North Carolina Department of Transportation
Division of Highways
Transportation Mobility and Safety Division (TMSD)

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GUIDELINES for Leading Pedestrian Interval (LPI) Implementation

A. TOPIC OWNER

Traffic Safety Unit & Transportation Systems Management and Operations Unit (TSMO)

Regional Traffic Engineers (RTEs) and Division Traffic Engineers (DTEs) will be consulted when locations are considered for LPI. The Signal Design Section will be consulted for design and operations technical advice during implementation.

B. PURPOSE

Describes the guidelines for determining need for Leading Pedestrian Interval (LPI) at new and existing traffic signals and as part of Transportation Improvement Program (TIP) projects, signal alterations, and safety projects. The goal for this guidance is consistent and increased implementation for LPI in NCDOT projects and at NCDOT-maintained traffic signals, and support for local government decisions to implement LPI. These guidelines describe site conditions, documentation, and an approval process to be met for LPI where installed at NCDOT-maintained traffic signals. The guidelines list additional conditions that may be used to prioritize locations for implementation. These guidelines do not address software controller or programming requirements, how to prepare signal plans where LPI is added, or how to conduct additional analysis for the study of impacts of LPI. However, this document will make reference to NCDOT resources that address these topics, where available.

C. OVERVIEW

Pedestrian safety is a focus of the NCDOT Highway Safety Improvement Program (HSIP), to address the increasing numbers of pedestrian crashes and fatalities on roadways in the state. Data specifically describing the number or rate of pedestrian crashes or fatalities occurring at signalized intersections is not readily available statewide; however, an increasing share of the state's pedestrian crashes occur at intersections. According to an inventory of NCDOT maintained signals updated in 2022, a minority of signals include WALK phases. Including proven safety countermeasures for pedestrians at signalized intersections is a key strategy for improving pedestrian safety.

LPI is a low-cost adjustment to signal timing that give pedestrians a head start entering the crosswalk before vehicles in the parallel direction are given the green signal indication. LPI are typically set between 3 and 7 seconds, depending on the length of the crossing, pedestrian walking speed, number of travel lanes, and signal phasing. LPI can be actuated or an automatic setting for all WALK phases; in most cases, LPI is pedestrian actuated using a call button.

LPI are typically implemented where pedestrian signal heads, crosswalks and curb ramps are available or will be installed. Pedestrian signal heads (WALK phases) should be installed where sidewalk exists[1], and other decision factors to be considered for pedestrian signal heads is outlined by the *NCDOT Pedestrian Crossing Guidance (2015).*

Figure 1: Photo of LPI in Washington D.C.

LPI is easy to implement, requiring reprogramming of a traffic signal to accommodate the advanced pedestrian movement. The agency who maintains or controls the signal may need to upgrade a traffic signal controller to accommodate the additional movement.

LPI is a FHWA proven safety countermeasure for reducing pedestrian crashes at signalized intersections. Pedestrians who use the LPI enter the crosswalk ahead of turning traffic, improving visibility of pedestrians in the crosswalk and increasing yielding of turning drivers and vehicles. The Crash Reduction Factor (CRF), according to a study published in 2018, for all pedestrian crashes is 13%.[2] There is not a CRF available for all crashes (including vehicles) for LPI or for pedestrian fatal crashes only. Implementation of LPI supports the 2019 NC Strategic Highway Safety Plan (SHSP) which has established an area of emphasis on pedestrian safety with a goal to reduce pedestrian fatalities and serious injuries by half by 2035.

LPI is most common in urban centers or other areas of high pedestrian activity such as near schools and universities. However, LPI is beneficial in suburban areas when pedestrian actuated. LPI is deployed where drivers make left or right turns that conflict with or are not held during the WALK phase. The advance WALK phase allows pedestrians to enter the crosswalk before vehicles make permitted turns, and can be effective at one-way road intersections, T-intersections, or other locations where drivers are less likely to look in both directions before proceeding with the turning movement. LPI improves intersection sight distance where limited by streetscape features, buildings set close to the intersection, or complex traffic operations.

