BOSTON REGION METROPOLITAN PLANNING ORGANIZATION

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TECHNICAL MEMORANDUM

DATE: **June 4, 2015**
TO: **Boston Region Metropolitan Planning Organization (MPO)**
FROM: **Seth Asante and Andrew Nagle, MPO Staff**
RE: **Pedestrian Signal Phasing Study**

This memorandum summarizes a review of the literature on existing practices and guidelines for pedestrian signal phasing and the results of an MPO survey about municipal pedestrian signal phasing. Based on the literature review and survey, MPO staff recommends measures to improve pedestrian safety at signalized intersections.

1 INTRODUCTION

Pedestrian signals provide indications intended exclusively to control pedestrian traffic at signalized intersections. Pedestrian signals are incorporated into the overall traffic signal cycle and can operate as an exclusive or concurrent pedestrian phase. Exclusive pedestrian phasing allows pedestrians to cross the intersection in all directions while vehicular traffic is stopped. This phasing type is typically favored for pedestrian safety, but it forces pedestrians to wait through an entire cycle of traffic before crossing is permitted. Concurrent pedestrian phasing allows pedestrians to cross simultaneously with parallel traffic and can therefore reduce pedestrian delay, but conflicts may arise between pedestrians and turning vehicles.

Because of safety and operational impacts, pedestrian signal phase type must be selected to maximize safety benefits and maintain efficient traffic flow. The selection of pedestrian signal phase type involves several complicated factors and often poses challenges to municipalities. Currently, very little guidance exists to help municipalities identify appropriate pedestrian signal phase type at intersections. Also, municipalities may not be aware of advances in technology producing new devices and methods to enhance pedestrian safety at intersections.

2 OBJECTIVE

The objective of the study is to identify the conditions under which each type of pedestrian phasing is appropriate. Municipalities in the MPO region can then apply this guidance to develop policies for pedestrian signals and phasing when

redesigning signalized intersections. Another objective of the study is to determine state-of-the-art practices for applying exclusive or concurrent pedestrian signal phasing.

3 LITERATURE REVIEW

The following sections describe the operations and factors that distinguish the two pedestrian signal-phasing methods.

3.1 Exclusive Phasing

An exclusive pedestrian phase is a portion of a traffic signal cycle that is reserved for pedestrian movements while displaying red on all traffic signals for vehicles. Exclusive phasing is most often considered for intersections in downtown areas or central business districts with high pedestrian volumes. Exclusive phasing is also considered for intersections with excessive pedestrian-vehicle conflicts caused by factors such as limited sight distance, road geometry, and high traffic volumes. Assuming perfect compliance, exclusive signal phasing eliminates pedestrian-vehicle conflicts during the pedestrian phase.

The decision to implement an exclusive pedestrian phasing as part of a pedestrian solution must be weighed against its impact on traffic as a whole. To add an exclusive pedestrian phase to the overall traffic signal cycle, either the cycle length must be lengthened or other phase lengths in the signal cycle must be shortened. In either case, incorporating an exclusive phase for pedestrians significantly decreases the intersection's capacity and increases delays for motorized vehicles. Similarly, an exclusive pedestrian phase increases pedestrian delays and the potential for pedestrian violations during the do-not-walk interval.

For exclusive pedestrian phasing to be employed properly, clear and appropriate audible cues must be provided for the visually impaired. This helps pedestrians with disabilities to navigate the crossings and avoid vehicular conflicts.[1] Several studies have proposed thresholds where exclusive phasing can effectively improve pedestrian safety. Zegeer et al. found that exclusive pedestrian phasing, compared with concurrent signal phasing or none at all, yields measurable reductions in collisions only when pedestrian volume exceeds 1,200 persons per day.[2] Tian et al. created a pedestrian phasing model which indicated that

[1] National Cooperative Highway Research Program, Web-Only Document 150: Accessible Pedestrian Signals: A Guide to Best Practices (Workshop Edition 2010), Contractor's Guide for NCHRP Project 3-62A, Submitted November 2009

[2] Charles V. Zegeer et al., "Effect of Pedestrian Signals and Signal Timing on Pedestrian Accidents," *Transportation Research Record: Journal of the Transportation Research Board* No. 847 (1982): 62-72.

exclusive phasing is appropriate for intersections where the time ratio of combined through-traffic phases to pedestrian phases is lower than 0.5. The model also suggested that concurrent phasing is appropriate for intersections when the ratio is larger than 1.5. Conditions between 0.5 and 1.5 would require additional investigation based on vehicle and pedestrian volumes and other factors.[3] For more localized guidance, the *Boston Complete Streets Guidelines* suggest that exclusive phasing should be implemented in the City of Boston when: [4]

- Conflicting turning vehicle volumes are equal to or greater than 250 vehicles per hour
- Intersections are predominantly used by the elderly, children, and hospital patients
- Other geometric factors restrict vehicles' turning performance

3.2 Concurrent Phasing

Concurrent phasing allows pedestrians and nonconflicting traffic to move simultaneously at a signalized intersection. This typically improves vehicular operations by shortening the cycle length and also reduces waiting time for both vehicles and pedestrians. The chief disadvantage of concurrent phasing is the potential conflict between pedestrians and turning vehicles. Signal phasing solutions such as a leading pedestrian interval, protected left-turn phasing, and turning restrictions, when implemented appropriately, can increase pedestrian safety and traffic efficiency.

Leading Pedestrian Interval (LPI)

An LPI begins the walk signal about 3 to 6 seconds before the concurrent vehicle phase.[5] Thus, pedestrians get a head start in crossing and are more visible to turning vehicles, which are then more likely to yield. An LPI may be appropriate if a high percentage of pedestrian crossings are compromised by having to yield to turning vehicles. As a means of reducing pedestrian-vehicle crashes, an LPI is also a relatively low-cost solution.

[3] Tian et al., "Pedestrian Timing Alternatives and Impacts on Coordinated Signal Systems Under Split-Phasing Operations," Transportation Research Record: Journal of the Transportation Research Board No.1748 (2001): 46-54.

[4] "Boston Complete Streets Guidelines Chapter 4: Intersection, Exclusive vs. Concurrent Phasing," Boston Transportation Department, accessed March 26, 2014, http://issuu.com/bostontransportationdepartment/docs/4_9.

[5] "Pedestrian Signals," Pedestrian and Bicycle Information Center, accessed March 26, 2014, http://www.pedbikeinfo.org/planning/facilities_crossings_pedsignals.cfm.

Protected versus Permissive Turning

Signal phasing for left and right turns has a major impact on pedestrian activity at signalized intersections. There are two major signal-phasing operations for turning vehicles: protected and permissive. Protected phasing provides turning vehicles the right-of-way, indicated by a green arrow on a signal head. Under permissive phasing, turning vehicles must yield to oncoming traffic and pedestrians.

Traditionally, the factors to determine which phasing to use is based on number of crashes, sight distance, crossing distance, number of through lanes and turning lanes, volume of through traffic and turning traffic, speed limit, and turning delay.[6] Protected phasing benefits the specified turning movements and reduces pedestrian-vehicle conflicts but potentially increases intersection delays. Permissive phasing provides the most efficient signal cycle and vehicular operations but may increase pedestrian-vehicle conflicts. Most studies of protected versus permissive turning focus on left turns, because those generate more conflicts than right turns.[7] Left-turning drivers also spend more time than right-turning drivers looking out for obstructions.[8] Right turns are usually permissive unless noted otherwise.

