Designing for Pedestrian Safety

Building it better

2022

SAN MATEO COUNTY Transportation Authority

alta

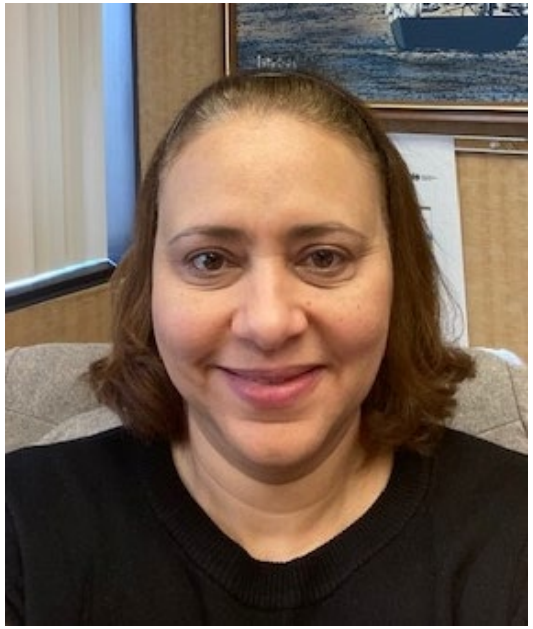
Agenda

- Welcome
- Introductions
- Why are we here?
- Pedestrian Training
  - Accessibility & Universal Design
  - Crossing the Street
  - Intersection Geometry
  - Signalized Intersections
- Funding Pedestrian Projects
- Q&A throughout!

For Participants:

- Be ready to answer questions on your computer for live Zoom polls
- Turn off background apps, email, and silence phone
- **Raise your hand to ask questions throughout!**
- The presentation will be recorded and available upon request

Introductions



Heba El-Guindy
SMCTA
Deputy Director

Joe Gilpin
Alta Planning and Design
Principal

Patrick Gilster
SMCTA
Manager of Programming
& Monitoring

Introduce yourself to us by adding your name, organization, and email into the chat!

WHY ARE WE HERE?

Transportation Authority

The San Mateo County Transportation Authority (TA) manages the voter approved Measure A & Measure W sales taxes that fund various types of transportation improvements. The TA is striving to better incorporate Complete Streets across all our programs.

Highways | Local Streets and Roads | Grade Separations | Transit | Pedestrian and Bicycle | Transportation Demand Management

Objectives

1. Improve Pedestrian Safety with a Focus in this Presentation on Infrastructure Projects
2. Increase Pedestrian/Walking Modal Share and Improve Access and Connectivity to Transit and Land Uses
3. Enhance Accessibility to Meet ADA Requirements
4. Improve Roadway Comfort and Sense of Security with Best Practice Design and Operational Principles
5. Create Competitive Multimodal Projects! (end of training)

ISSUES & CONCERNS

Safety – San Mateo County (Pedestrians)

1,242
Crashes Involving Pedestrians

52
Fatalities
1,297
Injuries

20%
Result in a fatal or life altering injury

20%
Occurred on State Highways

32%
Occurred at Night

3
Root Causes

Totalling **78%** of Crashes

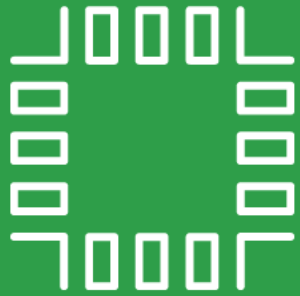
- Failure to Yield by Driver
- Pedestrian Violation
- Unsafe Speed

Data 2014-2018: Source San Mateo County Comprehensive Bicycle and Pedestrian Master Plan Update

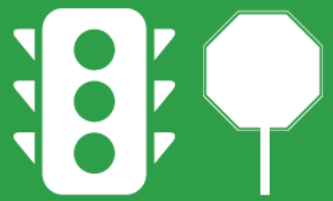
Safety – San Mateo County (Pedestrians)

52%
Occurred in Intersections

52%
Occurred in a Crosswalk in an Intersection



34%
Occurred in controlled Intersection



21%
Occurred When Crossing Outside of a Crosswalk

Data 2014-2018: Source San Mateo County Comprehensive Bicycle and Pedestrian Master Plan Update

Improve Pedestrian Safety

Countermeasure	All Crashes	Pedestrian Crashes
Along the Road		
Provision of Shoulders on Roadway		71%
Provision of Sidewalks along Roadway		88%
Install Raised Median		25%
Install Raised Pedestrian Crossing	30%	
Narrow Roadway from 4 to 3 lanes (suburban)	29% - 47%	
Add Overhead Lighting		23%
Rectangular Rapid Flashing Beacons		47%
Pedestrian Hybrid Beacon		55%
Signalized Intersections		
Prohibit permitted Left Turns	70%	
High Visibility Crosswalks		48%
Increase Pedestrian Crossing Time		51%
Leading Pedestrian Interval		58%

** Data accessed from the Crash Modification Factors Clearinghouse at www.cmfclearinghouse.org*

How Driver Speed Affects Perception

PERIPHERAL VISION AT 10-15 MPH

How Driver Speed Affects Perception

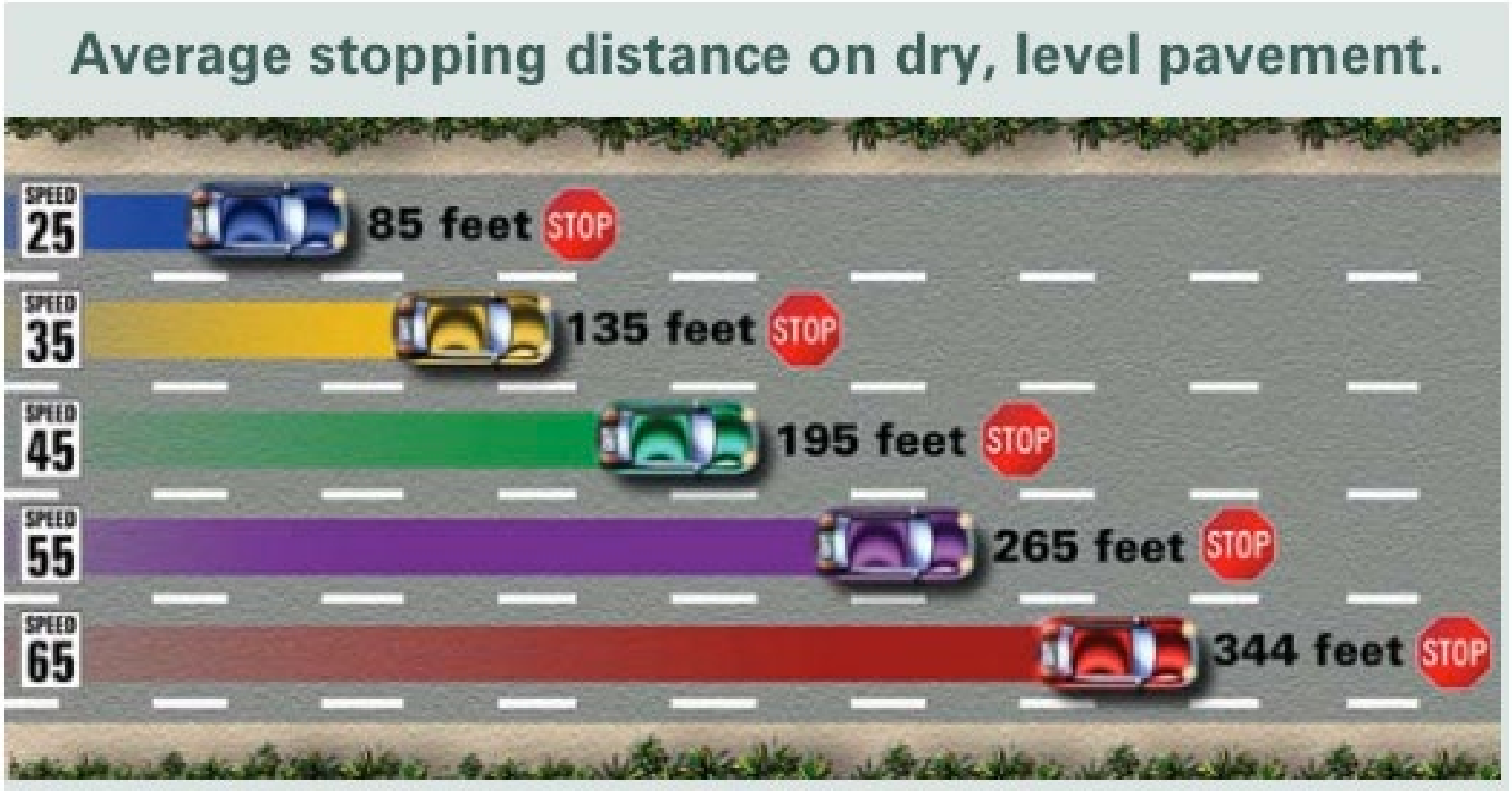
PERIPHERAL VISION AT 20-25 MPH

How Driver Speed Affects Perception

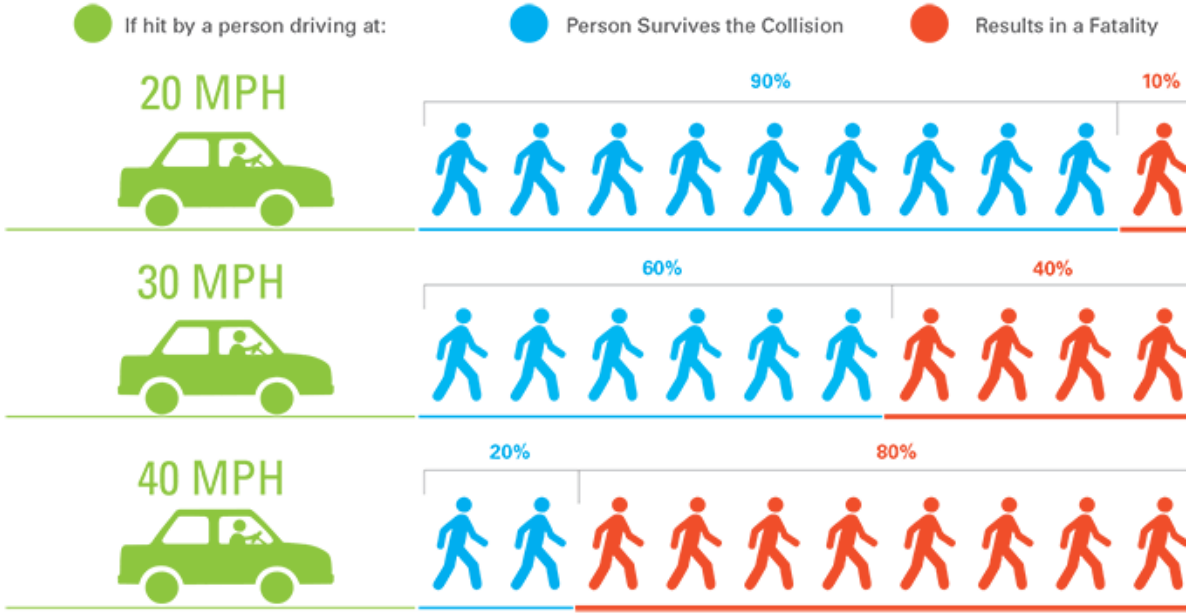
PERIPHERAL VISION AT 30-35 MPH

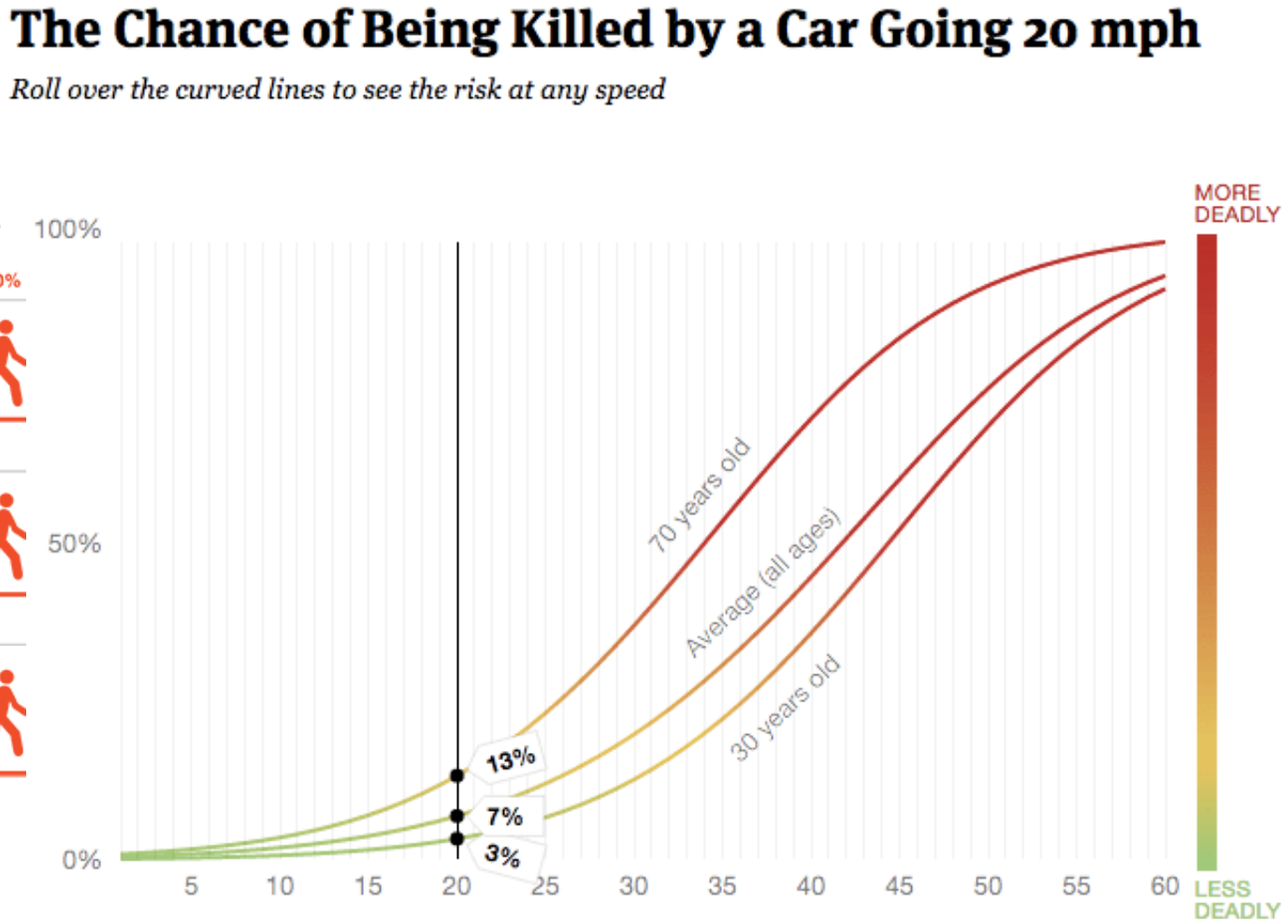
Speed Vs Stopping Distance

Cars travelling faster take longer to stop (Driver's perception-reaction time)



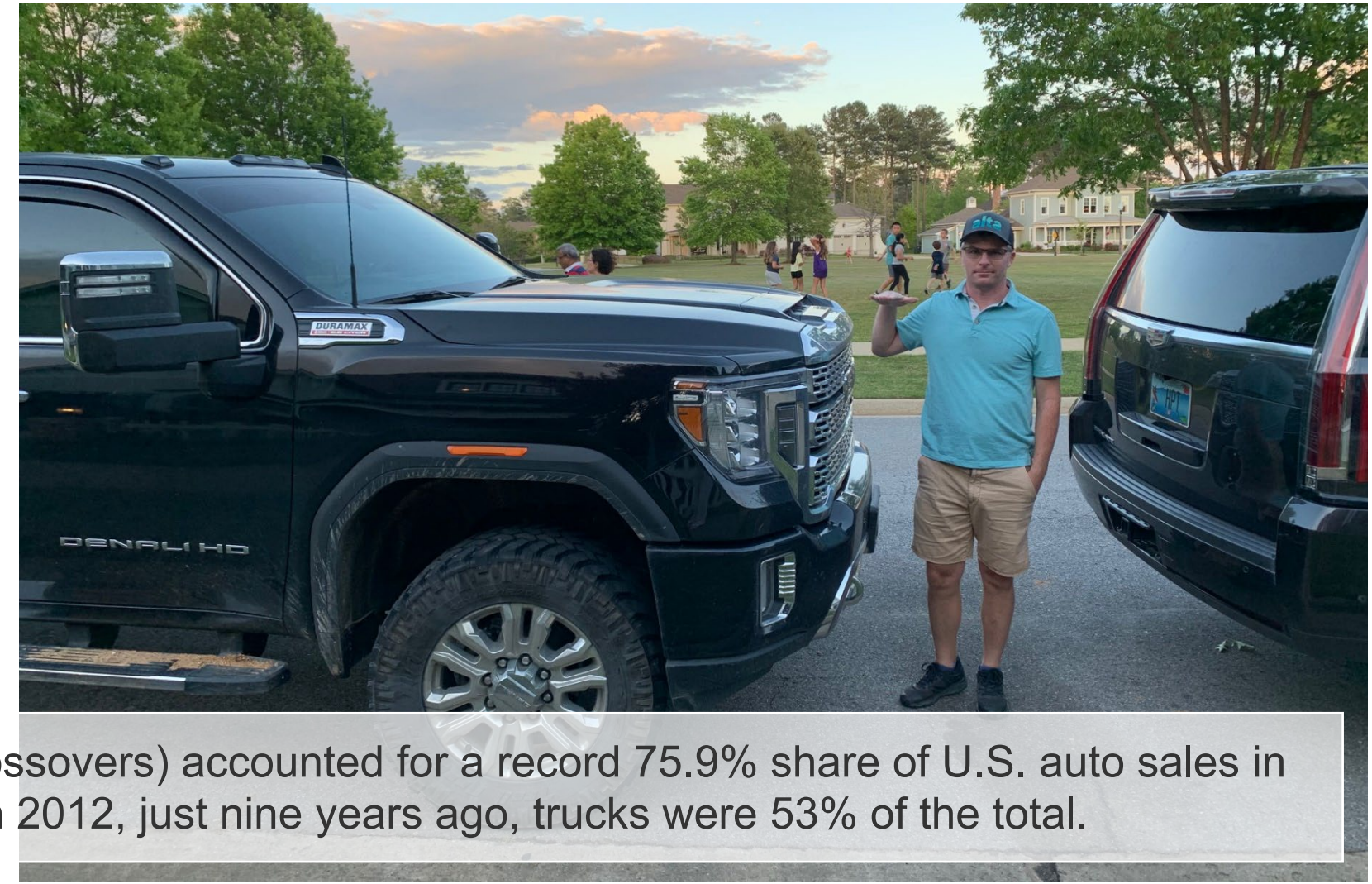
Risk of Pedestrian Fatality in a Collision Relative to Travel Speed





Risk of Pedestrian Fatality in a Collision

- Vehicle size
- Front shape/height
- Vehicle mix
- Infotainment
- Cell phones
- More vehicles!



Light trucks (pickups, SUVs, crossovers) accounted for a record 75.9% share of U.S. auto sales in 2020, up from 71.7% in 2019. In 2012, just nine years ago, trucks were 53% of the total.

Low Pedestrian Comfort

Ped LOS = - 1.2021 ln (Lateral Separation) +

0.253 ln (Vol_{15}/L) + 0.0005 SPD^2 + 5.3876

Where:

Lateral Separation = Effective separation to traffic

Vol_{15} = Average traffic during a 15-minute period

L = Total number of (through) lanes

SPD = Average speed of motor vehicle traffic (mi/hr)

Low Comfort

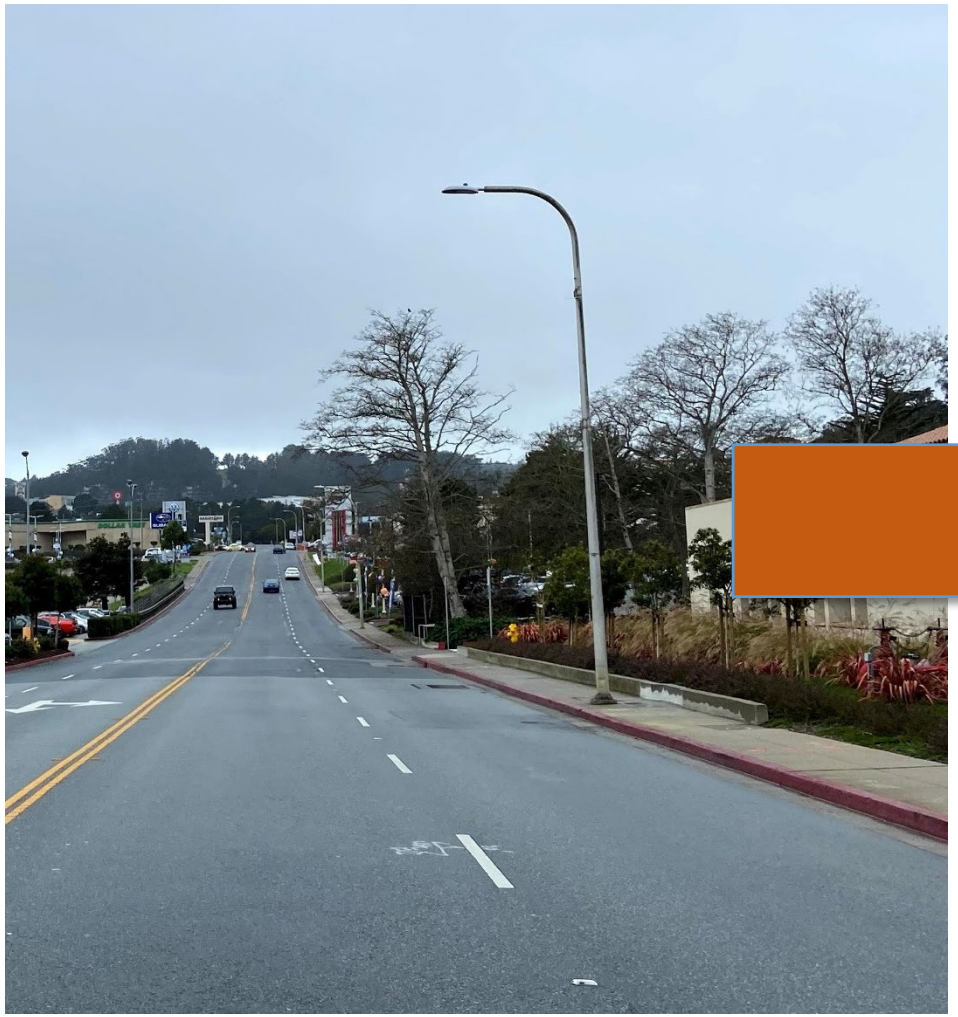
Lateral Separation

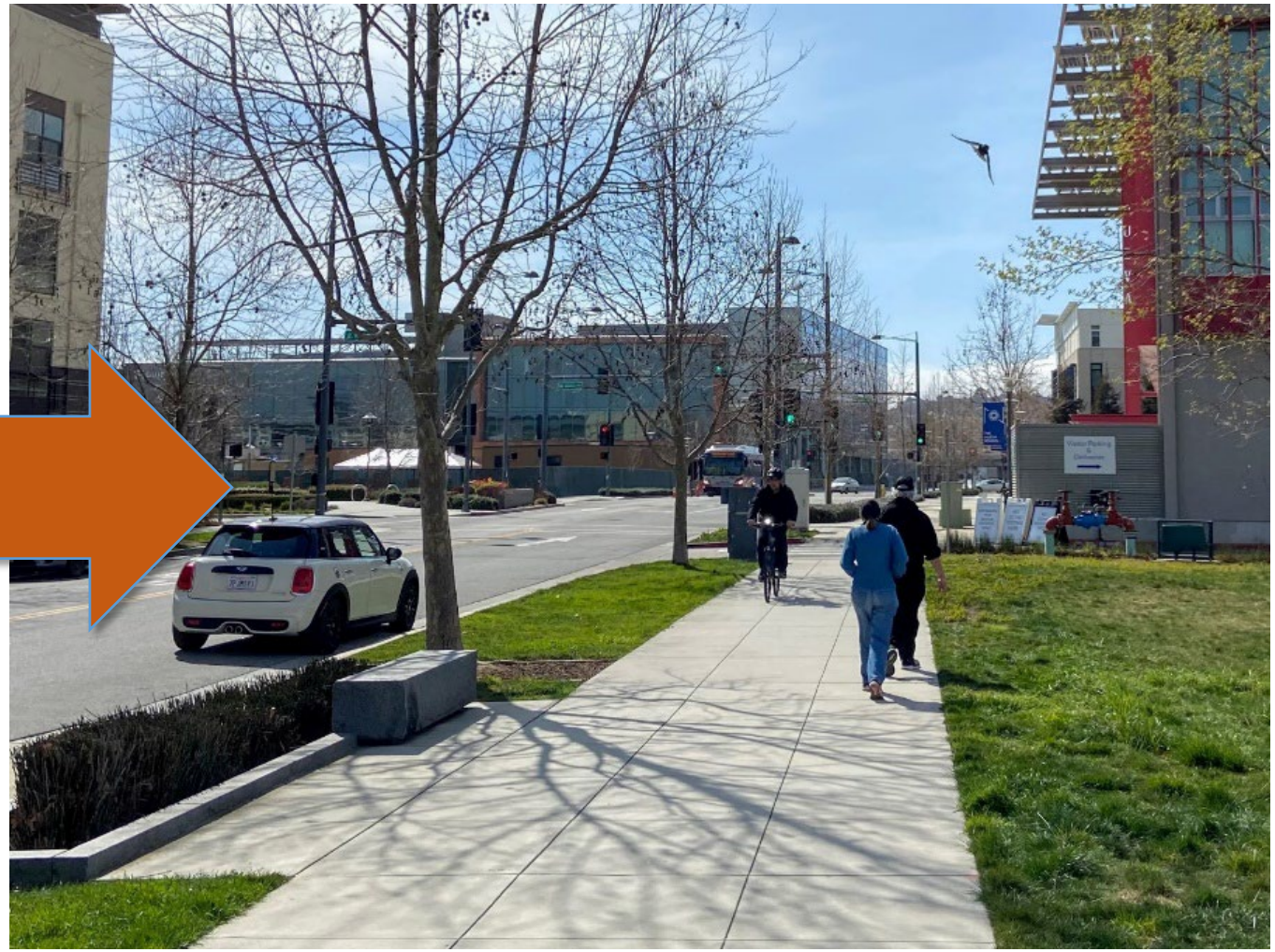
- Width of Outside Lane
- Width of Shoulder or Bike Lane
- Presence of on-street parking
- Buffer Width
- Buffer Objects (like trees, more = better)
- Width of sidewalk
- Presence of adequate lighting

Pedestrians

Vehicles

Improve Roadway Comfort for Pedestrians





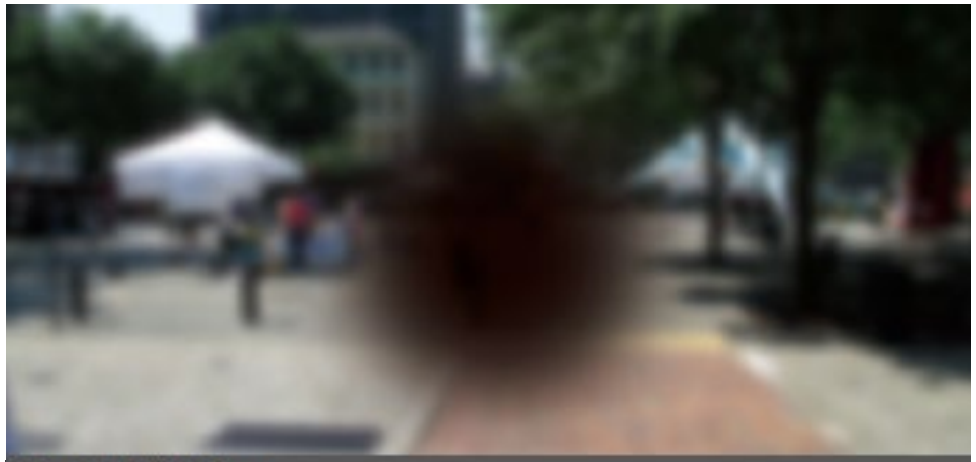
Importance of Accessibility

- 12.5% (2019 ACS – 42 million people)
- 20% (2010 Census, over 51 million people)
- 5% of San Mateo County Residents under 65 (2020 Census)

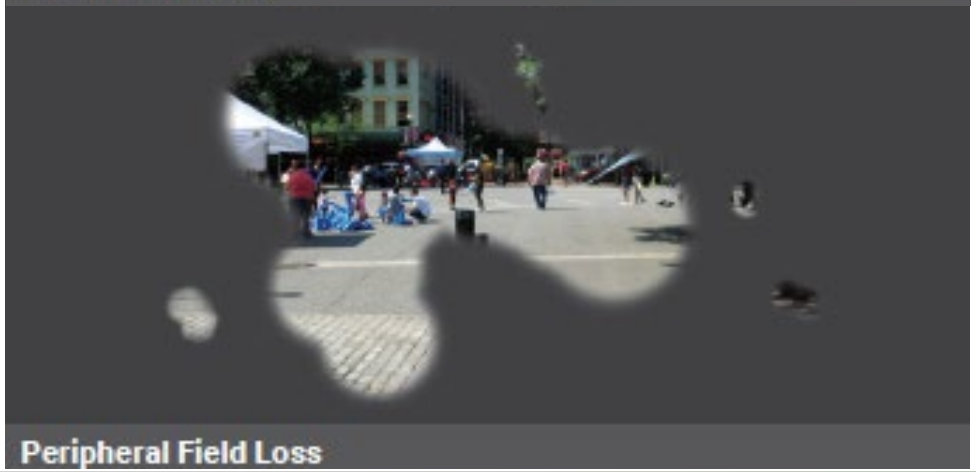
- 70% of Americans will have a temporary or permanent disability at some point in their life

What is Universal Design?

Design for equitable use by people with diverse abilities



Central Field Loss



Peripheral Field Loss

Reduced Visual Acuity

Images – FHWA Accessible Shared Streets

Universal Design Principles

1) **Equitable Use**
   Useful to people with diverse abilities

2) **Flexibility In Use**
   The design accommodates a wide range of individual preferences and abilities

3) **Simple and Intuitive Use**
   Easy to understand regardless of language, abilities, knowledge, or concentration level

4) **Perceptible Information**
   The design communicates information effectively to the user regardless of the user's sensory abilities

5) **Tolerance For Error**
   The design minimizes hazards and the adverse consequences of accidental or unintended actions

6) **Low Physical Effort**
   The design can be used efficiently and comfortably and with a minimum of fatigue

7) **Size and Space For Approach and Use**
   Appropriate size and space is provided for approach and use of facility regardless of user's body size, posture, or mobility

Universal Design Principles

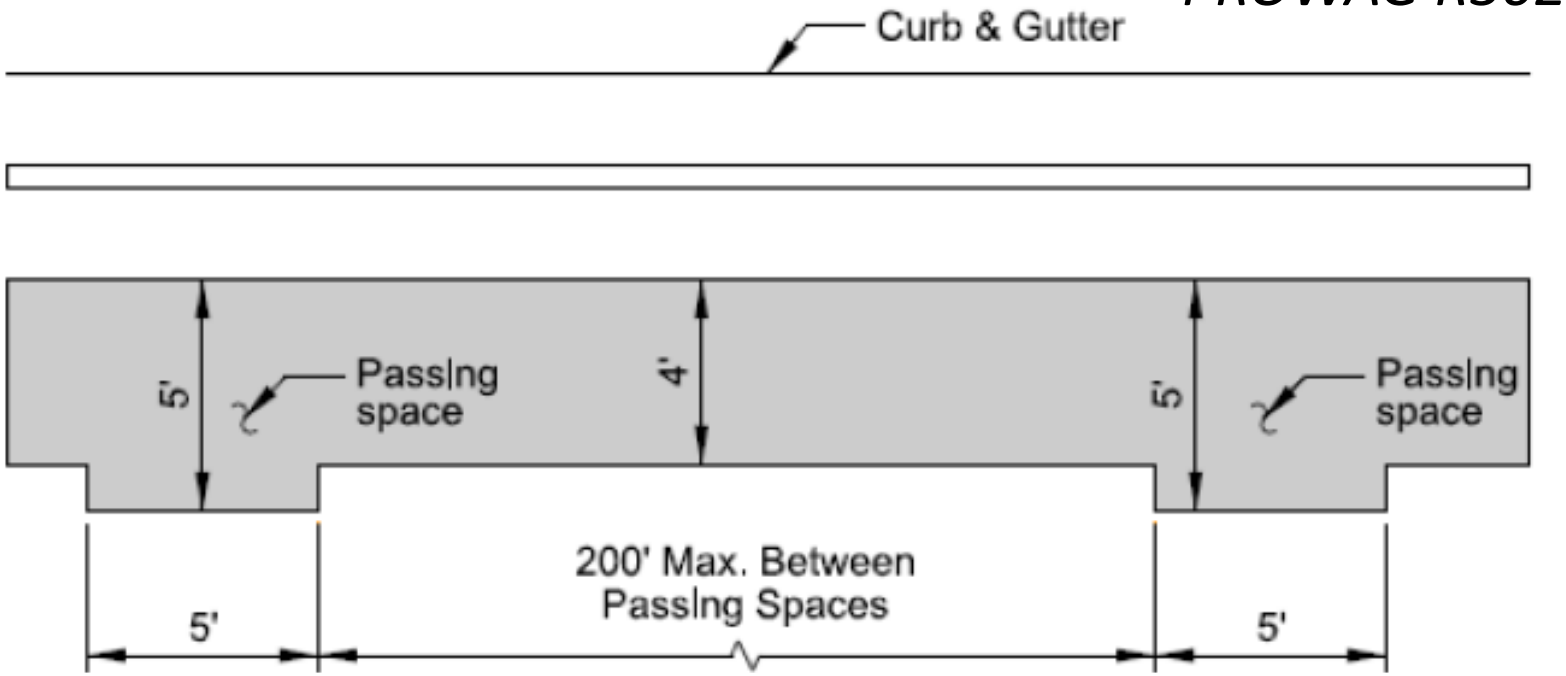
Pedestrian Access Route (PAR) Criteria:

- Continuous Width
- Grades
- Surfaces, Grates
- Vertical Discontinuities
- Protruding Objects
- Curb Ramps

Continuous Width

If an accessible route is less than 60 in. (5 feet) clear width, then passing spaces at least 60 in. by 60 in. shall be located at reasonable intervals, not to exceed 200 ft.

