MEMORANDUM

TO: **Transportation Planning and Programming Committee of the Boston Region Metropolitan Planning Organization** **December 4, 2008**

FROM: **Mark S. Abbott, PE**
Efi Pagitsas

RE: **MBTA Transit Signal Priority Study: Arborway Corridor**

BACKGROUND

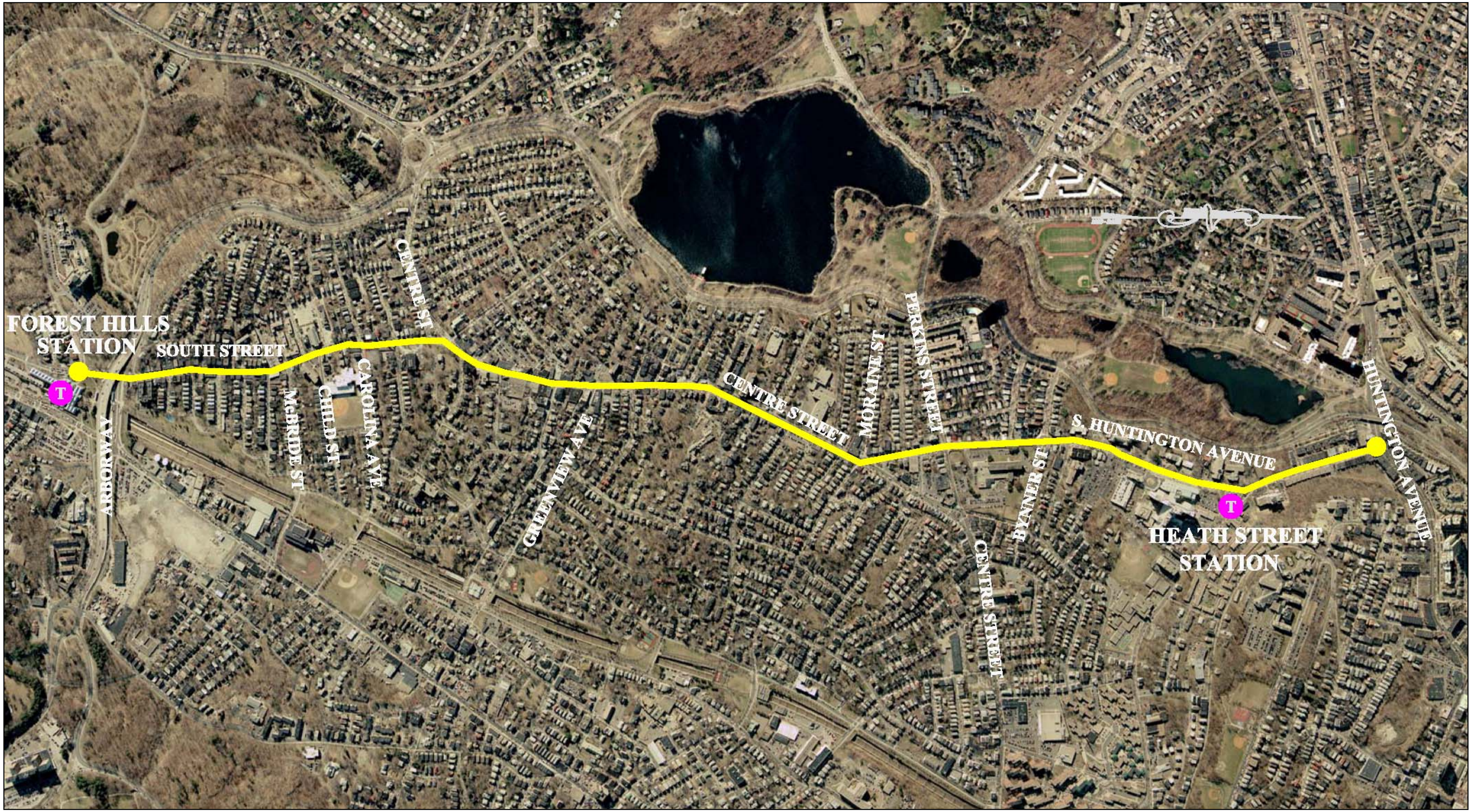
Performing a transit signal priority (TSP) pilot study was one of the Mobility Management System (MMS) recommendations. In response to concerns stemming from changes in the State Implementation Plan (SIP), the Transportation Planning and Programming Committee (TPPC) of the Boston Region MPO recommended the Arborway corridor for the pilot study. Specifically, the recommendation was for a pilot study that would evaluate the effectiveness of TSP for MBTA buses operating along the Arborway corridor between Heath Street and the Forest Hills station of the Orange Line.

The Arborway Corridor study area (see Figure 1) is roughly 2.2 miles long. It consists of South Huntington Street, Centre Street, and South Street, from Heath Street (end of the "E" Green Line) to the Orange Line's terminus at Forest Hills.

Since the early '90s there have been numerous MBTA feasibility studies and public participation activities related to a plan to construct a new light rail vehicle (LRV) system as part of the 1991 mitigation package for the Central Artery/Tunnel project. The LRV project was part of past State Implementation Plans (SIPs) but with the approval of the EPA is no longer included in the revised SIP.

The corridor is presently served primarily by MBTA bus 39, an articulated 6- to 7-minute-headway bus serving the Back Bay, South End, and Jamaica Plain neighborhoods with termini at Back Bay Station and Forest Hills Station. In addition, buses 38, 41, and 48 run along various segments of the corridor at lower frequencies. Bus 39 traverses numerous intersections including 13 traffic signals that are not part of the City of Boston computerized traffic control system. Five of the traffic signals are for pedestrians only; the rest are either semi- or fully-actuated signals.

The Boston neighborhoods along the Arborway corridor are culturally diverse and densely populated. South Huntington Street, the widest segment of the corridor, is 54 feet wide and is primarily characterized by institutional uses. Centre Street is about 42 feet wide and is characterized by intense commercial activity. Finally, South Street is the narrowest segment, 40



CTPS

FIGURE 1
Project Study Area

MBTA Transit Signal Priority Study: Arborway Corridor

vehicles per day along South Street, 15,000 along South Huntington Street, and 17,000 along Centre Street. Pedestrian volumes are rather high; however, bicyclist use is not as high. There are approximately 579 on-street parking spaces along the corridor and 136 spaces in municipal lots.

This study was funded by the Boston Region MPO, and a work program was approved on July 20, 2006. Appendix A contains a copy of the work program for the study.

GOALS AND OBJECTIVES

The goal of this study was to determine how best to improve MBTA bus travel time and schedule reliability along the Arborway corridor. In order to meet this goal, the study set the following objectives:

1. Evaluate the performance of a potential traffic signal coordination system and various potential transportation system management (TSM) measures (traffic signal timing and phasing, geometric configuration, etc.) that would need to be implemented for successful signal interconnection.

2. Evaluate the potential for transit signal priority under two scenarios: with present bus stop locations and with bus stop consolidation.

3. Document performance evaluation of all three strategies in terms of impacts on delays, travel time, queues, pedestrians, parking, and bus travel time.

DEFINITION OF TERMS

Traffic system management (TSM) measures are various corrective measures requiring a relatively short time for implementation that can be applied to an intersection to optimize its performance and improve its safety. For signalized intersections these include operational-type improvements, such as lane reallocations, minor geometric changes, markings, and signal design and retiming. Even minor improvements of this type can make a significant difference in the operations at a signalized intersection for increased throughput, lower delays, reduced emissions, improved bus travel times, and safer pedestrian crossings.

