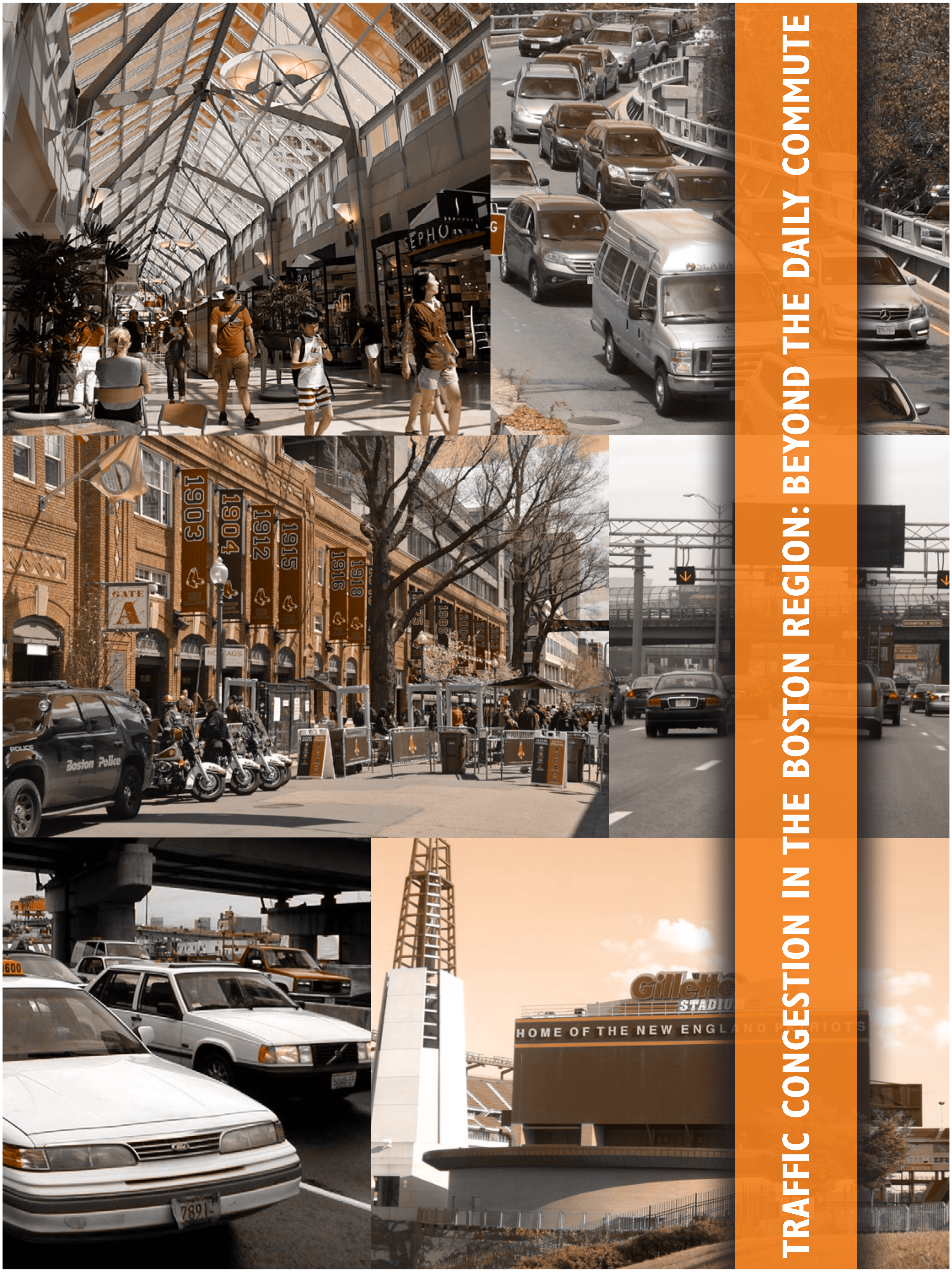
TRAFFIC CONGESTION IN THE BOSTON REGION: BEYOND THE DAILY COMMUTE



Traffic Congestion in the Boston Region

Beyond the Daily Commute

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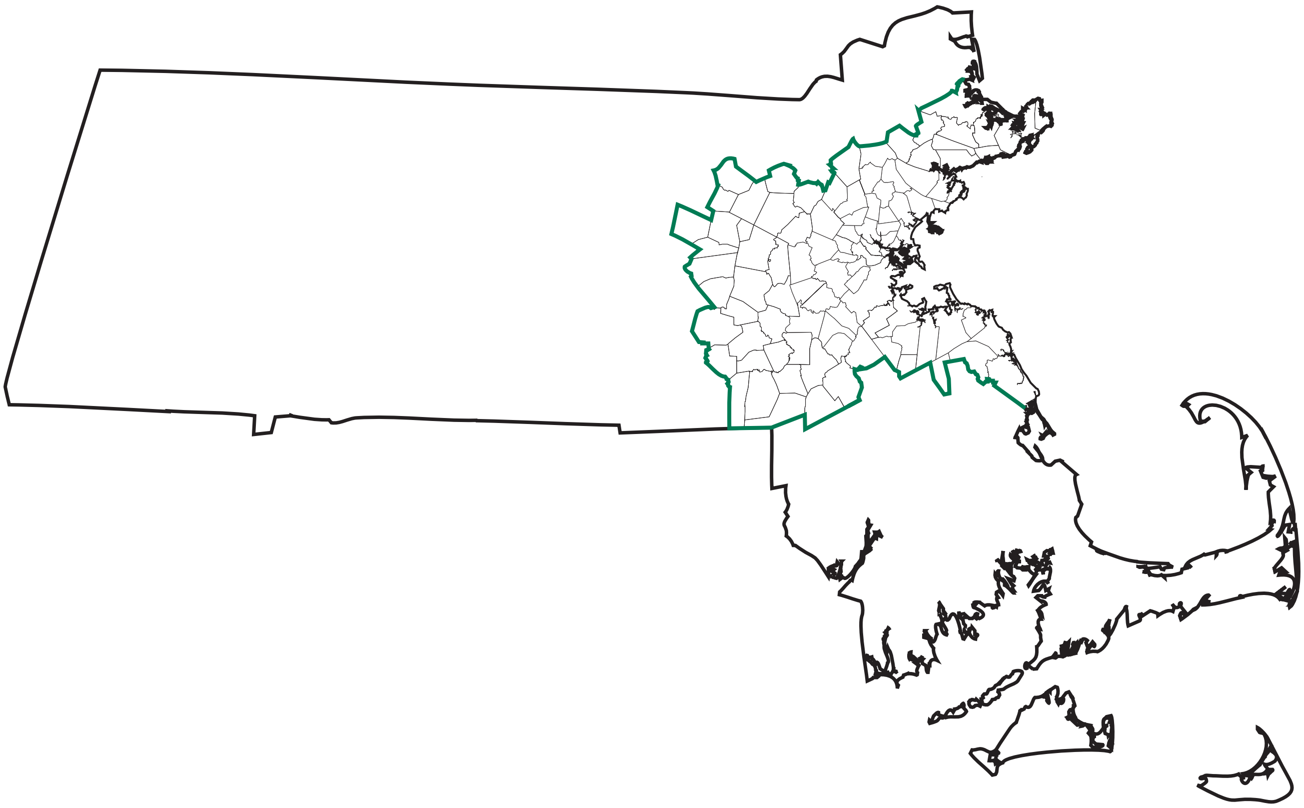

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Abstract

Traffic conditions in the Boston region are monitored through the Boston Region Metropolitan Planning Organization's Congestion Management Process (CMP). The purpose of the CMP is to identify locations where congestion occurs and the factors that contribute to it, and to develop strategies to alleviate the congestion. While most of the CMP's traffic monitoring focuses on congestion caused by the recurring travel of the daily commutes residents in the region take to and from work in the morning and afternoon and evening peak travel periods, this study examined incidents when congested roadway conditions developed during times other than the traditional commuting hours or because of traveling associated with special events or holidays.

Seven case studies are included in this report detailing roadway congestion levels, times when congestion occurred, and specific roadway locations where congestion was the worst. The report discusses strategies that could be implemented in the future to address congestion when similar events occur. When events affected roadways on which MBTA buses operate, bus on-time performance was evaluated.

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Executive Summary

On a typical weekday in the Boston region, many residents who commute to their jobs by car find themselves in congested roadway conditions along with their fellow commuters who drive the same route each day at approximately the same time. This type of travel is referred to as *recurring travel*, as it occurs regularly at the same time and location day after day during the peak travel times. Roadway congestion caused by recurring travel is monitored by the Boston Region Metropolitan Planning Organization (MPO) through the Congestion Management Process (CMP).

Until recently, the CMP did not focus on incidents when congested roadway conditions developed during times other than the traditional commuting hours or because of traveling associated with special events or holidays. Now, with the availability of *big data*—which comprises large datasets that contain information that can be queried and analyzed relatively quickly—it is possible for the MPO to monitor and analyze traffic conditions that develop during off-peak travel times, weekends, holidays, and times leading up to special events and activities.

This report describes the results of seven case studies that examined incidents when congestion occurred in the Boston region during times other than typical commuting hours or during special events. The topics of the case studies are as follows:

- New England Patriots regular season games held at 1:00 PM on Sundays
- Red Sox weekday games held at 7:00 PM
- Saturdays
- New England Patriots' Super Bowl parade
- Wednesday before Thanksgiving
- Fridays
- Black Friday

The case studies examined roadway congestion levels, identified the times when the congestion occurred and specific roadway locations where congestion was the worst, and prioritized strategies that could be implemented to relieve the congestion from similar events or occurrences in the future. When events affected roadways on which Massachusetts Bay Transportation Authority (MBTA) buses operate, bus on-time performance was evaluated. The report also discusses the data sources and performance measures that were used to measure and evaluate the congestion.

Chapter 1—Congestion in the Boston Region

On a typical weekday in the Boston region, many residents who commute to their jobs by car find themselves in congested roadway conditions along with their fellow commuters who drive the same route each day at approximately the same time. This type of travel is referred to as *recurring travel*, as it occurs regularly at the same time and location day after day during the peak travel times. Roadway congestion caused by recurring travel is monitored by the Boston Region Metropolitan Planning Organization (MPO) through the Congestion Management Process (CMP).

Until recently, the CMP did not focus on incidents when congested roadway conditions developed during times other than the traditional commuting hours or because of traveling associated with special events or holidays. Now, with the availability of *big data*—which comprises large datasets that contain information that can be queried and analyzed relatively quickly—it is possible for the MPO to monitor and analyze traffic conditions that develop during off-peak travel times, weekends, holidays, and times leading up to special events and activities.

The purpose of this study was to identify locations in the Boston region where *nonrecurring travel* results in roadway congestion and determine strategies that could be employed to alleviate congestion when similar events occur in the future. The first sections of this report identify the methodology and the process of measuring congestion in the region, and the latter sections focus on seven case studies that examined incidents when congestion occurred in the Boston region either during times other than typical commuting hours or during special events. The topics of the case studies are as follows:

- New England Patriots regular season games held at 1:00 PM on Sundays
- Red Sox weekday games held at 7:00 PM
- Saturdays
- New England Patriots' Super Bowl parade
- Wednesday before Thanksgiving
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The case studies examined roadway congestion levels, identified the times when the congestion occurred and specific roadway locations where congestion was the worst, and prioritized strategies that could be implemented to relieve the congestion from similar events or occurrences in the future. When events affected roadways on which Massachusetts Bay Transportation Authority (MBTA) buses operate, bus on-time performance was evaluated. The report also discusses the data sources and performance measures that were used to measure and evaluate the congestion.

Chapter 2—Selection and Analysis of Available Data Sources

This section summarizes the results of a comparison of data sources that were available for use in this study to measure roadway congestion. Datasets from INRIX and Bing Maps, and the National Performance Management Research Data Set (NPMRDS) were compared. The focus area for this study included the 97 municipalities in Boston Region MPO's planning area. (Some corridors monitored were in the 163-municipality area covered by the Boston Region MPO's regional travel demand model.)

2.1 DATA SELECTION

One of the CMP's primary goals is to conduct performance monitoring for the regions roadways and transit system, as well as for safety (as measured by roadway crashes). The CMP employs performance measures, which are statistical indicators used to monitor system performance or track progress toward a goal, to conduct performance monitoring of the region's highways and identify congested locations on the region's highways.

In order to complete performance monitoring in 2013, the Boston Region MPO purchased a roadway monitoring dataset from INRIX (the 2012 dataset). The MPO staff used the dataset to produce two interactive dashboards and the Needs Assessment for the Long-Range Transportation Plan (LRTP), *Charting Progress to 2040*. The MPO was satisfied with the accuracy, coverage area, and overall usefulness of the dataset and decided to purchase a second dataset from INRIX (the 2015 dataset) in 2016. In addition, the MPO staff discovered other data sources that are also useful for roadway monitoring: the NPMRDS and the Bing Maps dataset.

At the outset of this study, it was important to determine the best datasets to use for each of the MPO's congestion monitoring activities. The MPO staff initially compared the INRIX, NPMRDS, and Massachusetts Department of Transportation's (MassDOT's) Real Time Traffic Management (RTTM) datasets and documented the results in a memorandum titled "Massachusetts Department of Transportation and National Performance Management Research Dataset Roadway—Monitoring Dataset Analysis" and dated December 2015. (MassDOT's RTTM dataset is now referred to as Go-Time.) Since the publication of that memorandum, the Boston Region MPO purchased the new 2015 INRIX dataset, the NPMRDS data provider changed from HERE to INRIX, and MPO staff discovered a new way to mine roadway travel-time data from online Bing Maps using application programming interface (API) calls.

In addition to these highway-specific datasets, additional datasets were used to analyze transit (bus on-time) performance and roadway safety (vehicle crashes per day) during events of interest.

2.2 DATASET RECOMMENDATIONS

A test was done to determine how well the datasets available to the Boston Region MPO gauge nonrecurring congestion. The test revealed that the INRIX dataset was able to show typical congestion patterns before, during, and after a New England Patriots game. The Bing Maps data was not able to accurately reflect the congestion patterns during those same time periods. Therefore, MPO staff recommended using INRIX data to measure nonrecurring congestion.

If INRIX data were not available for the analysis of an event of interest (if, for example, the INRIX dataset for the year of the event had not been purchased), then the MPO staff recommended using the NPMRDS. The MPO staff determined that the Bing Maps data should be used as a last resort, as this dataset has been evaluated the least. Also, it remains to be seen if the dataset is accurate on a basis of one-day samples, which were required for the evaluations in some of the case studies described in this report.

The MPO staff recommended using the NPMRDS freight dataset to analyze freight traffic only on expressways, as there were not enough samples from arterials. The freight dataset is incomplete, but it is the only dataset available that monitors freight traffic on the region’s roadways.

The MPO staff recommended using the MBTA’s Back on Track dataset to monitor bus on-time performance during nonrecurring events. This dataset was the most readily available dataset that tracks occurrences of bus delay. However, the MBTA’s Back on Track dataset was only available from 2016 to the present, so assumptions were made for certain case studies.

The MPO staff recommended using MassDOT’s crash database to analyze roadway safety conditions during nonrecurring events. At the time this study was done, crash records for the years prior to 2016 were available.

Chapter 3—Performance Measures

To monitor congested conditions resulting from nonrecurring events, the MPO staff relies on performance measures. Performance measures are statistical indicators that are used to monitor system performance or track progress toward a goal. The performance measures used in this study utilized transportation data to gauge nonrecurring congestion at specific locations. Highway, safety, and transit performance measures were used in this study. All performance measures—except those for *corridor/segment delay, bottleneck factor, planning time failure, minutes of planning time failure,* and *number of crashes during the day*—have previously been used in the Boston Region MPO's CMP. Previous analyses are available on the MPO's website.[1][2]

3.1 HIGHWAY PERFORMANCE MEASURES

For the purpose of this report, the term "highway" refers to any roadway that is located on the CMP network, including both arterials and expressways. Arterials are full access roadways that are often equipped with signals at intersections. Expressways are limited access roadways that typically do not have signals. Generally, arterials are for local travel, while expressways are for regional, statewide, and interstate travel. The performance measures listed below can monitor the duration, extent, intensity, and variability of congestion.

3.1.1 Congested Time

Congested Time is the average number of minutes that drivers experience congested conditions during a specific time period. By the Boston MPO's CMP standards, roadways are considered congested when vehicle speeds are below 35 miles per hour (MPH) on expressways or below 19 MPH on arterials. Congested time is measured in minutes per hour of analysis.

3.1.2 Average Travel Speed

Average Travel Speed associated with a specific roadway is calculated using travel times and road segment lengths. The average observed travel speed is a good indicator of congestion in the roadway network and can highlight the need

[1] Boston Region MPO website, "Express Highway Performance Dashboard," accessed on September 24, 2018, available online at https://www.ctps.org/maploc/www/apps/express_dashboard_2015_Final/index.html.

[2] Boston Region MPO website, "Arterial Performance Dashboard," accessed on September 24, 2018, available online at https://www.ctps.org/maploc/www/apps/arterial_dashboard_2015_Final/index.html.

to identify solutions to mobility problems. Average travel speed is also a factor in calculating other metrics, such as travel time.

3.1.3 Corridor/Segment Delay

Delay is the extra time required to travel through a roadway segment or corridor during the time of the event compared to the time required during optimum conditions. Delay is calculated as the travel time during the period monitored minus travel time during free-flow conditions. This measure is effective for assessing travel time between two landmarks along a roadway or roadway corridor.

3.1.4 Bottleneck Factor

The *Bottleneck Factor* is the intensity of congestion—the average speed in the Traffic Messaging Channel (TMC) location—plus the duration of time that a TMC location is congested (congested time).[3] This measure can be used to rank problem areas in the roadway network. The bottleneck factor is on an unlimited scale from zero, with zero indicating no congestion and severe congestion indicated by a value greater than one.

3.1.5 Travel Time Index

The *Travel Time Index* compares travel conditions during the peak period to travel conditions during free-flow periods. This measure is the ratio of peak-period time to free-flow time, and it indicates the severity of peak-period congestion on a roadway. Travel time index always has a value of at least 1.00, and a higher number indicates more congestion. For example, at a location that has a travel time index of more than 2.00, a vehicle will take twice as long to travel on that roadway during the monitoring time than during off-peak times.

3.1.6 Planning Time Failure Index

The *Planning Time Failure Index* applies to instances in which the travel time during an event is longer than the amount of time that a traveler should budget for travel on a typical weekday, as measured by the *planning time index*.[4] This performance measure shows where there is an extreme spike in congestion at a

[3] The Traffic Messaging Channel (TMC) location code is a common industry convention developed and maintained by the leading electronic map database vendors to uniquely define road segments. For expressways, a TMC location is defined as the segment between two interchanges. Oftentimes, the TMC segment definition varies for arterial roadways.

[4] The planning time index compares near-worst-case travel time to free-flow travel time to determine the contingency time needed to ensure on-time arrival 95 percent of the time. For example, a value of 2.5 means that to arrive on time 95 percent of the time, a traveler should budget an additional 45 minutes for a trip that takes 30 minutes during free-flow conditions.

certain time and location. At locations that have a planning time failure index of more than 1.00, the travel time for vehicles during an event will be higher than the time indicated in the planning time index.

3.1.7 Minutes of Planning Time Failure

The performance measure for *Minutes of Planning Time Failure* shows the duration of time that the travel time during an event is longer than the planning time index travel time for a typical weekday.

3.2 SAFETY PERFORMANCE MEASURE

In this study, safety performance measures were used to analyze the location and frequency of crashes during the time of interest, and to compare the number of crashes to those of a typical day. MassDOT's crash database was the source of data for the safety analyses.

3.2.1 Number of Crashes during the Day of Event

This performance measure compares the number of crashes that occurred during the day of the event to the number of crashes that occurred during a typical day during the same year to determine if the crash rate increased during the event. This performance measure may consider crashes that occurred during a typical weekday or weekend day, or a specific day of the week (for example, a typical Thursday compared to the Thursday of the event).

3.3 TRANSIT PERFORMANCE MEASURE

In this study, transit performance measures were used to analyze the on-time performance of the MBTA bus system during specific events. The MBTA Back on Track dataset was the data source used for these evaluations.

3.3.1 On-Time Performance

On-Time Performance is reported according to the MBTA's definition of reliability. Data relating to this performance measure is available on the MBTA's Back on Track dashboard.[5] Bus service is measured at the starting point and terminus of the route and at midpoints to determine the rate of travel.

[5] For buses that have headway of 15 minutes or less, an on-time trip is defined as a trip that departs a timepoint no more than three minutes later than the scheduled time. For buses scheduled less frequently than every 15 minutes, an on-time trip is defined as a trip that departs a timepoint no more than six minutes later than the scheduled time.

3.4 FREIGHT PERFORMANCE MEASURE

In this study, one freight performance measure was used—*Level of Travel Time Reliability* (LOTTR). LOTTR is a performance measure that was developed by the Federal Highway Administration (FHWA). Freight monitoring was limited to the Black Friday case study.

3.4.1 Level of Travel Time Reliability

LOTTR is an index that shows the reliability and variability of speed on a roadway segment over a period of time. LOTTR is calculated by dividing the 80th percentile travel time by the 50th percentile travel time. Roadway segments that have LOTTR higher than 1.50 are determined to be unreliable. LOTTR can also be calculated over a regional network to determine a percentage of the roadway network that is unreliable.

Chapter 4—Methodology

4.1 SELECTION OF EVENTS FOR STUDY

At the outset of this study, the MPO staff compiled a list of events and occurrences that could be evaluated to determine the degree of congestion on roadways at those times. For each event and occurrence, affected corridors and bus routes were identified. Then staff ranked each event and occurrence based on its potential to produce congestion and considered the availability of data for conducting a congestion analysis.

Some of these events occurred once and others were recurring. Therefore, some case studies relied on data specific to the time of the events—such as the case studies on sporting events—while others relied on average statistics—such as the case studies on weekend traffic.

Initially, in addition to the subjects selected for study, the MPO staff intended to pursue several other case studies to explore congestion resulting from events such as concerts and graduations at large institutions, roadway construction, vehicular crashes, and inclement weather, however those topics were ultimately excluded because of either a lack of data or inconclusive results. For example, a case study on the Blizzard of 2015 was excluded because of a lack of vehicle probe data resulting from the statewide travel ban that went into effect during the storm. Another case study that compared dry weather days to rainy days was inconclusive because the available data did not reveal a marked difference in travel patterns.

4.2 SELECTION OF BOTTLENECKS

When the events and occurrences were identified for study, staff determined the location of the bottlenecks on the roadway network that were to be evaluated. In some cases, staff examined the entire network monitored by the Boston Region MPO's CMP. For others, only a few selected corridors located near the event were evaluated.

4.3 CONTENT OF THE CASE STUDIES

Each case study includes the following information.

Description of Event and Location

This section describes the nature and location of the event or occurrence, the duration of the traffic monitoring, the time of the day that the roadway system was affected by the event, and the roadways that were affected.

Dates

This section lists the dates during which congestion levels were analyzed. In certain cases, the dates of the analysis were different than the date that the event occurred. The reason for this is because some events alter traffic patterns on other days of the week. For example, in the case study on the Wednesday before Thanksgiving, traffic patterns were analyzed for the day before the holiday because many people travel on that day, rather than on Thanksgiving Day.

Times Monitored

This section indicates the time of day that congestion levels were monitored.

Roadways Analyzed

This section indicates the roadway corridors that were analyzed. In many instances, a regional analysis focused on the entire Boston region CMP network.

Bus Routes Analyzed

This section lists the MBTA bus routes that were analyzed. Because of the limited availability of data and the fact that some areas of interest do not have bus service, some case studies did not analyze MBTA bus routes.

Datasets Used for Analysis

This section indicates the datasets that were used in the analysis. In most cases, INRIX was used to analyze the roadway network. However, there were a few instances in which the NPMRDS or Bing Maps data were used. The MBTA's Back on Track dataset was used to monitor the MBTA's bus network, and MassDOT's crash database was used to analyze the safety of the roadway network.

Performance Measure Summary

This section discusses the performance of the roadway and/or bus networks and the safeness of the roadway network in the study area.

The results of the data analyses pertaining to roadways were compared to performance metrics. Some studies include corridor-specific analyses that examine delay during an event versus a typical peak travel period. The most congested locations in the analyzed corridors are indicated.

The case studies of events that affect the bus system report on the on-time performance of the bus system during the events as compared to the on-time performance during a typical weekday for the individual bus routes and the entire MBTA system.

The crash analyses typically show the number of crashes that occurred during an event compared to the average number of crashes that occur during a typical day at that location. In certain instances, a five-year trend from 2011 to 2015 was analyzed.

Findings

This section summarizes interesting results of the analysis and observations about system performance, identified bottlenecks, periods of severe congestion, effects on bus service, and crash trends.

Strategies and Recommendations

This section recommends strategies to help relieve congestion during the event or occurrence. These strategies are based on the Boston Region MPO's 2013 CMP report. Cost effective strategies, that do not require roadway expansion, are available to relieve nonrecurring congestion at locations throughout the region. Some of these strategies focus on reducing single-occupancy-vehicle (SOV) demand, while other strategies focus on minor infrastructure improvements to help the roadway network operate better. There are also strategies that help improve communication between vehicle operators and other roadway users to help both parties make better decisions.

Chapter 5—Case Study: New England Patriots Regular Season Games

5.1 DESCRIPTION OF EVENT AND LOCATION

The New England Patriots play their home games at Gillette Stadium in Foxborough, MA. During the 2015 National Football League (NFL) season, the team played six home games that started at 1:00 PM on Sundays. Because of the frequency of games played during this time slot, it was possible to analyze traffic patterns to identify recurrent traffic problems leading to and from Gillette Stadium on game days.

The specific dates and times of the analysis, roadways and routes of focus, and datasets used in the analysis are as follows:

- Dates: September 20, September 27, October 25, November 8, December 20, and December 27, 2015
- Times monitored: 9:00 AM to 8:00 PM
- Roadways analyzed: Interstate 95 and Route 1
- MBTA bus routes analyzed: None
- Datasets used for analysis: INRIX and MassDOT crash database

The main roadways that provide access to Gillette Stadium are Interstate 95 and Route 1. The traffic patterns showed moderate congestion leading to the stadium before the game and extreme congestion leading from the stadium after the game. Traffic after the game was more intense because attendees typically leave the game at the same time, whereas fans traveling to the game are arriving over a longer period of time, typically to tailgate. Usually on game days, Route 1 has a contraflow operation between the interchange of Route1 and Interstate 95 and Interstate 495. One or more lanes on Route 1 are added to the peak direction before and after games to temporarily add capacity. In addition, vehicles are typically permitted to drive in the breakdown lane on highways near the stadium during these times.

The MBTA runs special commuter rail train service to Foxborough on game days and for other events for a round trip price of $20. One train travels from South Station in Boston and another train travels from TF Green Airport in Providence, Rhode Island, to the station near Gillette Stadium shortly before game time.

Thirty minutes after the games, trains make the return trip to South Station and TF Green Airport. Both trains commonly sell out on game day. [6]

Additionally, those attending these games might opt to use a ridesharing service, such as Uber or Lyft, to avoid the high cost of parking at the stadium (parking on game days is $40) and other issues related to parking.[7] Ridesharing might have increased travel trips to the stadium, whereas in the past attendees would have carpooled or taken public transportation to the games.

5.2 PERFORMANCE MEASURE SUMMARY

5.2.1 Roadways

Travel Times

Figures 1, 2, 3, and 4 show the travel times on Interstate 95 northbound, Interstate 95 southbound, Route 1 northbound, and Route 1 southbound, respectively, on Patriots game days. Of the four directional corridors, both Route 1 northbound and southbound experienced travel times on game days that were worse than travel times on a typical weekday peak period.

Interstate 95 northbound experienced an increase in travel times between 4:00 PM and 6:00 PM, which represents traffic that was flowing from Foxborough to Boston and other surrounding communities after the Patriots games. Interstate 95 southbound experienced a slight increase in travel time between 10:00 AM and 11:00 AM, before the Patriots games.

Route 1 northbound experienced an increase in travel times of up to 100 percent between 3:15 PM and 6:30 PM; the worst travel times occurred between 4:45 PM and 5:45 PM. Route 1 southbound experienced two periods when there was an increase in travel times: from 9:30 AM to 11:30 AM and 4:00 PM to 7:00 PM. The morning travel times showed a more significant increase than the evening travel times; travel time increased by 50 percent between 9:30 AM and 11:30 AM. This trend represents game attendees traveling to Gillette Stadium before the Patriots games.

