

INFRASTRUCTURE AND SPEED REDUCTION FOR PEDESTRIAN SAFETY

THE FHWA PERSPECTIVE

PETER EUN

FHWA RESOURCE CENTER SAFETY & DESIGN TST

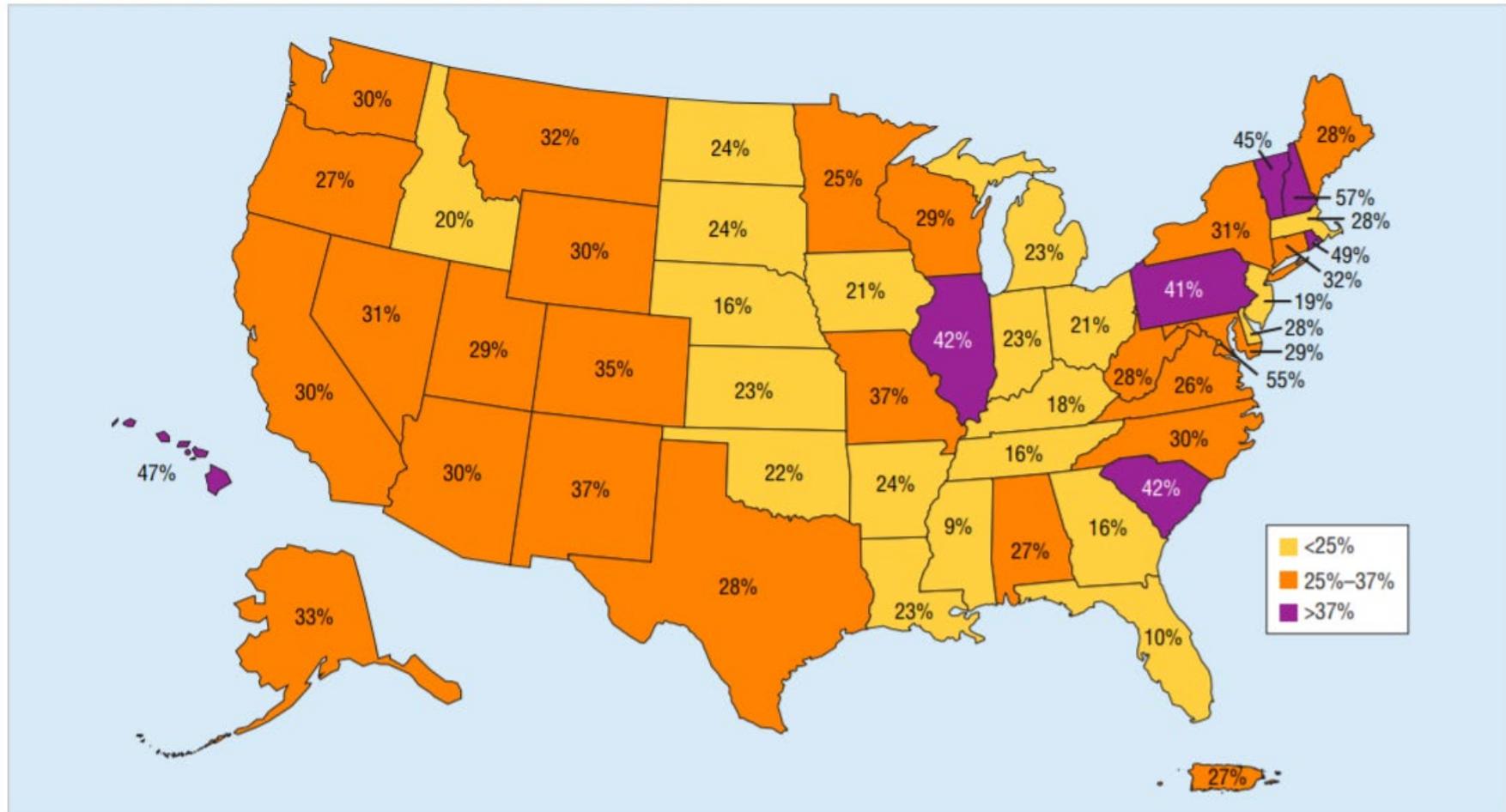
9/10/2019

IL DOT Pedestrian Safety Peer Exchange

NHTSA Traffic Safety Facts 2017

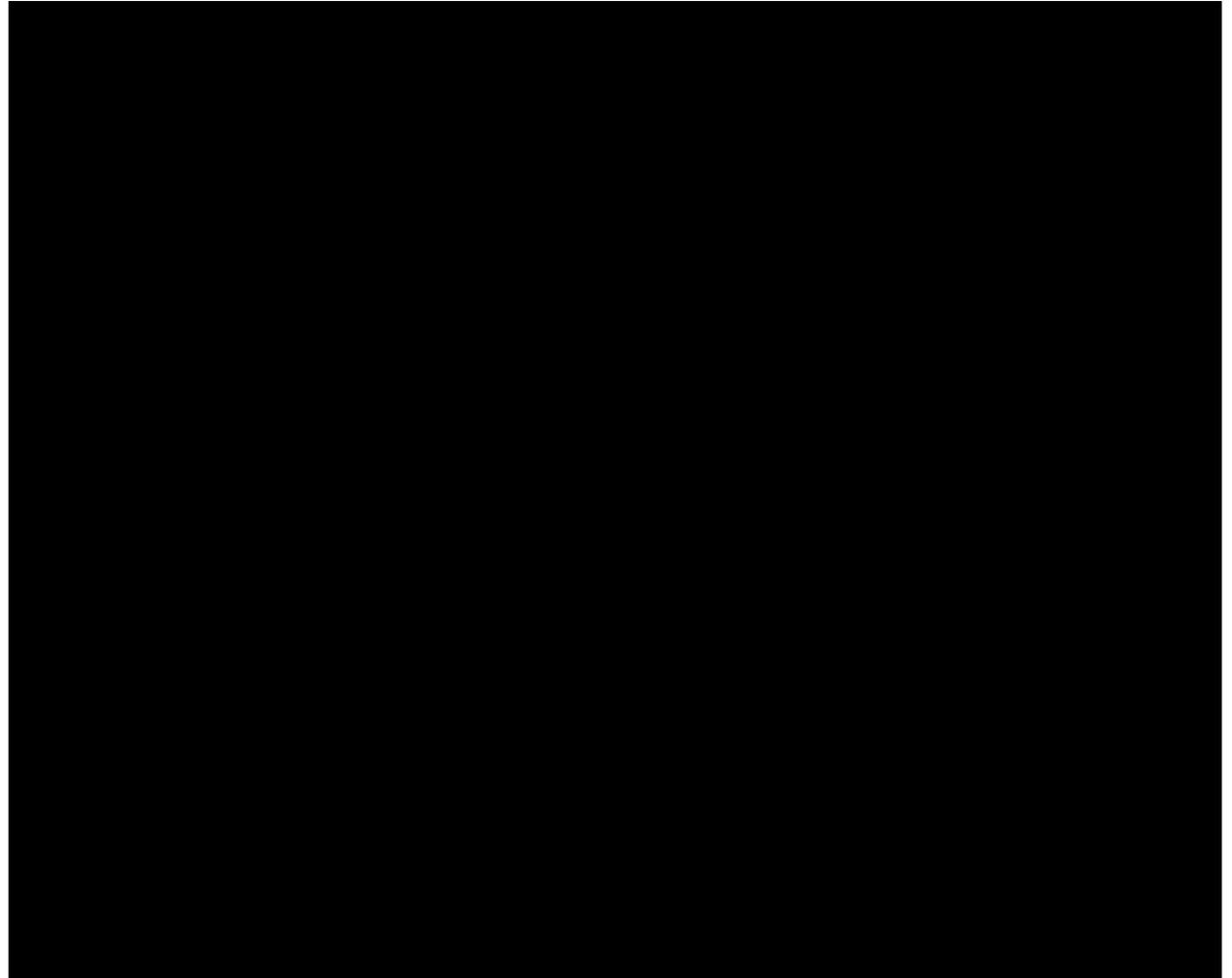
Speeding

Figure 9
Percentage of Speeding-Related Fatalities, by State, 2017



Australian PSA on Speed

- 60 kph vs.
65 kph
- 37 mph vs.
40 mph



— PEDESTRIAN FATALITY & SERIOUS INJURY RISK +

18%



50%



77%



— 20 MPH

30 MPH

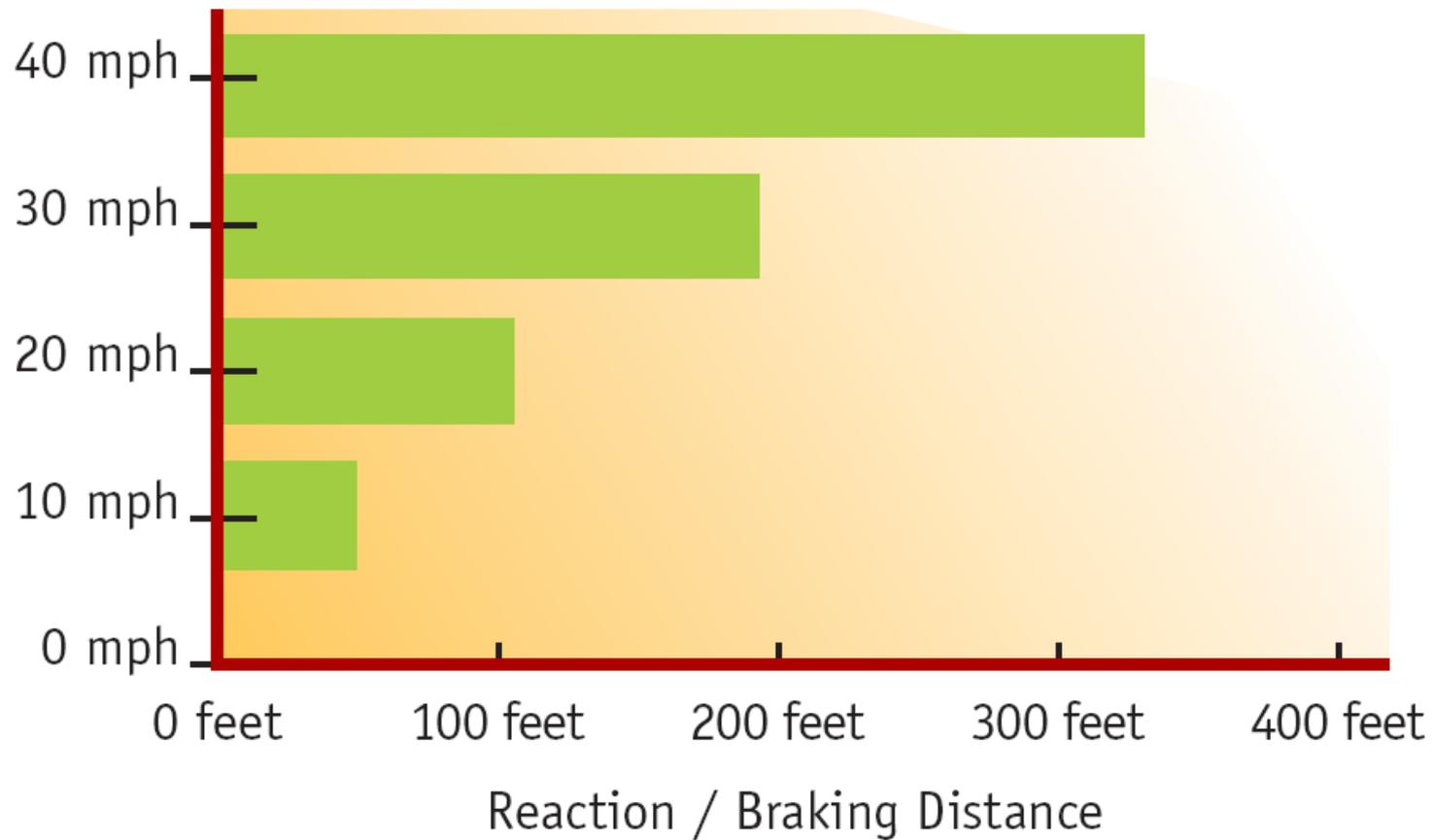
40 MPH +



CONE OF VISION

