

Memorandum

*Making Conservation
a California Way of Life*

To: DISTRICT DIRECTORS

Date: September 2, 2021

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Subject: **TRAFFIC SAFETY BULLETIN 21-01: LEADING PEDESTRIAN INTERVAL (LPI)
IMPLEMENTATION GUIDELINES**

This bulletin announces the establishment of the Guidelines for Implementing Leading Pedestrian Interval (LPI), attached. The LPI is a signal-timing tool effective in reducing vehicle-pedestrian conflicts hence making pedestrians less susceptible to fatal and serious injuries. This guideline incorporates the scope and benefits of the Federal Highway Administration's (FHWA) proven safety countermeasure. California Department of Transportation (Caltrans) staff should follow these guidelines to assess and implement LPI at signalized intersections that encounter a large number of pedestrian-vehicle crashes, have high pedestrian crossing and vehicle turning volumes, have a long crossing distance across multiple lanes, cater to vulnerable (young and aging) populations and have limited or restricted visibility due to geometry and/or obstructions.



Why it Works: LPI gives pedestrians the opportunity to enter an intersection 3 to 7 seconds before vehicles are given a green indication. With this head start, pedestrians can better establish their presence in the crosswalk before vehicles have priority to turn. LPI provides the benefits of increased visibility of crossing pedestrians, reduced conflicts between pedestrians and vehicles, and increased likelihood of motorists yielding to pedestrians.

Crash Modification Factor: FHWA studies have shown a reduction in total pedestrian-vehicle crashes at intersections by 13%.

Source: https://safety.fhwa.dot.gov/provencountermeasures/lead_ped_int/

This guidance is available for use by local agencies; it is critical that they are encouraged to implement LPI at candidate locations, as 64% pedestrian fatalities and 75% pedestrian serious injuries in California occurred on local roadway network over the 10-year period of 2009-2018¹. Sites and strategies should be selected for LPI implementation based on engineering judgment. This guidance focuses on safety for pedestrians and vulnerable populations; and is applicable for both reactive and systemic safety improvement projects.

LPI specifically addresses Strategic Highway Safety Plan's "Intersections" and "Pedestrian" Challenge Areas by providing an easy and inexpensive countermeasure that can be incorporated into pedestrian safety projects and become routine practice. Implementing LPI is an excellent strategy to realize the multi-modal vision and achieve goals of enhancing pedestrian safety throughout California with a goal to reduce traffic fatalities and serious injuries to zero, as outlined in these supporting policy documents:

- California Transportation Plan 2050
- Caltrans Strategic Plan 2020-2024
- Strategic Highway Safety Plan (SHSP) 2020-2024
- Climate Action Plan for Transportation Infrastructure
- Toward an Active California-State Bicycle and Pedestrian Plan

If you have questions regarding the Guidelines for Implementing LPI, please contact your district traffic operations experts or Russ Wenham, Traffic Engineering Specification Specialist, Office of Safety Systems and Devices, Division of Safety Program at (916) 217-0031 or by e-mail at <russell.wenham@dot.ca.gov>.

Attachment

Guidelines for Implementing Leading Pedestrian Interval (LPI)

¹ Statewide Integrated Traffic Records System (SWITRS), July 2019. Accessed August 11, 2021

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Guidelines for Implementing Leading Pedestrian Interval (LPI)

INTRODUCTION

Since intersections are where vehicles and pedestrians are most likely to interact and where most pedestrian injuries occur, the Leading Pedestrian Interval (LPI) strategy is an important tool to realize the multi-modal vision in the “Toward an Active California-State Bicycle and Pedestrian Plan” and achieve goals of the 2020-2024 Strategic Highway Safety Plan (SHSP) to improve traffic safety throughout California with a goal to reduce traffic fatalities to zero. LPI is a relatively simple and inexpensive countermeasure that should be incorporated into pedestrian safety action plans and policies and become routine practice.

