# Designing Traffic Signals for Pedestrians

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**January 11, 2009**

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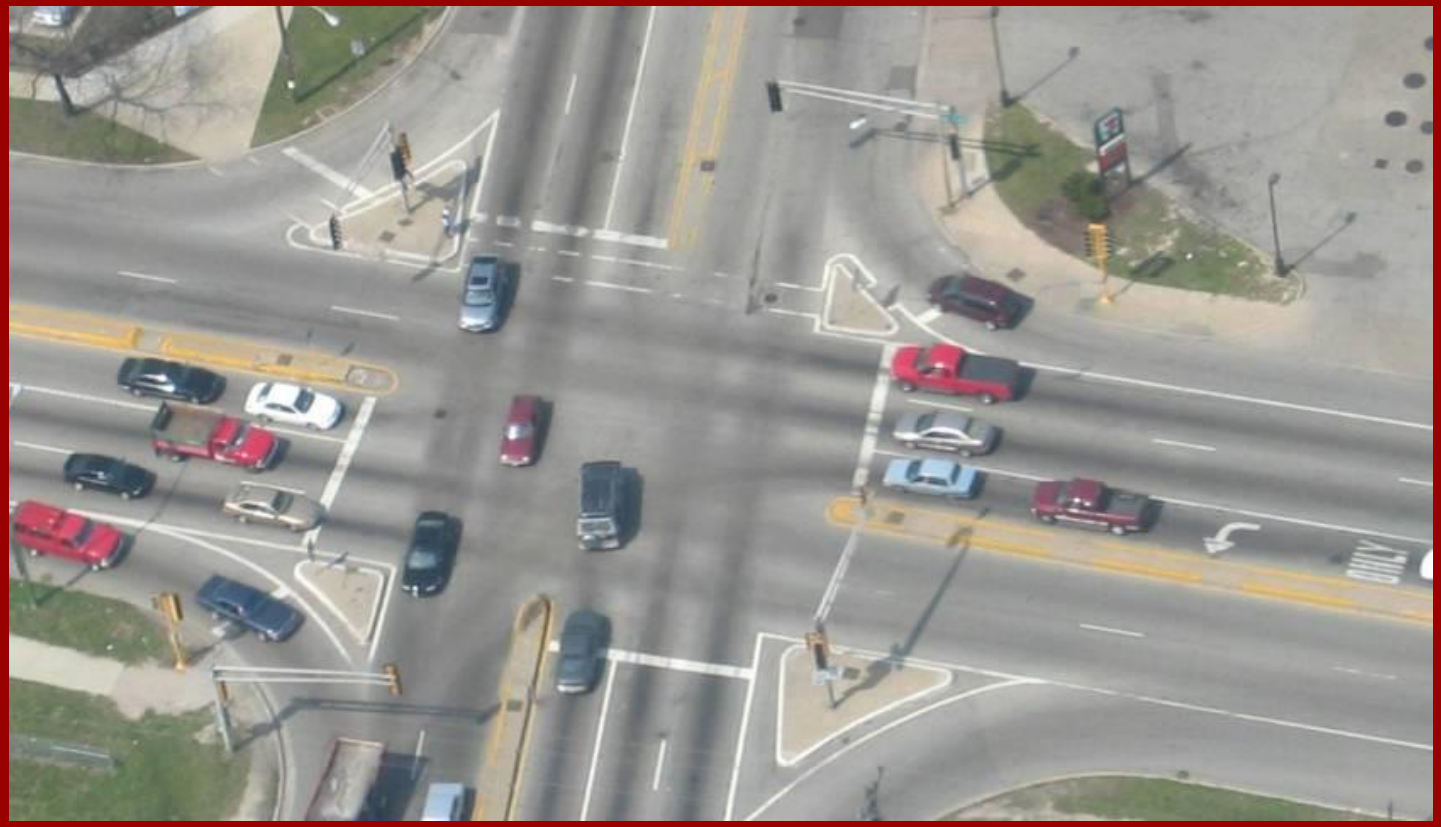
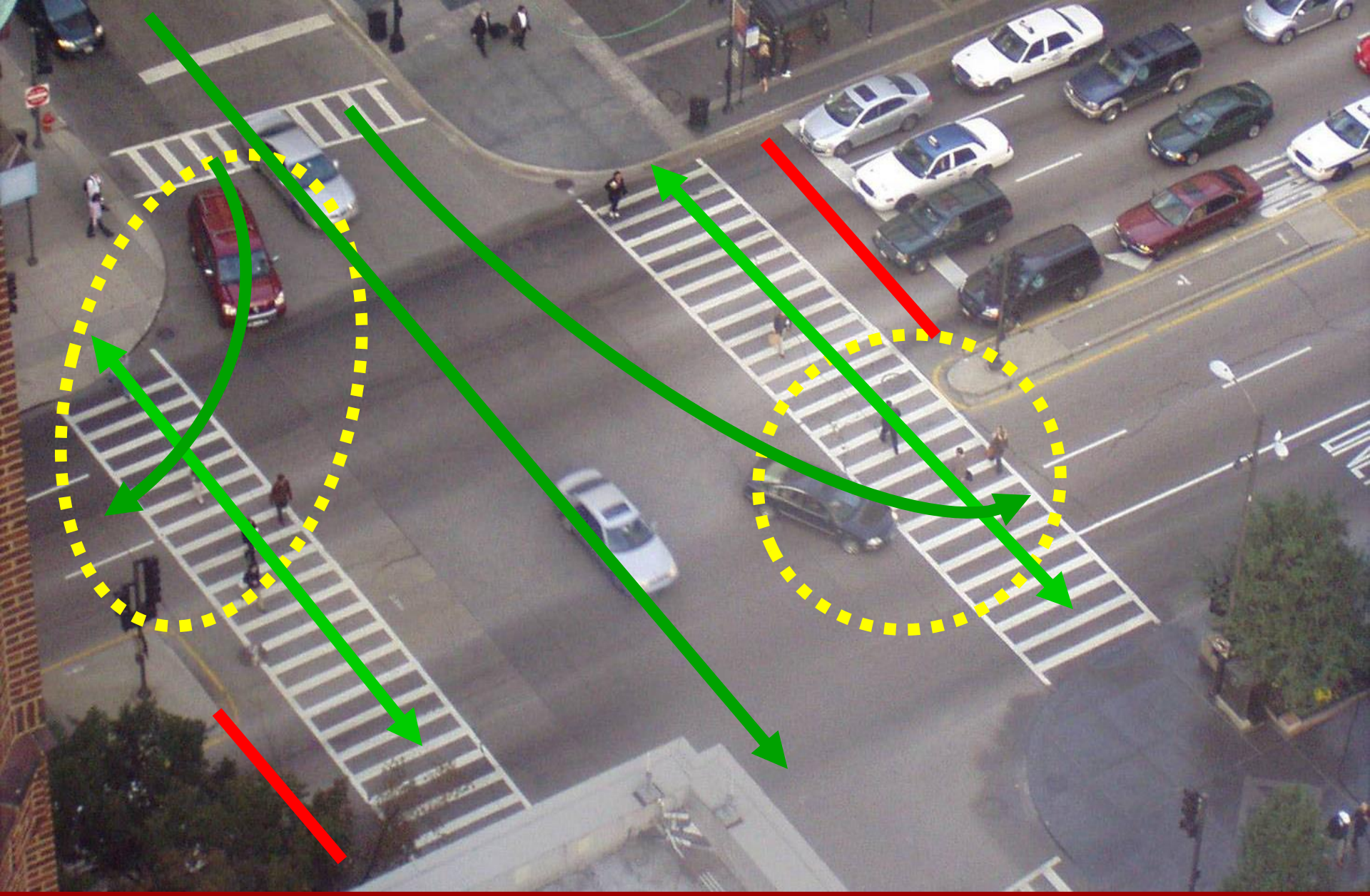
# Traffic signals assign the of right of way, regulate the flow of traffic and create gaps



Traffic signals do not guarantee safety – in fact, signalized intersections have more crashes than non-signalized



Turn movements often result in conflicts

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# Traffic signals don’t ensure protection

Peds routinely ignore the light *(usually quite safely)*

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# Traffic signals don’t ensure protection

Pedestrians will cross where it’s convenient

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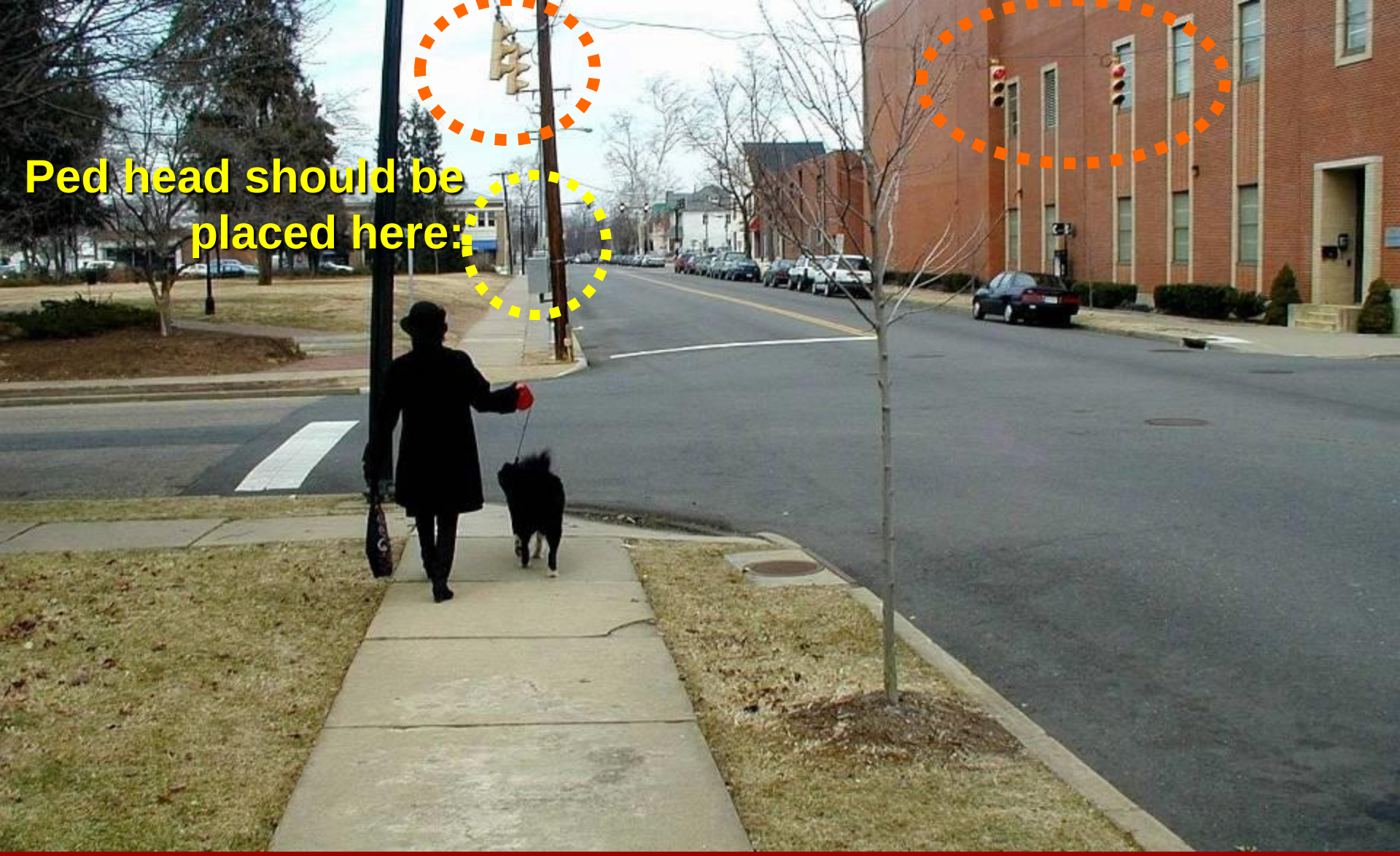
# Traffic signals don't ensure protection

Pedestrians are at risk *when crossing with the light*

# Placing Pedestrian Heads Where They Can Be Seen




Pedestrian signals should be provided,

Otherwise pedestrians don’t know when to cross

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Lack of pedestrian signals on one way street:
The pedestrian cannot see the signal

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# Ped head placement: close to crosswalk, visible to pedestrians, especially with long crosswalk

Poor example

Good example

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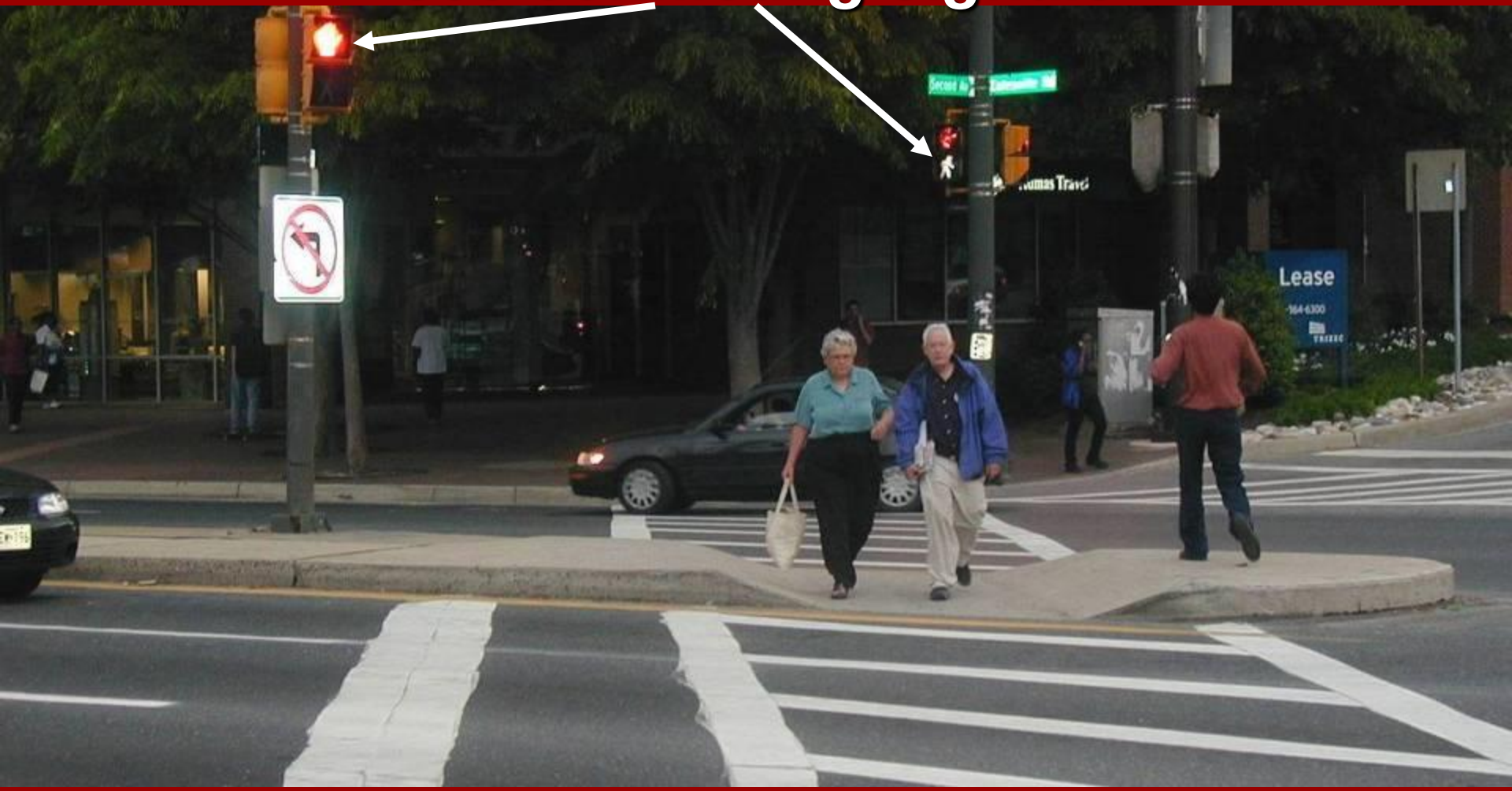
# Two-step signals: ensure pedestrians don't see conflicting signals




These pedestrians kept walking, against light

# Are ped heads always needed?

In general, **YES**

Possible exceptions:

- Narrow street
- High ped use
- Simple intersections/simple signal phasing
- Appropriate vehicular signal heads are readily visible in both directions
- Ped clearance time can be accommodated by vehicular yellow plus all-red

# Pedestrian Walking Speed Requirements

# Background

- Every traffic engineer receives complaints:
  "I don't have enough time to cross the street."

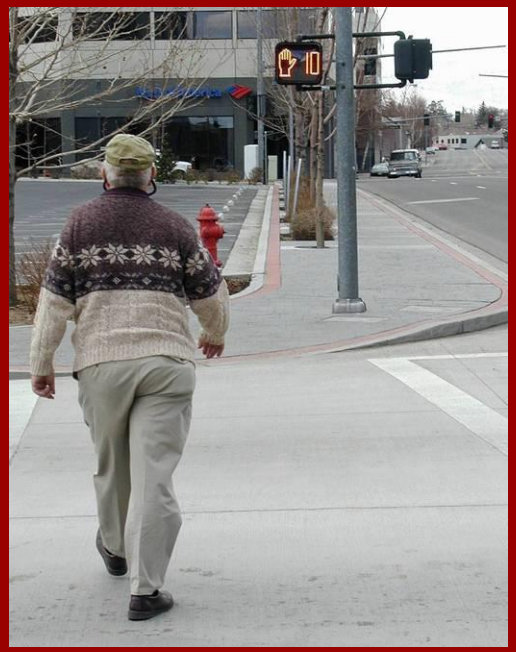
Partly this is because 50% of pedestrians in the U.S. do not understand that "Flashing Don't Walk" really means it is OK to continue walking

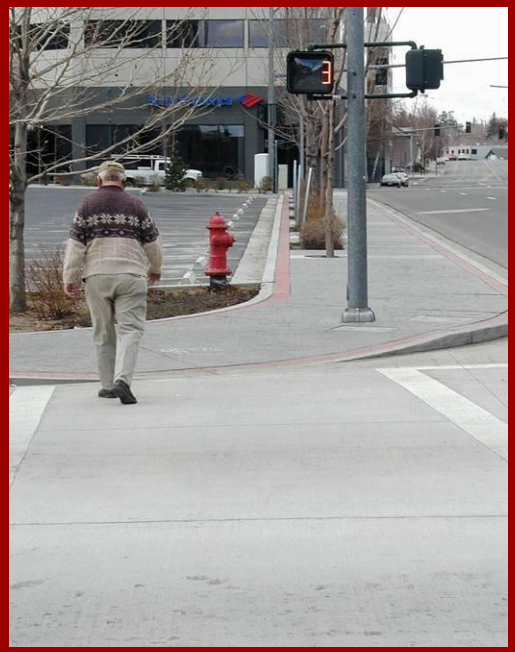
So we put signs like this to "correct" the problem

# Countdown Clocks

Pedestrian count-down signals tell pedestrians how much crossing time is left

# Countdown Clocks




- Pedestrians understand how it works
- Even though more pedestrians start to cross during clearance phase…
- Fewer peds begin walking <u>late</u> in clearance phase
- No peds left in crosswalk in steady don't walk phase

# Countdown Clocks

Results from San Francisco:

25% Crash Reduction Factor after countdown signals installed

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# Countdowns in New MUTCD

- The existing option of using pedestrian countdown displays will now be a requirement for all new ped installations
- All existing pedestrian signal installations should be upgraded with countdown clocks within 10 years
- Only exception is where the duration of the pedestrian change interval (flashing Don't Walk) is less than 7 seconds

# Proposed Change for 2009 MUTCD

New meaning of flashing hand when countdown pedestrian signals are present:

• Pedestrians may leave the curb if they are out of the traveled way by the time a conflicting vehicular movement is allowed to proceed.

