

TRAFFIC SIGNALS:

FLASHING YELLOW ARROW

**LEADING PEDESTRIAN
INTERVAL (LPI)**

DPS 201

FLASHING YELLOW ARROW (FYA)

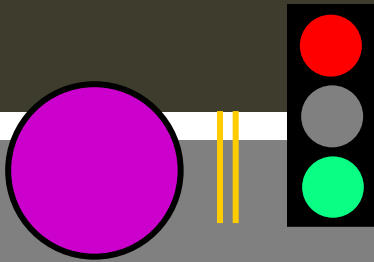
DPS 201

PROTECTED VS. PERMISSIVE LEFT TURNS

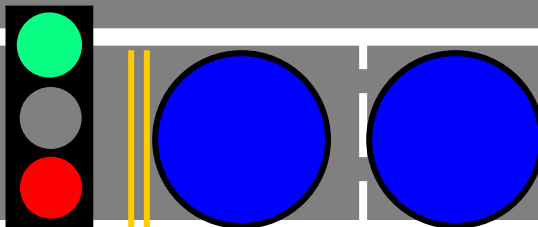
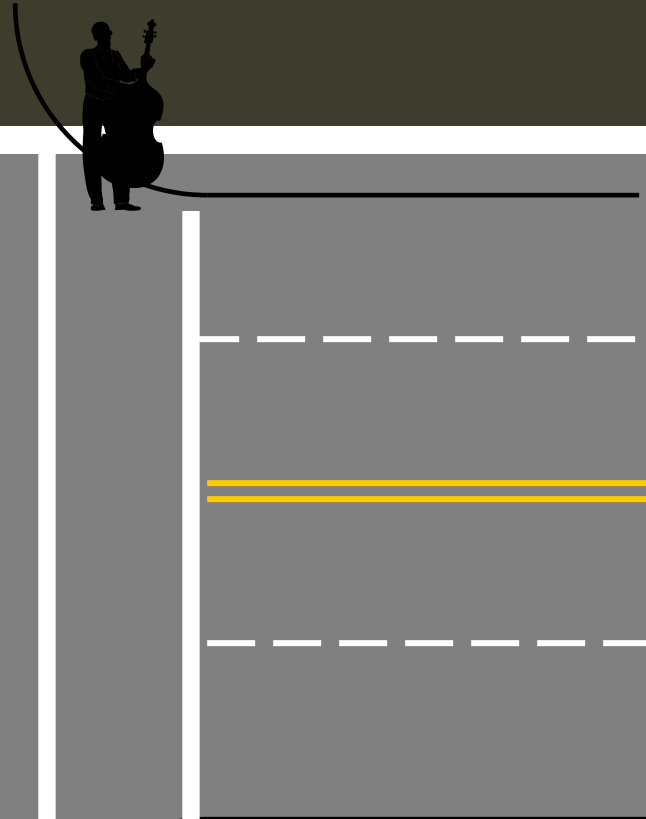


* **CMF = 0.3 (CRF 70%) (all crashes) converting permissive left turns to protected only left turns**