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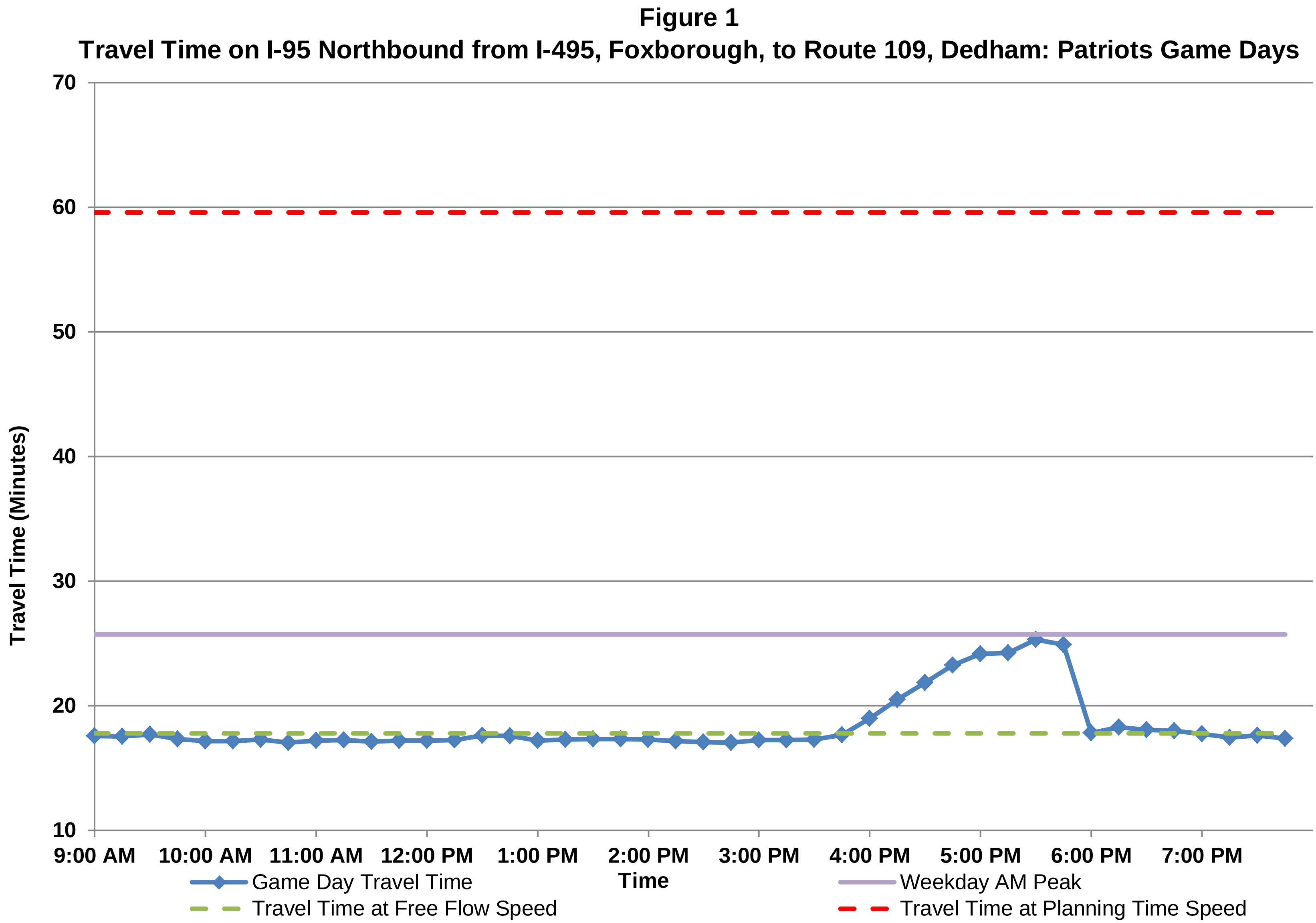
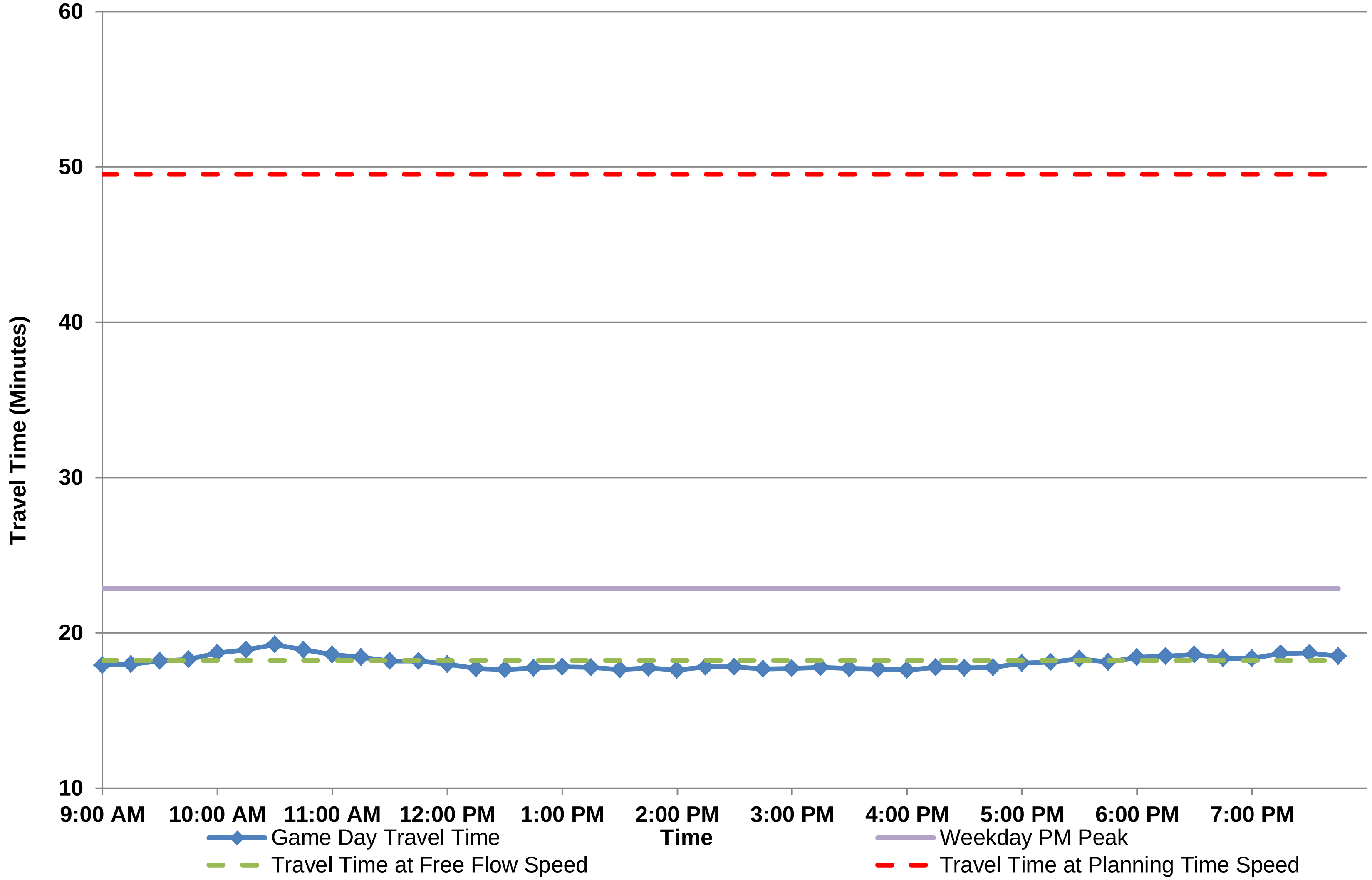
[6] MBTA website, “Gillette Stadium,” accessed on September 24, 2018, available online at https://www.mbta.com/destinations/gillette-stadium.

[7] Gillette Stadium website, “Parking,” accessed on September 24, 2018, available online at https://www.gillettestadium.com/parking/.



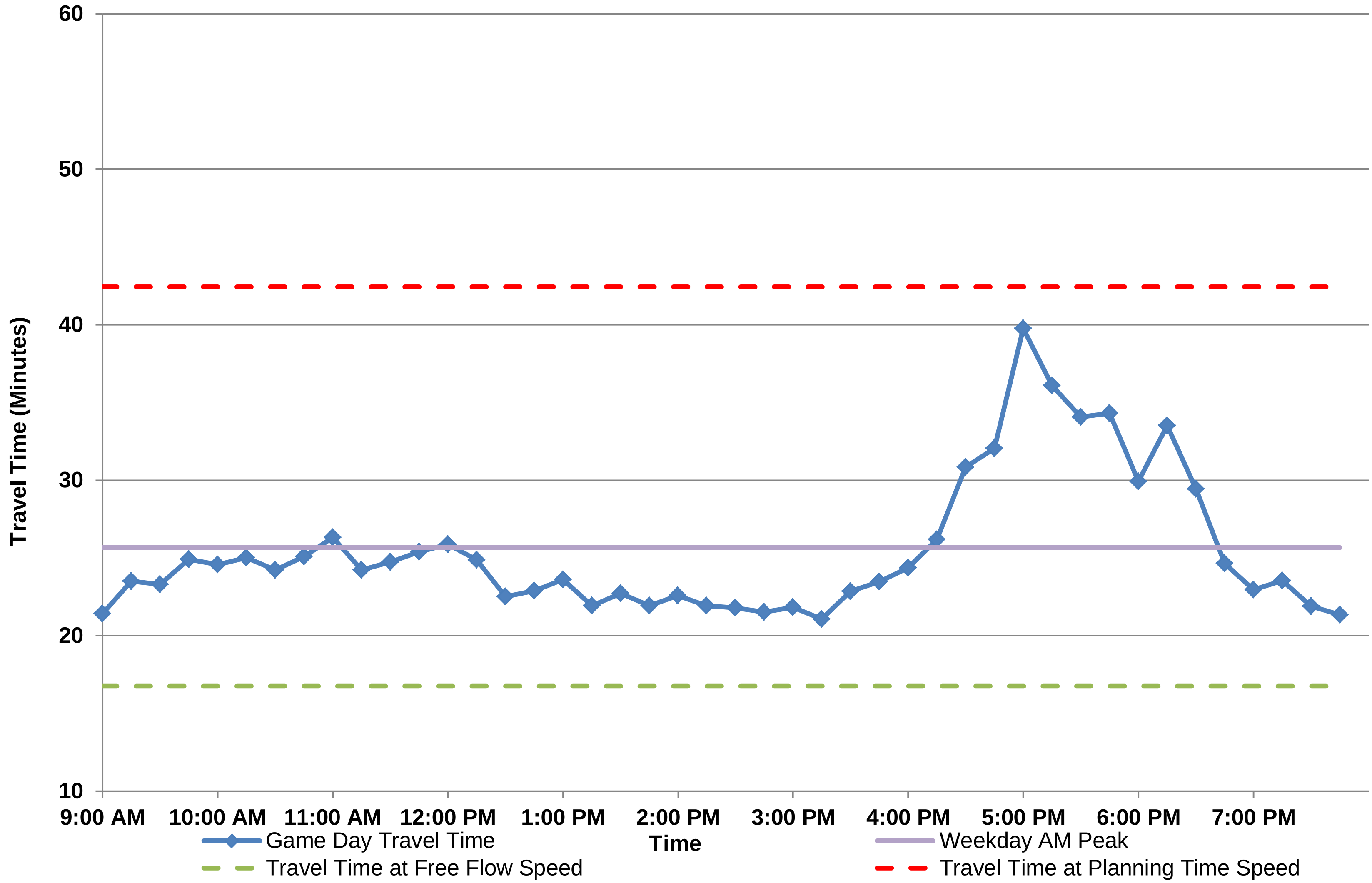
Source: INRIX

Figure 2
Travel Time on I-95 Southbound from Route 109, Dedham, to I-495, Foxborough: Patriots Game Days



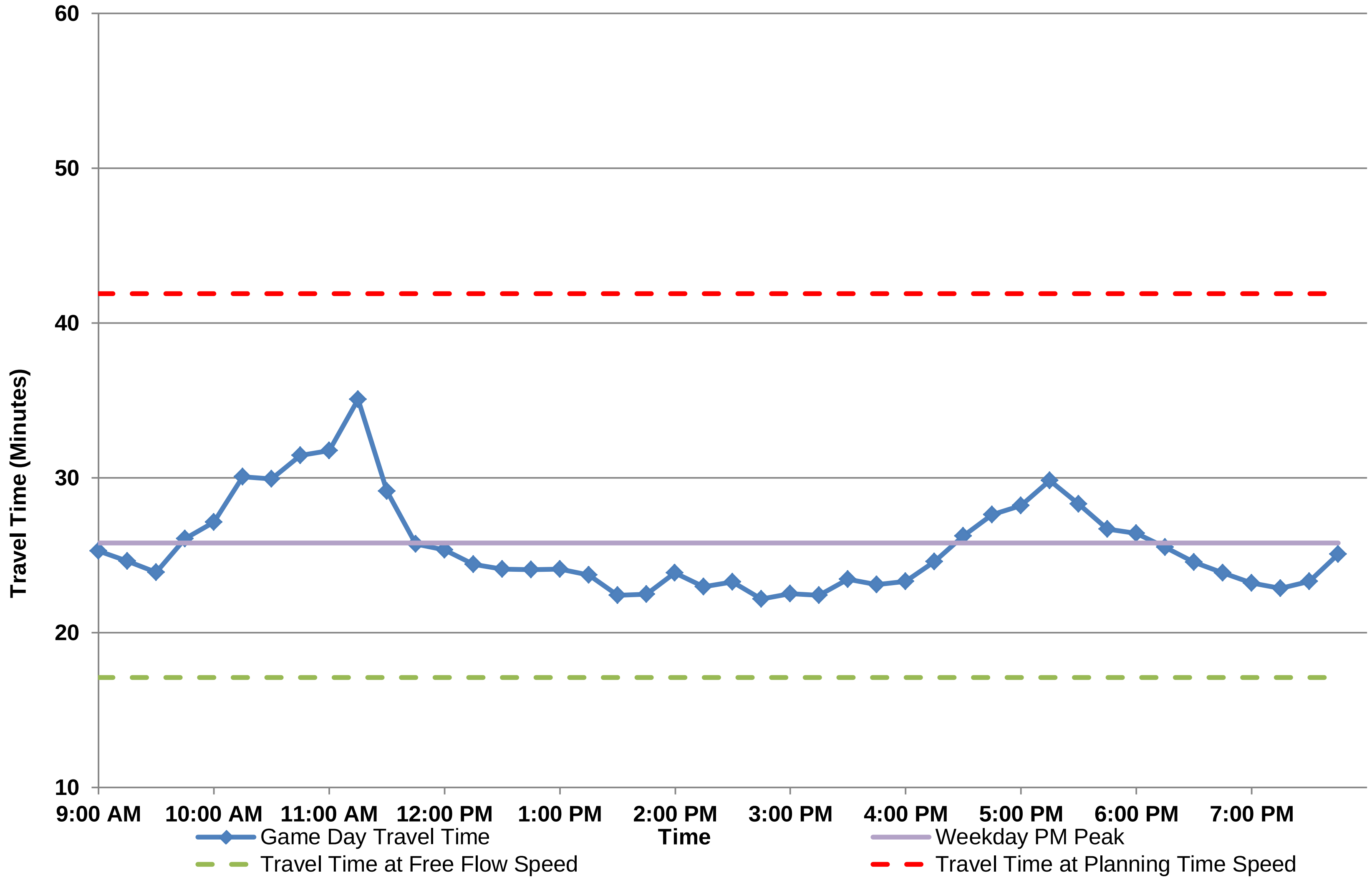
Source: INRIX

Figure 3
Travel Time on Route 1 Northbound from I-495, Plainville, to I-95, Dedham: Patriots Game Days



Source: INRIX

Figure 4
Travel Time on Route 1 Southbound from I-95, Dedham, to I-495, Plainville: Patriots Game Days



Source: INRIX

Tables 1 and 2 display the performance results for both Interstate 95 and Route 1 respectively. Both the typical weekday and game day performance results are displayed in each table. Both Interstate 95 northbound and southbound experienced less congestion than a typical weekday peak period on game days, but Route 1 northbound and southbound experienced an increase in congestion on game days. The Interstate 95 northbound and southbound corridors experienced no congested minutes per hour on game days. Route 1 northbound experienced the lowest speeds and had the highest travel time index of the corridors. Based on the average speed and other performance measures, the most congested location during a Patriots game day is on Route 1 northbound from North Street to Interstate 95 between 4:45 PM and 5:45 PM.

Table 1
Traffic Conditions on I-95: Weekday Peak Period versus Game Day

Performance Measure	I-95 Northbound (Dedham – Foxborough) Weekday	I-95 Northbound (Dedham – Foxborough) Game Day	I-95 Southbound (Dedham – Foxborough) Weekday	I-95 Southbound (Dedham – Foxborough) Game Day
Distance (miles)	19.99	19.99	20.3	20.3
Congested minutes per hour	17:56	0:00	9:51	0:00
Average travel time (minutes)	19:07	18:24	22:25	18:07
Average speed (MPH)	62.72	65.17	54.34	67.26
Average delay (minutes)	1:21	0:38	4:13	0:00
Bottleneck factor	0.64	N/A	0.38	N/A
Travel time index	1.08	1.03	1.23	1
Travel time / planning time ratio	32%	31%	45%	37%

MPH = miles per hour.
Source: INRIX.

Table 2
Traffic Conditions on Route 1: Weekday Peak Period versus Game Day

Performance Measure	Route 1 Northbound (Plainville – Dedham) Weekday	Route 1 Northbound (Plainville – Dedham) – Game Day	Route 1 Southbound (Plainville – Dedham) Weekday	Route 1 Southbound (Plainville – Dedham) - Game Day
Distance (miles)	13.76	13.76	13.98	13.98
Congested minutes per hour	5:52	6:29	5:17	5:34
Average travel time (minutes)	22:57	25:30	23:58	25:34
Average speed (MPH)	35.97	32.42	34.99	32.81
Average delay (minutes)	6:13	8:44	6:51	8:28
Bottleneck factor	0.39	0.54	0.37	0.51
Travel time index	1.37	1.52	1.40	1.49
Travel time / planning time ratio	54%	60%	57%	61%

MPH = miles per hour.
Source: INRIX.

Worst Locations and Times

Figure 5 shows the locations on Interstate 95 and Route 1 that experience a decrease in speed after 1:00 PM games concluded between 4:45 PM and 5:45 PM, compared to the weekday PM peak speeds. The most congested segment of Route 1 northbound at this time is between North Street and Interstate 95. This segment is located less than half a mile from Gillette Stadium.

Table 3 shows the performance results for Route 1 northbound between 4:45 PM and 5:45 PM on game days. At that time, motorists experienced 49 minutes of congestion per hour. Additionally, travel times on the corridor were worse than the planning time travel times for a typical peak period for 18 minutes out of every hour. Also, travel speeds were 12 MPH, and the travel time index was 3.9.

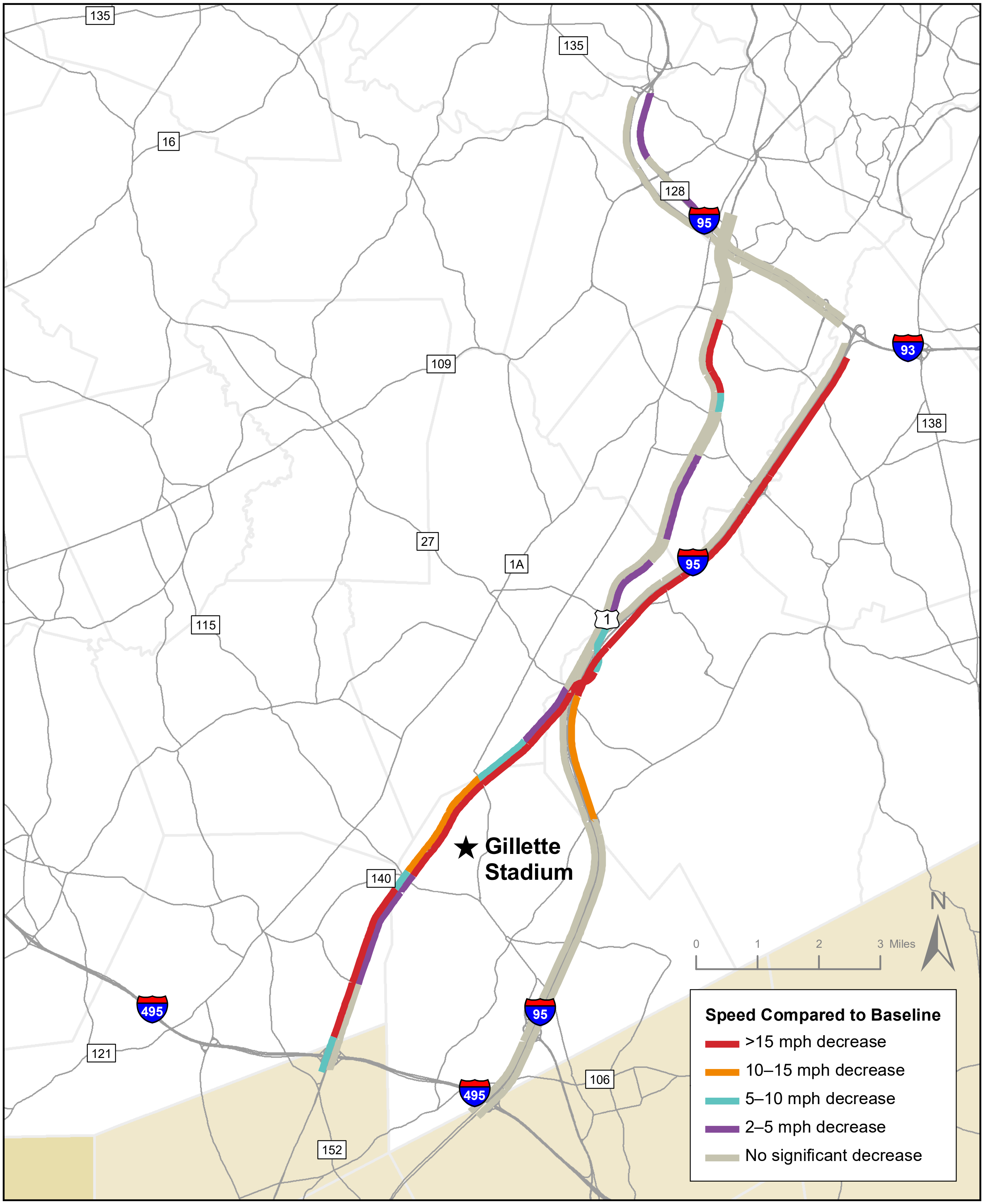


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Figure 5
Travel Speeds after Patriots Games Compared to Weekday Speeds

Traffic Congestion in the Boston Region: Beyond the Daily Commute

Table 3
Traffic Conditions on Route 1 Northbound:
Worst Hour (4:45 PM to 5:45 PM)

Performance Measure	Route 1 Northbound (Plainville – Dedham) Weekday	Route 1 Northbound (Plainville – Dedham) Game Day
Distance (miles)	13.76	13.76
Congested minutes per hour	5:52	16:24
Average travel time (minutes)	22:57	34:06
Average speed (MPH)	35.97	24.21
Average delay (minutes)	6:13	17:22
Bottleneck factor	0.39	2.54
Travel time index	1.37	2.04
Travel time / planning time ratio	54%	80%

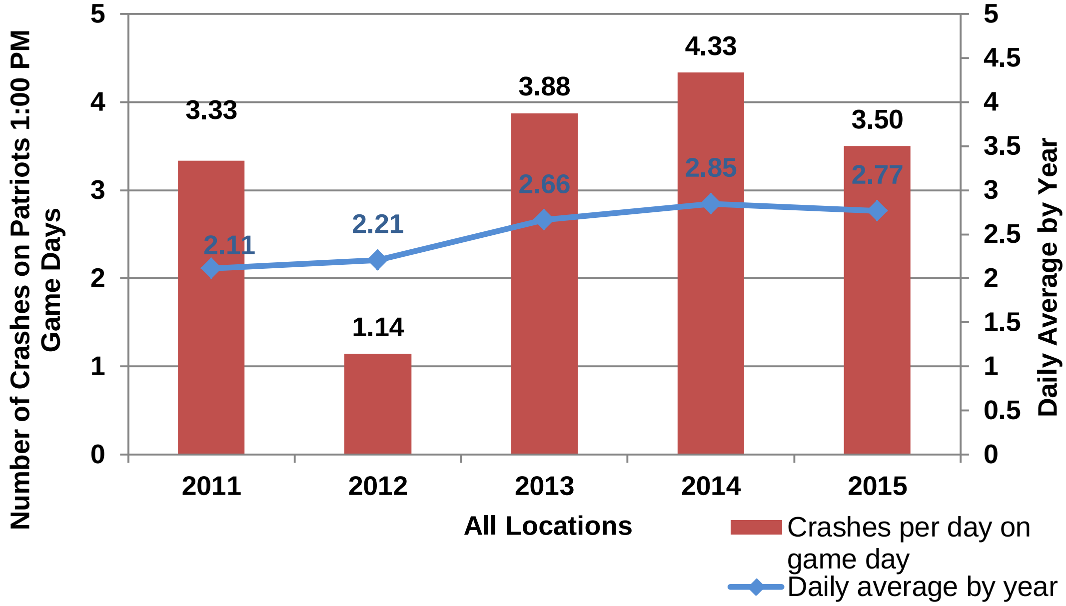
MPH = miles per hour.
Source: INRIX.

5.2.2 Safety

Crashes

Figure 6 compares the number of crashes that occurred on Route 1 and Interstate 95 on New England Patriots game days in 2011 through 2015 to the number of crashes that occurred on a typical day at these locations during the same time period. Most of the crashes on Route 1 between North Street and Interstate 95, which is the most congested location after the Patriots games, were caused by rear-end collisions.

Figure 6
Crashes on Route 1 and I-95: New England Patriots Game Days, 2011-15



Source: MassDOT Crash Database.

5.2.3 Findings

- Congestion mostly occurred northbound on Interstate 95 and Route 1 after the Patriots games, between 4:45 PM and 5:45 PM. However, there were no drastic congestion patterns on the southbound lanes before the games. This could reflect that fans drive to Gillette Stadium at various times throughout the morning and early afternoon, but leave the stadium in unison after the games.
- Travel time on Route 1 southbound, leading to Gillette Stadium, began to spike at 9:30 AM before the games.
- The spike in traffic congestion during the worst hour, 4:45 PM to 5:45 PM, indicated that there is a sudden increase in travel demand on the northbound roadways, particularly Route 1 and Interstate 95 at that time.
- The crash rate on game days was higher than a typical day.
- According to the MBTA website and online reviews, there have been issues with crowding and delays on the MBTA's Foxborough train service on game day.

5.2.4 Strategies and Recommendations

- Continue to publicize information about peak congestion times, and specifically let game attendees know that peak congestion occurs between 4:45 PM and 5:45 PM. Also, encourage attendees to delay their

trips home until after 6:00 PM. There are numerous restaurants and stores nearby to accommodate people who would like to wait until traffic dissipates.
- Provide additional trains on game day, possibly at different times. The trains on game day are often sold out and crowded.
- Improve operations on the trains, as there have been numerous complaints about train delays. Study how to modernize the Foxborough spur to eliminate slow zones.
- Study innovative ways to pay for increasing public transit, such as advertising or branding to pay for the operations of additional trains.
- Provide transit service, in addition to the commuter rail train, to and from the stadium by adding direct bus service from certain locations in the region, such as MassDOT's park-and-ride lots (similar to the Logan Express network).
- Improve response to traffic incidents and crashes on Route 1.
- Provide temporary dynamic message signs (DMS) that will inform travelers of a detour if congestion or an incident occurs. Traffic could be detoured from Route 1 to Interstate 95 via Route 140, or to Route 1A north.
- Continue to make contraflow alterations on Route 1 to provide extra capacity on the roadway for motorists traveling to and from Gillette Stadium before and after the game.

Chapter 6—Case Study: Red Sox Weekday Games

6.1 DESCRIPTION OF EVENT AND LOCATION

In 2015, the Boston Red Sox baseball team played 162 games. Of the 81 home games at Fenway Park, 42 games were played on weekday nights starting between 7:00 PM and 8:00 PM. Unlike many of the case studies that were reviewed in this report, this case study highlights an event that takes place during peak period travel times. This case study compared travel times on weekdays when the Red Sox played nighttime home games to travel times on non-game weekdays to determine if there is a difference in traffic congestion on Interstate 90 and several arterials near Fenway Park.

Typically, Jersey Street (formerly Yawkey Way) and Van Ness Street are closed during the games. As of April 27, 2017, Landsdowne Street is also closed to traffic during games .[8] In addition, some other streets near the ball park are closed and others are converted to a contraflow operation on game days.

This case study

- analyzed traffic on nearby expressways and arterials before, during, and after Red Sox night games;
- compared regular peak period congestion to the PM peak period congestion on game nights;
- compared crash rates for game days to crash rates for non-game days; and
- examined locations that had the most increase in congestion during game days.

The specific dates and times of the analysis, roadways and routes of focus, and datasets used in the analysis are as follows:

- Dates in 2015: April 17; May 1, 4-6, 19- 22; June 2, 3, 5, 12, 15, 23-25; July 3, 7, 8, 10, 24, 27-29, 31; August 14, 17-21, 31; September 1, 4, 8, 9, 21-25 (2017 data was used for the bus analysis)
- Times monitored: 2:00 PM to 12:00 AM

[8] Boston Globe, "As a Precaution, Police to Shut down Lansdowne Street on Red Sox Game Days," April, 27, 2017, available online at https://www.bostonglobe.com/metro/2017/04/27/precaution-boston-police-shut-lansdowne-street-near-fenway-park-game-days/vsp93qrvXhWnENim64Lq1M/story.html

- Roadways analyzed: Interstate 90 between Interstate 95 and Interstate 93, Storrow Drive, Beacon Street, Route 20 (Commonwealth Avenue), Massachusetts Avenue, Riverway/Park Drive, Brookline Avenue, and Route 9 (Huntington Avenue) in Boston
- MBTA bus routes analyzed: 170, 501, 502, 503, 504, 505, 553, 554, 556, 558, 60, 66, 32, 35, 38, 39, 66, 192, 9, 55, 10, 193, 57, 65, 8, 16, 701, and 1
- Datasets used for analysis: INRIX, MassDOT crash database, and MBTA Back on Track dataset

6.2 PERFORMANCE MEASURE SUMMARY

6.2.1 Roadways

Expressways

Table 4 shows the comparison of performance results for Interstate 90 between dates when the Red Sox had night games and dates when the team did not have night games. On Interstate 90, overall travel speeds were actually slower during the PM peak period on weekdays when the Red Sox did not play compared to weekdays when the team played night games. However, traffic speeds were slower at roadway segments near the stadium on dates when there were night games.

