BOSTON REGION METROPOLITAN PLANNING ORGANIZATION

Stephanie Pollack, MassDOT Secretary and CEO and MPO Chair
Karl H. Quackenbush, Executive Director, MPO Staff

TECHNICAL MEMORANDUM

DATE: **August 17, 2017**
TO: **Boston Region Metropolitan Planning Organization**
FROM: **Ryan Hicks, MPO Staff**
RE: **Intersection Improvement Program Summary**

BACKGROUND

In the FFY 2014 Transportation Improvement Program (TIP), the MPO allocated $350,000 in Congestion Mitigation and Air Quality Improvement (CMAQ) funds to a pilot program called the Intersection Improvement Program. The objectives of the program were to identify short-term improvements at signalized intersections, implement signal retiming as needed, and recommend the implementation of other short-term improvements to municipalities.

This program aligns with the desired outcomes of the Congestion Management Process (CMP), which encourages the construction of low-cost improvements to congested locations rather than adding roadway capacity through the building of expensive projects. Additionally, the CMP recognizes that appropriately maintained traffic signals can provide for the smooth flow of traffic along streets, thereby reducing vehicle delays and consequently lessening the negative impacts to air quality and fuel consumption.

LOCATION IDENTIFICATION

The MPO worked in collaboration with MassDOT to hire a consultant to implement this program. Intersections were initially selected by MPO staff based on the presence of vehicle crashes. Once the vehicle crash locations were identified, candidate locations were further refined with the following criteria:

- Located on a roadway that is municipally owned
- Located on a federal-aid eligible roadway
- Not located near a programmed TIP project
- Has congested traffic conditions

Preference was given to intersections that were located on a roadway corridor and within reasonable proximity to each other. The preselected intersections were presented to the municipalities and the municipalities could either (1) agree to participate in the program and submit the preselected intersections, (2) agree

to participate in the program and submit alternate intersections that meet the criteria above, or (3) decline to participate in the intersection improvement program.

SUMMARY OF OUTCOMES

Over the duration of the project, 44 intersections were evaluated in 16 municipalities. Howard Stein Hudson, the traffic engineering consultant, visited each intersection and recorded their findings in mini reports. The documents include information on proposed signal retiming, impacts to safety, and the effects on all roadway users, including bicyclists, pedestrians, and mobility impaired travelers. The estimated cost for constructing the recommended improvements is included in the mini reports.

Of the $350,000 in CMAQ funds, $294,000 was spent to retime 44 intersections and to recommend other low-cost capital improvements that municipalities may implement with other sources of funding. The average cost to complete the signal timings and document the low-cost improvement recommendations is approximately $6,700 for each intersection. There is a regional reduction of 526 daily peak period vehicle hours of delay from the implementation of the signal retimings from this program, resulting in an estimated cost of $2.24 per vehicle-hour of delay reduction over the course of one year.

CONSULTANT'S REPORT

The attached memorandum contains the overall results for the Intersection Improvement Program (referred to as the Low Cost Traffic Signal Improvements Program) as documented by the consultant firm Howard Stein Hudson. (The detailed analysis and recommendations for each intersection that was evaluated are documented separately through the mini reports.) The attached final assessment states the purpose of the program, lists the locations of the intersections, describes the data collection procedures, and compares the existing conditions to projected future conditions, if the suggested capital improvements were to be implemented.

TO:	Robert Tong MassDOT Traffic Section	DATE:	December 30, 2016
FROM:	Alexandra Siu, P.E., PTOE Jared Hite	HSH PROJECT NO.:	2013084
SUBJECT:	MassDOT Low Cost Signal Improvements		

Introduction

Howard Stein Hudson (HSH) has prepared this memorandum to summarize the Low Cost Traffic Signal Improvements Program initiated by the Central Transportation Planning Staff (CTPS) and funded by the Massachusetts Transportation Department (MassDOT). The purpose of this program is to reduce traffic congestion, vehicle delay and queues, and ensure that all signalized intersections comply with current State and Federal regulations.

The traffic signal locations that were included in this program were required to meet the following criteria:

- Isolated on municipality controlled and operated roadways;
- Is located on federal-aid-eligible roadways;
- Has not been advertised or programmed in the TIP; and
- Have traffic operation problems that would benefit from low-cost signal timing improvements.

