

Draft Report

Central Square Access and Circulation Study Existing Conditions Analysis

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Prepared for City of Cambridge
by IBI Group
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1 Introduction

IBI Group has been engaged by the City of Cambridge (hereinafter referred to as the 'City') to study the transit routing, circulation, and access for MBTA routes around Central Square and to develop recommendations for reducing crowding for people waiting for the bus on narrow sidewalks and to improve access to and circulation around Central Square.

This project consists of the following tasks:

- Task 1 includes data collection and analysis activities to provide information on the existing conditions for transit around Central Square.
- Task 2 involves creating a list of issues, starting with those identified by Cambridge staff in the Request for Proposals (RFP), and added to or refined based on background information developed in Task 1 and a review of the 2013 K2C2 Central Square Final Report. The aim of this task is to provide a list of issues to consider while developing ideas for improving bus circulation and access in Central Square.
- Task 3 is intended to develop a list of potential ideas to improve the bus circulation, routing, stops, and layover locations, and refines the list with to include up to three (3) conceptual bus circulation plans.
- Task 4 is intended to develop a draft report, which provides more detail on the conceptual design level for the selected three (3) bus circulation plans, along with high level opinions of probable cost estimates.

This Task 1 Report summarizes the existing conditions for transit routing, layover, and stops around Central Square.

1.1 Background

Central Square is an important mixed-use downtown district in the City of Cambridge. It is located at the center of the Cambridgeport, Riverside, Mid-Cambridge, and Area 4 neighborhoods and is in close proximity to the Massachusetts Institute of Technology (MIT) and Harvard University. It is a major transportation hub that serves all the surrounding residential communities and the commercial, entertainment, and retail spaces.

In order to encourage further development of this area and ensure that Central Square (along with Kendall Square) continues to be an important multi-use area and transportation hub, the Cambridge City Manager commissioned a comprehensive development study. The final report from this study, titled the Kendall Square Central Square (K2C2) Planning Study was released in 2013. One of the recommendations of the K2C2 Planning Study with respect to transit was "to look at routing, layover, and stop changes for the Central Square buses" along with the associated goal to "look at ways to reduce the crowding from people waiting for the bus on narrow sidewalks". The objective of this study is to further investigate and come up with recommendations to achieve this goal.

1.2 Document Structure

This document is structured as follows:

- Section 1 provides an overview of the study, the structure of this document, and related information.
- Section 2 presents a summary of the Study Area, including the basemapping and transportation facilities, the MBTA bus routes which are routed through Central Square, and an audit of the associated bus stops within the Study Area.
- Section 3 presents a summary of the transit access and transfer situation in the Central Square Study Area. The analysis in this section is primarily based on the Red Line and Bus Passenger surveys conducted by the Central Transportation Planning Staff (CTPS) in 2008-2009.
- Section 4 presents an analysis of Automatic Passenger Counter (APC) Data collected from the bus routes operating in the Central Square Study Area. The APC data are analyzed to delve deeper into the existing route-level and stop-level conditions for bus routing, layover, schedules, and crowding.

- Section 5 presents a summary of the observations from a field survey of the Central Square Study Area. The field observation verifies and supplements the information gathered in the previous sections, with further information on bus routing, stop locations, layovers, signage, and wayfinding.
- Section 6 identifies the next steps in the study process.

1.3 Referenced Documents

The following documents were referenced as part of this report:

- MBTA Systemwide Passenger Survey: Rapid Transit 2008–2009 - Red Line, 2010, *prepared for MBTA Planning and Development, by Central Transportation Planning Staff*
- MBTA Systemwide Passenger Survey: Bus System 2008–2009 - Albany Garage, 2010, *prepared for MBTA Planning and Development, by Central Transportation Planning Staff*
- MBTA Systemwide Passenger Survey: Bus System 2008–2009 - Cabot Garage, 2010, *prepared for MBTA Planning and Development, by Central Transportation Planning Staff*
- MBTA Systemwide Passenger Survey: Bus System 2008–2009 – Charlestown and Fellsway Garages, 2010, *prepared for MBTA Planning and Development, by Central Transportation Planning Staff*
- MBTA Systemwide Passenger Survey: Bus System 2008–2009 - Somerville Garage, 2010, *prepared for MBTA Planning and Development, by Central Transportation Planning Staff*
- Kendall Square Central Square (K2C2) Planning Study, 2013, prepared for Cambridge Community Development Department, by Goody Clancy, Nelson Nygaard, Carol R. Johnson Associates, MJB Consulting, wZHA.

2 Study Area Basemapping and Transportation Facilities

The Study Area is a rectangular area around Central Square, roughly bounded by Bishop Allen Drive, Landsdowne St, Auburn St., and Bigelow St, with Massachusetts Avenue (or 'Mass Ave') running through the Study Area parallel to the longer edge of the rectangle. Figure 1 illustrates the Study Area bounded by the rectangle.

Figure 1: Central Square Study Area



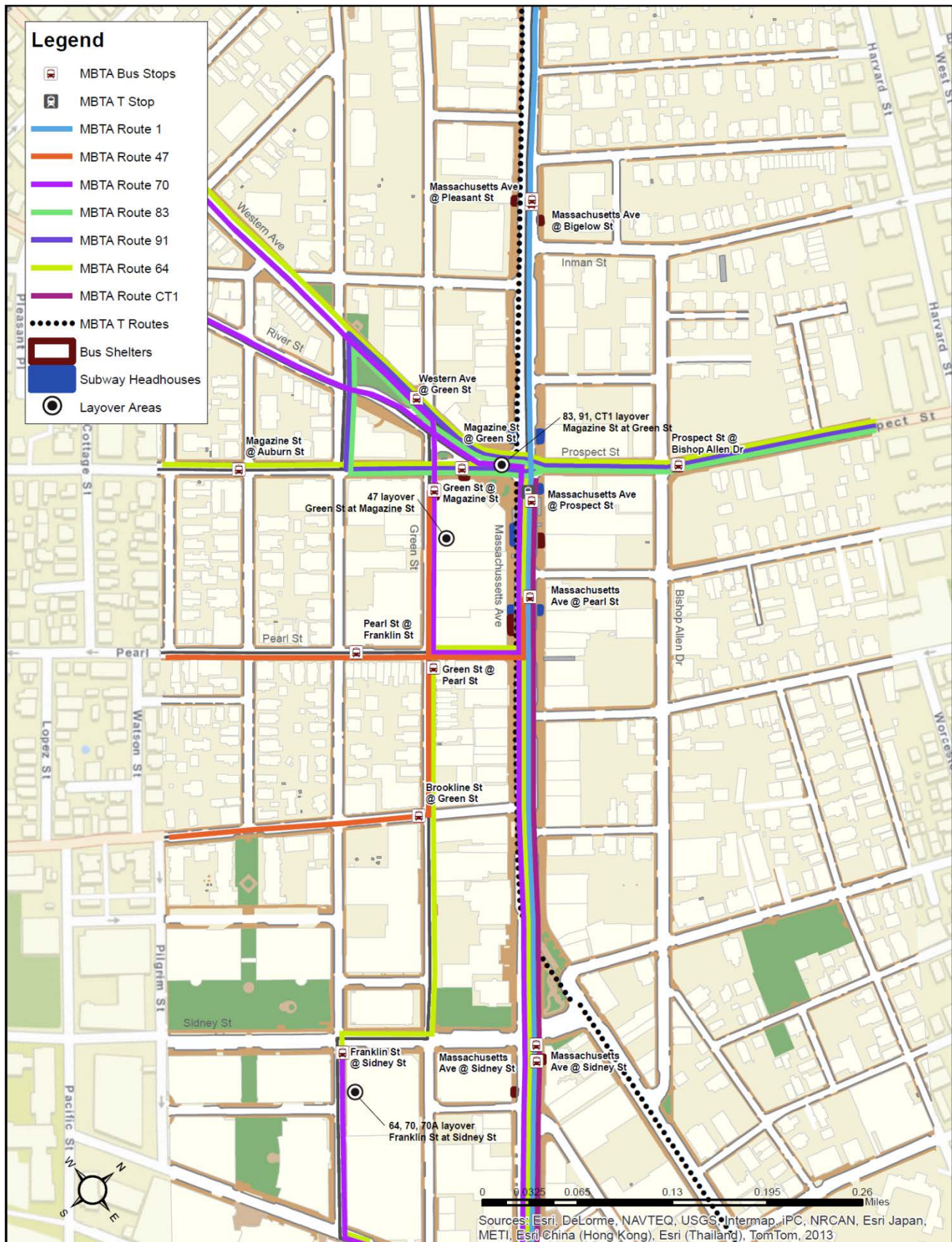
There are a variety of transit related features within the Study Area, including the Central Square subway station headhouses, bus stops, bus shelters, Hubway stations, bicycle facilities, street lights, benches and other facilities as shown in Figure 2. The following bus routes operate within the Study Area: 1, CT1, 47, 64, 70, 70A, 83, and 91. Figure 3 shows the routing of the buses and the associated bus stops and bus shelters.

Figure 2: Central Square Study Area Transit Amenities



Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

Figure 3: Central Square Study Area MBTA Service Audit



The results of the audit of facilities associated with each bus stop in the Study Area are presented in the following table.

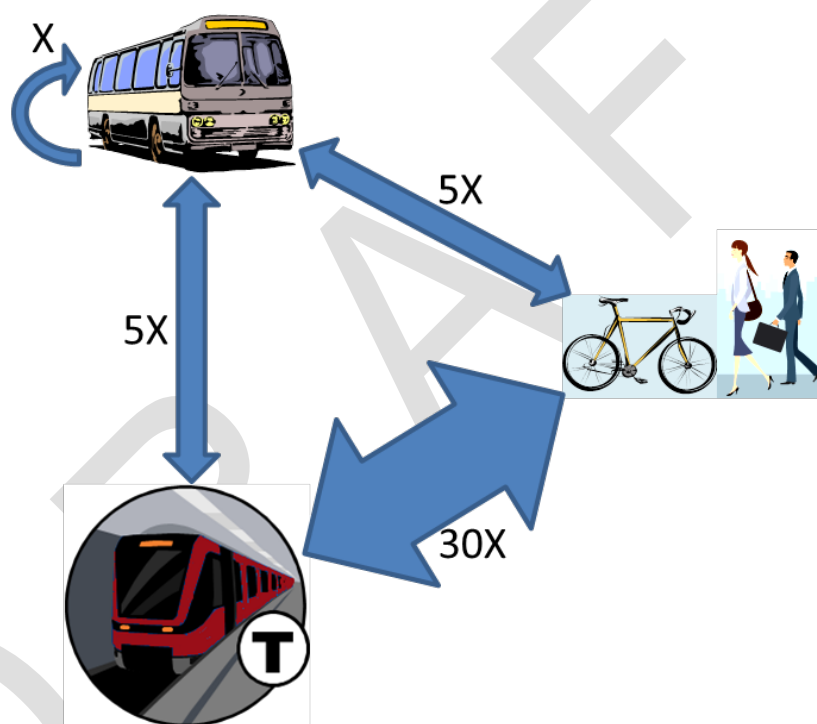
BUS STOP	ROUTES SERVED	SHELTER	SEATING	LIGHTING	ROUTE SIGNAGE	SCHEDULE INFO
Mass Ave at Prospect St	1, CT1	✓	✓	✓	✓	
Mass Ave at Pearl St	1, 47, 64, 70, 70A, CT1	✓	✓	✓	✓	
Mass Ave at Sidney St (Eastbound)	1, CT1, 64, 70, 70A	✓	✓	✓	✓	1, CT1, 64, 70, 70A
Mass Ave at Sidney St (Westbound)	1, CT1	✓	✓	✓	✓	1, CT1
Mass Ave at Pleasant St	1	✓	✓	✓	✓	1
Mass Ave at Bigelow St	1	✓	✓	✓	✓	1
Franklin St at Sidney St	64, 70, 70A					
Brookline St at Green St	47				✓	
Green St at Pearl St	47, 64, 70, 70A				✓	
Pearl St at Franklin St	47				✓	
Prospect St at Bishop Allen Dr (Northbound)	64, 83, 91				✓	
Prospect St at Bishop Allen Dr (Southbound)	64, 83, 91				✓	
Green St at Magazine St	47, 64, 70, 70A	✓	✓	✓	✓	64, 83, 91, CT1
Magazine St at Green St Berth 1	64, 83, 91, CT1	✓	✓	✓	✓	CT1, 83, 91
Magazine St at Green St Berth 2	CT1	✓	✓	✓	✓	
Magazine St at Auburn St	64				✓	
Western Ave at Green St	64, 91				✓	

3 Central Square Transit Access and Transfer Summary

It is estimated that approximately 35,000 person-trips (journeys) by transit originate, terminate, or make transfers in the Study Area. Approximately a quarter of these make a transfer between MBTA services within the Study Area and more than three-quarters of these journeys access or egress from the MBTA services on foot or by bicycle.

Central Transportation Planning Staff (CTPS) conducted a system-wide survey of Massachusetts Bay Transportation Authority (MBTA) riders for the MBTA in 2008–09. This survey covered all of the modes operated by the MBTA: bus (including trackless trolley), rapid transit or ‘heavy rail’ (the Blue, Red, and Orange Lines), light rail (the Green Line and the Mattapan High-Speed Line), commuter rail, and boat. The results were summarized in a series of summary reports. These summary reports were consulted to gain an understanding of the transit and transfer activity within the Central Square area. Figure 4 provides a summary of the approximate relative proportions of intermodal transit transfer activity near Central Square as estimated from these survey reports.

Figure 4: Approximate Relative Proportions of Intermodal Transfer Activity near Central Square



The relevant detailed results from the survey reports are summarized in this section. Section 3.1 presents the results from the Red Line Passenger Surveys and Section 3.2 presents the results from the Bus Passenger Surveys.

3.1 Red Line Passenger Survey Results for Central Square Station

3.1.1 Methodology

The results presented in this section are based on the Red Line survey. CTPS’ survey methodology included provision of survey forms to all riders entering each Red Line station between 6:00 AM and 3:00 PM on a typical weekday in 2008 or 2009. According to CTPS, “this distribution strategy was designed to provide approximately 85% of the weekday riders on the Red Line with an opportunity to receive a survey form during what would be considered typical travel conditions”. Surveys were not given to riders transferring to the Red Line at Park Street

or Downtown Crossing Stations because CTPS staff felt that such riders would be covered at the station at which they first entered the rapid transit system.

The survey responses were collected and the survey data were expanded to cover 100% of results by weighting them to equal typical boardings during the survey hours using the most recently available ridership figures.

3.1.2 Modal Distribution for Passengers Accessing or Egressing at Central Square

Figures 5 and 6 present the modal distribution of passengers accessing or egressing from the Red Line at Central Square station. Figure 5 presents the combined results for both access and egress, while Figure 6 distinguishes between the access and egress results through two separate pie charts.

Figure 5: Modal Distribution for Red Line Access and Egress at Central Square

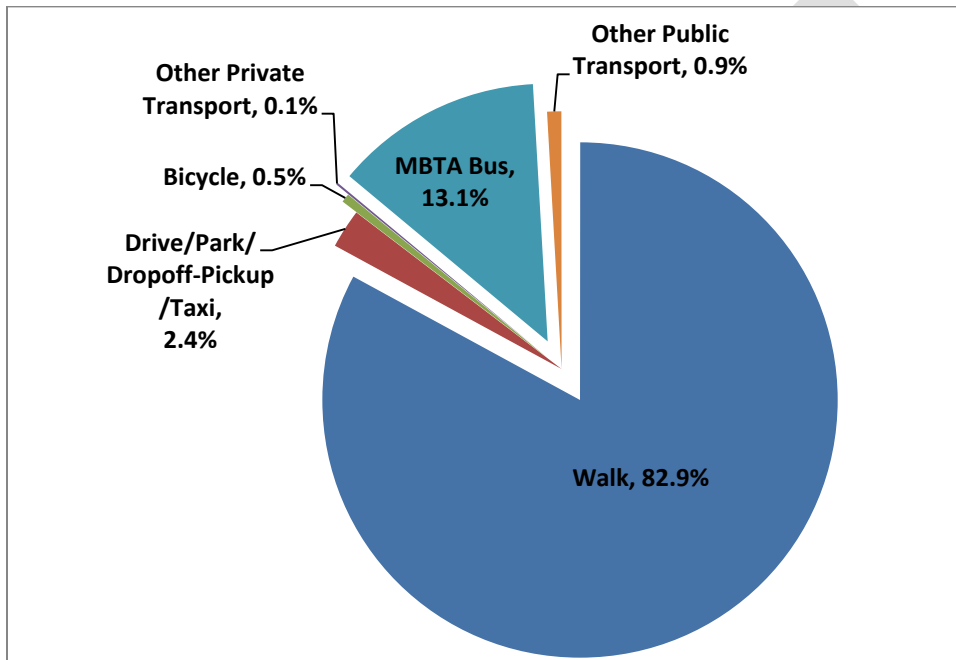
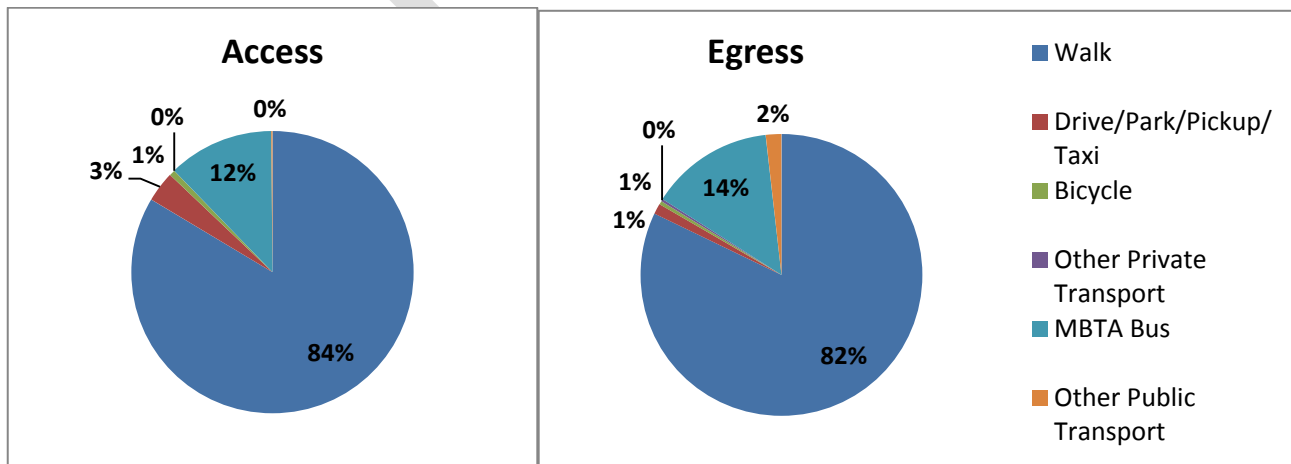