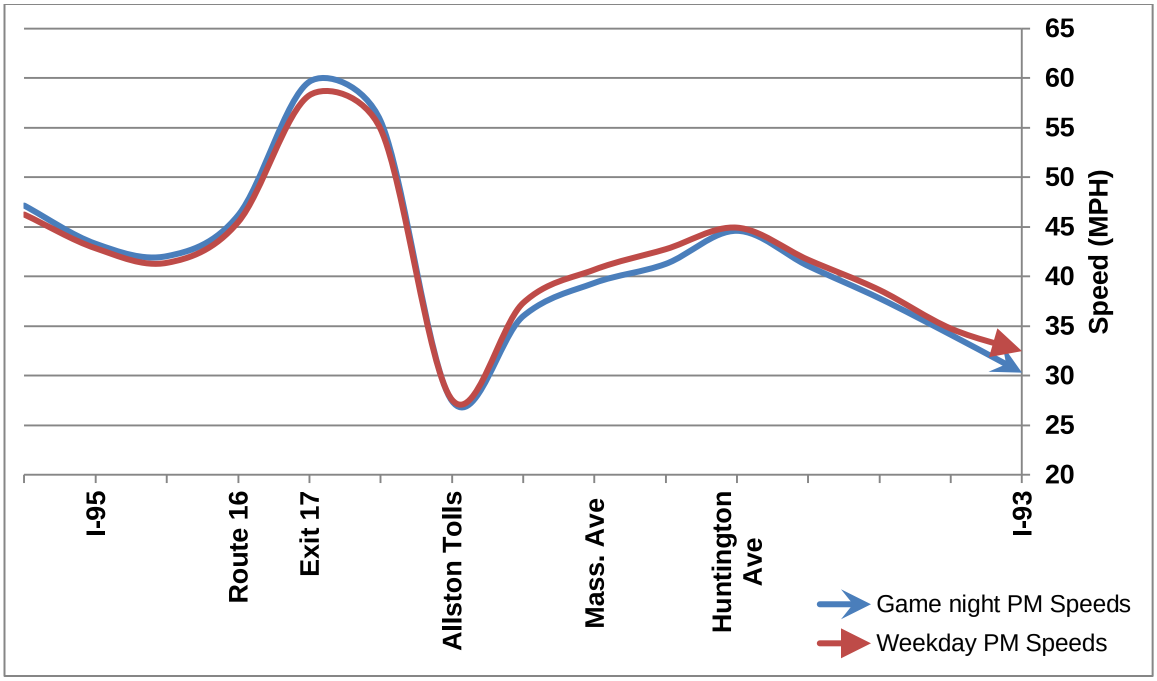
Table 4
Traffic Conditions on Expressways: Weekdays versus Days of Red Sox Night Games, PM Peak Period

Performance Measure	I-90 (Both directions) Game Day	I-90 EB Game Day	I-90 WB Game Day	I-90 (Both directions) Weekday	I-90 EB Weekday	I-90 WB Weekday
Distance (miles)	22.1	11.45	10.66	22.1	11.45	10.66
Congested minutes per hour	16:52	15:59	17:49	19:38	15:39	23:54
Average travel time (minutes)	30:25	15:07	15:22	32:01	15:11	17:10
Average speed (MPH)	43.6	45.44	41.64	41.41	45.26	37.27
Average delay (minutes)	7:43	3:11	4:35	9:20	3:15	6:23
Bottleneck factor	0.63	0.58	0.69	0.74	0.59	0.91
Travel time index	1.34	1.27	1.43	1.41	1.27	1.59
Travel time / planning time ratio	48%	47%	49%	50%	47%	55%

EB = eastbound; I = Interstate; MPH = miles per hour; WB = westbound.
Source: INRIX.

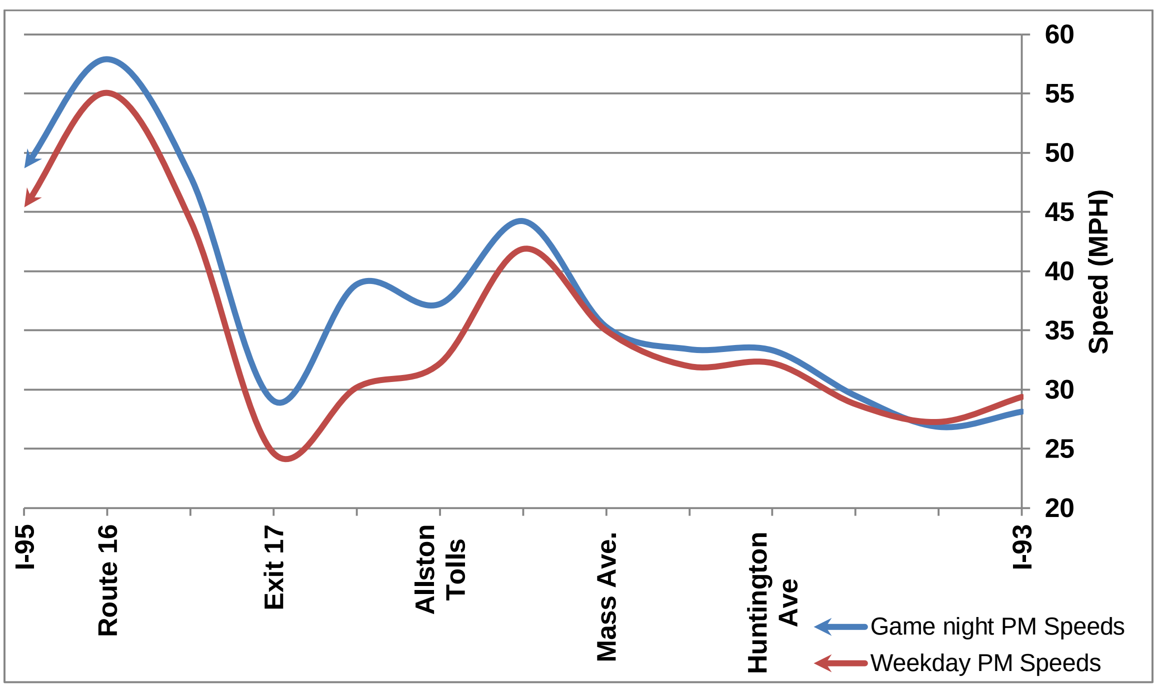
Figures 7 and 8 show the flow of game day and non-game day traffic speeds, by location and travel direction. The travel speeds on the eastbound lanes of Interstate 90 on game nights were slightly higher between Interstate 95 and the Allston Tolls. East of the Allston Tolls, motorists on Interstate 90 eastbound experienced slower speeds on game day compared to regular weekdays. The game day speeds on Interstate 90 westbound were higher at every location except between Interstate 93 and Huntington Avenue. The reason why travel speeds might be higher during game days could be because motorists avoid driving near Fenway Park during a game. In addition, the games tend to let out after 11:00 PM, which is during the off-peak travel period. Even though there would be an influx of traffic at this time, Interstate 90 has the capacity to carry this traffic without a resulting speed reduction.

Figure 7
Travel Speeds on I-90 Eastbound: Days of Red Sox Night Games



MPH = miles per hour.
Source: INRIX.

Figure 8
Travel Speeds on I-90 Westbound: Days of Red Sox Night Games



MPH = miles per hour.
Source: INRIX.

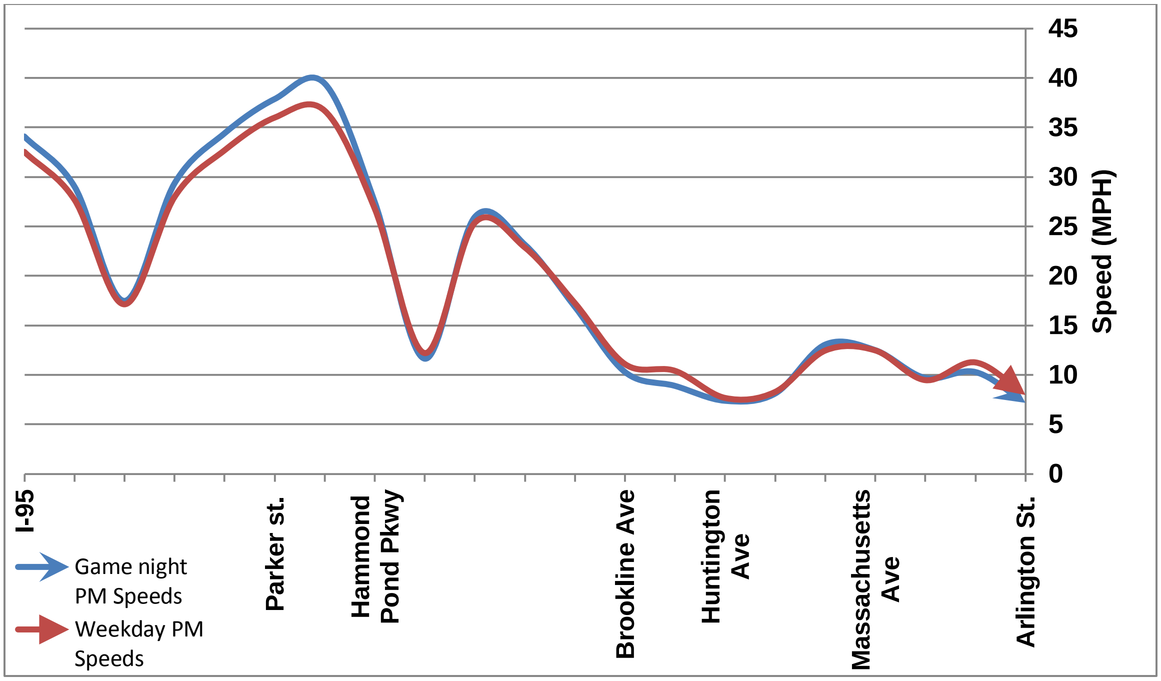
Arterials

The combined average PM peak speeds for all arterials in the study area actually increased slightly during game days. In addition, the number of congested minutes per hour decreased by one minute and 13 seconds on game days versus non-game days. All arterials, except Massachusetts Avenue (both directions) and Brookline Avenue (both directions), experienced faster speeds and lower congested minutes on game days than on non-game days. In many cases, however, roadway speeds on game day were slower than speeds on non-game days on the roadways close to Fenway Park. In addition, Route 9 westbound, Massachusetts Avenue westbound, and Brookline Avenue eastbound all had a travel time index higher than 2.00 compared to a travel time index congested threshold standard of 1.30, which indicates that these locations are experiencing extreme congestion on game days.

Figures 9 and 10 show the travel speeds during the PM peak period on game days and non-game days on Route 9 eastbound and westbound, respectively. On Route 9 eastbound, the game night PM speeds were actually higher than the non-game night speeds west of Hammond Pond Parkway. However, the speeds for both nights were nearly equal east of Hammond Pond Parkway.

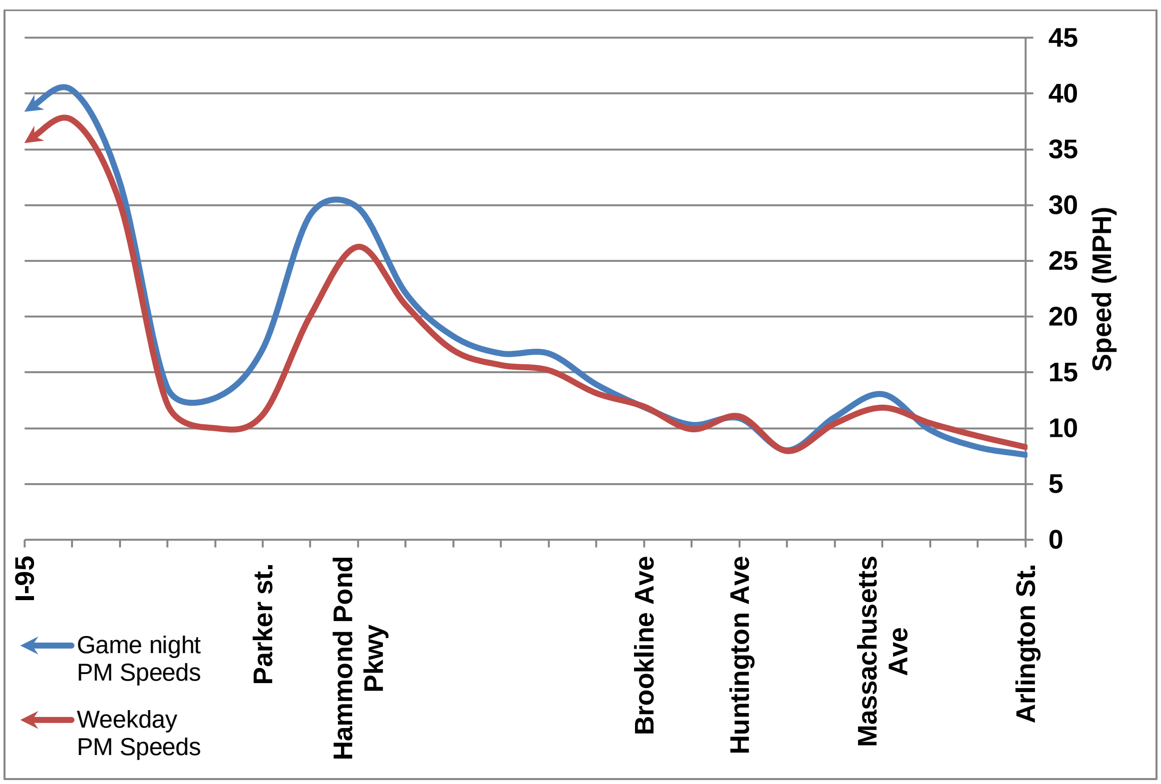
On Route 9 westbound, an interesting finding is that travel speeds were consistently higher on game days versus non-game days. At some locations, speeds were as much as five MPH higher. There might have been less traffic on game nights because many commuters may avoid Route 9 if they know that a Red Sox game is scheduled for that night. In addition, the congestion on Route 9 westbound usually occurs after the game and well after the peak travel period ends.

Figure 9
Travel Speeds on Route 9 Eastbound: Days of Red Sox Night Games



Source: INRIX.

Figure 10
Travel Speeds on Route 9 Westbound: Days of Red Sox Night Games



Source: INRIX.

Congested Locations

Figure 11 shows the locations near Fenway Park that experience a decrease in average speeds of more than 2 MPH on days when Red Sox night games were played. One map shows the locations where speeds decrease before the game between 3:00 PM and 7:00 PM. The other map shows the locations where speeds decrease after the games, between 10:00 PM and 12:00 AM. During the PM peak period before the game, most of the speed decreases occur near Fenway Park. After the game (10:00 PM to 12:00 AM), the decreases in speeds are more extreme at some locations and several locations experience decreases of more than 5 MPH.

Table 5 lists the specific locations where traffic speeds decreased on days when Red Sox night games were played. Most of the speed reductions occurred after the games ended and attendees were leaving the Fenway area. However, travel speeds on Storrow Drive, which is a limited-access arterial, typically decreased before a game compared to the same time on a non-game day.

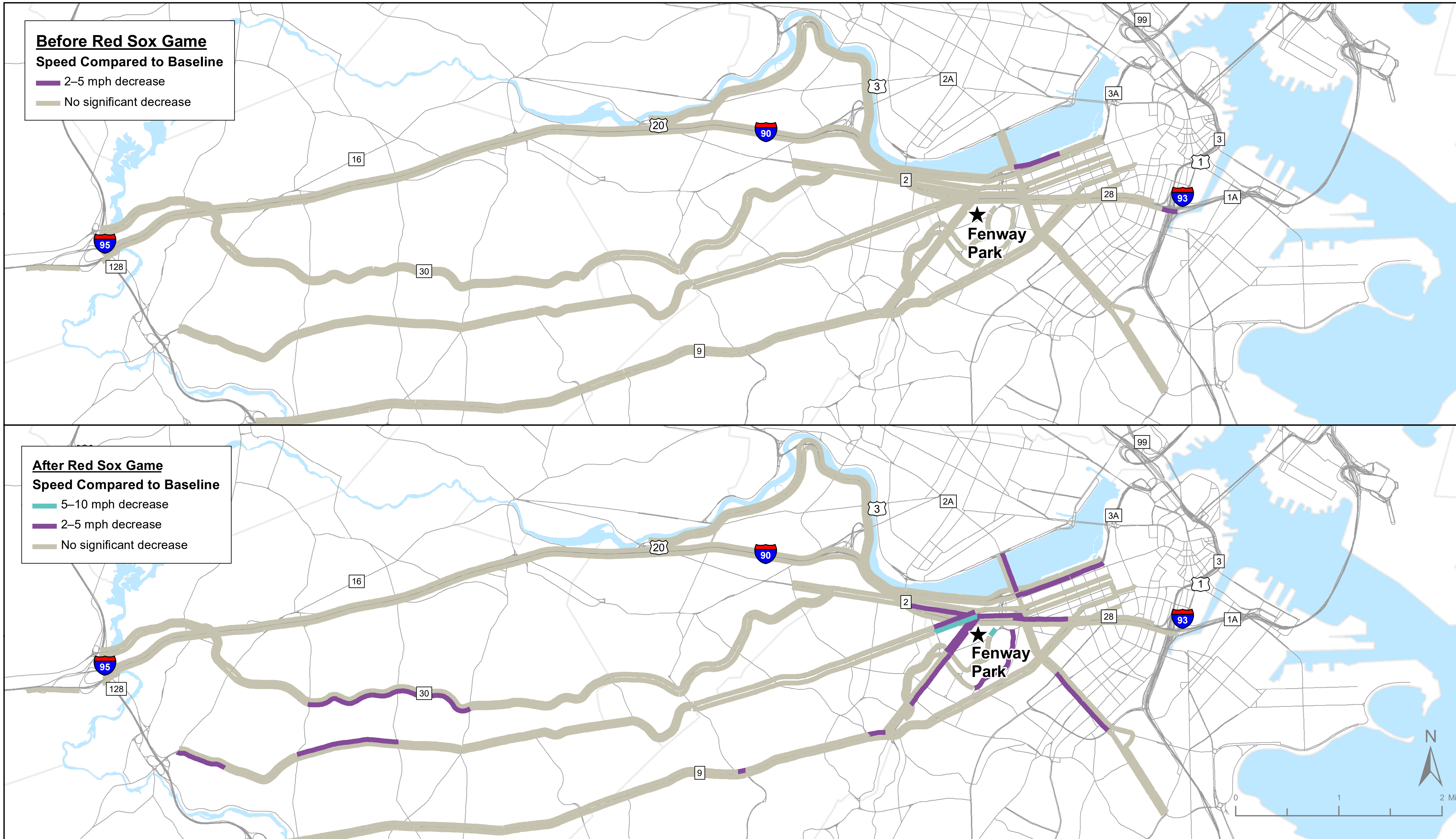


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Figure 11
Locations Where Travel Speeds Decrease: Days of Red Sox Night Games, 3:00 PM to 7:00 PM and 10:00 PM to 12:00 AM

Traffic Congestion in the Boston Region: Beyond the Daily Commute

Table 5
Top 5 Locations where Speeds Decrease on Days of Red Sox Night Games

Roadway	Direction	From	To	Time	Change in Speed (MPH)
Storrow Drive (Boston)	Westbound	MA-28	Massachusetts Avenue	5:30 PM-7:30 PM	-14.60
Beacon Street (Newton)	Westbound	Walnut Street	Chestnut Street	11:00 PM-12:00 PM	-13.54
Boylston Street (Boston)	Eastbound	Boylston Street	Park Drive	10:00 PM-12:00 PM	-10.38
Beacon Street (Boston)	Eastbound	MA-2/Park Drive	Commonwealth Avenue	10:30 PM-11:30 PM	-9.34
Brookline Avenue (Boston)	Eastbound	Riverway/Park Drive	Commonwealth Avenue	10:00 PM-11:30 PM	-6.45

MA = Massachusetts highway route. MPH = miles per hour.
Source: INRIX.

6.2.2 Safety

Crashes

Table 6 compares the crash rates on arterials and expressways near Fenway Park on weekdays in 2015 when the Red Sox night games were held to weekdays when night games were not held. The overall crash rates were slightly higher on game days than non-game days on both arterials and expressways and more crashes occurred per day on the arterials in the study area than on the expressways.

Table 6
Crashes on Days of Red Sox Night Games versus Non-Game Days, 2011-15

Event	Number of Days (2015)	Total Crashes on Arterials	Crashes per Day on Arterials	Total Crashes on Expressways	Crashes per Day on Expressways
Game Days	42	113	2.7	67	1.6
Non-Game Days	73	176	2.4	106	1.5

Source: INRIX.

Table 7 shows the locations where the most crashes occurred on game days. The location where the most crashes occurred is the Charlesgate interchange, which experienced a 74 percent increase in crashes on game days versus non-game days. The location that experienced the most significant increase in crash rate was Beacon Street, between Winchester Street and Harvard Avenue; the crash rate increased 248 percent on days when there were night games.

Table 7
Locations with the Most Crashes on Days of Red Sox Night Games

Route	Location	Crashes on Game Days	Crashes per Day on Game Days	Crashes on Non-game Days	Crashes per Day on Non-game Days	Change in Crashes per Day on Non-game Days	Percent Increase of Crashes per Day
Storrow Drive (Boston)	Charlesgate Interchange	9	0.21	9	0.12	0.09	74%
Beacon Street (Newton)	Centre Street	3	0.07	5	0.07	0	4%
Route 9 (Newton)	The Shops at Chestnut Hill	3	0.07	2	0.03	0.04	161%
Storrow Drive (Boston)	Clarendon Street	4	0.1	3	0.04	0.05	132%
Beacon Street (Brookline)	Winchester Street to Harvard Avenue	4	0.1	2	0.03	0.07	248%

Source: INRIX.

6.2.3 Findings

- Typically there is less congestion on the expressways and arterials on Red Sox game nights than there is during non-game nights. A possible reason for this is that many commuters could be avoiding the Fenway Park area when games are scheduled.
- There was generally more congestion on arterials close to Fenway Park on game days than on non-game days.
- The travel speeds on arterials increased after 10:30 PM on nights when Red Sox night games were not held, but the travel speeds leveled off at 10:30 PM on game nights. Attendees leaving the games caused a disparity in travel speeds after 11:00 PM on game days versus non-game days.
- The worst time to drive to Fenway Park for a night game is between 5:00 PM and 6:00 PM.
- Storrow Drive experienced the most significant decrease in travel speeds before a game, which indicates that there is an increase of travel delay on Storrow Drive before games, compared to non-game days.
- The crash rate per day value increased slightly on game days.
- The on-time performance of buses was approximately two percent higher on non-game days.
- Due to limited parking, most attendees do not drive directly to Fenway Park. Red Sox games have a limited effect on roadway congestion because most spectators either use public transit or drive to a transit station and complete the trip to the stadium on public transportation.

6.2.4 Strategies and Recommendations

- Implement transit signal prioritization on the MBTA's Green Line to speed up Green Line service along Commonwealth Avenue and Beacon Street, as many people use this service to reach Fenway Park.
- Implement designated waiting areas for ridesharing services, as idling ridesharing vehicles can cause traffic congestion on busy arterial roadways.

Chapter 7—Case Study: Saturdays

7.1 DESCRIPTION OF EVENT AND LOCATION

Congestion that occurs on Saturdays is assumed to be caused by non-work based trips, which may include travel for shopping, leisure, out of state travel, and events. These trips occur at various times of the day, resulting in traffic patterns that are unpredictable.

Originally, the CMP only monitored peak period congestion on weekdays. However, federal legislation passed in 2018 now requires MPOs to monitor congestion on Saturdays using the Level of Travel Time Reliability (LOTTR) performance measure. For this study, the 2015 INRIX dataset was used to compare Saturdays that correspond with CMP monitoring dates for two time periods: 12:00 PM to 4:00 PM and 4:00 PM to 8:00 PM. Traditional CMP performance measures (congested minutes, average speed, and travel time index) were used as a substitute for LOTTR to monitor Saturday congestion for this study.

The specific dates and times of the analysis, roadways and routes of focus, and datasets used in the analysis are as follows:

- Dates in 2015: March 7, 14, 21, and 28; April 4 and 11; May 2, 9, and 16; September 12, 19, and 26; October 3, 10, 17, and 24; and November 7 and 14 (2017 data was used for the bus analysis)
- Times monitored: 12:00 PM to 4:00 PM on Saturday afternoons and 4:00 to 8:00 PM on Saturday evenings
- Roadways analyzed: Entire CMP network
- MBTA bus routes analyzed: All MBTA bus routes
- Datasets used for analysis: INRIX, MBTA Back on Track dataset, MassDOT crash database

7.2 PERFORMANCE MEASURE SUMMARY

7.2.1 Roadways

Regional Monitoring

Figures 12 and 13 show the locations where vehicles experienced a decrease in speeds on Saturday afternoon and Saturday evenings compared to weekdays. The maps show the decrease in speeds for both arterials and expressways, comparing the Saturday afternoon period to the a typical weekday between 12:00 PM and 4:00 PM and the Saturday evening period compared to a typical weekday between 4:00 PM and 8:00 PM. During the Saturday afternoon period, travel speeds increased slightly on expressways and decreased slightly on arterials. The most significant speed decreases occurred in the downtown Boston area (particularly on Interstate 93) and in the suburbs.

On Saturday evenings, the average travel speeds increased by 5 MPH on expressways and 2 MPH on arterials, compared to weekdays at the same time. On Saturday evenings, there were significantly fewer locations that experienced decreases in speeds, compared to Saturday afternoons. Most of the locations where speeds decreased were concentrated on both Route 1 and Interstate 95, north of Boston where the two expressways converge. There were a small number of other locations across the region where speeds decreased.

Table 8 shows the performance results for expressways and arterials on Saturday afternoons and Saturday evenings, compared to the 12:00 to 4:00 PM and 4:00 to 8:00 PM weekday periods. The results for all of these performance measures show a slight increase in expressway travel speeds and a slight decrease in travel speeds on arterials on Saturday afternoons. Travel speeds increased noticeably on expressways and slightly on arterials on Saturday evenings.

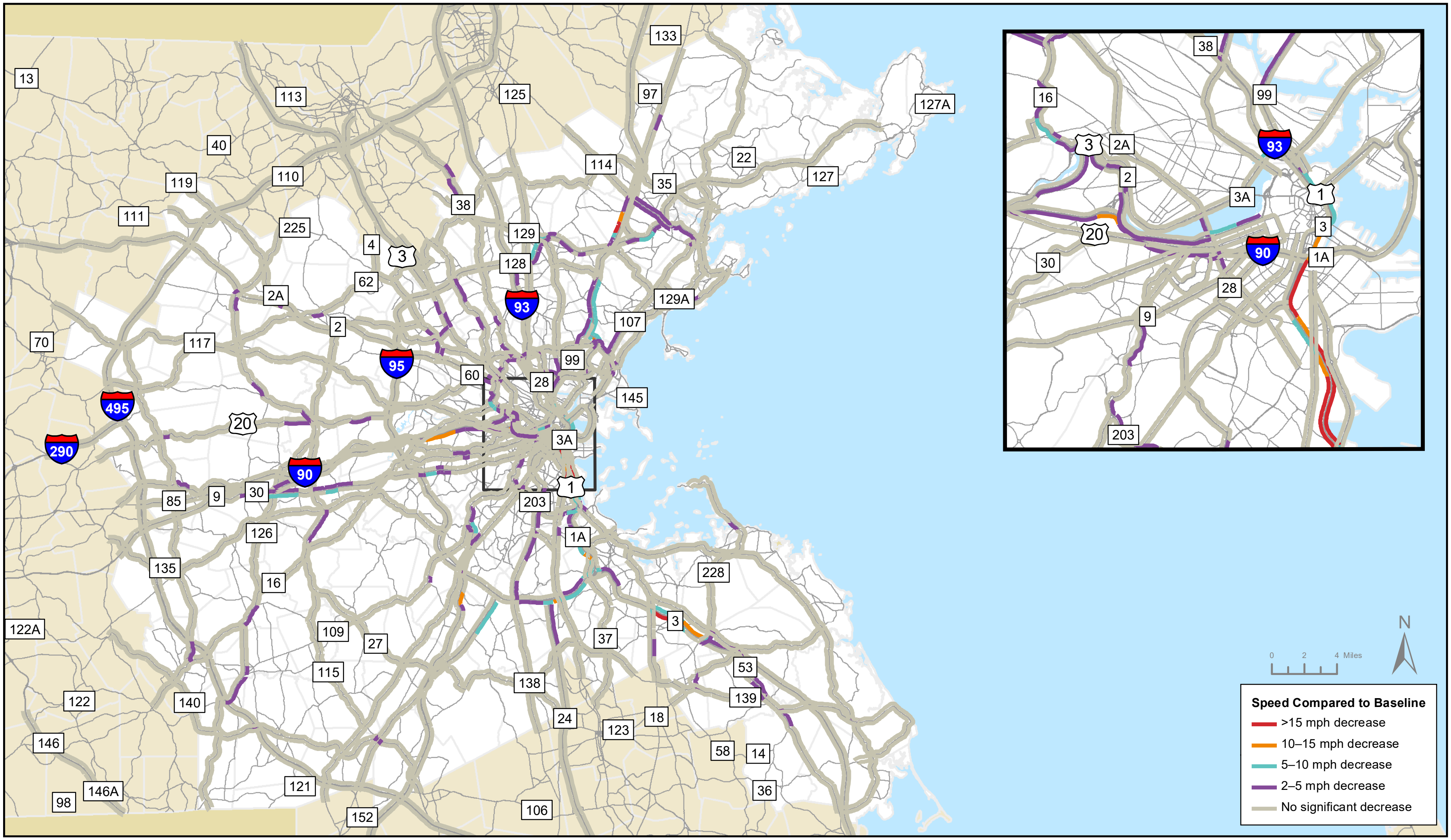

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Figure 12
Difference between Weekday Afternoon and Saturday Afternoon Travel Speeds

Traffic Congestion in the Boston Region: Beyond the Daily Commute

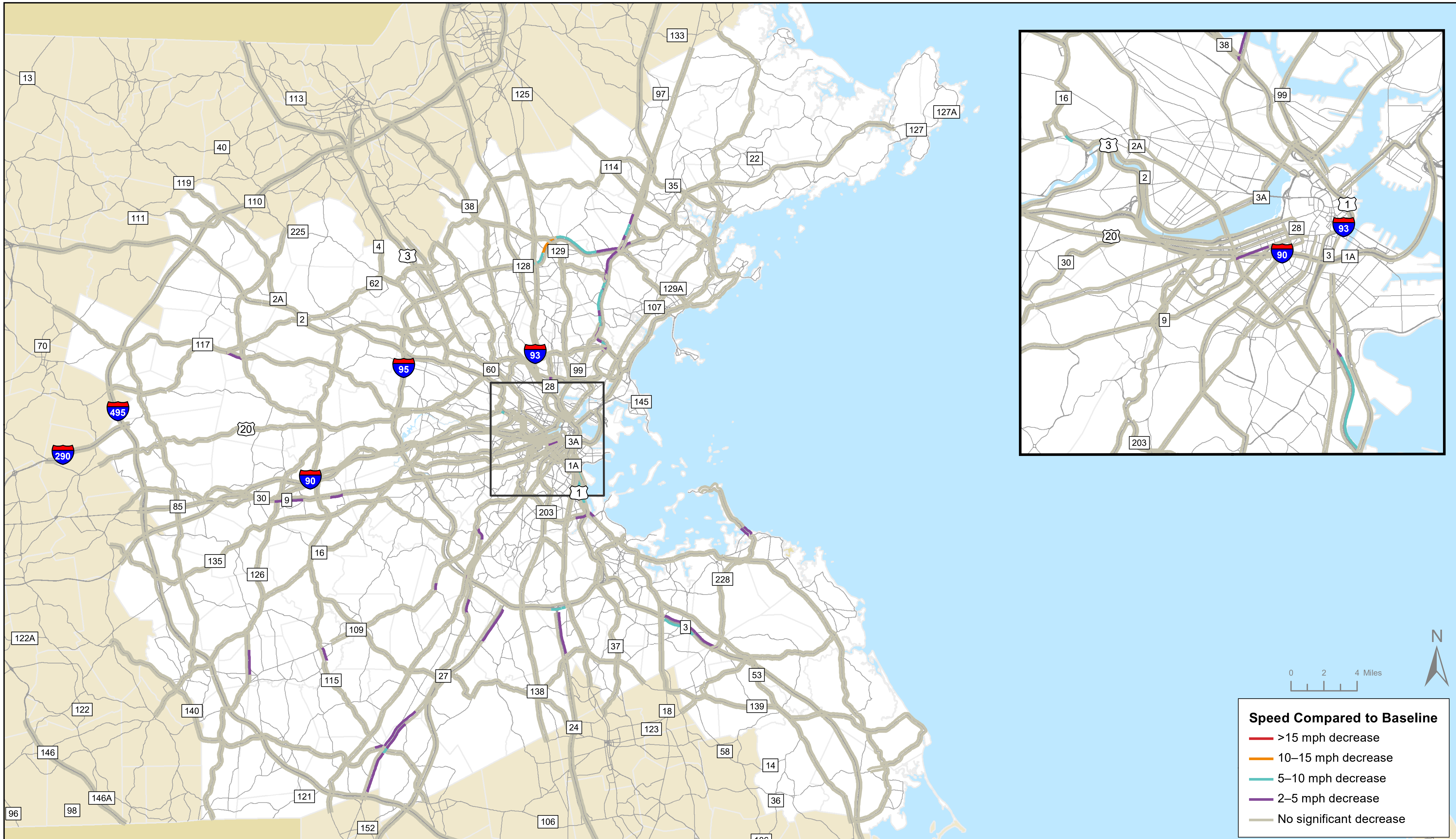

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Figure 13
Difference between Weekday Evening and Saturday Evening Travel Speeds

Traffic Congestion in the Boston Region: Beyond the Daily Commute

Table 8
Traffic Conditions on Expressways and Arterials: Weekdays versus Saturdays

Performance Measure	Weekday AM	Weekday PM	Saturday Afternoon	Saturday Evening
Expressway average speed (MPH)	62.63	59.12	63.8	63.75
Expressway congested minutes	1:29	5:25	1:39	1:10
Expressway travel time index	1.04	1.11	1.03	1.03
Arterial average speed (MPH)	28.79	27.83	28.46	29.37
Arterial congested minutes	8:18	10:26	9:11	7:17
Arterial travel time index	1.27	1.32	1.29	1.25

MPH = miles per hour.
Source: INRIX.

