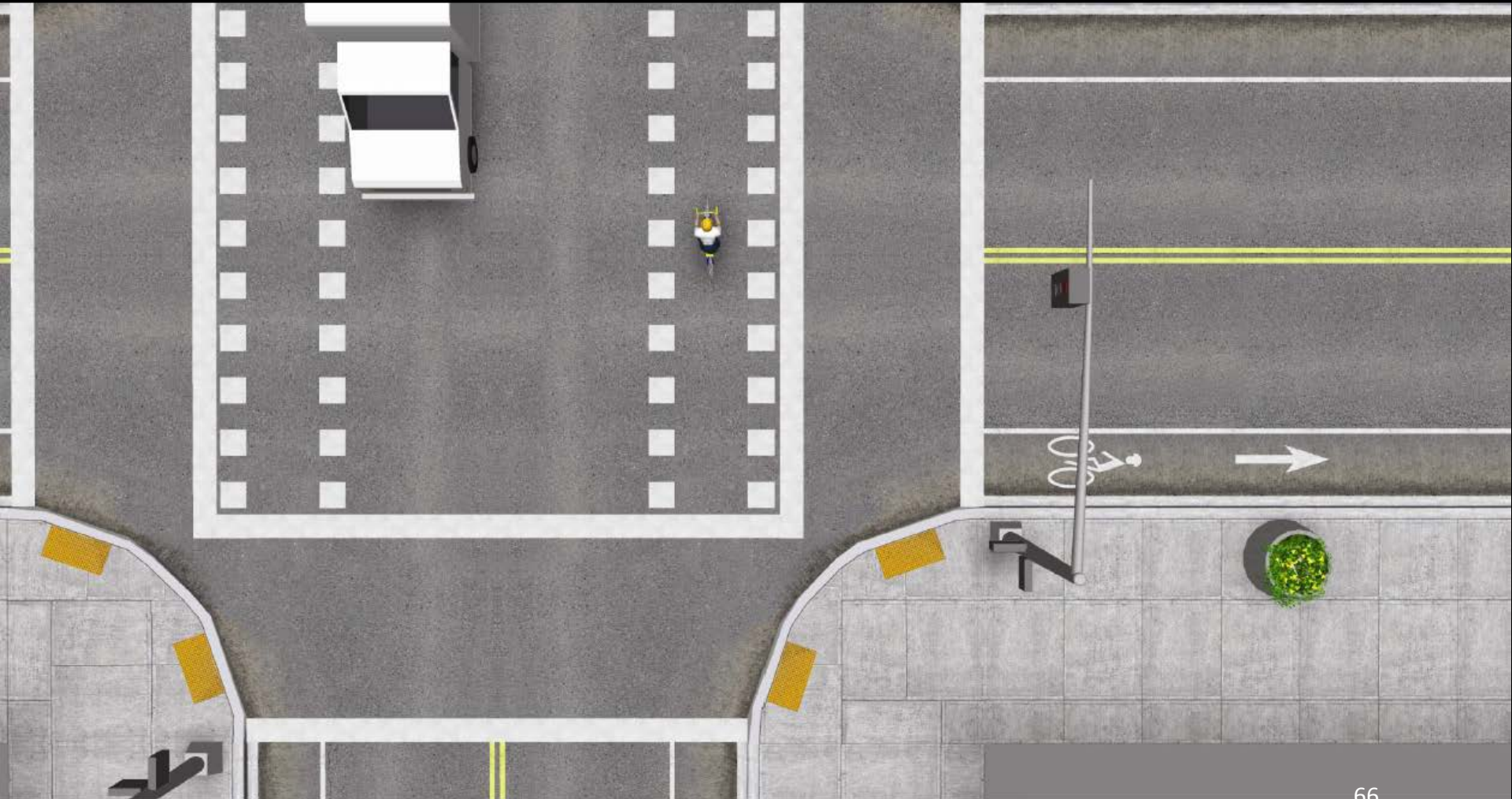
# Intersection Crossing Markings





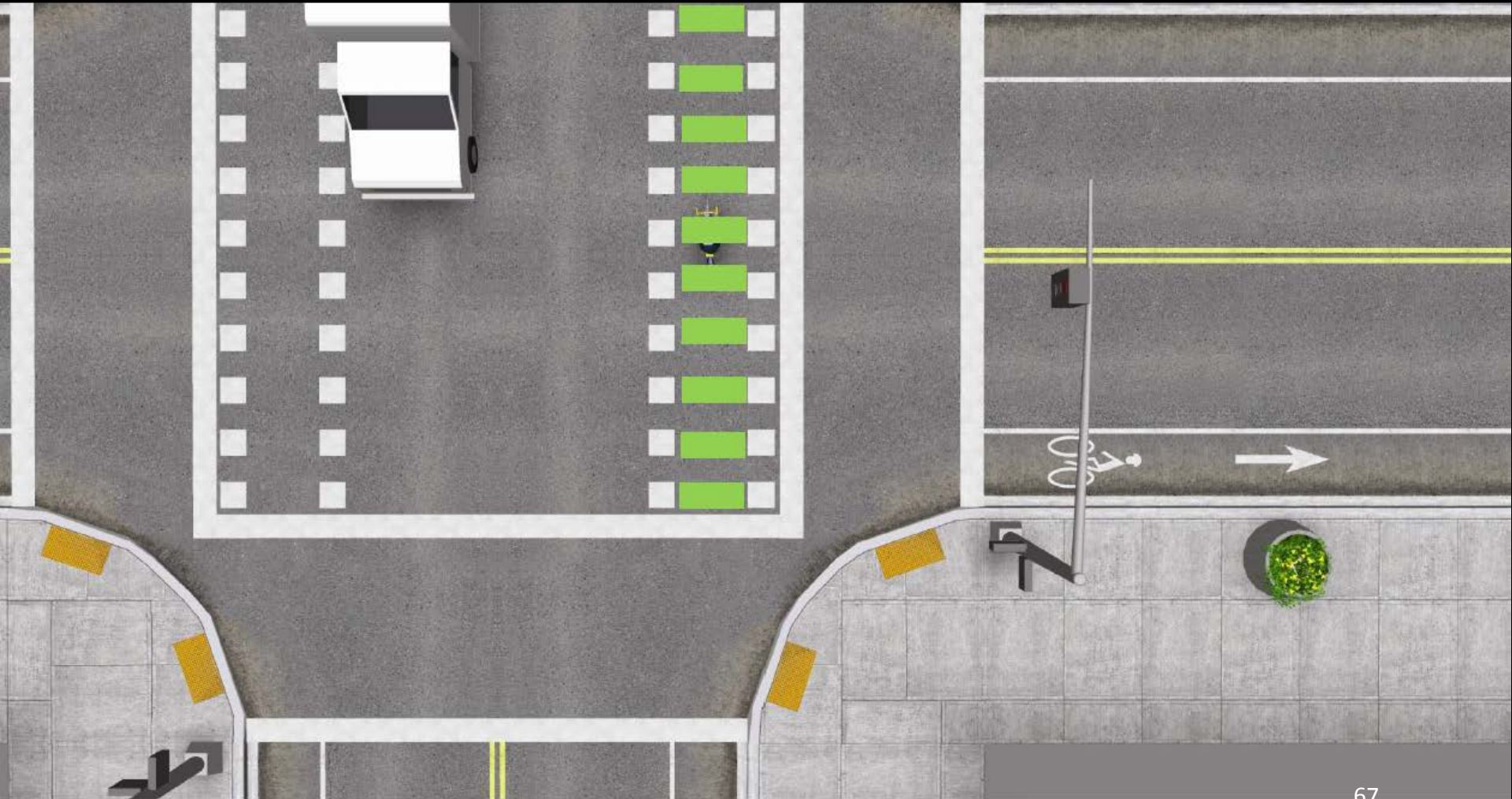


# Intersection Crossing Markings





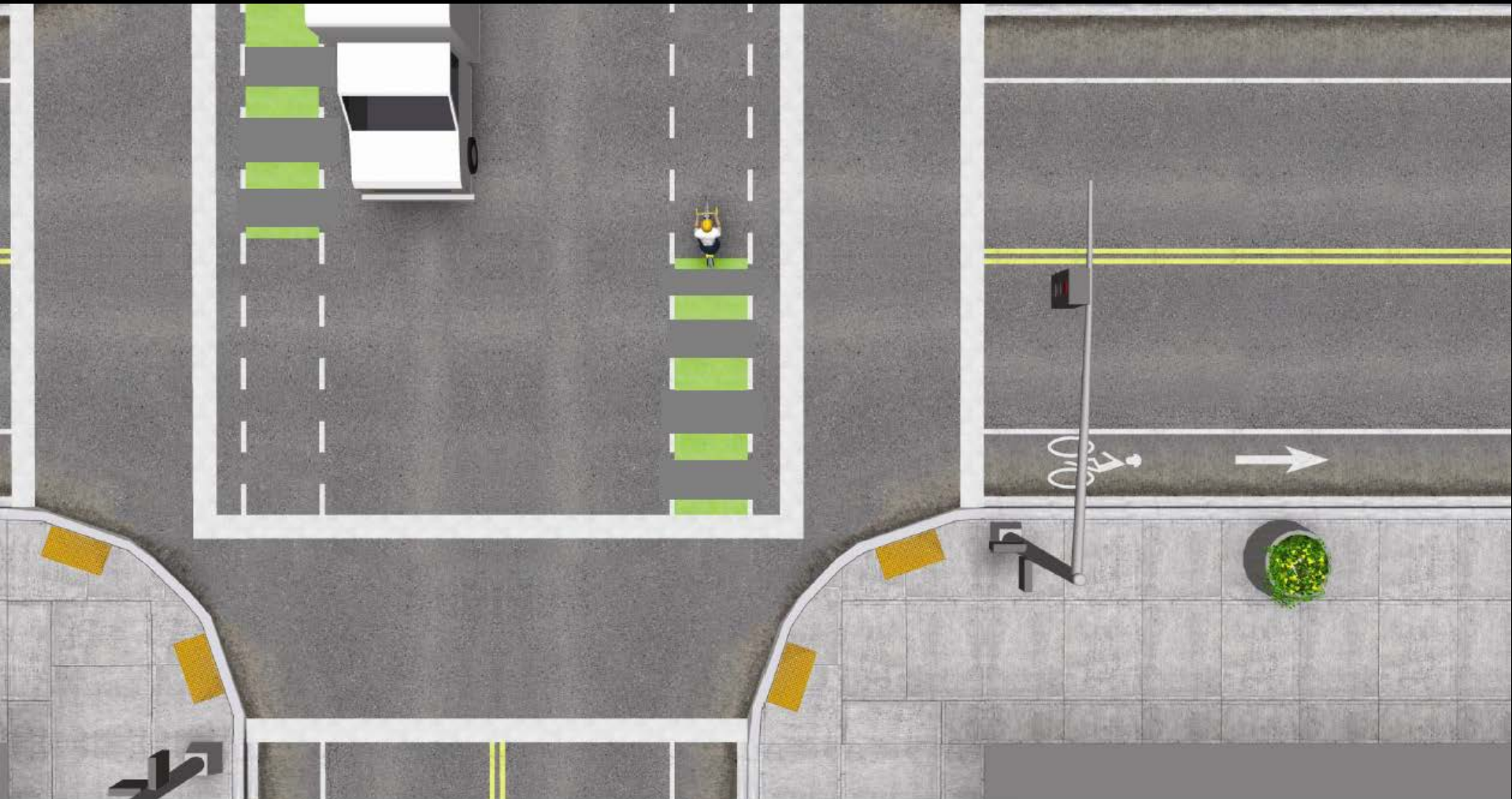
# Intersection Crossing Markings







# Intersection Crossing Markings







# TWO-STAGE TURN QUEUE BOX



Chicago, IL







**Cycle Track Buffer Configuration**



**Parking Lane Configuration**



**Crosswalk Setback Configuration**  
Wider corner radii, set back pedestrian crossing, and/or narrowed bikeway space, provides opportunity for queue box.



