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

OLDER BIKEWAY TYPES

- “Bike Route”
- “Bike Path”

Neither term is clear

They are all bikeways

BIKEWAY NETWORK

- Just like roads and sidewalks, bikeways need to be part of an connected network
- Combine various types, including on and off-street facilities
**Hierarchy of Bikeways**

- Shared-Use Paths
- Separated Bike Lanes
- Bike Lanes
- Shoulders
- Shared Roadway

Photo by Harvey Muller
**SHARED ROADWAY**
- Most common—roads as they are
- Appropriate on low-volume or low-speed
- 85% or more of a well-connected grid

**SHARED LANE MARKING**

**SHARED LANES**
- Unless prohibited, all roads have shared lanes
- No special features for:
  - Minor roads
  - Low volumes (< 1000 vpd)
  - Speeds vary (urban v. rural)

- Supplemental features
  - Pavement markings or “sharrows”
  - Detectors & signal timing

**SHARED LANE MARKING**
- Lateral position
- Connect gaps in bike lanes
- Roadway too narrow for passing
- Position in intersections & transitions

**SHARED LANE MARKING**
- Center in lane
  - Prevent “dooring”
  - Prevent passing too closely
  - Keep bicyclist visible

**SHARED LANE MARKING**
- More than 1 lane
- Downhill or level
- Short segment to fill gap in bikeway
- Speed < 30 mph
- High bicycle use

- Single lane
- Uphill
- Parallel route option
- Long segment
- Speed > 40 mph
- Low bicycle use
SHARED LANE MARKING

Portland, Oregon

SHARED ROAD SIGNS

- Ride side-by-side?
- Chase bicyclist?
- Warning or regulation?
- Opposite forces?

...and who “shares”?  

New Orleans, LA

- Reminder for motorists

Philadelphia, PA

- Low speed/low volume
- Up to 25 mph for LTS 1

Corvallis, Oregon

- TCD’s not meant to be educational
- Limit to areas with identified problem

California

- Low speed/low volume
- Up to 30 mph for LTS 2

Corvallis, Oregon
Low speed street

Increased speed or volume, increased LTS

Increased speed or volume, increased LTS

Rural back roads

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

PAVED SHOULDERS
**SHOULDER BIKEWAY**

Min: 5’ against curb, parking or barrier, 4’ on open shoulder

Travel lane dimensions per relevant standards

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

---

**RUMBLE STRIPS**

- Safety countermeasure for motor vehicle ROTR crashes
- Can render shoulder unrideable

---

**SHOULDER BIKEWAY**

<table>
<thead>
<tr>
<th>Functional classification</th>
<th>Volume (AADT)</th>
<th>Speed (mph)</th>
<th>Recommended Minimum Paved Shoulder Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor Collector</td>
<td>up to 1,100</td>
<td>35 (55 km/h)</td>
<td>5 ft (1.5 m)</td>
</tr>
<tr>
<td>Major Collector</td>
<td>up to 2,600</td>
<td>45 (70 km/h)</td>
<td>6.5 ft (2.0 m)</td>
</tr>
<tr>
<td>Minor Arterial</td>
<td>up to 6,000</td>
<td>55 (90 km/h)</td>
<td>7 ft (2.1 m)</td>
</tr>
<tr>
<td>Principal Arterial</td>
<td>up to 8,500</td>
<td>65 (100 km/h)</td>
<td>8 ft (2.4 m)</td>
</tr>
</tbody>
</table>

---

**RUMBLE STRIPS**

- 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

---

Benton County, Oregon
BIKE LANE DEFINED

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
- Improve visibility

ADVANTAGES

- Travel at bicyclist’s pace

ADVANTAGES

- Guide cyclists behavior
  - Visible
  - Predictable

ADVANTAGES

- Reduce pedestrian conflicts
- Improve visibility at driveway conflicts
EFFECT ON RIDER CHOICE

Riders at sites with sidewalks & 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