Traffic Signal Locations

The MPO identified and then notified a total of 25 Cities and Towns of intersections within their jurisdiction that were under consideration for inclusion in this improvement program. A total of 64 intersections were initially selected for the program. After notification and acceptance by the municipality to participate, HSH made initial observations at these locations to confirm the presence of congestion and/or poor operations. Upon such investigation, it became apparent that several identified locations operated without congestion and queues typically cleared through the intersection within one cycle. Additionally, some identified locations were, in fact, stop sign controlled and thus immediately removed from consideration as part of this program. The

municipalities that chose to participate in the program were given the opportunity to select additional signalized intersections under their jurisdiction that seemed, by their experience, to have congestion issues. The total number of intersections decreased from 64 intersections to a total of 44 intersections selected from the list of signalized intersections provided by MPO staff, MassDOT, and the suggested locations by the municipalities. The following are the participating municipalities and the total number of signalized intersections analyzed in each city or town:

- Arlington (1)
- Framingham (2)
- Lexington (2)
- Lynn (2)
- Marlborough (1)
- Medfield (3)
- Natick (4)
- Peabody (5)
- Quincy (2)
- Reading (3)
- Revere (7)
- Salem (4)
- Sherborn (1)
- Swampscott (1)
- Walpole (1)
- Westwood (5)

Intersection Analysis

For each traffic signal location, a mini report was created documenting the existing traffic conditions, an inventory of the existing traffic signal equipment, recommendations for low cost traffic signal improvements, and additional capital improvements that each municipality could implement to further improve congestion.

Data Collection

HSH conducted Manual Turning Movement Counts (TMCs) during the morning peak hour (7:00 – 9:00 a.m.) and the evening peak hour (4:00 – 6:00 p.m.). Extended evening hours was obtained from (2:00 – 6:00 p.m.) at study intersections nearby schools. The TMCs included vehicle, bicycle, and pedestrian counts at the study area intersections.

Signal Equipment Inventory

A signal equipment inventory checklist was conducted at each intersection with descriptions of all the available components and their current condition. The item list consisted of:

- Controller;
- Controller type;
- Signal posts;
- Mast arms;
- Detection;
- Vehicle signal heads;
- Back plates;
- Pedestrian indications;
- Pedestrian push-button; and,
- Emergency pre-emption.

Part of the inventory was to identify any malfunctioning or broken equipment. At some intersections there were pull box covers broken and detached from its frame, broken push-buttons, loose traffic signal posts, malfunctioning pedestrian indications, and broken loop detectors. Other locations had potential hazards to pedestrian located along the sidewalks, such as missing hand-hole covers at the base of mast arms exposing signal wiring and anchor bolts fixed within the concrete sidewalk from previously removed equipment. Replacing or repairing these items can improve the safety of all users.

Existing Condition Analysis

Traffic operations were determined through an analysis of intersection Level of Service (LOS) calculations, using Synchro 9.0. The LOS and delay (in seconds) were based on intersection geometry and traffic volumes. In accordance with MassDOT guidelines, the peak 15 minutes of data collected during each peak hour were isolated in order to calculate the peak-hour factors for each approach. The percentage of heavy vehicles was noted for each approach as well. Signal timing information was taken from the controllers in the field and used in the Existing Conditions analysis. All LOS analyses were checked against actual conditions in the field. Calibrations and factors used in the Synchro analysis are shown in **Table 1**.

Table 1. Synchro Adjustment Factors

Adjustment Factor	Used in Analysis?	Notes
Lane Widths	Yes	Based on geometries measured in field
Area type	Yes	CBD Assumed
Right turn on red	Yes	Based on current conditions
Conflicting peds/bikes	Yes	Based on TMC data
Peak-hour Factor	Yes	Based on TMC data by approach
Heavy vehicle %	Yes	Based on TMC data by movement
Bus blockages/hour	No	

