Designing On-Road Bikeways

Module B

Learning Outcomes:
- ✗ Describe features of on-road bikeways
- ✗ Select design criteria for on-road bikeways in various contexts

Bicycle Characteristics

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

Bicycle Design Vehicle

<table>
<thead>
<tr>
<th>Bicyclist Type</th>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical upright adult bicyclist</td>
<td>Speed (paved level terrain)</td>
<td>8-15 mph</td>
</tr>
<tr>
<td></td>
<td>Speed (downhill)</td>
<td>20-30 plus mph</td>
</tr>
<tr>
<td></td>
<td>Speed (uphill)</td>
<td>5-12 mph</td>
</tr>
<tr>
<td></td>
<td>Perception reaction time</td>
<td>1.0-2.5 seconds</td>
</tr>
<tr>
<td></td>
<td>Acceleration rate</td>
<td>1.5-5.0 ft/s²</td>
</tr>
<tr>
<td></td>
<td>Coefficient of friction for braking (dry level pavement)</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>Deceleration rate (dry level pavement)</td>
<td>0.16 ft/s²</td>
</tr>
<tr>
<td></td>
<td>Deceleration rate (wet conditions)</td>
<td>8.0-10.0 ft/s²</td>
</tr>
</tbody>
</table>

Older Bikeway Types

Bike facilities have often been referred to as “bike route” or “bike path”. Neither terminology was clear—bike facilities are more appropriately referred to as “bikeways.”
Bikeway Network

Just like roads and sidewalks, bikeways need to be part of a connected network

Combine various types, including on and off-street facilities

Hierarchy of Bikeways
A roadway with no bikeway facilities is a shared-lane roadway.

Shoulders can serve bicyclists.

Roadway with wide shoulder lane

Shared-lane for buses & bikes

Bike lane with on-street parking

Separated bike lane
**SHARED ROADWAY/SHARED LANE**

- Most common type of bikeway:
  - Roads as they are—*no specific dimensions*
  - Appropriate on low-volume or low-speed streets
  - 85% or more of streets on a *well-connected* grid
  - Appropriate on local streets in a *well-connected* grid
  - Great for getting around neighborhoods
  - Not as practical for longer distances
  - Intersections with stop control can be a nuisance for bicyclists

On a roadway where bicycle may be legally operated and bicycle shares travel lane with motor vehicles that is too narrow for in-lane passing

- No specific design criteria
- Good design features
  - Pavement quality
  - Sight distance
  - Lower speed & volume
  - Bicycle compatible grates, railings, tracks, & expansion joints
- Supplemental features
  - Pavement markings or “sharrows”
  - Detectors & signal timing
Unless prohibited, all roads have shared lanes

No special features for:
- Minor roads
- Low volumes (< 1000 vpd)
- Speeds vary (urban v. rural)

**Wide Outside Lanes**
- ROW constraints
- > 25 mph
- > 3000 vpd
- May be low comfort

**Marked Shared Lanes**
- ROW constraints
- < 35 mph
- On-street parking
- May be low comfort

Photo taken by Carl Sundstrom, Seattle, WA, 2008. [https://www.pedbikeimages.org](https://www.pedbikeimages.org)
**Shared Lane Markings**

“Sharrow”
- Reinforces concept
- Keep bikes away from doors

Where to use:
- Narrow road where bicyclists too close to cars
- Low-speed roads with high parking turnover

Design considerations
- Lateral position
- Connect gaps in bike lanes
- Roadway too narrow for passing
- Downgrade
- Position in intersections

**Supporting Characteristics**
- More than 1 lane or wide curb lane in direction of travel
- Downhill or level
- Short segment to fill gap in bikeway
- Speed < 30 mph
- High bicycle use

**Non-supporting Characteristics**
- Single lane in direction of travel
- Uphill
- Parallel route option
- Long segment
- Speed > 40 mph
- Low bicycle use
Wheaton, Colorado

Portland, Oregon

Pavement Marking Placement

✗ Streets with parallel parking
   ✗ Minimum 11 feet from curb

✗ Streets with no parallel parking
   ✗ Minimum 4 feet from curb

✗ May place further in lane
Shared Road Signs

Ride side-by-side?

Motorists chase bicyclists?

Warning or regulation?

Opposing forces?

...and who “shares”?

Q: Should “share the road” signing be used to inform drivers of the likely presence of bicyclists and to inform them to pass bicyclists safely?

