Potential MBTA Fare Changes in SFY 2015: Impact Analysis

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Potential MBTA Fare Changes in SFY 2015

Impact Analysis

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ABSTRACT

This study analyzes the various effects of a potential MBTA fare-pricing scenario aimed at achieving a balanced budget in state fiscal year 2015. The proposed scenario raises new revenue from a 5% average fare increase; the Authority is not planning to reduce or eliminate service to meet its revenue targets. We use two different modeling methodologies to estimate the effects on ridership, revenue, air quality, and fare equity. The methodologies are complementary, each providing some information the other is not designed to gather. In addition, generating two sets of estimates produces a wider range of possible impacts.

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EXECUTIVE SUMMARY

In response to the Massachusetts state Legislature's requirement that the MBTA generate a portion of its revenue from fares, the MBTA proposed to establish a pattern of modest, regularly scheduled fare changes, beginning with a 5% fare increase in state fiscal year (SFY) 2015. The Central Transportation Planning Staff (CTPS) to the Boston Region Metropolitan Planning Organization (MPO), using a spreadsheet model, assisted the MBTA in determining the fare levels for each mode and fare category that would be needed in SFY 2015 to reach the MBTA's fare revenue targets. CTPS used the spreadsheet model and the Boston Region MPO's regional travel demand model set to estimate the projected ridership loss associated with the proposed fare increase and the net revenue change that would result from the lower ridership and higher fares. By employing both techniques, CTPS produced a range of estimates of potential impacts on ridership and revenue. Staff also used the travel demand model set to predict the effects of the fare increase on regional air quality and populations protected under Title VI and environmental justice.

Table E-1 presents a summary of the total ridership and revenue projections for SFY 2015. As the table indicates, revenue should increase by approximately three-to-four percent with a loss of slightly less than one percent of ridership. Compared to the spreadsheet model, the regional travel demand model set predicted a slightly lower ridership loss and a lower revenue gain. Most of the difference lies in the greater loss in ridership and smaller revenue gains for the more expensive modes—commuter rail and ferry.

TABLE E-1.
Range of Revenue and Ridership Projections for the Proposed Fare Increase: SFY 2015

		Spreadsheet Model			Regional Travel Demand Model		
Analysis Category	**Existing Values**	**SFY 2015 Projected**	**Projected Change**	**Projected % Change**	**SFY 2015 Projected**	**Projected Change**	**Projected % Change**
Ridership	403.4M	399.7M	-3.8M	-0.9%	400.6M	-2.8M	-0.7%
Revenue	$603M	$627.2M	$24.5M	4.1%	$622.8M	$20.0M	3.3%

We expect changes in travel behavior resulting from the fare changes to cause only very minor negative impacts on air quality in terms of all pollutants. The estimated magnitude of the air quality impacts reflect the increase in vehicle-miles traveled and vehicle-hours traveled projected to occur as transit riders divert to automobile trips and cause additional congestion on the region's roads.

CTPS performed a fare equity analysis using the spreadsheet model and the regional travel demand model set. In this analysis, we compared the absolute and relative fare increases between riders who are minorities and all riders and between riders who are low-income and all riders. We applied the MBTA's disparate-impact and disproportionate-burden policies and found neither the presence of a disparate impact nor a disproportionate burden.

CHAPTER 1. INTRODUCTION

In recent years, the MBTA has managed to balance its budget through cost reductions, special appropriations by the Legislature, and fare and fee increases. In 2007, simultaneous with the introduction of the Automated Fare Collection (AFC) technology, the MBTA restructured its fare system and raised fares an average of 21%. The Authority did not raise fares again until July 2012, when it implemented a 23% average increase. Almost a year later, the state Legislature—in Chapter 46, An Act Relative to Transportation Finance—required that the MBTA attain revenue benchmarks, which it could satisfy by changing fares, fees, or any other funds directly collected by the Authority.[1,2] In response, the MBTA proposed to establish a pattern of modest, regularly scheduled fare changes, as needed, beginning with a 5% fare increase in SFY 2015. Modest, predictable fare increases will be less disruptive for the Authority and its customers compared to past major fare increases.

CTPS, using an elasticity-based spreadsheet model, provided technical assistance to the MBTA in determining fare levels for each mode and fare category necessary to reach the MBTA's fare revenue targets in SFY 2015. CTPS used the spreadsheet model and the Boston Region MPO's regional travel demand model set to estimate the projected ridership loss associated with the proposed fare increase and the net revenue change that would result from the lower ridership and higher fares. By employing both techniques, CTPS produced a range of estimates of potential impacts on ridership and revenue. Staff analysts also used the travel demand model set to predict the effects of the fare increase on regional air quality and on populations protected under Title VI and environmental justice.

