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

- 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
Intersection Treatments

Module C

Designing for Bicyclist Safety

Placement of Bikeway Thru Intersection
**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
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

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

INTERSECTIONS WITH SEPARATED BIKE LANES

- No dedicated right turn
- Bicyclists may use crosswalk
- RTOR Prohibited
INTERSECTIONS WITH SEPARATED BIKE LANES

Queue storage length depends on volume and operations
Lever side bike signal
Taper length depends on traffic speed

INTERSECTIONS WITH SEPARATED BIKE LANES

Queue storage as needed for operations, shorter preferred
4 ft Min.
30 ft Minimum for visibility
30 ft Minimum range bars
39 ft Minimum
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% fatalities and serious injuries
Essential Roundabout Characteristics

- Slow speed entry = yield
- Slow speed exit
- Truck apron
- Splitter island
- Crosswalk 1 car length back
- Lots of deflection = slow speeds throughout
- Slow speed entry = yield

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
Roundabouts: Designing to accommodate Bicyclists

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
Intersection Treatments

Module C
What if a cyclist doesn’t want to enter the roundabout?

Bike ramps at roundabouts for sidewalk use
Bike Design Detail: Exit ramp to sidewalk
Designing for Bicycle Safety

BICYCLE DETECTION
BICYCLE DETECTION AT SIGNALS

- Induction loops

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

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

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
**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”
Jocelyn Mora – KGUN 9 On Your Side
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

merge area

50’ – 100’
“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.”
Intersection Treatments

- Motorist's view at conventional bike lane
- Motorist's view at separated bike lane

Visibility at Conflict Points

- Protected intersection
- Conventional bike lane

Photo source: Jonathan Maus

massDOT
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
PROTECTED INTERSECTIONS IN THE US

- Salt Lake City, UT
- Chicago, IL
- Austin, TX
- Davis, CA

APPROACH CLEAR SPACE

<table>
<thead>
<tr>
<th>Vehicular turning design speed</th>
<th>Minimum approach clear space</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10 mph</td>
<td>20’</td>
</tr>
<tr>
<td>10 mph</td>
<td>40’</td>
</tr>
<tr>
<td>15 mph</td>
<td>50’</td>
</tr>
<tr>
<td>20 mph</td>
<td>60’</td>
</tr>
</tbody>
</table>
**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
COMMUNICATING PRIORITY AT CROSSINGS

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

RAISED CROSSINGS

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

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.

**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
Are these really needed for a sidewalk level SBL?

This should extend across the entire width of the crossing, including the bike lane.

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
**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**

- Concurrent bike phase with concurrent permissive vehicle turns

```
| none | time separation from motor vehicles | full |
```
**Intersection Treatments**

**Module C**

**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

- None
- Time separation from motor vehicles
- Full
Allowing Motor Vehicle Turns Across Bike Lanes

<table>
<thead>
<tr>
<th>Separated Bike Lane Operation</th>
<th>Two-way Street</th>
<th>One-way Street</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Right Turn</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>2. Left Turn across One Lane</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>3. Left Turn across Two Lanes</td>
<td>50</td>
<td>50</td>
</tr>
</tbody>
</table>

Signal Phasing Overview

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

1. None
2. Time separation from motor vehicles
3. Full
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

Diagram showing

- Protected Bike Phase
- Time separation from motor vehicles
- Full
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

one-way SBL
two-way SBL
Bicycle Detection

- Actuated signals
- Bicycle minimum green
- Protected bicycle phases

100' for advanced detection