A: The SHARE THE ROAD (W16-1P) plaque was introduced into the MUTCD in the context of slow-moving farm equipment with no associated mention of bicyclists. Since that time it has become prevalent in conjunction with the Bicycle (W11-1) warning sign with the intent of warning drivers of
the presence of bicyclists and warning drivers to pass safely. Research has shown that the “share the road” message when applied to bicyclists does not adequately communicate the responsibilities of either user group on the roadway. Road users are unclear whether “share the road” means that drivers should give space when passing or that bicyclists should pull to the side to allow drivers to pass. Where bicyclists are expected or preferred to use the full lane, that message is more clearly communicated with the Bicycles May Use Full Lane (R4-11) sign, supplemented by shared-lane markings as appropriate. When using the Bicycle (W11-1) warning sign, many jurisdictions have phased out the use of “share the road” in favor of an IN LANE or ON ROADWAY word message plaque, more clearly indicating the condition ahead instead of giving an unclear instruction. It is still compliant with the MUTCD if a jurisdiction chooses to post a SHARE THE ROAD (W16-1P) plaque under a Bicycle (W11-1) warning sign, but it would not be the best practice.

Source: http://mutcd.fhwa.dot.gov/knowledge/faqs/faq_part9.htm#signsq5

Anticipated for next edition of MUTCD.

Recommended by National Committee on Uniform Traffic Control Devices for inclusion in the next edition of the MUTCD.
Passing Signs

Q: The agency I work for has recently enacted a law that requires the motorist to keep a minimum lateral distance of 3 feet from the bicyclist when overtaking the bicyclist. I have seen this sign used elsewhere, but cannot find the sign in the Manual. Where can I find the standard sign for this situation?

A: No standard sign exists. The purpose of highway signing is not to create awareness, which is typically the intent of a sign conveying programmatic rules of the road. Other media—such as radio, television, and newspaper ads; notices on 511 travel information systems; postal mailings; and Web sites—are more appropriate for and conducive to promoting and/or marketing specific programs and new regulations. Special word message signs for the three-foot law should not be installed haphazardly and should be limited to locations where the operation of the two vehicle types is demonstrating a problem or crash history. Thus, installing these signs where say a physically-separated bikeway exists would be counterproductive to achieving the agency's goal. An example of a special word-only message sign for this application could be a four-line black on white regulatory sign with the legend CHANGE :: LANES :: TO PASS :: BICYCLES.

Source: http://mutcd.fhwa.dot.gov/knowledge/faqs/faq_part9.htm#signsq1
PAVED SHOULDERS

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

Min: 5’ against curb, parking or barrier, 4’ on open shoulder
Travel lane dimensions per relevant standards

Shoulder Bikeway
- Use AASHTO shoulder standards
- For bicycles: 4 ft minimum, 6 ft desirable
- No special pavement markings

Rural & County Roads
Common approach for providing bikeways on rural and county roads
Considerations

- Space for crash avoidance by all roadway users
- A place for pedestrians and bicyclists where no dedicated facilities
- Increases crossing distance at intersections
- Turning radius can increase speeds
- Street sweeping of shoulders critical for bicyclists

Paving driveway aprons will prevent gravel from washing or tracking onto shoulder.
Shoulders may be added prior to scheduled pavement resurfacing for seamless pavement.

A graded shoulder is an opportunity to widen the pavement for bicyclists.

**Rumble Strips**
- Safety countermeasure for motor vehicle ROTR crashes
- Can render bike route unrideable
- Minimum clear path
  - 4 feet
  - 5 feet adjacent to curb
- Periodic gaps
  - Minimum length 12 feet
  - Interval 40 – 60 feet
- Gaps at intersections
  - 10 – 20 feet prior to cross-street or driveway
- Bicycle tolerable (?) rumble strips

**Centerline Rumble Strips**
- Safety countermeasure for motor vehicle head-on collision
- Motorist may shy away from centerline towards bicyclist
  - 6 foot shoulder
  - 4 foot clear path
BIKE LANES
Portion of the roadway or shoulder designated for exclusive or preferential use by people riding bicycles.

Advantages
- Low stress on wide/low speed streets
- Access to major destinations
- Mobility on arterials
- Guide bicyclist behavior—more visible and predictable
- Improve visibility
- Space for bicyclist to travel at bicyclist’s chosen pace
- Reduce conflicts from bikes on sidewalks

Disadvantages
- LTS 3 or 4 on arterials
- Often too narrow
- Removal of parking
**Effect on Rider Choice**

![Pie chart showing rider choice at sites with sidewalks and no bike lanes.]