Expressway Travel Times

Table 9 show the expressway locations where the most significant speed reductions occurred on Saturdays between 12:00 PM and 4:00 PM. Except for Interstate 93, which is the only major north-south connector in the study area, all of these roadways are limited-access roadways that are not built to interstate standards. In addition, many of these expressways are near major shopping areas.

Table 9
Expressway Locations with Significant Speed Decreases: Weekday Peak Periods versus Saturdays, 12:00 PM to 4:00 PM

Route	Direction	From	To	Community	Weekday Speed (MPH)	12-4 PM Saturday Speed (MPH)	Change in Speed (MPH)
I-93	Northbound	MA-203/Exit 12	US-1/Exit 24	Boston	53.06	30.43	-22.63
MA-3	Southbound	MA-18 /Exit 16	Derby Street St/Exit 15	Hingham, Weymouth	59.92	38.37	-21.56
US-1	Southbound	Lowell Street	I-95/MA-128	Peabody	43.71	25.44	-18.26
I-93	Southbound	Massachusetts Ave/Exit 18	Morrissey Boulevard	Boston	43.44	28.22	-15.23
US-1	Southbound	MA-99	MA-60	Revere	44.18	30.66	-13.52

I = Interstate. MA = Massachusetts highway route. MPH = miles per hour. US = United States highway route.
Source: INRIX.

Table 10 shows the expressway locations that experience speed reductions on Saturdays from 4:00 PM to 8:00 PM. Again, some of these corridors are located on non-interstate roadways, near shopping areas and central business districts. For example, the Route 1 corridor is located on a right-in right-out limited-access roadway, which contains numerous shops and restaurants.

Table 10
Expressway Locations with Significant Speed Decreases: Weekday Peak Periods versus Saturdays, 4:00 PM to 8:00 PM

Route	Direction	From	To	Community	Weekday Speed (MPH)	4-8 PM Saturday Speed (MPH)	Change in Speed (MPH)
I-95	Southbound	Walnut Street/ Exit 43	MA-28/Main Street/Exit 38	Lynnfield, Wakefield, Reading	58.59	46.21	-12.38
I-93	Northbound	Morrissey Boulevard/ Exit 14	Columbia Road/Exit 15	Boston	45.40	36.87	-8.53
US-1	Southbound	I-95/ Peabody Road	I-95/MA-128	Peabody	41.22	33.18	-8.04
I-93	Northbound	MA-24/Exit 4	MA-28/ Randolph Avenue/Exit 5	Quincy, Randolph	55.73	48.88	-6.85
MA-3	Southbound	MA-18/Exit 16	Derby Street/Exit 15	Hingham, Weymouth	57.91	51.65	-6.26

I = Interstate. MA = Massachusetts highway route. MPH = miles per hour. US = United States highway route.
Source: INRIX.

Arterial Travel Times

Table 11 show the arterial locations where the most significant speed reductions occurred on Saturdays from 12:00 PM to 4:00 PM compared to the weekday peak periods. With the exception of Route 203 and Fresh Pond Parkway, all of the arterials where speed reductions occurred are located near shopping areas. Both the Route 9 and Route 30 corridors are located near the Natick Mall, which is analyzed in the Black Friday case study.

Table 11
Arterial Locations with Significant Speed Decreases:
Weekday Peak Periods versus Saturdays, 12:00 PM to 4:00 PM

Route	Direction	From	To	Community	Weekday Speed (MPH)	12-4 PM Saturday Speed (MPH)	Change in Speed (MPH)
US-1	North-bound	Pleasant Street	Everett Street/ University Avenue	Norwood	36.65	26.45	-10.21
Fresh Pond Parkway	East-bound	MA-16/ Huron Avenue	Mount Auburn Street	Cambridge	19.78	10.27	-9.50
MA-9	East-bound	MA-30/ Edgell Road	Oak Street	Framingham, Natick	32.51	23.55	-8.96
Memorial Drive	West-bound	New Rutherford Avenue	MA-28/Charles Street	Boston, Cambridge	20.55	12.09	-8.46
MA-203	East-bound	Granite Avenue/ Adams Street	I-93/US-1/ MA-3A/ Southeast Expressway	Boston	21.84	14.57	-7.27

MA = Massachusetts highway route. MPH = miles per hour. US = United States highway route.
Source: INRIX.

Tables 12 show the arterial locations where the most significant speed reductions occurred between 4:00 PM and 8:00 PM. Unlike the 12:00 PM to 4:00 PM period, some locations where speed reductions occurred are not near shopping areas. Both Fresh Pond Parkway and Route 109 traverse residential areas. Most of the locations in Table 12 are in suburbs.

Table 12
Arterial Locations with Significant Speed Decreases: Weekday Peak Periods versus Saturdays, 4:00 PM to 8:00 PM

Route	Direction	From	To	Community	Weekday Speed (MPH)	4-8 PM Saturday Speed (MPH)	Change in Speed (MPH)
Fresh Pond Parkway	East-bound	Brattle Street	Mount Auburn Street	Cambridge	16.29	10.94	-5.35
US-1	North-bound	Madison Street	North Street	Wrentham, Foxboro	40.29	35.17	-5.13
Morrissey Boulevard	North-bound	Popes Hill Street/ Tenean Street	I-93/US-1/MA-3A/Freeport Street	Boston	29.12	24.07	-5.05
MA-9	East-bound	Walnut Street	Oak Street	Natick	28.32	24.99	-3.33
MA-109	East-bound	Nahatan Street	Gay Street	Westwood	24.89	21.61	-3.28

I = Interstate. MA = Massachusetts highway route. MPH = miles per hour. US = United States highway route.
Source: INRIX.

7.2.2 Safety

Crashes

Table 13 shows a comparison of the number of crashes that occurred on Saturdays and the number of crashes that occurred on weekdays. The analysis covered 63 weekdays and 18 Saturdays between March and November 2015. The daily crash rate for both expressways and arterials was the highest during the weekday PM peak period. The Saturday evening crash rate was the lowest for both arterials and expressways. During the period analyzed, one fatality occurred during the weekday AM peak period on an expressway and another fatality occurred during a Saturday evening on an arterial.

Table 13
Crashes on Weekdays and Saturdays: March – November 2015

Measure	CMP Weekdays AM Period	CMP Weekdays PM Period	CMP Saturday Afternoon	CMP Saturday Evening
Expressway crashes	592	647	106	86
Expressway crash rate	9.4	10.27	5.89	4.78
Expressway fatalities	1	0	0	0
Arterial crashes	869	1,299	288	195
Arterial crash rate	13.79	20.62	16	10.83
Arterial fatalities	0	0	0	1

CMP = Congestion Management Process.
Source: MassDOT Crash Database.

Table 14 shows the expressway locations in the region where the most crashes occurred on Saturdays in 2015. Interstate 93 at Interstate 95 in Woburn experienced the most Saturday crashes in 2015, followed by Route 3 at Route 18, and Interstate 93 at Furnace Brook Parkway. The number of crashes per day at all of the top ten crash locations were fewer on Saturdays as compared to weekdays.

Table 14
Expressway Locations with the Most Crashes on Weekends in 2015

Route	Location	Weekday Crashes	Weekday Crashes per Day	Saturday Crashes	Saturday Crashes per Day	Increase in Crashes per Day on Saturdays	Percent Increase of Crashes per Day
I-93	I-95	242	0.96	11	0.21	-0.76	-78.5%
Route 3 South	Route 18	91	0.36	9	0.17	-0.19	-53.2%
I-93	Furnace Brook Parkway	70	0.28	7	0.13	-0.15	-52.6%
I-93	Route 28	83	0.33	7	0.13	-0.20	-60.1%
Route 1	Between Route 60 and Lynn Street	77	0.31	7	0.13	-0.17	-56.9%

I = Interstate. MA = Massachusetts highway route. US = United States highway route.
Source: MassDOT Crash Database.

Table 15 shows the arterial locations in the region where the most crashes occurred on Saturdays in 2015. Most Saturday crashes occurred at Route 9 and Interstate 95 in Wellesley. The locations where crashes per day on Saturdays were highest relative to weekdays are Hanson Street and Route 1A in Lynn and Hopkins Street and Main Street in Reading.

Table 15
Arterial Locations with the Most Crashes on Weekends in 2015

Route	Location	Weekday Crashes	Weekday Crashes per Day	Saturday Crashes	Saturday Crashes per Day	Increase in Crashes per Day on Saturdays	Percent Increase of Crashes per Day
Route 9 and I-95	Wellesley	120	0.48	5	0.22	-0.26	-54.5%
East Main Street and Cedar Street	Milford	59	0.24	4	0.17	-0.06	-26.0%
Route 28	Randolph	70	0.28	4	0.17	-0.10	-37.6%
Route 37 and Forbes Road	Braintree	81	0.32	4	0.17	-0.15	-46.1%
Hanson Street and Route 1A	Lynn	19	0.08	4	0.17	0.10	129.7%

I = Interstate. MA = Massachusetts highway route. US = United States highway route.
Source: MassDOT Crash Database.

7.2.3 Bus Service

On-Time Performance

In 2017, on-time performance for buses in the study area was on average 69 percent on Saturdays and 66 percent on weekdays. However, several routes experienced a decrease in on-time performance on Saturdays. They are displayed in Table 16. The most significant decrease was on Route 171, which experienced a 42 percent decrease in on-time performance on Saturdays as compared to weekdays. Route 171 connects Boston's Roxbury neighborhood with Logan Airport through South Boston. The second highest decrease was on Route 90, where on-time performance decreased by 13 percent. The Route 90 bus travels from Davis Square in Somerville to Wellington Station in Medford. This route includes stops at Assembly Square in Somerville.

Table 16
MBTA Bus Routes with Significant Declines in On-Time Performance: Saturdays, 2017

Route	Weekdays	Saturday	Difference
171	59%	17%	-42%
90	62%	49%	-13%
104	59%	48%	-11%
132	72%	63%	-9%
86	58%	50%	-8%
31	78%	70%	-8%
9	75%	67%	-7%
11	71%	65%	-6%
89	62%	57%	-6%

Source: MBTA Back on Track website.

7.2.4 Findings

- The major causes of traffic congestion on Saturdays are non-work trips, including trips to
  - vacation destinations, such as Cape Cod;
  - shopping areas;
  - restaurants (especially during the afternoon period); and
  - special events in the Boston region.
- Overall, there was less congestion regionwide on Saturdays than during the AM and PM weekday peak periods, but there were some extreme spikes in congestion at certain locations on Saturdays, particularly at the locations listed above.
- The crashes per day were considerably less on Saturdays on expressways than on weekdays. However, the crash rates for arterials on Saturday afternoons and Saturday evenings were higher than the crash rates during the AM weekday peak period.
- One fatality occurred during the weekday AM peak period and another on Saturday evening.
- On-time performance for buses was three percent higher on Saturdays than on weekdays.

7.2.5 Strategies and Recommendations

- If data were available, it would be interesting to compare current roadway data on Saturday traffic in the Boston region to roadway data from 2005 or 2006. Traffic volumes on Saturdays may have decreased since 2005 because of the following two factors:

    - Since 2006, there has been a sharp increase in sales by online retailers, such as Amazon, which has reduced shopping trips to traditional stores.
    - In 2007, the United States suffered a financial crisis involving the housing market, which indirectly altered growth patterns of metropolitan areas in the subsequent years. Many cities ceased expanding during this time and overall vehicle-miles traveled declined.
- Data on Saturday traffic should continue to be collected by the Boston Region MPO to improve understanding about congestion patterns on Saturdays. Also, incidents and other nonrecurring events should be monitored to see how they affect traffic on Saturdays.
- Properly synchronize and time traffic signals near shopping malls. A significant amount of congestion that occurs on Saturdays is a result of non-work-based shopping trips near shopping malls. Investigate the possibility of implementing adaptive traffic signals, which can adjust signal timings according to traffic patterns, near shopping areas.
- If possible, provide transit discounts on Saturdays for commuter rail and buses, to encourage more transit trips and reduce travel by automobile.
- Consider expanding the schedule for the Cape Flyer train, which travels from Boston to Hyannis, to provide year round service. The Cape Flyer currently runs from Memorial Day to Labor Day. This train provides travelers an alternative to driving from Boston to Cape Cod. Increasing train service would help alleviate a bottleneck on Route 3 southbound en route to Cape Cod.

Chapter 8—Case Study: Super Bowl Parade

8.1 DESCRIPTION OF EVENT AND LOCATION

When the New England Patriots football team wins the Super Bowl, it is customary for the City of Boston to host a victory parade, which draws thousands of spectators to downtown Boston. Following the Patriots' Super Bowl victory in 2015, a parade was held on Wednesday, February 4, following a snow storm that occurred earlier in the week.[9]

The parade, coupled with the effects of the snow storm, had an adverse effect on traffic congestion in the morning of February 4. Figure 14 shows the parade route, which began at the Prudential Tower and ended at City Hall Plaza.[10] Specifically, the parade traveled from the Prudential Tower eastbound on Boylston Street to Tremont Street. From there, the parade traveled northbound on Tremont Street and continued on Cambridge Street until reaching City Hall. The street closures included Boylston Street from Massachusetts Avenue to Tremont Street, Tremont Street from Boylston Street to Court Street, and Cambridge Street from Court Street to New Chardon Street.

Many additional trips were made that day by automobile and transit by fans attending the parade. The parade began at 11:00 AM, but many fans arrived earlier to settle into a good viewing location. This case study compared traffic congestion on the region's roadways on the date of the Super Bowl parade with the traffic congestion that occurred on a typical weekday.

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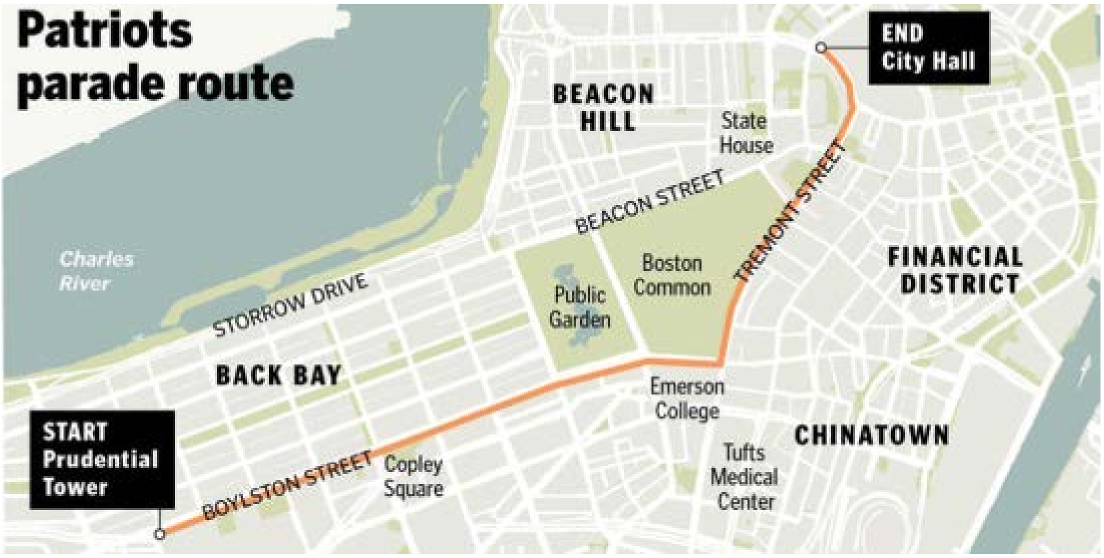
[9]Boston Globe, "Patriots victory parade is delayed until Wednesday," February 2, 2015, available online at https://www.bostonglobe.com/metro/2015/02/02/parade/hDkBsxq1Xtu6TSEAeFz0qJ/story.html.

[10] SB Nation, "Patriots Super Bowl parade 2015: Victory celebration rescheduled for Wednesday," February 2, 2015, available online at https://www.sbnation.com/nfl/2015/2/2/7963327/patriots-super-bowl-victory-parade-2015-date-time-route.

Figure 14
Patriots Super Bowl Parade Route



Source: Boston Globe.

The specific dates and times of the analysis, roadways and routes of focus, and datasets used in the analysis are as follows:

- Date: February 4, 2015
- Times monitored: 5:00 AM to 5:00 PM
- Roadways analyzed: All CMP-monitored roadways
- MBTA bus routes analyzed: None due to lack of MBTA data (the MBTA's Back on Track data was not available for 2015)
- Datasets used for analysis: MassDOT crash database and INRIX 2015 dataset

8.2 PERFORMANCE MEASURE SUMMARY

8.2.1 Roadways

Regional Performance

Figure 15 shows the expressway and arterial locations where travel speeds decreased on the morning of the Super Bowl parade versus a typical weekday. The most significant decreases occurred at select arterials in downtown Boston and expressways in the suburbs that lead to Boston. The widespread decreases in travel speeds might be attributed to the fact that the region experienced a major snow storm the day before the parade.

Table 17 compares the performance results for expressways and arterials on a typical weekday AM peak period and on the date of the Super Bowl parade. On the date of the parade, the average speeds on expressways decreased 2.7 MPH and the congested minutes per peak period hour increased by approximately 1.5 minutes. In addition, the travel time index on expressways increased by 0.05. This shows that traffic congestion increased slightly regionwide on expressways on the date of the parade, compared to a typical weekday.

On the day of the parade, the average speeds on arterial roadways decreased 0.5 MPH and the number of congested minutes decreased slightly. One reason that an increase in congestion was not evident is that parade traffic on arterials increased after the AM peak period ended as the parade began at 11:00 AM (the AM peak period is 6:30 AM to 9:30 AM). Additionally, local street closures and increased travel on arterials occurred closer to the start of the parade. In addition, many attendees might have opted to take public transportation to the parade rather than drive on the arterials close to Boston and look for parking.

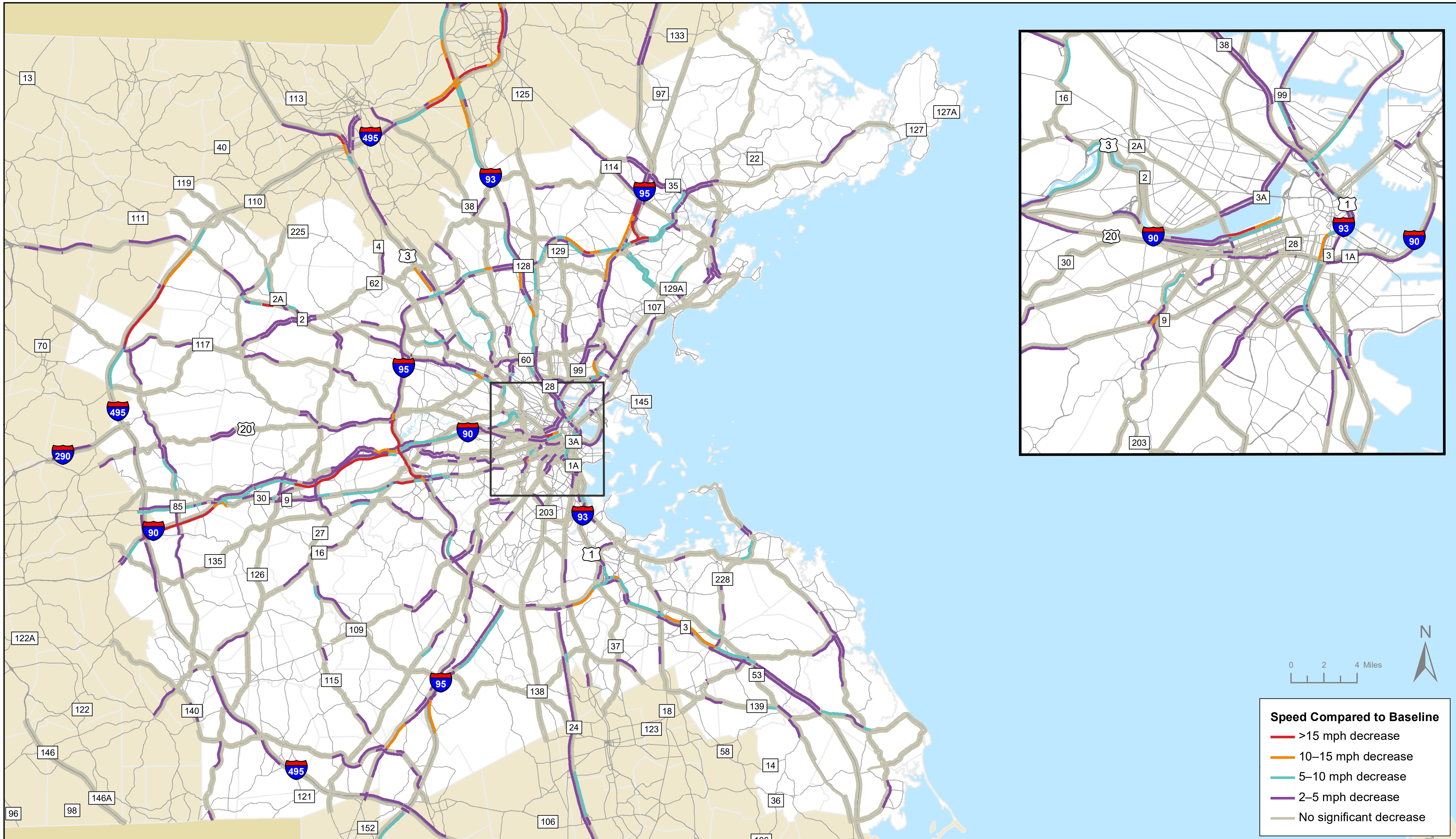


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Figure 15
Difference between Weekday Morning and Super Bowl Parade Morning Travel Speeds

Traffic Congestion in the Boston Region: Beyond the Daily Commute

Table 17
Traffic Conditions on Expressways and Arterials: Weekdays versus Super Bowl Parade Day

Performance Measure	Weekday AM	Super Bowl Parade AM
Expressway AM average speed (MPH)	58.89	56.18
Expressway AM congested minutes	5:44	7:25
Expressway AM travel time index	1.11	1.16
Arterial AM average speed (MPH)	28.24	27.67
Arterial AM congested minutes	9:28	9:14
Arterial AM travel time index	1.3	1.33

MPH = miles per hour.
Source: INRIX.

Expressway Travel Times

Tables 18 show the expressway locations where the most significant decreases in travel speeds occurred on the day of the parade. At some locations, speed decreases were as high as 53 MPH on the date of the parade. All of these locations are either on or outside the Route 128 corridor, which indicates that the most significant increase of traffic on the day of the parade might have been caused by fans from the suburbs driving directly into Boston or to an MBTA station.

Table 18
Expressway Locations with Significant Speed Decreases: Super Bowl Parade Day

Route	Direction	From	To	Times	Speed (MPH)	Change in Speed from Normal Peak Period (MPH)	Worst Location
I-95	Southbound	MA-114/Andover Street/Exit 47 (Topsfield)	MA-128/Exit 45 (Peabody)	6 AM - 9 AM	12.46	-53.54	US 1 to Route 128
I-95	Southbound	MA-28/Main Street/Exit 38 (Reading)	Totten Pond Road/Winter Street/Exit 27 (Waltham)	9 AM - 11 AM	10.13	-50.78	Middlesex Turnpike
I-495	Southbound	MA-97/Broadway/Exit 50 (Haverhill)	I-93/Exit 40 (Andover)	7 AM - 10 AM	13.14	-48.67	Marston Street/ Merrimack Street
I-90	Eastbound	I-495 (Westborough)	Exit 14 (Weston)	8 AM - 11 AM	18.19	-46.69	Route 30/Exit 13
MA-24	Southbound	MA-123/Exit 17 (Brockton)	US-44/Exit 13 (Bridgewater)	4 PM - 5 PM	16.54	-46.55	Route 104

I = Interstate. MA = Massachusetts highway route. MPH = miles per hour. US = United States highway route.
Source: INRIX.

Arterial Travel Times

Tables 19 show the arterial locations that had the most significant decreases in travel speeds on the day of the parade. These locations are throughout the Boston region, but some notable arterials are close to the parade route, including Storrow Drive and Brookline Avenue in Boston. These locations experienced speed reductions of as much as 35 MPH.

Table 19
Arterial Locations with Significant Speed Decreases: Super Bowl Parade Day

Route	Direction	From	To	Times	Speed (MPH)	Change in Speed from Normal Peak Period (MPH)	Worst Location
MA-9	Eastbound	Weston Road (Natick)	Cedar Street (Wellesley)	7 AM - 12 PM	9.03	-35.33	Oakland Street to Cedar Street
Storrow Drive	Westbound	MA-28/Embankment Road (Boston)	MA-2A/Massachusetts Avenue (Boston)	7 AM – 12 PM	15.28	-26.24	Clarendon Street to Massachusetts Avenue
MA-28	Northbound	Franklin Street (Stoneham)	Montvale Avenue (Stoneham)	5 AM – 6 AM	23.00	-25.48	Franklin Street to Montvale Avenue
MA-9	Eastbound	MA-27/Main Street (Natick)	Oak Street (Natick)	2 PM – 3 PM	11.08	-22.31	Walnut Street to Oak Street
Storrow Drive	Eastbound	Charlesgate (Boston)	MA-28/Embankment Road (Boston)	8 AM – 10 AM	16.97	-21.30	Boylston Street to Clarendon Street

MA = Massachusetts highway route. MPH = miles per hour. US = United States highway route.
Source: INRIX.

8.2.2 Safety

Table 20 compares the number of crashes that occurred on the day of the Super Bowl parade with a typical weekday. This analysis compared crash frequencies and crash rates for expressways and arterials on the day of the Super Bowl Parade, February 4, 2015, to other weekdays in 2015. There were 46 crashes on expressways and 66 crashes and on arterials on the day of the parade. On other weekdays, there were 8,194 crashes, including 23 fatal crashes, on expressways and 16,035 crashes, including 26 fatal crashes, on arterials. The average daily crash rate was 31.3 per day and the fatal crash rate was 0.1 per day on expressways. The average daily crash rate was 61.2 per day and the fatal crash rate was 0.1 per day on arterials. Compared with other weekdays, the daily crash rate on Super Bowl Parade day increased 47 percent for expressways and 8 percent for arterials.

Table 20
Crashes and Fatalities: Super Bowl Parade Day versus Weekdays, 2015

Measure	CMP Weekdays	Super Bowl Parade Day
Expressway crashes	8,194	46
Expressway crash rate	31.3	46
Expressway fatalities	23	0
Expressway fatality rate	0.1	0
Arterial crashes	16,035	66
Arterial crash rate	61.2	66
Arterial fatalities	26	0
Arterial fatality rate	0.1	0

Source: MassDOT Crash Database.

8.2.3 Findings

- The average speeds on the expressways decreased by 2.7 MPH on the day of the parade, and the average speeds on the arterials decreased by 0.5 MPH. However, there were certain locations were speeds decreased by over 50 MPH.
- The most significant decrease in travel speeds on expressways occurred in the suburbs of Boston. This indicates that fans attending the parade tended to drive to MBTA stations, and take public transportation to the city. There is evidence that travel speeds decreased at locations leading to MBTA stations, such as Interstate 495 at Marston Street.
- Congested minutes on arterials actually decreased on the day of the parade.