- *PROWAG R302.3*

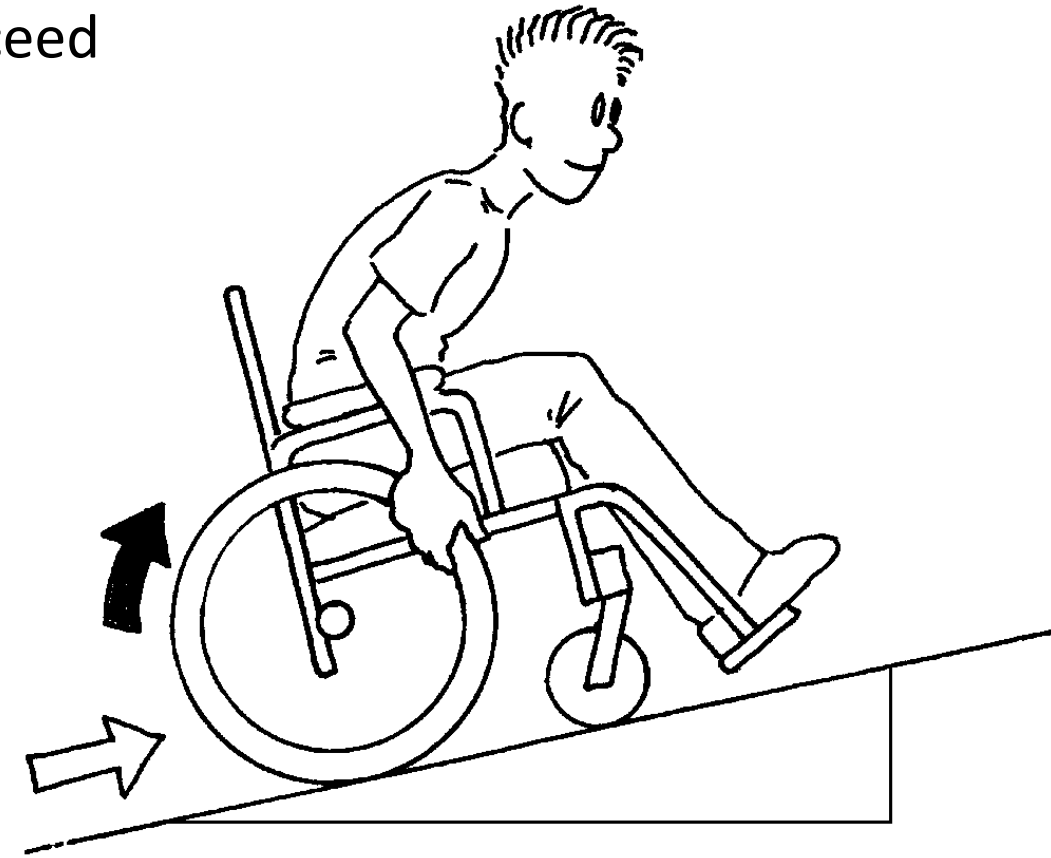


Grades - Running

PAR's contained within a highway R.O.W., shall not exceed the general grade of the adjacent highway

PAR's not contained within the R.O.W shall be 5% MAX.

- PROWAG R302.5



Designing Sidewalks and Trails for Access, FHWA, 2001

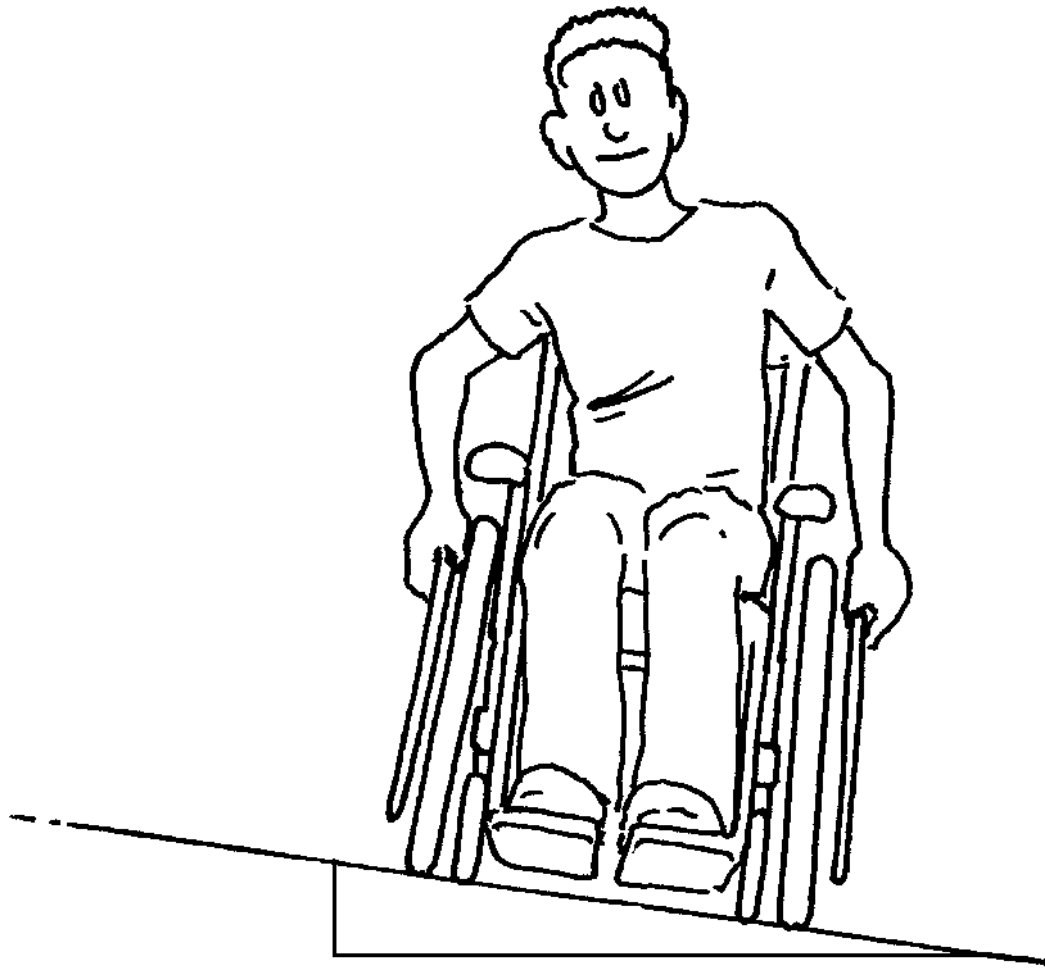
Grades – Cross Slope

Generally, 2 % MAX.

Exceptions:

- Street crossings w/o yield or stop control
- Midblock crossings

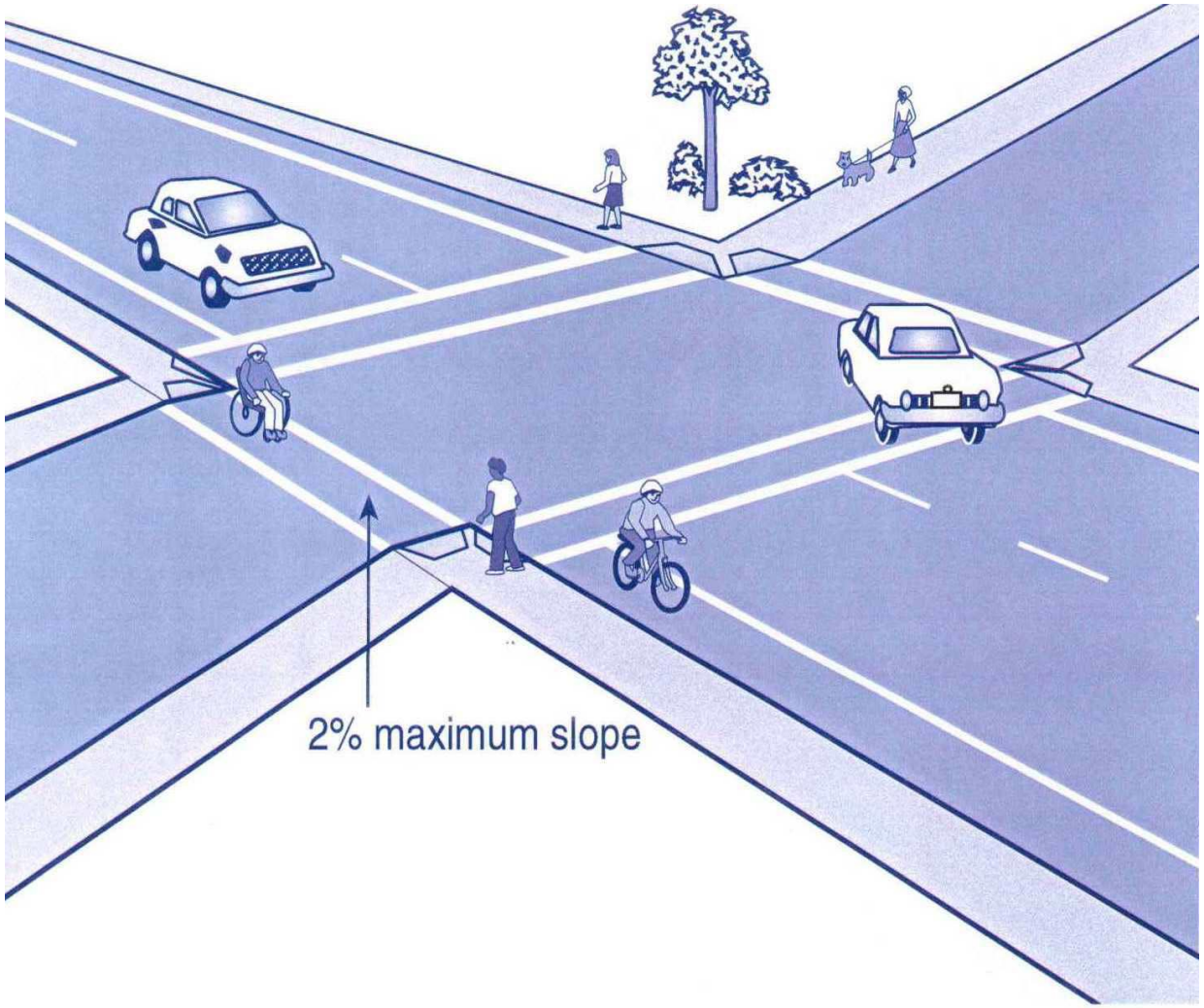
Question: Should we design to 2%?



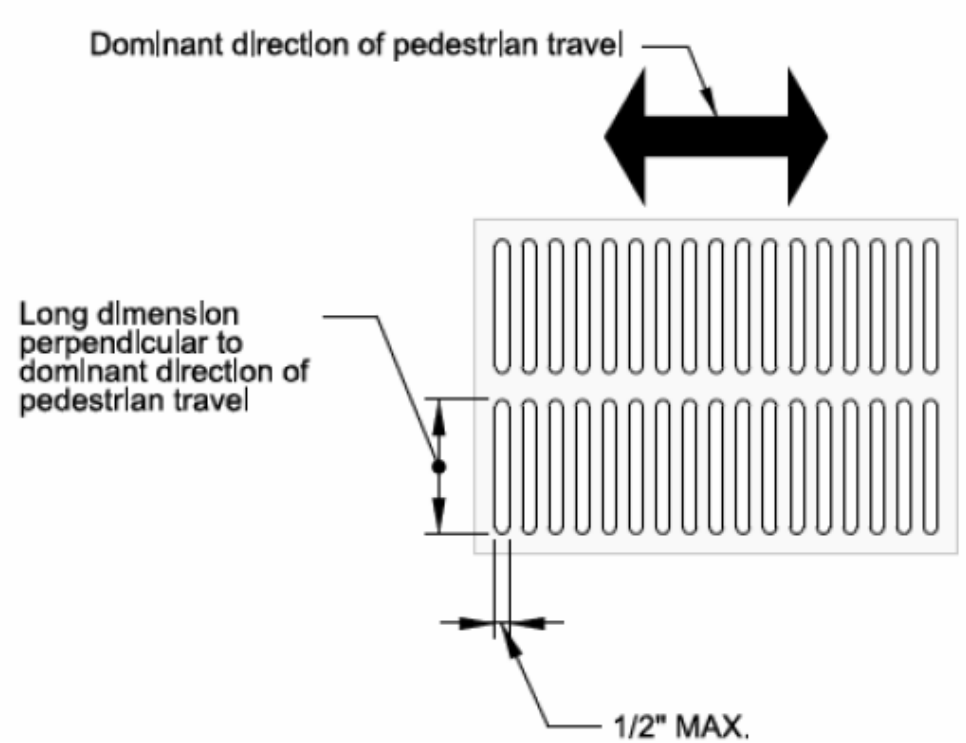
Designing Sidewalks and Trails for Access, FHWA, 2001

Grades – Cross Slope

What about crosswalks?

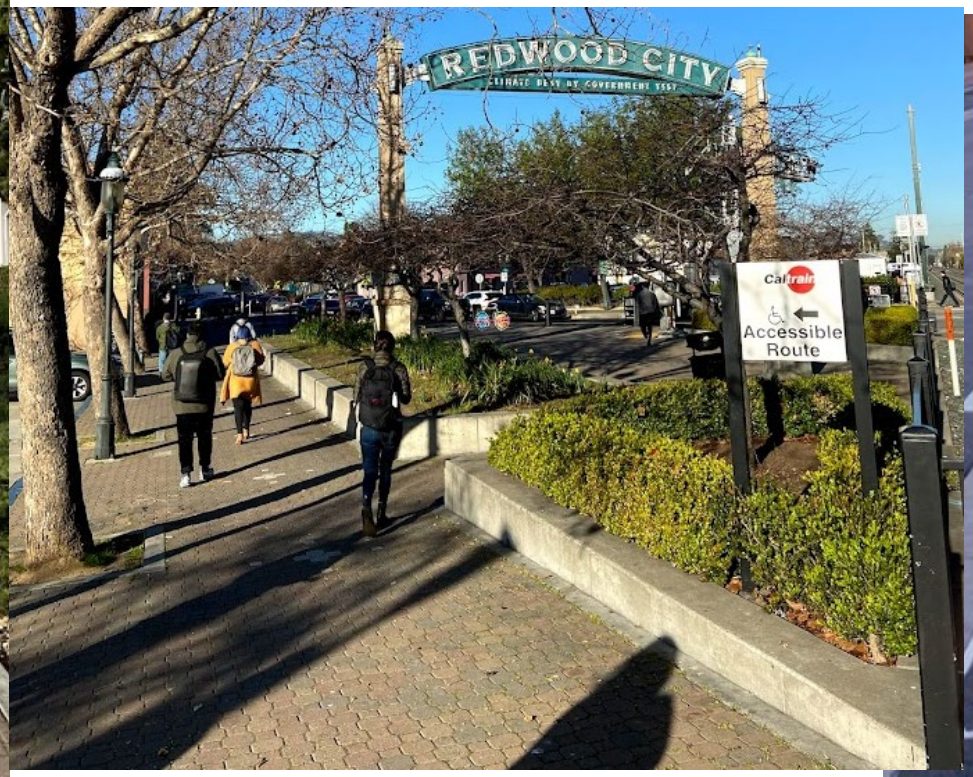


Surfaces – Gaps/Openings



R302.7.3 Horizontal Openings - . . . Shall not permit passage of a sphere no more than 0.5 in. Elongated openings shall be placed so the long dimension is perpendicular to the dominate direction of travel.

Surfaces – Pavement Type

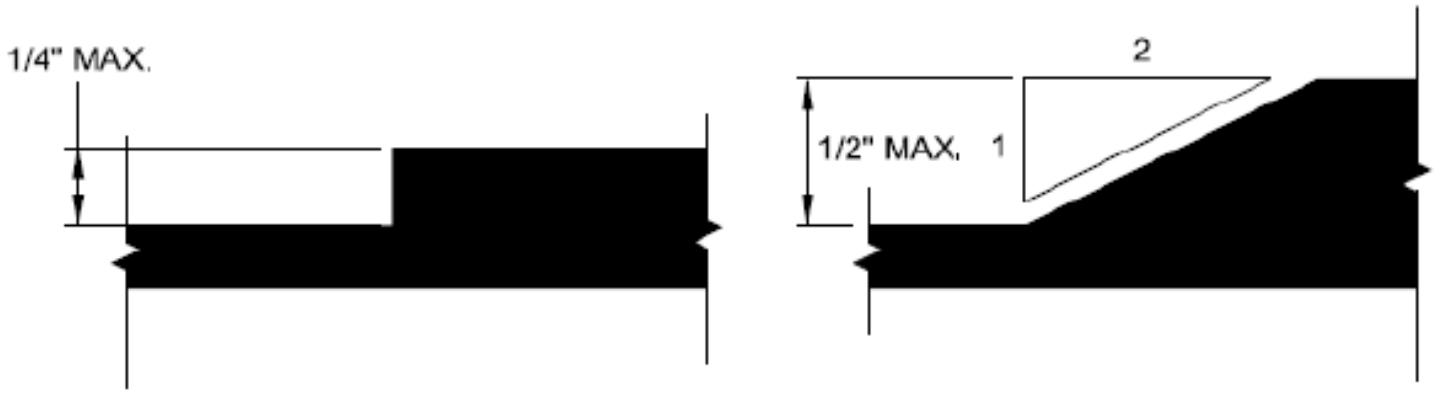


Sidewalk surfaces shall be firm, stable, and slip resistant. **Concrete sidewalks shall have a broom finish to increase skid resistance**

Surfaces – Crosswalks Too!

Sidewalk surfaces shall be firm, stable, and slip resistant. **Concrete sidewalks shall have a broom finish to increase skid resistance**

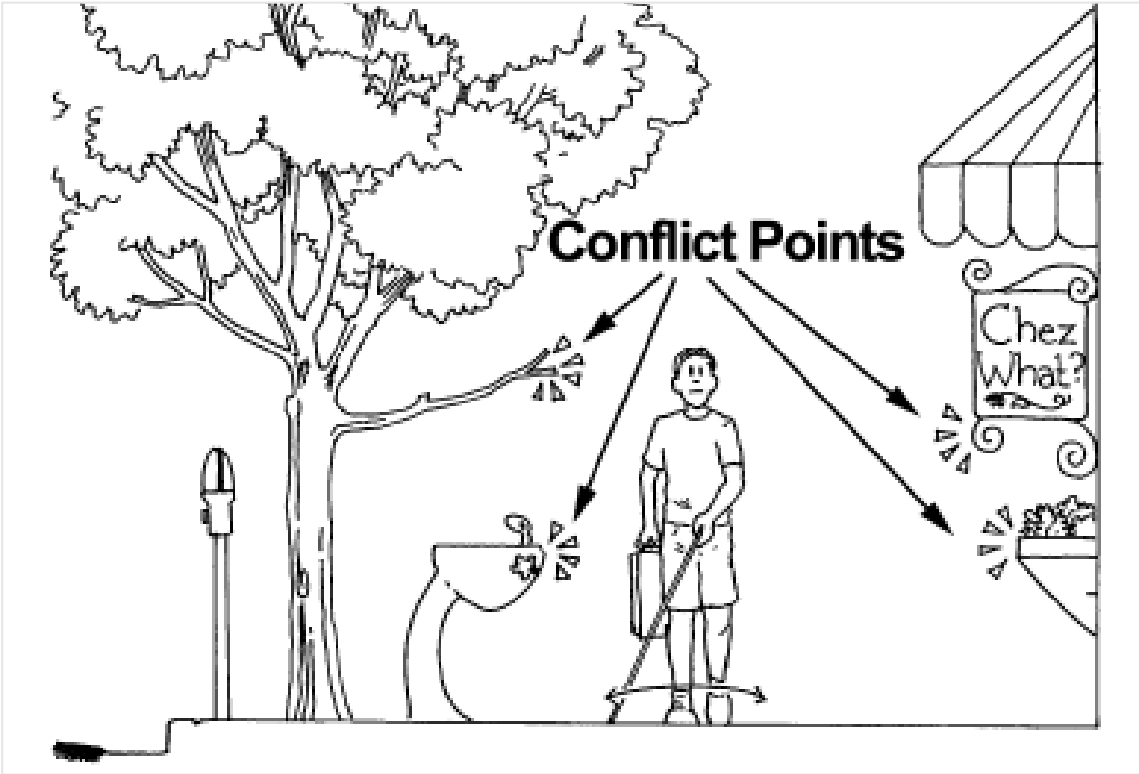
Vertical Discontinuities



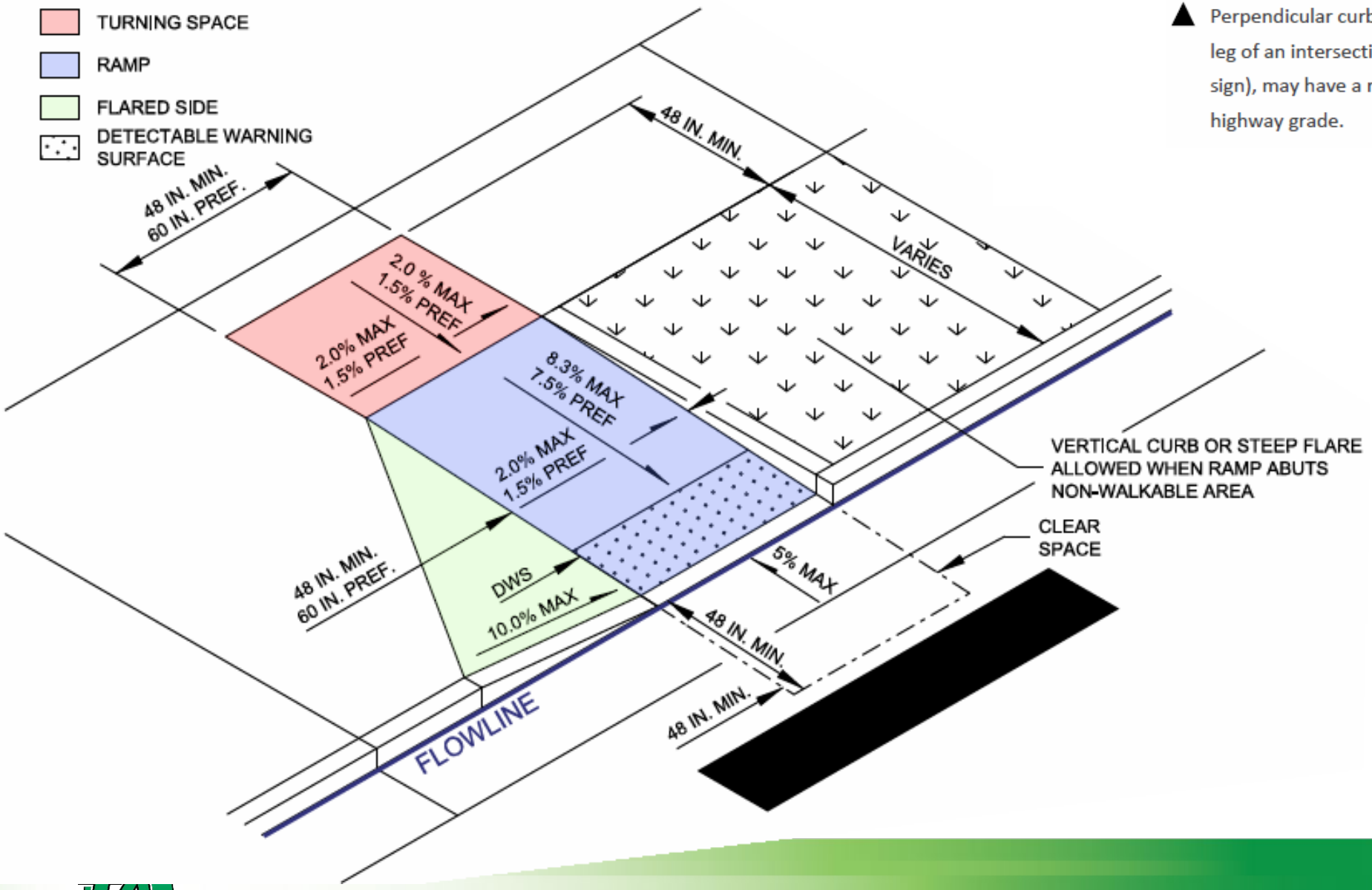
R302.7.2 Vertical Surface Discontinuities – Vertical surface discontinuities shall be 0.5 in. maximum. Vertical surface discontinuities between 0.25 in. and 0.5 in shall be beveled . . .

Protruding Objects

R402.2– Objects with leading edges more than (2.25 ft /27 in) and not more than (6.7 ft/80 in) above the finish surface shall protrude (4 in) maximum horizontally into pedestrian circulation paths.

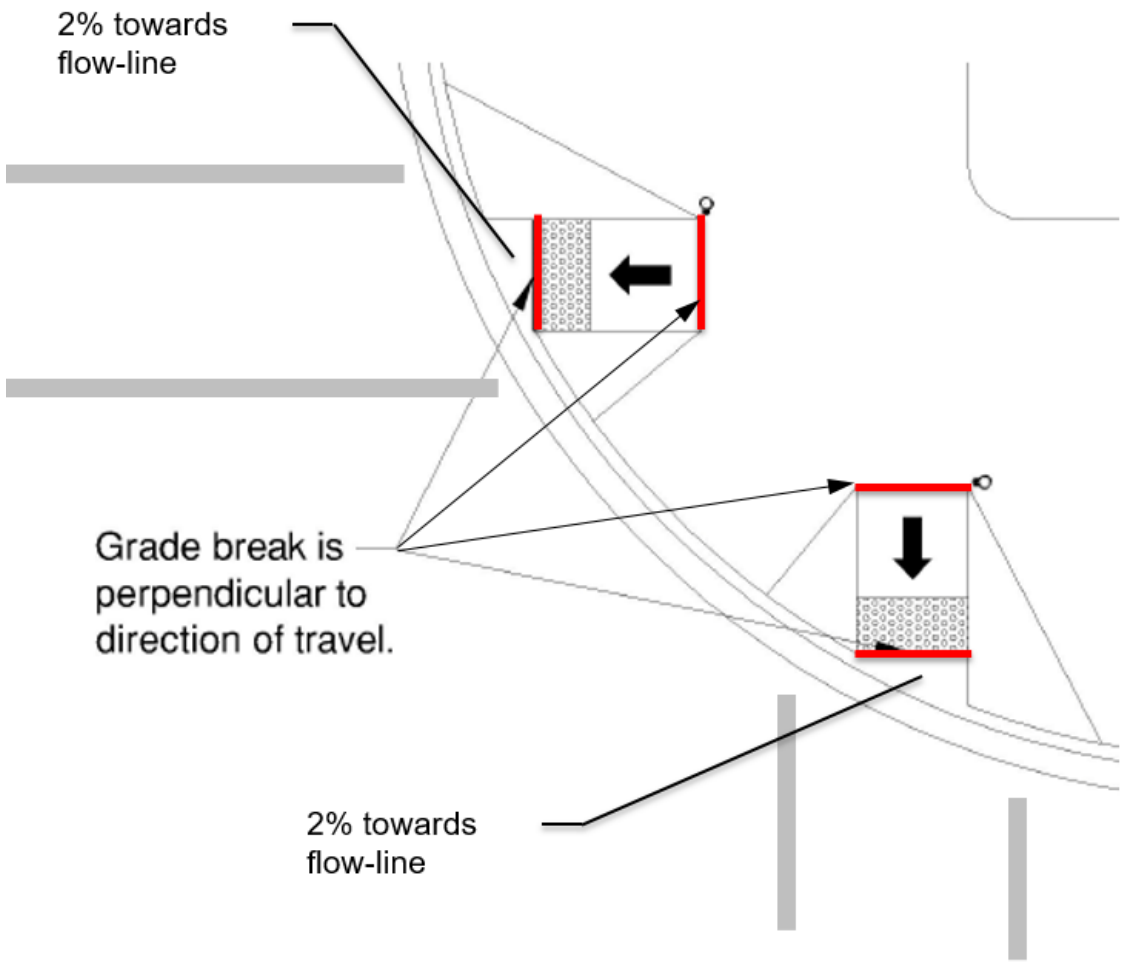


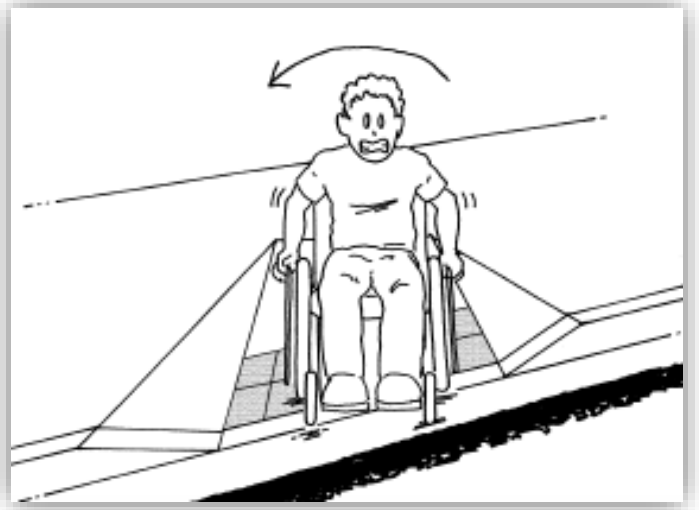
Curb Ramps - Perpendicular

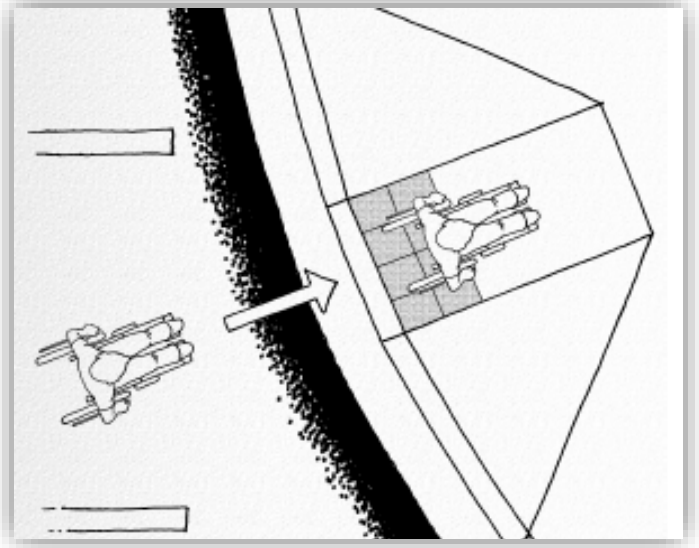


▲ Perpendicular curb ramps at a mid-block crossing, or crossing a leg of an intersection without stop control (yield sign, or stop sign), may have a ramp and turning space that equal the highway grade.