Concurrent pedestrian phasing is preferred if there is a protected left-turn phase because of a large number of left-turning vehicles. This typically results in higher pedestrian compliance and limits pedestrian-vehicle conflicts to right-turning vehicles only. However, concurrent pedestrian phasing is also preferred with a permissive left-turn phase if there is a light-to-moderate amount of left- and right-turn volumes and adequate sight distance. In such a case, pedestrian-vehicle conflicts can arise for both left- and right-turning vehicles.

Right-Turn-on-Red Restrictions

Right-turn-on-red (RTOR) restrictions prohibit vehicles from turning right while the traffic signal indication is red. RTOR restrictions are implemented using low-cost static or dynamic signage at the intersection such as no-turn-on-red signs. With recent advancements in technologies, RTOR restrictions are possible using dynamic LED signs, which allow the RTOR prohibition to be triggered by a pedestrian pushing the button for the pedestrian signal. Instead of relying on

[6] "Traffic Signal Timing Manual Chapter 4: Traffic Signal Design," USDOT, accessed March 26, 2014, http://ops.fhwa.dot.gov/publications/fhwahop08024/chapter4.htm.

[7] Nicolas J. Garber and Raghavan Srinivasan, "Characteristics of Accidents Involving Elderly Drivers at Intersections," *Transportation Research Record: Journal of the Transportation Research Board* No.1325 (1991): 8-16.

[8] Heikki Summala et al., "Bicycle Accidents and Drivers' Visual Search at Left and Right Turns, *Accident Analysis & Prevention* Vol.28, No. 2 (1996): 147-153.

peak-hour or time-of-day restrictions to reduce vehicle-pedestrian conflicts, this method provides real-time restrictions based on pedestrian demand.[9]
RTOR restrictions are usually considered when exclusive pedestrian phases or high pedestrian volumes are present. RTOR restrictions with an exclusive pedestrian phase eliminate vehicle-pedestrian collisions. RTOR restrictions are also beneficial with concurrent pedestrian phasing, especially when it is supplemented with an LPI. Prohibiting RTOR along with an LPI provides pedestrian benefits with minimal impacts to motorized traffic. Part-time RTOR restrictions during peak hours also provide similar benefits while removing the prohibition when pedestrian or vehicular traffic is low.

3.4 Benefits and Concerns of Pedestrian Signal Phase Types

Table 1 presents the benefits and concerns of the two phase types and factors that affect their selection.

TABLE 1
Comparison of Exclusive and Concurrent Pedestrian Phasing

Exclusive Pedestrian Phase	Concurrent Pedestrian Phase
Conflicts	**Conflicts**
Feeling of security for all pedestrians when there are no vehicle conflicts	Conflict between turning vehicles and pedestrians
Delay	**Delay**
Longer delays for motor vehicles and pedestrians	Fewer delays for motor vehicles and pedestrians
Compliance	**Compliance**
Less compliance: pedestrians often cross against the traffic light concurrent with parallel traffic if no conflicts are apparent.	High compliance: incorporation of LPI lessens conflict with turning vehicles.
User judgment	**User judgment**
May require no-right-turn-on-red sign to operate effectively	Pedestrians must exercise more caution and judgment; incorporation of LPI lessens conflict with turning vehicles.
Conditions for application	**Conditions for application**
• High pedestrian volume • Pedestrian flow > 1200 persons per day • Conflicting turning vehicles ≥ 250 vehicle/hour	• Low to moderate pedestrian volume • Pedestrian flow ≤ 1200 persons per day • Conflicting turning vehicles ≤ 250 vehicle/hour

[9] Innovative Intersection Safety Improvement Strategies and Management Practices: A Domestic Scan, Chapter 3 Traffic Control Devices for Motorists, Federal Highway Administration, United States Department of Transportation, September 2006

Exclusive Pedestrian Phase	Concurrent Pedestrian Phase
• Signalized intersections with high concentrations of older pedestrians, students, disabled (not visually impaired), or very young pedestrians	• Signalized intersections with low concentrations of older pedestrians, students, or very young pedestrians
• Complex intersections with poor sight distance	• Simple intersections with good sight distance
• Long crosswalks > 55 feet	• Short crosswalks < 55 feet
Accessibility	**Accessibility**
It is a disadvantage for pedestrians with disabilities who rely on traffic sounds to determine the signal phases. In addition, initial alignment and maintaining alignment during crossings may be difficult due to the absence of parallel moving traffic. APS may address some of these issues	It is an advantage for pedestrians with disabilities who rely on traffic sounds to determine the signal phases. In addition, initial alignment and maintaining alignment during crossings may be difficult due to the absence of parallel moving traffic.
Pedestrian convenience	**Pedestrian convenience**
Pedestrian crossings may be made diagonally for pedestrian efficiency but will increase delay for drivers.	Pedestrian crossing is always parallel to the nonconflicting through movements of drivers.

4 PEDESTRIAN SIGNAL-PHASING POLICIES IN NEW ENGLAND STATES

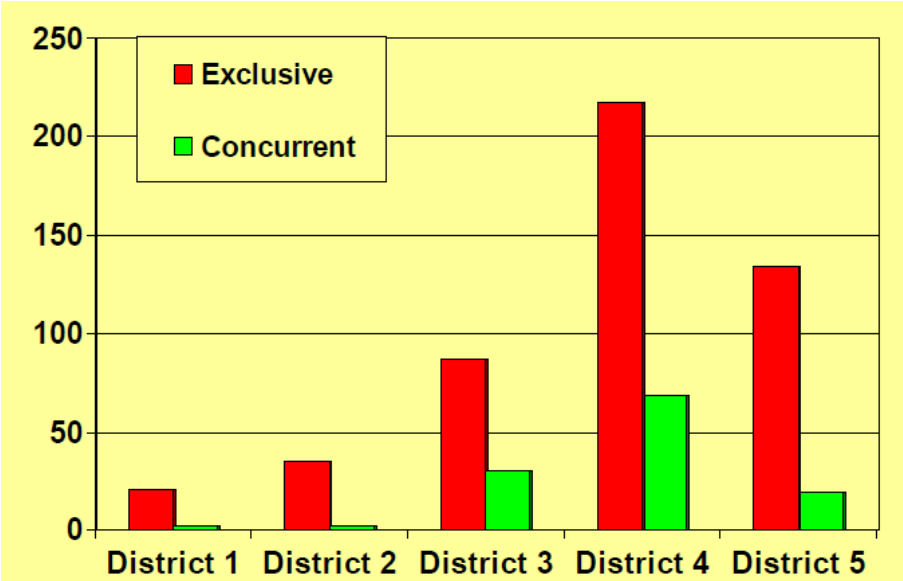
Statewide and regional pedestrian policies are an important means of reducing user confusion and providing consistency throughout the state's transportation network. Such policies establish the approval process for selecting, installing, modifying, and removing pedestrian traffic signals. In addition, statewide pedestrian signal policy promotes consistent practices across municipalities, which increases pedestrian understanding and compliance with pedestrian signals. The following are the pedestrian signal policies of the six New England states; they show no clear preference among the states for a particular phase type.[10]