Traffic signal coordination is an intelligent transportation systems (ITS) technology applied to traffic signals to improve vehicle and pedestrian capacity along a corridor. When traffic signals are coordinated, they are timed in such a way that a platoon of vehicles traveling at the speed anticipated by the coordination arrives at each intersection during the green interval and is processed through in the direction of the next intersection. Benefits of coordination include reduced traffic delays, improved air quality, and reduced driver and passenger frustration. Generally, traffic signals spaced less than a quarter mile apart can qualify for coordination, as greater separation than this may promote the dispersion of platoons. Also, prior to coordination, qualified traffic signals are usually examined for operational improvements, like the TMS measures described earlier, in order to achieve as effective coordination as possible.

Transit signal priority (TSP) is an operational strategy that facilitates the movement of transit vehicles through signal-controlled intersections. TSP allows buses equipped with communication devices to request priority as they approach a traffic signal. There are many TSP strategies which can be deployed. The two primary strategies tested in this study were: Green Extension and Early Green. The Green Extension strategy extends the green interval for the approach where the bus travels, thus allowing the bus to clear the intersection before the signal changes to red. The Early Green strategy returns a green interval to serve the bus approach by shortening the green phases of other movements. Depending on the adopted strategy, the bus may communicate with the signal in this manner every time it is approaching a traffic signal or only when the bus is late. The bus communicates with the traffic signal via detector loops in the pavement or other detection technologies located in advance of a signal and/or after a bus stop.

Bus priority systems are more effective when bus stops are located on the far side of intersections along a multi-lane roadway. This is because near-side stops, which are typically located too close to the traffic signal, can cause a bus to be caught in queues. This can prevent the bus from reaching the bus stop, or can hinder it from pulling out from a stop. Both of these problems for near-side stops can be overcome by TSP, but to do so requires additional green time for the bus, which penalizes the other movements at the intersection. This matters even more when the bus and the rest of the traffic share a one-lane approach to the intersection, because the effects of on-street parking and other traffic interruptions are then more likely to delay bus arrivals to the intersection.

A TSP system can improve bus travel time and schedule reliability and, therefore, reduce the amount of passenger hours traveled in the bus transit system. Bus priority systems have been widely installed around the country with documented benefits. Both coordination and TSP systems require careful examination of impacts on side street traffic delays and queues.

TECHNICAL ADVISORY GROUP

The development of the study was overseen by a group of advisors with transit and traffic signal expertise from the City of Boston Transportation Department, Executive Office of Transportation and Public Works, Massachusetts Bay Transportation Authority, and CTPS. The advisory group met twice, once to review existing conditions and discuss analysis scenarios and another time to review the results of the options analyzed.

ANALYSIS APPROACH

To analyze existing conditions and evaluate the three scenarios specified in the objectives for this study, staff used two widely known traffic analysis and simulation models: SYNCHRO[1] and VISSIM.[2]

SYNCHRO can perform detailed analysis of single intersections or series of intersections in a network, including simulation. Input data include intersection geometry, traffic volumes, pedestrian volumes, and traffic signal design. Outputs include level of service, volume-to-capacity ratios, and queue lengths.[3] This model was used to perform TSM analysis prior to coordinating or applying TSP to traffic signals in the corridor. The results of the TSM portion of the analysis are in Appendix B.

The main software used to analyze existing conditions and evaluate the three alternative options for the study was VISSIM. It is a traffic simulation tool which allows for a great deal of flexibility and, most importantly, allows for the modeling capability to address the TSP component of this study. The software's flexibility allows for the modeling of many different modes of transportation, which for this study included general traffic, 60-foot articulated buses, 40-foot standard buses, pedestrian traffic, light-rail transit, and on-street parking. Models were developed for both the AM and PM peak hours for the corridor. The following are the data needs for developing a calibrated VISSIM model.

ANALYSIS DATA

Traffic Volumes

Traffic volumes for the project were a combination of existing counts completed by a prior study and updated spot counts to verify the existing counts. The study for the Arborway Streetcar Restoration[4] completed by Vanasse Hangen Brustlin (VHB) contained balanced volumes for the entire corridor. To verify that these traffic volumes were still accurate and reflected the operations of the corridor in the present, CTPS conducted turning movement counts (TMCs) at key intersections. These intersections included South Huntington Avenue and Perkins Street, South Huntington Avenue and Centre Street, Centre Street and South Street, and South Street and New Washington Street. The CTPS TMCs verified that the VHB counts still reflected the existing traffic flow patterns of the study area. These volumes are shown in Appendix C.

Traffic Signal Information

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[1] Trafficware Ltd.
[2] PTV America Inc.
[3] Level of service (LOS) measures the quality of flow for an intersection, intersection approach, or traffic movement. LOS ranges from A to F, with E and F generally deemed as failing conditions. Volume-to-capacity (V/C) ratio describes how full an intersection is. A V/C equal to 1.0 or greater implies that the intersection is at capacity. Queue lengths are useful measures, especially in situations where a traffic movement blocks the processing of another movement through the intersection.
[4] *Arborway Streetcar Restoration*, Vanasse Hagen Brustlin, Inc., 2002.

Traffic signal information, which included the signal timings, signal phasing, and layout, was provided by the Boston Transportation Department (BTD). This information was then verified in the field by observing the operations at the signalized intersections and comparing them with the BTD information. The comparison revealed the BTD information does reflect the signal operations in the field.

The traffic signals included in the model are shown in Figure 2 and include:

- Huntington Avenue and South Huntington Avenue
- Pedestrian signal at Heath Street
- Pedestrian signal at VA Hospital
- South Huntington Avenue and Bynner Street
- South Huntington Avenue and Perkins Street
- South Huntington Avenue and Centre Street
- Centre Street and Greenview Avenue
- Centre Street and South Street (flashing operations)
- South Street and Carolina Avenue
- Pedestrian signal at Child Street
- Pedestrian signal at McBride Street
- South Street and New Washington Street
- South Street and Washington Street

MBTA Bus Service

The buses which serve the Arborway corridor are routes 38, 39, 41, and 48. These routes are shown in Figure 3 and the number of stops for each route is shown in Table 1. Table 2 provides information on the scheduled headways for each of the lines. The 39 bus is the only service that travels the entire corridor, and its service is made up entirely of the 60-foot articulated buses. Information for the MBTA buses was gathered from CTPS and MBTA data, which included bus stop locations, bus stop lengths, headways, ridership, bus stop dwell times, and bus travel times along the corridor. A problem for bus 39 along the Arborway corridor is the lengths of the existing bus stops. Many of the stops do not provide sufficient length for the 60-foot articulated buses to pull to the curb; most buses stop in the travel lane to pick up/drop off passengers.

Table 1 Bus Stop Information in Corridor

Bus Route	Number of Stops	
	Inbound	Outbound
38	4	5
39	18	19
41	6	5
48	6	5

CTPS

FIGURE 2
Traffic Signals

MBTA Transit Signal Priority Study: Arborway Corridor

Table 2 Scheduled Bus Headways (minutes)

Bus Route	AM Peak Hour		PM Peak Hour	
	Inbound	Outbound	Inbound	Outbound
38	22	22	22	22
39	6	6	7	7
41	30	24-30	24	22-25
48	*	**	40	40

* Does not run during the morning peak period (7:00 AM to 9:00 AM).
** One bus during the morning peak period (7:00 AM to 9:00 AM).