Curb Ramps - Perpendicular

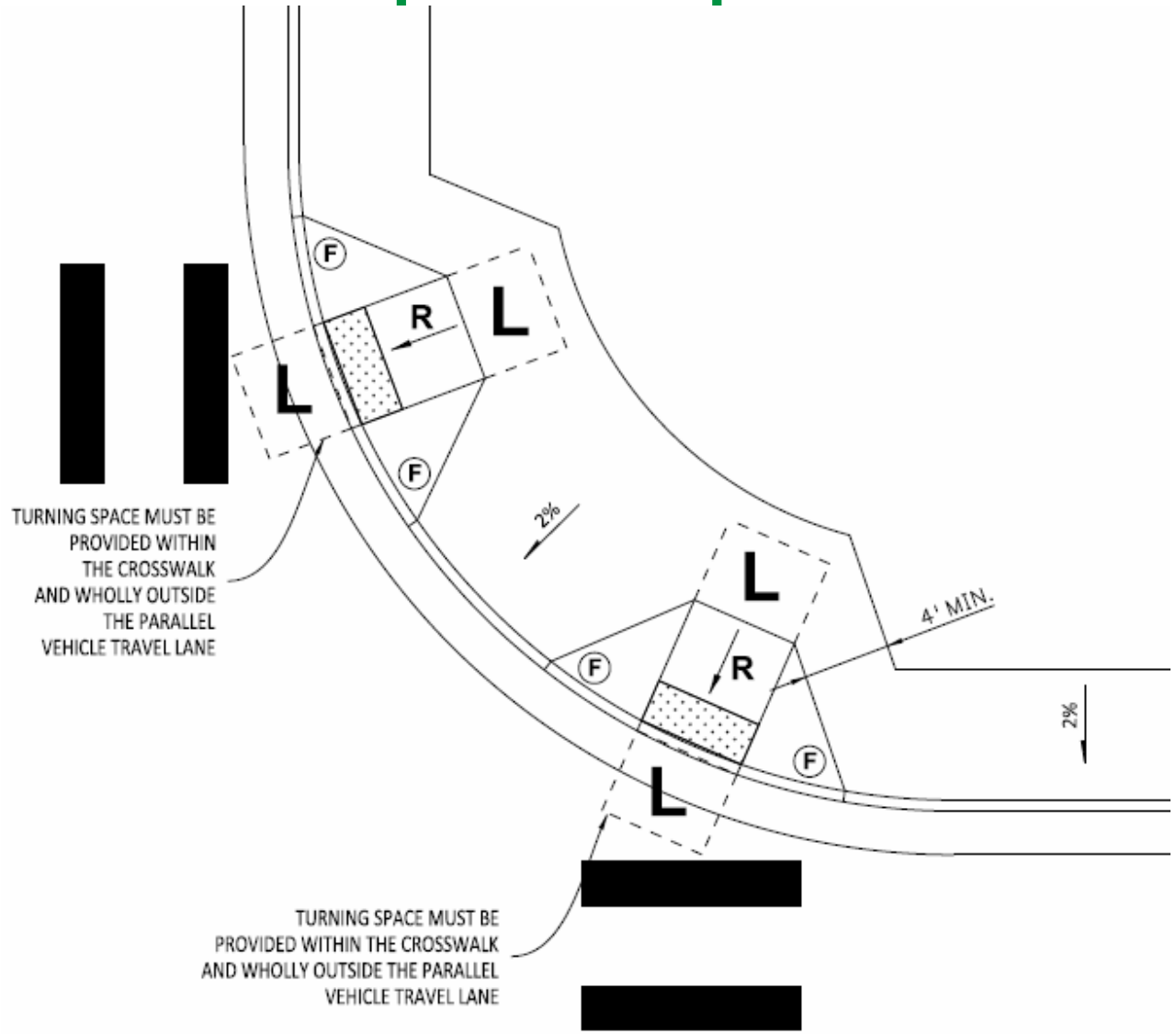






Skewed grade breaks are unstable when they cause one wheel strike before the others.

Curb Ramps - Perpendicular



LEGEND:

L = **LANDING/TURNING SPACE**
4' X 4' MIN. (5' X 5' PREFERRED) AND MAX 2.0% SLOPE IN ALL DIRECTIONS. PREFERRED DESIGN VALUE = 1.5%.

R = **RAMP SURFACE**
SLOPE SHALL BE LESS THAN 8.33% MAX IN THE DIRECTION SHOWN. THE CROSS SLOPE SHALL NOT EXCEED 2.0%. PREFERRED DESIGN VALUES = 7.5% AND 1.5%.

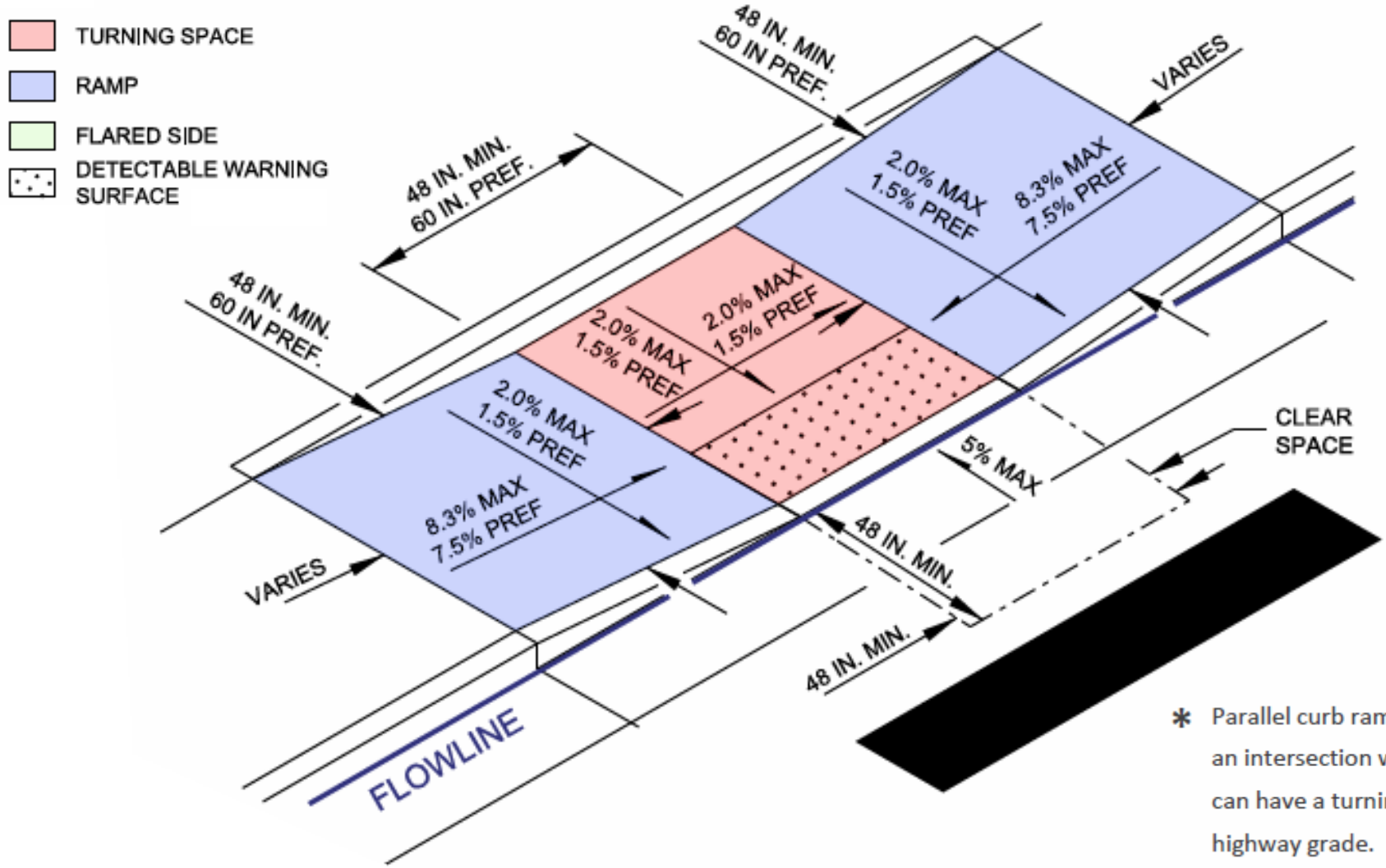
= **DETECTABLE WARNING SURFACE**
MAY BE PART OF LANDING AREA IF IT IS NOT FEASIBLE TO CONSTRUCTA LANDING OUTSIDE OF THE DWS AREA.
SEE M-608-1 FOR REQUIREMENTS

= MAX 2.0% SLOPE IN FRONT OF GRADE BREAK. DRAIN TO FLOW LINE.

(F) = **RAMP FLARE**
SLOPE SHALL BE LESS THAN 10.00% MAX. FLARES MUST BE PRESENT WHEN RAMP ABUTS A WALKABLE SURFACE

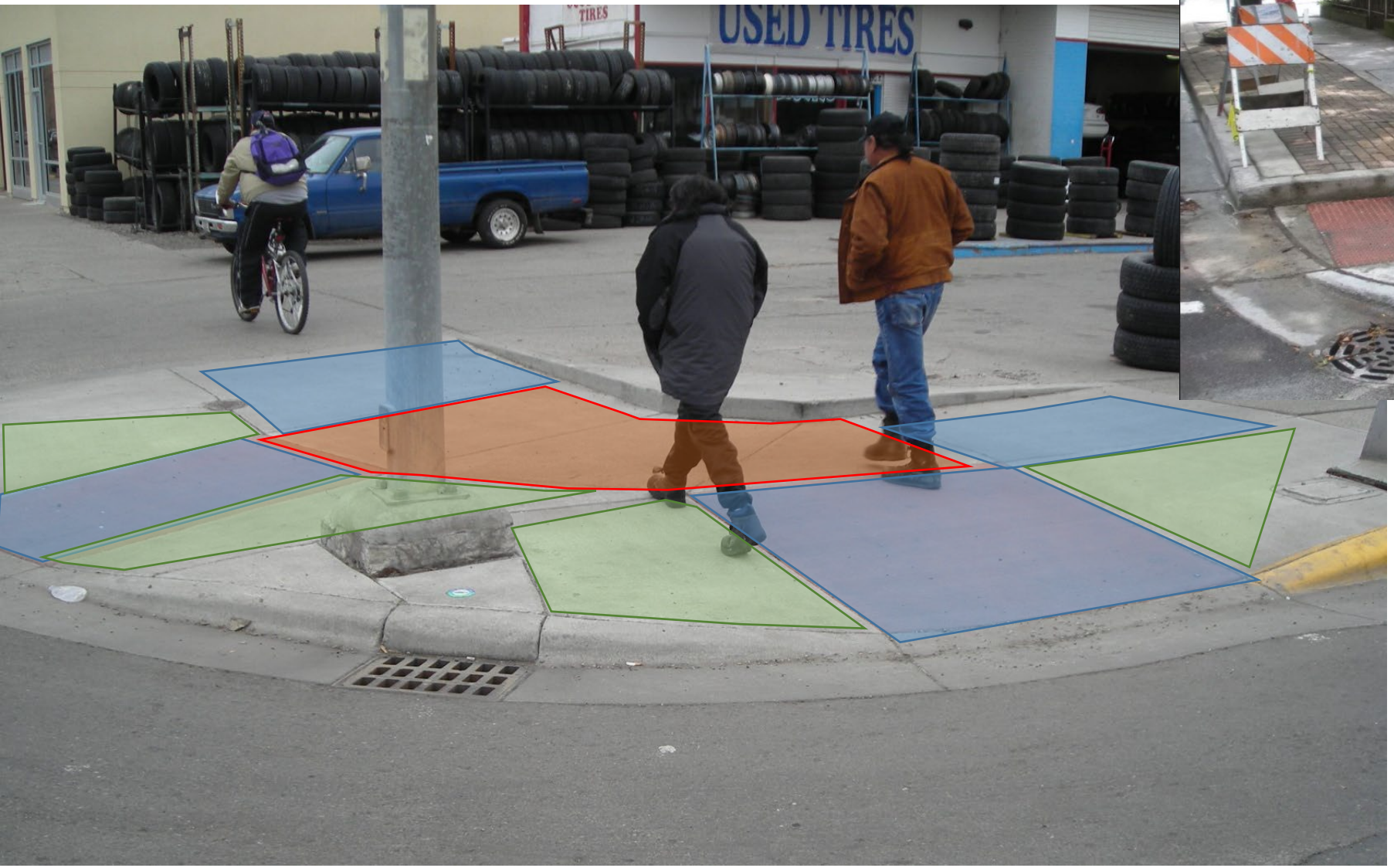
Curb Ramps - Perpendicular

Curb Ramps - Parallel



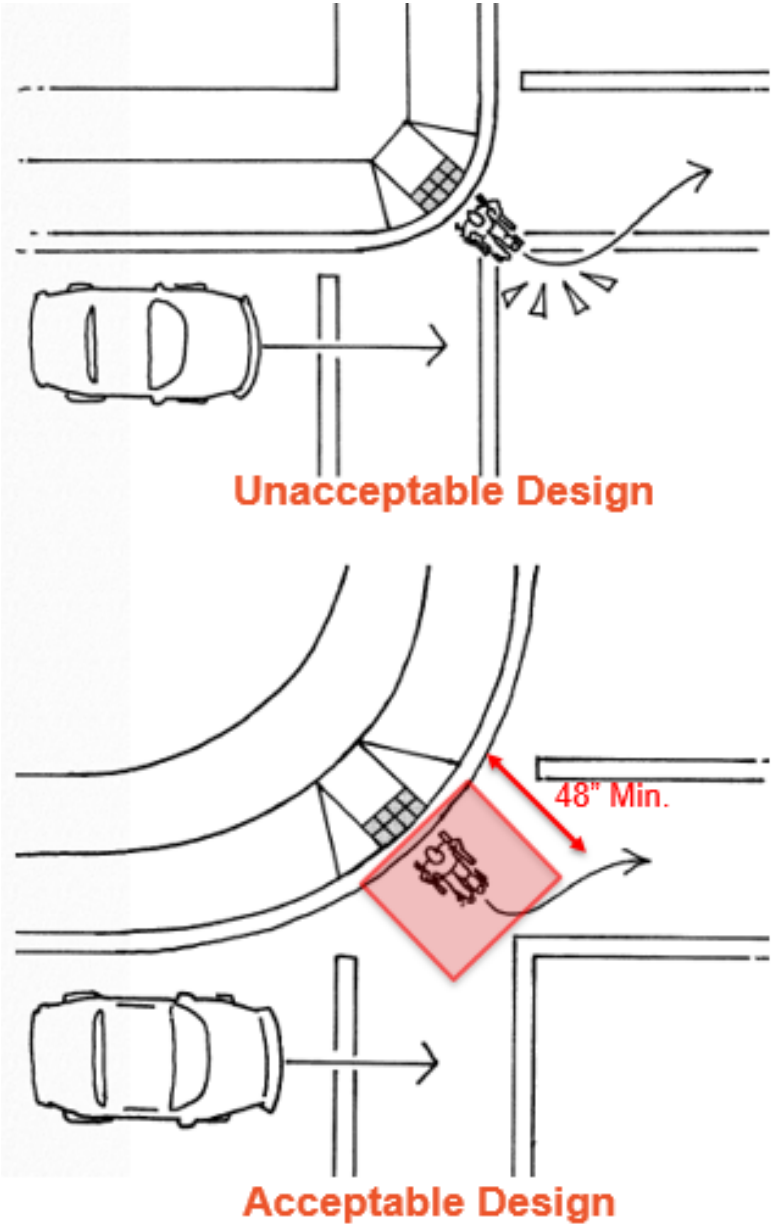
* Parallel curb ramps at a mid-block crossing, or crossing a leg of an intersection without stop control (yield sign, or stop sign), can have a turning space cross slope which may equal the highway grade.

Curb Ramps - Combination



Curb Ramps - Diagonal

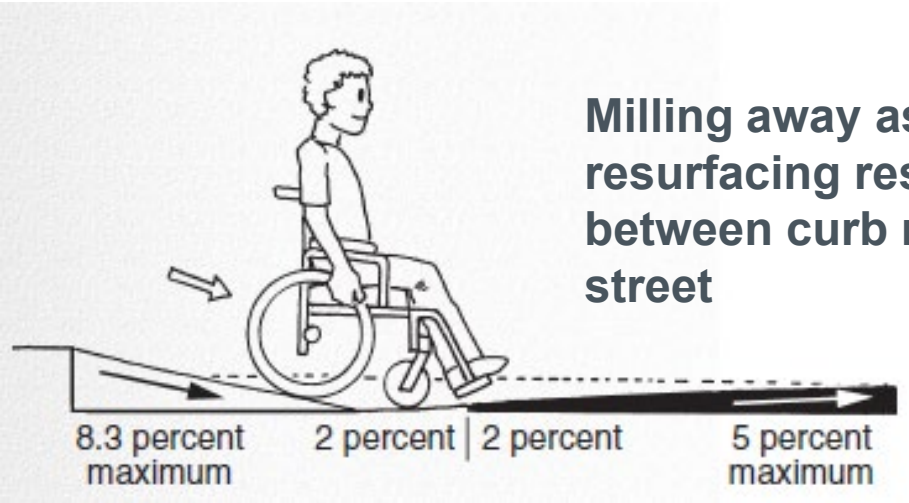
- Provide a turning space at the bottom of a diagonal curb ramp
- Turning space must be located outside the path of adjacent vehicle travel lanes
- Diagonal ramp must be contained within both crosswalks
- Grade breaks must be perpendicular to path of pedestrian travel
- Alterations only!



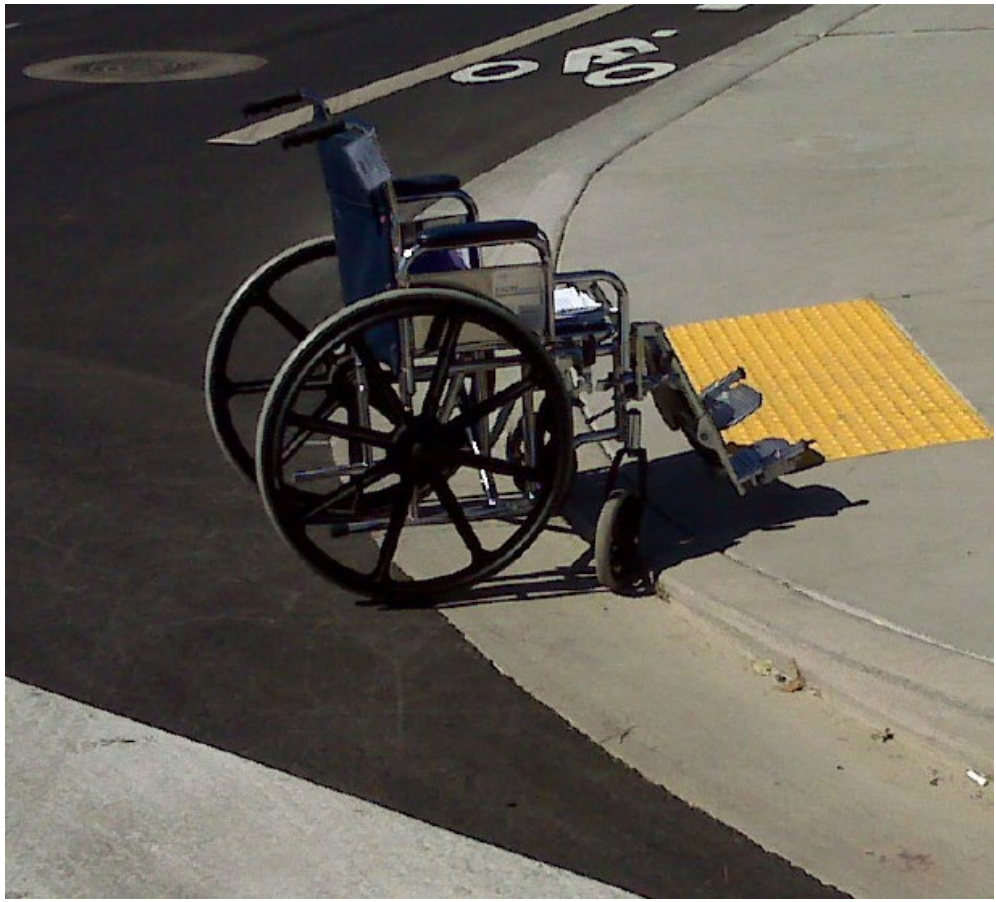
Curb Ramps - Diagonal

Curb Ramps – Curb Transition

Overlaying existing asphalt without milling away the old asphalt can create steep slopes near the gutter-pan line



Milling away asphalt before resurfacing results in flatter slopes between curb ramps, gutters, and the street



Improve Pedestrian Safety

Countermeasure	All Crashes	Pedestrian Crashes
Install Shoulders on Roadway		71%
Install Sidewalks		88%
Add Overhead Lighting	20-80%	23%

** Data accessed from the Crash Modification Factors Clearinghouse at www.cmfclearinghouse.org*

CROSSING THE STREET

What does the law say?

Crosswalks and Crossings

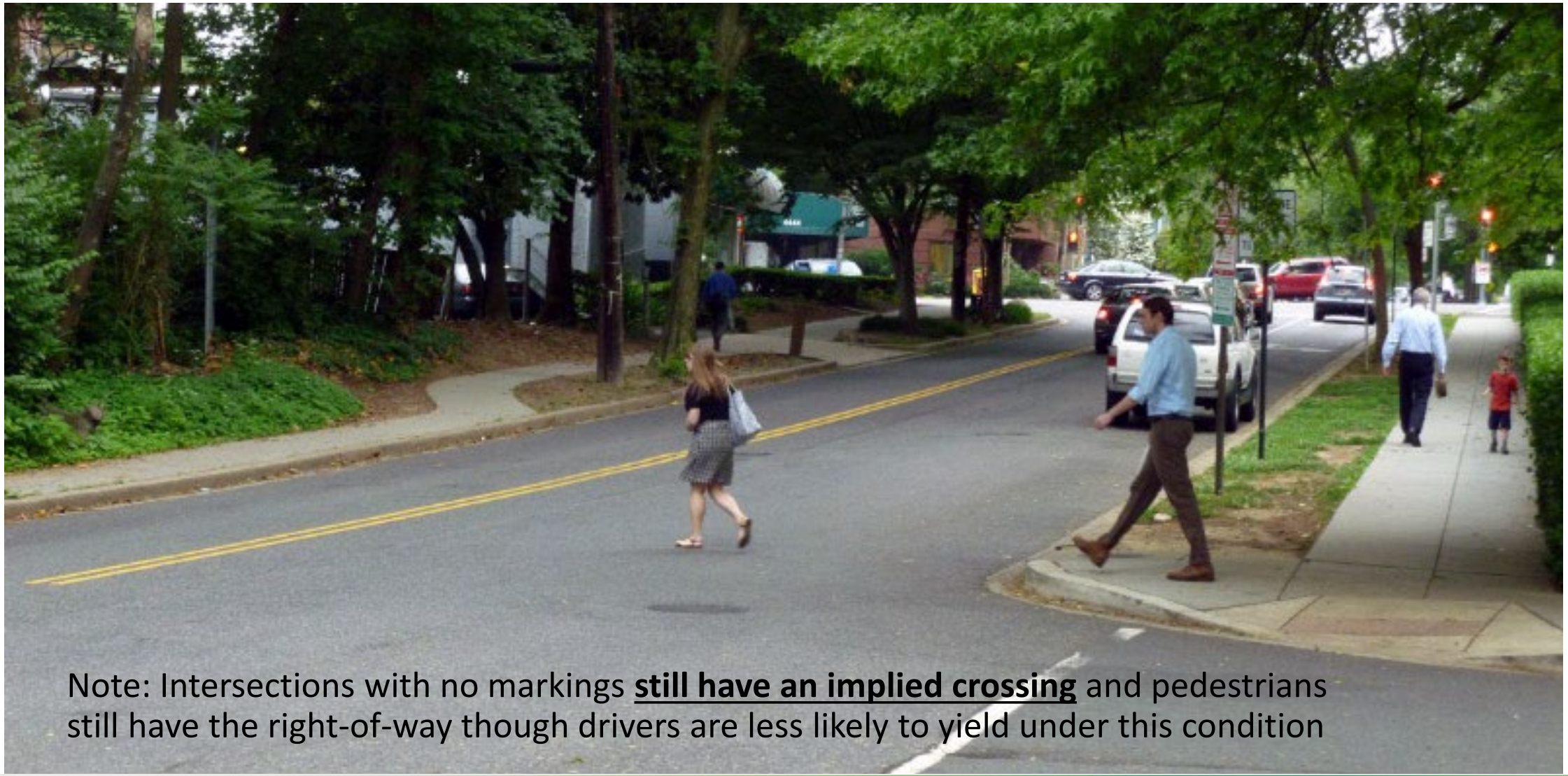
"Crosswalk" means any portion of the road that's been designated with crossing lines or other markings as a location for pedestrians to cross the road, or it's also defined as "that portion of a roadway included within the prolongation or connection of the boundary lines of sidewalks at intersections where the intersecting roadways meet at approximately right angles, except the prolongation of such lines from an alley across a street."

The Motorist's Obligation

<u>Division 11, Chapter 5, 21950</u> Pedestrians' Rights and Duties *California Vehicle Code*

(a) The driver of a vehicle shall yield the right-of-way to a pedestrian crossing the roadway within any marked crosswalk or within any unmarked crosswalk at an intersection

Legal Obligations



Note: Intersections with no markings **still have an implied crossing** and pedestrians still have the right-of-way though drivers are less likely to yield under this condition

The Pedestrians' Obligation

Division 11, Chapter 5, 21951 Pedestrians' Rights and Duties *California Vehicle Code*

Whenever any vehicle has stopped at a marked crosswalk or at any unmarked crosswalk at an intersection to permit a pedestrian to cross the roadway, the driver of any other vehicle approaching from the rear shall not overtake and pass the stopped vehicle.

The Pedestrians' Obligation

Division 11, Chapter 5, 21950 Pedestrians' Rights and Duties *California Vehicle Code*

(b) This section does not relieve a pedestrian from the duty of using due care for his or her safety. No pedestrian may suddenly leave a curb or other place of safety and walk or run into the path of a vehicle that is so close as to constitute an immediate hazard. No pedestrian may unnecessarily stop or delay traffic while in a marked or unmarked crosswalk.

(c) The driver of a vehicle approaching a pedestrian within any marked or unmarked crosswalk shall exercise all due care and shall reduce the speed of the vehicle or take any other action relating to the operation of the vehicle as necessary to safeguard the safety of the pedestrian.

(d) Subdivision (b) does not relieve a driver of a vehicle from the duty of exercising due care for the safety of any pedestrian within any marked crosswalk or within any unmarked crosswalk at an intersection.

The Pedestrians' Obligation

<u>Division 11, Chapter 5, 21954</u> Pedestrians' Rights and Duties *California Vehicle Code*

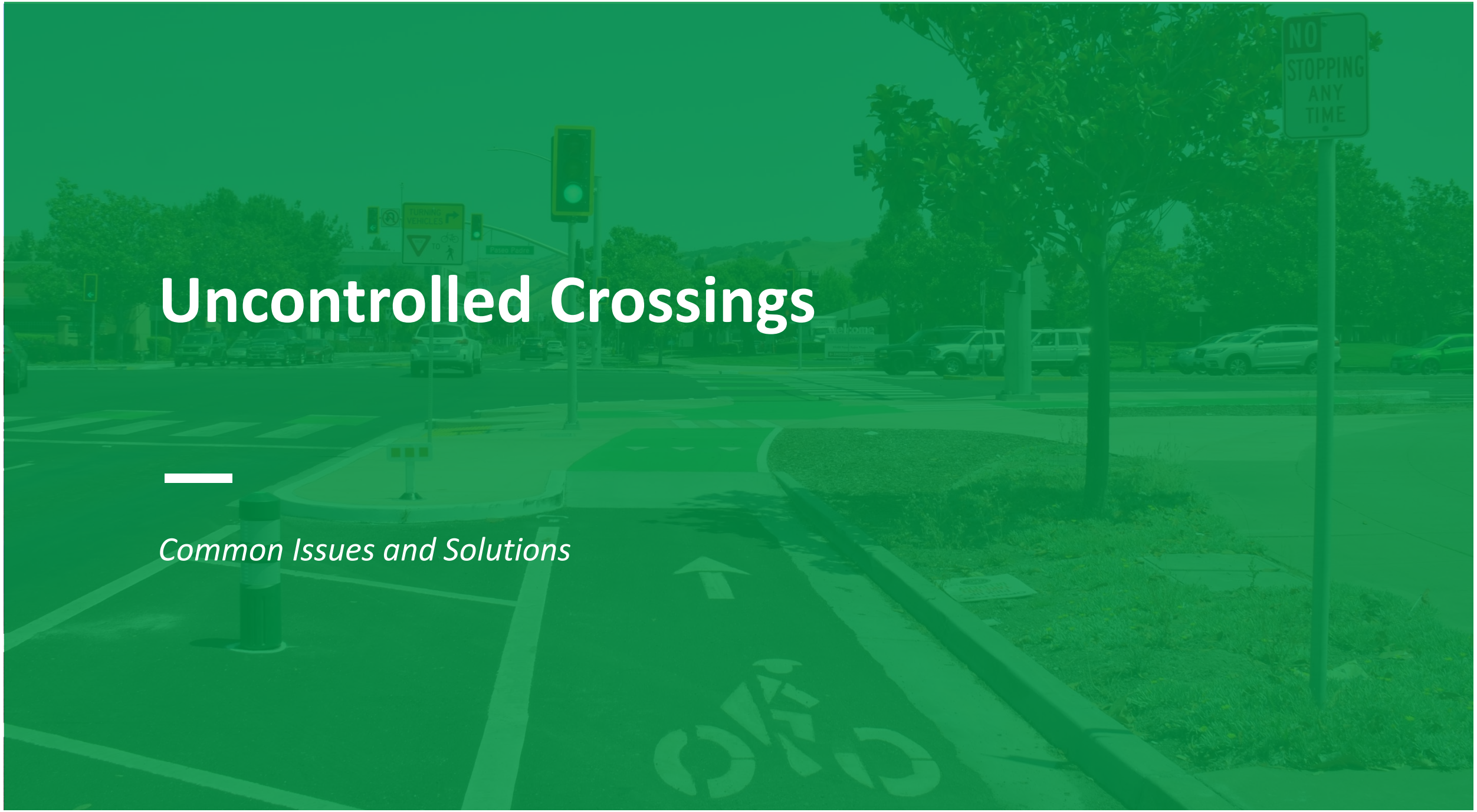
(a) Every pedestrian upon a roadway at any point other than within a marked crosswalk or within an unmarked crosswalk at an intersection shall yield the right-of-way to all vehicles upon the roadway so near as to constitute an immediate hazard.

(b) The provisions of this section shall not relieve the driver of a vehicle from the duty to exercise due care for the safety of any pedestrian upon a roadway.

Pedestrians' Obligations

<u>Division 11, Chapter 5, 21955</u> Pedestrians' Rights and Duties *California Vehicle Code*

Between adjacent intersections controlled by traffic control signal devices or by police officers, pedestrians shall not cross the roadway at any place except in a crosswalk



Uncontrolled Crossings

Common Issues and Solutions

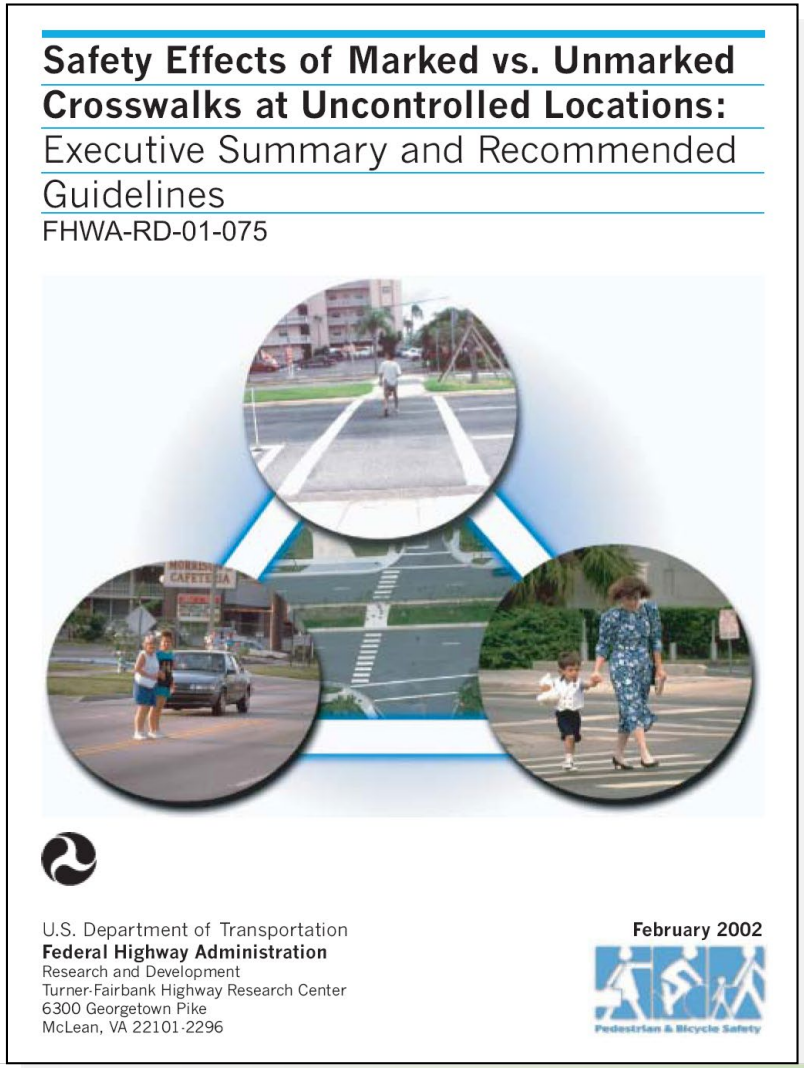
Effectiveness of Crosswalks

Poll:

Have you ever heard marking crosswalks makes the roadway more dangerous?