**Bike Box Configuration**  
Bicyclists yield to pedestrians. Not recommended in areas with high pedestrian volumes.



**T-Intersection Parking Lane Configuration**



**T-Intersection "Jughandle" Sidewalk Configuration**



Chicago, IL



# MEDIAN REFUGE ISLAND

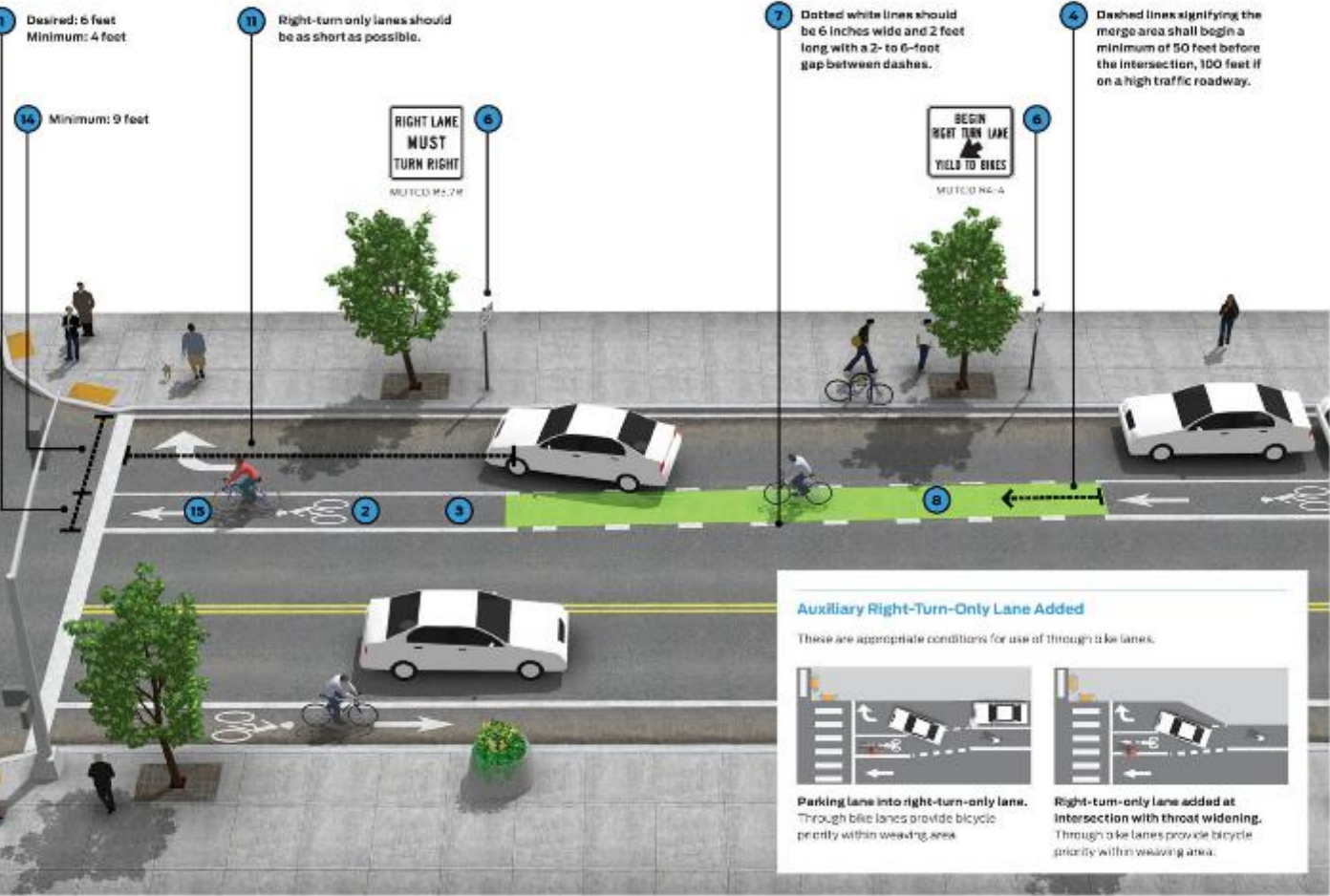


Chicago, IL





# THROUGH BIKE LANES



- 12 Terminating the bike lane in advance of the intersection is discouraged.
- 13 For intersections that lack the physical width to install a bicycle pocket, a combined bike/turn lane should be used.
- 14 Vehicle turn lane width should not be reduced to less than 9 feet.
- 15 Bicycle detection should be provided within the through bike lane.

- ### Optional Features
- 16 On streets with a combined turn and through lane, shared lane markings may be used in the center of the lane.
  - 17 A bike box may be used in lieu of a designated through bike lane.
  - 18 Bicycle warning signs may be used in advance of the merge transition area.

### Through Travel Lane Transitions into Right-Turn-Only Lane

These are generally appropriate conditions for use of through bike lanes. Consider alternate treatments.



Exclusive bicycle signal phases used to separate conflicting movements.



Bicycle lane dropped in advance of the intersection encourages bicyclists to merge across as gaps permit. Shared lane markings may be used to provide additional guidance.



Bicyclists are not provided priority in weaving area and must use caution to merge across potentially high-speed motor vehicle traffic. Dotted lane line transition areas to through bike lanes should not be provided at these locations.

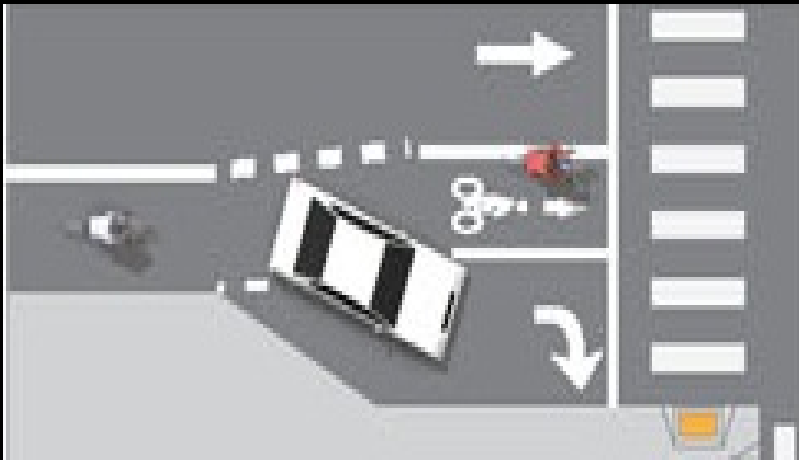
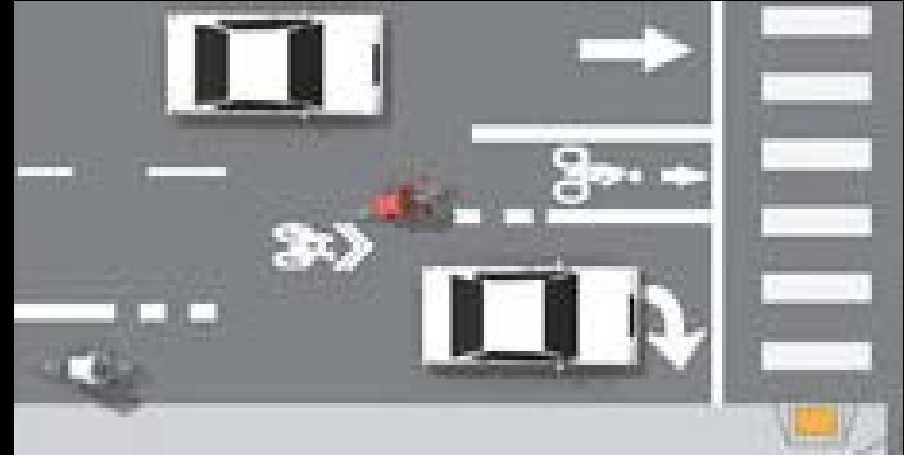
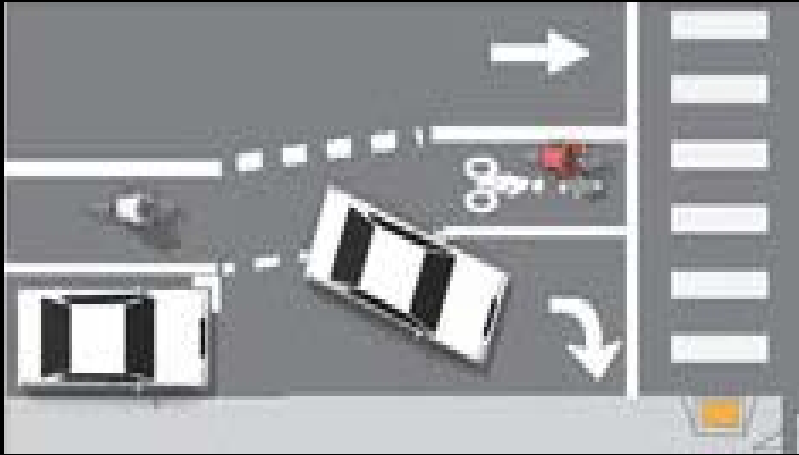
### Auxiliary Right-Turn-Only Lane Added

These are appropriate conditions for use of through bike lanes.

**Parking lane into right-turn-only lane.**  
Through bike lanes provide bicycle priority within weaving area.

**Right-turn-only lane added at intersection with throat widening.**  
Through bike lanes provide bicycle priority within weaving area.

