PEDESTRIAN & BICYCLIST SAFETY COUNTERMEASURES FOR FIRST/LAST MILE

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DEPARTMENT OF TRANSPORTATION
UNITED STATES OF AMERICA

TRAFFIC OPERATIONS

FEHR & PEERS
PRESENTATION OUTLINE

SECTION 1: General Considerations for First/Last Mile Transit Accessibility

SECTION 2: Pedestrian Facilities

SECTION 3: Bicycle Facilities

SECTION 4: Uncontrolled Crossings

SECTION 5: Bike/Ped Accommodations at Intersections

SECTION 6: Transit Facilities

SECTION 7: Bus/Bike Interface

SECTION 8: Bike/Ped Accommodations at Interchanges

SECTION 9: Questions and Sources for Guidance
GENERAL CONSIDERATIONS FOR FIRST/LAST MILE TRANSIT ACCESSIBILITY
THE GOAL OF TRANSIT

The primary goal of transit is to carry passengers between residences, employment, and other destinations in a safe, efficient, and reliable manner.

The physical safety of ALL passengers is vital to the success of any transit system— not only to retain riders, but to encourage new riders.

However...
There are numerous competing needs:

- Increases in ridership
- Crashes
- Amenities
- Conditions
- Vehicle needs
- Stop characteristics
- Capacity
- Security concerns
- Real time information
- Customer information
- Roadwork/Construction
- Transit plans
- Enforcement
- Private development
- Driver needs
- Special needs
- Funding
AGENCY CONSIDERATIONS: TRANSIT VS. DOT RESPONSIBILITY

DOT Responsibility

Transit Stop

Transit Route

Transit Responsibility
HIGH-USE LOCATIONS
KEY GENERATORS & TRANSFERS
ACCESS TO TRANSIT

Access to transit exists on multiple levels:

- Access at transit stop
- Access to transit stop
- Connections to transit routes
The catchment area is defined as the area served by transit. Transit access considers elements within catchment area.

In general, people are willing to:

- Walk up to ¼ Mile to access Local Bus transit
- Walk up to ½ Mile to access BRT or Rail transit
- Bike between 1-3 Miles to access Rail transit
- Drive 15 miles
CATCHMENT AREA

- Bus Stop
- Bus Stop Catchment Area
- Corridor Catchment Area
INFRASTRUCTURE NEEDS: TRANSIT STOP INVENTORY

Tool to identify needs at transit stops and transit corridors

Immediate transit stop characteristics inventoried and evaluated

Includes surrounding ped/bike connections

Ped/bike facilities at the stop
INFRASTRUCTURE NEEDS: ADA COMPLIANCE

Source: Google Maps
PEDESTRIAN CRASHES

Pedestrian Crashes
- Minor Injury
- Moderate-Severe Injury
- Fatal
COMBINE ALL ELEMENTS

- Transit ridership
- Transit stop inventory (ADA compliance and other design elements)
- Crashes
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- Transit stop inventory (ADA compliance and other design elements)
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SAFETY ANALYSIS
KEY SAFETY FACTORS

- Speed
- Number of lanes
- Visibility
- Traffic volume & composition
- Conflict points
- Proximity
- Connectivity
SPEED MATTERS

15 MPH

Source: FHWA
SPEED MATTERS

20 MPH

Source: FHWA
SPEED MATTERS

25 MPH

Source: FHWA
PEDESTRIAN FACILITIES: SIDEWALKS AND ADA

Section 2
SIDEWALKS AND CURBSIDES
SIDEWALK ZONE SYSTEM

Range (feet)

A  Minimum Pedestrian Clear Area
  Clearance from Face of Curb (pick the largest)
  4'-0"

B  Parallel Parking (Car Door Clearance)
  1'-6" to 2'-0"

C  Curbside Bus Stop
  2'-0"

D  Light Poles
  2'-6" to 3'-6"

E  Street Furniture Zone
  3'-0" to 5'-6"

F  Traffic Signal Poles and Boxes
  3'-0" to 4'-0"

G  Planter Box
  3'-0" to 4'-6"

H  Bus Bench
  3'-0" to 5'-0"

J  Bus Shelter
  5'-0" to 8'-0"

K  Pedestrian Clearance from Building (zero setback)
  1'-6"

L  Window Shopping Zone
  3'-0"

M  Street Furniture Zone
  3'-0" to 5'-6"
ADA CONSIDERATIONS

ADA addresses the needs of people with a variety of disabilities

Some disabilities are obvious
ADA CONSIDERATIONS

ADA addresses the needs of people with a variety of disabilities

Some disabilities are less obvious
MOST CRITICAL ENVIRONMENT WITH EXCESSIVE CROSS SLOPE: DRIVEWAYS
BICYCLE FACILITIES: CORRIDOR TREATMENTS

Section 3
TYPES OF BICYCLISTS

WHAT TYPE OF BIKE RIDER ARE YOU?