- **Vermont DOT** – Assess each intersection on a case-by-case basis, no written policy
- **New Hampshire DOT** – Primarily use exclusive phasing, but consider concurrent phasing on coordinated signal systems
- **Maine DOT** – Typically use concurrent phasing
- **Connecticut DOT** – Assess each intersection on a case-by-case basis
- **Rhode Island DOT** – Use concurrent phasing as a default, no written policy
- **MassDOT** - Primarily use exclusive phasing, no written policy

[10] A presentation to the New England Chapter of the Institute of Transportation Engineers

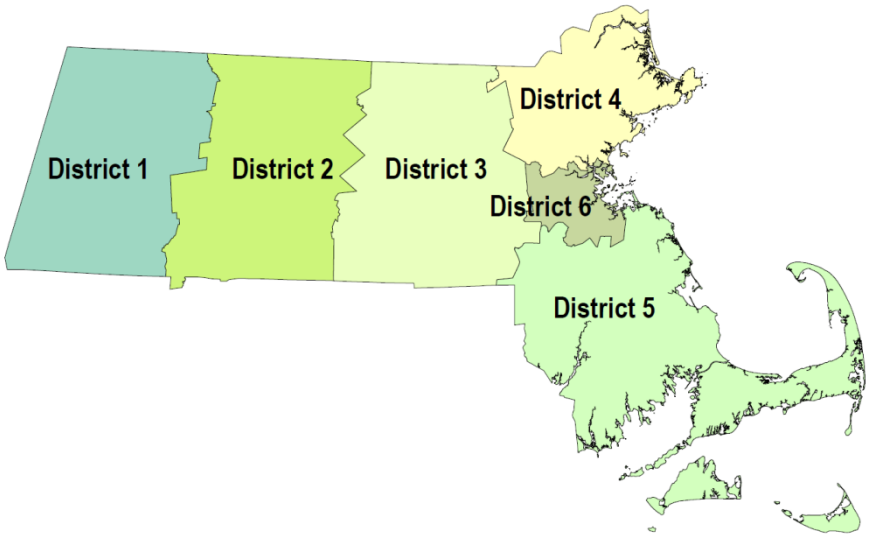
The Figures 1A and 1B shows the distribution of exclusive and concurrent pedestrian signal phasing in MassDOT-owned traffic signal systems, separated by Highway Division district. Preference for exclusive pedestrian phasing is well established. Highway districts in Eastern Massachusetts, especially District 4 and District 5 (part of which was reorganized into District 6), appear to have significant proportions of concurrent pedestrian signal phasing.

FIGURE 1A
MassDOT Traffic Signal Pedestrian Phase Types



Source: MassDOT Highway Division

FIGURE 1B
MassDOT Highway Districts



Source: Central Transportation Planning Staff

5 MUNICIPAL PEDESTRIAN SIGNAL POLICY

A survey created by MPO staff has been used to collect information from selected municipalities throughout the MPO area. The purpose was to investigate existing pedestrian signal policies and guidelines and what insight they can provide on selecting and operating pedestrian signals. City and town engineers and public-works directors from 35 municipalities were solicited; 14 municipalities completed the survey.

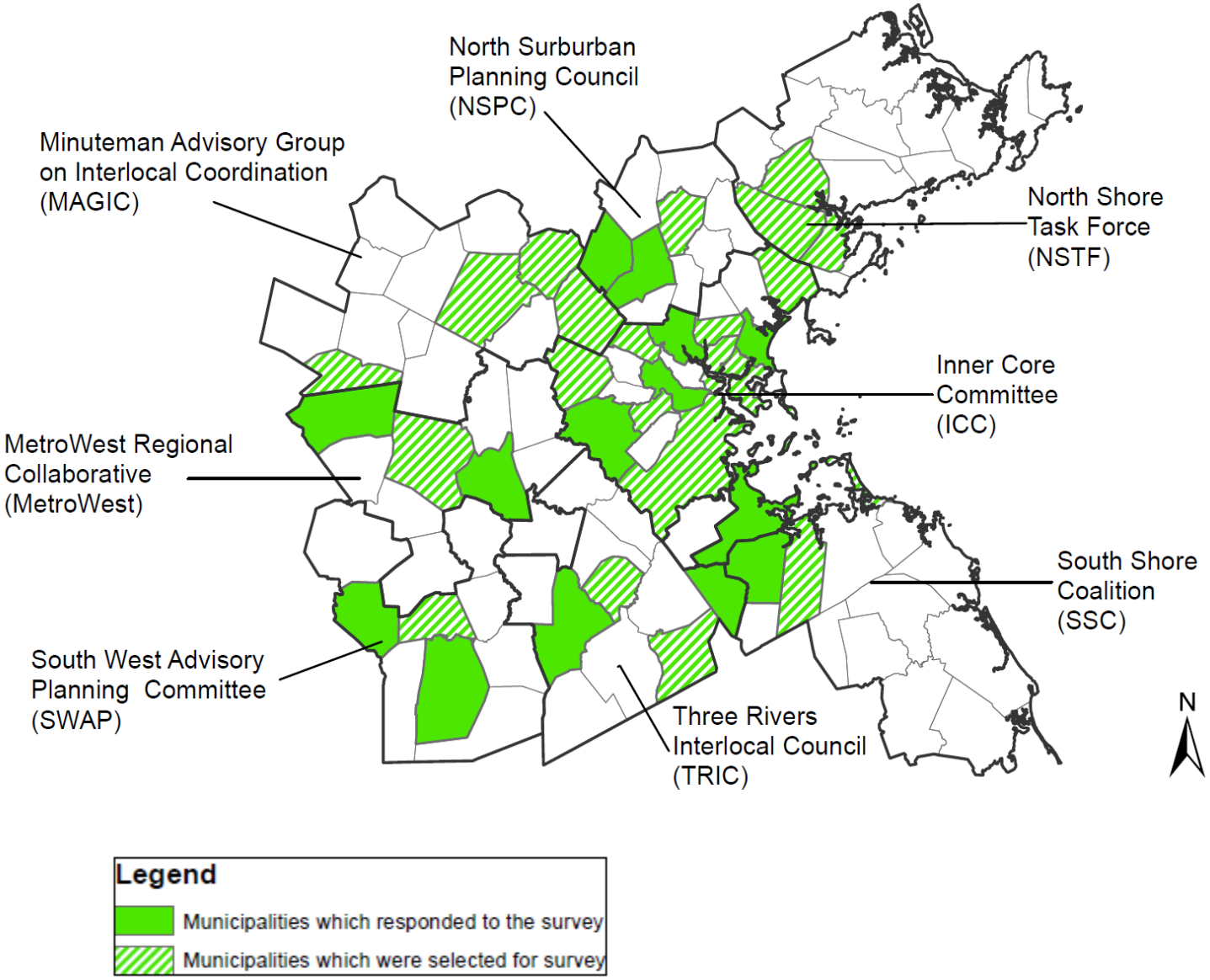
5.1 Survey Design

The selection was designed to include municipalities of each of the following types:

- Municipalities that include environmental-justice (EJ) areas and zones intended to provide fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies
- Municipalities that own and operate traffic signals, since state-owned traffic signals were excluded from the survey
- At least two municipalities in each of the eight Metropolitan Area Planning Council (MAPC) sub-regions (Figure 2)
- Municipalities with a range of experience with pedestrian signal phasing, ranging from urban communities with intersections that experience high traffic and pedestrian volumes to suburban communities that do not

The survey questionnaire was divided into four parts: 1) general information about the town or city, 2) pedestrian signal policy, 3) pedestrian signal phasing selection criteria, and 4) methods to enhance pedestrian signal phasing. The survey was distributed to municipalities in June 2014. MPO staff allowed two weeks and an extra one-week reminder for municipalities to respond. A map of the 35 municipalities selected to participate in the survey and the 14 municipalities that responded to the survey is shown in Figure 2. The full survey is provided in Appendix A and the responses in Appendix B.

FIGURE 2
Municipal Pedestrian Signal Phasing Survey



Source: Central Transportation Planning Staff

5.2 Analysis and Results of Survey

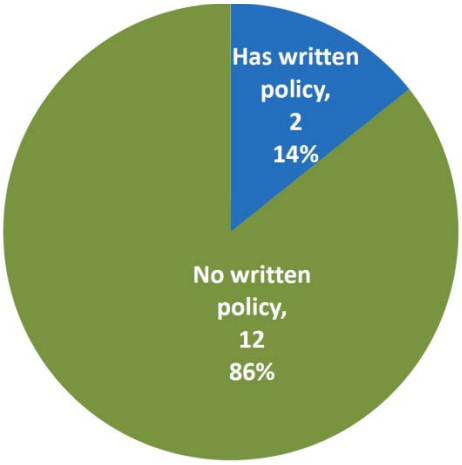
Pedestrian Signal Policy

Part II, Questions 3 through 5 of the survey explored how municipalities decide whether to use concurrent or exclusive pedestrian signal phasing. The aim was to determine if municipalities have established policies for the selection process and how those policies might change.

Written Policy

- The majority of the municipalities do not have written policies guiding the selection of pedestrian signal phases. Only two municipalities have written policies for implementing pedestrian signal phasing (Figure 3).
- The majority of municipalities do not expect to develop a written policy for implementing pedestrian signal phasing in the near future. Two municipalities plan to develop written policies in the near future (Figure 4).
- Municipal engineering departments, consultants, and traffic safety committees/councils play significant roles in choosing a specific pedestrian phasing. For example, seven municipalities do not plan on developing a policy in the near future, primarily because the municipalities either have an engineering department or use traffic engineering consultants.

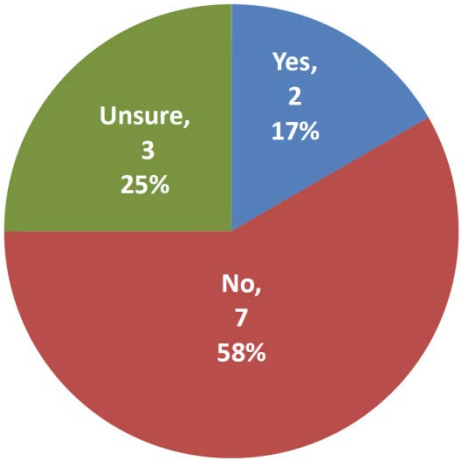
Figure 3
Written Policy



Does your municipality have a written policy for pedestrian signal phasing?

Source: Central Transportation Planning Staff

Figure 4
Future Policy Changes



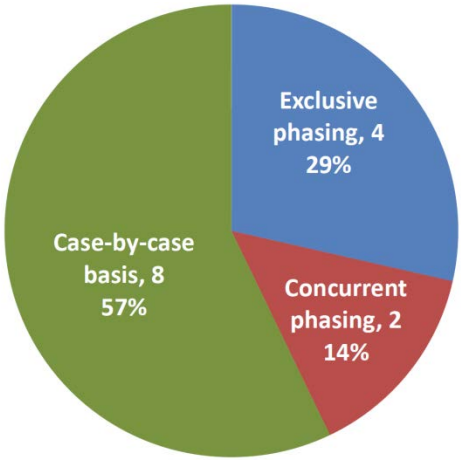
If your municipality does not have a written policy for pedestrian signal phasing, do you expect that one would be developed in the near future?

Source: Central Transportation Planning Staff

Preference

- Approximately 57 percent of the municipalities do not have preferred pedestrian signal phase type (Figure 5). They select a specific pedestrian signal phase type on a case-by-case basis.
- Four municipalities prefer exclusive pedestrian phasing and two municipalities prefer concurrent pedestrian phasing (Figure 5).
- The four municipalities that prefer exclusive phasing are suburban communities; the two municipalities that prefer concurrent pedestrian phasing are in the MAPC Inner Core Committee sub-region (see Figure 2).

Figure 5
Preference



What type of pedestrian phasing does your municipality primarily use?

Source: Central Transportation Planning Staff

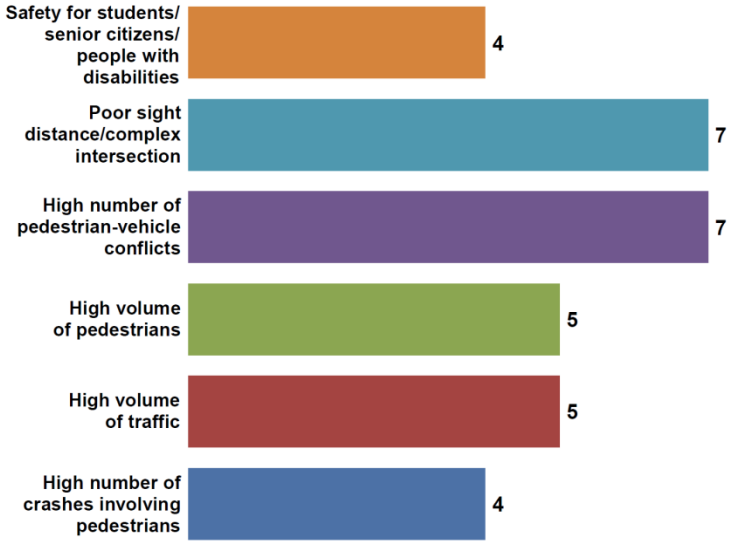
Selection Criteria for Implementing Pedestrian Signal Phasing

Part of the survey focused on criteria for selecting pedestrian signal-phasing (Questions 6 and 7). The aim was to identify the selection criteria and how uniformly they were used. The questions permitted selecting multiple answers; therefore, the total number of responses exceeds the number of municipalities.

Exclusive Pedestrian Phasing

- Multiple factors contribute to selecting exclusive pedestrian signal phasing, all of which address safety for pedestrians.
- High numbers of pedestrian-vehicle conflicts and poor pedestrian safety due to sight distance or complex intersections have the most influence on the selection of exclusive pedestrian phasing.
- High volumes of pedestrian and vehicular traffic influence exclusive pedestrian phasing.