# THROUGH BIKE LANES





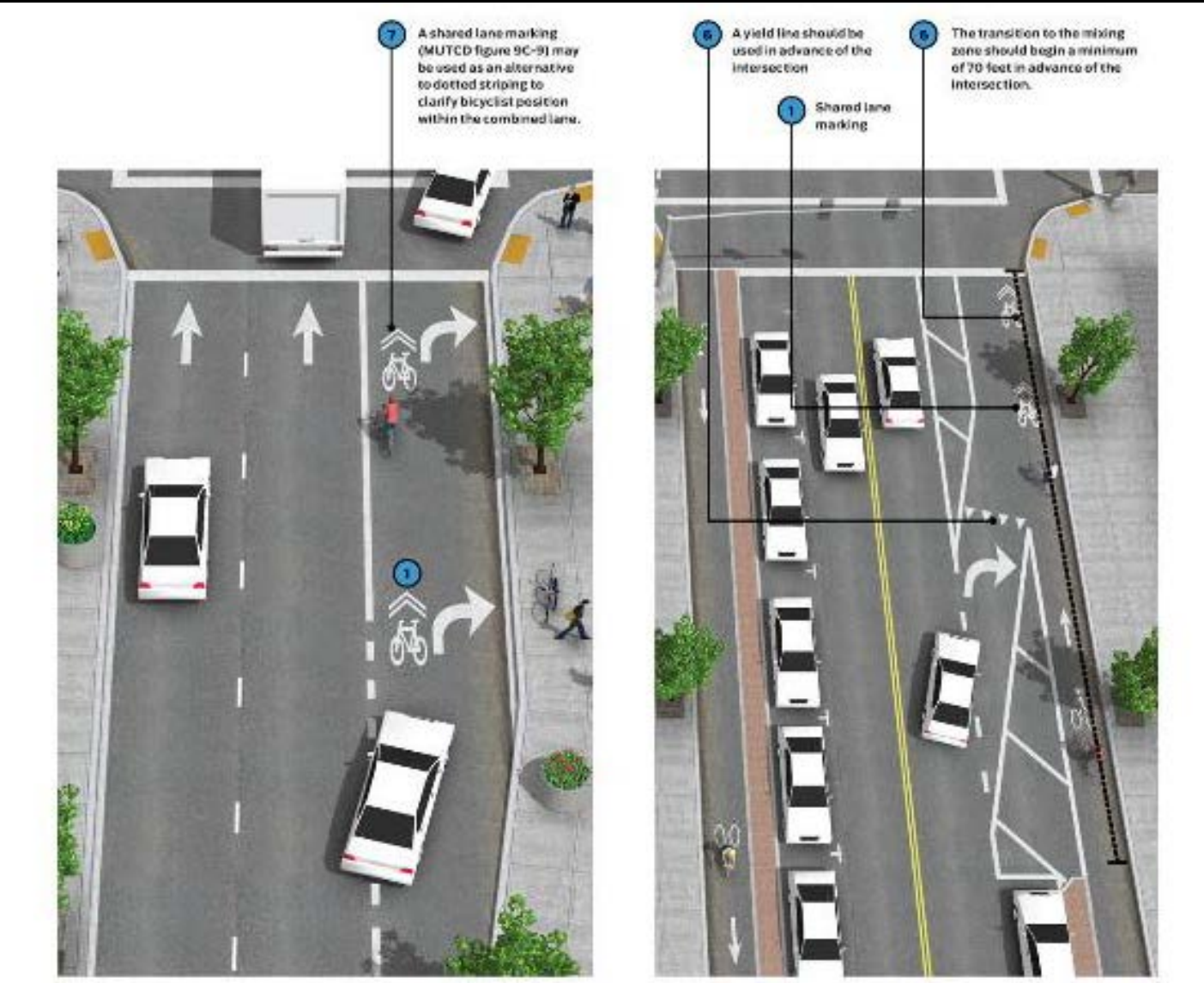
# THROUGH BIKE LANES



Urbana, IL



# COMBINED TURN LANE, BIKE LANE





Chicago, IL

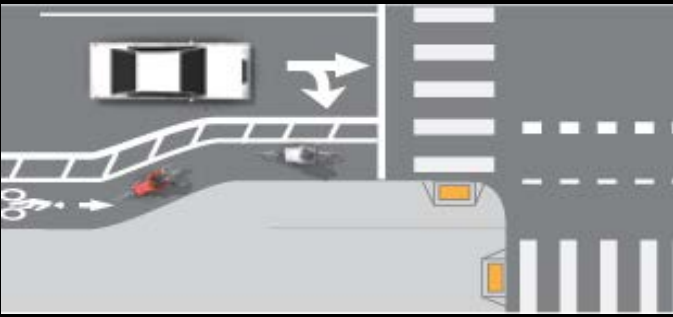
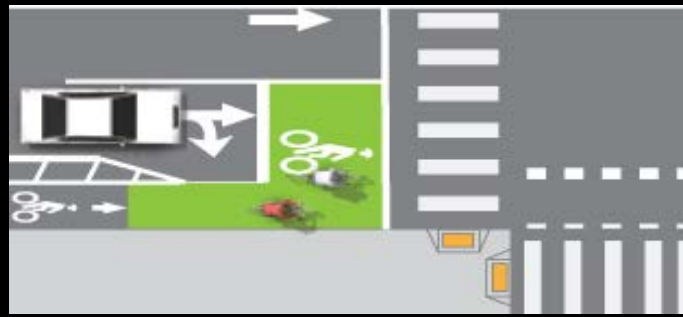
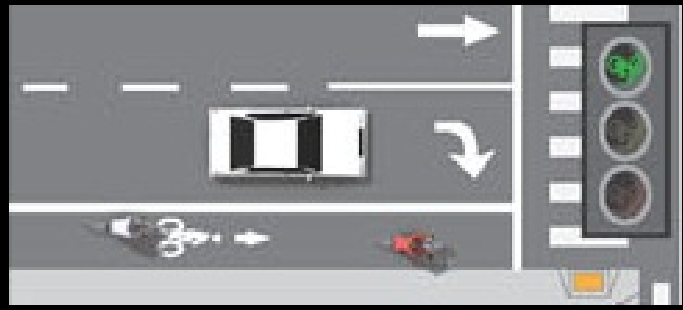




Chicago, IL



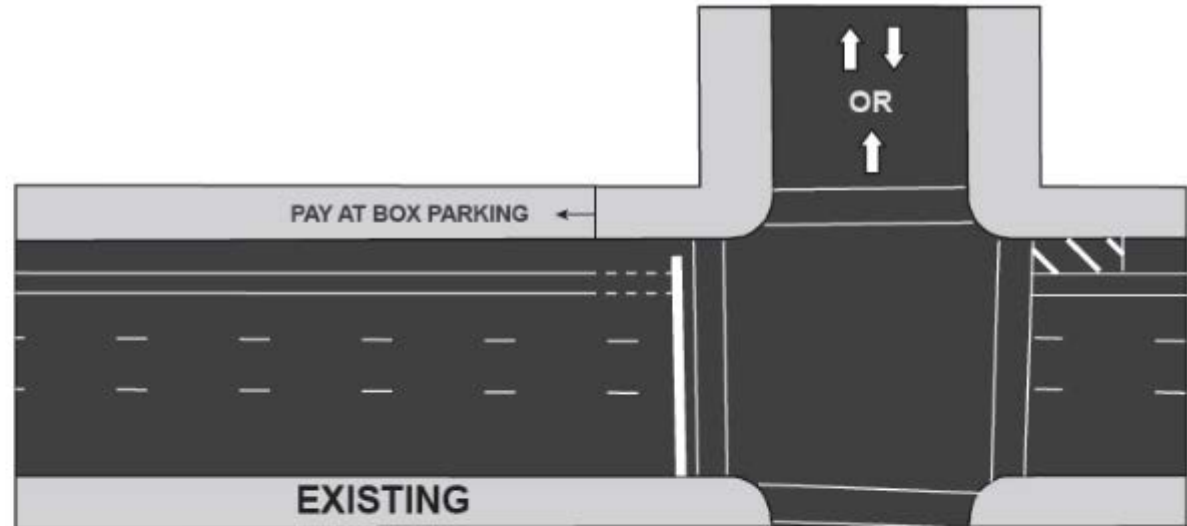
# CYCLE TRACK INTERSECTION APPROACHES



# TWO-WAY CYCLE TRACK DESIGN LANE AND PARKING IMPACTS

## EXISTING

- 30 foot parking setback for left turning vehicles.
- No left turn lane.

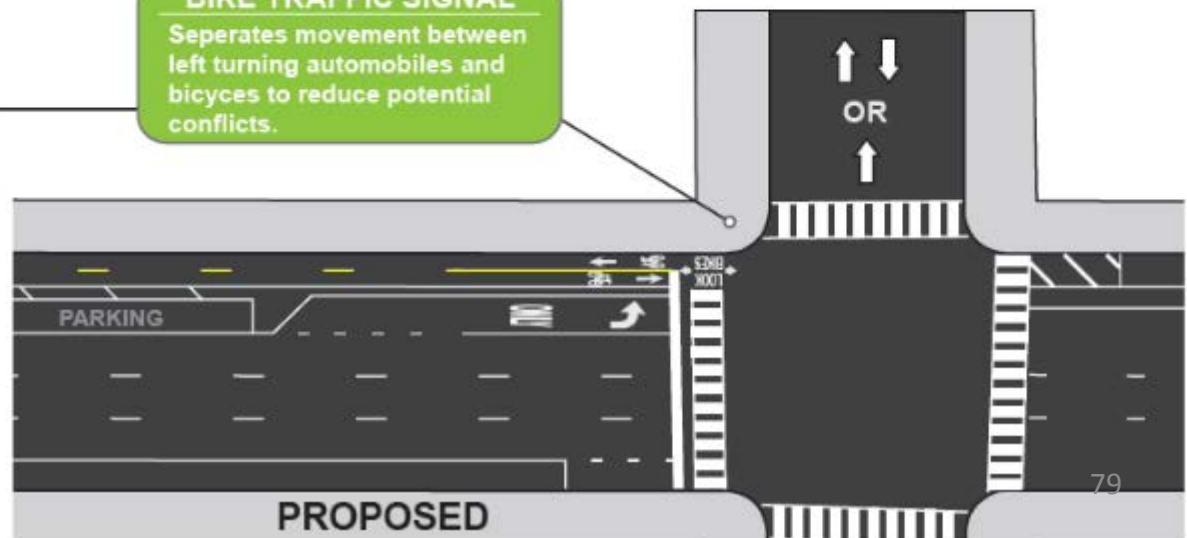


## BIKE TRAFFIC SIGNAL

Separates movement between left turning automobiles and bicycles to reduce potential conflicts.