1% STRONG AND FEARLESS
Riding is a strong part of my identity, and I am undeterred by traffic speed, volume, or other roadway conditions.

7% ENTHUSED AND CONFIDENT
I am comfortable sharing the road with motor vehicles, but I prefer to use bike lanes and bike-friendly streets.

60% INTERESTED AND CONCERNED
I like riding a bike, but I don’t ride much. I would like to feel safer when I do ride, with less traffic and slower speeds.

33% NO BIKING
I don’t bike at all due to inability, fear for my safety, or simply a complete and utter lack of interest.
LEVEL OF TRAFFIC STRESS

Level of traffic stress (LTS) is a way to evaluate the stress a bike rider will experience while riding on a road. It is used to categorize roads by the types of riders above who will be willing to use them. LTS is...

NUMBER OF TRAVEL LANES
NUMBER OF VEHICLES
PRESENCE OF BIKE LANES
PRESENCE OF PHYSICAL BARRIER
WIDTH OF TRAFFIC
SPEED OF TRAFFIC

LTS SCORE

Fehr & Pears’ LTS tool allows us to calculate LTS for an entire city. Know with certainty how your bike network serves each rider type.

LTS 4
Only the “strong and fearless” will ride on these high-stress streets with high speeds limits, multiple travel lanes, limited or non-existent bikeways, and long intersection crossing distances.

LTS 3
Bike riders who are “enthusiastic and confident” but who still prefer having their own dedicated space for riding will feel safe while traveling on streets of this nature.

LTS 1 & 2
LTS1: Most children can feel safe riding on these streets
LTS2: The mainstream, “interested but concerned,” adult population will feel safe riding on these streets.
BICYCLE INFRASTRUCTURE

Why build bicycle infrastructure?

- Safety
- Comfort
- Access and network connections
- Link to other investments to provide choices
- Build infrastructure that people want to use

Source: Fehr & Peers
BICYCLE INFRASTRUCTURE

Class I: Bike Path

Class II: Bike Lane

Class III: Bike Route

Class IV: Separated Bike Lane

Sources: Fehr & Peers, Metro & LA EcoVillage
BUFFERED BIKE LANES (CLASS II)

- Higher travel speeds
- More truck traffic
- Extra lanes or lane width
- Transit stop conflicts
GREEN COLORED BIKE LANES (CLASS II)

- Approved for use in CA based on FHWA Interim Approval (CA MUTCD IA-14)
- Guidance in FHWA Interim Approval Memo
- Caltrans example at Alpine Rd/I-280 (District 4)
BICYCLE INFRASTRUCTURE

Conflict Area Markings

Source: Fehr & Peers

Source: NACTO
BIKE BOULEVARDS (CLASS III)

Collection of treatments

- Wayfinding
- Traffic calming
- Volume management
- Crossing treatments
- Green infrastructure
- Traffic control adjustments
- Route planning

Source: DavidBaker+Partners.com
CLASS IV: SEPARATED BIKE LANES/ CYCLE TRACKS

On-street facilities that provide physical protection from moving traffic

Comprised of buffer space and bike lane

Protection is provided through:

- Tubular markers
- Movable planters
- Raised curb
- Floating parking
- Landscaping buffer
- Elevated bicycle facility
### Contextual Guidance for Selecting All Ages & Abilities Bikeways