- Speeds at some of the locations on expressways were 9.5 times slower on the day of the parade than during free-flow hours. Speeds at some of the locations on arterials were 17 times slower on the day of the parade than during free-flow hours.
- The daily crash rate was slightly higher on the day of the parade than on a typical weekday for both expressways and arterials.

8.2.4 Strategies and Recommendations

Inform the public about the location of the parade and road closures by social media, and news and radio outlets so that commuters can properly plan their travel for the day.

Chapter 9—Case Study: Wednesday before Thanksgiving

9.1 DESCRIPTION OF EVENT AND LOCATION

The day before Thanksgiving is a busy travel day. Oftentimes, travelers will leave the Boston region to travel to other areas of the country. Typically, travelers leave the Boston region during various times during the week, but the most popular time to leave is the Wednesday before Thanksgiving, between 12:00 PM and 10:00 PM.

This case study analyzed four expressway corridors in the region that typically contain the most congested locations on the day before Thanksgiving, according to Boston.com: Interstate 93 northbound between Interstate 90 and the New Hampshire border, Interstate 93 southbound between the Zakim Bridge and Interstate 95, Interstate 95 northbound from Interstate 90 to the New Hampshire border, and Interstate 95 from Interstate 93 to the Rhode Island border .[11]

The specific dates and times of the analysis, roadways and routes of focus, and datasets used in the analysis are as follows:

- Date: November 25, 2015
- Times monitored: 12:00 PM to 10:00 PM
- Roadways analyzed: Interstate 93 northbound between Interstate 90 and the New Hampshire border, Interstate 93 southbound between the Zakim Bridge and Interstate 95, Interstate 95 northbound from Interstate 90 to the New Hampshire border, and Interstate 95 from Interstate 93 to the Rhode Island border
- MBTA bus routes analyzed: 325, 326, 350, 351, 352, and 354
- Datasets used for analysis: INRIX, MassDOT crash database, and MBTA Back on Track dataset

9.2 PERFORMANCE MEASURE SUMMARY

9.2.1 Roadways

Travel Times

Figure 16 shows the locations where travel speeds decreased on the Wednesday before Thanksgiving in 2015 versus a typical weekday. Of the four

[11] Boston.com, "Boston's 10 worst traffic bottlenecks around Thanksgiving, according to AAA", November 18, 2017, available online at Boston's 10 worst traffic bottlenecks around Thanksgiving, according to AAA | Boston.com | Boston.com.

corridors that were analyzed in this case study; the main locations where travel speeds decreased were Interstate 95 southbound between Interstate 93 and Interstate 290, Interstate 95 northbound at Route 62, and Interstate 95 northbound between Interstate 93 and Route 28.

Tables 21 and 22 show the performance results for the Interstate 93 and Interstate 95 corridors, respectively. Of the corridors, Interstate 93 southbound between the Zakim Bridge and Interstate 95 was the most congested on November 25, 2015; this location ranked as the worst in terms of congested minutes, average speed, delay per mile, bottleneck factor, and travel time index.

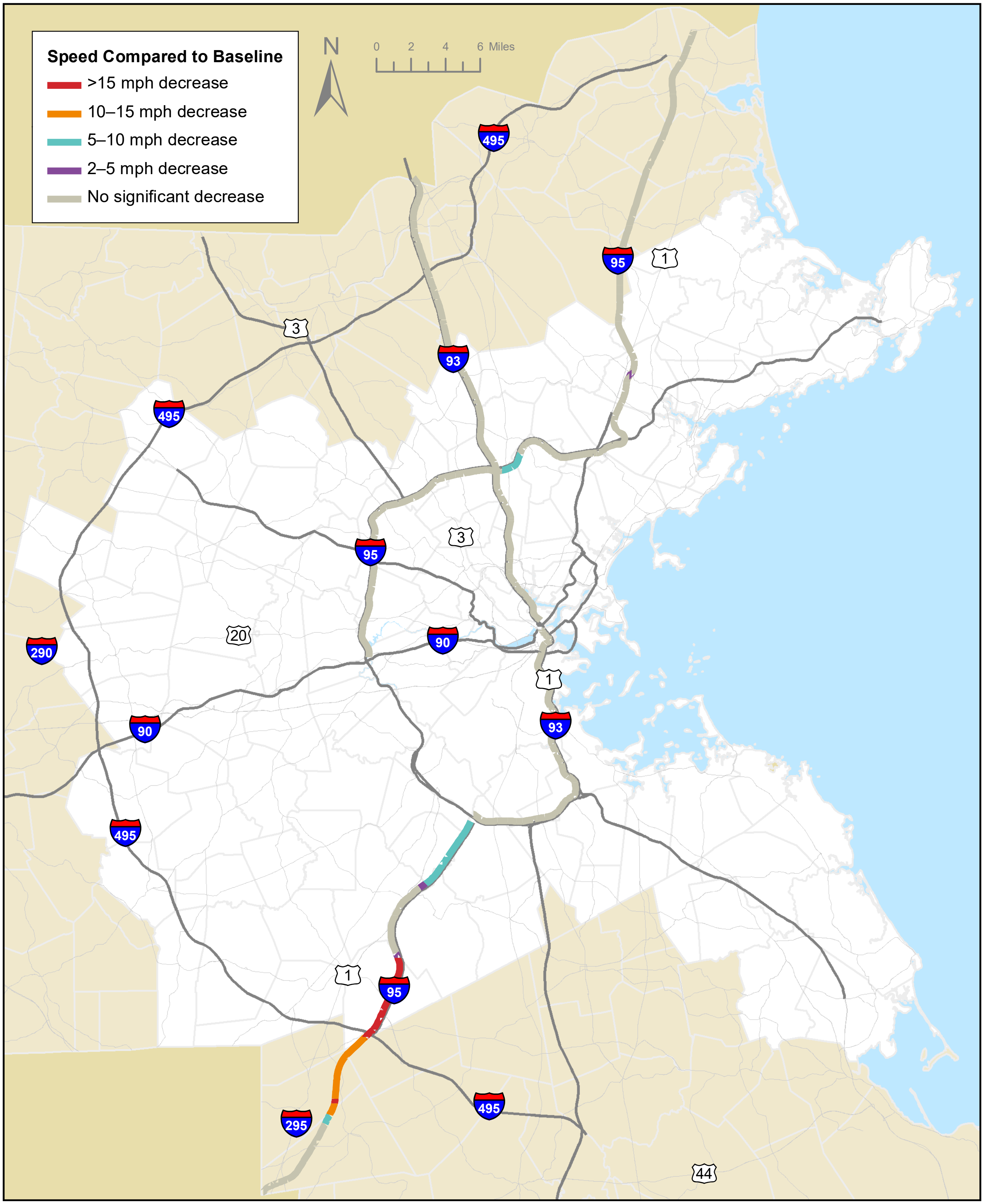

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Figure 16
Difference between Weekday and Thanksgiving Eve Travel Speeds

Traffic Congestion in the Boston Region: Beyond the Daily Commute

Table 21
Traffic Conditions on I-93: Typical Weekday Compared to November 25, 2015, 12:00 PM to 10:00 PM

Performance Measure	I-93 Northbound (Boston – New Hampshire) Weekday	I-93 Northbound (Boston – New Hampshire) Holiday	I-93 Southbound (Boston – Dedham) Weekday	I-93 Southbound (Boston – Dedham) Holiday
Distance (miles)	29.86	29.86	18.06	18.06
Congested minutes per hour	21:22	6:00	34:30	30:00
Average travel time	44:35	36:23	40:31	31:55
Average speed (MPH)	40.19	49.24	26.7	33.97
Average delay (minutes)	17:25	9:13	23:08	14:31
Bottleneck factor	0.86	.19	1.73	1.23
Travel time index	1.64	1.34	2.32	1.83
Travel time / planning time ratio	48%	39%	49%	38%

Source: INRIX.

Table 22
Traffic Conditions on I-95: Typical Weekday Compared to November 25, 2015, 12:00 PM to 10:00 PM

Performance Measure	I-95 Northbound (Weston – New Hampshire) Weekday	I-95 Northbound (Weston – New Hampshire) Holiday	I-95 Southbound (Dedham-Rhode Island) Weekday	I-95 Southbound (Dedham-Rhode Island) Holiday
Distance (miles)	51.50	51.50	26.07	26.07
Congested minutes per hour	11:55	3:30	04:48	3:00
Average travel time	61:18	56:22	26:29	28:13
Average speed (MPH)	50.4	54.82	59.1	55.45
Average delay (minutes)	14:38	9:41	3:31	1:24
Bottleneck factor	0.49	.10	0.19	.09
Travel time index	1.31	1.21	1.15	1.23
Travel time / planning time ratio	53%	88.9%	59%	102.8%

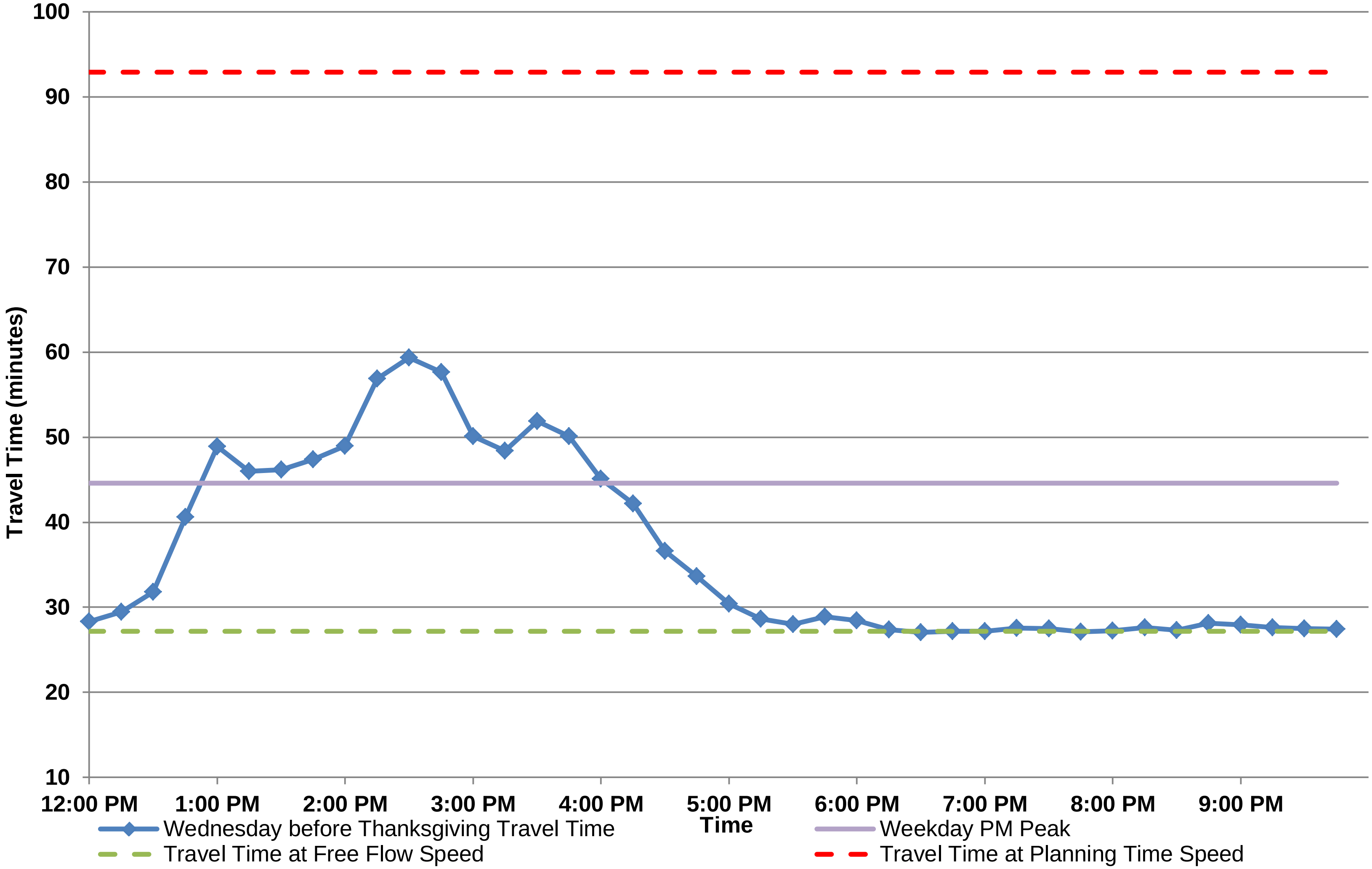
Source: INRIX.

Figures 17, 18, 19, and 20 show the travel times on the corridors studied. Travel times on all four corridors were longer than travel times during a typical peak period at points between 12:00 PM and 10:00 PM on the day before Thanksgiving. Travel times on Interstate 95 southbound were longer than the planning time index of a typical weekday between 4:00 PM and 4:15 PM.

I-93 Northbound between I-90 and New Hampshire

There was a spike in congestion on Interstate 93 northbound between Interstate 90 and the New Hampshire border beginning at 12:30 PM and continuing until 4:00 PM. After 4:00 PM, the travel times improved significantly until reaching free-flow travel time levels by 5:15 PM. The most congested location was between Interstate 95 and Interstate 495, which experienced congestion worse than that of a typical weekday peak period between 12:45 PM and 3:15 PM. At this time, the travel time index increased to 2.18, which is significantly higher than the travel time index of 1.64 as occurs on a typical PM peak on a weekday. In addition, this location experienced an average of 18 congested minutes per hour at this time.

Figure 17
Travel Times on I-93 Northbound from I-90 Interchange, Boston, to New Hampshire Border

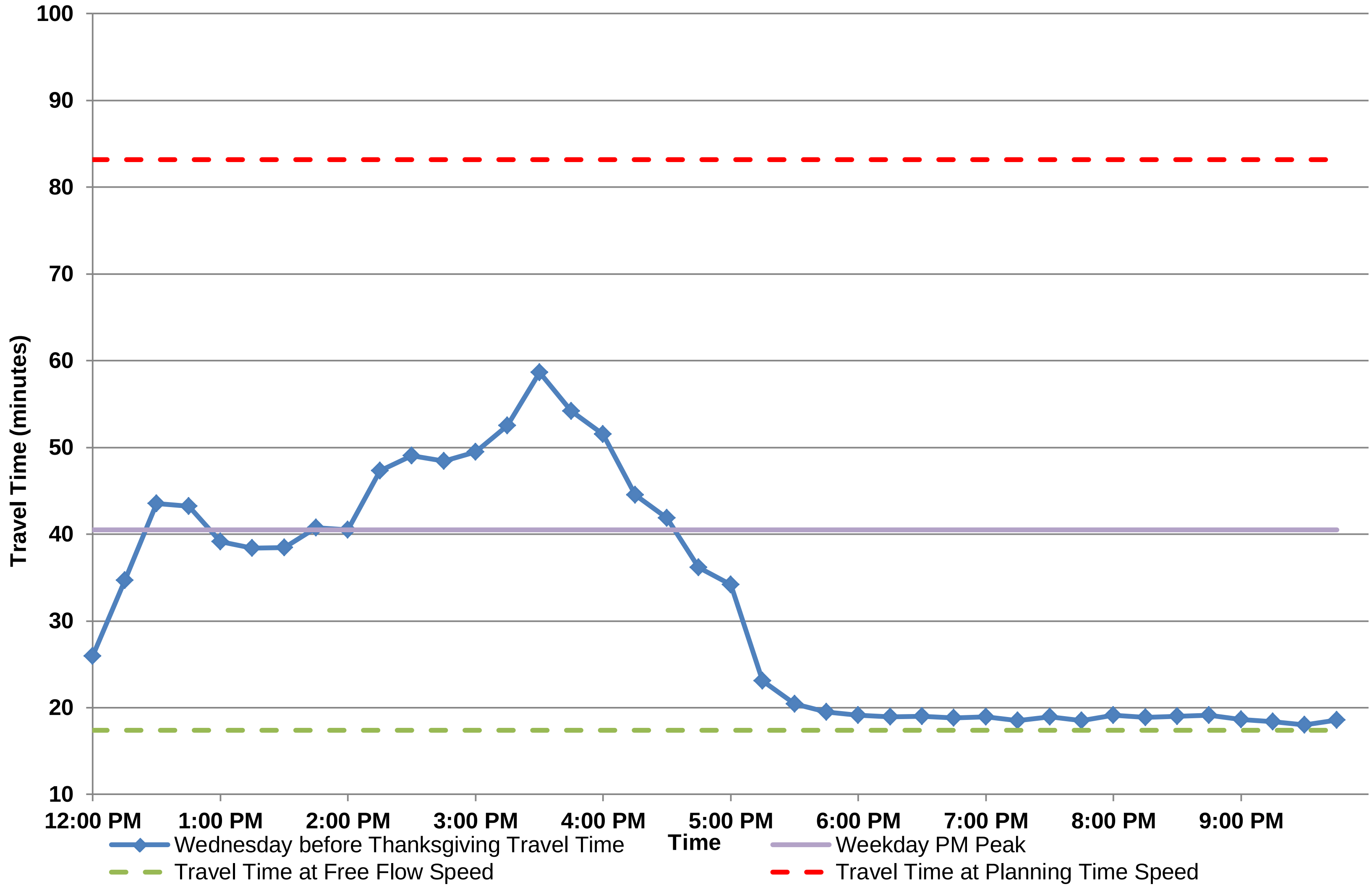


Source: INRIX

I-93 Southbound between Zakim Bridge and I-95

On November 25, 2015, I-93 southbound between Zakim Bridge and Interstate 95 was the most congested of the corridors analyzed. Travel times on Interstate 93 southbound were as much as 50 percent longer than on a peak period of a typical weekday between 2:00 PM and 4:30 PM. The entire corridor experienced extreme congestion. Between 2:00 PM and 4:30 PM the travel time index increased to 3.37 and there were 60 minutes of congestion per hour, which is the maximum. The analysis showed that Interstate 93 was constantly congested during this time and that travelers would have had to budget at least three times as much travel time to arrive at their destination on time versus when there are free-flow conditions.

Figure 18
Travel Times on I-93 Southbound from Zakim Bridge, Boston, to I-95 Interchange, Dedham

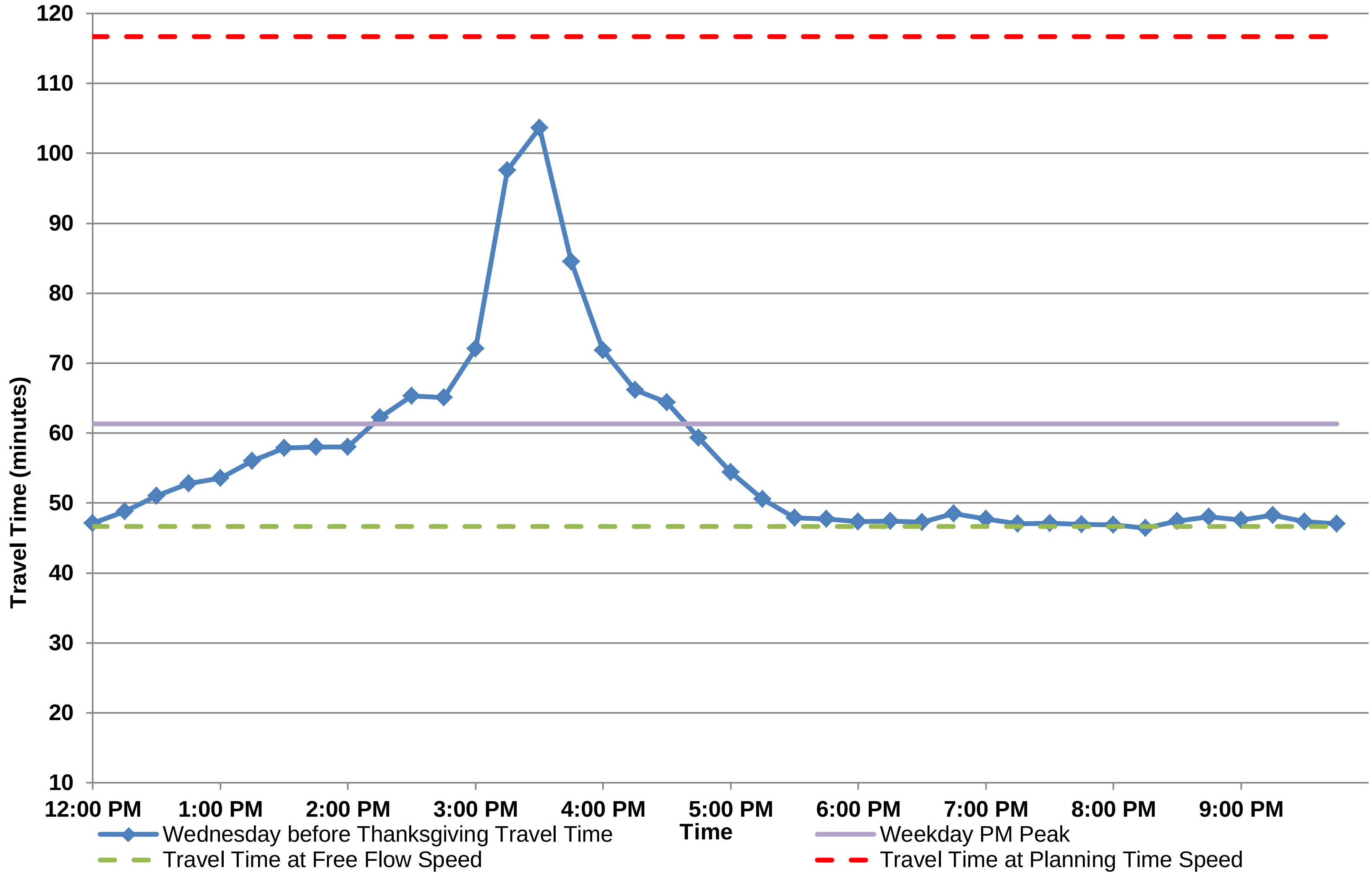


Source: INRIX

I-95 Northbound from I-90 to New Hampshire

Interstate 95 northbound between Interstate 90 and the New Hampshire border experienced congestion that spikes between 3:00 PM and 4:00 PM on the Wednesday before Thanksgiving. The congestion level was 68 percent worse than on a typical weekday PM peak period. The spike in travel times on Interstate 95 northbound lasted a relatively short time, between 2:45 PM and 4:15 PM. The most congested location on the Interstate 95 northbound corridor was between Route 3 and I-93, where the travel time index spiked to 1.68 and there were 10.5 minutes of congestion per hour during the analysis period.

Figure 19
Travel Times on I-95 Northbound from I-90 Interchange, Weston, to New Hampshire Border

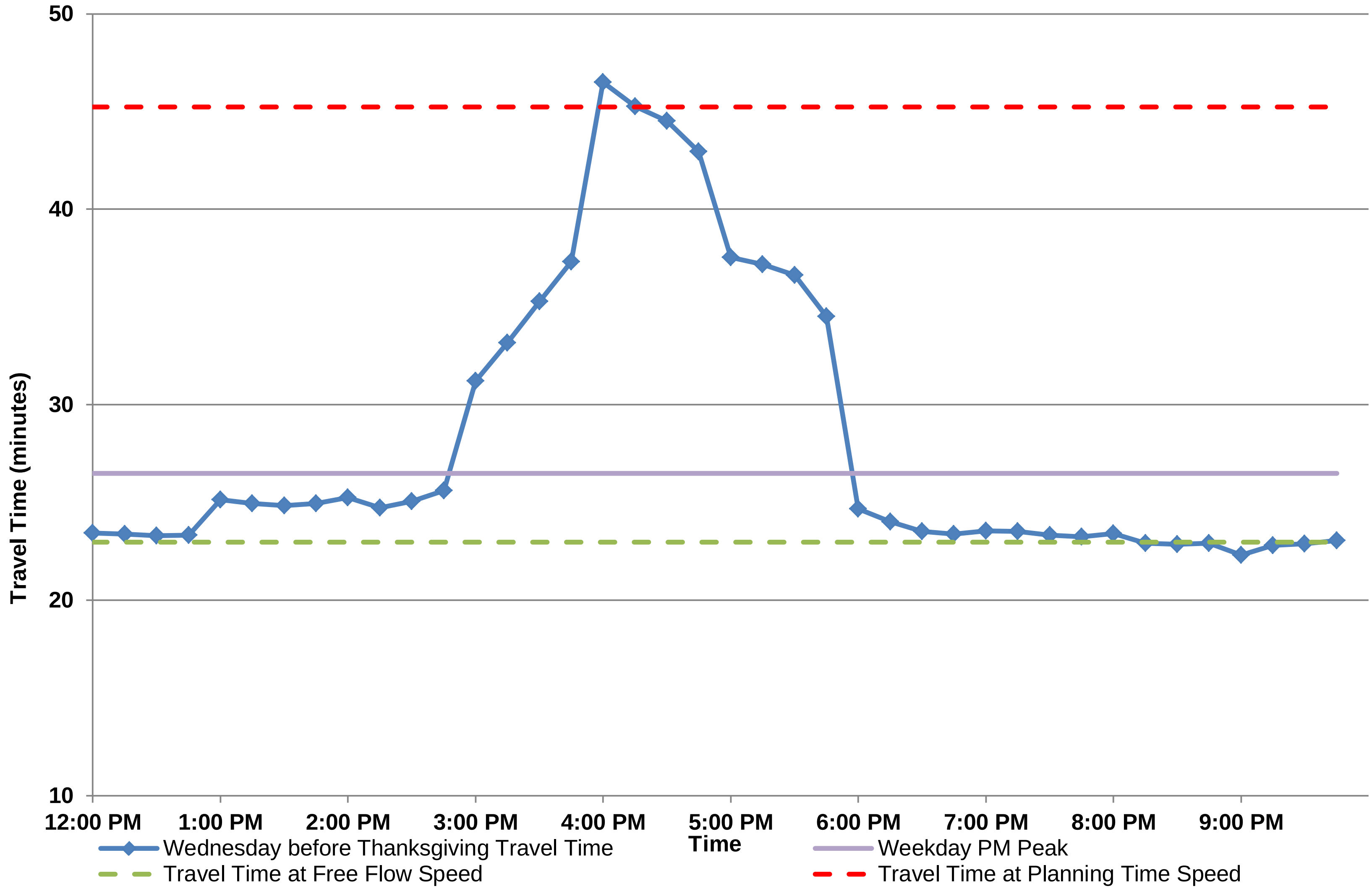


Source: INRIX

I-95 Southbound from I-93 to Rhode Island

On November 25, 2015, Interstate95 southbound between Interstate 93 and the Rhode Island border experienced congestion up to 75 percent higher than a typical peak period. This corridor also briefly experienced travel times that were two percent longer than the planning time index travel time. The most congested times were between 3:45 PM and 5:00 PM and the congestion lasted from 2:45 PM to 6:00 PM. The most congested location was Interstate 95 between Interstate 93 and Interstate 495, which experienced travel times that were six percent higher than the weekday planning time index, and there were six congested minutes for every hour during the monitoring period.

Figure 20
Travel Times on I-95 Southbound from I-93 Interchange, Dedham, to Rhode Island Border



Source: INRIX

Worst locations and times

Tables 23 and 24 show the most congested corridors during a typical weekday and on the day before Thanksgiving on I-93 and I-95, respectively. On the day before Thanksgiving, the most congested locations and times along the corridors that were analyzed were as follows:

- Interstate 93 North – Interstate 95 to Interstate 495 (Reading to Andover) between 2:15 PM and 2:45 PM
- Interstate 93 South – Zakim Bridge to Route 3 (Boston to Braintree) between 3:00 PM and 4:00 PM
- Interstate 93 South – Route 3 to Interstate 95 (Braintree to Dedham) between 3:00 PM and 4:00 PM
- Interstate 95 North – Route 3 to Interstate 93 (Burlington to Reading) between 3:15 PM and 4:15 PM
- Interstate 95 South – Interstate 93 to Interstate 495 (Dedham to Foxborough) between 4:00 PM and 5:00 PM

Interstate 95 between Interstate 93 and Interstate 495 experienced the highest increase in congested minutes per hour, with an increase of 27 minutes per hour. This corridor also had the most significant decline in travel speeds, with a decrease of 26.5 MPH on the day before Thanksgiving, compared to the weekday PM peak period. Travel times on this section of Interstate 95 were nearly as high as the planning time index travel time. Interstate 93 southbound from the Zakim Bridge to Route 3 had the highest increase in average delay and the highest travel time index during the most congested time. Interstate 95 northbound had the highest bottleneck factor during its most congested time.

Table 23
Traffic Conditions at Most Congested Locations on I-93: Typical Weekday Compared to Most Congested Time on Wednesday before Thanksgiving

Performance Measure	I-93 North – I-95 to I-495 (Reading – Andover)-Weekday	I-93 North – I-95 to I-495 (Reading – Andover)-Holiday	I-93 South – Zakim Bridge to Route 3 (Boston – Braintree)-Weekday	I-93 South – Zakim Bridge to Route 3 (Boston – Braintree) - Holiday	I-93 South – Route 3 to I-95 (Braintree-Dedham)-Weekday	I-93 South – Route 3 to I-95 (Braintree-Dedham) - Holiday
Time of analysis	PM Peak	2:15 PM-2:45 PM	PM Peak	3:00 PM-4:00 PM	PM Peak	3:00 PM-4:00 PM
Distance (miles)	12.02	12.02	10.85	10.85	7.21	7.21
Congested minutes per hour	11:28	27:37	46:31	57:13	16:26	28:06
Average travel time	13:59	21:07	27:07	39:41	8:54	13:04
Average speed (MPH)	51.55	34.15	24.02	16.40	48.61	33.10
Average delay (minutes)	3:29	10:37	16:20	28:55	2:17	6:27
Bottleneck factor	0.43	1.10	2.44	2.93	0.78	2.66
Travel time index	1.33	2.01	2.52	3.68	1.35	1.97
Travel time / planning time ratio	48%	73%	42%	61%	49%	73%

MPH = miles per hour.
Source: INRIX.