D. REQUIREMENTS

LPI shall be implemented in accordance with the most recent adopted Manual on Uniform Traffic Control Devices (MUTCD). The MUTCD (2023) includes guidance on the LPI in Section 4I.06 Pedestrian Intervals and Signal Phases. In Section 4I.06, paragraphs 22-24, the MUTCD provides the following as 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

[1] NCDOT Guidelines for Traffic Signal Recommendations for Transportation Improvement Projects (2020)
[2] Goughnour, E., Carter, D., Lyon, C., Persaud, B., Lan, B., Chun, P., ... Signor, K. (2018). 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.

is used, consideration should be given to prohibiting turns across the crosswalk during the leading pedestrian interval. At locations where a leading pedestrian interval is used, the minimum time for the WALKING PERSON (symbolizing WALK) indication should be the time provided for the leading pedestrian interval plus 7 seconds [unless used with Accessible Pedestrian Signals (APS)][3]."

Section 4I.06, paragraph 25 of the MUTCD provides the following support for the guidance:

> "At intersections with pedestrian volumes that are so high that drivers have difficulty finding an opportunity to turn across the crosswalk, the duration of the green interval for a parallel concurrent vehicular movement is sometimes intentionally set to extend beyond the pedestrian clearance time to provide turning drivers additional green time to make their turns while the pedestrian signal head is displaying a steady UPRAISED HAND (symbolizing DONT WALK) signal indication after pedestrians have had time to complete their crossings."

The NCDOT Transportation Systems Management and Operations Unit (TSMO) issued guidance in 2021 for "Leading Pedestrian Interval Programming for Oasis and ASC/3-2070." This guidance was incorporated as general signal design changes in the NCDOT TMSD Design Manual for Signals Design: Part 1 and as programming and timing application updates to the Design Manual for Signals Management: Part 2.

LPI duration is calculated per traffic configuration, considering opposing left turn movements and pedestrian phases. Final determination about minimum and maximum duration for LPI will be made based on the intersection geometry and per determination made by the Division or City Traffic Engineer. The Signal Design Manual says the following about duration of the LPI and use with Accessible Pedestrian Signals (APS):

> "In urban and suburban areas, when practical, use Leading Pedestrian Interval (LPI) of at least 3 seconds. An LPI should allow a pedestrian to cross at least one travel lane during the LPI. If APS is not used with an LPI, there should be least 4 seconds between WALK and LPI times. If APS is used, LPI time may be equal to but not exceed the programmed WALK time."

The MUTCD provided the following support for APS with LPI in Section 4I.06, paragraph 20-21:

> "Accessible pedestrian signals (see Chapter 4K) where leading pedestrian intervals are used provide information in non-visual formats (such as audible tones and/or speech messages, and vibrating surfaces) so that a pedestrian with vision disabilities can know when to cross the street in the absence of the audible cues normally provided when the onset of the vehicular and pedestrian movements coincide. If a leading pedestrian interval is used without accessible features, pedestrians with vision disabilities might begin crossing at the onset of the vehicular movement when vehicle operators are not expecting them to begin crossing."

[3] Note: "[unless used with Accessible Pedestrian Signals (APS)]" added based on interpretation offered by FHWA.

For more information about using APS with LPI, see the Additional Considerations section of this guidance. The NCDOT signal design guidance allows for field implementation of configurations described within the guidance with a Plan of Record Changes submitted as soon as possible after implementation. For configurations not covered within the guidance, "a new signal plan and electrical detail should be requested prior to implementing the LPI in the field."

E. GUIDELINES

LPI can be implemented in response to site-specific safety conditions or specific request for single intersections, but LPI is well suited for "systemic" application (proactive and widespread treatment for locations with similar risk or characteristics). The goal of this guidance is to increase consistent application of LPI in all areas of the state that have similar conditions for pedestrian activity and crash risk with opposing turning traffic.

Intersections and signal phasing should typically be designed to allow for single-stage pedestrian crossings, and the LPI duration should be set based on crossing distance and complexity of the intersection configuration. LPI installation will typically include push button pedestrian actuation. In suburban areas, pedestrian activity and WALK phase/LPI actuation will have minimal impact on traffic operations. In urban centers or other areas where pedestrian activity is expected to be heavy or consistent, LPI can be implemented with signals that default to Pedestrian Recall and Rest in Walk. Side street operations and signal coordination should be reviewed when determining which legs of the intersection should receive LPI. See Table 2 for additional considerations when implementing LPI.

