

Signalized Intersections

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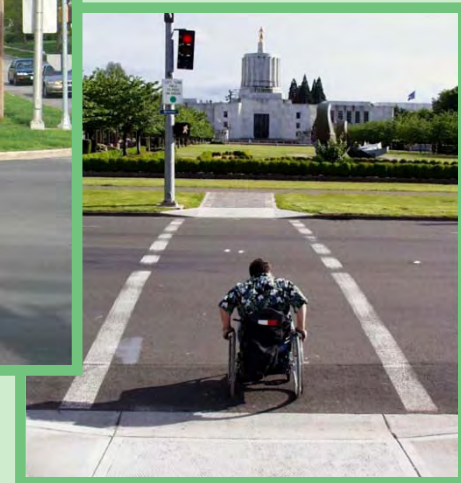
Presented by:

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Nelson\Nygaard Consulting Associates, Inc.

September 27, 2010



Learning Outcomes

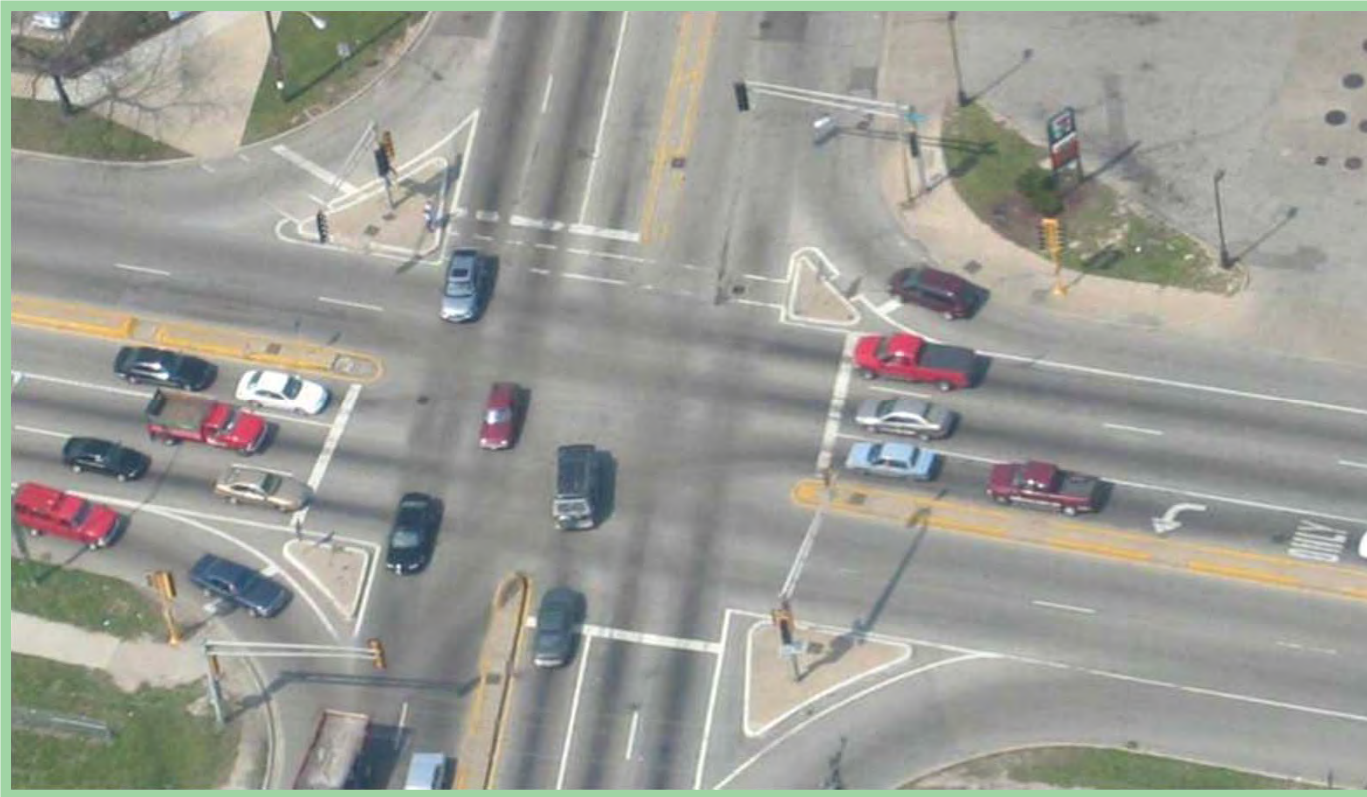
- ⇒ At the end of this module, you will be able to:
- ⇒ Explain why traffic signals don't "guarantee" safety: *they assign the right of way*
- ⇒ Identify major conflicts: *concurrent turn movements*
- ⇒ Select *protected turns* to improve ped safety
- ⇒ Identify signal timing techniques that *favor ped crossings*

Signalized Intersections Can Be Improved For Pedestrians By:

1. *Using good geometric design*
2. *Placing islands to break up complex crossings*
3. *Placing crosswalks in logical locations*
4. **Providing pedestrian signal heads**
5. **Placing push-buttons in convenient locations**
6. **Timing signals to minimize ped delay & conflicts**

- *1, 2 & 3 addressed in earlier module*

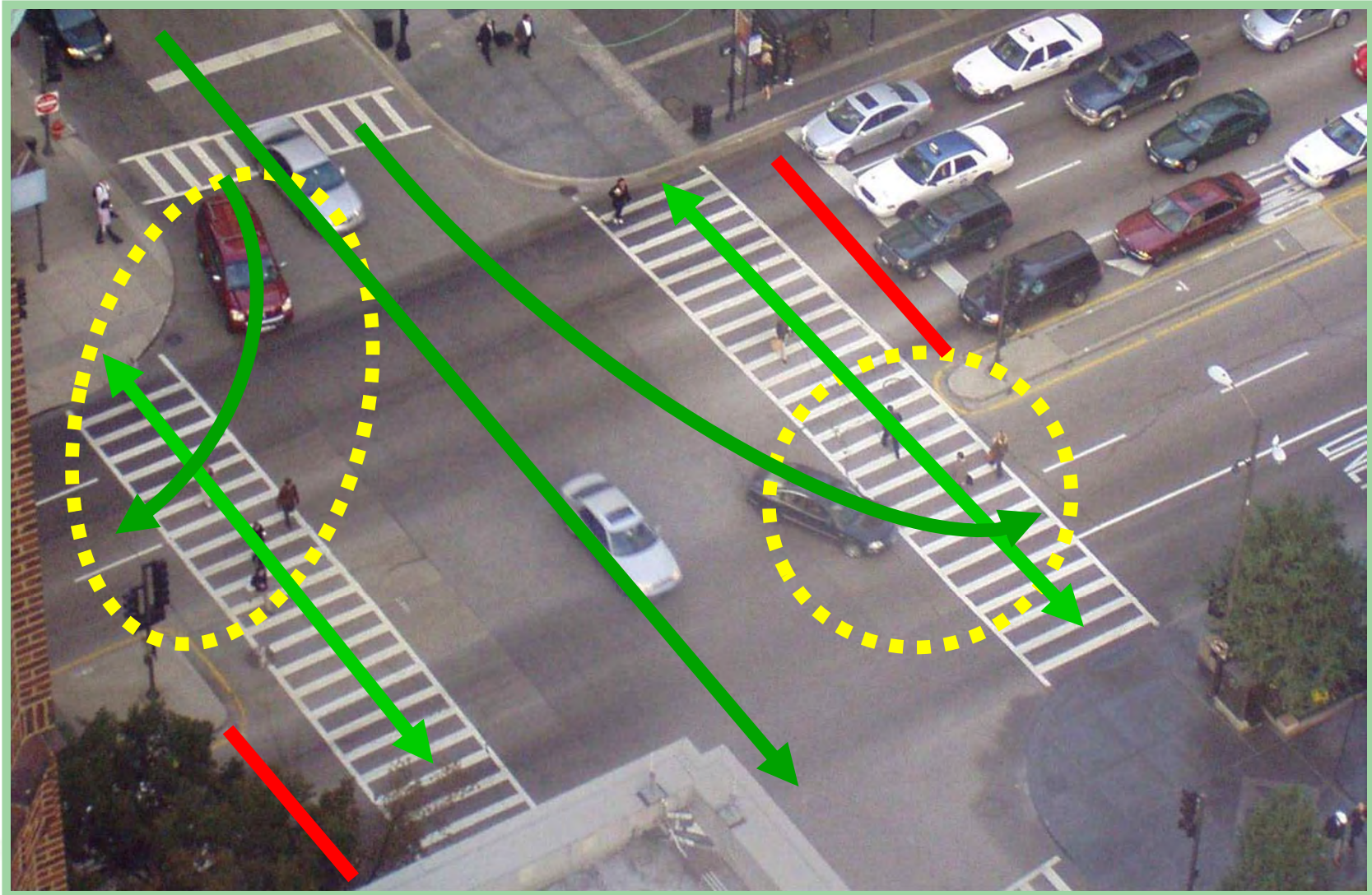
Traffic signals assign the of right of way, regulate the flow of traffic and create gaps



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



Turn movements often result in conflicts



Turn movements often result in conflicts

Traffic signals don't ensure protection



Peds routinely ignore the light (usually quite safely)

Traffic signals don't ensure protection



Pedestrians will cross where it's convenient

Traffic signals don't ensure protection



Red-light running



**Concurrent left turns
on Green**

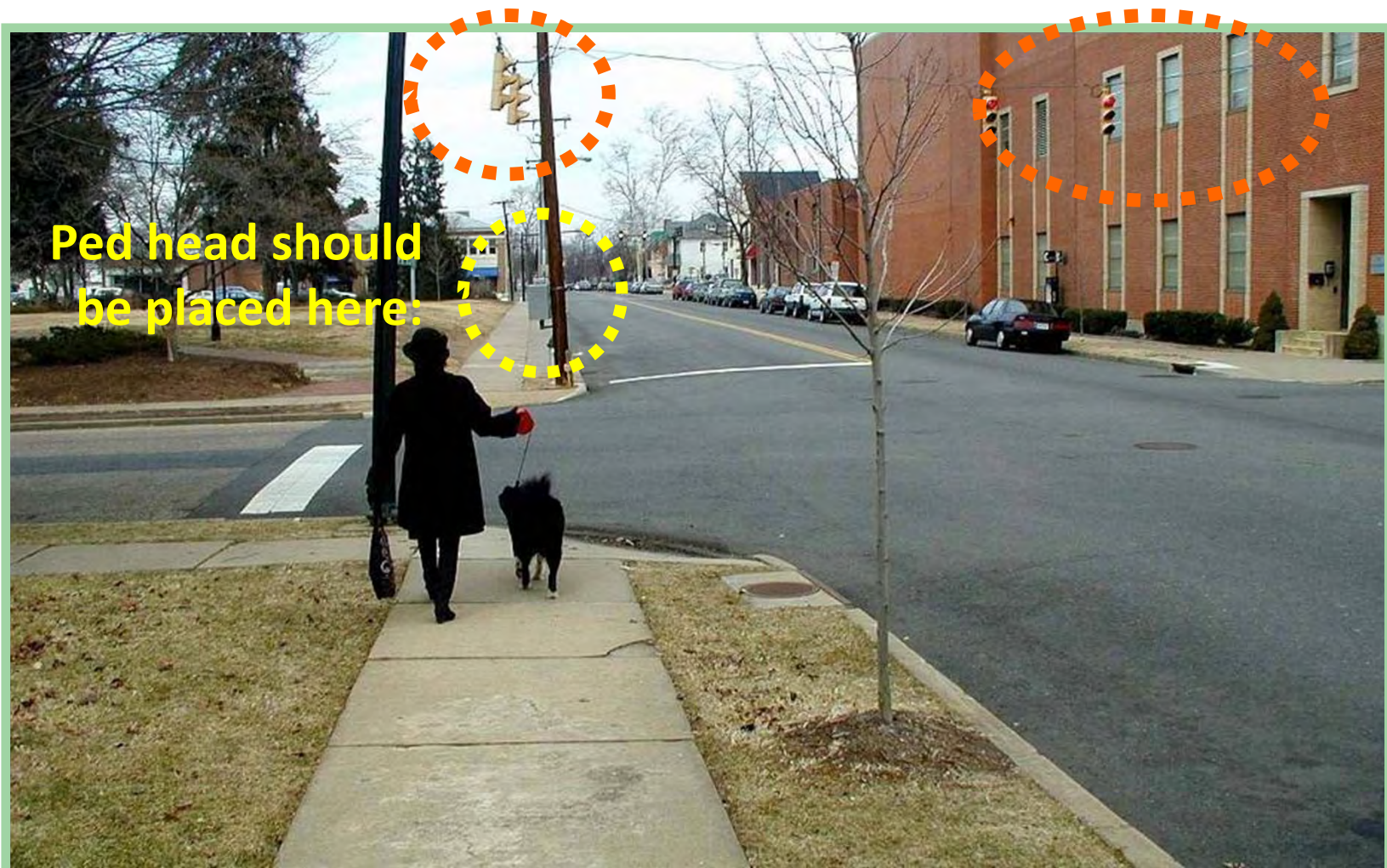
Pedestrians are at risk when crossing with the light

Pedestrian Signals at Signalized Intersections (AKA Ped Heads/Pedestrian Indicators) Need and Placement





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



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Otherwise pedestrians don't know when to cross**

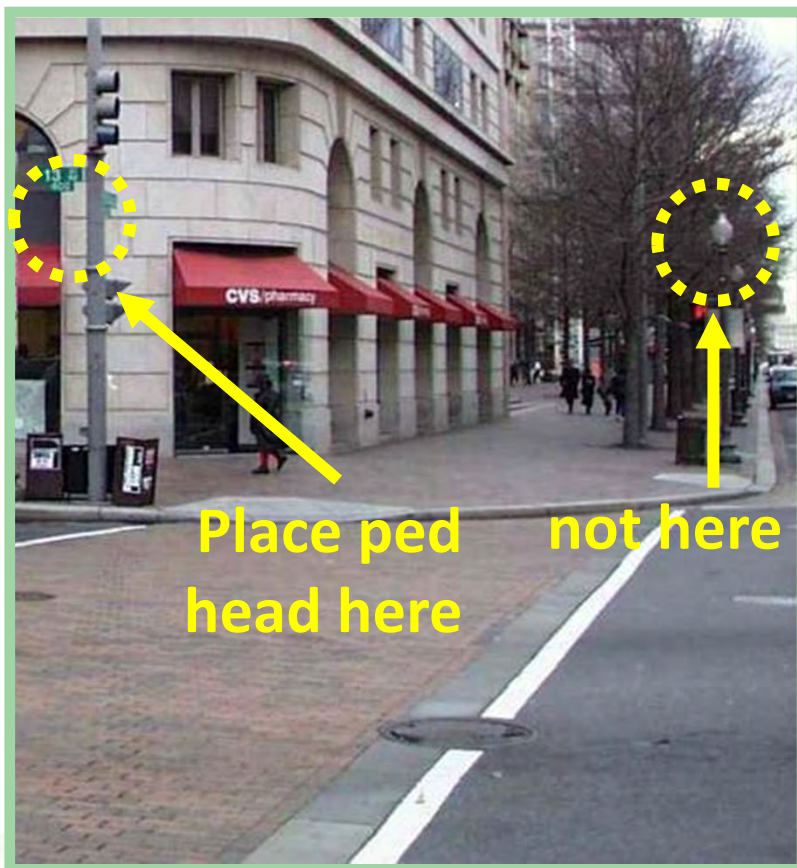


**Lack of pedestrian signals on one way street:
The pedestrian may not notice the signal**



**Lack of pedestrian signals on one way street:
The pedestrian may not notice the signal**

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

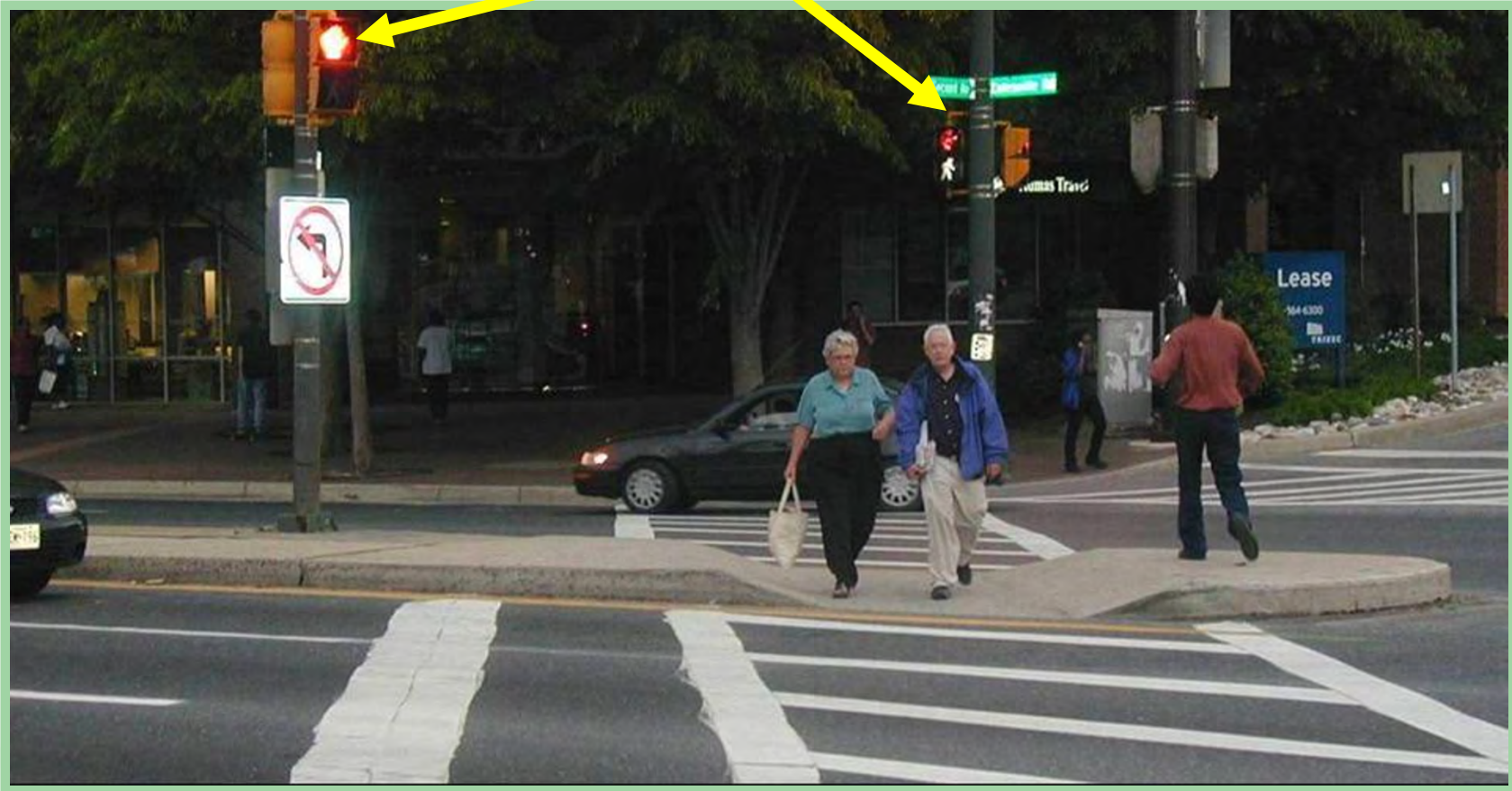


Poor example



Good example

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



These pedestrians kept walking, against light

Old System

1. Ped symbol or WALK
2. Flashing **Hand** or **DON'T WALK**
3. Steady **Hand** or **DON'T WALK**

1/2 of Americans don't understand it;

Is there a better system?

- * Flashing **orange hand/DON'T WALK** is ped clearance interval: very counterintuitive





Problem with old system: People not sure if they can start during flashing **hand / **DON'T WALK****



Countdown pedestrian signal tells pedestrians how much crossing time is left



Countdown pedestrian signal research results:

1. Pedestrians understand how it works
2. More people start crossing during clearance phase, but...
3. Fewer people initiate walk late in clearance phase
4. No pedestrians left in crosswalk in steady don't walk
5. Drivers don't take a cue and accelerate to beat the light

What about crash reduction?