* Typical shared roadway
DISADVANTAGES

- LTS 3 or 4 on arterials
- Often too narrow
- Removal of parking

BIKE LANES

- Urban thoroughfares
- Efficient cross-town travel
- Stop or signal control
- Little point on local streets

BIKE LANES

- 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 WIDTH

Desirable: 7 feet
AASHTO Guide minimum: 5 Feet
Designing for On-Road Bikeways

**BIKE LANE SURFACE**
- Cross slope
  - 2% preferred
  - 8% allowable when constrained
- Pavement
  - Asphalt
  - Concrete joints
  - Avoid pavers

**SHY DISTANCE**
- Lateral offset
  - Height < 36” no offset
  - Height > 36” 6” offset
- Vertical clearance
  - 100”

**GUTTER PAN**

**BUFFERED BIKE LANE**
- Shy distance
- Bike passing
- Door zone
- Wider w/out confusing motorists
- More comfortable

**BUFFERED BIKE LANE**

**WIDE BIKE LANE/LOW SPEED**

LTS 1
**BUFFERED BIKE LANE**

LTS 1

**5 FT BIKE LANE/30 MPH**

LTS 2

**5 FT BIKE LANE/35 MPH**

LTS 3

**5 FT BIKE LANE/40 MPH**

LTS 4

**PAVEMENT MARKING & SIGNING**

- Longitudinal marking required
  - Solid white line between bikes & motor vehicles
  - Line recommended between bikes & parking
- Symbols at beginning & interval
- Signs

**PAVEMENT MARKING**

[Diagram showing pavement marking options]
Designing for On-Road Bikeways

Module B

Section 9.24 Chevron and Diagonal Crosshatch Markings

Options:
1. Chevrons and diagonal crosshatch markings may be used to designate travel on certain paved areas, such as shoulders, gaps, areas, bike facilities, paved areas between sidewalks and the yellow center line markings, or between white channelizing lines approaching intersections in the roadway (see Section 9.10 and Figure 9.15), between solid double yellow center line markings or channelized travel paths of intersections (see Figure 9.10 and 9.15), before space between preference lines and paved purpose lanes (see Figures 9.10 and 9.15), and at grade crossings (see Part 9).

Standard:
2. When crosshatch markings are used in paved areas that separate traffic flows in the same general direction, they shall be white and they shall be spaced at 20 feet on centerlines with the point of each chevron facing toward approaching traffic, as shown in Figures 9.15 and 9.16.

Optional:
3. When crosshatch markings are used in paved areas that separate opposing directions of traffic, they shall be yellow diagonal markings that start away from traffic and end in the adjacent travel lanes, as shown in Figures 9.22, 9.25, and 9.28 of Figure 9.31.

Guidance:
4. When crosshatch markings are used in paved areas that start away from traffic and end in the adjacent travel lanes, the diagonal markings shall be yellow when used on the left-hand shoulders of the roadway or divided highways and on right-hand shoulders of one-way street or ranges. The diagonal markings shall be white when used on right-hand shoulders.

5. The chevrons and diagonal lines used for crosshatch markings shall be at least 12 inches wide for maximum housing a speed of 45 miles per hour or greater and at least 8 inches wide for moderate housing speeds of 30 miles per hour or less. The maximum length of the chevron or diagonal lines should be determined by engineering judgment considering factors such as speed and general visual impact. The chevrons and diagonal lines should form an angle of approximately 10 to 45 degrees with the longitudinal lines that they intersect.

- Avoid premature wear
**PAVEMENT MARKINGS**

- Add green pavement marking – bike lanes & sharrows

**SIGNING**

- Beginning, end, & interval
- Optional

![signs](image.png)

**R3-17aP R3-17bP**

![signs](image.png)

**R81A (CA) R81B (CA)**
CONTRA-FLOW BIKE LANE

Reasons for:
- Continuity on one-way
- Avoid conflicts
- Maximize space

Considerations:
- Markings
- Signing
- Intersections

Double yellow line creates 2-way street
With-flow cyclists ride in “normal” bike lane...