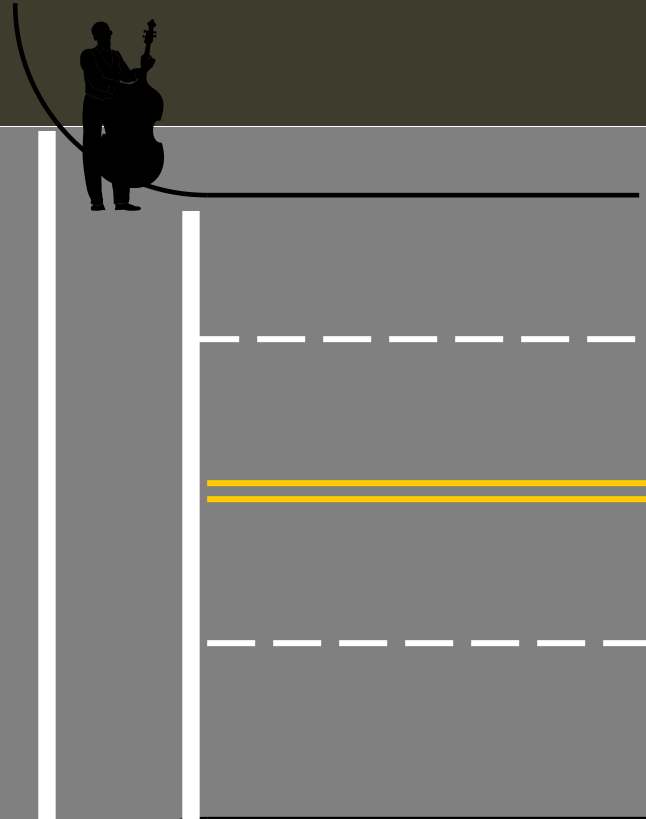
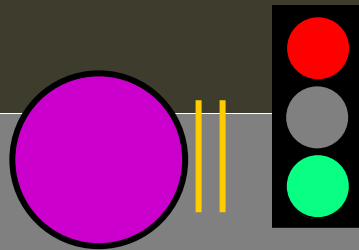
PERMISSIVE LEFT TURNS



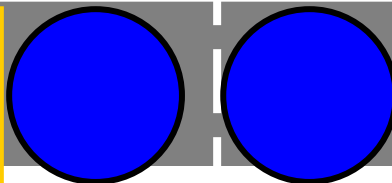
**Pedestrians cross at same
time as left-turning car;
Drivers turning left on a green
ball don't look for pedestrians.**



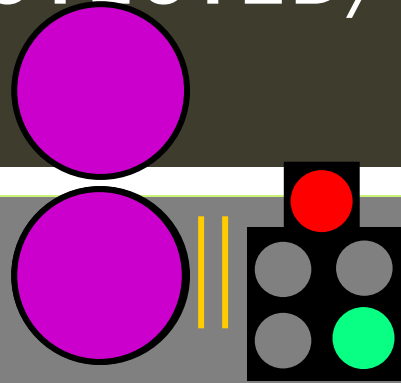
PROTECTED LEFT TURNS



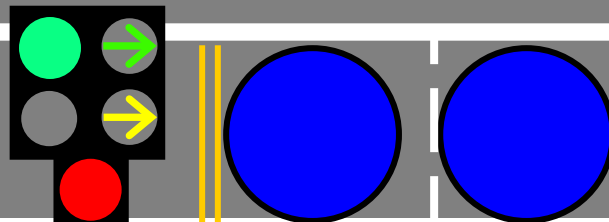
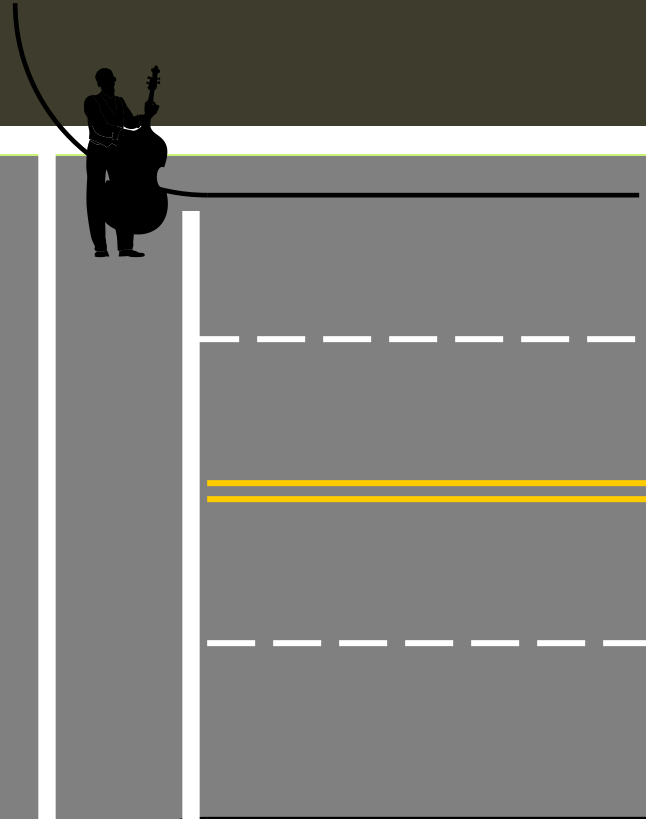
Pedestrians cross after left-turning car, with thru-traffic;
Pedestrian and car not in conflict