1.1 Document Structure

The remainder of this document is organized according to the following structure:

- A review the methodology used for the analysis (Chapter 2)

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[1] Bill H. 3535: An Act Relative to Transportation Finance: malegislature.gov/Bills/188/House/H3535.
[2] Bill H. 3535; Section 61(a),(b), and (c)

- A description of the proposed fare changes (Chapter 3)
- The results of our ridership and revenue analyses (Chapter 4)
- The results of an air-quality analysis (Chapter 5)
- The results of a fare-equity analysis (Chapter 6)
- Conclusions (Chapter 7)

This report contains four appendices comprised of:

- A more detailed review of the spreadsheet model's methodology (Appendix A)
- An environmental-justice analysis (Appendix B)
- A description of the potential fares the MBTA could implement in SFY 2016 (Appendix C)
- An example application of the MBTA's proposed disparate-impact policy (Appendix D)

CHAPTER 2. METHODS USED TO ESTIMATE RIDERSHIP AND REVENUE

CTPS used two separate approaches to estimate the impact of the proposed fare increase on MBTA ridership and revenue. One approach utilized a set of spreadsheets created by CTPS in consultation with the MBTA specifically to perform such calculations. The second approach applied the Boston Region MPO's regional travel demand model set to estimate demand for each MBTA mode using the existing and proposed fare levels.

CTPS also employed the travel demand model set as a complement to the spreadsheet model when estimating the effects of the SFY 2007 fare restructuring and three proposed fare increase and service-change scenarios for SFY 2013. Together, the two models showed the potential range of impacts on ridership and revenue. Unlike the spreadsheet model, the travel demand model set provides the data necessary for CTPS to perform air-quality analyses and more comprehensive environmental justice impact analyses.

2.1 CTPS Spreadsheet Model Approach

The spreadsheet model estimates the revenue and ridership impacts of the proposed fare-increase scenario. This model reflects the many fare-payment categories of the MBTA pricing system and applies price elasticities to analyze various changes across these categories. CTPS determined that this methodology met expectations through two post-fare increase analyses: one following the SFY 2007 fare restructuring and one following the SFY 2013 fare increase.

Modeling of Existing Ridership and Revenue

Inputs to the spreadsheet model include existing ridership in the form of unlinked trips by mode, fare-payment method, and fare-media type. An unlinked trip is an individual trip on any single transit vehicle; a single journey composed of many unlinked trips on multiple vehicles is a “linked trip.”

The MBTA provided CTPS with existing ridership statistics (to which the spreadsheet model applies price elasticity values—see Section 2.1.2) for the local bus, express bus, and rapid transit networks in the form of automated fare-collection (AFC) data.[3] The MBTA provided the ridership data by station, fare payment type (for example, cash, monthly pass, and weekly pass), fare media (the physical instrument used to pay a fare, for example, CharlieCard, CharlieTicket, and cash), day of the week, and route for buses and the light rail system.

Because the MBTA has not deployed AFC equipment on the commuter rail or commuter boat systems, CTPS estimated the number of trips made on these modes using sales figures. Single-ride trips on commuter rail and ferry were set equal to the number of single-ride fares sold. The number of trips made using passes on these modes was estimated by multiplying the number of pass sales by the estimated average number of trips made using the respective pass type, calculated using survey responses from a corporate pass-users survey conducted in the spring of 2008. Because the underlying pass-usage patterns likely have not changed significantly from the initial survey, we have not conducted additional surveys.

The MBTA also provided data for the number of trips made on THE RIDE by fare payment type and the number of cars that parked at MBTA parking lots.
The spreadsheet model calculates revenue for single-ride trips by multiplying the number of trips in each fare/mode category by that category’s price.[4] The spreadsheet model calculates revenue for pass trips by pass type by multiplying the number of pass sales by the pass price. The model distributes pass revenue between mode categories based on each category’s ridership and most-equivalent single-ride fare (generally, the lowest-priced adult fare).

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3 “Existing ridership” is for SFY 2013 (July 1, 2012–June 30, 2013).

4 For example, if there were 30 million adult CharlieCard fares paid at stations, the revenue generated is equal to 30 million multiplied by $2.00—the adult CharlieCard fare—or $60 million.