LPI shall be implemented at signalized intersections where all of the following conditions and a vehicle-pedestrian interaction is existing, in design, or under construction at one or more approaches:

- Countdown pedestrian signal heads
- Pedestrian pushbuttons, where pedestrian phase is not automatic
- Marked crosswalks
- Accessible ramps at marked crosswalks
- Sidewalk on marked crosswalk approaches
- Supporting controller

"LPI is reasonable to consider in areas with low or any level of pedestrian activity since LPI installation will typically include push button pedestrian actuation. In suburban areas, pedestrian activity and WALK phase/LPI actuation will have minimal impact on traffic operations."

These conditions describe the infrastructure that should be present to support LPI, and these are locations that would benefit from the addition of LPI. Leading Pedestrian Interval is a cost-effective treatment and is reasonable to consider for locations with low pedestrian activity and where the WALK phase is pedestrian actuated. Considering that LPI will only be activated when the WALK phase is actuated, regardless of the time of day, LPI is not expected to produce a significant impact to traffic operations. LPI should be implemented at as many approaches of the intersection where turning movements oppose any portion of the WALK phase and where supporting infrastructure is present or planned.

As cities and NCDOT upgrade signal systems, LPI can be implemented quickly and across a broad area. However, staff time or fiscal resources for implementing LPI may be limited; and

NCDOT, in consultation with the local agency, may need to prioritize areas or locations for near-term LPI addition. For example, site conditions or local agency policy require additional physical improvements be in place prior to LPI. Plans unrelated to LPI to improve intersections or signal timing may also cause delay in implementation.

Prioritize LPI implementation at signalized intersections based on the following, but not limited to, unranked existing conditions:

- Moderate to high pedestrian activity
- Several nearby pedestrian generators
- K-12 schools or College/University Campuses
- Pedestrian crash history
- Trail crossings
- Light rail, BRT or high-frequency transit stop locations
- Vulnerable pedestrians
- Atypical locations with limited sight distance
- One-way and T- intersections
- Heavy turning movements in shared thru/left or thru/right lanes
- Public request

These conditions represent areas of increased pedestrian crossing activity, pedestrian safety concern, and/or pedestrian safety risk. Pedestrian count data (i.e. numbers of people walking along or crossing a roadway at a location, for a specific duration) may help support decisions to implement or prioritize LPI; but pedestrian activity can change over time and this guidance does not recommend using a specific threshold or pedestrian count warrant for LPI.

Conditions describing expected pedestrian activity can help prioritize the installation/construction of the above minimum infrastructure needed to support LPI. These conditions are explained in more detail below:

- Moderate to high pedestrian activity – areas of lesser to significant numbers of pedestrians, such as urban/downtown areas, near schools, shopping centers, etc.
- Several nearby pedestrian generators – often includes shopping centers, restaurants, neighborhoods, employment centers, etc.
- K-12 Schools or Colleges/Universities – roads alongside, providing access to, or passing through public or private school campuses for elementary through post-graduate students
- Pedestrian crash history – any intersection with at least one crash involving a turning vehicle and a crossing pedestrian
- Trail crossings – intersections where a trail crosses at least one leg
- Light rail, BRT or high-frequency transit stop locations – this will be relative to the available transit service, but high-frequency transit is typically every 15 minutes or faster
- Vulnerable pedestrians – include older pedestrians and children that may require more time to cross an intersection or are less visible within the crosswalk
- Heavy turning movements in shared thru/left or thru/right lanes – drivers may only expect conflict from one or no direction and so may not look for pedestrians elsewhere when turning

- Atypical locations with limited sight distance – buildings set closely to the intersection, utilities, street trees or other objects may obscure driver visibility of pedestrians approaching or in the crosswalk
- One-way and T-intersections – drivers may only look toward oncoming or conflicting traffic and not look for pedestrians crossing on all approaches
- Public request – a person who crosses frequently at an intersection or has a safety concern may ask for changes to reduce turning movement conflicts

The *NCDOT Leading Pedestrian Interval (LPI) Assessment Checklist* is a tool for documenting conditions at locations being considered or prioritized for LPI implementation. The Checklist is not a required application form for implementing LPI, but this form may be useful for recording existing conditions where LPI is considered.

There are conditions where further evaluation is needed before implementing LPI. The following are locations where LPI will not typically be implemented, or impacts to traffic operations should be considered:

- LPI can provide a similar safety benefit to an exclusive pedestrian phase while also reducing delay for vehicles and pedestrians. LPI allows pedestrians to enter crosswalk before turning vehicles, while exclusive phase completely restricts turning movements during the pedestrian phase. LPI is an alternative consideration to exclusive pedestrian phases.