Table 24
Traffic Conditions at Most Congested Locations on I-95: Typical Weekday compared to most congested time on Wednesday before Thanksgiving

Performance Measure	I-95 North – Route 3 to I-93 (Burlington–Reading) Weekday	I-95 North – Route 3 to I-93 (Burlington–Reading) Holiday	I-95 South – I-93 to I-495 (Dedham–Foxborough Weekday	I-95 South – I-93 to I-495 (Dedham–Foxborough) Holiday
Time of analysis	PM Peak	3:15 PM – 4:15 PM	PM Peak	4:00 PM – 5:00 PM
Distance (miles)	5.72	5.72	14.19	14.19
Congested minutes per hour	36:10	43:45	6:05	33:38
Average travel time	10:08	20:37	14:37	26:46
Average speed (MPH)	33.84	16.64	58.29	31.82
Average delay (minutes)	4:50	15:19	2:05	14:14
Bottleneck factor	1.93	3.77	0.22	1.45
Travel time index	1.91	3.14	1.17	2.14
Travel time / planning time ratio	31%	63%	53%	97%

MPH = miles per hour.
Source: INRIX.

The traffic conditions on the four most congested roadway TMC locations of the corridors described in table 23 and table 24 on the day before Thanksgiving are described below.

I-93 Northbound from Concord Street to Route 125

This 2.5 mile stretch of roadway contains three interchanges. The most congestion was seen at this location between 2:15 PM and 2:45 PM. During that period, this location was congested every minute. The delay per mile was two minutes and 33 seconds and the travel time index spiked to 3.96 at this location. This section of Interstate 93 northbound has a narrow breakdown lane, therefore additional congestion can result during an incident.

I-93 Southbound from Route 3 to Route 28

The most congestion at this location occurred between 3:00 PM and 4:00 PM. This location includes the Braintree Split, where Route 3 diverges from Interstate 93. The bottleneck continues to the exit to Route 28, which is the exit before Route 24 diverges from Interstate 93 leading to locations such as New Bedford and Fall River. This location was congested for the full 60 minutes during the worst hour of the analysis. Also during the worst hour, this location had a delay per mile of up to two minutes and 10 seconds per mile and a travel time index of 3.31. Congestion at this location could be caused by weaving movements of vehicles at both the Braintree Split and before Route 24. Drivers commonly have to cross two or three lanes to exit or avoid exiting Interstate 93.

I-95 Northbound from Route 38 to I-93

The most congested time at this location was between 3:15 AM and 4:15 PM. This location experienced congestion during this entire time with a delay per mile of five minutes and 13 seconds. The travel time index at this location was 7.33. There is a brief lane drop on Interstate 95 northbound at Interstate 93, where the expressway goes from four lanes to three lanes plus an auxiliary lane, which could be the cause of the bottleneck. The bottleneck may have been amplified because of a crash on Interstate 95 near North Avenue in Wakefield during this travel time sample.

I-95 Southbound between Route 140 and I-495

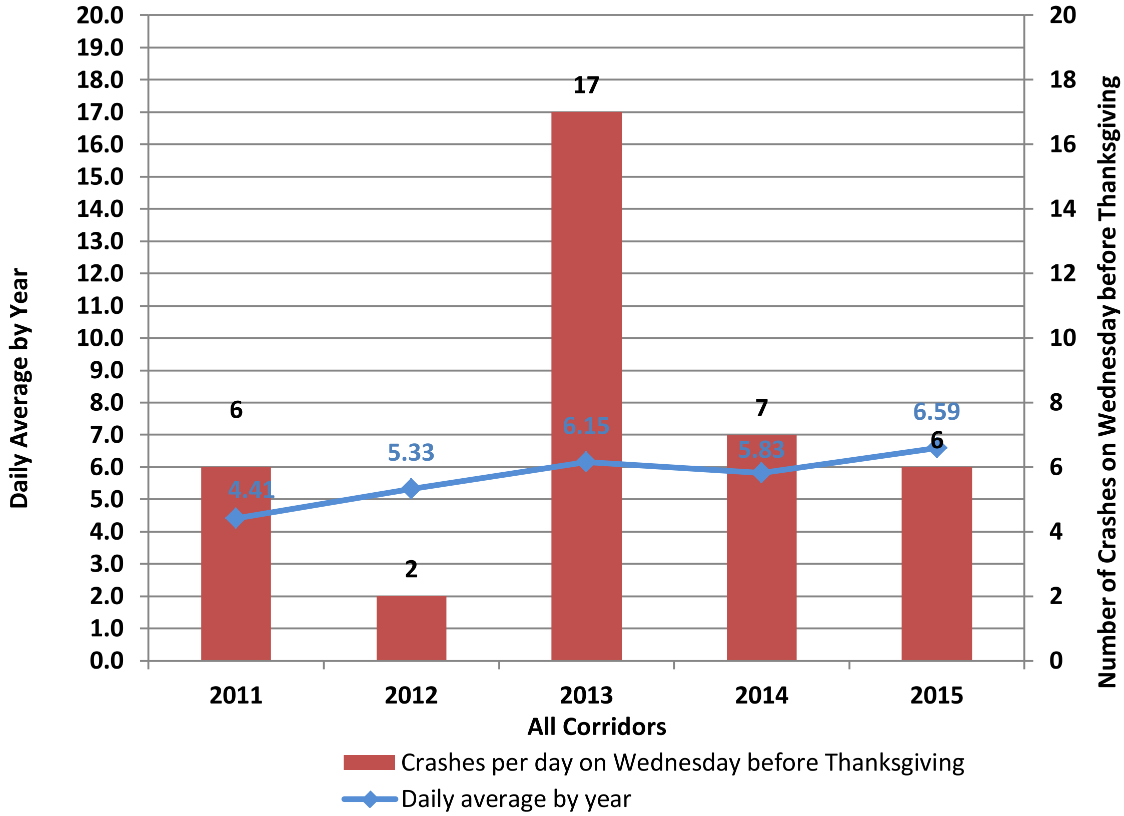
The most congested time at this location was between 4:00 PM and 5:00 PM, when congested conditions endured for the entire hour. The delay per mile at this location was two minutes and 25 minutes per mile. The travel time index at this location was 3.78. The geometric configurations of the interchange between Interstate 95 and Interstate 495 should be analyzed to determine if improvements are needed at this interchange.

9.2.2 Safety

Figure 21 shows the five-year trend for crashes on the day before Thanksgiving. In most years, the number of crashes during the day before Thanksgiving is slightly higher than the number of crashes on a typical day for the corridors analyzed in this case study. However, there was a noticeable spike in crashes in 2013, where there were 17 crashes on the day before Thanksgiving compared to 6.15 crashes on a typical day at these locations in 2013. The reason for this spike in crashes on this date can be attributed to a rainstorm that dropped over an inch of water. In 2013, the most significant spikes in crashes on the day before Thanksgiving occurred on Interstate 93 between the Zakim Bridge and Route 3 and on Interstate 95 southbound between Interstate 495 and the Rhode Island border.

The locations that had the most crashes on the day before Thanksgiving between 2011 and 2015 were Interstate 95 northbound at Route 20 and Interstate 93 southbound at Neponset Circle; three crashes occurred at each location. On Interstate 95 northbound at Route 20, two of the three crashes were either rear-end or angle collisions. On Interstate 93 southbound at Neponset Circle, all three crashes were sideswipes in the same direction, which could indicate that vehicles changing lanes to exit the expressway caused the crashes. In addition, there was a crash on Interstate 95 northbound in Wakefield at 2:45 PM on November 25, 2015. This crash did result in an injury and was probably the cause of the spike in congestion on Interstate 95 northbound on that date.

Figure 21
Five-Year Crash Trend, Day before Thanksgiving, 2011-15



Source: MassDOT Crash Database.

9.2.3 Findings

- Overall, traffic increases on these corridors on the day before Thanksgiving earlier than on a normal weekday peak period. This is likely because workers either take the entire day off or work half days before leaving the city. This is a good practice because it disperses the traffic throughout the entire day, which will decrease the intensity of the traffic congestion during the peak travel time. Because of this travel behavior, it is recommended that travelers using these corridors leave as early as 12:00 PM to avoid any traffic congestion. Table 25 shows the recommended times that travelers should leave to avoid encountering congestion in a corridor.

Table 25
Recommended Times to Leave Boston on the Day before Thanksgiving

Corridor	I-93 Northbound	I-93 Southbound	I-95 Northbound (from I-90)	I-95 Southbound (from I-93 in Westwood)
Recommended leave time	Leave before 12:00 PM or after 4:45 PM	Leave before 12:00 PM or after 5:15 PM	Leave before 12:30 PM or after 5:00 PM	Leave before 2:30 PM or after 6:00 PM

Source: Central Transportation Planning Staff.

9.2.4 Strategies and Recommendations

- Inform travelers of the recommended departure times for this day. Communicate these departure times through TV, social media, and news outlets.
- Improve response to weather events and road surface problems as inclement weather is common during this time of the year, and can lead to an increased number of crashes. Many of the crashes that occurred on the day before Thanksgiving took place during rainy or snowy conditions.
- Make sure signage is adequate for alerting travelers that they are approaching the Braintree Split and other exits and interchanges to reduce vehicle weaving. Crashes often occur when travelers change lanes to exit an expressway.

Chapter 10—Case Study: Fridays

10.1 DESCRIPTION OF EVENT AND LOCATION

Typically, through the CMP, congestion in the Boston region is monitored on Tuesdays, Wednesdays, and Thursdays. However, congestion that occurs on Fridays may be more extreme than mid-week congestion. The Friday evening peak period (3:00 PM to 7:00 PM) includes both work-based trips and trips for travelers heading out of town for the weekend. One possible cause of congestion on Fridays is traffic created by Boston area residents who leave the region for the weekend by taking Interstates 93, 90, 95, and Route 3.

The specific dates and times of the analysis, roadways and routes of focus, and datasets used in the analysis are as follows:

- Dates: CMP monitoring dates in 2015
- Times monitored: 12:00 PM to 10:00 PM
- Roadways analyzed: Interstate 93 northbound from Interstate 90 to the New Hampshire border, Interstate 93 southbound from Zakim Bridge to Interstate 95, Interstate 90 westbound from Interstate 93 to Westborough, Interstate 95 northbound from Interstate 90 to the New Hampshire border, Interstate 95 southbound from Interstate 93 to the Rhode Island border, and Route 3 southbound from Interstate 93 to Route 6
- MBTA bus routes analyzed: 325, 326, 350, 351, 352, 354, 170, 501, 502, 503, 504, 505, 553, 554, 556, and 558
- Datasets used for analysis: INRIX, MassDOT crash database, and MBTA Back on Track dataset

10.2 PERFORMANCE MEASURE SUMMARY

10.2.1 Roadways

Regional Performance of Expressways

The entire expressway system for the Boston region was analyzed for the Friday PM peak period and compared to a typical CMP monitored weekday (Tuesdays, Wednesdays, and Thursdays). Figure 22 shows the expressway locations that experienced a decrease in speed during the Friday PM peak, compared to a typical weekday PM peak. The locations where the most significant speed decreases occurred on Fridays were on the expressways leading away from Boston, and on Interstate 495 between Lowell and Lawrence.

Table 26 compares the performance results for all expressways in the Boston region during the Friday PM peak period to the PM peak period of a typical weekday in 2015. Throughout the region, the expressways speeds decreased by 2 MPH during the Friday PM peak period compared to the peak period of a typical weekday. In addition, the congested minutes per hour increased by 2.5 minutes on Fridays.

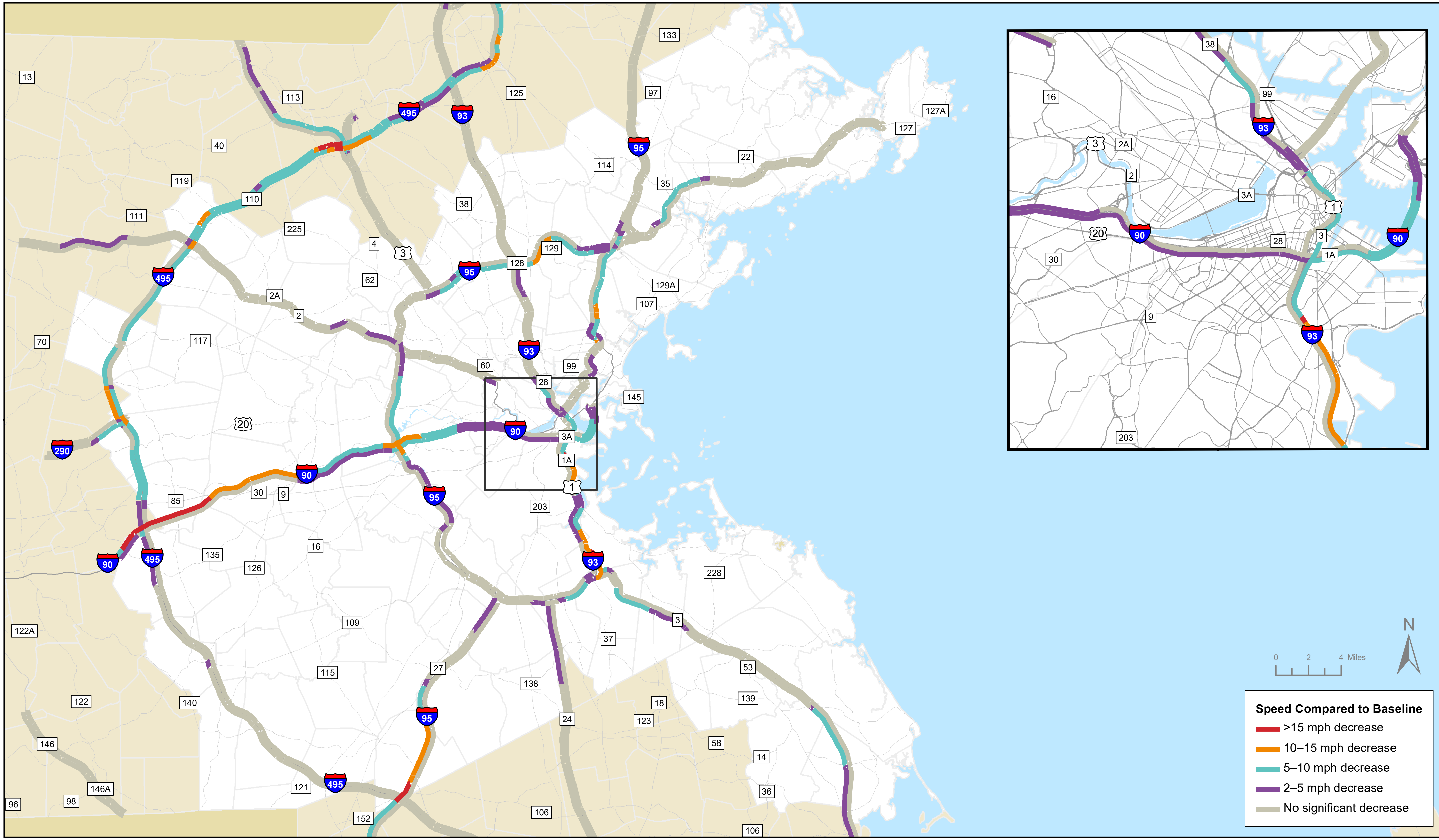


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Figure 22
Difference between Weekday and Friday Afternoon and Evening Travel Speeds

Traffic Congestion in the Boston Region: Beyond the Daily Commute

Table 26
Traffic Conditions on Expressways: Weekdays versus Fridays, PM Peak Period

Performance Measure	Weekday (Tuesday – Thursday) PM	Friday PM
Average speed (MPH)	58.84	56.83
Congested minutes	5:54	8:21
Travel Time index	1.11	1.15

MPH = miles per hour.
PM Peak Period = 3:00 PM to 7:00 PM.
Source: INRIX.

Corridor Performance

Tables 27, 28, 29 and 30 compare the performance results for the corridors of interest in this case study. Of the corridors, Interstate 93 southbound had the most congested minutes per hour, 19.16 minutes. All corridors experienced a net increase of travel time during the PM peak periods on Fridays. However, Interstate 90 westbound experienced the most percentage change in travel time between Fridays and a typical weekday. The most congested time was between 4:00 PM and 5:00 PM on Interstate 93 northbound and Interstate 95 northbound. The most congested time on all of the other corridors was between 5:00 PM and 6:00 PM.

Table 27
Friday Traffic Conditions on Expressways: I-90, Fridays, PM Peak

Performance Measure	I-90 Westbound (Boston – Westborough) (Tuesday-Thursday)	I-90 Westbound (Boston – Westborough) (Friday)
Distance (miles)	30.11	30.11
Congested minutes per hour	14:23	26.25
Average travel time	38:16	47:16
Average speed (MPH)	47.21	38.22
Average delay (minutes)	9:55	18:55
Bottleneck factor	.59	.79
Travel time index	1.35	1.67
Travel time / planning time ratio	46%	57%

MPH = miles per hour.
PM Peak Period= 3:00 PM to 7:00 PM.
Source: INRIX

Table 28
Friday Traffic Conditions on Expressways: I-93, Fridays, PM Peak

Performance Measure	I-93 Northbound (Boston – New Hampshire) (Tuesday-Thursday)	I-93 Northbound (Boston – New Hampshire) (Friday)	I-93 Southbound (Boston – Dedham) (Tuesday-Thursday)	I-93 Southbound (Boston – Dedham) (Friday)
Distance (miles)	29.86	29.86	18.06	18.06
Congested minutes per hour	21:22	18:45	34:30	52:30
Average travel time	44:35	44:31	40:31	41:14
Average speed (MPH)	40.19	40.24	26.7	26.3
Average delay (minutes)	17:25	17:21	23:08	23:50
Bottleneck factor	0.86	.56	1.73	2.10
Travel time index	1.64	1.64	2.32	2.37
Travel time / planning time ratio	58%	48%	49%	50%

MPH = miles per hour.
PM Peak Period= 3:00 PM to 7:00 PM.
Source: INRIX.

Table 29
Friday Traffic Conditions on Expressways: I-95, Fridays, PM Peak

Performance Measure	I-95 Northbound (Weston – New Hampshire) (Tuesday-Thursday)	I-95 Northbound (Weston – New Hampshire) (Friday)	I-95 Southbound (Dedham – Rhode Island) (Tuesday-Thursday)	I-95 Southbound (Dedham – Rhode Island) (Friday)
Distance (miles)	51.50	51.50	26.07	26.07
Congested minutes per hour	11:54	14:17	4:48	4.62
Average travel time	61:18	66:57	26:29	28:30
Average speed (MPH)	50.4	46.15	59.1	54.88
Average delay (minutes)	14.38	20:17	3:31	5:32
Bottleneck factor	.49	.73	0.19	0.16
Travel time index	1.31	1.43	1.15	1.24
Travel time / planning time ratio	53%	57%	59%	63%

MPH = miles per hour.
PM Peak Period= 3:00 PM to 7:00 PM.
Source: INRIX.

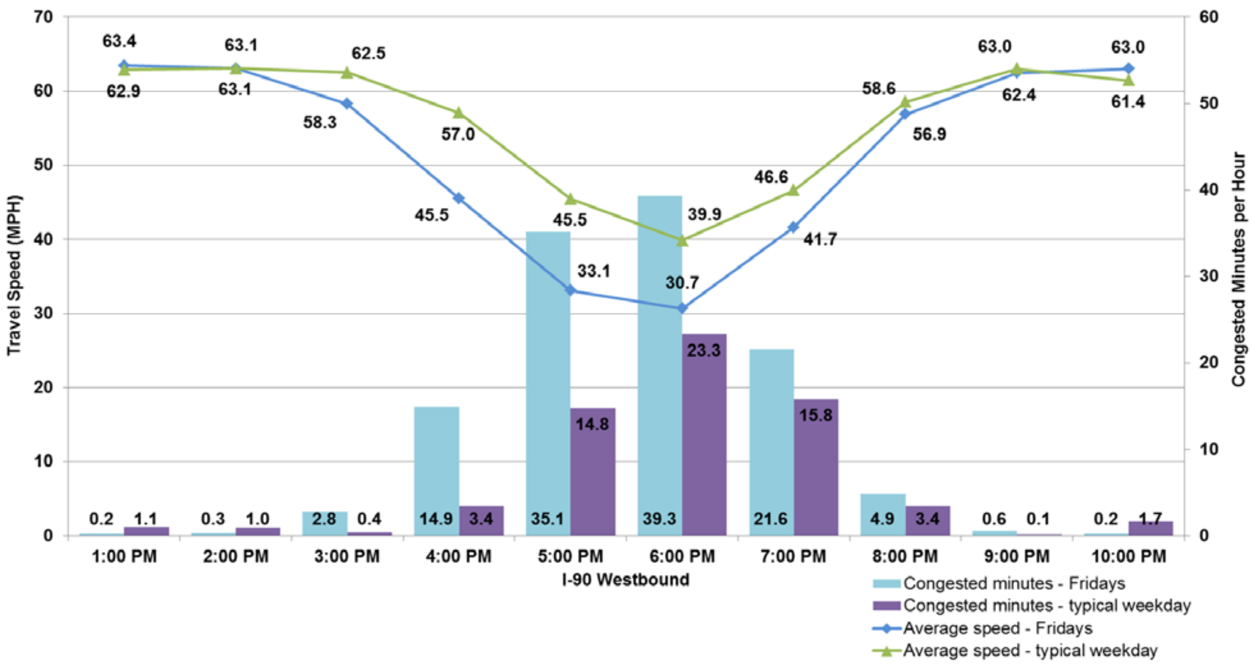
Table 30
Friday Traffic Conditions on Expressways: Route 3 South, Fridays, PM Peak

Performance Measure	Route 3 South Southbound (Braintree – Sagamore Bridge) (Tuesday-Thursday)	Route 3 South Southbound (Braintree – Sagamore Bridge) (Friday)
Distance (miles)	42.47	42.47
Congested minutes per hour	2.40	3.12
Average travel time	43:52	45:01
Average speed (MPH)	58.09	56.6
Average delay (minutes)	5:03	6:13
Bottleneck factor	0.10	.17
Travel time index	1.13	1.16
Travel time / planning time ratio	83%	85%

MPH = miles per hour.
PM Peak Period= 3:00 PM to 7:00 PM.
Source: INRIX.

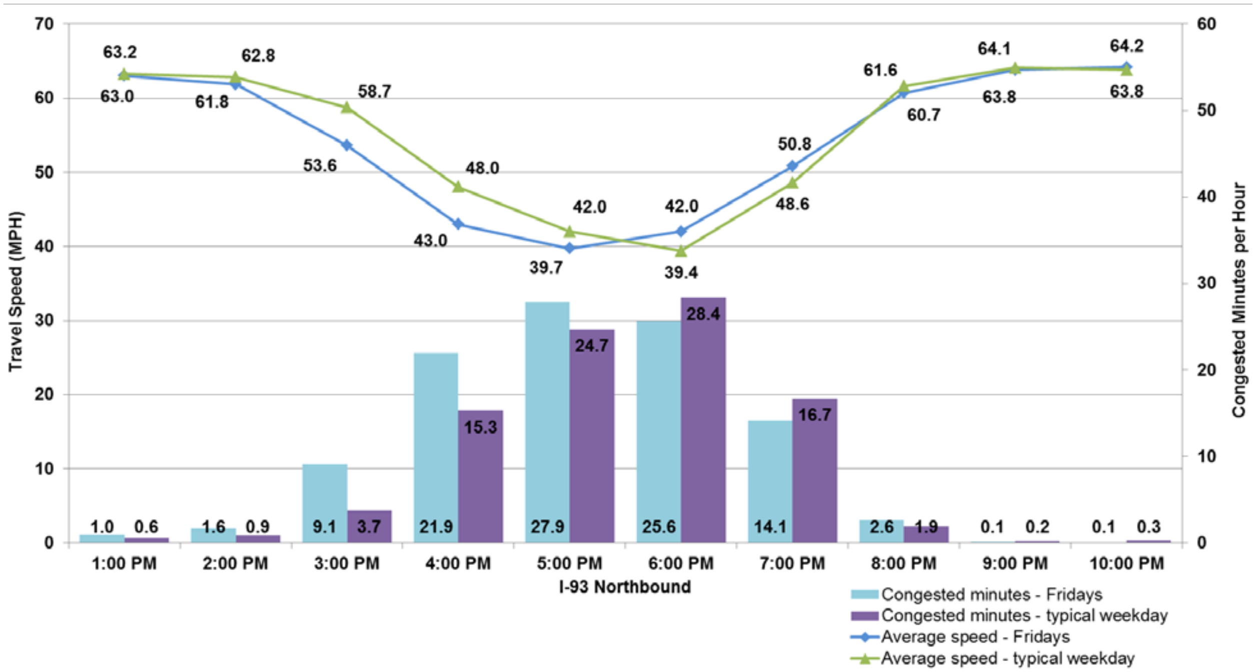
Figures 23, 24, 25, 26, 27, and 28 show the travel speeds for Friday afternoons and evenings on Interstate 90 westbound, Interstate 93 northbound, Interstate 93 southbound, Interstate 95 northbound, Interstate 95 southbound, and Route 3 southbound, respectively. Interstate 90 westbound experienced the largest decline in travel speeds relative to a typical weekday; travel speeds were as much as 12.4 MPH (27 percent) slower at 5:00 PM on Fridays versus the same time on a typical weekday. On Interstate 93 northbound, the Friday speeds were slower before 5:00 PM and slightly faster after 5:00 PM. On Interstate 93 southbound, the Friday speeds were slower before 6:00 PM and nearly even afterwards. On Interstate 95 northbound, the travel speeds were slower on Friday between 2:00 PM and 7:00 PM and nearly even afterwards. On Interstate 95 southbound, the Friday speeds were slower between 3:00 PM and 9:00 PM. On Route 3 southbound, the Friday speeds were slower between 1:00 PM and 8:00 PM. The sustained decrease in speeds on Interstate 95 southbound and Route 3 southbound were likely due to the fact that these corridors are located further away from Boston than the other corridors. These corridors likely carry a higher percentage of travelers who are leaving the Boston region.

Figure 23
Travel Speeds on I-90 Westbound: Typical Weekday versus Friday



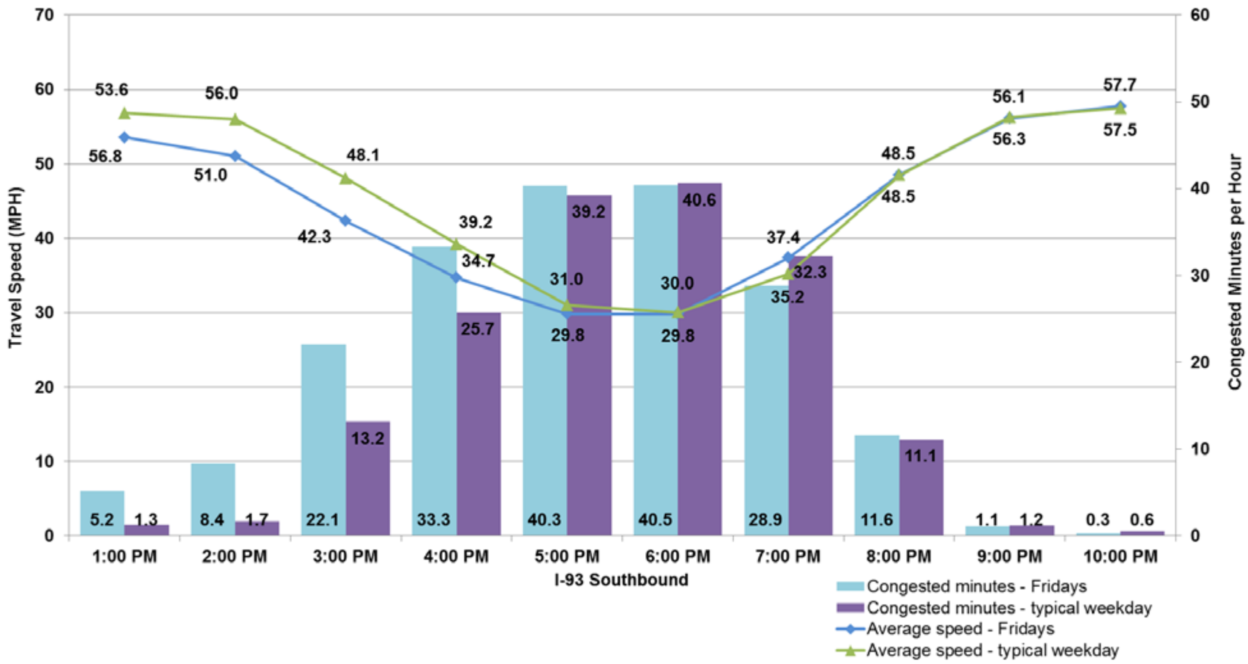
Source: INRIX.

Figure 24
Travel Speeds on I-93 Northbound: Typical Weekday versus Friday



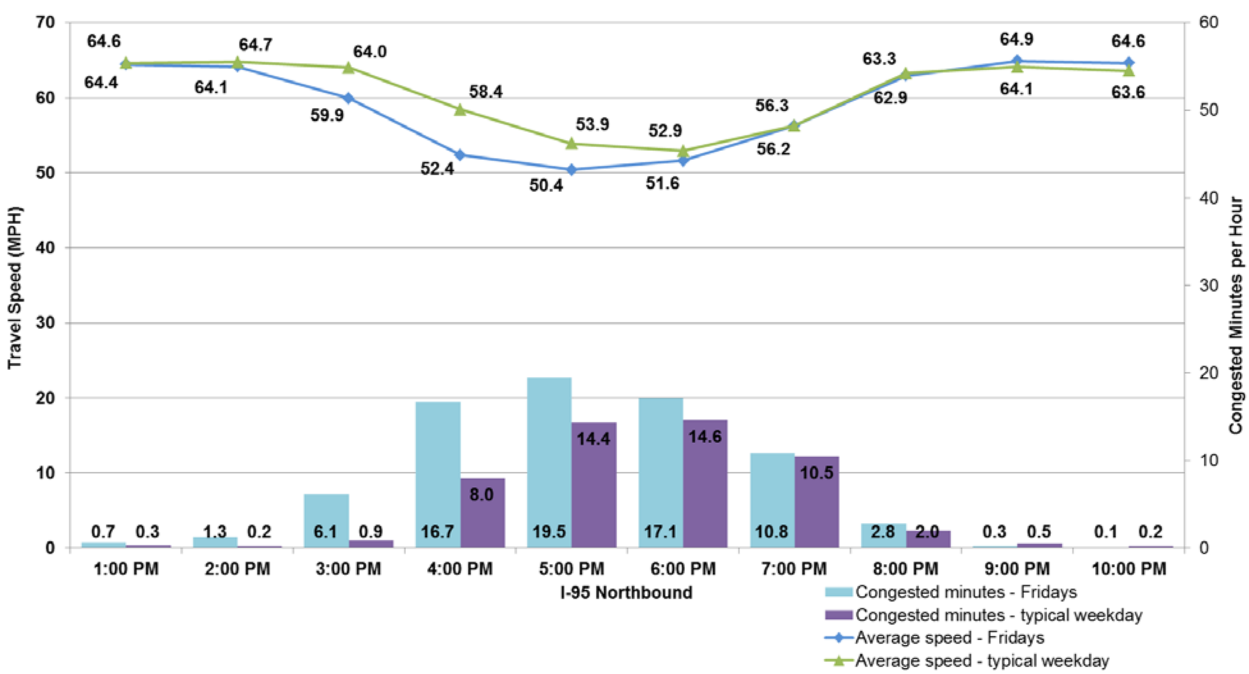
Source: INRIX.