## PROPOSED

- 100-150 foot parking setback for
- Left turn lane.
- Bike traffic signal.
- Barrier-protected bike lane.
- Removal of 70-120 feet of parking/loading





Bike Lanes

Cycle Tracks

Intersections

Signals

Signs & Markings

Bike Boulevards

# BEND-IN



Washington, DC  
Photo: DDOT - Jim Sebastian





# SIGNALIZED BIKE LANE



Chicago, IL

# **SIGNALS**

**BIKE SIGNAL HEADS  
DETECTION & ACTUATION  
ACTIVE WARNING BEACON (RRFB)  
HYBRID BEACON**

# BIKE SIGNAL HEADS

bicyclists to use  
is a low-cost  
of the pedestrian  
(typically timed  
and) is usually  
bicyclists. The  
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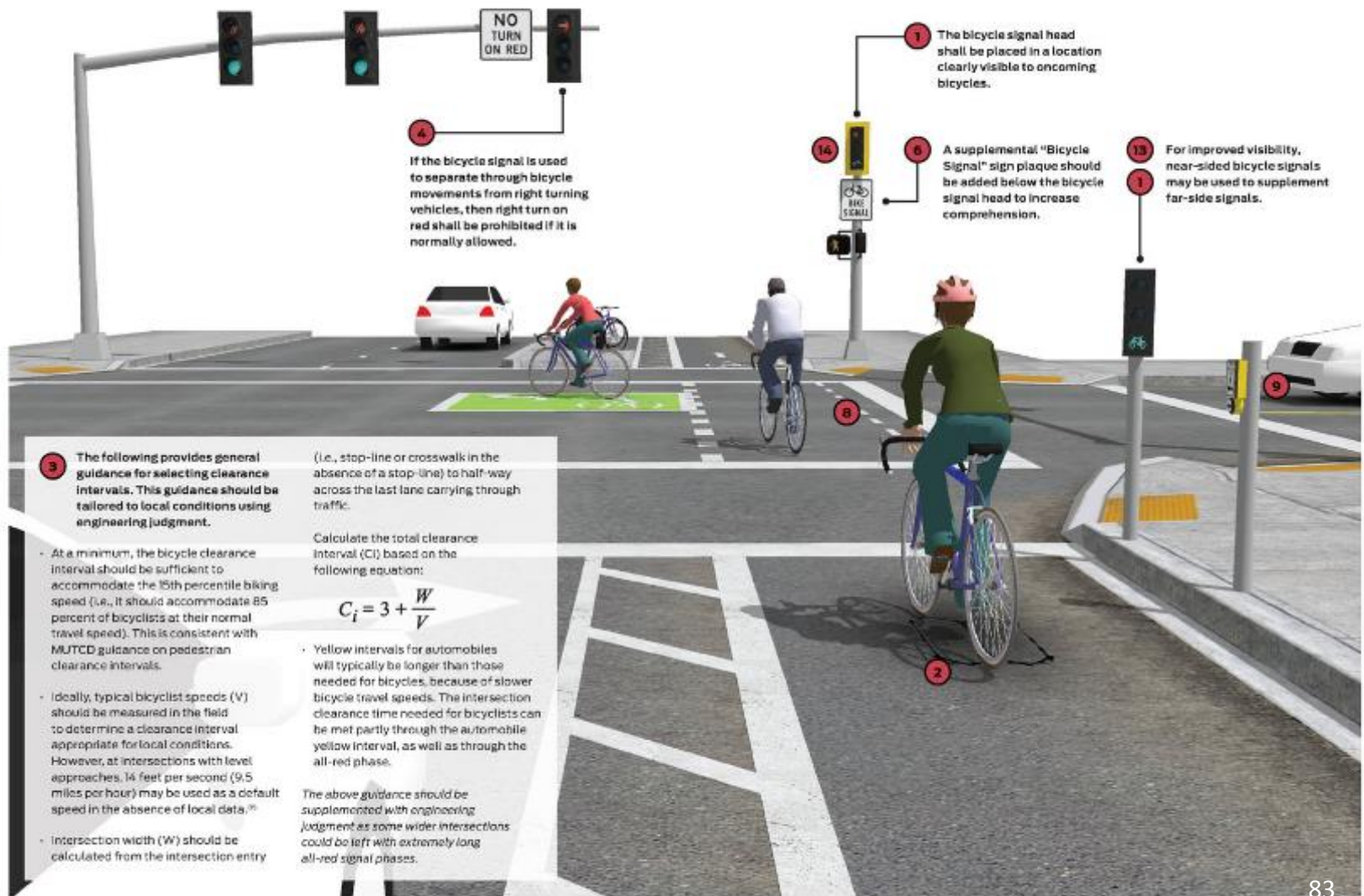
## Key Features

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**3** The following provides general guidance for selecting clearance intervals. This guidance should be tailored to local conditions using engineering judgment.

- At a minimum, the bicycle clearance interval should be sufficient to accommodate the 15th percentile biking speed (i.e., it should accommodate 85 percent of bicyclists at their normal travel speed). This is consistent with MUTCD guidance on pedestrian clearance intervals.
- Ideally, typical bicyclist speeds (V) should be measured in the field to determine a clearance interval appropriate for local conditions. However, at intersections with level approaches, 14 feet per second (9.5 miles per hour) may be used as a default speed in the absence of local data.<sup>10</sup>
- Intersection width (W) should be calculated from the intersection entry

(i.e., stop-line or crosswalk in the absence of a stop-line) to half-way across the last lane carrying through traffic.

Calculate the total clearance interval (CI) based on the following equation:

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

- Yellow intervals for automobiles will typically be longer than those needed for bicycles, because of slower bicycle travel speeds. The intersection clearance time needed for bicyclists can be met partly through the automobile yellow interval, as well as through the all-red phase.

The above guidance should be supplemented with engineering judgment as some wider intersections could be left with extremely long all-red signal phases.

**1** The bicycle signal head shall be placed in a location clearly visible to oncoming bicycles.

**6** A supplemental "Bicycle Signal" sign plaque should be added below the bicycle signal head to increase comprehension.

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

**10** There are standard appropriate clearance factors in choosing clearance interval travel speed at. At most signal vehicular clearance likely function. Exceptions include signals bicycle facilities to serve significant cyclists. See g clearance inter at left.

**11** Bicyclists longer m than motor vel acceleration sp usually more c on minor-road crossing dista typically great roads, and cro roads are ofte green intervals green time is d bicycle crossing bicycles.<sup>11</sup>

**12** Design a bicycle s consider gene on standards f where applica signal indicat and shielding of the MUTCD traffic signals bicycle signals with bicycle sig some cities ha mounted sign adjacent to the lower overall h designs use sh to limit the driv





Chicago, IL

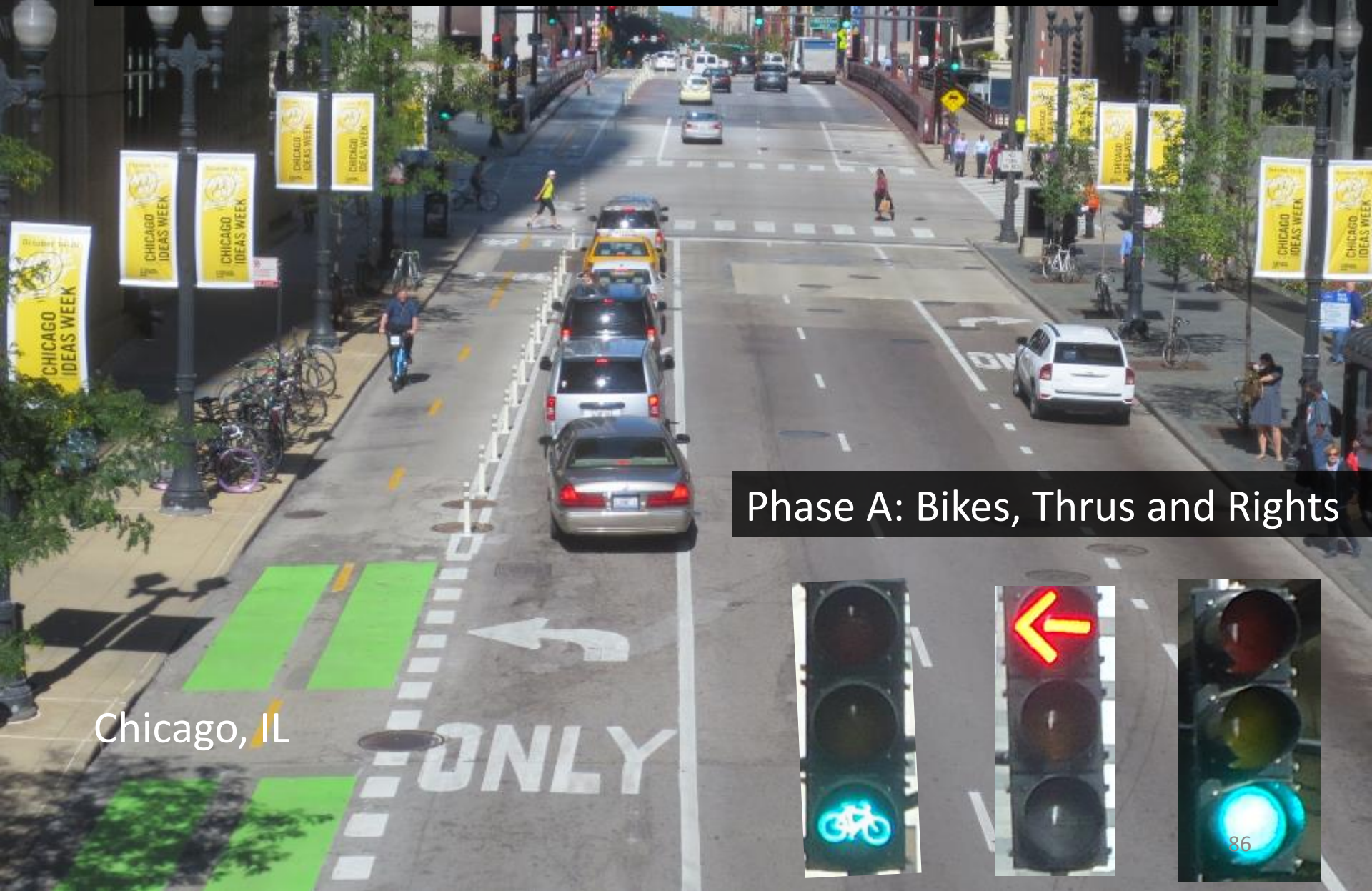




Chicago, IL



# TRAFFIC SIGNAL PHASING



Phase A: Bikes, Thrus and Rights

Chicago, IL





# TRAFFIC SIGNAL PHASING



Phase B: Bike Clearance

Chicago, IL

ONLY





# TRAFFIC SIGNAL PHASING



Phase C: Lefts and Thrus

Chicago, IL



# TRAFFIC SIGNAL PHASING

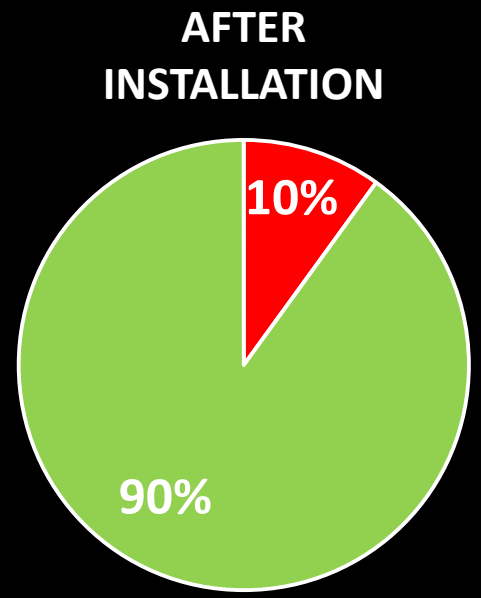
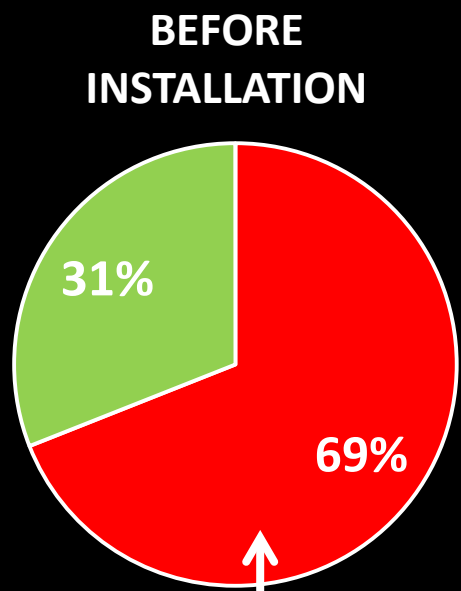