...or in a shared travel lane without bike lane

BIKE LANE PLACEMENT
- Both sides of two-way streets
**BIKE LANE PLACEMENT**

- Exception – may omit on downhill

**BIKE LANE PLACEMENT**

- Add shared-lane for uphill
  - discourage wrong-way

**BIKE LANE PLACEMENT**

- Between parking and travel lane

**BIKE LANE PLACEMENT**

- Right side of one-way

**BIKE LANE PLACEMENT**

- Exception—left side to avoid conflicts

**BIKE LANE PLACEMENT**

- Exception—left side to avoid conflicts
BIKE LANE PLACEMENT

- Exception – two-way to avoid conflicts

BIKE LANES & ON-STREET PARKING

- Use wider bike lane with
  - High turnover parking
  - Narrow parking lane

Is diagonal parking compatible with bicycling?

BACK-IN DIAGONAL PARKING

- Back-in diagonal parking
  - Improve sight distance
  - No door conflicts
  - Easier trunk access
  - Passengers channeled to curb

SEPARATED BIKE LAINES

- Exclusive bike facility
- Adjacent to or on roadway
- One-way or contra-flow
- Separated from traffic by vertical element
**SEPARATED BIKE LANES**

- **Mid-block (LTS 1)**

- **Mid-block (LTS 1)**

- **Mid-block (LTS 2)**

- **Mid-block (LTS 1 – except at intersection)**

- **Mid-block (LTS 1 – except at driveways)**

**Advantages**
- Very low stress midblock
- Encourages bike riding
- More conspicuous
- Crash rate reductions
### SEPARATED BIKE LINES

**Disadvantages**
- Special intersection treatments
- Special driveway treatments
- Additional space needed
- More costly than bike lanes
- More to learn

**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

### 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

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

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

Look beyond current MUTCD
Designing for On-Road Bikeways

**Design Guidance**

- MassDOT

**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
- intermediate level
- street level
- raised bike lane

**Sidewalk Level**

- Motor vehicle separation
- Reduces debris
- Passing
- Ped/bike encroachment

**Street Level**

- Sidewalk delineation
- Accessible parking
- Existing drainage
- Retrofits
- Beveled curbs
**INTERMEDIATE LEVEL**
- Curb & drainage flexibility
- Smaller transitions
- Curb reveal:
  - 2-3" on bike lane
  - 6" on street

**RAISED BIKE LANE**
- One-way
- No parking for two-way
- No protected intersection
- Curb reveal:
  - 2" on bike lane
  - 4" on street

**COMPARISON OF BIKE LANE ZONES**

<table>
<thead>
<tr>
<th>Sidewalk Level SDL</th>
<th>Sidewalk</th>
<th>Bike Lane</th>
<th>Street Buffer</th>
<th>Street</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intermediate Level SDL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Street Level SDL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raised Bike Lane</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**BIKE LANE WIDTH**
- One-way
  - Widths vary by peak hour volume
  - 6.5-10 ft recommended
  - 5-8 ft minimum
  - 4’ allowable at bus stops or accessible parking

6.5’ min. for comfortable passing

**ONE-WAY BIKEWAY**
**BIKE LANE WIDTH**

- **Two-way**
  - Widths vary by peak hour volume
  - 10-14 ft recommended
  - 8-11 ft minimum

<table>
<thead>
<tr>
<th>Bidirectional Traffic/Net Peak Hour</th>
<th>Bike Lane Width [ft]</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;500</td>
<td>10.0</td>
</tr>
<tr>
<td>500-800</td>
<td>11.0</td>
</tr>
<tr>
<td>&gt;800</td>
<td>14.0</td>
</tr>
</tbody>
</table>

**BIKE LANE WIDTH**

- **Maintenance**
  - Sweeping
  - Snow removal

**STREET BUFFER WIDTH**

- 6' preferred
- 2' when constrained
- 1' along raised SBL
- 6-16.5' optimum for intersections