Estimation of Ridership Changes Resulting from a Fare Increase

Fares are one of many factors that influence the level of ridership on transit services. Price elasticity is a measure of the rate of change in ridership relative to a change in fares if all other factors remain constant. On a traditional demand curve that describes the relationship between price, on the y-axis, and demand, on the x-axis, elasticities are equivalent to the slope along that curve. Price elasticities are usually negative, meaning that a price increase will lead to a decrease in demand (with a price decrease having the opposite effect). The larger the negative value of the price elasticity (the greater its distance from zero), the greater the projected impact on demand. Larger (more negative) price elasticities are said to be relatively "elastic," while smaller negative values (closer to zero), are said to be relatively "inelastic."[5] Thus, if the price elasticity of the demand for transit were relatively elastic, a given fare increase would cause a greater loss of ridership than if demand were relatively inelastic. Appendix A.5 presents an example of how the concept of price elasticity is applied.

The spreadsheet model permits the use of various ranges of elasticities to estimate different possible ridership impacts of price increases. Performing calculations in the spreadsheet model with the same prices but with a range of higher and lower elasticities provides a range of estimates. In the present analysis, the model uses the middle range of elasticities, called the base elasticities, as these represent the best estimate of where the elasticities should be set based on past experience and a post-SFY 2013-fare increase analysis. For a description of how we determined the base elasticities, see Appendix A.4. However, we also use both more inelastic and more elastic elasticities to determine a range of possible effects; the lower and higher ranges are plus or minus 0.10 the base value. If subtracting 0.10 from the base elasticity would result in an elasticity of 0.00, we subtracted 0.05 instead. This serves as a sensitivity analysis of the model's projections of the ridership losses and revenue gains. Table 2-1 presents the three elasticity ranges used in the spreadsheet model for this study's analysis.

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5 More specifically, an elasticity of less than -1 is considered "elastic"—a 1% increase in price will cause a greater than 1% decrease in demand; an elasticity of -1 is called "unit elasticity"—a 1% increase in price will cause a 1% reduction in demand; and elasticity greater than -1 is called "inelastic"—a 1% increase in price will result in a lower than 1% decrease in demand; an elasticity of 0 is called "perfectly elastic demand"—an increase in price does not affect demand.
The elasticity of transit ridership with respect to small fares changes is generally considered inelastic.

The spreadsheet model also uses ridership diversion factors. These factors reflect estimates of the likelihood of a switch in demand from one MBTA product type or mode to another resulting from a change in the relative prices of the product types or modes. The diversion factors essentially work to redistribute demand between two product types or modes after the model applies the respective price elasticities. Appendix A.5 provides examples of the application of diversion factors and the methodology for combining the use of price elasticities and diversion factors. While diversion factors estimate the migration of riders between MBTA product types and modes based on their price, the spreadsheet model can only estimate the total loss of riders from the MBTA transit system, not the diversion of riders to specific non-MBTA modes such as driving, biking, or walking. The ability to predict diversions to other modes is one of the primary strengths of the Boston Region MPO’s regional travel demand model set.

TABLE 2-1.
Single-Ride and Pass Elasticities by Fare Type and Mode

Modal Category	Low	Base	High
Cash Elasticities			
Bus and Trackless Trolley			
Bus-Adult	-0.15	-0.25	-0.35
Bus-Senior	-0.10	-0.20	-0.30
Bus-Student	-0.05	-0.15	-0.25
Subway	*n/a*	*n/a*	*n/a*
Subway-Adult	-0.15	-0.25	-0.35
Subway-Senior	-0.05	-0.15	-0.25
Subway-Student	-0.05	-0.10	-0.20
Surface Light Rail	*n/a*	*n/a*	*n/a*
Surface Light Rail-Adult	-0.20	-0.30	-0.40
Surface Light Rail-Senior	-0.10	-0.20	-0.30
Surface Light Rail-Student	-0.05	-0.15	-0.25
Commuter Rail			
Commuter Rail-Adult	-0.10	-0.20	-0.30
Commuter Rail-Senior	-0.05	-0.15	-0.25
Commuter Boat			
Commuter Boat-Adult	-0.20	-0.30	-0.40
Commuter Boat-Senior	-0.15	-0.25	-0.35
THE RIDE	-0.25	-0.35	-0.45
Parking	-0.10	-0.20	-0.30
Pass Elasticities			
Bus	-0.05	-0.15	-0.25
Inner Express	-0.15	-0.25	-0.35
Outer Express	-0.15	-0.25	-0.35
LinkPass	-0.05	-0.15	-0.25
1-Day LinkPass	-0.05	-0.15	-0.25
7-Day LinkPass	-0.05	-0.15	-0.25
Commuter Rail	-0.05	-0.10	-0.20
Commuter Boat	-0.10	-0.20	-0.30
Senior	-0.05	-0.10	-0.20
Student	-0.05	-0.10	-0.20