As motor vehicle speeds increase, the risk of serious injury or fatality for a pedestrian also increases (*AARP Impact Speed and a Pedestrian's Risk of Severe Injury or Death 2011, p. 1*). Also, motorist visual field and peripheral vision is reduced at higher speeds.

Speed Affects Crash Avoidance



High speeds equate to greater reaction and stopping distance

How have we built our urban roadway system?



Curbs & sidewalks slow traffic more than speed sign

Coburg OR

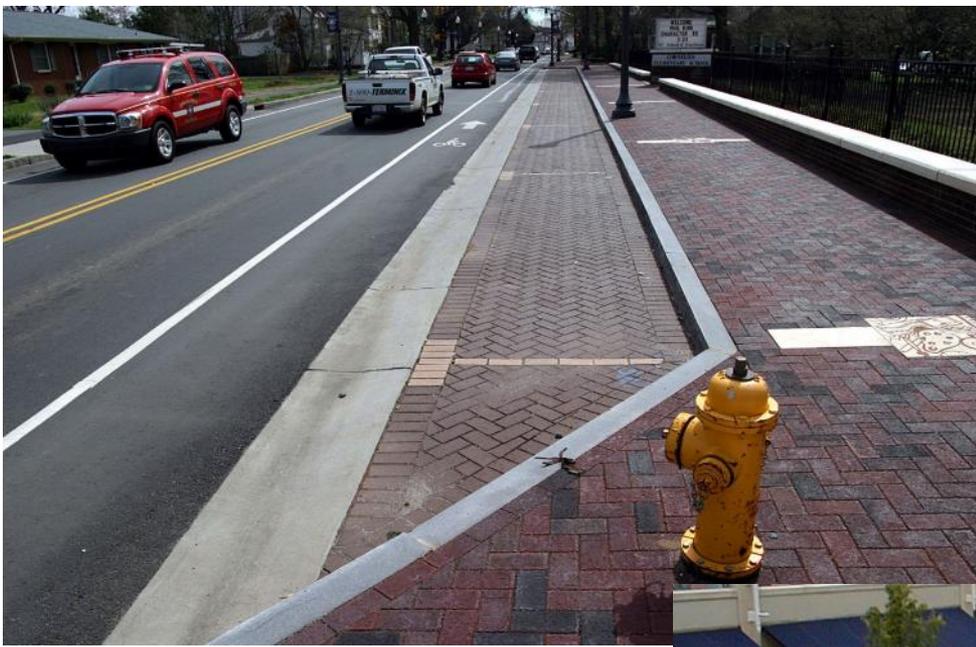




- Before: road looks and feels wide



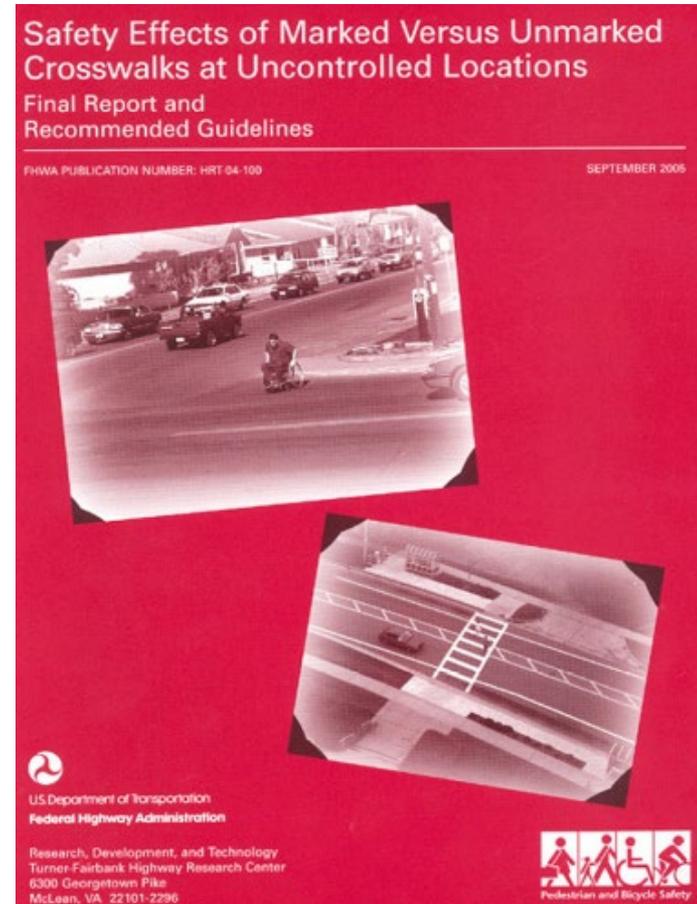
After: curb extension integral to sidewalk
Street looks narrow even with no parked cars