Roadway Characteristics

The characteristics of the corridor's roadway are very important in the development of the model. They provide the foundation to build a model that is accurate and well calibrated. The necessary information was collected in field visits and included:

- Travel speeds
- Posted speed limits
- Pavement widths
- Number of travel lanes
- Ability of vehicles to bypass stopped traffic
- Pedestrian crosswalks
- On-street parking
- Parking durations
- No-parking zones
- Bus stop locations
- Physical restrictions on bus stops
- Known congestion locations

VISSIM Model Network

The model network was developed from the data collected above. Information was coded into VISSIM to develop a model network that covered the corridor from Huntington Avenue to Washington Street by the Forest Hill Station. Signal heads were coded at each signalized intersection; along with the signal phasing and timing information. On-street parking was coded into the entire network; the spaces were estimated based on aerial photos and verified in the field.

VISSIM MODEL CALIBRATION

The VISSIM model was calibrated for both the AM and PM peak hours. This was accomplished by verifying model results with gathered data, which included traffic volumes, vehicle speeds, vehicle travel times, and bus speeds and travel times.

Two of the measures that were critical for the calibration and for evaluating TSP were traffic volumes and bus travel times. Table 3 provides a comparison of the existing traffic volumes and the traffic volumes from the models. As the table indicates, the overall difference between the existing count volumes and the model volumes is 4.95% for the AM peak hour and 7.06% for the

PM peak hour. This comparison assures that the model was simulating actual vehicle use in the corridor with sufficient accuracy.

Table 3 Comparison of Traffic Volumes

Intersection	AM Peak Hour			PM Peak Hour		
	Existing	Model	% Diff.	Existing	Model	% Diff.
Huntington Ave/S. Huntington Ave.	2713	2188	-19.4%	2864	2530	-11.7%
S. Huntington Ave./Bynner St.	1449	1208	-16.6%	1587	1391	-12.4%
S. Huntington Ave./Perkins St.	1481	1583	6.9%	1619	1719	6.2%
S. Huntington Ave./Centre St.	1307	1253	-4.1%	1515	1491	-1.6%
Centre St./Green St.	1460	1348	-7.7%	1577	1549	-1.8%
South St./Carolina Ave.	1123	1019	9.3%	1032	904	-12.4%
South St./New Washington/Arborway	1838	2209	20.2%	2414	2134	-11.6%
Total	**11,371**	**10,808**	**-5.0%**	**12,608**	**11,718**	**-7.1%**

Bus travel times are also critical in evaluating the effectiveness of TSP options. Table 4 provides a comparison of the existing Bus 39 travel times obtained from the MBTA and the model's Bus 39 travel times.

Table 4 Comparison of Bus 39 Travel Times (minutes)

Travel Segment	AM Peak Hour			PM Peak Hour		
	Existing	Model	% Diff.	Existing	Model	% Diff.
Inbound[5]	18.8	17.5	-6.9%	14.0	13.3	-5.0%
Outbound[6]	11.3	13.2	16.8%	16.4	17.1	4.3%

[5] Forest Hills to Heath St.
[6] Heath St. to Forest Hills.

STRATEGIES FOR BUS IMPROVEMENTS

The calibrated VISSIM model was used to test the impact of three strategies on bus operations. As stated in the objectives of this study, these are: traffic signal coordination, transit signal priority with existing bus stop locations, and transit signal priority with consolidated stop locations. MBTA bus route 39 was used to show and summarize the strategies because it travels the entire length of the study corridor, and improvements to the traffic signals (coordination and TSP) would potentially provide the most improvement for this bus route. The other routes would also potentially realize improvements. However since they only partially serve, and travel, the Arborway corridor, the operations of these bus routes would not improve greatly.

Strategy 1: Traffic Signal Coordination

Coordination allows traffic flows to move as efficiently as possible along a corridor by creating platoons along the direction of the coordination, usually along the main road. Of the existing signalized intersections in the Arborway corridor (shown in Figure 2),[7] the only ones which provide adequate signal spacing to benefit from coordination are:

- South Huntington Avenue and Bynner Street
- South Huntington Avenue and Perkins Street
- South Huntington Avenue and Centre Street

The intersections at Centre Street/South Street, South Street/Carolina Avenue, South Street/Child Street, and South Street/McBride Street are spaced appropriately close to each other, but the first location has flashing operations and the latter two are pedestrian crossing signals, which are activated with pedestrian buttons.

Strategy 2: Transit Signal Priority with Existing Bus Stop Locations

The TSP strategy that was evaluated for the corridor involved Early Green and Green Extension and was used in conjunction with signal coordination. These are the two most common forms of TSP and are the two that would work the most effectively in this corridor with the current signal system. The Early Green strategy shortens the green time of the preceding phases to allow the early return to green phase for the TSP-equipped vehicle. This strategy only works when the TSP-equipped vehicle is detected during a red phase. The Green Extension allows TSP vehicles to extend the green time on their approaches without having to stop, thus limiting delays. Both of these strategies were implemented together in the evaluation of TSP. Together they maximize the time within the signal cycle in which the TSP-equipped vehicle would be eligible for green priority.

The bus stop locations also play a very important part in the TSP strategy. Current bus stop locations are on both the near and far sides of intersection signals. Ideally for both Early Green and Green Extension priorities, bus stops should be located on the far side of the intersections.

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[7] Generally, intersections spaced within a quarter mile or less qualify for coordination.

This minimizes the chances of buses' being caught in queues before the intersections and also allows the buses easier access/egress to/from bus stops.

Strategy 3: Transit Signal Priority with Bus Stop Consolidation

Presently, there are 18 inbound and 19 outbound stops on the bus 39 route within the study corridor. The testing of this strategy included signal coordination in addition to TSP. A reduction of the number of stops was discussed with EOTPW and the MBTA. The scenario that was developed reduced the inbound stops to 11 and the outbound stops to 12. Two criteria used to reduce the number of stops were proximity of bus stops to each other and bus stop boardings. The reduction in stops was developed only as a test scenario: no plan or definitive locations for stops have been developed to implement such a strategy. Included in this scenario was a plan to also address the inadequacy of bus stop lengths. This strategy included a plan to provide curb bulb-outs at the bus stops to allow the passengers to get on and off the buses directly from the curb. This plan also minimizes the impact on existing on-street parking.

EVALUATION RESULTS

Table 5 presents the results of the analysis of the three strategies for improved bus 39 service. Some observations include:

- Generally, strategies 1 and 2 do not improve bus travel times significantly. The main reasons why strategy 1, traffic signal coordination, does not have a major effect on bus travel times are that only three traffic signals qualify for coordination and that there are high side-street traffic volumes at these locations which limit the ability to prioritize the mainline traffic. Strategy 2, TSP with existing bus stop locations, is ineffective along this corridor because of its physical constraints and the location of the bus stops at the near side of most intersections.

- Strategy 3, TSP with fewer bus stops, yields lower bus travel times overall, with the greatest improvement occurring in the morning off-peak direction.