2.2 Boston Region MPO Travel Demand Model Set Approach

CTPS's regional travel demand model set simulates travel on the road and transit networks in eastern Massachusetts. It represents all MBTA modes (commuter rail, rapid transit, and bus services, as well as all private express and other regional transit authority bus services).[6] The model set reflects service frequency (how often trains and buses arrive at a given transit stop), routing, travel time, and fares for all of these services. When modeling the highway system, the regional travel demand model set includes all express highways, all principal arterial roadways, and many minor arterial and local roadways.

The travel demand forecasting procedure used in this analysis is based on a traditional four-step, sequential process: 1) trip generation, 2) trip distribution, 3) mode choice, and 4) trip assignment. The travel demand model uses this process to estimate average daily transit ridership, primarily based on estimates of population and employment, and projected highway travel conditions (including downtown parking costs). CTPS used such a process to analyze MBTA ridership and revenue impacts based on the proposed fare increase.

The eastern Massachusetts geographic area is represented as 2,727 subareas known as transportation analysis zones (TAZs). A TAZ is a relatively homogenous geographic area defined by, among other characteristics, population and employment.

To model transportation choices, the travel demand model set employs complex techniques in each of the four sequential steps of the process:

Trip Generation: Estimates the number of trips produced in and attracted to each TAZ. The model uses estimates of the population, employment, and other socioeconomic and household characteristics of each TAZ to perform this step.

Trip Distribution: Links the trip ends estimated in the trip-generation step to determine movements between pairs of zones. The output of this step is a trip table. A trip table is a matrix containing the number of trips occurring between every origin-zone and every destination-zone; it includes travel within each TAZ.

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[6] In recent years, MBTA stations have opened outside of the regional travel demand model's boundaries. In the future, CTPS hopes to fully incorporate these few stations into the model. These stations are: Grafton, Worcester, North Leominster, Fitchburg, Providence, T.F. Green, and Wickford Junction. These stations are discussed in more detail in Chapter 6: Consideration of Off-Model Stations.

Mode Choice**:** Allocates the person-trips estimated in the trip distribution step to the primary competing modes, single-occupancy vehicle (SOV), high-occupancy vehicle (HOV), walk-access transit (WAT), drive-access transit (DAT), and non-motorized modes (walking and biking). This allocation is based on the desirability, or utility, of the modes a traveler can select based on the attributes of each mode and the characteristics of the individual. The output of this step results in the percentage of all travelers using each mode (SOV, HOV, WAT, DAT, and non-motorized modes).

Trip Assignment**:** Assigns the transit trips to the various transit lines, such as bus routes, rapid transit lines, commuter rail lines, and others. The model assigns each trip to one of several possible transit paths from one zone to another; each of these assignments is based on minimizing the generalized “cost” (including not only the transit fare, but also in-vehicle travel time, number of transfers, and other factors). These paths may involve just one mode, such as express bus or commuter rail, or multiple modes, such as a local bus and a transfer to the subway. The trip assignment step also assigns the highway trips to the highway network. The output of this step enables us to obtain traffic volumes on the highways and ridership on each transit mode.

Population and employment data are key inputs to the demand forecasting process; the Metropolitan Area Planning Council (MAPC) provided this data to CTPS. Recent CTPS studies provided inputs for highway travel times and downtown parking costs. The travel demand model set assumes that, in general, people wish to minimize transfers, travel time, and cost.

Note that the travel demand model set does not have the capability to model THE RIDE. As a result, the ridership and revenue impacts on THE RIDE included with the travel demand model set results are taken from the spreadsheet model results.

CTPS estimated existing revenue by multiplying the estimated number of trips for each mode combination (boarding mode and feeding mode) by the average fare for that mode combination. The regional travel demand model uses the spreadsheet model’s average fares as inputs.

We used two steps to estimate revenue from the regional travel demand model set. First, we input the new average fare, which is based on input from the spreadsheet model, for each transit mode combination. The model estimates the resulting changes in ridership and revenue. Next, we applied these proportional changes to the base SFY 2013 systemwide figures.

