BOSTON
TRANSPORTATION
DEPARTMENT

Boston Transportation Department
Traffic Signal Operations Design Guidelines
July 2018

1. **Objective:**

The objective of this document is to provide traffic engineers with guidelines to be used for the design of traffic signal phasing and timing plans in the City of Boston. The assumption has been made that the installation of any traffic signal under consideration has been justified based on the traffic signal warrant analysis procedure documented in the *Manual on Uniform Traffic Control Devices* (MUTCD) and an engineering report clearly defining the need and purpose of the proposed signal. As in the development of any traffic engineering plan, significant professional engineering judgment should be exercised. These guidelines shall be applied to all projects that impact traffic signals owned and operated by the City of Boston.

2. **Data Collection (minimum requirements)**

a. A condition diagram depicting existing intersection layout including such features as roadway geometry, channelization, grades, number and width of travel lanes, lane use, speed limit, parking restrictions, driveways, bus stops and sight distance restrictions. The location of any adjacent schools, senior citizen facilities, parks, playgrounds, community centers, mass transit stations, hospitals and other significant pedestrian generating facilities should be noted on the diagram. The condition diagram should be developed as a result of a field evaluation.

b. Turning movement vehicle and bicycle counts for each traffic movement from each approach and summarized in 15-minute intervals. Coverage should be at least 7 AM to 6 PM on a typical weekday. Additional counts and ATRs, including nights and/or weekends, may be required to establish cycle lengths for periods with low traffic volumes or special events.

c. Pedestrian volume counts on each crosswalk during the same periods of the vehicular counts.

d. The traffic count data for items b and c must clearly indicate the direction of travel (i.e. from the North) and include peak hour summaries (AM, midday and PM) along with a graphic layout depicting the peak hour movements occurring within the intersection.

e. Existing phasing & timing data for signals on intersecting streets within 1,000 feet of subject location.

f. Most recent 3-year period of crash data available.

3. Traffic Operations Analysis

Perform intersection capacity analysis using collected data and BTD approved methodology to determine critical movements and establish a traffic signal phasing and timing plan. Proper analysis shall include AM peak and PM peak periods at a minimum. BTD will require a midday analysis for traffic signals on the City's central computer system and other locations as directed. BTD may require timing plans for periods with low traffic volumes or special events. If the signalized intersection is, or will be adjacent to or between existing traffic signals operating in a coordinated system, cycle lengths must be consistent with those used in the existing network to maintain proper coordination. Otherwise, all the signalized intersections operating in the coordinated system must be analyzed for new cycle, splits and offsets.

Traffic signal timing & phasing analysis shall be performed using an approved software package such as Synchro - Version 9.0 or higher. Other software packages may be acceptable with prior BTD approval. The traffic signal timing and phasing analysis must be calibrated to reflect current conditions. Synchro model files along with both input and output files shall be submitted for review and approval by BTD. Printed, and/or electronic files may be required for submittal. Measures of Effectiveness (MOEs) such as Average Delay, Level of Service (LOS), Volume to Capacity Ratio (V/C) and 95% Vehicle Queues for each scenario, including the existing condition, shall be summarized on a table by movement, approach and intersection total for each scenario analyzed. Additional MOEs and/or network MOEs may also need to be summarized as required by BTD.

It is known that the goals of traffic safety and traffic capacity may conflict when determining the number of phases for an intersection. In all cases, the treatment of left-turn movements, pedestrian crossings and bicycle flows must be considered in the phasing and timing plan development. In order to maximize efficiency of signalized intersections, BTD requires that traffic signal controllers be designed for the minimum number of phases that are necessary to provide an acceptable level of safety. With this in mind, the traffic engineer must carefully select the appropriate use of protected/exclusive controller phases. Intersections that experience heavy conflicts between turning vehicles and pedestrians and/or between turning vehicles and through traffic or have restricted sight distance may require a protected/exclusive phase, which will have a detrimental effect on intersection operation and capacity.

4. Operational Considerations

a. Signal cycle lengths should be designed to reduce delays to both vehicles and pedestrians while maintaining adequate LOS and traffic signal coordination.

b. The signal phasing and timing plans should be designed for a vehicular LOS "D" or better where attainable and a V/C ratio of 0.85 or lower for each approach during peak hours.

c. Pedestrian WALK intervals should be maximized in correlation with corresponding vehicular movements.

d. A Pedestrian WALK interval shall be provided concurrently with the vehicular GREEN interval for the non-conflicting crosswalks at intersections with one-way streets.

e. Yellow, all-red, and pedestrian clearance intervals shall be calculated using the *Manual on Uniform Traffic Control Devices* (MUTCD) and *MassDOT Guidance on Calculating Clearance Intervals*

at Traffic Signals, issued January 8, 2013. Calculation sheets must be submitted to BTD showing that vehicular and pedestrian clearances for each traffic signal phase has been computed to meet the current city, state, and federal standards.

f. The Boston Transportation Department encourages the use of concurrent pedestrian phases where appropriate to ensure more pedestrians cross with the WALK phase and to reduce delays to pedestrians and vehicles by keeping cycle lengths as low as possible.

***Concurrent* WALK** should be considered where any of the following criteria are met:

- Concurrent WALK phasing will improve operations (i.e. reduce delays to both vehicles and pedestrians).
- There are low conflicting turning vehicle volumes (the sum of left and/or right is less than 250 vph).
- Available sight distance exceeds minimum stopping sight distance criteria listed in Chapter 3 of AASHTO's *A Policy on Geometric Design of Highways and Streets*.
- A half cycle can be used to reduce both pedestrian and vehicular delay.
- The main/coordinated street should rest in WALK.