Table 5 Bus 39 – Average Travel Times (minutes): Comparison of Alternative Strategies

Travel Segment	AM Peak Hour				PM Peak Hour			
	Model Base	Strategy 1	Strategy 2	Strategy 3	Model Base	Strategy 1	Strategy 2	Strategy 3
Inbound	17.5	17.6	17.6	16.8	13.3	13.7	13.7	12.8
Outbound	13.2	13.0	13.0	9.3	17.1	16.9	16.9	16.4

To help isolate and clarify further the effect of the reduced number of bus stops, the base case VISSIM model (existing traffic signal conditions) was run with the reduced number of stops. Table 6 shows the results and compares them with the results for the base case with the existing number of stops:

Table 6 Bus 39 – Average Travel Times (minutes): Base Case vs. Base Case with Reduced Number of Bus Stops

Travel Segment	AM Peak Hour			PM Peak Hour		
	Model Base	Base with Bus Stop Reduction	% Diff.	Model Base	Base with Bus Stop Reduction	% Diff
Inbound	17.5	15.1	-13.7%	13.3	13.1	-1.5%
Outbound	13.2	9.7	-26.5%	17.1	16.7	-2.3%

- During the morning peak hour, average bus travel time would be reduced by 2.4 minutes (13.7%) and 3.5 minutes (26.5%) for the peak and off-peak directions, respectively.

- During the evening peak hour, the effect of the reduced stops is not as significant as in the morning peak hour, because the traffic volumes are lower in the evening peak hour (since in the evening peak period the traffic is more spread out over time).

CONCLUSIONS

From the analysis and findings above, the following can be concluded:

- The most improvement for bus travel times along this section of the bus 39 route occurs with bus stop consolidation and curb extensions (without TSP). This strategy includes two things that improve bus service. The first is reduction of the number of stops each bus is required to make, thus cutting down on stopped time. The other is allowing passengers to board directly from the curb. Also, the curb extensions allow the buses to not pull in and out of bus stops. However, curb extensions have a drawback for one-lane-per-direction roads, as is the case in this corridor: they stop general traffic behind buses as they pick up and drop off passengers and could impact intersection operations, if located adjacent to an interection. This would tend to add delays to general traffic, although maybe would not increase them by much for this corridor, compared to the present practice. This is because the route 39 articulated buses do not fit entirely within the standard bus stop length and thus probably have this effect on traffic already.

- Signal coordination would be limited to three intersections, and therefore it would not be beneficial enough for bus operations to justify implementation for that purpose alone. However, signal coordination would be beneficial for general traffic in this part of the corridor, a good reason for the City of Boston to consider its implementation.

- Observations made during the study indicate that signal equipment at intersections could be upgraded. With the upgraded signal equipment, general traffic operations could be improved with a more traffic-responsive signal system to handle congestion along the corridor.
- A TSP strategy would not be effective along the Arborway corridor: the physical capacity of the roadway and the near-side location of most bus stops would not allow for an efficient and effective TSP system.

- When evaluating the performance of the traffic signals (see Appendix B) and identifying changes (TSM measures) that would be necessary to implement in association with strategies 1, 2, and 3, staff identified opportunities to improve signal timings at several intersections. These improvements can be implemented with beneficial effects to all traffic independently of the potential of signal coordination, TSP, or stop consolidation. Possibly included in these retimings would be concurrent pedestrian phases instead of the exclusive pedestrian phases at locations like South Huntington Avenue at Bynner and Perkins streets. However, pedestrian volumes, pedestrian use, and City policy would need to be examined prior to implementing any changes.

RECOMMENDATIONS

For improving bus 39 travel times, the following recommendations should be considered:

- For the City of Boston to implement the operational improvements documented in Appendix B of this study, which consist of signal timing optimization and signal coordination at Bynner Street, Perkins Street, and Centre Street.

- For the City to consider upgrading signal equipment, installing communication equipment and traffic cameras, and connecting signals to the City’s central traffic control system. These actions could improve the general traffic operations along the corridor, including bus 39 operations.

- For the MBTA, in cooperation with the City of Boston and neighborhood representatives, to develop, adopt, design, and implement a plan for the reduction of bus 39 stops along the corridor.

MSA/EP/msa

Attachments

APPENDIX A

WORK PROGRAM:
MBTA Transit Signal Priority - Arborway Corridor

BOSTON METROPOLITAN PLANNING ORGANIZATION

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John Cogliano
MPO Chairman

Approved by the TPPC
TPPC Chairman
8/3/06
Date

MEMORANDUM

DATE July 20, 2006

TO Transportation Planning and Programming Committee of the Boston Region Metropolitan Planning Organization

FROM Arnold J. Soolman, CTPS Director

RE Work Program for: MBTA Transit Signal Priority Study: Arborway Corridor

ACTION REQUIRED

Review and approval

PROPOSED MOTION

That the Transportation Planning and Programming Committee of the Boston Region Metropolitan Planning Organization, vote to approve the work program for MBTA Transit Signal Priority Study: Arborway Corridor

PROJECT IDENTIFICATION

Unified Planning Work Program Classification

44.26.05

CTPS Project Number

23313

CTPS Project Supervisors

Principal: Efi Pagitsas
Manager: Mark Abbott

Funding

MHD PL 3C Highway Planning Contract #42456; EOT 5303 3C Transit Planning Contract #X-017

IMPACT ON MPO WORK

This is MPO work and will be carried out in conformance with the priorities established by the MPO.