**Relative Danger Index**

<table>
<thead>
<tr>
<th>Facility</th>
<th>Relative Danger Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Streets w/out bike lanes</td>
<td>1.28</td>
</tr>
<tr>
<td>Minor Streets w/out bike lanes</td>
<td>1.04</td>
</tr>
<tr>
<td>Streets with bike lanes</td>
<td>0.5</td>
</tr>
<tr>
<td>Mixed-use paths</td>
<td>0.67</td>
</tr>
<tr>
<td>Sidewalks</td>
<td>5.32</td>
</tr>
</tbody>
</table>

1.00 = median value

*Typical shared roadway

Source: William Moritz, U.W. - “Accident Rates for Various Bicycle Facilities” - based on 2374 riders, 4.4 million miles
**Bike Lanes in Bikeway Network**

- Bike lanes most appropriate on urban thoroughfares
- They can get you across town efficiently
- Stop or signal control most appropriate at intersections
- Little point in striping bike lanes on local streets
- Preferred in urban/suburban
- Rural for high demand for bicycle travel

- Preferential space for bicyclists delineated
- Bicyclists may leave lane
  - Passing
  - Turning
  - Avoid debris
  - Avoid buses
- Priority for uphill

**Bike Lane Placement**

- With flow of traffic preferred
- Contra-flow
  - Conflicts with on-street parking
  - Conflicts at intersections & driveways
- Marking contra-flow
  - Approach and departure of intersections
  - Yellow stripe between opposing lanes
- Separated bike lane – more to come
**Bike Lane Width**

Desirable: 7 feet
AASHTO Guide minimum: 5 feet

Avoid using all minimum values across the cross-section—compounding negative effect!
NACTO Guidance:

Buffered Bike Lane
- Shy distance
- Bike passing
- Door zone
- Wider w/out confusing motorists
- More comfortable
NACTO Guidance:

The buffer shall be marked with 3 inch wide lines. Minimum buffer width: 10 inches

The combination of the buffer(s) and bike lane should be considered "bikeway width." Will respect to other guidance.

The buffer area shall have red or diagonal cross hatching or channel markings if 3 feet in width or wider.

Desired minimum next to on-street parking: 3 feet

Separation may also be provided between bike lane striping and the parking boundary to reduce approach speed.

Gutter Pan

- 4 ft width exclusive of typical gutter pan preferred
- 3 ft minimum
Designing On-Road Bikeways

**Buffered Bike Lane**

- 3' desirable between traffic
- 18” minimum between parking
- 5’ desirable lane

**Bike Lane Placement**

- Both sides of two-way streets—remember the return trip.
- Exception:
  - May omit on downhill where bicycle speeds are higher
  - Add shared-lane on uphill to discourage wrong-way bicycle travel

- Between parking and motor vehicle lane for visibility.
- Right side of roadway
- Exception: left side to avoid conflicts with driveways, transit stops, parking, double turn lanes, etc.

Corvallis, Oregon

Portland, Oregon
Pavement Marking & Signing

- Longitudinal marking required
  - 4-8” solid white line between bike and motor vehicle lanes
  - Recommended between bike and parking lanes for better positioning of both
- Symbol or word message at beginning and other locations as needed
  - After intersections
  - After busy driveways
  - On interval
- Arrow optional to indicate direction of travel
- Diamond marking is obsolete
Avoid premature wear of pavement messages by placing them outside of vehicle path.

The latest approach for marking buffered bike lanes is to use one dashed line and one solid line to indicate that vehicles may cross to park or turn into driveways.
**Signing**

Section 9B.04 Bike Lane Signs and Plaques (R3-17, R3-17aP, R3-17bP)

**Standard:**

01 The Bike Lane (R3-17) sign and the R3-17aP and R3-17bP plaques (see Figure 9B-2) shall be used only in conjunction with marked bicycle lanes as described in Section 9C.04.

**Guidance:**

02 If used, Bike Lane signs and plaques should be used in advance of the upstream end of the bicycle lane, at the downstream end of the bicycle lane, and at periodic intervals along the bicycle lane as determined by engineering judgment based on prevailing speed of bicycle and other traffic, block length, distances from adjacent intersections, and other considerations.

---

Section 9B.10 No Parking Bike Lane Signs (R7-9, R7-9a)

**Standard:**

01 If the installation of signs is necessary to restrict parking, standing, or stopping in a bicycle lane, appropriate signs as described in Sections 2B.46 through 2B.48, or the No Parking Bike Lane (R7-9 or R7-9a) signs (see Figure 9B-2) shall be installed.
Section 9B.10 No Parking Bike Lane Signs (R7-9, R7-9a)
Standard:
01 If the installation of signs is necessary to restrict parking, standing, or stopping in a bicycle lane, appropriate signs as described in Sections 2B.46 through 2B.48, or the No Parking Bike Lane (R7-9 or R7-9a) signs (see Figure 9B-2) shall be installed.