**Results from San Francisco study are promising:
CRF = 25% after countdown signals installed**

Change included in 2009 MUTCD

- ⇒ **Countdown displays** required for new pedestrian signals (except the rare situation where the change interval is 7 seconds or less)
- ⇒ **Why? Significant reductions in pedestrian-vehicle crashes, as well as all types of crashes**



Discussion:

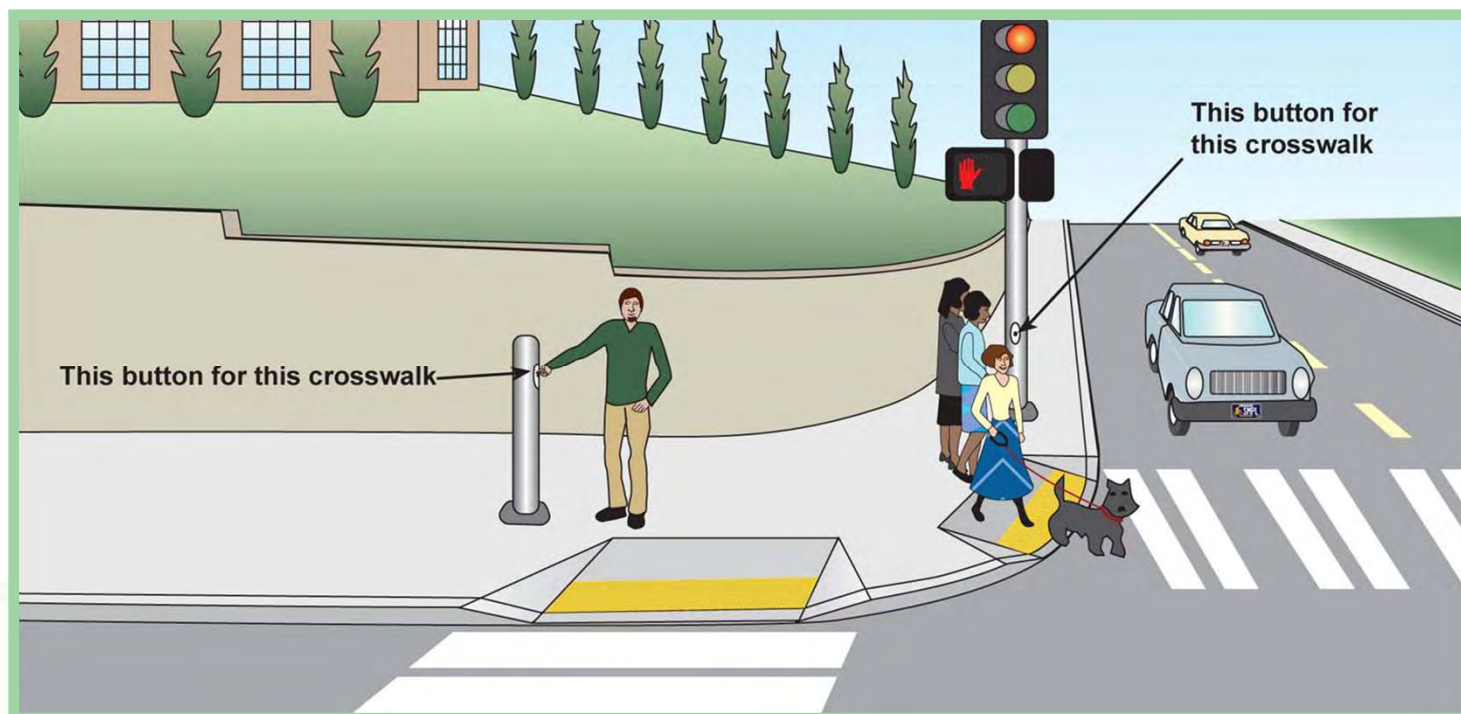
- ⇒ What are your policies & practices regarding the provision of pedestrian indicators and countdown signals?

Placing Push-buttons In Convenient Locations

Proper Push-button Placement

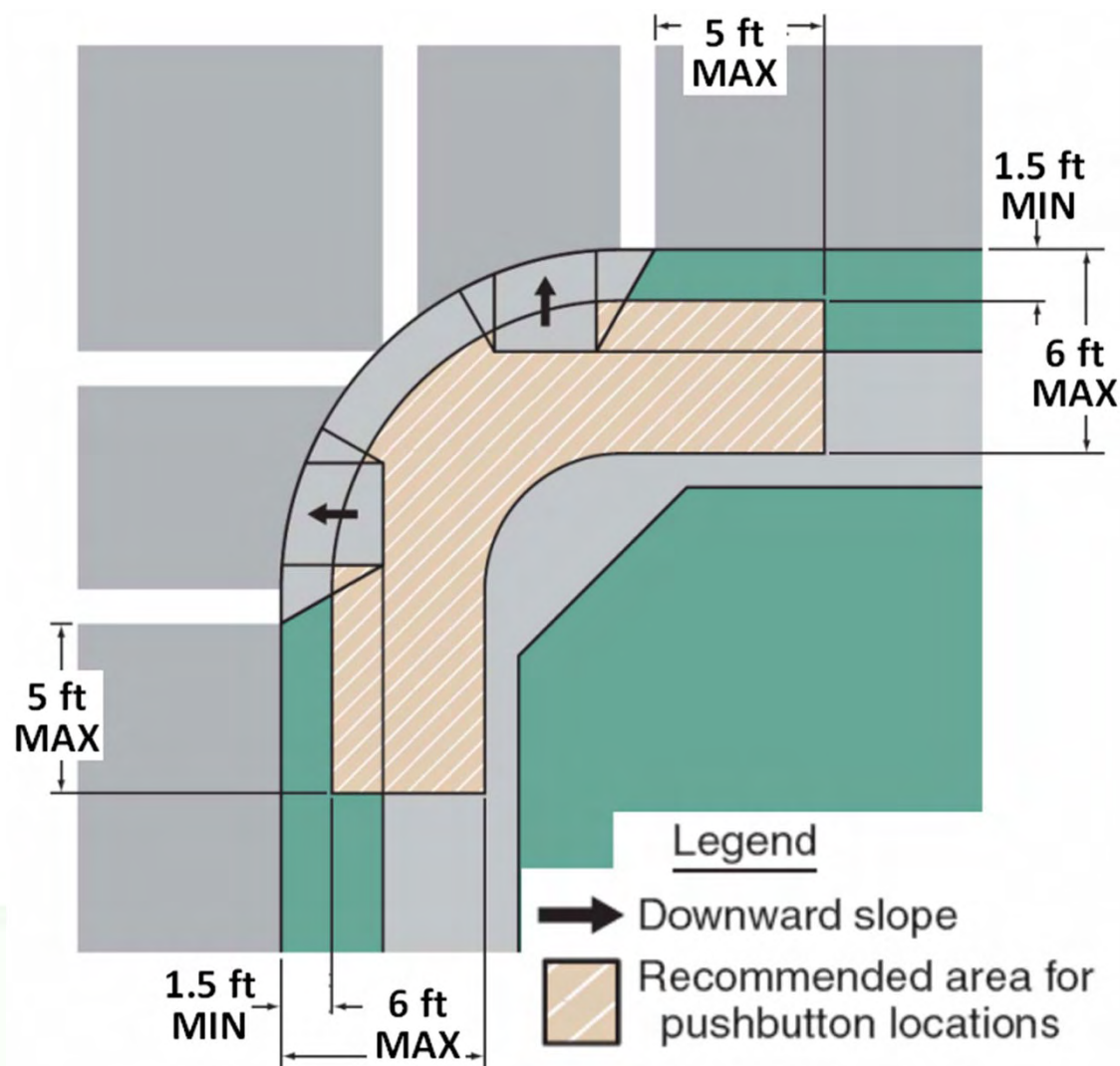
MUTCD Recommendations:

- ⇒ In line with crosswalk;
- ⇒ Buttons at least 10' apart;
- ⇒ Between 1.5' and 6' from curb
- ⇒ Button face parallel to xwalk



Proper Push-button Placement

⇒ The MUTCD recommends these dimensions



Poor Push-button Placement



Inconspicuous



Too far from ramp

Poor Push-button Placement



Behind guardrail



Behind vegetation

Poor Push-button Placement



At back of pole



In front of pole

Poor Push-button Placement



All of the Above?

Proper Push-button Placement



On side of pole

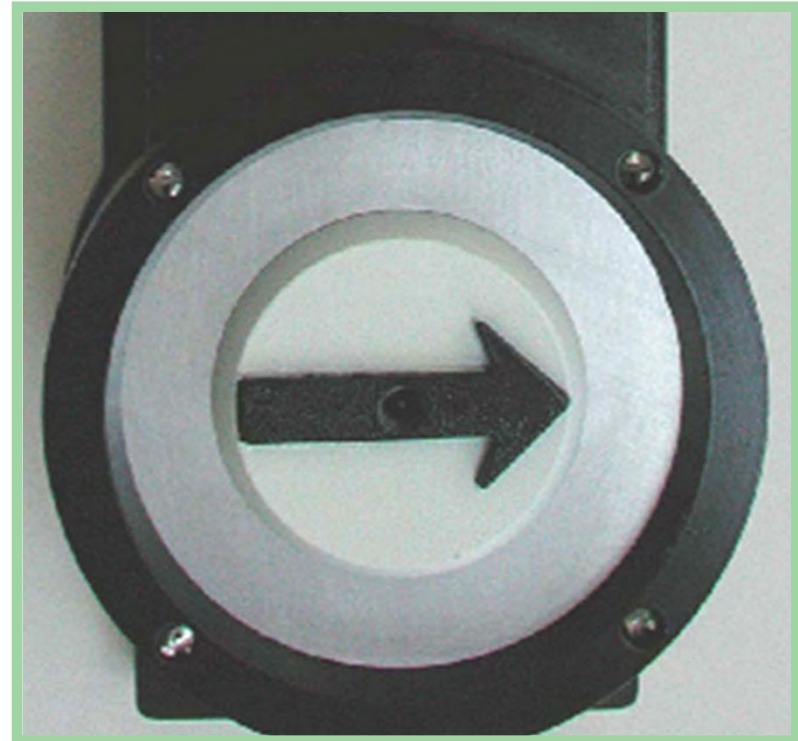


At top of ramp

Communicate With Pedestrians



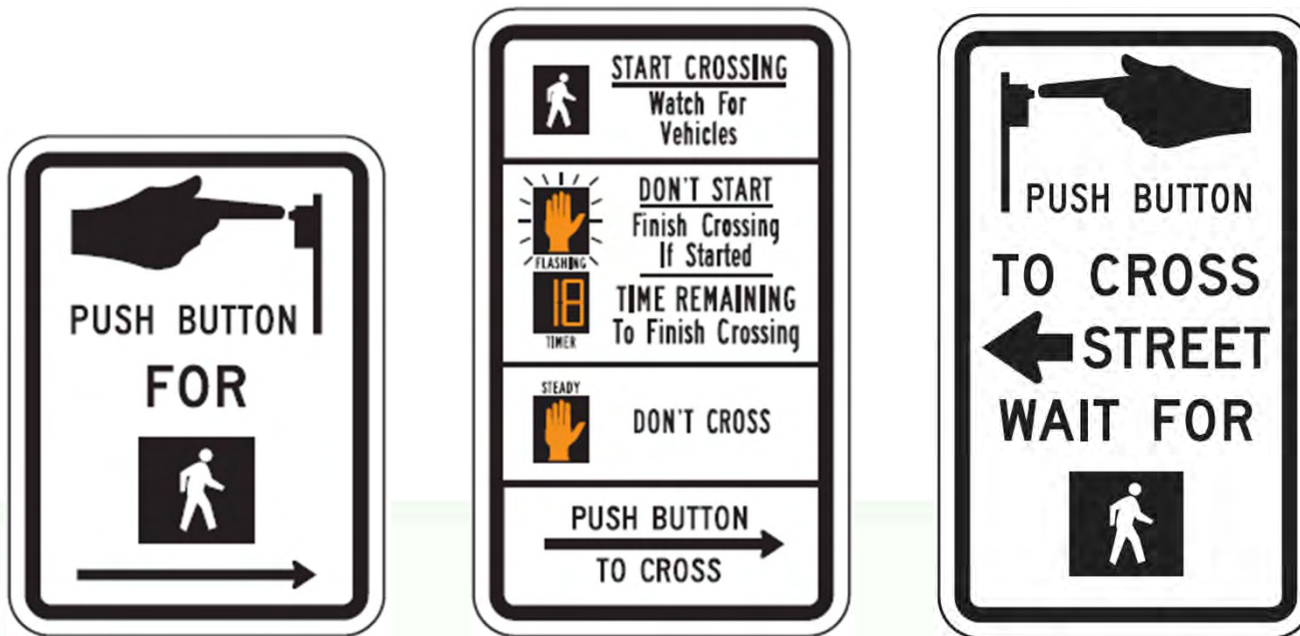
LED tells peds the button works and the signal has received the call (*like an elevator*)



Tactile arrow gives direction to blind and sighted pedestrians

New Requirement in the 2009 MUTCD

- ⇒ Positioning of pedestrian pushbuttons and legends on pushbutton signs shall clearly indicate which crosswalk signal is activated by each pushbutton



Signal Timing & Walking Speeds

Pedestrian Walking Speeds

2003 MUTCD requirements:

- ⇒ 7 sec steady walk (peds may enter crosswalk); 4 sec “option”
- ⇒ Pedestrian clearance time calculated at 4’/sec curb-to-curb
- ⇒ 60’ crosswalk requires 15 sec
- ⇒ **15 + 7 = 22 sec absolute minimum walk plus clearance**



Pedestrian Walking Speeds

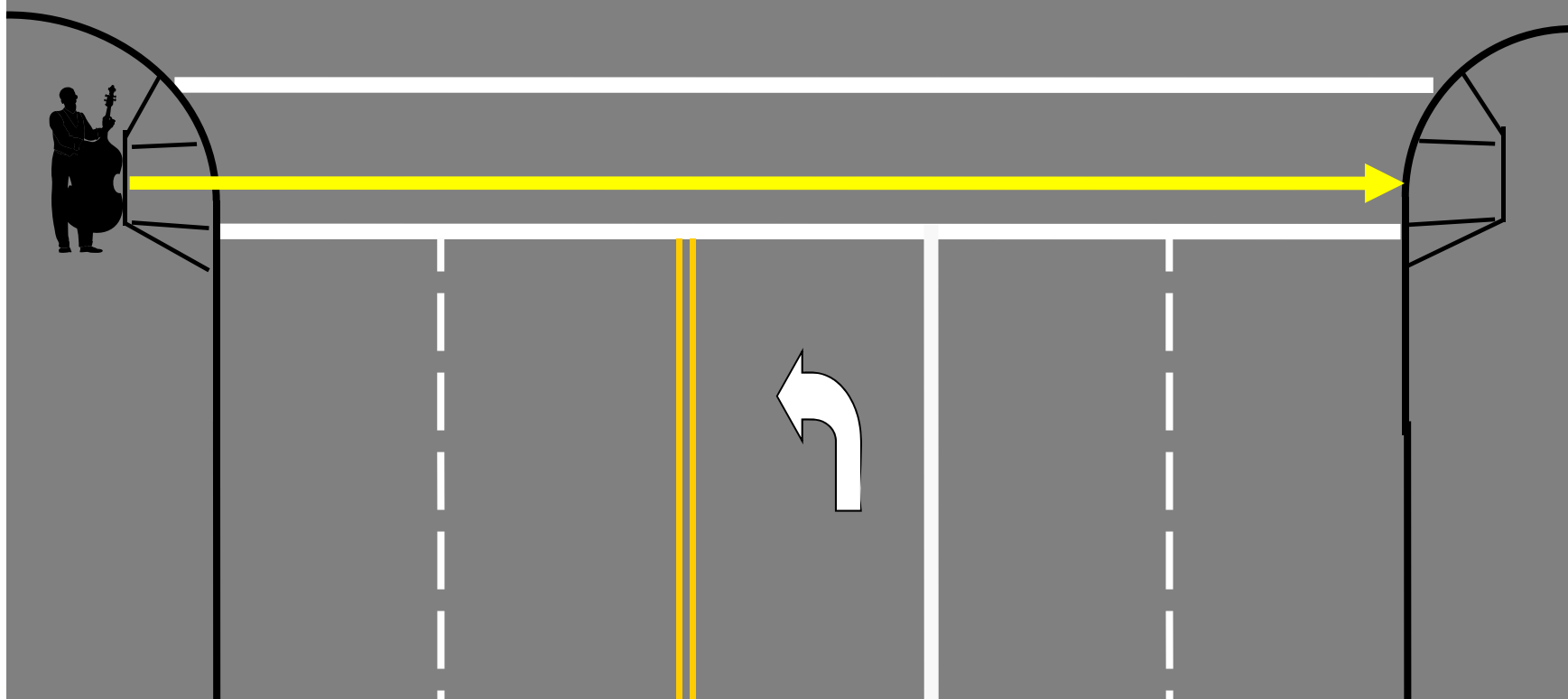
2009 MUTCD:

- ⇒ 7 sec walk, 4 sec option (no change)
- ⇒ Ped clearance time calculated at 3.5'/sec curb-to-curb.
- ⇒ 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
 - 60' crosswalk + 6' = 66'
 - **66' requires 22 sec**
 - 24 sec > 22 sec; passes test.



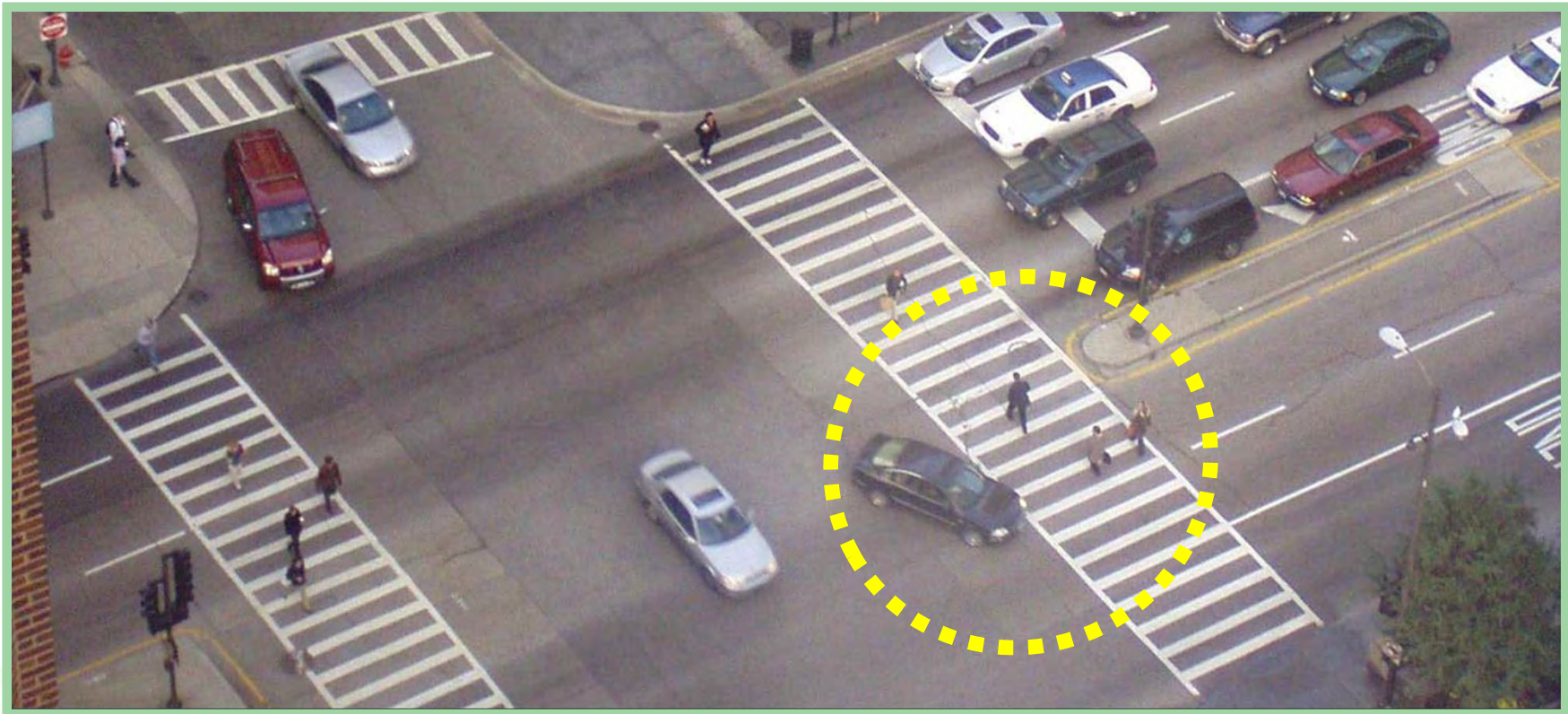
Guidance for walk plus clearance: Calculate time from pushbutton (or 6' from curb) to curb on other side at 3'/sec

60' crosswalk + 6' = 66' total; @ 3'/sec = 22 sec walk plus ped clearance

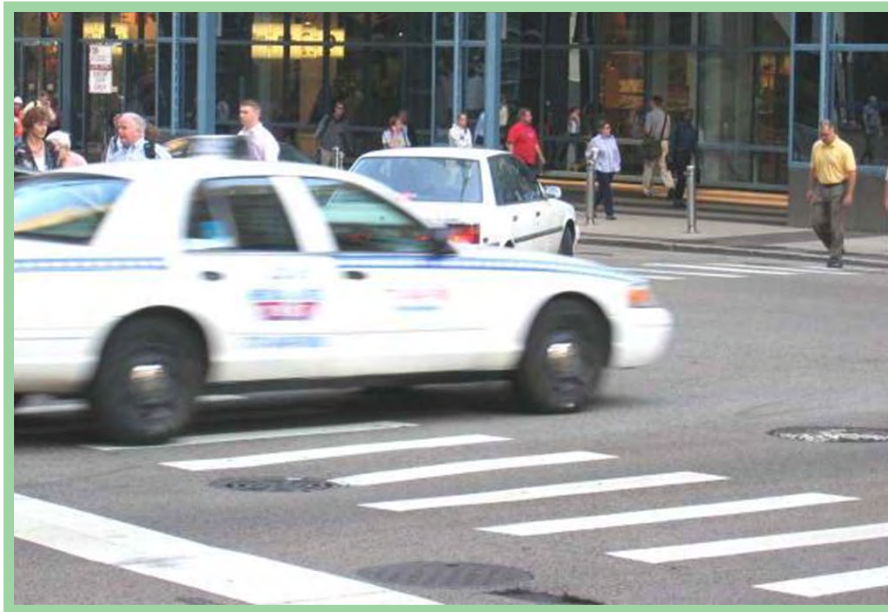


Note: pushbutton is considered the departure point for older pedestrians and people in wheelchairs.