PROTECTED/PERMISSIVE LEFT TURNS

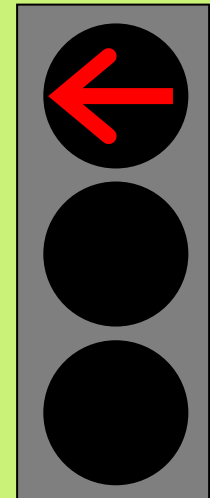
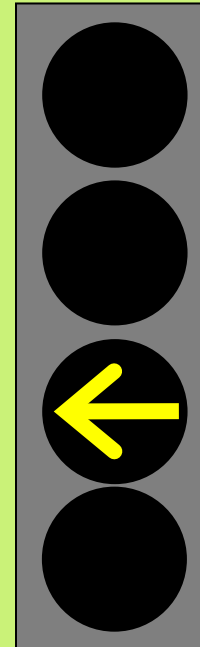


Pedestrians cross after most left-turning cars (protected phase);
Pedestrian and remaining cars are in conflict (permissive phase)



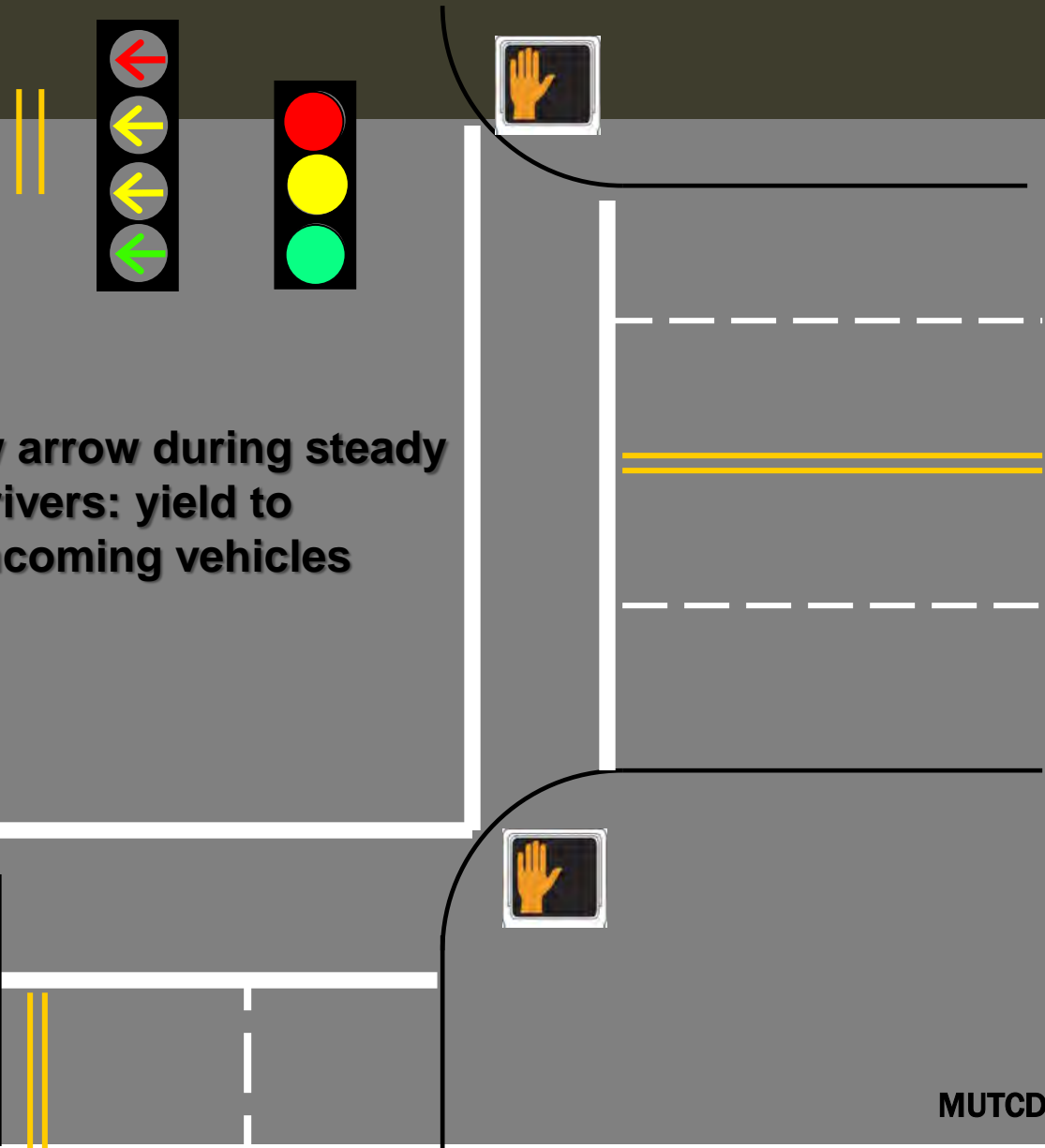
PROTECTED/PERMISSIVE LEFT TURNS: SOLUTIONS