Figure 6
Selection Criteria:
Exclusive Pedestrian Signal Phasing



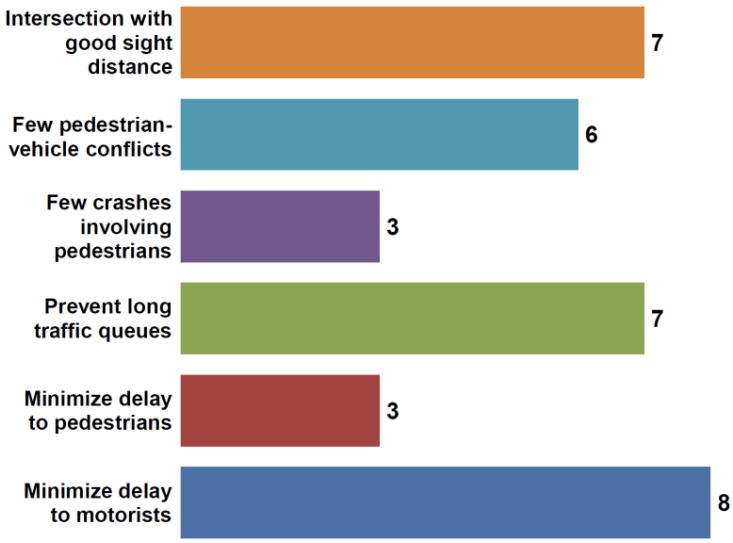
What criteria does your municipality use to determine whether exclusive pedestrian phasing should be installed?

Source: Central Transportation Planning Staff

Concurrent Pedestrian Phasing

- Multiple factors also contribute to selecting concurrent pedestrian phasing; however, the goal is to maximize safety for pedestrians and efficiency for traffic operations.
- The goals of minimizing delays to motorists and preventing long traffic queues have the most influence on the selection of concurrent pedestrian phasing.
- Simple intersections with good sight distance and intersections with few pedestrian-vehicle conflicts are typical candidates for concurrent pedestrian phasing.

Figure 7
Selection Criteria:
Concurrent Pedestrian Signal Phasing



What criteria does your municipality use to determine whether concurrent pedestrian phasing should be installed?

Source: Central Transportation Planning Staff

Methods Used to Enhance Pedestrian Signal Phasing

Part IV of the survey examined how municipalities enhance their existing pedestrian signal phases (Questions 8 through 10). The aims were to determine typical complaints municipalities receive from their citizens, methods that municipalities are using to improve safety performance of pedestrian signal phasings, and the process that is followed to change an existing pedestrian signal phasing. Multiple answers were allowed for these questions; therefore, the total number of responses exceeds the number of municipalities.

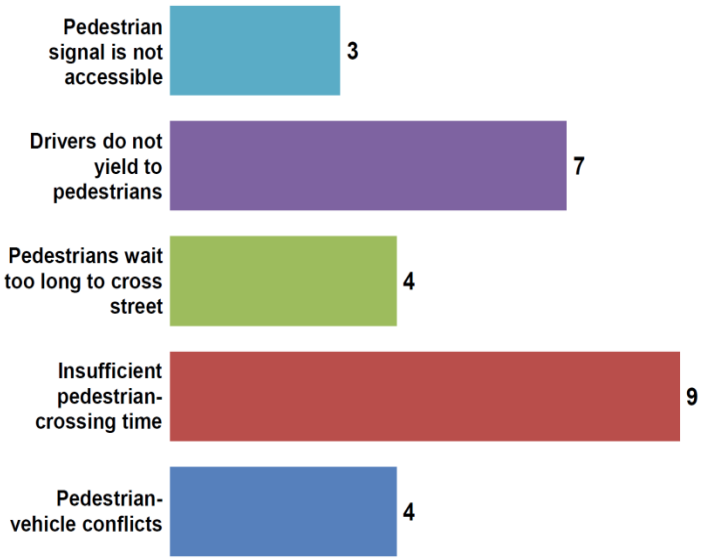
Complaints from Citizens

Complaints from citizens about pedestrian signal phasing are very common, and they receive high attention from municipal traffic engineers, planners, and elected officials (Figure 8).

- Citizens often complain about insufficient pedestrian crossing time and drivers not yielding to pedestrians in crosswalk. Pedestrian crossing time is a standard calculation based on crossing width and average walking speed of a pedestrian and is independent of pedestrian signal-phase type.

- Complaints that pedestrians wait too long to cross the street or about frequent pedestrian-vehicle conflicts were not the ones most often received.
- Citizens complain the least about accessible pedestrian signals (APS). APS is a device that communicates information about the WALK and DON'T WALK intervals at signalized intersections in nonvisual formats, such as audible tones, to pedestrians who are blind or have low vision.

Figure 8
Typical Complaints from Citizens



What are the typical complaints that you receive from citizens about pedestrian signal phasing?

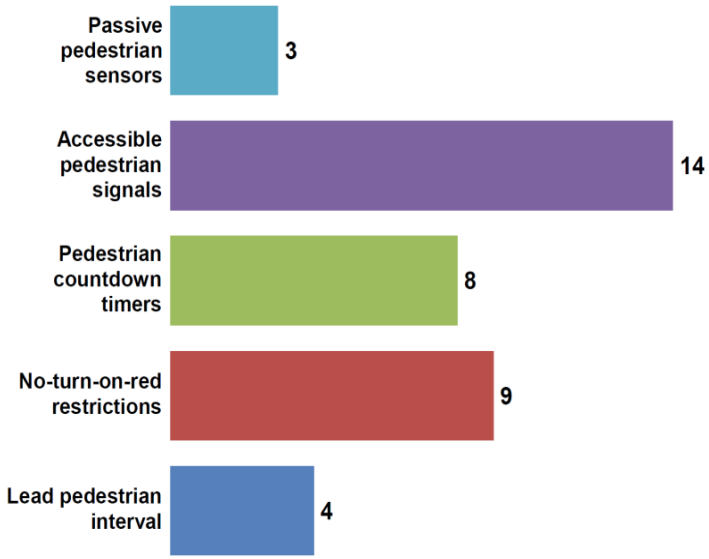
Source: Central Transportation Planning Staff

Safety Enhancements

Several methods are available to increase the safety and efficiency of pedestrian signal phase types, and they are receiving growing attention from many municipalities (Figure 9).

- APS is receiving the most attention in many municipalities. All 14 municipalities stated that they have enhanced pedestrian signal phasing by installing APS (Figure 9).
- Pedestrian countdown timers and no-turn-on-red restrictions are also used to enhance safety of pedestrian signal phasings.
- Few municipalities stated that they use LPI and passive sensors (devices that automatically detect pedestrian presence and request for pedestrian interval) to improve safety of pedestrian signal phasings.