*Note: For this to apply, state or local laws must be updated with this provision*

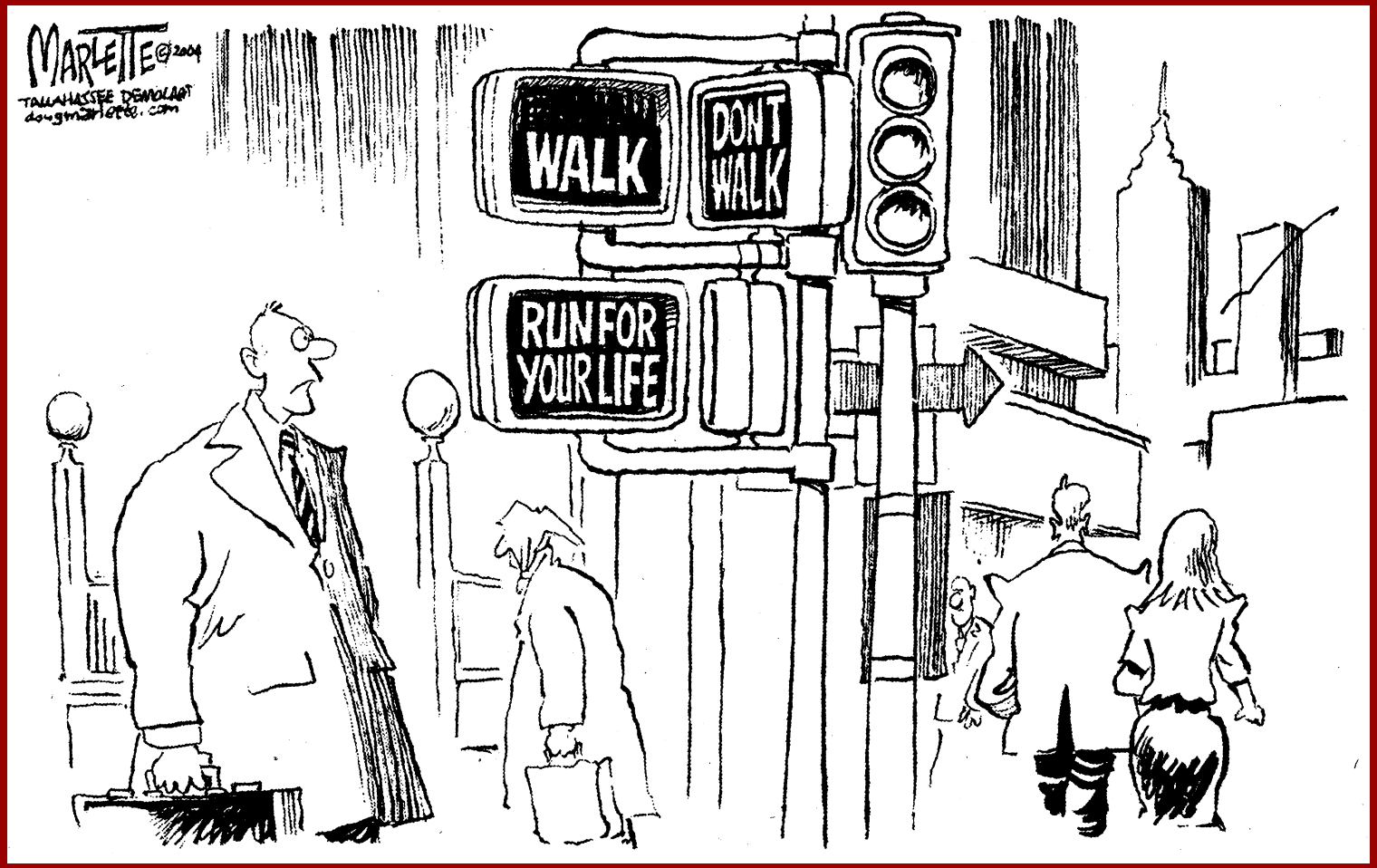
# Role of Walking Speed

- Current MUTCD says Pedestrian Clearance Time should be based on 4.0 ft/sec walking speed

- “Where pedestrians who walk slower than normal, or pedestrians who use wheelchairs, *routinely* use the crosswalk, a walking speed of less than 4 feet per second should be considered . . .”

# Role of Walking Speed

- Is this enough?



# PROWAAC Draft Guidelines

- In 2002, Public Rights-of-Way Access Advisory Committee (PROWAAC) released draft guidelines for public comment. They included:
  - Universal maximum ped walking speed of 3.0 fps
  - Crossing distance to include crosswalk length plus length of curb ramp

# PROWAAC Draft Guidelines

- TY Lin International asked by US Access Board to:
  - Determine history of current walking speed values
  - Estimate effect of recommended change on traffic operations

# Brief Walking Speed History

## 1948 MUTCD

- General language about the need to provide sufficient time for “most” peds to cross street
- “. . . the period during which it is not possible to start and complete a crossing at the *normal* walking speed should always be recognized . . . to prevent pedestrians from being stranded in the middle of the street.”

# Brief Walking Speed History

- 1952 John Exnicios' unpublished Yale master's thesis indicated:
  - Average walking speed of 4 fps for all crossing peds (3.5 fps as 15$^{th}$ percentile)
  - For elderly peds, average speed about 3.5 fps (15$^{th}$ percentile about 3.0 fps)

# Brief Walking Speed History

## 1961 MUTCD

- "A pedestrian clearance interval . . . shall be sufficient to allow a pedestrian to leave the curb and travel to the center of the farthest traveled lane . . . (*Normal* walking speed is assumed to be 4 feet per second.)"

# Brief Walking Speed History

## 1978 and 1988 MUTCD

- Similar to the 1961 version, with only minor differences with respect to the definition of ped clearance interval
- “Duration *shall* be . . .” was changed to “Duration *should* be . . .”

# Brief Walking Speed History

## Millennium Edition MUTCD

- Notes the need to consider peds who may move slower than the “normal” 4 fps walking speed
- “Where pedestrians who walk slower than normal, or pedestrians who use wheelchairs, *routinely* use the crosswalk, a walking speed of less than 4 feet per second should be considered . . .”

# Brief Walking Speed History

## 2003 MUTCD

- Altered the crossing distance to be considered when determining ped crossing time from the *center* of the furthest traveled lane to the *far side* of the traveled way

# Recent Research

- 2005 TCRP/NCHRP study by TTI indicated 3.77 fps as 15th percentile speed for all pedestrians, and 3.03 fps as $15^{th}$ percentile speed for older pedestrians
- It also reviewed past studies, and recommended 3.5 fps for all peds and 3.0 fps for older peds as $15^{th}$ percentile speeds

# PROWAAC Recommendations
# New MUTCD Requirements

- Calculate pedestrian signal clearance phase timing using 3.5 ft/sec pedestrian walking speed
- Also calculate total walk crossing time (Walk plus Flashing Don't Walk) using 3.0 ft/sec
- Include the length of the crosswalk and one curb ramp for calculating crossing distance

# Impact on Timing and Capacity

- 2005 Study by Kim and Hunter (TRR 1920) examined the effect of walking speeds, crossing distances, varying critical volume ratios, and cycle lengths on delay

# Impact on Timing and Capacity

- Effect on intersection performance most significant at low cycle lengths
- Where the discrepancy between critical lane volumes on the main street and cross street increased, the impact of pedestrian green times on vehicular delay also increased
- When cycle lengths increased to account for pedestrian constraints, optimal delay rarely increased by more than a few seconds

Paradise Rd

# Wide Street Design Options

- Check to ensure number of through and/or turning lanes are really needed

# Roadway Capacity Analysis

- Always design urban roadways to LOS D
- Designing to LOS C for peak hour means:
  - Unnecessary pavement, waste of tax dollars
  - Increased ped crossing times, thus reducing vehicular movement times
  - Increased operating speeds for other 22 hours

# Wide Street Design Options

- Check to ensure number of through and/or turning lanes are really needed
- Check lane widths to see if narrower lanes are an option

# Narrower Travel Lanes

- 70 mph lane widths not needed to handle 30 mph traffic

# Narrower Travel Lanes

**News Flash!** 10 and 11-foot lanes are <u>just as safe</u> as 12-foot lanes on urban arterials with posted speeds less than 45 mph

# Wide Street Design Options

- Check to ensure number of through and/or turning lanes are really needed
- Check lane widths to see if narrower lanes are an option
- Check corner radii to see if crossing widths can be reduced

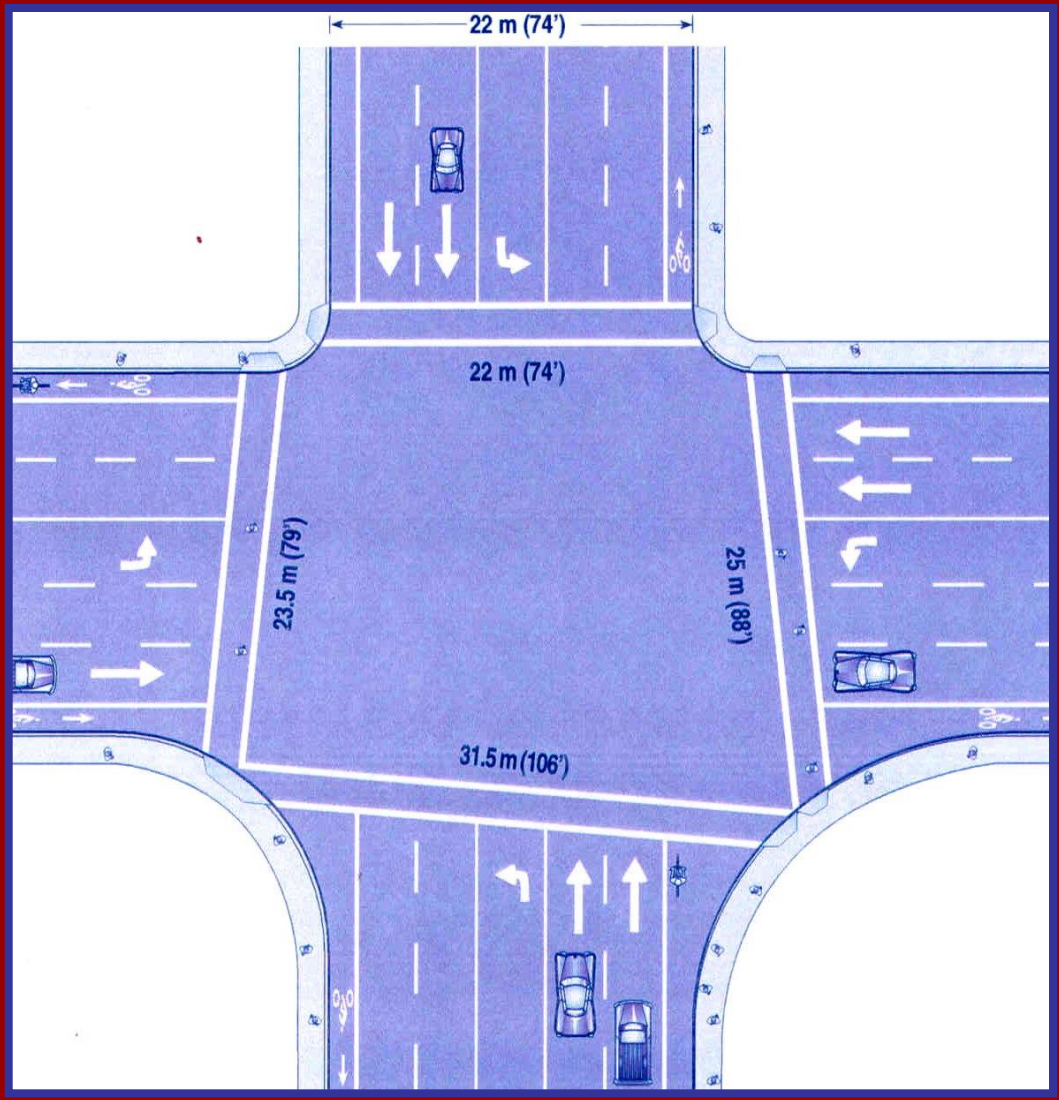
# Effect of large radius on drivers

They drive fast,
ignoring pedestrians

# Tighten Corner Curb Radii

Intersection geometry:

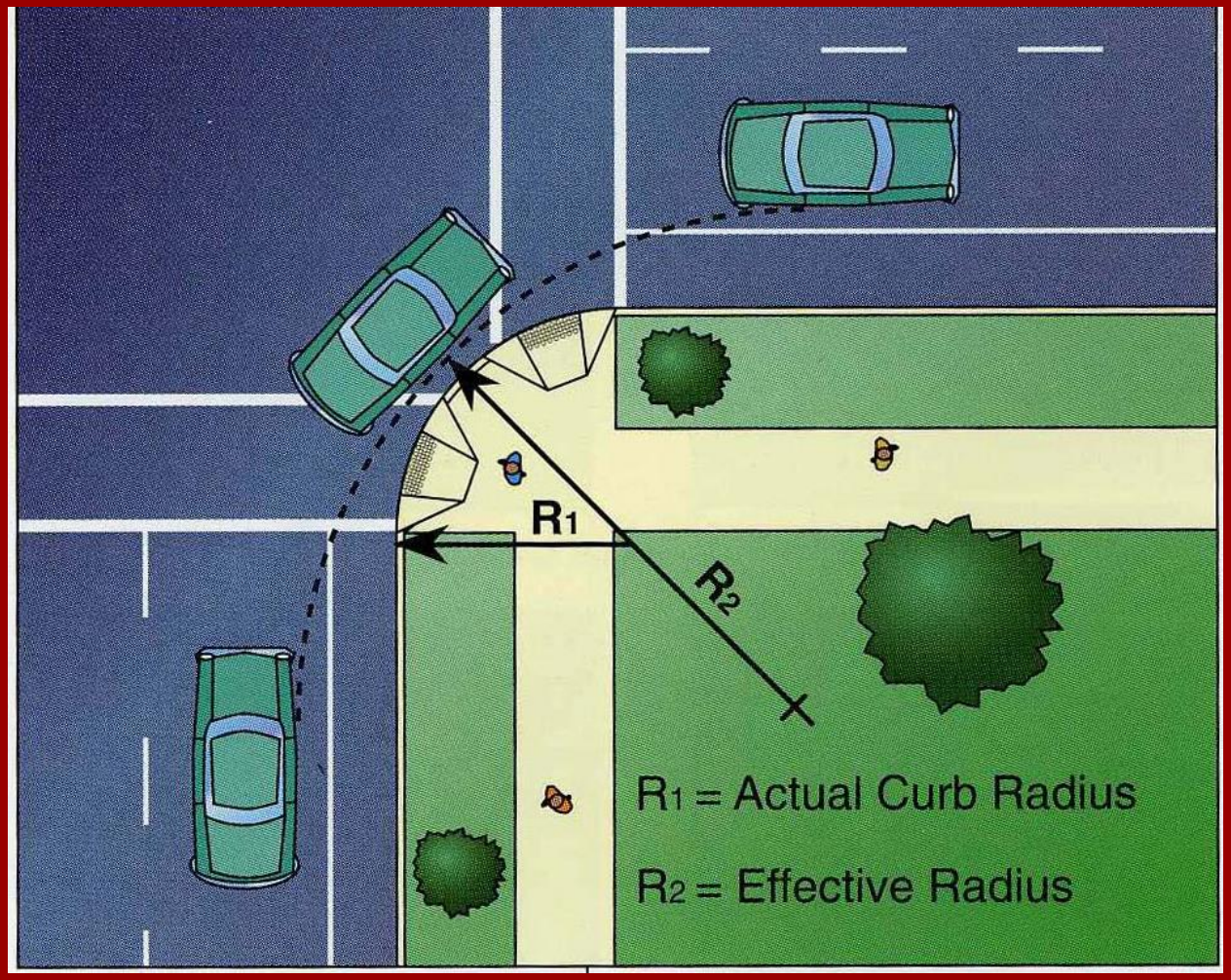
Large radii increase crossing distance, and affect crosswalk & ramp placement



# Tighten Corner Curb Radii

Actual curb radius (R1)

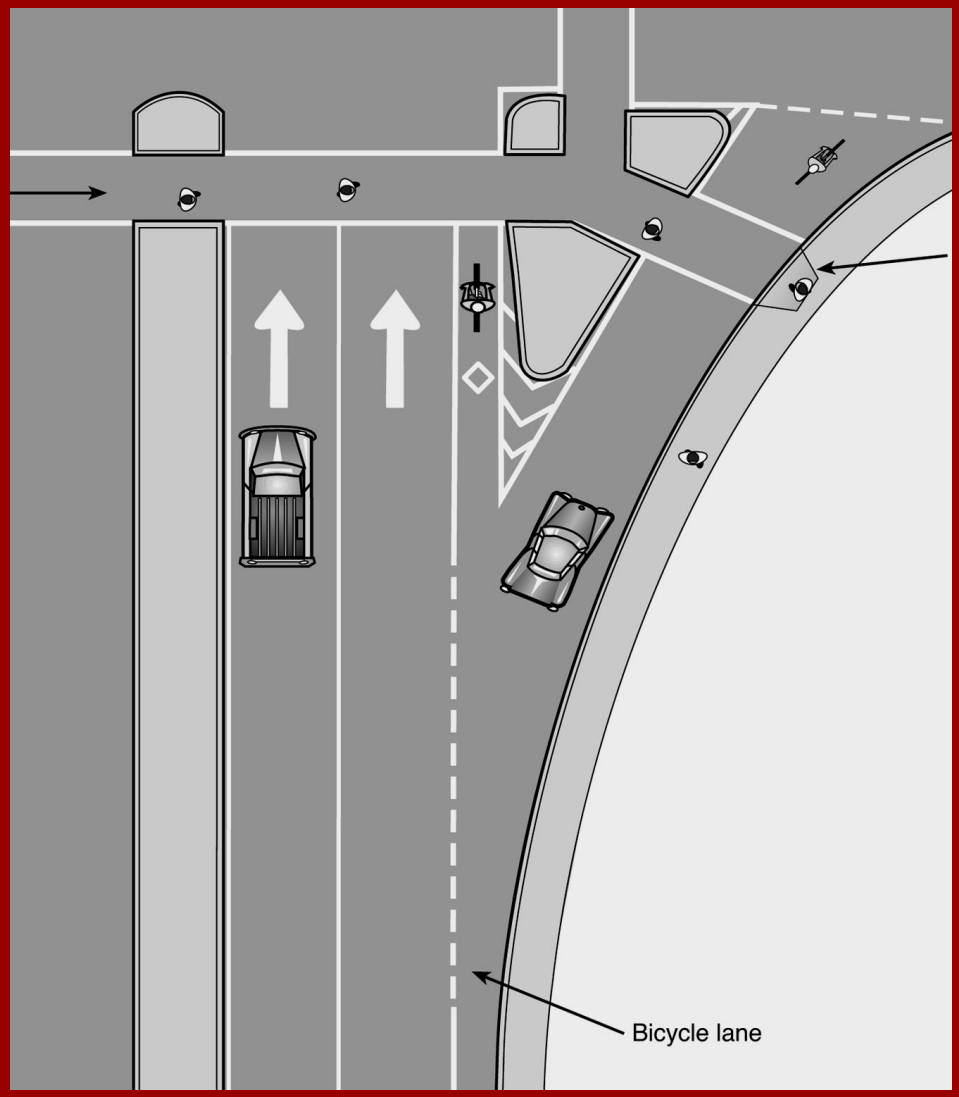
Effective radius (R2)