Chicago, IL

Phase D: Vehicle Clearance



# CYCLIST SIGNAL COMPLIANCE AT RED AND GREEN LIGHTS

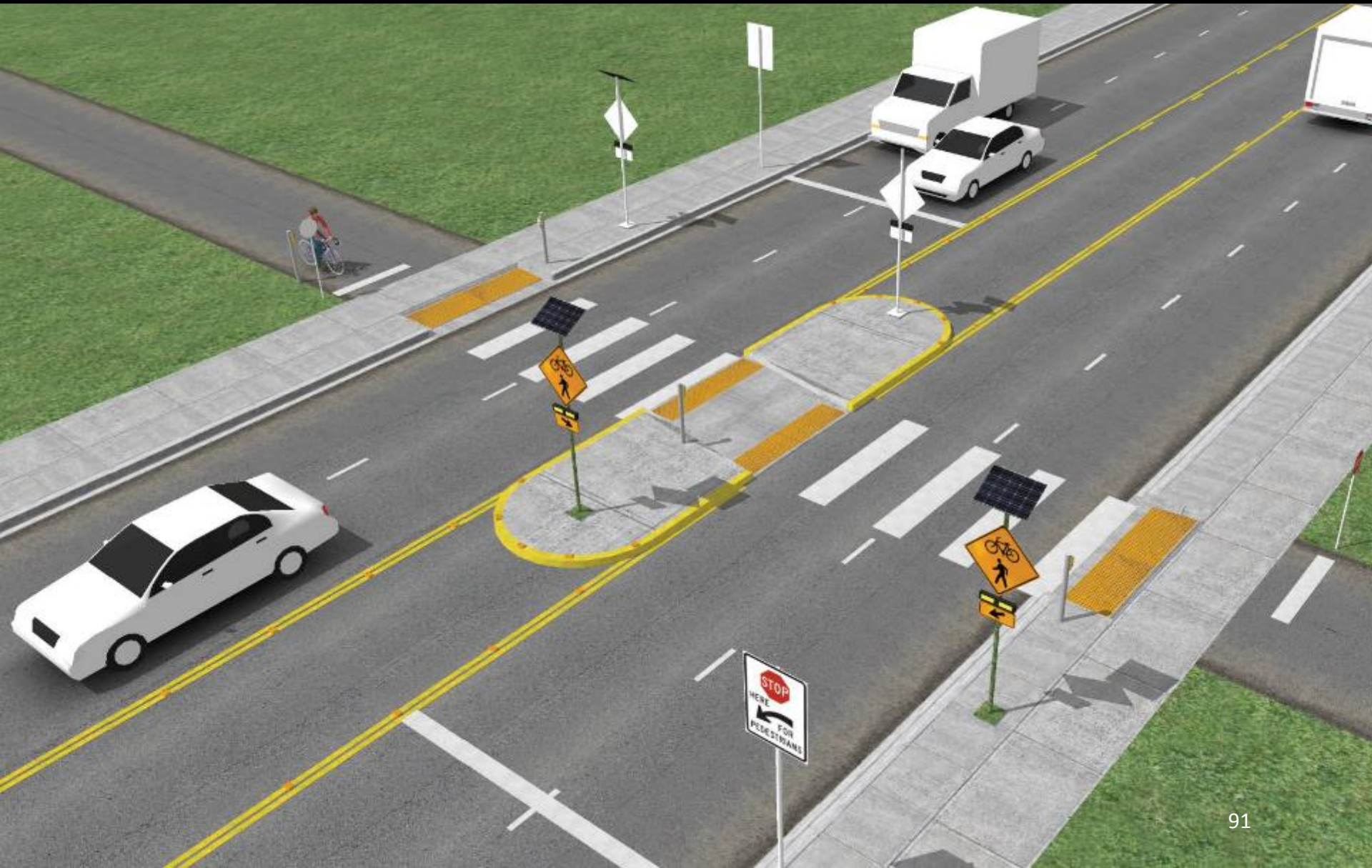


Bicyclists entering Intersection on Red Lights





# RECTANGULAR RAPID FLASHING BEACON (RRFB)



# HYBRID BEACON



## Sequence for Coordinated HAWK, Bicycle and Pedestrian Signal.

Interval	Motor Vehicle	Bicyclist	Pedestrian
1			
2	Flashing Yellow		
3			
4			
4			
5			
6			
7			
8	Alternating Flashing Red		
1			