BACKGROUND

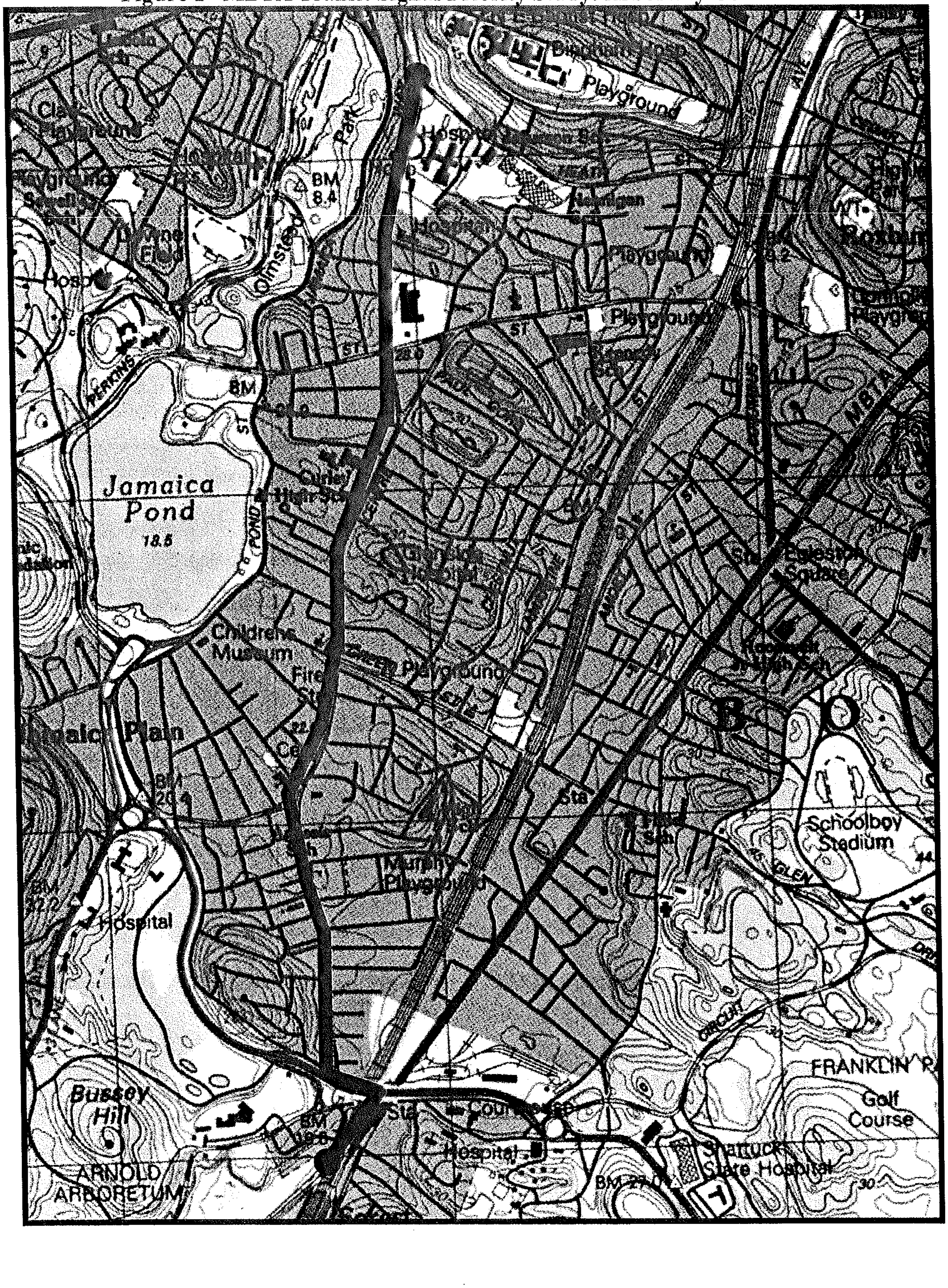
Traffic Signal Coordination and Transit Signal Priority (TSP) are two Intelligent Transportation Systems (ITS) technologies applied to traffic signals to improve traffic and person carrying capacity along a corridor. When traffic signals are coordinated, they are timed in such a way so that a platoon of vehicles traveling at the speed anticipated by the coordination arrives at each intersection during the green interval and is processed through in the direction of the next intersection. Benefits of coordination include reduced traffic delays, improved air quality, and reduced driver and passenger frustration. TSP is a technology that allows buses equipped with communication devices to request priority as they approach a traffic signal. Priority strategies include the extension of the green interval for the approach where the bus travels or the return to a green interval to serve the bus. The bus may communicate with the signal in this manner every time it is approaching a traffic signal or only when the bus is late. A TSP system can improve bus travel time and schedule reliability. Such systems have being widely installed around the country with documented benefits. Both coordination and TSP systems require careful examination of impacts on side street traffic delays and queues.

The Boston Region MPO has funded this study as part of the FY 2006 Unified Planning Work Program (UPWP).

The Arborway Corridor (see Figure 1), which is roughly 2.2 miles long, consists of South Huntington Street, Centre Street, and South Street, from Heath Street (end of the "E" Green Line) to the Orange Line's terminus at Forest Hills. The corridor is widely known in the region for numerous MBTA feasibility studies and public participation to construct a new Light Rail Vehicle (LRV) system as part of the 1991 mitigation package for the reconstruction of the Central Artery/Tunnel. Presently, the project is included in the most recent State Implementation Plan (SIP) and under negotiation between the Executive Office of Transportation and Construction and the Department of Environmental Protection regarding its status. The corridor continues to be served primarily by MBTA bus 39, an articulated 4-minute headway bus serving the Back Bay, South End, and Jamaica Plain neighborhoods with termini at Copley Square and Forest Hills. In addition, buses 38, 41, and 48 run along various segments of the corridor at lower frequencies. Bus 39 traverses numerous intersections including 14 traffic signals, which are not part of the City of Boston computerized traffic control system. Five of the traffic signals are for pedestrians only; the rest are either semi- or fully-actuated three-phase signals.

The Arborway Corridor is culturally diverse and densely populated. South Huntington Street, the widest segment of the corridor, is 54 feet wide and is primarily characterized by

Figure 1 MBTA Transit Signal Priority Study: Arborway Corridor



institutional uses. Centre Street is about 42 feet wide and is characterized by intense commercial activity. Finally, South Street is the narrowest segment, 40 feet wide, and mostly residential in nature. The corridor is two-lanes wide with 8-foot parking lanes and 8-foot sidewalks on both sides. Average Daily Traffic (ADT) is approximately 12,000 vehicles per day along South Street, 15,000 along South Huntington Street, and 17,000 along Centre Street. Traffic is mostly non-directional. Pedestrian volumes are rather high and bicyclist transportation is not as high. There are 579 on-street parking spaces along the corridor and 136 spaces in municipal lots. The total number of bus stops is 32.

OBJECTIVES

The goals of this study are to improve MBTA bus travel time and schedule reliability along the Arborway Corridor by satisfying the following objectives:

1. Evaluate the performance of a traffic signal coordination system and various Transportation System Management (TSM) measures (traffic signal timing and phasing, geometric configuration etc.) that need to be implemented for successful signal interconnection.
2. Evaluate the potential for transit signal priority under two scenarios: with present bus stop locations and with bus stop consolidation.
3. Document performance evaluation of all three strategies in terms of impacts in delays, travel time, queues, pedestrians, parking, and bus travel time.

WORK DESCRIPTION

To perform this study, staff will try its best to gather existing valid data from recent MBTA studies for the Arborway Corridor. However, this work program was written somewhat conservatively, as previous studies tested various LRV options and it is not clear as of this writing how relevant and applicable existing information is.

Task 1 Convene an Advisory Group to Work with and Oversee Study

In cooperation with MPO members, staff will convene an Advisory Group for brainstorming, direction, guidance, and preliminary product reviews. At a minimum, the group will consist of the MBTA and the City of Boston. In addition, as this is the first study of its kind performed at the Boston Region MPO, other MPO members may show interest to participate.

It is expected that the group will meet four times at key points during the study: at the beginning of the study, completion of existing conditions, definition of alternatives, and to present results and receive input. Staff will make appropriate preparations to present findings at these meetings and receive comments and guidance.

Product(s) of Task 1

Form an Advisory Group and convene four meetings to present intermediate products.

Task 2 Field Observation and Data Collection

Staff will review and evaluate intersection turning movement counts, intersection phase design and timings, crashes, pedestrian counts, and parking data that exists for the Arborway Corridor from past studies. If data is still valid they will be used or updated. If not, new data will be collected. Field visits will be made to observe traffic operations, take notes on intersection geometry, bus operations, locations of bus stops, and parking turnover. All this information and data will be used as direct input into the analysis or to calibrate simulation models to existing conditions.

Product(s) of Task 2

- Turning movement count data, intersection geometrics, crashes, pedestrian counts, bicycle counts, traffic signal design
- Notes from field reconnaissance on bus operations, parking turnover, traffic queues, and location of bus stops

Task 3 Existing Conditions

Using the data described earlier corridor existing conditions will be defined in terms of the following parameters: safety, traffic operations, parking, transit operations, and pedestrian and bicyclist movements.

Next, staff will use the software VISSIM to incorporate existing conditions data and information into the model to simulate traffic and transit operations, delay, queues, and travel time. The simulation of existing conditions serves as a benchmark to compare results from the testing of alternative strategies during subsequent runs of the model.