Curb extension integrated into sidewalk

Study of Crosswalk Markings (Zegeer et al 2005)

- Marked vs. Unmarked Analysis
- Speeds $<$ or $=$ to 40 mph
 - Two-lane roads: No significant difference in crash rate
 - Multilane roads (3 or more lanes)
 - Under 12,000 ADT: no significant difference in crash rate
 - Over 12,000 ADT w/ no median: crashes marked $>$ crashes unmarked
 - Over 15,000 ADT & w/ median: crashes marked $>$ crashes unmarked



Text in the 2009 MUTCD

- New marked crosswalks alone, **without other measures designed to reduce traffic speeds, shorten crossing distances, enhance driver awareness of the crossing, and/or provide active warning of pedestrian presence**, should not be installed across uncontrolled roadways where the speed limit exceeds 40 mph and/or either:
 - Has 4 or more lanes without a raised median or island and ADT of 12,000 or more, or
 - 4 or more lanes with raised median island and ADT of 15,000 or more
 - (2009 MUTCD Section 3B.18)



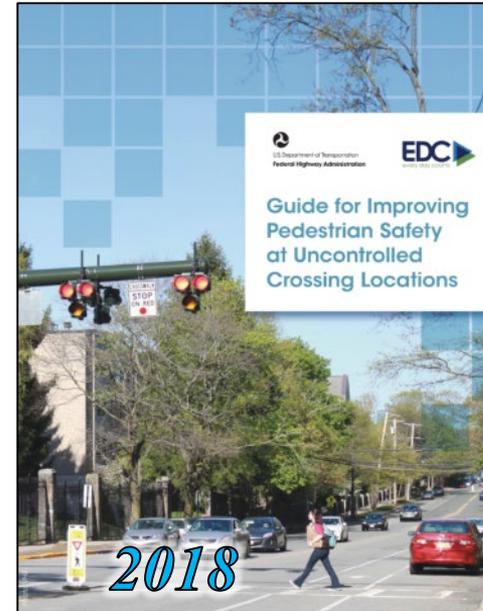
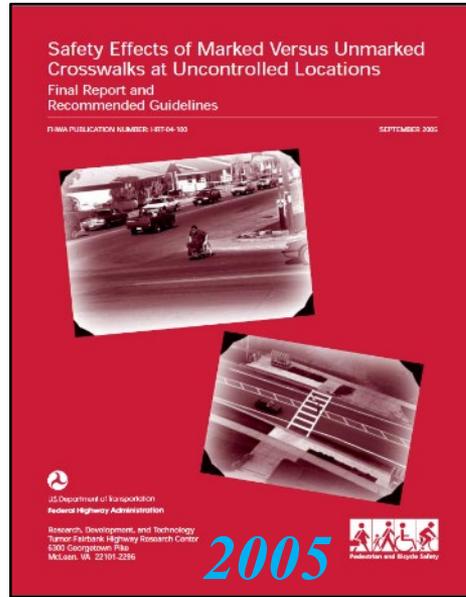


Table 11. Recommendations for installing marked crosswalks and other needed pedestrian improvements at uncontrolled locations.*

Roadway Type (Number of Travel Lanes and Median Type)	Vehicle ADT < 9,000		Vehicle ADT >9,000 to 12,000			Vehicle ADT >12,000-15,000			Vehicle ADT > 15,000			
	Speed Limit**											
	≤ 48.3 km/h (30 mi/h)	56.4 km/h (35 mi/h)	64.4 km/h (40 mi/h)	≤ 48.3 km/h (30 mi/h)	56.4 km/h (35 mi/h)	64.4 km/h (40 mi/h)	≤ 48.3 km/h (30 mi/h)	56.4 km/h (35 mi/h)	64.4 km/h (40 mi/h)	≤ 48.3 km/h (30 mi/h)	56.4 km/h (35 mi/h)	64.4 km/h (40 mi/h)
Two lanes	C	C	P	C	C	P	C	C	N	C	P	N
Three lanes	C	C	P	C	P	P	P	P	N	P	N	N
Multilane (four or more lanes) with raised median***	C	C	P	C	P	N	P	P	N	N	N	N
Multilane (four or more lanes) without raised median	C	P	N	P	P	N	N	N	N	N	N	N

* These guidelines include intersection and midblock locations with no traffic signals or stop signs on the approach to the crossing. They do not apply to school crossings. A two-way center turn lane is not considered a median. Crosswalks should not be installed at locations that could present an increased safety risk to pedestrians, such as where there is poor sight distance, complex or confusing designs, a substantial volume of heavy trucks, or other dangers, without first providing adequate design features and/or traffic control devices. Adding crosswalks alone will not make crossings safer, nor will they necessarily result in more vehicles stopping for pedestrians. Whether or not marked crosswalks are installed, it is important to consider other pedestrian facility enhancements (e.g., raised median, traffic signal, roadway narrowing, enhanced overhead lighting, traffic-calming measures, curb extensions), as needed, to improve the safety of the crossing. These are general recommendations; good engineering judgment should be used in individual cases for deciding where to install crosswalks.

** Where the speed limit exceeds 64.4 km/h (40 mi/h), marked crosswalks alone should not be used at unsignalized locations.

*** The raised median or crossing island must be at least 1.2 m (4 ft) wide and 1.8 m (6 ft) long to serve adequately as a refuge area for pedestrians, in accordance with MUTCD and American Association of State Highway and Transportation Officials (AASHTO) guidelines.

C = Candidate sites for marked crosswalks. Marked crosswalks must be installed carefully and selectively. Before installing new marked crosswalks, an engineering study is needed to determine whether the location is suitable for a marked crosswalk. For an engineering study, a site review may be sufficient at some locations, while a more in-depth study of pedestrian volume, vehicle speed, sight distance, vehicle mix, and other factors may be needed at other sites. It is recommended that a minimum utilization of 20 pedestrian crossings per peak hour (or 15 or more elderly and/or child pedestrians) be confirmed at a location before placing a high priority on the installation of a marked crosswalk alone.

P = Possible increase in pedestrian crash risk may occur if crosswalks are added without other pedestrian facility enhancements. These locations should be closely monitored and enhanced with other pedestrian crossing improvements, if necessary, before adding a marked crosswalk.

N = Marked crosswalks alone are insufficient, since pedestrian crash risk may be increased by providing marked crosswalks alone. Consider using other treatments, such as traffic-calming treatments, traffic signals with pedestrian signals where warranted, or other substantial crossing improvement to improve crossing safety for pedestrians.