# BIKE RIDE AND LUNCH

# **SIGNING AND MARKING**

**GREEN BIKE FACILITIES  
SHARED LANE MARKINGS**





# GREEN BIKE FACILITIES

**SOLID  
(DEDICATED)**



**SKIP  
(CONFLICT)**



**BOX  
(OUTLINE)**





# CYCLE TRACKS

# BIKE LANES





# BIKE BOXES





# ADVISORY (DASHED) BIKE LANES

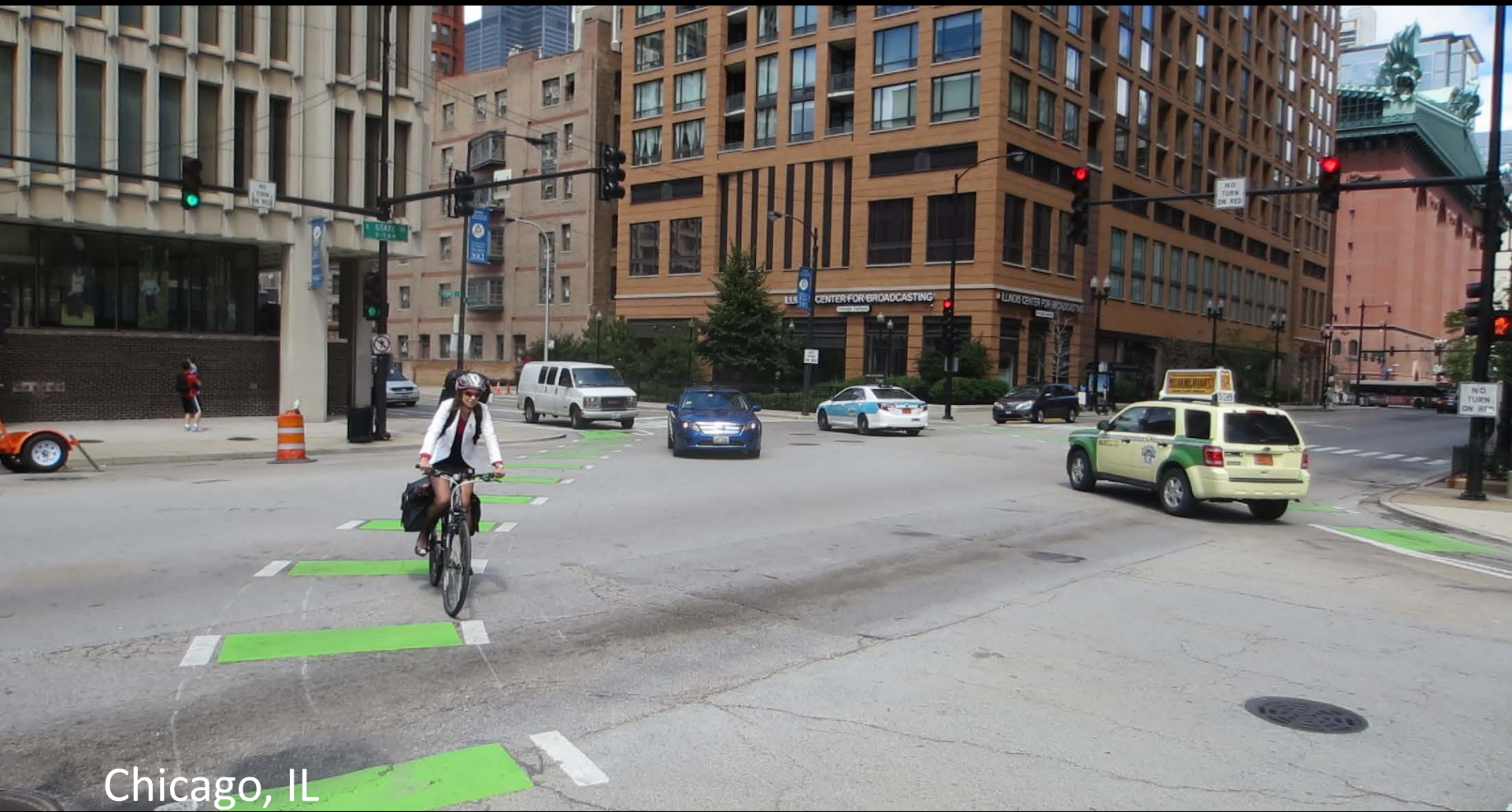




# CONTINUOUS GREEN SHARED **NOT** RECOMMENDED



# COLOR FOLLOWS SKIPS



Chicago, IL

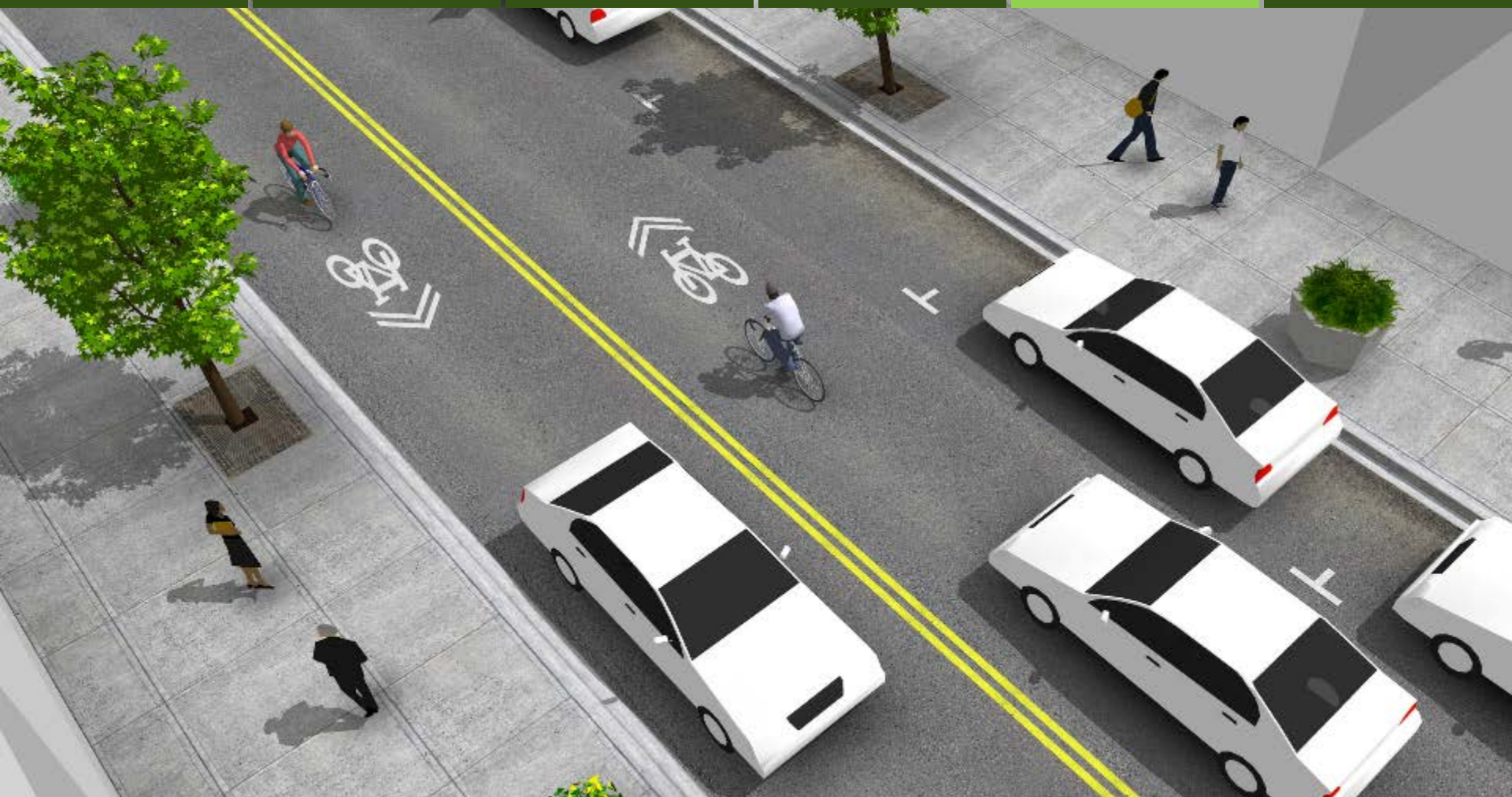


# GREEN BACKED SHARED LANE MARKING



Chicago, IL





# Shared Lane Markings

- Low volumes and speeds
- Position to right if wider
- Mark in center of travel lane if narrower
- Beginning of block and every 300'







Austin, TX



Brookline, MA





# **BIKE BOULEVARDS**

**ROUTE PLANNING**

**SIGNS AND MARKINGS**

**SPEED & VOLUME MANAGEMENT**

**MINOR & MAJOR STREET CROSSINGS**

**GREEN INFRASTRUCTURE**



# ROUTE PLANNING

**4** Minor street crossing treatments shall be implemented to minimize bicyclist delay along the route.

**5** Major street crossing treatments shall be implemented to maximize bicyclist safety and comfort at crossings.





# Bicycle Boulevards

- MV Volume  $\leq 3,000$  ADT ( $\leq 1,500$  preferred)
- MV Speed  $\leq 25$  mph ( $\leq 20$  mph preferred)
- Connections within large grids
- Parallel to main streets





# SIGNAGE













# REMEMBER: WHAT IS THE PROBLEM YOU ARE TRYING TO SOLVE?

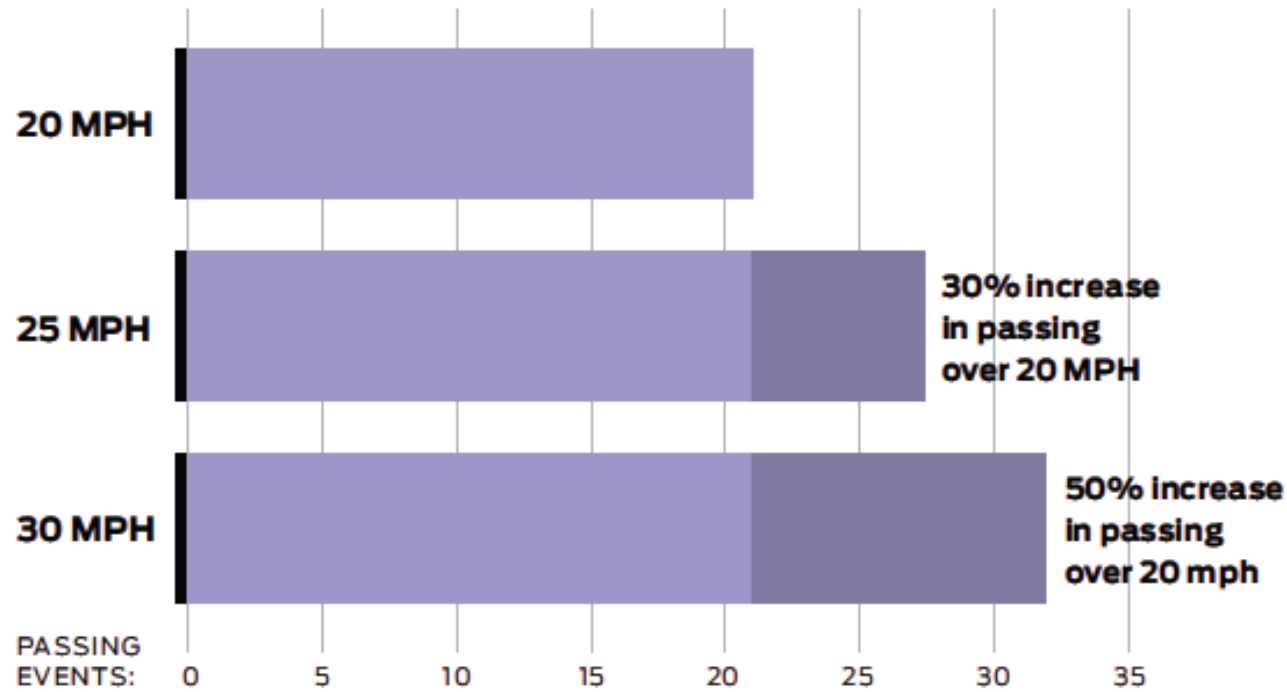
Volume / Speed	< 1,500	>1,500
< 20 MPH	Street is already comfortable	Consider volume management
> 20 MPH	Consider speed management	Consider both volume and speed management





# SPEED IMPACTS COMFORT

Depending on motor vehicle speeds, a bicyclist will be passed by a car going the same direction this many times during a 10 minute trip:



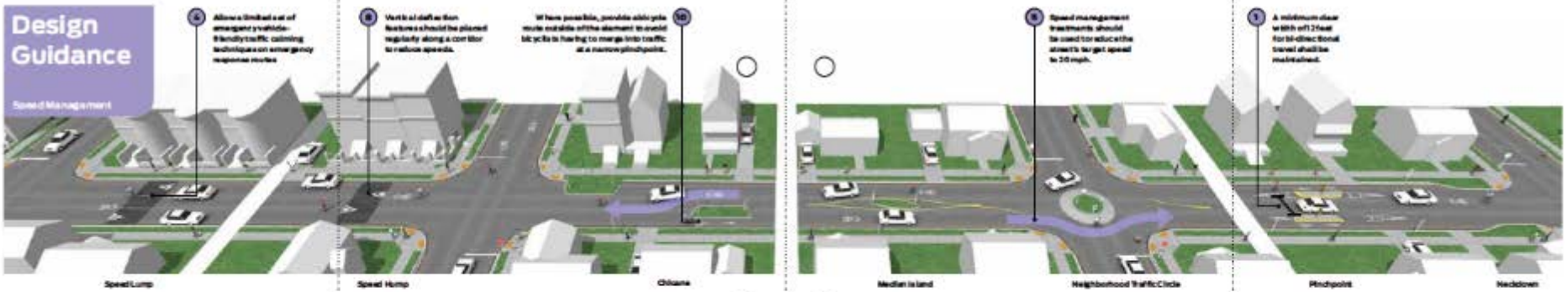
Values shown assume 3,000 VPD. Local street peak hour is 15 percent of ADT. 70 percent of peak hour traffic is in the peak direction. Cars are evenly spaced along the street: no platooning. Ten minute trip calculated during peak hour. Cars are travelling the posted speed limit (speed management techniques may be necessary). Note: Cars may pass bicyclists more or less frequently depending on how well these assumptions reflect reality.



# SPEED MANAGEMENT

## Design Guidance

### Speed Management



### Required Features

- When using horizontal speed management treatments, a minimum clear width of 12 feet for travel shall be maintained.
- Speed limits shall comply with local restrictions.
- Speed zones (other than statutory speed limits) shall only be established on the basis of an engineering study that has been performed in accordance with traffic engineering practices (MUTCD 2B.13).
- Speed limits shall be in multiples of 5 mph and signs shall be located at the points of change from one speed limit to another (MUTCD 2B.13).

### Recommended Features

- Emergency services should be in sync with transportation departments in recognizing that reducing speed and volume on local roadways, in addition to getting more people on foot and bike and out of cars, benefits their overall activity goals by reducing crash frequency and severity. The primary way of doing this is to develop an emergency response route designation map at the onset of the planning process, as discussed in route planning. Emergency vehicle response times should be considered where vertical deflection is used. Because emergency vehicles have a wider wheel base than passenger cars, speed lumps/cushions allow them to pass unimpeded while slowing no traffic.

### Strategies include the following:

- Seek approval by emergency response officials for treatments on emergency response routes.
- Allow a limited set of emergency-vehicle-friendly traffic calming techniques on emergency response routes.<sup>14</sup>
- Estimate travel time impacts on emergency vehicle response time, and define goals to evaluate during a trial.<sup>14</sup>
- Implement speed management treatments on a trial basis, and work with emergency response officials to determine whether permanent features are appropriate.

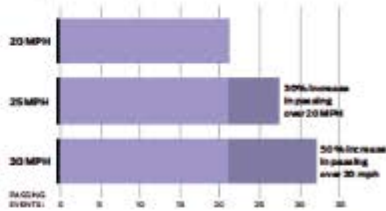
- 1. Allow a limited set of emergency-vehicle-friendly traffic calming techniques on emergency response routes.
- 2. Vertical deflection features should be placed regularly along a corridor to reduce speeds.
- 3. Where possible, provide side paths made visible off the element to avoid bicycles having to merge into traffic at a narrow pinchpoint.
- 4. Speed management treatments should be used to reduce the street's target speed to 20 mph.
- 5. Guidance for vertical traffic calming features:
  - Slopes should not exceed 1:10 or be less steep than 1:25.
  - Side slopes on tapers should be no greater than 1:6 to reduce the risk of bicycles losing their balance.
  - The vertical rise should be no more than a quarter-inch high (Dwyer, 2009).
- 6. Horizontal speed control measures should not intrude on bicycle space. Where possible, provide a bicycle route or a table of the element to avoid bicycles having to merge into traffic at a narrow pinchpoint. This technique can also improve drainage flow and reduce construction and maintenance costs.
- 7. A minimum clear width of 12 feet for bi-directional travel shall be maintained.