# Corner “Pork Chop” Islands

Benefits:

- Separate conflicts & decision points
- Reduce crossing distance
- Improve signal timing
- Reduce crashes

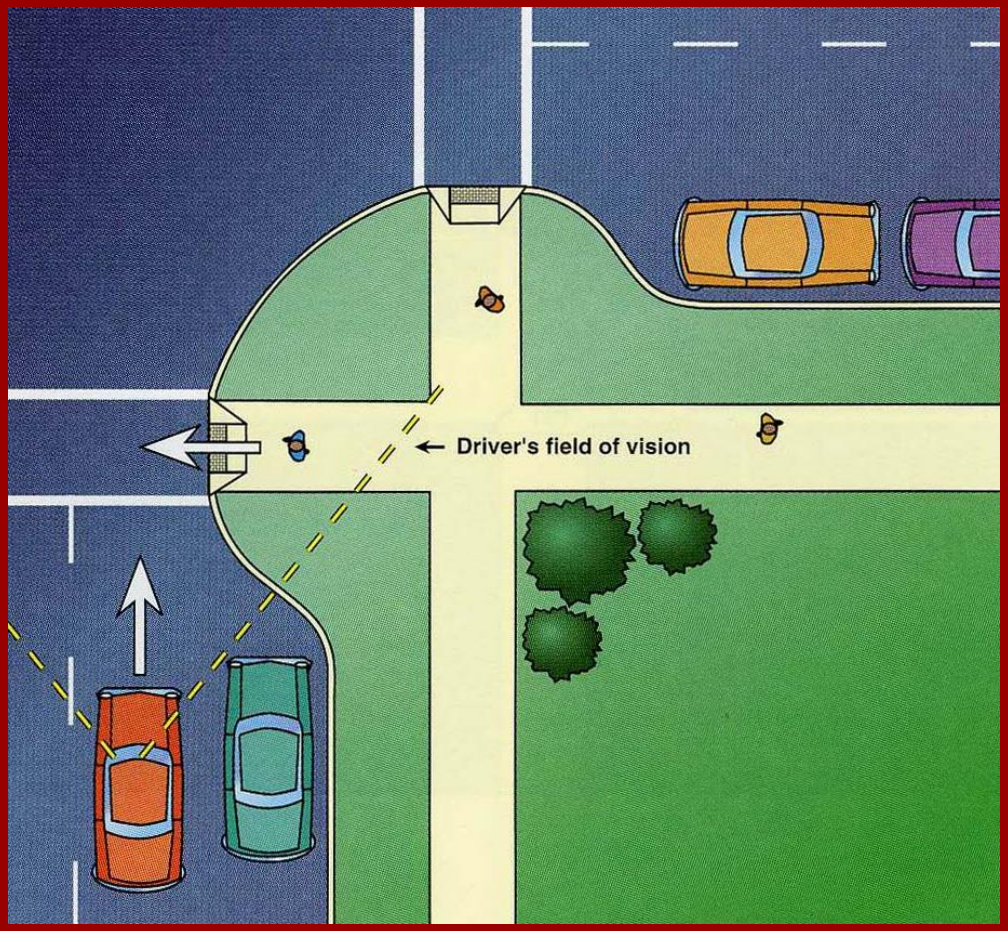


# Wide Street Design Options

- Check to ensure number of through and/or turning lanes are really needed
- Check lane widths to see if narrower lanes are an option
- Check corner radii to see if crossing widths can be reduced
- Where parking exists, use curb bulbs to shorten the crosswalk

# Curb Bulb-outs

- Reduce crossing distance
- Improve sight distance and sight lines
- Prevent encroachment by parked cars
- Create space for curb ramps and landings



# Wide Street Design Options

- Check to ensure number of through and/or turning lanes are really needed
- Check lane widths to see if narrower lanes are an option
- Check corner radii to see if crossing widths can be reduced
- Where parking exists, use curb bulbs to shorten the crosswalk
- Install extended time push button to get more walk time and retain 4.0 ft/sec as default setting

- In this example a high-tech signal was used to help slower pedestrians cross the street with minimal delay to traffic.
- A slower crossing speed would delay traffic significantly

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Microwave sensors are aimed at the crosswalks to track peds

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Pedestrian clearance is timed @ 4 ft/sec

The sensor tracks peds as they cross the street

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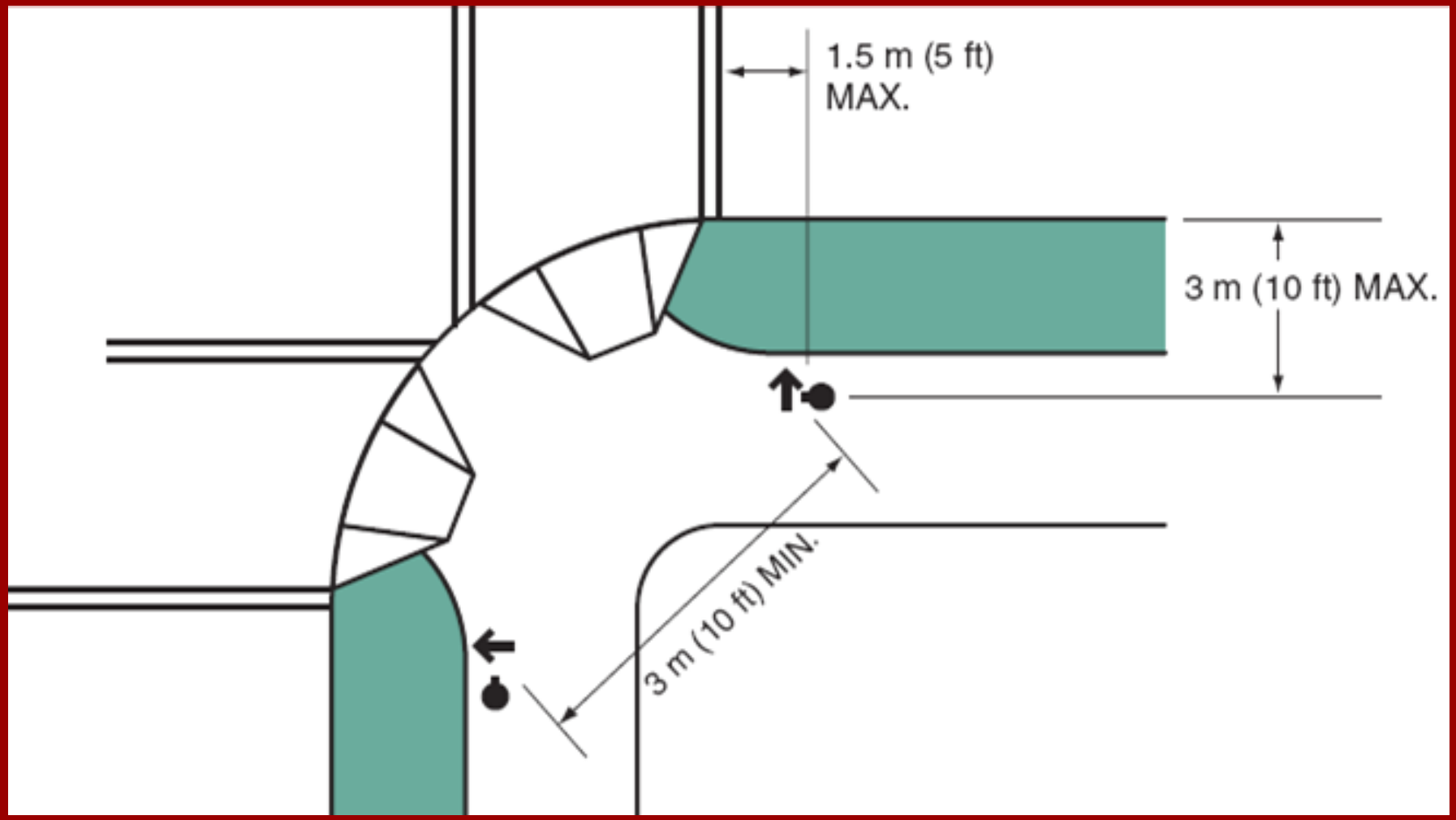
- The controller adds 4 seconds crossing time if pedestrian hasn’t finished crossing (8 seconds maximum)
- In this case, the walk phase was prolonged in 20% of crossings, reducing unnecessary traffic delay the other 80% of crossings.

# Wide Street Design Options

**Or, just learn to live with lower LOS for peak hour traffic to ensure pedestrian safety!**

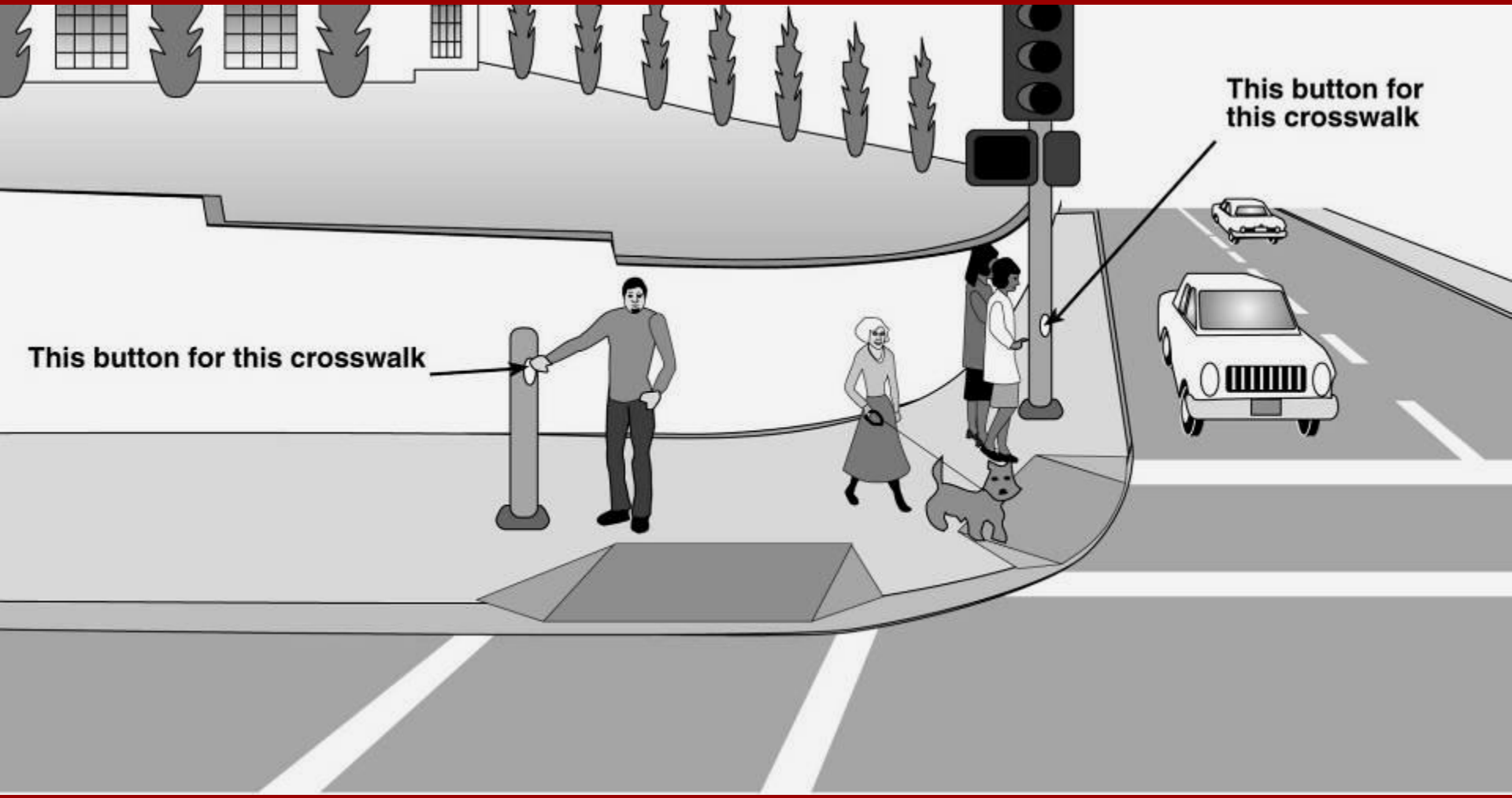
# Placing Push-buttons In Convenient Locations

# Proper Push-button Placement




Use MUTCD accessible signal (APS) standard so pedestrians will understand which button to push

# Preferred push-button placement: 2 separate buttons




Always next to landing at top of ramp,
in line with crosswalk

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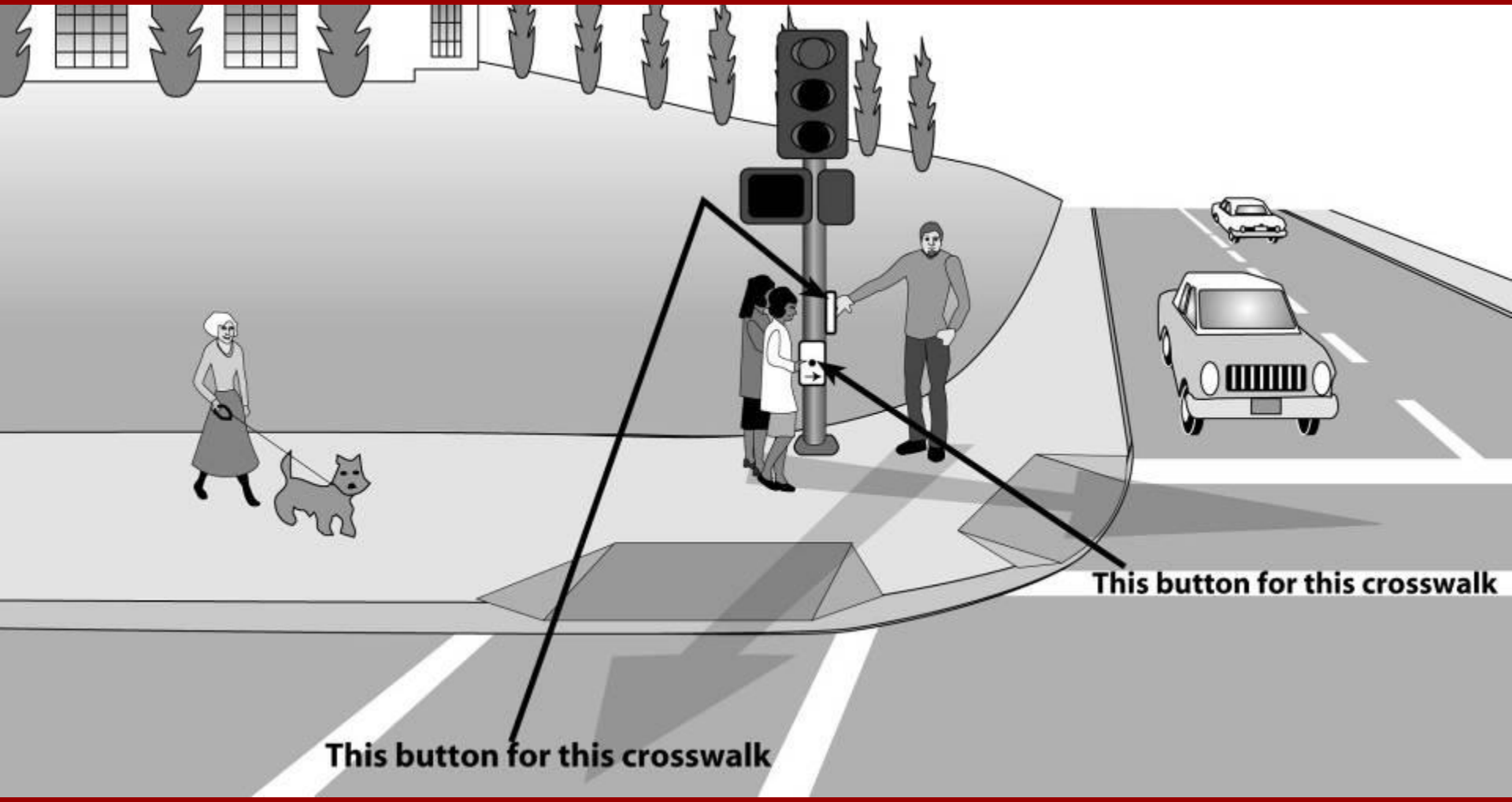
# Alternate push-button placement: 2 on single pole




Always next to landing at top of ramp,
in line with crosswalk

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# Poor Push-button Placement