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

Roadway Configuration	Posted Speed Limit and AADT								
	Vehicle AADT <9,000			Vehicle AADT 9,000-15,000			Vehicle AADT >15,000		
	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph
2 lanes (1 lane in each direction)	① 2 4 5 6	① 5 6 7 9 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②
3 lanes with raised median (1 lane in each direction)	① 2 3 4 5	① 5 6 7 9 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②
3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane)	① 2 3 4 5 6	① 5 6 7 9 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②
4+ lanes with raised median (2 or more lanes in each direction)	① 5 6 7 8 9	① 5 6 7 8 9	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②
4+ lanes w/o raised median (2 or more lanes in each direction)	① 5 6 7 8 9	① 5 6 7 8 9	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②	① 5 6 ②

Given the set of conditions in a cell,

- ① Signifies that the countermeasure is a candidate treatment of a marked uncontrolled crossing location.
- Signifies that the countermeasure should always be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location.
- Signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.*

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

- High-visibility crosswalk markings, parking restrictions on crosswalk approach, adequate nighttime lighting levels, and crossing warning sign
- Raised crosswalk
- Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line
- In-Street Pedestrian Crossing sign
- Curb extension
- Pedestrian refuge island
- Rectangular Rapid Flashing Beacon (RRFB)**
- Road Diet
- Pedestrian Hybrid Beacon (PHB)**

*Refer to Chapter 4, Using Table 1 and Table 2 to Select Countermeasures, for more information about using multiple countermeasures.
 **The RRFB and PHB are not both suitable for the same crossing location.

STEP Spectacular Seven



Crosswalk Visibility Enhancements



Raised Crosswalks



Pedestrian Refuge Island



Rectangular Rapid Flashing Beacon (RRFB)



Pedestrian Hybrid Beacon (PHB)



Road Diets



Leading Pedestrian Interval (LPI)

Crosswalk Visibility Enhancements

- High Visibility Markings
- Signs
- Curb Extensions
- Curb Radii
- Lighting
- Parking Restriction

Crosswalk Visibility Enhancements

SAFE TRANSPORTATION FOR EVERY PEDESTRIAN
COUNTERMEASURE TECH SHEET

This example combines curb extensions, high-visibility markings, and in-street signs on a two-lane roadway.



This example combines advance markings and signage, overhead lighting, parking restrictions, and high-visibility markings on a multilane roadway.



.....

Crosswalk visibility enhancements can reduce crashes by **23–48%**



.....

FEATURES:

- High-visibility marking improves visibility of the crosswalk compared to the standard parallel lines.
- Parking restriction on the crosswalk approach improves the sightlines for motorists and pedestrians.
- Advance STOP or YIELD markings & signs reduce the risk of a multiple-threat crash.
- Curb extension improves sight distance between drivers and pedestrians and narrows crossing distance.
- In-street STOP or YIELD signs may improve driver yielding rates.

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Crosswalk Visibility Enhancements

High Visibility Crosswalk

What Pedestrians See



Photo Source all 4: Michael Ronkin

What Drivers See

In-street pedestrian crossing signs

Tampa FL



R1-6



R1-6a

MUTCD signs

**Yield or Stop depends
on state law**

Gateway Treatments

Gateway Treatment, Three-Lane Configuration Without Refuge Island	
Travel Lanes	2
Passing/Turn Lanes	1
R1-6 Signs	4
Flexible Delineators	0
Yielding Compliance	Between 60% and 90% compliance rate if speed limit is 30mph or less for ADT up to 25,000. If the speed limit is 35 mph expect similar results if ADT is 12,000 or less. UNKNOWN above 12,000 ADT.
Approximate Cost	\$1,200 for materials 20-minute installation 8 minutes to remove for winter 8 minutes to reinstall in spring



Figure 6a

General Description:
 Note: By installing the gateway on the near side of the intersection, both crosswalks are covered with only four signs. Data show that a gateway at the near side crosswalk continues to be effective for the far side of the intersection, as the motorist on the far side has already passed through a gateway on the near side.

The signs on the curb side in the gutter pan would have a better chance of survival if they are moved placed between 3 and 50 feet in Advance of the crosswalk markings. This would reduce the chance of the sign being struck by a turning vehicle. Figure 6b shows a typical installation.

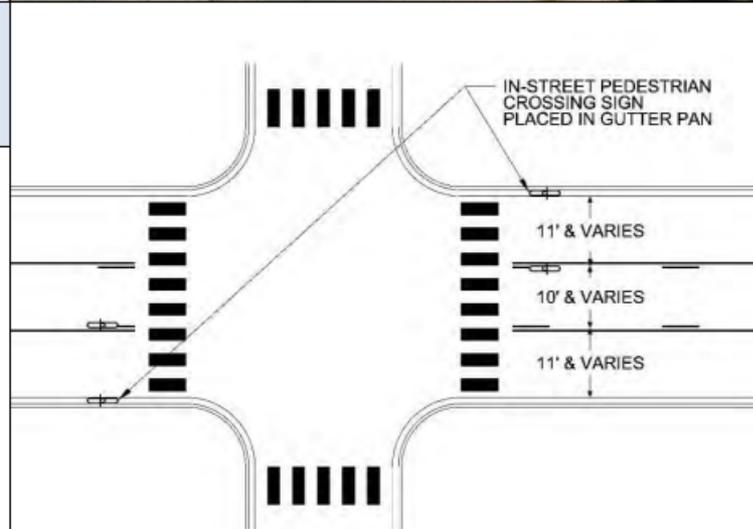
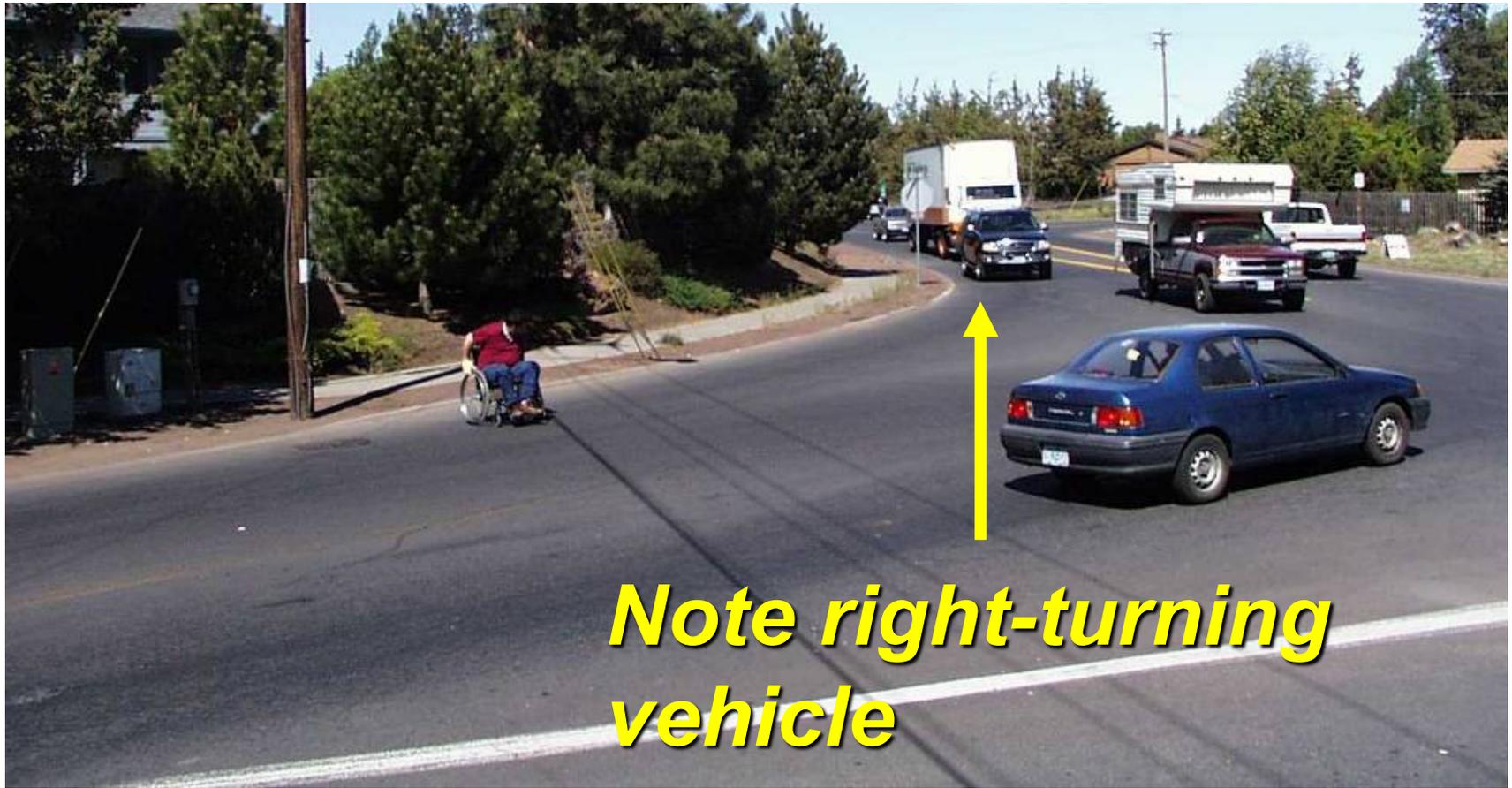