Figure 9
Safety Enhancements



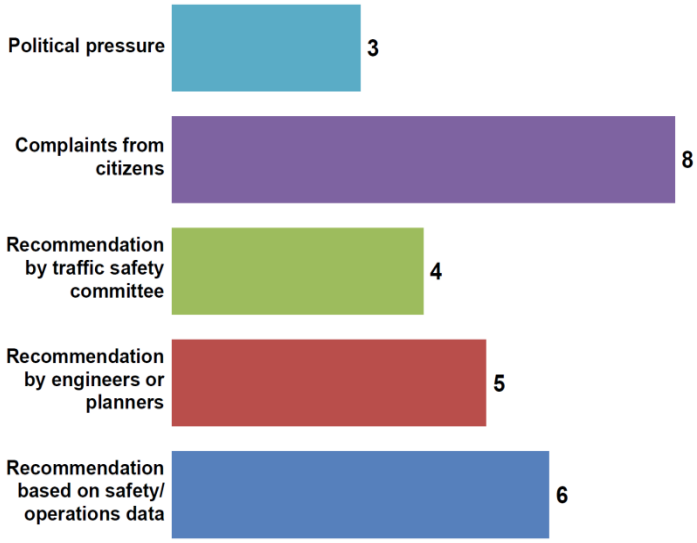
What safety enhancements does your municipality use to improve pedestrian signal phasing?

Source: Central Transportation Planning Staff

Converting Pedestrian Signal Phasings

Although conversion of pedestrian signal phase type is infrequent, the decision to change existing pedestrian signal phasing can evolve from several sources of input (Figure 10).

Figure 10
Converting Pedestrian Signal Phasings



What decision-making process does your municipality typically rely upon to change existing pedestrian signal phasing?

Source: Central Transportation Planning Staff

- Citizen complaints are the most influential factor that drives the process of changing a pedestrian signal phasing. Eight municipalities stated that they are greatly influenced by citizen complaints.
- Recommendations based on safety and operations data and the expertise of engineers and planners were also dominant factors that municipalities rely upon in changing pedestrian signal phasings.
- Political pressure appears to be the least influential factor that municipalities rely upon in changing pedestrian signal phasings.

5.3 Case Studies

Six municipalities were selected for evaluation of their practices, challenges, and recommendations for improvements: Braintree, Cambridge, Franklin, Marlborough, Newton, and Woburn. Inputs from these municipalities were also used in the findings and recommendations of this study. They include how they are impacted by the lack of:

- Educating motorists and pedestrians on concurrent and exclusive pedestrian signal phasing
- Statewide or regional policy recommendations for implementing pedestrian signal phasing
- Engineering studies (warrants) for justifying the choice of pedestrian signal phase type

As part of the case studies, MPO staff wanted to identify as many as four intersections where conversions from exclusive to concurrent pedestrian phasing or vice versa took place to conduct before-and-after safety evaluations. This objective was not met because of low sample sizes—few intersections had

experienced more than a few pedestrian crashes over a three-year period. Thus, a before-and-after study would likely have no statistical significance. In general, because reported pedestrian crashes are rare events, the large sample sizes required to study them would be beyond the means of this study.

6 FINDINGS, RECOMMENDATIONS, AND CONCLUSIONS

Based on a review of the literature, the municipal survey, and case studies, MPO staff have made the following findings, recommendations, and conclusions:

6.1 Findings

- Many municipalities have no written policies for selecting pedestrian signal phase type; they decide on a case-by-case basis.
- There is no clear preference for a particular type of pedestrian signal phasing. Selecting appropriate pedestrian signal phase type depends on a number of factors.
- The most influential factors used to select exclusive pedestrian signal phasing have to do with safety—such as safety for pedestrians at complex intersections with poor sight distance or high pedestrian-vehicle conflicts.
- The most influential factors used to select concurrent pedestrian signal phasing have to do with balancing safety with efficient traffic operations to minimize delay to motorists and pedestrians and prevent long queues. These factors are often considered at simple intersections with good sight distance.
- The complaint that drivers do not yield to pedestrians is a common complaint for concurrent pedestrian phasing, since exclusive pedestrian phasing removes all vehicle-pedestrian conflicts unless RTORs are permitted.
- According to the survey, citizens complain the least about APS. The survey shows that APS installation is receiving high attention from municipalities to improve safety for all types of pedestrians at intersections.
- LPI improves safety for concurrent pedestrian signal phasing. The head start allows pedestrians to establish themselves in the crosswalk before right-turning traffic starts to move, thereby reducing pedestrian-vehicle conflicts. However, the LPI does not receive much attention in the survey, perhaps because this practice may be uncommon in the MPO region or because the wide use of exclusive pedestrian signal phasing reduces the need for it.

- Complaints from citizens are the most influential factor driving the decision-making process of converting existing pedestrian signal phasing. There is a high probability that many of the complaints will lead the municipality to conduct studies and make recommendations based on safety and operations data.

6.2 Recommendations

General Recommendations

Policy

There appears to be a need for a statewide or regional policy recommendation to provide direction for implementing safe and efficient pedestrian phasing and provide the needed support to adopt a local policy. The lack of written policies hinders efforts to select appropriate pedestrian signal phasing based on site conditions. Some municipalities primarily use exclusive pedestrian signal phasing and do not consider concurrent pedestrian phasing, even in cases where it might increase pedestrian safety and efficiency.

Education

Pedestrian and driver education on how concurrent and exclusive pedestrian phasing work and their benefits are needed—many people perceive concurrent phasing as unsafe. Feedback from the survey indicated instances where concurrent pedestrian signal phasing that seemed to be functioning well was switched back to exclusive phasing because of neighborhood complaints or the impression that they were unsafe. Road users need a better understanding of the operations of exclusive and concurrent pedestrian signal phasings to reduce the potential for driver confusion and pedestrian-vehicle conflicts. Education campaigns to raise road users' awareness are also very much needed. Such education will require coordination between MassDOT Highway Division, MassDOT Registry of Motor Vehicles, and the municipalities to identify the appropriate media and content for the education campaigns.

Warrants

A warrant is an engineering study of traffic conditions, pedestrian characteristics, and physical characteristics of the location performed to determine whether a concurrent or exclusive pedestrian signal phasing is justified at a particular location. Neither mode of pedestrian signal phasing works for all locations. Therefore, warrants for selecting pedestrian signal phasing type, similar to the traffic-signal warrants used to justify the installation of traffic signals, would be useful. Concurrent pedestrian signal phasing with an LPI works well when it is prevalent throughout an area and pedestrians are familiar with and understand its operations. It also works well at locations where there is the need to balance pedestrian safety with efficient traffic operations. Exclusive pedestrian phasing,

when supplemented with RTOR restrictions, works well at locations with high pedestrian-vehicle conflicts or a high number of students or elderly people and at complex intersections with poor sight distance.

New Technologies

Many municipalities are upgrading their signal equipment to improve safety, accessibility, and operations. New technologies to improve the safety of pedestrian signal phasing include LPI, countdown timers, APS, pedestrian sensors (video and infrared), and dynamic signs.

Dynamic Signs: Pedestrian-Activated No-Turn-On-Red LED Sign or Red Arrow Indications

This system, upon detecting a pedestrian either by push button or passive sensors, activates a no-turn-on-red LED sign or a red right-turn arrow signal to eliminate the conflict between a right-turning vehicle and a crossing pedestrian (Figure 11). This system can be programmed to activate at certain times of the day and be turned off at other times. It can also be combined with exclusive pedestrian phasing by prohibiting vehicles from turning right across crosswalks during the pedestrian phase.