2.3 Differences between the Two Estimation Methodologies

There are several differences between the two methodologies. The chief strengths of the spreadsheet model are that it accounts for every distinct type of fare that can be paid for an MBTA transit mode and that it assigns the fare to the correct number of passengers who use that fare-payment/mode category. In comparison, the travel demand model set does not permit analysis of fares at such a detailed level, but rather assumes for each more-generalized modal category an average fare for all fare types. However, unlike the travel demand model set, the spreadsheet model cannot predict how many riders who leave the system because of a fare increase are switching to modes other than transit (driving alone, carpooling, bicycling, or walking). The travel demand model set provides the outputs necessary for conducting the air-quality and environmental justice impact analyses; the spreadsheet model provides no information on air quality and limited information on environmental justice impacts.

There is another key difference between the two approaches in how they estimate ridership changes. The use of elasticities in the spreadsheet model has a relatively simple premise: The greater the percentage change in price, the greater the percentage change in demand. In the travel demand model set, while a greater percentage increase in fares will undoubtedly trigger a greater decline in transit ridership, it is not the percentage change in transit fares that is important for determining the overall ridership change. Rather, it is the comparison of the resulting transit fares to the comparable cost of making the same trip via a different mode. For example, if the price of transit increases relative to the cost of driving, the travel demand model set will show transit diversions to driving.

Given a specific relative fare increase, one would expect a greater percentage of riders to shift away from modes with higher fares than those with lower fares since the absolute change is significantly greater. For example, a 10% increase on a $1.00 fare is only $0.10, while the same percentage increase on a $10.00 fare is $1.00. For the lower-priced mode, 5% of the riders might shift away from the previous $1.00 fare, while 8% of the riders on the more expensive mode might switch to a different mode.

Note: Neither model purports to project the future transportation system characteristics. Rather, each model estimates what the base year, SFY 2013, might have looked like if the MBTA's fares were the proposed fares. The models do not account for changes to the transportation network, gas prices, or the Consumer Price Index.

CHAPTER 3. DESCRIPTION OF PROPOSED FARE INCREASE SCENARIO

This chapter describes recent changes to the MBTA's fare structure and the proposed SFY 2015 fares.

3.1 Fare Structure Changes

The MBTA did not propose any new fare structure changes for SFY 2015. However, the MBTA did implement several changes to the fare structure as part of the latest fare increase at the beginning in SFY 2013, including:

- Using the CharlieTicket single-ride adult price rather than the CharlieCard single-ride adult price for setting the adult base fare.
- Instituting a premium fare for trips using THE RIDE outside of the Americans with Disabilities Act (ADA)-mandated service area or hours—when the trip origin and/or destination is greater than three-quarter miles from, or outside of operating hours for, MBTA bus or rapid transit service—and for same-day and will-call trips.[7]
- Eliminating tokens. The MBTA allowed token-holders to redeem their tokens for CharlieCard or CharlieTicket value until late July 2012.
- Adding a monthly student pass that is valid seven days per week to the existing five-day student pass, which is valid only Monday through Friday.
- Removing time restrictions on student passes.
- Changing the multi-ride ticket structure. Multi-ride tickets are now available for 10 rides for both commuter rail and ferry service, and the previous 12-ride commuter rail ticket and 60-ride ferry ticket were eliminated. In addition, the duration of the validity for the multi-ride ticket was reduced from 180 days to 90 days.
- Providing a lower fare for all commuter rail tickets that are purchased off-board (in stations or other retail locations).

The MBTA chose to retain each of these fare structure changes in the SFY 2015 proposal.

3.2 Fare Changes: Single-Ride Fares and Pass Prices

Table 3-1 presents the key existing and proposed single-ride fares for each fare category, along with the percentage change in price from the existing to the proposed price. Table 3-2 presents the same information for the pass prices. Table 3-2 also presents the value of monthly passes in terms of their single-ride

[7] Will-call trips are a type of same-day trip in which, although the passenger selects a time range for pick-up before the day of the trip, the passenger only specifies the exact pick-up time on the day of the trip.

equivalents, a concept discussed at the end of this section. This report did not analyze parking cost increases.

The overall price increase across all modes and fare/pass categories is 5.0%. This systemwide average is based on the percentage change between the existing average fare (total revenue divided by existing ridership) and the proposed average fare (total projected revenue divided by total projected ridership). Table 3-3 presents these average percentage increases by mode category. Note that the percentage changes in price can differ between modes that are similarly priced (such as local bus and the Silver Line–Washington Street, or subway and surface light rail) because of differences in how the riders on these modes pay for their trips (more riders use a monthly pass on the subway compared to the surface light rail system, for example).