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Any</td>
<td>Any</td>
<td>Any</td>
<td>Any</td>
<td>Any of the following: high curbside activity, frequent buses, motor vehicle congestion, or turning conflicts</td>
<td>Protected Bicycle Lane</td>
</tr>
<tr>
<td>&lt; 10 mph</td>
<td>Less relevant</td>
<td>No centerline, or single lane one-way</td>
<td>Pedestrians share the roadway</td>
<td>Shared Street</td>
<td></td>
</tr>
<tr>
<td>≤ 20 mph</td>
<td>≤ 1,000 – 2,000</td>
<td>≤ 500 – 1,500</td>
<td>&lt; 50 motor vehicles per hour in the peak direction at peak hour</td>
<td>Bicycle Boulevard</td>
<td></td>
</tr>
<tr>
<td>≤ 25 mph</td>
<td>≤ 1,500 – 3,000</td>
<td>Single lane each direction, or single lane one-way</td>
<td>Low curbside activity, or low congestion pressure</td>
<td>Conventional or Buffered Bicycle Lane, or Protected Bicycle Lane</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≤ 3,000 – 6,000</td>
<td>Greater than 6,000</td>
<td>Protected Bicycle Lane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 6,000</td>
<td>Any</td>
<td>Multiple lanes per direction</td>
<td>Protected Bicycle Lane, or Reduce Speed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 20 mph</td>
<td>≤ 6,000</td>
<td>Single lane each direction</td>
<td>Protected Bicycle Lane, or Reduce to Single Lane &amp; Reduce Speed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 6,000</td>
<td>Greater than 6,000</td>
<td>Multiple lanes per direction</td>
<td>Protected Bicycle Lane, or Bicycle Path</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-speed limited access roadways, natural corridors, or geographic edge conditions with limited conflicts</td>
<td>Any</td>
<td>High pedestrian volume</td>
<td>Bike Path with Separate Walkway or Protected Bicycle Lane</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low pedestrian volume</td>
<td>Shared-Use Path or Protected Bicycle Lane</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*While posted or 85th percentile motor vehicle speed are commonly used design speed targets, 85th percentile speed captures high-end speeding which causes greater stress to bicyclists and more frequent passing events. Setting target speed based on this threshold results in a higher level of bicycling comfort for the full range of riders.*

*Setting 25 mph as a motor vehicle speed threshold for providing protected bikeways is consistent with many cities’ traffic safety and Vision Zero policies. However, some cities use a 30 mph posted speed as a threshold for protected bikeways, consistent with providing Level of Traffic Stress Level 2 (LTS 2) that can effectively reduce stress and accommodate more types of riders.*

*Operational factors that lead to bikeway conflicts are reasons to provide protected bike lanes regardless of motor vehicle speed and volume.*
THE CVC DEFINITION

What is an Unmarked Crosswalk?

California Vehicle Code §275
“Crosswalk” is either:

a) That portion of a roadway included within the prolongation or connection of the boundary lines of sidewalks at intersections where the intersecting roadways meet at approximately right angles, except the prolongation of such lines from an alley across a street.

b) Any portion of a roadway distinctly indicated for pedestrian crossing by lines or other markings on the surface.
MARKED CROSSWALK PURPOSE

Provide guidance for pedestrians
Help alert drivers to pedestrian crossing
Establish legal mid-block crossing
TO MARK OR NOT TO MARK

Herms, Bruce. (1972) Pedestrian crosswalk study: accidents in painted and unpainted crosswalks. Transportation Research Record, 406.

- “The San Diego study”
- Marked crosswalks vs. unmarked crosswalks
- Increased incidence of pedestrian collisions in marked crosswalks
- Did not differentiate between:
  - Number of lanes
  - Traffic volume
  - Speed limit
Safety Effects of Marked versus Unmarked Crosswalks at Uncontrolled Locations (2002)

- “The Zegeer study”
- Marked vs. unmarked
- Two-lane roads - no difference in pedestrian crash rate
- Multilane roads - marked crosswalk, without other measures, associated with higher crash rate on roadways with higher ADT and speed
MULTIPLE THREAT CRASH
Table 1. Recommendations for installing marked crosswalks and other needed pedestrian improvements at uncontrolled locations.*

<table>
<thead>
<tr>
<th>Roadway Type (Number of Travel Lanes and Median Type)</th>
<th>Vehicle ADT &lt; 9,000</th>
<th>Vehicle ADT &gt;9000 to 12,000</th>
<th>Vehicle ADT &gt;12,000 - 15,000</th>
<th>Vehicle ADT &gt; 15,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤ 30 mi/h</td>
<td>35 mi/h</td>
<td>40 mi/h</td>
<td>≤ 30 mi/h</td>
</tr>
<tr>
<td>2 Lanes</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>C</td>
</tr>
<tr>
<td>3 Lanes</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>C</td>
</tr>
<tr>
<td>Multi-Lane (4 or More Lanes) With Raised Median***</td>
<td>C</td>
<td>C</td>
<td>P</td>
<td>C</td>
</tr>
<tr>
<td>Multi-Lane (4 or More Lanes) Without Raised Median</td>
<td>C</td>
<td>P</td>
<td>N</td>
<td>P</td>
</tr>
</tbody>
</table>

Key:
C = Candidate sites for marked crosswalks;
P = Possible increase in pedestrian crashes may occur if crosswalks are marked without other pedestrian enhancements;
N = Marked crosswalks alone are insufficient.
Regardless of whether marked crosswalks are used, there remains the fundamental obligation to get pedestrians safely across the street.

