U.S. Department of Transportation
Federal Highway Administration

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Pedestrian and Bicycle Information Center

# How-to-Develop a Pedestrian Safety Action Plan

## *Engineering Strategies*

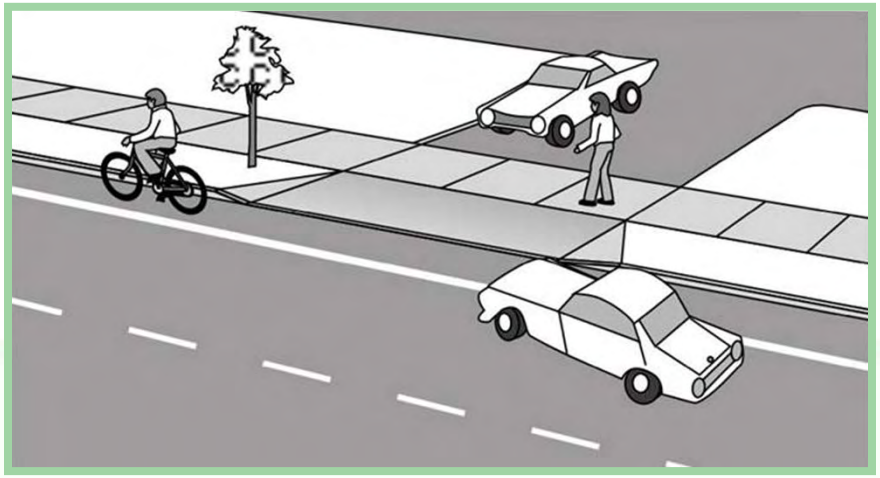

***Hillary Isebrands, PE***
***FHWA Resource Center Safety Specialist***

***Michael Moule, PE, TE, PTOE***
***Principal Transportation Engineer, Nelson\Nygaard Consulting Associates, Inc.***


# Engineering: Learning Objectives

***At the end of this module, you should be able to:***

⇨**Describe effective engineering strategies and how to integrate them into your Pedestrian Safety Action Plan**



# Engineering: Subjects Covered

- **Walking along the road:** the effectiveness of sidewalks and shoulders
- **Street crossings:** human behavior, midblock crossings, crosswalks, medians, signals
- **Pedestrian-friendly intersection design:** geometry, corner radii, curb extensions, islands
- **Signals:** how to make them work for pedestrians
- **Transit:** stop locations & ped crossings
- **Road diets:** creating room for pedestrians

# Countermeasures for Walking Along the Road Crashes

# Rural Environments: Paved Shoulders

**Crash Reduction Factor (CRF) = 70%**

**6’ width preferred for effectiveness**

Benton Co OR

# Urban/suburban Environments: Sidewalks

**CRF = 88%**

Salem OR

## Reno NV

# Buffer sidewalks with planter strip/furniture zone:

- ⇨ Space for trees and street furniture
- ⇨ Easy to meet ADA at driveways and curb ramps
- ⇨ More pleasant to walk on.

## Henderson, NV

**5 feet needed for two people to walk comfortably side-by-side (or to pass each other)**

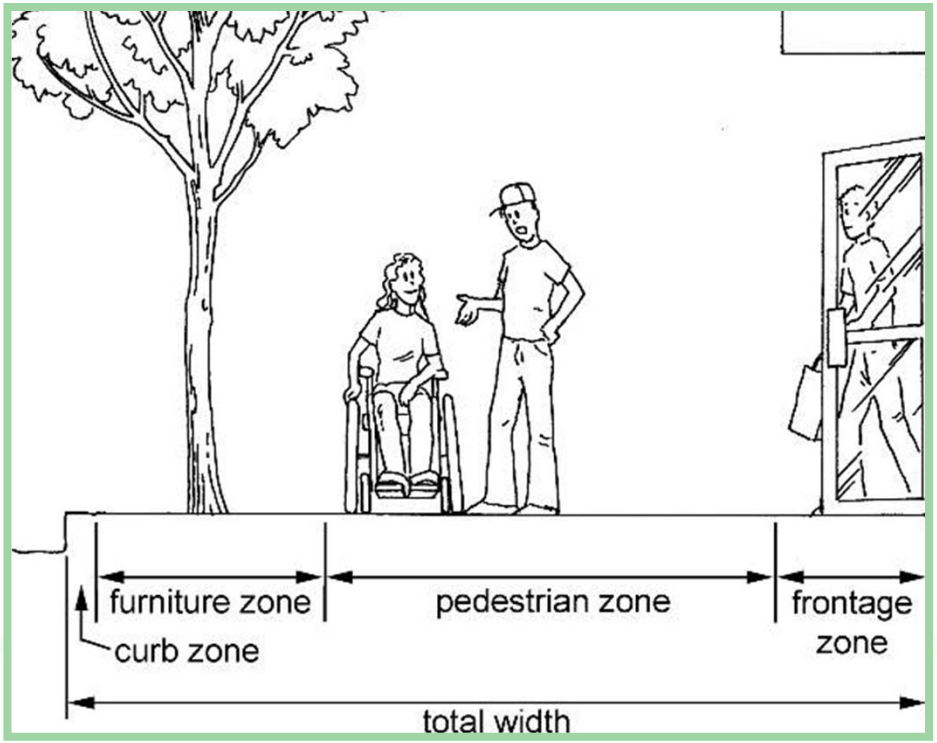
## Casper WY

# Mountable curbs are not appropriate on local streets

# Sidewalk Corridors—The Zone System

**The sidewalk corridor extends from the edge of roadway to the right-of-way and is divided into 4 zones:**

- ⇨ **Curb zone**
- ⇨ **Furniture zone**
- ⇨ **Pedestrian zone**
- ⇨ **Frontage zone**



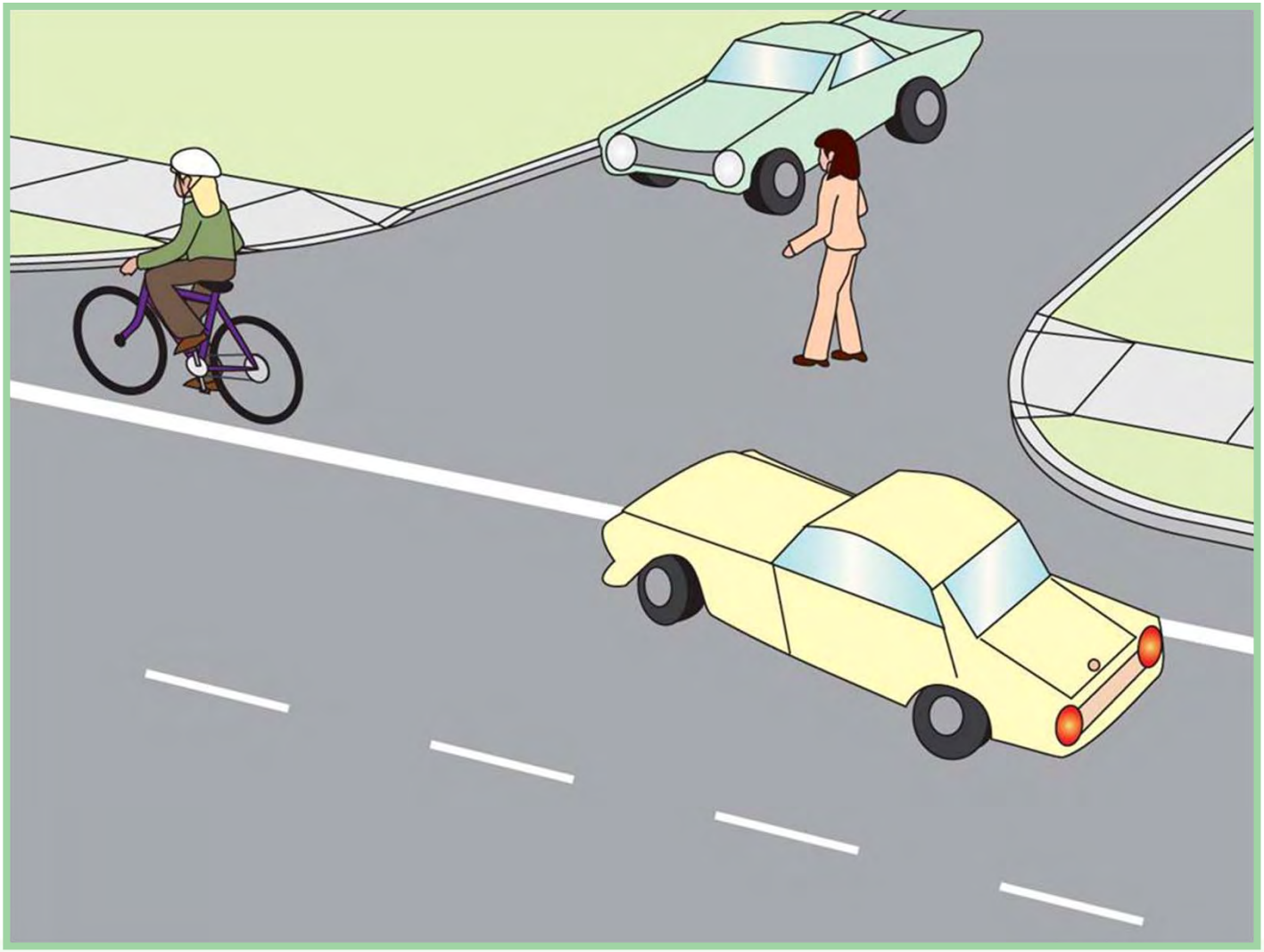
# The Zone System – Residential Street

# The Zone System – Commercial Street

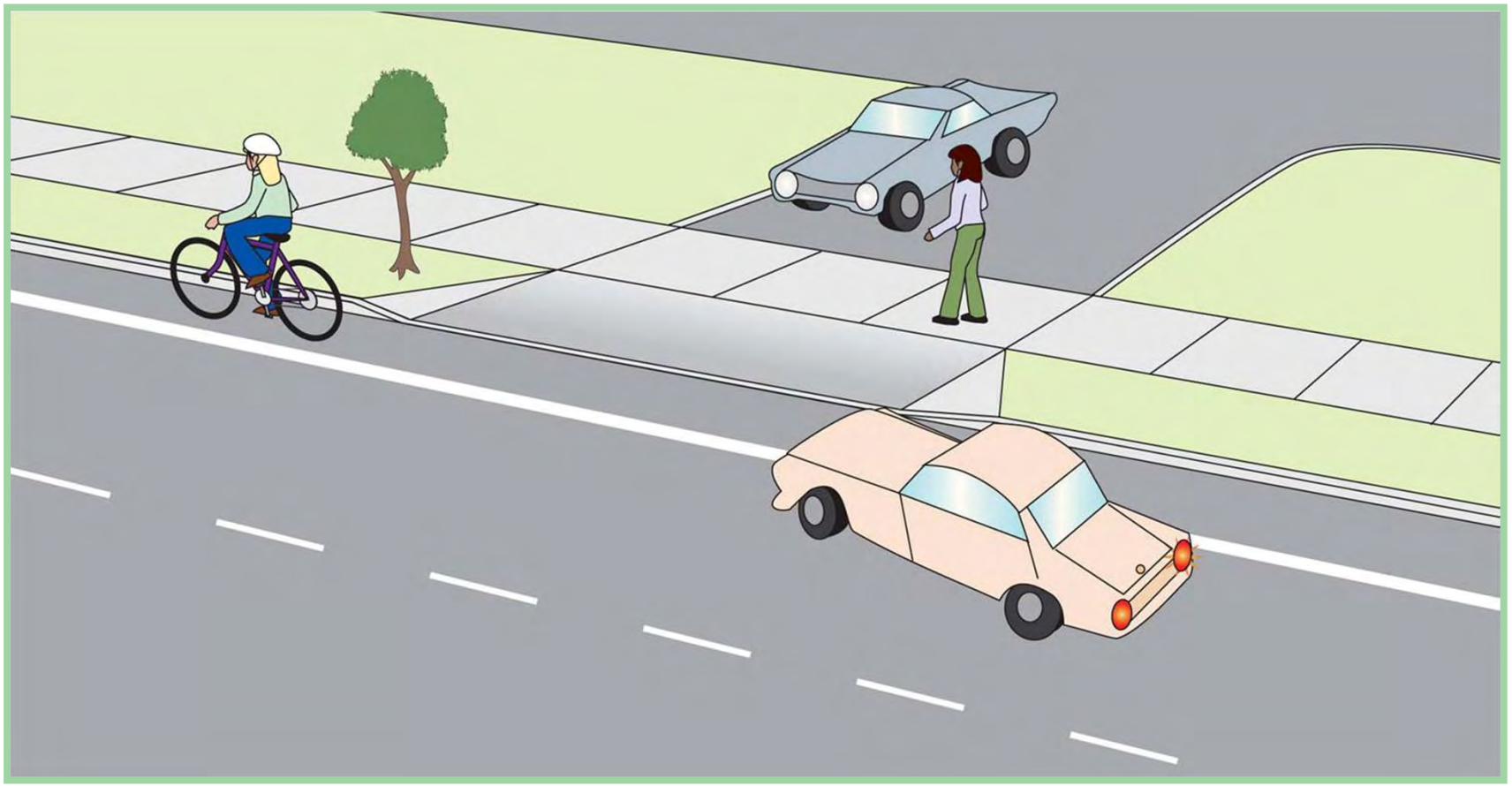

Washington DC

# Driveways

**Driveways are the source of most conflicts with motor vehicles on sidewalks**



**Driveways built like intersections encourage high-speed turns**



**Driveways built like driveways encourage slow-speed turns**


**Separated sidewalk keeps sidewalk level at driveways**

Salem OR

# ADA Requirements For Sidewalks

**Well-designed sidewalks meet ADA:**

- ⇨ **Sidewalks should be clear of obstructions:**
  - **3’ min clearance, 4’ proposed**
- ⇨ **Sidewalk should have smooth surface**
- ⇨ **Sidewalk should be at 2% max cross-slope including at driveways**

**The zone system creates a safer and more pleasant place to walk, *and* makes it easier to meet ADA requirements.**

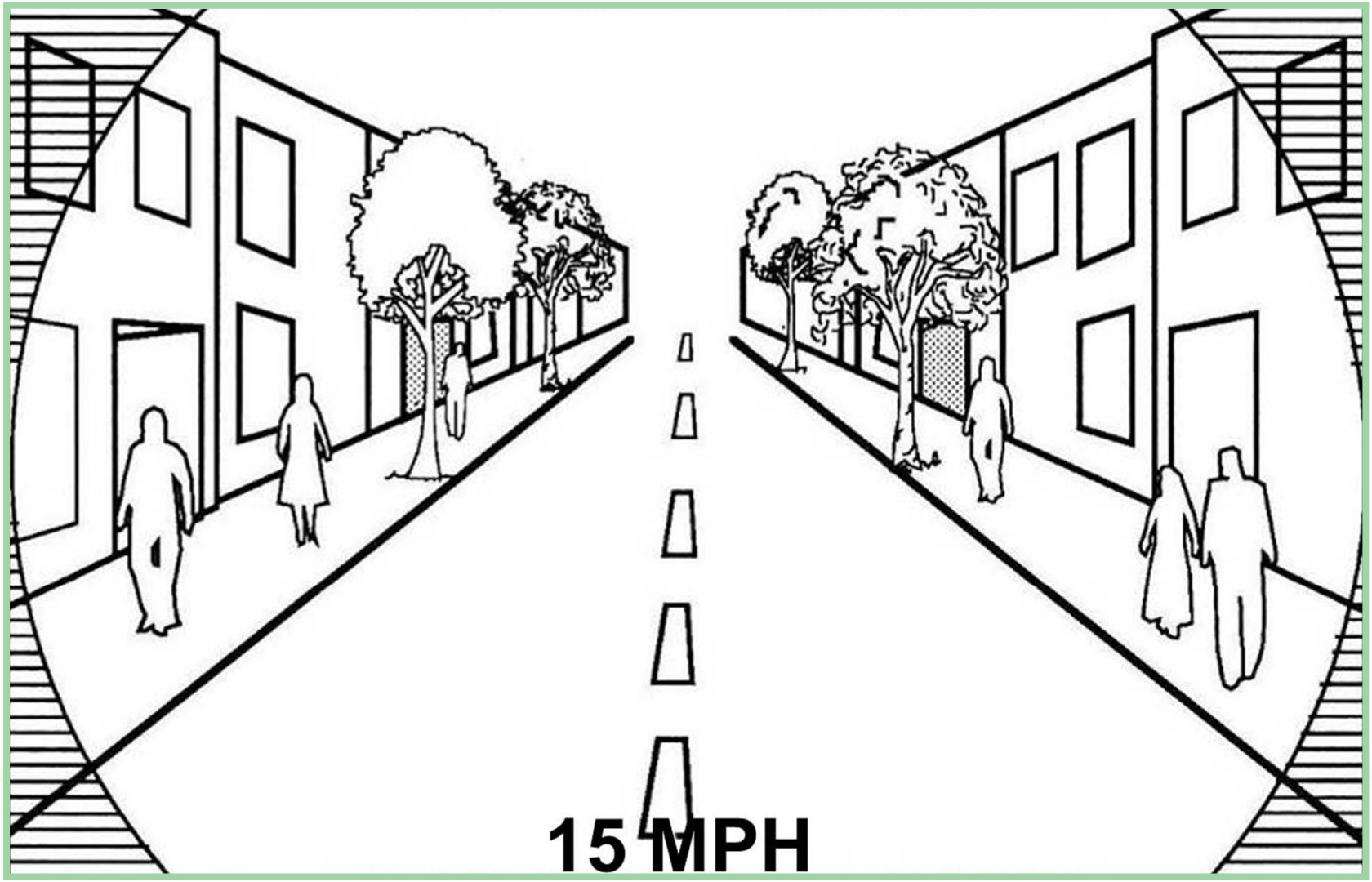
# Countermeasures for Crossing Crashes

# Crossing Crashes: Speed Matters

**Speed Affects:**

1. **Drivers' field of vision & ability to see pedestrians**
2. **Drivers' ability to react and avoid a crash**
3. **Crash Severity**

# As speed increases, driver focuses less on surroundings



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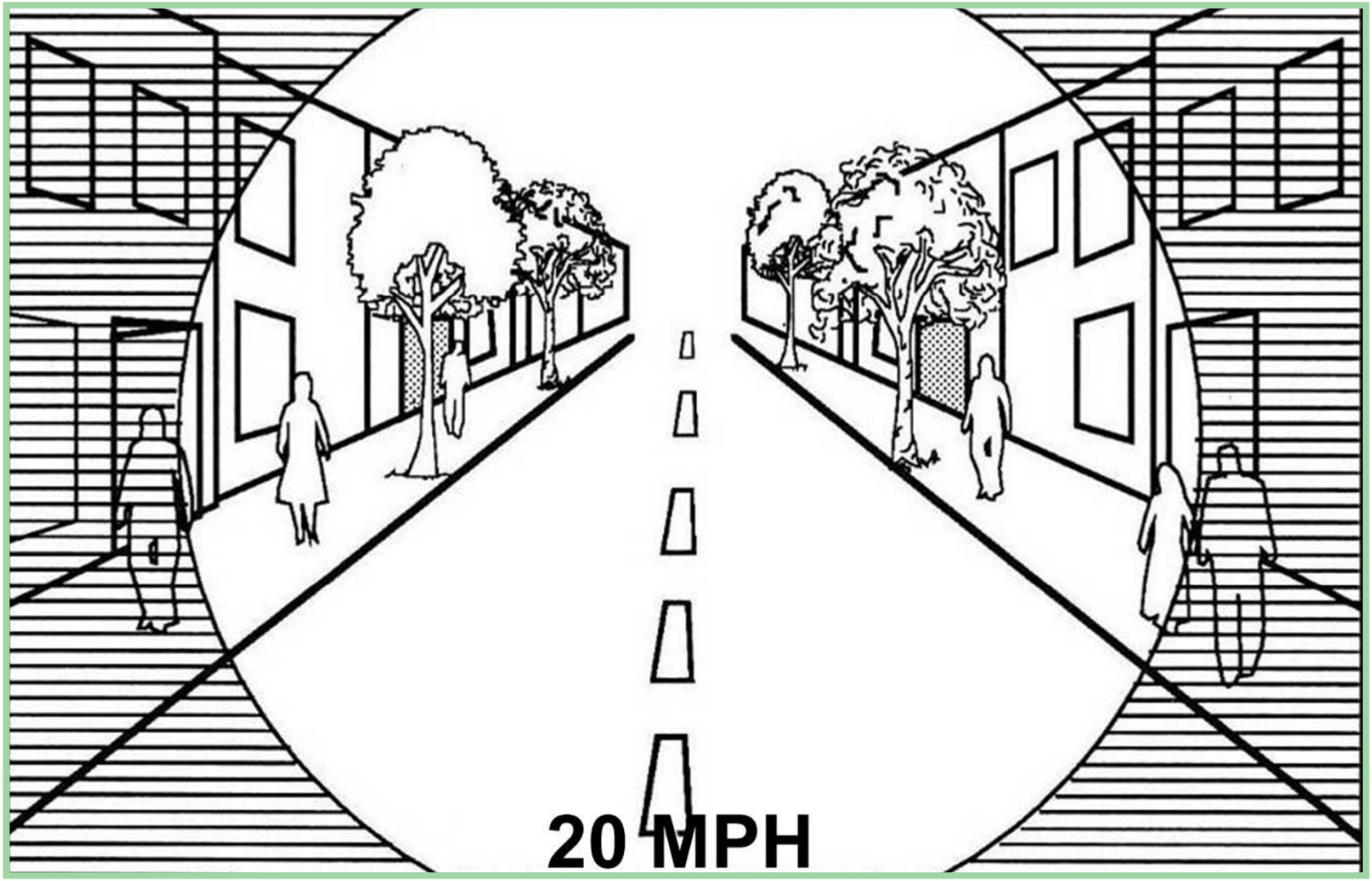