Reducing Pedestrian & Left-Turning Vehicle Conflicts

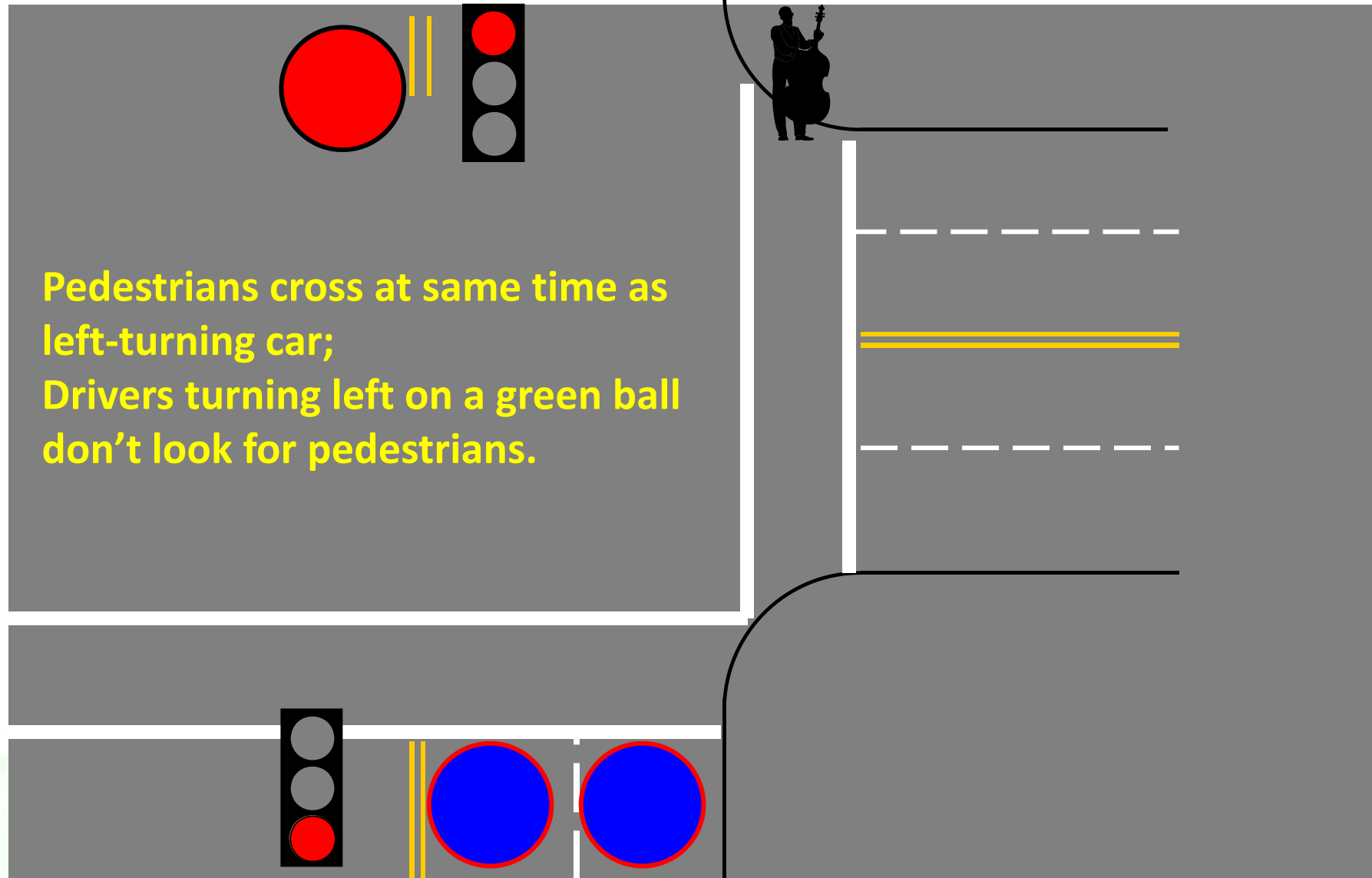


Protected Vs. Permissive Left Turns



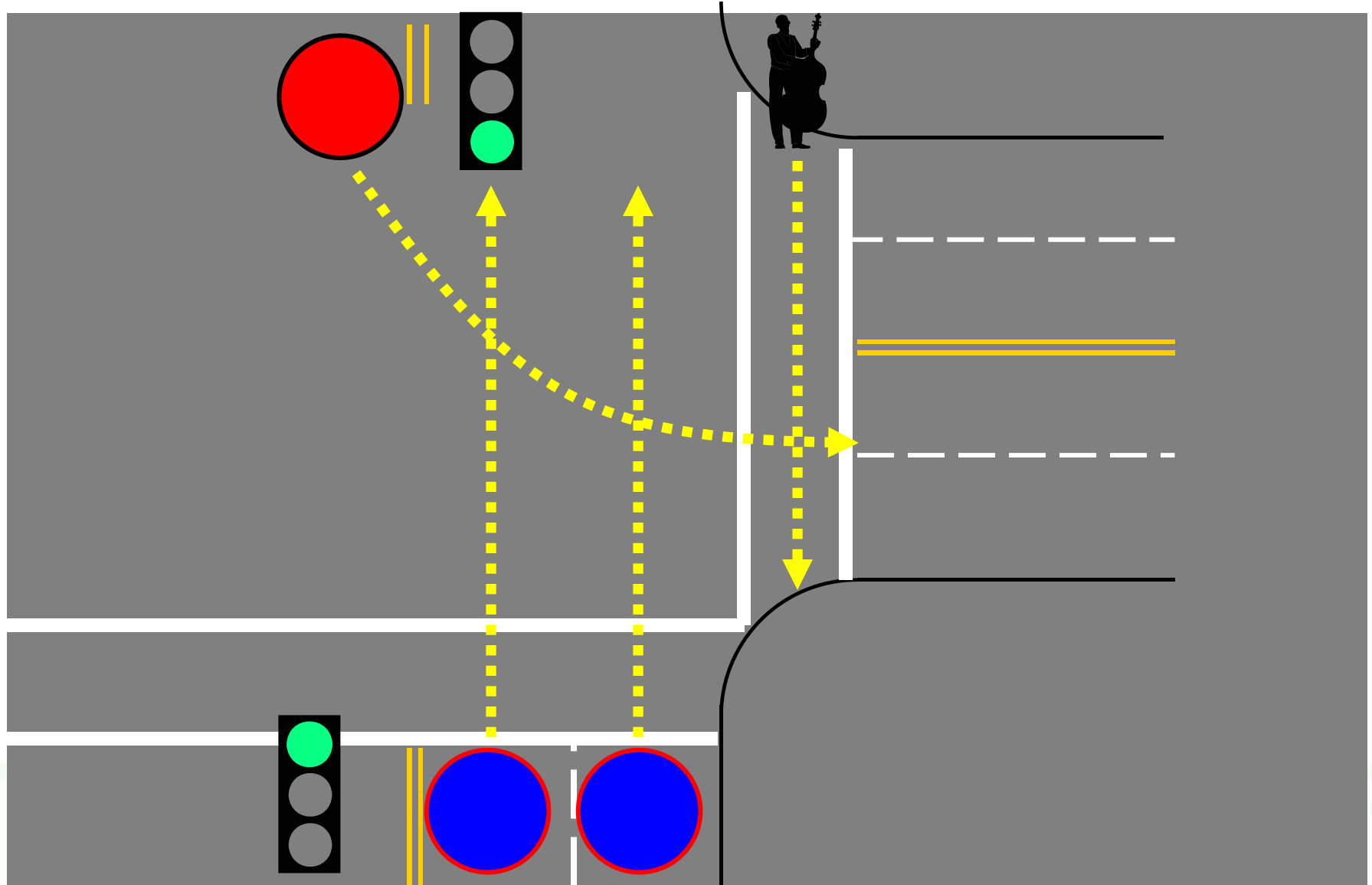
- ⇒ At signals, turning movements account for most ped crashes;
Left/right turn ratio is roughly 2:1
- * CRF 70% (all crashes) converting permissive left turns to
protected only left turns

Permissive Left Turns

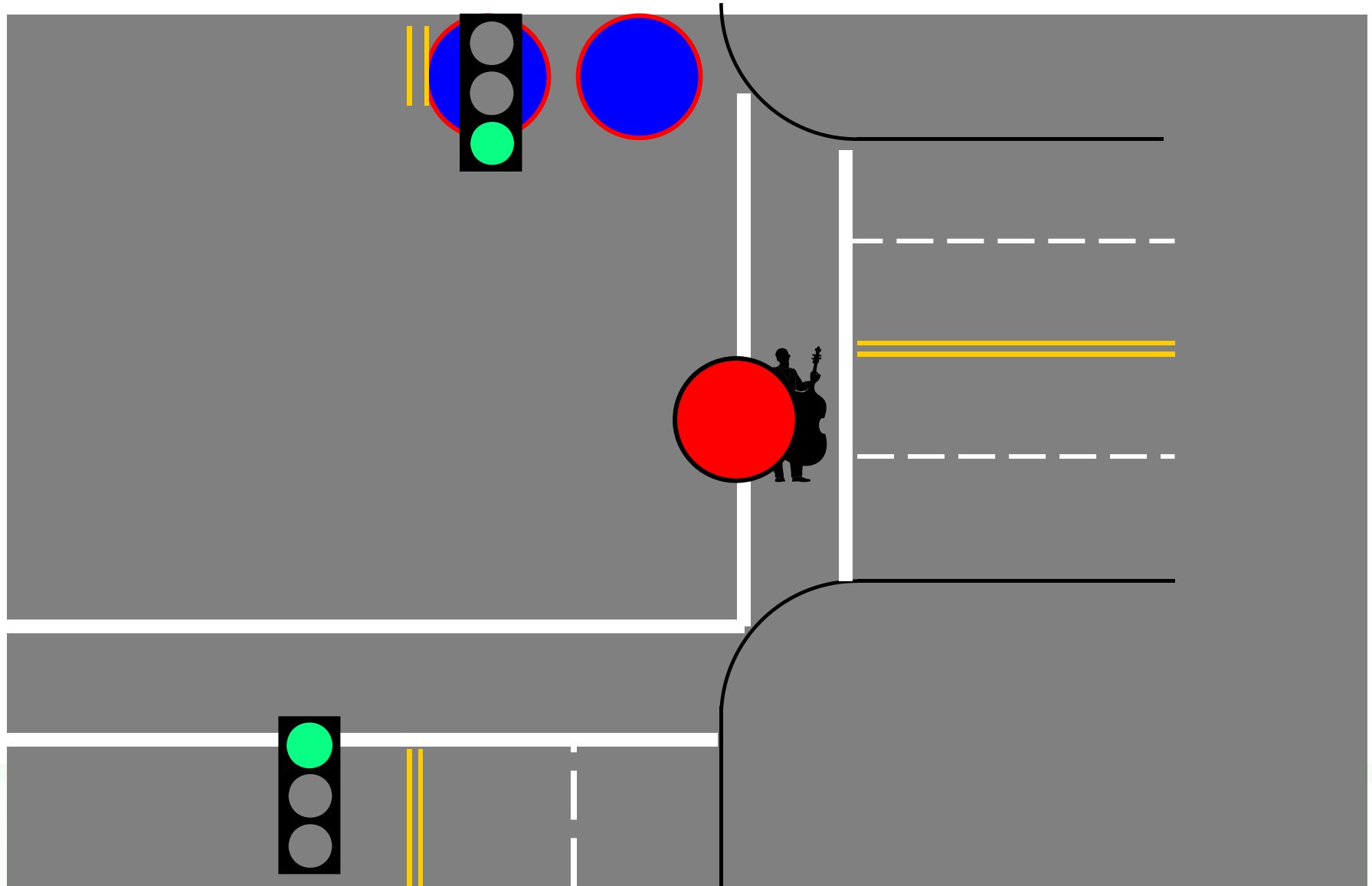


Pedestrians cross at same time as left-turning car;
Drivers turning left on a green ball don't look for pedestrians.