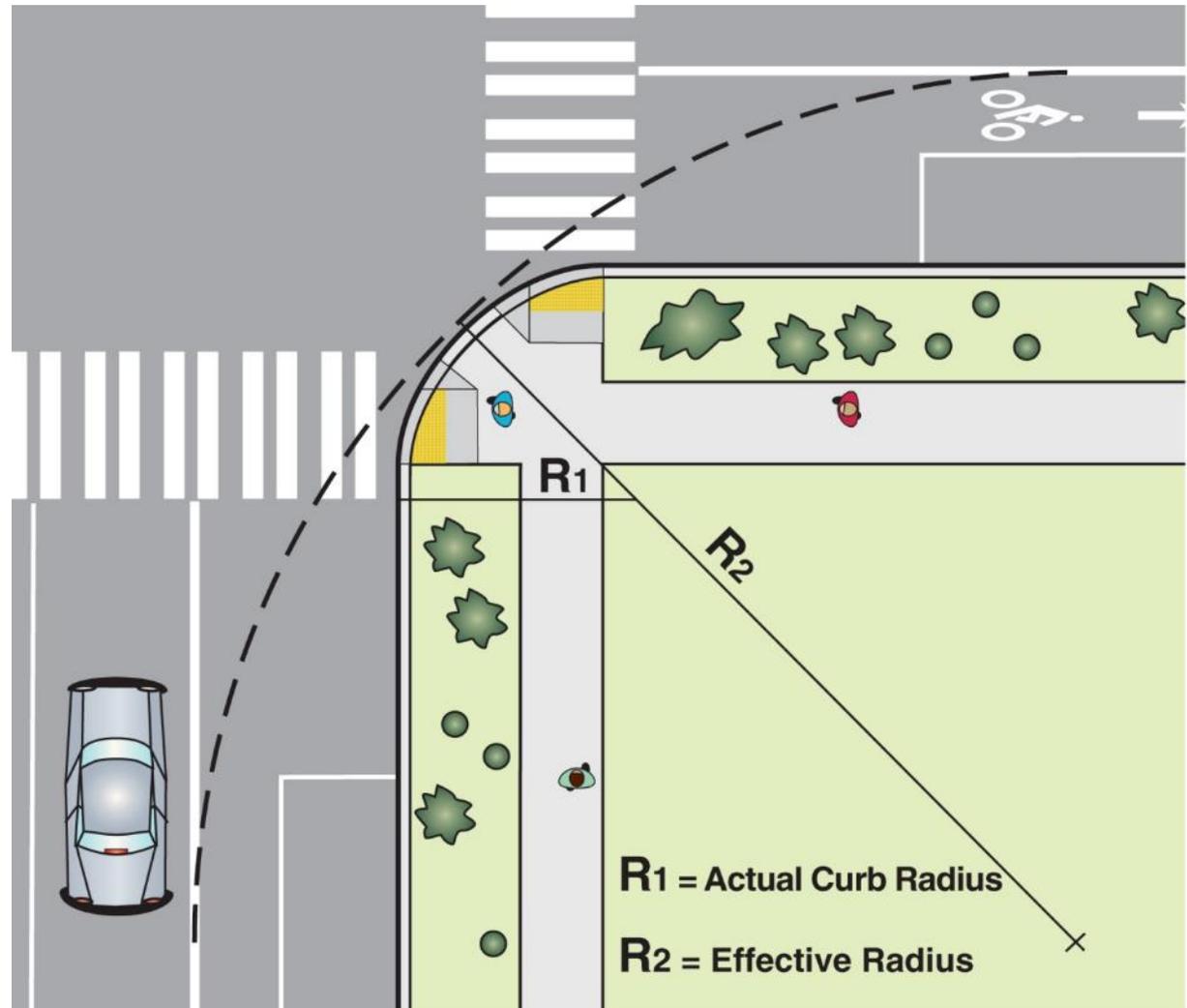
Figure 6b



Effect of large radius: higher speed turns

Minimize curb radius

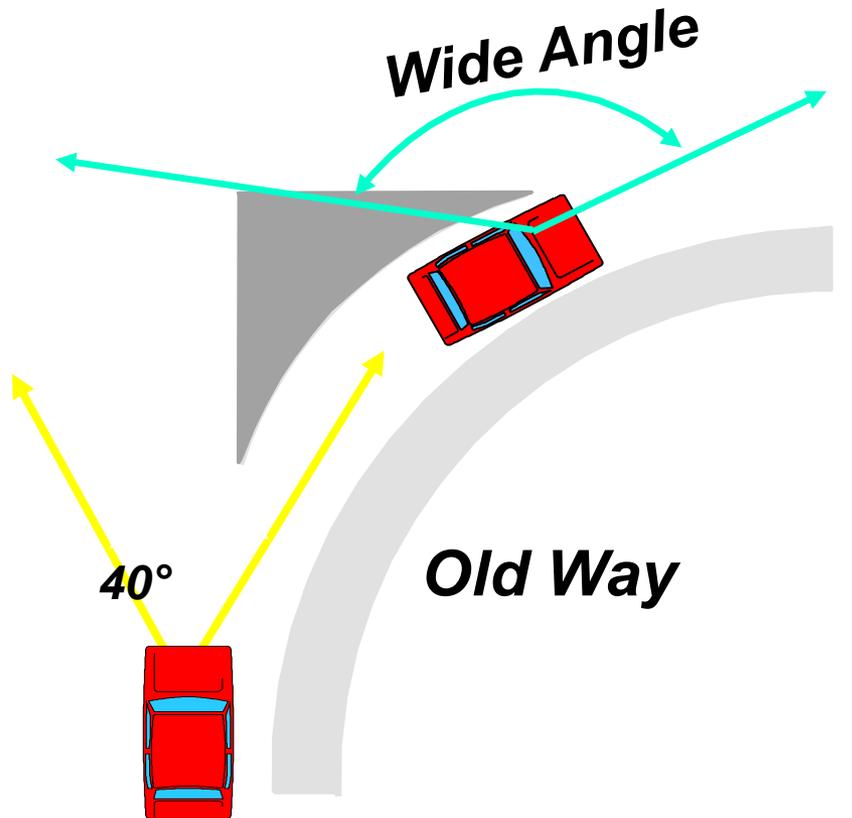
Calculate effective radius: Larger than built radius if travel lanes offset from curb with parking and/or bike lane