Inconspicuous

Too far from ramp

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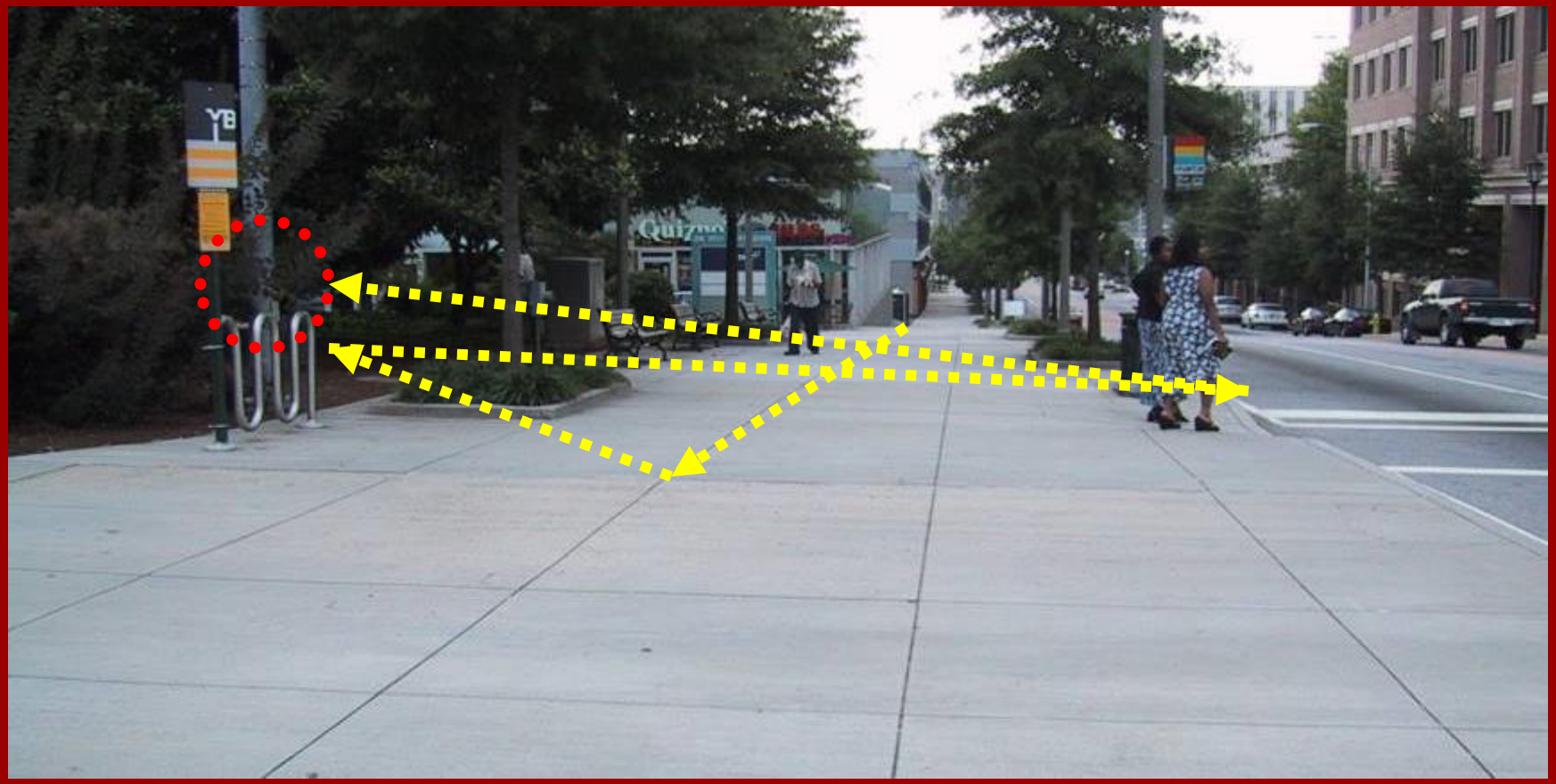
# Poor Push-button Placement



Find the pushbutton.  Now line up to cross.
Missed your chance? Do it again…

# Poor Push-button Placement

Behind guardrail

Behind vegetation

# Poor Push-button Placement

At back of pole

In front of pole

# Proper Push-button Placement

On side of pole

At top of ramp

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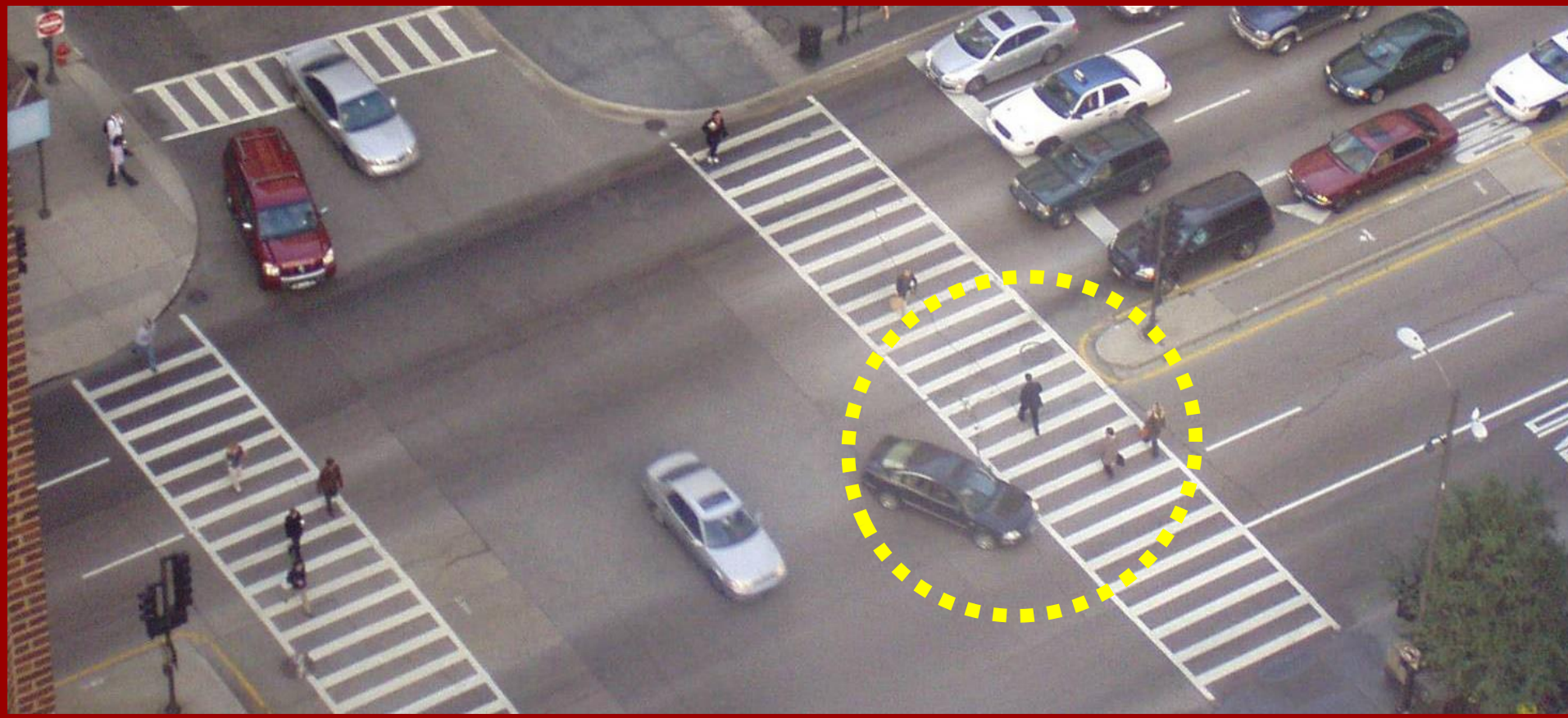
# Reducing Pedestrian & Left-Turning Vehicle Conflicts



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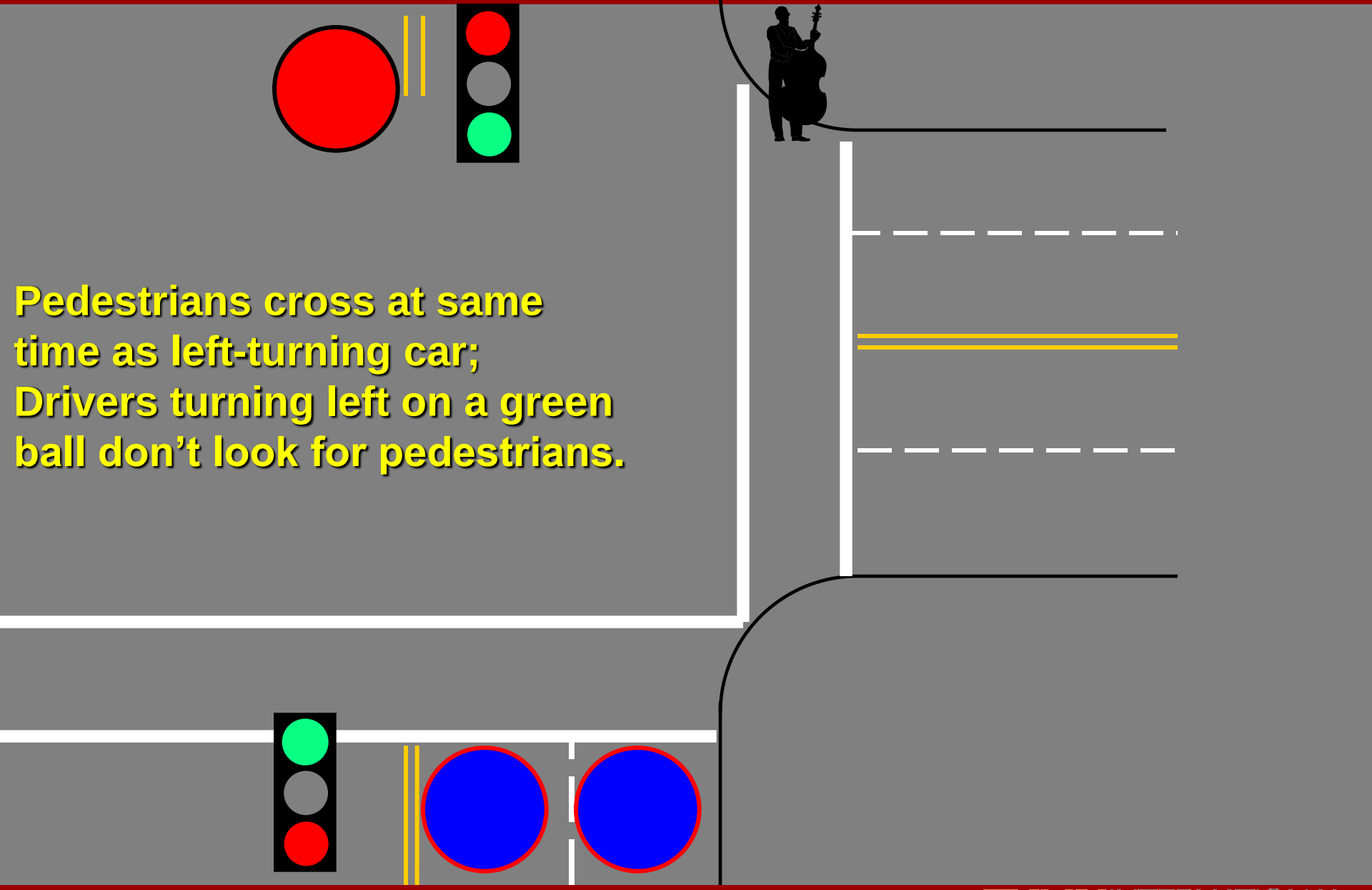
# Protected Vs. Permissive Left Turns

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

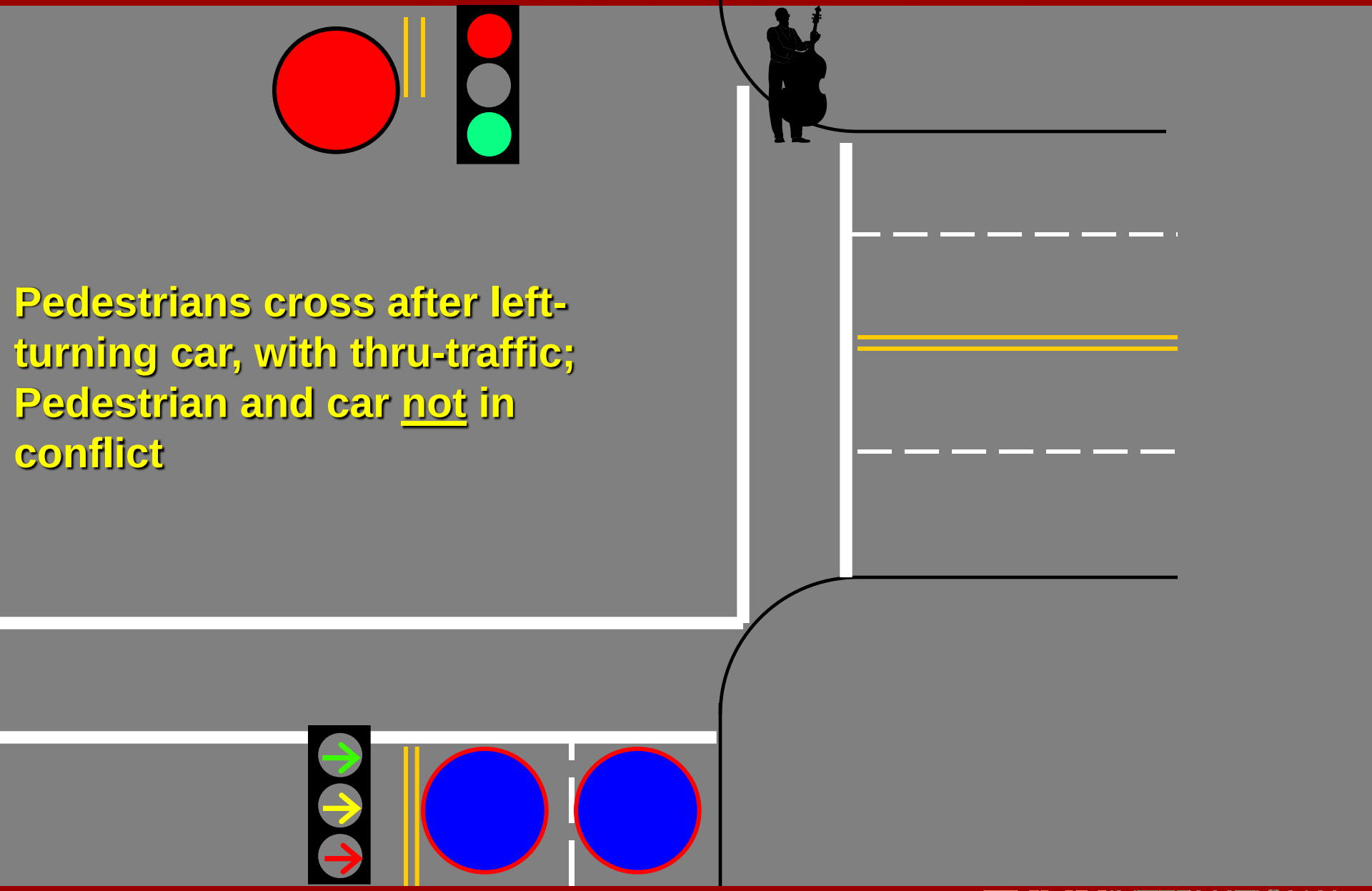
** CRF 70% (all crashes) converting permissive left turns to protected only left turns*

# Permissive Left Turns



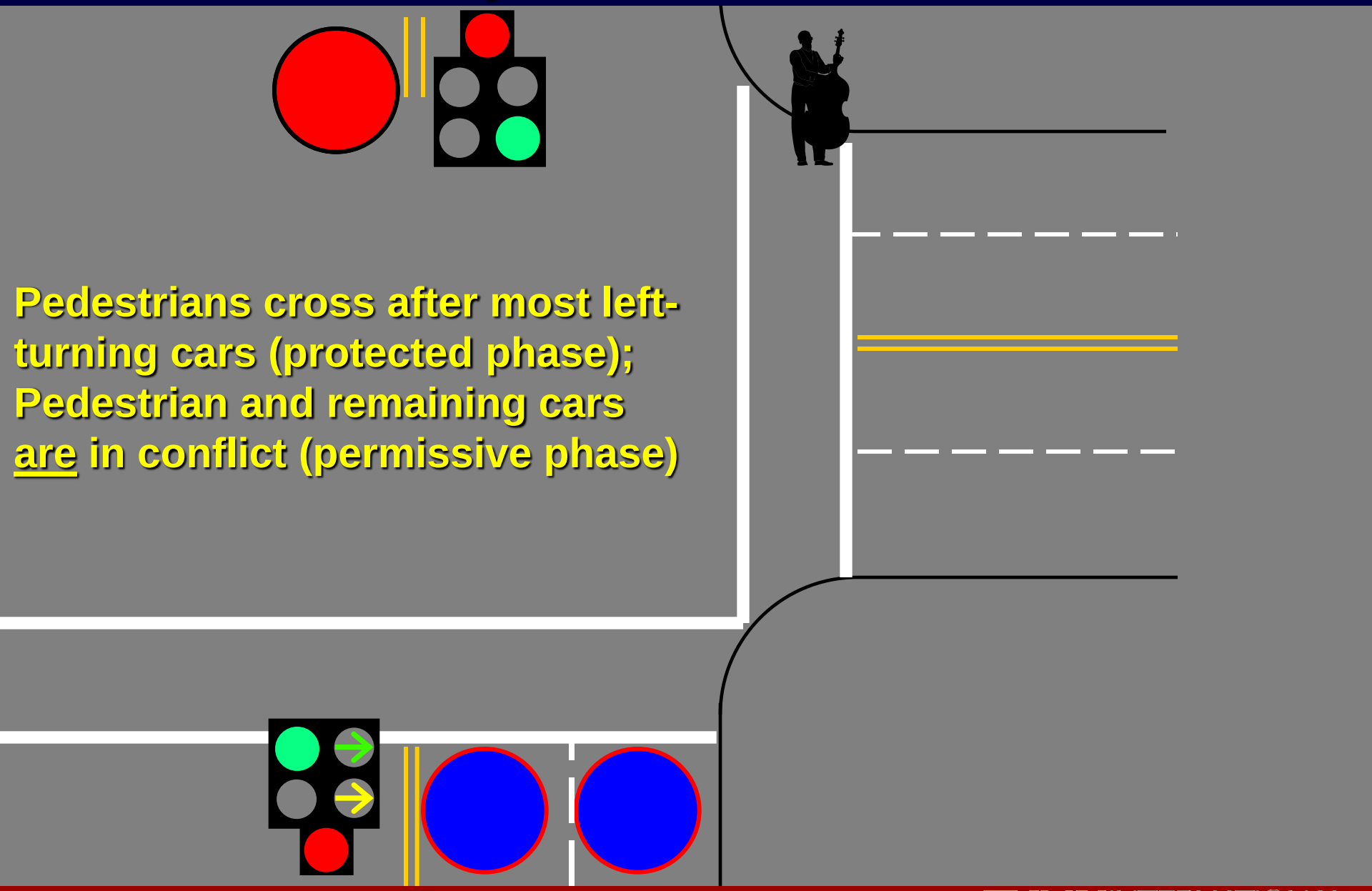
Pedestrians cross at same time as left-turning car; Drivers turning left on a green ball don’t look for pedestrians.

