Your presenter

Sagar Onta, PE, PTOE
Denver Engineering Director

15 years of experience street design, transportation planning, traffic engineering, and bicycle facility design
Toole Design Group is the nation’s leading planning, engineering, and landscape architecture firm specializing in multimodal transportation.
Toole Design Group

150+ Employees 13 Offices

Equal Design and Planning

41% Women Designers
Our guidance work

AASHTO Guide for the Development of Bicycle Facilities

NCHRP 803 Pedestrian and Bicycle Transportation Along Existing Roads

FHWA Achieving Multimodal Networks: Applying Design Flexibility & Reducing Conflicts

Massachusetts DOT Separated Bike Lane Planning & Design Guide
1974 “Guide for Bicycle Routes”

GUIDE FOR BICYCLE ROUTES

Prepared by the Standing Committee on Engineering Operations, American Association of State Highway and Transportation Officials.

Figure 3.3.14. Recommended Intersection Design for Intersecting Arterial Roads with Bikeways on Each Road. Intersection is Symmetrically Designed to Provide Bicycle Queue Areas at the Entrance to the Crossings. (Reference 98, p. 23)

Protected Bike Lanes & Intersections

Davis, California 1967
Intersections and Crossings

Because the number and severity of conflicts between motorists, bicyclists, and pedestrians are greatest at intersections and crossings, utmost care must be taken in designing intersection which are to accommodate bicycle traffic. The safest and most effective way of eliminating conflicts where a bicycle route crosses another roadway is to provide a grade separation. This may be feasible in some cases, as discussed under grade separation structures. However, a grade separation usually cannot be provided because of lack of available space, especially where bicycle lanes or shared roadways cross at or near existing at-grade street intersections. Even where space is available, there seldom is warrant for the high cost of the structure. Therefore, a design which utilizes existing at-grade street intersections usually must be provided.

Wherever a bicycle lane is carried across an at-grade street intersection, some form of channelization with specific routings for bicycles should be provided to minimize the number of possible conflict points between bicycles, motor vehicles, and pedestrians within the intersection. Such channelization would not normally be necessary when shared roadways intersect a cross street, except where bicycle and motor vehicle traffic is heavy, motor vehicle speeds are in excess of 30 mph, or where there is a heavy percentage of motor vehicles making right turns out of the shared roadway.

Channelization usually consists of some form of striping or marking which clearly delineates the path which bicycles must take in crossing the intersection. In most cases the crossing should be adjacent to—but striped separately from—the pedestrian crosswalk. Bicyclists who wish to turn left should be encouraged to cross the cross street first and then proceed to the left within a marked path provided for the second stage. The undesirable effect of the conflict between right-turning motorists and straight-through bicyclists can be reduced to some extent by offsetting the bicycle crossing of the cross street away from the intersection.

Examples of channelization arrangements to accommodate bicyclists at intersections are illustrated in Figure 7. Figure 7(a) depicts a pair of bicycle lanes which are carried straight through the intersection. With this arrangement, the bicycle route is a part of the street, directly aligned with the bicycle lane both upstream and downstream. The arrangement in Figure 7(b) likewise carries the bicycle lane through the intersection, but the bicycle crossing is offset from the...
But then...
“Vehicular cycling...Is faster and more enjoyable, so that the plain joy of cycling overrides the annoyance of even heavy traffic.”

John Forester
Protected bike lanes removed in first edition of the Bike Guide

(1.5m). Bicycle lanes should always be placed between the parking lane and the motor vehicle lanes. Bicycle lanes between the curb and the parking lane create hazards for bicyclists from opening car doors and poor visibility at intersections and driveways, and they prohibit bicyclists from making left turns; therefore this placement should never be considered.
1980s – 1990s  The Wide Outside Lane

Design User
Inside the world of local cycling’s WEEKEND WARRIORS

BY STEVE GOLDSTEIN
PHOTOS BY SKIP BROWN

fast and furious

1-2%
“Bicycle lanes tend to complicate both bicycle and motor vehicle turning movements at intersections.”
AASHTO Bike Guide History

- Written in 2010
- Conforms to 2009 MUTCD which was written in 2007
Other guidance in recent years

2014
NACTO Urban Bikeway Design Guide

2015
Massachusetts DOT Separated Bike Lane Planning & Design Guide

2016
CROW Design Manual for Bicycle Traffic

2016
FHWA Achieving Multimodal Networks: Applying Design Flexibility & Reducing Conflicts
### Ranking of issues in for the next edition:

<table>
<thead>
<tr>
<th>Topic</th>
<th>Score</th>
<th>Rank</th>
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<tbody>
<tr>
<td>Design of transitions between treatments</td>
<td>200</td>
<td>1</td>
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<tr>
<td>Intersection treatments (e.g. bike boxes, 2-stage turn boxes)</td>
<td>171</td>
<td>2</td>
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<tr>
<td>Separated bike lanes</td>
<td>167</td>
<td>3</td>
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<tr>
<td>Buffered bike lanes</td>
<td>164</td>
<td>4</td>
</tr>
<tr>
<td>Application of PROWAG</td>
<td>155</td>
<td>5</td>
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<tr>
<td>Bicycle signals and detection</td>
<td>151</td>
<td>6</td>
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<tr>
<td>Other (please describe in next question)</td>
<td>146</td>
<td>7</td>
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<tr>
<td>Use of green color in bike lanes</td>
<td>137</td>
<td>8</td>
</tr>
<tr>
<td>Bicycle boulevards</td>
<td>128</td>
<td>9</td>
</tr>
<tr>
<td>Electric assist bicycle (e-bikes)</td>
<td>121</td>
<td>10</td>
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</table>
52% of Americans would like to live in a place where they do not need to use a car very often.
1. Introduction
2. Bicycle Planning
   • Includes wayfinding
3. Bicycle Operation & Safety
4. Design of On-Road Facilities
   • Includes elements of design, shared lanes, shoulders, bike lanes, traffic signals, roundabouts, and structures
5. Design of Shared Use Paths
6. Bicycle Parking Facilities
7. Maintenance and Operations
2018 Preliminary Chapter List

1. Introduction
2. Bicycle Operation & Safety
3. Planning
4. Facility Selection
5. Elements of Design
6. Shared Use Paths
7. Separated Bike Lanes
8. Bicycle Boulevards
9. Bike Lanes & Shared Lanes
10. Traffic Signals and Active Warning Devices
11. Roundabouts, Interchanges, and Other Intersections
12. Rural Area Bikeways
13. Structures
14. Wayfinding
15. Maintenance & Operations
16. Parking & End of Trip Facilities
1: Introduction: MUTCD Delays

- Current MUTCD content is pre-2007
- Update in 2020 at the earliest
- FHWA issuing interim approvals for new treatments

2018 Guide includes treatments not in MUTCD

- Upfront caveat for compliance and experimentation
- Caveat each time discussed
2: Bicycle Operation & Safety

- **4 - 7%** Experienced and confident
- **5 - 9%** Somewhat confident
- **51 - 56%** Interested but Concerned

Lower stress tolerance vs. higher stress tolerance

2 : Bicycle Operation & Safety Default Design User for Guide

Experienced & Confident Cyclist
AASHTO 2012

4 - 7%

Interested but Concerned Cyclist
AASHTO 2018

51 - 56%
### 3: Planning Principals

<table>
<thead>
<tr>
<th></th>
<th>Safety</th>
<th>Reduce crashes and conflicts</th>
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<td>![icon]</td>
<td>Comfort</td>
<td>Conditions should not deter use</td>
</tr>
<tr>
<td>![icon]</td>
<td>Connectivity</td>
<td>Direct and convenient</td>
</tr>
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</table>
3: Perceived Comfort & Objective Safety

perceptions

reported crashes

comment frequency

Spot/Route Improvement Comments

BICYCLE CRASH FREQUENCY
ALL REPORTED BICYCLE CRASHES
2004-2012

total number of crashes

1

Cambridge Bicycle Network Plan
3 : Reporting and Exposure

Crash Rate = \frac{\text{Crash Frequency}}{\text{Number of Vehicles}}

- Bike crashes go unreported
- Bike volumes not always available
- Perception of safety **can** tell us what’s going on
Table 14. Option diagram for road sections inside the built-up area

<table>
<thead>
<tr>
<th>Cycle network category</th>
<th>Road Type</th>
<th>Vehicle Speed</th>
<th>Vehicle Volume</th>
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<tbody>
<tr>
<td>Basic network (</td>
<td>Local</td>
<td>18 mph</td>
<td>&lt; 2,500</td>
</tr>
<tr>
<td>Cyclo route (</td>
<td>Arterial</td>
<td>30 MPH</td>
<td>2x1 lane</td>
</tr>
<tr>
<td>Main cyclo route (</td>
<td>Arterial</td>
<td>45 MPH</td>
<td>2x2 lane</td>
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</table>