LPI is one of the Federal Highway Administration's (FHWA) Proven Safety Countermeasures to reduce pedestrian-vehicle crashes at intersections by 13%¹. An LPI is a signal timing function which displays a brief (3-7 second) advance WALK indication for the crosswalk before the traffic light turns green. LPI helps pedestrians begin their crossing before parallel traffic is given a green indication, thereby establishing their presence in the crosswalk ahead of turning traffic, increasing their visibility and encouraging drivers to yield right-of-way to pedestrians.

The purpose of this LPI Implementation Guidance is to provide direction about incorporating LPI into pedestrian signal timing at potential/candidate intersections on the State Highway System involving intersections with pedestrian presence. LPI is not required at all signalized intersections; this document provides guidance to analyze where LPI is useful and how it should be applied and is not a substitute for or replacement of engineering judgment. Caltrans' Division of Safety Programs staff are available to advise staff, local agencies and consultants on the implementation of this guidance.



Figure 1 : Typical 4-way Urban Intersection with Pedestrian Crosswalk



Figure 2 : Pedestrian crossing the street during WALK signal

¹ https://safety.fhwa.dot.gov/provencountermeasures/lead_ped_int/



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GUIDANCE

Caltrans should utilize LPI as a countermeasure at appropriate locations, based on engineering judgment, while following these guidelines and selecting sites and strategies based on intersection characteristics and considerations outlined below.

While LPI is typically used to address conflicts with right turns on two-way streets, or with left turns on one-way streets, it can be useful in addressing left turn conflicts on two-way streets as well. Restricting Right Turns on Red (RTOR) in addition to LPI can help better control conflicts with right-turning vehicles. Approaches with little or no opposing traffic, such as a T-intersection or a low volume street, can use LPI to affect drivers' yielding behavior to pedestrians.

It is preferable for intersection approaches to have crosswalk markings, Accessible Pedestrian Signals (APS), and pedestrian countdown signals before LPI is implemented. *California Manual on Uniform Traffic Control Devices (CA MUTCD)* Section 4E.06 offers guidance for consideration of APS when LPI is used. Using LPI with APS will provide indications for persons with disabilities. If LPI is used without accessible features, pedestrians who are visually impaired may begin crossing at the onset of the vehicular movement, which defeats the purpose of LPI.

CA MUTCD Section 4E.06 also provides guidance to consider prohibiting turns across the crosswalk during the LPI. As evident from the review of existing studies², RTOR prohibitions contribute significantly to the effectiveness of LPI. The RTOR prohibition would ensure that right turning vehicles waiting at the red light are not entering the pedestrian right-of-way during the LPI. In situations where RTOR prohibitions significantly affects vehicular capacity, engineering judgment should be used in determining whether operating the LPI without RTOR prohibitions is still beneficial. To address potential conflict between RTOR and pedestrians during the LPI while still providing RTOR capacity at other times during the cycle, it may be appropriate to use a no RTOR blank-out sign during the LPI.

Crosswalk markings provide guidance for pedestrians by defining and delineating paths on approaches within signalized intersections. High-Visibility crosswalks can be considered in combination with LPI for intersections with no crosswalk markings. CA MUTCD Section 3B.18 provides guidance on crosswalk markings.

In some locations, LPI may not be necessary for pedestrians to establish themselves ahead of turning traffic. This can be true at approaches with very wide nearside crosswalks, or when a substantial setback exists for the vehicle limit line. Also, the presence of protected pedestrian

² Saneinejad, S. , and Lo, J. . Leading Pedestrian Interval: Assessment and Implementation Guidelines. In Transportation Research Record: Journal of the Transportation Research Board, No. 2519, Transportation Research Board, Washington, D.C., 2015, pp. 85–94.