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



FLASHING YELLOW ARROW

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



CASE STUDY: 12TH ST AND NORTHERN AVE FOUNDATION FOR BLIND CHILDREN



PROTECTING PEDESTRIANS FROM LEFT TURNERS



PROTECTING BLIND PEDESTRIANS FROM LEFT TURNS



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PROTECTING PEDESTRIANS FROM LEFT TURNERS



PUSHBUTTON ACTUATES PROTECTED LEFT-TURN ARROW – ELIMINATES PEDESTRIAN CONFLICT



LEADING LEFT-TURN ARROW



FOLLOWED BY **RED** LEFT-TURN ARROW DURING WALK



PROTECTING PEDESTRIANS FROM LEFT TURNERS



LEADING PEDESTRIAN INTERVAL (LPI)

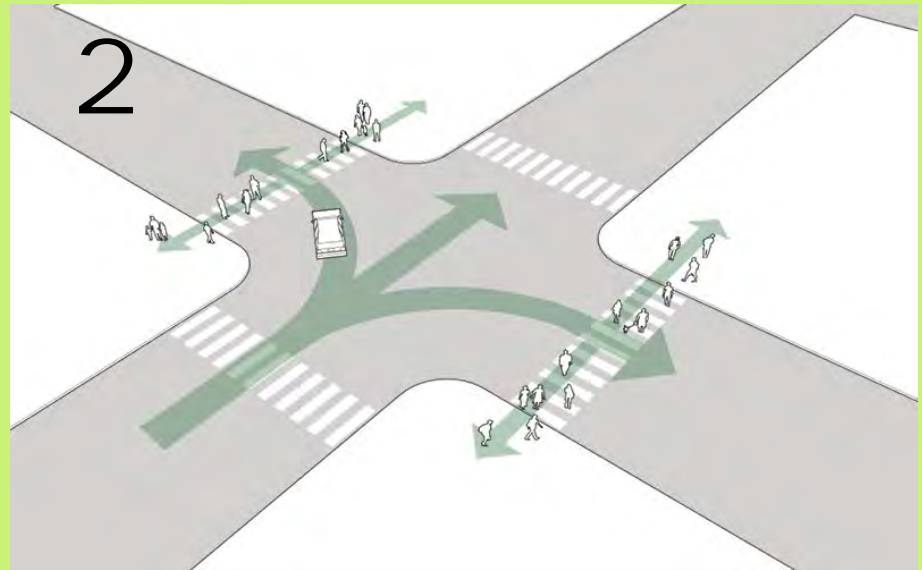
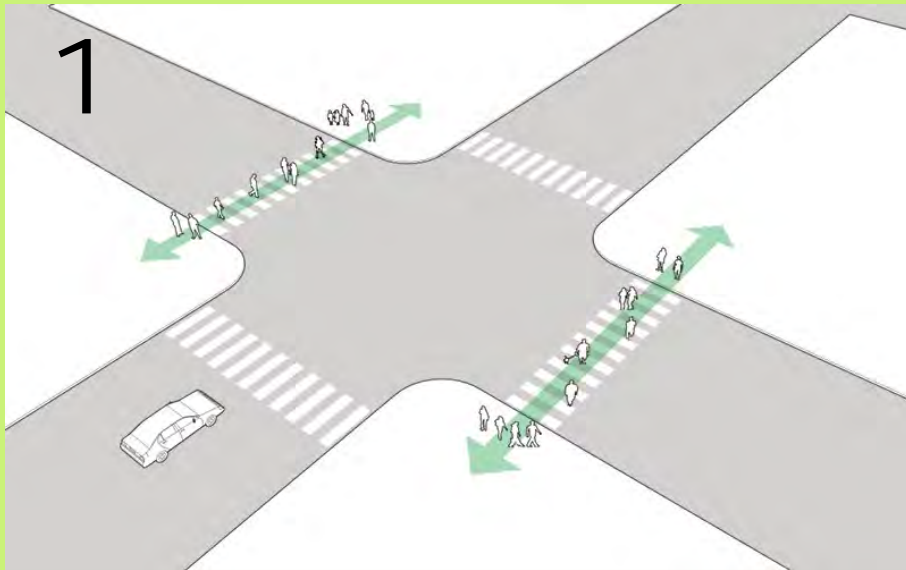
DPS 201

WHAT'S AN LPI?

Leading Pedestrian Interval



HOW THE LPI WORKS



NACTO

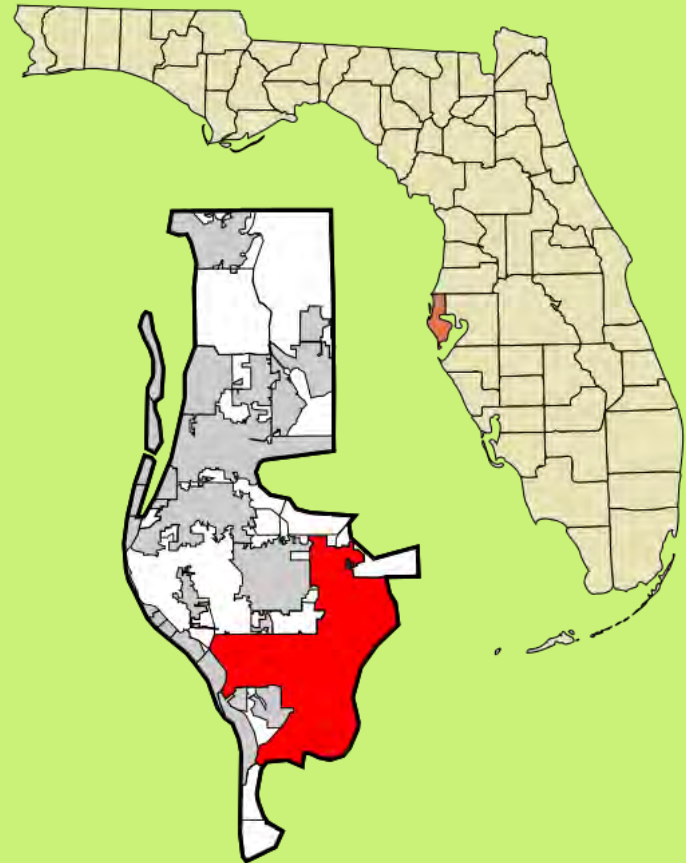
WHY – GETS PEDESTRIANS ESTABLISHED IN CROSSWALK