Low Cost Improvements

Low cost signal recommendations consisted entirely of timing changes and updates to clearance intervals by using the existing traffic signal equipment. The yellow, all-red, and pedestrian clearance times were calculated to ensure they met the minimum requirements set forth in the MassDOT memo titled *Guidance on Calculating Clearance Intervals at Traffic Signals* dated January 8, 2013. Many of the studied intersections had insufficient pedestrian clearance times that did not meet the 2009 *Manual on Uniform Traffic Control Devices* (MUTCD) guidelines. The flashing don't walk times were calculated based on the 2009 MUTCD and a recommended pedestrian walking speed of 3.5 feet per second. Reducing the walking speed increased the flashing don't walk time and the split times; therefore, either adjustments to the overall cycle length was established or green-time was reallocated while maintaining or reducing the existing cycle length. While increasing vehicle and pedestrian clearance intervals typical worsen operations, providing sufficient clearance intervals will improve safety and potentially reduce crashes at the signalized intersections.

The low cost improvements suggested at the 33 of the 44 intersections within the Boston MPO resulted in delay reductions. While the average overall delay savings at each intersection generally ranged between 1 and 80 seconds during the peak hours, the reduction in vehicle-delay hours are significant. **Table 2** shows the overall existing and low cost vehicle-hours of delay for all 44 of the studied intersections.

Table 2. Existing vs. Low-Cost-related Delay

	Existing		Low Cost	
	AM	PM	AM	PM
Average Vehicle Delay (hrs.)	44	43	37	38
Total Vehicle Delay (hrs.)	1,944	1,891	1,625	1,684

With simple retiming of intersections with minimal cost, the average vehicle-hour delay reduction for these 44 intersections is 7 vehicle-hours in the a.m. peak hour and 5 vehicle-hours during the p.m. peak hour. The overall total vehicle-hour delay reduction is 319 vehicle-hours in the a.m. peak hour and 207 vehicle-hours during the p.m. peak hour.

Capital Improvements

Capital improvements recommended consisted of changes to the intersection that are beyond the scope of the Boston Region MPO's Intersection Improvement program and require additional funds and consideration by each municipality. These changes included providing:

- Additional travel lanes;
- Pavement markings;
- Signage;
- Curb extensions;
- ADA compliant wheelchair ramps;
- Light emitting diode (LED) signal heads;
- Leading Pedestrian Intervals (LPI);
- Countdown timer pedestrian indications;
- Accessible Pedestrian Signal (APS);
- Flashing yellow arrow signal heads;
- Concurrent pedestrian phasing;
- Vehicle detection;
- Signal coordination;
- Updates traffic signal timings; and,
- Updates traffic signal phasing.

Table 3 shows, once again, for all of the 44 studied intersections, the overall existing and capital vehicle-hours of delay.

Table 3. Existing vs. Capital Improvement-related Delay

	Existing		Capital Improvement	
	AM	PM	AM	PM
Average Vehicle Delay (hrs.)	44	43	24	25
Total Vehicle Delay (hrs.)	1,944	1,891	1,039	1,122

Operations further improved beyond the simple retiming by implementing additional capital improvements. The average vehicle-hour delay reduction for these 44 intersections is 20 vehicle-hours in the a.m. peak hour and 18 vehicle-hours during the p.m. peak hour. The overall total vehicle-hour delay reduction is 905 vehicle-hours in the a.m. peak hour and 769 vehicle-hours during the p.m. peak hour.

The most significant capital improvement consisted of removing exclusive pedestrian phases and replacing them with concurrent pedestrian phases. Concurrent pedestrian phasing provides more efficient signal operation and reduces overall delays for both pedestrians and vehicles.

Conclusion

Low cost signal retiming is a cost effective tool to generate quantifiable benefits as measured by decreased vehicle delay, increased safety, lower emissions and reduced fuel consumption. Qualitative benefits, such as decreased cut-through traffic on alternate routes, reduced driver frustration and the cost of time for that driver can also be realized. A focused signal retiming program can also provide municipalities with additional opportunities to examine the need for additional capital improvements that can even further reduce delay beyond simple retiming and help identify maintenance issues. With just these 44 locations, retiming saved over 500 hours of driver delay in just the peak hours alone. With further capital expenditures, many of which are relatively inexpensive to implement, a further reduction in delay can be realized, almost double over simple retiming.