FHWA Safety Effects of Marked v. Unmarked Crosswalks
DEMAND CONSIDERATIONS

Location is near an existing or proposed park, school, hospital or other major pedestrian generator/attractor

20 pedestrians per hour (15 elderly and/or children) or 60 in 4 hours cross at location and ADT ≥ 1500 vpd

Pedestrian injuries or fatalities have occurred at this location in the past 5 years

Citizen surveys or walkability audits overwhelmingly suggest the need for proactive treatment

No action recommended

Nearest appropriately marked or protected crosswalk is at least 300 feet away

40 pedestrians per hour (30 elderly and/or children) or 120 in 4 hours cross at location

Direct pedestrians to the nearest marked or protected crosswalk

Pedestrians can be easily seen from a distance 10x the speed limit or 250 feet

Is it feasible to remove sight distance obstruction or lower speed limit?

Direct pedestrians to the nearest marked crosswalk or consider installing signal or grade separation

Use Crosswalk Treatment Identification Tool and Engineering Judgment to determine treatment options

YES

NO

YES

NO

YES

NO

YES

NO

YES

NO

YES

NO

YES

NO

YES

NO
# 2018 FHWA GUIDANCE

## Table 1. Application of pedestrian crash countermeasures by roadway feature.

<table>
<thead>
<tr>
<th>Roadway Configuration</th>
<th>Speed Limit</th>
<th>Vehicle AADT &lt;9,000</th>
<th>Vehicle AADT 9,000–15,000</th>
<th>Vehicle AADT &gt;15,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤30 mph</td>
<td>35 mph</td>
<td>≥40 mph</td>
<td>≤30 mph</td>
</tr>
<tr>
<td>2 lanes*</td>
<td>1 2 3 4</td>
<td>1 5 6 8</td>
<td>1 5 6 8</td>
<td>1 3 4 5</td>
</tr>
<tr>
<td>3 lanes with raised median*</td>
<td>5 5 7 7</td>
<td>5 5 7 7</td>
<td>5 5 7 7</td>
<td>5 5 7 7</td>
</tr>
<tr>
<td>3 lanes w/o raised median*</td>
<td>5 5 7 7</td>
<td>5 5 7 7</td>
<td>5 5 7 7</td>
<td>5 5 7 7</td>
</tr>
<tr>
<td>4+ lanes with raised median*</td>
<td>1 2 3 4 5 6 7 8</td>
<td>1 2 3 4 5 6 7 8</td>
<td>1 2 3 4 5 6 7 8</td>
<td>1 2 3 4 5 6 7 8</td>
</tr>
<tr>
<td>4+ lanes w/o raised median*</td>
<td>1 2 3 4 5 6 7 8</td>
<td>1 2 3 4 5 6 7 8</td>
<td>1 2 3 4 5 6 7 8</td>
<td>1 2 3 4 5 6 7 8</td>
</tr>
</tbody>
</table>

*One lane in each direction  
**Two or more lanes in each direction  

Given the set of conditions in a cell:

- **Signifies that the countermeasure should always be considered**
- " indicates that the countermeasure should be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location.
- **Signifies that the countermeasure is a candidate treatment at a marked uncontrolled crossing location.

The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgment.

1. High-visibility crosswalk markings, parking restriction on crosswalk approach, adequate nighttime lighting levels
2. Raised crosswalk
3. Advance Yield Here To (Stop Here For Pedestrians sign and yield (scip) line
4. In-Street Pedestrian Crossing sign
5. Curb extension
6. Pedestrian refuge island
7. Pedestrian Hybrid Beacon
8. Road Diet

SIGNING AND STRIPING

- 6’ minimum width, 10’ recommended
- Should be straight
- High-visibility (continental, ladder) recommended at uncontrolled and mid-block locations
- W11-2 sign with W16-7P (two per approach, especially on multilane approaches)
- Advanced yield/stop lines at uncontrolled multi-lane approaches (20-50 feet)
- R1-5 signs are required when advanced yield/stop lines are used on multilane approaches