CASE STUDY: LPI (ST. PETERSBURG, FL)

Problem/Background

- High rate of collisions between left-turning motorists and pedestrians during WALK interval
- LPI - 3 intersections
- Pedestrian crossings averaged 60 per hour
- No public outreach / awareness to ensure unbiased results



CASE STUDY: LPI (ST. PETERSBURG, FL)

Details

- Installed 3-second LPI
- Study pedestrian behavior and conflicts with turning vehicles
- Each street had four lanes & high traffic volume
- 30 mph posted speed
- Data collected for:
 - pedestrian/motor vehicle conflicts
 - pedestrians beginning to cross during the 5-second period at the start of the WALK interval
 - pedestrians starting to cross during the remainder of the WALK interval



CASE STUDY: LPI (ST. PETERSBURG, FL)

Results

- Conflicts virtually eliminated for pedestrians departing during start of the WALK interval
 - Before: average of 2-3 conflicts per 100 pedestrians
 - After: no observation period had more than 2 conflicts per 100 pedestrians & 34 of the 41 periods had no conflicts
- Smaller reduction in conflicts during the remainder of the WALK interval
- Four months after installation, no reduction in effectiveness


LEADING PEDESTRIAN INTERVAL - SAFETY



- **2018 FHWA Study: 13% reduction in pedestrian/vehicle crashes (Goughnour, et al.)**
- **ITE Toolbox: Modify signal phasing to implement LPI - associated with a 5% decrease in pedestrian crashes.**
- **Penn State Pre/Post Evaluation: 58% reduction in pedestrian-vehicle crashes at treated intersections.**
- **Reference**
 - **Institute of Transportation Engineers (2004). Toolbox of Countermeasures and Their Potential Effectiveness to Make Intersections Safer, Briefing Sheet 8, FHWA.**
 - **Orlando, FL study (2000)**
 - **CMF Star Rating for FHWA 2018 study: Five Stars**
 - **“Safety Effectiveness of Leading Pedestrian Intervals Using the Empirical Bayes Method” (2009)**

CMF (CRF)

■ CRF 58% pedestrian crashes


CRASH MODIFICATION FACTORS CLEARINGHOUSE

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▼ Countermeasure: Modify signal phasing (implement a leading pedestrian interval)


<input type="checkbox"/>	CMF	CRF(%)	Quality	Crash Type	Crash Severity	Area Type	Reference	Comments
<input type="checkbox"/>	0.413	58.7	★★★★☆	Vehicle/pedestrian	All	Urban	Fayish and Gross, 2009	Pedestrian crossing volumes reached nearly ... [read more]

Manual on Uniform Traffic Control Devices

for Streets and Highways

2009 Edition



 U.S. Department of Transportation
Federal Highway Administration

MUTCD

Section
4E.06
Pedestrian
Intervals
and Signal
Phases

MUTCD OPTION

- At intersections with high pedestrian volumes and high conflicting turning vehicle volumes, a brief leading pedestrian interval, during which an advance WALKING PERSON (symbolizing WALK) indication is displayed for the crosswalk while red indications continue to be displayed to parallel through and/or turning traffic, may be used to reduce conflicts between pedestrians and turning vehicles.



**Section 4E.06,
Paragraph 19**

MUTCD GUIDANCE

ACCESSIBLE PEDESTRIAN SIGNALS

- **Guidance:**

If a leading pedestrian interval is used, the use of accessible pedestrian signals (see Sections 4E.09 through 4E.13) should be considered.

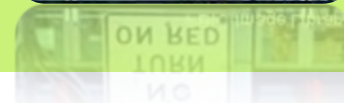
Vision-impaired pedestrians use the sound of moving traffic to start crossing

If No APS, how do vision impaired pedestrians know when to cross?