The percentage changes in prices are relatively consistent across fare payment types. The most notable departures from the baseline are:

- THE RIDE's ADA fares decrease 25%—because of a policy decision made in January 2014
- Commuter rail interzone fares 1-3 increase almost 10%—a result of rounding
- One-day link pass cost increases 9%—a result of rounding

Another factor the MBTA considers when raising fares is the pass-ride value, which is the number of trips required at the lowest cost single-ride fare to expend the cost of the pass.[8] Lower pass-ride values indicate that a passenger needs to make fewer trips to make the pass financially worthwhile. Table 3-2 presents the changes to the single-ride to-pass ratios. The changes in the single-ride to-pass ratios from the current fare structure are minimal, and the pass-ride values tend to be close to 32 trips per month.

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[8] For example, the monthly bus pass will cost $50. The lowest price single-ride bus fare is $1.60, which a passenger may obtain by using a CharlieCard. Thus, a $50 monthly bus pass is equal to 31.25 single-ride CharlieCard bus trips.

TABLE 3-1.
Key Single-Ride Fares: Existing and Proposed

Fare Category	Existing Fare	Proposed Fare	Percent Change	Absolute Change
CharlieCard				
Adult				
Local Bus	$1.50	$1.60	6.7%	$0.10
Rapid Transit	2.00	2.10	5.0	0.10
Bus + Rapid Transit	2.00	2.10	5.0	0.10
Inner Express	3.50	3.65	4.3	0.15
Outer Express	5.00	5.25	5.0	0.25
Senior				
Local Bus	$0.75	$0.80	6.7%	$0.05
Rapid Transit	1.00	1.05	5.0	0.05
Bus + Rapid Transit	1.00	1.05	5.0	0.05
Student				
Local Bus	$0.75	$0.80	6.7%	$0.05
Rapid Transit	1.00	1.05	5.0	0.05
Bus + Rapid Transit	1.00	1.05	5.0	0.05
CharlieTicket or Cash				
Adult				
Local Bus	$2.00	$2.10	5.0%	$0.10
Rapid Transit	2.50	2.65	6.0	0.15
Bus + Rapid Transit	4.50	4.75	5.6	0.25
Inner Express	4.50	4.75	5.6	0.25
Outer Express	6.50	6.80	4.6	0.30
Commuter Rail				
Zone 1A	$2.00	$2.10	5.0%	$0.10
Zone 1	5.50	5.75	4.5	0.25
Zone 2	6.00	6.25	4.2	0.25
Zone 3	6.75	7.00	3.7	0.25
Zone 4	7.25	7.50	3.4	0.25
Zone 5	8.00	8.50	6.3	0.50
Zone 6	8.75	9.25	5.7	0.50
Zone 7	9.25	9.75	5.4	0.50
Zone 8	10.00	10.50	5.0	0.50
Zone 9	10.50	11.00	4.8	0.50
Zone 10	11.00	11.50	4.5	0.50
InterZone 1	$2.50	$2.75	10.0%	$0.25
InterZone 2	3.00	3.25	8.3	0.25
InterZone 3	3.25	3.50	7.7	0.25
InterZone 4	3.50	3.75	7.1	0.25
InterZone 5	4.00	4.25	6.3	0.25
InterZone 6	4.50	4.75	5.6	0.25
InterZone 7	5.00	5.25	5.0	0.25
InterZone 8	5.50	5.75	4.5	0.25
InterZone 9	6.00	6.25	4.2	0.25
Ferry				
F1: Hingham	$8.00	$8.50	6.3%	$0.50
F2: Boston	8.00	8.50	6.3	0.50
F2: Cross Harbor	13.00	13.75	5.8	0.75
F2: Logan	16.00	17.00	6.3	1.00
F4: Inner Harbor	3.00	3.25	8.3	0.25
THE RIDE				
ADA Service Area	$4.00	$3.00	-25.0%	-$1.00
Premium Service Area	5.00	5.25	5.0	0.25