- At interchange ramps, vehicles are often traveling at higher speeds and in higher volumes. This can lead to less acceptance of increased delay, which can happen when LPI is introduced. These locations should be analyzed for impact to operations before implementing LPI.

- Where there are no expected interactions between the WALK phase and vehicle turning movements, such as one-way streets that terminate at the intersection, LPI is not typically implemented at those crossings.

E. ADDITIONAL CONSIDERATIONS

LPI is implemented in context of current or planned signal phasing, controller software, type of signal coordination, intersection geometry, and overall traffic operations. LPI is further implemented with consideration for pedestrian activity. In areas of higher pedestrian activity or volumes, LPI may be implemented with other improvements such as Pedestrian Recall or shorter cycle lengths. Complex intersection geometry or traffic operations may limit implementation of LPI on all approaches/cycles.

Table 2 lists basic categories of conditions at signalized intersections to be considered with LPI. More specific features for these conditions are listed, and Table 2 identifies common challenges associated with using LPI under these conditions. Each challenge is matched with a mitigation strategy and other considerations to review when implementing LPI.

Table 2: Additional Considerations for LPI

	Feature	Challenges	Mitigation	Other Considerations
Signal Phasing	Protected-Permitted Left-Turn	LPI prohibits the use of through movements if a shared turn lane is present.	Shorter LPI intervals may limit the impact to motorists.	See *Lead-Lag phasing* and *Flashing Yellow Arrow*, below. Refer to NCDOT LPI Programming Guide for more specific application details.
	Flashing Yellow Arrow	Signal plan designs typically require custom logic to suppress the FYA signal head displays during LPI.	Location-specific design plans must be developed, reviewed and approved.	See *Protected-permitted Left-Turn, above* and *Lead-Lag Phasing*, below.
	Lead-Lag Phasing	LPI may impact leading or lagging operation.	Utilize LPI only on side streets if existing lead/lag phasing must be retained.	See *Protected-permitted Left-Turn* and *Flashing Yellow Arrow*, above.
	Split Phasing	If LPI is used to cross the major approaches, two LPIs are required with split phasing, instead of one LPI.	Reevaluate signal timing and phasing plans to consider removal of split phasing. If LPI is installed, consider actuated ped phases.	Refer to NCDOT LPI Programming Guide for more specific application details.
	Single Pedestrian Crossing on Major Approach	Controller requires additional programming to install LPI.	Program a dummy pedestrian phase on the major street approach without LPI, with identical timing intervals.	Refer to NCDOT LPI Programming Guide for more specific application details.
	Two-Stage Pedestrian Crossing	If the "Walk" phase is set such that pedestrians cannot fully cross in one cycle, then two LPIs are required with a two-stage crossing, instead of one LPI.	Reevaluate signal timing and phasing plans to consider extension of the Walk phase. If LPI is installed, consider actuated ped phases.	Two stage pedestrian crossings may be undesirable. Coordinate with NCDOT and/or local agency to consider alternatives.
Controller Software	McCain 2033	Software will skip a phase to enter LPI, rather than operate out of coordination, resulting in high vehicle delay.	Carefully consider which approaches the LPI may be installed on. Explore options for alternative controller software when feasible.	Most current signal controller software will operate out of coordination for one cycle while serving LPI, then return to coordination.
Coordination	Pretimed	LPI will be called for all cycles. Unnecessary vehicular delay may occur.	Install detection and pedestrian pushbuttons.	Pretimed LPI cycles may be most practical with urban intersections and high pedestrian volumes.
	Actuated-Coordinated	Requires pedestrian pushbuttons for all crossings, which may have specific location requirements if APS are included.	Locate pushbuttons according to MUTCD and NCDOT guidance and standards.	LPI actuation may take intersection out of coordination temporarily.
Time of Day Operation	Time of Day use of Protected Left-Turn Phasing	Time of day designs typically include FYA operations. See Flashing Yellow Arrow, above.	Location-specific design plans must be developed, reviewed and approved.	LPI may be implemented on a time-of-day basis, if justified.
Recall	Pedestrian Recall	LPI will be called for all cycles. Unnecessary vehicular delay may occur.	Use pedestrian recall sparingly for crossing the major approach. For low to moderate pedestrian volumes, vehicle recall may be more applicable.	Pedestrian recall or Rest in Walk may be applied more easily on the major street approaches. If LPI and Rest in Walk are applied concurrently, coordination timing may be impacted.
Intersection Geometry	Dual Left-Turn	Dual left turns typically operate as protected-only movements, cannot operate concurrently with conflicting LPI.	Lag left-turn phases as necessary to allow for a leading pedestrian interval.	Pedestrian movements across dual left-turn movements may be undesirable. Coordinate with NCDOT and/or local agency to consider alternatives.
	Dual Right-Turn	Short interval timing may not allow for pedestrians to become fully established in crosswalk area.	Utilize longer LPI time (5 seconds or more).	If the right-turn movement is protected-permitted, a longer LPI may be implemented with less impact on through traffic.