Figure 6: Modal Distribution for Red Line Access or Egress at Central Square



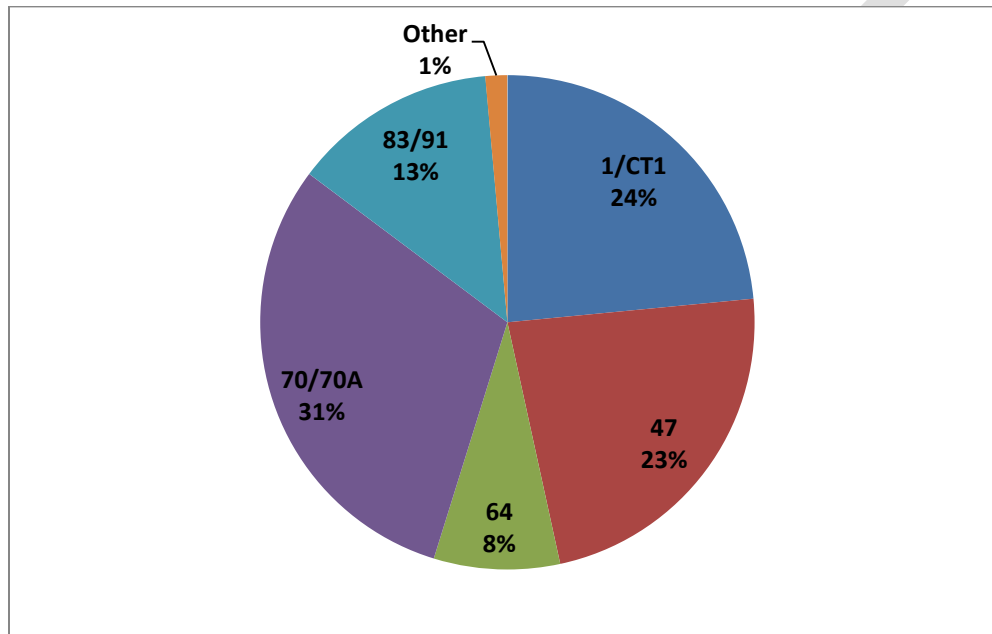
As evident from the two figures, the majority of passengers, equivalent to around 82-84%, walk to or from the Red Line at Central Square Station. There is no significant difference between passengers accessing or

egressing. Approximately 12-14% passengers transfer between MBTA buses and the Red Line at Central Square Station.

3.1.3 Intermodal Transfers between Red Line Station and MBTA Bus Routes

The 13% of passengers transferring between the Red Line and MBTA buses can be further distinguished based on the bus route taken either to access the Red Line or after egressing from the Red Line. Figure 7 presents the survey results for passengers transferring between the Red Line at Central Square and the various MBTA bus routes.

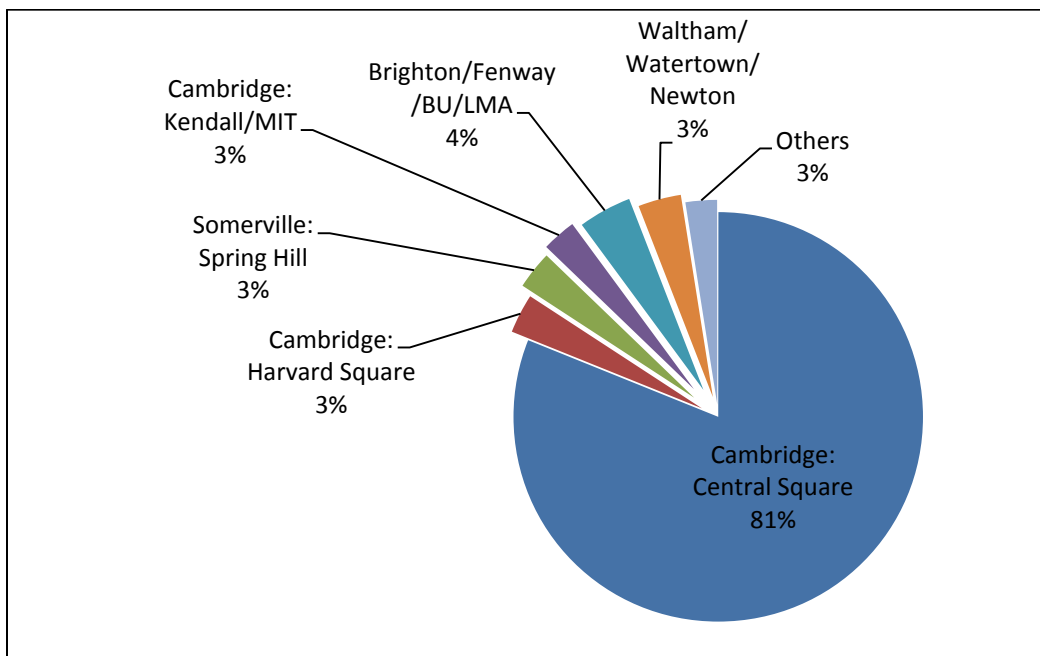
Figure 7: Intermodal Transfer between Red Line and MBTA Bus Routes at Central Square Station



3.1.4 Origin Locations for Passengers Entering Red Line at Central Square Station

The Red Line Passenger survey presents the origin locations for passengers accessing the Red Line at Central Square Station. Figure 8 presents the summary of these origin locations.

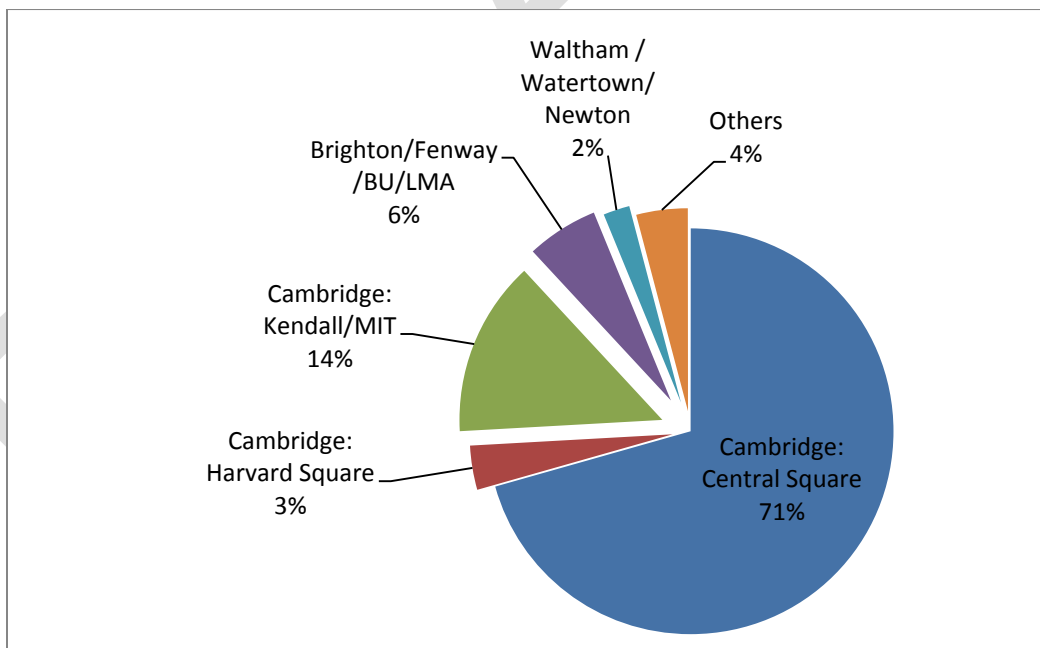
Figure 8: Origin Locations for Passengers Entering Red Line at Central Square Station



3.1.5 Destination Locations for Passengers Exiting Red Line at Central Square Station

The Red Line Passenger survey presents the destination locations for passengers exiting the Red Line at Central Square Station. Figure 9 presents the summary of the destination locations.

Figure 9: Destination Locations for Passengers Exiting Red Line at Central Square Station



3.2 Bus Passenger Survey Results for Routes Serving Central Square Station

3.2.1 Survey Methodology

The results presented in this section are based on the bus survey. CTPS' survey methodology for buses was similar to that for the Red Line and included the provision of survey forms to all riders riding the various MBTA bus routes between 6:00 AM and 3:30 PM on a typical weekday in 2008 or 2009. According to CTPS' Passenger survey reports, "this distribution strategy was designed to provide approximately 85% of the weekday riders on the buses with an opportunity to receive a survey form during what would be considered typical travel conditions".

The survey responses were collected and the data collected from the survey were expanded to cover 100% of results by weighting them to equal typical boardings during the survey hours using the most recently available ridership figures.

The following sections present a summary of results for the following routes: 1, CT1, 47, 64, 70, 70A, 83, 91.

3.2.2 Intermodal Transfers between MBTA Bus Routes

The bus survey provides a summary of passengers transferring between MBTA bus routes, but does not explicitly describe the location at which the transfers take place. However, because the majority of bus routes considered here only intersect or meet at Central Square Station, it is reasonable to assume that that these passengers transfer within the Central Square Study Area. Figure 10 presents the summary of intermodal transfers between the different bus routes.

Figure 10: Intermodal Transfers between MBTA Bus Routes near Central Square

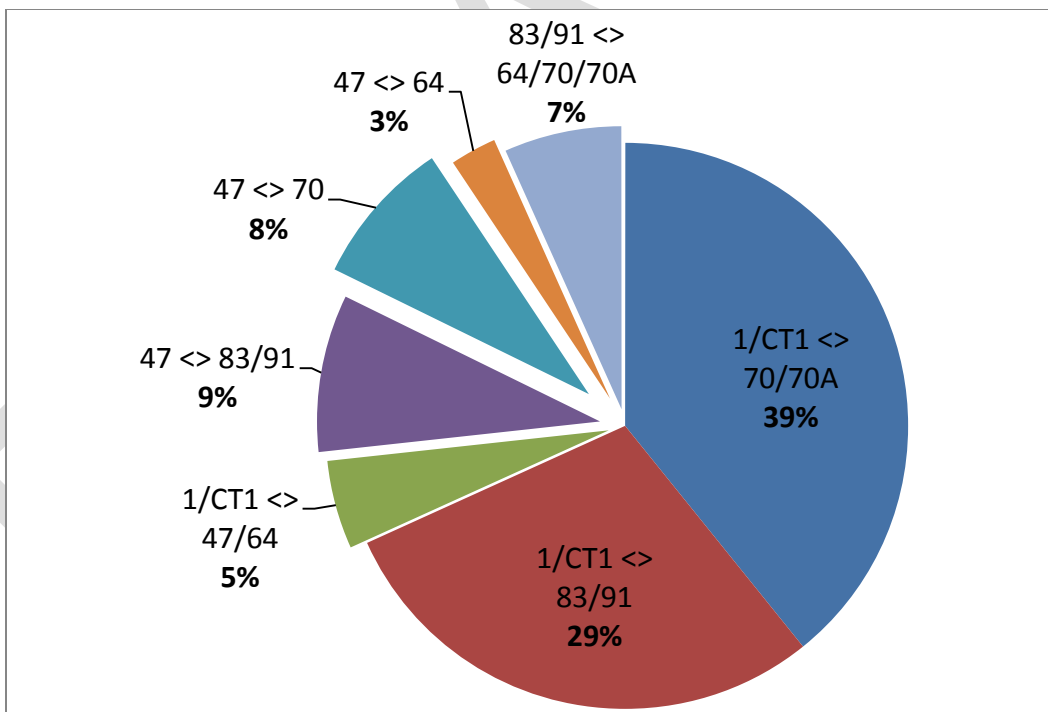
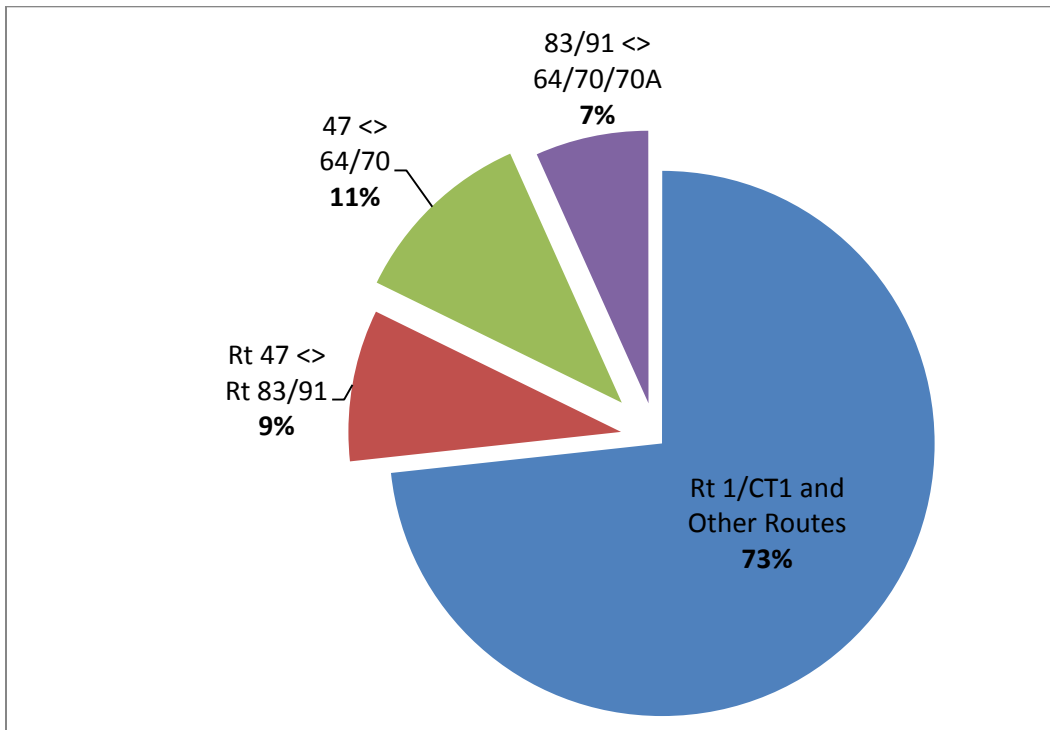


Figure 11 presents the same information as Figure 10, but with the routes grouped together by general direction of travel. If we group routes together, it is evident that the majority of people, 73%, transfer between routes running along Mass Ave (1/CT1) and routes running effectively perpendicular to Mass Ave (all other routes).

Figure 11: Intermodal Transfers between MBTA Bus Routes near Central Square (with routes grouped together by direction of travel)



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4 APC Travel Time and Load Analysis

This section presents the results of the following four analyses:

- Dwell Time Analysis at Route 1 and CT1 stops in the Study Area
- Duration between Scheduled Arrival and Departure Times for Routes in the Study Area
- Passenger Loads Analysis for Routes 64, 70, and 70A
- Crowding at Stops in the Study Area

4.1 APC Data Overview

Data from the MBTA's Automatic Passenger Counters (APCs) were analyzed to understand bus operating conditions in and around Central Square. These on-board devices count the number of passengers boarding and alighting a bus at each stop and provide the time at which the bus makes movements and opens/closes its doors. Specifically the devices provide:

- Bus travel time – the time from when the bus starts moving away from a stop to the time when the door opens at the next stop
- Bus dwell time – the time from when the bus opens its doors at a stop to the time the bus closes its doors at a stop
- Bus wait time – the time from when the bus closes its doors at a stop to the time when the bus starts moving away from the stop
- Overall travel time – the sum of the bus travel time, dwell time, and wait time
- Passenger load – the boarding and alighting information also allows calculation of the passenger load (i.e. the number of passengers in the bus) after each stop.

There are APC data for trips in both the AM and PM weekday periods, providing a dataset for bus performance during these times.¹ The routes analyzed were:

- Route 1 – operating between Harvard Square and Dudley Square (via Central Square)
- Route CT1 – operating between Central Square (at Magazine St at Green St) and B.U. Medical Center
- Route 47 – operating between Central Square (at Massachusetts Ave and Pearl St) and Broadway Station in South Boston
- Route 64 – operating between Central Square (at Franklin St at Sidney St) and Oak Square in the off-peak and Kendall Square and Oak Square in peak times
- Routes 70 and 70A– operating between Central Square (at Franklin St at Sidney St) and Cedarwood, North Waltham or Watertown Square
- Route 83 – operating between Central Square (at Magazine St at Green St) and Rindge Ave
- Route 91 – operating between Central Square (at Magazine St at Green St) and Sullivan Square Station

The following sections further describe the data analysis done for each bus route.