# Protected Left Turns



**Pedestrians cross after left-turning car, with thru-traffic; Pedestrian and car <u>not</u> in conflict**

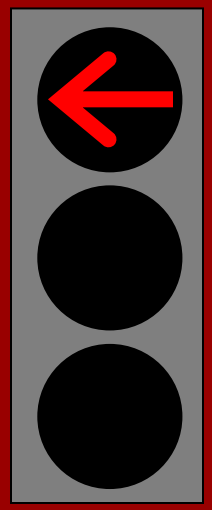
# Protected/permissive Left Turns



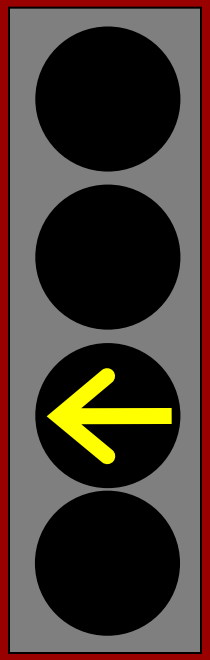
**Pedestrians cross after most left-turning cars (protected phase); Pedestrian and remaining cars <u>are</u> in conflict (permissive phase)**

# Protected/permissive Left Turns: Solutions

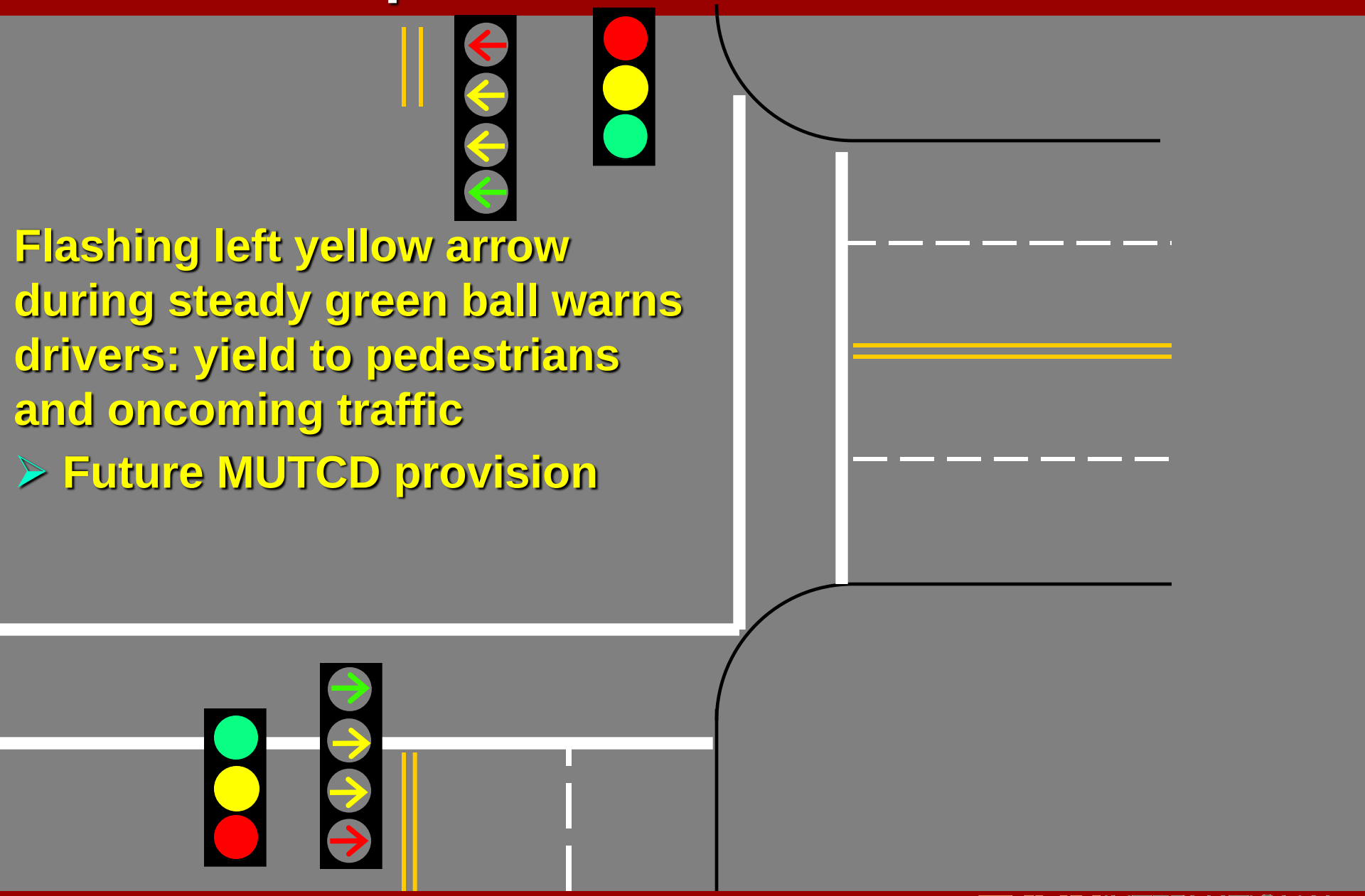
1. Provide protected-permissive phasing by default, but revert to protected-only when pedestrian button is pushed



2. Flashing Yellow Arrow (details on the next slide)



# Protected/permissive Left Turns: Solution



Flashing left yellow arrow during steady green ball warns drivers: yield to pedestrians and oncoming traffic

- Future MUTCD provision

# Signal Timing To Minimize Pedestrian Delay & Conflicts

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# Use Short Signal Cycle Length

Long wait causes stacking: pedestrians wait in street, or don’t wait and cross against the signal

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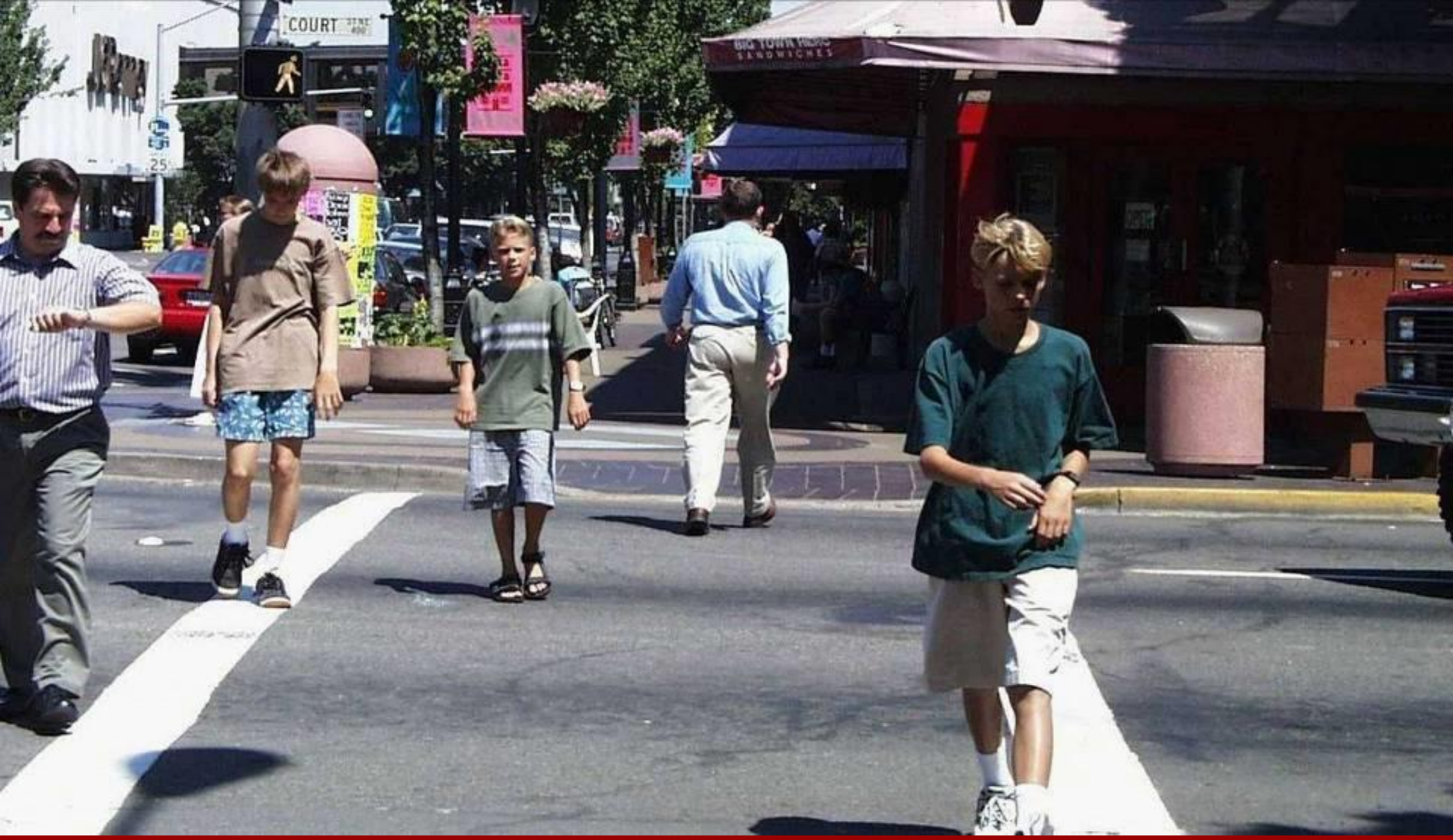


At high-use crosswalks,
pedestrians should get a signal at every cycle

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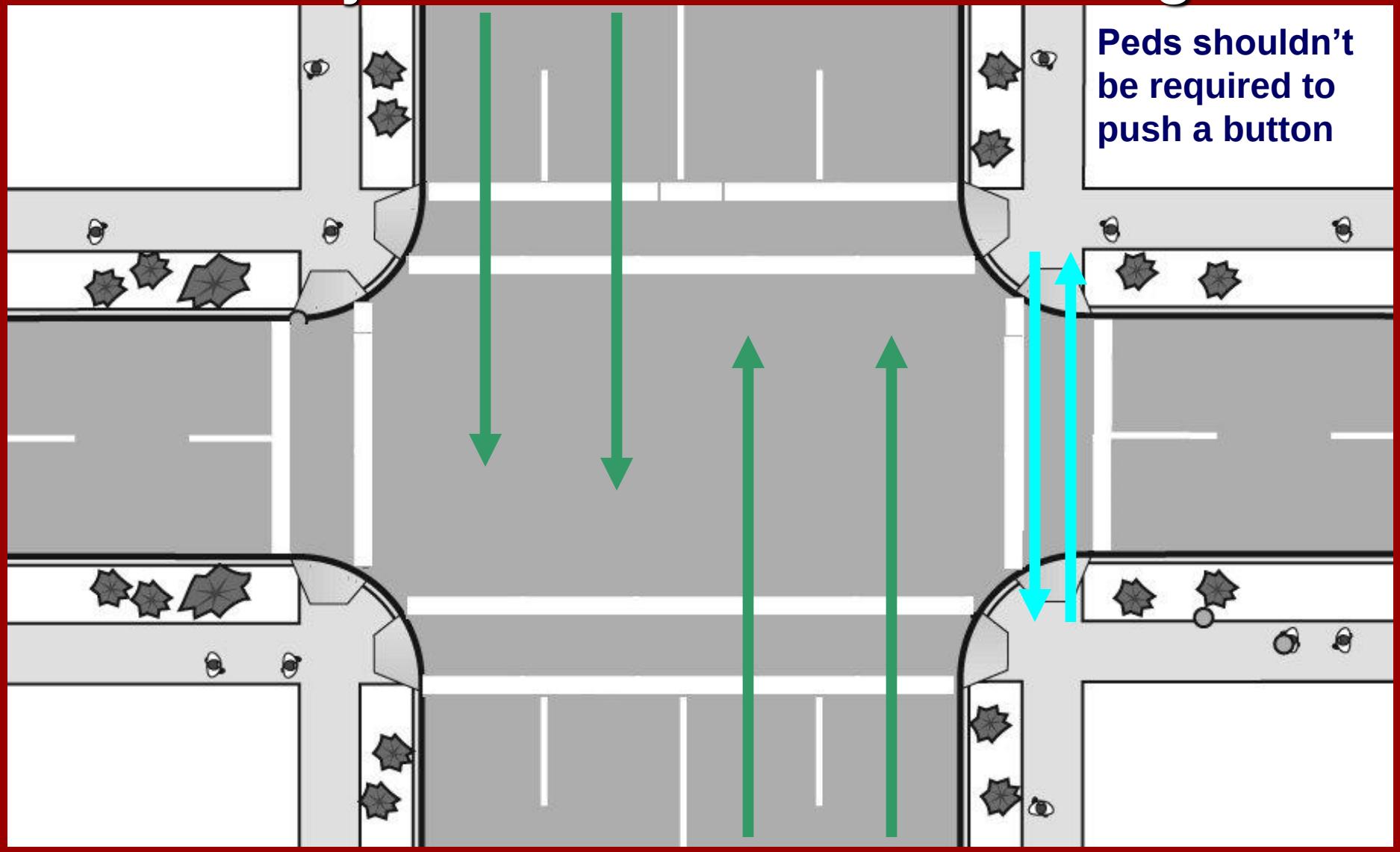
# Set pedestrians to recall to WALK when major street is set to recall to green



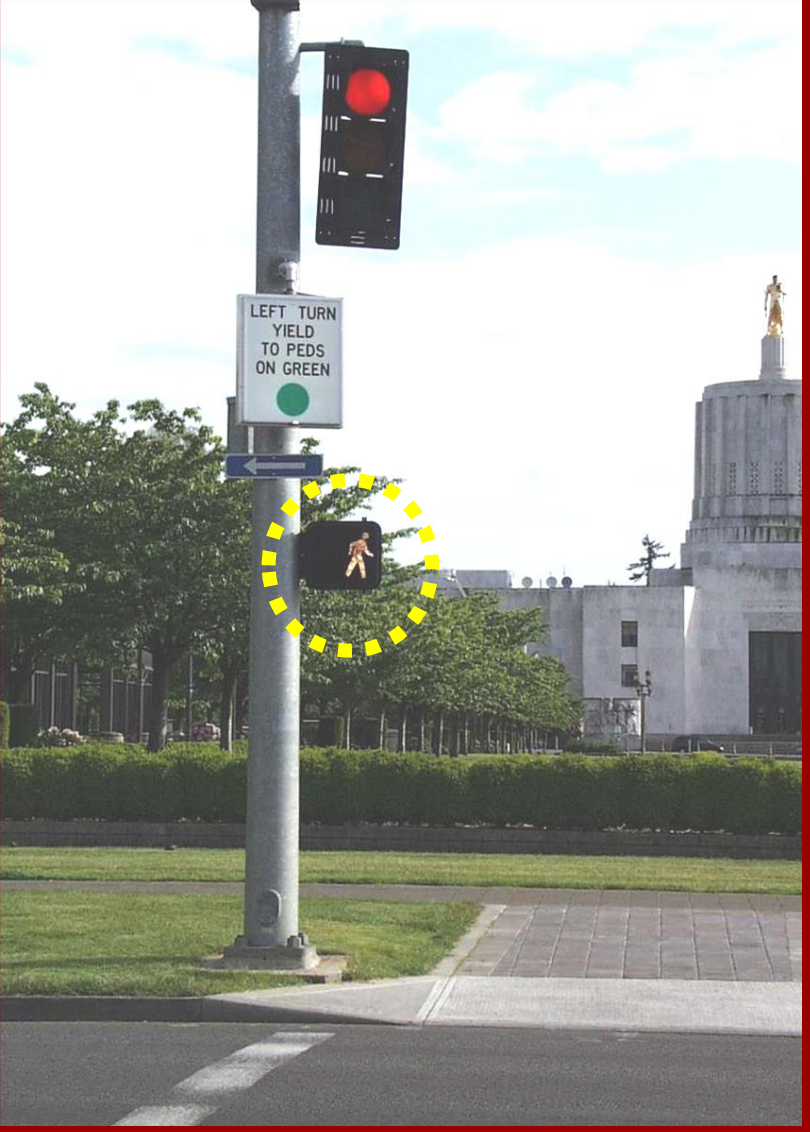
# LPI

**LPI = Lead Pedestrian Interval**

***LPI gives pedestrians a head start***

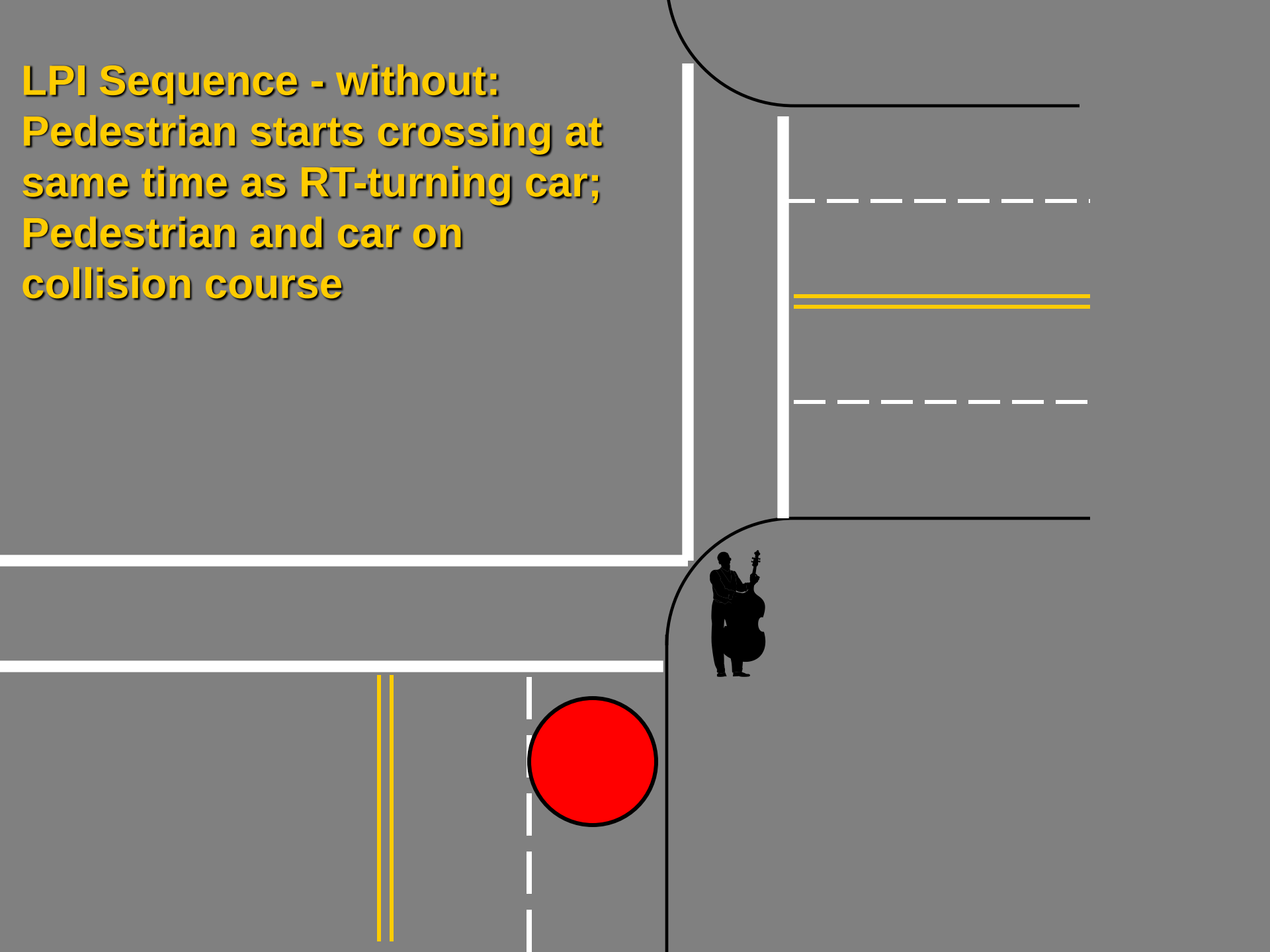
**Looks like a regular signal to drivers**