Leading Pedestrian Interval (LPI) should be considered where any of the following criteria are met:

- LPI+Concurrent WALK phasing will improve operations (i.e. reduce delays to both vehicles and pedestrians).
- Conflicting turning vehicle volumes (the sum of left and/or right) are greater than 150 vph.
- Pedestrian volumes are high (more than 250 pedestrians crossing per hour in at least one crosswalk).
- At intersections within "safety zones" near elderly housing, elementary schools, recreational areas, playgrounds, and health facilities, etc…
- At intersections where left-turning vehicles do not need to yield to oncoming traffic (T-intersections and one-way street to one-way street intersections).
- Available sight distance is less than minimum stopping sight distance criteria listed in Chapter 3 of AASHTO's *A Policy on Geometric Design of Highways and Streets*.
- Intersection geometry is unusual, resulting in unexpected conflicts and/or visibility issues.
- No YELLOW TRAP is created for vehicular traffic.

* *LPI Guidance* – LPI WALK time should allow pedestrians to establish themselves in the crosswalk before concurrent traffic is released (typically 4 to 7 seconds). No Turn on Red restrictions should be considered. If used, No Turn on Red signs should be installed near the appropriate signal head. LPIs should not be used at crosswalks where there is leading protected+permissive left-turn phasing or where its operation would have a detrimental effect on other modes of transportation. LPIs should not preclude the use of Concurrent WALK using half-cycle to reduce bicycle, pedestrian, and vehicular delay if sight distance is not restricted and safety would not be compromised.

***Exclusive* WALK** should be considered where any of the following criteria are met:

- There are high conflicting turning vehicle volumes (the sum of left and right is greater than or equal to 250 vph) and/or pedestrian volumes are high.
- Available sight distance is less than minimum stopping sight distance criteria listed in Chapter 3 of AASHTO's *A Policy on Geometric Design of Highways and Streets.*
- Intersection geometry is unusual, resulting in unexpected conflicts and/or visibility issues.
- At intersections within "safety zones" near elderly housing, elementary schools, recreational areas, playgrounds, and health facilities, etc…

* *Exclusive WALK Guidance* – No Turn on Red restrictions should be considered. If used, No Turn on Red signs should be installed near the appropriate signal head.

g. Protected or Protected + Permissive left-turn phase should be considered in the following cases:
   - The cross-product of the left-turn traffic multiplied by the opposing traffic is greater than 50,000 for one lane and is greater than 100,000 for 2 or more lanes and the left-turn volumes are at least 75 vph, during the two peak hours.
   - Available sight distance is less than minimum stopping sight distance criteria listed in Chapter 3 of AASHTO's *A Policy on Geometric Design of Highways and Streets.*
   - There were 4 or more left-turn crashes in the last year or 6 in the last 2 years that are susceptible to correction.
   - There is more than one left-turn lane.
   - Intersection geometry dictates that permissive left-turns may be confusing or dangerous (i.e. 5-legged or skewed intersections).
   - Where a protected + permissive phasing is provided along with an exclusive turn lane, a Flashing Yellow Arrow or Flashing Red Arrow should be installed for all new traffic signals and signal equipment upgrades, and should be considered for all other cases.

h. Pedestrian intervals should be designed so that pedestrians can cross the entire street on one phase. If a multi-phase pedestrian WALK is the most feasible alternative, a pedestrian push-button must be installed. The median width shall not be less than 6 feet.

i. No Turn on Red restrictions should be considered at locations that meet the criteria listed in Section 2B.54 of the MUTCD. If used, No Turn on Red signs should be installed near the appropriate signal head.

j. Accessible Pedestrian Signals (APS) should be installed in accordance with the City's Accessible Pedestrian Signal Policy and guidance provided in the MUTCD to analyze intersections where APS should be installed.

k. Pedestrian Recall should be considered at high pedestrian volume locations during hours when pedestrian actuations occur more than 50% of all cycles and/or there are more than 250 pedestrians crossing per hour in at least one crosswalk. Automatic 24/7 pedestrian recall should be considered at intersections with concurrent pedestrian operation and no vehicle detection. Pedestrian recall will be considered at other intersections on a case-by-case basis when an engineering study determines that it can be accommodated without adversely impacting operations for all modes.

l. New traffic signal equipment shall be designed to meet BTD signal system specifications and allow for maximum flexibility such as rest in walk on main and side streets phases, providing automatic pedestrian phasing during certain times of the day and providing pedestrian and/or vehicle overlap phases that allow pedestrians and/or vehicles to move during multiple phases when appropriate.

m. Overnight Flashing Mode Policy: Traffic signals shall operate in steady (stop-and-go) mode 24 hours per day at intersections where one or more approaches are classified as either urban principal arterial or urban minor arterial on MassDOT's Road Inventory Map. Other traffic signals should operate in steady (stop-and-go) mode 24 hours per day at intersections on a case-by-case basis when an engineering study determines that safety would be compromised by operating the signal in flashing mode overnight. All other signals may operate in flashing mode between 3 AM and 6 AM and these hours may be adjusted as needed.

Approved:

John DeBenedictis, P.E.
Director of Traffic Management & Engineering