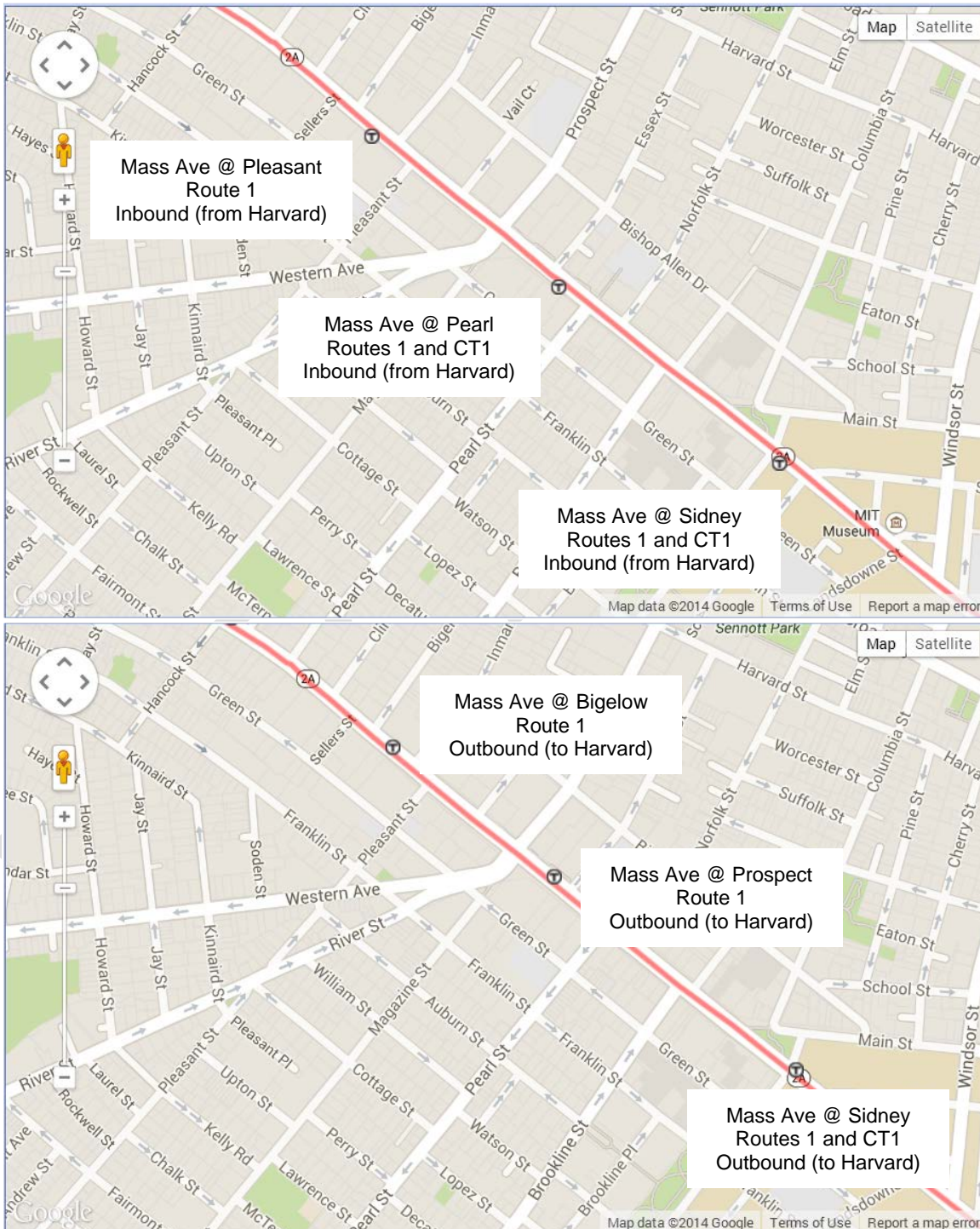
4.2 Dwell Time Analysis at Route 1 and CT1 Stops in the Study Area

The APC data provide the times when the buses' doors open at a stop and the time when the buses' doors close at a stop. This allows the dwell time of the bus at a stop to be determined. The dwell times at stops on

¹ Data were collected for trips made during the spring of 2014. Approximately 25 percent of MBTA buses are equipped with APCs. AM peak is 7am – 9am and PM peak is 4pm – 6:30pm.

Massachusetts Ave within the study area during the AM and PM peaks were calculated for Routes 1 and CT1. The stops are shown in the figure below. The dwell time for each stop for each trip in the AM and PM peaks were calculated and are shown in the plots below. The dwell times are arranged in increasing order on the y-axis (the x-axis has no value because it is just the relative (ordinal) position of the dwell times). Dwell times will vary throughout the course of the day depending on how many passengers board the bus. A dwell time of up to 20 seconds is typical for buses in normal operations. Dwell times consistently over 20 seconds are a sign that passenger activity may be unusually concentrated at that location.

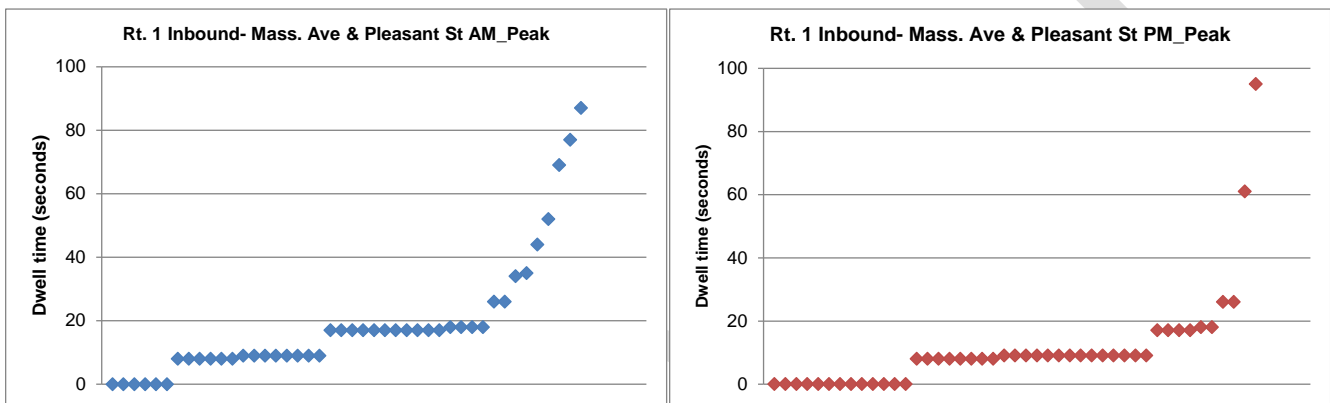
Figure 12: Stops on Massachusetts Ave in Study Area



Based on this analysis, it was found that the dwell times at Mass Ave at Pearl St and Mass Ave at Prospect St are highly variable. This is to be expected because both stops are located at the center of the Central Square area and near the entry and exit points for the subway. The dwell times at Mass Ave at Pleasant St and Mass Ave at Bigelow St show low variability and the majority of dwell times are below 20 seconds, indicating that the extent of passenger boardings and alightings at stops is not typically problematic. The stops in both directions at Mass Ave at Sidney St however exhibit a greater degree of dwell time variability in the PM peak, with dwell times quite often greater than 20 seconds. Further details of the analysis are presented in Sections 4.2.1-4.2.6, which address individual locations

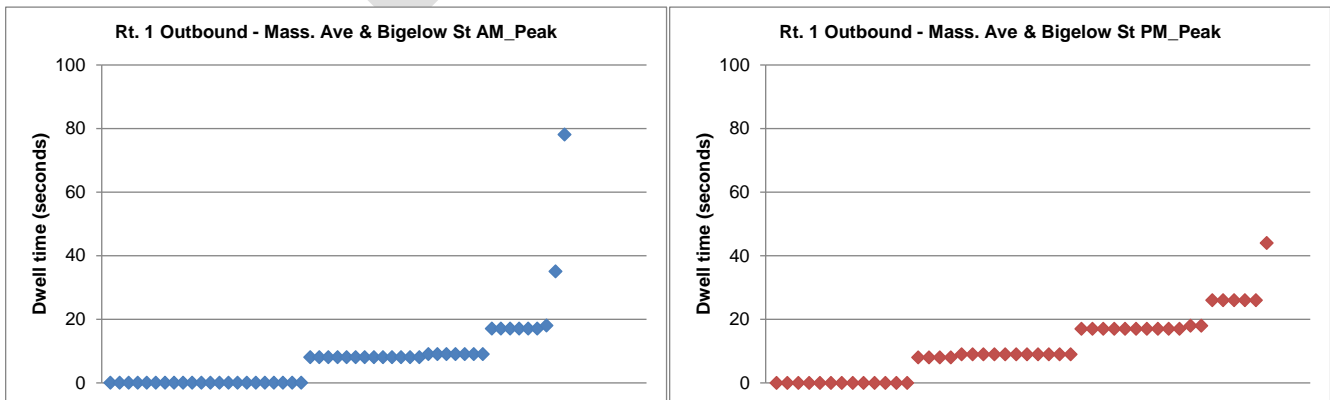
4.2.1 Massachusetts Ave and Pleasant St

The stop at Massachusetts Ave and Pleasant St (Route 1 in the Inbound direction from Harvard to Dudley) has a typical distribution of a bus stop without any indication of overcrowding or other dwell time issues with most (~84%) of the dwell times in the peaks being below 20 seconds.



4.2.2 Massachusetts Ave and Bigelow St

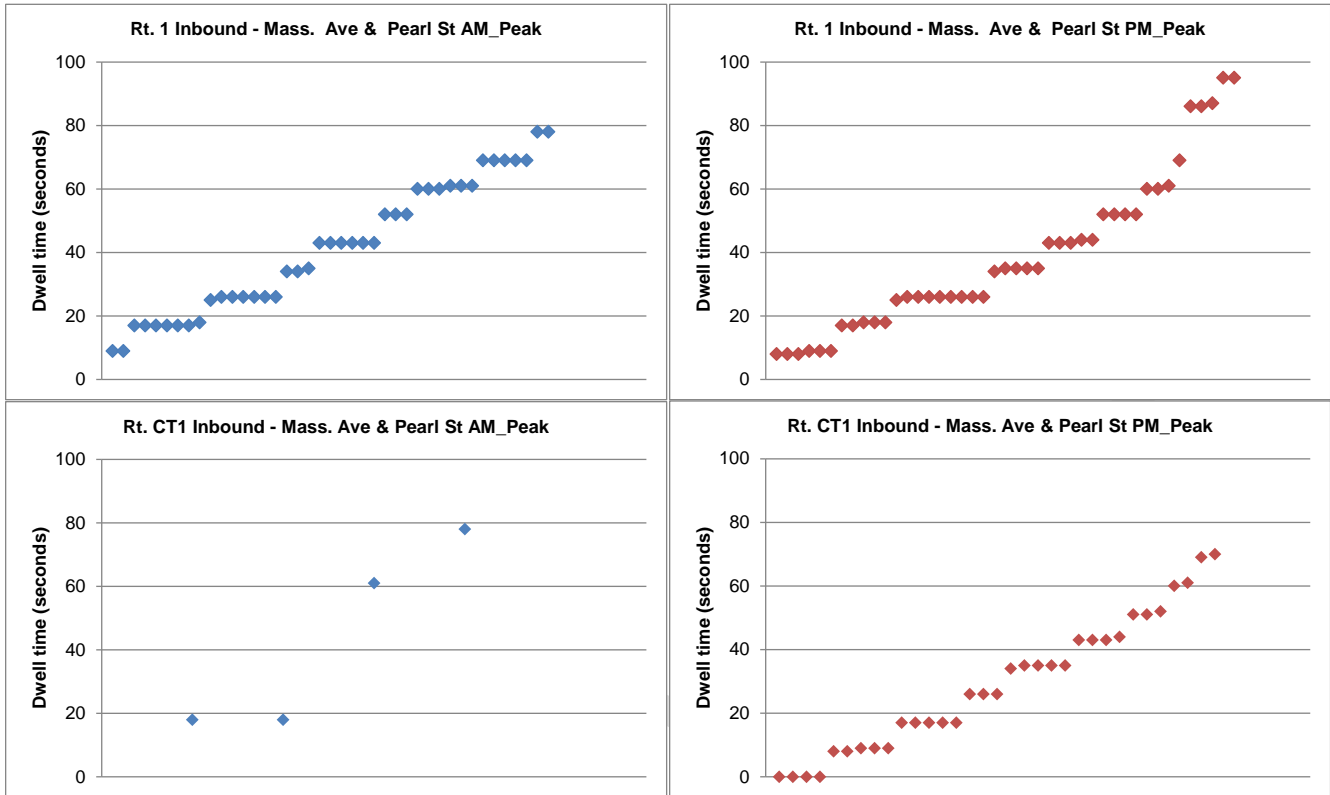
The stop at Massachusetts Ave and Bigelow St (Route 1 in the Outbound direction to Harvard from Dudley) has a typical distribution of a bus stop without indication of overcrowding or other dwell time issues with most (92%) of the dwell times in the peaks below 20 seconds.



4.2.3 Massachusetts Ave and Pearl St

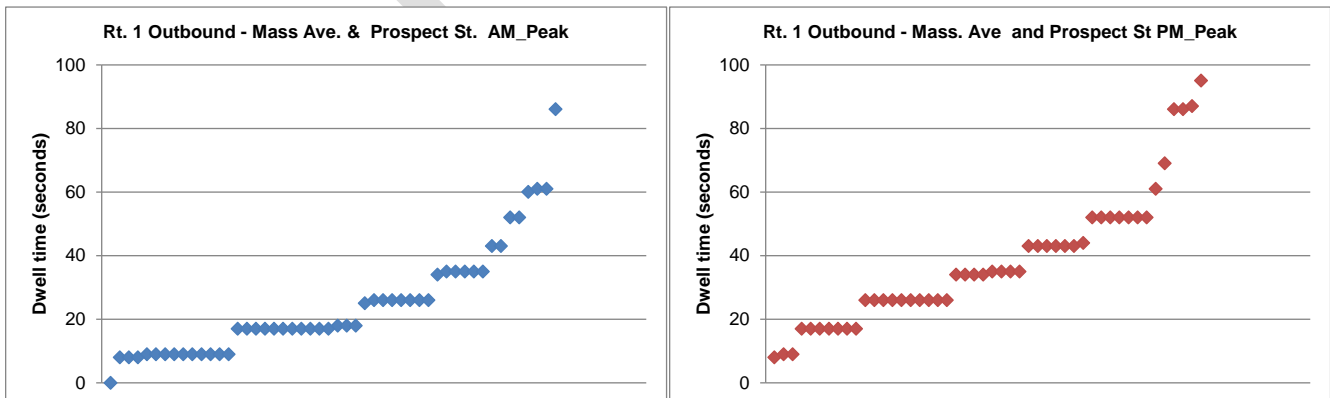
The stop at Massachusetts Ave and Pearl St (Route 1 in the Inbound direction from Harvard to Dudley and Route CT1 in the Inbound Direction from Central to B.U. Medical Center) has a typical distribution of a bus stop with a high level of passenger activity. This is the stop that is right outside the Central Square Red Line subway station. Only 22% of the dwell times in the peaks for Route 1 and 40% for Route CT1 are below 20 seconds.

This suggests that the passenger volumes (likely people transferring to or from the Red Line) are causing the long dwell times for both routes.



4.2.4 Massachusetts Ave and Prospect St

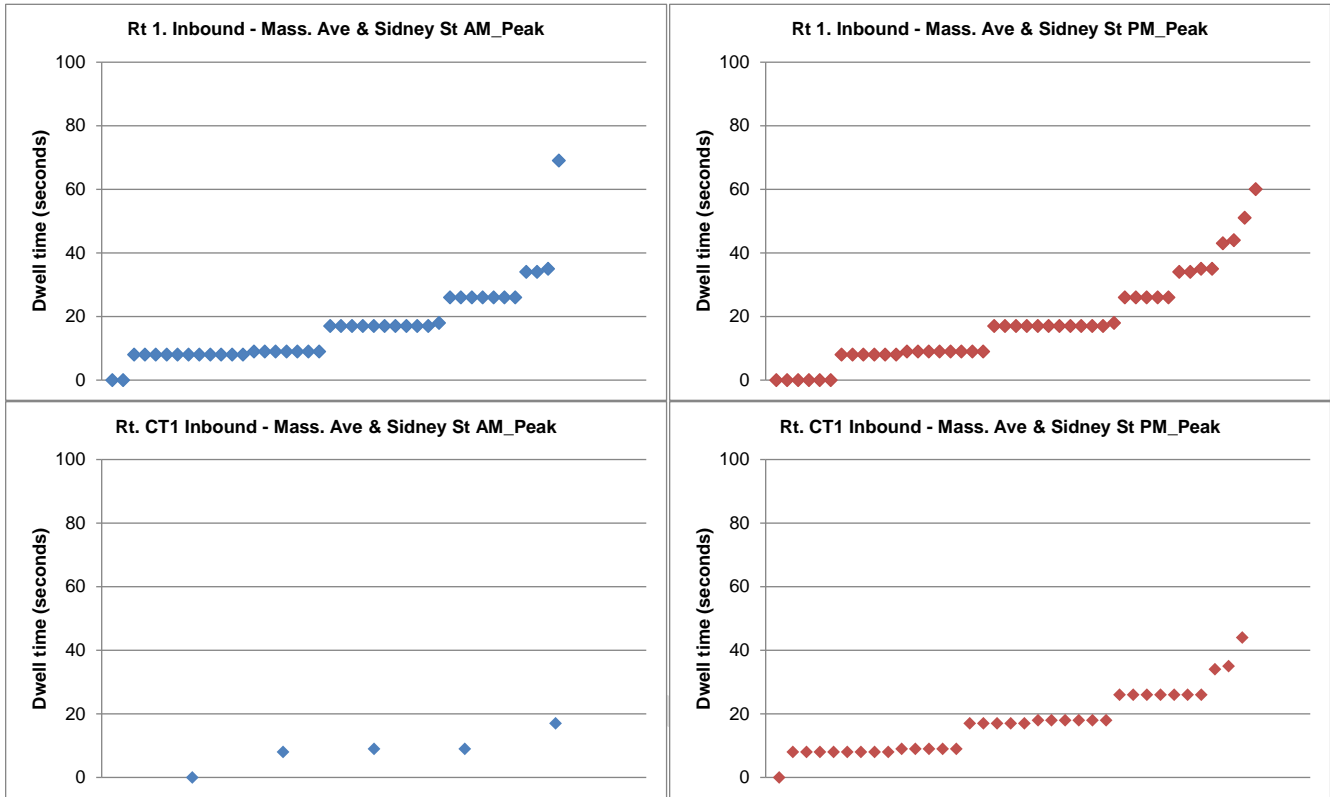
The stop at Massachusetts Ave and Prospect St (Route 1 in the Inbound direction from Harvard to Dudley) has a typical distribution of a bus stop with some overcrowding or other dwell time issues. Only 38% of the dwell times in the peaks are below 20 seconds. This shows that the passenger volumes or other conditions at this stop are causing long dwell times, but not so long as the stop at Pearl St.