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movements such as exclusive pedestrian phase (pedestrian scramble) may render LPI unnecessary as there are no vehicle-pedestrian conflicts. While implementing an LPI might improve the safety of pedestrians crossing the street, consideration of the tradeoffs associated with them should be made. Particularly at intersections with short cycle lengths, an LPI on one or both crossings can have a significant effect on green time and could result in increased congestion. While safety should guide any recommendations, engineering judgment must be exercised when making signal timing changes that will affect a wide variety of users across multiple modes.

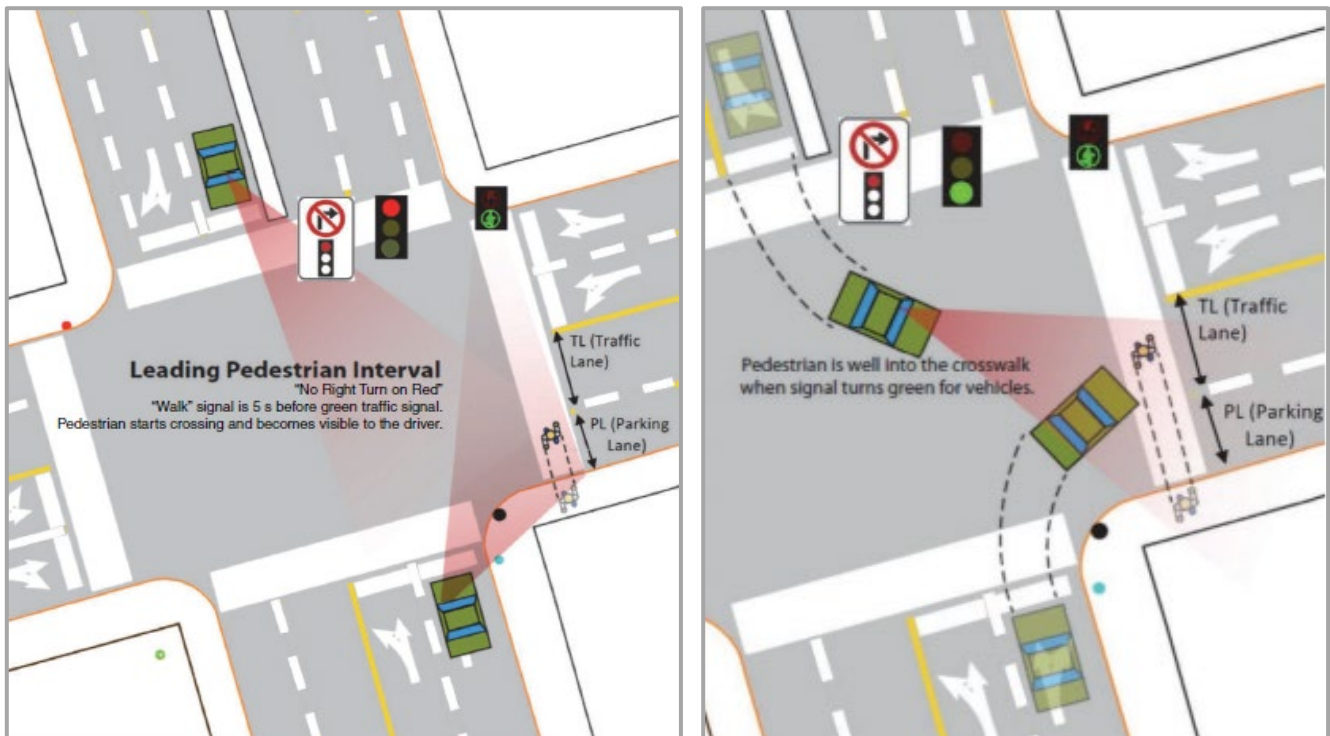


Figure 3 : How LPI helps pedestrians to establish themselves (Source: Toronto LPI Guideline)

COSTS AND BENEFITS

Costs for implementing LPI are very low, when only signal timing alteration is required. LPI requires reprogramming the traffic signal to accommodate the advance pedestrian interval. In rare cases, signal controllers may need to be upgraded. The cost associated with LPI can range from \$200 (controller setting changes only) to \$1200 each (pedestrian/vehicle study, retiming analyses and incorporating associated setting changes)³. Installing a new signal can range

³ Safety Evaluation of Protected Left Turn Phasing and Leading Pedestrian Intervals on Pedestrian Safety, Federal Highway Administration, Report No. FHWA-HRT-18-044. Washington, D.C.