Looks like a regular signal to drivers: *green-yellow-red*

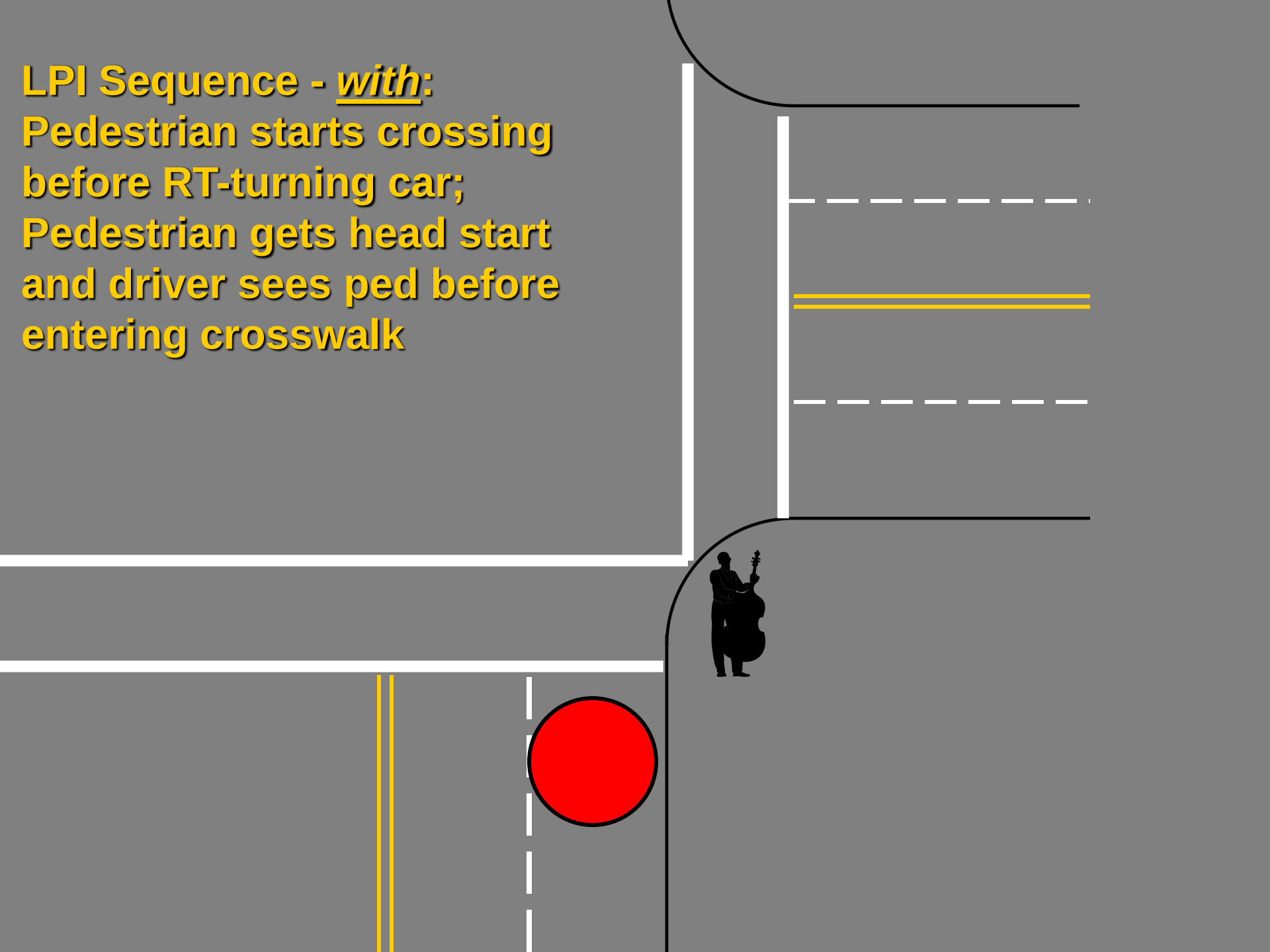


LPI : *WALK comes on 2 to 5 seconds prior to the vehicular green; pedestrians enter crosswalk before turning vehicles arrive there.*

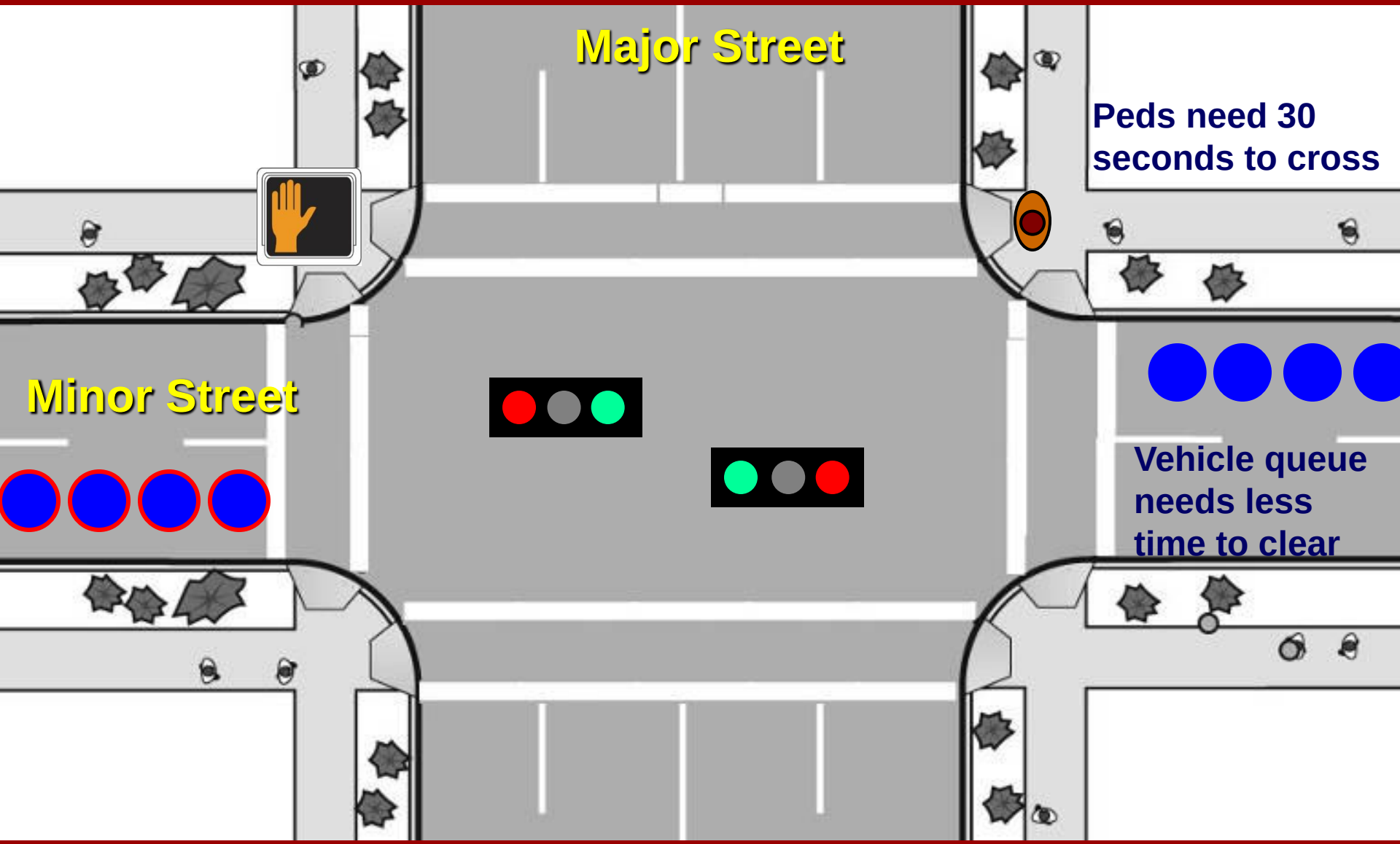
# LPI Sequence - without: Pedestrian starts crossing at same time as RT-turning car; Pedestrian and car on collision course



**LPI Sequence - *with*:**
**Pedestrian starts crossing before RT-turning car;**
**Pedestrian gets head start and driver sees ped before entering crosswalk**



# Where do the extra 3-5 seconds come from?



These peds waited 3 cycles before turning drivers let them cross *as legally required.* LPI would give them a head start.

**CRF: 5%**

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# Simple & Innovative Ideas To Minimize Pedestrian Conflicts

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# Signs: Remind Turning Drivers to Yield to Peds

Revised R10-15 in draft 2009 MUTCD

Local variations, using MUTCD-approved lettering and symbols:

New York

Alaska

# Restricting Right Turns on Red:

1. At all times

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# Restricting Right Turns on Red:

1. At all times
2. When pedestrians are present

*Difficult to enforce*

# Restricting Right Turns on Red:

1. At all times
2. When pedestrians are present

*Difficult to enforce*

3. By time of day

*Limits most RTOR*

# Restricting Right Turns on Red:

1. At all times
2. When pedestrians are present
   *Difficult to enforce*
3. By time of day
   *Limits most RTOR*
4. When ped pushes button or as set by controller

Note: An on-demand NTOR sign can be used to improve the effectiveness of a Lead Pedestrian Interval

# Pedestrian Scramble (Barnes Dance)

Popular because all traffic stops and pedestrians can cross in any direction *(must ban turns on red)*

Pedestrians pay a price in delay:

Pedestrians wait for traffic in one direction

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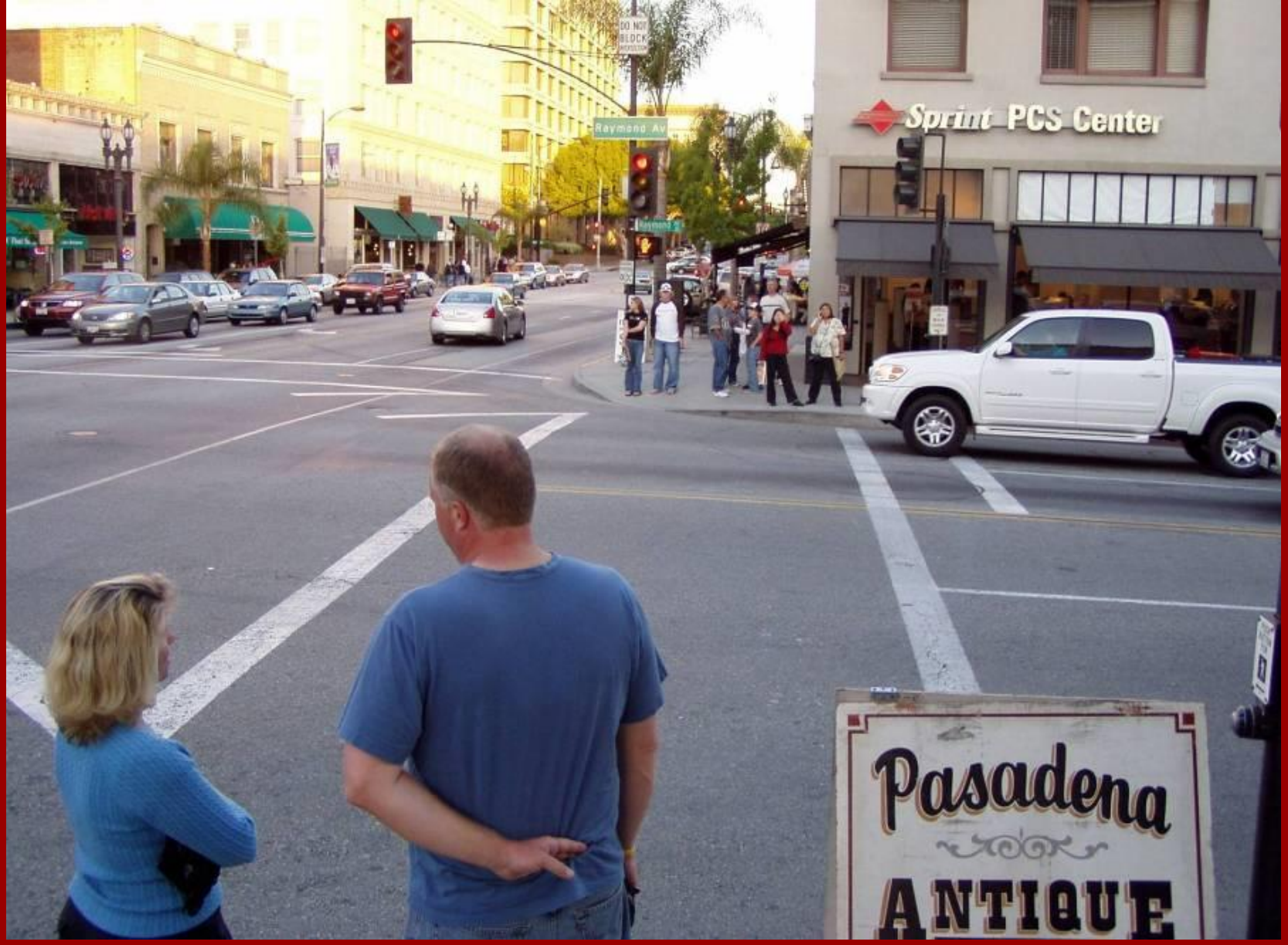


Pedestrians wait for traffic in other direction

**Pedestrian scramble increases safety**

***(CRF 34%)***

**but decreases efficiency of intersection**

**Use where there are high ped volumes and many turning vehicles**

Reward: Pedestrians can cross in any direction

# HAWK Pedestrian Hybrid Signal

HAWK (High Intensity Activated Crosswalk)

Drivers see Beacon

Peds see Pedhead

At rest, blank

Flashing then steady yellow

Steady red

Wig-wag red

# HAWK Pedestrian Hybrid Signal

**1**

**Blank for drivers**

**2**

**Flashing yellow**

**3**

**Steady yellow**

**4**

**Steady red**

**5**

**Wig-Wag**

**Return to 1**

HAWK Sequence

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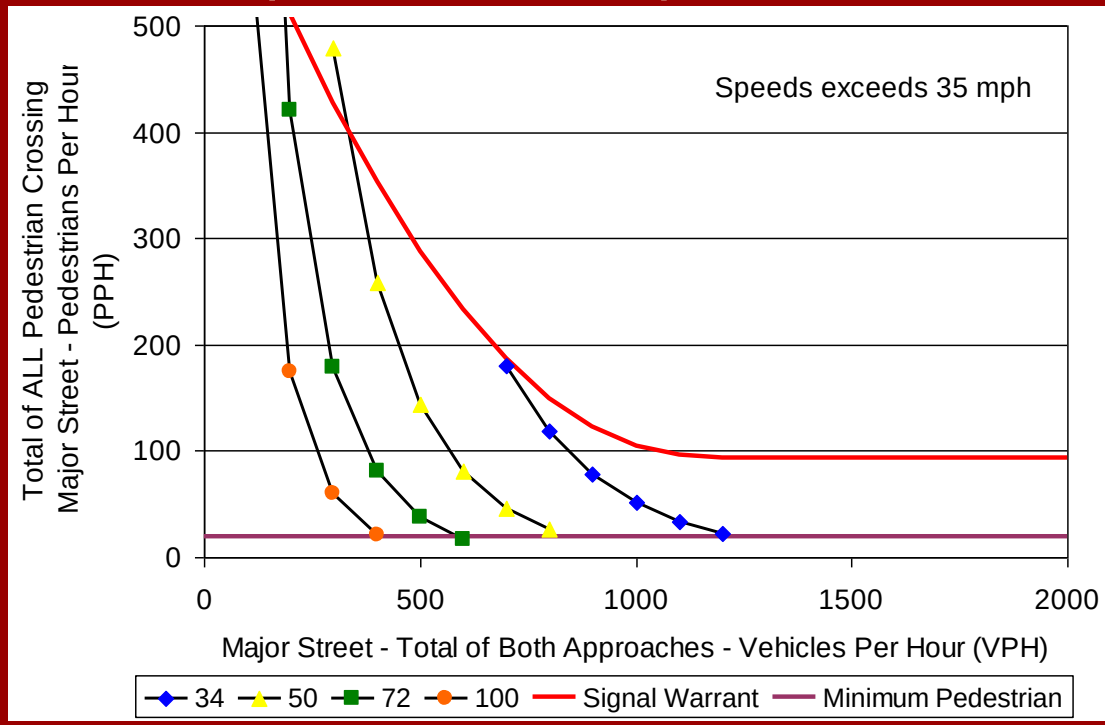
# HAWK Pedestrian Hybrid Signal

Hawk effectiveness

| Crossing Treatment | TCRP D-08/NCHRP 3-71 Study: Compliance – Staged Pedestrian Crossing | | | Compliance – General Population Pedestrian Crossing | | |
|---|---|---|---|---|---|---|
| | # of Sites | Range (%) | Average (%) | # of Sites | Range (%) | Average (%) |
| **Red Signal or Beacon** | | | | | | |
| Midblock Signal | 2 | 97 to 100 | 99% | 4 | 91 to 98 | 95% |
| Half Signal | 6 | 94 to 100 | 97% | 6 | 96 to 100 | 98% |
| HAWK Signal Beacon | 5 | 94 to 100 | 97% | 5 | 98 to 100 | 99% |
| **Active When Present** | | | | | | |
| In-Roadway Warning Lights | NA | NA | NA | NA | NA | NA |
| Overhead Flashing Beacon (Pushbutton Activation) | 3 | 29 to 73 | 47% | 4 | 38 to 62 | 49% |
| Overhead Flashing Beacon (Passive Activation) | 3 | 25 to 43 | 31% | 3 | 61 to 73 | 67% |

# Pedestrian Hybrid Signals Can Significantly Improve Accessibility for Blind Pedestrians

- Pedestrians with visual impairments have difficulty crossing at unsignalized locations
- Normal pedestrian signal warrants are hard to meet (red line is 2009 MUTCD warrant for – minimum 93 peds/hr)
- Hybrid Signal allows much lower ped volumes (varies on street width but minimum 20 peds/hr)
- Minimum values are for high vehicle volumes