Flashing Yellow Arrow (FYA) Left/Right

FYA is a widespread safety treatment implemented by NCDOT at signals with flashing yellow arrow left turn displays (LT FYA). LPI can be implemented during the red arrow indication at signalized intersections with LT FYA. FYA has been implemented for right turns (RT FYA) on a more limited scale. Traffic operations and driver behaviors vary between RT and LT FYA during WALK indication.

Consider installing signs or other signal controls to clearly communicate requirements to yield-to pedestrians or posted restrictions for right-turn-on-red during the WALK indication, where implementing RT FYA with LPI. The MUTCD R10-15 sign (see Figure 2) is recommended wherever where right-turning vehicles conflict with pedestrians in the crosswalk during the WALK phase. Dual right turns pose additional risk to pedestrian crossing safety and should be evaluated for additional pedestrian phasing or intersection design options.

Figure 2: R10-15 sign

Logical programming must be entered into the controller software to ensure proper operation of the LPI phase, primarily to prohibit any permissive turning movements that may otherwise appear on a RT or LT FYA display. Signal plans designed for concurrent use of LPI and FYA must be sealed by a professional engineer licensed in North Carolina and approved by NCDOT.

Accessible pedestrian signals (APS)

Accessible pedestrian signals (APS) provide information in non-visual formats, such as audible messages or tones to indicate the "Walk" and "Don't Walk" phases, allowing blind and low-vision pedestrians to know when to cross the street in the absence of other cues produced by the onset of vehicular movements. APS is not a current requirement for installation of LPI in the MUTCD; however, public requests for APS will be considered. Public requests are reviewed by the Division and Regional Traffic Engineer staff for potential improvements.

If a city requests to install APS at an NCDOT-maintained signal, NCDOT will accept that request as part of the signal plan review. Additionally, since appropriate location of pushbuttons is critical for proper installation of APS, pushbuttons at new signal installations should be designed to meet all current MUTCD and ADA guidance (i.e., separated by a minimum of ten feet). If LPI and APS are not immediately planned for installation but may be added in a future condition, proper pushbutton location allows for more cost-effective and seamless upgrades. Additionally, when a slip lane is going to use Accessible Pedestrian Signals (APS) for a crossing, the crossing shall be signalized.

Right Turn Restrictions

In North Carolina, drivers turning right must yield right-of-way to pedestrians moving toward and reasonably close to crossing the intersection. Otherwise, right turns at a red light are permitted after a complete stop unless otherwise restricted by signage and/or signal controls. (G.S., 20-158). Drivers expect to turn right with red during the LPI portion of the WALK phase unless signed as restricted or when yielding right-of-way to pedestrians.

Multiple right turn lanes may pose additional risk to pedestrians crossing in conflict with right turns, and signs restricting right turns on red should be considered in combination with LPI at pedestrian crossings. Research studies have recommended adding blank-out "NO TURN ON RED" signs or "TURNING VEHICLES YIELD TO PEDESTRIANS" signs along with activated LPI implementations to improve the safety at crossings conflicting with right turning traffic.[4] The dynamic feature of the blank out sign may improve yielding over static signage.[5] There are complexities with adding blank out signs, such as retrofitting an existing location with structures to support the sign, and they may not be feasible for installation at all locations.

Bicyclists, Transit and Other Vehicle Types

LPI may be installed in conjunction with emergency vehicle, railroad, or other forms of preemption, as well as transit priority systems. Depending on the priority assigned to a preemption phase, the pedestrian WALK interval may be arrested to transition to another phase.

LPI may be used by bicyclists- referred to as Leading Bicycle Interval - is where bicycle traffic does not justify a bicycle signal phase but bicyclists would benefit from entering the intersection before parallel vehicle traffic. In this application of LPI, signs should direct bicyclists to use the pedestrian signal, and timing should be set considering speeds of bicyclists and pedestrians.