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from \$40,000-\$100,000⁴. The cost of a marked crosswalk can range from an average of \$750 for a striped crosswalk to nearly \$2,600 for a high visibility crosswalk⁵. The baseline estimated cost to furnish and install an APS unit on an existing pole is \$1000 and a typical quadrant intersection would require eight units. So, the cost of retrofitting a four-legged intersection to include APS on all four crosswalks would be approximately \$8,000⁶. In many instances, an intersection may require additional work that increases the cost of the installation.

FHWA's *Handbook for Designing Roadways for the Aging Population*⁷ recommends the use of LPI at intersections with high turning vehicle volumes. LPI can provide the following benefits:

- Increased visibility of crossing pedestrians
- Reduced conflicts between pedestrians and vehicles
- Increased likelihood of motorists yielding to pedestrians
- Enhanced safety for pedestrians who may be slower to start into the intersection

In an FHWA study⁸, annual dollar benefit from reduced crashes was determined to be \$41,707 per intersection and a benefit-cost (B/C) ratio ranging from 1:207 to 1:517 if only the basic LPI adjustments were made. These results suggest that LPI, even with conservative assumptions on cost, service life, and the value of a statistical life, can be a cost-effective countermeasure for reducing pedestrian crashes at signalized intersections.

SELECTING SITES FOR LPI IMPLEMENTATION

LPI can be installed across systems of signalized intersections to improve pedestrian safety. Where to incorporate LPI can be prioritized to maximize limited resources after considering several primary factors:

- **Collision history:** A review of a minimum 3 years and up to 5 years of collision data for intersections with multiple crashes or a history of severe injury and fatal crashes should be a priority. The information from Conflict Analysis⁹ can also be used to supplement crash data. A conflict is an observable situation in which two or more road users (including pedestrians) approach each other in space and time to such an extent that there is a risk of collision if their movements remain unchanged unless an evasive maneuver is

⁴ http://www.pedbikesafe.org/pedsafe/countermeasures_detail.cfm?CM_NUM=12

⁵ http://guide.saferoutesinfo.org/engineering/marked_crosswalks.cfm

⁶ New York City Department of Transportation Accessible Pedestrian Signals Program Status Report, November 2014. <https://www1.nyc.gov/html/dot/downloads/pdf/2014-aps-program-status-report.pdf>

⁷ https://safety.fhwa.dot.gov/older_users/handbook/aging_driver_handbook_2014_final%20.pdf

⁸ <https://www.fhwa.dot.gov/publications/research/safety/18060/18060.pdf>

⁹ [Traffic Conflict Techniques for Safety and Operations: Observers Manual](#), Federal Highway Administration, Report No. FHWA-IP-88-027, January 1989.



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undertaken. The purpose of conflict analysis is to determine the degree of different types of conflicts between motorized vehicles and pedestrians. Collision history is a measure of the safety of an intersection, and repeated interactions between pedestrians and vehicles can warrant an LPI. Crash history can also help in identifying locations prone to pedestrian-vehicle crashes.