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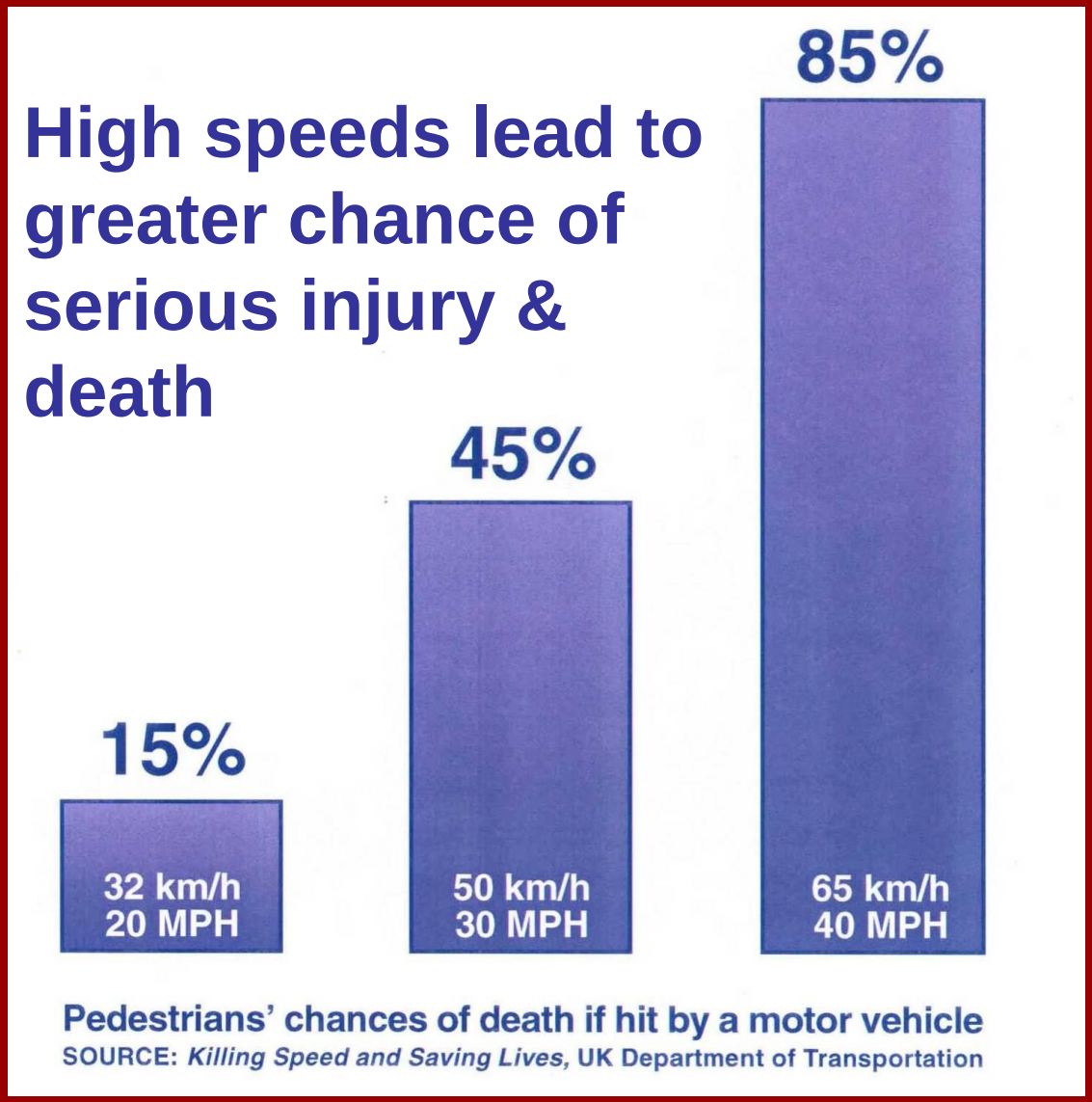
# HAWK Pedestrian Hybrid Signal

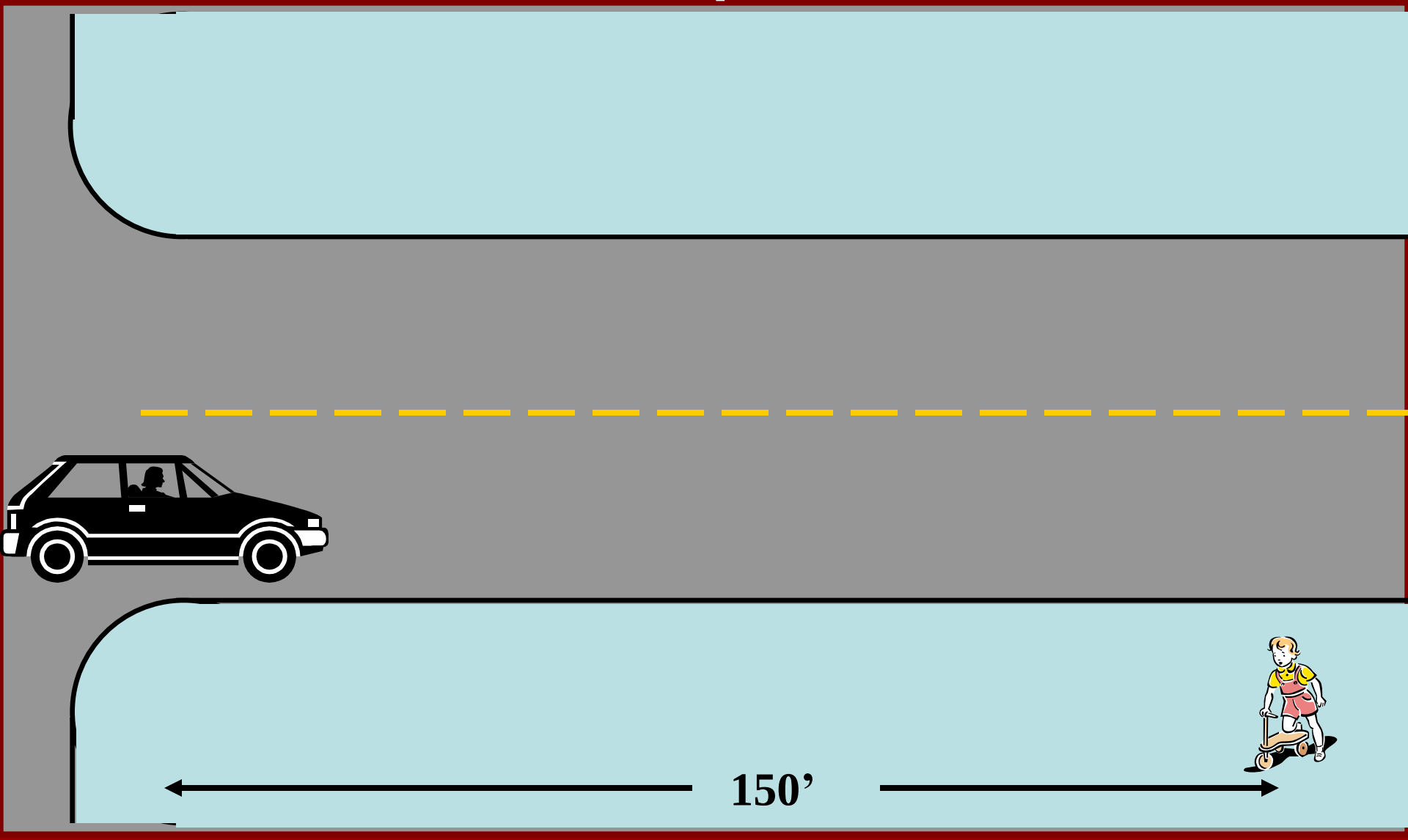
- A new Chapter added to describe the application, design, and operation of pedestrian hybrid signals.
- Vehicular signal rests in blank
- Ped signal rests in Don’t Walk (except when used with roundabouts where they can rest in blank)

# Using Traffic Signals to Control Speeds

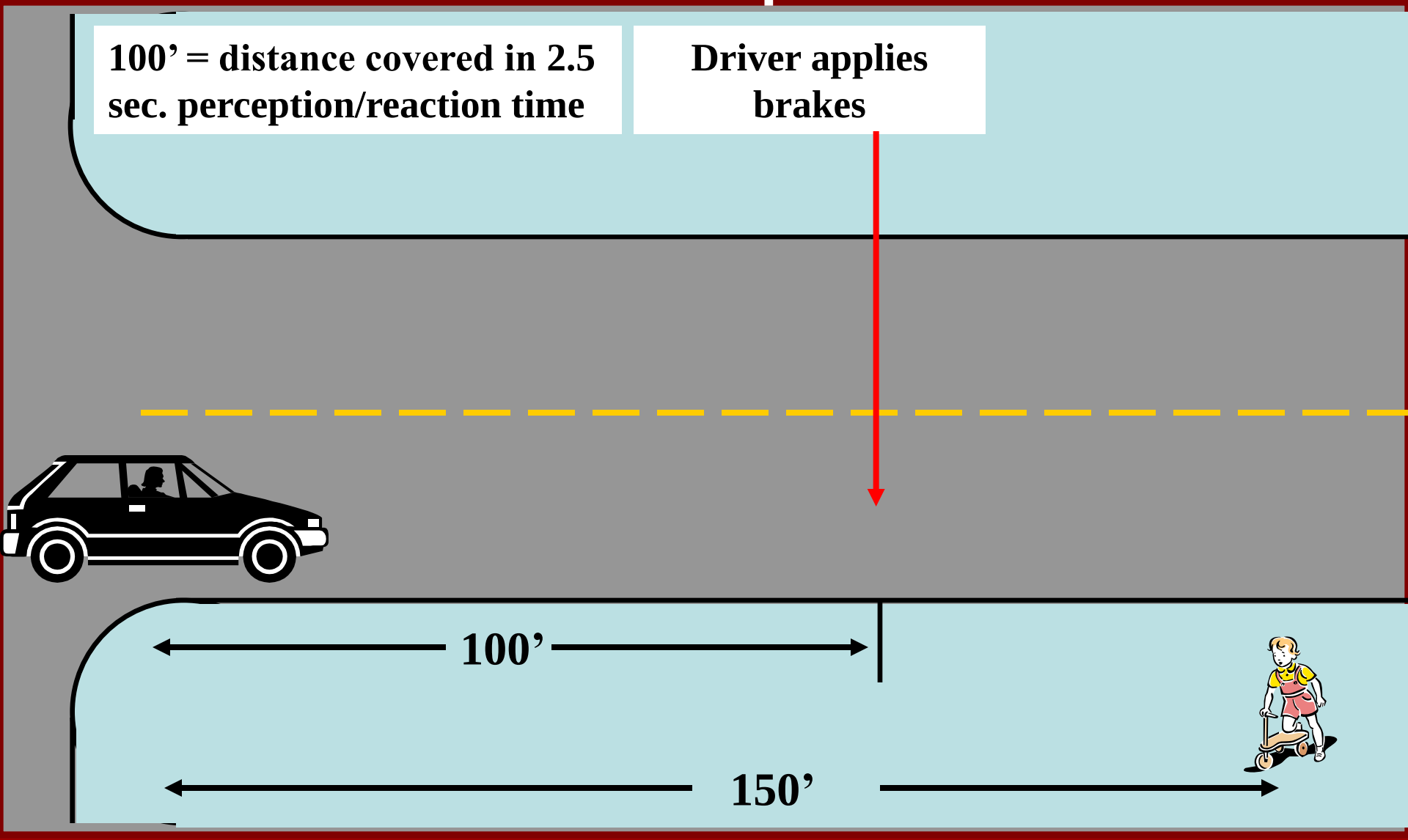
# Speed Matters



# Child dart-out: speed is a factor!



# First scenario: Speed 25 MPH



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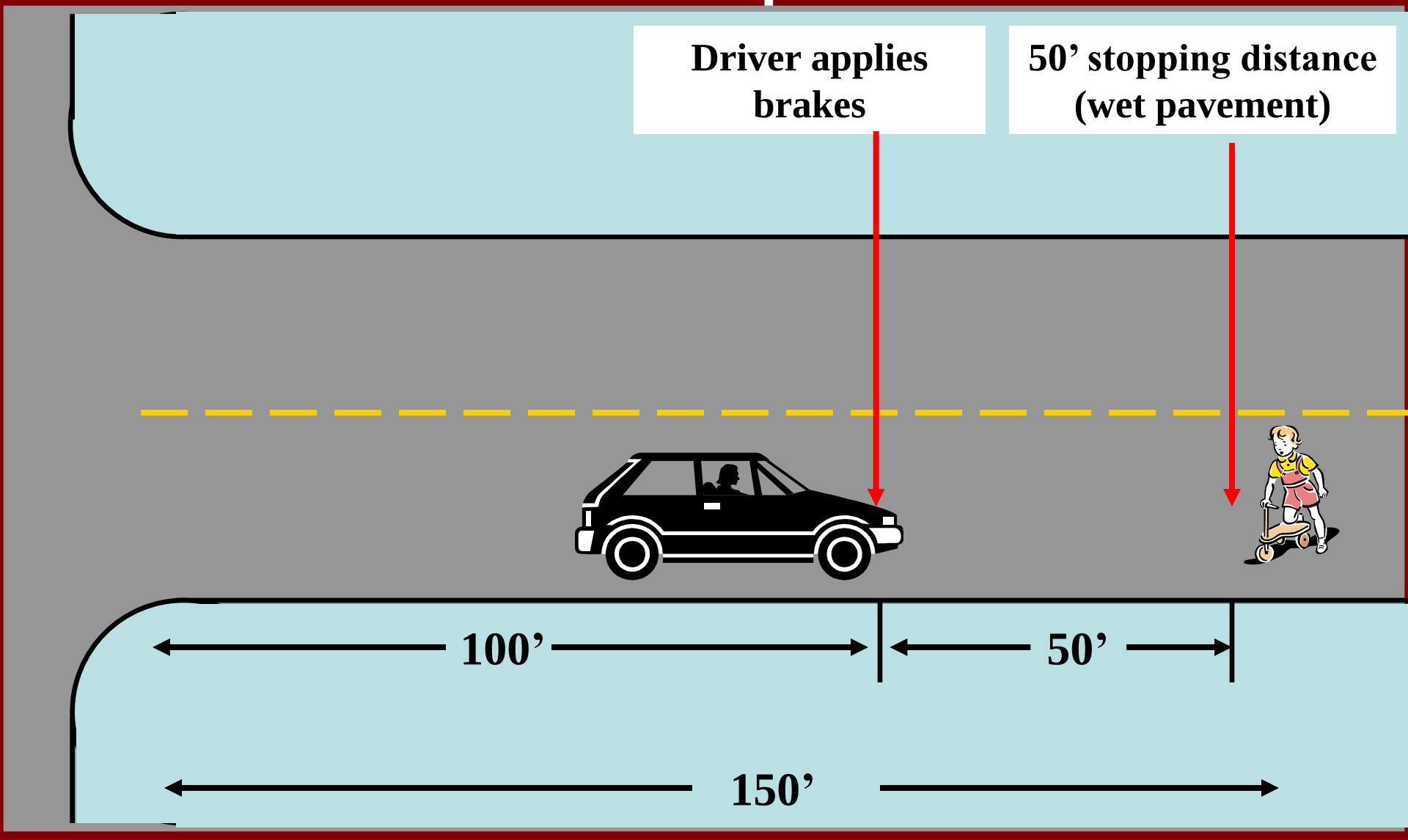
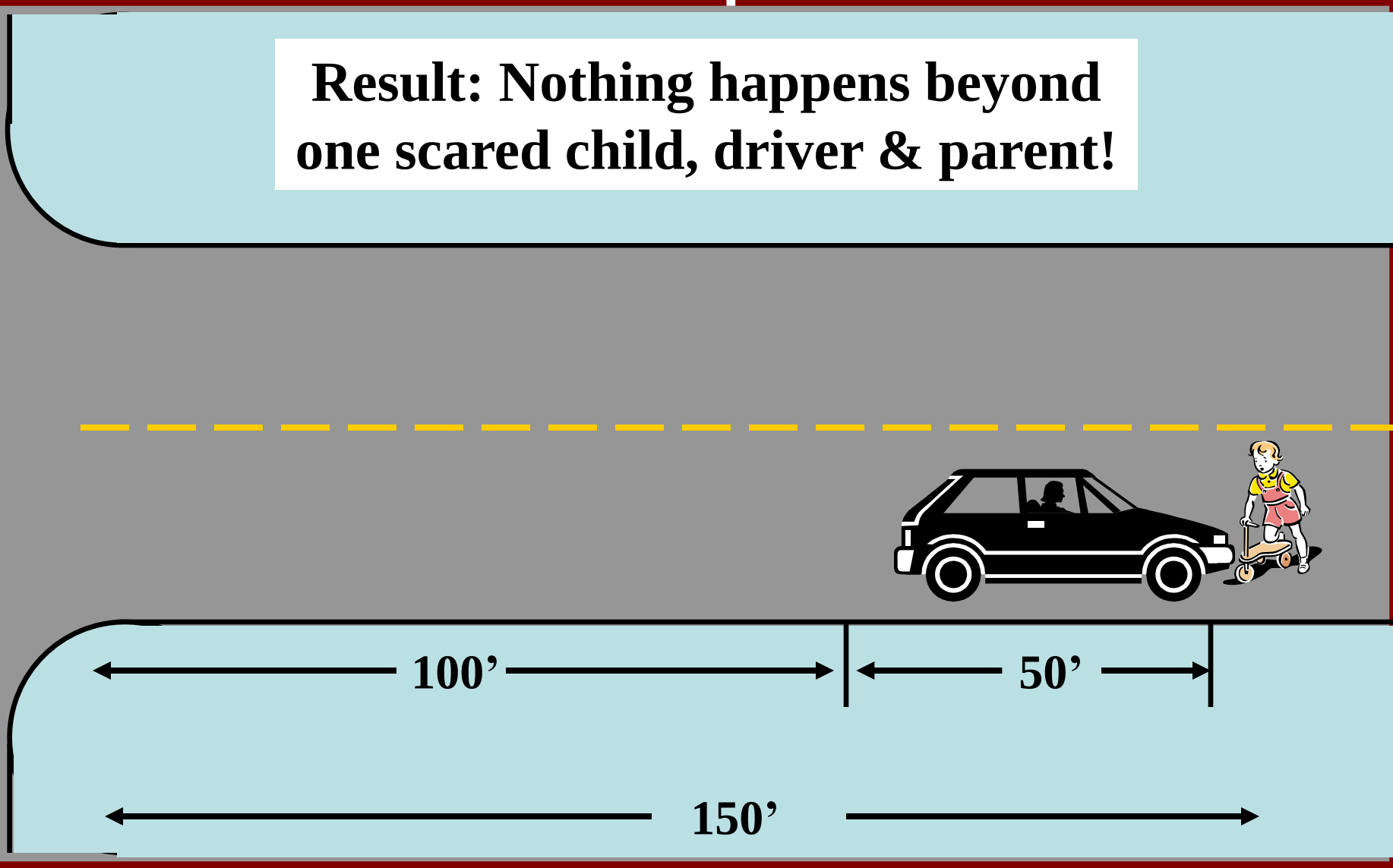
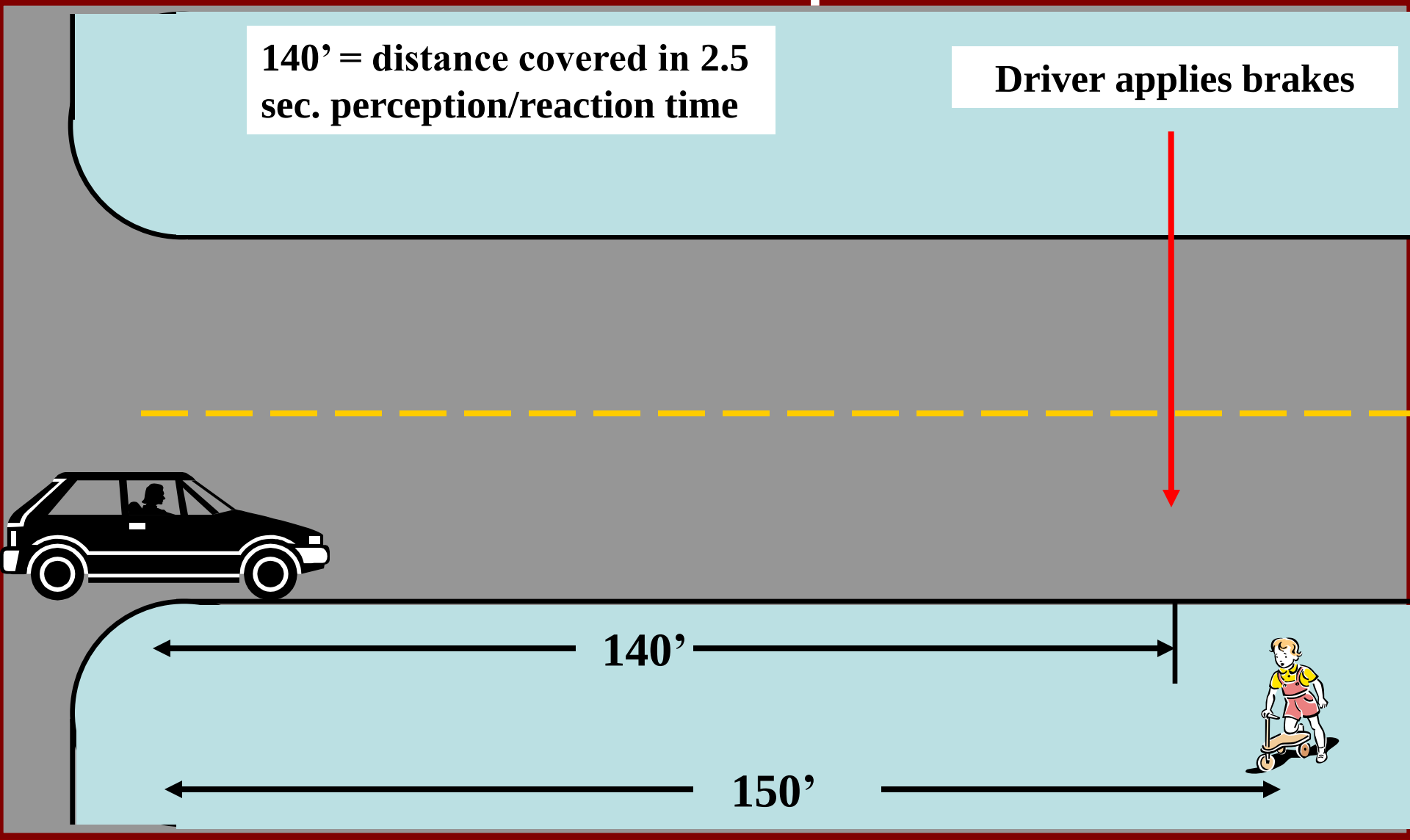