4.2.5 Massachusetts Ave and Sidney St (Inbound)

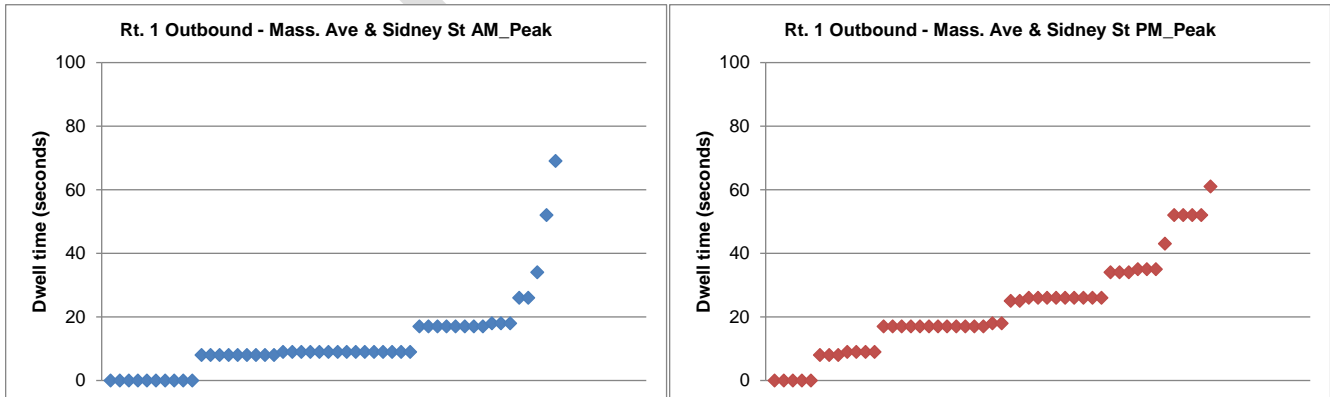
The stop at Massachusetts Ave and Sidney St (Route 1 in the Inbound direction from Harvard to Dudley and Route CT1 in the Inbound Direction from Central to B.U. Medical Center) has a typical distribution of a bus stop with some crowding or other dwell time issues. Approximately 71% of the dwell times in the peaks for Route 1

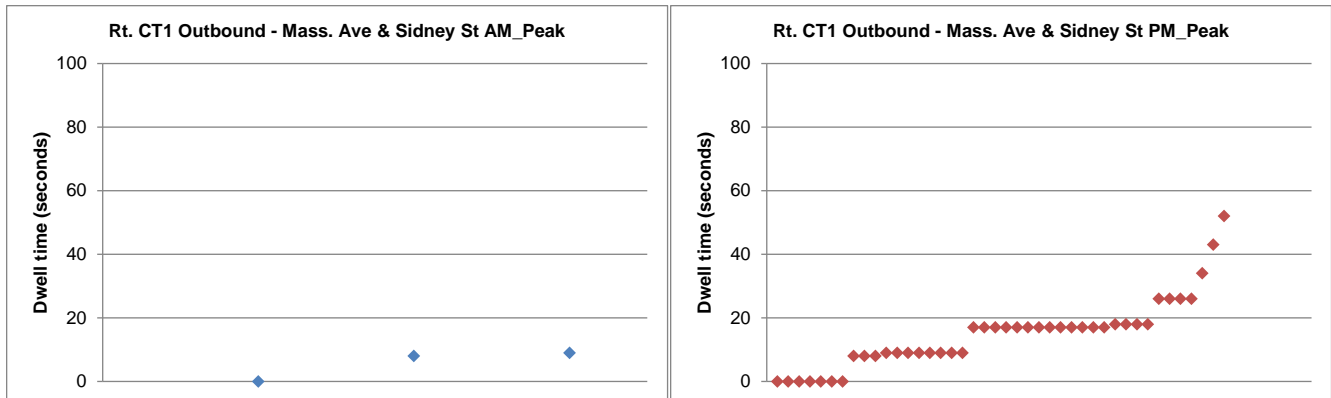
and 75% for Route CT1 are below 20 seconds. This suggests that the passenger volumes or other conditions at this stop are causing dwell times for both routes that are sometimes higher than typical.



4.2.6 Massachusetts Ave and Sidney St (Outbound)

The stop at Massachusetts Ave and Sidney St (Route 1 in the Outbound direction to Harvard from Dudley and Route CT1 in the Outbound Direction to Central from B.U. Medical Center) has a typical distribution of a bus stop with some crowding or other dwell time issues. Approximately 80% of the dwell times in the peaks for Route 1 and 84% for Route CT1 are below 20 seconds. This shows that the passenger volumes or other conditions at this stop are causing dwell times for both routes that are sometimes higher than normal.





4.3 Time between Scheduled Arrivals and Departures at Central Square

Routes 47, 64, 70, 70A, 83, 91, and CT1 all have layover locations within the Study Area. The GTFS schedule was analyzed to determine the duration between scheduled arrivals and departures for each route at Central Square. These scheduled durations were compared to the distribution of cumulative travel times at the stop just outside the study area in the direction towards Central Square for each route to estimate if there was a reasonable amount of scheduled layover time in Central Square.

The difference between the 95th percentile and the median of cumulative travel time at the stop just outside the study area represents the variability of travel time for each route by the time it gets to Central Square. If the variability of the cumulative travel time is greater than the scheduled duration between arrival and departure times at Central Square, there could be operational issues that require longer scheduled times. Conversely if the estimated variability of the cumulative travel time is much less than the scheduled duration between arrival and departure times then that time could possibly be reduced.

The observations from this analysis are summarized by route as follows:

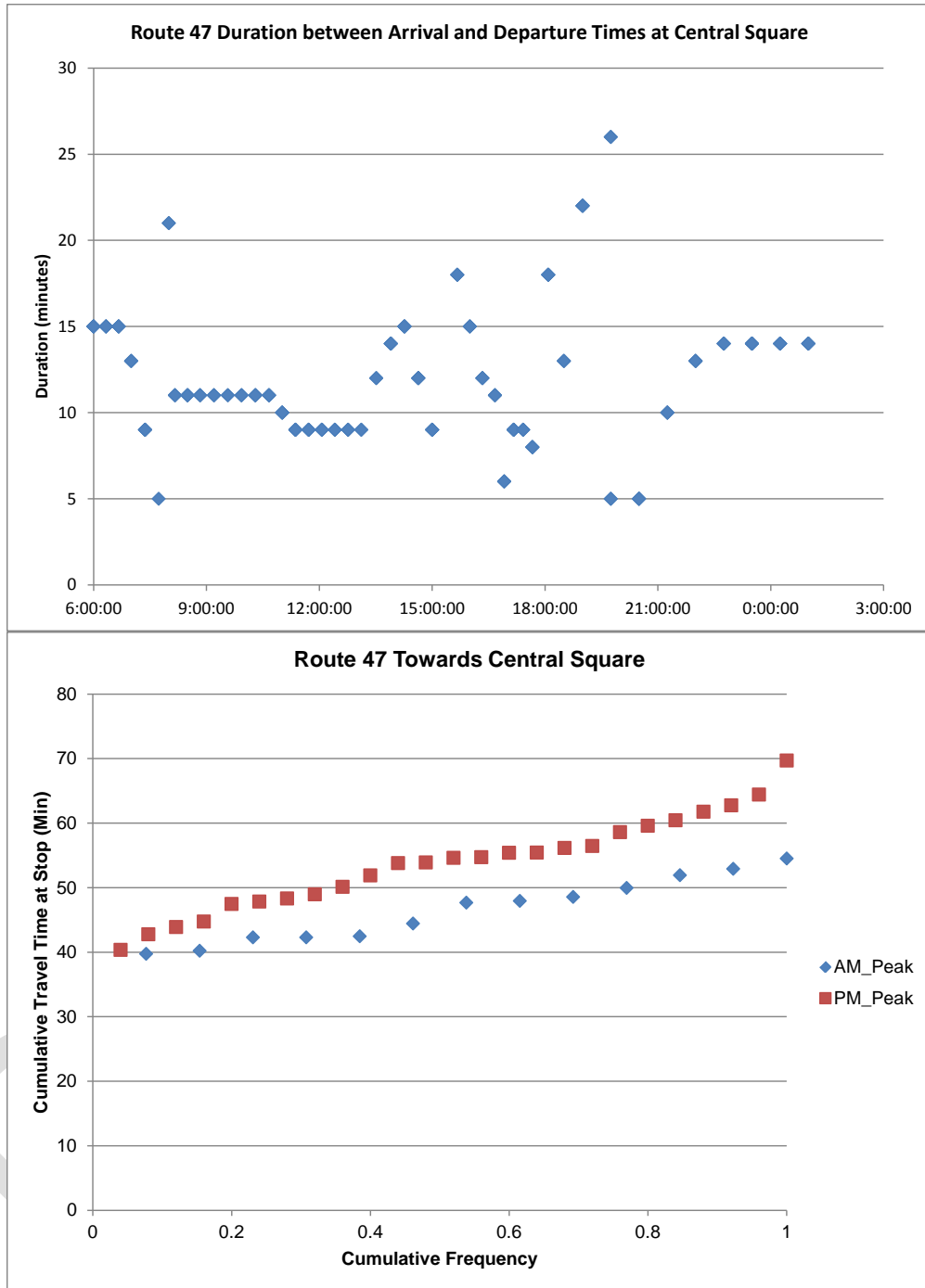
- Route 47 - There may be some unnecessary scheduled duration time between arrivals and departures in the AM peak.
- Route 64 - The scheduled duration times between arrivals and departures in the AM peak seem to be reasonable. It is unclear whether or not the PM peak scheduled duration times between arrivals and departures are reasonable
- Route 70 - Some additional scheduled duration time between arrivals and departures may be needed in the AM peak.
- Route 70A - Some additional scheduled duration time between arrivals and departures may be needed in the AM and PM peaks.
- Route 83 - Some additional scheduled duration time between arrivals and departures may be needed in the AM and PM peaks.
- Route 91 - There may be some unnecessary duration time between arrivals and departures in the AM and PM peaks.

The above statements are conditioned with the word ‘may’ because circumstances outside the Study Area, maintenance of schedules headways, or other MBTA operational requirements may govern the actual amount of layover that is appropriate. Further details of the analysis are presented in Sections 4.3.1-4.3.6.

4.3.1 Route 47

The scheduled durations between arrival and departure times vs. the time of day of the start of the trip for Route 47 according to the GTFS schedule data are shown below. The median scheduled duration is approximately 11 minutes in the AM and PM peaks. The cumulative travel time at Brookline St at Tudor St is also shown below vs. the cumulative frequency of that travel time. The difference between the 95th percentile and the median is 6

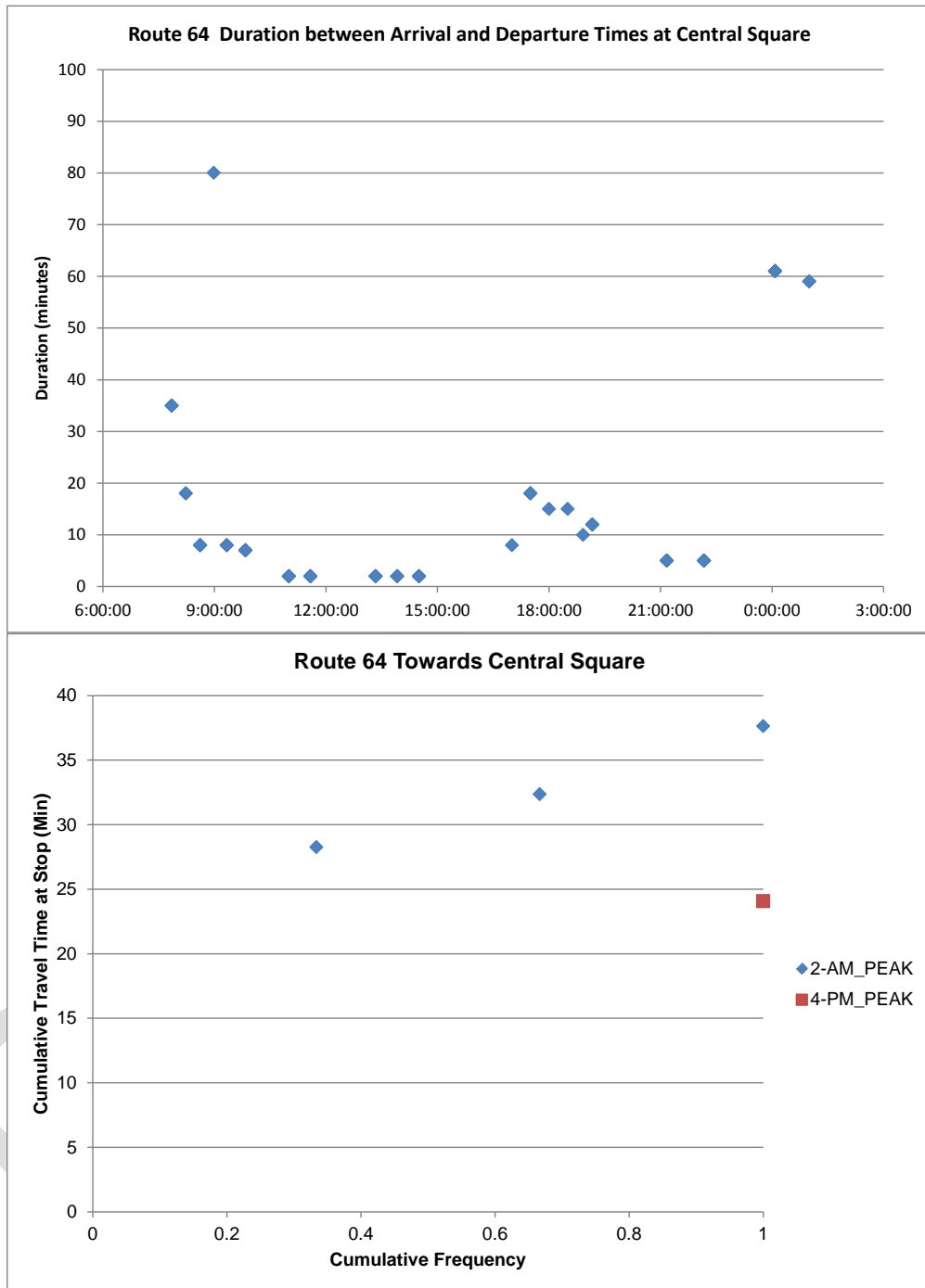
minutes in the AM peak, and 9 minutes in the PM peak. There may be some scheduled duration time between arrivals and departures in the AM peak that is not required for schedule recovery alone.