When planning and installing the first LPI in a particular region, public outreach and education may be useful. With widespread application of LPI, or in a region where LPI is used elsewhere, limited or no public outreach is needed. The FHWA Safe Transportation for Every Pedestrian (STEP) program developed a video introduction to LPI which may be useful for educating public road users.

Implementation Strategies

LPI is an effective mitigation strategy for new development, prompting more complicated intersections and increasing pedestrian activity. Local agencies should coordinate with developers and NCDOT staff to determine the LPI requirements of new traffic signals, or where developer-driven projects require signal upgrades. New signals and signal upgrades should be designed to allow for ease of future implementation of LPI.

Some local agencies have effectively worked with NCDOT to cost share implementation of LPI within the municipal system. The cost of preparing and updating Plan of Record for the signal(s) inclusive of LPI, installing additional signage, and other updates to the intersection may be eligible for NCDOT and local agency cost participation.

Local agencies should review all signalized intersections in a developed area for LPI consider systemic or area-wide application. Systemic safety application of LPI addresses locations where safety conditions are consistent across the city, along a corridor, and/or where the signal system is coordinated. Consider area-wide application of LPI where land use context produces higher

[4] Lin, P.S., Wang, Z., Chen, C., Guo, R., Zhang, Z. Development of Statewide Guidelines for Implementing Leading Pedestrian Intervals in Florida. Report No. BDV25-977-22, Florida Department of Transportation, Tallahassee, FL, 2017

[5] Guidelines for Implementation of Right Turn Flashing Yellow Arrows and Leading Pedestrian Intervals (2020)

pedestrian activity, such as in central business districts or near universities. Consult with NCDOT for best practices and methods for area-wide or systemic application of LPI.

Supporting Analysis

Analysis to document a new or proposed LPI installation is completed on a case-by-case basis. Impacts of LPI on traffic operations have been studied in few instances, and analysis demonstrates that delay typically produces minimal delay to vehicle travel. The magnitude of increase in delay depends on a number of factors such as the length of the leading pedestrian interval, whether the intersection is in coordination, cycle length, and whether the LPI has been implemented for pedestrian phases on the major, minor-street, or both. Engineering studies completed for this purpose include, but are not limited to, the following analyses and considerations:

- Capacity analysis and simulation to evaluate vehicular delays and anticipated queue lengths
- Crash analysis and identification of safety problems
- Data collection, vehicle and pedestrian counts
- Pedestrian delay

G. ADDITIONAL PEDESTRIAN SAFETY STRATEGIES AND RESOURCES FOR SIGNALIZED INTERSECTIONS

The following signal timing or phasing options may also be considered for improving pedestrian safety at signalized intersections:

- Extended WALK – This strategy to maximize the WALK interval may be used as default, especially for long side street crossings where side street traffic volumes are small and pedestrian activity is high. For coordinated phases, this strategy uses the "Rest in WALK" setting during the green phase.
- Shorter cycle lengths – This strategy is used to minimize pedestrian delay in areas with high levels of pedestrian activity by providing more frequent WALK phases. This strategy complements Pedestrian Recall settings for the WALK phase. The 4th edition of the Highway Capacity Manual described pedestrian delay over 40 seconds as a LOS E and contributing to higher rates of pedestrian noncompliance at signalized intersections.[6]
- Exclusive pedestrian phase ("Barnes Dance")– This strategy provides a WALK phase in all directions of travel at the intersection while vehicle traffic is prohibited from entering the intersection from all approaches. When a protected WALK phase (protected LT and restricted RT) is called at signals where two one-way streets intersect, the effect is an exclusive pedestrian phase. The phasing will delay vehicle movements until the end of the pedestrian clearance phase, eliminating the vehicle interaction during pedestrian actuation.

Other strategies for improving pedestrian safety and mobility at signalized intersections, including geometric improvements, visibility enhancements, detection options, and additional signal phasing strategies are discussed in the following publications:

6 NCHRP 969: Traffic Signal Control Strategies for Pedestrians and Bicyclists. 2022. Washington, DC: The National Academies Press. https://doi.org/10.17226/26491.

- NCHRP 926: Guidance to Improve Pedestrian and Bicyclist Safety at Intersections (2020).
- NCHRP 969: Traffic Signal Control Strategies for Pedestrians and Bicyclists (2022).
- "Guidance on Signal Control Strategies for Pedestrians to Improve Walkability." ITE Journal (May 2018).