Figure 11
Dynamic Signs

Source: CTPS photo

Benefits: At signalized intersections where significant conflicts exist with vehicles turning right across active crosswalks, pedestrian activation of a no-turn-on-red LED sign can eliminate the conflict. The concept of restricting right turns across active pedestrian crosswalks can be extended to prohibit left-turning vehicles across active pedestrian crosswalks.

Concerns: If pedestrian activation occurs throughout the pedestrian phase, vehicles will have no time to turn right. This could have a negative impact on traffic flow. An assessment is needed to determine the impact of a no-turn-on-red sign on traffic flow—such assessment should examine the congestion implications for vehicles traveling through the intersection as well as for vehicles turning right at the intersection.

Automatic Extension of Pedestrian Signal Phase

This system uses passive sensors to detect pedestrians who enter the crosswalk at the end of the pedestrian walk interval and extends the interval long enough for the pedestrian to finish crossing. In addition, the system can cancel the call for the pedestrian signal if the pedestrian leaves the area. This feature can help prevent congestion caused by extended walk-signal times. Although automatic detection and extension of the walk signal for pedestrians is still in the early-deployment stage in the United States, the system has been used successfully in Europe and Australia for many years.

Benefits: This system may be particularly beneficial at signalized intersections where there is a wide range of walking speeds among pedestrians, such as those with concentrations of older pedestrians, disabled pedestrians, or very young pedestrians.

Concerns: In coordinated systems, signal coordination is more difficult to achieve, and in congested urban areas with heavy pedestrian traffic, a constant flow of pedestrians activating extended walk phases may contribute to congestion.

6.3 Conclusion

This study provides information about current practices for implementing concurrent and exclusive pedestrian signal phasing. The information, gathered from a review of the literature and the MPO's survey, is useful to municipal engineers and planners in the MPO area for selecting appropriate pedestrian signal phase type and enhancements to maximize safety and efficiency for pedestrians and motorists. The study is also useful to the MPO and MassDOT by identifying needed actions:

- Educating road users about the operation of pedestrian signal phasings to reduce the potential for pedestrian or driver confusion
- Formulating statewide or regional policy recommendations for implementing pedestrian signal phasing
- Reducing pedestrian-vehicle conflicts at intersections using LPI and other new technologies

SAA/ASN

APPENDIX A

Survey Questionnaire

A Survey about Pedestrian Signal Phasing on Municipal Systems

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Part I: General Information

1. Please select your city or town. (Choose one)

   [ ] (required)

2. Please provide the contact information of the person filling out this survey.

   Name: [ ] (required)

   Phone: [ ]

   Email: [ ] (required)

Part II: Pedestrian Signal Policy

3. How does your municipality decide whether to use concurrent or exclusive pedestrian signal phasing? (Please choose one)

   - ○ Has written policy, primarily uses exclusive pedestrian phasing
   - ○ No written policy, primarily uses exclusive pedestrian phasing
   - ○ Has written policy, primarily uses concurrent pedestrian phasing
   - ○ No written policy, primarily uses concurrent pedestrian phasing
   - ○ Assess each intersection on case-by-case basis
   - ○ Other (Please specify)

   [ ]

4. If your municipality has a written policy for pedestrian signal phasing, who developed it? (Please choose one)

   - ○ Engineering Department alone
   - ○ Engineering Department with consultant input
   - ○ Traffic safety committee/traffic commission/traffic council
   - ○ Consultant
   - ○ Other (Please specify)

   [ ]

5. If your municipality does not have a written policy for pedestrian signal phasing, do you expect that one would be developed in the near future? (Please choose one)

- ○ Yes (Please give the reason in the space provided below)

- ○ No
- ○ Unsure

Part III: Pedestrian Signal Phasing Selection Criteria

6. What criteria does your municipality use to determine whether exclusive pedestrian phasing should be installed? (Check all that apply)

- ☐ High number of crashes involving pedestrians
- ☐ High volume of traffic (pedestrians risk exposure)
- ☐ High volume of pedestrians (pedestrians risk exposure)
- ☐ High number of pedestrian-vehicle conflicts (high volume of turning vehicles)
- ☐ Safety for pedestrians because of poor sight distance or complex intersection
- ☐ Safety for pedestrians because of nearby student or senior citizen activity or people with disabilities
- ☐ Other (please specify below)

7. What criteria does your municipality use to determine whether concurrent pedestrian phasing should be installed? (Check all that apply)

- ☐ Minimize delay to motorists
- ☐ Minimize delay to pedestrians
- ☐ Prevent long traffic queues
- ☐ Few crashes involving pedestrians
- ☐ Few pedestrian-vehicle conflicts
- ☐ Simple intersection with good sight distance
- ☐ No nearby activities involving students or senior citizens or people with disabilities
- ☐ Other (please specify below)

Part IV: Enhancing Pedestrian Signal Phasing

8. What are the typical complaints that you receive from citizens about pedestrian signal phasing? (Check all that apply)

- ☐ Pedestrian-vehicle conflicts
- ☐ Insufficient pedestrian-crossing time
- ☐ Pedestrians wait too long to cross street
- ☐ Drivers do not yield to pedestrians
- ☐ Pedestrian signal is not accessible
- ☐ Other (please specify below)

9. What safety enhancements does your municipality use to improve pedestrian signal phasing? (Check all that apply)

- ☐ Leading pedestrian interval where pedestrians are allowed 2-4 seconds to leave the curb before

vehicles are permitted to turn concurrently
- ☐ No-turn-on-red restrictions for exclusive pedestrian signal phasing
- ☐ Pedestrian countdown timers
- ☐ Accessible pedestrian signals
- ☐ Passive pedestrian sensors
- ☐ Signs
- ☐ Other (please specify below)

10. What decision-making process does your municipality typically rely upon to change an existing pedestrian signal phasing?

- ☐ Recommendation based on safety and operations data
- ☐ Recommendation based on experience and knowledge engineers/planners
- ☐ Recommendation by traffic safety committee/traffic commission/traffic council
- ☐ Complaints from citizens
- ☐ Political pressure
- ☐ Other (please specify below)

11. Please use the space below to share information on one or two intersections whose pedestrian signal phasing was changed because of safety or operational concerns.

12. Please use the space below to share any additional comments or recommendations regarding the pedestrian signal phasing in your municipality.

Submit Survey Reset

Please send your response and any information you think may be useful to this project to Seth Asante at sasante@ctps.org; 10 Park Plaza, Suite 2150, Boston MA 02116; telephone 617-973-7098; or fax: 617-973-8855.