MUTCD GUIDANCE

- *If a leading pedestrian interval is used, it should be at least 3 seconds in duration and should be timed to allow pedestrians to cross at least one lane of traffic or, in the case of a large corner radius, to travel far enough for pedestrians to establish their position ahead of the turning traffic before the turning traffic is released.*
- *If a leading pedestrian interval is used, consideration should be given to prohibiting turns across the crosswalk during the leading pedestrian interval*



HOW MANY SECONDS TO LEAD WITH?

MUTCD minimum is 3 seconds - but is there good guidance to determine other values?

- D.C. has 117 intersections with LPI
 - Most of these intersections have LPI on all four approaches
 - Typically 3 sec
 - Rare occasions use 7 or 8 sec for unusual geometrics
 - No chart or diagram for calculating time
- Philadelphia has about 24 LPI intersections
 - Use 3 sec
- Boston
 - 3 to 7 sec
- Phoenix has 3 LPI intersections
 - Use 5 sec
 - Time of day LPI
- VDOT - Northern Region - 7 sec
 - “Extended” LPI - 14 sec
 - Push-button operated LPI



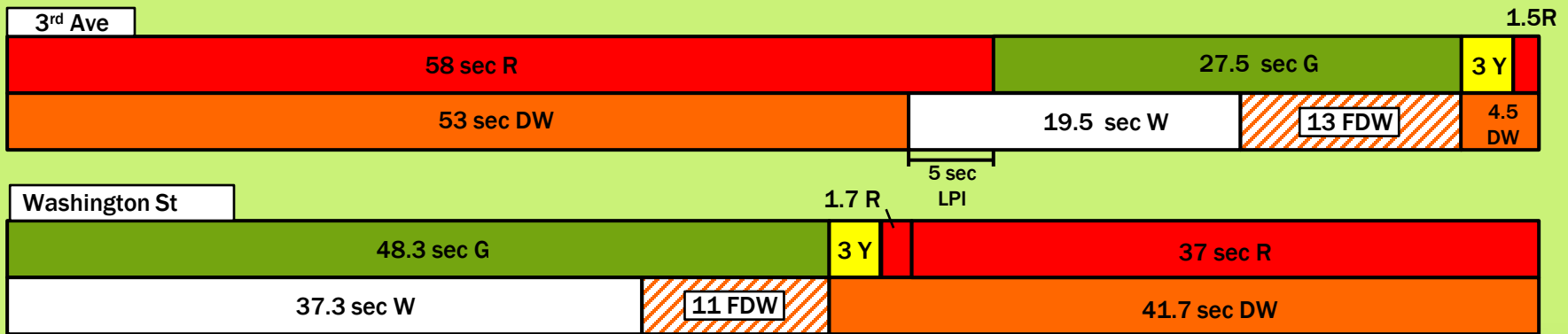
LPI INTERSECTION - PHOENIX



- Two one-way streets
- 5 sec LPI
- Heavy left-turn movement conflicts with heavy crossing
- Outside City Hall & City Court and main parking structure for both

LPI SIGNAL PHASING DIAGRAM

3RD AVE AND WASHINGTON ST



- Heavy northbound left-turn conflicts
- 5 Sec LPI for north/south pedestrians crossing before left-turn green
- Time-of-day/fixed-time



HANDBOOK FOR THE DESIGN OF ROADWAYS FOR AGING POPULATIONS

$$\text{LPI} = (\text{ML} + \text{PL} + 6.0) / 3.0$$

Where:

LPI (sec)

ML = width of moving lane in ft

PL = width of parking lane (if any) in ft

6.0 = distance from the edge of curb (ft)