# First scenario: Speed 25 MPH

**Result: Nothing happens beyond one scared child, driver & parent!**



# Second scenario: Speed 38 MPH



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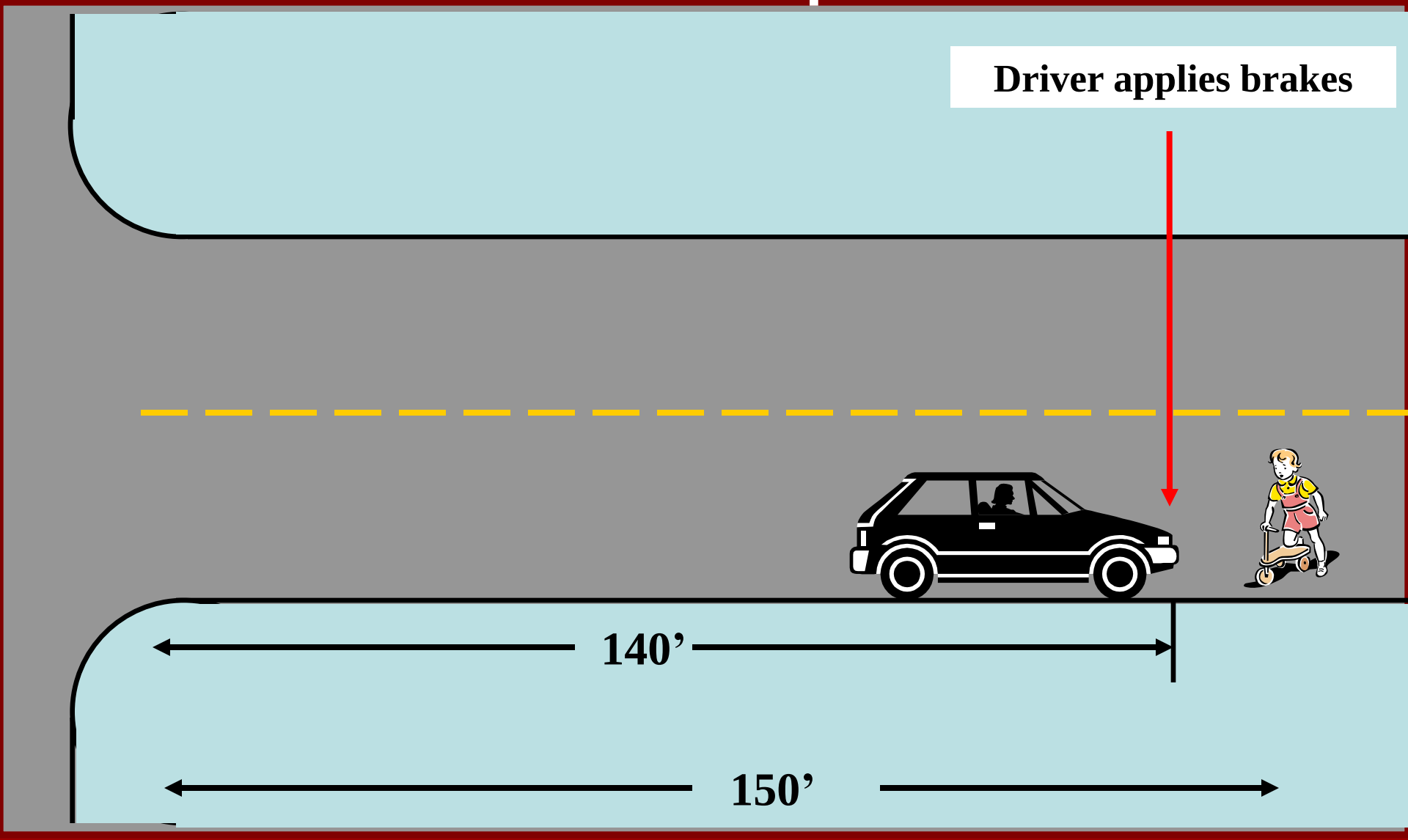

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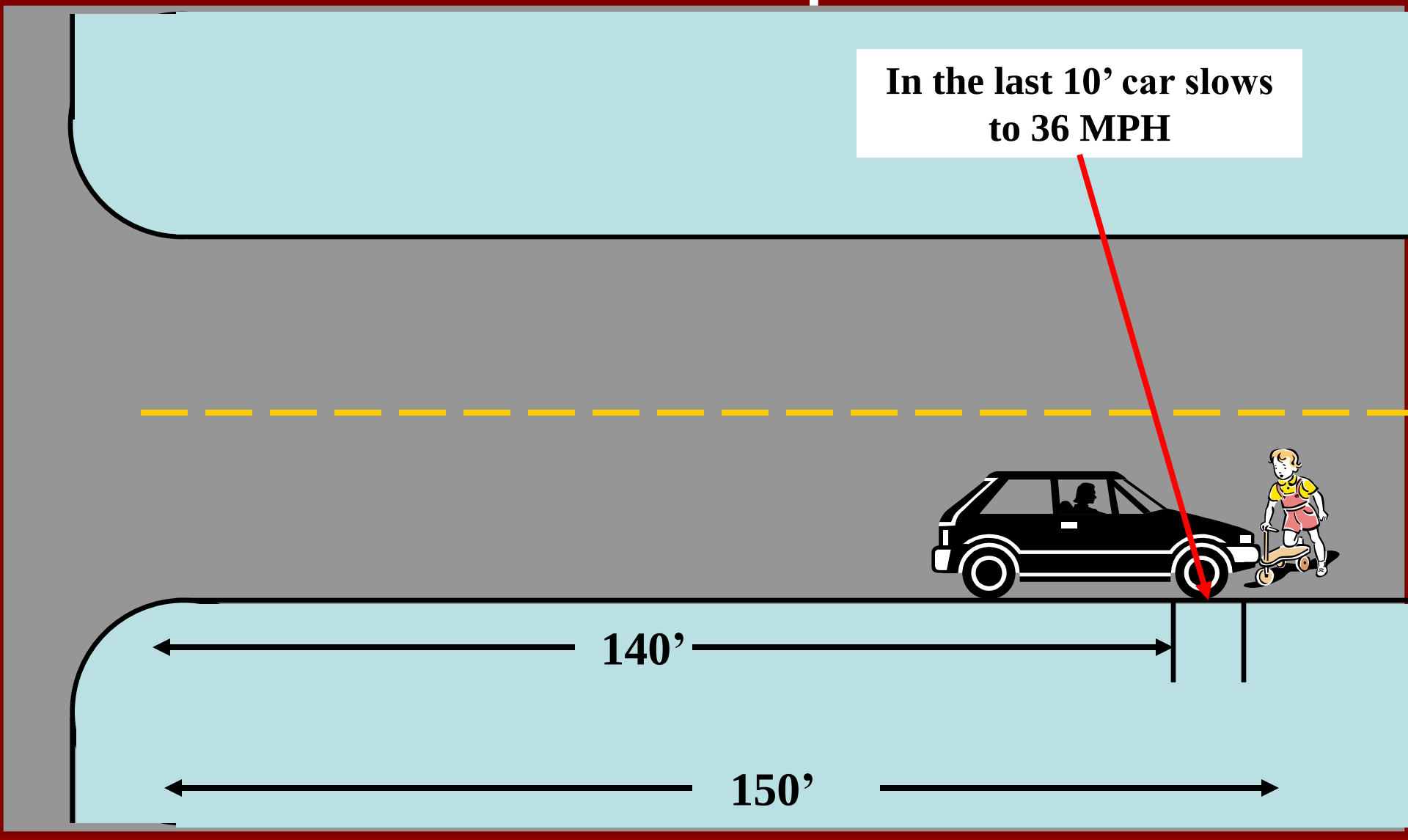
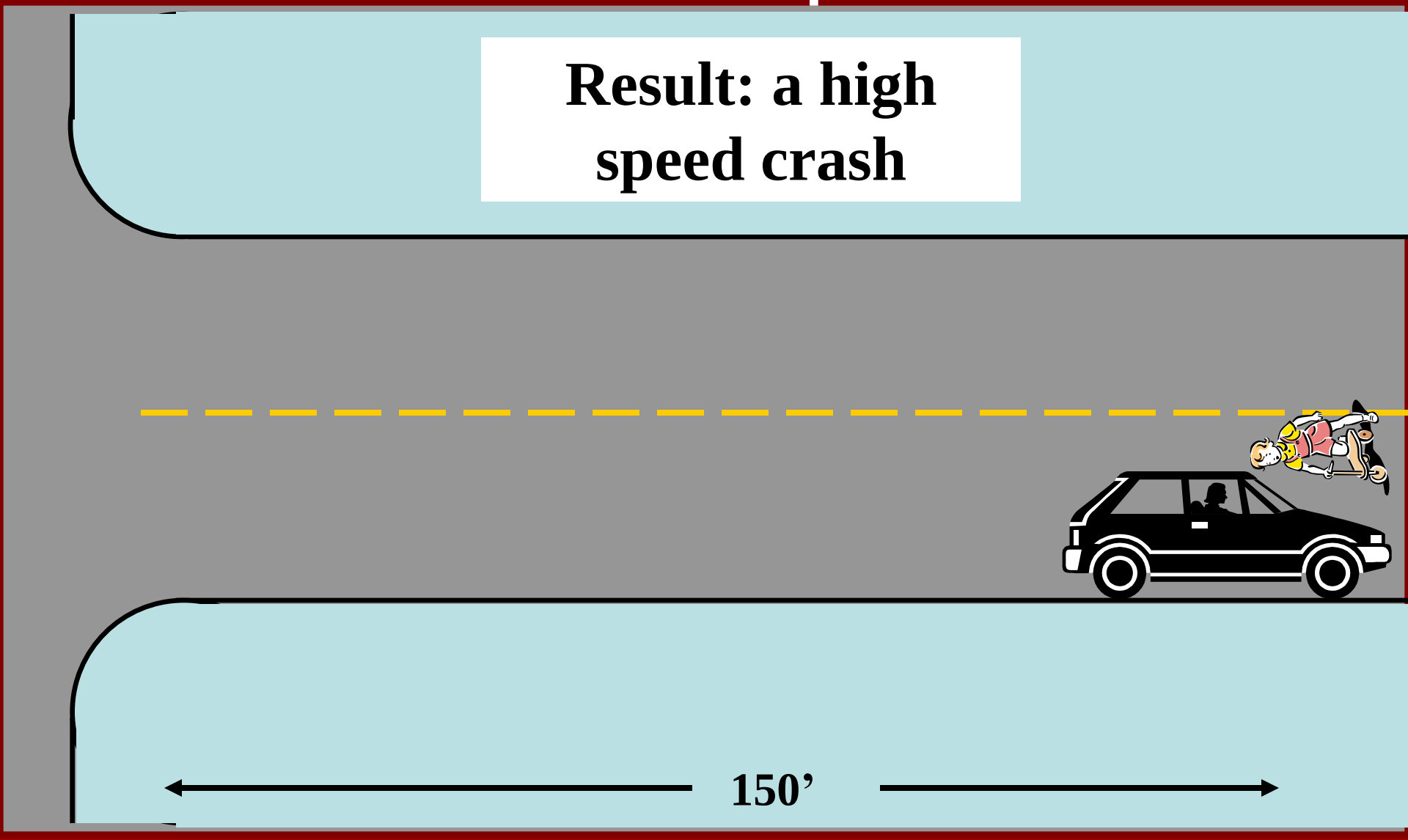


# Second scenario: Speed 38 MPH

**Result: a high speed crash**



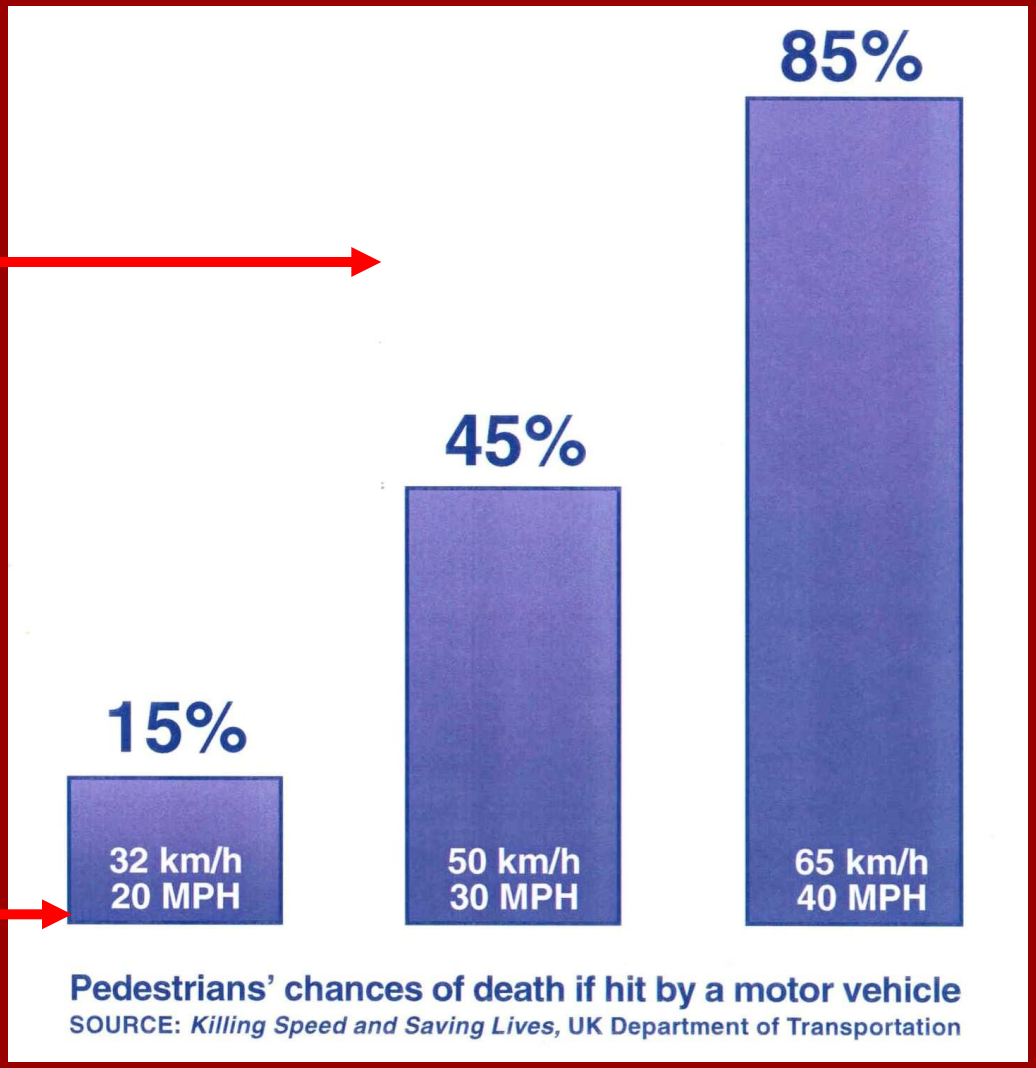
# Where do these two scenarios lie on the pedestrian fatality risk scale?

Second scenario:

Crash speed 36 MPH

First scenario:

no crash



# Defining Mobility

- Typical experience:
  - 45 mph speed
  - 2 min wait at signal

# Defining Mobility

- Viable alternative:
  - 2-way progression set for 30 mph

# Benefit/Cost Analysis

- Reducing speed from 45 mph to 30 mph
  - For a 5-mile trip, a 3.33-minute delay
  - Assume 30,000 ADT and $20/hr driver cost
  - $12.5 million in loss to economy, right?
- **Wrong!**
  - Delay for each person is still under 4 minutes
  - Less time than their daily stop for Starbucks
- Community benefit
  - Slower operating speeds
  - Safer and more comfortable ped crossings

# QUESTIONS?

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