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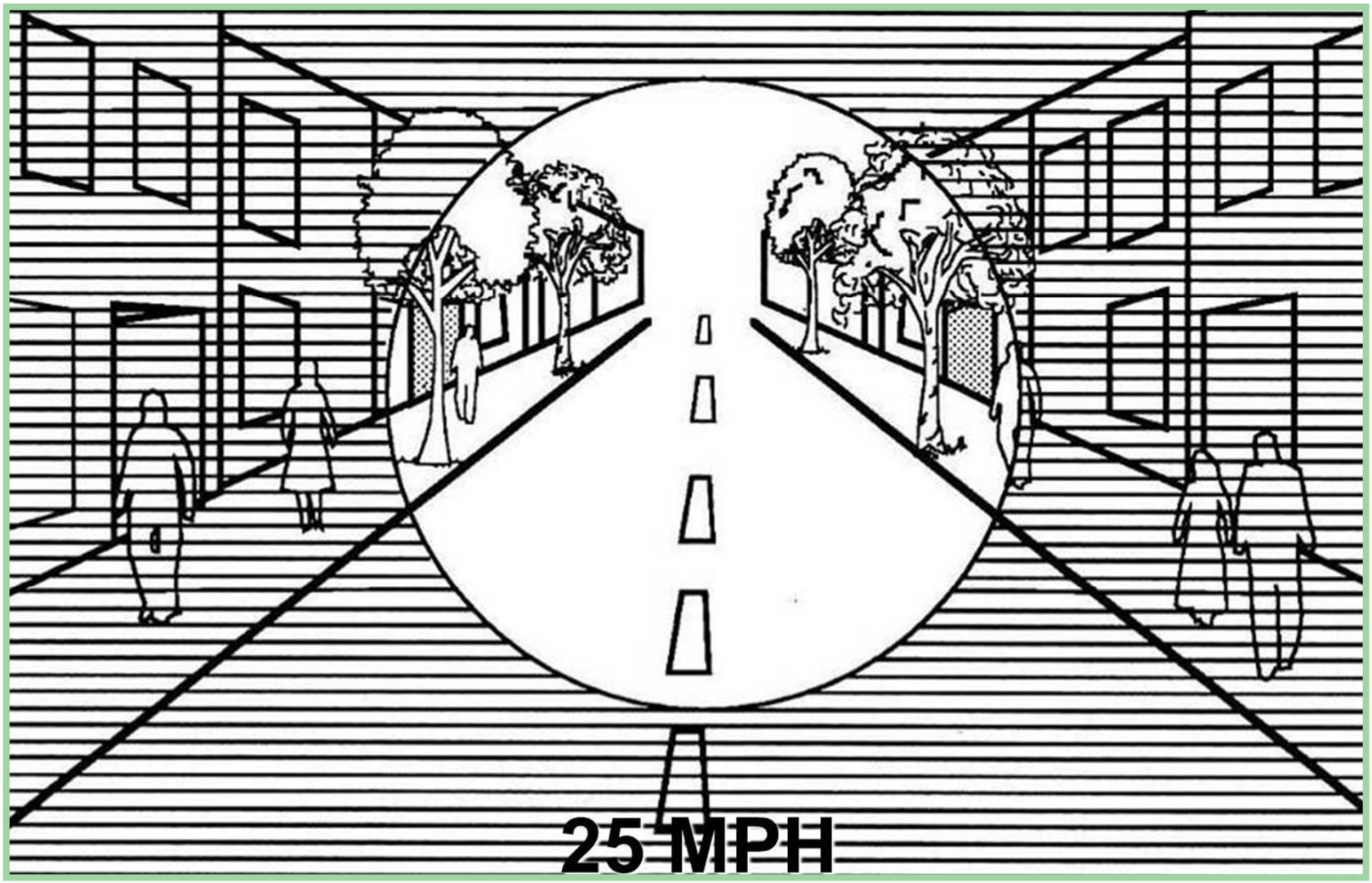

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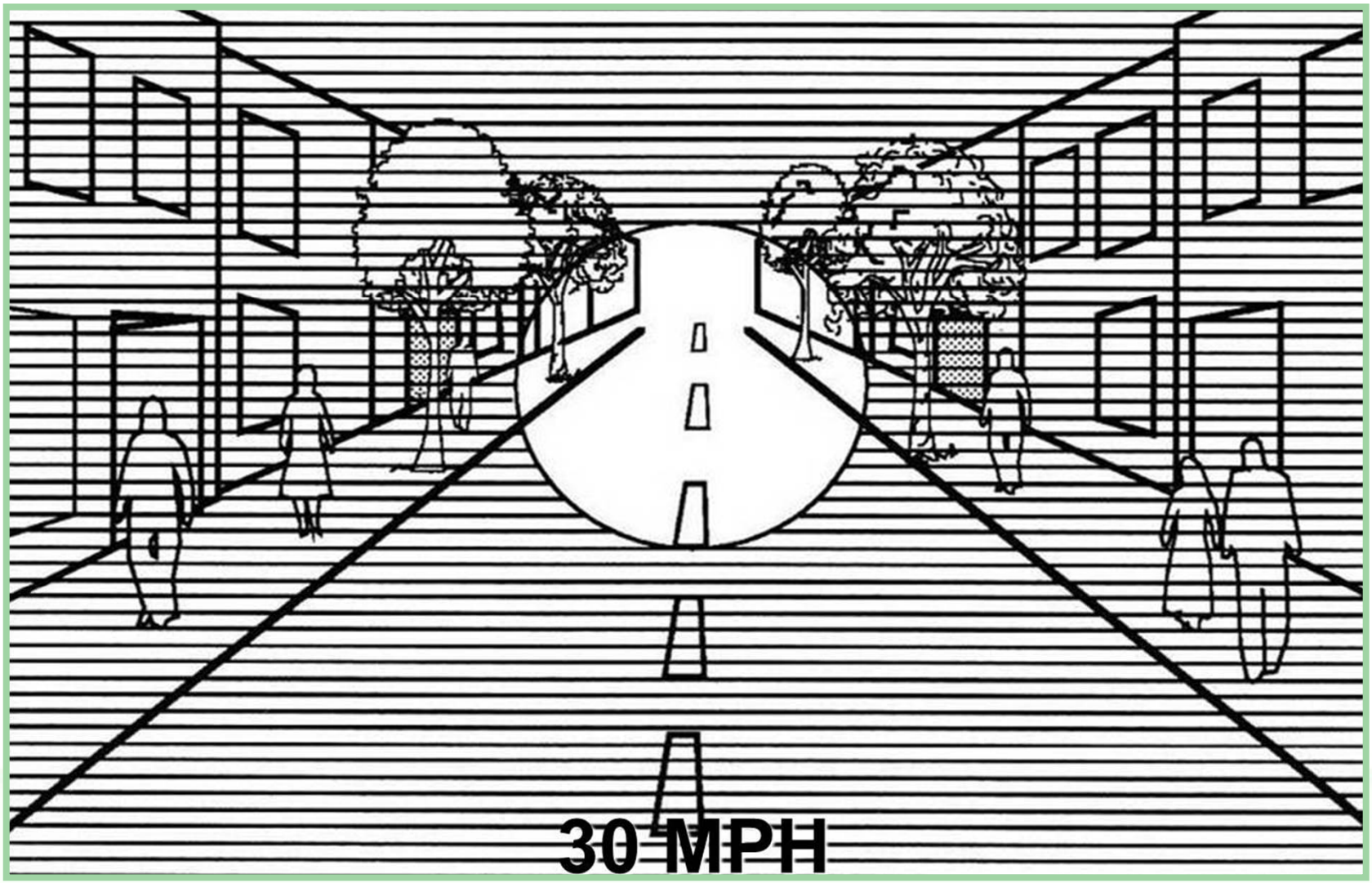
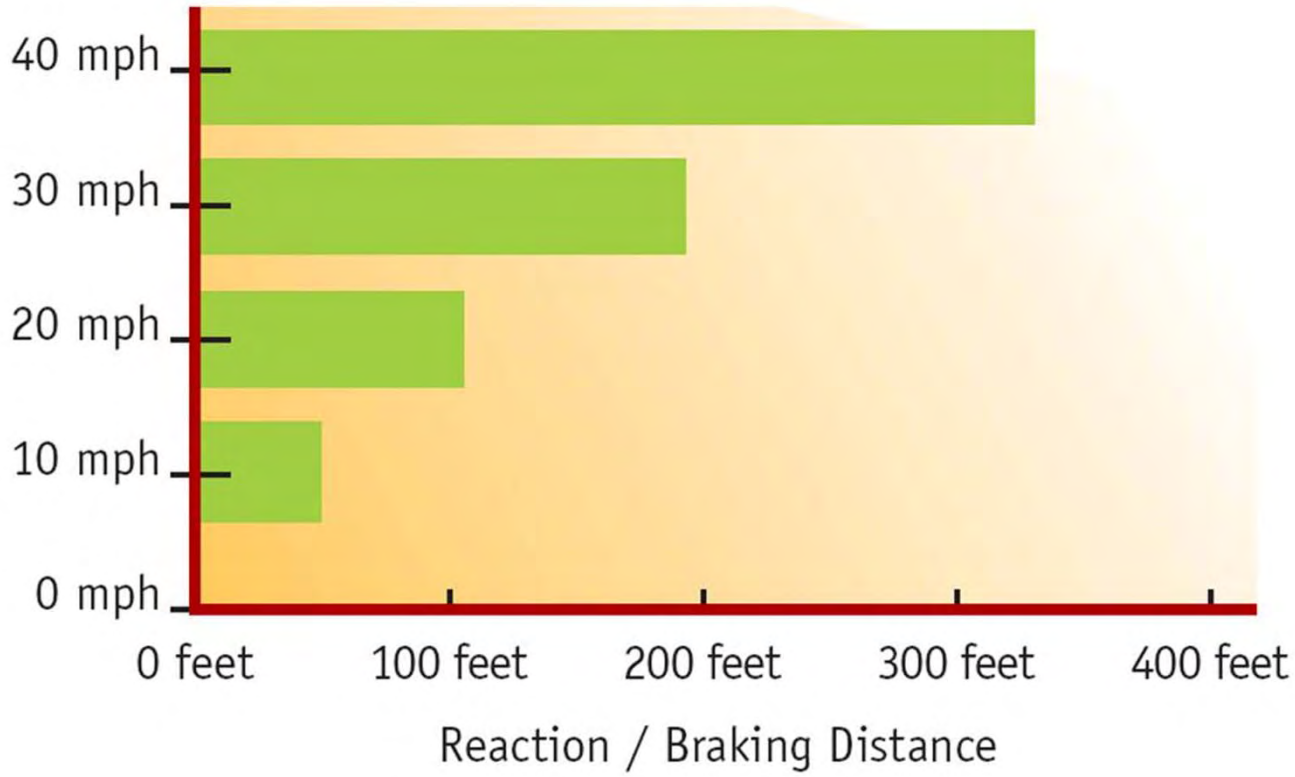


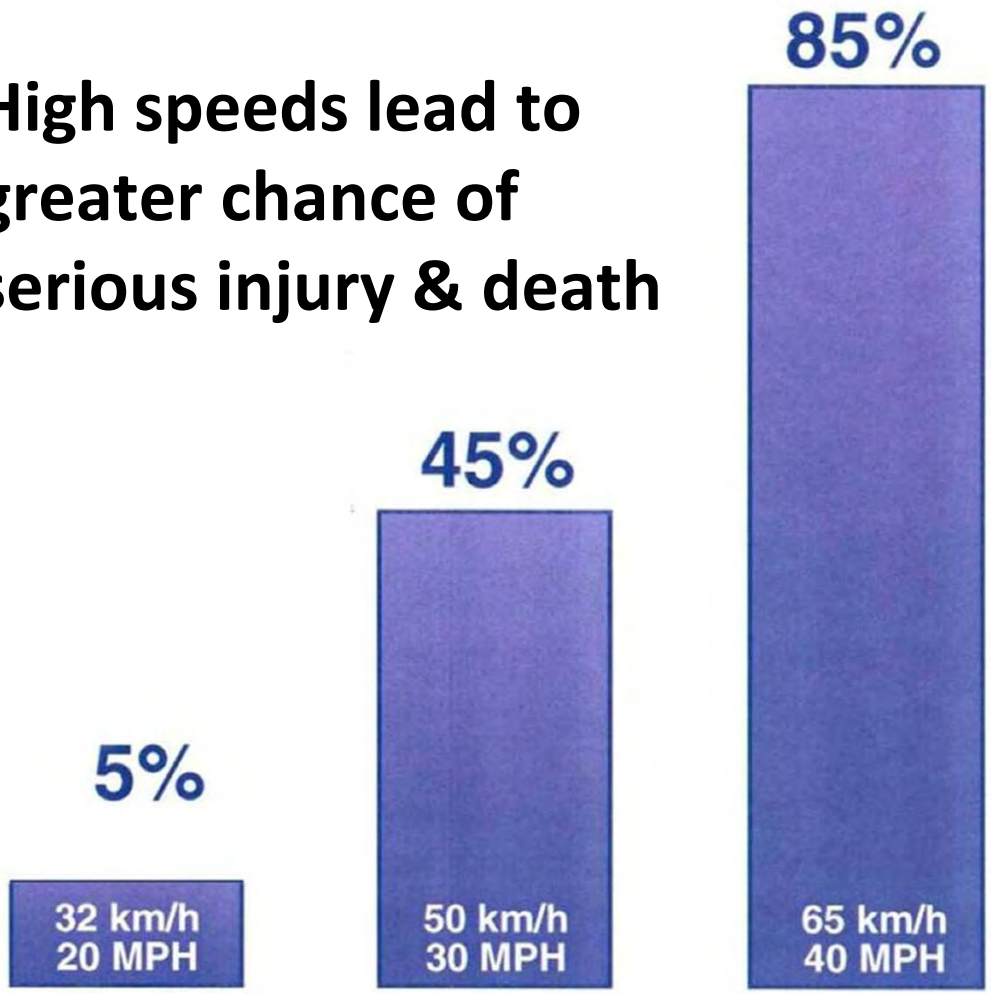
# Speed Affects Crash Avoidance




**High speeds equate to greater reaction and stopping distance**

# Speed Affects Crash Avoidance

**High speeds lead to greater chance of serious injury & death**




Pedestrians' chances of death if hit by a motor vehicle
SOURCE: *Killing Speed and Saving Lives*, UK Department of Transportation

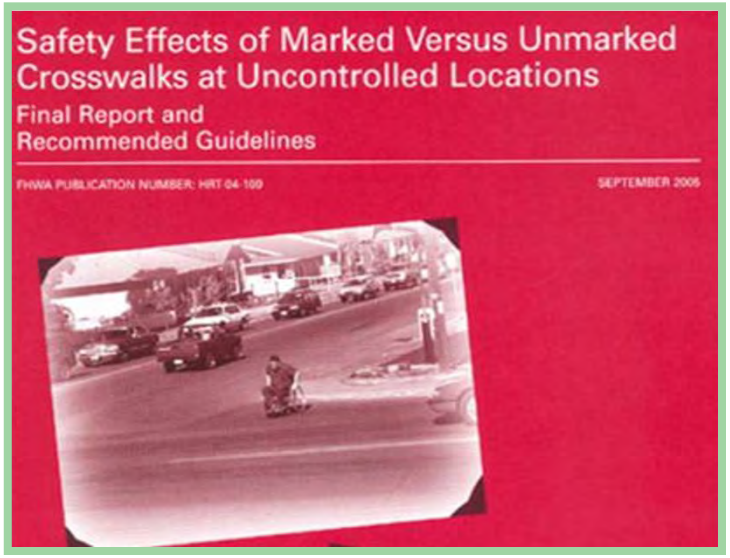
# Crosswalks

**Crosswalks are provided to indicate to pedestrians where to cross and to indicate to drivers where to expect pedestrians**

# Results of Most Recent Crosswalk Safety Study (Zegeer et al 2002)

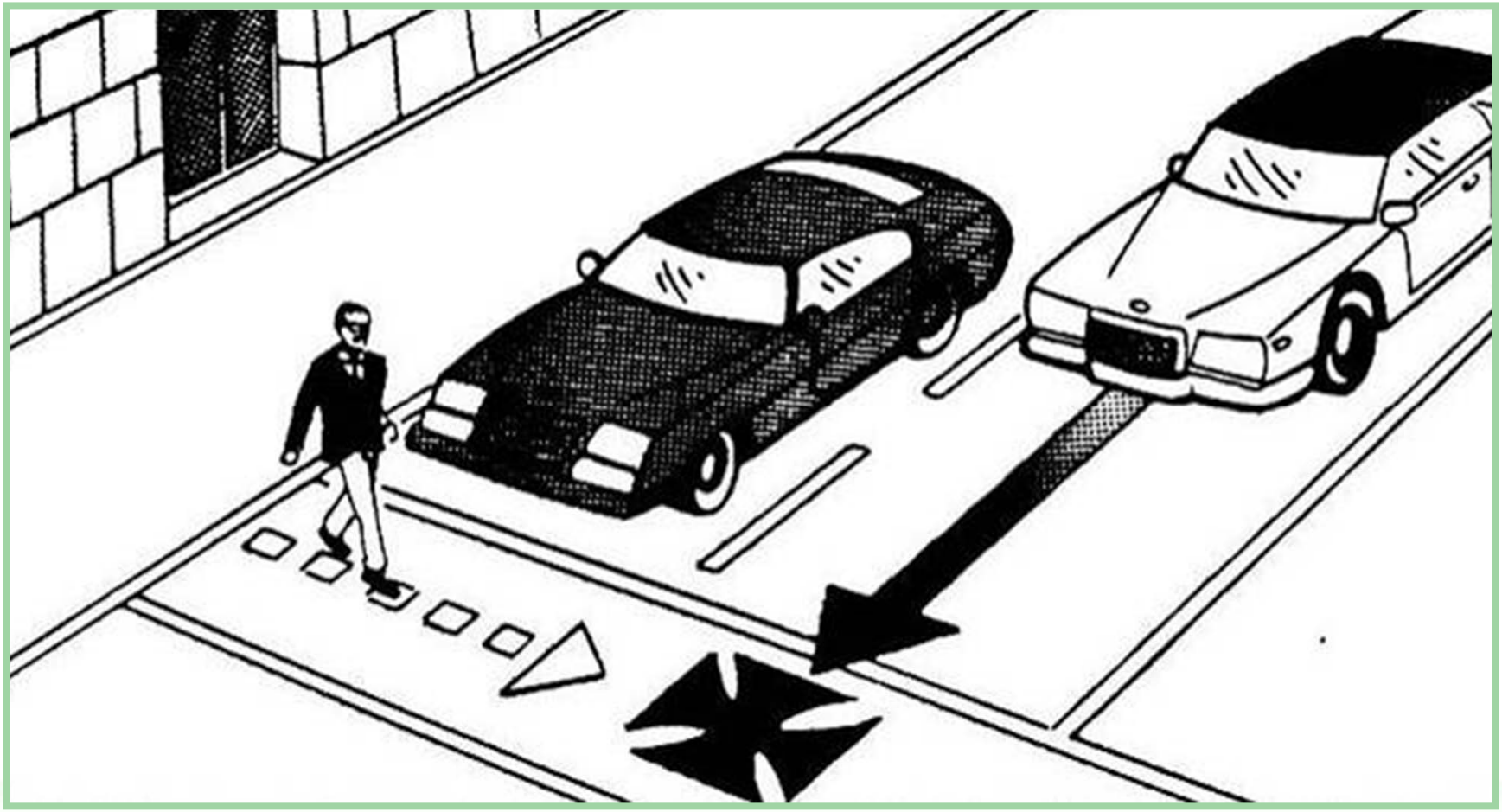
**Marked (alone) vs. Unmarked Analysis**

- ⇨ **Two-lane roads: No significant difference in crash rates**
- ⇨ **Multilane roads (3 or more lanes)**
  - **Under 12,000 ADT: no significant difference in crash rates**
  - **Over 12,000 ADT w/ no median: crash rate for marked > unmarked**
  - **Over 15,000 ADT & w/ median: crash rate for marked > unmarked**




- ⇨ **Pedestrians are not less vigilant in marked crosswalks:**
  - **Looking behavior increased after crosswalks installed**