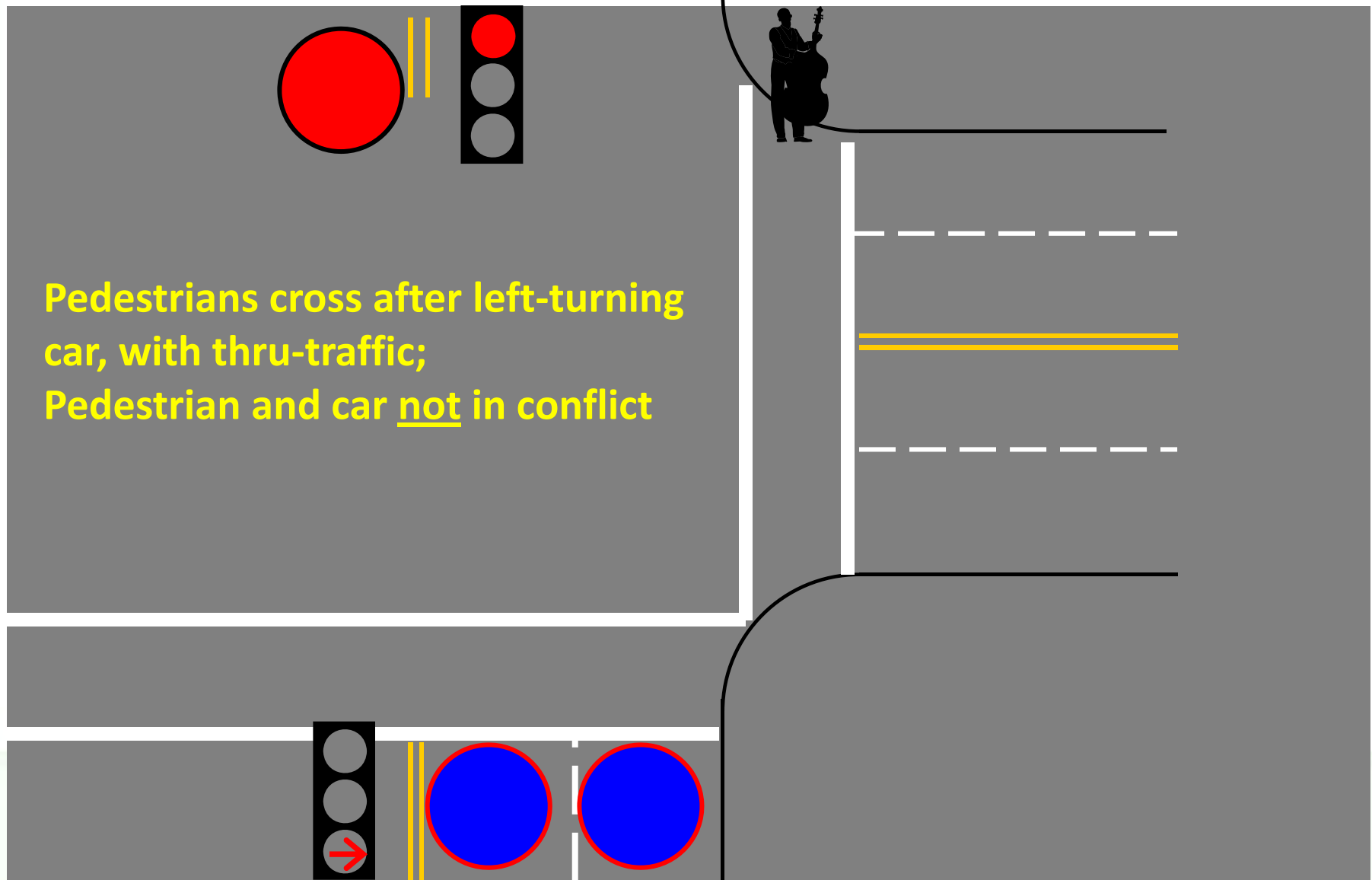
Permissive Left Turns



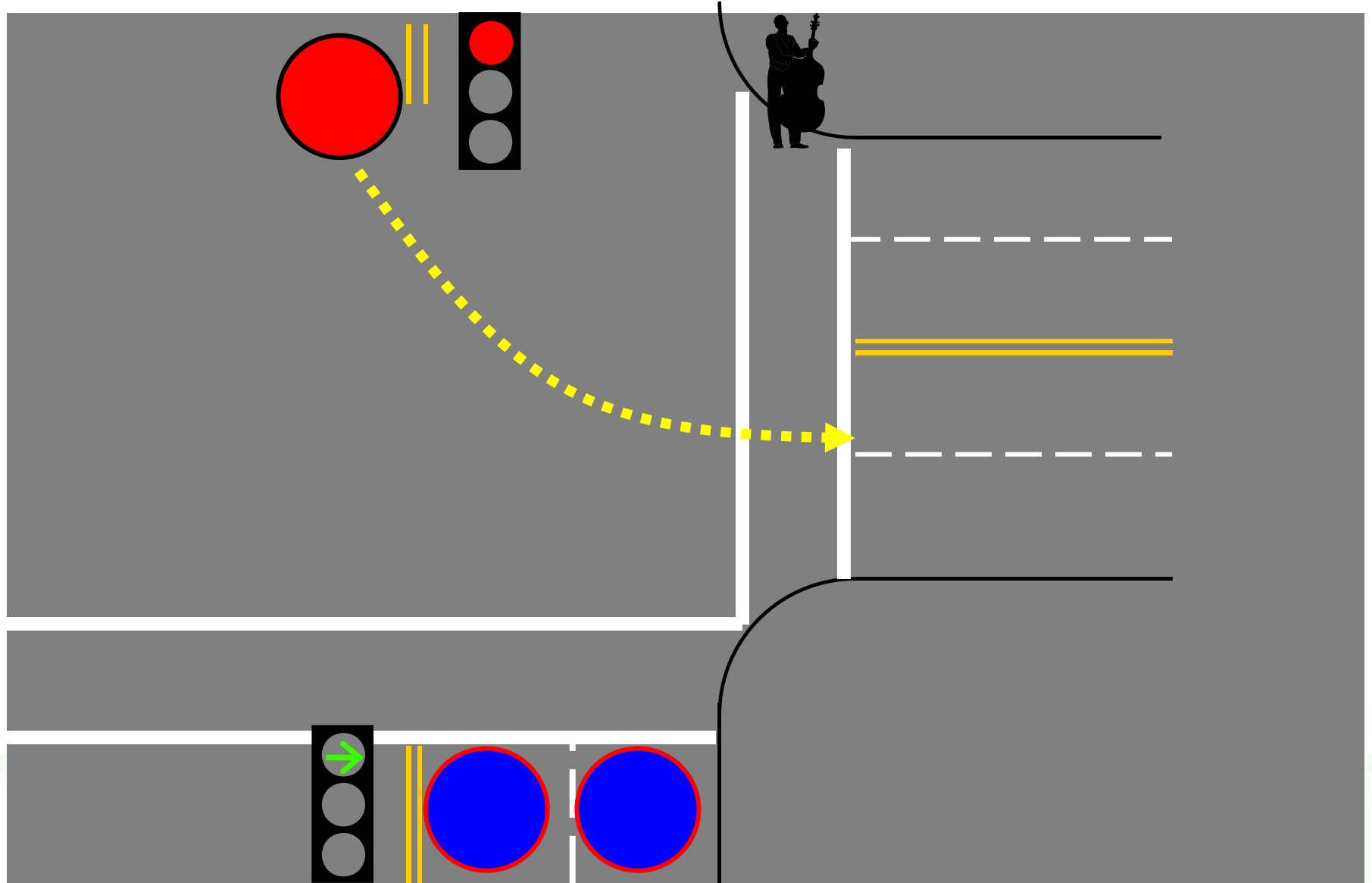
Permissive Left Turns



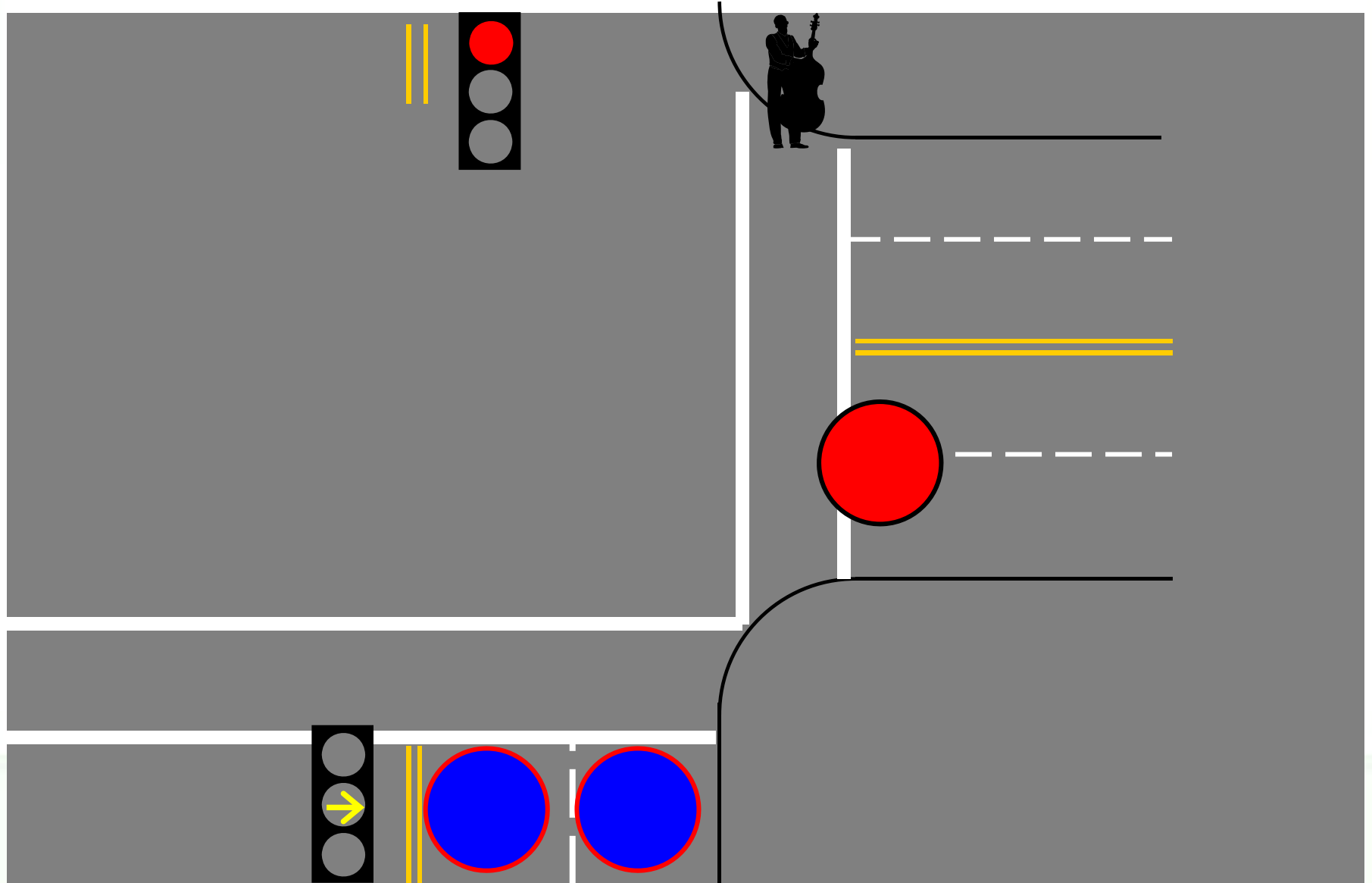
Protected Left Turns



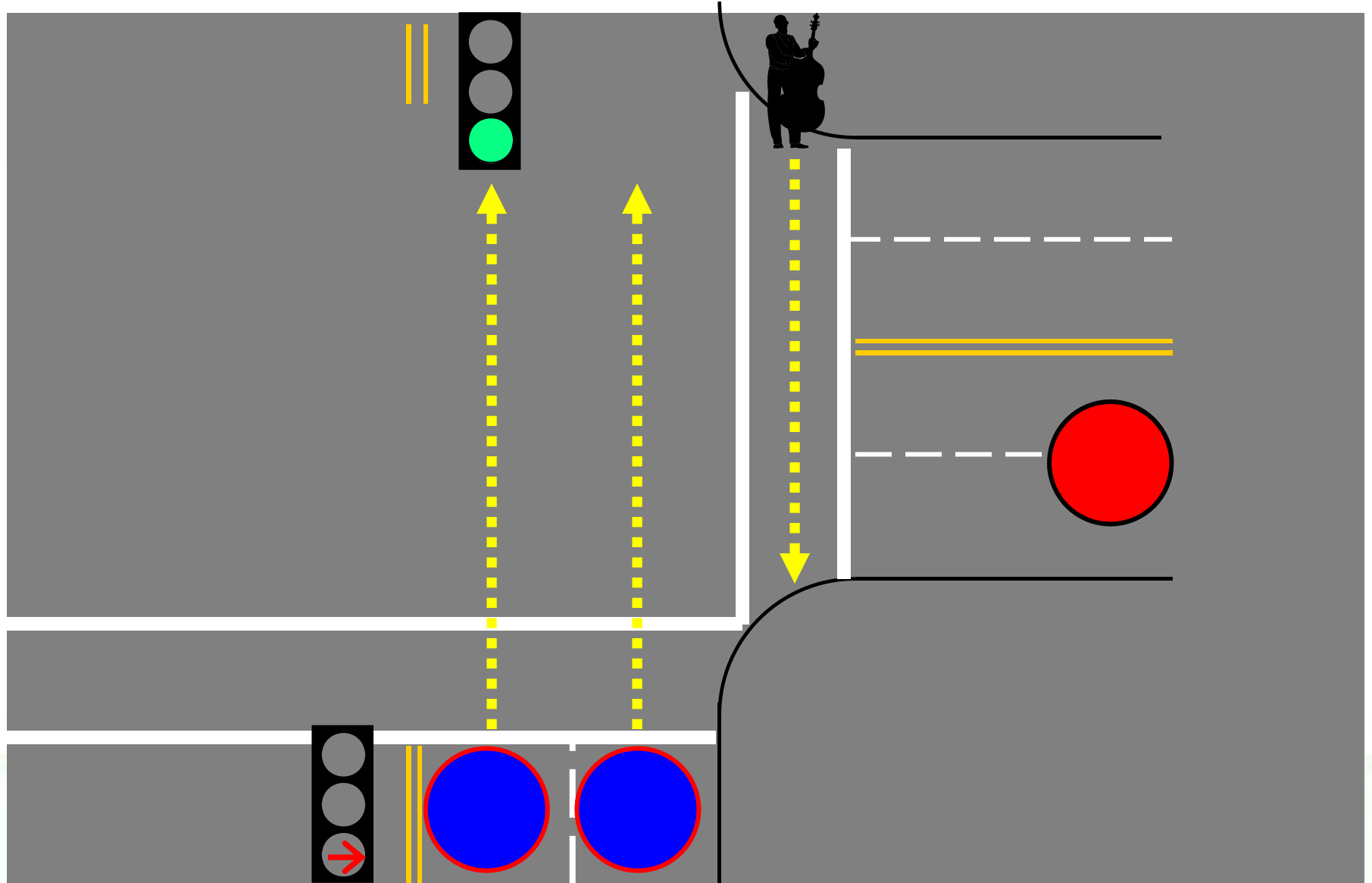
Protected Left Turns



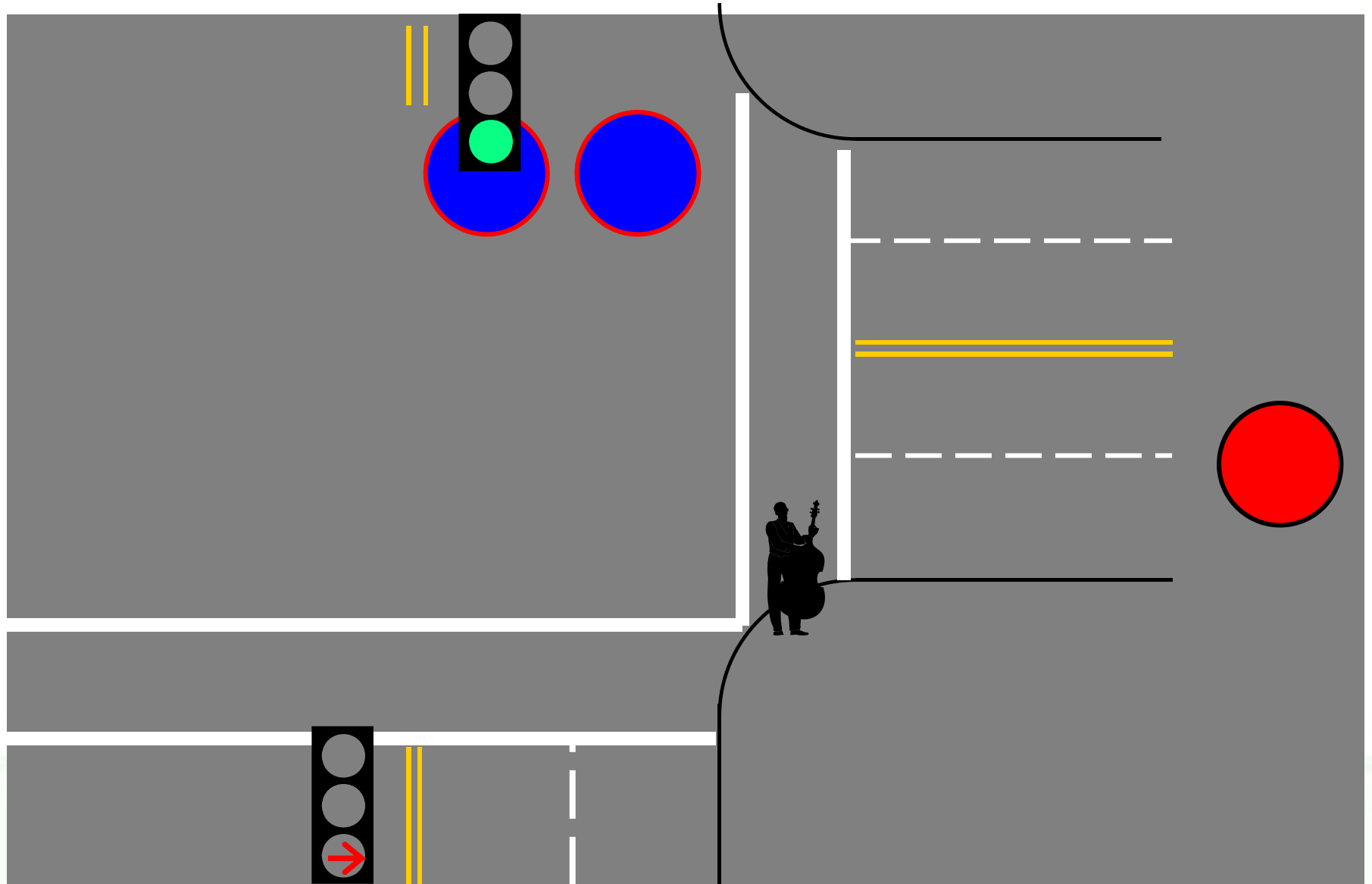
Protected Left Turns



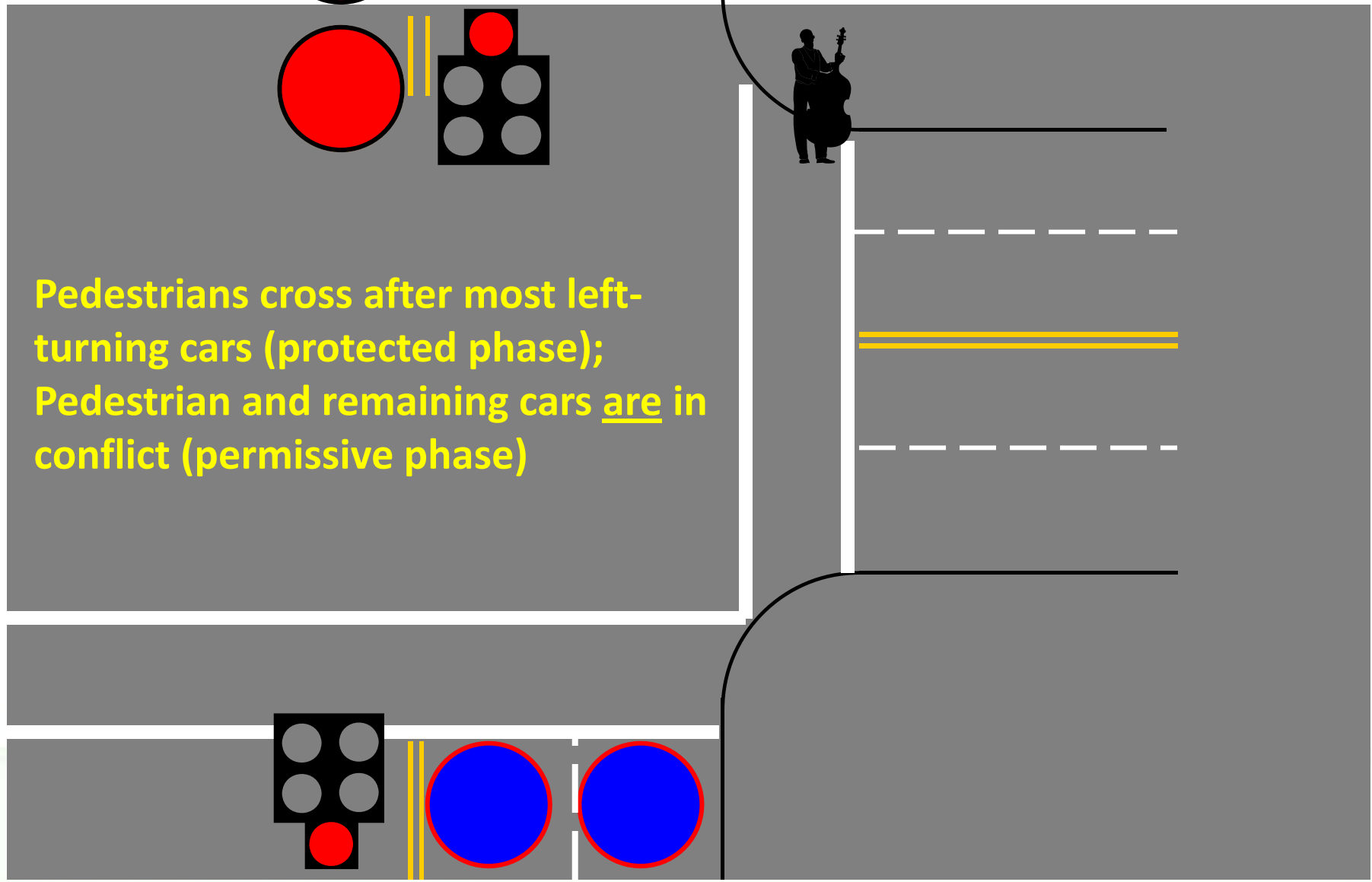
Protected Left Turns



Protected Left Turns

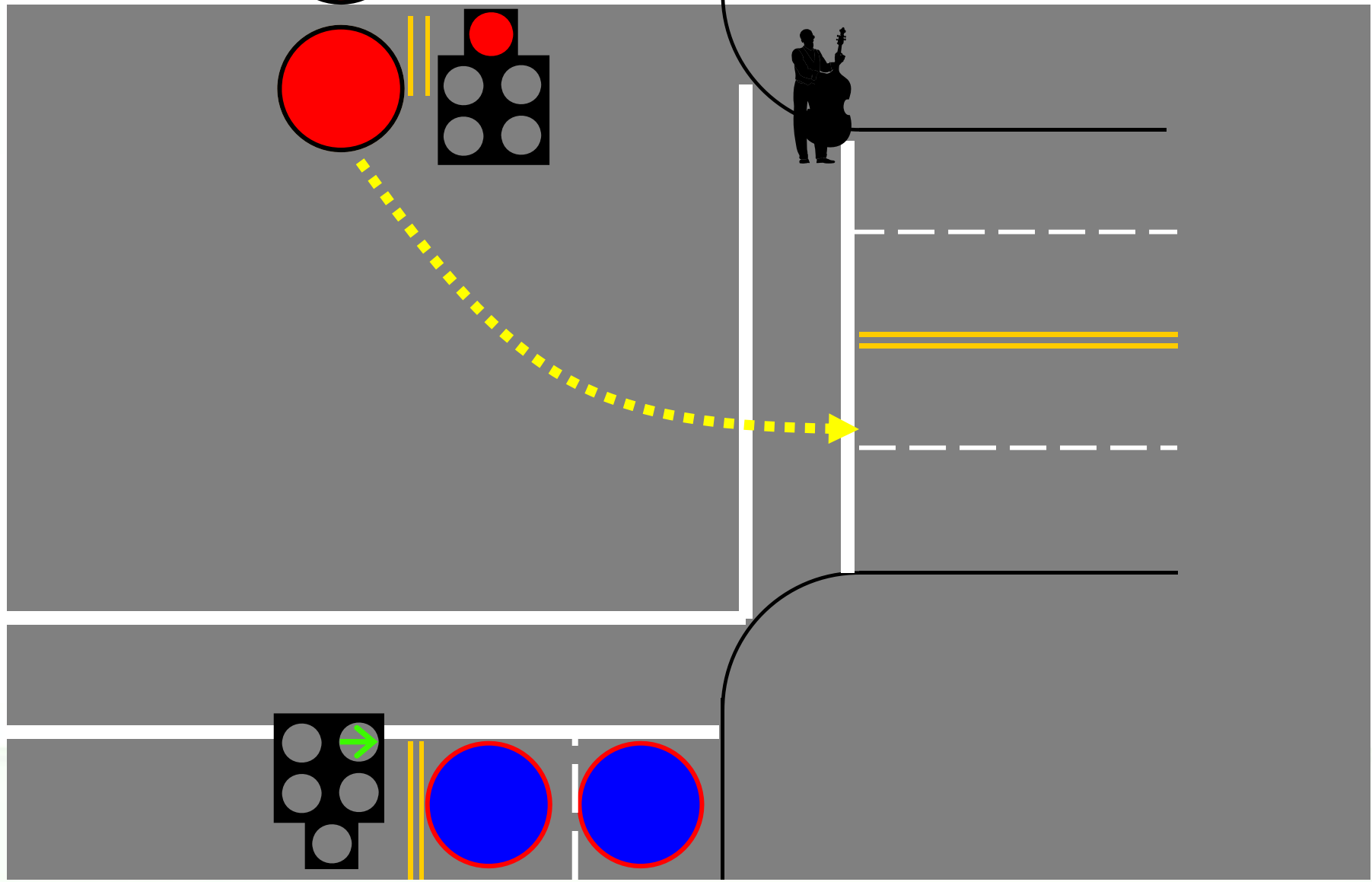


Protected/permissive Left Turns

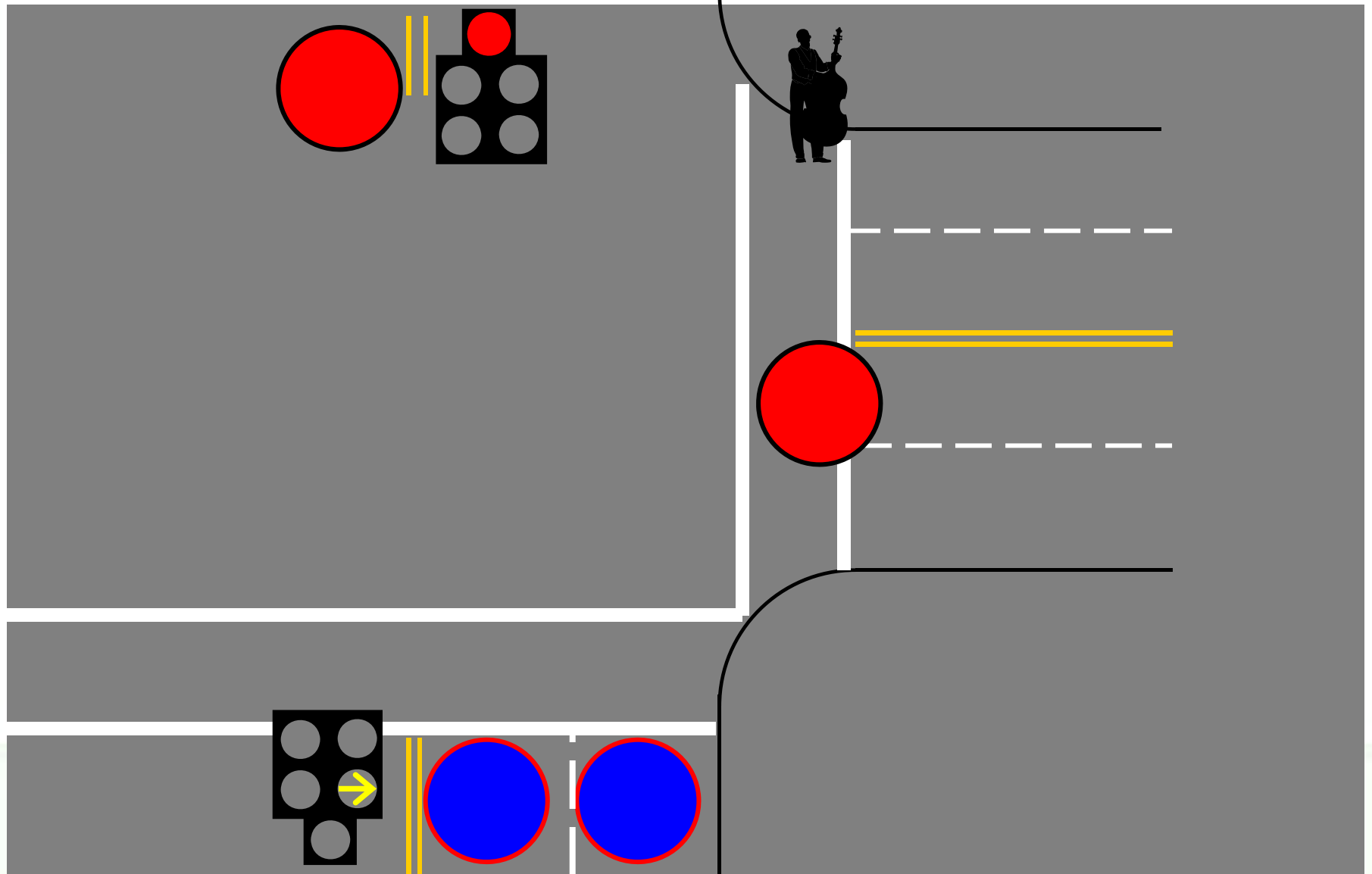


Pedestrians cross after most left-turning cars (protected phase);
Pedestrian and remaining cars are in conflict (permissive phase)