Product(s) of Task 3

Technical memorandum discussing existing conditions, including results of the simulation model runs

Task 4 Evaluation of Traffic Signal Coordination and TSP Strategies

The calibrated VISSIM model will be used to test the impact of three strategies on bus operations, traffic operations, and parking. These are: traffic signal coordination, transit signal priority with existing bus stop locations, and transit signal priority with consolidated stop locations. Presently, there are a total of 32 bus stops in the corridor. To test the third strategy, staff will use the reduced number of station locations identified in the most recent Arborway Streetcar Restoration Study by MBTA and its consultant through public participation. The TSP strategy will likely be a combination of green extension and/or early return to the phase of the approach of the bus (red truncation), depending the location of the bus stops (far side or near side) and the established bus detection decision. The evaluation of the traffic signal coordination strategy will include assumptions about certain required TSM improvements (for example, phase and timing changes, traffic lane assignments) to allow for a more effective coordination. Finally, each strategy will be evaluated for feasibility of implementation, cost, and impacts on delay, travel time, queues, pedestrians, parking, and bus travel time for a five-year horizon.

Product(s) of Task 4
Technical memorandum discussing evaluation results of simulated strategies

Task 5 Documentation

The results of existing conditions findings and future impacts for each of the strategies will be documented in a comprehensive document.

Product(s) of Task 5
Study documentation

ESTIMATED SCHEDULE

It is estimated that this project would be completed 12 months after the notice to proceed is received. The proposed schedule, by task, is shown in Exhibit 1.

ESTIMATED COST

The total cost of this project is estimated to be $92, 704. This includes the cost of 45.5 person-weeks of staff time, overhead at the rate of 83.51 percent and travel. A detailed breakdown of estimated costs is presented in Exhibit 2.

AJS/EP/ep

Exhibit 2

ESTIMATED COST

Arborway Corridor: Traffic Signal Coordination and Transit Signal Priority for Buses

Direct Salary and Overhead	$92,604

Task	Person-Weeks									Direct Salary	Overhead (@ 83.51%)	Total Cost
	M-1	P-5	P-4	P-3	P-2	SP-3	SP-1	Temp	Total			
1. Convene Advisory Group	0.5	0.0	3.0	0.0	0.0	0.0	0.0	0.0	3.5	$4,214	$3,519	$7,734
2. Field Observation & Data Collectio	0.5	0.0	1.0	0.0	0.0	0.0	0.0	5.0	6.5	$4,895	$4,088	$8,983
3. Existing Conditions	1.0	0.0	15.0	0.0	0.0	0.0	0.0	0.0	16.0	$18,779	$15,682	$34,461
4. Evaluation of Strategies	1.0	0.0	12.0	0.0	0.0	0.0	0.0	0.0	13.0	$15,329	$12,801	$28,130
5. Documentation	0.5	0.0	5.0	0.0	0.0	1.0	0.0	0.0	6.5	$7,245	$6,050	$13,296
Total	3.5	0.0	36.0	0.0	0.0	1.0	0.0	5.0	45.5	$50,463	$42,141	$92,604

Other Direct Costs	$100
Travel	$100
General office equipment	$0
Data processing equipment	$0
Consultant(s)	$0
Printing	$0
Other (VISSIM purchase and training will be funded outside the budget of this work program)	$0

TOTAL COST	$92,704

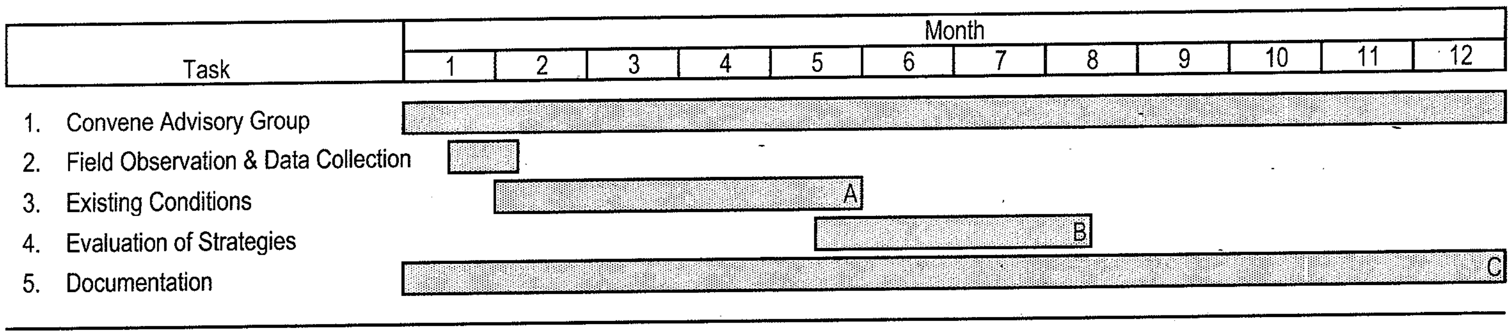
Funding

MHD 3C PL Highway Planning Contract #XXXXX; EOT 5303 3C Transit Planning Contract #XXXXX

Exhibit 1

ESTIMATED SCHEDULE

Arborway Corridor: Traffic Signal Coordination and Transit Signal Priority for Buses



Products/Milestones

A: Technical memorandum no. 1

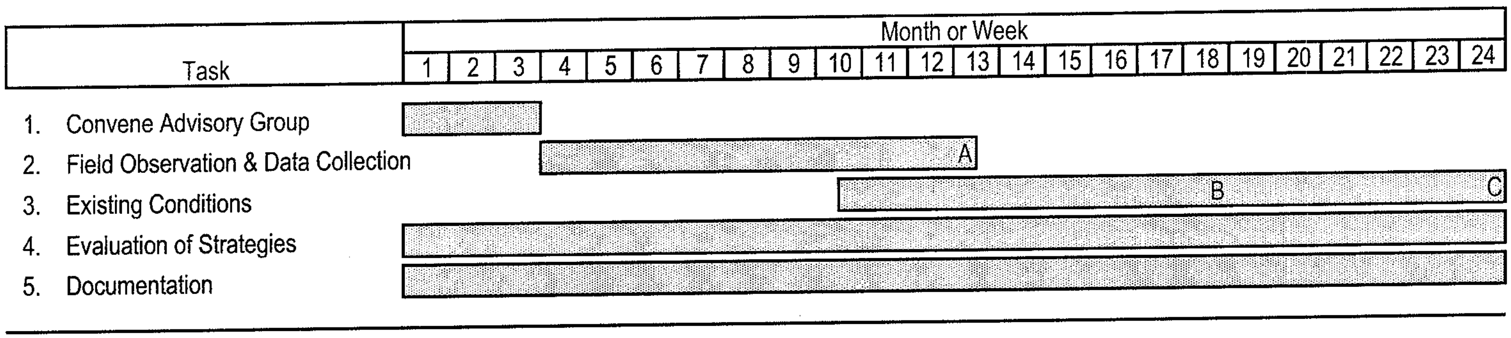
B: Technical memorandum no. 2

C: Technical Report

Exhibit 1

ESTIMATED SCHEDULE

Arborway Corridor: Traffic Signal Coordination and Transit Signal Priority for Buses