# 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…)***

# Study Recommendations

1. OK to mark crosswalks on 2-lane roadways
2. On multi-lane roadways, marked crosswalks alone are not recommended on roadways with:
   - ADT > 12,000 w/o median
   - ADT > 15,000 w median*
   - Speeds greater than 40 mph
3. Use raised medians to reduce risk
4. Signals or other treatments should be considered where many young and/or elderly pedestrians

** Note: effect of advance stop bar not studied (none at any observed sites)*

# Increase Effectiveness Of Crosswalks With:

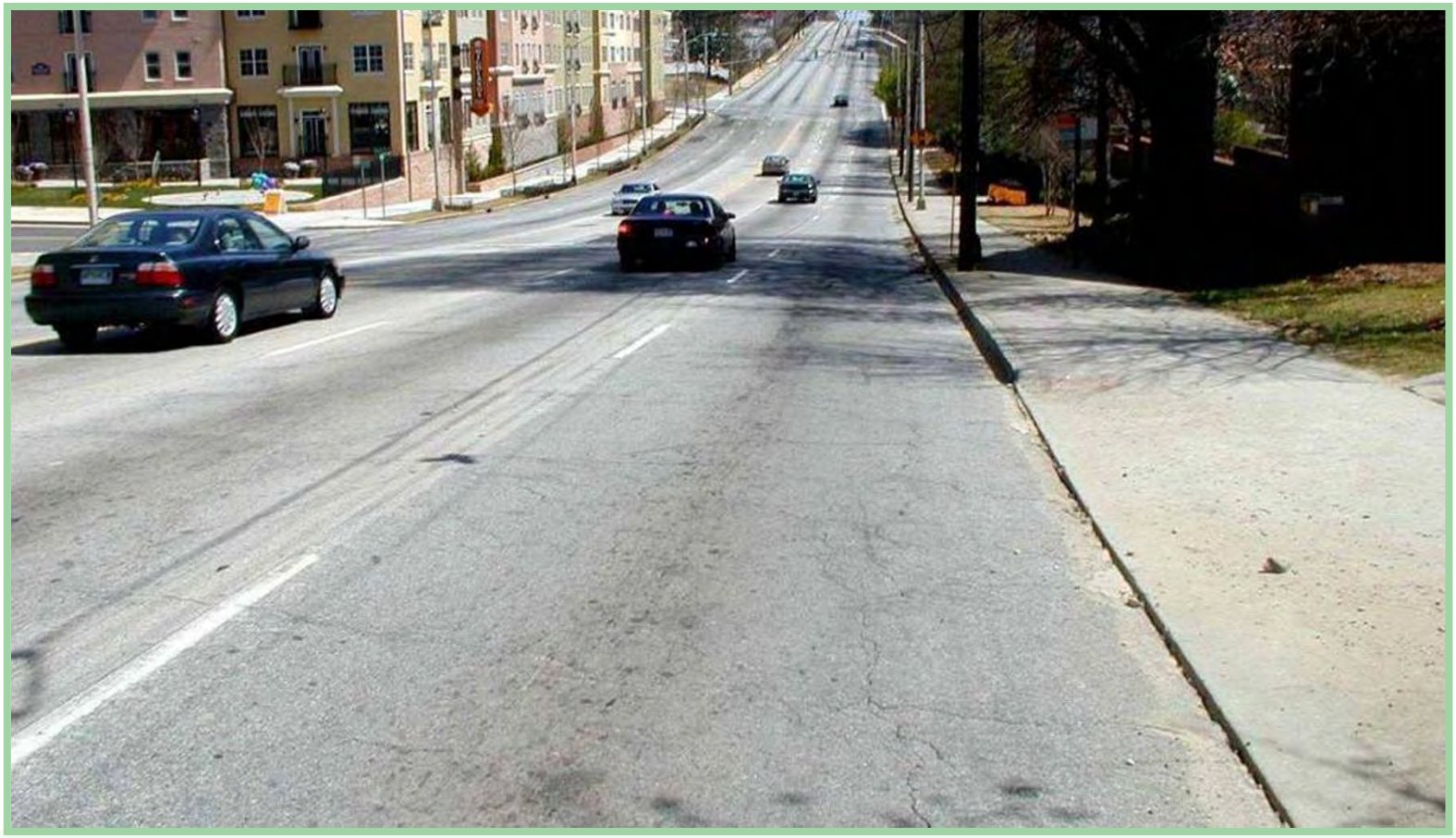
- ⇨ Proper location
- ⇨ High Visibility Markings
- ⇨ Illumination
- ⇨ Signing
- ⇨ Advance Stop Bars
- ⇨ Median Islands
- ⇨ Curb Extensions
- ⇨ Signals

# Marked crosswalks must be visible to the DRIVER

## What the pedestrian sees

Atlanta GA

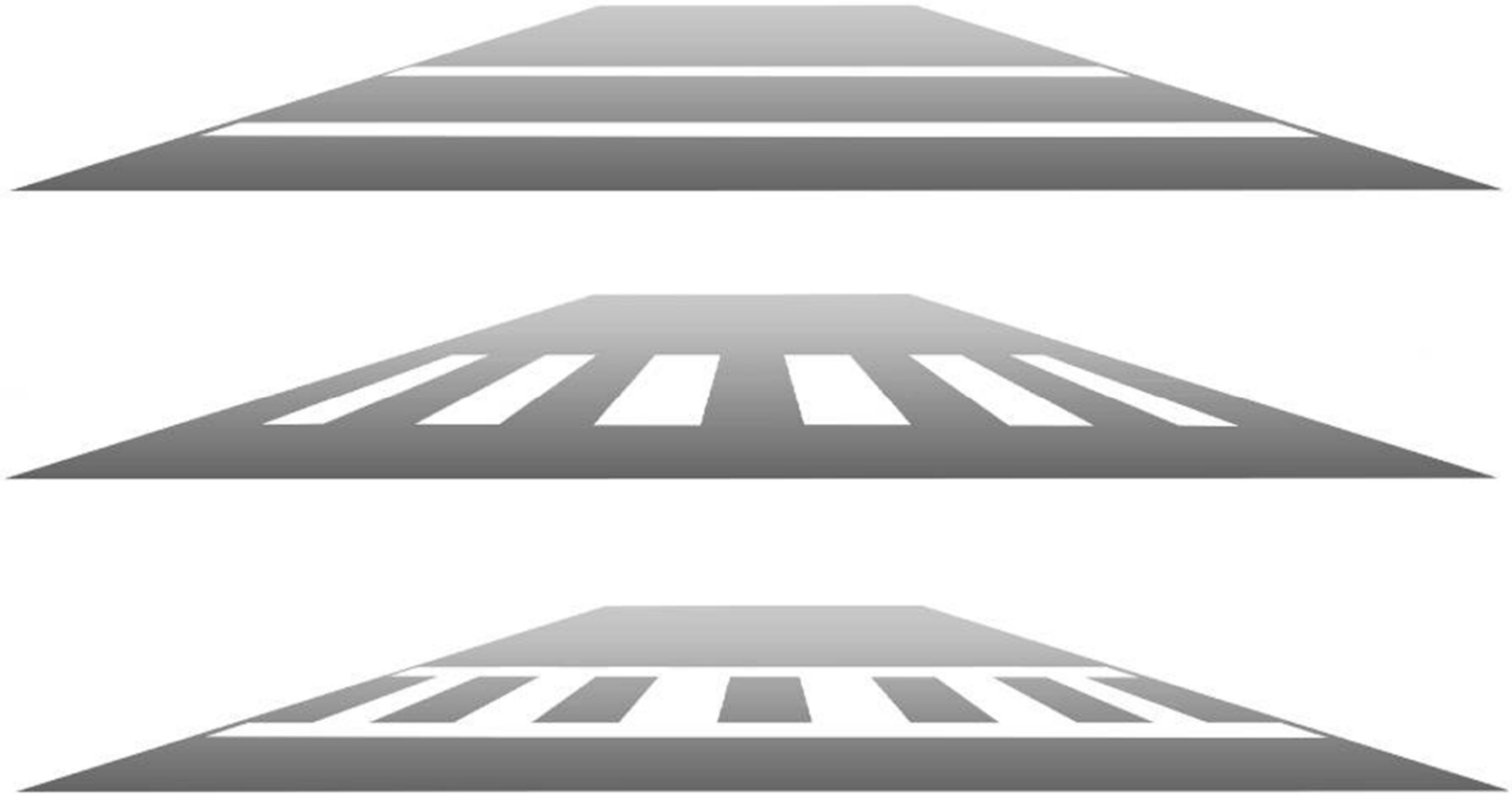
# Marked crosswalks must be visible to the DRIVER



## What the driver sees (same crosswalk)

Atlanta GA

# Crosswalk Visibility

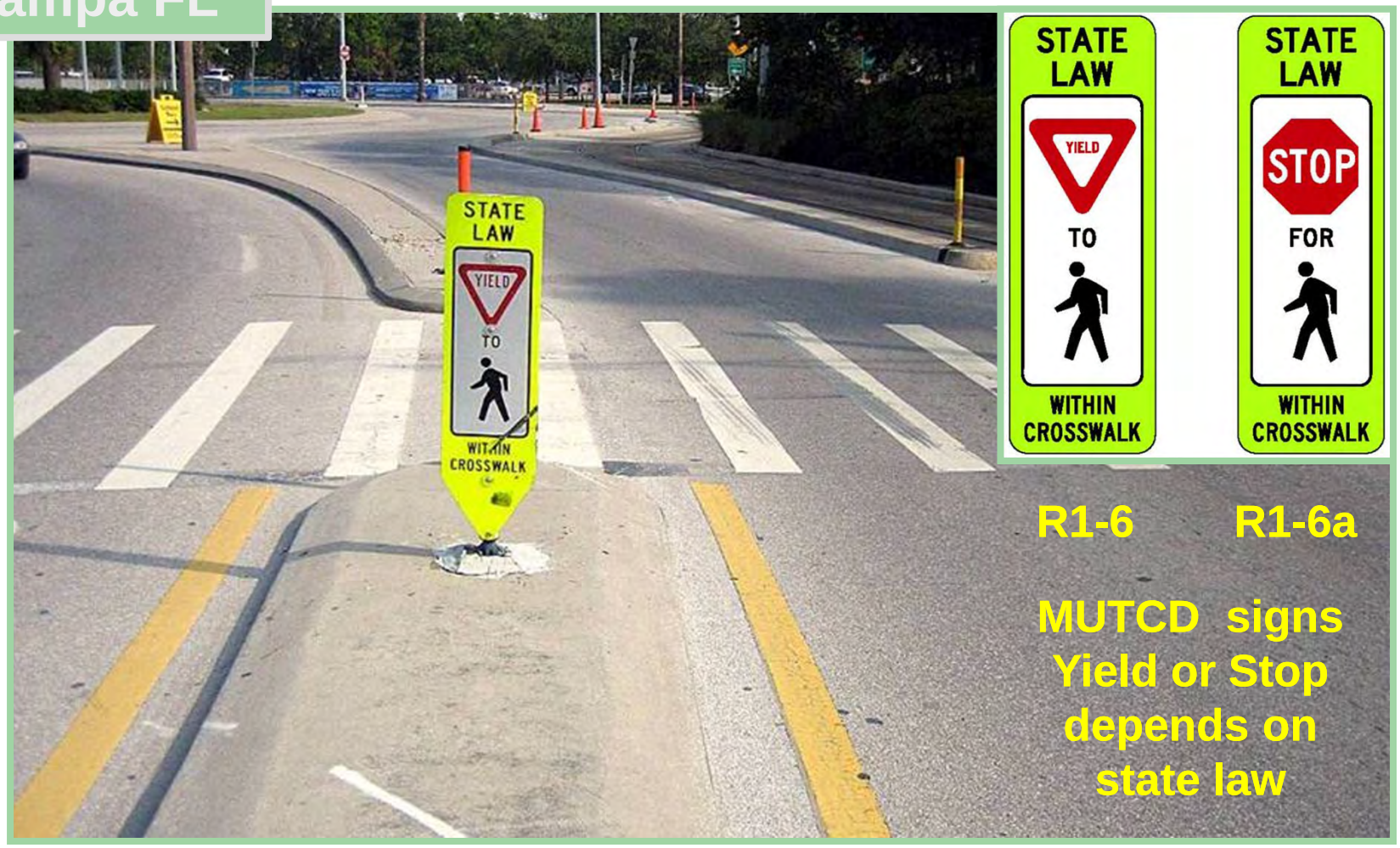


## Crosswalk Marking Types

**Place longitudinal markings to avoid wheel tracks, reducing wear & tear & maintenance**

Sweet Home OR

## Tampa FL




**In-street pedestrian crossing signs**

# Rectangular Rapid Flash LED Beacon

- Not in MUTCD — received Interim approval from FHWA in July 2008
- Studies indicate motorist yield rates increased from about 20% to 80%
- Beacon is yellow, rectangular, and has a rapid "wig-wag" flash
- Beacon located between the warning sign and the arrow plaque
- Must be pedestrian activated (pushbutton or passive)