- Speed management treatments should be used to reduce the street's target speed to 20 mph.
- After speed management measures are implemented, posted speed limits should also be reduced to match 85th percentile speed (5 mph speed increments are recommended).
- The impacts to traffic on adjacent streets should be monitored, while speed management treatments primarily affect motor vehicle speeds, they also tend to avoid slower traffic.<sup>14</sup>
- Vertical deflection features should be placed regularly along a corridor to reduce speeds.<sup>14</sup>

### Optional Features

- Speed management may be implemented on a trial basis to gauge residents' support prior to finalizing the design. Temporary speed humps, tables, and bumpers available. Temporary traffic calming should be used with caution as they can diminish residents' options due to unappealing design and reduced functionality.

Depending on motor vehicle speeds, a bicyclist will be passed by a car going the same direction this many times during a 10-minute trip:



14. See also the 2009 ITE's "Traffic Calming Handbook" published by ITE's 2009 publication. The data is based on the ITE's "Traffic Calming Handbook" published by ITE's 2009 publication. The data is based on the ITE's "Traffic Calming Handbook" published by ITE's 2009 publication. The data is based on the ITE's "Traffic Calming Handbook" published by ITE's 2009 publication.







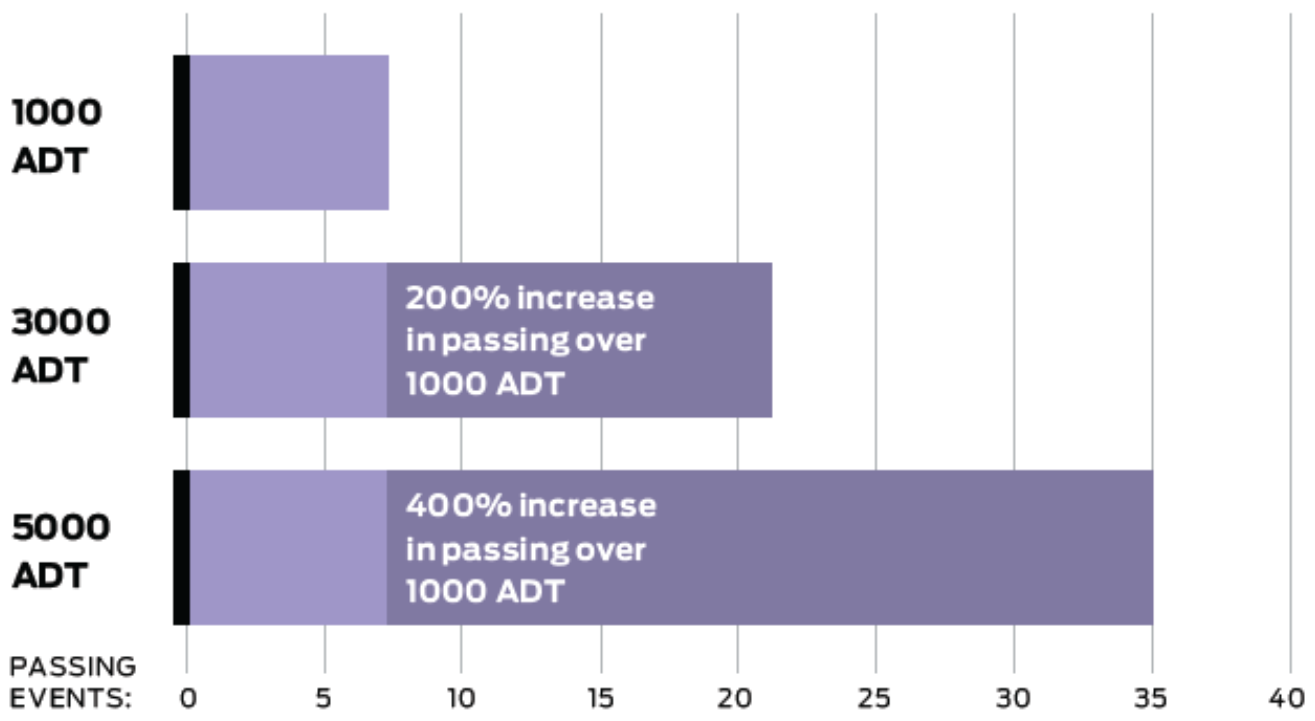
# MINI TRAFFIC CIRCLE



Chicago, IL

# VOLUME ALSO IMPACTS COMFORT

Depending on motor vehicle volumes, a bicyclist will be passed by a car going the same direction this many times during a 10 minute trip:



Values shown assume 20 mph posted speed. Local street peak hour is 15 percent of ADT. 70 percent of peak hour traffic is in the peak direction. Cars are evenly spaced along the street: no platooning. 10 minute trip calculated during peak hour. Cars are travelling the posted speed limit (speed management techniques may be necessary). Note: Cars may pass bicyclists more or less frequently depending on how well these assumptions reflect reality.





# VOLUME MANAGEMENT

## Design Guidance

### Volume Management

**10** Curb heights lower than 6 inches may be used on diverters and median barriers to allow emergency vehicles to mount and cross barriers.

**9** Diverters should be liberally signed and marked to alert drivers to expect bicyclists emerging from or not turning at the feature.

**4** A partial closure should extend almost to the centerline of the street, leaving at least 4 feet for the contraflow bike lane.

**4** The length of the closure should be about 30 feet, an uncomfortable distance for drivers traveling the wrong way.

**5** Diagonal diverters should have clear widths sufficient for single-unit trucks to make turns without encroaching on opposing lanes.

**1** Where emergency vehicle access is provided, an absolute minimum of 10 feet of clear space shall be maintained between bollards or features.



Regulatory Partial Closure

Channelized right-/right-out island

Partial Closure (Edge land with Pass Through)

Half Closure (Extension)

Diagonal Diverter

Full Closure

### Required Features

**1** Where emergency vehicle access is provided, an absolute minimum of 10 feet of clear space shall be maintained between bollards or features. The presence of mountable curbs, flexible or collapsible objects, or restricted lanes may reduce space requirements.

**2** Volume management treatments shall provide bicycle access, either through a 4-foot minimum contra-flow bike lane or a 5- to 6-foot opening between vertical curbs.

### Recommended Features

**3** Appropriate signs should be used to prohibit and restrict automobile movements and access while permitting desired bicycle access.<sup>11</sup>

**4** For a partial closure, the curb extension or edge island should extend almost to the centerline of the street, leaving at least 4 feet for the contraflow bike lane, and the adjacent travel lane may be narrowed through the closure. The length of the closure should be about 30 feet, an uncomfortable distance for drivers traveling the wrong way.

**5** Diagonal diverters, median barriers, and forced-turn islands should have clear widths sufficient for single-unit trucks to make turns without encroaching on opposing lanes.

**6** Volume control measures should not be used along primary emergency response routes. See route planning and speed management for a discussion of designating an emergency response network and minimizing impacts to emergency vehicles along bicycle boulevards.

**7** Traffic volumes on other parallel non-arterial streets should be monitored to determine the impacts to volumes, which may require further

mitigation. Neighbors and nearby businesses should be consulted to build support for volume management treatments prior to implementation.

**8** Appropriate education for use of proposed treatments should be provided to neighbors and others who are likely to use the corridor.

**9** Closures and diverters should be liberally signed and marked to alert drivers to expect bicyclists emerging from or not turning at the feature.

### Optional Features

**10** The partial closure curb extension or edge island may be tapered to deflect drivers to the right as they approach the feature.

**8** Curb heights lower than 6 inches may be used on diverters and median barriers to allow emergency vehicles to mount and cross barriers.

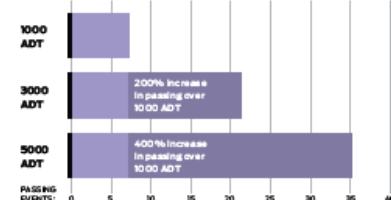
**10** Bollards may be used for diagonal diverters, but 5 feet should be provided between them to accommodate one direction of bicycle travel.

**11** Measures may be implemented on a trial basis to gauge resident support prior to finalizing the design. Temporary closures can be created with construction barriers or planters; however, an unappealing design aesthetic may diminish residents' opinions.

**12** Channelizing devices may be used along a center line to preclude turns or along lane lines to preclude lane changing, as determined by engineering judgment.<sup>14</sup>

**13** Consider defining a threshold of acceptable motor vehicle volume impacts to traffic on adjacent streets when using speed and volume management.<sup>15</sup>

Depending on motor vehicle volumes, a bicyclist will be passed by a car going the same direction this many times during a 10 minute trip:



Values shown assume a 20 mph posted speed. Local street peak-hour left percent of ADT: 32 percent of peak-hour traffic is by the peak direction. Cars are evenly spaced along the street in a posted 30 mph zone trip calculated during peak hour. Cars are traveling the posted speed. If the speed management by drivers may be necessary. Note: Carries pass bicyclists more or less frequently depending on how well the measures impact vehicle traffic.