TABLE 3-2.
Pass Prices: Existing and Proposed

Pass Category	Existing Fare	Proposed Fare	Percent Change	Absolute Change	Existing Pass Ride	Proposed Pass Ride
Local Bus	$48.00	$50.00	4.2%	$2.00	32.00	31.25
LinkPass	70.00	75.00	7.1	5.00	35.00	35.71
Senior/TAP	28.00	29.00	3.6	1.00	28.00	27.62
Student 5-Day Validity	25.00	26.00	4.0	1.00	25.00	24.76
Student 7-Day Validity	28.00	29.00	3.6	1.00	28.00	27.62
1-Day	11.00	12.00	9.1	1.00	5.50	5.71
7-Day	18.00	19.00	5.6	1.00	9.00	9.05
Inner Express	110.00	115.00	4.5	5.00	31.43	31.51
Outer Express	160.00	168.00	5.0	8.00	32.00	32.00
Commuter Rail						
Zone 1A	$70.00	$75.00	7.1%	$5.00	35.00	35.71
Zone 1	173.00	182.00	5.2	9.00	31.45	31.65
Zone 2	189.00	198.00	4.8	9.00	31.50	31.68
Zone 3	212.00	222.00	4.7	10.00	31.41	31.71
Zone 4	228.00	239.00	4.8	11.00	31.45	31.87
Zone 5	252.00	265.00	5.2	13.00	31.50	31.18
Zone 6	275.00	289.00	5.1	14.00	31.43	31.24
Zone 7	291.00	306.00	5.2	15.00	31.46	31.38
Zone 8	314.00	330.00	5.1	16.00	31.40	31.43
Zone 9	329.00	345.00	4.9	16.00	31.33	31.36
Zone 10	345.00	362.00	4.9	17.00	31.36	31.48
InterZone 1	$82.00	$86.00	4.9%	$4.00	32.80	31.27
InterZone 2	100.00	105.00	5.0	5.00	33.33	32.31
InterZone 3	109.00	114.00	4.6	5.00	33.54	32.57
InterZone 4	118.00	124.00	5.1	6.00	33.71	33.07
InterZone 5	134.00	141.00	5.2	7.00	33.50	33.18
InterZone 6	151.00	159.00	5.3	8.00	33.56	33.47
InterZone 7	167.00	175.00	4.8	8.00	33.40	33.33
InterZone 8	184.00	193.00	4.9	9.00	33.45	33.57
InterZone 9	201.00	211.00	5.0	10.00	33.50	33.76
Commuter Boat	$262.00	$275.00	5.0%	$13.00	32.75	32.35

TABLE 3-3.
Weighted Average Percentage Change in Average Fares, by Mode Category, for Unlinked Passenger Trips

Mode Category	Percent Change
Bus	**6.5%**
Rapid Transit	**5.7%**
Subway	5.7
Silver Line–Washington St.	6.5
Silver Line–Waterfront	5.8
Surface Light Rail	5.7
Commuter Rail	**4.9%**
Zone 1A	5.4
Zone 1	4.9
Zone 2	4.4
Zone 3	4.3
Zone 4	4.4
Zone 5	5.6
Zone 6	5.2
Zone 7	5.2
Zone 8	5.0
Zone 9	4.8
Zone 10	4.8
InterZone	5.7
Onboard	5.0
Ferry	**6.3%**
F1: Hingham-Boston	6.2
F2: Boston	6.0
F2: Cross Harbor	5.7
F2: Logan	6.2
F4: Inner Harbor	7.6
THE RIDE	**-19.3**%
ADA Service Area	-24.2
Premium Service Area	4.8
Total System	**5.0%**

CHAPTER 4. RIDERSHIP AND REVENUE IMPACTS

4.1 Overview of Results

We project the proposed fare changes would increase the MBTA's revenue by between $18.0 million (according to the travel demand model set) and $24.5 million (according to the CTPS spreadsheet model). The estimated annual ridership losses are 2.8 million and 3.8 million, respectively. We expect to see additional utilization of THE RIDE—approximately 120,000 additional trips.

4.2 Spreadsheet Model Estimates

Projections

Table 4-1 presents CTPS's estimates of the fare revenue and ridership impacts of the fare increase produced using the spreadsheet model and its base elasticities.[9] The existing fare revenue and ridership numbers, also presented, represent existing conditions prior to the fare increase.

The total projected fare revenue increase from the scenario is $24.5 million, a 4.1 percent increase. We estimate the total projected ridership loss to be 3.8 million unlinked passenger trips, a 0.9 percent decrease. The projected revenue increases are, on a relative basis, fairly similar for all modes except for THE RIDE's ADA-fare, which received a significant price reduction in January 2014—no further fare increase is proposed for SFY 2015. The MBTA will derive the plurality of its new fare revenue from the heavy rail system ($8.6 million). The ferry system is expected to have the highest percentage—but lowest absolute—decrease in ridership (-1.6 percent). Ferry riders are more sensitive to the price of their fares compared to the riders on other modes.