Bike Lanes & On-Street Parking

✗ Use wider bike lane with
  + High turnover parking
  + Narrow parking lane

Back-In Diagonal Parking

✗ Back-in diagonal parking
  + Improve sight distance
  + No door conflicts
  + Easier trunk access
  + Passengers channeled to curb
Contra-Flow Bike Lane

- Optional treatment used in rare situations for continuity
- Place on the right side of the street, separate from on-coming traffic with *double yellow line:*
  - Bicyclists are legally riding on the street in a dedicated travel lane
- Sign intersecting alleys and streets so motorists expect two-way bicycle traffic
- Ensure there are signals and detection for bicyclists
- Another perspective: Two-way street, one direction bikes only
SEPARATED BIKE LANES

- Exclusive bike facility
- Adjacent to or on roadway
- One-way or contra-flow
- Separated from traffic by vertical element
  + Delineators
  + Bollards
  + Barrier
  + Median
  + Raised bike lane
  + Planters
  + Wheel stops
  + Parked cars

Advantages

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

Disadvantages

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

Design Guidance


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

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

**Look beyond current MUTCD**

FHWA, *Separated Bike Lane Planning and Design Guide*, 2015

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

**NACTO, Urban Bikeway Design Guide**

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

**Considerations**

- Are cyclists already using corridor?
- Would potential cyclists use the corridor if a separated facility existed?
- Could a SBL connect origins and destinations?
- How can a SBL help build a low stress bicycle network?
- Could a separated bike lane improve connections for disadvantaged populations?

**Separated Bike Lane Zones**

**Bike Lane Elevation**

- Considerations
  - Ped/bike encroachment
  - Usable bike lane width
  - Accessibility
  - Frequency of transition ramps
  - Drainage
  - Maintenance
Sidewalk Level

- High degree of motor vehicle separation
- Reduces roadway debris in bike lane
- Passing constrained corridors
- Pedestrian/bicycle encroachment may be an issue

Street Level

- Strong sidewalk delineation
- Compatible with Accessible parking, loading, existing drainage
- Ideal for retrofits
- Beveled bike lane curbs recommended

Intermediate Level

- Curb & drainage flexibility
- Smaller elevation transitions
- Curb reveal:
  + 2-3” on bike lane
  + 6” on street
Raised Bike Lane
Use only when combined bike lane and street buffer < 7 ft.

- Limited to one-way bike operation on corridors with on-street parking
- No parking for two-way
- No protected intersection
- Curb reveal
  - 2” on bike lane
  - 4” on street

Bike Lane Width
Widths vary by peak hour volume for bicycles

- One-way
  - 6.5-10 ft recommended
  - 5-8 ft minimum
  - 4’ allowable at bus stops or accessible parking

- Two-way
  - 10-14 ft recommended
  - 8-11 ft minimum
**Maintenance**
- Sweeping
- Snow removal

**Vertical Elements**

*Curb angle & height influence:*
- Wheel & pedal strike hazard
- Bicycle access to sidewalk
- Motor vehicle encroachment
- Cross section width

- Supplement with painted median
- Parking may eliminate need
- Lower cost
- Considerations
  - Shy distance
  - Spacing
  - Durability
  - Clear zone
Vertical Elements

- Raised median
  - Any bike lane elevation
  - Higher cost
  - Consider streetscape landscaping, & drainage

Drainage

- Grates outside of bike lanes
- Stormwater management opportunity
  - Bike lane elevation
  - Roadway crown
  - Existing catch basins
  - Existing utilities
  - Median openings
Constrained Corridors

When looking for trade-offs on constrained corridors, look first to see if motor vehicle lanes can be narrowed, then consider reducing buffers, then the bike lane, and finally the sidewalk.

Complete Street
Designing On-Road Bikeways

Driveways

Curbside Activity

Accessible Parking

Source: FHWA SBL Guide
Loading Zones

Source: FHWA SBL Guide
Accessible Passenger Loading Zone

Transit Stops

- Considerations
  - Separate bike lane and transit stops on opposite side of street
  - Guide passengers to clearly marked crossings
  - Two crossings recommended
  - Communicate yielding/stopping responsibility to bicyclists
  - Recommend bus stop island
  - Recommend in-lane bus operation
**Designing On-Road Bikeways**

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

*Source: FHWA SBL Guide*
Only consider where island not feasible

- Align crosswalks with doors
- Green pavement
- Do not pass when bus is stopped

**Before/After**
Designing On-Road Bikeways