- ❑Yes
- ❑No

Effectiveness of Crosswalks Alone



- On two lane roads and on multi-laned roads with less than 12,000 average daily traffic (ADT) – no significant impact to ped safety
- On multi-lane roads with greater than 12,000 ADT, marked crosswalks **alone** significantly **increased** pedestrian crashes

For more information see Zegeer, et al., Safety of Marked vs. Unmarked Crosswalks at Uncontrolled Locations. FHWA, 1999.

Uncontrolled Crossing Issues - Marking Visibility

What the pedestrian sees

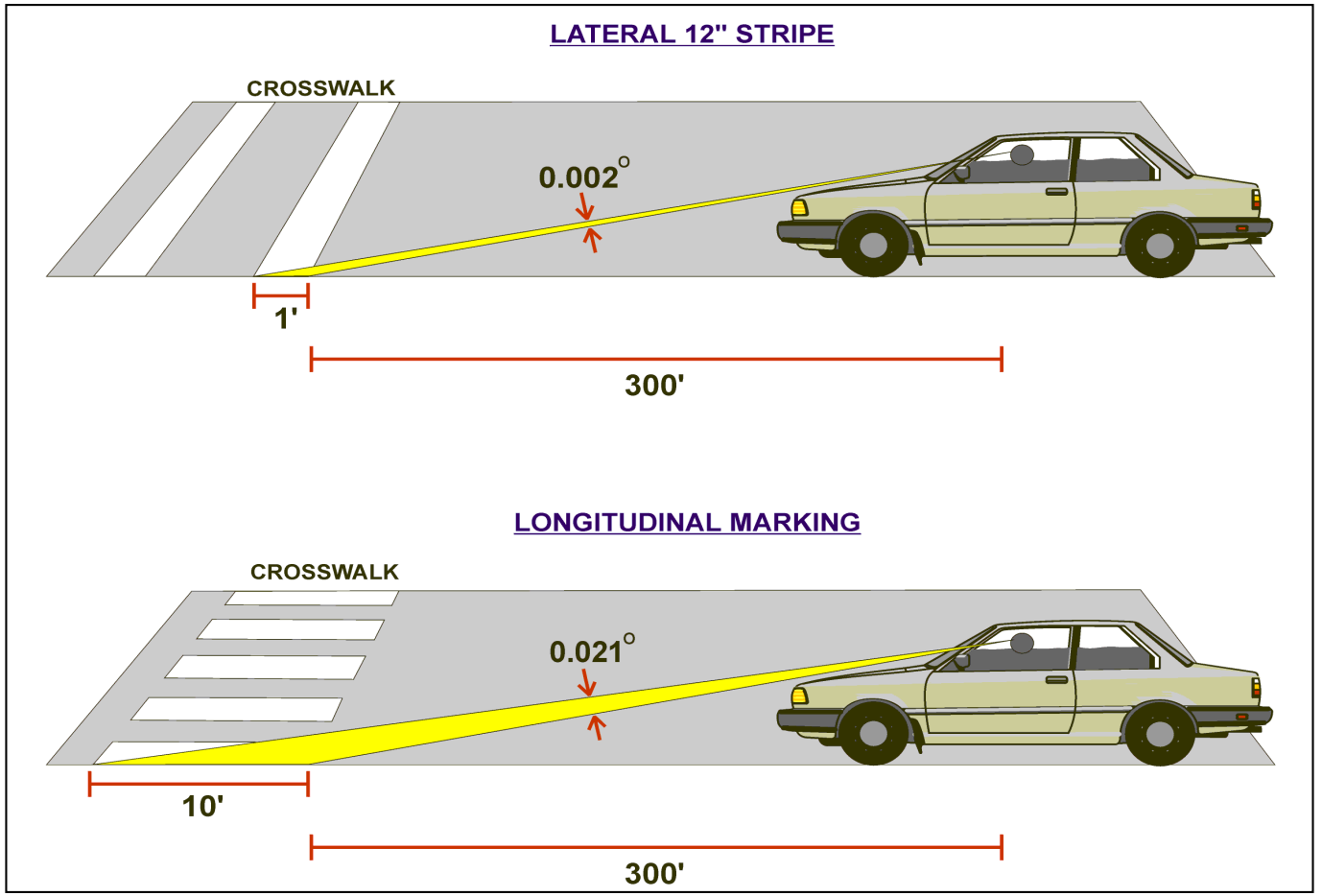
Uncontrolled Crossing Issues - Marking Visibility

What the driver sees (same crosswalk)

Uncontrolled Crossing Issues - Marking Visibility

Longitudinal markings improve visibility from afar

Uncontrolled Crossing Issues - Marking Visibility



Longitudinal markings are more visible to driver from afar

Some markings are more visible

"…the continental marking was detected at about twice the distance upstream as the transverse marking during daytime conditions. This increase in distance reflects 8 s of increased awareness of the crossing for a 30-mi/h operating speed."

TECHBRIEF

Crosswalk Marking Field Visibility Study

FHWA Publication No.: FHWA-HRT-10-067.

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This document is a technical summary of the Federal Highway Administration (FHWA) report, *Crosswalk Marking Field Visibility Study*, FHWA-HRT-10-068.

Objective

The objective of this study was to investigate the relative daytime and nighttime visibility of three crosswalk marking patterns: transverse lines, continental, and bar pairs.

Background

Crosswalk markings provide guidance for pedestrians crossing roadways by defining and delineating paths on approaches. These markings are used in conjunction with signs and other measures to alert road users to a designated pedestrian crossing point. Part 3 of the *Manual on Uniform Traffic Control Devices* (MUTCD) contains basic information about crosswalk markings.[1] Because some States adopt their own supplement or manual on traffic control devices and some develop policies and practices for subjects not discussed in the MUTCD, differences in markings occur among States, cities, and other jurisdictions.

While greater emphasis has recently been placed on researching pedestrian treatments, there is insufficient research to identify the relative visibility and driver behavior effects of the many different styles and patterns of crosswalk markings being used in the United States and abroad. Previous studies focused on whether the presence of the markings (rather than a specific pattern) was effective.[2-4] The lack of knowledge of the relative visibility of different marking patterns has inhibited the development of a consensus on whether more uniformity is needed in the form of tighter MUTCD standards or more comprehensive guidance on crosswalk markings.

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www.tfhrc.gov

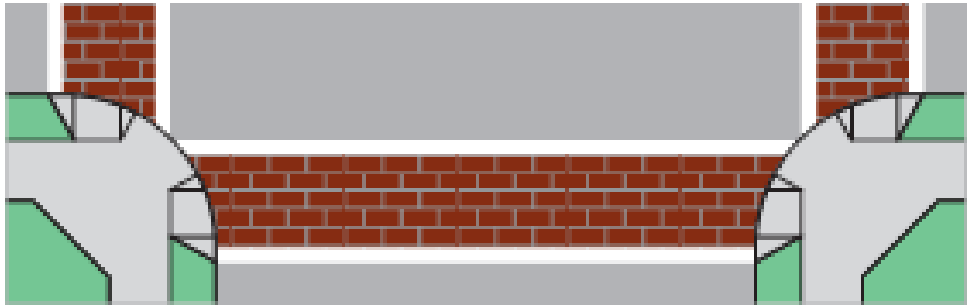
https://www.fhwa.dot.gov/publications/research/safety/pedbike/10067/10067.pdf

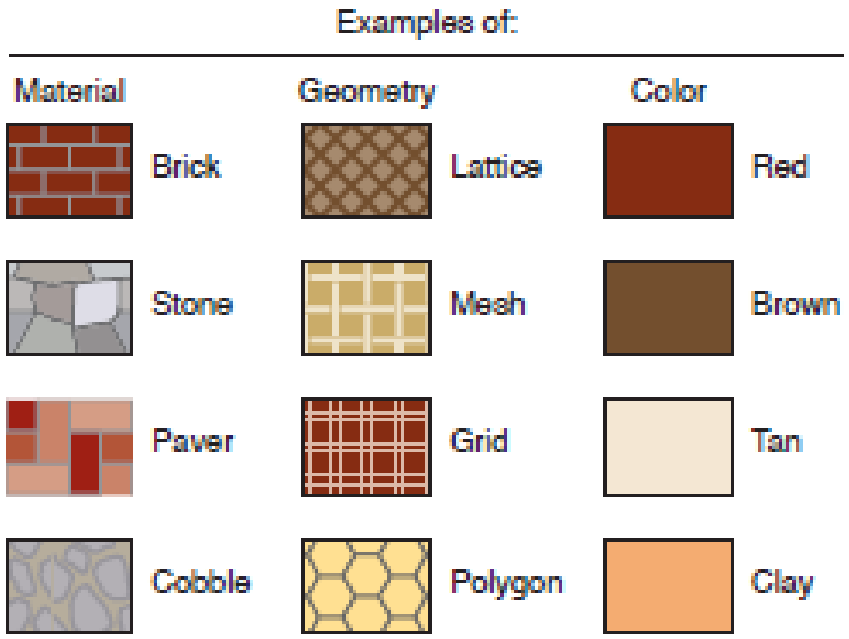
But What About Fancy Crosswalks?

Colored / Patterned Crosswalks

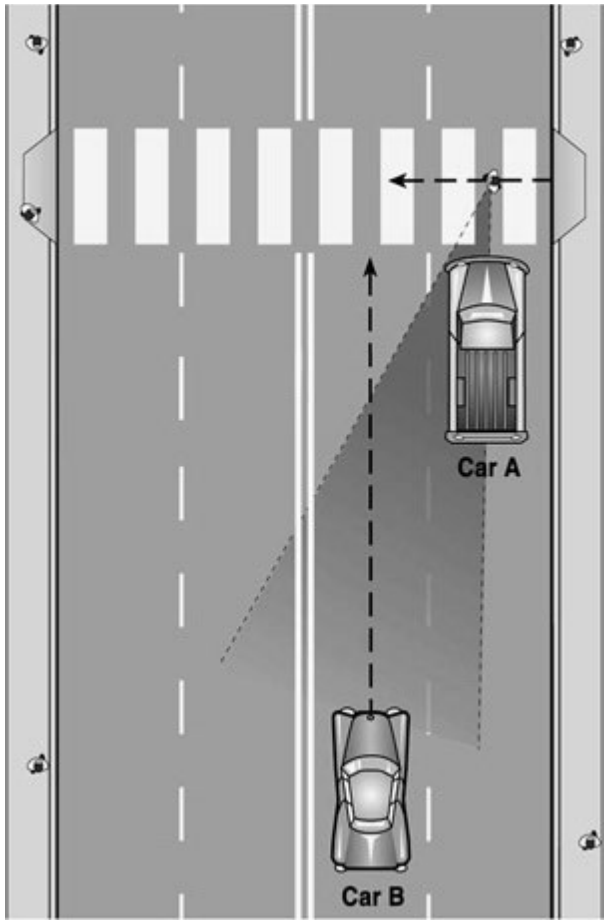
Next MUTCD

Figure 3H-1. Aesthetic Treatments for Basic Crosswalks





One explanation of higher crash rate at marked crosswalks: multiple-threat crash



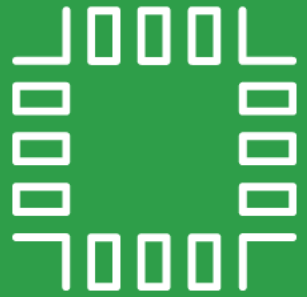
1st car stops too close, masks visibility for driver in 2nd lane

Solution: advance stop bar (comes later…)

Safety – San Mateo County (Pedestrians)

52%

Occurred in a Crosswalk in an Intersection



21%

Occurred When Crossing Outside of a Crosswalk

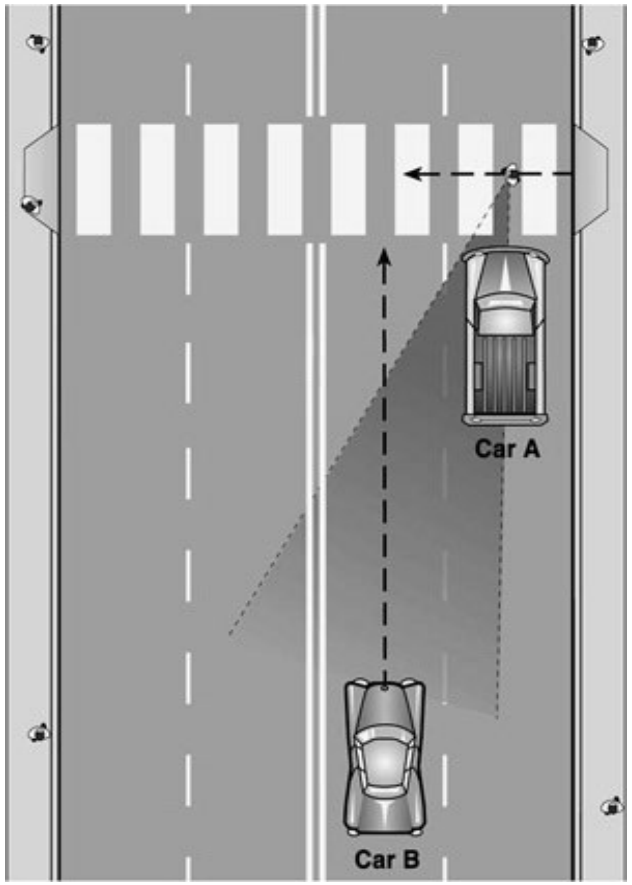
Increase Effectiveness Of Crosswalks With:

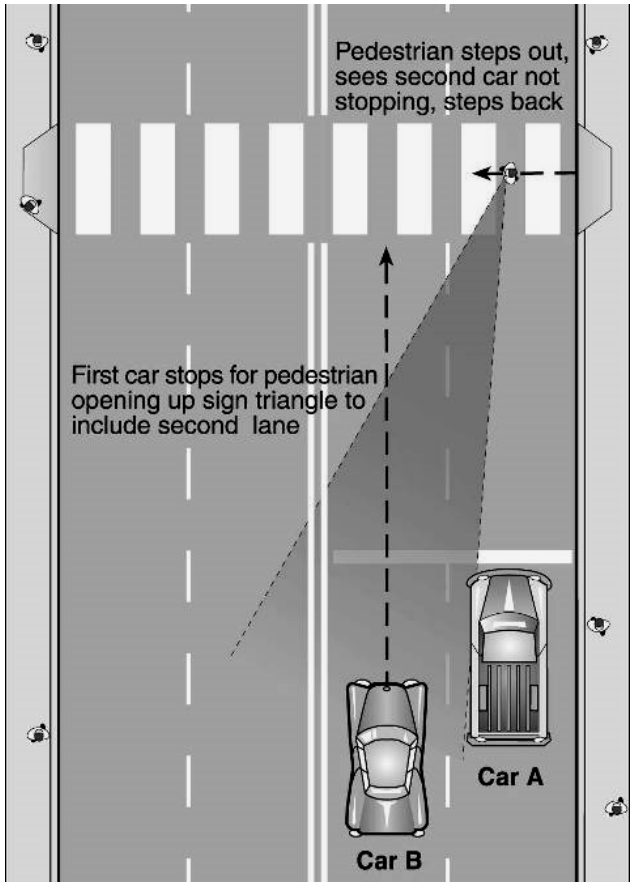
- Proper location
- High Visibility Markings
- Illumination
- Signing
- Advance Stop Bars
- Median Islands
- Curb Extensions
- Beacons/Signals

Advance Yield Lines

Advance yield line

- 1st car stops further back, opening up sight lines
- 2nd car can be seen by pedestrian





Advanced Yield Lines

- Advance yield line (shark's teeth) & sign
- Consider double white lines for no passing

CMF = 0.75 (CRF of 25%)
(NCHRP 17-56)

Advance yield lines shown to increase likelihood of yielding to a pedestrian in a multiple threat scenario by 61%

Source: "Advance yield marking and drivers' performance in response to muliple-threat scenarios at mid-block crosswalks." Fisher & Garay-Vega, 2012 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3482473/

Raised Medians And Islands

Significant crash reductions:

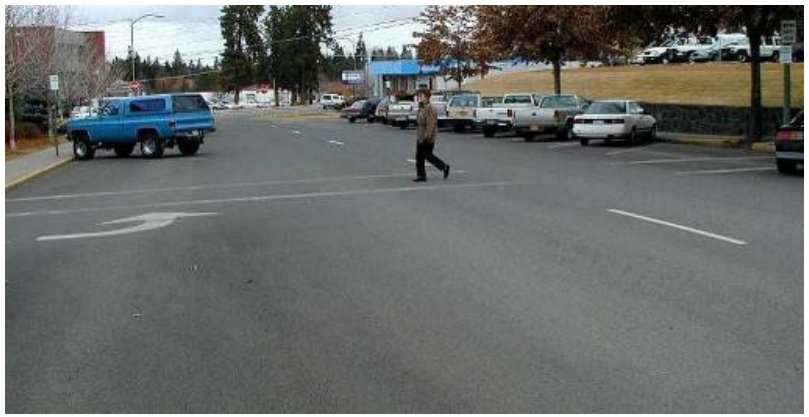
- Marked crosswalks
  - CMF = 0.54 (CRF = 46%)

Unmarked crosswalks

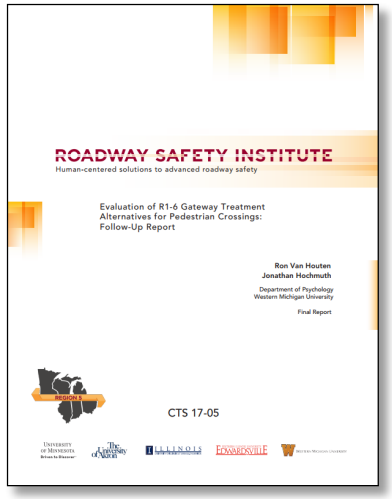
  - CMF = 0.61 (CRF = 39%)

Zegeer Study Results

- Median reduces crashes by 32 to 40 percent
- Pedestrians over 65 are over-represented in crosswalk crashes
- Pedestrians are not less vigilant in marked crosswalks:
  - Looking behavior increased after crosswalks installed



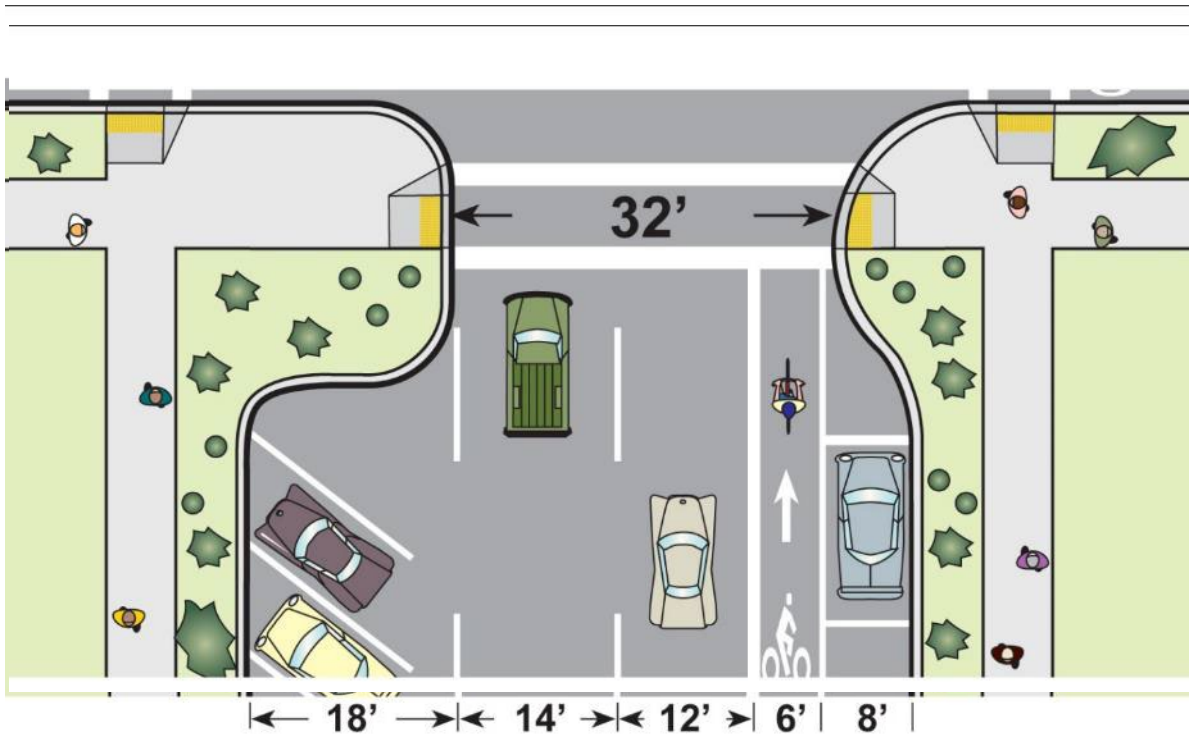
In-Street Pedestrian Crossing Signs



- Increase of drivers yielding to pedestrians at midblock and multilane urban and suburban locations from 15% to 70%
  - Increases endured without any decrement over the spring, summer and fall of 2016.
- Speed data collected showed 4 to 5 mph reduction in mean speed when motorists traversed the crosswalk when pedestrians were absent.
  - These speed changes persisted over time.
- Placing signs between 5, 10, 20, 30, and 50 ft in advance of the crosswalk were equally effective and enticed drivers to yield further ahead of the crosswalk.

Curb Extensions

- Benefits
  Reduced Pedestrian Crossing Distance
- Better visibility between pedestrians and motorists (clear intent to cross)
- Traffic calming
- Additional enhancement space for streetscape



Curb Extensions

Pedestrians wait where they can see, in front of parked cars

Curb ext. places pedestrian where he can see and be seen

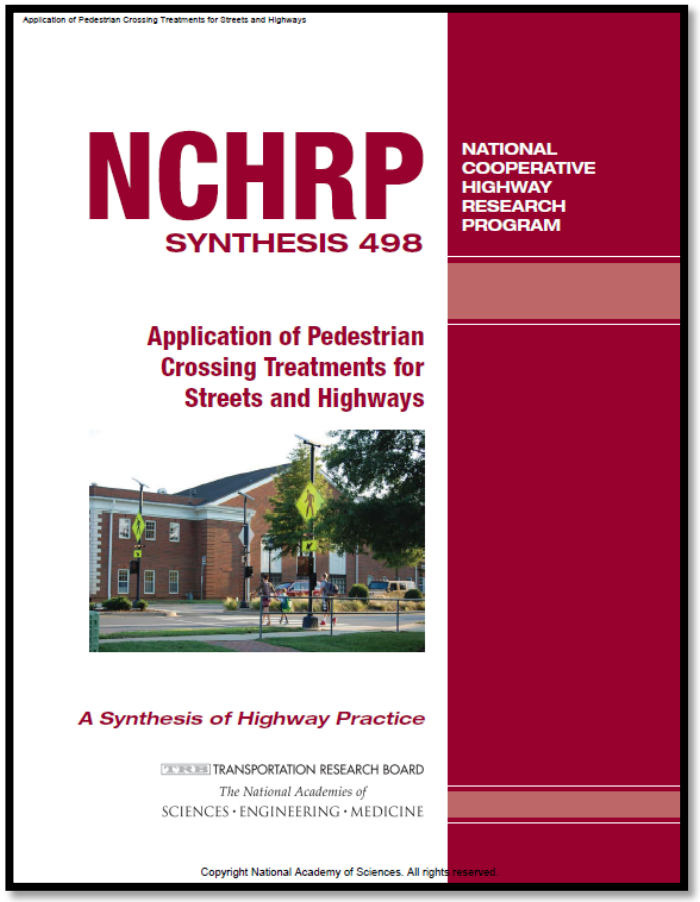
Curb Extensions

Raised Crosswalk

- Typically installed on 2-lane or 3-lane roads
- Speed limits of 30 mph or less
- AADT below about 9,000

Raised Crosswalk

- Lower speeds
- Improved motorist yielding at some locations
- 30% CRF for all crashes
- 36% CRF for all fatal injury crashes



http://www.trb.org/Publications/Blurbs/175419.aspx

Rectangular Rapid Flashing Beacons (RRFBs)

- Studies indicate motorist yield rates increased from about 20% to 80%
- When another set of rapid flash LED beacons were added to the medians the average yield rate jumped to 88%. Further research is showing yielding rates averaging 90% with some as high as 97%.

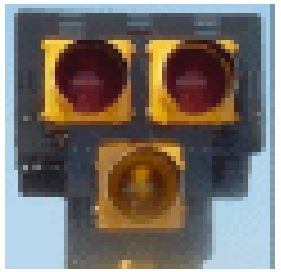
Pedestrian Hybrid Beacon (PHB)

- When you need to STOP traffic!
- Appropriate with higher speeds, volumes and number of lanes crossed
- Mid-block or intersection

PHB Sequence

1

Blank for drivers



2

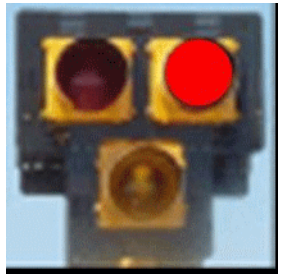
Flashing yellow

3

Steady yellow

4

Steady red



5

Wig-Wag

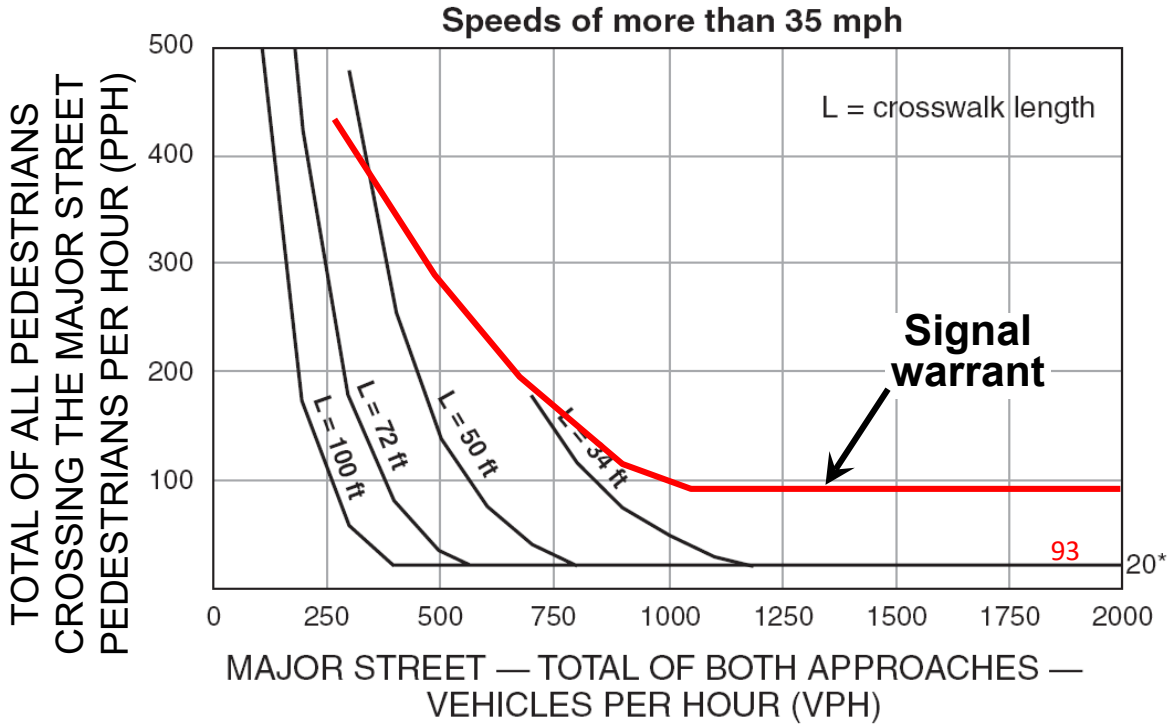
Return to 1

MUTCD Section 4F.02

PHB Warrants

MUTCD Sections 4F.1 and 4F.2

- 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



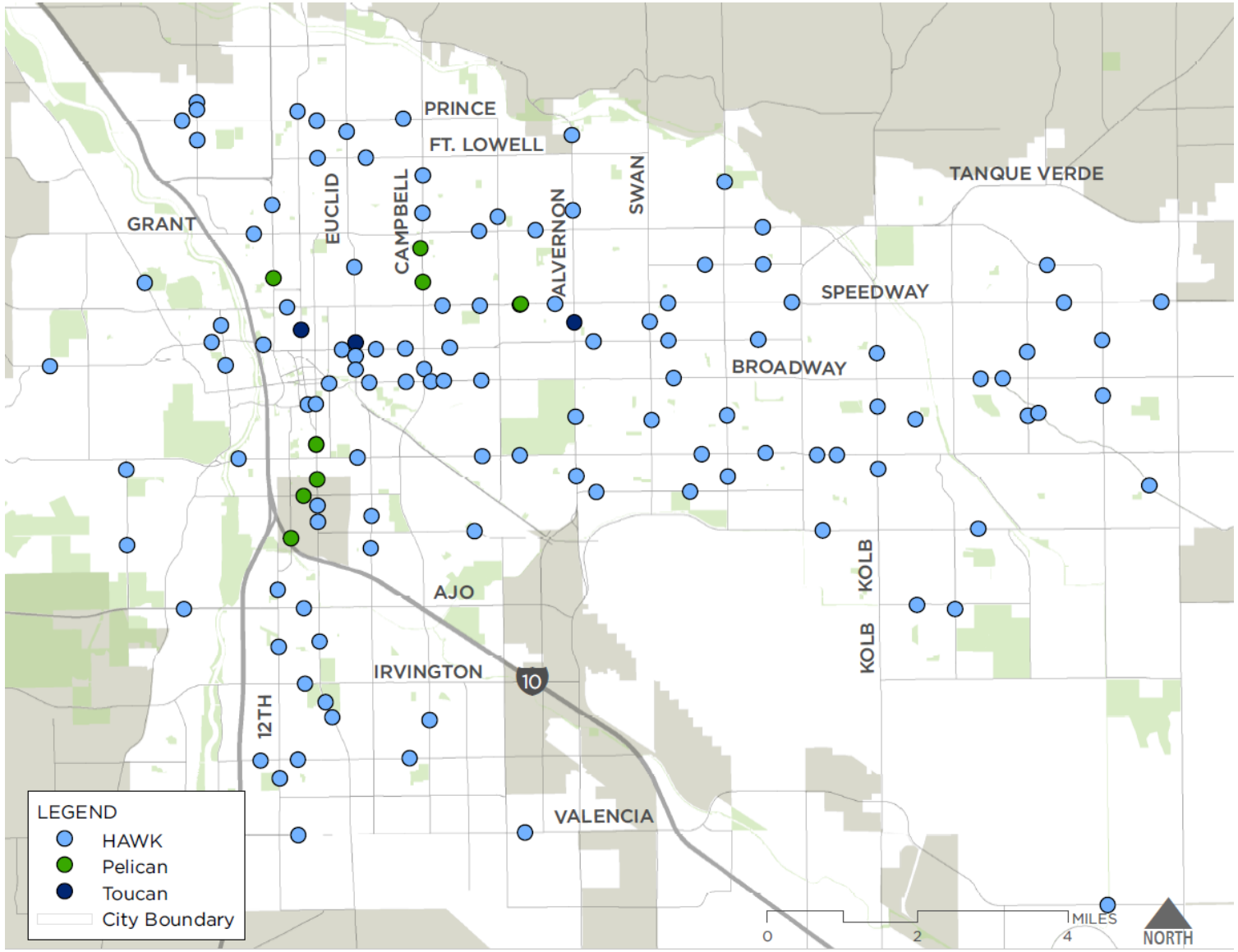
Side-Mount PHBs to Save Cost

Integrate Bicycle Crossings with PHBs

How Many?