- **Pedestrian crossing volumes:** Districts may look for pedestrian volumes exceeding traditional pedestrian signal warrants when considering LPI. The estimated exposure (product of pedestrian and turning traffic volumes) is another factor for consideration. The exposure allows the volume criteria to be satisfied in a variety of conditions, intersections with moderate turning traffic and high pedestrian volumes, as well as locations with excessively high turning traffic and moderate pedestrian volumes. Also, AM, Mid-day, and PM peak hour exposures can be evaluated separately to consider high levels of pedestrian activity during particular hours of the day.
- **Vulnerable populations:** Districts can prioritize LPI where school-aged children or older adults are expected to cross. These pedestrians may enter the crosswalk more slowly than other pedestrians.
- **One-Way streets or at T-intersections:** At intersections where left-turning vehicles are not typically expected to yield to oncoming vehicles, LPI may be useful to increase yielding to pedestrians in the crosswalk.
- **Intersection visibility:** LPI may be prioritized where the visibility of a crosswalk is limited or restricted. Limited sightlines may exist between turning traffic and pedestrians starting their crossing on the corner due to street furniture, other obstructions, or geometry.

SIGNAL-TIMING FACTORS

Incorporating LPI will involve signal-timing modification and may consider the trade-offs associated with each alteration, based on engineering judgement. Some of the parameters to be considered are:

- **Minimum duration:** The minimum duration of an LPI is defined by the *CA MUTCD* Section 4E.06 as being at least 3 seconds. Districts should refer to the *CA MUTCD* for guidance on LPI duration. The goal is to give the pedestrians opportunity to establish themselves in the intersection ahead of turning traffic.



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- **Delay:** On congested approaches where an LPI is being considered, a reduction in green time will further exacerbate congestion. Consideration may be given to reducing the cross street split to add green time back to the congested approach, which could lead to no net loss of green time on the congested approach. When rebalancing the splits, consider the effects on coordination, and adjust the signal offset accordingly. If the pedestrian signal is actuated, LPI will only delay vehicles when there is pedestrian presence.
- **Cycle:** When implementing an LPI at intersections with short cycle lengths (e.g. 60-75 seconds [s]), consider increasing the cycle length. An increased cycle length may mitigate transit delay concerns. LPI on one or both crossings can have a significant effect on green time and could result in increased congestion. For example, at an intersection with a 60s cycle, 4-second yellows and 1-second all-reds, a 4-second LPI for both crossings will result in a 16% reduction in available green time to vehicles. This reduction in green time can increase delay for transit on a given approach. If the signal is part of a coordinated system, changing the cycle length may impact adjacent intersections in the same system.
- **Signal coordination:** When implementing an LPI in a coordinated system, consideration of the signal offset should also be made. If there is a coordinated platoon of vehicles arriving at the intersection, the offset should be adjusted (if possible) so they arrive on green, not during the LPI. These types of setting changes are particularly important on corridors where the signals have been set for a consistent travel speed, such as one-way coordinated arterial corridors. Additionally, implementing LPI at only one location on a coordinated street can create a bottleneck to the progression bandwidth along the corridor. The bottlenecks should be reviewed to see how they could affect overall corridor progression.
- **Signal phasing:** Consideration may be given to the signal phasing prior to recommending an LPI. On a two-way street with a leading protected-permissive left turn phase, an LPI should not be used for the crosswalk to the left of the left turn movement. If an LPI is used in this situation, the delay in the start of opposing traffic may encourage left turning drivers to continue to turn during the start of the permissive portion of the left turn phase, conflicting with pedestrian crossing during the LPI. If the length of the signal phase is governed by pedestrian crossing times, instead of vehicle demand, LPI can be easily implemented.



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GUIDANCE FOR TYPICAL INTERSECTIONS

The following case examples are meant to provide guidance on implementing an LPI at several typical intersection types. These examples and recommendations are provided as guidance and are not a substitute for, or replacement of, engineering judgment. Signal Operations should be consulted to learn about unique challenges of specific location before implementing LPI.

Case 1: Major Arterial and Major Arterial

The intersection of two major arterial streets can present challenges to pedestrians crossing them, due to factors such as long crossing distances across multiple lanes, the high likelihood of turning vehicles, and high vehicle volumes. LPI for all 4 crossings can be useful in addressing turn conflicts between pedestrians crossing and turning traffic.