4.3.2 Route 64

The scheduled durations between arrival and departure times vs. the time of day of the start of the trip for Route 64 according to the GTFS schedule data are shown below. The typical scheduled duration is approximately 8 minutes in the AM peak and 15 minutes in the PM peak. The cumulative travel time at Magazine St at Auburn St vs. the cumulative frequency of that travel time is also shown below. There were very few APC data records for Route 64 due to lower sampling and more data errors. It is therefore not possible to estimate the variability of the cumulative travel time with any confidence. However, the difference between the 95th percentile and the median

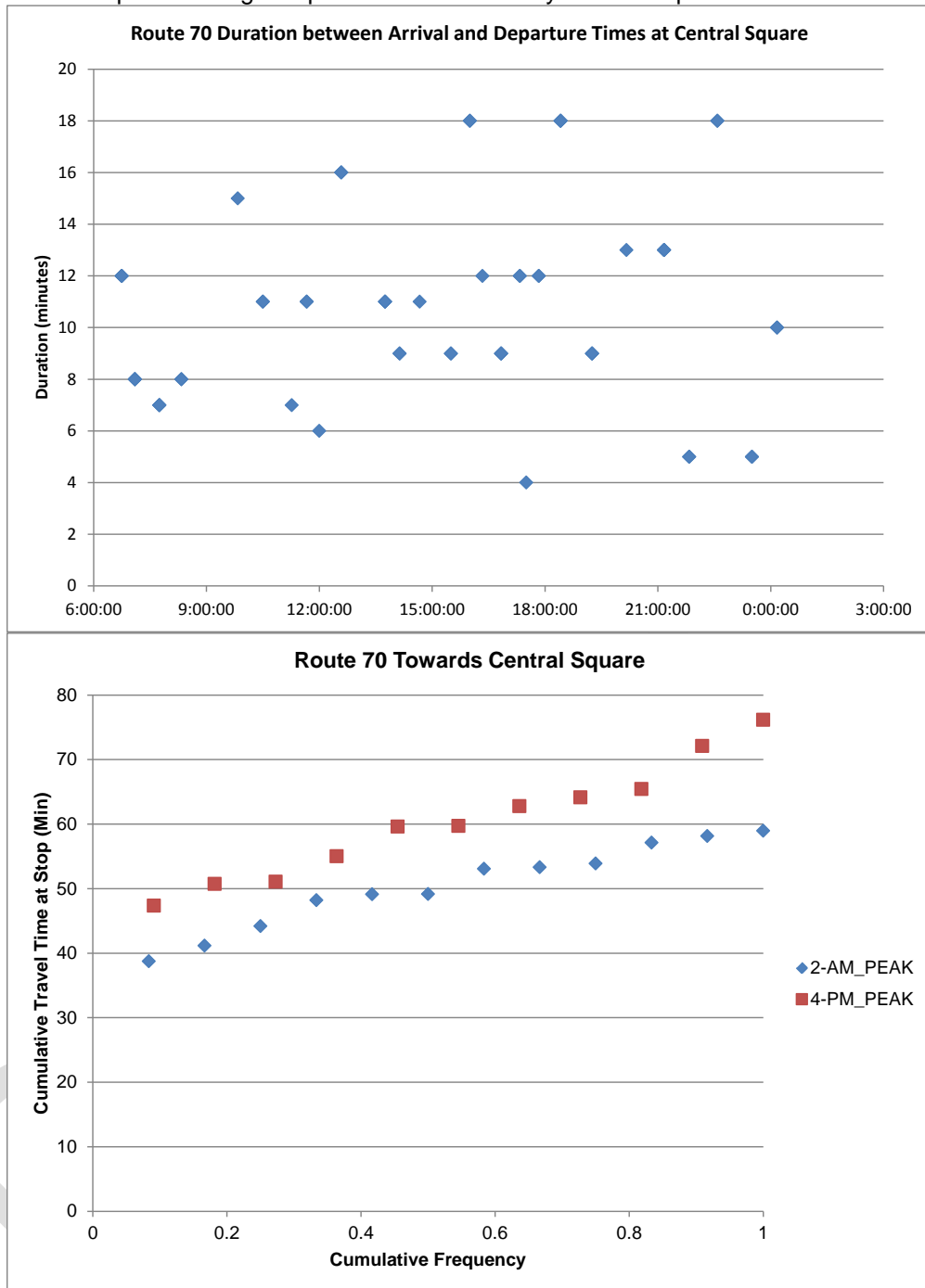
(with the few data points that are there) is only 5 minutes in the AM peak. It appears that the scheduled duration times between arrivals and departures in the AM peak are reasonable. The data are insufficient to support a statement about the PM peak scheduled duration times between arrivals and departures.



4.3.3 Route 70

The scheduled durations between arrival and departure times vs. the time of day of the start of the trip for Route 70 according to the GTFS schedule data are shown below. The median scheduled duration is approximately 8 minutes in the AM peak 12 minutes in the PM peak. The cumulative travel time at River St at Pleasant St vs. the cumulative frequency of that travel time is also shown below. The difference between the 95th percentile and the

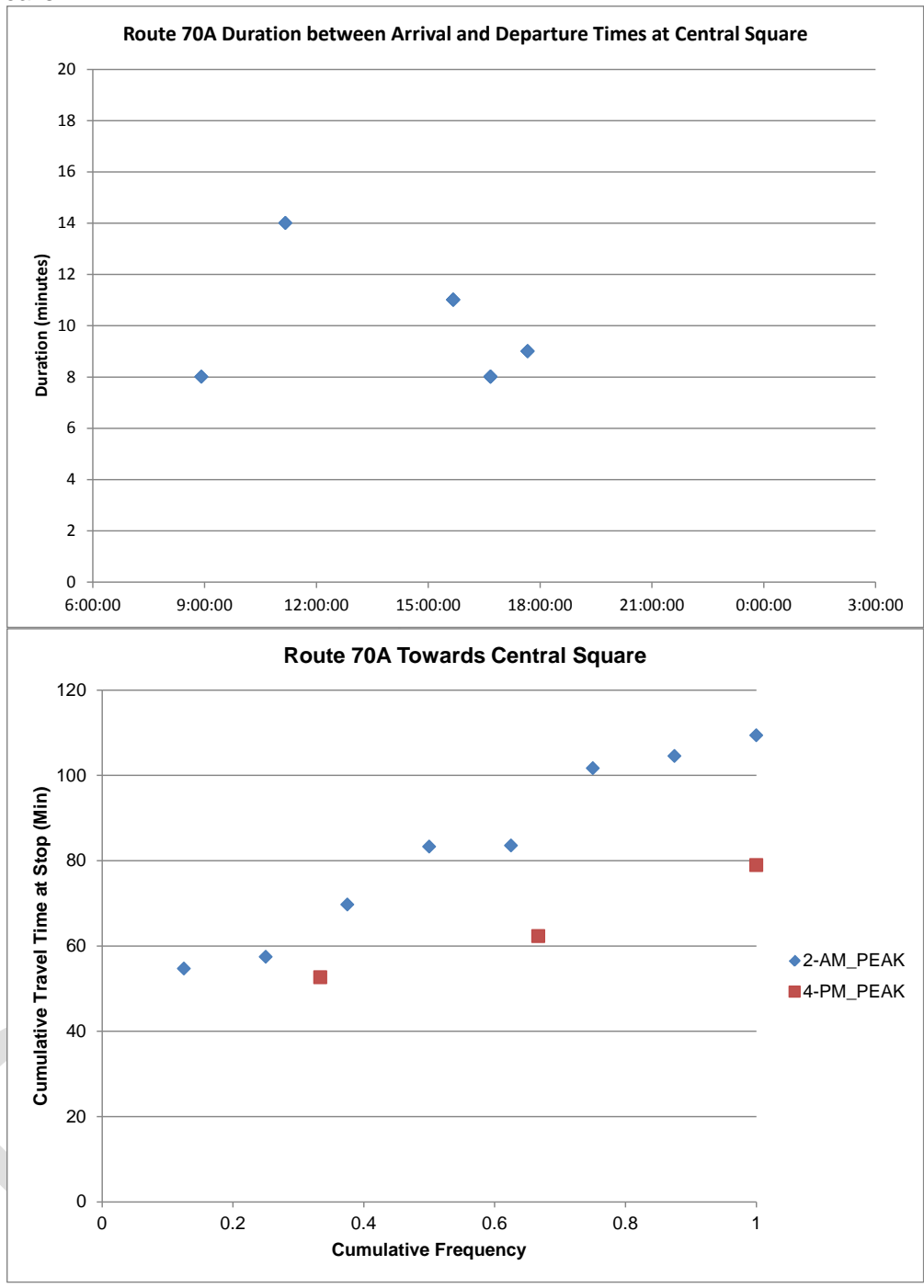
median is 7 minutes in the AM peak, and 14 minutes in the PM peak. Some additional scheduled duration time between arrivals and departures might improve service reliability in the AM peak.



4.3.4 Route 70A

The scheduled durations between arrival and departure times vs. the time of day of the start of the trip for Route 70A according to the GTFS schedule data are shown below. The median scheduled duration is approximately 8 minutes in the AM and PM peaks. The cumulative travel time at River St at Pleasant St vs. the cumulative frequency of that travel time is also shown below. There were very few APC data records for Route 70A due to lower sampling and more data errors. It is therefore not possible to estimate the variability of the cumulative travel time with any confidence. However, the difference between the 95th percentile and the median (with the

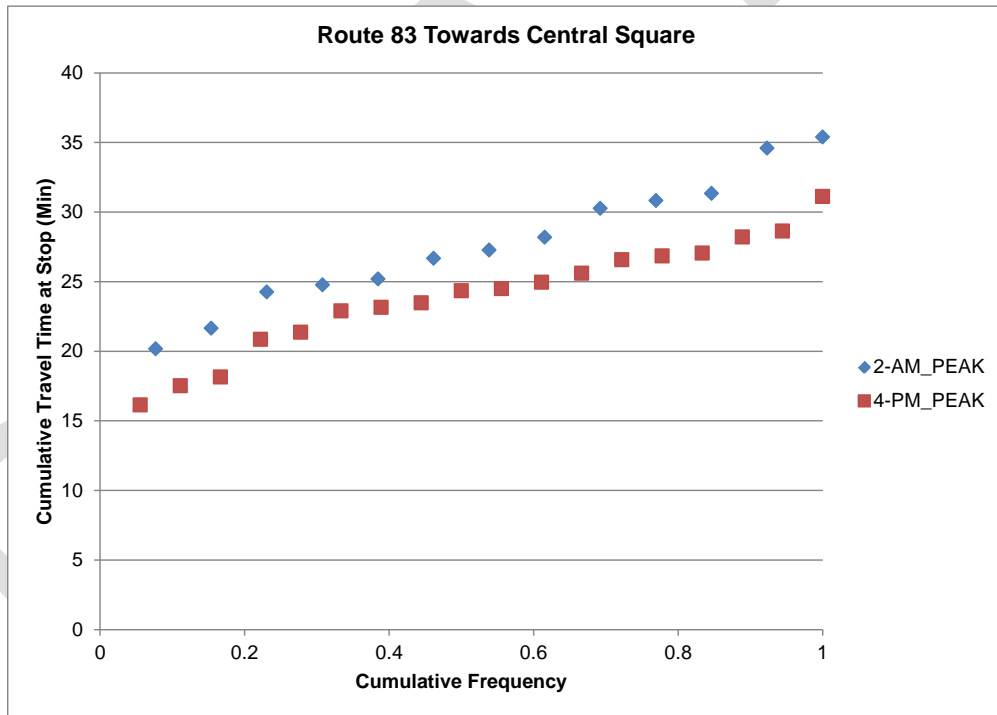
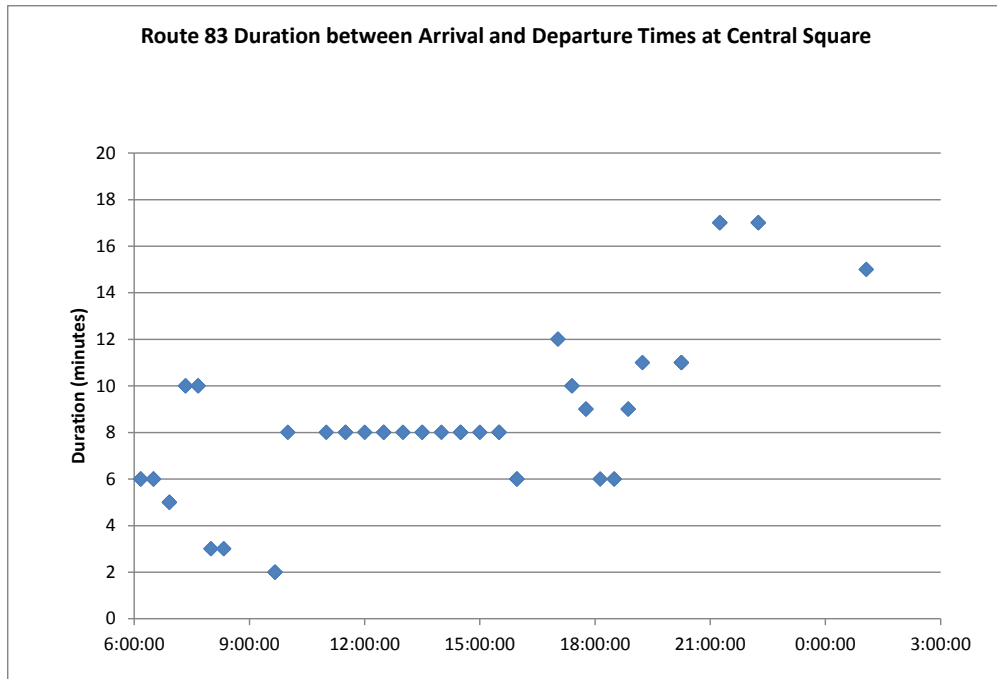
few data points that are there) is 24 minutes in the AM peak and 15 minutes in the PM peak. Some additional scheduled duration time between arrivals and departures might be able to improve service reliability in both the AM and PM peaks.



4.3.5 Route 83

The scheduled durations between arrival and departure times vs. the time of day of the start of the trip for Route 83 according to the GTFS schedule data are shown below. The median scheduled duration is approximately 10 minutes in the AM peak and 9 minutes in the PM peak. The cumulative travel time at Prospect St at Harvard St vs. the cumulative frequency of that travel time is also shown below. The difference between the 95th percentile

and the median is 8 minutes in the AM peak, and 5 minutes in the PM peak. Some additional scheduled duration time between arrivals and departures might be able to improve service reliability in both the AM and PM peaks.



4.3.6 Route 91

The scheduled durations between arrival and departure times vs. the time of day of the start of the trip for Route 91 according to the GTFS schedule data are shown below. The median scheduled duration is approximately 10 minutes in the AM peak and 12 minutes in the PM peak. The cumulative travel time at Prospect St at Harvard St vs. the cumulative frequency of that travel time is also shown below. The difference between the 95th percentile

For Routes 64, 70, and 70A in the inbound direction, the passenger load analysis indicated that during the AM peak the majority of passengers alight at the closest stop to Central Square. For Route 64, this is Magazine St at Green St, and for Route 70/70A, this stop is Mass Ave at Pearl St. A similar pattern was seen during the PM peak for Route 70 and 70A. In the outbound direction for Route 70/70A, the majority of passengers board at Green St at Magazine St, despite there also being a stop at Green St at Pearl St which is nearly as close to Central Square.

As noted in Section 3, a significant number of the passengers transfer between these routes and the Red Line, or have Central Square as their origin/destination, and this has implications for the pedestrian access to and from the buses.

Further details of the analysis are presented in Sections 4.4.1-4.4.3.

4.4.1 Route 64

In the peak periods Route 64 runs from Oak Square to Kendall Square via the stop at Magazine and Green Streets as shown in the figures below.

Figure 13: Route 64 Inbound (Towards Kendall) in Peak Periods

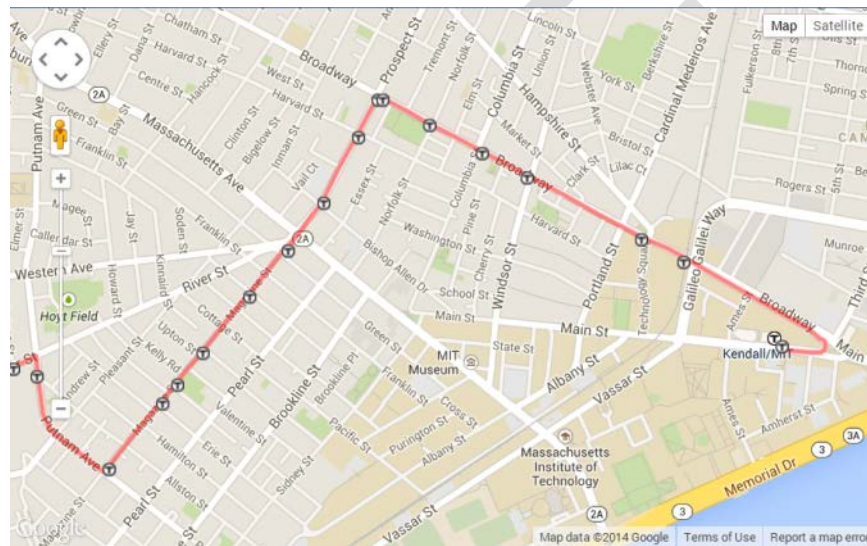
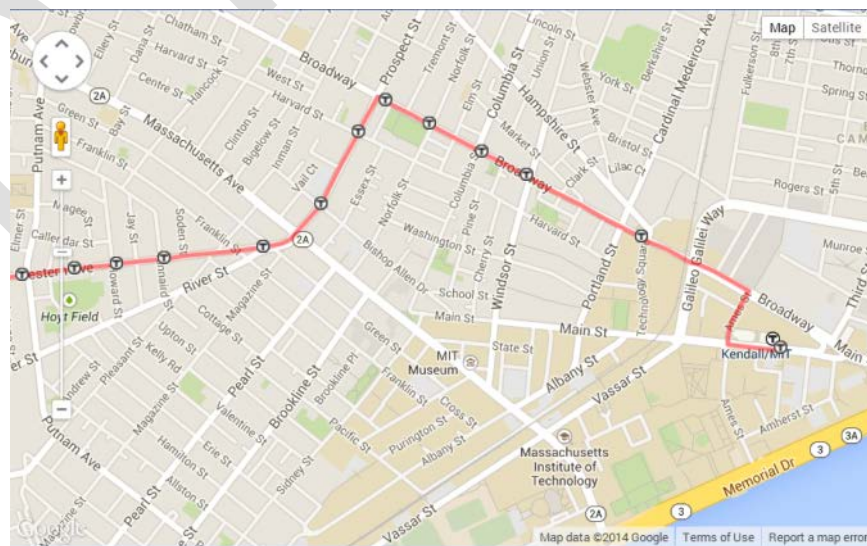
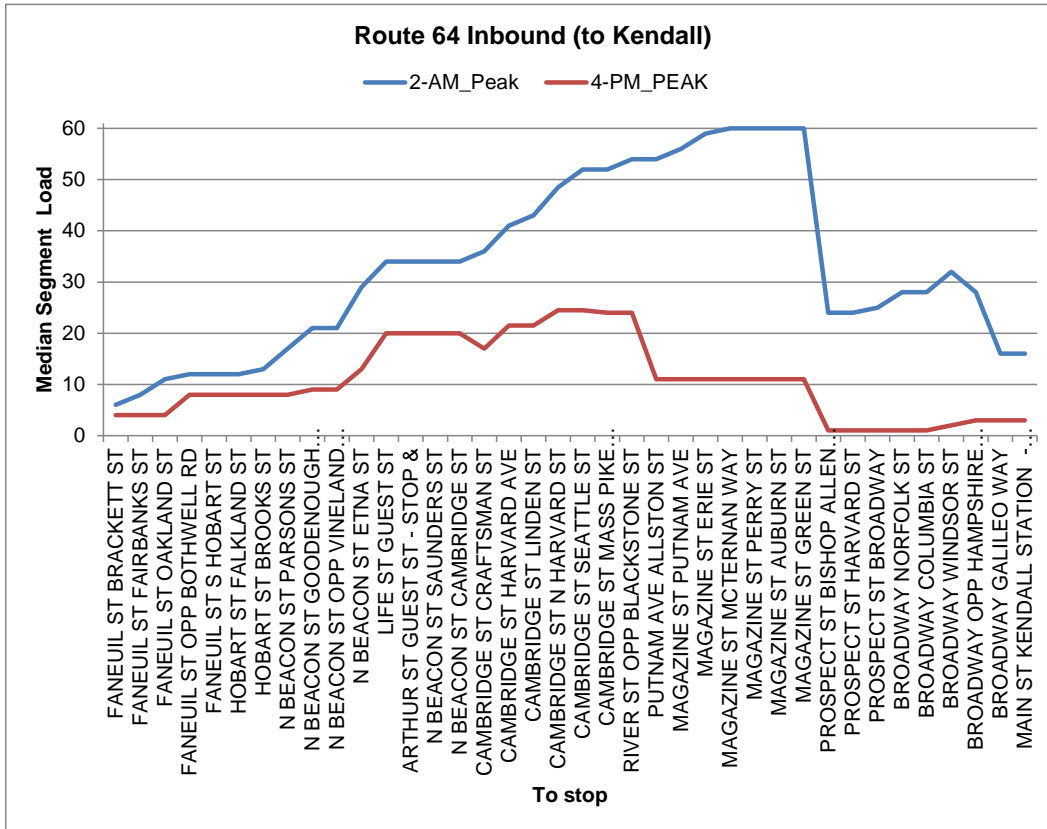