Example: Tucson, AZ

- 140 Hybrid Beacons
- Dozens more planned



Yielding Compliance

Crossing Type		Change in Yielding Compliance
In-Street Pedestrian Crossing Sign		30-40% increase (Michigan DOT) 15-70% in parallel study from RSI
Rectangular Rapid Flashing Beacons (RRFBs)		Before: 20% compliance After: 80-90% compliance (FHWA: Shurbutt and Van Houten 2010 Study)
Pedestrian Hybrid Beacon (PHB)		94% compliance (TCRP/NCHRP Report 112/562)

FHWA STEP GUIDE

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

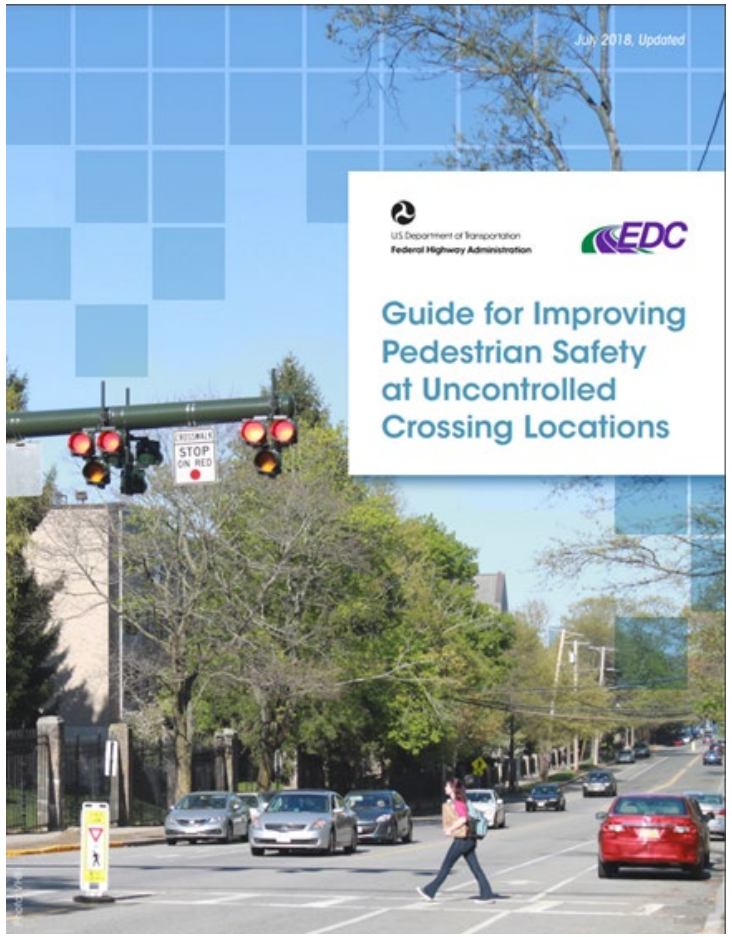
Roadway Configuration	Posted Speed Limit and AADT								
	Vehicle AADT <9,000			Vehicle AADT 9,000–15,000			Vehicle AADT >15,000		
	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph
2 lanes (1 lane in each direction)	● 2 4 5 6	● 5 6 7 9	○ 5 6 ● ●	● 4 5 6	● 5 6 7 9	○ 5 6 ● ●	● 4 5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

Given the set of conditions in a cell,

- # Signifies that the countermeasure is a candidate treatment at 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.

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



Lighting

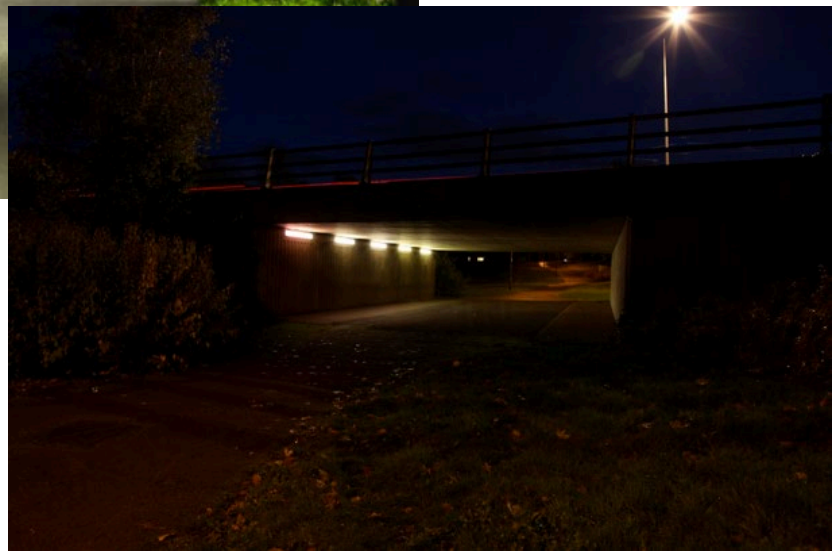

Sporadic lighting


Lighting does not cover sidewalk


Lighting is consistent and covers sidewalk

Lighting

Lighting

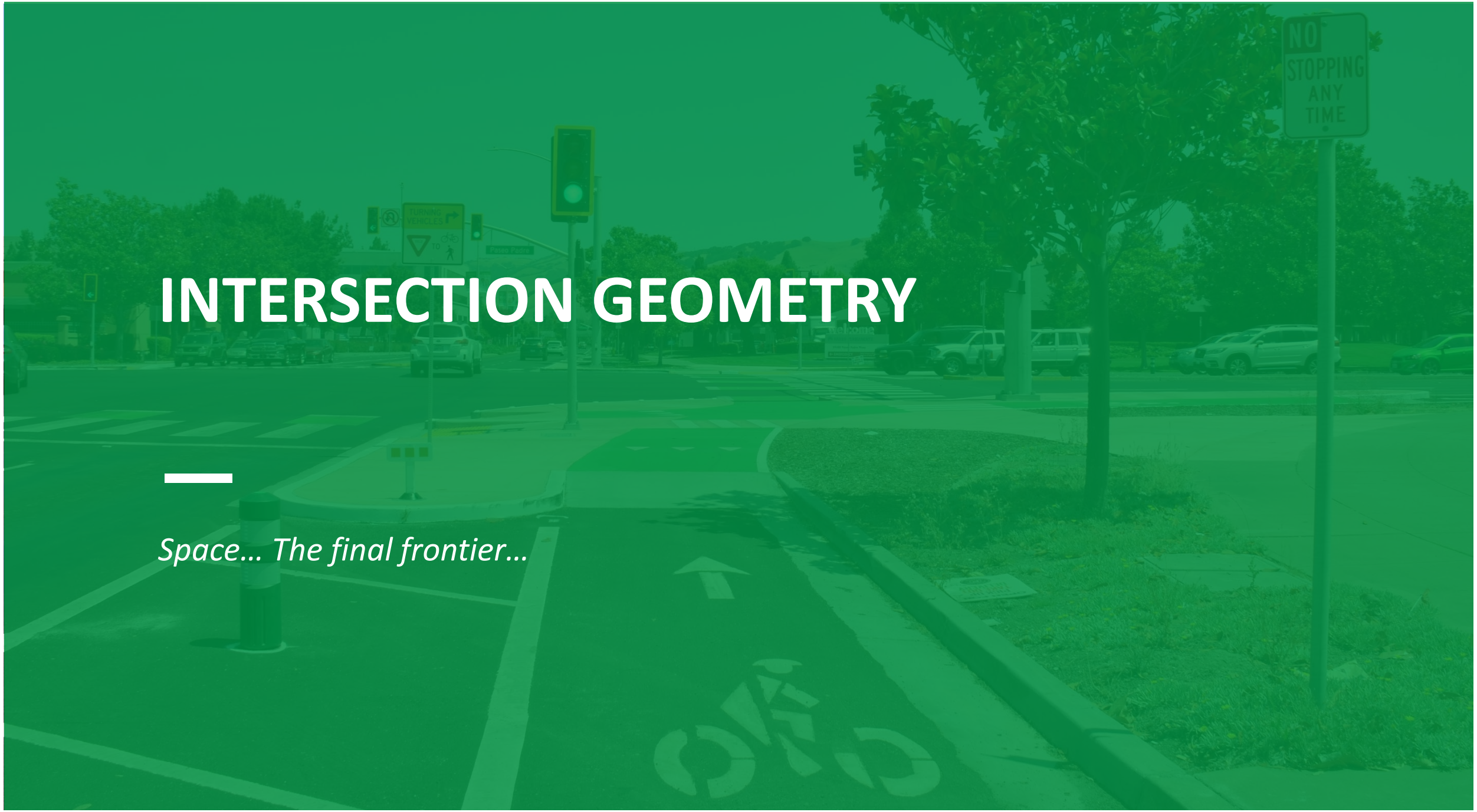


Improve Pedestrian Safety – Uncontrolled

Countermeasure	All Crashes	Pedestrian Crashes
Install Raised Median		25%
Install Raised Intersection	5-13%	
Install Raised Pedestrian Crossing	30-36%	
Advance Yield Markings at Multiple Threat	25%	
Narrow Roadway from 4 to 3 lanes (suburban)	29-47%	
Install Rectangular Rapid Flashing Beacons (RRFBs)		47%
Install Pedestrian Hybrid Beacon (PHB)		55%
Add Overhead Lighting		23%

** Data accessed from the Crash Modification Factors Clearinghouse at www.cmfclearinghouse.org*

Example: Highway 1 in El Granada



INTERSECTION GEOMETRY

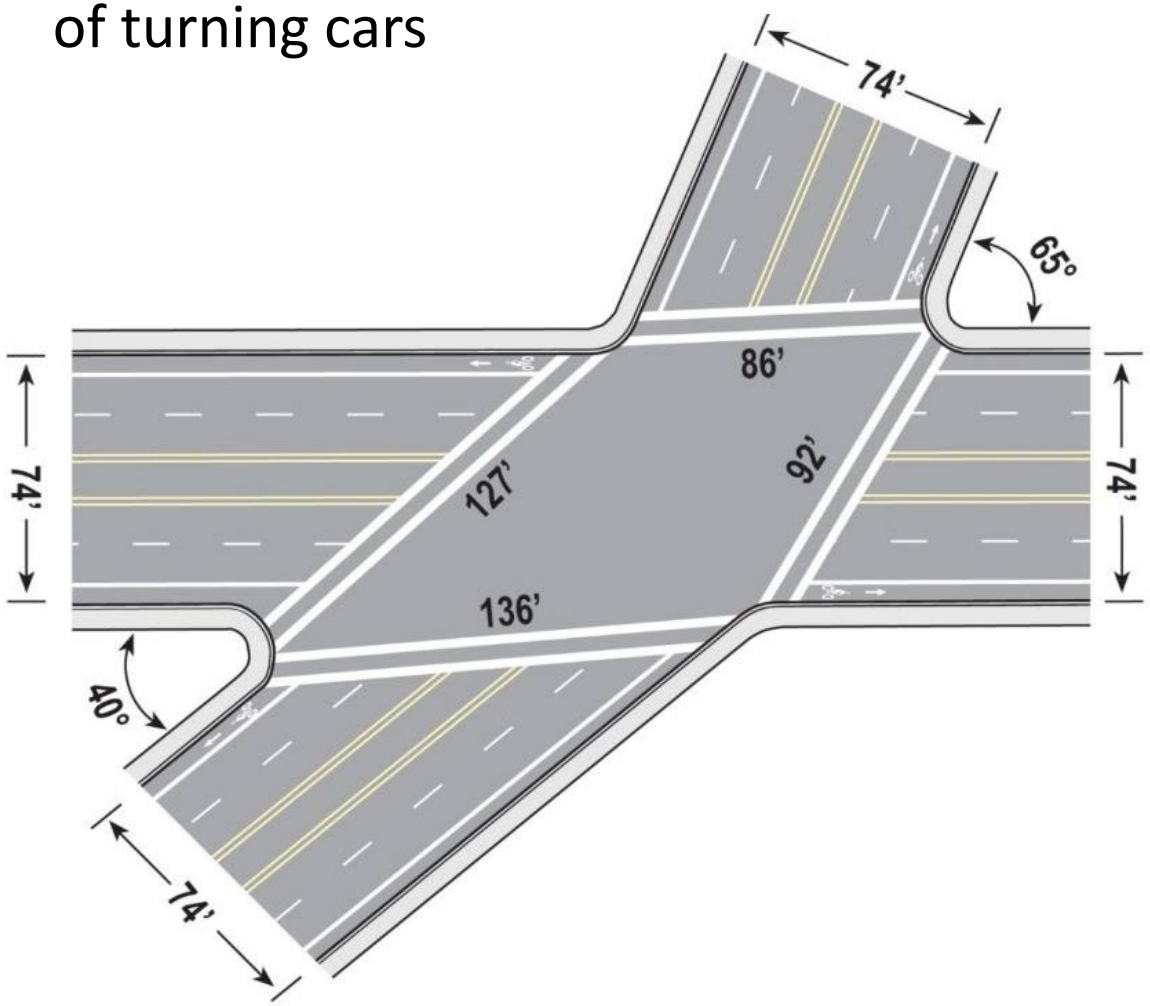
Space… The final frontier…

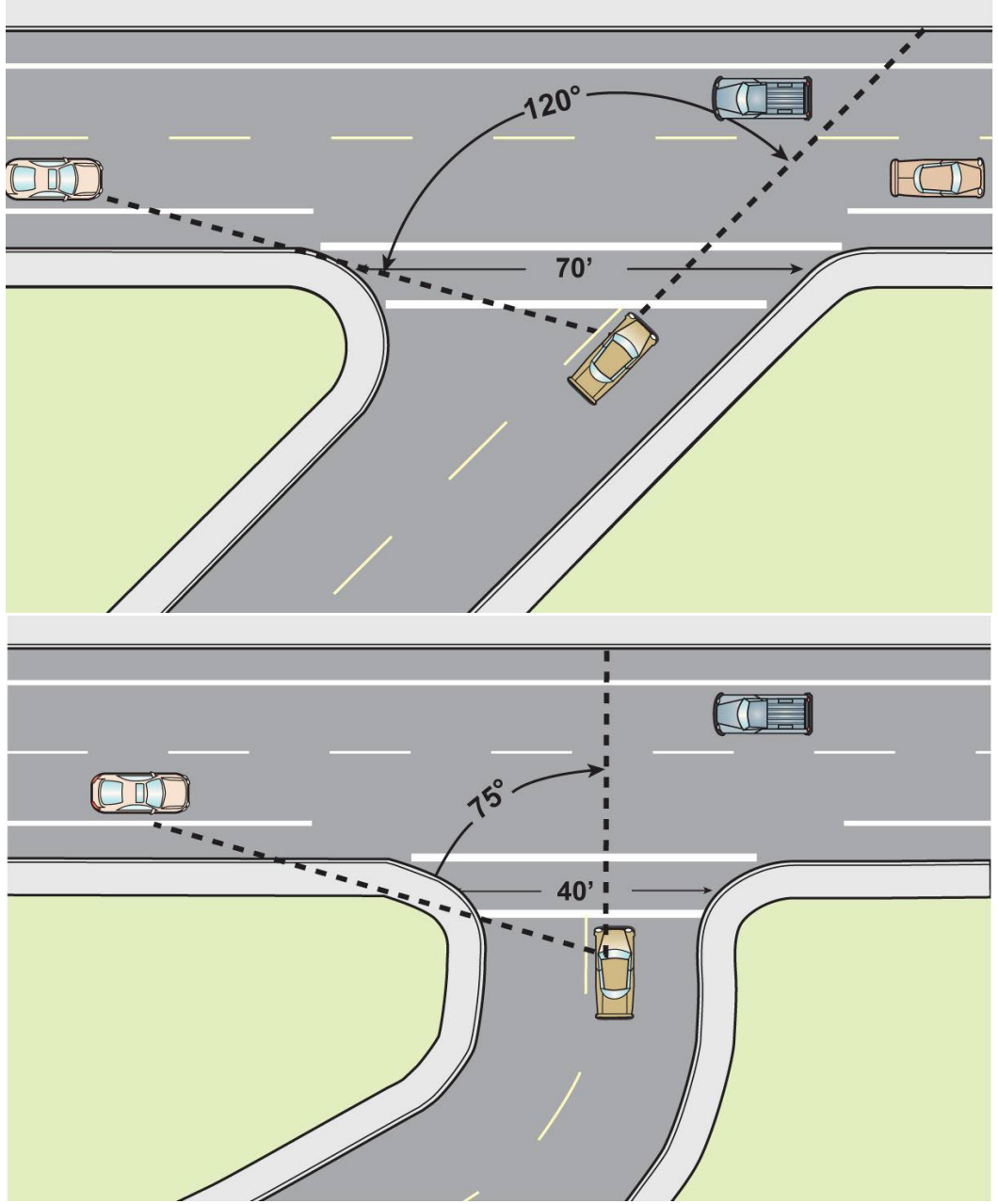
Intersection Design Principles

1. Square Things up
2. Compact Intersections
3. Minimize Speed
   - For Right turns
   - For Left Turns
4. Increase Awareness / Conspicuity – Clear Intent
5. Isolate Conflicts
6. Clearly Assign Priority

Skewed Intersections

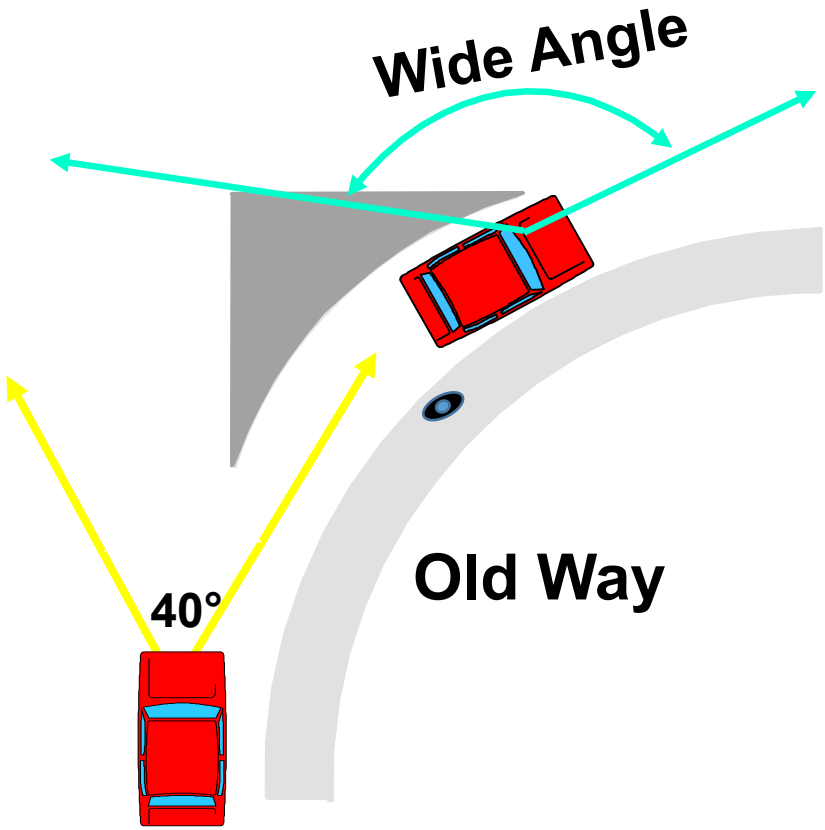
Skew increases crossing distance & speed of turning cars



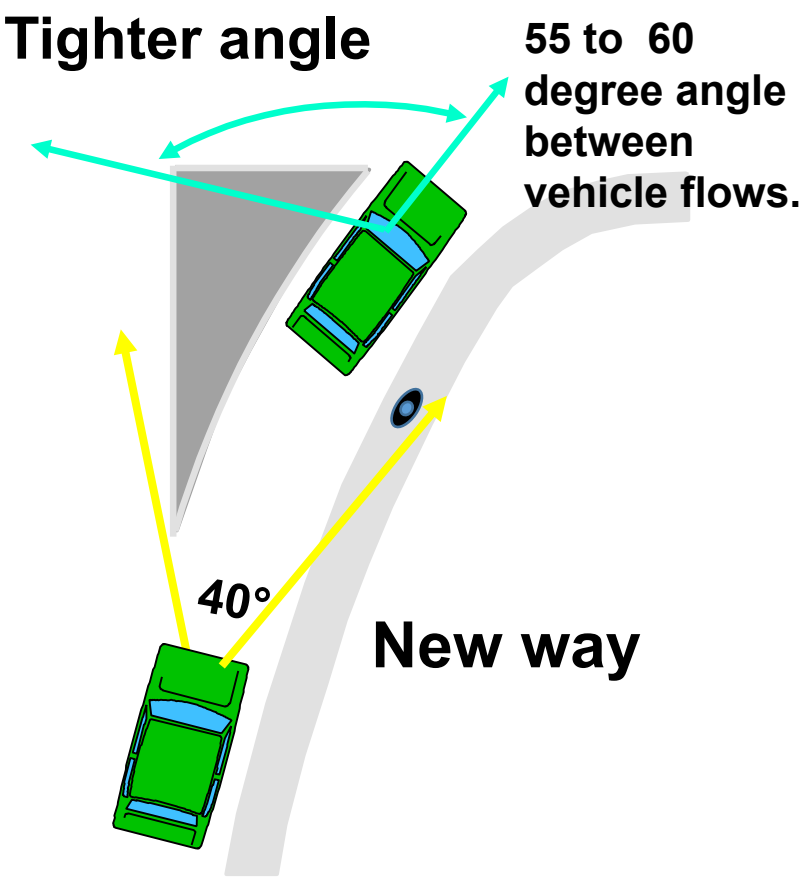


Skewed Intersections

Channelized Turns



High speed, head turner = low visibility of pedestrians



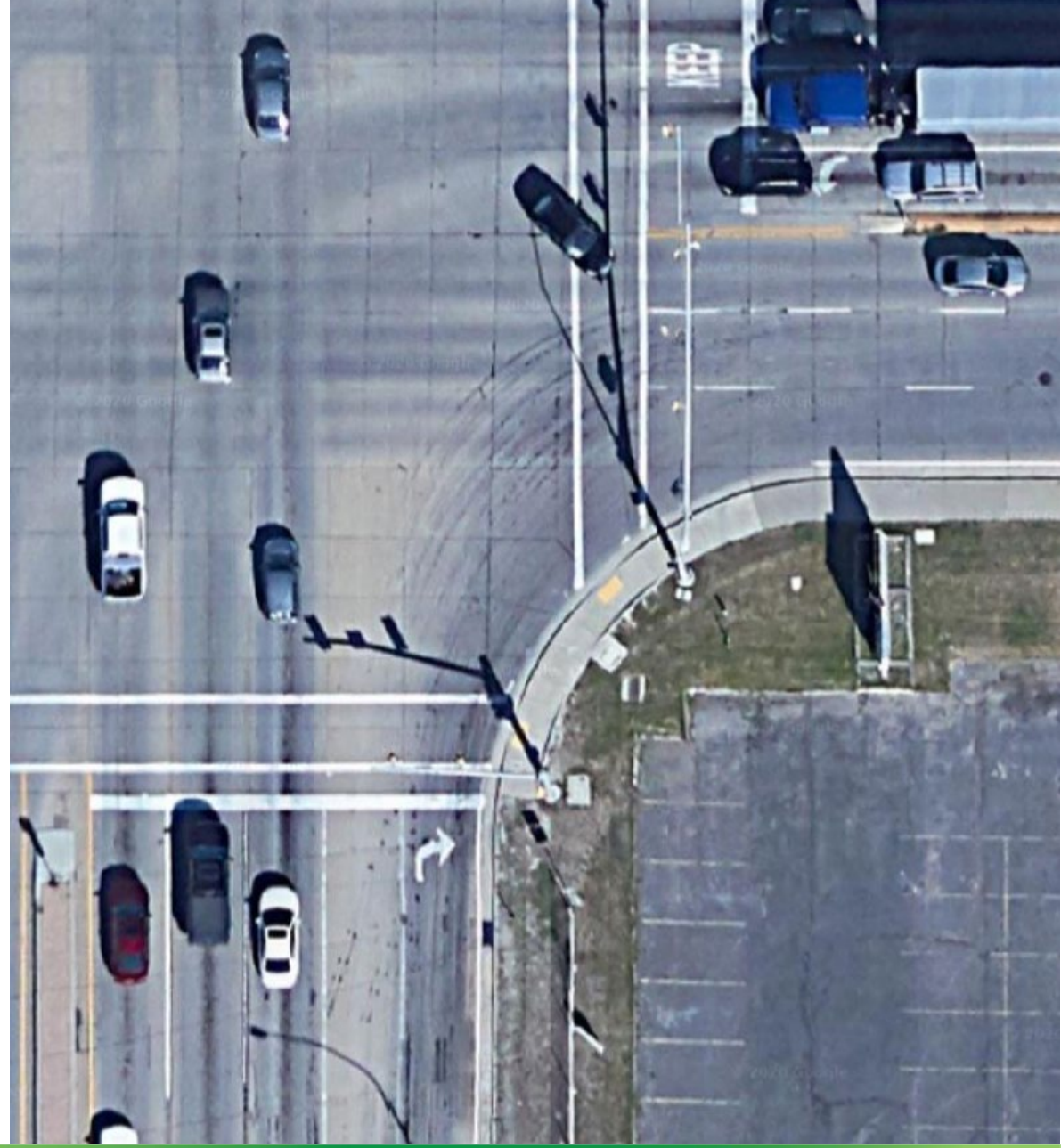
Slow speed, good angle = good visibility of pedestrians

Compact Intersections

- Small, square intersections best for pedestrians…
- Simple, few conflicts, slow speeds

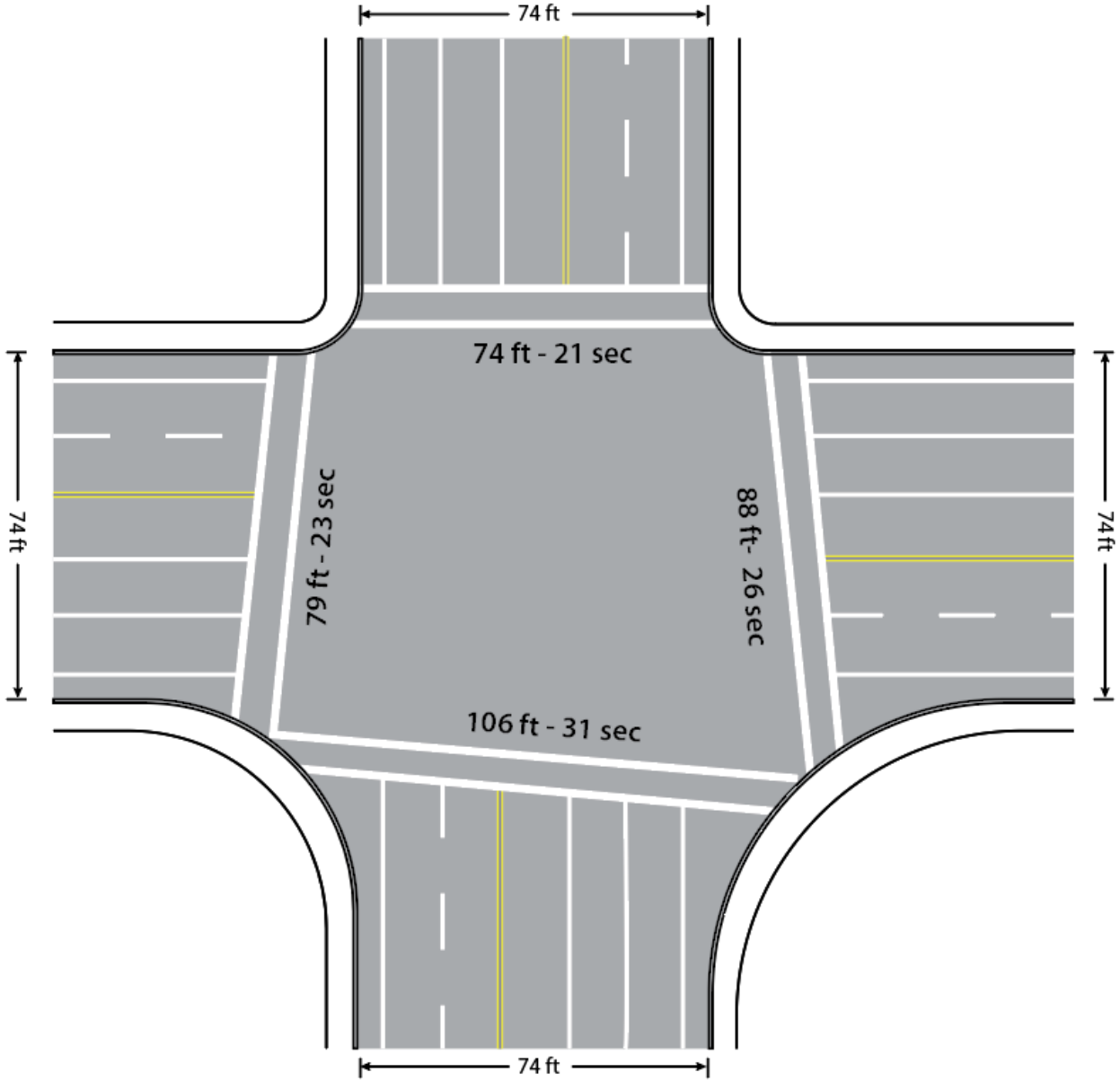
Compact Intersections

Why do we have corners like this?
(answers in the chat box)



Compact Intersections

- Corner Radii impacts:
  - Vehicle Turning Speed
  - Pedestrian Crossing Time
  - Pedestrian Exposure Distance



Quiz

Quiz: Which pedal would we prefer a driver have their foot over near crossing pedestrians?

Turning Speed Vs Corner Radius

Horizontal Curve Radius and Speed

V (mph)	E	F*	R (ft)
8	0	0.38	11
10	0	0.38	18
12	0	0.35	27
15	0	0.32	47

Values from AASHTO Green Book 2011, Table 3-7 and Equation 3-8

The formula for calculating turning speed is R = V2/15(.01E + F) where:

R is the turning radius (effective)
V is speed in miles per hour (mph)
E is super-elevation. This is assumed to be zero in urban conditions.
F is side friction factor

AASHTO. *A Policy on Geometric Design of Highways and Streets*. 2011. Table 3-7 and Equation 3-8

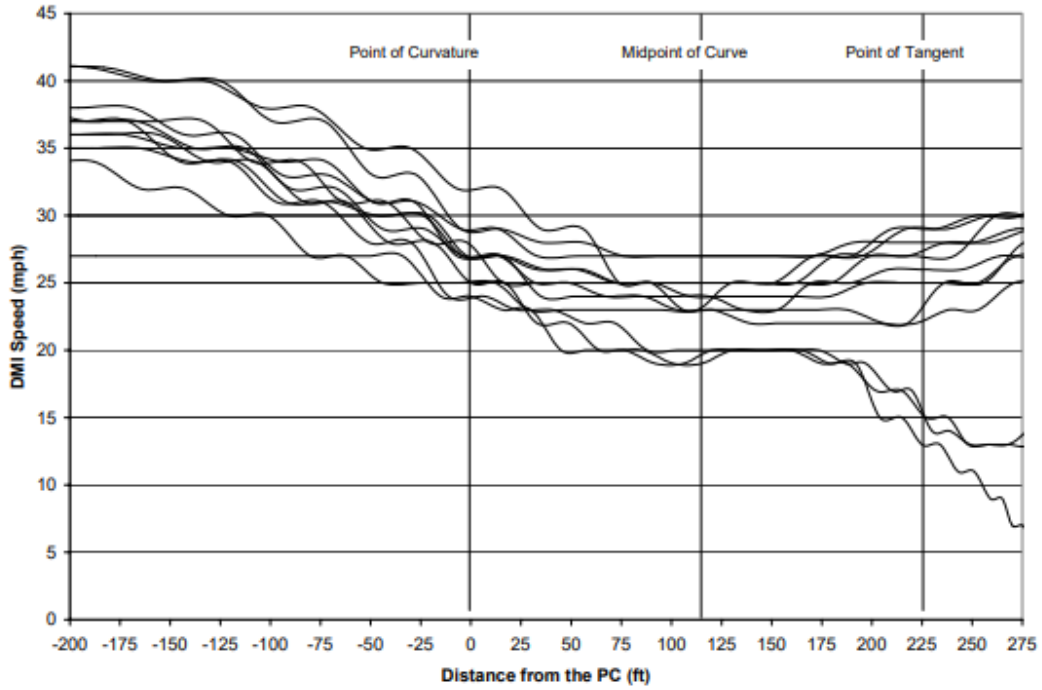


Figure 15. DMI Vehicle Speed Through Right Turn at Site 2.

TTI Study - Deceleration to midpoint in corner then acceleration out of corner.