An LPI can potentially reduce pedestrian crashes at an intersection with multiple turning lanes where the line of sight from the inside turning lane to the pedestrians is blocked by bigger size vehicles on the outside turning lane.

Where to Use:

LPI for such crossings should be considered. On approaches with transit service (if present), consideration should be given to the trade-offs between addressing turning conflicts and potential transit delay.

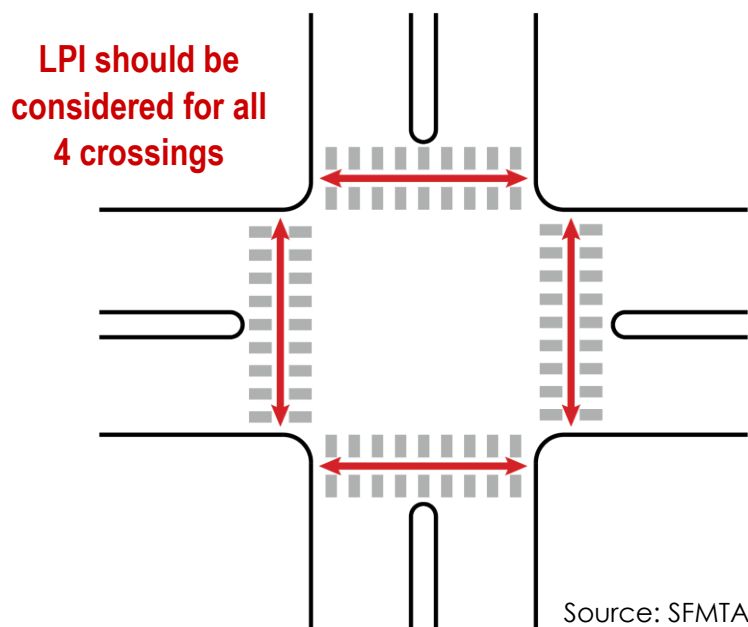


Figure 4: Typical intersection of two major arterial streets



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Case 2: Major Arterial and Minor Collector

Intersections of a minor collector with a major arterial can present potential challenges for people crossing the major arterial. These challenges can include long crossing distances and increased exposure to turning vehicle conflicts. This increase in exposure to turning conflicts is due to the likelihood that vehicles on the minor street approach will turn onto the major street. At many of these intersections the side street split is governed by the pedestrian crossing time, which typically results in a longer green time than needed for vehicle demand. On these approaches, LPI will not affect vehicle capacity significantly, while providing pedestrians crossing the major street with an opportunity to establish themselves in the intersection ahead of turning traffic. Additionally, an LPI for pedestrians crossing the major street would likely benefit the majority of pedestrians crossing, as the major street usually has more than half of the cycle's split, meaning pedestrians wanting to cross the major street will likely queue up and be ready to take advantage of the LPI.

An LPI for pedestrians crossing the side street, needs to be weighed against possible tradeoffs. In general, most traffic on a major street will drive through, not turn. This means the likelihood of the first vehicle turning is low, and the effectiveness of an LPI is reduced. Major streets usually have transit service, and are often congested, meaning reduced green time could increase transit and vehicle delay.

Where to Use:

An LPI for pedestrians crossing the major street is recommended. An LPI for pedestrians crossing the side street can be considered if engineering judgment determines it would address a potential collision pattern.