# PARTIAL CLOSURE





# DIAGONAL DIVERTER





# MEDIAN DIVERTER

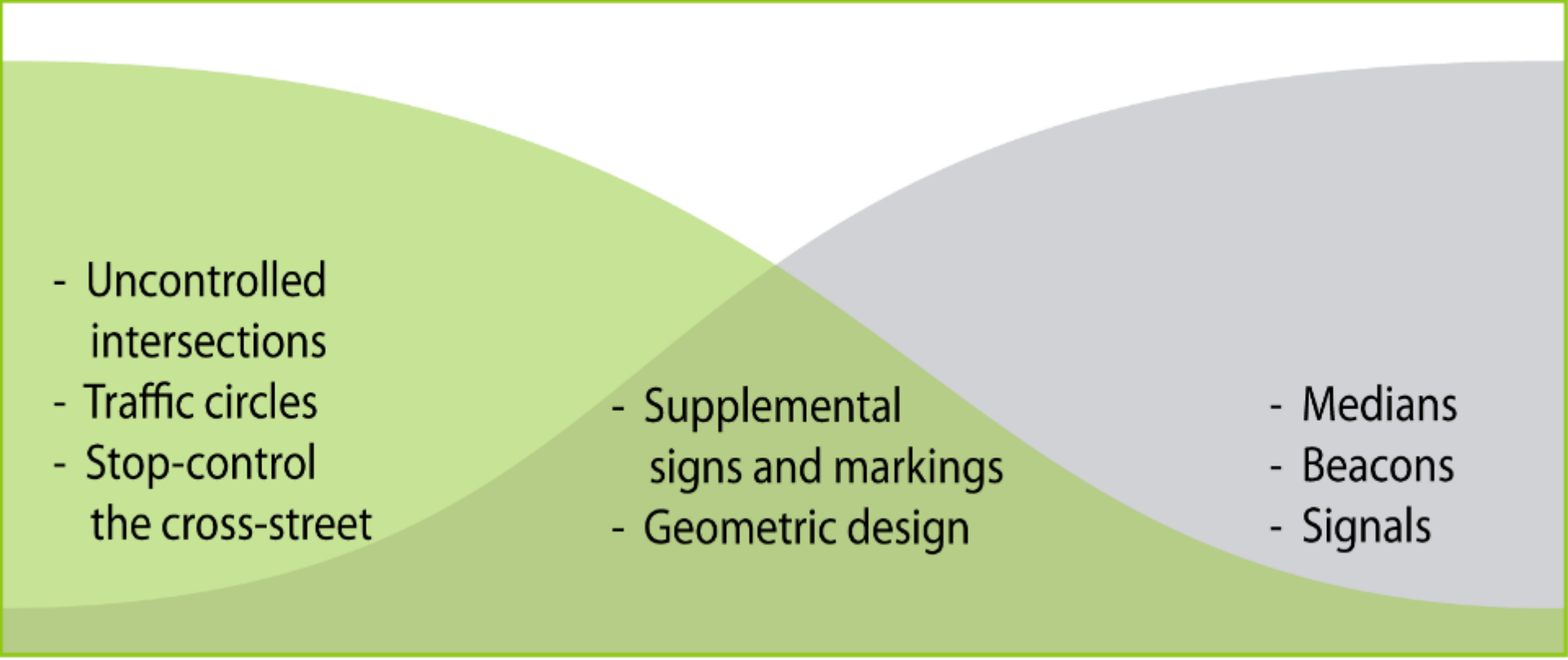




# MINOR & MAJOR STREET CROSSINGS

**Minimize Delay**

**Maximize Safety**



**Increasing Cross Street Complexity**

Increasing speed, volume, number of lanes and decreasing number of crossing gaps.

# MINOR STREET CROSSINGS

## Design Guidance



Curb Extension



Stop Sign for Cross Traffic



Neighborhood Traffic Circle

### Approved Features

1 There is no minimum required element to a minor street crossing since they can vary significantly depending on the geometry and the speed/volume of cross traffic. Treatments shall be considered using engineering judgment and shall consider the safety and comfort of bicycle movements along the bicycle boulevard.

### Recommended Features

- 2 Stop signs or geometric design elements should be considered at all minor street crossings to control the intersecting street and allow for the continuous flow of bicycles.
- 3 Stop signs should control cross traffic only along the bicycle boulevard, implement volume control measures, if vehicle speeds increase along the bicycle boulevard, implement speed control measures.

### Optional Features

- 4 The bicycle crossing sign (MUTCD sign W1-2) maybe supplemented with AHEAD plaque may be used on the cross street to indicate the crossing.
- 5 The CROSS TRAFFIC DOES NOT STOP plaque (MUTCD sign W1-4) maybe used in combination with a STOP sign on the cross street to indicate the crossing.
- 6 Parking may be prohibited up to 20 feet back on all intersection approaches to improve visibility.

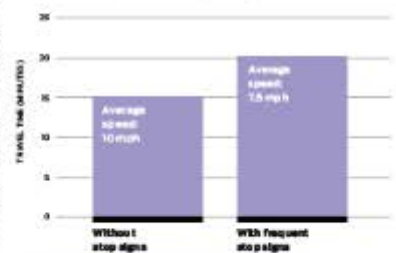


IRVING, CA



IRVING, CA

### Travel Time Impacts of Stop Signs on Bicyclists



Source: California Department of Transportation, 2010. Adapted from the California Department of Transportation, 2010. Adapted from the California Department of Transportation, 2010.





# RE-ORIENT STOP SIGNS





# MAJOR STREET CROSSINGS

## Design Guidance

### Major Street Crossings



Bike Box with Partial Closure

Median Refuge Island



Hybrid Beacon

Bicycle Forward Stop Bar

### Required Features

- 1 Crossing devices shall be considered at any bicycle boulevard crossing of a roadway that is not stop controlled. Treatments should be selected based on the number of existing gaps and the desired gap profile<sup>10</sup>
- 2 All beacons and signals shall be installed with appropriate detection and actuation, unless the bicycle boulevard crossing phase is set to red all cycle.

### Recommended Features

- 3 System entry signs and markings such as warning signs and crosswalk markings should be provided at bicycle boulevard crossings of major roads to improve crossing visibility.
- 4 At signalized intersections, longer minimum green times should be provided for bicyclists due to slower activation speeds. See detector and actuation for more information.
- 5 Volume management should be considered at signalized intersections along the bicycle boulevard to discourage motorists from using the route.

### Optional Features

- 6 Geometric elements such as median refuge islands, curb extensions, neck-downs, and raised crosswalks as provided to improve sight distance for bicyclists on the bicycle boulevard as well as for diversion on the cross street.
- 7 At stop-controlled unsignalized crossings with curb extensions, forward stop bars for bicyclists may be provided.



TUCSON, AZ (COURTESY CITY OF TUCSON)



PORTLAND, OR

Crossing major streets without signalization requires an adequate number of acceptable gaps. Treatments that reduce the duration of the minimum acceptable gap can improve the number of crossing gap opportunities for bicyclists.

To calculate the minimum acceptable gap for a bicyclist to cross a major roadway the following equation is adapted from the ITE Manual of Traffic Engineering Studies (based on minimum acceptable gap for pedestrians):

$$G = (W / S) + R$$

- 10 = minimum acceptable gap in feet
- 11 = crossing distance in feet of roadway
- 12 = bicyclist speed in ft/s (assumed to be 10 ft/sec for a bicyclist)
- 13 = acceleration, ft/s<sup>2</sup>



A bicycle forward stop bar can reduce the minimum acceptable gap by one second per cycle of the street.

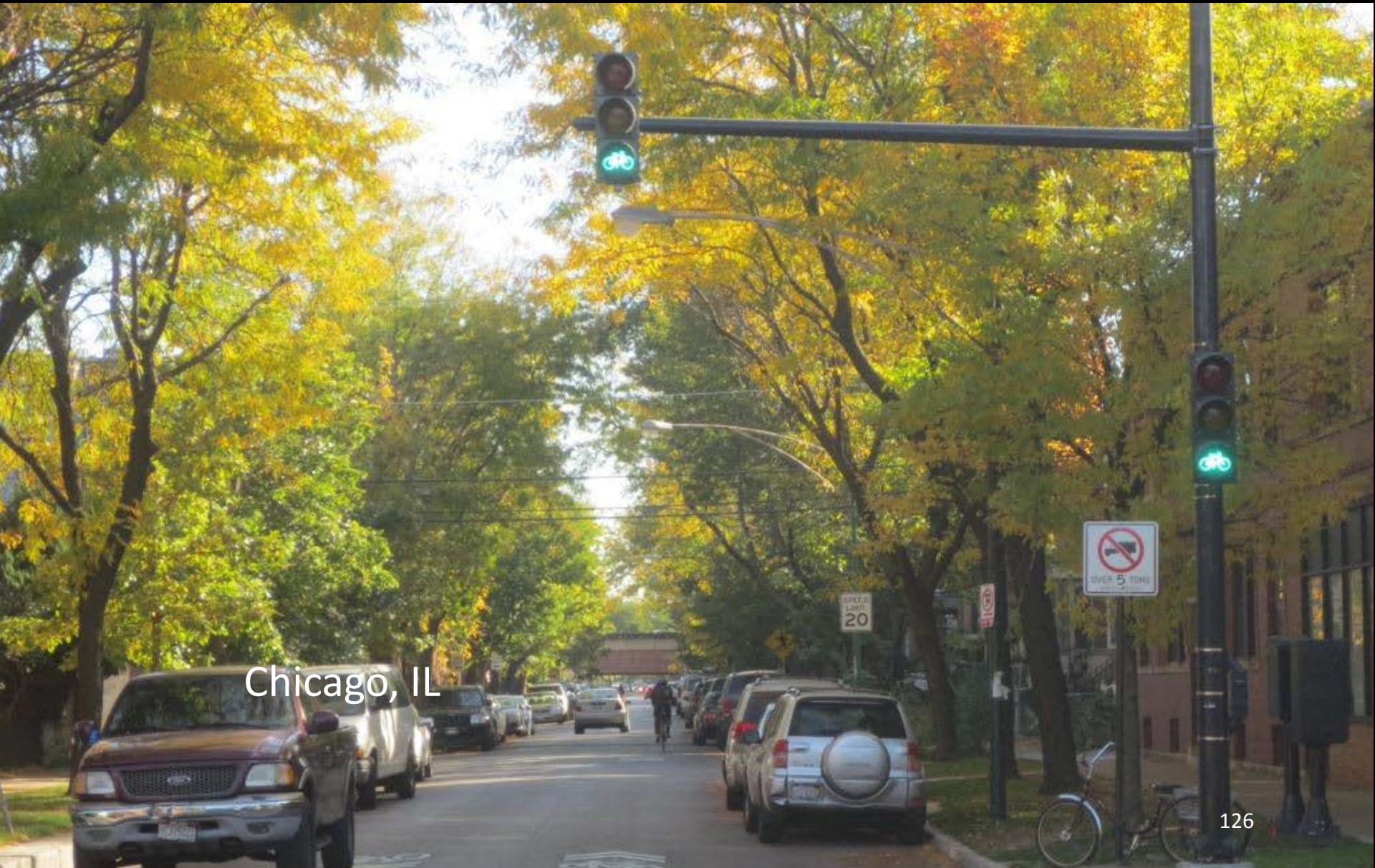


A median refuge area can cut the acceptable gap needed to cross a major street by 50 percent.





# MAJOR STREET CROSSINGS



Chicago, IL





# OFFSET INTERSECTIONS





# GREEN INFRASTRUCTURE

**Design Guidance**  
Green Infrastructure



- Required Features**
- 1 Plantings shall not impede sightlines or block signs or other traffic control devices.
- Optional Features**
- 10 Neighborhood associations or community groups may assist with maintenance.
- Recommended Features**
- 2 Infiltration basins should drain a storm event within 30 hours and may not be appropriate in areas with high water tables.
  - 3 Some green street features, such as pervious pavers, may not be appropriate along bicycle boulevards.



Chicago CHICAGO, IL



Naciodown PALO ALTO, CA



Neighborhood Traffic Circle TUCSON, AZ



Curb Extension Biowala Detroit PORTLAND, OR



Signal Diverter PORTLAND, OR



Median Refuge Island DAVIS, CA





Chicago, IL





Chicago, IL



# THANK YOU & QUESTIONS



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# DESIGN EXERCISE