85th % Speed in a Free Flowing Corner

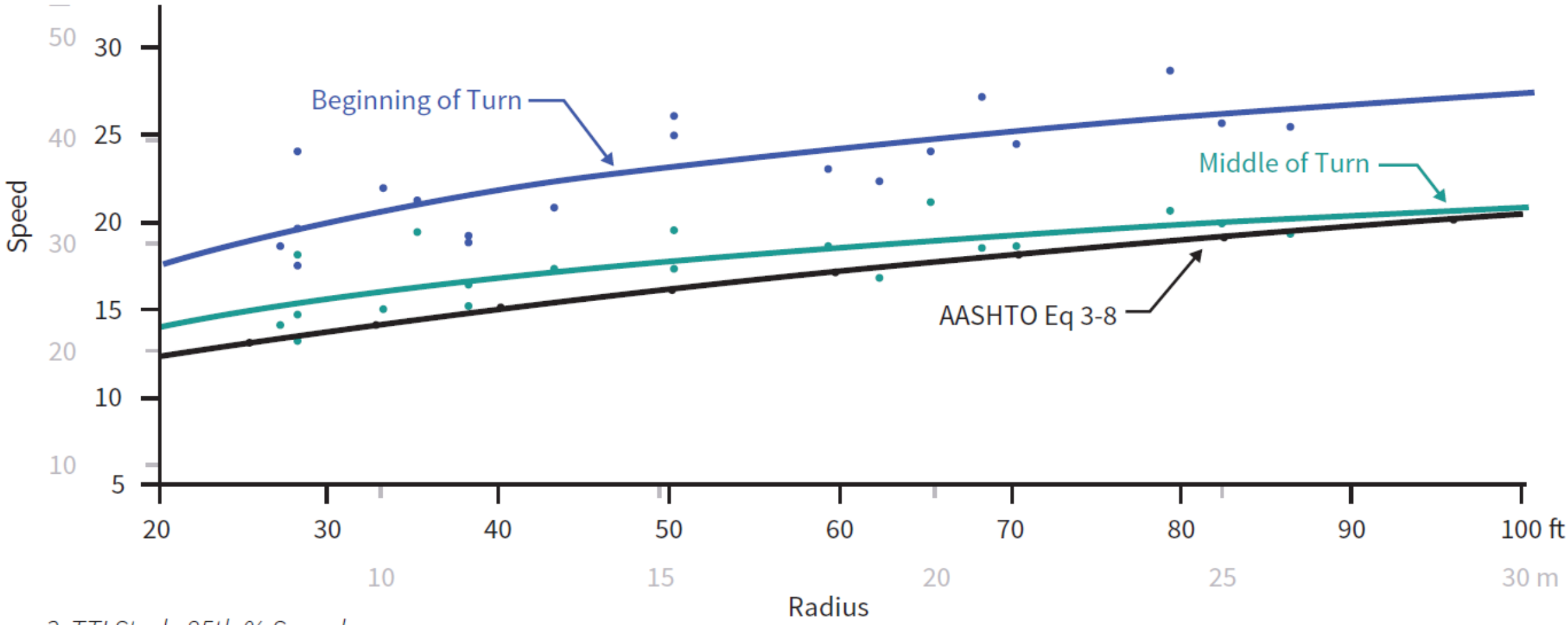


Figure 3: TTI Study 85th % Speeds

Stopping Sight Distance

$$d = 1.47Vt + 1.075\frac{V^2}{a} \quad \textit{(Imperial)}$$

$$d = 0.278Vt + 0.039\frac{V^2}{a} \quad \textit{(Metric)}$$

Where,

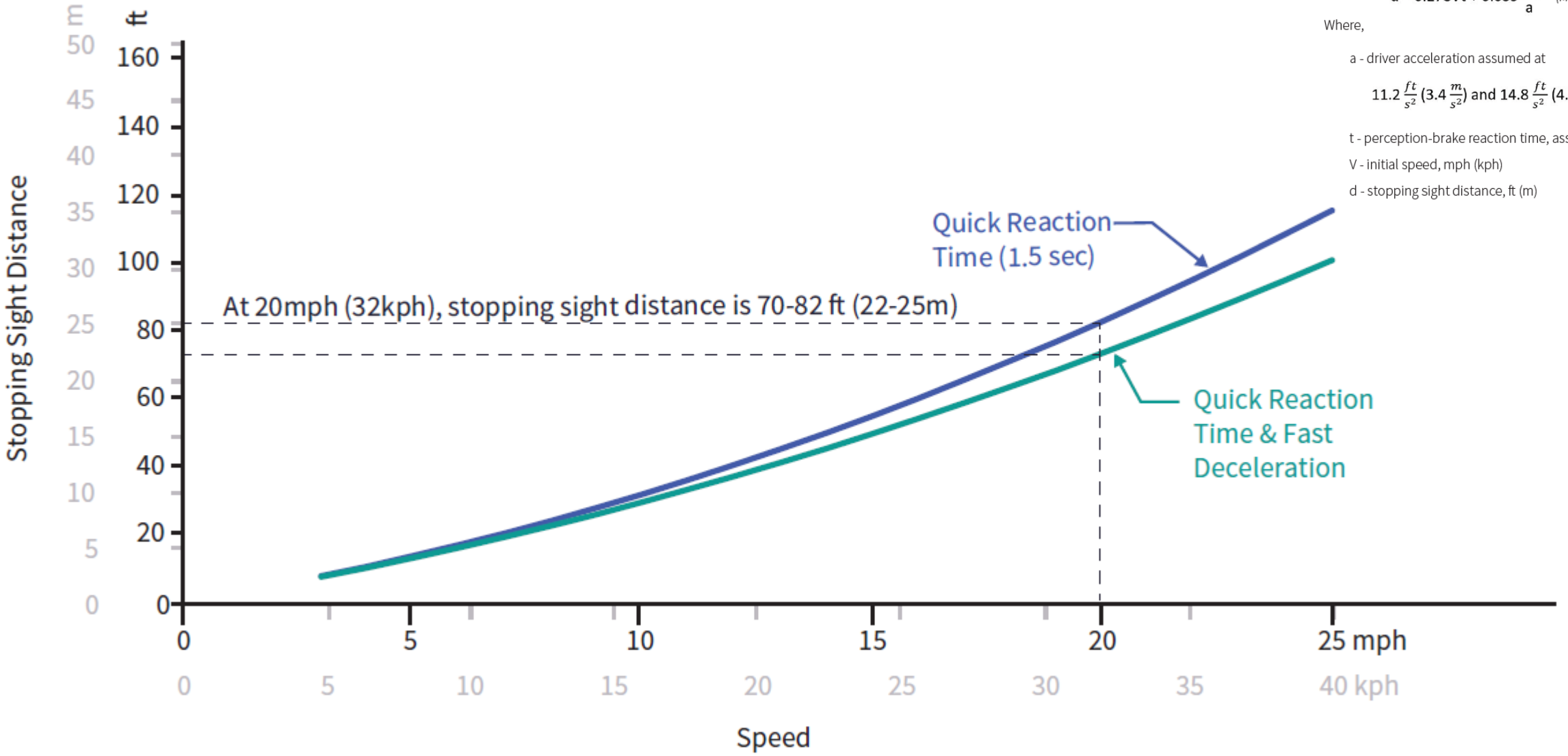
a - driver acceleration assumed at

$11.2\ \frac{ft}{s^2}\ (3.4\ \frac{m}{s^2})$ and $14.8\ \frac{ft}{s^2}\ (4.5\ \frac{m}{s^2})$

t - perception-brake reaction time, assumed to be 1.5s

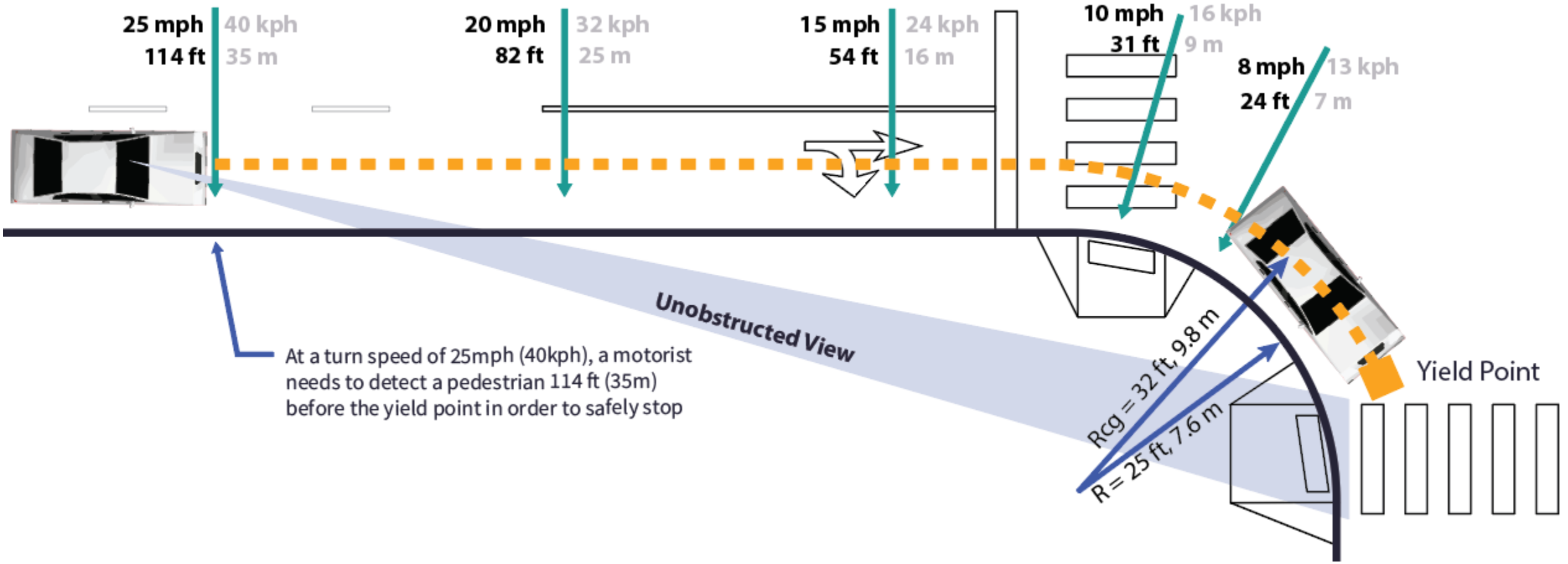
V - initial speed, mph (kph)

d - stopping sight distance, ft (m)



Stopping Sight Distance

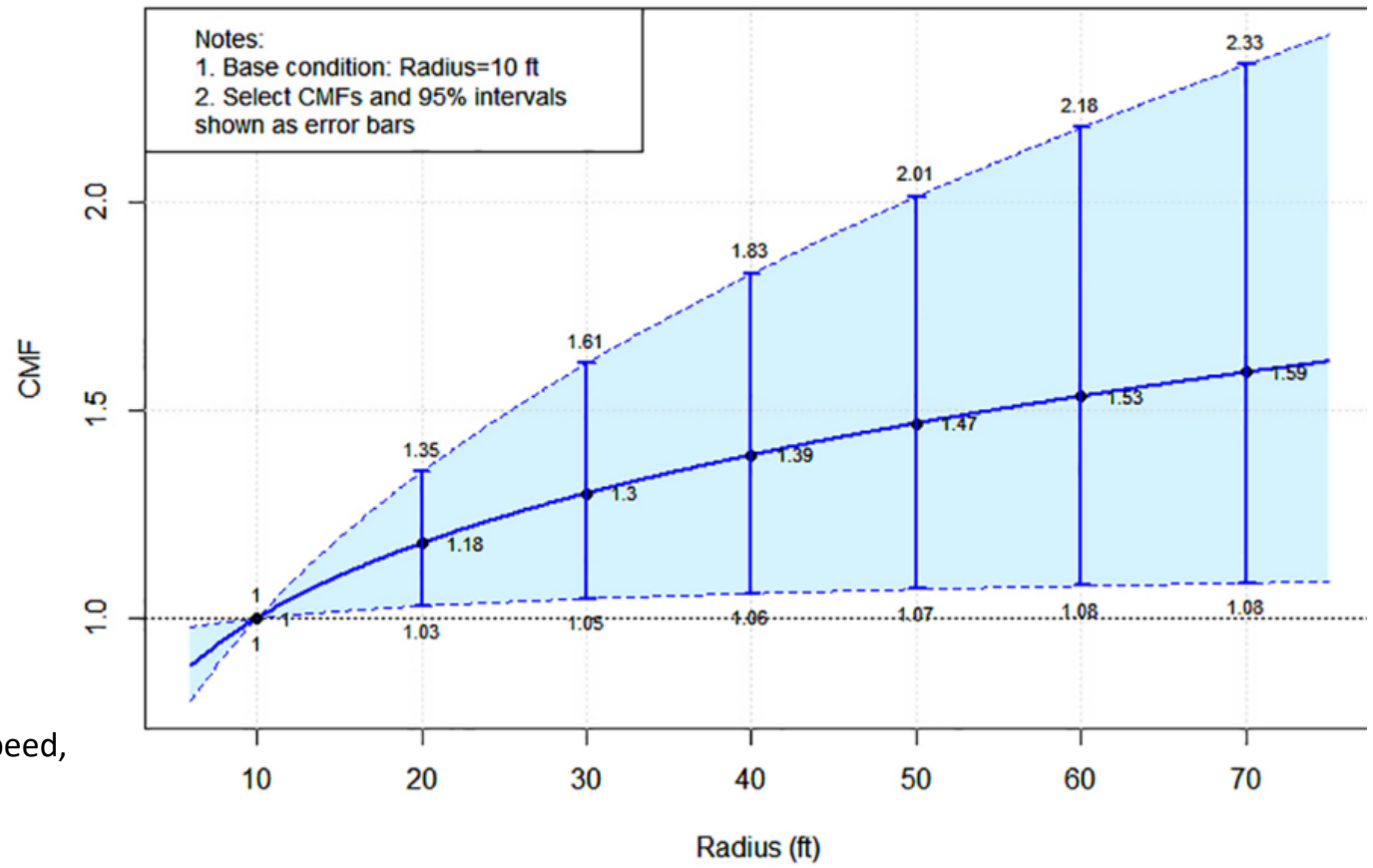
Cars travelling faster take longer to stop



Crash Risk of Higher Turn Speeds

- Right turns speeds are a function of corner radius
- Larger corner radii are linked to more pedestrian crashes
- 50-foot radius would lead to an approximate 50% increase in crashes over base condition

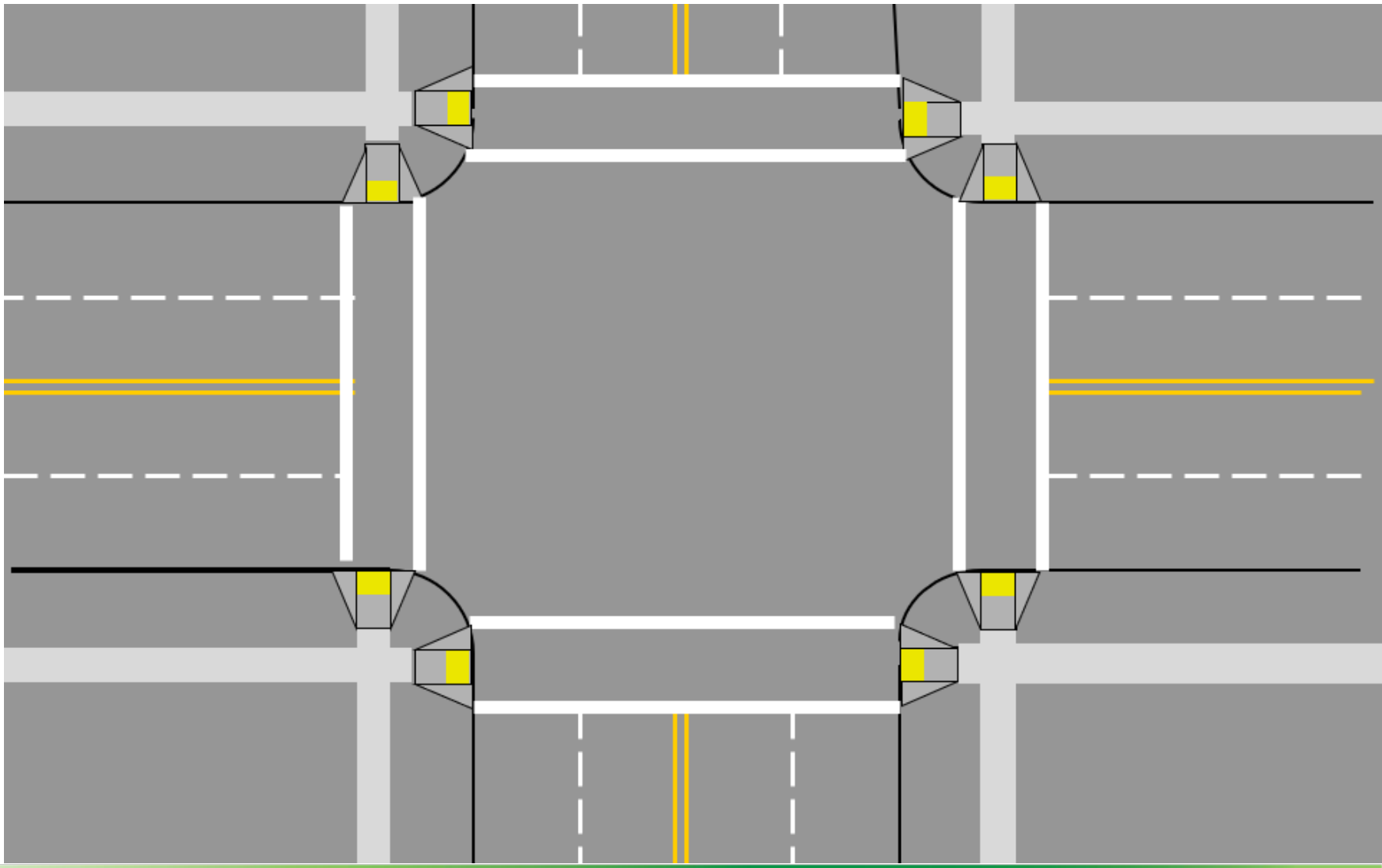
Figure 1. Graph. Corner radius CMF for pedestrian crashes based on Virginia model.



USDOT Crash Modification Factor for Corner Radius, Right-Turn Speed, and Prediction of Pedestrian Crashes at Signalized Intersections