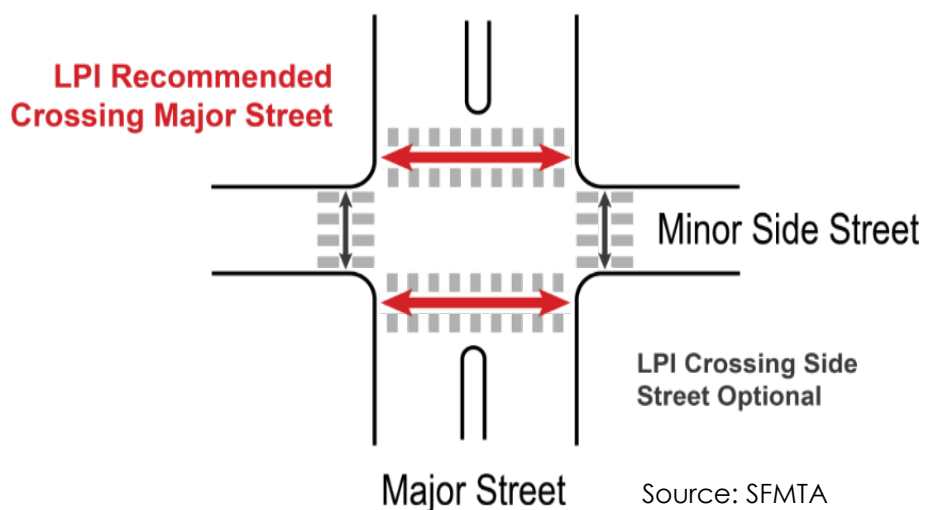


Figure 5: Typical intersection of a major arterial and a minor collector



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Case 3: One-way and One-way

Intersections of one-way to one-way streets can present potential challenges for pedestrians crossing the legs of the intersection where turns take place. These intersections are typically arterial to arterial connections, which means there is a reasonable likelihood that the first vehicle will turn. For left turns in particular, due to the lack of opposing traffic and the potential for the drivers' reduced visibility of pedestrians crossing on the left due to vehicle's windshield pillar obstruction, an LPI can help pedestrians crossing the street establish themselves and be more visible to drivers. Since one-way streets are typically timed for progression, consideration should be given to signal offsets when implementing an LPI.

Where to Use:

An LPI may be recommended for such crossings.

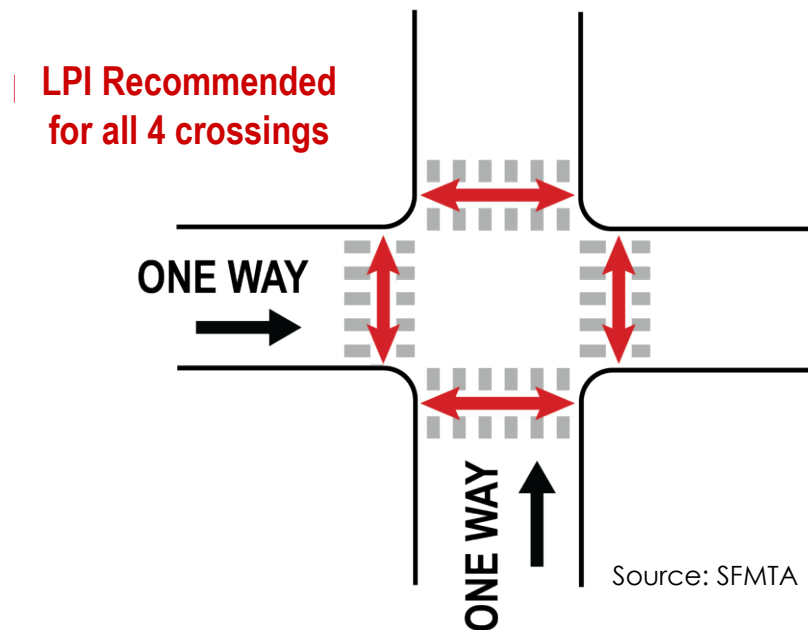


Figure 6: Typical intersection of two one-way streets



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Case 4: T-intersection

T-intersections present potential conflicts between vehicles on the stem approach and pedestrians crossing parallel to the stem, as all vehicles on the stem approach must turn either left or right leading to high turning volumes. An LPI can help by allowing pedestrians crossing parallel to the stem of the T to establish themselves before turning vehicles are released.