Products/Milestones

A: Technical memorandum no. 1

B: Technical memorandum no. 2

C: Technical memorandum no. 3

APPENDIX B

SYNCHRO LEVEL-OF-SERVICE RESULTS:
Arborway Corridor Signalized Intersections

AM PEAK HOUR

Intersection	Approach	Existing Conditions[1]			Optimized[2]			Coordinated[3]		
		LOS	Delay	V/C	LOS	Delay	V/C	LOS	Delay	V/C
Huntington Ave/S. Huntington Ave*	EB	D	42.7		D	42.7		D	42.7	
	WB	D	40.7		D	40.7		D	40.7	
	NB	D	42.3		D	42.3		D	42.3	
	Overall:	**D**	**42.0**	**0.86**	**D**	**42.0**	**0.86**	**D**	**42.0**	**0.86**
S. Huntington Ave/Bynner Street[3]	EB	C	23.4		E	78.2		E	77.1	
	WB	B	17.3		C	28.6		D	40.6	
	NB	B	13.3		B	12.7		B	10.2	
	SB	A	6.5		A	5.6		A	4.6	
	Overall:	**B**	**13.5**	**0.73**	**C**	**22.7**	**0.94**	**C**	**21.9**	**0.71**
S. Huntington Ave/Perkins Street[3]	EB	F	214.7		F	92.9		F	80.5	
	WB	C	25.7		C	23.4		C	24.2	
	NB	D	45.4		C	30.6		A	8.4	
	SB	C	24.5		B	17.8		B	13.3	
	Overall:	**F**	**91.7**	**1.12**	**D**	**46.8**	**1.07**	**C**	**34.7**	**0.84**
S. Huntington Ave/Centre/Moraine Street[3]	Boylston WB	D	41.7		C	32.5		D	42.7	
	Moraine EB	F	241.0		E	73.0		F	89.6	
	Centre NB	E	62.4		F	108.0		D	37.1	
	Centre SB	D	54.2		E	66.4		F	89.1	
	S. Huntington SB	C	26.6		C	27.0		C	27.6	
	Overall:	**F**	**88.8**	**0.99**	**E**	**78.0**	**1.10**	**E**	**56.0**	**0.88**
Centre St/Green St	EB	C	21.0		B	16.5		B	16.5	
	WB	D	48.4		C	27.0		C	27.0	
	NB	A	7.7		A	7.2		A	7.2	
	SB	A	7.4		A	8.7		A	8.7	
	Overall:	**B**	**17.4**	**0.61**	**B**	**12.6**	**0.64**	**B**	**12.6**	**0.64**
South St/Carolina Ave	WB	C	22.5		C	25.0		C	25.0	
	NB	A	6.4		A	6.7		A	6.7	
	SB	A	5.5		A	5.1		A	5.1	
	Overall:	**A**	**9.8**	**0.48**	**B**	**10.4**	**0.48**	**B**	**10.4**	**0.48**
South St/Washington/Arborway/Bus	Washington WB	E	63.3		F	95.0		F	95.0	
	Bus Ramp WB	D	46.1		D	44.1		D	44.1	
	Arborway Ramp EB	D	50.5		D	46.5		D	46.5	
	South St NB	B	19.1		A	9.0		A	9.0	
	South St SB	B	14.8		B	12.0		B	12.0	
	Overall:	**D**	**54.8**	**1.09**	**D**	**50.8**	**1.08**	**D**	**50.8**	**1.08**

1. Existing signal timings and phasing.
2. Optimized signal timings and phasing.
3. Coordinated signal operations along South Huntington Avenue at Bynner, Perkins and Centre streets, includes optimized timings and phasing.

* Timings were not changed. Intersection part of City of Boston's Huntington Avenue signal system.

Shaded Areas are approaches used by bus 39.

PM PEAK HOUR

Intersection	Approach	Existing Conditions[1]				Optimized[2]				Coordinated[3]		
		LOS	Delay	V/C		LOS	Delay	V/C		LOS	Delay	V/C
Huntington Ave/S. Huntington Ave*	EB	D	37.4			D	37.4			D	37.4	
	WB	E	71.0			E	71.0			E	71.0	
	NB	F	125.4			F	125.4			F	125.4	
	Overall:	**E**	**69.1**	**1.13**		**E**	**69.1**	**1.13**		**E**	**69.1**	**1.13**
S. Huntington Ave/Bynner Street[3]	EB	C	30.5			D	45.5			E	63.1	
	WB	C	25.4			C	30.1			D	37.8	
	NB	D	49.6			A	5.7			A	6.4	
	SB	F	115.7			A	9.8			A	9.7	
	Overall:	**E**	**75.8**	**0.89**		**B**	**16.2**	**0.69**		**B**	**19.9**	**0.69**
S. Huntington Ave/Perkins Street[3]	EB	D	45.9			F	98.0			E	72.3	
	WB	C	29.8			C	30.7			C	33.8	
	NB	D	38.0			A	7.2			A	9.0	
	SB	E	79.3			A	9.4			B	11.7	
	Overall:	**D**	**54.6**	**0.97**		**C**	**31.8**	**0.80**		**C**	**28.1**	**0.78**
S. Huntington Ave/Centre/Moraine Street[3]	Boylston WB	E	55.9			D	40.5			E	63.4	
	Moraine EB	D	44.4			C	29.6			D	40.9	
	Centre NB	E	58.0			C	22.5			D	40.2	
	Centre SB	F	106.1			D	46.7			E	60.7	
	S. Huntington SB	E	58.0			B	13.4			C	31.3	
	Overall:	**E**	**67.8**	**0.87**		**C**	**26.5**	**0.72**		**D**	**44.0**	**0.84**
Centre St/Green St	EB	B	17.0			C	21.3			C	21.3	
	WB	D	47.9			D	41.3			D	41.3	
	NB	A	8.2			A	7.5			A	7.5	
	SB	B	14.0			A	6.4			A	6.4	
	Overall:	**C**	**20.9**	**0.80**		**B**	**15.5**	**0.76**		**B**	**15.5**	**0.76**
South St/Carolina Ave	WB	C	25.3			C	34.9			C	34.9	
	NB	A	6.5			A	4.8			A	4.8	
	SB	A	8.4			A	7.0			A	7.0	
	Overall:	**B**	**11.2**	**0.48**		**B**	**12.0**	**0.47**		**B**	**12.0**	**0.47**
South St/Washington/Arborway/Bus	Washington WB	F	86.4			F	150.3			F	150.3	
	Bus Ramp WB	D	41.8			D	36.2			D	36.2	
	Arborway Ramp EB	E	66.1			E	66.8			E	66.8	
	South St NB	C	24.8			B	11.6			B	11.6	
	South St SB	C	34.0			C	23.2			C	23.2	
	Overall:	**C**	**26.2**	**0.48**		**F**	**108.6**	**1.37**		**F**	**108.6**	**1.37**

1. Existing signal timings and phasing.
2. Optimized signal timings and phasing.
3. Coordinated signal operations along South Huntington Avenue at Bynner, Perkins and Centre streets, includes optimized timings and phasing.