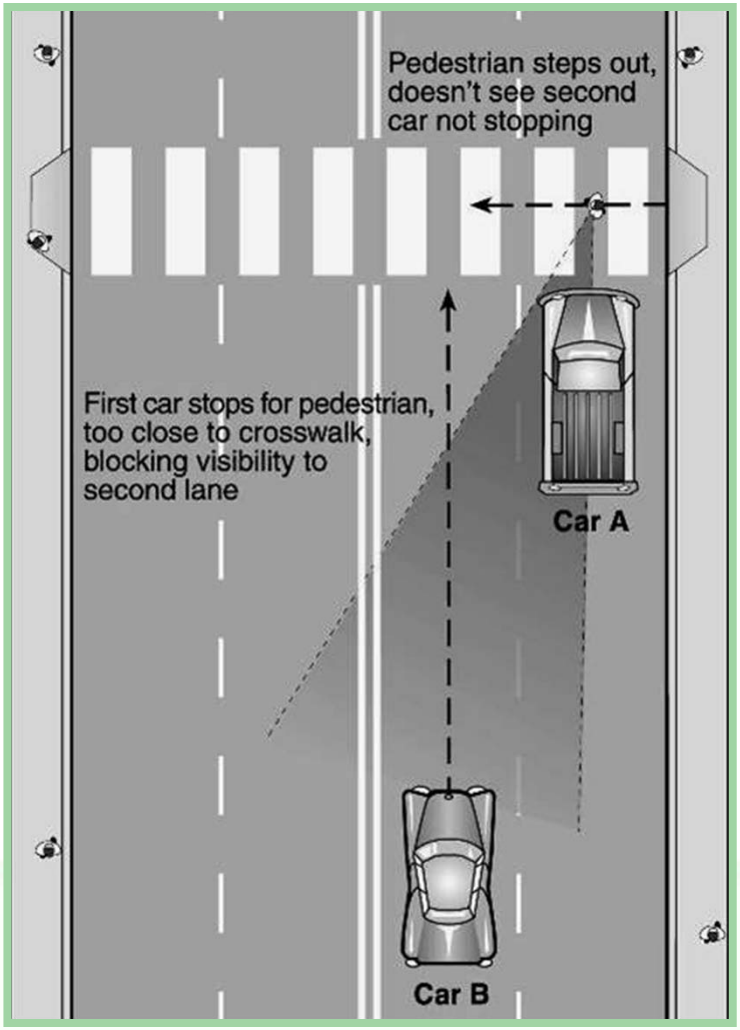
Coconut Grove FL

# Advance Stop or Yield Line: Reduces Multiple-threat Crashes

# Multiple Threat Crash Problem

**1st car stops to let pedestrian cross, blocking sight lines**

**2nd doesn't stop, hits pedestrian at high speed.**

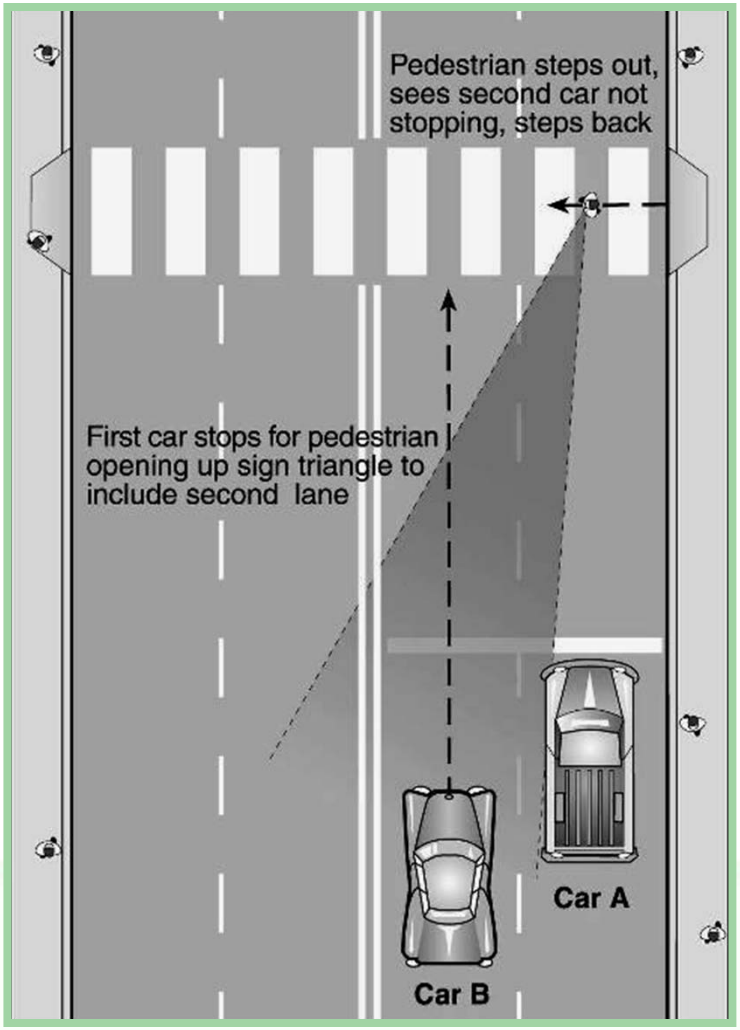


# Multiple Threat Crash Solution

## Advance stop/yield line

## 1st car stops further back; opening up sight lines

## 2nd car can be seen by pedestrian




R1-5


R1-5a

**(Use where local law says yield to pedestrians)**


R1-5b


R1-5c

**(Use where local law says stop for pedestrians)**

# Milwaukee WI


**Advanced yield line (shark's teeth) & sign**

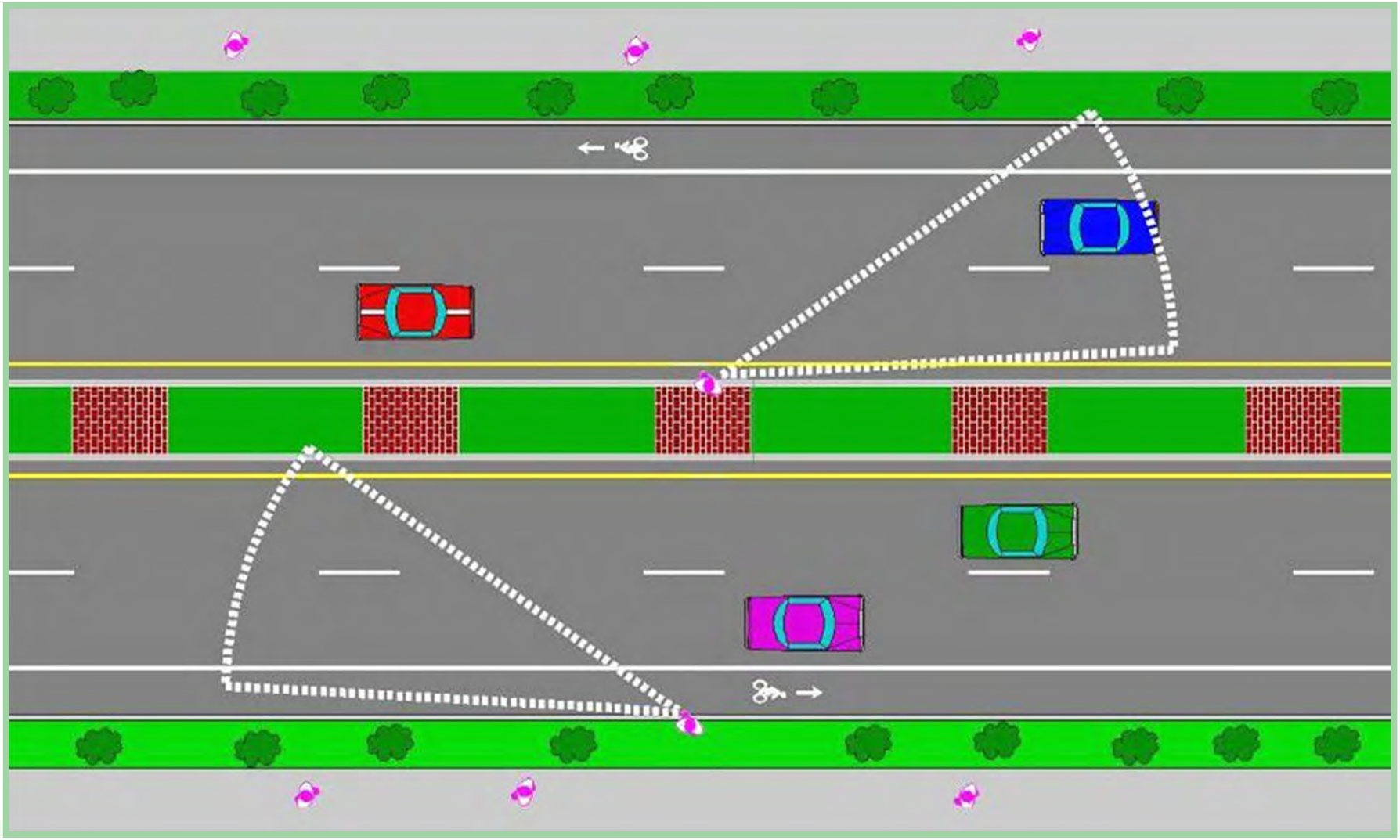
# Portland OR


**Advanced stop line and sign**

# Raised Medians And Islands Reduce Pedestrian Crashes:

**At marked crosswalks CRF = 46%**

**At unmarked crosswalks CRF = 39%**

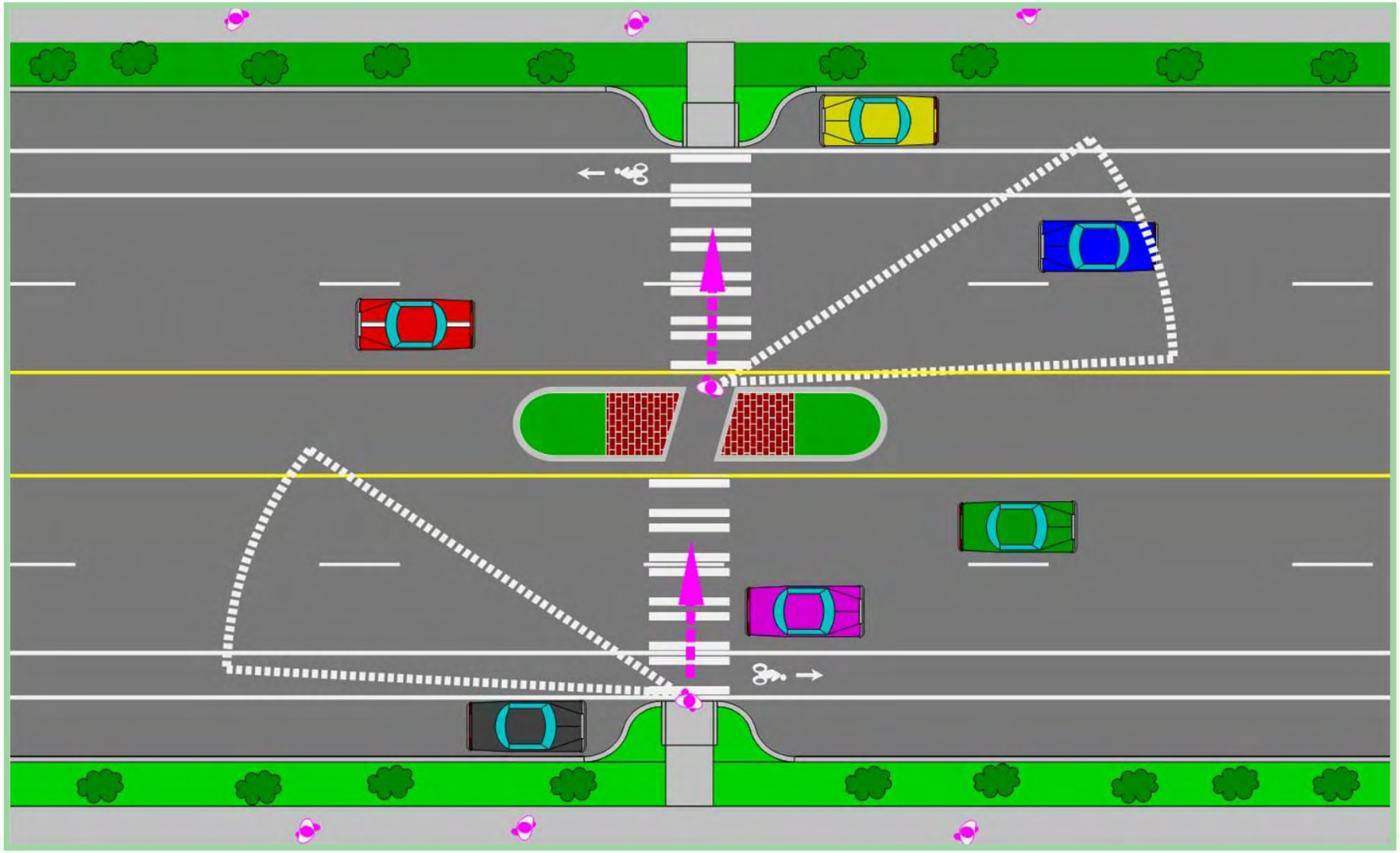


**Continuous raised median – Basic Principle**

***Breaks long complex crossing into two simpler crossings***

# Eugene OR

**Medians make random crossings safer**



**Crossing island at marked crosswalk - Same Principle**

***Breaks long complex crossing into two simpler crossings***

# Asheville NC


**Islands improve safety at designated crosswalks**

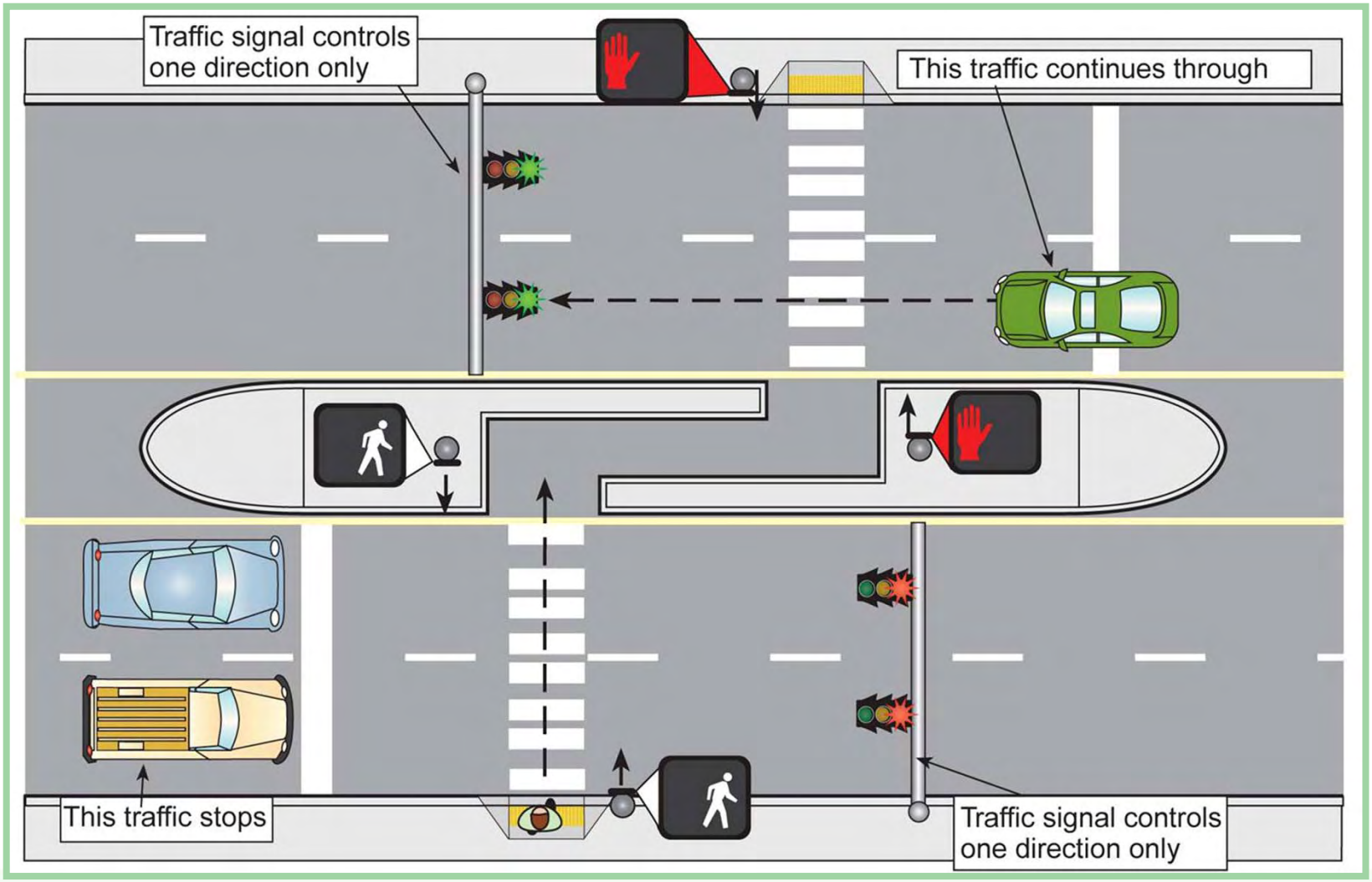
# Pedestrian Signal

## Washington DC

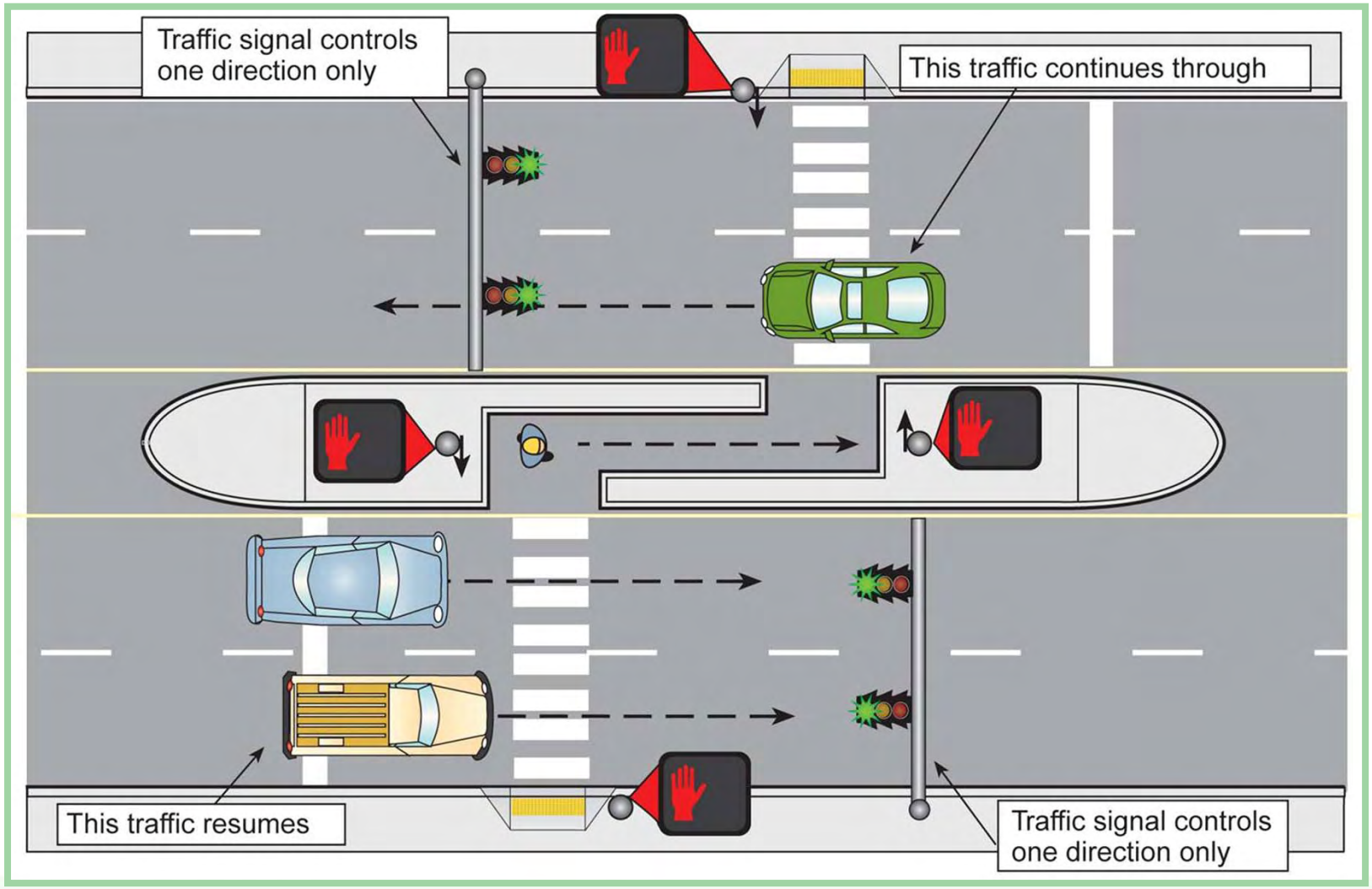

**Provide a HOT response**
**Otherwise pedestrians won't wait for the light**

# Pedestrian Signal

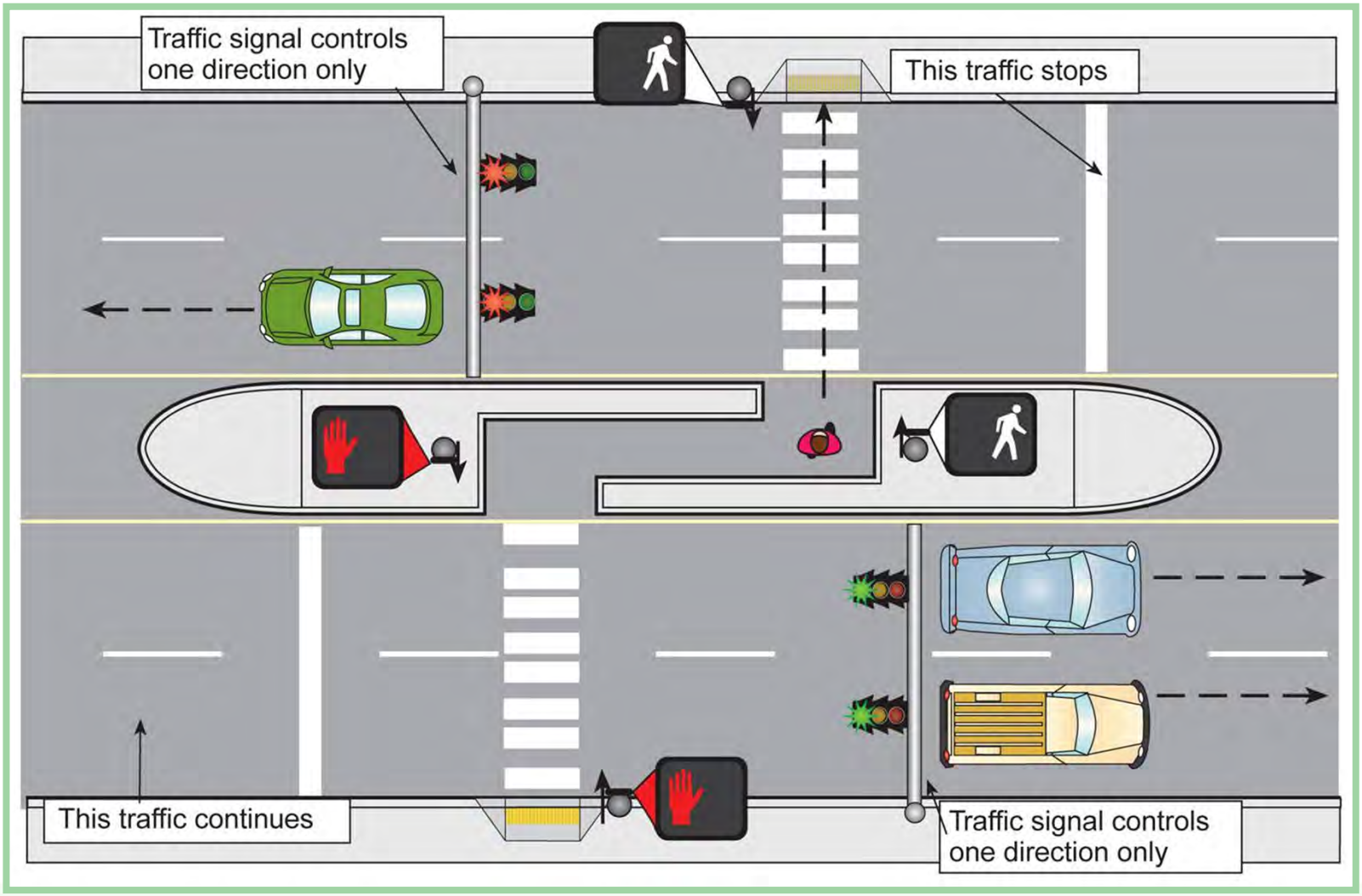
**2-stage crossing increases effectiveness and disrupts traffic less**




# 1. Ped pushes button, waits, crosses to island




## 2. Ped crosses to island, proceeds to 2nd button




## 3. Ped on island – pushes button to finish crossing

# Countermeasures for Intersection Crashes

# Characteristics To Make Intersections Safer For Pedestrians

**Pedestrian-friendly intersections are:**

- ⇨ **Tight**
- ⇨ **Simple**
- ⇨ **Square**
- ⇨ **Slow speed**
- ⇨ **Easy to understand**
  - **If complex, broken into smaller steps**
- ⇨ **Avoid free-flow movements**

# Curb radius – small radii are safer for pedestrians

**Large corner radii:**

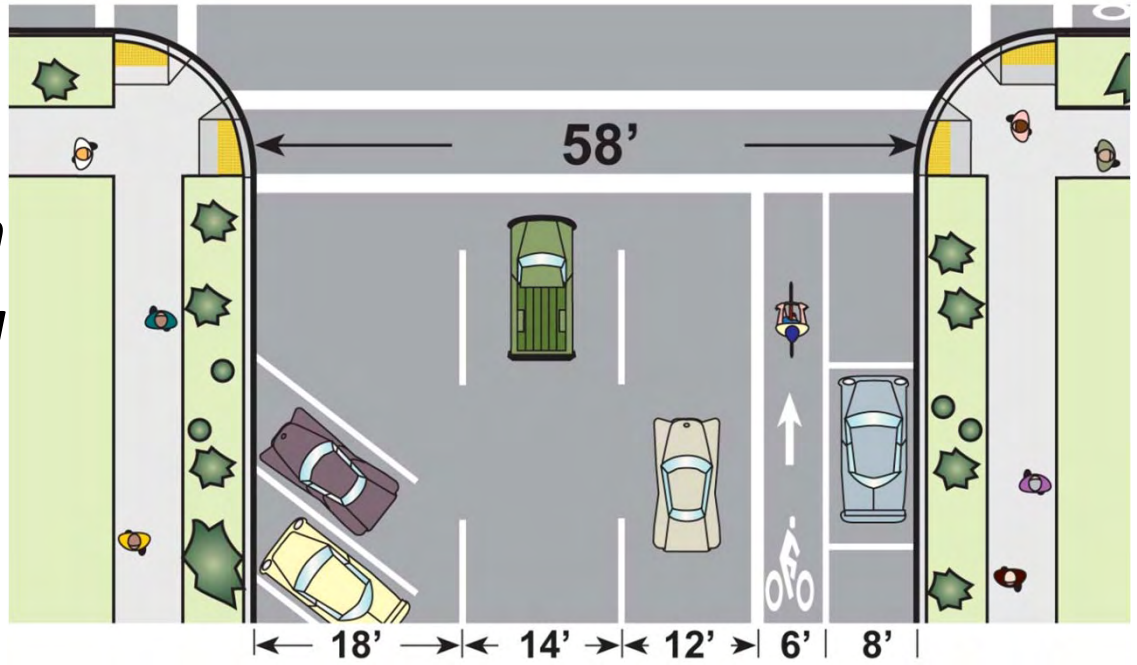
- ⇨ **Increase crossing distance,**
- ⇨ **Make crosswalk & ramp placement more difficult**
- ⇨ **Allow high-speed turns by cars**

## Canyonville OR


**Must consider large vehicles, but don't choose larger design vehicle than necessary**

## Curb extensions

***Most focus has been on reducing crossing distance***



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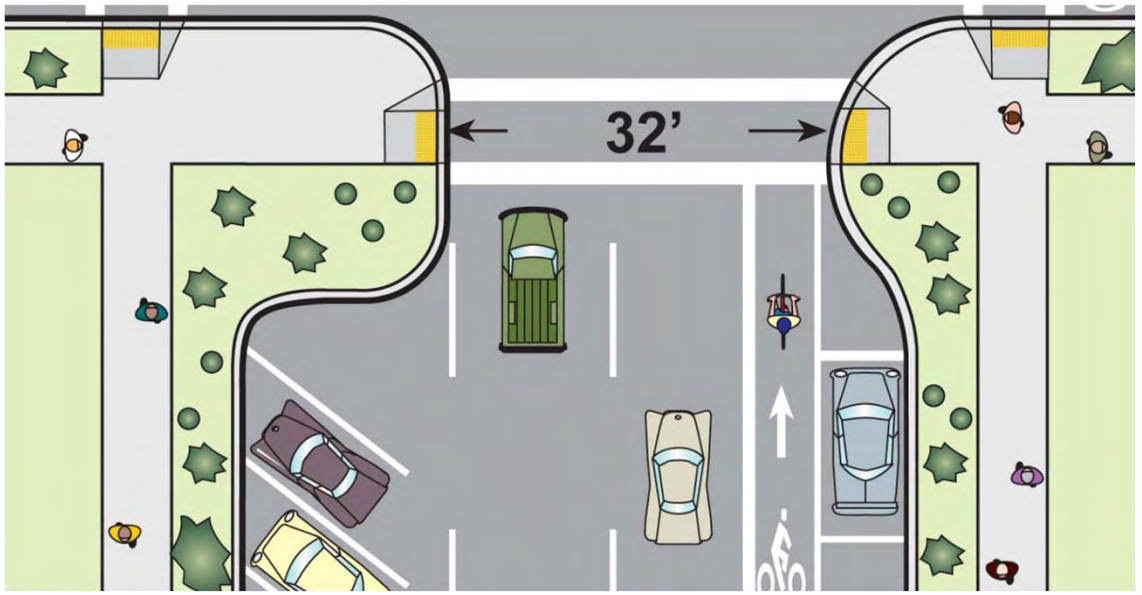