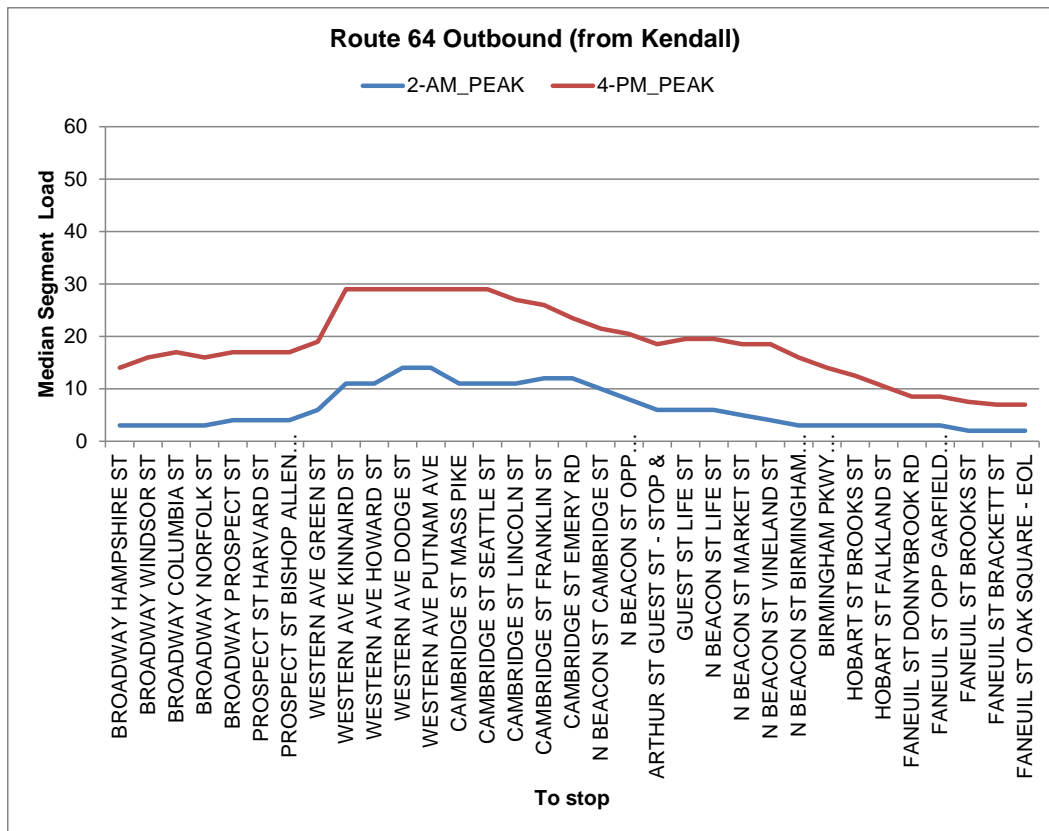
Figure 14: Route 64 Outbound (From Kendall) in Peak Periods



The load profiles show that there are far more passengers in the Inbound direction in the morning and that most passengers are alighting at the stop closest to Central Square (Magazine St at Green St). The average net alightings of about 35 passengers at this stop suggests that there could be crowding issues there in the morning peak period.



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During the off-peak periods, Route 64 operates between Oak Square and Central Square using the stop at Green St at Magazine St in the Outbound direction as shown in the figures below.

Figure 15: Route 64 Inbound (Towards Central) in Off-Peak Periods

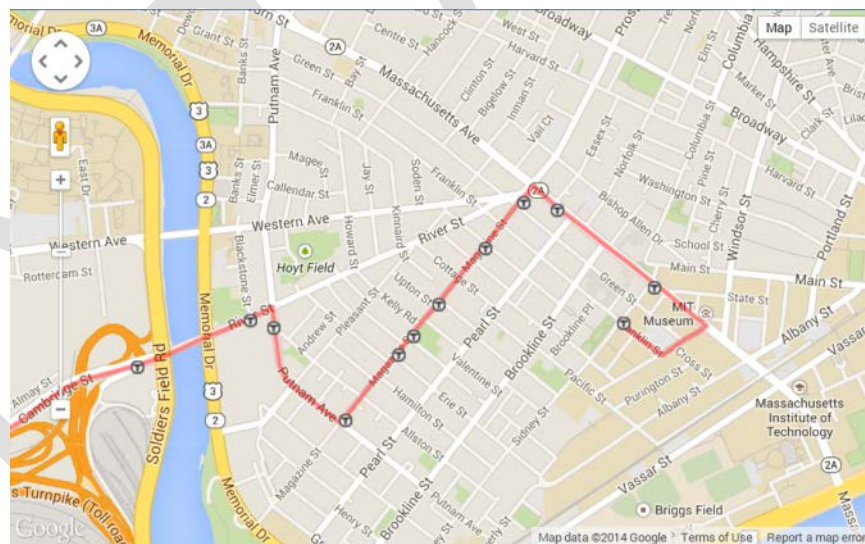
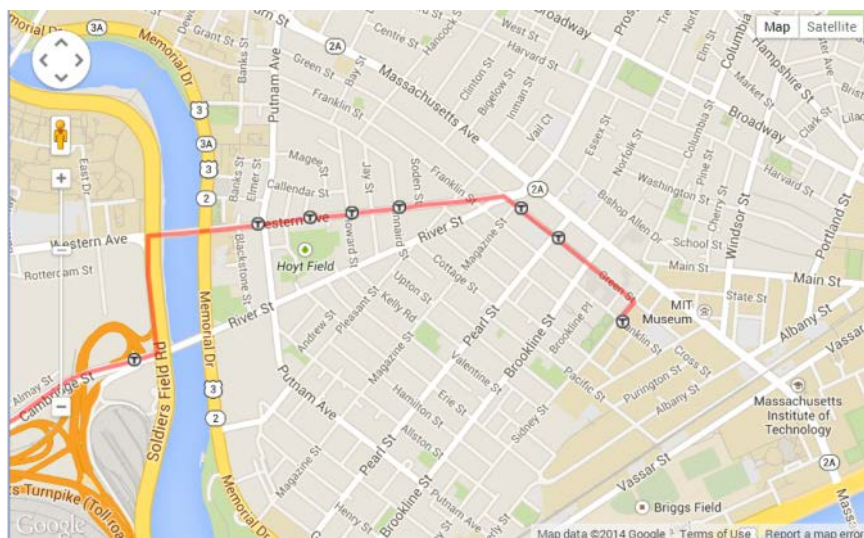
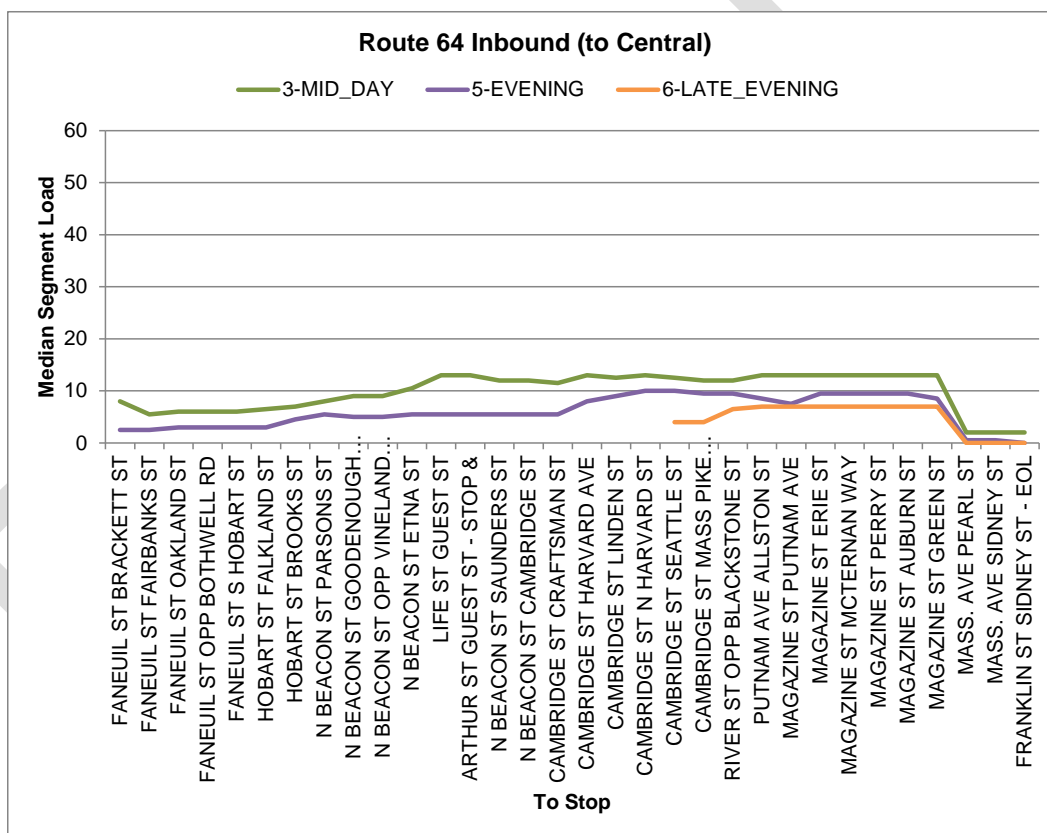
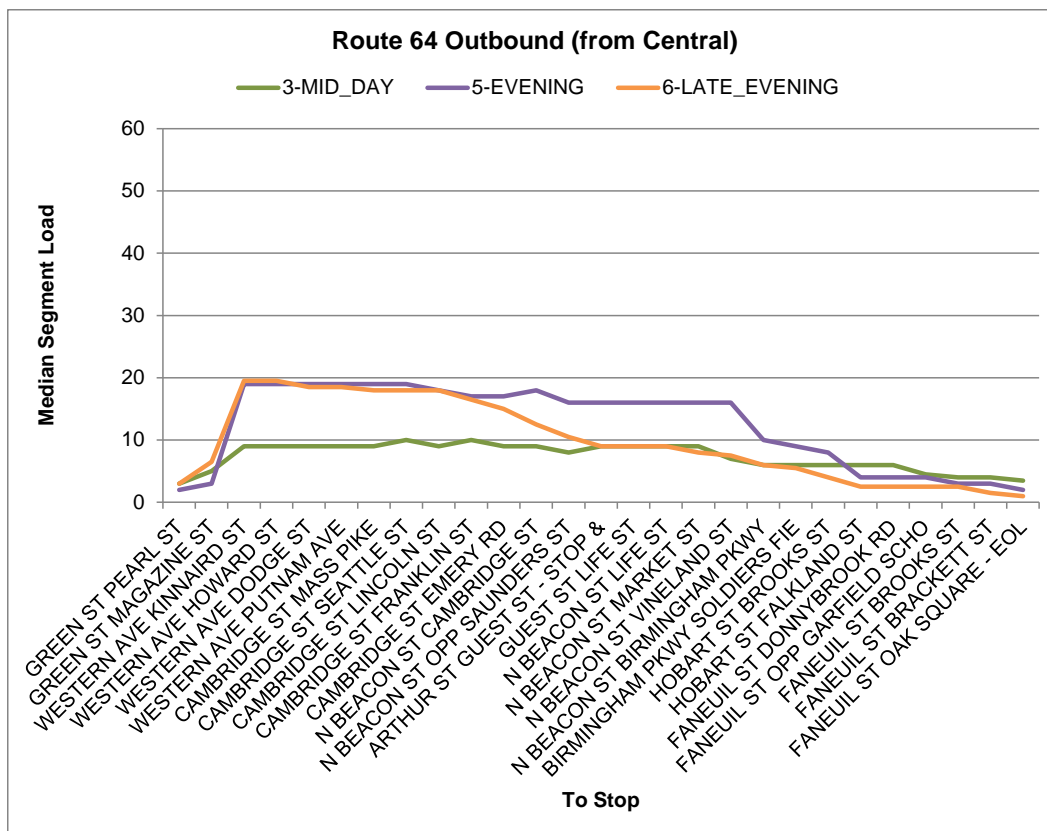


Figure 16: Route 64 Outbound (From Central) in Off-Peak Periods



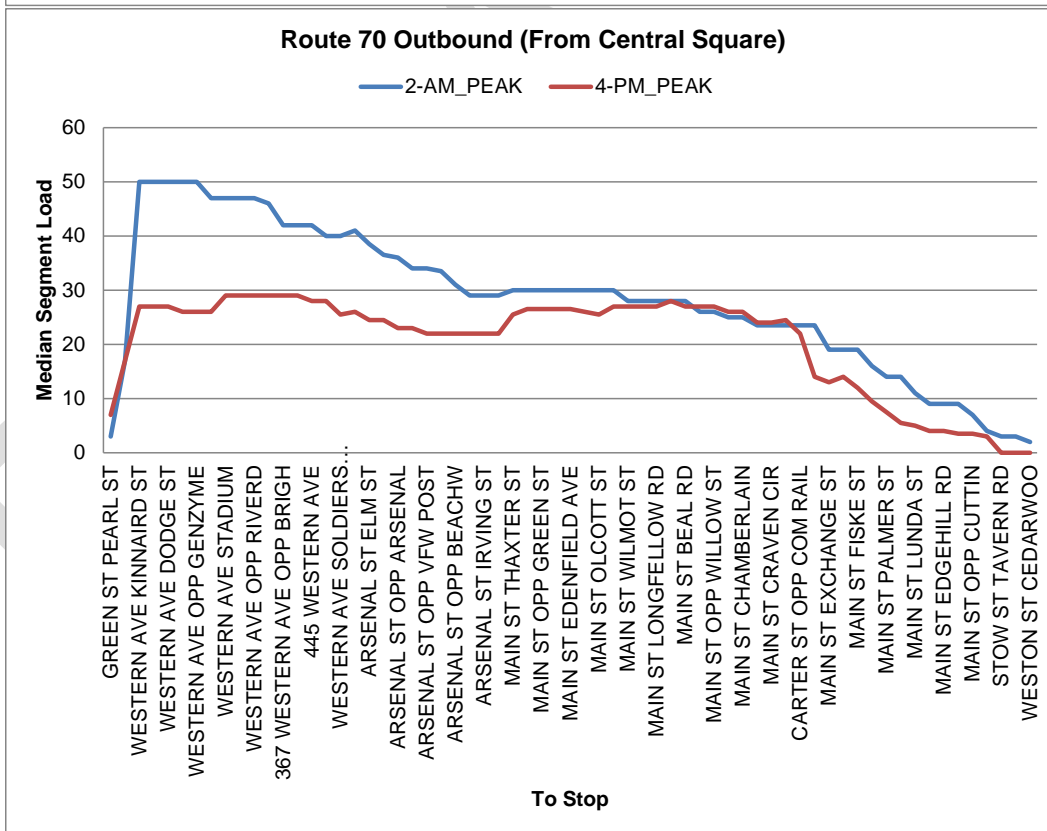
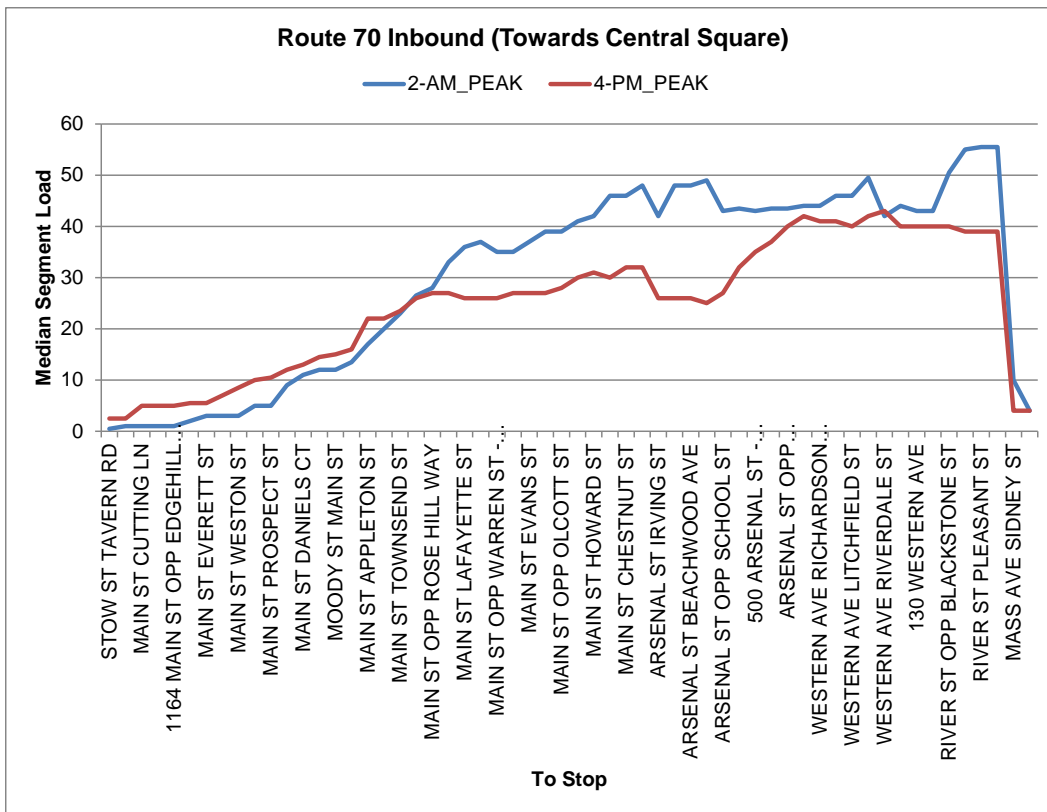
The load profiles show that there are far fewer passengers using this route variant. The highest loads are seen in the outbound direction with most people getting on at Green St at Magazine St at then steadily alighting at stops in Allston/Brighton.