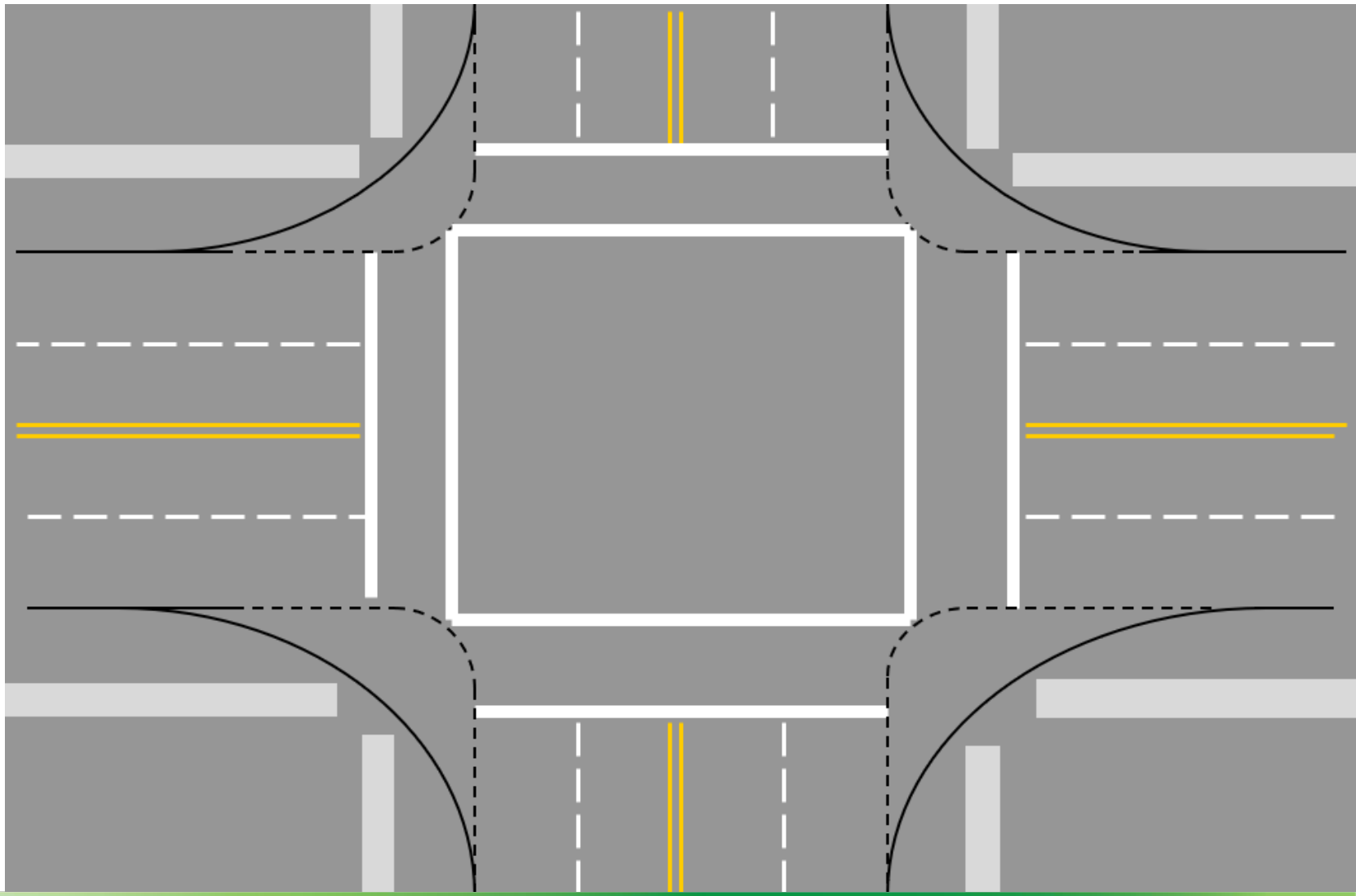
Corner Radii and Ramp Placement

Small radii allow two ramps, shortest crosswalks, direct travel paths



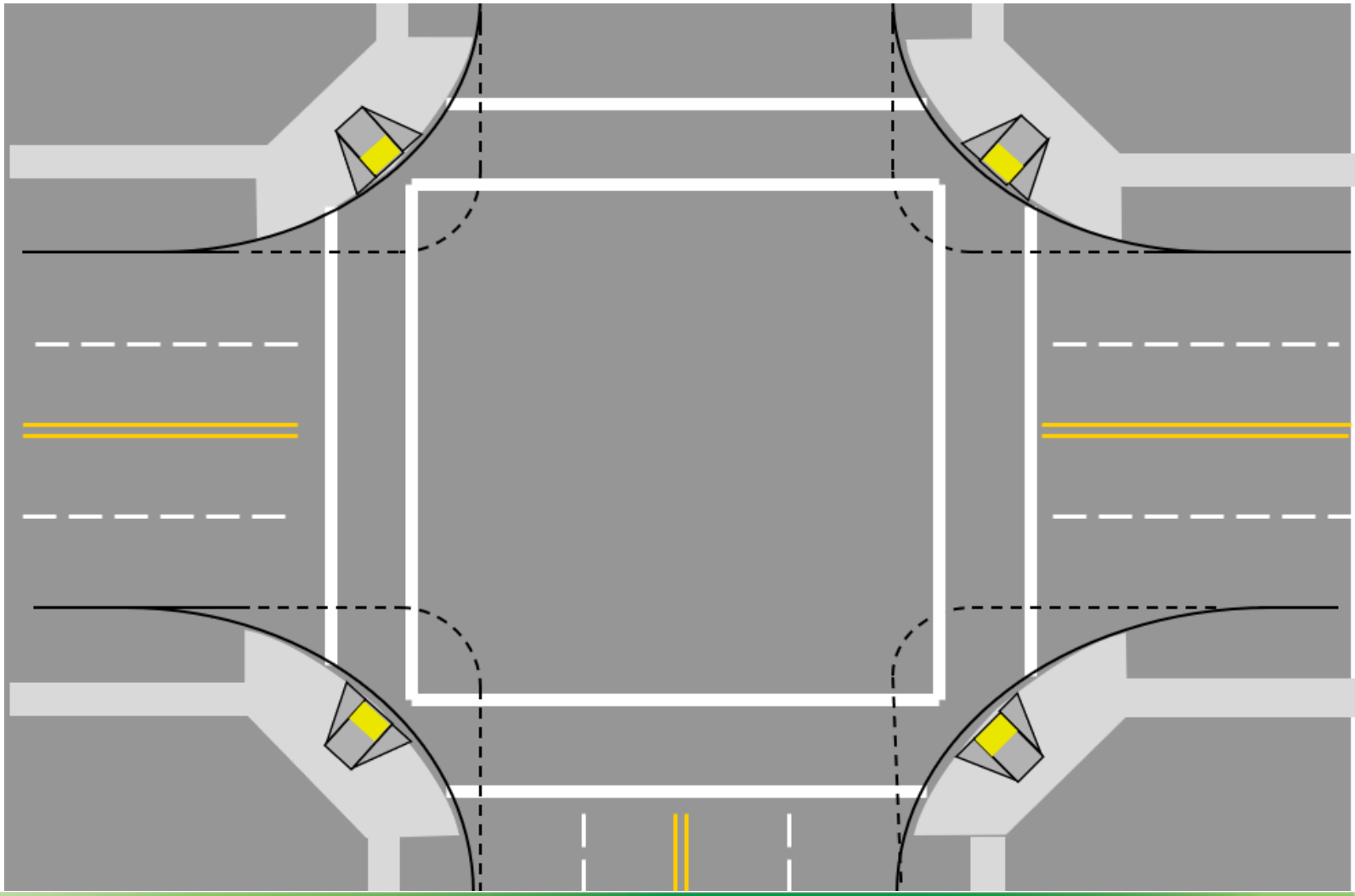
Corner Radii and Ramp Placement

Large radii create large undefined areas



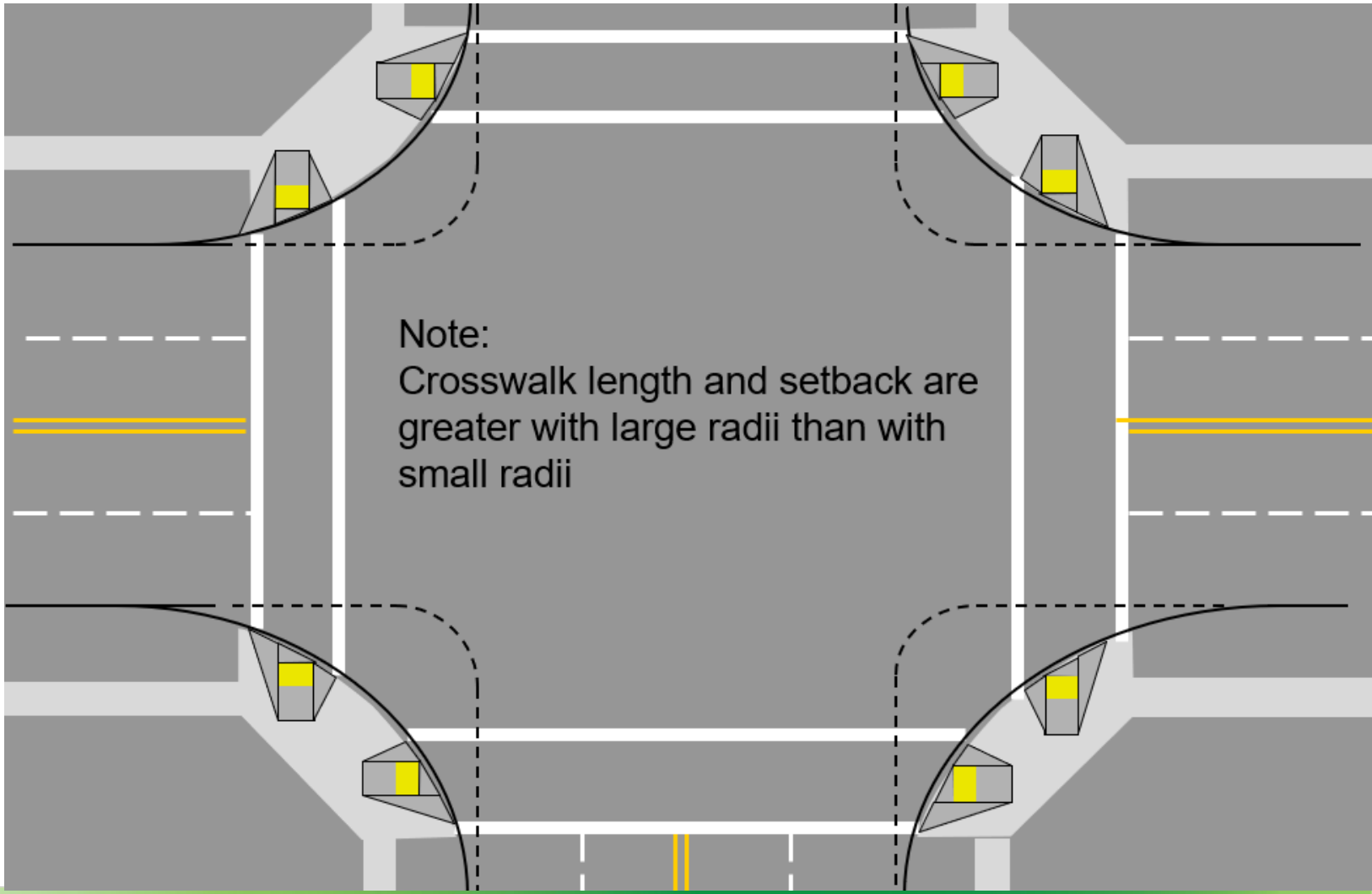
Corner Radii and Ramp Placement

Single ramp reduces crosswalk setback but lengthens crosswalk



Corner Radii and Ramp Placement

Balance Goals



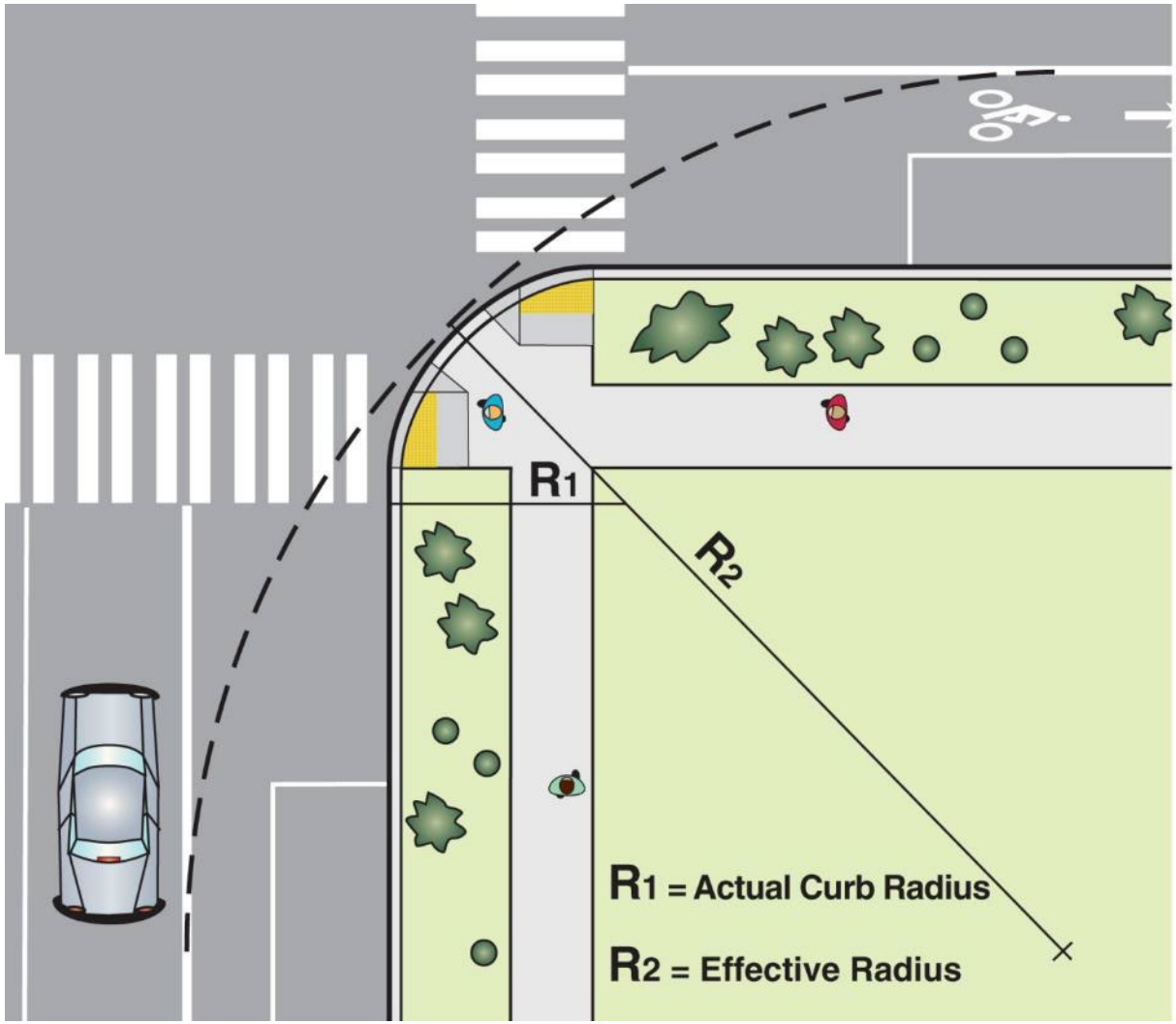
Corner Radii and Ramp Placement

Expectation vs Reality

Accommodating Large Vehicles

1. Minimize Curb Radius

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

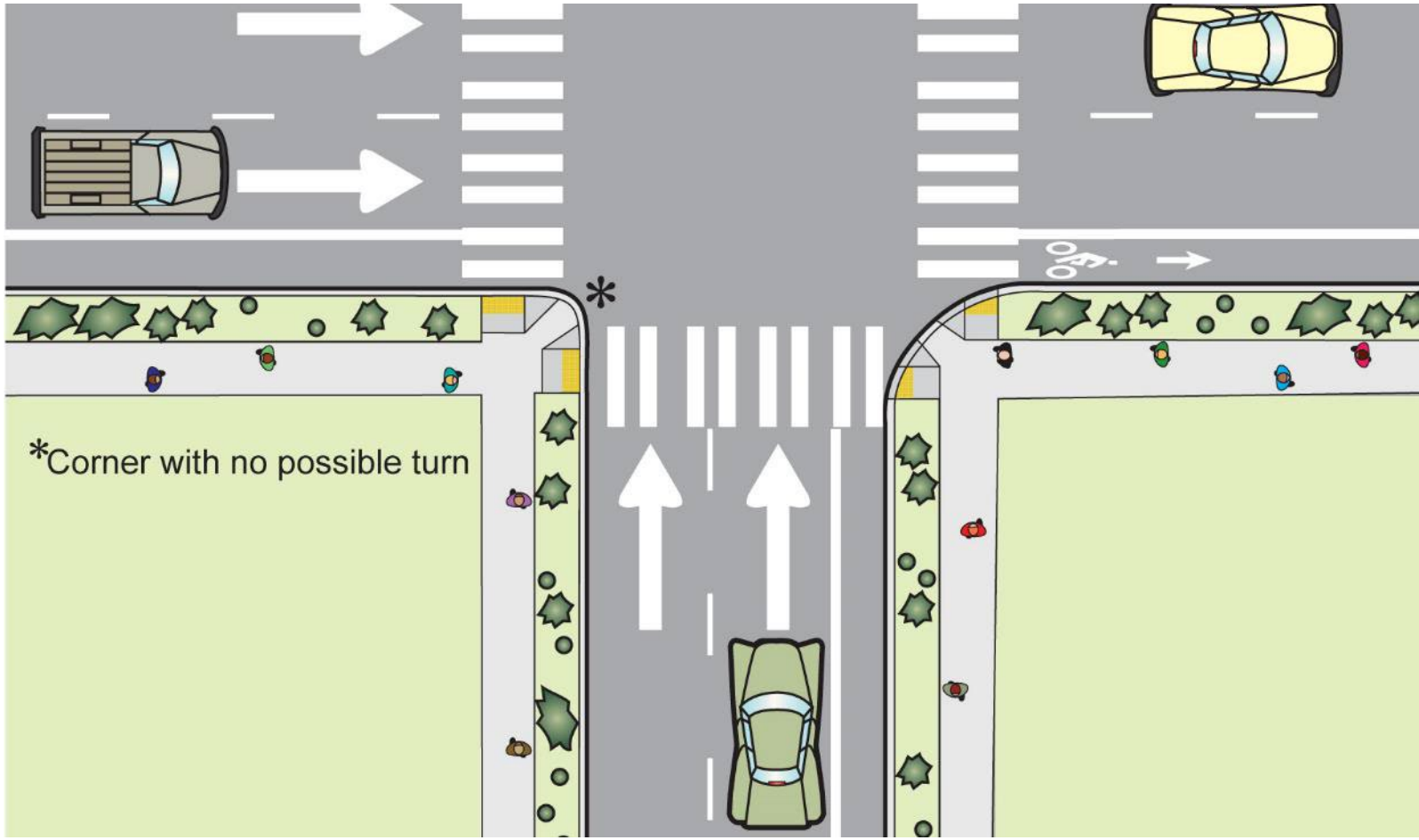


Accommodating Large Vehicles

Accommodating Large Vehicles

2. Only provide space where needed

At one-way streets, corner with no turns can have tight radius



Accommodating Large Vehicles

3. Don’t choose a larger design vehicle than necessary

Bus makes this corner several times an hour

Accommodating Large Vehicles

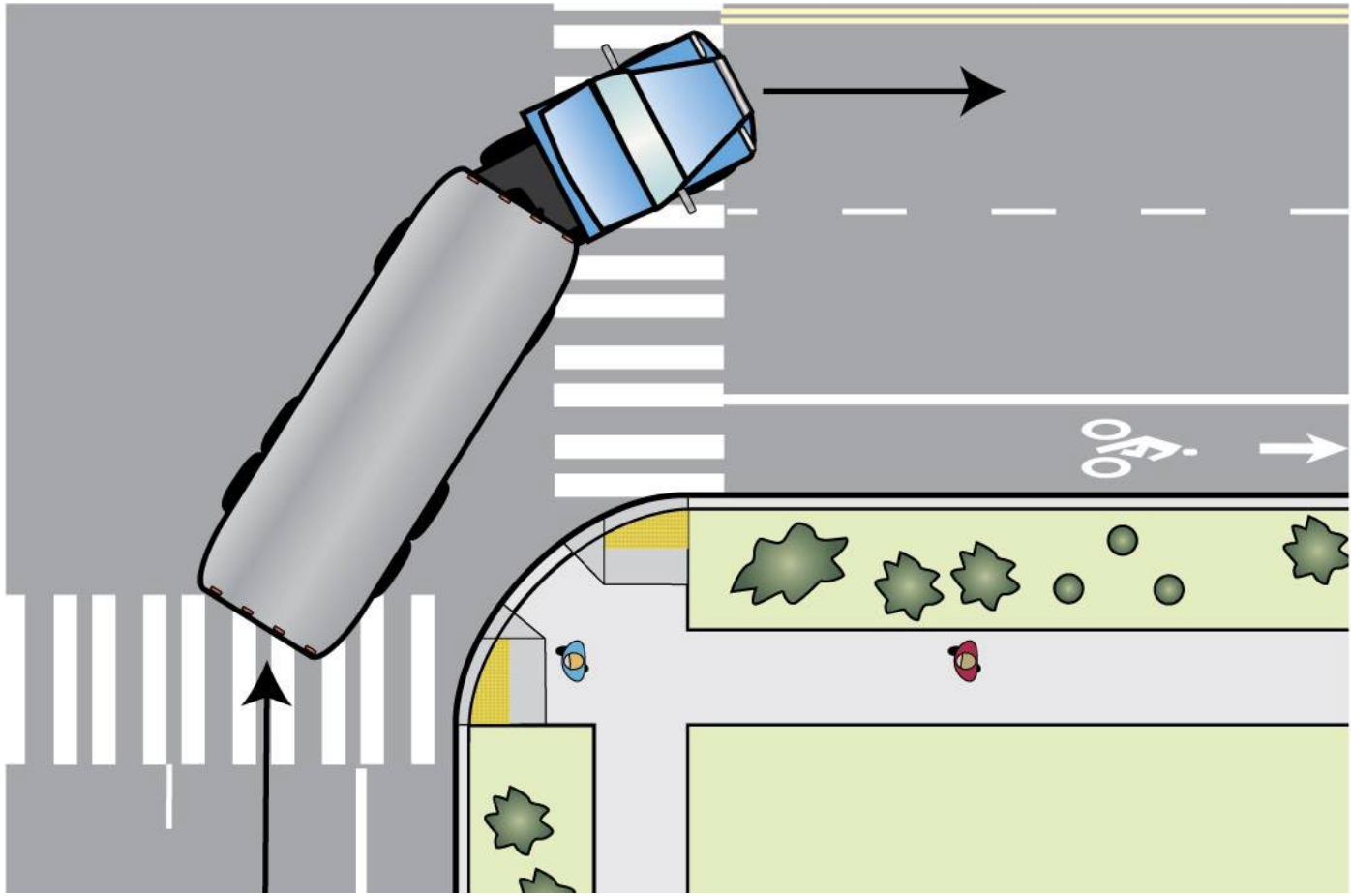
3. Don’t choose a larger design vehicle than necessary

Moving van, once or twice a year; peds cross every few minutes!

Accommodating Large Vehicles

4. Allow vehicles to use all receiving lanes

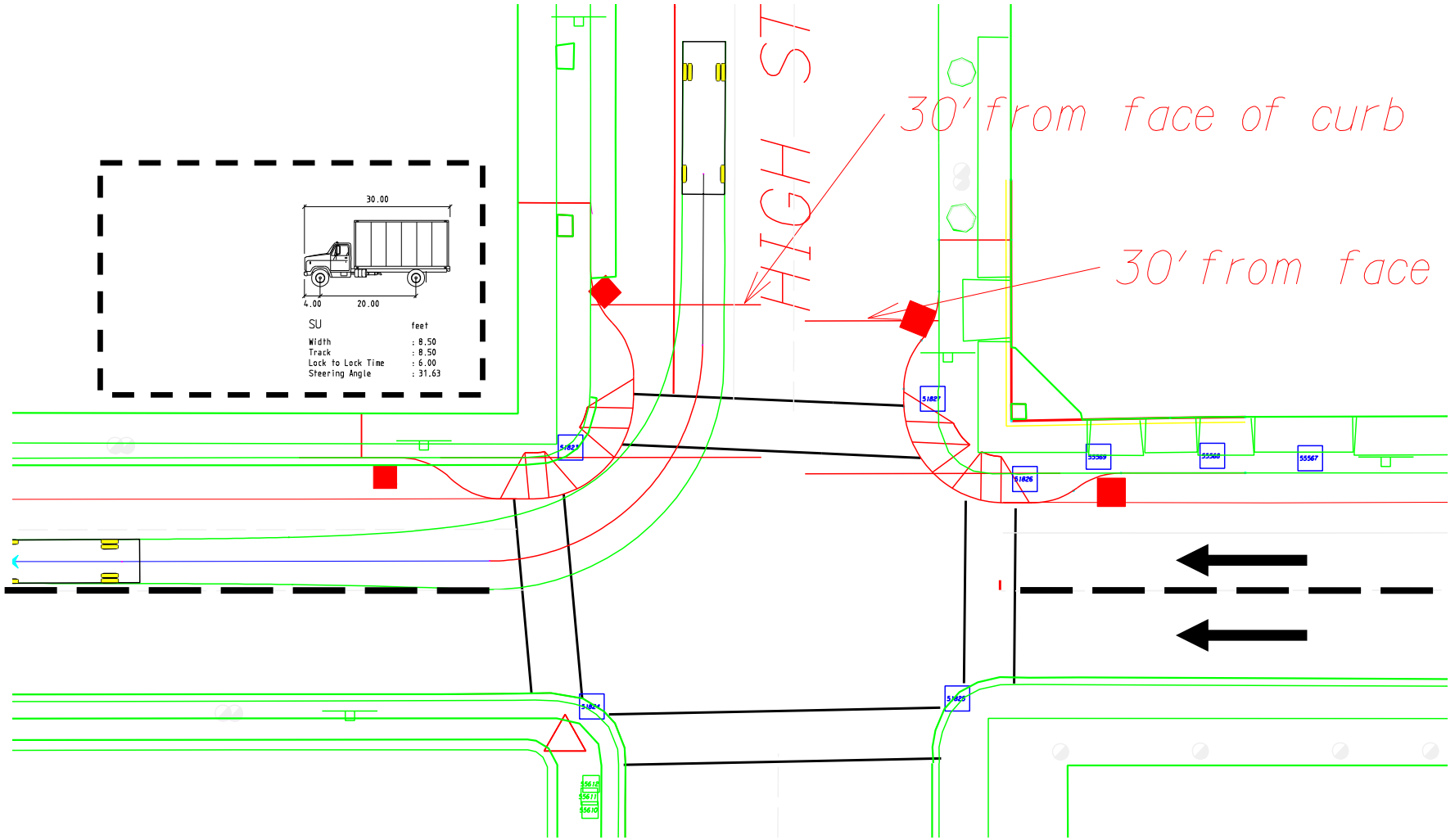
Moving van, once or twice a year; peds cross every few minutes!



Accommodating Large Vehicles

3. Turn SU-30 into near lane

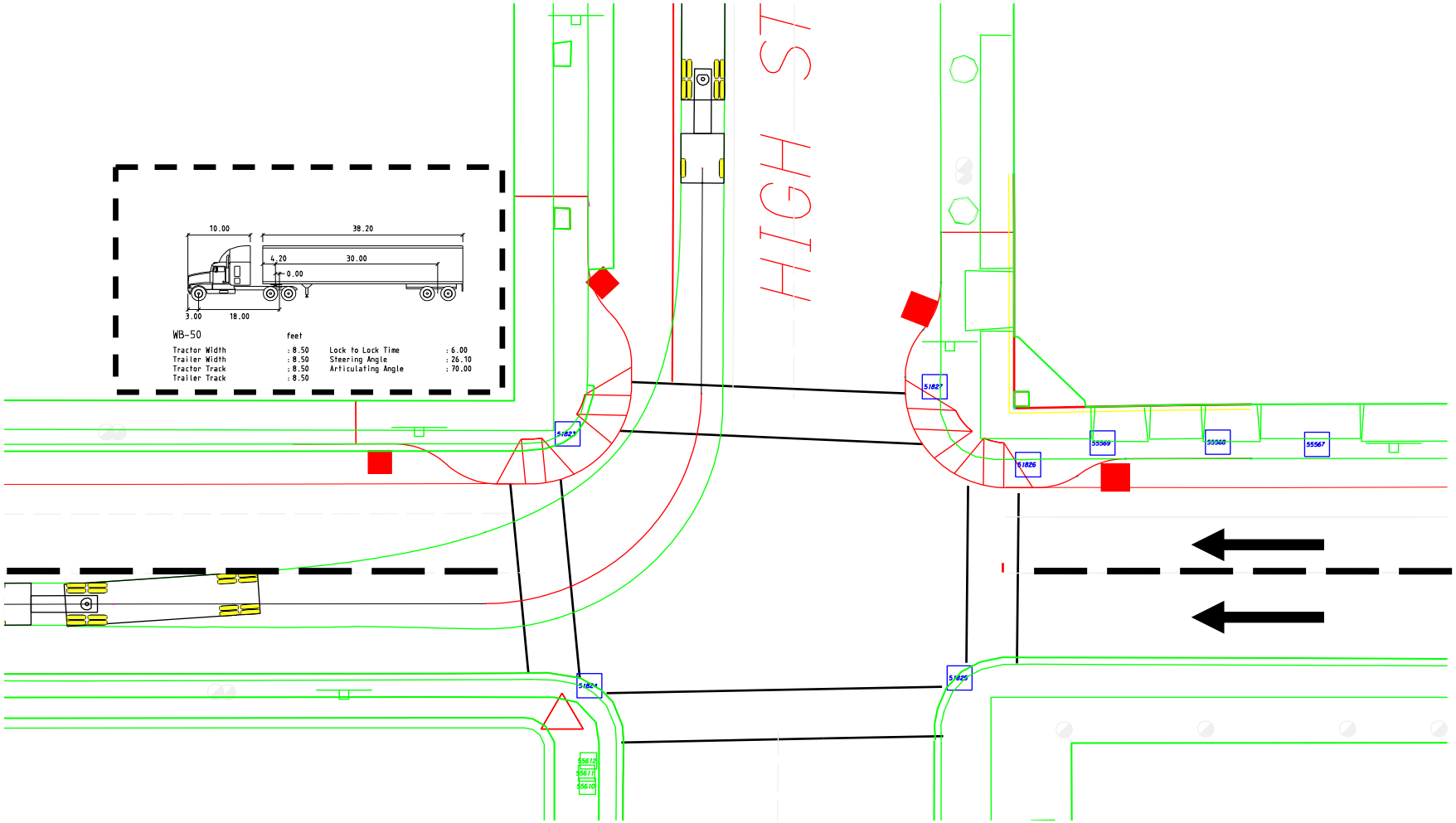
"Design Vehicle"



Accommodating Large Vehicles

3. Turn less common Semi (WB-50) into 2nd lane

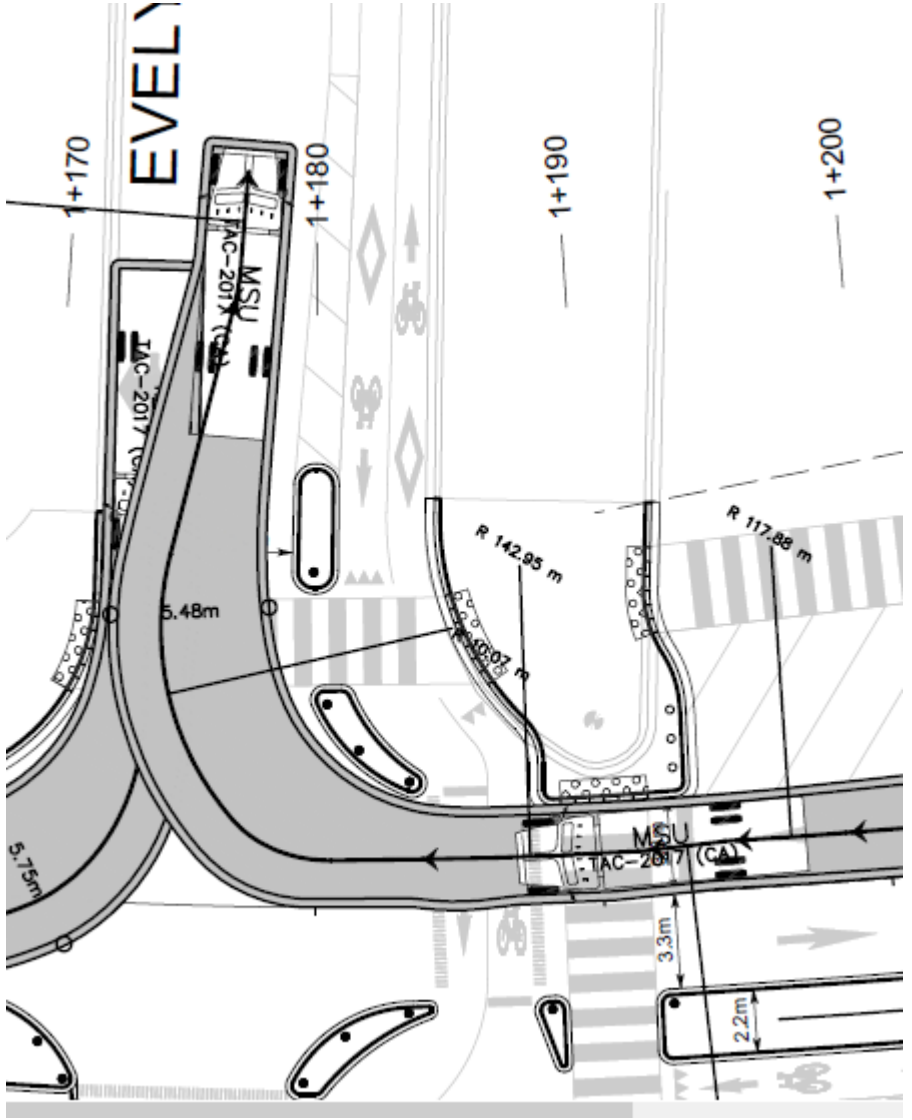
"Control Vehicle"



Accommodating Large Vehicles - Policies

- Defines typical design and control vehicles by intersection corner type
- Defines turning design speeds by vehicle
- Defines vehicle starting position – Infrequent turns may straddle
- Defines allowable vehicle ending position – Large control vehicles can:
  - Take up multiple receiving lanes
  - Occupy oncoming lanes in select circumstances

https://www.toronto.ca/wp-content/uploads/2018/05/90c8-Curb-Radii-Guideline-Version-1.1.1-May-2018.pdf



Accommodating Large Vehicles – Truck Aprons

Accommodating Large Vehicles – Truck Aprons

Accommodating Large Vehicles – Truck Aprons

- NYC - Over 230 locations installed
  - Median right turn speeds have decreased by 32.7%
  - Average right turn speeds have decreased by 34.1%
  - 85th percentile right turn speeds have decreased by 47.2%
  - Maximum right turn speeds have decreased by 48.7%
- Serious pedestrian injuries down by 30-40 percent

Slowing Left Turns

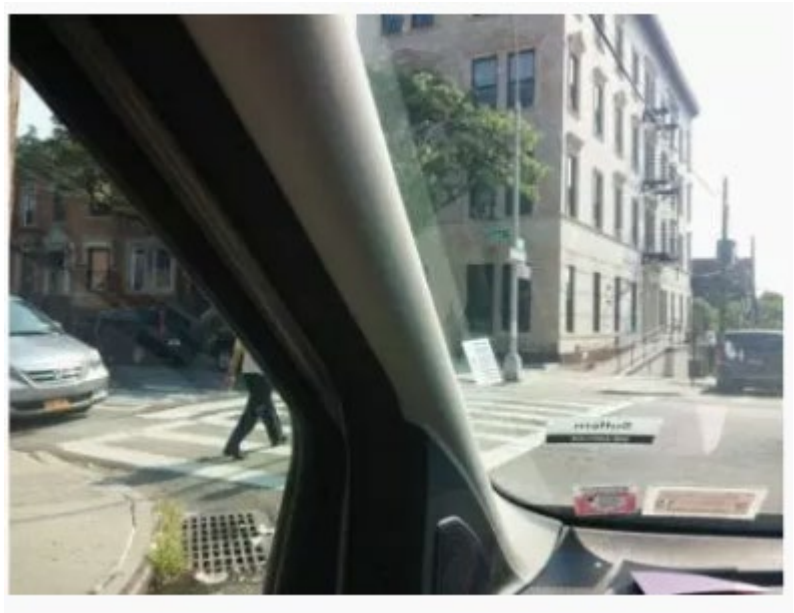
Median nose protects pedestrians from high-speed left-turning cars

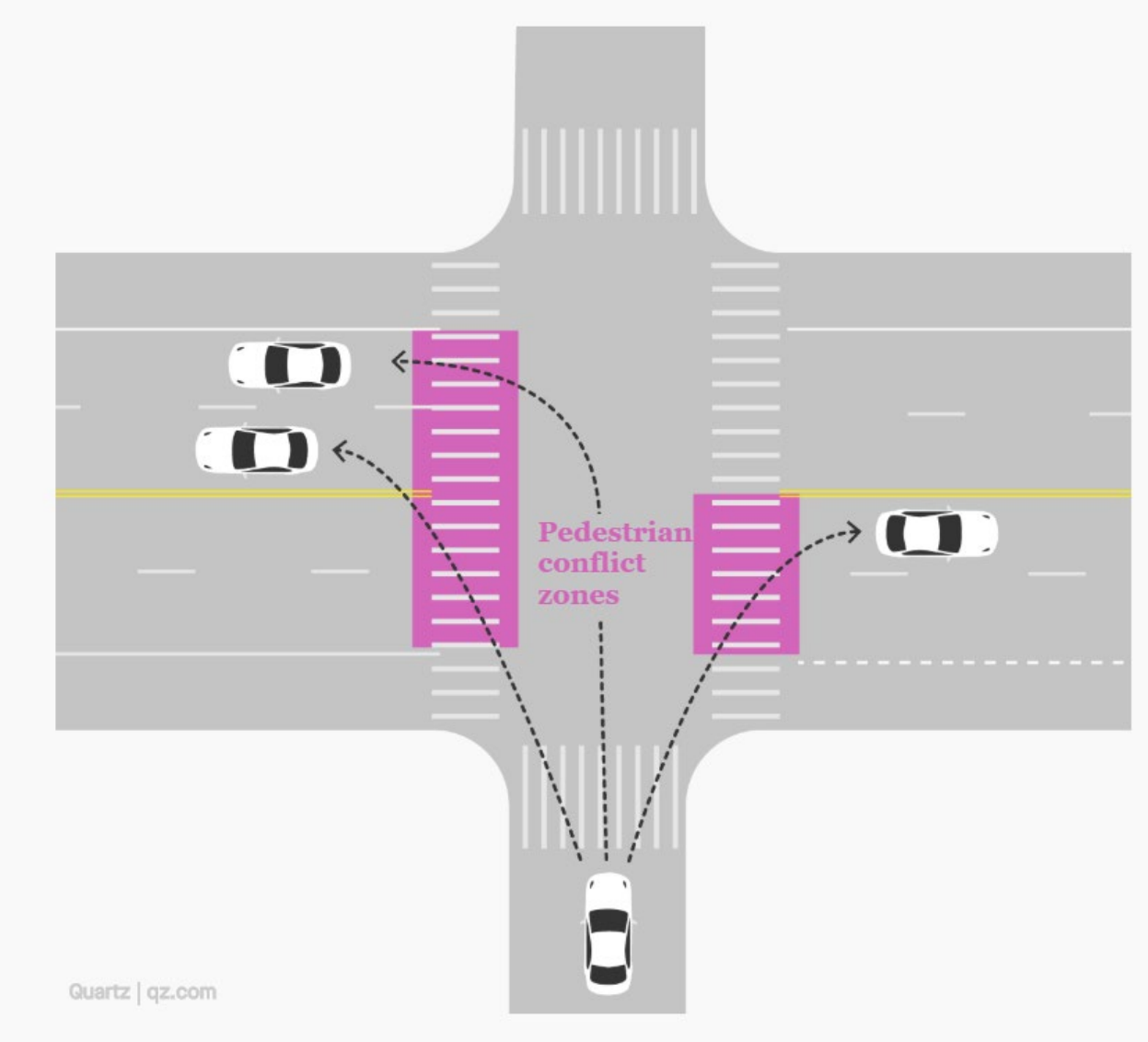
- Provides refuge
- Sharpens left turn – slowing vehicle

Slowing Left Turns

NYC

- 13% of deaths involving bikes/peds were from left turns from 2010 to 2014
- Cars cut corners when turning
- Car frames block visibility when turning

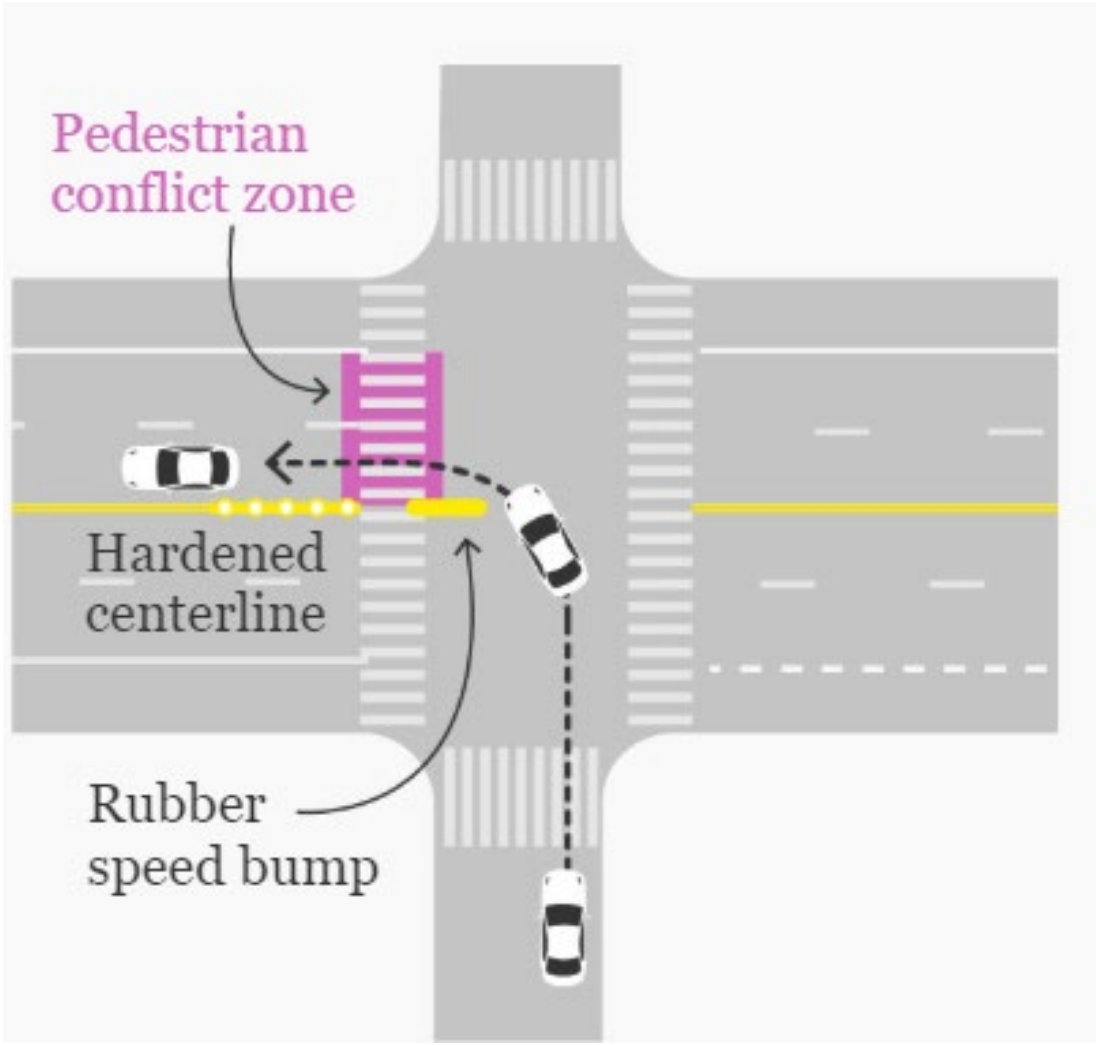




Slowing Left Turns

NYC

- Invented the “Hardened Centerline”
- With rubber bump, slows down left turns and discourages drivers from cutting corners



Slowing Left Turns

Slowing Left Turns

NYC – Findings From 360 Locations

In New York City intersections pedestrian injuries have **decreased by 20%** where Turn Calming treatments have been implemented, declining faster than nearby comparable locations. Additional results from Turn Calming locations:

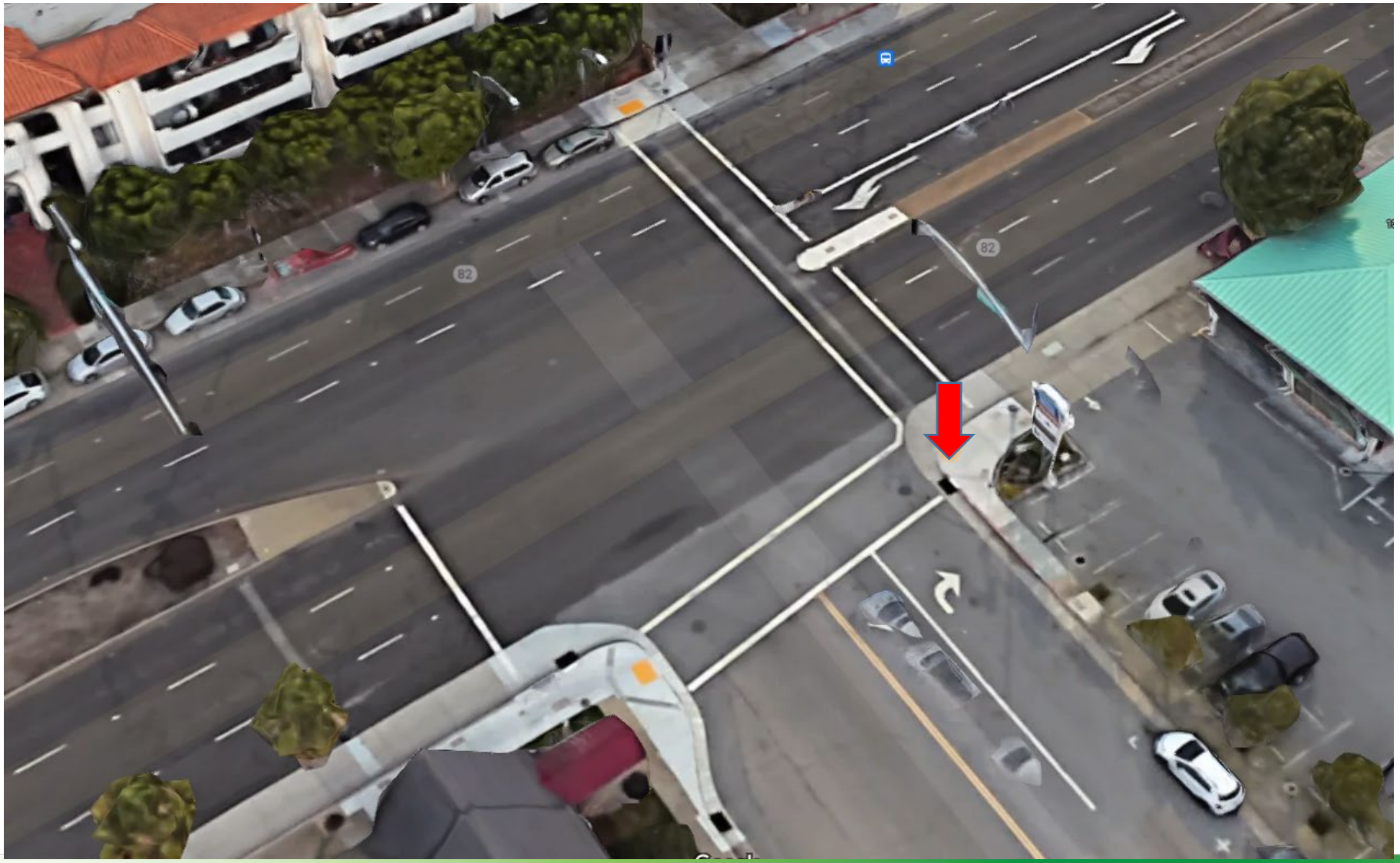
- Median left turn speeds have decreased by 54.3%
- Average left turn speeds have decreased by 52.6%
- 85th percentile left turn speeds have decreased by 59.8%
- Maximum left turn speeds have decreased by 37.7%

Vehicles are making safer turns as well; the rate of crossing the double yellow line while turning has dropped by 78.9% for locations that have a treatment extending to the stop bar and 100% for locations that have a treatment extending all the way to the crosswalk.