## Other advantages

- ⇨ **Better visibility (both ways)**
- ⇨ **Traffic calming**
- ⇨ **Room for street furniture**

**Curb extensions should be the width of the parking lane and not encroach on bike lanes or travel lanes**

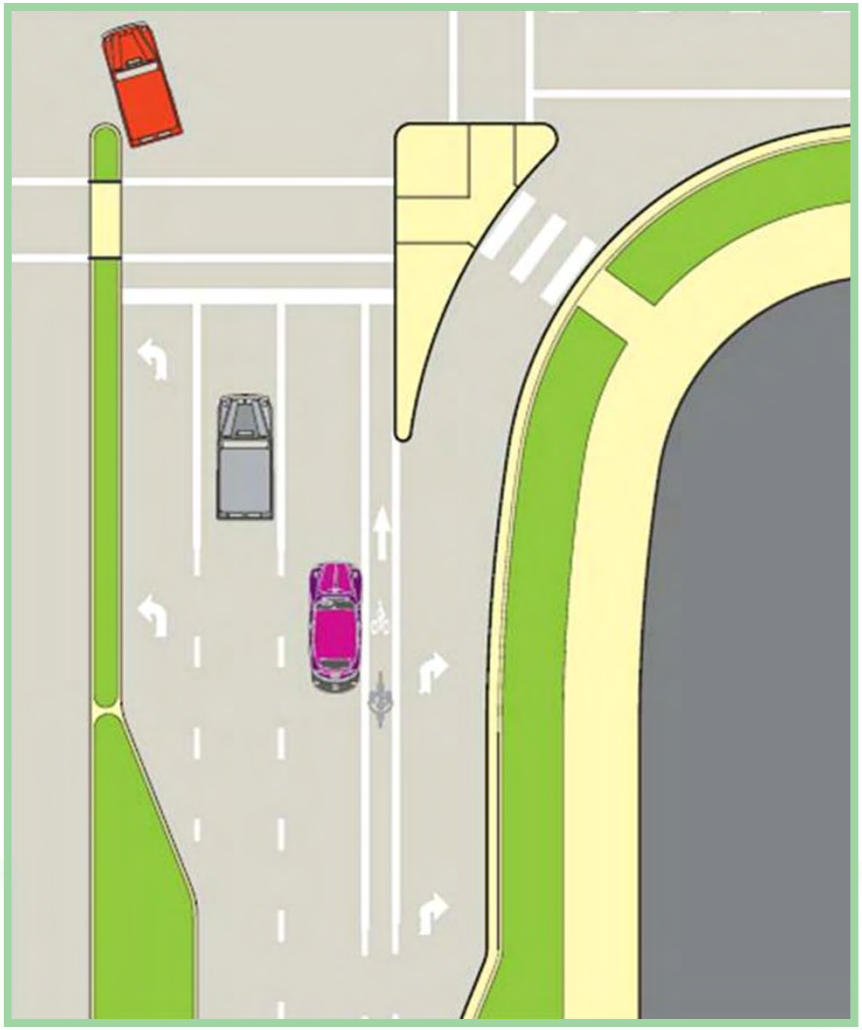

**Pedestrians wait where they can see, in front of parked cars**

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

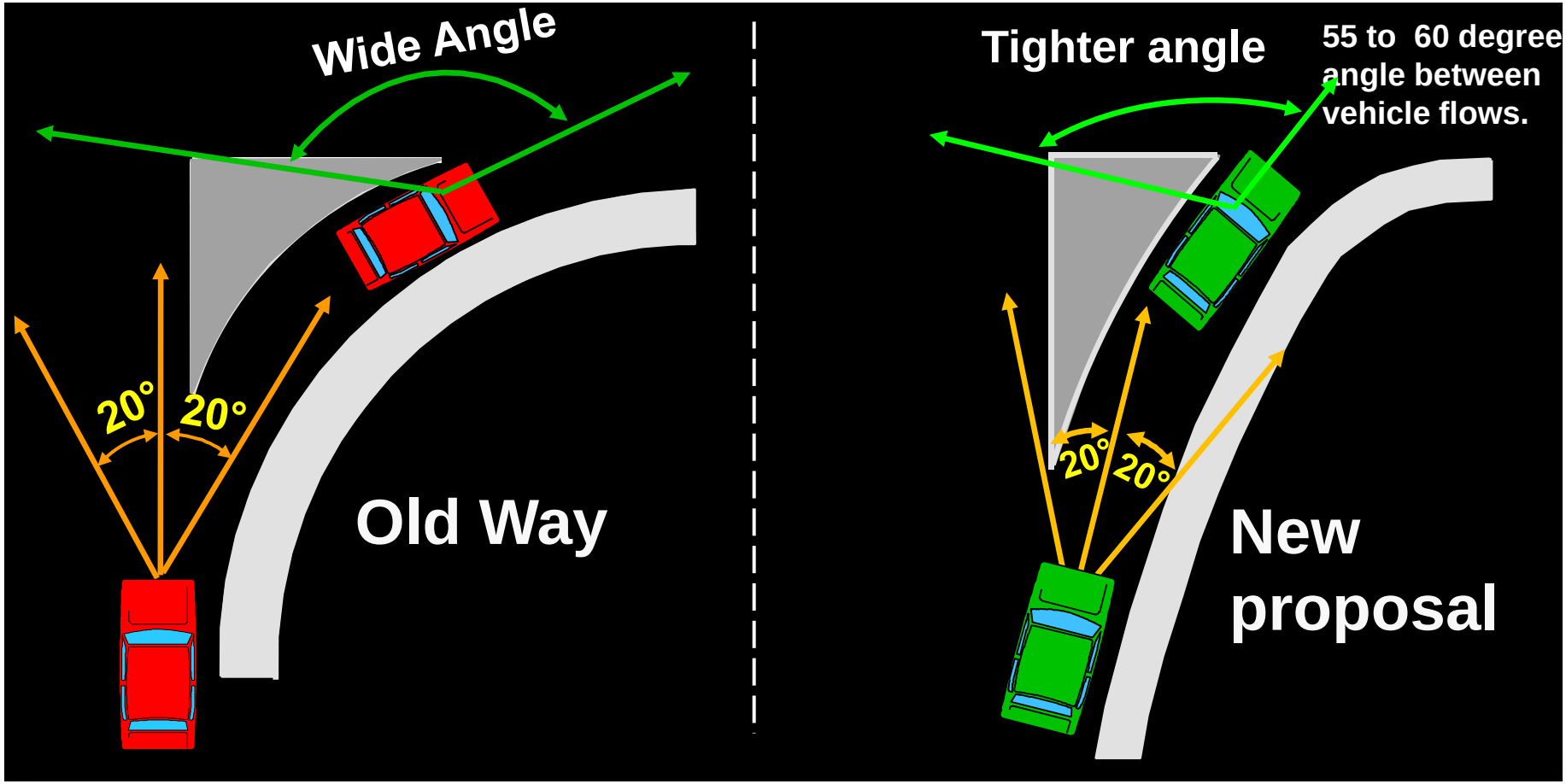
# Islands at Intersections

**Benefits:**

- ⇨ **Separate conflicts and decision points**
- ⇨ **Reduce crossing distance**
- ⇨ **Improve signal timing**
- ⇨ **Reduce crashes**



# Right-Turn Slip Lane: Design for pedestrians




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

**Slower vehicle speeds, good angle, good visibility of pedestrians**

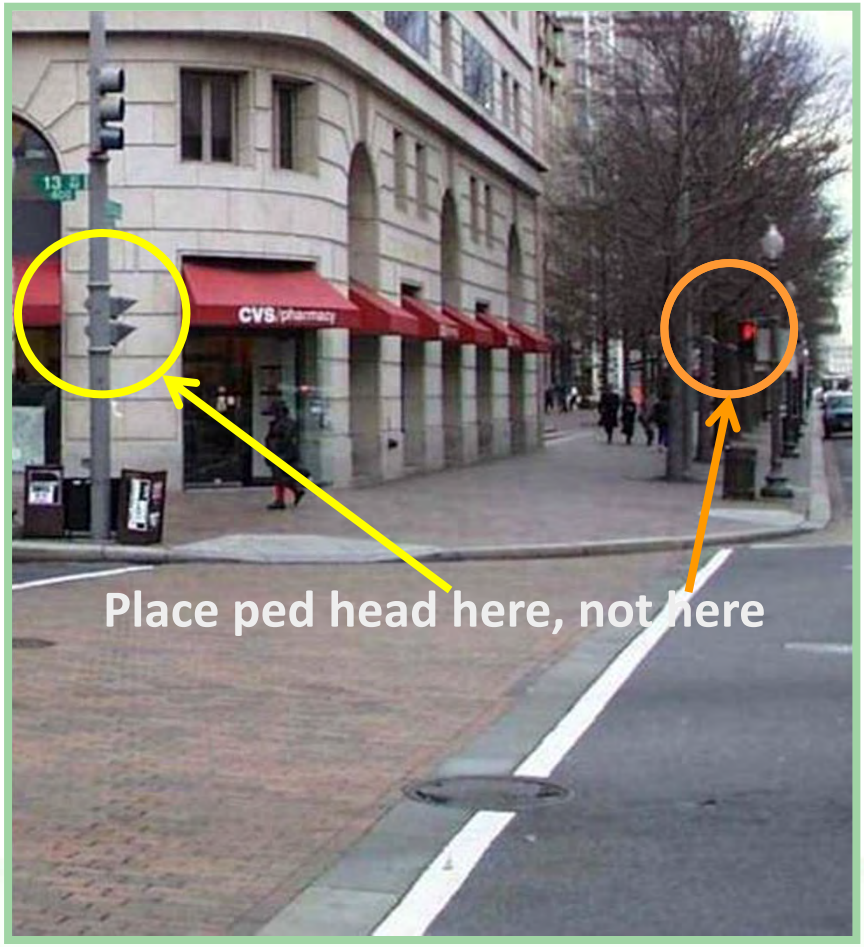
# Countermeasures for Signalized Intersection Crashes

## Fredericksburg VA


**Pedestrian signals should be provided, otherwise pedestrians don't know when to cross**

Fredericksburg VA

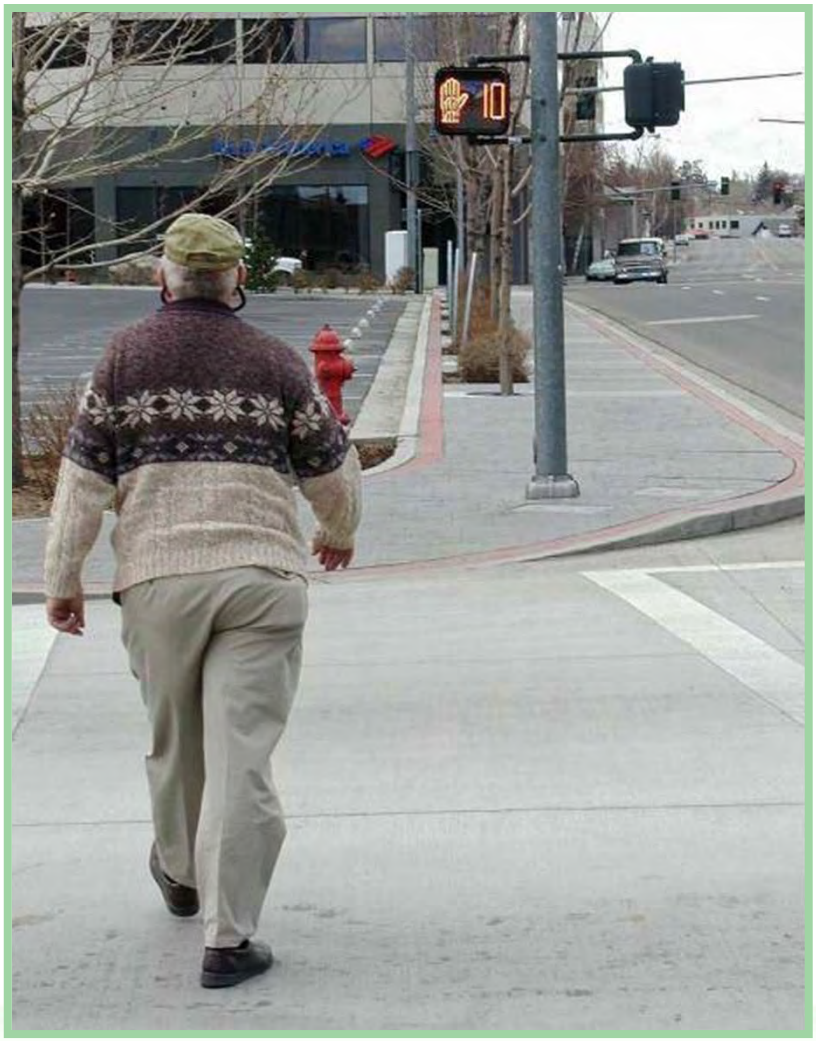
# Ped head placement: close to crosswalk, visible to pedestrians, especially with long crosswalk




Poor example


Good example

## Reno NV

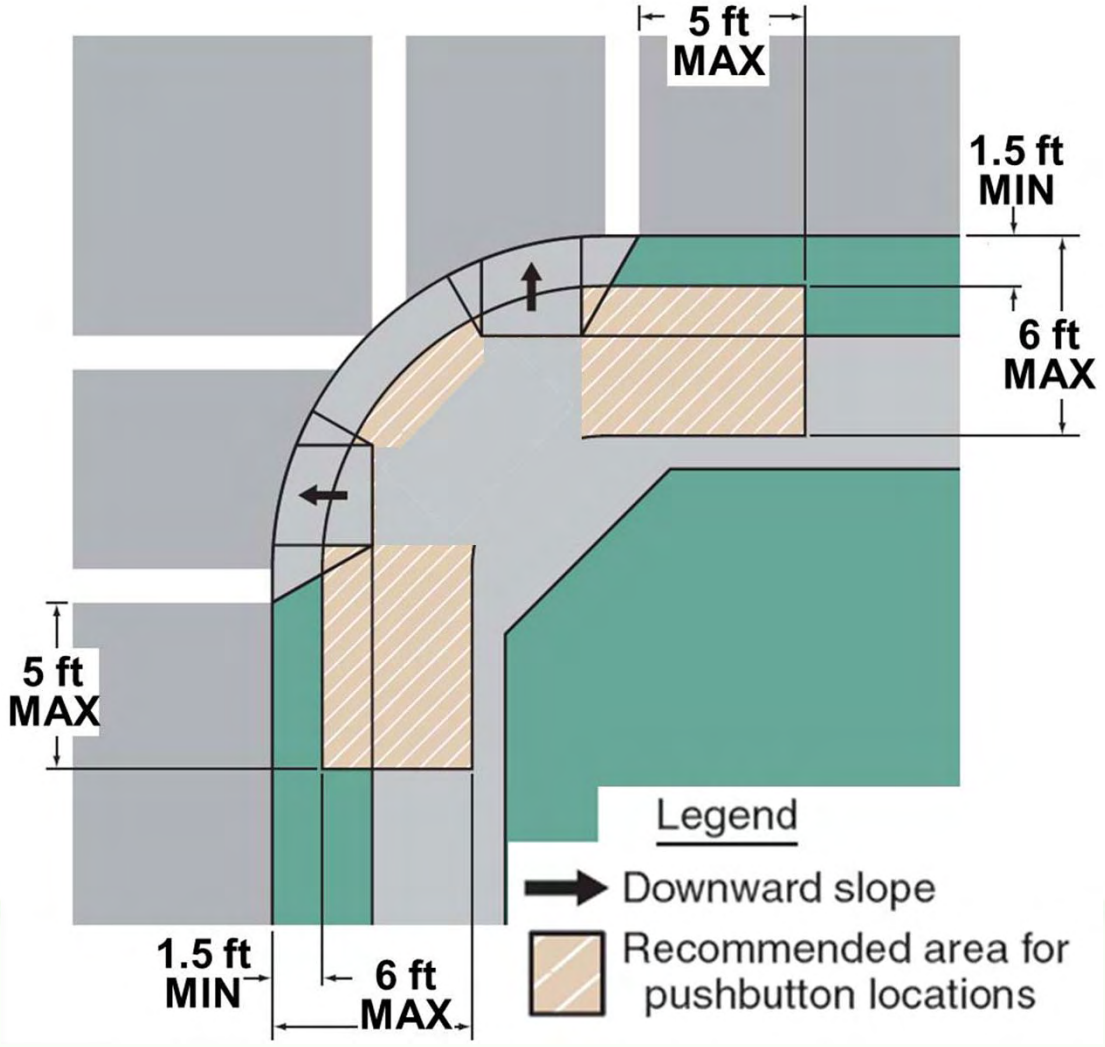




**Pedestrian count-down signal tells pedestrians how much crossing time is left. 25% CRF in San Francisco**

# Proper Push-button Placement

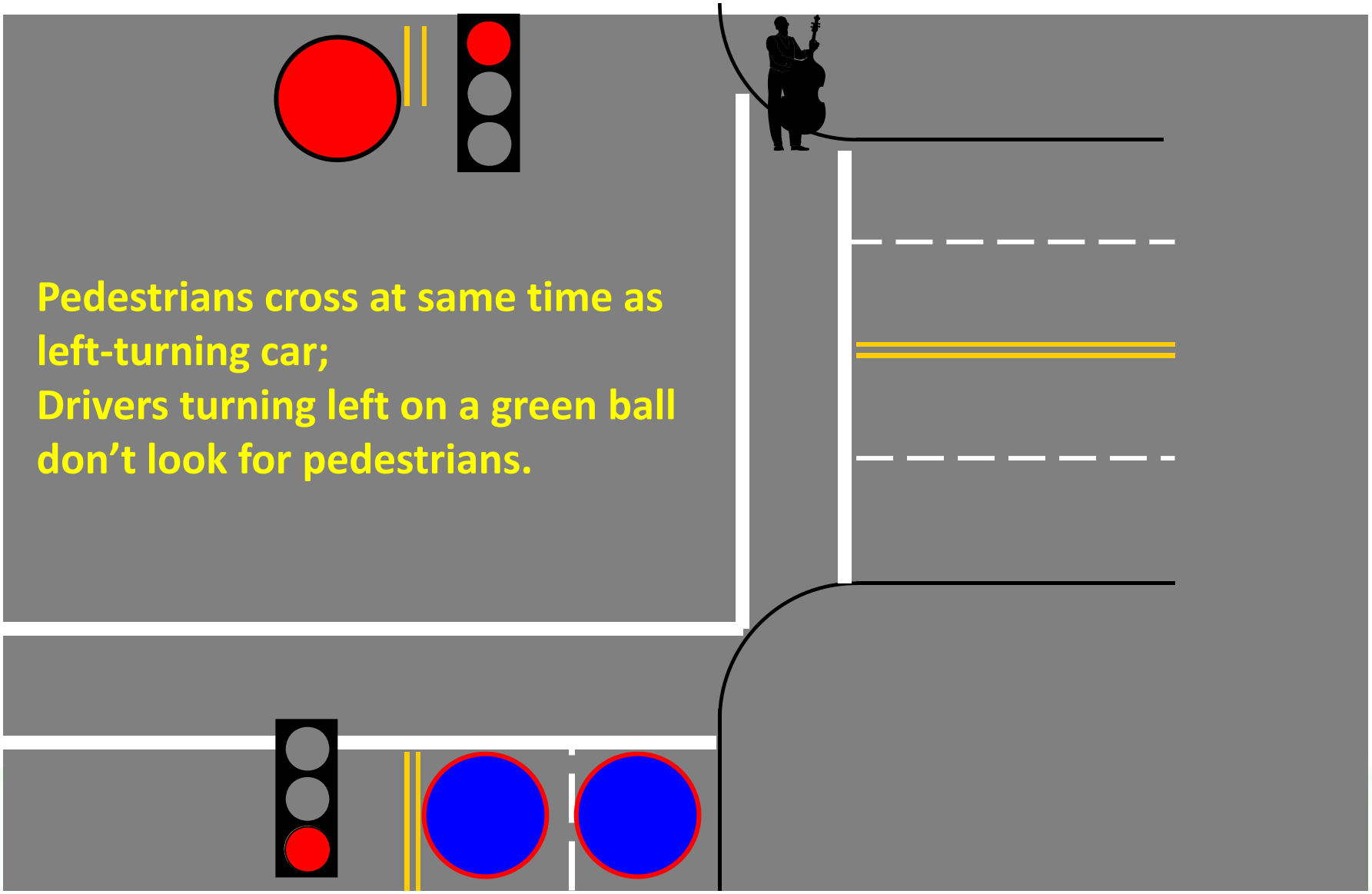
**The MUTCD recommends these dimensions**