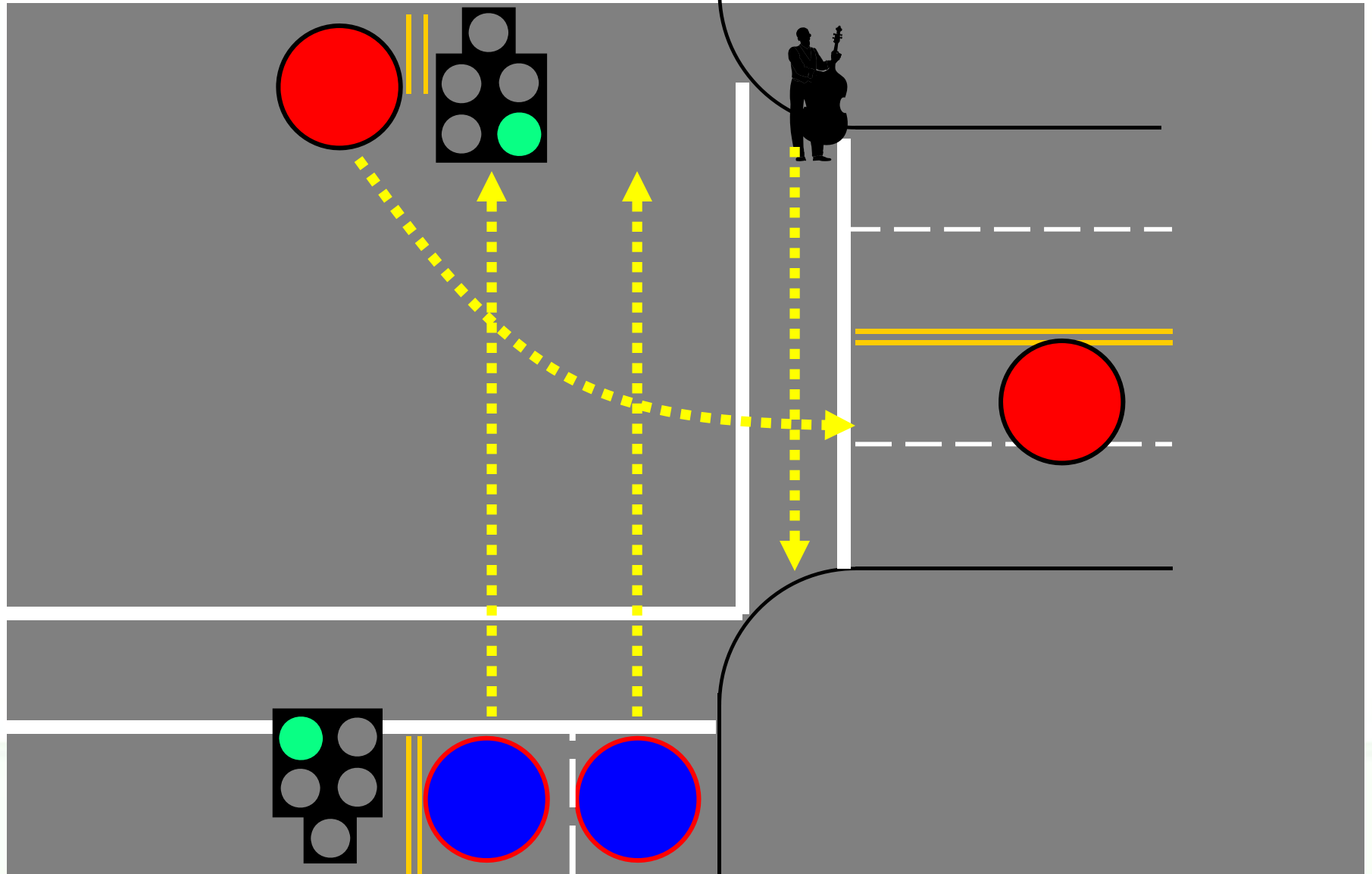
Protected/permissive Left Turns



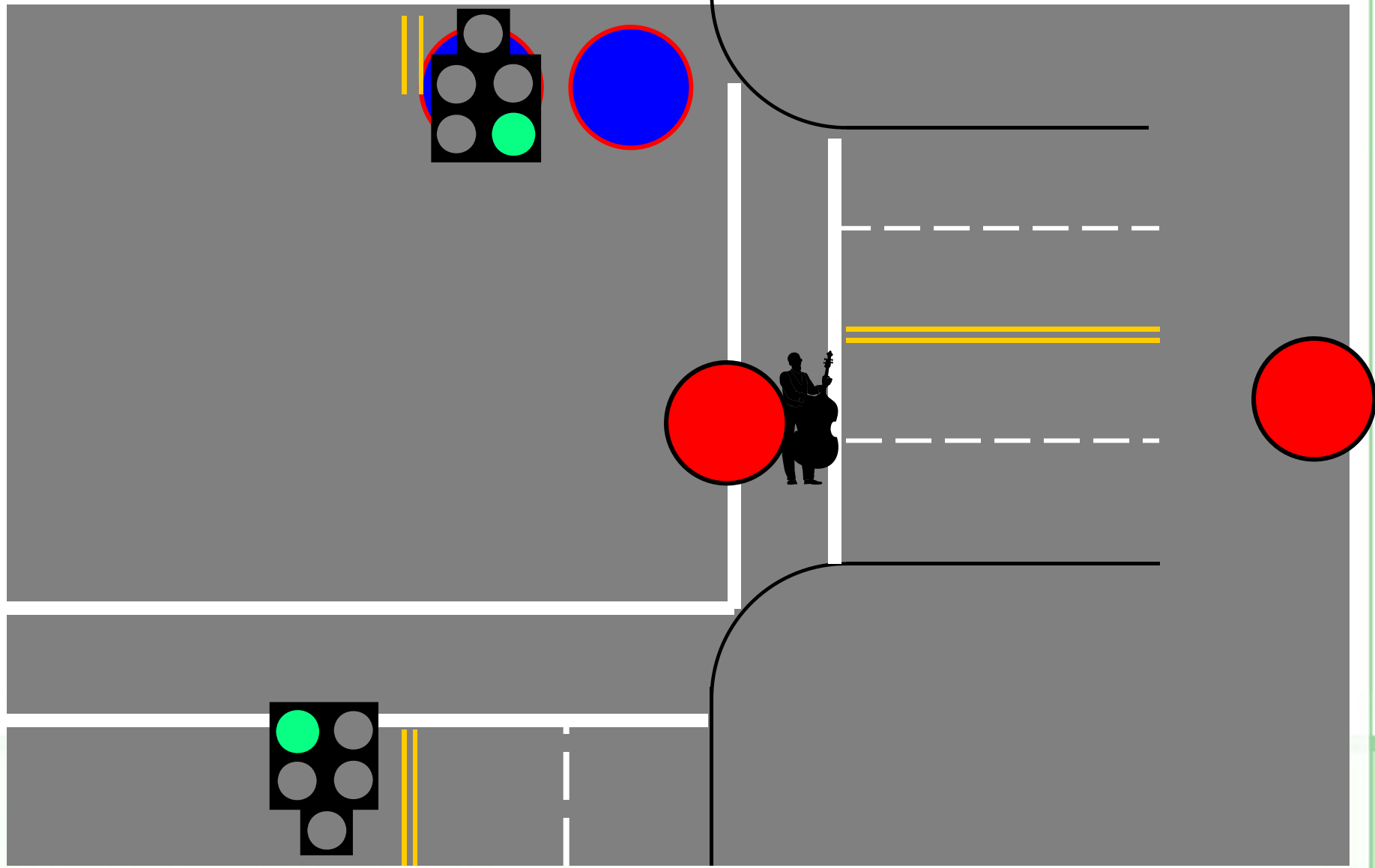
Protected/permissive Left Turns



Protected/permissive Left Turns

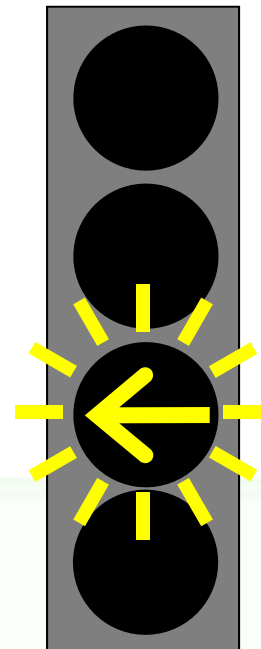
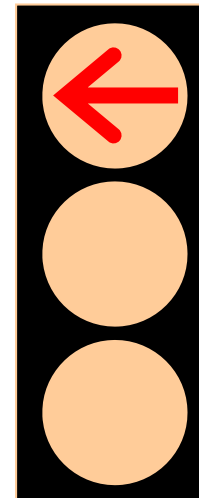


Protected/permissive Left Turns



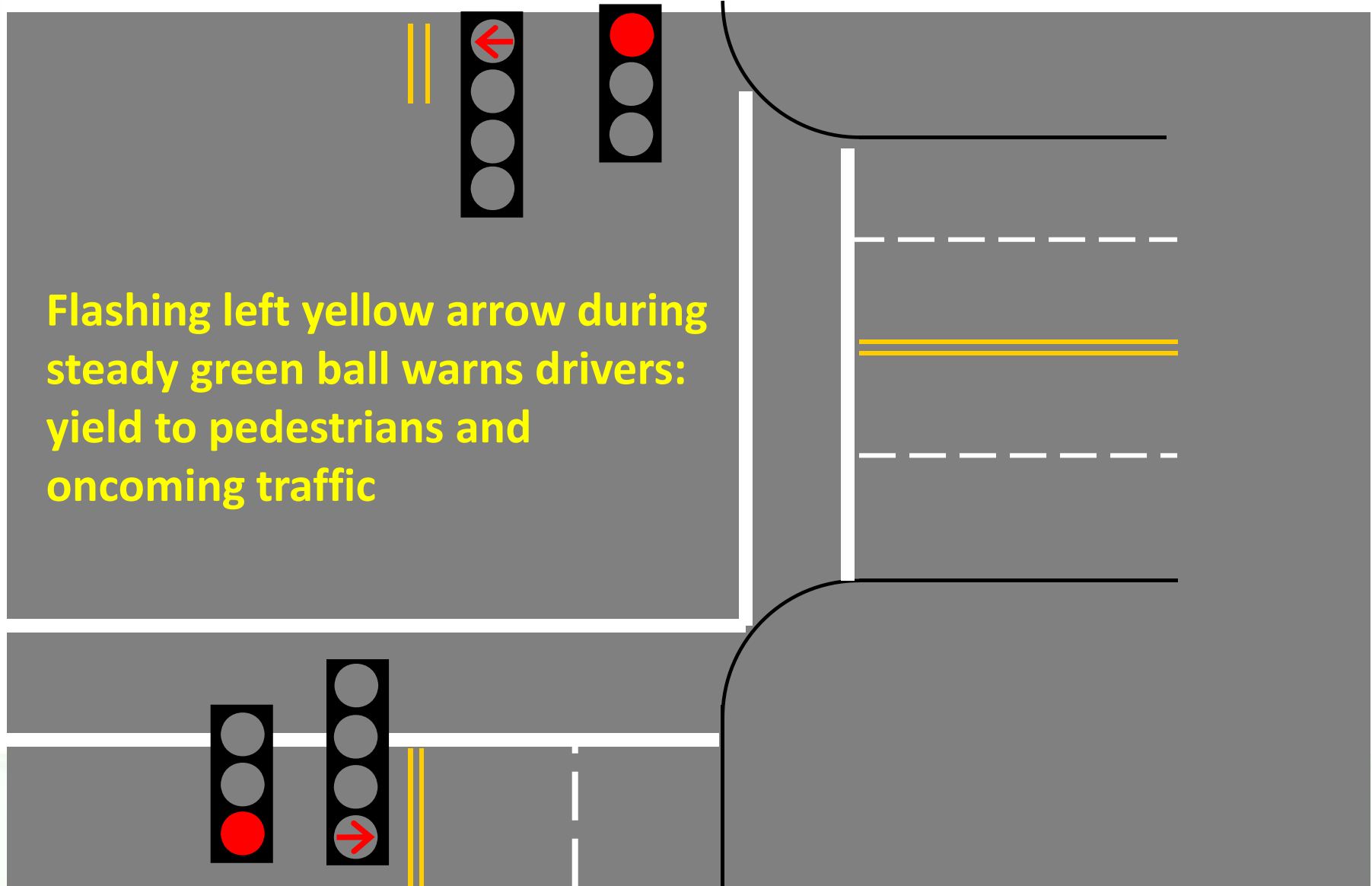
Protected/permissive Left Turns: Solutions

1. Provide protected-permissive phasing by default, but revert to protected-only when pedestrian button is pushed
2. Flashing Yellow Arrow (details on the next slide)



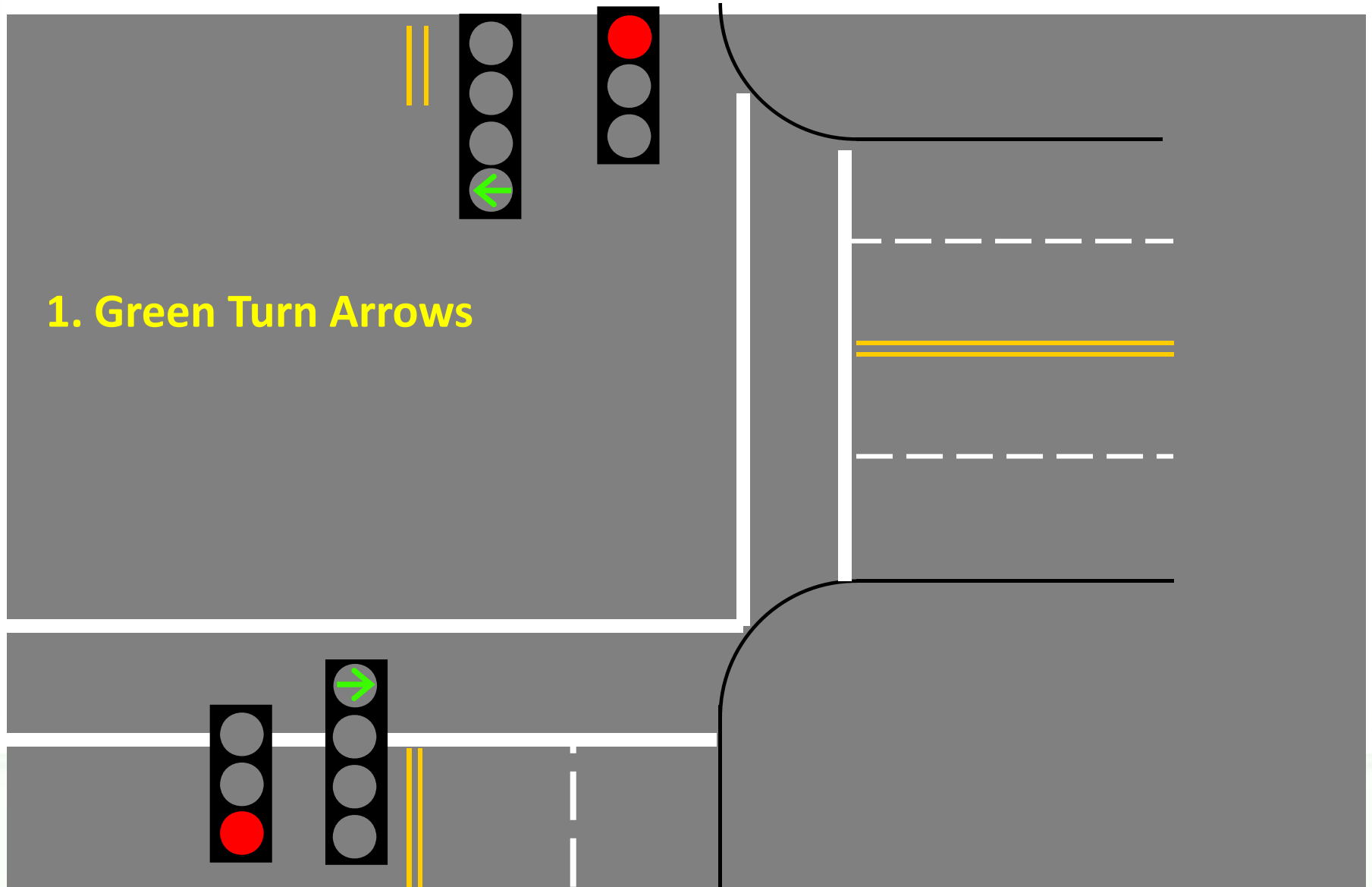
Protected/permissive Left Turns: Solutions

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



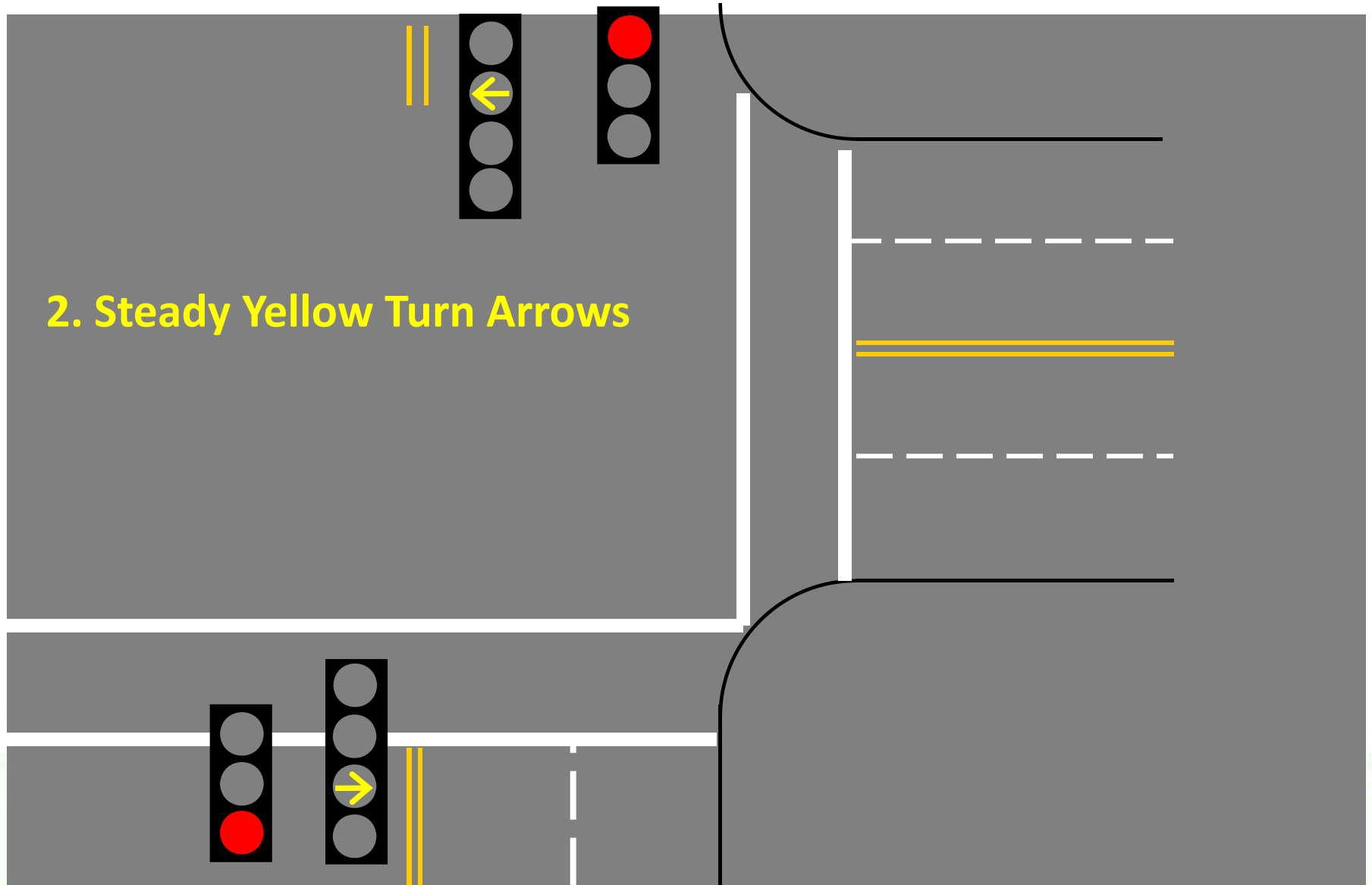
Protected/permissive Left Turns: Solutions