Where to Use:

An LPI is recommended for pedestrians crossing parallel with the stem of the T. An LPI for pedestrians crossing the stem of the T should be considered if engineering judgment determines it would address a potential collision pattern.

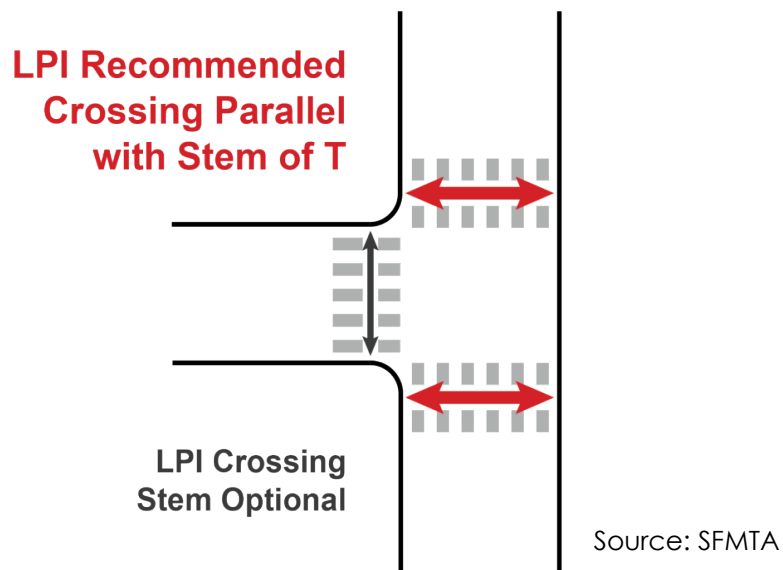


Figure 7: A typical T-intersection



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Case 5: Entrance/Exit Ramp and Major Arterial

The intersection of entrance or exit ramps streets with a major arterial can present potential challenges to pedestrians, due to factors such as long crossing distances across multiple lanes, the high likelihood of turning vehicles, high vehicle volumes and vehicles travelling at high speed. An LPI for all four crossings can be useful in addressing turn conflicts between pedestrians crossing and turning traffic.

Where to Use:

LPI for such crossings should be considered.

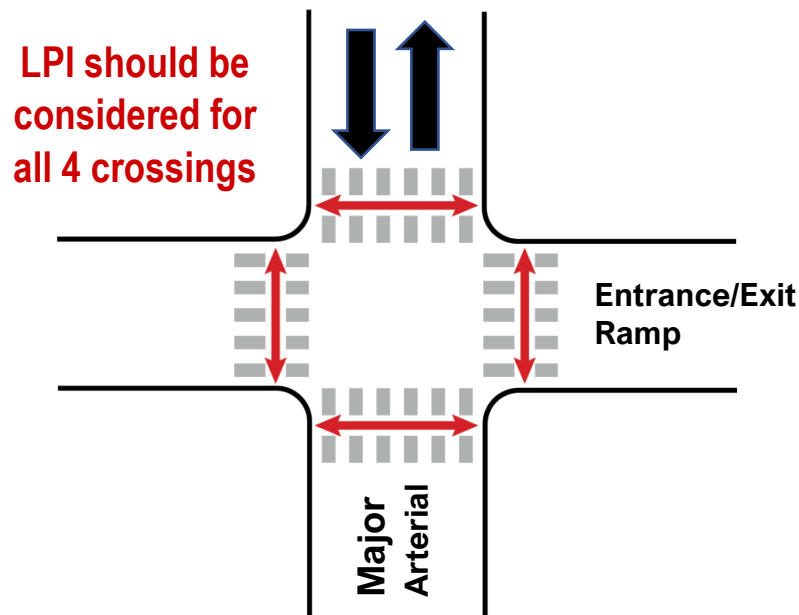


Figure 8: Typical intersection of an Entrance/Exit ramp with a major arterial



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