# Protected-Only Left Turn Phasing

**CRF up to 70%**

# Permissive Left Turns



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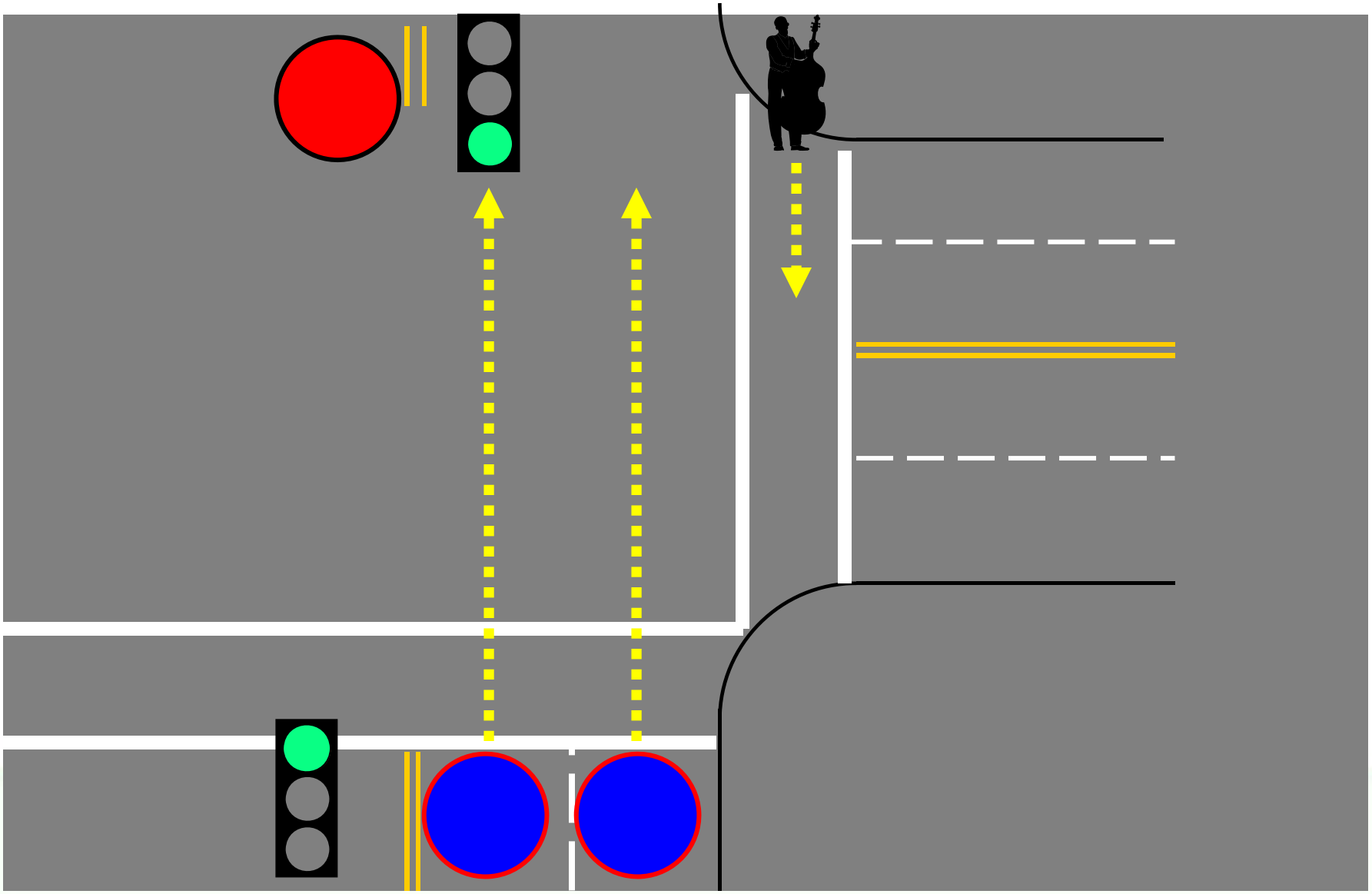

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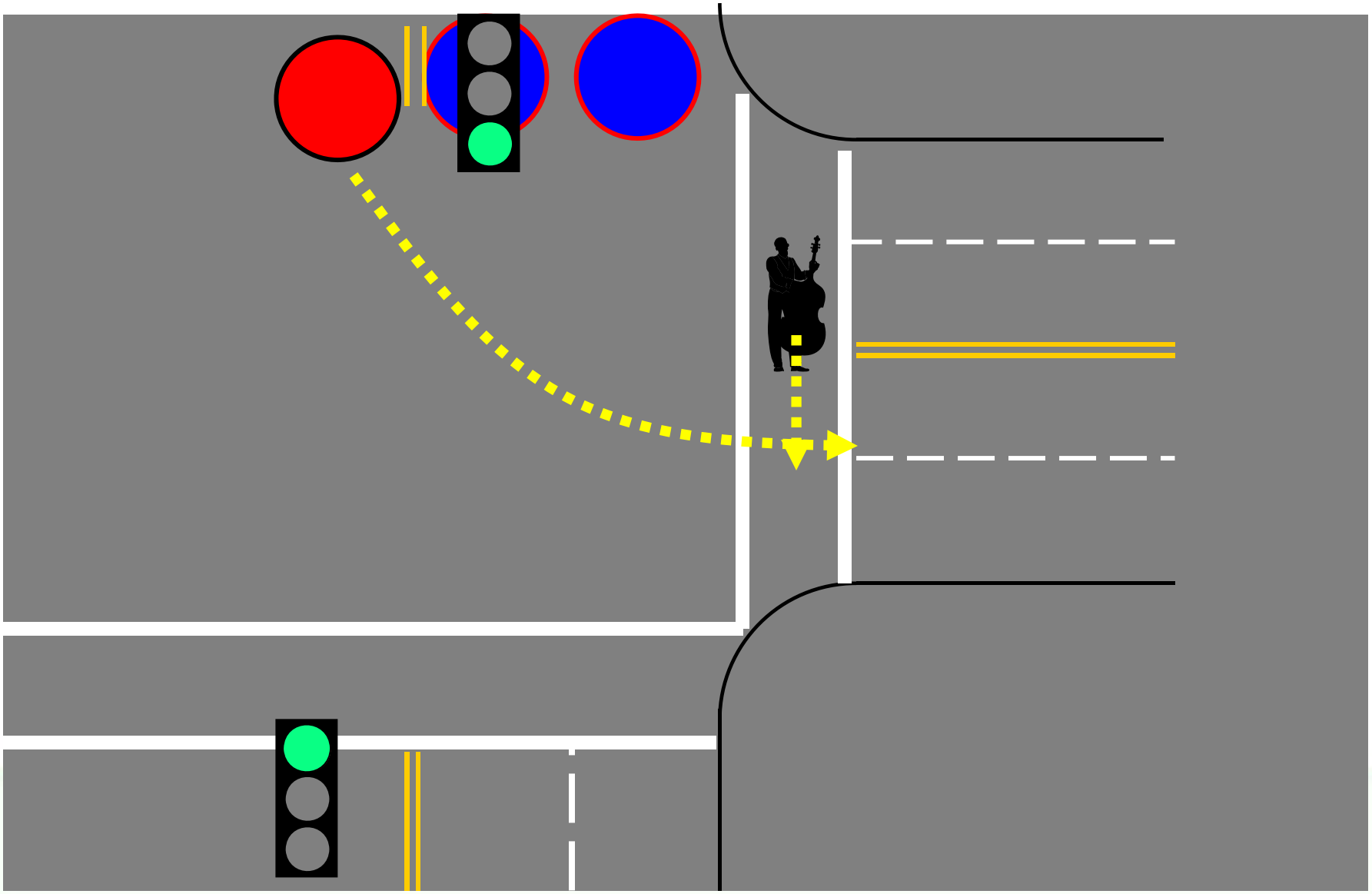

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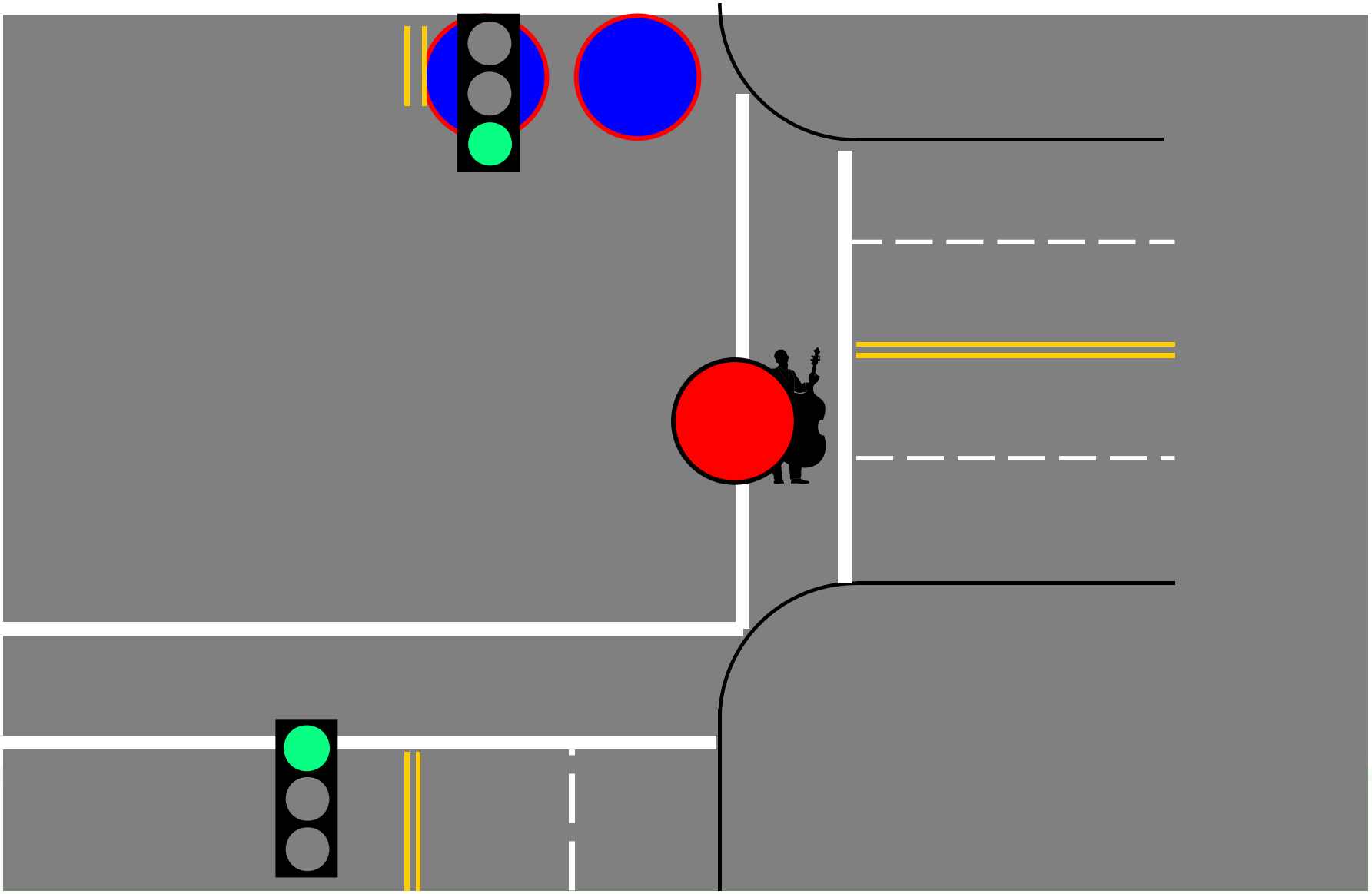
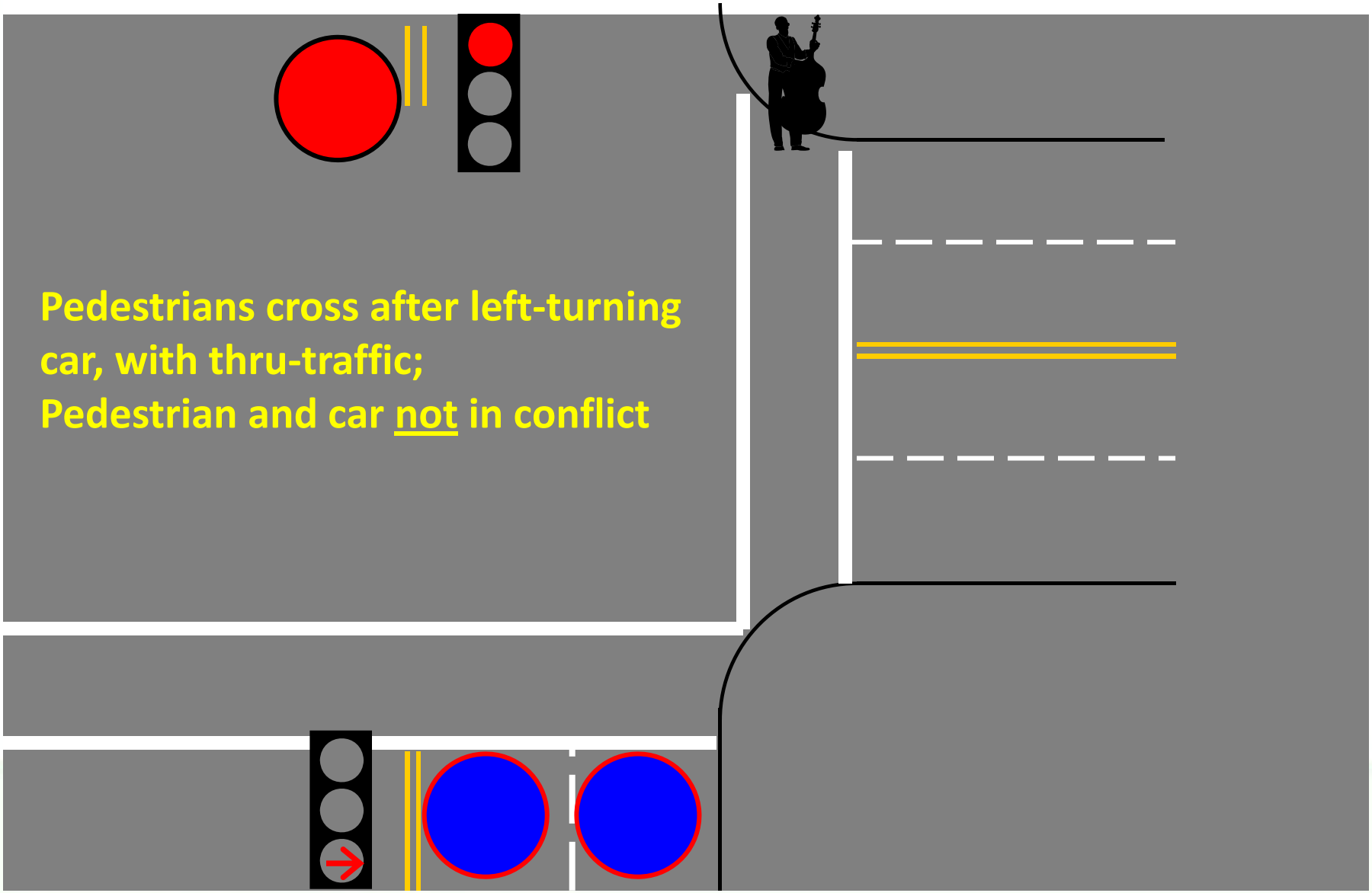


# Protected Left Turns



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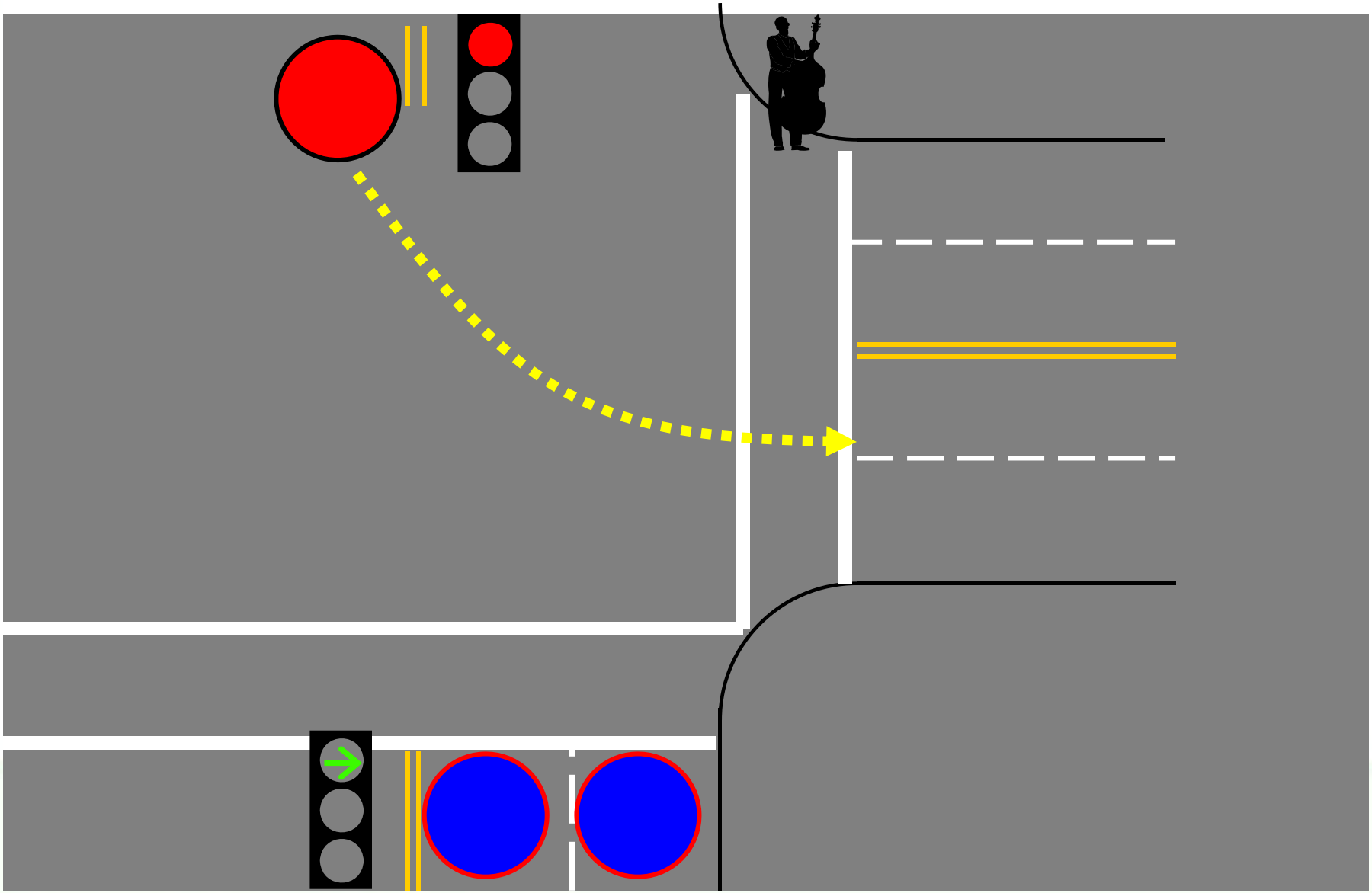