1. Green Turn Arrows

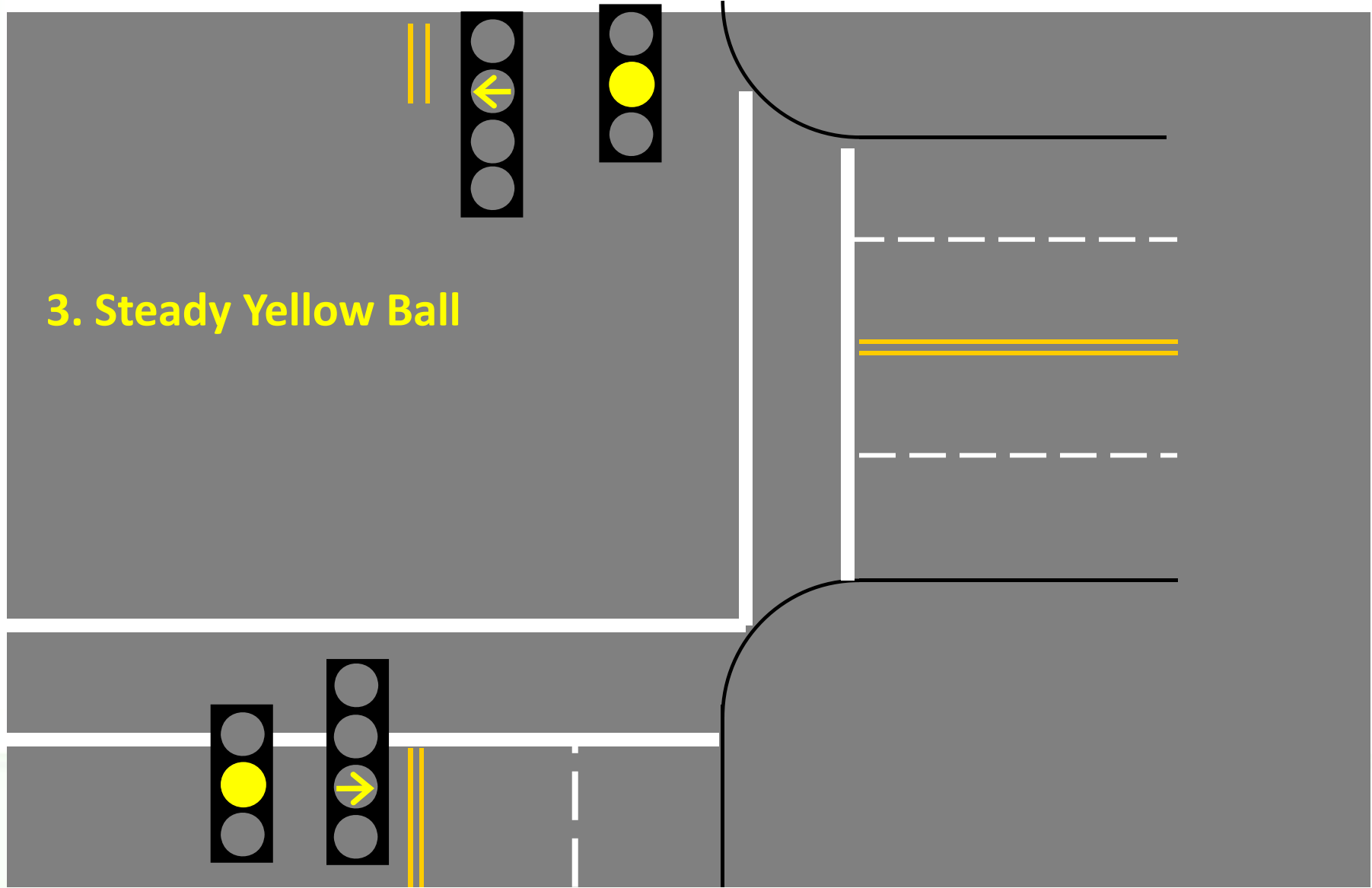


Protected/permissive Left Turns: Solutions

2. Steady Yellow Turn Arrows



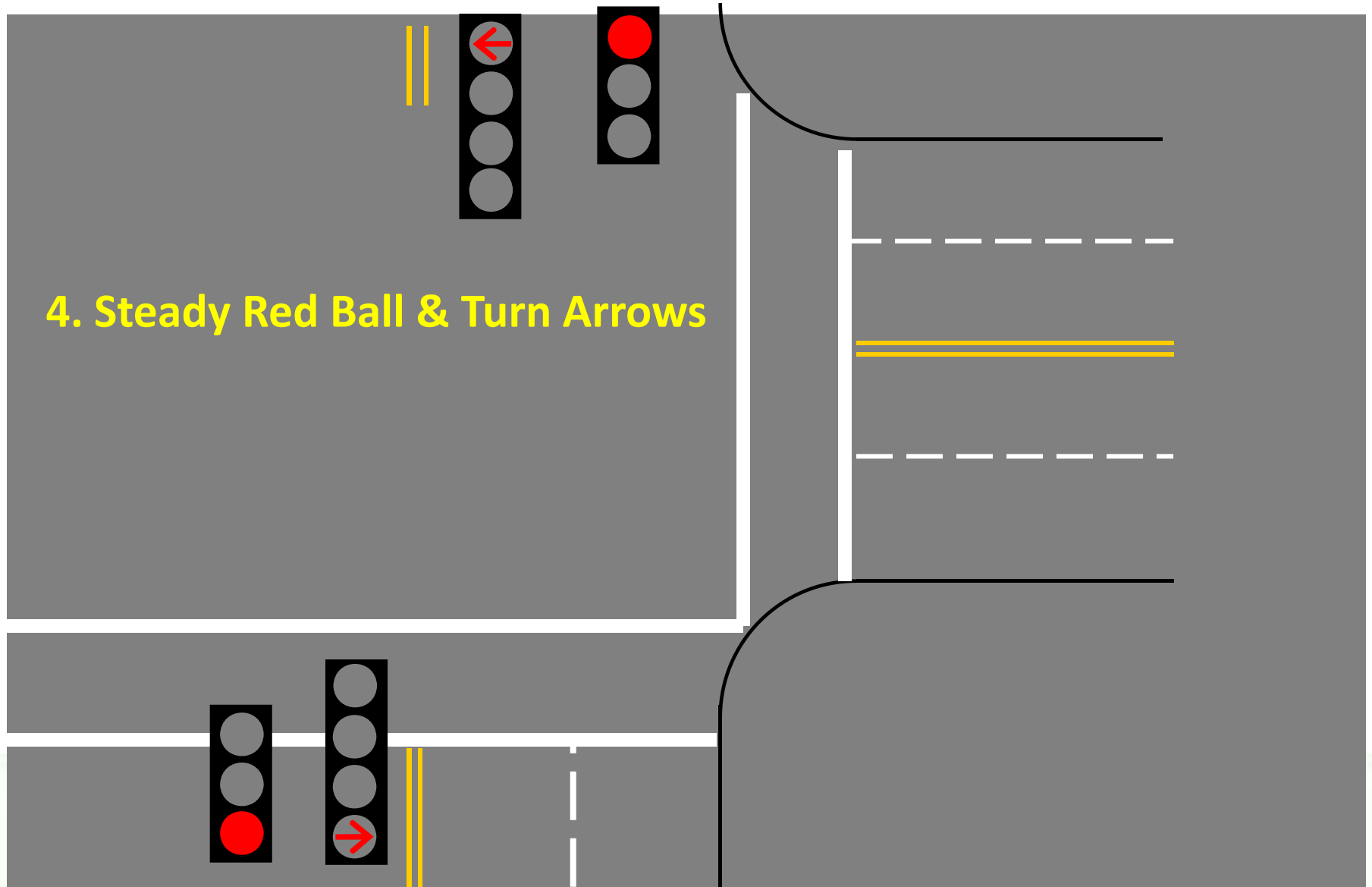
Protected/permissive Left Turns: Solutions



3. Steady Yellow Ball

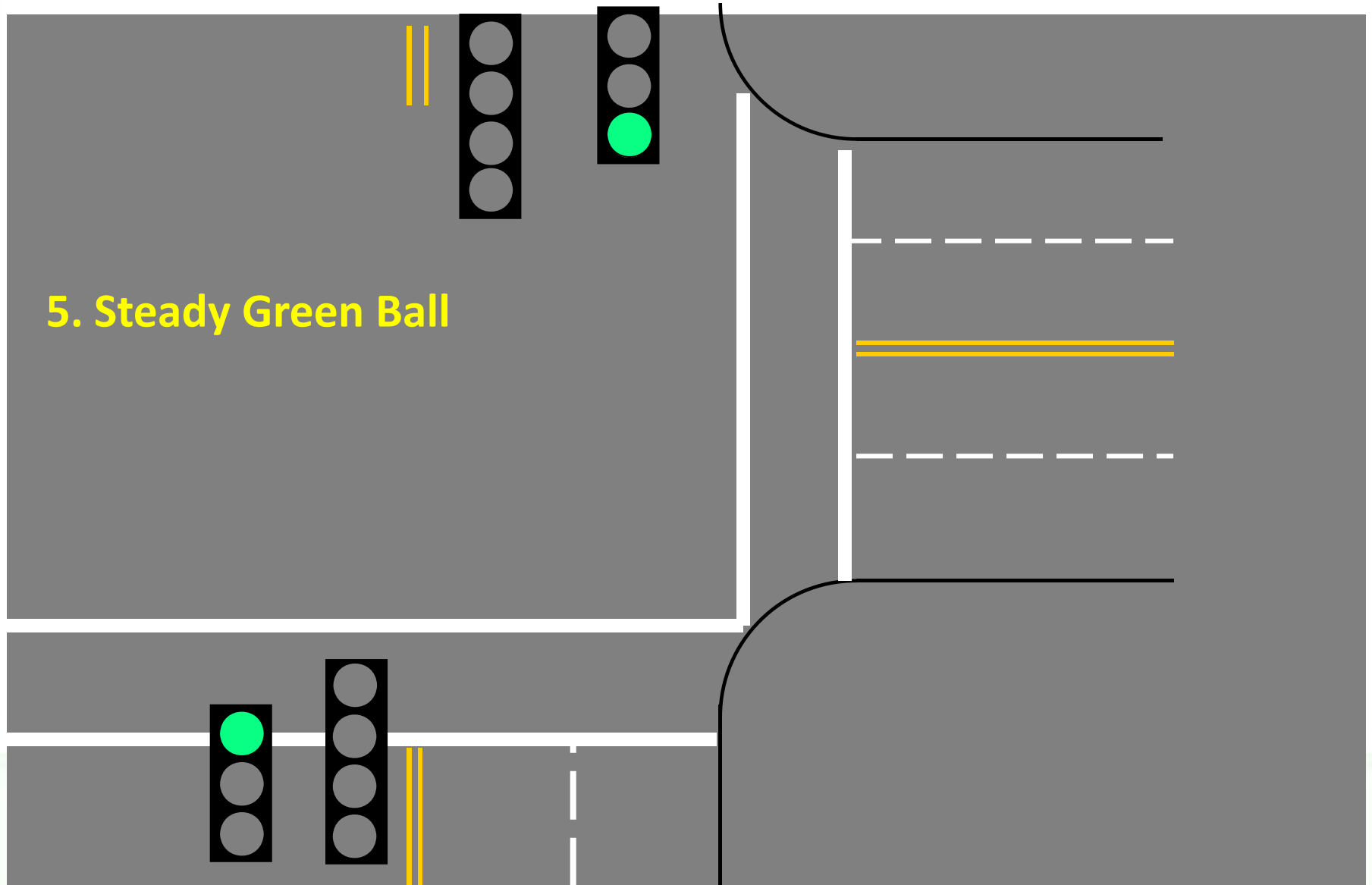
Protected/permissive Left Turns: Solutions

4. Steady Red Ball & Turn Arrows

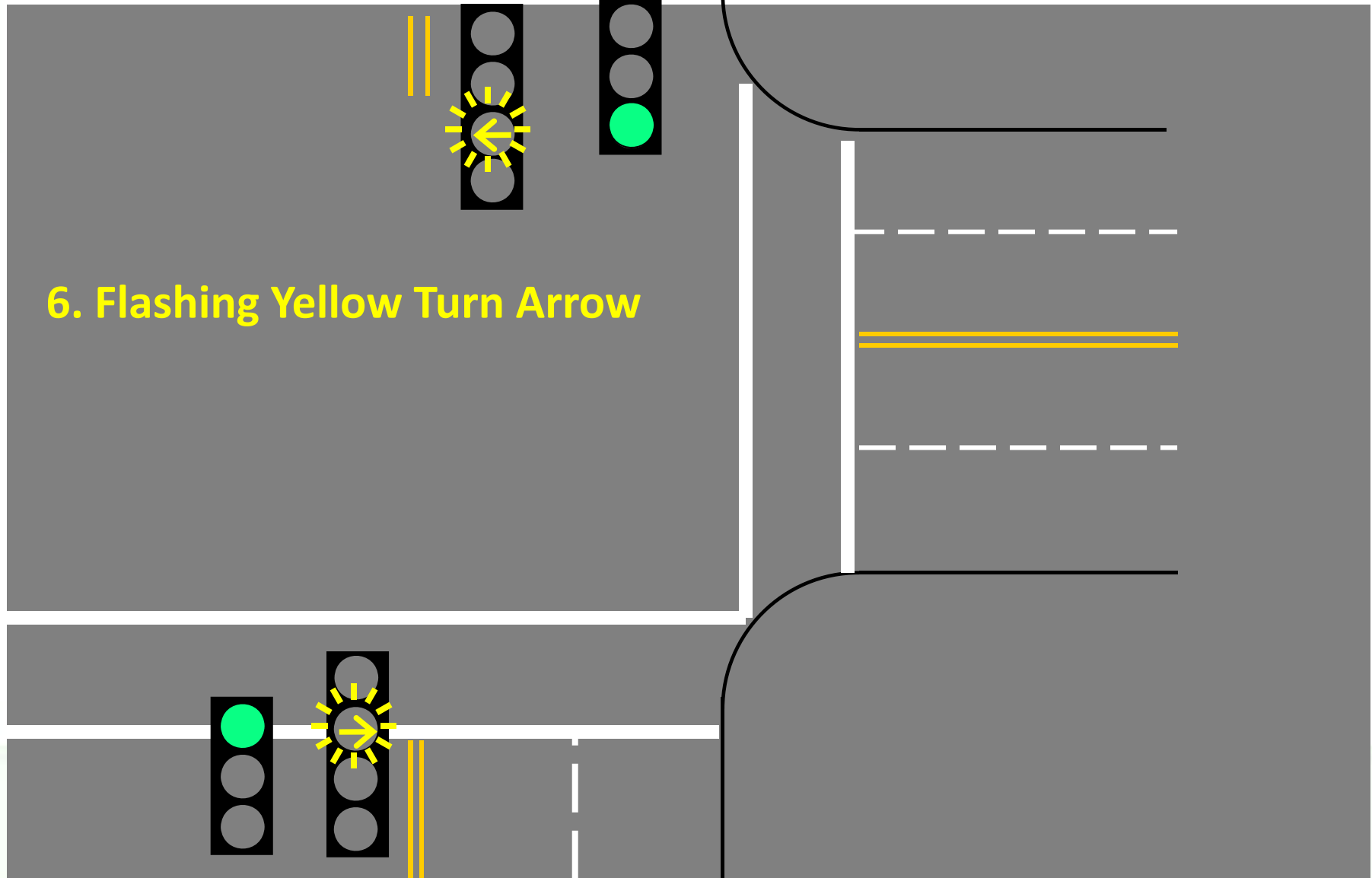


Protected/permissive Left Turns: Solutions

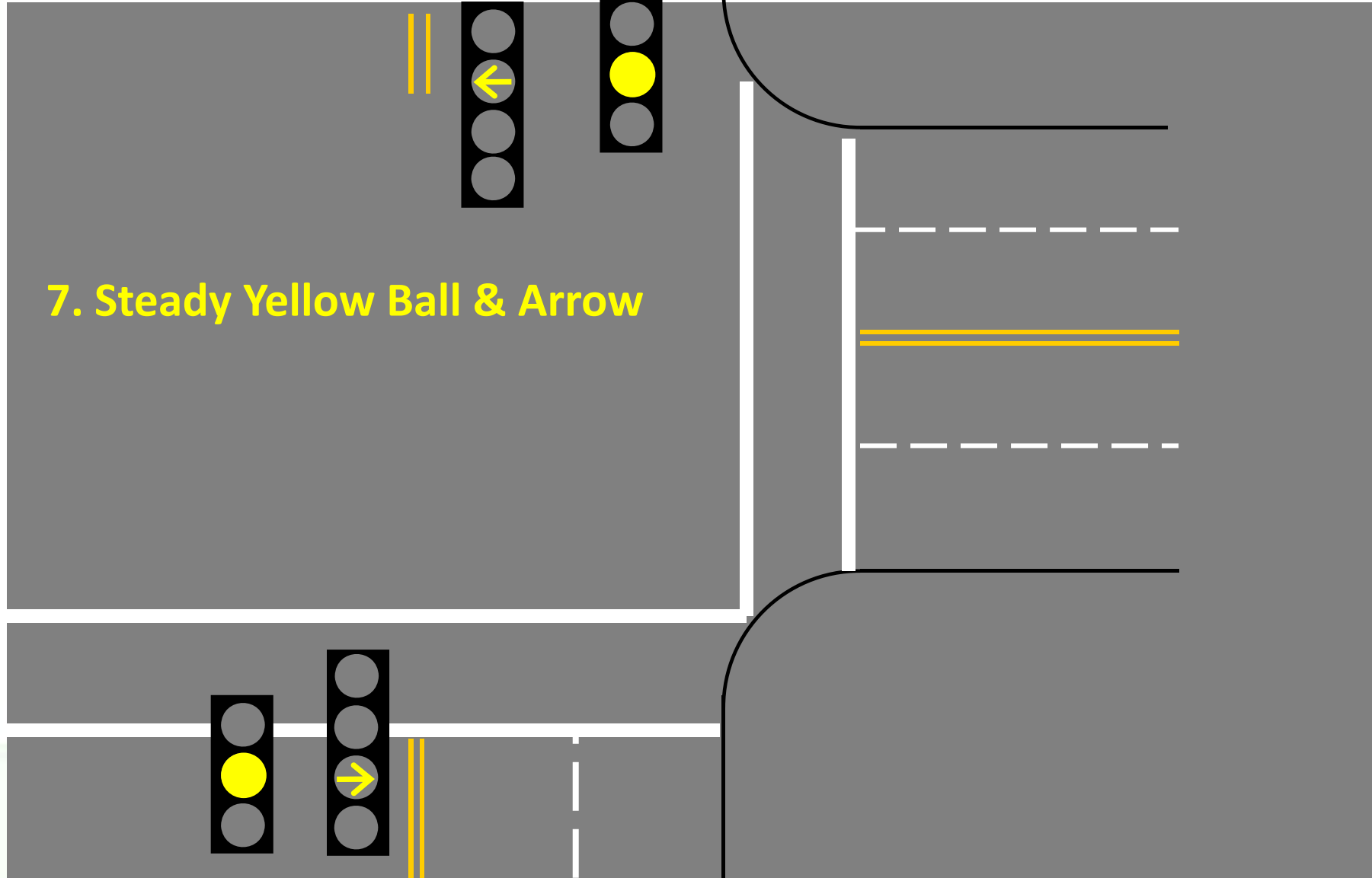
5. Steady Green Ball



Protected/permissive Left Turns: Solutions

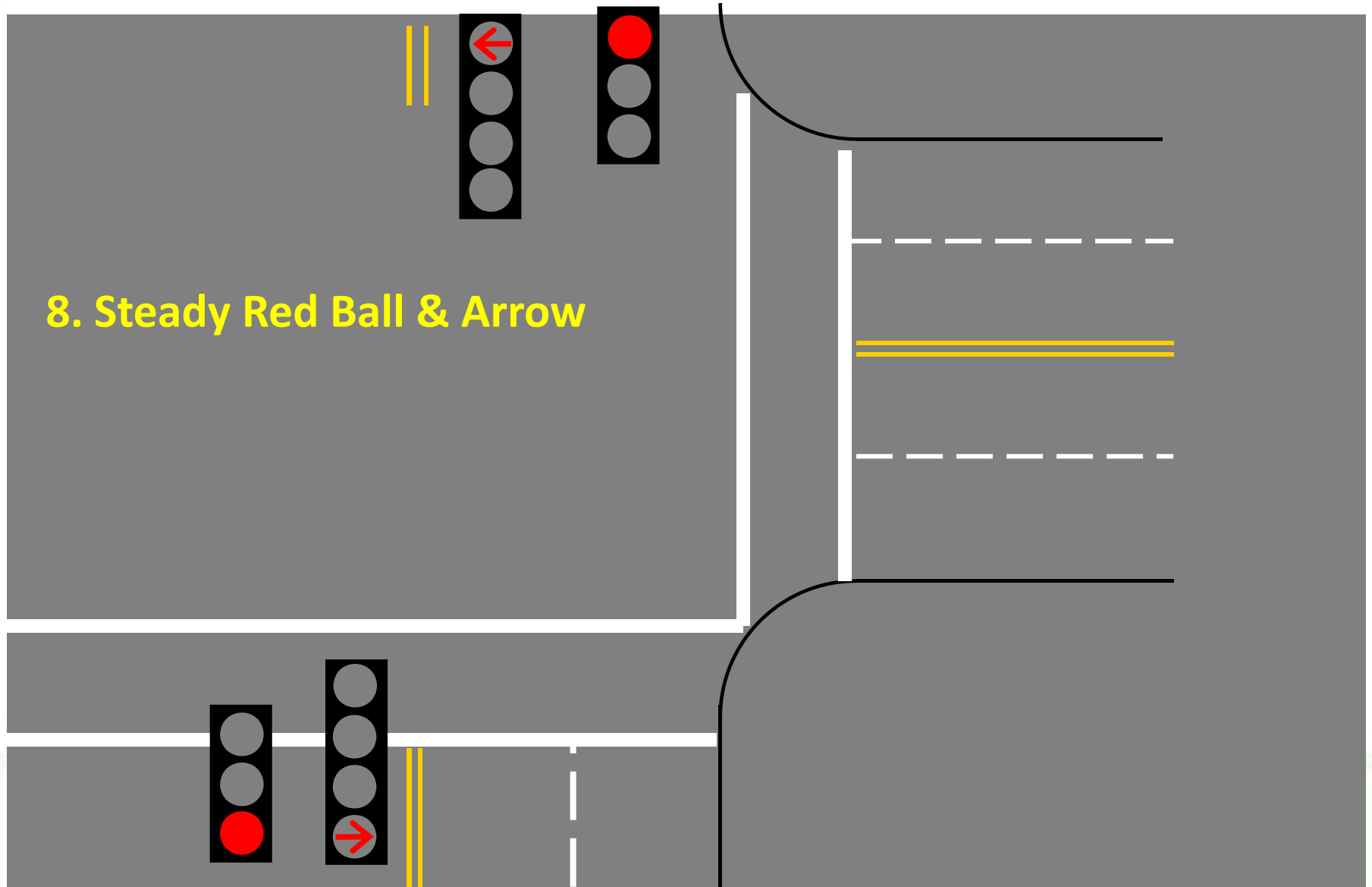


Protected/permissive Left Turns: Solutions



Protected/permissive Left Turns: Solutions

8. Steady Red Ball & Arrow



Discussion

- ⇒ **What are your traffic signal timing policies?**
- ⇒ **Do you use protected left turns to protect pedestrians from turning vehicles?**
- ⇒ **Do you use protected/permissive phasing?**
- ⇒ **If so, have you considered flashing left yellow arrow during the steady green ball?**