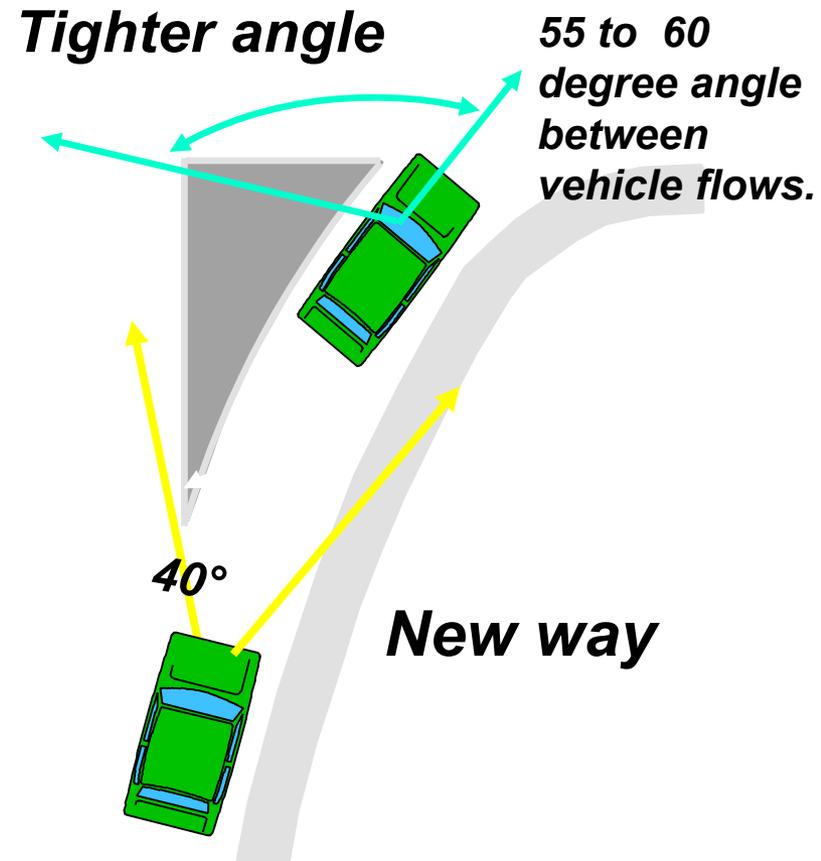
Effective Curb Radius



Right-Turn Slip Lane: Design for Pedestrians



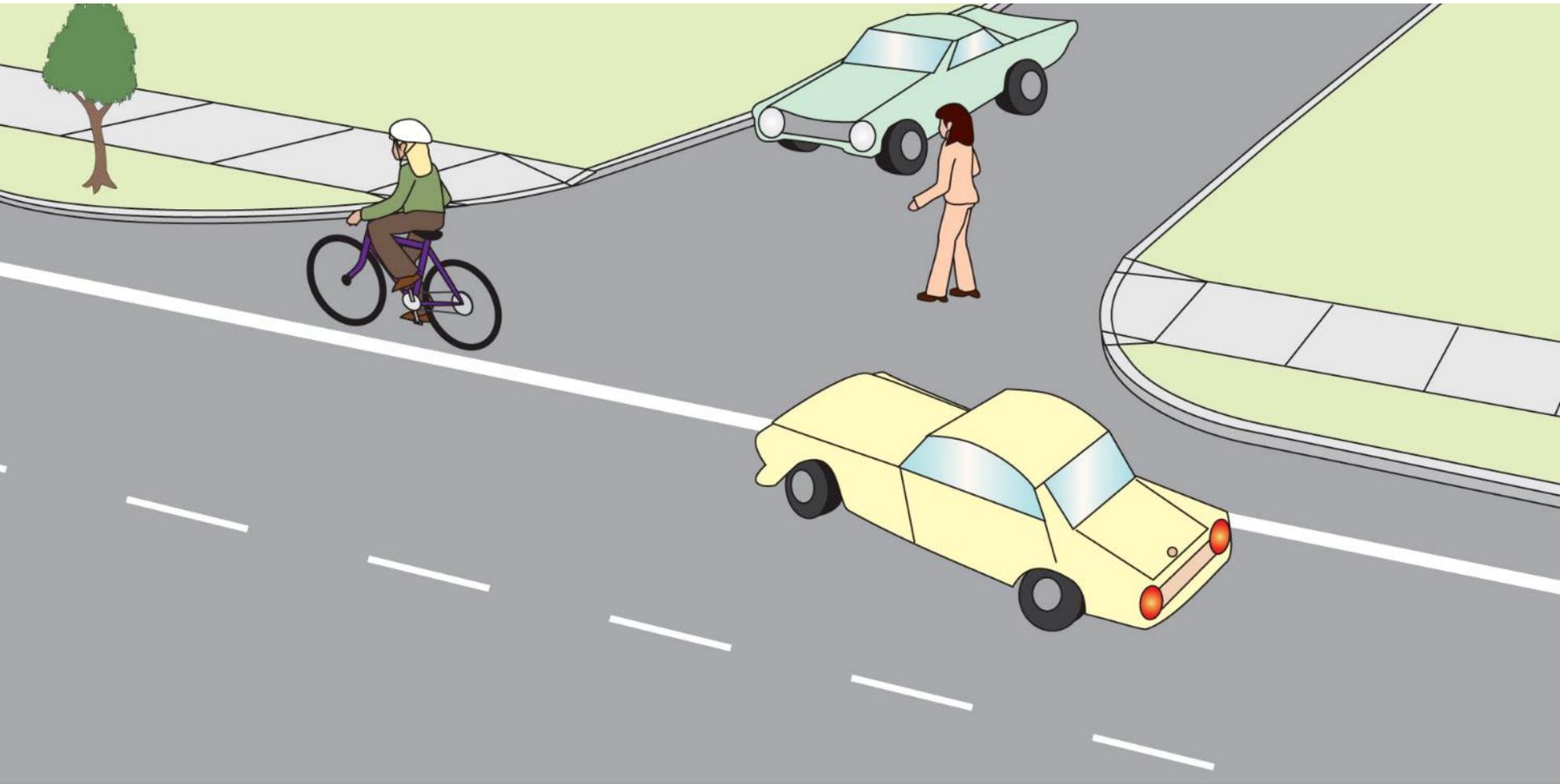
**High speed, head turner =
low visibility of pedestrians**



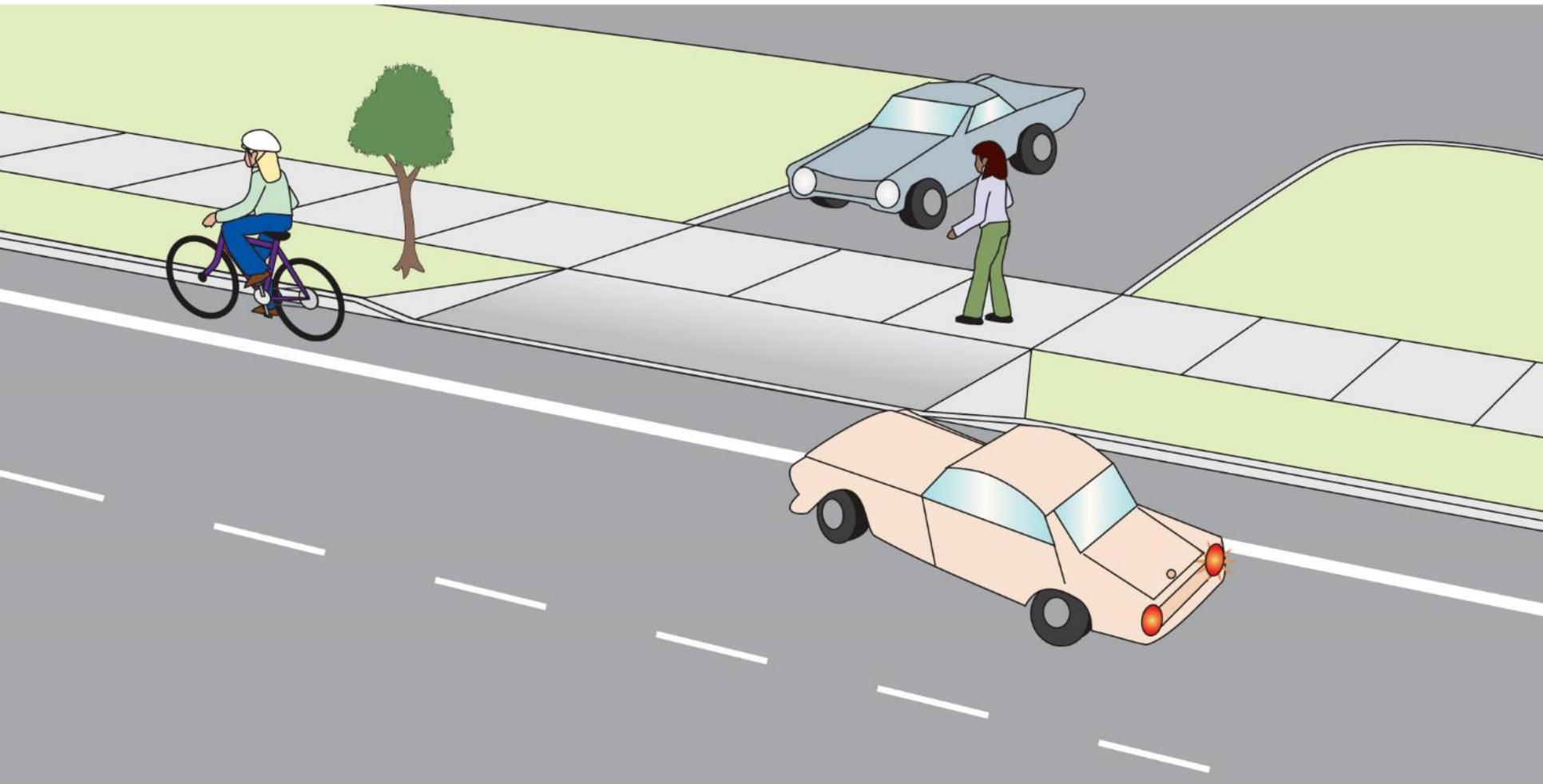
**Slow speed, good angle =
good visibility of pedestrians**