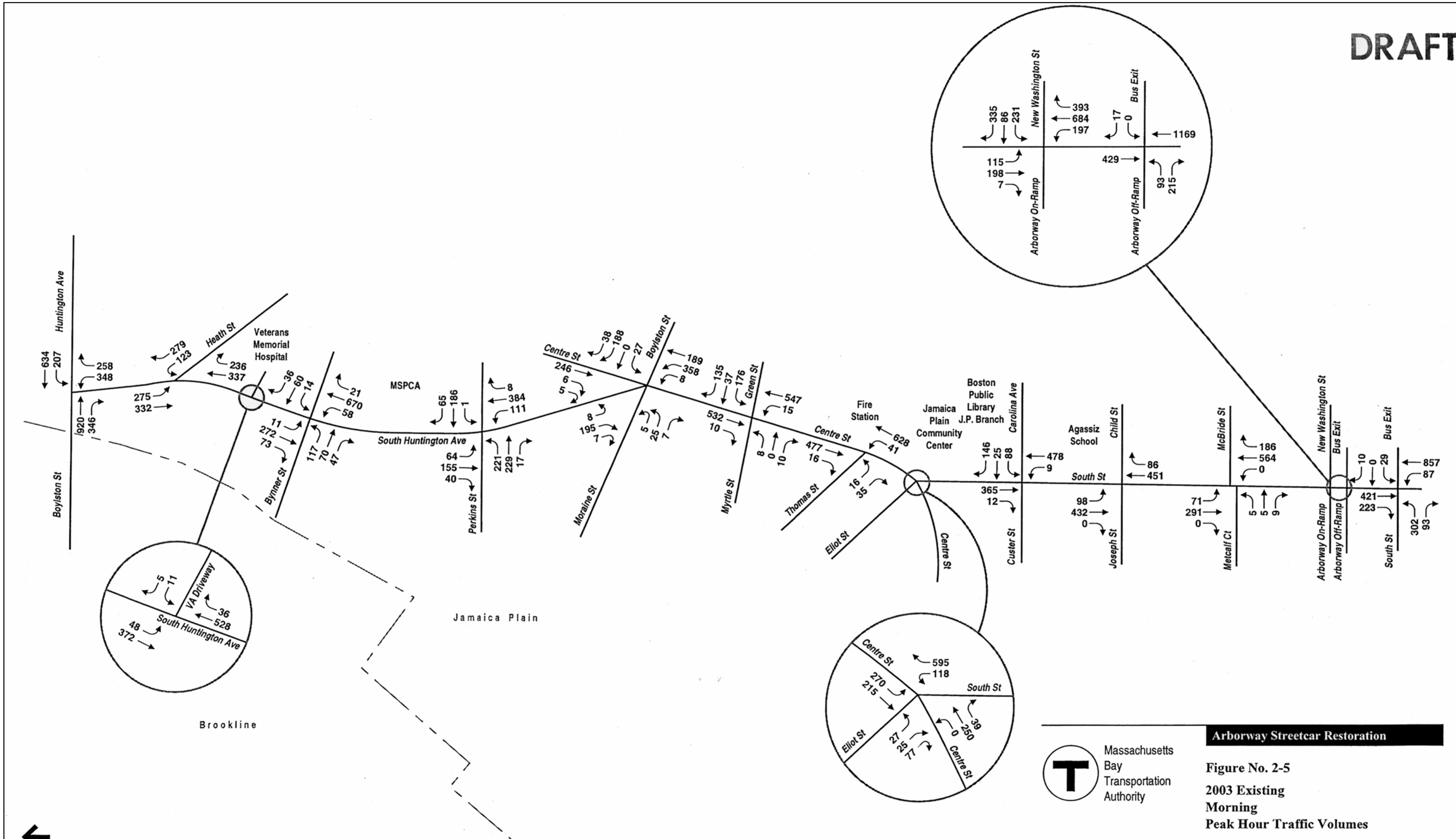
* Timings were not changed. Intersection part of City of Boston's Huntington Avenue signal system.

Shaded Areas are approaches used by bus 39.

APPENDIX C

PEAK HOUR TRAFFIC VOLUMES:
Arborway Corridor Modeling

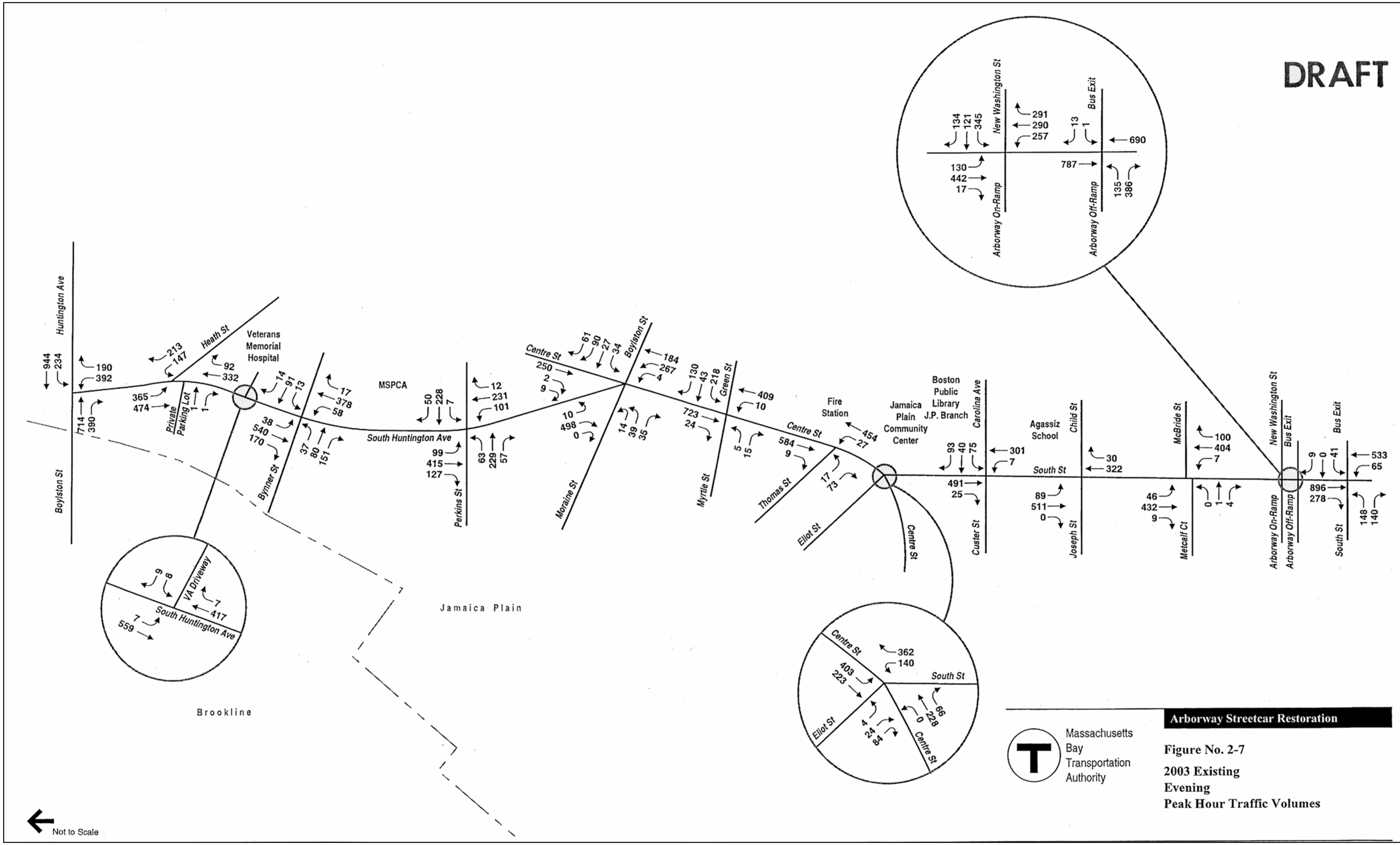
Arborway Streetcar Restoration, Vanasse Hagen Brustlin, Inc., 2002.



AM Peak Hour
Traffic Volumes

CTPS

MBTA Transit Signal Priority Study: Arborway Corridor



PM Peak Hour Traffic Volumes

CTPS

MBTA Transit Signal Priority Study: Arborway Corridor