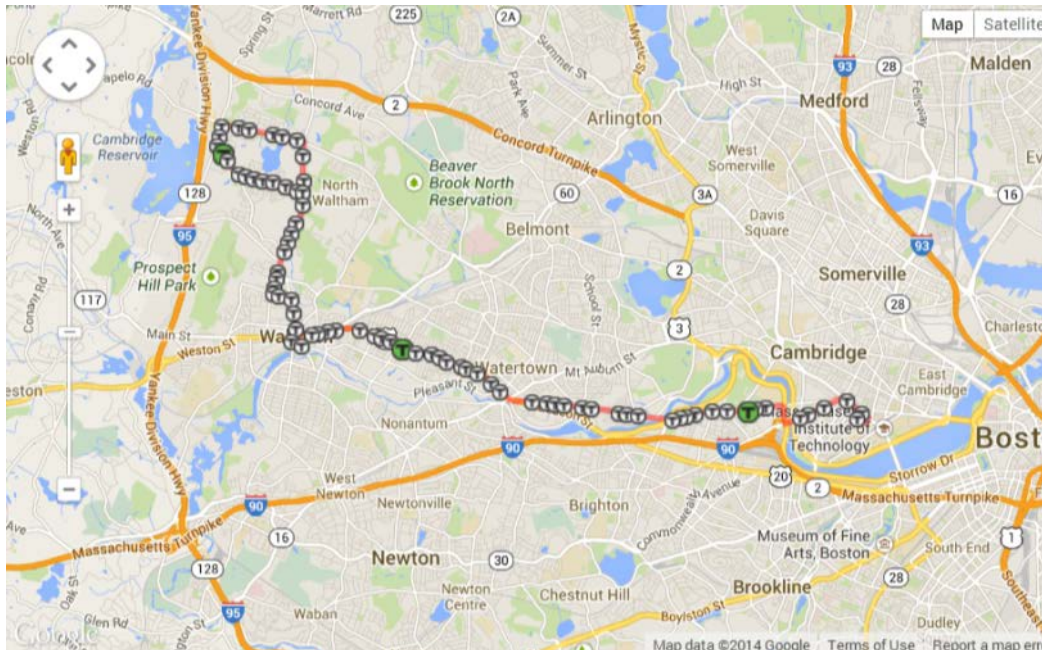
4.4.2 Route 70

The most frequent variant of Route 70 operates between Weston St at Cedarwood Ave in Waltham to Franklin St at Sidney St in Central Square. In the inbound direction the load profiles below show that most passengers are boarding steadily through Waltham and Watertown with steady loads once the route reaches Western Ave in Boston. There is a large drop in load at Massachusetts Ave and Pearl St. which is the stop closest to Central Square subway station. In the outbound direction, especially in the AM peak most passengers are boarding at the Green St at Magazine St stop, which from site visits also showed large numbers of crowding. There is a steady decline in loads until the Waltham commuter rail station.

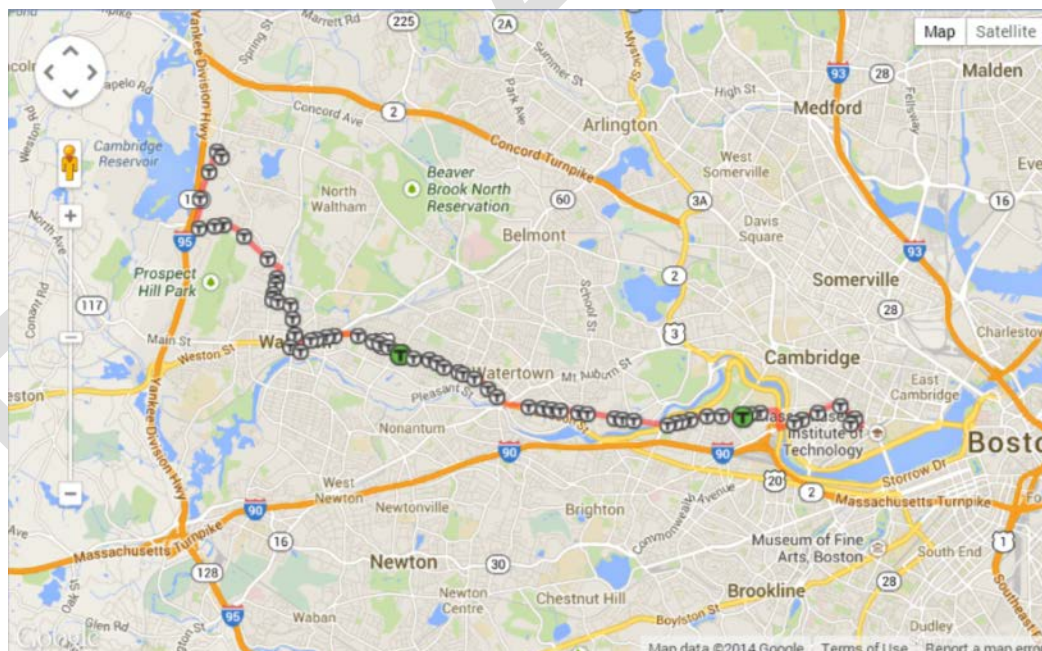


4.4.3 Route 70A

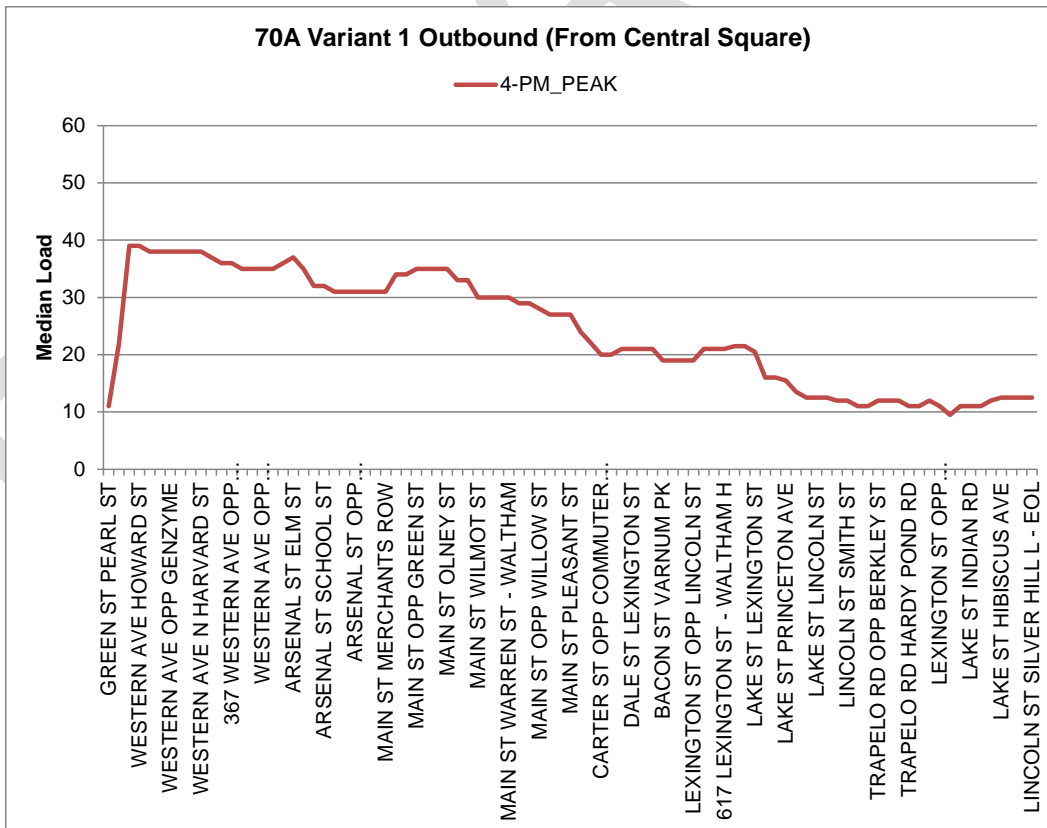
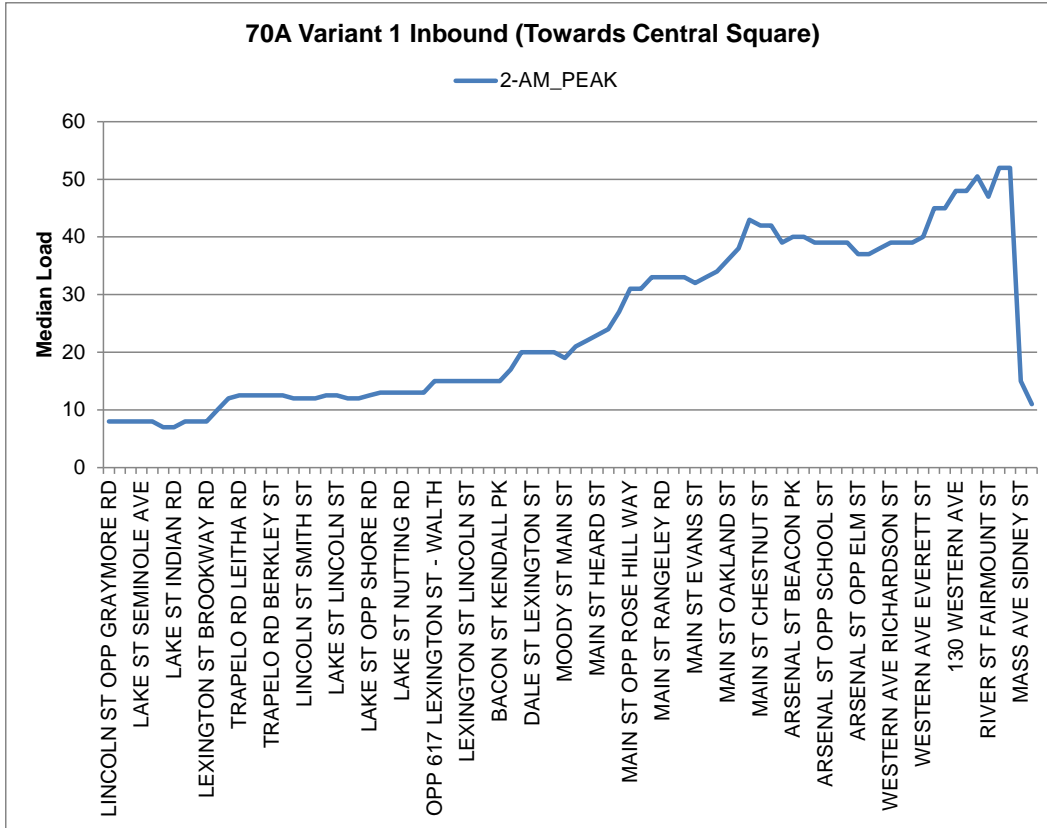
Route 70A operates between Cedarwood and North Waltham or Watertown Square and Central Square with different variants based on the time of day. All 70A variants analyzed operate to and from the stop at Franklin St at Sidney St. Route 70A Variant 1 operates via the route shown below.

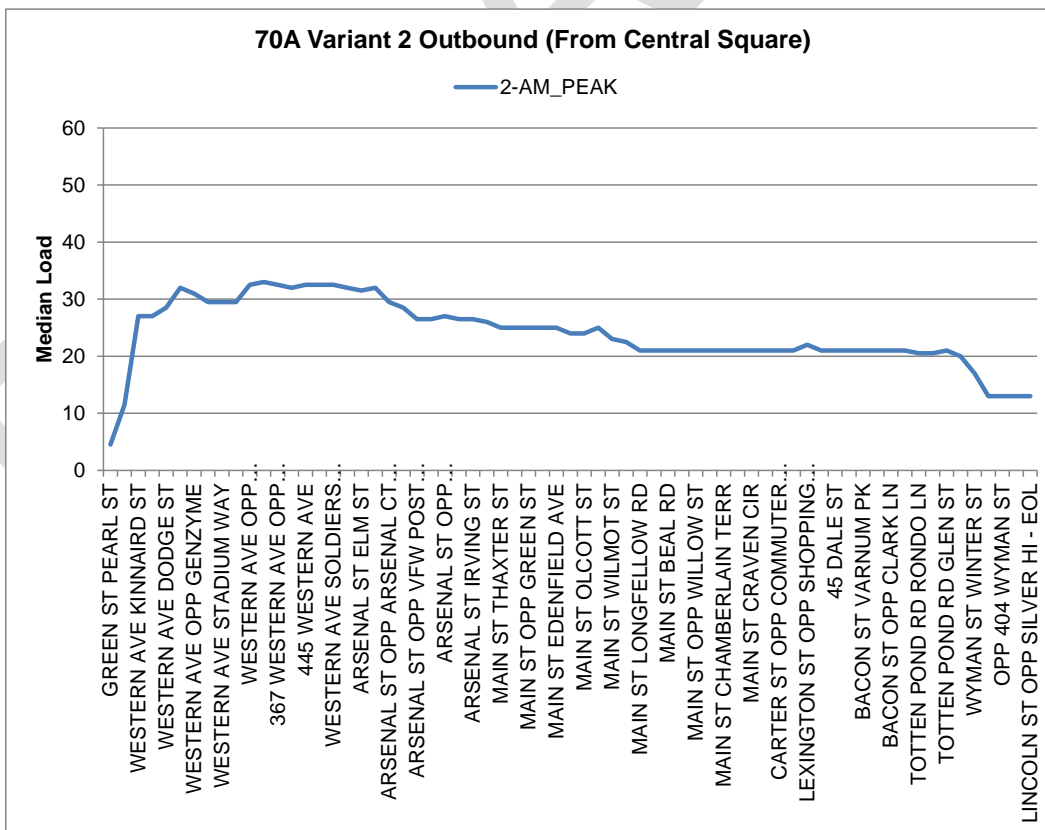
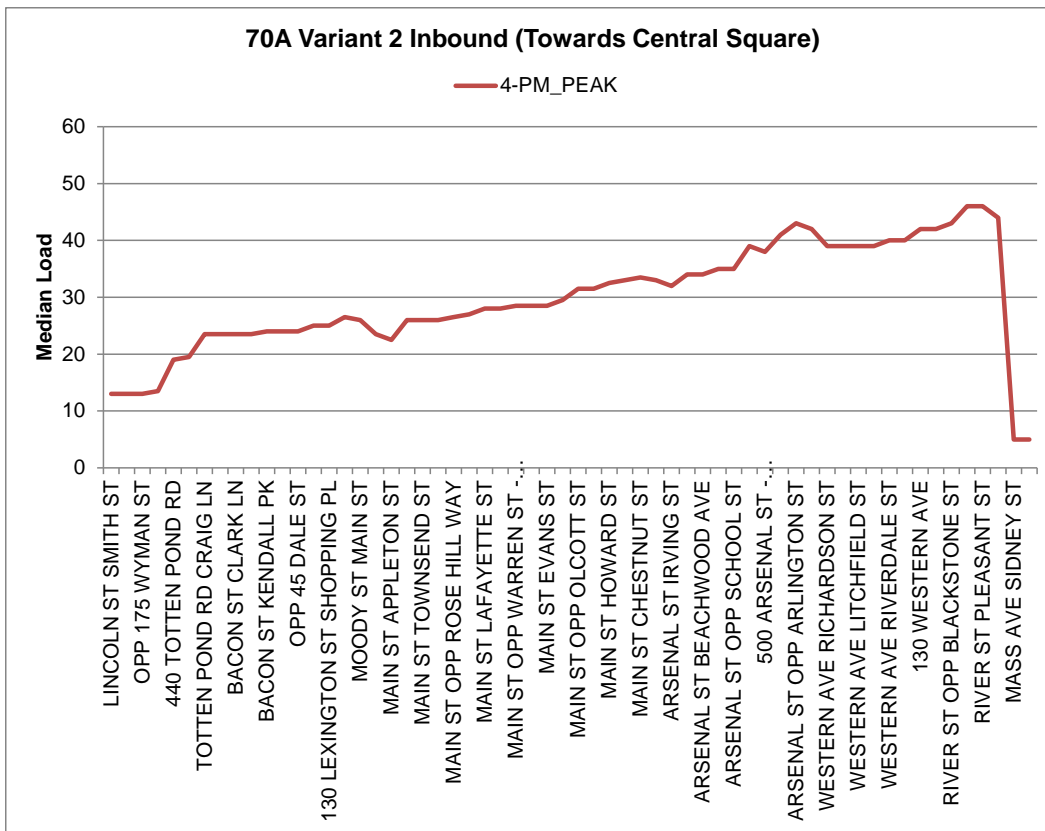


Route 70A Variant 2 operates via the route shown below.