Minimize Curb Radius w/Truck Apron





Driveways built like intersections encourage high-speed turns



Driveways built like driveways encourage slow-speed turns



Reno NV

- This driveway was built like an intersection
- Driver exits at high speed, not looking at pedestrians



Santa Monica, CA

This driveway tells drivers watch for pedestrians



Raised Crosswalk

- May be appropriate for roads with:
- Two or three lanes
- Speed limits of 30 mph or less
- AADT below 9,000

Raised Crosswalk

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COUNTERMEASURE TECH SHEET



W11-2, W16-7P
R1-64

Local and collector roads with high speeds pose a significant challenge for pedestrians crossing the roadway.

A raised crosswalk can reduce vehicle speeds and enhance the pedestrian crossing environment.

.....

Raised crosswalks can reduce pedestrian crashes by **45%**



.....

FEATURES:

- Elevated crossing makes the pedestrian more prominent in the driver's field of vision, and allows pedestrians to cross at grade with the sidewalk
- Approach ramps may reduce vehicle speeds and improve motorist yielding

OFTEN USED WITH:

- Crosswalk visibility enhancements

Raised crosswalks are ramped speed tables spanning the entire width of the roadway, often placed at midblock crossing locations. The crosswalk is demarcated with paint and/or special paving materials. These crosswalks act as traffic-calming measures that allow the pedestrian to cross at grade with the sidewalk.

In addition to their use on local and collector streets, raised crosswalks can be installed in campus settings, shopping centers, and pick-up/drop-off zones (e.g., airports, schools, transit centers).

Raised crosswalks are flush with the height of the sidewalk. The crosswalk table is typically at least 10 feet wide and designed to allow the front and rear wheels of a passenger vehicle to be on top of the table at the same time. Detectable warnings (truncated domes) and curb ramps are installed at the street edge for pedestrians with impaired vision.

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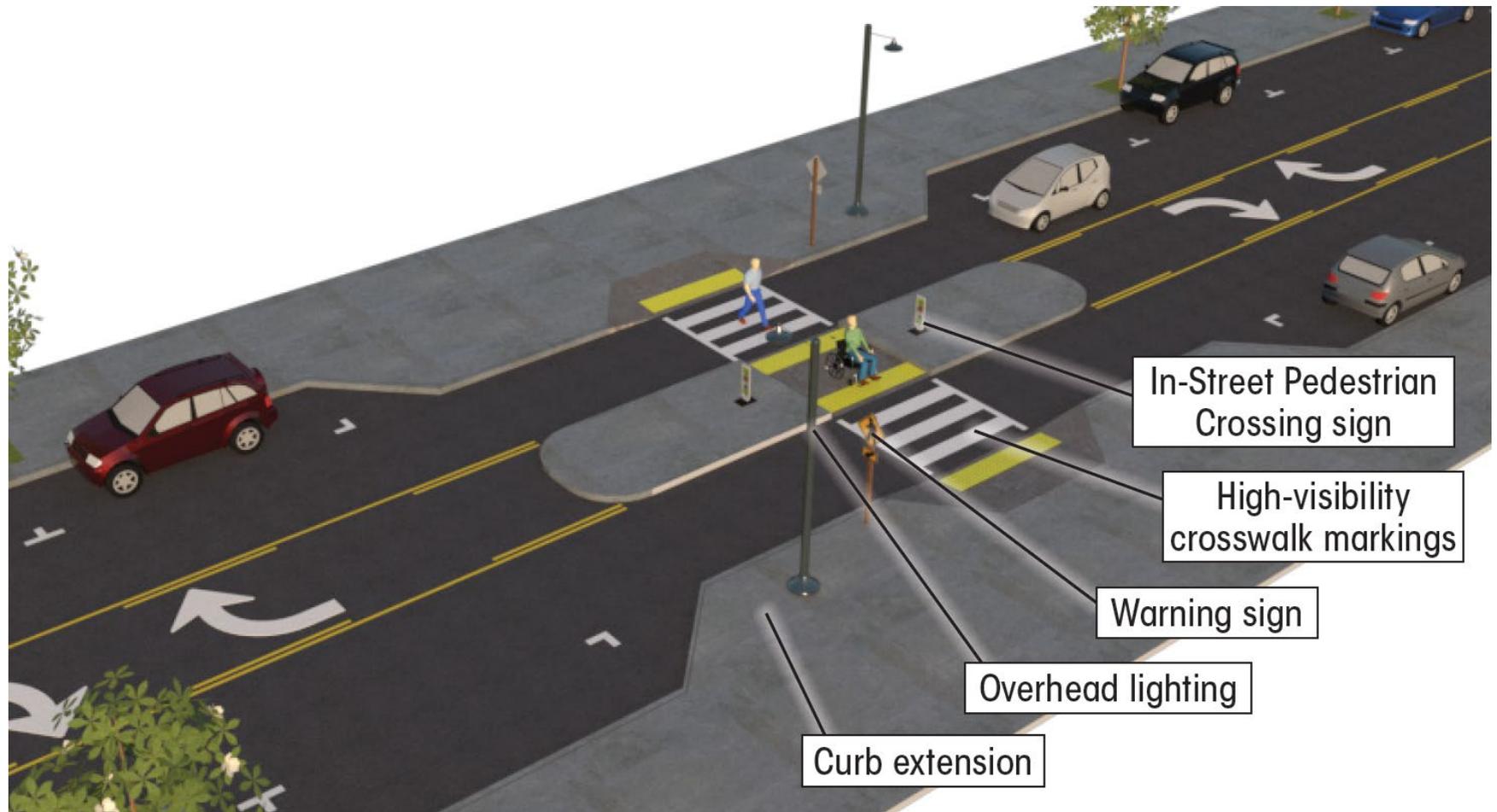
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every day counts



Figure 3.14.4. Raised Crosswalk at Intersection
(Source: City of Cambridge, Massachusetts)

Pedestrian Refuge Islands



Pedestrian Refuge Islands



Rectangular Rapid Flashing Beacon

Rectangular Rapid-Flashing Beacon (RRFB)

SAFE TRANSPORTATION FOR EVERY PEDESTRIAN
COUNTERMEASURE TECH SHEET



An RRFB is a pedestrian-actuated conspicuity enhancement used in combination with a pedestrian crossing warning sign to improve safety at uncontrolled crossing locations. The device includes two rectangular-shaped yellow indications, each with an LED-array-based light source, that flash with high frequency when activated.