**VERTICAL ELEMENTS**

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

**VERTICAL CURB**

- Vertical
- Beveled 1V:1H
- Mountable 1V:4H
**BEVELED CURB**

![Beveled Curb Image](Atlanta, GA)

**MOUNTABLE CURB**

![Mountable Curb Image](Portland, OR)

**VERTICAL ELEMENTS**

- Painted median
- Parking
- Lower cost
- Considerations
  - Shy distance
  - Spacing
  - Durability
  - Clear zone

**FLEXIBLE DELINEATORS**

**TURTLES**

![Turtles Image](Austin, TX)

**ARMADILLOS**

![Armadillos Image]
Designing for On-Road Bikeways

**PARKING STOPS**
Washington, DC

**RIGID BOLLARDS**
Indianapolis, IN

**PLANTERS**
Vancouver, BC

**CONCRETE BARRIER**
New York, NY

**LOCAL BRANDING**
Seattle, WA

**INTERIM CONNECTIONS**
Minneapolis, Minnesota
**VERTICAL ELEMENTS**

- Raised median
  - Any bike lane elevation
  - Higher cost
  - Considerations
    - Streetscape
    - Landscaping
    - Drainage

**SIDEWALK BUFFER**

- Width considerations
  - Minimum continuous sidewalk width 4’
  - Minimum sidewalk for passing 5’
  - Wider in commercial centers
  - Shy distance
  - Visual contrast

**CONSTRANGED CORRIDORS**

- Sidewalk
- Sidewalk buffer
- Bike lane
- Street buffer
- Street

**DRAINAGE**

- Grates
- Stormwater management
  - Bike lane elevation
  - Roadway crown
  - Existing catch basins
  - Existing utilities
  - Median openings
**LANDSCAPING**

- Considerations
  - Clear zone
  - Usable sidewalk width
  - Tree clutter
  - Lateral offset
  - Vertical clearance
  - Sight distance

**DRIVEWAYS AND CROSSINGS**
DRIVEWAYS

CURBSIDE ACTIVITY
- Motor vehicle parking
- Bike parking
- Loading zones
- Bus stops

MOTOR VEHICLE PARKING

MOTOR VEHICLE PARKING

BIKE PARKING
Austin, TX

BIKE PARKING
Austin, TX

Columbus, OH
TRANSIT STOPS

- Considerations
  - Opposite side of street
  - Guide passengers
  - Two crossings
  - Communicate to bicyclists
  - Floating bus stop
  - In-lane bus operation

TRANSIT STOPS

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

TRANSIT STOPS

- Columbus, OH

TRANSIT STOPS

TRANSIT STOPS
TRANSIT STOPS

Seattle, Washington

TRANSIT STOPS

Austin, TX

TRANSIT STOPS

Minneapolis, Minnesota

Only consider where island not feasible
- Align crosswalks with doors
- Green pavement
- Do not pass when bus is stopped
Designing for On-Road Bikeways

- **Transit Stops**

- **Shared-Use Paths**
  - Not all paths are low stress

- **Evaluate with FHWA Shared-Use Path Level of Service Calculator**
LEVEL-OF-SERVICE

Path width Considerations:
- Based on anticipated user types, speeds, and volumes
- FHWA Shared Use Path Level of Service
- 10 ft minimum
- Research finds 11 feet best for overtaking (3 lanes)
- Wider in more populated areas
  - 14 feet in urban areas desired

SHARED USE PATHS

Design strategies:
- Clearances/shoulders
- Separation
- Turning movements
- Intersections

SEPARATION OF USERS ALLOWED

- Bi-directional walking lane for pedestrians with directional lanes of travel for cyclists
  - 5 ft min width for pedestrians
  - At least 10 feet for bicyclists

SEPARATION OF USERS

- When pedestrians outnumber bicyclists, they are less likely to follow the rules.