Signal Timing To Minimize Pedestrian Delay & Conflicts



Use Short Signal Cycle Length

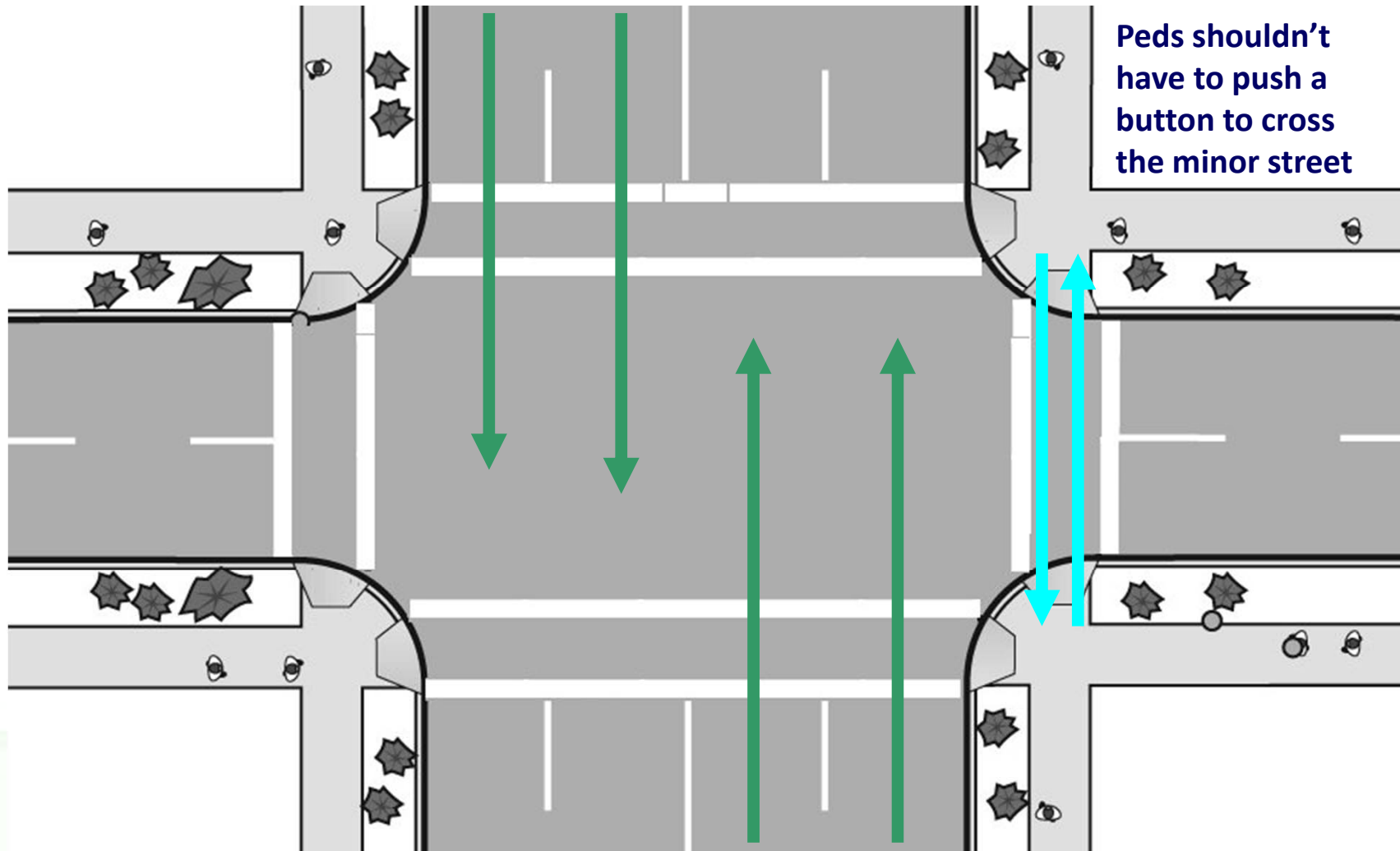


Long wait causes stacking: pedestrians wait in street, or don't wait and cross against the signal



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

Set pedestrian signals 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



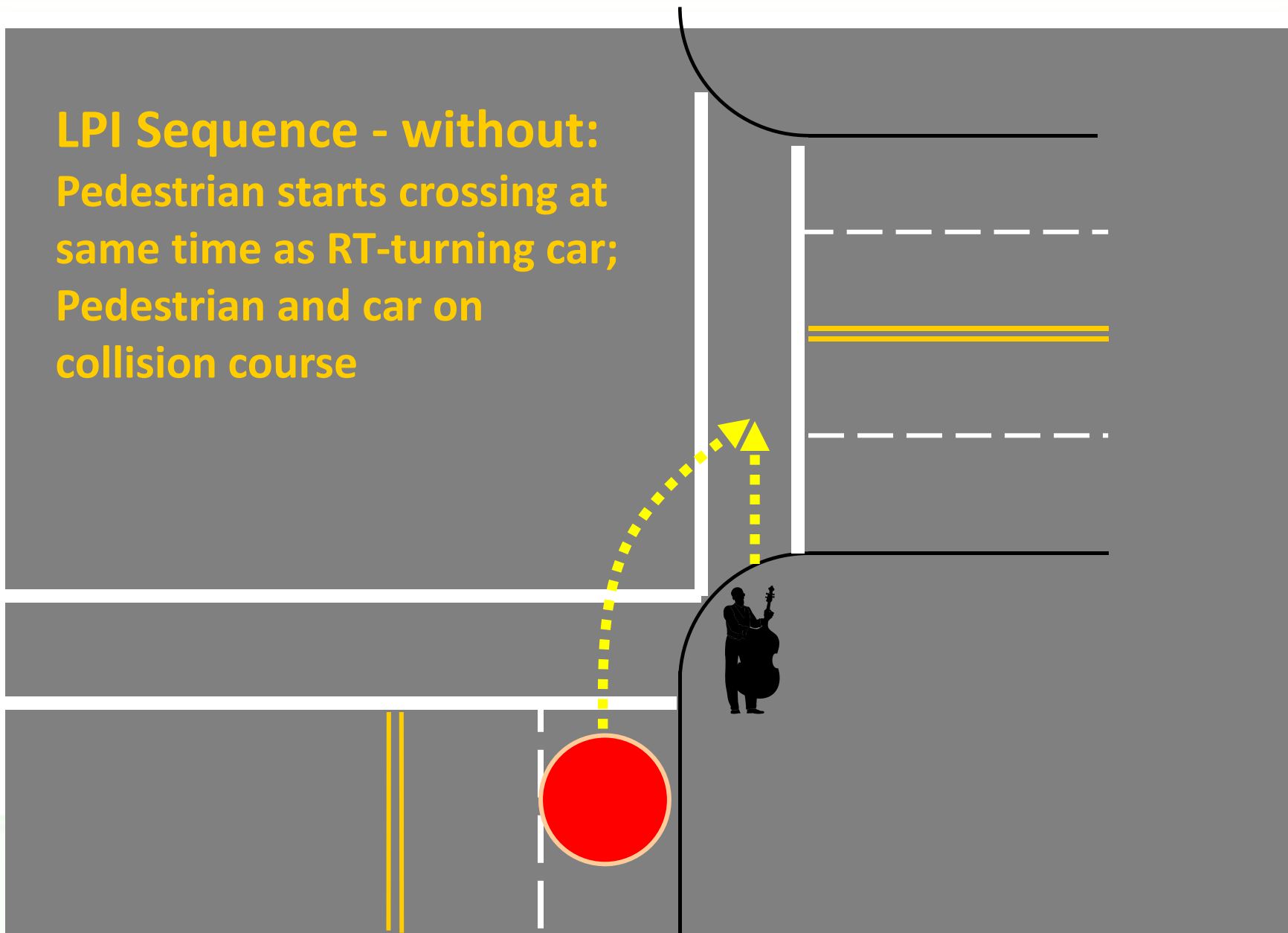
Looks like a regular signal to drivers: green-yellow-red



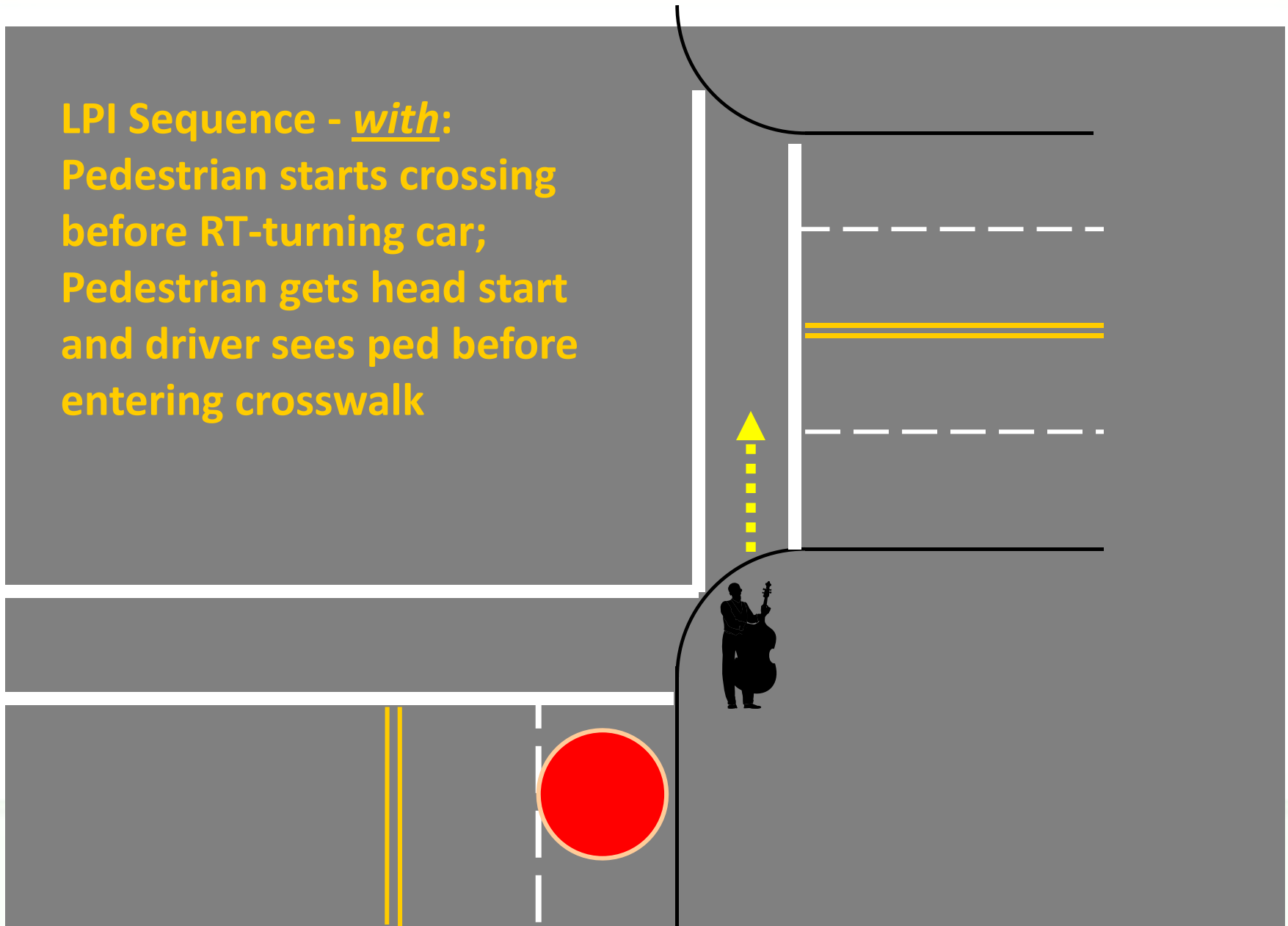


LPI : WALK comes on at least 3 seconds prior to the green signal; pedestrians enter crosswalk before turning vehicles arrive there.

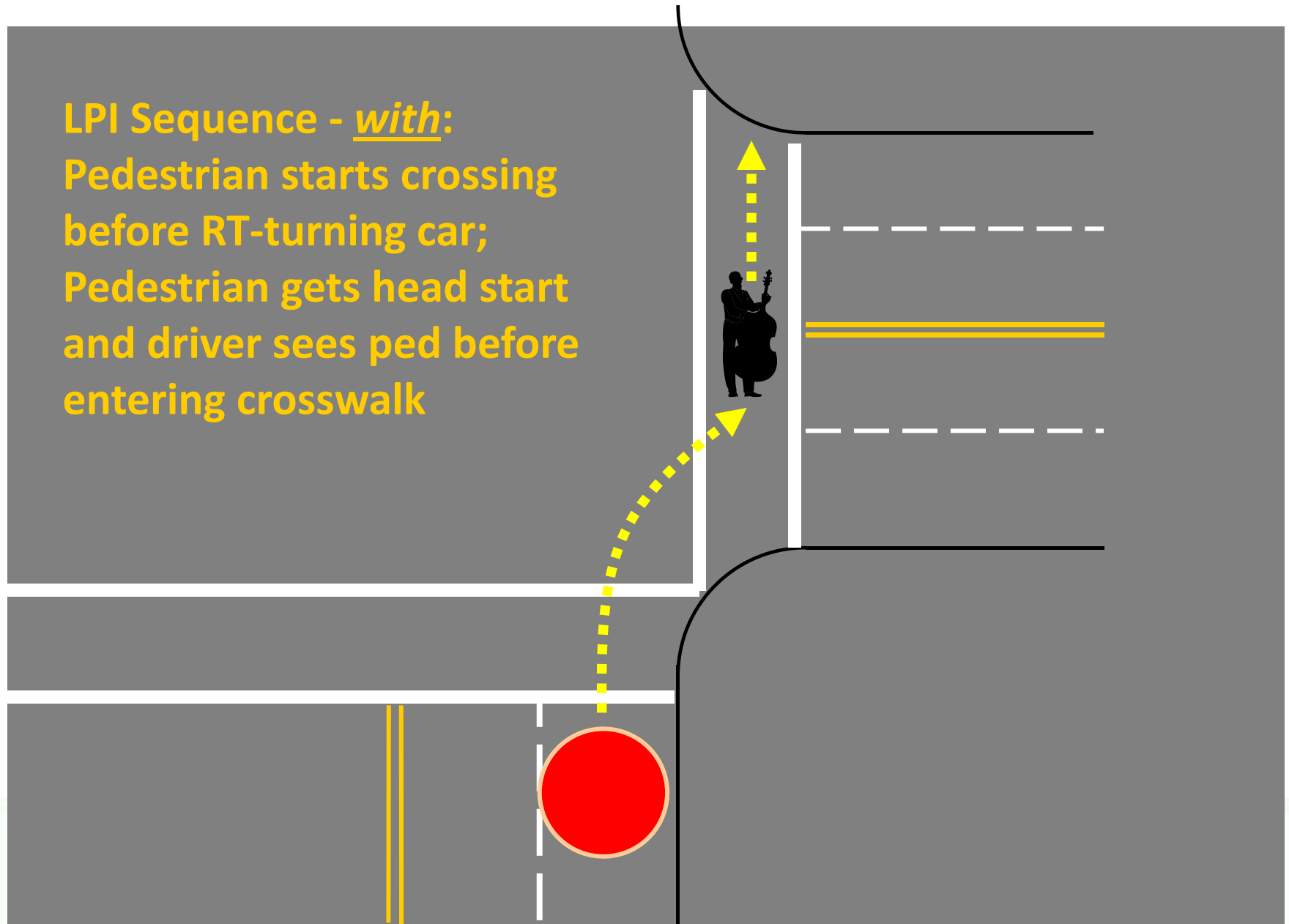
LPI Sequence - without:
Pedestrian starts crossing at
same time as RT-turning car;
Pedestrian and car on
collision course



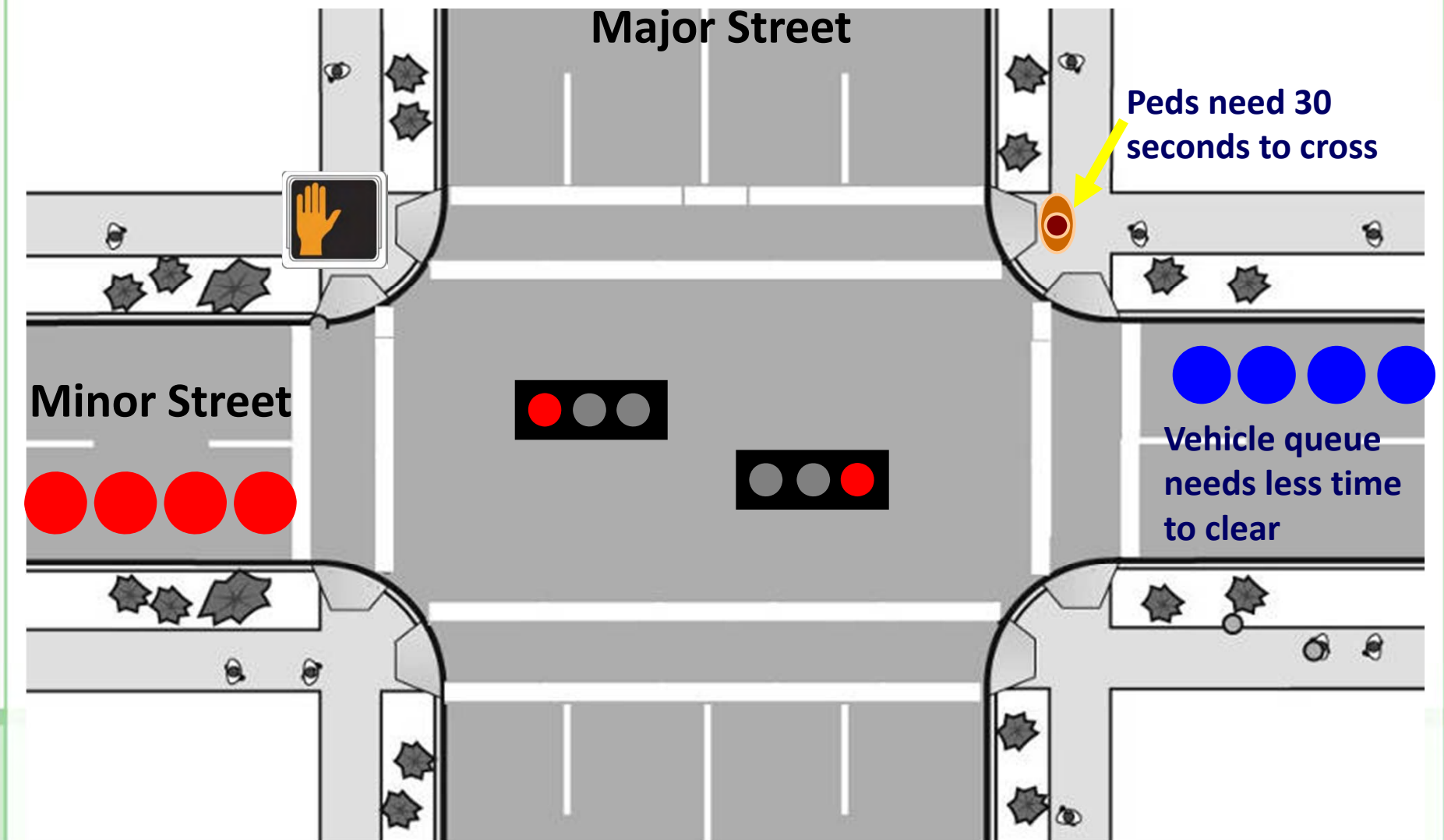
LPI Sequence - with:
Pedestrian starts crossing
before RT-turning car;
Pedestrian gets head start
and driver sees ped before
entering crosswalk