The RRFB is a treatment option at many types of established pedestrian crossings. For example, an RRFB may be a consideration for crossings of 2 or more lanes with speed limits of 35 mph or above and/or at crossings of 3 or more lanes with any speed limits. However, for high-speed roads (40 mph or greater) combined with high vehicle volumes (annual average daily traffic of 15,000 and above) and/or certain combinations of high-volume and high-speed, the RRFB may not be sufficient, and a Pedestrian Hybrid Beacon is likely a better option.

 High speeds and multiple lanes of traffic create challenges for pedestrians crossing at unsignalized locations.

 RRFBs can make crosswalks and/or pedestrians more visible at a marked crosswalk.

RRFBs can reduce pedestrian crashes by **47%**



FEATURES:

- Enhanced warning improves motorist yielding

OFTEN USED WITH:

- Crosswalk visibility enhancements
- Pedestrian refuge island
- Advance STOP or YIELD markings and signs





St. Petersburg FL

IA-21 3.a For any approach two RRFB required, One on right-hand and one on left-hand of roadway. If divided highway left-hand should be installed on median if practical rather than far left-hand.

Pedestrian Hybrid Beacons (PHB)

Pedestrian Hybrid Beacon (PHB)



A Pedestrian Hybrid Beacon head consists of two red lenses above a single yellow lens. Unlike a traffic signal, the PHB rests in dark until a pedestrian activates it via pushbutton or other form of detection. When activated, the beacon displays a sequence of flashing and solid lights that indicate the pedestrian walk interval and when it is safe for drivers to proceed (see figure on back page).

The PHB is often considered for installation at locations where pedestrians need to cross and vehicle speeds or volumes are high, but traffic signal warrants are not met. These devices have been successfully used at school crossings, parks, senior centers, and other pedestrian crossings on multilane streets. PHBs are typically installed at the side of the road or on mast arms over midblock pedestrian crossings.

SAFE TRANSPORTATION FOR EVERY PEDESTRIAN
COUNTERMEASURE TECH SHEET

⚠️ High speeds and multiple lanes of traffic create challenges for pedestrians crossing at unsignalized locations.

💡 PHBs can warn and control traffic at unsignalized locations and assist pedestrians in crossing a street or highway at a marked crosswalk.

PHBs can reduce pedestrian crashes by 55%

FEATURES:

- Beacons stop all lanes of traffic, which can reduce pedestrian crashes.

OFTEN USED WITH:

- High-visibility crosswalk markings
- Raised islands
- Advance STOP or YIELD signs and markings





Pedestrian Hybrid Beacon (PHB)
EDC-4 STEP: https://www.ftwa.dot.gov/innovation/everydaycounts/edc_4/step.cfm



Pedestrian Hybrid Beacons (PHB)



CRF: Vehicle/Pedestrian 69%



1
Blank for drivers



2
Flashing yellow



3
Steady yellow



4
Steady red



5
Wig-Wag

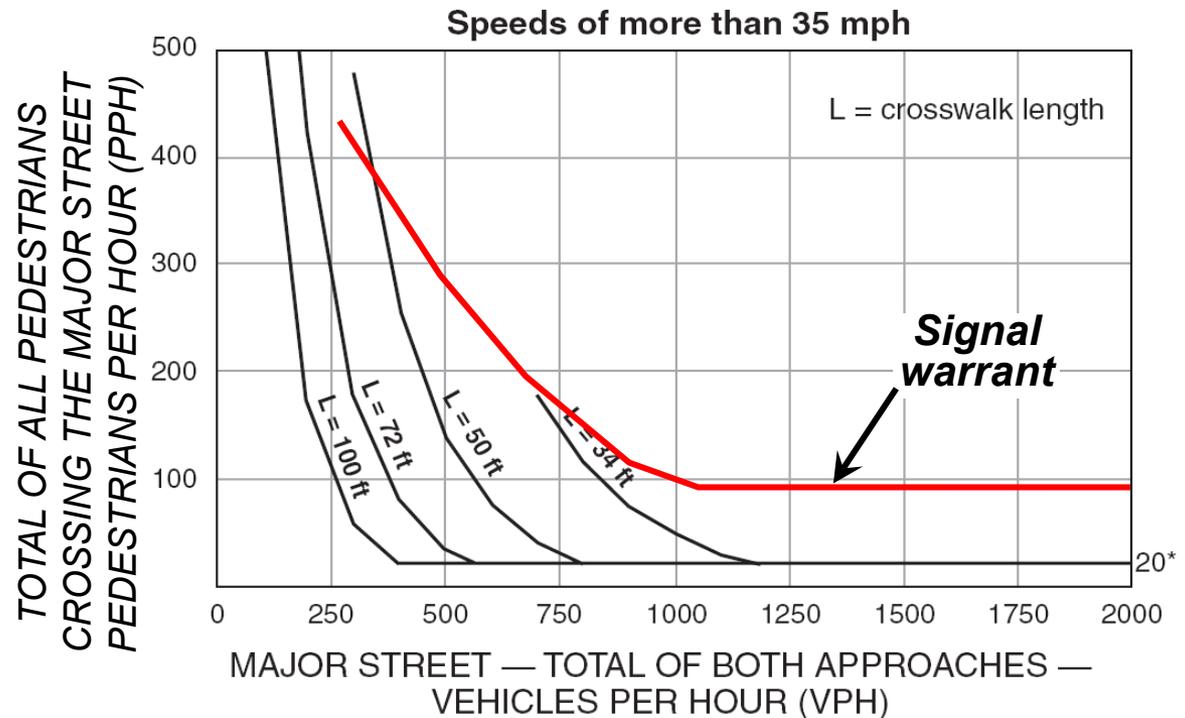


Return to 1



Excerpts from 2009 MUTCD Chapter 4F For Pedestrian Hybrid Beacons

- The CROSSWALK STOP ON RED sign shall be used
- There are **Guidelines** (similar to signal warrants) for Pedestrian Hybrid Beacons – variables include:
 - Pedestrian volume
 - Traffic speeds
 - Traffic volumes
 - Crosswalk length



93

2009 MUTCD mandated sign

- Standard:
A CROSSWALK STOP ON RED (symbolic circular red) (R10-23) sign shall be mounted adjacent to a PHB face on each major street approach.
- Option:
 - State MUTCD's may allow other appropriate MUTCD approved ped, bike or school crossing signs



Optional Signing

Courtesy: City of Columbus



Road Diet / Roadway Reconfiguration / Road Buffet



Before



After

Road Diet

SAFE TRANSPORTATION FOR EVERY PEDESTRIAN
COUNTERMEASURE TECH SHEET

Multilane roads can take longer to cross and vehicle speeds may be high.

Road Diets can decrease the lane crossing distance and reduce vehicle speeds.

Road Diets can reduce total crashes by **19-47%***

*19% in urban areas, 47% in suburban areas.

FEATURES:

- Reduced crossing distance and exposure.
- Reduced vehicle speeds.
- Promote Complete Streets.
- Provide space for installing curb extensions and widening sidewalks.
- Create space for bicycle, transit, and/or parking lanes.

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Before



Charlotte NC

Reclaiming road space creates room for ped islands

After



Charlotte NC

Reclaiming road space creates room for ped islands

Intersections

- Signal timing or phasing changes at intersections to optimize operations and safety benefits
- Roundabouts Single Lane
 - ~ 20,000 ADT



Before and After Example

8-42

Asheville NC



Before and After Example

Asheville NC



FHWA Perspective in Summary

1-44

- Yes the speed of a vehicle can determine if a pedestrian who is hit lives or dies.
- Yes infrastructure can make a difference in the speed of vehicles
- Yes we can design roads that move vehicles but doesn't kill pedestrians

Contact Information

Peter Eun

- FHWA Resource Center Safety & Design TST
- Located: Olympia WA
- Transportation Safety Engineer
- peter.eun@dot.gov
- 360-328-3044