Example crosswalk markings

![Crosswalk Markings Diagram]
ILLUMINATION: ESSENTIAL FOR ANY CROSSING

Marked crosswalk?
- Light it

Over 70% of pedestrian fatalities occur during darkness in California
RAISED CROSSWALKS

- FHWA Study “The Effects of Traffic Calming Measures on Pedestrian and Motorist Behavior” - 2001
- Increase pedestrian visibility & likelihood the driver yields to pedestrians especially when combined with an overhead flashing light
- Most appropriate on low speed local or neighborhood streets
- Should not be used on emergency routes, bus routes, or high speed streets
- Drainage of storm water runoff and snow plowing considerations may also be a concern with raised crosswalks

Figure 6. Raised crosswalk and overhead flasher, Towerview Drive, Durham, North Carolina.
ADVANCE YIELD LINE
IN-STREET PEDESTRIAN CROSSING SIGN

2009 MUTCD Section 2B.12 and Figure 2B-2
CURB EXTENSIONS

- Increases pedestrian visibility
- Allows pedestrians to better observe approaching motorists
- Decreases crossing distance
- Reduces pedestrian exposure to traffic
- Improves opportunity for directional curb ramps
- Can reduce speeds by visually narrowing the street
- Slows turning vehicles
- Can improve signal timing/may reduce cycle length
MEDIAN ISLANDS

- 6’ minimum width for refuge, 8’ or larger recommended to accommodate bicyclists, higher pedestrian volumes
- Consider fire department requirements
  - Often 20’ clear to pass stopped vehicles
  - Wider for hook & ladder trucks
- 5’ minimum opening for ADA, width of crosswalk recommended
- At roadway grade, with detectable surface
- Place signs, beacons both right-side and in median
RECTANGULAR RAPID FLASHING BEACON (RRFB)

- **RRFBs**
  - FHWA issued Interim Approval (IA-11) in July 2008; was recently terminated
  - Caltrans has recently requested blanket approval regarding IA-21 from FHWA
PEDESTRIAN HYBRID BEACONS

- Similar in design and cost to pedestrian signal
- Pedestrian head shall rest with upraised hand

Standard R10-23 sign

Modified R10-23 sign
PEDESTRIAN HYBRID BEACONS

1. Blank for drivers
2. Flashing yellow
3. Steady yellow
4. Steady red
5. Wig-Wag

Return to 1
“CLASSIC ROAD DIET”
4 to 3 Lanes | San Antonio, TX
3 CRASH TYPES CAN BE REDUCED BY GOING FROM 4 TO 3 LANES: WHICH ONES?
3 CRASH TYPES CAN BE REDUCED BY GOING FROM 4 TO 3 LANES:

1) REAR ENDERS

![Diagram of rear end collision](image1)

![Diagram showing reduced rear end collisions](image2)
3 CRASH TYPES CAN BE REDUCED BY GOING FROM 4 TO 3 LANES:
2) SIDE SWIPES
3 CRASH TYPES CAN BE REDUCED BY GOING FROM 4 TO 3 LANES:
3) LEFT TURN/BROADSIDE
PEDESTRIAN SIGNALS

- Cannot be used at intersection
- Same standards as full traffic signal
TREATMENT SELECTION TOOLS
ACCESSIBILITY REQUIREMENTS

DIB 82-05

- Now allows ramps to be oriented perpendicular to a gutter grade break
- Alternative to orientation perpendicular to curb face
- Facilitates crosswalk with directional ramps at corners
INTERSECTION DESIGN PRINCIPLES

Reduce speed
Minimize exposure to conflicts
Communicate right-of-way priority
Provide adequate sight distance
Shorten crossings
Keep it direct
Light at night
Access for all
INTERSECTION DESIGN PRINCIPLES

Common Issues
INTERSECTION DESIGN PRINCIPLES

Candidate Solutions (Low-Cost)
INTERSECTION DESIGN PRINCIPLES

Free Right-Turn with Raised Crosswalk
INTERSECTION DESIGN PRINCIPLES

Candidate Solutions (High Cost)

Source: Fehr & Peers
INTERSECTION DESIGN PRINCIPLES

Right-Turn Lane Design

Design affects:
- Vehicle turning speeds
- Clarity of path for bicyclists
- Controlled vs. uncontrolled crosswalks
- Vehicle delay
INTERSECTION DESIGN PRINCIPLES