The load profiles for the two variants are shown in the figures below. They have similar load profiles to Route 70.





4.5 Potential for Crowding at Stops in the Study Area

APC data were used to estimate the number of passengers boarding and alighting at the two stops at Green and Magazine streets. If the stop is not an origin or destination point of the route, this was done by taking the load at the segment after the stop minus the load of the segment before the stop. For these routes, Route 64, 70, 70A, the boarding and alighting estimates are not exact because passengers are both boarding and alighting at the stop and only the net result is known. For stops where many more passengers board than alight, the load of the following segment will be much higher than the load of the previous segment. Therefore this is a conservative estimate of the number of passengers that boarded the stop. If there is not much difference between the load of the following segment vs. the load of the previous segment, it could be that no one got on or off, or the same number of people got on and off. However, the routes where the stop is not the origin or destination, 64, 70, and 70A, the stop of interest is very close to the start/end of the route and the boarding/alighting estimates at this stop should be good estimates.

If the route terminated at the stop (Route 47 Outbound, 83 Inbound, 91 Inbound, and CT1 Inbound) the load of the last segment was used. This is a good estimate of the number of passengers that alighted at this stop because passengers are not allowed to board at the last stop. If the route originated at the stop (Route 83 Outbound, 91 Outbound, and CT1 Outbound), the load of the first segment was used.

This analysis found that the Green St at Magazine St bus stop is likely crowded throughout the day. Further details are in Sections 4.5.1-4.5.3.

4.5.1 Green St at Magazine St

The stop on Green St. at Magazine St. serves routes, 47, 64, 70, and 70A.

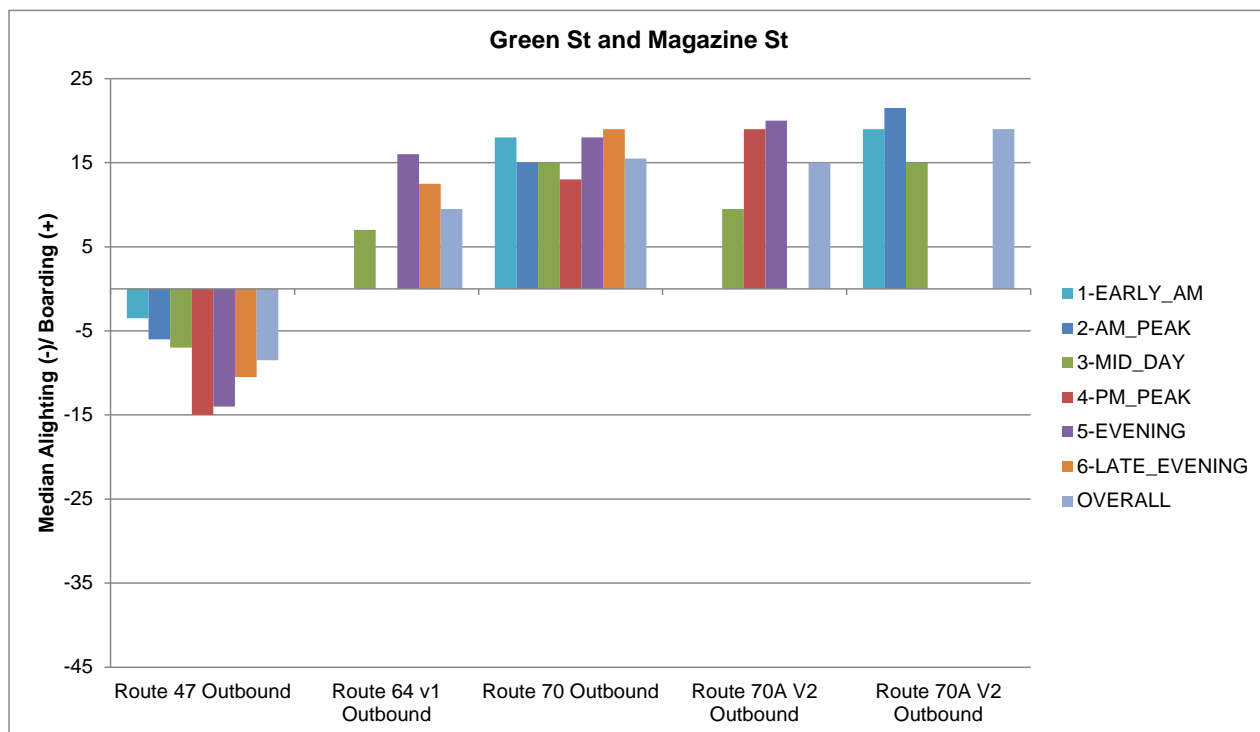
This stop is the last stop for Route 47 in the Outbound direction (towards Central Square).

This stop is also served by the variant of Route 64 that starts in Central Square in the outbound direction in the off-peak. This is the 3rd stop of this route variant. This route originates at Franklin St at Sidney St. then stops at Green St at Pearl St., then stops at Green St at Magazine St before carrying on with the rest of the route.

Routes 70 and 70A use this stop in the Outbound direction. This is the 3rd stop for these routes. These routes originate at Franklin St at Sidney St, then stop at Green St at Pearl St, then stop at Green St at Magazine St, before carrying on with the rest of the route.

This figure shows that this stop is an alighting location for Route 47, with the most passengers alighting during the PM peak. This stop is a boarding location for the other routes. Boardings at this stop for Route 70 are relatively similar at all times of the day, and for Route 64 in off-peak times and 70A at peak times, showing that the stop is likely crowded at all times of the day.

Figure 17: Bus Median Alightings/Boardings



4.5.2 Magazine St at Green St. Berth 1

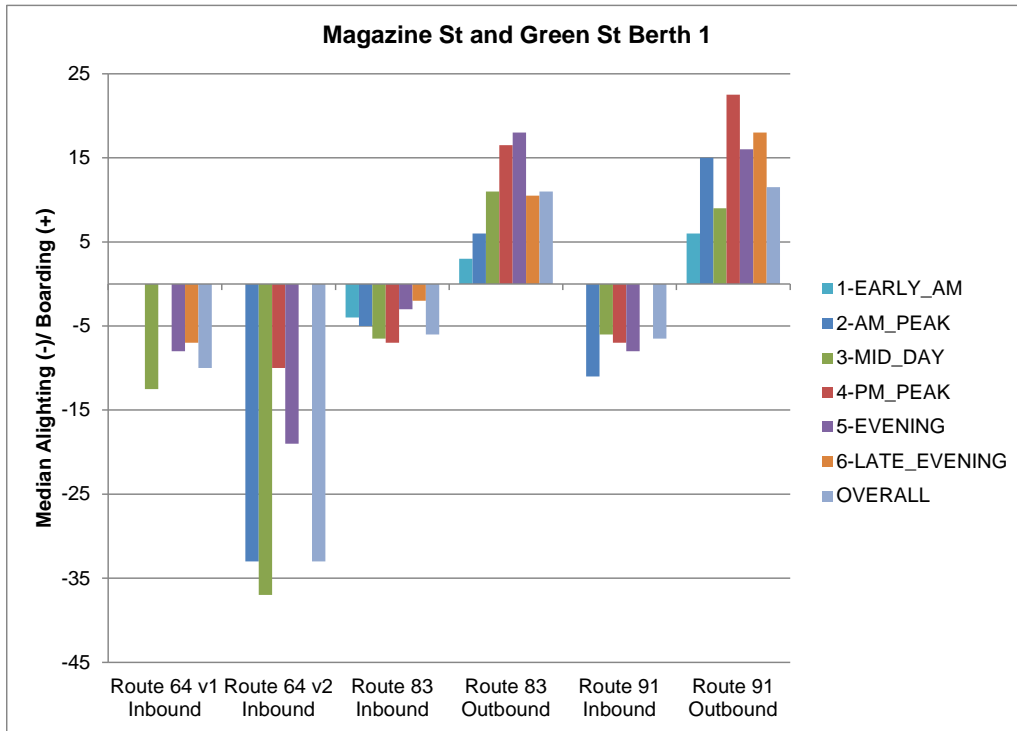
The stop on Magazine St. at Green St. berth 1 serves Route 64, 83, and 91.

There are two variants of Route 64 that serve this stop in the Inbound direction. Variant 1 is in the off-peak inbound to Central and variant 2 is in the peak times inbound to Kendall). This stop is the 3rd to last stop for variant 1 (followed by Massachusetts Ave. and Pearl St., then Massachusetts Ave. and Sidney St., and terminating at Franklin St at Sidney St.) This stop is the 10th to last stop for variant 2 that terminates at Kendall Square. Note: there are very few data points for Route 64 v2 (3 data points for AM peak, 2 data points for Midday, and 1 data point each for PM peak and Evening).

Trips for the Inbound direction for Routes 83 and 91 terminate at this stop and trips in the Outbound direction for these routes originate at this stop.

This stop is a boarding location for Routes 83 and 91 in the Outbound direction. These are highest in the PM peak and evening for Route 83, and the peaks, evening, and late evening for Route 91. This is an alighting stop for Routes 64, 83, and 91 in the Inbound direction. Alightings are highest for Route 64 for the variant to Kendall Square in the AM peak and Midday.

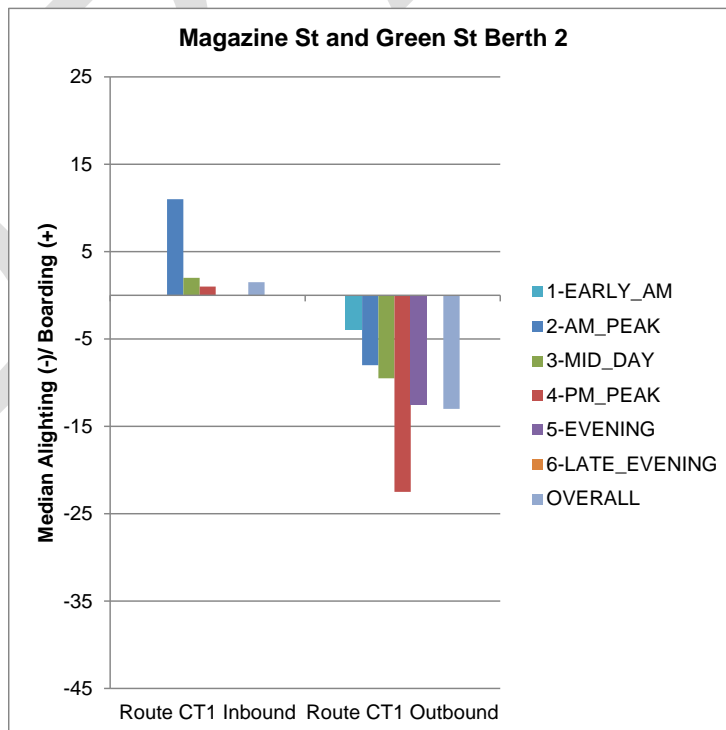
Figure 18:



4.5.3 Magazine St at Green St. Berth 2

The stop on Magazine St. at Green St. Berth 2 only serves Route CT1. The Outbound direction terminates at this stop and the Inbound direction originates at this stop. This stop has the largest number of passengers alighting in the PM peak.

Figure 19:



5 Field Observation Summary

The IBI Group team, with representatives from the City of Cambridge, and the MBTA, conducted a field survey of Central Square on August 5, 2014. The field survey included a visit to the various bus stops within the Study Area and discussions with MBTA staff regarding their observations and major concerns for their operations within the Study Area. In addition, IBI Group attended a second visit to the Study Area with the Transit Committee on August 13, 2014. This section presents a summary of the important observations from those site visits. Section 4.1 presents the bus routing related observations, Section 4.2 presents bus stop and layover related observations, and Section 4.3 presents signage and wayfinding related observations.

5.1 Bus Routing

During the site visit, it was observed that some buses do not follow the MBTA-established routing from Green St to Magazine St. When the layover bay at Magazine St at Green St Berth 2 island is not occupied by the CT1, rather than turning at the signalized intersection of River St at Green St, some buses turn towards Central Square via the bus layover bay at Magazine St at Green St Berth 2 (Figure 20). Additionally, some buses are routed to drive around the First Baptist Church by taking a left on Western Ave, a left on Franklin St, and a right on Magazine St, but instead turn directly from Green St towards Central Square via the second bus layover bay. This saves them time but is hazardous because it was not designed for this purpose and is an extremely tight turn.

Figure 20: Route 47 bus ad-hoc routing via the Magazine St at Green St Berth 2 bus layover bay



As per MBTA and City of Cambridge staff, because the pedestrian crossing at Mass Ave and Pearl St is unsignalized, during periods of peak pedestrian traffic this can cause delays for the buses (Rt. 47 and Rt. CT1) and other vehicles that turn from Mass Ave onto Pearl St, and other vehicles behind them. The turning is particularly tough for vehicles and bus routes turning left from Massachusetts Ave (Rt. CT1). This turning is the source of multiple pedestrian and motor vehicle conflicts.

The location of the taxi stands on Mass Ave between Pearl St and Essex St can also cause conflicts with buses, bicycles, and cars traveling along Mass Ave.

It was also noted that the use of different stops for Route 64 by time of day (Figure 21) may create confusion among passengers.

Figure 21: Route 64 signage for routing change by time of day



5.2 Bus Stops and Layover Locations

The main bus stops along Mass Ave near Central Square are very imbalanced. The stop at Mass Ave and Prospect St only serves buses on one route (Rt. 1), while the stop at Mass Ave and Pearl St serves buses from up to six routes (Rts.1, 47, 64, 70, 70A, CT1).

The length of the bus layover spot at Magazine St at Green St Berth 1 is not sufficient to accommodate one bus each from both designated routes for this stop, 83 and 91. As shown in Figure 22, when two buses layover at the same time, the rear of the second bus in the queue blocks both the pedestrian crossing as well as a part of Green St. This hinders the movement of pedestrians and vehicles coming from Green St.

Figure 22: Bus layover at Magazine St at Green St Berth 1



Bus drivers, however, report that they like the layover location at Magazine St at Green St due to the location of the convenience/grocery store and restrooms.

Bus drivers are also reported to like the location at Franklin St at Sidney St for bus layovers, particularly due to the ease of using restrooms. MBTA staff noted that this location is also preferable for making layovers because it can accommodate multiple buses.

It was also observed that the loading zone on Mass Ave (Eastbound) near River St is quite often occupied by illegally parked vehicles (Figure 23). On occasion, some buses (typically Route 47) also layover at this location.

Figure 23: Illegally occupied loading zone on Mass Ave (Eastbound) near River St



5.3 Signage and Wayfinding

For Route 70/70A, the bus stop at Green St at Magazine St is not very wide and can easily get overcrowded. When this happens, the pedestrian movement gets restricted. This problem is further compounded by the placement and design of the pedestrian shelter, which can act as a barrier to pedestrian movement. Figure 24 illustrates this problem during a Route 70 weekday peak boarding scenario. The placement of the trash bin in close proximity to the shelter further hinders movement along the sidewalk.

Figure 24: Bus Shelter for Routes 70/70A at Green St at Magazine St



During the site visits, it was noted that the existing signage for buses could not be easily viewed by passengers. This was due to the placement of the signage and the associated sightlines. Particularly in the case of routes 64, 70/70A, 83, and 91, there is no signage directing passengers coming from Central Square toward the location of bus stops. While moving from Massachusetts Ave along Magazine St, passengers are required to negotiate through a series of signs to find their relevant route. The signs are also facing away from Central Square and are attached to different poles at a significant height, and often right next to the bus shelters, increasing the level of difficulty in negotiating through them. Figure 25 shows the signage for Routes 64, 83, and 91 while Figure 26 shows signage for Route CT1.

Figure 25: Signage for Routes 64, 83, 91 at Magazine St at Green St Berth 1



Figure 26: Signage for Route CT1 at Magazine St at Green St Berth 2



As can be seen, some of the route signs are not easily viewed by passengers. In addition, there is no wayfinding from Central Square to the bus routes near Central Square. Better wayfinding information could be provided near the bus shelters and within the Red Line station.

The bus information provided at some of the bus shelters and bus stops is not always location-specific. As shown in Figure 27, the schedules for routes 64, 83, 91, and CT1 are provided in the bus shelter at the Green St at Magazine St, despite the fact that this stop specifically caters to routes 70 and 70A.

Figure 27: Schedules at Green St at Magazine St shelter

The image shows a bus shelter with four schedule boards. The boards are for routes 64, 83, 91, and CT1. Each board lists arrival and departure times for various days of the week. The boards are arranged in a grid-like fashion. The top row shows route 64 (Weekday and Saturday) and route 91 (Weekday and Saturday). The bottom row shows route 83 (Weekday and Saturday) and route CT1 (Weekday Inbound). The boards are printed on a light-colored background with black text. The text is organized into columns and rows, with headers indicating the route and day. The boards are slightly tilted and appear to be part of a larger display.

It was also observed that there is no signage within the Central Square Red Line Station directing passengers to different bus routes. Some of the station maps within the subway are also on wrong platform. For example, the inbound map is on the outbound side, and vice versa.

6 Next Steps

As the next step in this project, IBI Group will review and refine the list of issues identified by Cambridge staff in the RFP. This list of issues will be refined on the basis of the 2013 K2C2 Central Square Final Report and the information developed as part of Task 1. Task 2 will result in the compilation of a final list of issues to consider while developing ideas for improving bus circulation and access in Central Square. In Task 3 IBI Group will develop a list of potential ideas to improve bus access and circulation, culminating in a report including conceptual cost estimates as the result of Task 4.

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