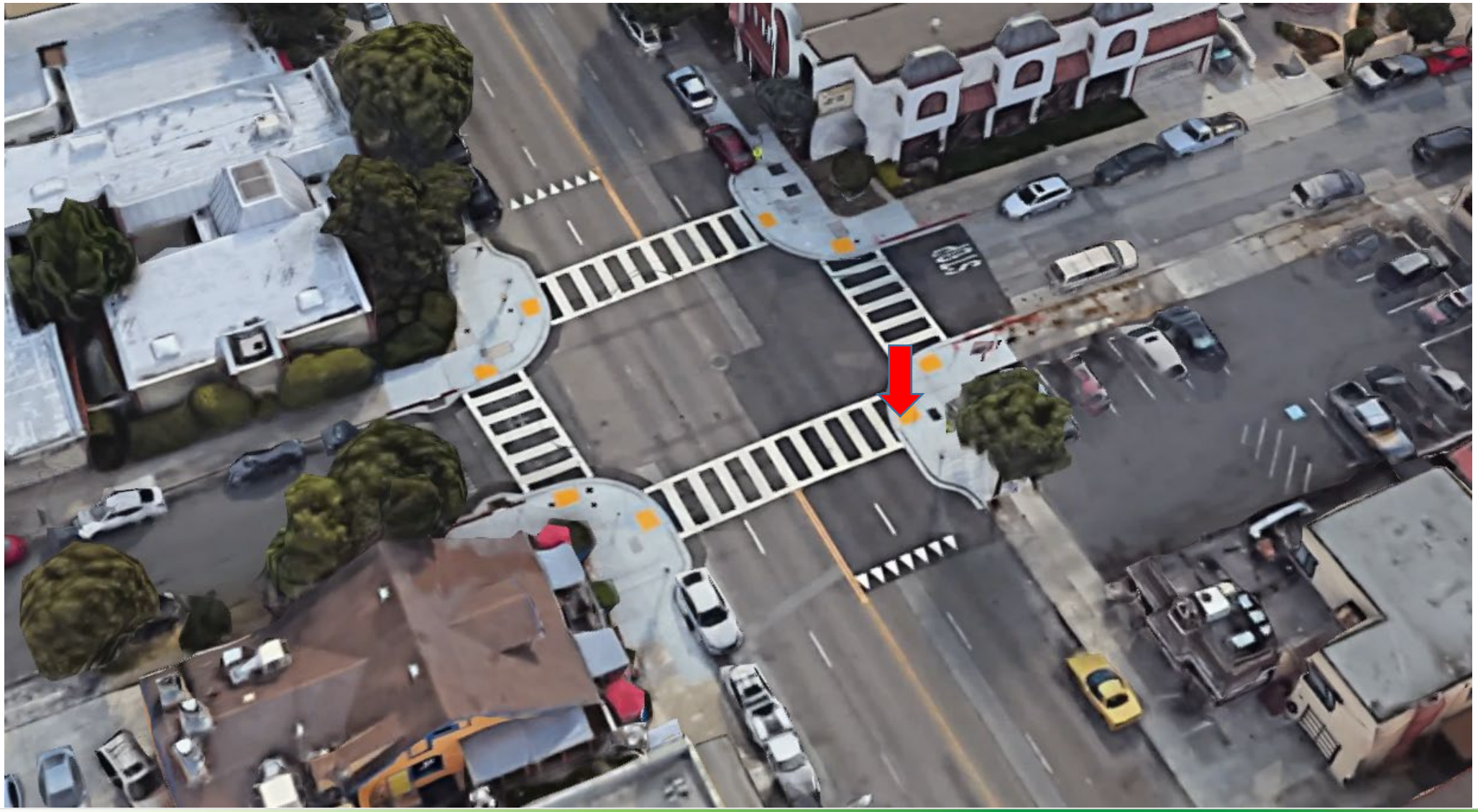
Increase Conspicuity

Increase Conspicuity

Increase Conspicuity



Increase Conspicuity



Clarify Intent

Clearly Assign Priority

Clearly Assign Priority

Improve Pedestrian Safety

Countermeasure	All Crashes	Pedestrian Crashes
Reduce Corner Radii from 50 to 10 feet		50%
Reduce Corner Radii from 50 to		30%
Speed Hump Hardened Centerline (NYCDOT)		20% (injuries)

** Data accessed from the Crash Modification Factors Clearinghouse at www.cmfclearinghouse.org*

Signalized Intersections

How can we make them work better for pedestrians?

What are Traffic Signals For?

Quiz:

- Increase safety
- Assign the right of way
- Regulate traffic flow
- Create gaps

How Can We Improve Signalized Intersections?

1. Using good geometric design
2. Placing islands to break up complex crossings
3. Placing crosswalks in logical locations
4. Improving convenience and ease of use of pedestrian pushbuttons and signals
5. Using techniques to reduce conflicts with turning vehicles

Already discussed topics 1-3

How is Pedestrian Comfort at Signals Defined?

Let's look first to the 2004 Walk for Science Project:

Pedestrian LOS for Signalized Intersections =

a_1(**RightTurnonRed** + **Permitted Lefts**) +

a_2(**PerpTrafVol** x **PerpTrafSpeed**) +

a_3(**LanesCrossed** 0.514) + $a_4$ln(**PedDelay**) -

RTCI (0.0027PerpTrafVol – 0.1946) + C

How is Pedestrian Comfort at Signals Defined?

Other Qualitative Elements:

Pay attention to Pedestrian Storage

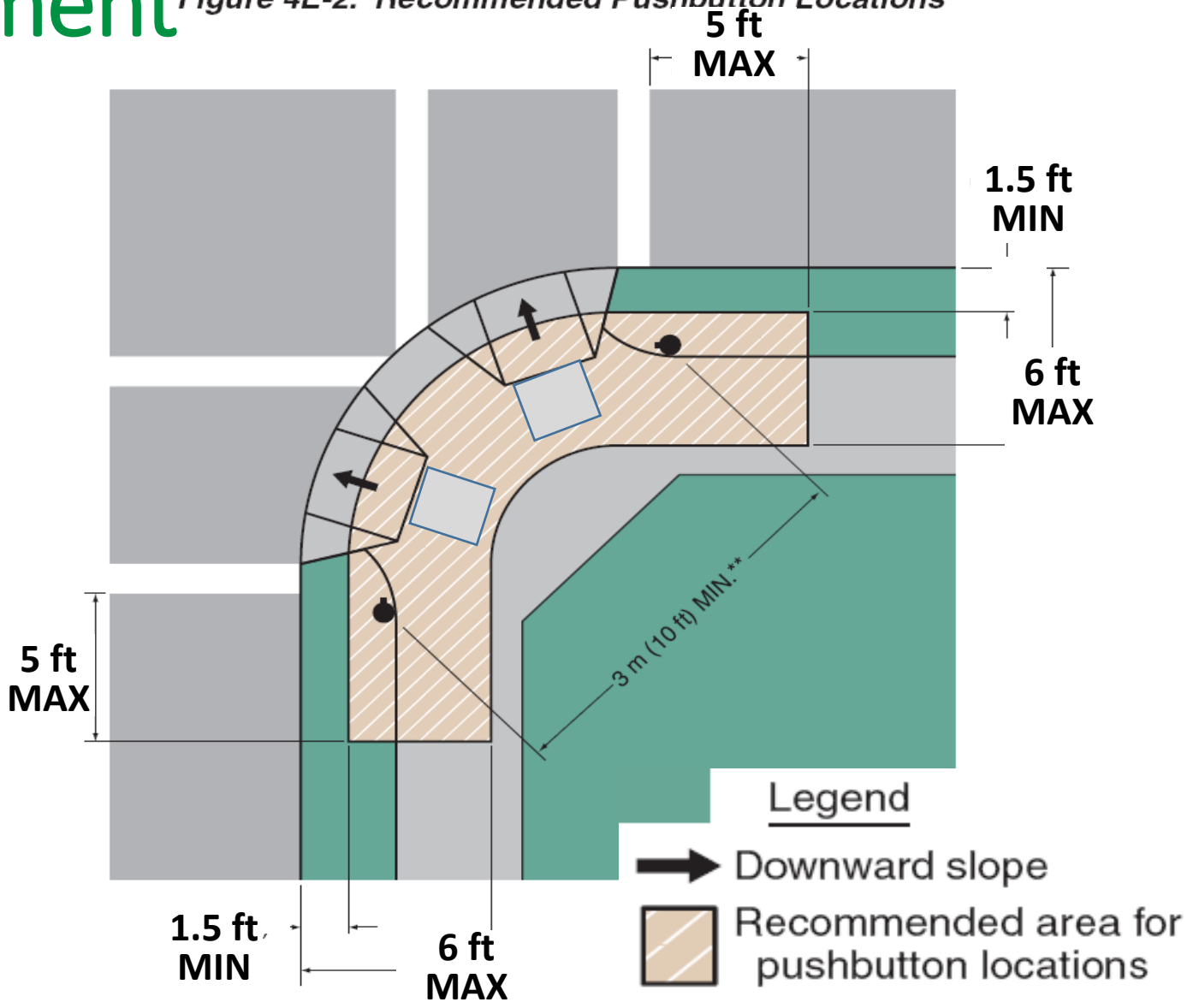
Long wait or high pedestrian volumes causes stacking: pedestrian wait in the street, or don't wait and cross against the signal

Proper Button Placement

Good Button Placement:

- Accessible from “landing” by wheelchair
- Close to curb line
- Impossible to confuse direction

Figure 4E-2. Recommended Pushbutton Locations



Proper Button Placement

Be careful!

Proper Button Placement

On side of pole

At top of ramp

Accessible Pedestrian Signals (APS)

- Provide ped signal information in audible, visual (red light) and vibrotactile format
- Benefit all pedestrians by providing redundancy
- The 2009 MUTCD describes the features of APS, but does not require them
- PROWAG will require APS at all new and altered signals – Adoption rumored soon!

Question: Is your city using APS?

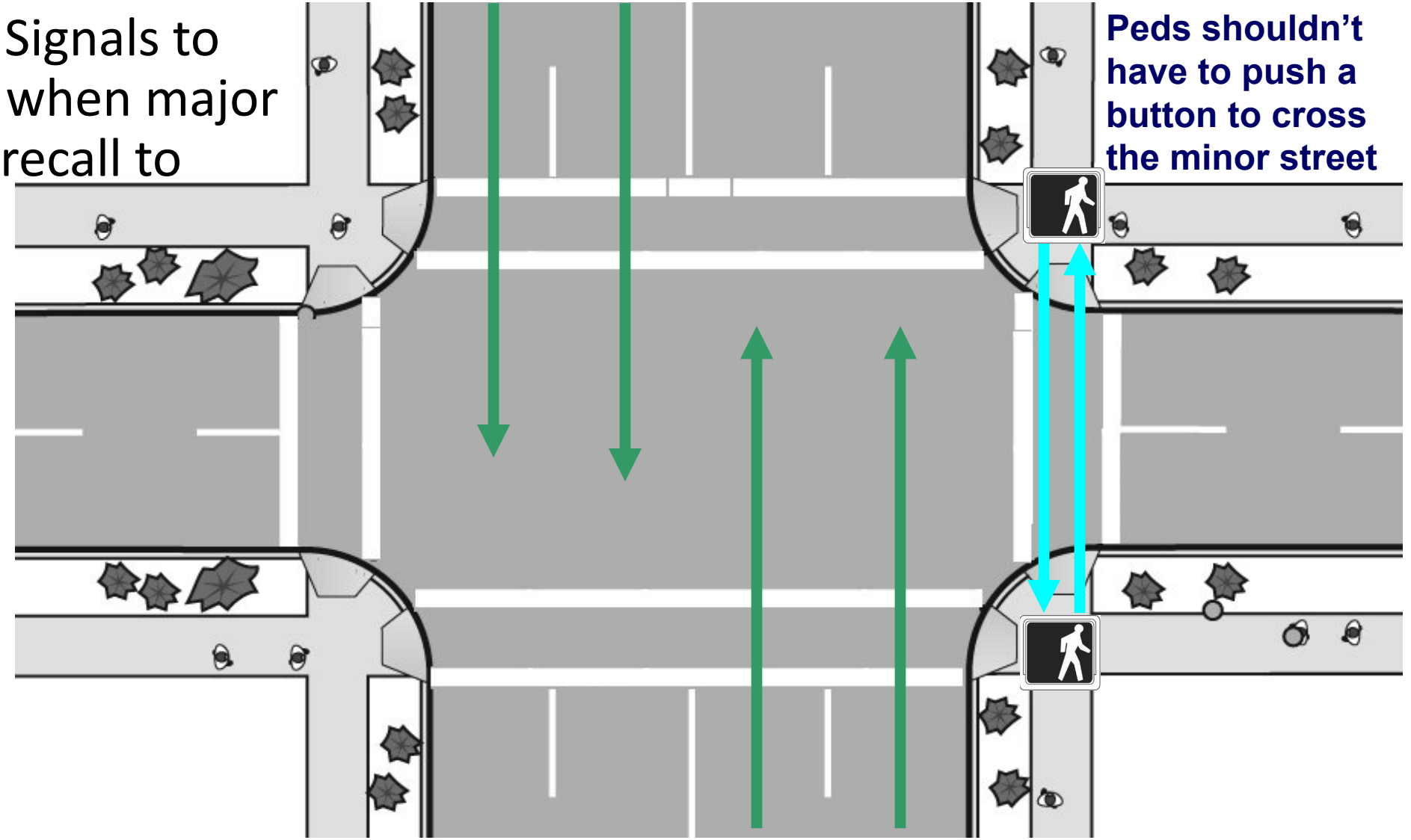
Accessible Pedestrian Signals (APS)

Features:

- Hearing Impaired: Red light to indicate activation, vibrotactile button
- Visually Impaired: Locator tone, tactile arrow, audible messaging, adjustable volume
- Button operable with a closed fist and requires little force

Recall to Walk

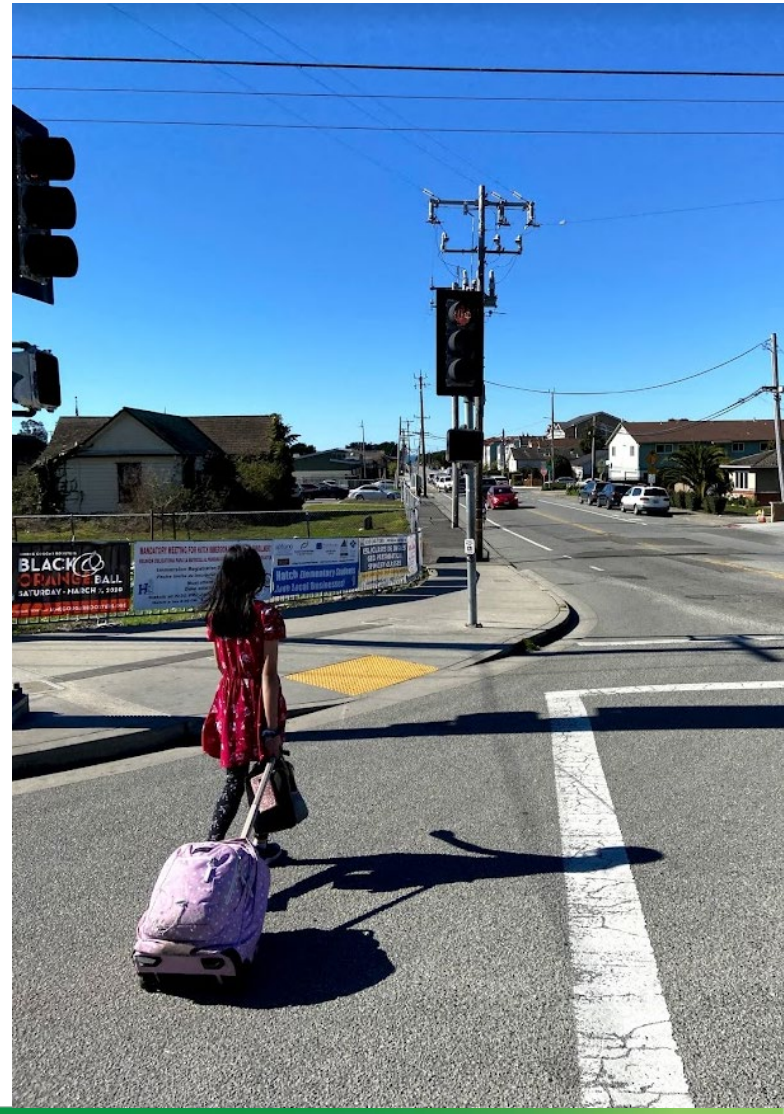
Set Pedestrian Signals to recall to WALK when major street is set to recall to green



Adequate Crossing Time

2009 MUTCD:

- 7 sec walk, 4 sec option (no change)
- Ped clearance time (flashing hand) calculated at 3.5’/sec curb-to-curb.
- Example: 60’ crosswalk requires 17 sec
  - 7 + 17 = 24 sec total
- Additional test for walk plus clearance time: Calculate travel time from push button (or 6’ feet from curb if no button) to curb on other side at 3’/sec
  - Example: 6’ + 60’ crosswalk = 66
    - 66’ requires 22 sec
    - 24 sec > 22 sec; passes test.



Pedestrian Signal Heads

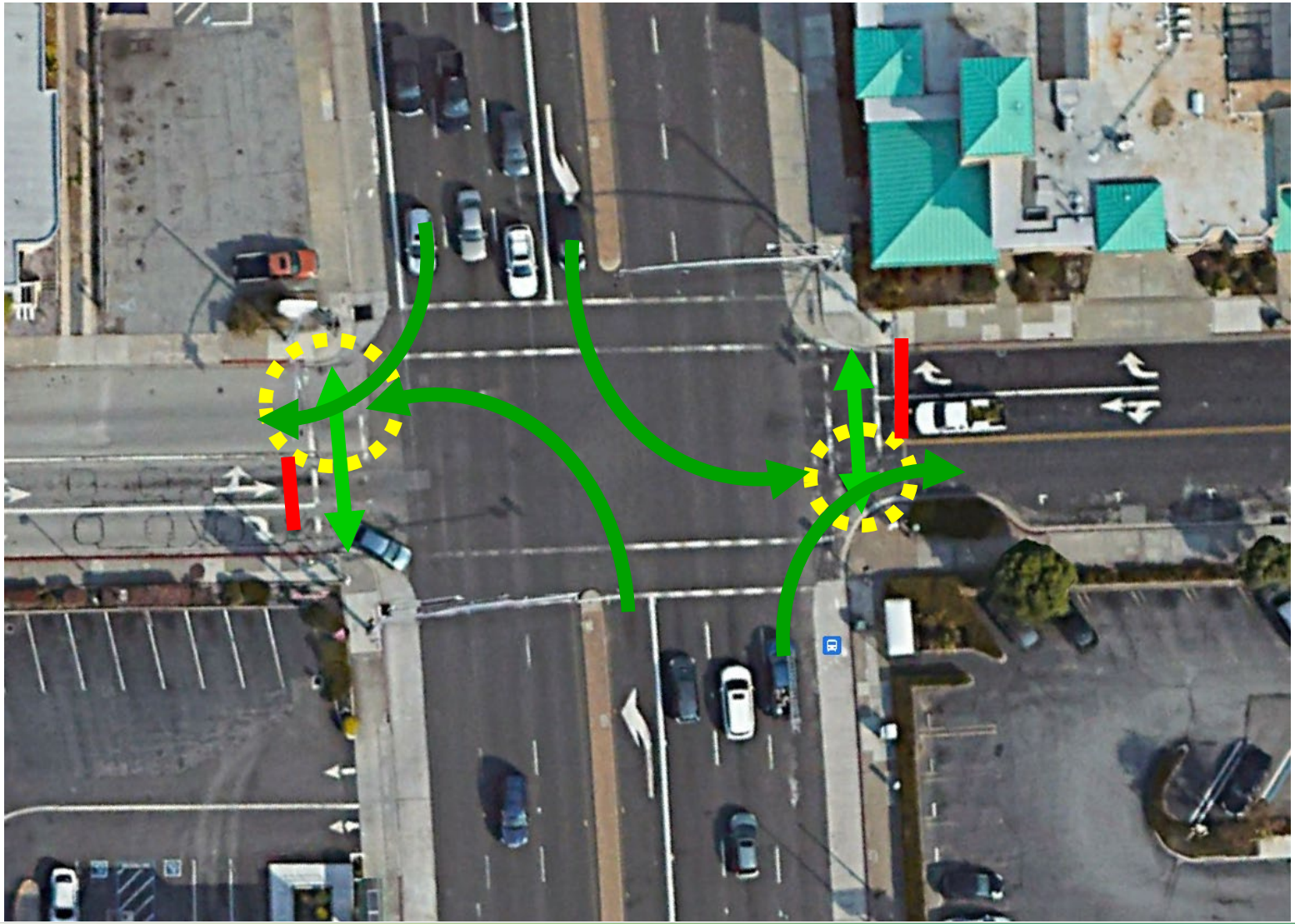
Pedestrian Signal Heads

- 1/2 of Americans don't understand it;
- People not sure if they can start during flashing hand / DON'T WALK
- Studies found between 25 and 52% possible crash reduction by upgrading pedestrian signal heads to countdown.

What Creates Problems for Pedestrians?

Quiz:

(chat box)



Reduce Conflicts

- At signals, turning movements account for most ped crashes
- Left/right turn ratio is roughly 2:1

So what can we do?

Reduce Conflicts

1

Strategy 1: Eliminate permissive left turns

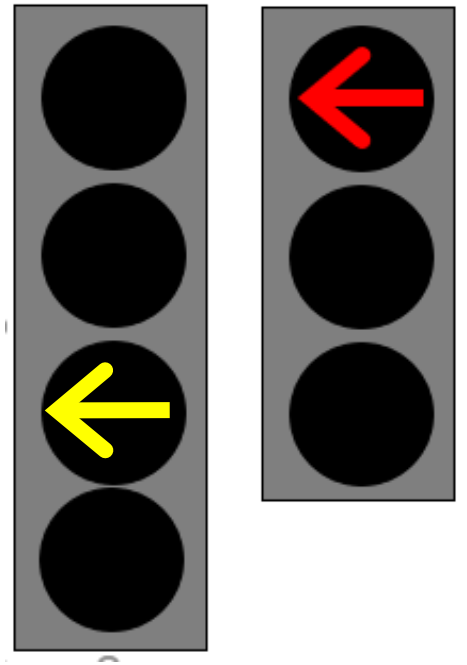
CMF = 0.3 (CRF 70%) (all crashes) converting permissive left turns to protected only left turns

Reduce Conflicts

1

Strategy 1: - If Permissive Turns Must Remain:

- Provide protected-permissive phasing by default, but revert to protected-only when pedestrian button is pushed or based on time of day
- Provide Flashing Yellow Arrow



Reduce Conflicts

2

Strategy 2: Restrict Right Turn on Red

- Poor sight distance between vehicles and peds;
- An unusual number of ped conflicts with turns on red (compared to turns on green);
- An exclusive pedestrian phase; or
- A leading pedestrian interval

Reduce Conflicts

2

Strategy 2: Restrict Right Turn on Red

- Restriction can be:
  - At all times
  - When pedestrians are present
  - By time of day

Effectiveness likely to be low

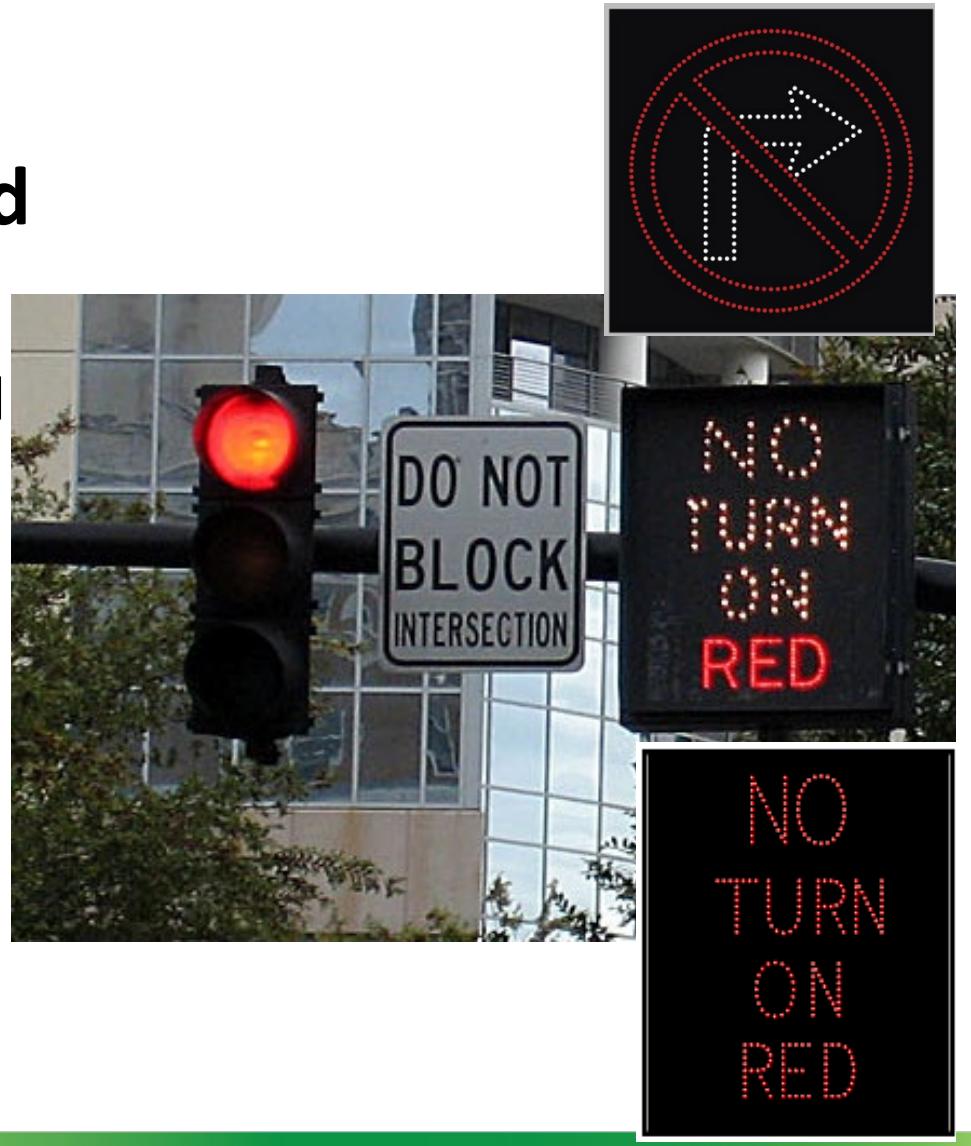
Reduce Conflicts

2

Strategy 2: Restrict Right Turn on Red

- Restriction can be:
  - Changeable message sign – can be activated when ped pushes button or as set by controller

Improves effectiveness



Reduce Conflicts

3

Strategy 3: Exclusive Ped Signal Phase

- Popular because all traffic stops and pedestrians can cross in any direction (must ban turns on red)
- Pedestrians incur more delay but improved safety
- Vehicles get turning with no pedestrian conflicts
- Pedestrian Crash Reduction of 34%

Reduce Conflicts

3

Strategy 3: Exclusive Ped Signal Phase

LADOT Criteria

- Pedestrian volume meets or exceeds 30% of vehicle volume during peak hour, AND;
- Turning traffic through any crosswalk exceeds 200 VPH, AND;
- History of collisions involving turning-vehicle sand pedestrians exceeds city average

VisionZeroLA
@VisionZeroLA

ICYMI: 0 crashes at Hwood / Highland since scramble installed on 11/15/15 (avg 13/yr prev). Thx @MitchOFarrell!

LADOT and 7 others

Reduce Conflicts

4

Strategy 4: Leading Pedestrian Interval (LPI)

- LPI gives pedestrians a head start
- It's like a "mini" exclusive phase
- **WALK** comes on 3 – 5 seconds prior to the green signal;
- Pedestrians enter crosswalk before turning vehicles arrive there.

Reduce Conflicts

4

Strategy 4: Leading Pedestrian Interval (LPI)

- Without APS, pedestrians with vision impairments cross by listening to vehicle movement
- With an exclusive ped phase or LPI, the walk signal does not coincide with vehicle movement
- Use APS with LPI or exclusive ped phases
- 59% Crash Reduction Factor for Peds

Reduce Conflicts

5

Strategy 4: Adjust Crossing Time

- Detector extends clearance interval if pedestrians are still in crosswalk.
- In this example, the walk phase was prolonged in 20% of crossings using radar, reducing unnecessary traffic delay the other 80% of crossings.
- Video and infrared detectors also have functionality
- CMF = 51% for increasing crossing time

Signal Countermeasures – Safety Review

Countermeasure	All Crashes	Pedestrian Crashes
Pedestrian Countdown Signalheads		25-52%
Exclusive Pedestrian Phase		34%
Eliminate Permissive Left Turns	70%	
If Permissive Lefts Kept – Install Flashing Yellow Arrow	14%	
Leading Pedestrian Interval (LPI)		59%
Increase Pedestrian Crossing Time		51%

** Data accessed from the Crash Modification Factors Clearinghouse at www.cmfclearinghouse.org*

When Are Upcoming Funding Opportunities?

Patrick Gilster

SMCTA Manager of Programming & Monitoring

Utilize Funding

- Federal
  - RAISE
  - INFRA
- State
  - Active Transportation Program
  - Highway Safety Improvement Program
  - Local Partnership Program
- Regional/Countywide
  - Measure A (SMCTA)
  - Measure W (SMCTA)
  - Measure M (C/CAG)
  - One Bay Area (MTC)

C/CAG Comprehensive Bicycle & Pedestrian Plan (2021) includes a complete list of state and local funding sources:

Funding Source	Administering Agency	Weblink
State Funding Sources		
California Active Transportation Program	California Transportation Commission	www.dot. ca.gov/hq/ LocalPrograms/atp
California Office of Traffic Safety Grants	California Office of Traffic Safety	www.ots.ca.gov/ Grants/default. asp
Highway Safety Improvement Program	Caltrans	www.dot. ca.gov/hq/ LocalPrograms/hsip.html
Affordable Housing and Sustainable Communities Program	California Strategic Growth Council	www.sgc.ca.gov/Grant-Programs /AHSCProgram.html
Sustainable Transportation Planning Grants	Caltrans	https://dot.ca.gov/programs/transportation-planning/regional-planning/sustainable-transportation-planning-grants
Recreational Trails Program	California Department of	http://ohv.parks.ca.gov/?page_id=24881

https://ccag.ca.gov/wp-content/uploads/2021/06/San-Mateo-County-Comprehensive-Bicycle-and-Pedestrian-Plan-Update-Final-Plan.pdf

How will the TA incorporate Complete Streets?

- **Highway Program:**
  - Measure W allows pedestrian and bicycle projects along/across the highway system to be funded
  - Projects of Countywide Significant are being re-evaluated to include multimodal elements
- **Bicycle & Pedestrian Program:**
  - Quick build projects may be prioritized for the small capital projects category
  - Class III Bike Routes will no longer be funded, only Neighborhood Routes with sufficient traffic calming
  - Jurisdictions will need to show bike projects improve comfort levels
  - Extra “readiness” points will be given for jurisdiction staff who attend SMCTA technical trainings

2022 Calls for Projects Opportunities

Alternative Congestion Relief (ACR) & Transportation Demand Management (TDM) Program

- CFP will be released in **April**
- Example Ped projects include:
  - Crossing improvement at a singular location with features such as RRFB, PHB, median, curb extension, crosswalk striping between two transit stops
  - Signal detection or pedestrian upgrades near regional transit stations

Sub-Categories	Competitive Funds
ITS Planning & Design	$885,600.00
TDM Competitive Funds	$3,075,000.00
Small/Coastal (30%)	*$922,500.00*
Mid/Large (70%)	*$2,152,500.00*
ACR/TDM Planning Funds	$775,800.00
Total	**$4,736,400.00**

For more information on this category, see the recently adopted SMCTA ACR/TDM Plan:

https://www.smcta.com/Projects___Programs/TDM.html

2022 Calls for Projects Opportunities

Bicycle & Pedestrian Program

- CFP will be released in **August**
- Example Ped planning:
  - Pedestrian Plans
  - Transit Access Studies
  - Corridor Improvement Plans
  - Vision Zero/High Injury Networks
- Example capital projects
  - Spot pedestrian crossing treatments
  - Quick build pedestrian projects
  - Corridor-wide or bundles of pedestrian project locations

Sub-Categories	Competitive Funds
Capital	$16,713,350
Capital - Large	*$11,197,945*
Capital - Small	*$5,545,676*
Planning/Promotion	$592,325
Safe Routes to School	$439,825
Total	**$17,775,771**

For more information on this category and see past successful projects visit:

https://www.smcta.com/Projects___Programs/Pedestrian_and_Bicycles.html

Thank you!

If you have any questions please contact:

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