3.0 = walking speed in ft/s

Example: $(12 + 8 + 6)/3.0 = 8.7$ sec

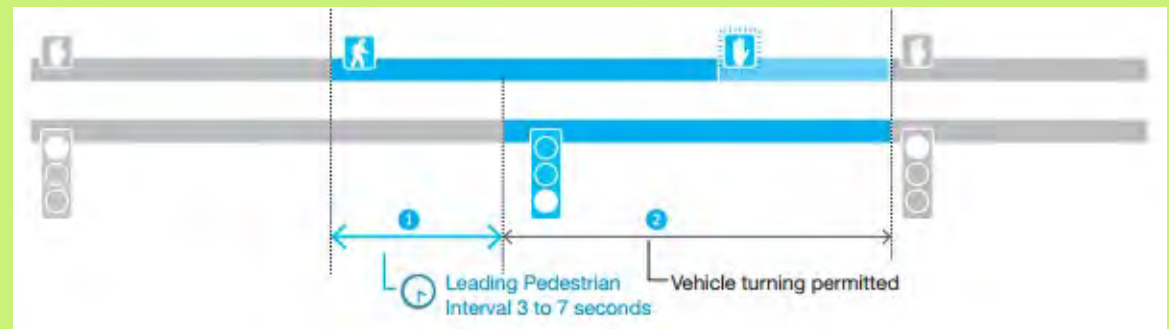
Source: FHWA publication, https://safety.fhwa.dot.gov/older_users/handbook/

BOSTON COMPLETE STREETS GUIDE

- 3 to 7 seconds
- Consider if high conflicts between Peds and Turning Vehicles
- Lagging Left-Turn Arrow
- Use TURNING VEHICLES YIELD TO PEDESTRIANS signs
- Use APS

Consider

- NTOR signs
- Allow turns after the pedestrian crossings
- Leading Bicycle Interval



VDOT - NORTHERN REGION

- Typically use 7 sec
- Extended LPI – 14 sec (rare)
- LPI Initially driven by complaints
- T-intersections where peds conflict with turning vehicles from the stem of the T
- 4-leg intersections where opposing traffic is low and left-turn movements is high
- All LPI is pushbutton operated



Guidance: *“Where a pedestrian phase is served at the same time as a conflicting permissive left-turn movement, a leading pedestrian interval (LPI) should be used when it does not significantly degrade the operational performance of the intersection”*

CITY OF TORONTO

LPI = greater of 5 seconds, or $(TL/2 + PL)/W$

Where:

- **LPI (seconds)**
- **TL = distance to clear the total width of all moving lanes between the curb and the center line, not including the parking lane (m)**
- **PL = distance to clear parking/merge lane, if any (m)**
- **W = walking speed of 1.0 m/s (3 ft/sec).**

CITY OF TORONTO

Suitability Assessment for LPI based on:

- **Drivers make left turns without the need to yield to oncoming traffic**
- **Visibility issues**
- **Citizen complaints**
- **High pedestrian crossings**
- **Ped-Veh conflicts & crashes**
- **Close proximity to elementary school**
- **High level of elderly ped activity**
- **Impact on vehicular traffic**

ISSUES

- **Left Turn Arrows** – Best with lagging protected arrows
- **Synchronization with other signals** – should not be an issue
- **One-Way Streets** – Treat left-turn LPI same as right-turn – May want to add a few more seconds in some instances
- **NTOR** highly recommended for LPI
- **Congestion** – separating pedestrians from turns should help reduce congestion

HOW TO INCREASE LPI EFFECTIVENESS

- Provide enough LPI time for pedestrians to occupy crosswalk
- Prohibit turns on red
- Provide APS for vision-impaired pedestrians



COST

- Low (if new controller not needed)
- Time & effort to program & implement
- NTOR signs
- APS push buttons (Highly Desirable)



QUESTIONS / RESOURCES

- MUTCD Section 4E.06 Pedestrian Intervals and Signal Phases
 - <http://mutcd.fhwa.dot.gov/hlm/2009r1r2/part4/part4e.htm>
- "Safety Effectiveness of Leading Pedestrian Intervals Using the Empirical Bayes Method." TRB 88th Annual Meeting Compendium of Papers CD-ROM. Washington, DC (2009).
Study Citation: Fayish, and Gross
 - http://nacto.org/docs/usdg/safety_effectiveness_of_lpi_fayish.pdf