Figure 25
Travel Speeds on I-93 Southbound: Typical Weekday versus Friday



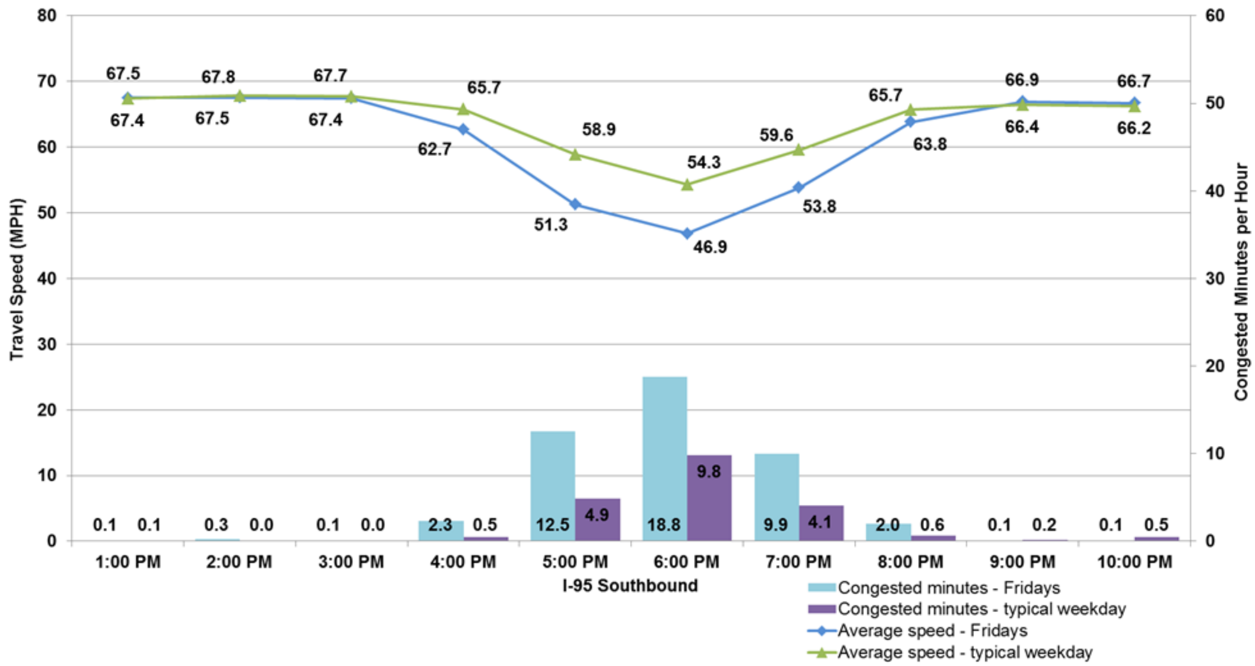
Source: INRIX.

Figure 26
Travel Speeds on I-95 Northbound: Typical Weekday versus Friday



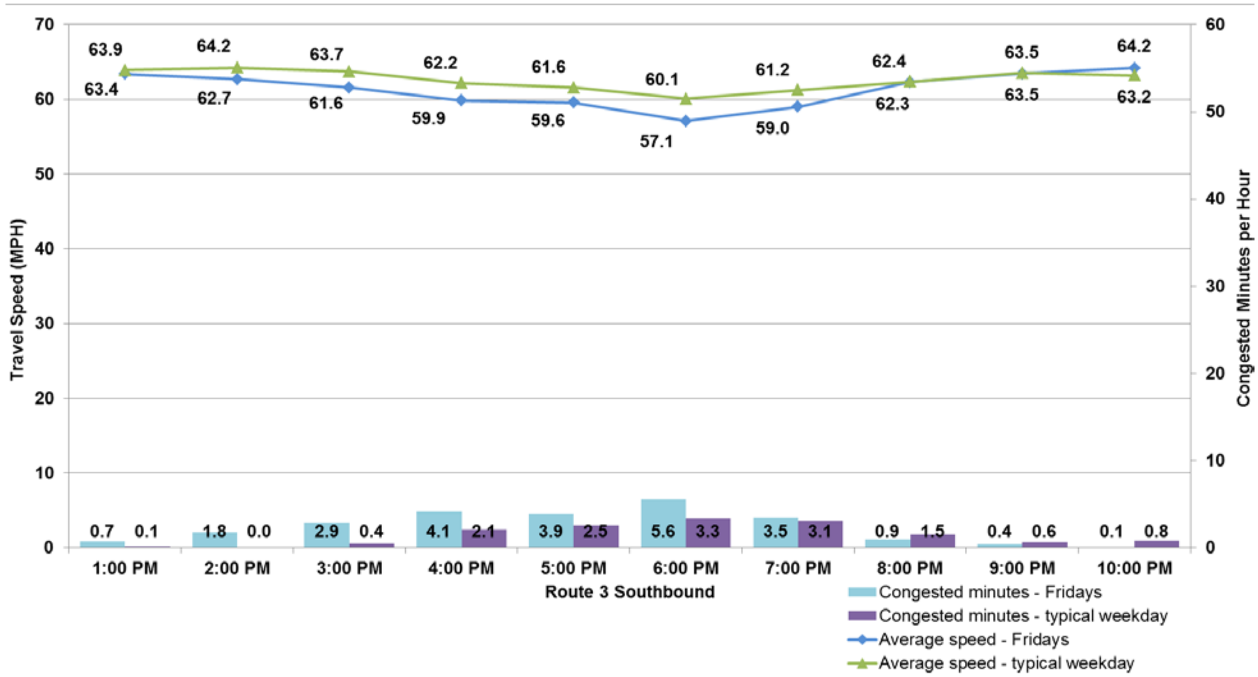
Source: INRIX.

Figure 27
Travel Speeds on I-95 Southbound: Typical Weekday versus Friday



Source: INRIX.

Figure 28
Travel Speeds on Route 3 Southbound: Typical Weekday versus Friday



Source: INRIX.

Worst Locations

Table 31 shows the locations that experienced the most significant speed reductions on Fridays compared to a typical weekday. The location where the most significant speed reductions occurred was on Interstate 90 between Interstate 95 and the Westborough Plaza/Rest Stop. The spot with the worst congestion on this segment was at the Interstate 495 interchange where speeds declined by 30 MPH and congestion persisted between 2:00 PM and 8:00 PM.

Table 31
Expressway Locations with Speed Decreases on Friday, PM Peak Period

Route	Direction	From	To	Times	Speed (MPH)	Change in Speed from Normal Peak Period (MPH)	Worst Location
I-90	Westbound	I-95 (Weston)	Westborough Plaza (Westborough)	2 PM to 8 PM	34.61	-30.27	I-495
I-90	Westbound	Allston Tolls (Boston)	I-95 (Weston)	3 PM to 7 PM	31.72	-21.98	Route16
I-95	Northbound	Middlesex Turnpike (Burlington)	I-93 (Woburn)	2 PM to 5 PM	32.35	-21.68	Winn Street
MA-3	Southbound	Union Street (Braintree)	Derby Street (Hingham)	1 PM to 4 PM	36.11	-21.64	Route 18 to Derby Street
I-95	Southbound	Route 1 (Sharon)	I-295 (Attleboro)	3 PM to 7 PM	28.71	-20.24	I-495

I = Interstate. MA = Massachusetts highway route. MPH = miles per hour. US = United States highway route.
PM Peak Period= 3:00 PM to 7:00 PM.
Source: INRIX.

10.2.2 Safety

Comparison of Weekday versus Friday

As shown in Table 32, 693 crashes (crash rate = 33.0) occurred on expressways on Fridays in 2015. On other weekdays monitored by the CMP in 2015, 8,194 crashes (crash rate =31.3) occurred on expressways. The crash rate for expressways on Fridays was higher than crash rate on weekdays.

Table 32
Crashes and Crash Rates: Typical Weekday versus Fridays, 2015, Entire Day

Measure	CMP Weekdays	Fridays
Expressway crashes	8,194	693
Expressway crash rate	31.3	33

CMP = Congestion Management Process.
Source: MassDOT Crash Database.

10.3 FINDINGS

- Interstate 90 westbound is the corridor that experienced the most significant increase in congestion on Fridays relative to other weekdays. The spot with the worst congestion on this segment was at the Interstate 495 interchange.
- Interstate 93 southbound is the corridor that experienced the highest travel time index. The worst congestion occurred at the interchange of Interstate 90. Interstate 93 southbound also experienced the most congested minutes per hour.
- Every corridor analyzed in this case study experienced a speed decrease on Fridays.
- The most significant speed decreases occurred on expressways between 3:00 PM and 5:00 PM.
- The crash rates on Fridays were higher than the weekday crash rates on expressways.
- The crash rates on Fridays were lower that the weekday crash rates on arterials.

10.4 STRATEGIES AND RECOMMENDATIONS

- If travelers desire to avoid congestion, inform travelers to depart at the times recommended in Table 33.
- Consider installing dynamic message signs to display traffic alerts in other states, such as Connecticut and New York, to inform travelers and truckers of the fastest route to the Boston region based on current traffic conditions. Also, display traffic alerts from other states in the Boston region for roadways such as Interstate 91 or Interstate 95 in Connecticut.
- Research ways to improve intercity bus services from Boston to other locations such as Cape Cod, Maine, New Hampshire, Vermont and Rhode Island.
- Allow the use of roadway shoulders for traveling vehicles at certain times of the day to improve the flow of traffic.

Table 33
Recommended Leave Times on Fridays by Corridor

Corridor	Leave by
I-90 Westbound	Leave Boston by 2:15 PM
I-93 Northbound	Leave Boston by 2:15 PM
I-93 Southbound	Leave Boston by 1:15 PM
I-95 Northbound	Leave Weston by 3:30 PM
I-95 Southbound	Leave Westwood by 3:45 PM
Route 3 South	Leave Braintree by 3:00 PM

Source: Central Transportation Planning Staff.

Chapter 11—Case Study: Black Friday

11.1 DESCRIPTION OF EVENT AND LOCATION

Black Friday, the day after Thanksgiving, is an important shopping day for consumers and retailers. On Black Friday, many consumers travel to shopping malls and other stores to purchase goods, which are sharply discounted for one day. Consumers will travel to these malls during all times on Black Friday, as stores are sometimes open for 24 hours.

This case study analyzed traffic patterns near the "Golden Triangle," which is a location with a large cluster of commercial activity near the Natick Mall in the Natick-Framingham area. Sections of the following roadways in Natick and other nearby communities were analyzed over a 24-hour period on November 27, 2015: Route 9, Route 30, Route 126, Route 27, and Interstate 90.

The specific dates and times of the analysis, roadways and routes of focus, and datasets used in the analysis are as follows:

- Dates: November 27, 2015
- Times monitored: 24 hours
- Roadways analyzed: Route 30 between Pine Hill Road and Route 27; Route 126 between Route 135 and Plain Street; Route 9 between Interstate 90 and Oak Street; Interstate 90 between Route 9 and Interstate 95; Route 27 from Route 135 to Route 30
- MBTA bus routes analyzed: All MBTA Routes
- Datasets used for analysis: INRIX, MBTA Back on Track dataset, and MassDOT crash database

11.2 PERFORMANCE MEASURE SUMMARY

11.2.1 Roadways

Data Quality

This case study involved a one-day analysis, so the availability of roadway data was limited for this case study. On Interstate 90, the data was reliable for the entire 24-hour period. However, the data availability on the arterials was intermittent between 11:00 PM and 6:00 AM. Therefore, in some instances, synthetic travel speeds, which were estimated based on the speed values of adjacent TMCs, were used for some TMCs between 11:00 PM and 6:00 AM.

Arterial Travel Speeds

Table 34 compares the performance results for the AM and PM peak periods on Black Friday to those of a typical weekday. Overall travel speeds on the arterials near Natick Mall were 3 MPH faster during the AM peak period and 1.5 MPH faster during the PM peak period on Black Friday compared to a typical weekday. The overall speeds might be higher in the peak periods on Black Friday because many workers in the Boston region may have taken the day off of work, which would reduce normal peak period traffic volumes and thereby offset the increase in traffic to shopping centers.

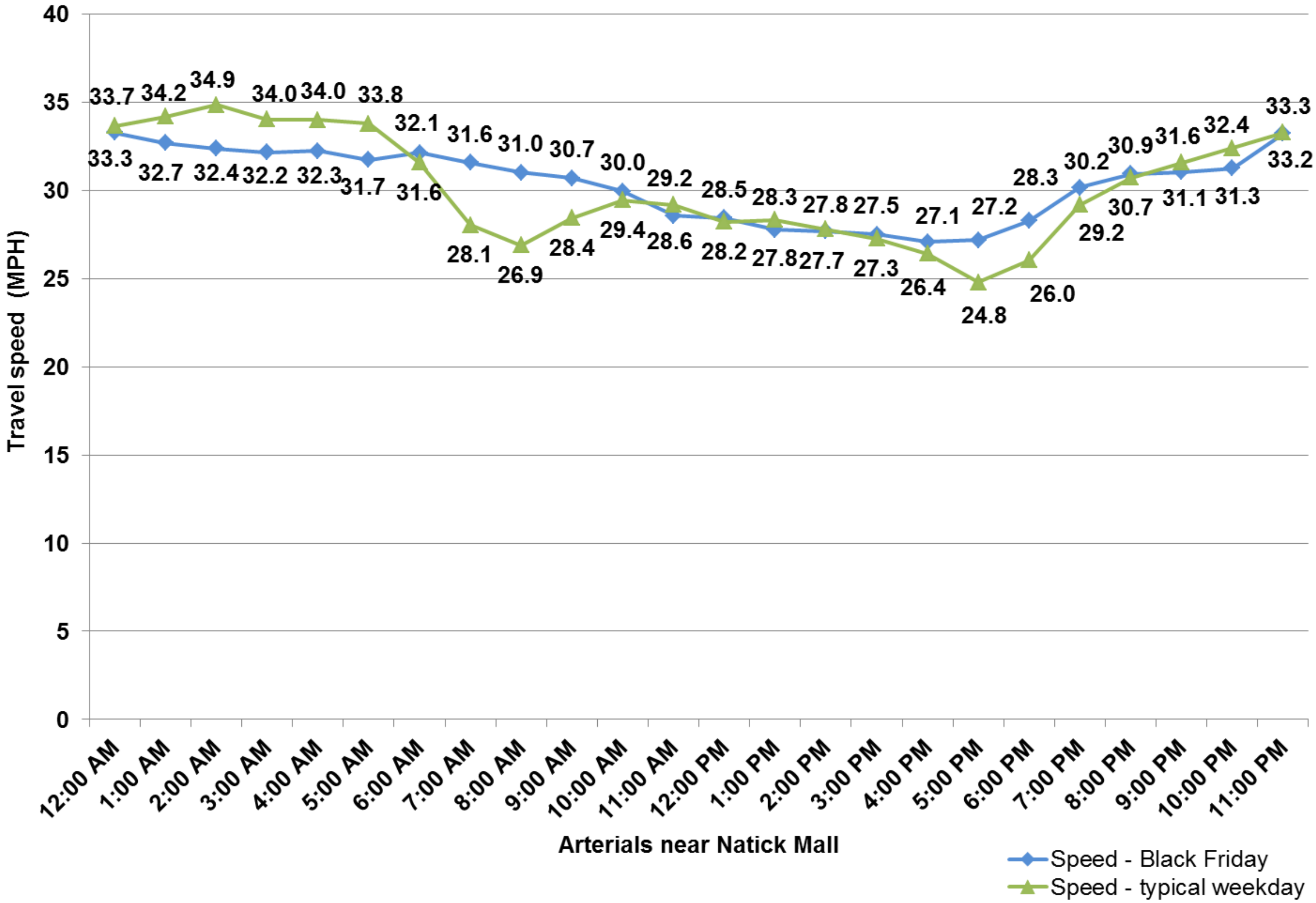
Table 34
Traffic Conditions on Arterials near the Natick Mall: Typical Weekday versus Black Friday, 2015

Performance Measure	Weekday AM	Weekday PM	Black Friday AM	Black Friday PM
Average speed (MPH)	28.04	26.00	31.25	27.45
Travel time index	1.35	1.46	1.21	1.38

Source: INRIX
MPH = miles per hour.

Figure 29 shows the travel speeds on arterials located near the Natick Mall over the 24-hour period that corresponds with Black Friday in 2015. At most times of the day, the travel speeds on Black Friday were equal to or higher than the travel speeds on a typical weekday. The only times when the speeds were slower was overnight between 10:00 PM and 6:00 AM.

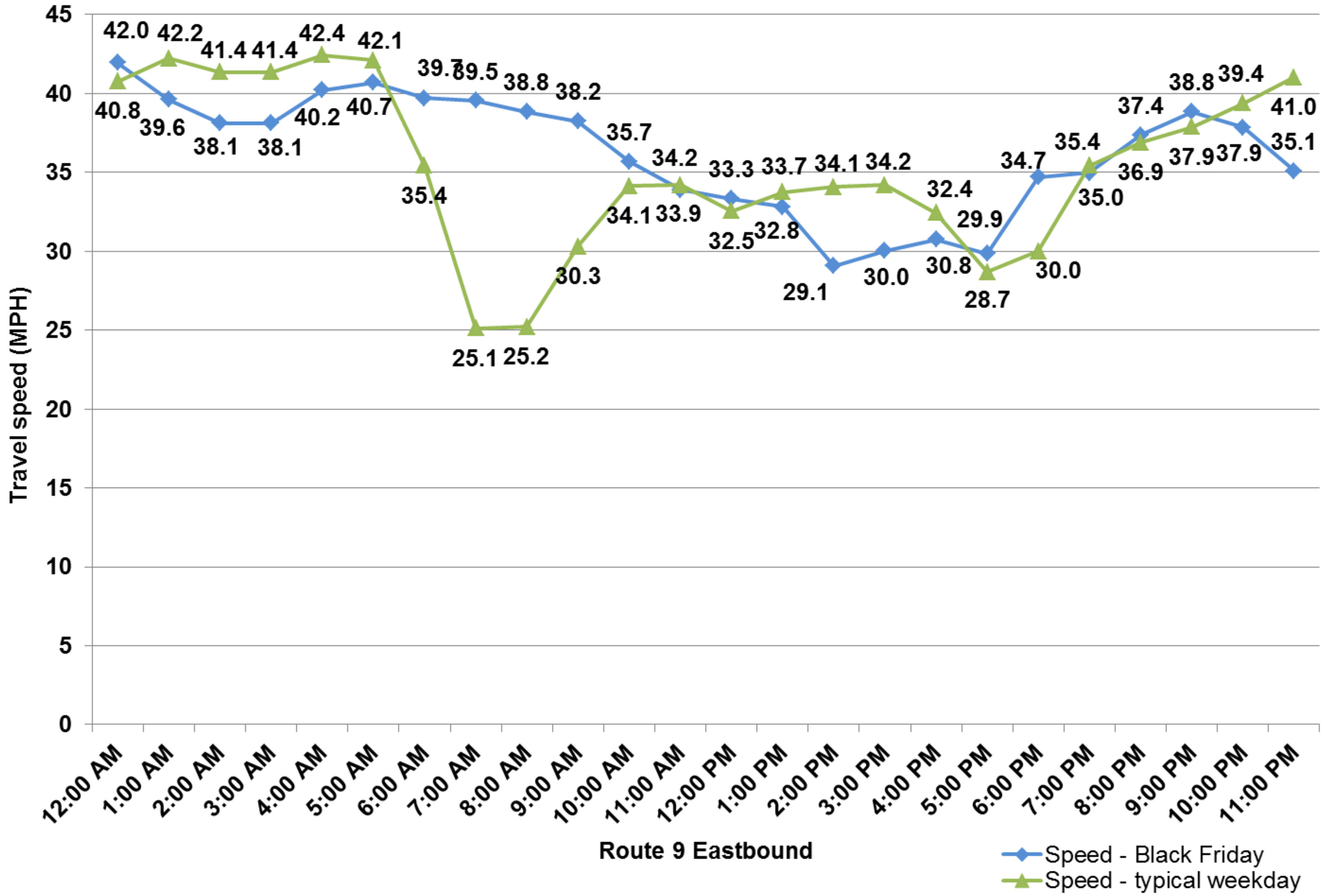
Figure 29
Travel Speeds on Arterials near the Natick Mall: Typical Weekday versus Black Friday, 2015



Source: INRIX

Figure 30 shows the travel speeds on Route 9 eastbound, during the duration of Black Friday. The uniform traffic congestion and speed decrease seen during the AM peak period of a typical weekday were not observed on Black Friday. However, between 1:00 PM and 6:00 PM on Black Friday the travel speeds were slower than the travel speeds on a typical weekday.

Figure 30
Travel Speeds on Route 9 Eastbound near the Natick Mall: Typical Weekday versus Black Friday, 2015

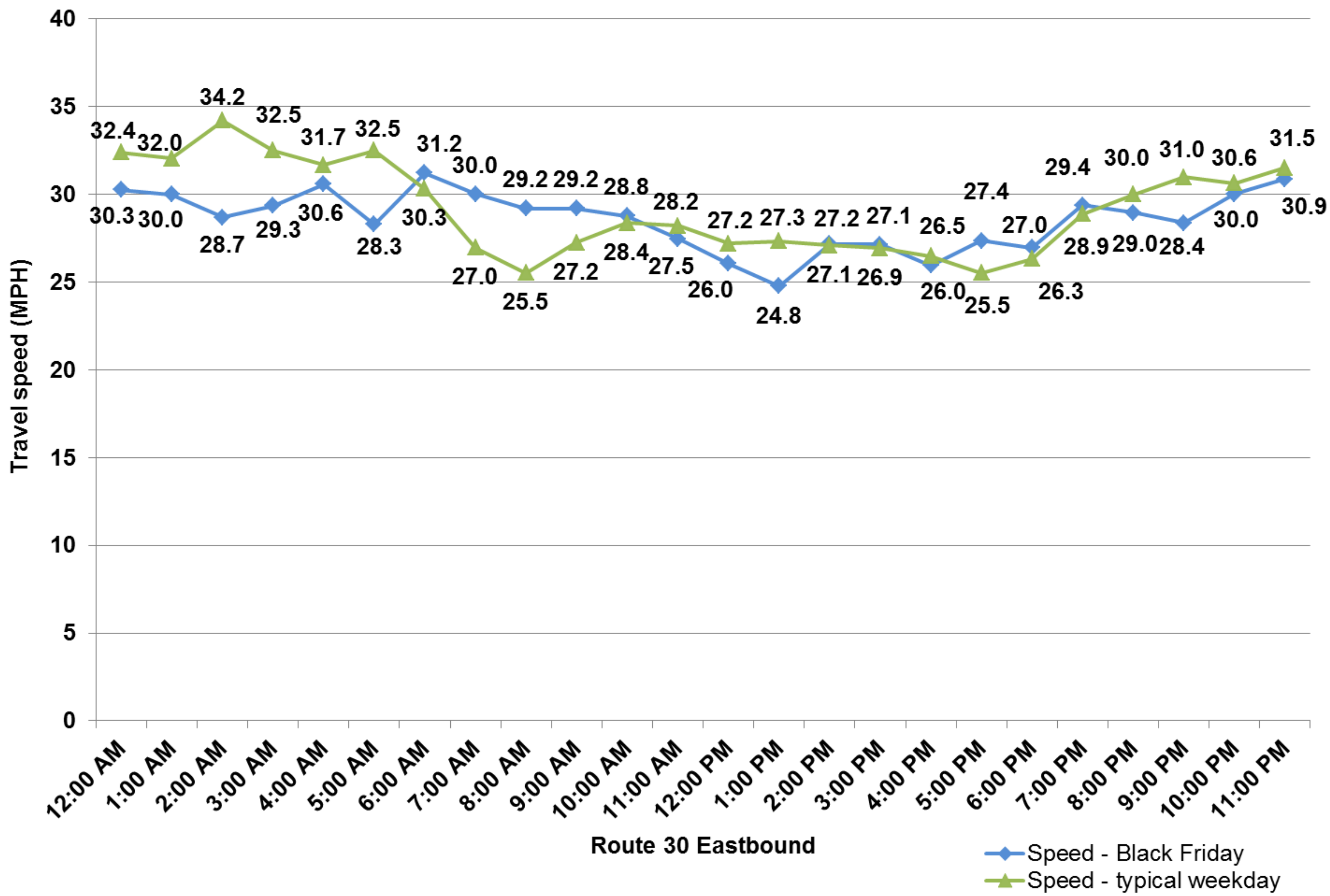


Source: INRIX

Figure 31 shows the travel speeds for Route 30 eastbound on Black Friday. Similar to Route 9, Route 30 eastbound experienced slower speeds between 12:00 PM and 3:00 PM, which highlights a peak shopping time at the Natick Mall on Black Friday. In addition, travel speeds between 10:00 PM to 6:00 AM were slower than those of a typical weekday.

Figure 31

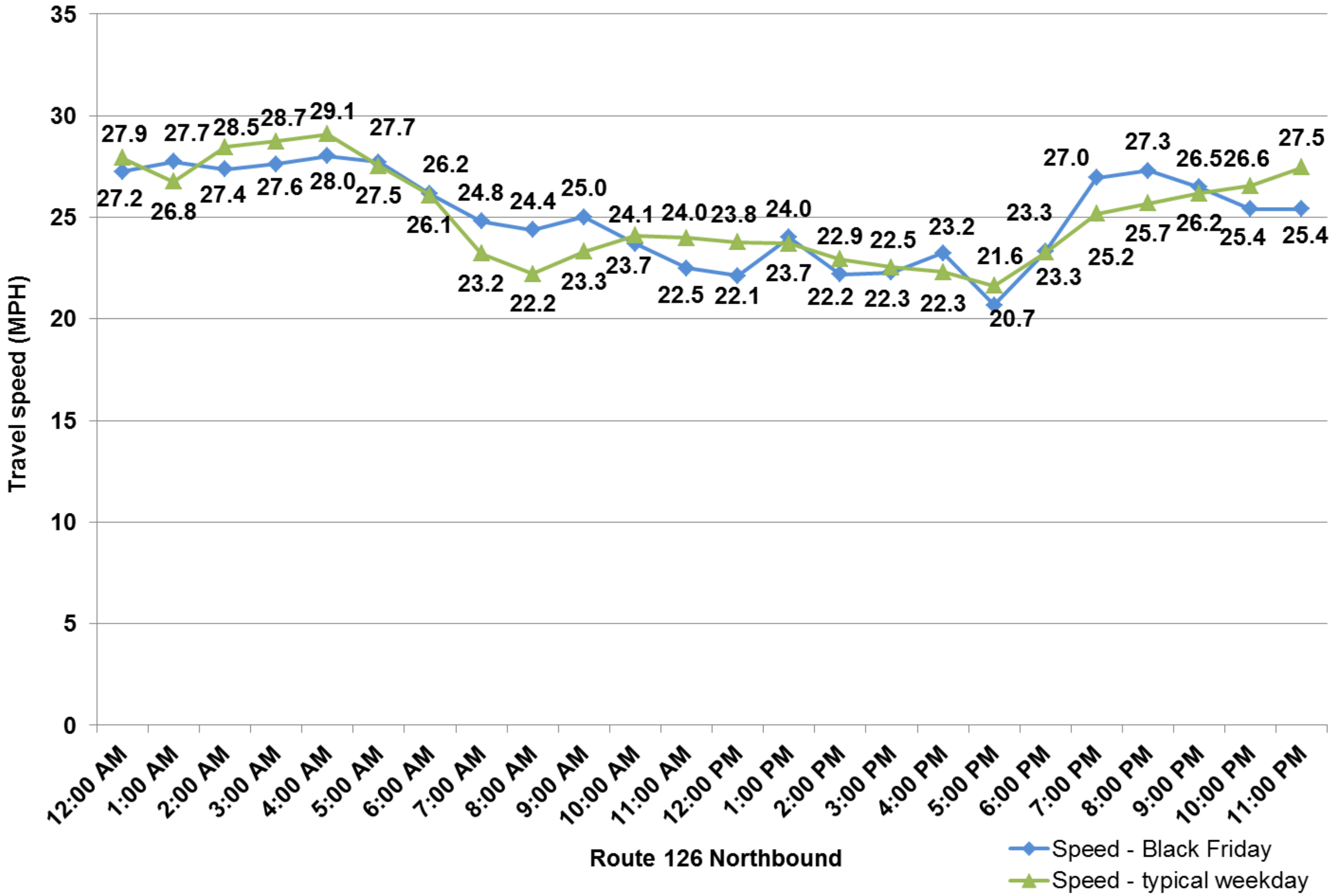
Travel Speeds on Route 30 Eastbound near the Natick Mall: Typical Weekday versus Black Friday, 2015



Source: INRIX

Figure 32 compares the travel speeds on Route 126 near the Natick Mall on Black Friday to the speeds on a typical weekday. The travel speeds on Route 126 were slower on Black Friday than on a typical weekday between 10:00 AM and 2:00 PM. This indicates that people were traveling from Framingham and points beyond to the Natick Mall, and that this is a peak shopping time at the Natick Mall on Black Friday.