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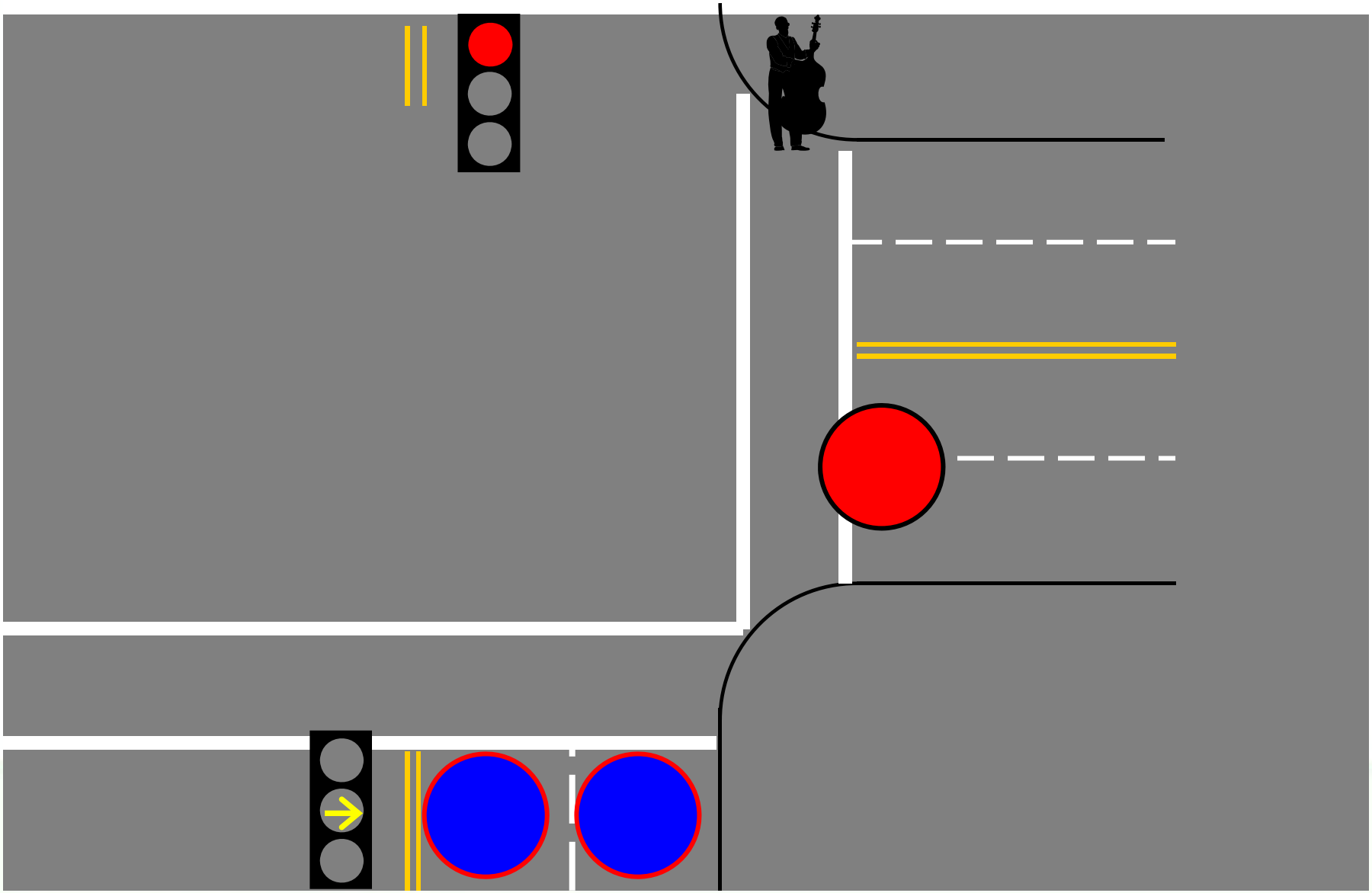

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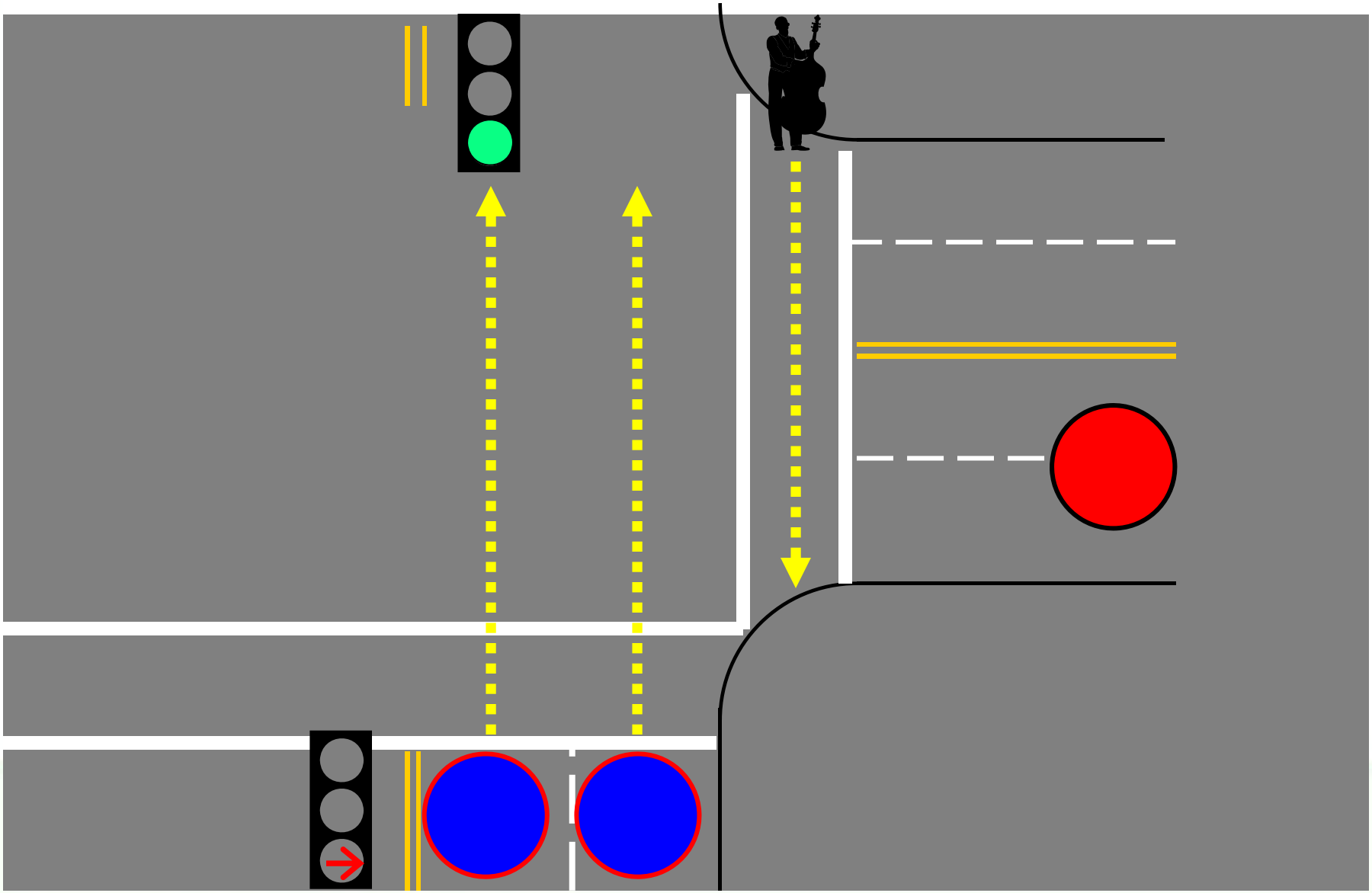
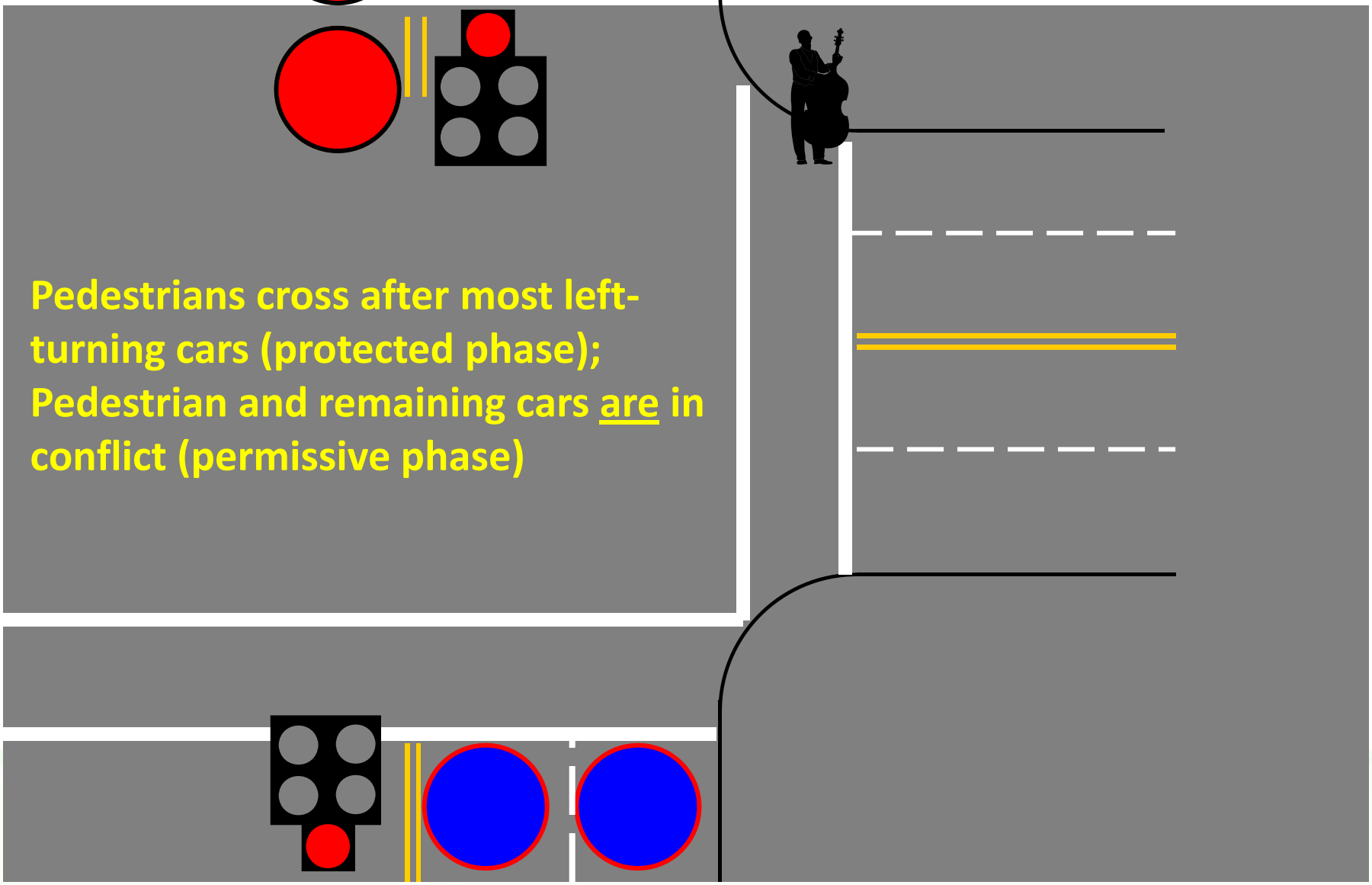


# Protected/permissive Left Turns



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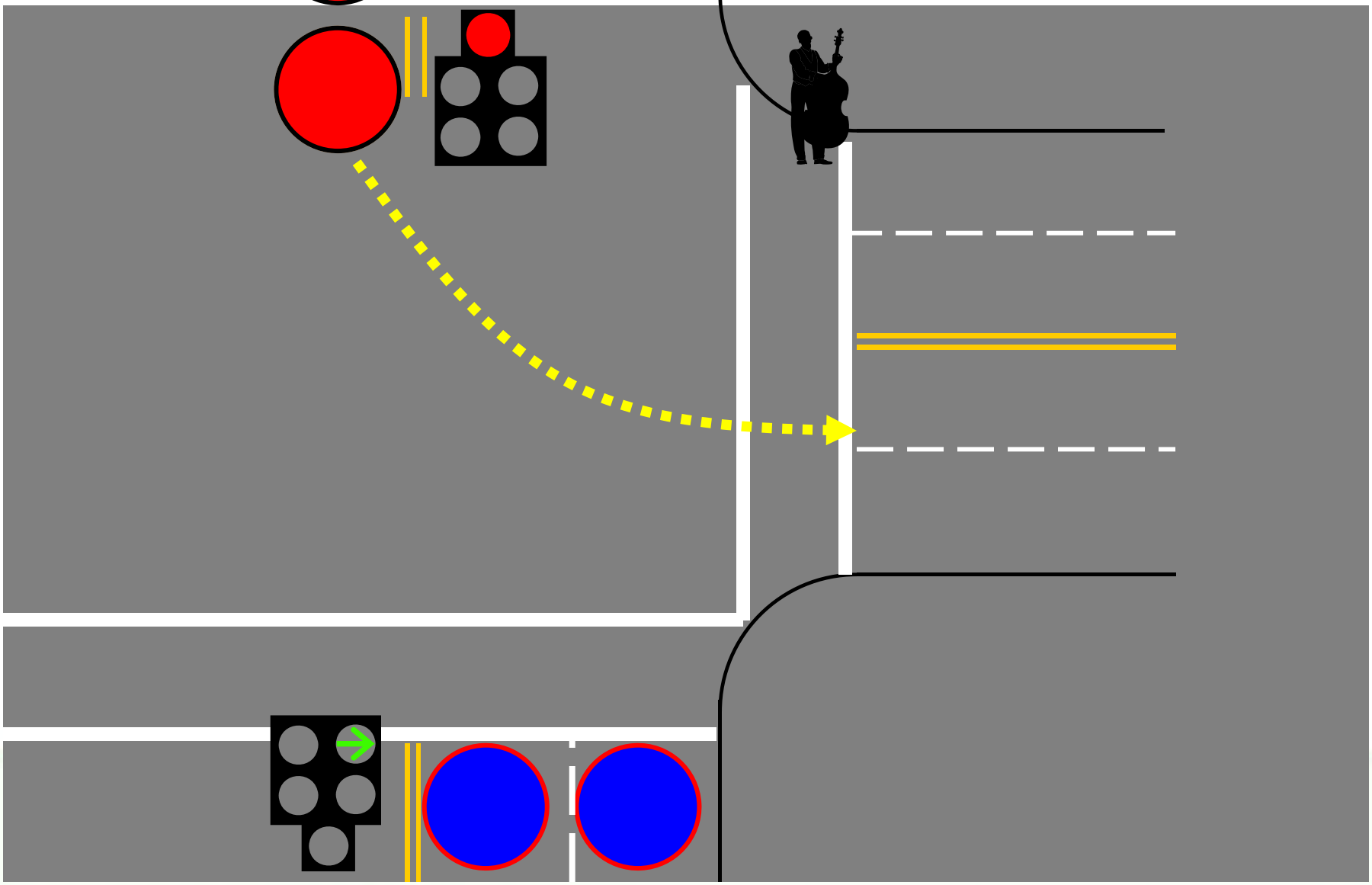

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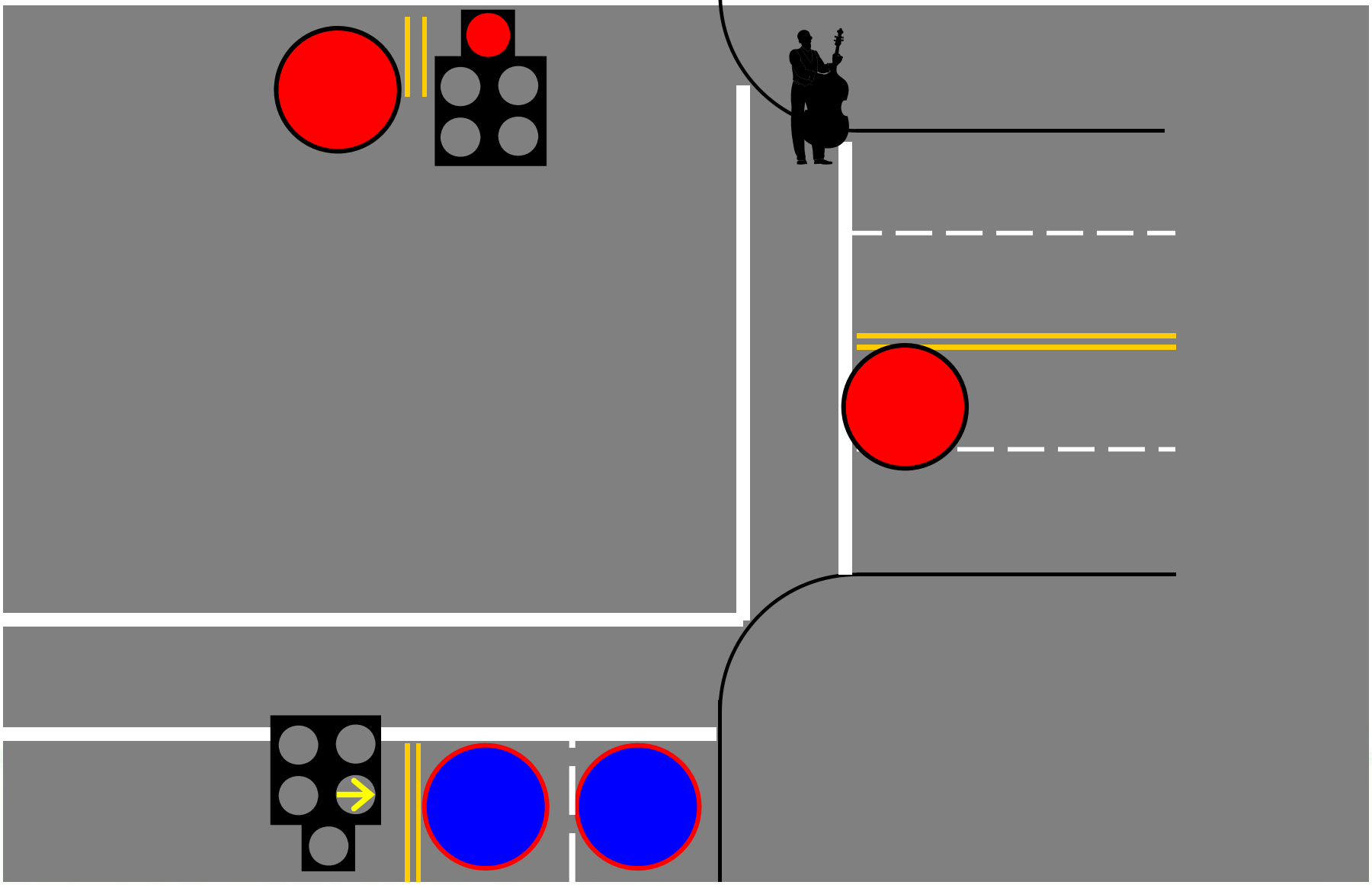

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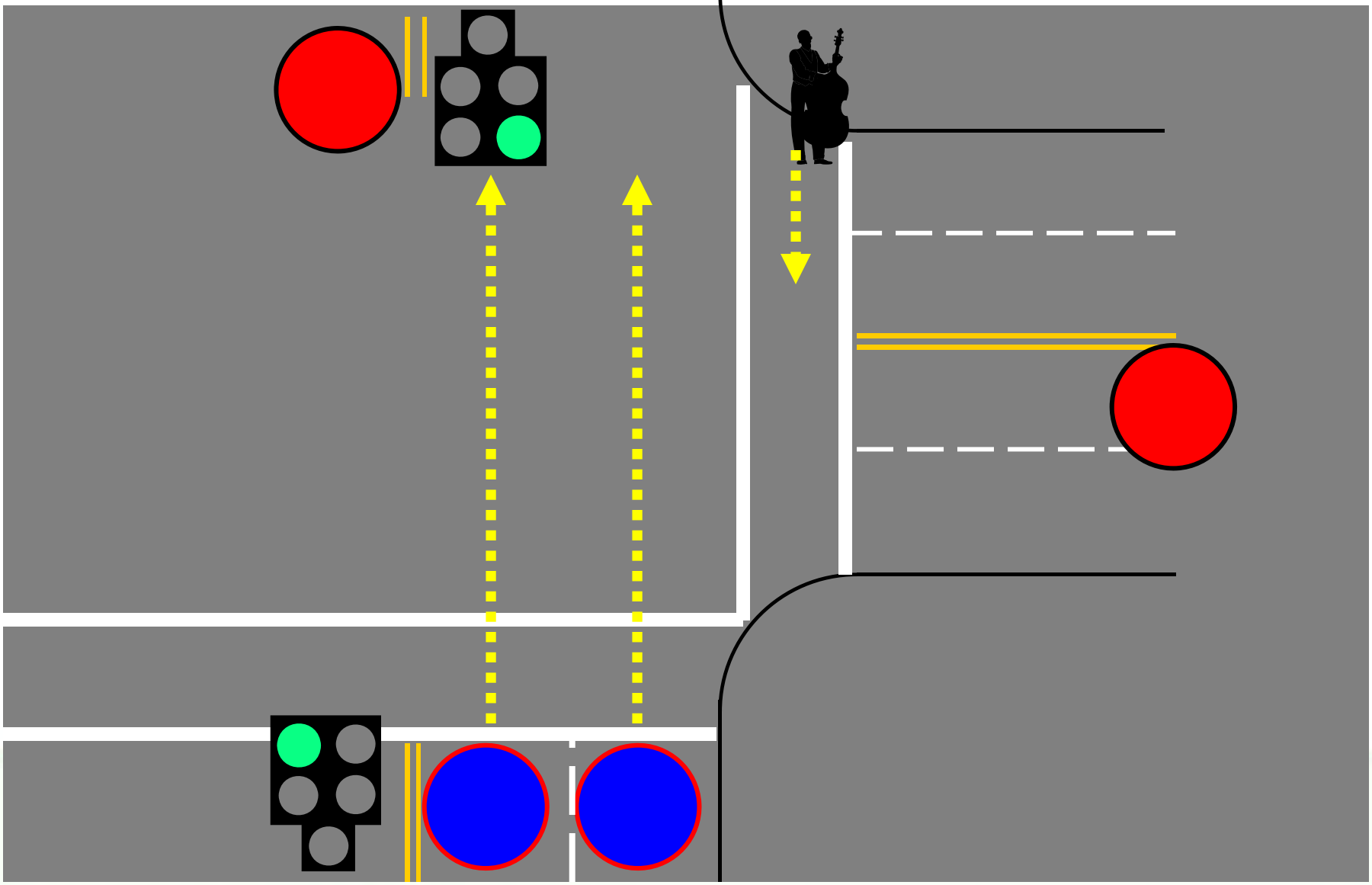