APPENDIX B

Survey Response

Survey Response

ID	COMMUNITY	RESPONDENT	QUESTION 3 CHOICE	QUESTION 3 TEXT	QUESTION 4 CHOICE	QUESTION 4 TEXT	QUESTION 5 CHOICE	QUESTION 5 TEXT	QUESTION 6 CHOICES	QUESTION 6 TEXT	QUESTION 7 CHOICES	QUESTION 7 TEXT	QUESTION 8 CHOICES	QUESTION 8 TEXT
1	Braintree	Bob Campbell	2		5	We have no written policy. It seems non-transportation professionals have decided that exclusive pedestrian crossings are needed. Warrants are not considered. Exclusive phases are implemented followed by "no turn on red" signs (as required at exclusive ped crossings per mutcd.)	1	I would like to see more concurrent pedestrian phasing and a regional policy recommendation would provide the support needed to adopt a local policy.	2,4,5,6		8	I believe we have no concurrent pedestrian phase signals.	2,5,6	Have to wait too long for pedestrian phase to come up. ("Insufficient crossing time" complaint is from people who don't understand what the "flashing don't walk" means.)
2	Burlington	Brian White	2				2		7	All are exclusive unless high vehicle volume/high road congestion is expected especially if it is coordinated with other signals.	1		4	
3	Cambridge	Jeffrey R. Parenti, P.E.	3		1				4	Geometry, such as T intersections; neighborhood input	1,2,3,5,6	Pedestrians demonstrate obvious desire to cross concurrently.	1,2,4,5	
4	Franklin	Michael Maglio	2				2		3,4,5,6		1,3,4,5		5	
5	Marlborough	Timothy F. Collins	5				3		1,2,4,5,7	All of the criteria checked are used when determining traffic and pedestrian signalling needs. All requests are investigated by the D.P.W. Engineeirng Division and a recommendation is made to the Traffic Commission for their consideration, adoption and implementation.	1,3,4,5,6	All of the criteria checked are used when determining pedestrian and traffic signalling needs. All requests are investigated by the D.P.W. Engineeirng Division and a recommendation is made to the Traffic Commission for their consideration, adoption and implementation.	1,2,3,4,6	Inability to hear audible signals. Request for audible pedestrian signal system.
6	Medford	Joseph	5				2		3		6		2,3	
7	Milford	Scott Crisafulli	5		2		3		3		5		4	
8	Natick	Gordon Van Tassel	2	We use and traffic engineering firm, Beta, whenever we have a traffic light issue.			2						2	
9	Newton	William G. Paille	5		4		1	City already has policy	1,2,4,5		1,2,3,6		1,4	
10	Quincy	Frank A. Tramontozzi, PE	6	Engineering study/judgment	5	N/A	2		7	Engineering study/judgment	8	Engineering study/judgment.	2	
11	Randolph	David Zecchini	5		5	none	3		7	Case by case basis when new signalization is considered			2,4	
12	Revere	Nicholas Rystrom	5				2		1,4,5,6		1,3,5,6		2,3	
13	Walpole	Margaret Walker	5				2		1,2,3,4,5,6,7	All of the above would be considered by us and by any consultant we hired	1,2,3,4,5,6,7,8	All of the above would be considered by us and by any consultant we hired	1,2,4,6	Ped phase appears not to activate
14	Woburn	John Corey	4			No written policy. Traffic Commission works with Engineering	1	We expect the Traffic Commission to adopt one this calendar year	2,3,5		1,3,6	Downtown areas give priority to pedestrians	3	

Source: Central Transportation Planning Staff

Survey Response

COMMUNITY	RESPONDENT	QUESTION 9 CHOICES	QUESTION 9 TEXT	QUESTION 10 CHOICES	QUESTION 10 TEXT	QUESTION 11 TEXT	QUESTION 12 TEXT
Braintree	Bob Campbell	2,4,6,7	Since "no turn on red" signs are so prevalent and often unjustified they are ignored. We've been puting up "turning traffic must yield to pedestrians" instead, which would still be useful if concurrent phasing were adopted.	6	Pedestrian signal phasing is seldom changed. Many believe that exclusive phasing is all that should be considered. Once in place it is not changed.	N/A	Concurrent phasing, with leading pedestrian intervals works well where it is prevalent throughout the area. It seems it would be hard to implement without a statewide or region-wide direction to consider it as a first option and only use exclusive in unique areas where pedestrian warrants are met.
Burlington	Brian White	3,4,6		1,2,3,4,5		One signal intersection at a hospital entrance was changed to increase ped crossing time more than the standard pedestrian movement speeds due to adjacent MBTA bus stop and large amount of elderly crossings.	
Cambridge	Jeffrey R. Parenti, P.E.	1,2,3,4		1,2,4,5		Too many to mention, but an interesting example was 3 intersections on Mass Ave. between Harvard and Porter Square where I switched to concurrent per our written policy, then switched back after an uproar from the neighborhood.	Crash rates involving pedestrians are way down since we started using concurrent phasing, however many people still don't like it. That said, exclusive phasing is counterproductive when most peds cross concurrently anyway.
Franklin	Michael Maglio	4,6		1		During the design of the Downtown Improvement Project, original design had a concurrent ped phase at a new signal location at Emmons St and West Central St. Where this location was a major ped crossing for Dean College and a high traffic area, the town required this to be changed to exclusive phasing for safety reasons.	
Marlborough	Timothy F. Collins	2,3,4,5,6		1,2,3,4,5		Downtown area traffic signals originally installed with non-exclusive pedestrian movements (signed to pedestrians to "Watch for Turning Vehicles") have been changed to exclusive pedestrian movements. One signalized intersection was aslo restricted with No Right Turn on Red as a result of a pedestrain traffic accident (at the request of a City Councilor).	Bidding a project with infrared sensors fro pedestrian crossing - 1st time in the City. Traffic Signals being upgraded will be implementing the MUTCD change to upgrade pedestrian crossings with a countdown timer.
Medford	Joseph	2,4,5		4		Increase ped. time for senior citizen	
Milford	Scott Crisafulli	4		4			
Natick	Gordon Van Tassel	2,4		3		We have one intersection in town next to a school. One approach is downhill and 90% of the traffic turns left right in front of the school where there is a crossing guard for the children. The PED cycle was on the phase right after this downhill left turn and many times vehicles would be stuck in the middle of the intersection when the PED cycle would begin. I was able to move the PED phase so now we have removed the conflict we had.	
Newton	William G. Paille	1,2,3,4,6		2		Beacon & Centre - High Pedestrian Traffic - Implemented Lead Pedestrian Phase. Walnut & Lincoln - Relocated and lengthened crosswalk - increased length of walk phase.	City is implementing program to upgrade all signals with countdown timers, APS pushbuttons and concurrent walk phase and/or lead pedestrian phase where warranted.
Quincy	Frank A. Tramontozzi, PE	2,3,4,6,7	Education	6	Engineering study/judgment.		
Randolph	David Zecchini	2,3,4,6		4		Warren Street at Highland Ave-- ped signals upgraded--old style was still in use.	Very limited funding available for this type of work.
Revere	Nicholas Rystrom	4,6		6	City Traffic Commission		
Walpole	Margaret Walker	7	All of the above would be considered by us and by any consultant we hired	1,2,4			
Woburn	John Corey	1,3,4		1,3,4		Our best upgrades have been the audible pedestrian signals with the countdowns. We are retrofitting all signals through our downtown area which has the busiest pedestrian traffic	Our upgraded traffic signals have Aldis cameras which count traffic volumes, turning movements and pedestrian crossings

Source: Central Transportation Planning Staff