Figure 32
Travel Speeds on Route 126 Eastbound near the Natick Mall: Typical Weekday versus Black Friday, 2015

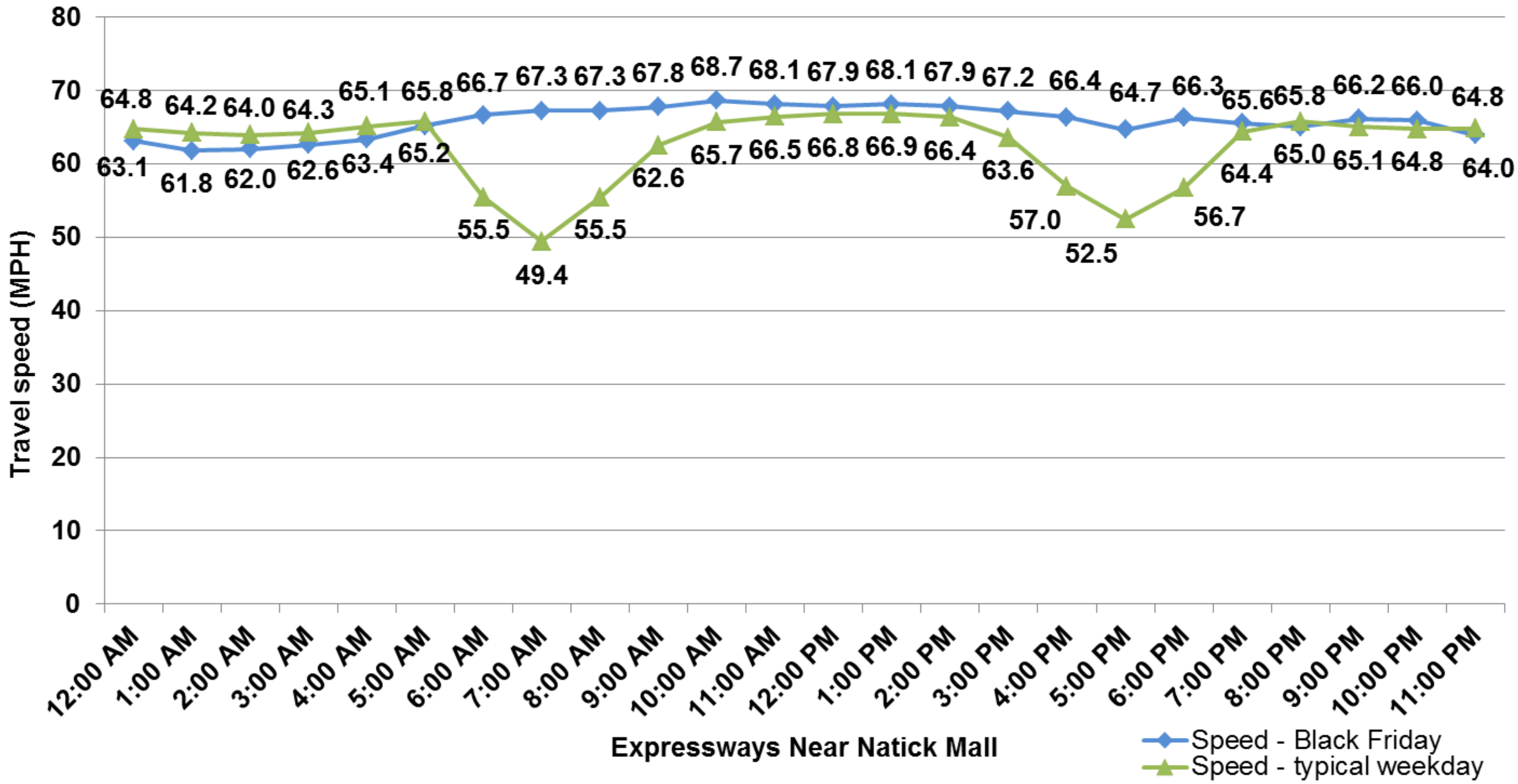


Source: INRIX

Expressway Travel Speeds

Figure 33 compares the travel speeds on Interstate 90 between Route 9 and Interstate 95 in both directions on Black Friday to a typical peak period. The travel speeds on Interstate 90 during Black Friday were consistent throughout the entire day, whereas the travel speeds on a typical weekday showed a clear slowdown during the peak periods. This indicates that there were not large numbers of travelers driving long distances to this mall. Also, these data confirm that significantly fewer people commute to Boston on Black Friday.

Figure 33
Travel Speeds on Expressways near the Natick Mall: Typical Weekday versus Black Friday, 2015



Source: INRIX

Worst Locations

Figure 34 shows the locations near the Natick Mall where travel speeds were slower on Black Friday compared to a typical weekday. Additionally, table 35 compares the locations that experienced the largest decrease in travel speeds on Black Friday to a typical weekday. The location that experienced the largest decrease in travel speed was Route 9 eastbound between Walnut Street and Oak Street. A slowdown occurred between 2:00 PM and 8:00 PM, which could again indicate that this is a peak shopping time. Another location that experienced a decrease in travel speed was Route 30 between Route 9 and Interstate 90 at 4:00 AM to 6:00 AM. This speed decrease could have resulted from a combination of AM peak period commuter traffic and vehicles heading to the stores, as many stores open early on Black Friday.

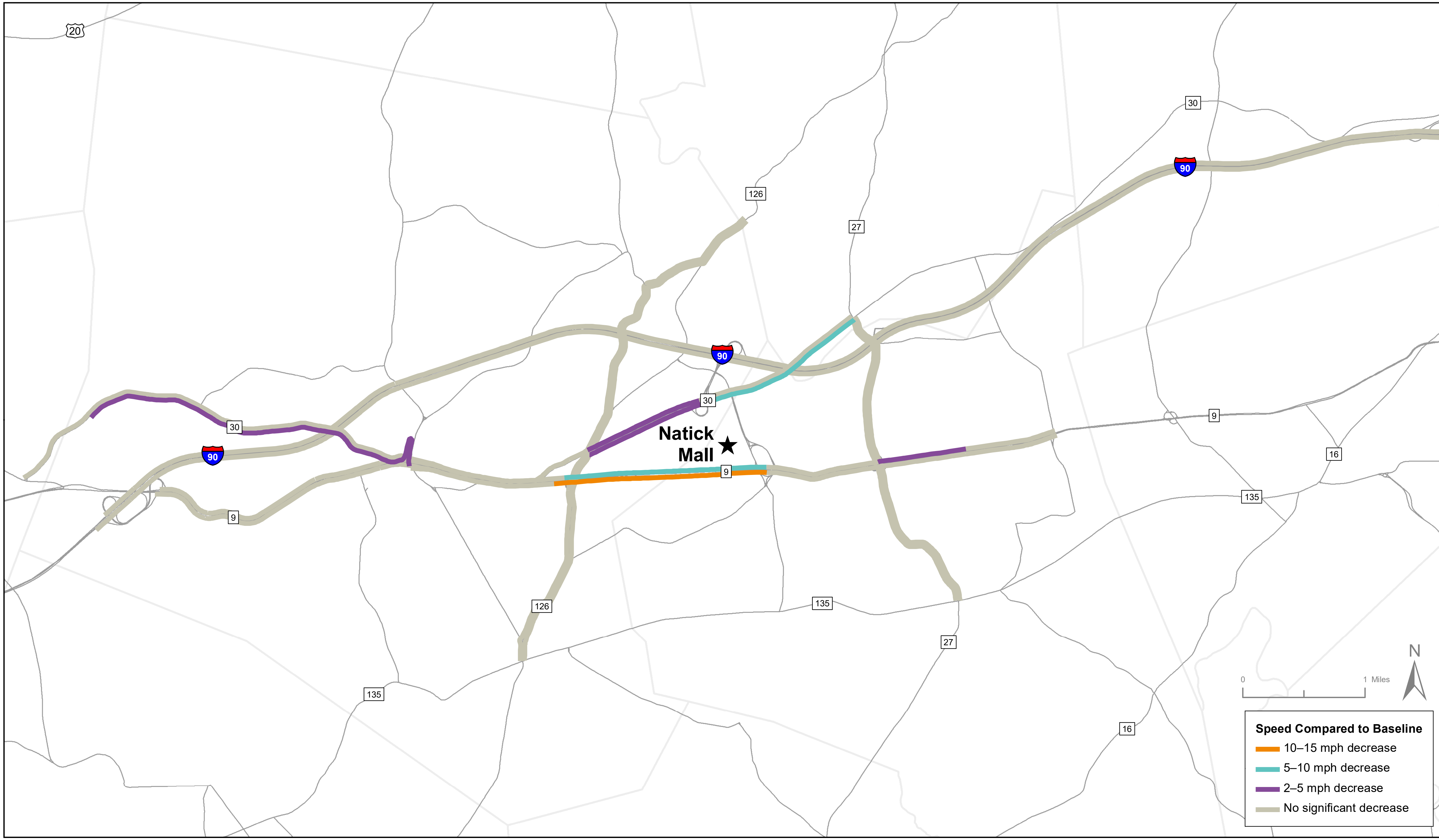


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Figure 34
Difference between Weekday and Black Friday Travel Speeds

Traffic Congestion in the Boston Region: Beyond the Daily Commute

Table 35
Arterial Locations near Natick Mall where Speeds Decrease on Black Friday

Route	Direction	From	To	Times	Weekday Speed (MPH)	Speed (MPH)	Change in Speed from Peak Period
Route 9	Eastbound	Walnut Street (Natick)	Oak Street (Natick)	2 PM - 8 PM	31.75	12.38	-19.37
Route 30	Eastbound	Route 9 (Framingham)	I-90 (Framingham)	4 AM - 6 AM	29.9	14	-15.9
Route 9	Eastbound	Route 30 (Framingham)	Speen Street (Natick)	1 PM - 9 PM	24.59	9.83	-14.76
Route 27	Northbound	Route 135 (Natick)	Route 9 (Natick)	4 AM - 7 AM	28.79	15	-13.79
Route 126	Northbound	Route 9/ Route 30 (Framingham)	Route 30 (Framingham)	5 AM - 6 AM	30.82	19	-11.82

I = Interstate.
Source: INRIX.

11.2.2 Freight Traffic on Black Friday

The Black Friday case study included a freight analysis focused on the region's expressways. This analysis was conducted using the freight portion of the NPMRDS dataset. The freight data for expressways on Black Friday, November 24, 2017, was compared to the freight data available for the CMP monitoring dates in 2017, which represent a typical weekday. Due to the limited availability of the NPMRDS freight data, only 2017 data could be used to analyze freight traffic on Black Friday. Therefore, NPMRDS data from November 24, 2017, was used rather than data from November 27, 2015.

On that Black Friday, travel speeds were 6.5 MPH higher during the AM peak period and 5.5 MPH higher during the PM peak period than during those same periods on a typical weekday. The speed index also increased on Black Friday. Additionally, the Level of Travel Time Reliability (LOTTR) decreased from 1.20 to 1.06 in the AM peak period, and from 1.20 to 1.08 in the PM peak period, as compared to those periods on a typical weekday. The percentage of expressway miles that remained above (failed) the LOTTR congestion threshold changed from 11.7 percent on a typical day to 0.3 percent on Black Friday in the AM peak period, and from 9.2 percent on a typical day to 1.3 percent on Black Friday in the PM peak period.

Table 36
Traffic Conditions on Freight Network: Black Friday 2017

Performance Measure	Value
AM freight speed (MPH)	54.46
AM Black Friday speed (MPH)	60.97
AM freight LOTTR	1.20
AM freight LOTTR percent of roadways congested	11.7%
AM Black Friday LOTTR	1.06
AM Black Friday LOTTR percent of roadways congested	0.3%
PM freight speed (MPH)	53.72
PM Black Friday speed (MPH)	59.37
PM freight LOTTR	1.20
PM freight LOTTR percent of roadways congested	9.2%
PM Black Friday LOTTR	1.08
PM Black Friday LOTTR percent of roadways congested	1.3%

LOTTR = Level of Travel Time Reliability. MPH = miles per hour.
Source: NPMRDS.

The following locations failed the LOTTR threshold in the AM peak period:

- Route 24 southbound between Harrison Boulevard and Route 27 (Stoughton and Brockton)
- Lowell Connector southbound between Route 3A and Plain Street (Lowell)

The following locations failed the LOTTR threshold in the PM peak period:

- Interstate 93 northbound between Montvale Avenue and Interstate 95 (Woburn)
- Route 2 eastbound between Spring Street and Waltham Street (Lexington)
- Interstate 93 northbound between Route 28 and Route 37(Randolph and Braintree)
- Interstate 93 southbound from Essex Avenue to Massachusetts Avenue (Boston)
- Interstate 95 southbound between North Avenue and Route 28 (Wakefield and Reading)
- Interstate 495 northbound between Interstate 95 and Route 1 (Foxborough and Plainville)

- Interstate 93 southbound between Furnace Brook Parkway and Route 3 (Quincy and Braintree)
- Route 128 southbound between Endicott Street and Route 114 (Danvers and Peabody)

The results of the analysis revealed that there was less freight congestion during both peak periods on Black Friday than on a typical weekday. Further, significantly more corridors failed to meet the LOTTR threshold during the PM peak period on Black Friday than during the AM peak.

11.3 FINDINGS

- The peak periods as a whole are significantly less congested on Black Friday than on a typical weekday.
- Shoppers drive to the Natick Mall mostly between 10:00 AM and 2:00 PM, and from the mall between 1:00 PM and 6:00 PM.
- There are a few locations, including Route 9 eastbound between Walnut Street and Oak Street and Route 30 between Route 9 and Interstate 90, where speeds decrease in the early morning on Black Friday.
- Between 1:00 PM and 6:00 PM on Black Friday the travel speeds were slower than the travel speeds on a typical weekday. This indicates that this time is a peak shopping time on Black Friday at the Natick Mall.

11.4 STRATEGIES AND RECOMMENDATIONS

- Review access management on Route 9 leading to Natick Mall. Alterations to the driveways leading to malls and other businesses between Route 9 and the Natick Mall can help relieve congestion. Also, determine if left-turning vehicles are contributing to the congestion.
- Optimize the traffic signal timings on all arterials near the Natick Mall.

Chapter 12—Results and Summary of Case Studies

12.1 CONGESTION DURING EVENTS

The case studies discussed in this report examined incidents when congested roadway conditions developed during times other than the traditional commuting hours or because of traveling associated with special events or holidays. While these events are considered to be nonrecurring traffic for the purposes of traffic analysis and do not represent typical weekday congestion patterns, most of the events reoccur regularly. Because most of these events recur at least annually, sufficient data samples are usually available to detect regular traffic patterns.

Overall, congestion levels and roadway safety conditions varied between the events studied, based on the type of event, the day of the week, the time of day, and the location. Table 37 shows the definitions used to categorize the degree of impact each event had on roadway congestion, safety, and transit performance. Table 38 shows the traffic conditions that were present during the monitoring times of each case study, indicating the intensity of congestion on expressways and arterials, and the effect of congestion on buses (as evidenced by on-time performance).

Of all the events examined in the case studies, the most significant increase of arterial traffic occurred during the New England Patriots' regular season games. Congestion on expressways was the worst on the day before Thanksgiving of 2015, the day of the Super Bowl Parade, and Fridays. Lastly, the analyses showed that all of the events affected transit performance less than roadway traffic, as the only time that MBTA buses experienced a moderate decrease in on-time performance was during Friday evenings.

Table 37
Definitions of the Impact of Events

Impact of Event	Roadway Traffic	Safety	Transit Traffic
None	No change or increase in roadway speeds during event	No change or decrease in crashes per day during event	No change or increase in bus on-time performance during event
Low	Slight decrease in travel speeds during event	Slight increase in crashes per day during event	Slight decrease in bus on-time performance during event
Moderate	Noticeable decrease in travel speeds during event	Noticeable increase in crashes per day during event	Noticeable decrease in on-time performance during event
High	Significant decrease in travel speeds during event	Significant increase in crashes per day during event	Significant decrease in on-time performance during event

Source: Central Transportation Planning Staff.

Table 38
Traffic Conditions during Case Studies

Case Study	Prevalence of Event	Arterial Traffic	Expressway Traffic	Safety	Transit Traffic
New England Patriots Regular Season Games	As many as eight times annually	High	High	Moderate	N/A
Red Sox 7:00 PM Weekday Games	As many as 81 times annually	Moderate	Low	Low	Low
Saturday Congestion	As many as 52 times annually	Moderate	Moderate	Moderate	Low
Super Bowl Parade	Varies (no more than once annually)	Moderate	High	Moderate	N/A
Wednesday before Thanksgiving	Annually	N/A	Moderate	Moderate	None
Fridays	As many as 52 times annually	N/A	High	Moderate	Moderate
Black Friday	Annually	Moderate	None	Low	Low

Source: Central Transportation Planning Staff.

12.2 RECOMMENDED STRATEGIES

The case studies resulted in recommendations of ways to alleviate roadway congestion during the time period of each event. Table 39 shows the types of strategies that were recommended in each case study. Travel demand management, improved incident management, better use of intelligent transportation systems, and encouraging the use of public transportation are popular strategies for relieving congestion during events. Enhancements to intelligent transportation systems remain the most effective strategy, which focuses on either coordinating signals or communicating the location of traffic congestion to drivers and suggesting alternative methods of travel during the events. For a detailed analysis of the recommended strategies, please refer to the individual case studies.

Table 39
Recommended Strategies from Case Studies

Case Study	Travel Demand Management	Incident Management	Intelligent Transportation Systems	Traffic Management and Operations	Public Transportation
New England Patriots Regular Season Games	X	X	X	X	X
Red Sox 7:00 PM Weekday Games			X		X
Saturday Congestion			X	X	X
Super Bowl Parade					X
Wednesday before Thanksgiving		X	X	X	
Friday Afternoon/Friday Evening	X		X		X
Black Friday		X	X	X	

Source: Central Transportation Planning Staff.

Overall, congestion associated with many of the events studied could be alleviated by the implementation of intelligent transportation system (ITS) strategies. These solutions primarily entail communicating with travelers to inform them of locations and times when congestion is expected so that they can plan their travel accordingly. Another popular ITS strategy is to synchronize traffic signals on arterials. Also, adaptive signals may reduce congestion on arterials.

Another strategy for relieving congestion during events is to improve public transportation options. Although public transportation is available for many of these events, it is often overcrowded and inefficient. If funding is an issue for providing public transportation during these events, decision makers should look at innovative funding mechanisms such as advertising and branding.

A third strategy is to focus on traffic management and operations. These solutions are often location specific and offer direct improvements to a roadway location, such as by expanding or utilizing a shoulder, reconfiguring turn lanes, or reducing the number of access points to a retail location.

12.3 FINDINGS

- Of the events studied, the most significant increase of arterial traffic occurred during the New England Patriots' regular season games.
- Congestion on expressways was the worst on the day before Thanksgiving of 2015, the day of the Super Bowl Parade, and Fridays.
- Congestion at some locations during special events might be inevitable. A good strategy is to inform travelers of the time and location of the congestion, so that they will avoid the location if possible. Communication is important to let travelers know the best route to take to their destination.
- Congestion that results from sporting events may be at its worst after the conclusion of the event, rather than before the event, because attendees will often participate in a pre-game activity, such as tailgating or meeting before the game. Therefore arrival times at the stadium vary. After the game, attendees often will all leave at the same time.
- Congestion does not increase before Red Sox games at Fenway Park except on roadways immediately near the park and on Storrow Drive in Boston. One reason for this is because many attendees take public transportation to the games. There is a spike in traffic after the games, but usually the nearby roads have the capacity to carry the traffic because the vehicles are exiting the area during non-peak travel periods.
- Traffic congestion on Saturdays is less regionwide, but the traffic is concentrated in certain areas, such as near shopping malls, central business districts, and entertainment venues.

- The most significant increases in congestion levels during the day of the New England Patriots' Super Bowl parade occur in the suburbs. Many parade attendees take public transportation into Boston.
- The best time for travelers to leave Boston and avoid traffic on the day before Thanksgiving is before 12:00 PM. Most traffic in the region diminishes after 6:00 PM on that day.
- On Fridays, it is recommended that travelers leave by 1:15 PM to avoid congestion on Interstate 93 southbound. Additionally, it is recommended that travelers leave by 2:15 PM to avoid congestion on Interstate 90 westbound and Interstate93 northbound. Travelers should leave by 3:45 PM to avoid congestion on Interstate 95 southbound, south of Interstate 93 in Westwood.

Chapter 13—Recommendations and Next Steps

13.1 NEXT STEPS

The Boston Region MPO's staff can create an online dashboard that can be posted on the MPO's website to profile each of these case studies. The dashboard can display maps similar to those on the MPO's existing Express Highway Performance Dashboard and Arterial Performance Dashboard. The new dashboard can also include graphs, data, and other visuals. This report and the new dashboard can be presented at future conferences and webinars as a resource for other MPOs considering similar studies.

The MPO staff will also reach out to communities that have congestion bottlenecks as a result of these events. The MPO board may recommend undertaking additional studies in its Unified Planning Work Program that will further examine congestion on specific corridors highlighted in this report. The results of the studies would be shared with engineers and planners from communities in the region who can then recommend projects or policies to address congestion problems.

13.2 CONCLUSION

Nonrecurring congestion in the Boston region has a major effect on mobility in the region. Also, congestion may have an impact on the attendance at the events or lower the quality of life for people who have to endure congestion on certain days of the week, even if it is not during the peak period. Events that cause nonrecurring congestion are unique and each has a variable effect on congestion levels. The traffic on the day before Thanksgiving functions quite differently from traffic on the day of a parade, for example. Many roadways examined in this study have congestion during nonrecurring events that is worse than peak period congestion.

The availability of big datasets, such as INRIX, has made it possible to study the Boston region's congestion beyond the typical weekday peak travel periods. This dataset provided myriad data that were previously unavailable on traffic volumes during off-peak times, such as weekends, holidays, and special events. These data have allowed the Boston Region MPO staff to potentially expand the CMP monitoring beyond the traditional peak periods.

The MPO staff does not recommend that a community build its way out of the problem of nonrecurring congestion by expanding roads, as this option would require a significant investment to relieve congestion on facilities that may only experience congestion occasionally. In order to relieve congestion at the locations discussed in this report, strategies will need to be deployed. Implementing ITS, increasing public transportation options, and traffic management and operations solutions are all excellent strategies that can be used to alleviate nonrecurring congestion. .

Appendix A: Detailed Performance Measures Description

Table 40
Performance Measures

Mode	Type of Performance Measure	Performance Measure	Definition/Description	Required Metrics	Threshold	How measure will be displayed
Highway	Duration	Congested Time	Congested time is the average number of minutes that drivers experience congested conditions (speeds below 35 MPH on expressways, or 19 MPH on arterials), during a specific time period. Congested Time is measured in minutes per analyzed hour. *Congested Time (Minutes) = (Number of Minutes with Speeds below 35 MPH / Total Number of Minutes in Sample) x 60*	Congested speed threshold Number of records with congested speed	Roadway segments that have more than 30 minutes of congestion per hour during an event are considered to have a long duration of congestion.	GIS mapping Line graphs
Highway	Intensity	Average Travel Speed	Average travel speed associated with a specific roadway is calculated using travel times and segment lengths. The average observed travel speed is a good indicator of a mobility deficiency in the roadway network and is used to identify solutions to mobility problems. Average Travel Speed is also a factor in calculating other performance measures, such as travel time. *Average Travel Speed (MPH) = (Segment Length/Travel Time) x 60*	Average travel speed Roadway segment length	Typically expressway segments with an average speed of less than 35 MPH or arterial segments with an average speed of less than 19 MPH are considered to be congested.	GIS mapping Line graphs
Highway	Intensity	Corridor/Segment Delay	Delay is an effective means of measuring on a roadway network between two landmark locations. Example: 14 minute delay between the Braintree Split and the Masspike on I-93 northbound. *Corridor Delay=Travel time during event - Free-Flow Travel Time*	Average travel time Free-flow travel time	Threshold would vary by corridor	Line graph reference to compare different corridors
Highway	Intensity	Bottleneck Factor	Bottleneck factor combines the intensity of congestion (average speed of congested records) with duration of time that a TMC location is congested (congested time). Bottleneck factor can be used to rank roadway network problem areas. A high bottleneck factor indicates severe congestion. A location that has a bottleneck factor of 0 indicates that the location is not congested. *Bottleneck Factor = Minutes of Congestion per Hour during an event/ Congested Speed*	Minutes of congestion per peak-period hour Congested speed	Any roadway segment that has a bottleneck factor of more than 0 has some degree of congestion.	GIS mapping for the region by TMC
Highway	Reliability	Travel-Time Index	Travel-time index compares travel conditions during the peak period to travel conditions during free-flow periods. Travel-time index is the ratio of peak-period time to free-flow time. Travel-time index indicates how severe peak-period congestion is for a facility. For example, a travel-time index of 1.20 indicates a trip that takes 20 minutes in the off-peak period will take 24 minutes in the peak period, which is 20 percent longer. *Travel-Time Index = Travel Time during event / Free-Flow Travel Time*	Average travel time during event Free-flow travel time	Any roadway segment that has a travel-time index of more than 1.3 is considered to be congested.	GIS mapping for the region by TMC

GIS =Geographic Information System. MPH = miles per hour. PTI = Planning Time Index. TMC = Traffic Messaging Channel.
Source: Central Transportation Planning Staff.

Table 40
Performance Measures (Cont.)

Mode	Type of Performance Measure	Performance Measure	Definition/Description	Required Metrics	Threshold	How measure will be displayed
Highway	Reliability	Planning-Time Failure	Planning-time failure shows instances where the travel time during an event is longer than the planning time index travel time of a typical weekday. This performance measure shows where there is an extreme spike in congestion at a certain time and location. Locations that have a planning time failure index of more than 1 have a travel time during an event that is higher than the planning time index travel time during a typical weekday. *Planning-Time Failure Index = travel time during event/ 95 percentile peak period travel time*	Weekday planning time index Average travel time during event	Any roadway that has a planning time failure index of more than 1 is experiencing extreme congestion.	Line graph GIS mapping
Highway	Duration	Minutes of Planning-Time Failure	This performance measure shows the duration of time that the travel time during an event is longer than the planning time travel time for a typical weekday. *Minutes exceeding PTI = Number of records that are under PTI speed x Number of minutes per epoch*	Weekday planning time index Average travel time during event Number of records that are under PTI speed	Any roadway that has any minutes of planning time failure is considered to be congested	displayed in a table
Safety	Intensity	Number of Crashes during the day (s) of event	The number of crashes during an event are compared to the number of crashes that occur during a typical day. The number of crashes for the day of the event is compared to the number of crashes that occur during a typical day.	Date, time, and location of crashes	Threshold would vary by location	Bar graph Maps of crash locations
Safety	Intensity	Number of crashes that occur on a typical day during the year of the event	This performance measure compares the number of crashes that occur during an event to the number of crashes that occur during a typical day. This performance measure may look at crashes that occur during a typical weekday/weekend day, or the performance measure can look at a particular day of the week (example: typical Thursday versus the Thursday of the event). *number of crashes that occur on a typical day during the year of the event=total number of crashes per year/number of days per year*	Number of crashes during event. Number of crashes during year of event	Threshold would vary by location	Bar graph
Transit/Bus	Reliability	On-time performance	On-time performance data can be obtained from the MBTA Back on Track website. Bus speed is measured at timepoints along the bus route, at both terminuses of the route and at midpoints. • For buses that have headway of 15 minutes or less, an on-time trip is defined as a trip that departs a timepoint no more than three minutes later than the scheduled time. • For buses scheduled less frequently than every 15 minutes, a bus that leaves a timepoint between less than one or as much as six minutes earlier than the scheduled time is considered to be on time. This performance measure compares the day of the event to a typical day during that season. On-time performance is provided in peak/off peak periods, so only periods during a day (AM, PM and Off-peak) can currently be analyzed. *On-time performance = Number of timepoints made on time/number of total timepoints*	Number of timepoints made on time Number of total timepoints	Bus routes that make less than 60 percent of their timepoints on time are considered to be congested.	Bar graph Maps

GIS = Geographic Information System. MPH = miles per hour. PTI = Planning Time Index. TMC = Traffic Messaging Channel.
Source: Central Transportation Planning Staff.

Appendix B: Nonrecurring Congestion

Various types of events that affect traffic patterns and cause nonrecurring congestion occur in the Boston region. Different types of events can have different effects on traffic congestion. Some of these events are unique or rare, while others recur many times over a defined period like a baseball season.

B.1 SPORTING EVENTS

Oftentimes, sporting events occur on multiple days at the same time throughout the season. These events attract as many as 70,000 people. This study analyzed traffic associated with two sporting events: Boston Red Sox weekday night games held at 7:00 PM on weeknights and New England Patriots games held at 1:00 PM on Sundays.

B.2 WEEKENDS AND OTHER OFF-PEAK TIMES

Even though the CMP focuses on recurring congestion during peak travel periods, there is significant congestion that occurs on off-peak days and weekends. Most of this traffic is generated from non-work trips, such as those made for shopping or visiting. This study examined congestion that occurs on Saturday afternoons, Saturday evenings, and Fridays evenings.

B.3 BLACK FRIDAY

Black Friday is a popular shopping day that occurs on the day after the Thanksgiving holiday every year. Oftentimes on this day, there is significant congestion, especially near shopping malls. This study examined traffic on Black Friday of 2015.

B.4 HOLIDAYS

Holidays are designated days of the year, where certain groups in the United States celebrate, depending on the specific holiday. On many holidays, businesses and school are closed. Over the course of the year, there are several holidays that dramatically alter traffic patterns. Sometimes, traffic increases on the date of the holiday. Other times, traffic increases either the day preceding or succeeding the holiday. The holiday that was chosen for this study is the Wednesday before Thanksgiving.

B.5 PARADES

Parades are gatherings that occur at a designated location, which performances are given in the form synchronized marching along a corridor. Parades often increase traffic to a specific area, and temporary road closures may be put in place. Depending on the location and size, parades can also affect travel on public transportation as well. This study examined the effects of the parade that celebrated the New England Patriots' 2015 Super Bowl championship.