(bicycles: > 750/day), (bicycles: 500-2500/day), (bicycles: > 2000/day)
<table>
<thead>
<tr>
<th></th>
<th>CROW Manual</th>
<th>vs</th>
<th>AASHTO Manual</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shared Lanes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max volume</td>
<td>2,500 ADT</td>
<td></td>
<td>3,000 ADT</td>
</tr>
<tr>
<td>Max speed</td>
<td>18 mph</td>
<td></td>
<td>25 mph</td>
</tr>
<tr>
<td><strong>Bike Lanes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max volume</td>
<td>5,000 ADT</td>
<td></td>
<td>6,000 ADT</td>
</tr>
<tr>
<td>Max lanes</td>
<td>1 / direction</td>
<td></td>
<td>No max lanes</td>
</tr>
<tr>
<td>Max speed</td>
<td>30 mph</td>
<td></td>
<td>30 mph</td>
</tr>
<tr>
<td><strong>Separated Bike Lanes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More than 2 lanes</td>
<td></td>
<td></td>
<td>More than 6,000 ADT</td>
</tr>
<tr>
<td>Speed</td>
<td></td>
<td></td>
<td>Speed over 30 mph</td>
</tr>
</tbody>
</table>
5 : Elements of Design

“How to” chapter for critical design elements

- approach clear space

- Chapter 5: Elements of Design
  - 5.1 Introduction
  - 5.2 Design Speed
    - 5.2.2 Facility Context Examples
    - 5.2.3 Acceleration and Deceleration
    - 5.2.4 Roadway and Street Operating Speeds
  - 5.3 Sight Distance
    - 5.3.1 Criteria for Measuring Sight Distance
    - 5.3.2 Stopping Sight Distance
    - 5.3.3 Decision Sight Distance
    - 5.3.4 Intersection Sight Distance
  - 5.4 Geometric Design Elements
    - 5.4.2 Operating Width and Clearances
    - 5.4.3 Surface Considerations
    - 5.4.4 Horizontal Alignment
    - 5.4.5 Cross Slope
    - 5.4.6 Grade
    - 5.4.7 Vertical Alignment/Vertical Curves
MassDOT 2.0

Improvements over MassDOT:
- ADA Guidance
- Transit Stop Design
- Sight Distance Assessment
- Constrained Tradeoff Assessment
- Transition Guidance
7: Separated Bike Lanes

- Designs for transit access
- Two-way vs. one-way guidance
- Can have “win-win-win” scenarios
7: Separated Bike Lanes – Some Design Elements
8: Bicycle Boulevards

- Incorporating NACTO bicycle boulevard design treatments
- Speed management
  - Creating enclosure
  - Horizontal and vertical deflection
  - Crossing islands
- Traffic diversion
- Traffic control at intersections
A bicycle boulevard does not exist unless major street crossings are safe.

**Major Street Crossing Opportunities**
- 120 crossings/hour preferred
- 60 crossings/hour minimum

**Motor Vehicle Operating Speeds**
- 15 mph preferred
- 20 mph acceptable
- 25 mph maximum

**Daily Volumes:**
- 1,000 ADT preferred
- 2,000 ADT acceptable
- 3,000 ADT maximum

**Hourly Volumes**
- 50 vehicles/hour preferred
- 75 vehicles/hour acceptable
- 100 vehicles/hour maximum
• “Wide curb lanes are therefore not recommended as a strategy to accommodate bicycling”
• Recommends SHARE THE ROAD signs not be used, instead:
“Shared lane markings are most advantageous on roadways with traffic volumes below 3,000 vehicles per day, and speeds that are 25 mph or less.”
Establishes a standard for marking buffered bike lanes
10: Active Beacons and Traffic Signals

Creates a clear process to evaluate major street crossings
10: Bicycle signal heads

FHWA Interim Approval

Bike signal head warrant/requirement:
- Leading or protected phasing
- Contra-flow movements
- Signal heads beyond cone of vision

Bike signal head application:
- Can only be used **without** conflicting vehicle turns
Options for concurrent movements?
Requests to experiment
11: Roundabouts, Interchanges & Alternative Intersections

• Provide separated facilities
• Separate pedestrians and bikes
• Uncontrolled motorist crossings should be < 25mph…
  • Unless lots of gaps
  • Add active warning
  • Add control
12 : Rural Roadways

Design User:
Between Towns & Villages
Experienced & Confident

In Towns & Villages
Interested but Concerned

Recommended Minimum Shoulder
for Urban and Suburban Roadways see Chapter ##
12 : Rural Roadways

- Shoulder width recommendations
- Transition recommendations
- Rumble Strip spacing, location, and gap guidance
14: Wayfinding

Expanded guidance for sign design and placement

Added flexibility for sign design
AASHTO Bike Guide Schedule

- 2nd Draft submitted late 2017
- 3rd Draft: early 2018
- Final Draft and Balloting: mid 2018
  AASHTO Subcommittee Approvals needed from: design, traffic, bicycle

Final Comments and Publication: Mid 2019?