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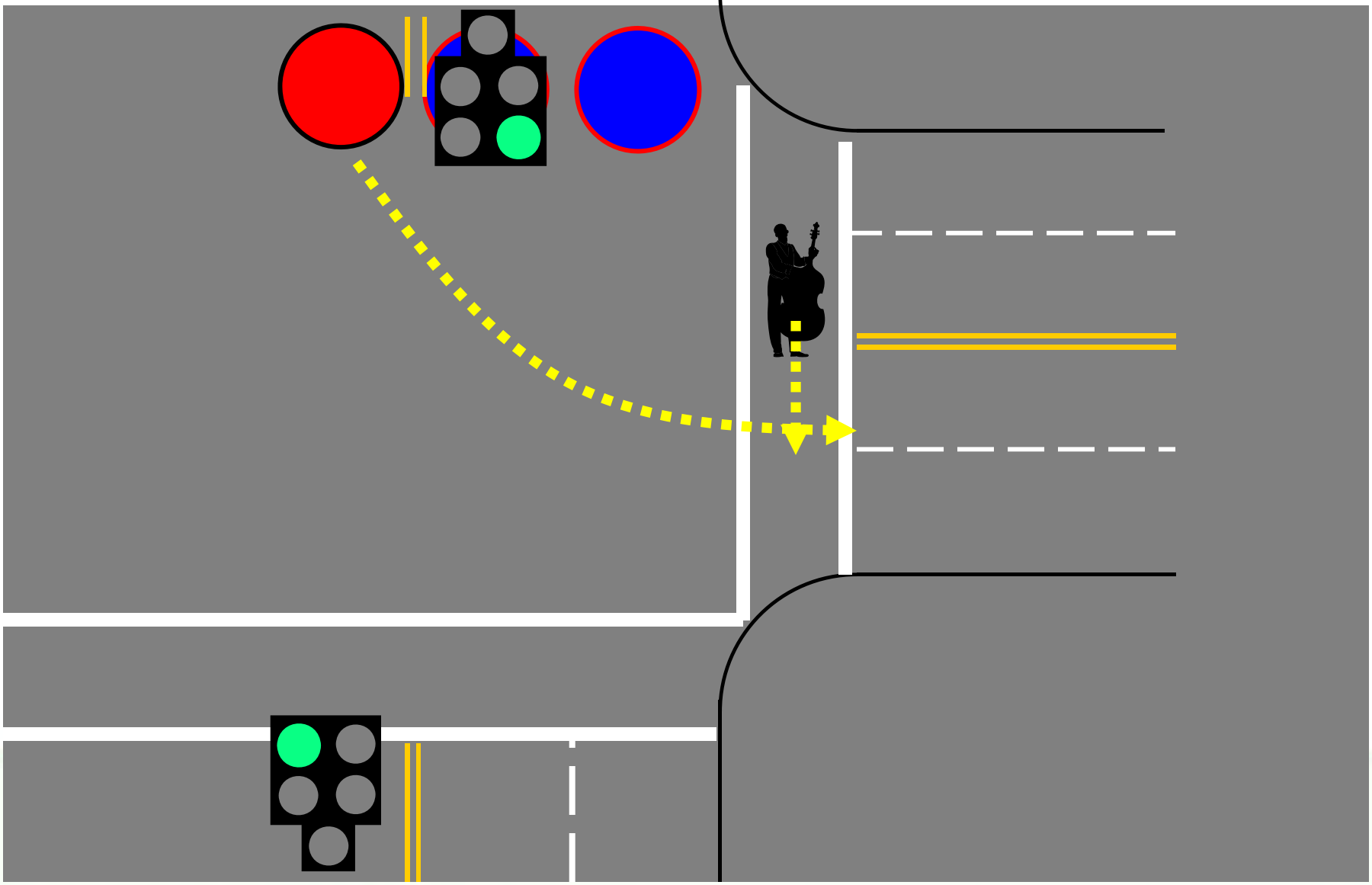
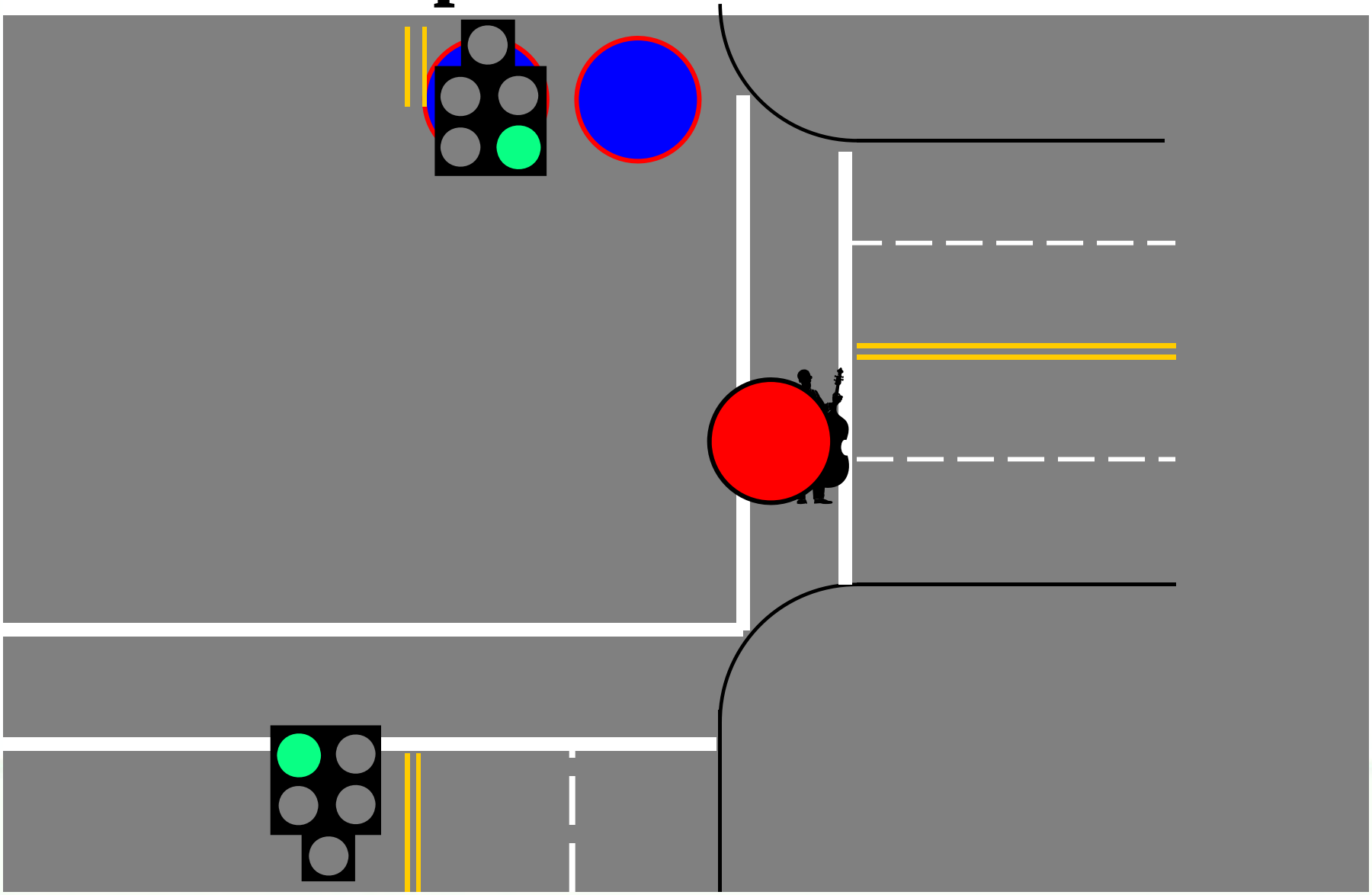
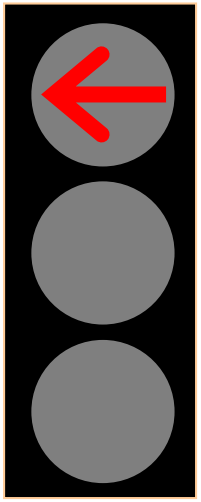


# Protected/permissive Left Turns



# Protected/permissive Left Turns: Solutions

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



# Protected/permissive Left Turns: Solutions

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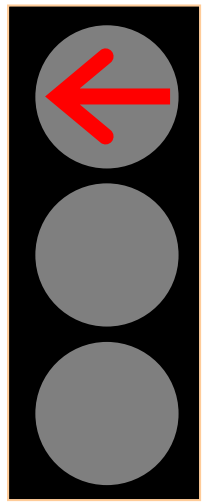
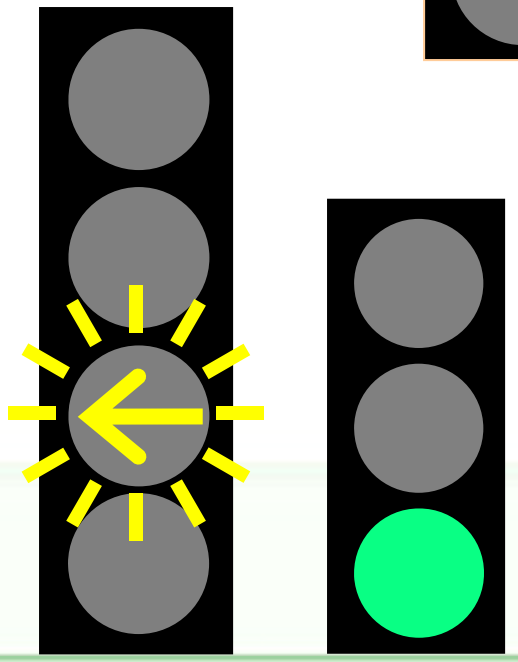


2. **Flashing left Yellow Arrow during steady green ball warns drivers: yield to pedestrians and oncoming vehicles (details next)**



Portland OR

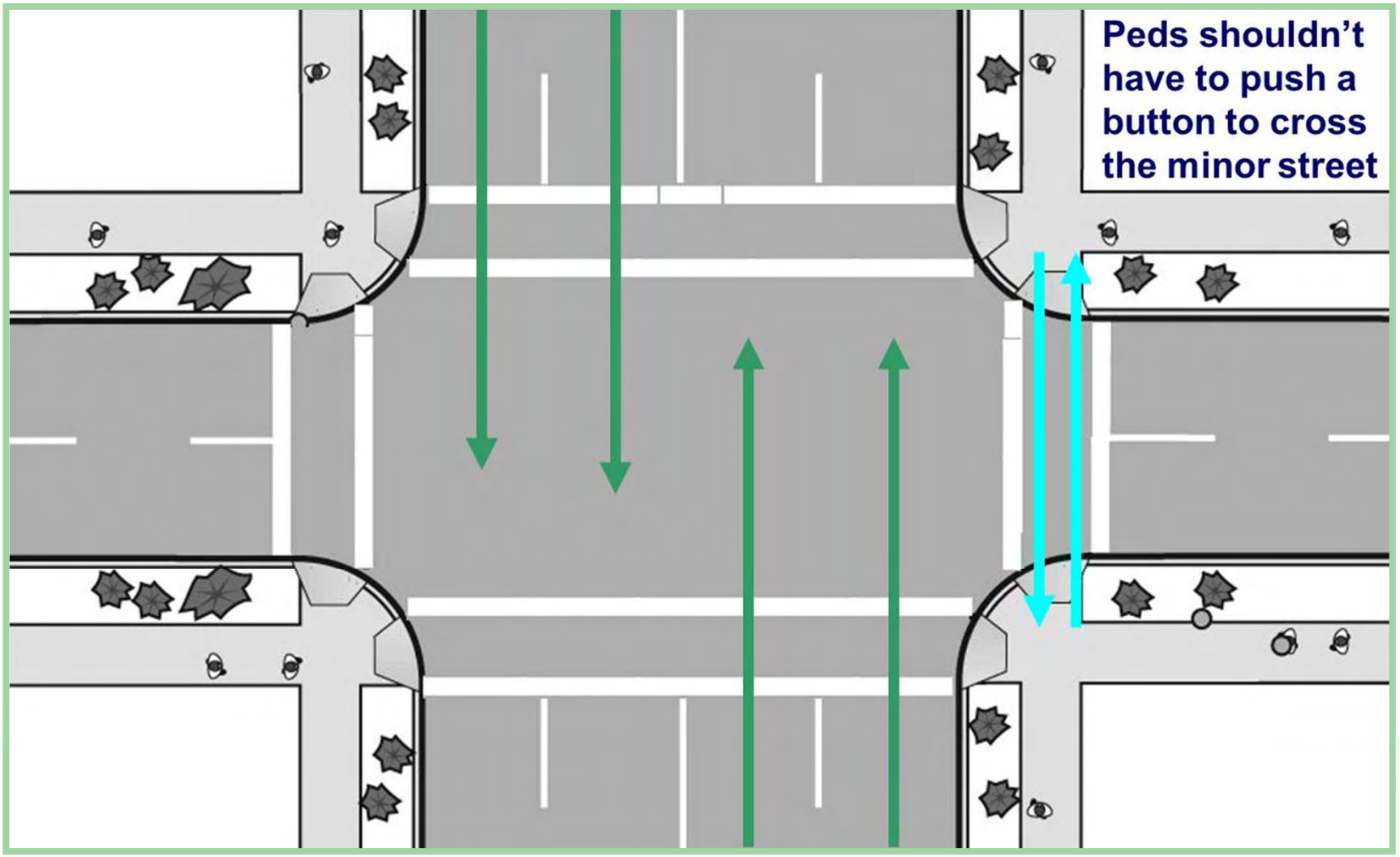
# Use Short Signal Cycle Length


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

## Salem OR


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

# Set pedestrian signal 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**

## Salem OR


**LPI : WALK comes on 3 seconds prior to the vehicular green; pedestrians can enter crosswalk before turning vehicles arrive there.**

Pasadena CA

## Exclusive Pedestrian Phase (Barnes Dance)


**Exclusive pedestrian phase increases safety but increases delay for all including pedestrians**

# Transit

- ⇨ Ensure transit stops are convenient and accessible;
- ⇨ Ensure users can safely cross the street at transit stops.
- ⇨ Many pedestrian crashes are associated with transit
- ⇨ "Every transit stop is a pedestrian crossing location"

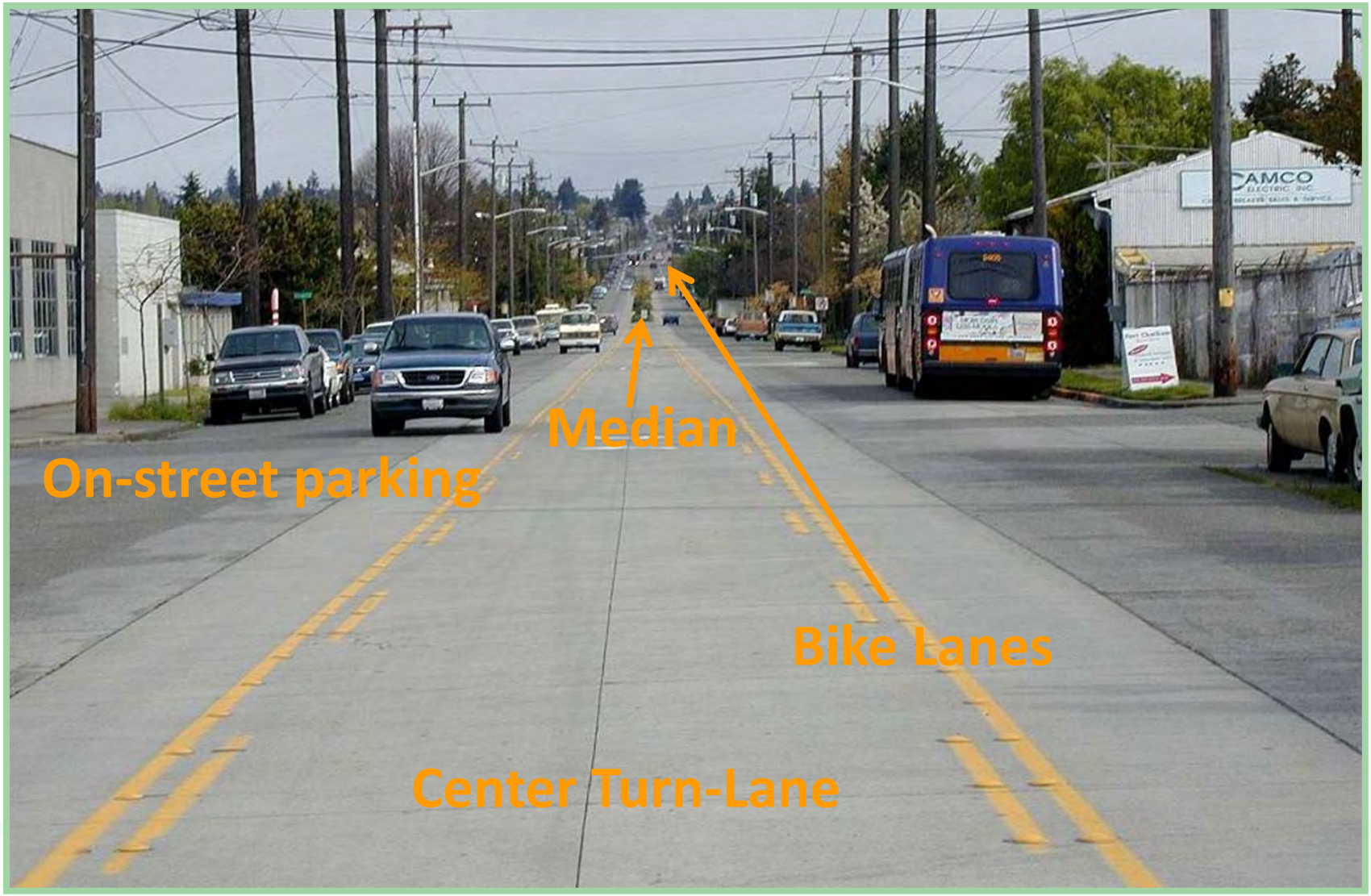
# Road Diets

# “Classic Road Diet”

**4 to 3 lanes**

San Antonio TX

## Seattle WA




**Road diets: reclaim street space for other uses**

## Charlotte NC


**Reclaiming road space creates room for ped islands**

## Charlotte NC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**Reclaiming road space creates room for ped islands**

# Road Diets


**This space was recaptured from a 4th travel lane**

Portland OR

# Benefits of Road Diets for Pedestrians

- Reduces crossing distance
- Reduces "multiple threat" crash types
- Provides room for crossing island to break crossing into 2 simpler crossings
- Reduces top end travel speeds
- Buffers sidewalk from travel lanes (parking or bike lane)
- Reclaims street space for "higher and better use" than moving peak hour traffic

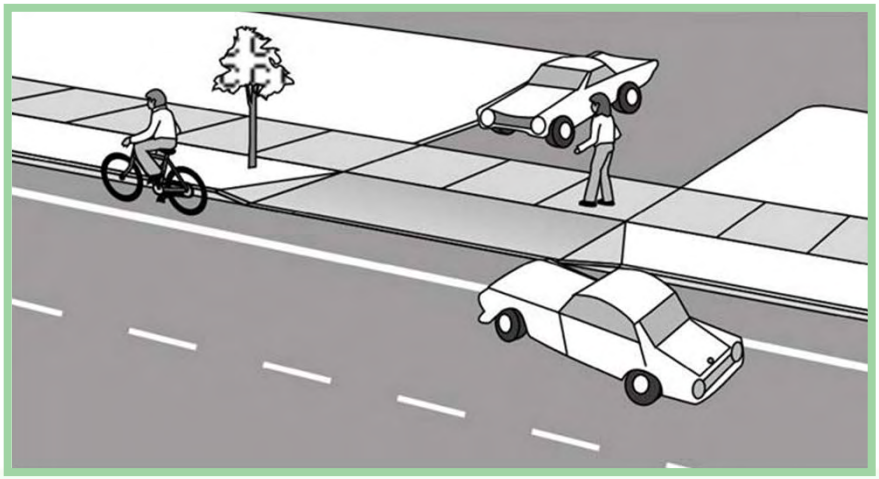
# Engineering Strategies Summary:

- Sidewalks reduce walking along the road crashes
- Human behavior must be considered when choosing street solutions
- Street crossing solution include crosswalks, medians, signals
- Pedestrian-friendly intersections depend on good geometry, tight corner radii, curb extensions, islands
- Signals can be improved for pedestrians
- Road diets create safer conditions for pedestrians

# Engineering: Learning Objectives

***You should be able to:***

⇨**Describe effective engineering strategies and how to integrate them into your Pedestrian Safety Action Plan**



# Questions?