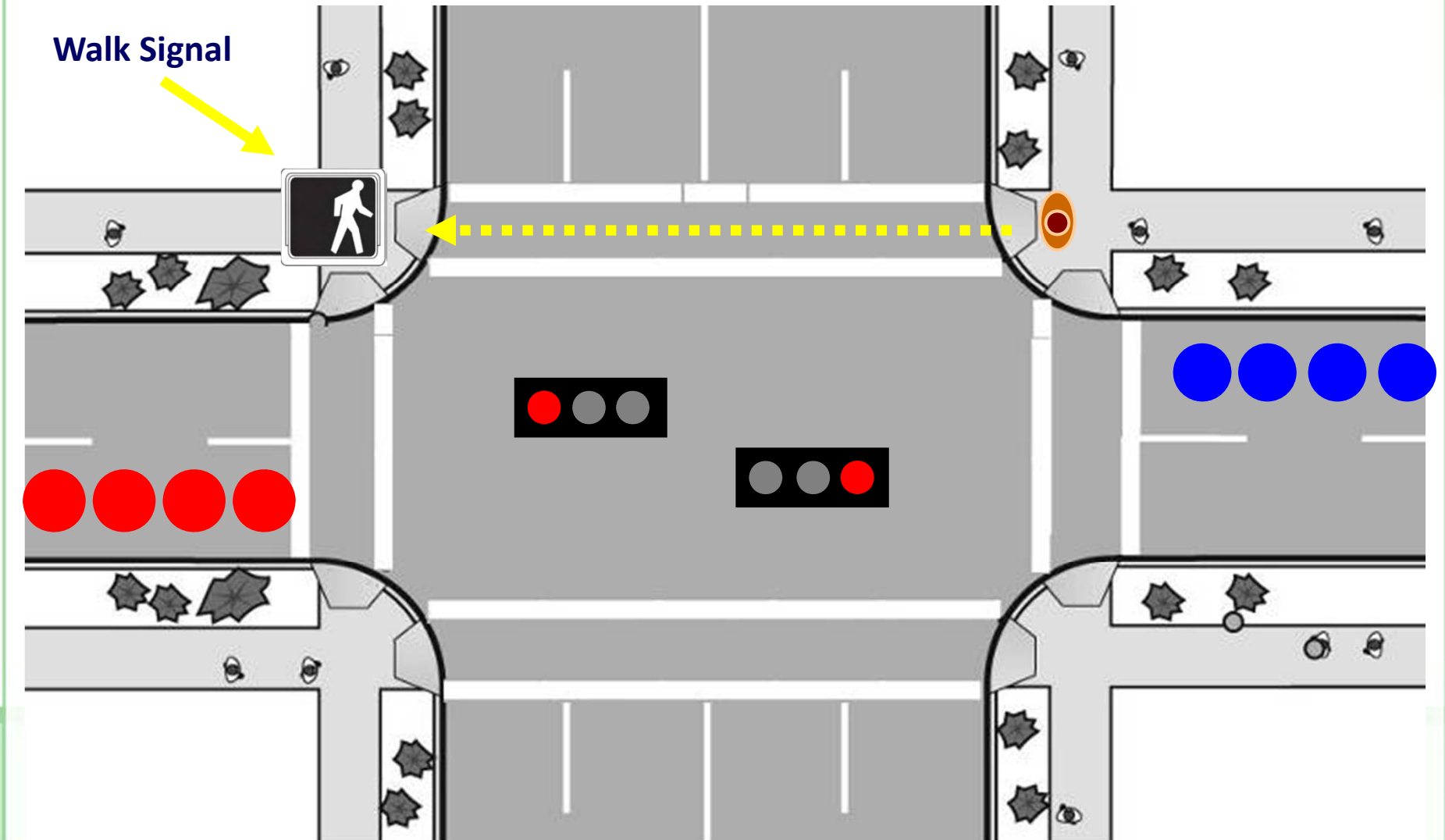
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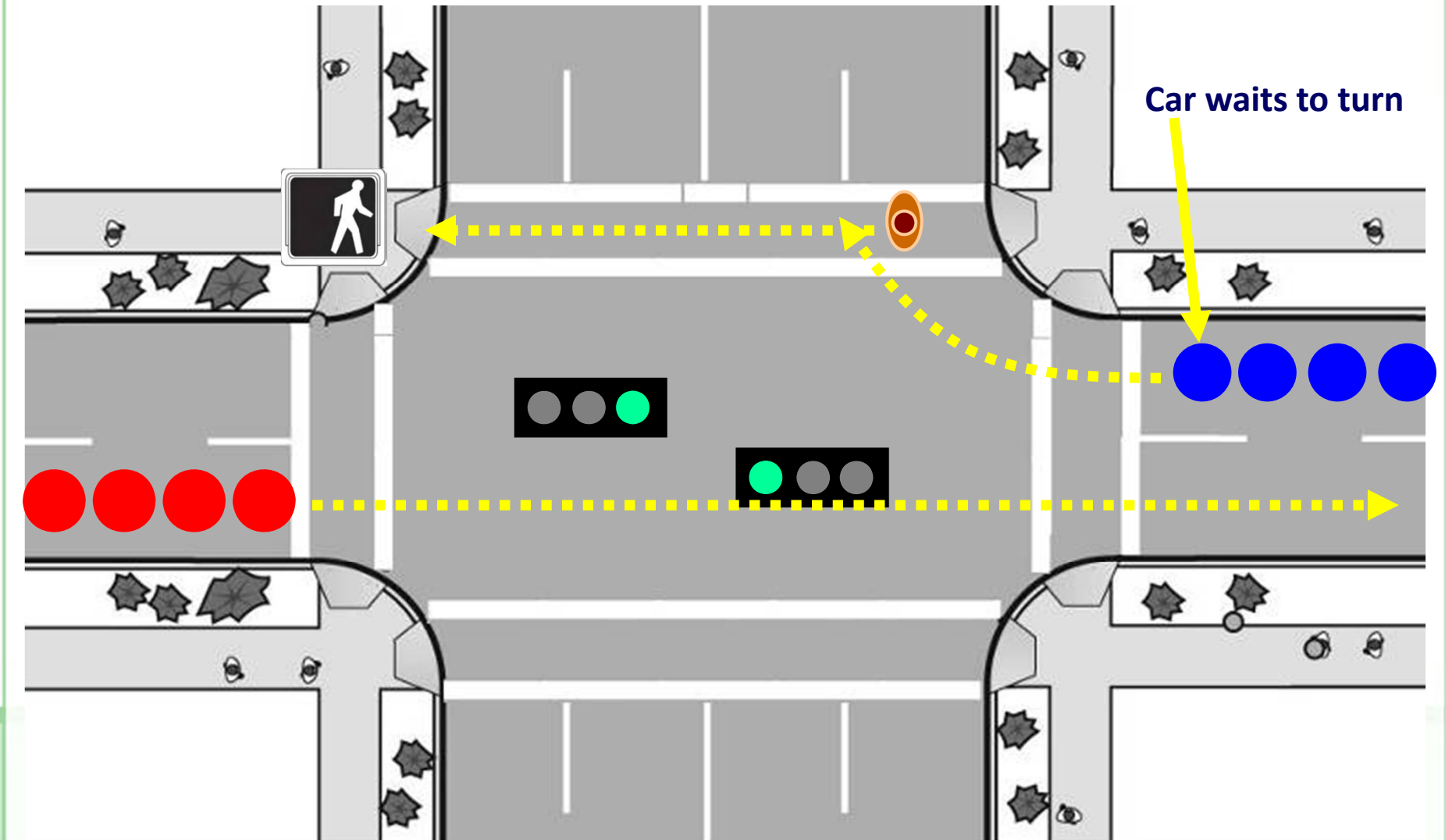
Where do the extra 3-5 seconds come from?



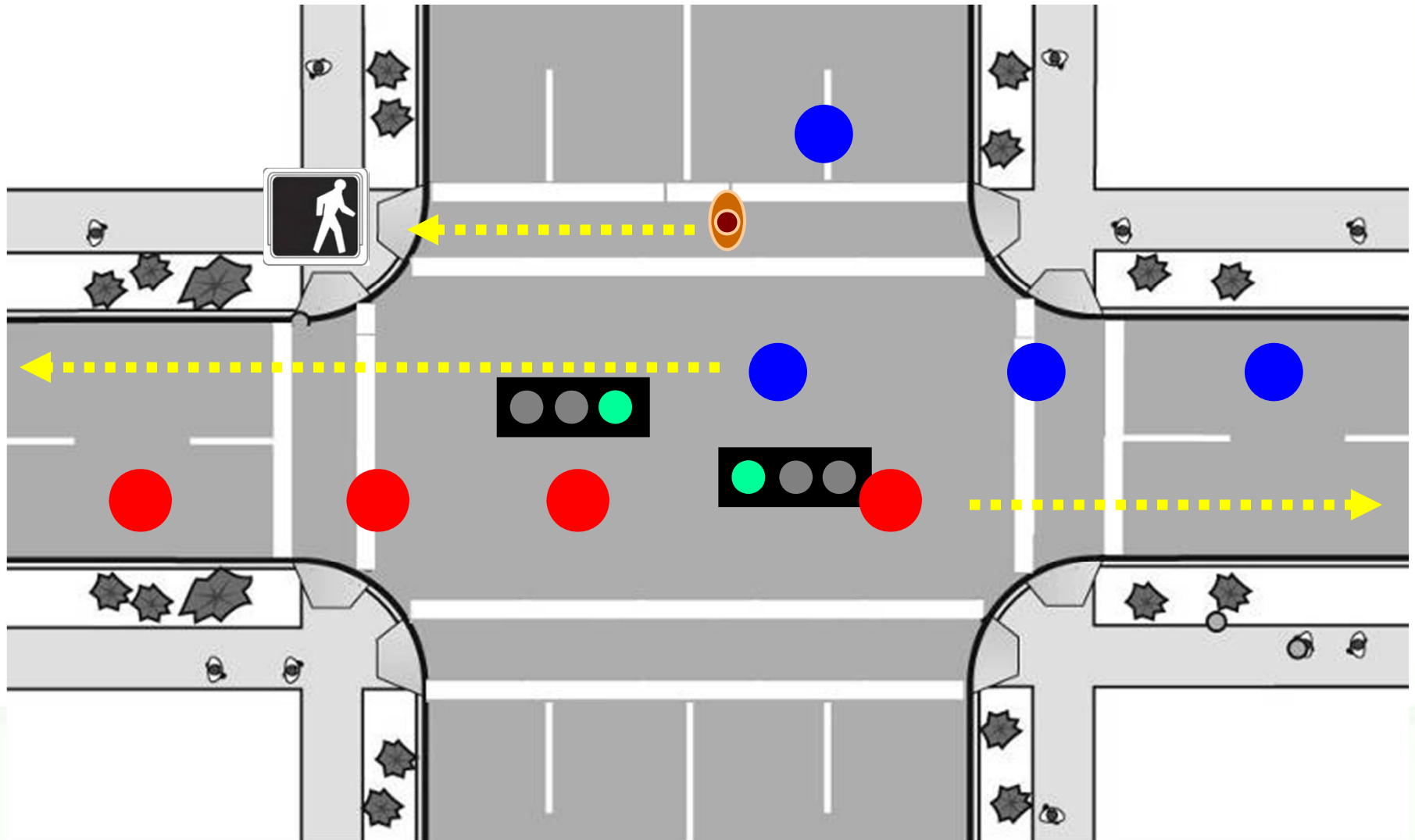
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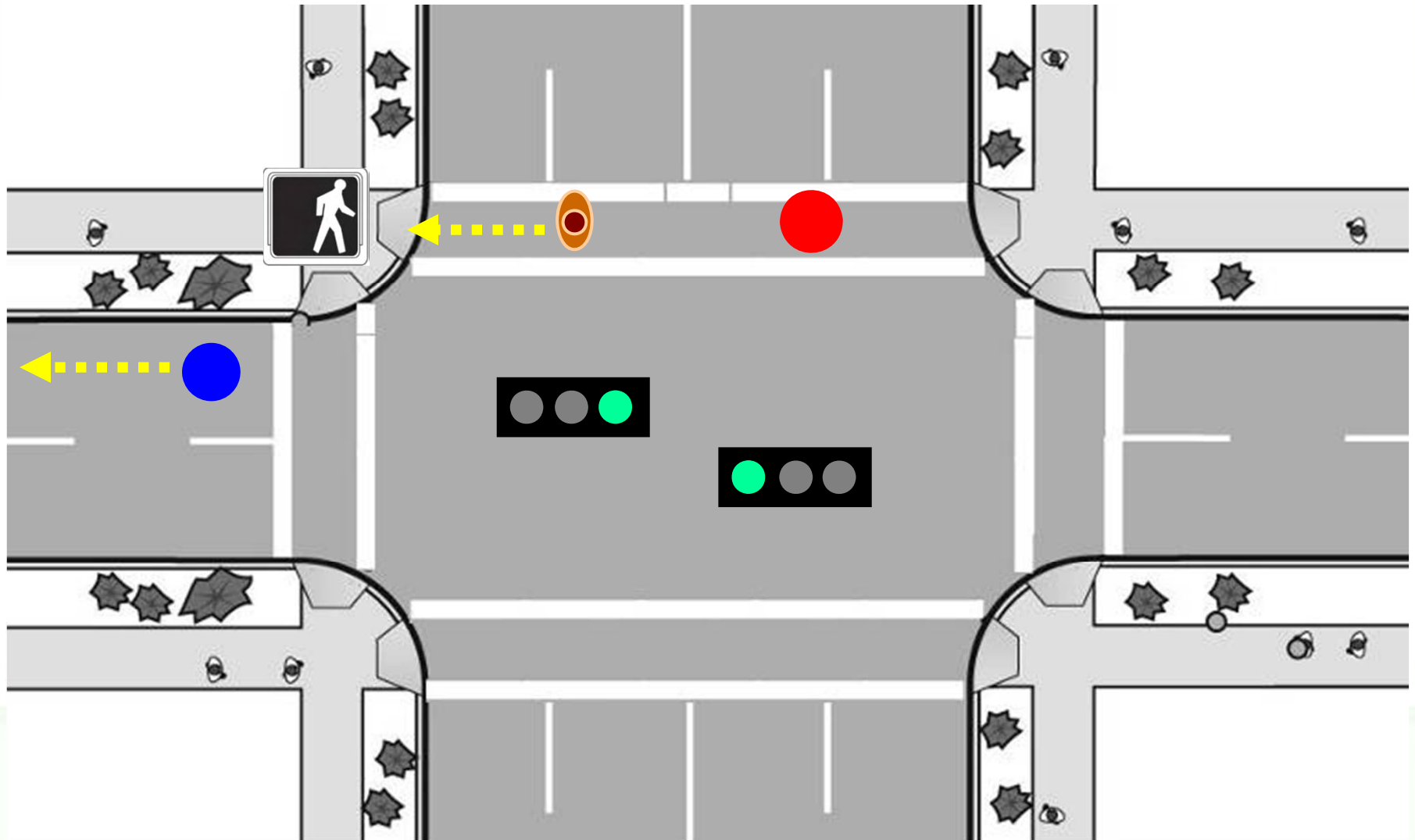
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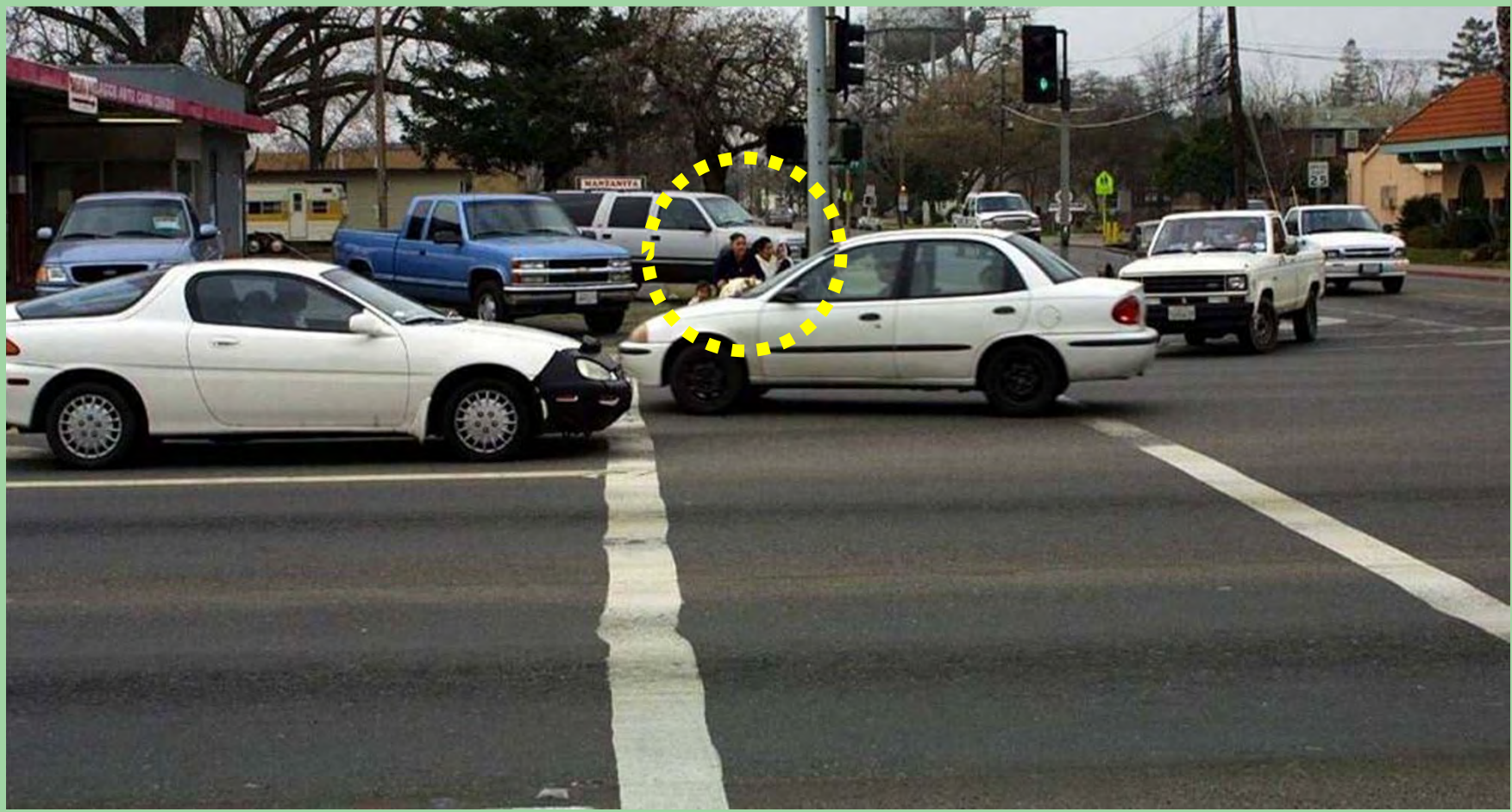


Where do the extra 3-5 seconds come from?



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%

Simple & Innovative Ideas To Minimize Pedestrian Conflicts

Signs: Remind Turning Drivers to Yield to Peds

Older local variations, using MUTCD-approved lettering and symbols:



Leesburg, FL



Juneau, AK



Orlando, FL

Signs: Remind Turning Drivers to Yield to Peds



Old MUTCD R10-15



R10-15 in
2009 MUTCD

Restricting Turns on Red

- ⇒ Consider No Turn on Red signs where there is:
- 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



Restricting Turns on Red

1. At all times



Restricting Turns on Red

2. When pedestrians are present
 - Difficult to enforce



Restricting Turns on Red

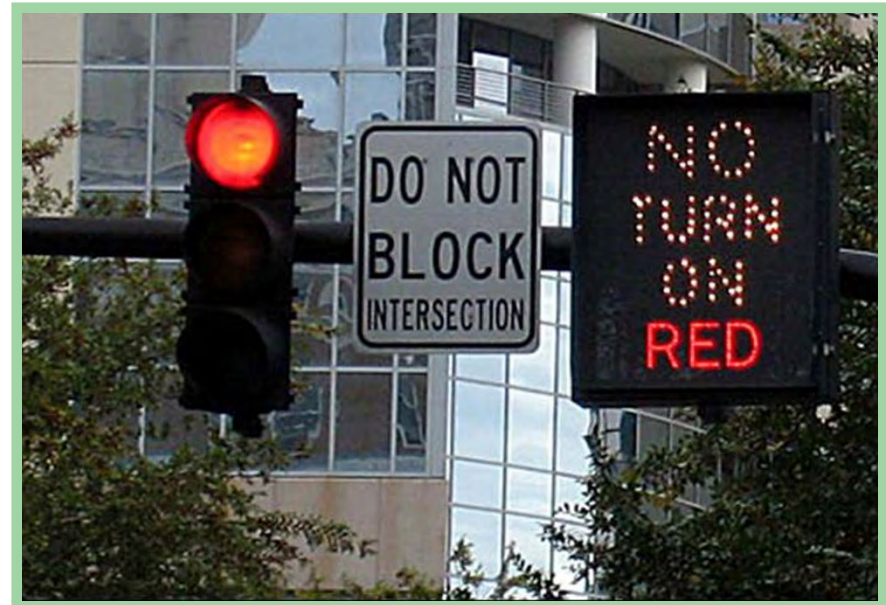
3. By time of day

- Limits most turns on red



Restricting Turns on Red

4. Changeable message sign – can be activated 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



Exclusive Pedestrian Phase (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



Pedestrians wait for traffic in other direction



Reward: pedestrians can cross in any direction



- ⇒ Exclusive pedestrian phase increases safety (CRF 34%) but decreases efficiency of intersection
- ⇒ Use where there are high ped volumes and many turning vehicles

Using ITS to Help Pedestrians



- ⇒ 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



Microwave sensors are aimed at the crosswalks to track peds



**Pedestrian clearance
is timed @ 4 ft/sec**



**The sensor tracks peds as
they cross the street**

- ⇒ **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.**



Learning Outcomes

You should now be able to:

1. Explain why traffic signals don't "guarantee" safety; they assign the right of way
2. Identify major conflicts: concurrent turn movements
3. Select protected turns to improve ped safety
4. Identify signal timing techniques that favor pedestrian crossing

Questions?

⇒ For more information see archived TRB Webinar:

Accommodating Pedestrians at Signalized Intersections

[https://www1.gotomeeting.com/
register/622595628](https://www1.gotomeeting.com/register/622595628)