We expect THE RIDE's January 2014 ADA-fare decrease to increase use of the service. With the combined effect of the decrease of the ADA-fare and increase of the premium fare, we estimate that there will be an additional 120,000 trips made on THE RIDE. The current average variable cost of operating a trip on THE RIDE is approximately $43.[10] These new trips will cost the MBTA slightly more than $5 million to operate—eroding a significant portion of the new revenue generated by the fare increase.

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9 See Chapter 2 for a discussion of the range of elasticities used in this analysis.

10 A variable cost is a cost that changes as the quantity of service provided changes. This includes fuel costs and driver wages. Fixed costs do not change as the quantity of service provided changes. Fixed costs could include costs associated with storage facilities and certain administrative costs.

TABLE 4-1.
Spreadsheet Model Estimates of Annual Ridership Impacts
(in Unlinked Passenger Trips)

Mode	Existing Fare Revenue	Revenue Change	Revenue Change	Existing Ridership	Ridership Change	Ridership Change
Bus	$105,816,930	$5,692,577	5.4%	117,087,612	-1,167,676	-1.0%
Heavy Rail	185,661,914	8,623,282	4.6	162,113,109	-1,573,044	-1.0
Light Rail	73,156,619	3,323,908	4.5	78,532,906	-831,085	-1.1
Commuter Rail	183,512,995	7,674,689	4.2	35,323,276	-247,526	-0.7
Ferry	8,504,104	390,059	4.6	1,256,705	-19,701	-1.6
THE RIDE	6,997,234	-1,002,010	-14.3	1,936,098	119,219	6.2
Parking	39,109,795	-202,923	-0.5	7,166,047	-35,818	-0.5
Total System	602,759,591	24,499,582	4.1%	403,415,753	-3,755,632	-0.9%

Notes: The average variable cost of each RIDE trip to the MBTA is $42.66. The combined changes to THE RIDE's fares will induce ridership, causing the MBTA to pay approximately $5 million in additional operating expenses. Subtracting these new operating costs from the new revenue, the net fiscal impact would be $19,414,000.
Note that parking ridership and revenue losses are not a result of parking price increases, but rather they are a result of riders who once parked no longer parking because another part of their trip became more expensive.
In this table, "Fare Revenue" includes revenue generated from parking at lots where the MBTA retains the revenue. "Ridership" includes the number of vehicles that parked at these lots.

Sensitivity Analysis

Table 4-1 presents the results of the spreadsheet model using the base elasticities. Table 4-2 presents a sensitivity analysis of the spreadsheet model, showing the range of estimated fare revenue and ridership impacts using the range of elasticities shown in Table 2-1. In the ranges of ridership-change estimates in the table, the greater losses are those resulting from the higher range of elasticities, while in the ranges of fare-revenue-increase estimates, the greater increases are those resulting from the lower range of elasticities.

The use of the higher range of elasticities results in much greater estimates of ridership losses: 6.0 million unlinked trips, compared to 1.7 million using the lower range of elasticities; using the base range of elasticities results in a loss of 3.8 million unlinked passenger trips. As a result, the projected revenue gain from the fare increase estimated using the higher range of elasticities is approximately $21.1 million, compared to $27.5 million using the lower range of elasticities; using the base range of elasticities results in an increase of $24.5 million as shown in Table 4-1.

TABLE 4-2.
Spreadsheet Model Ranges of Estimates of Annual Ridership and Fare Revenue Impacts using Low and High Elasticities

Mode	Range of Increases in Revenue ($ in Millions)	Range of Revenue Percent Increases	Difference between Maximum and Minimum	Range of Ridership Changes (Trips in Millions)	Range of Ridership Percent Changes	Difference between Maximum and Minimum
Bus	$5.0 to $6.4	4.7% to 6.0%	$1.4	-0.55 to -1.81	-1.5% to -0.5%	1.26
Heavy Rail	7.4 to 9.8	4.0 to 5.3	2.3	-0.69 to -2.49	-1.5 to -0.4	1.80
Light Rail	2.9 to 3.8	3.9 to 5.2	0.9	-0.39 to -1.28	-1.6 to -0.5	0.89
Commuter Rail	6.7 to 8.4	3.7 to 4.6	1.6	-0.11 to -0.43	-1.2 to -0.3	0.32
Ferry	0.3 to 0.4	3.9 to 5.2	0.1	-0.01 to -0.03	-2.2 to -1.0	0.01
THE RIDE	-1.1 to -0.9	-15.7 to -12.9	0.2	0.15 to 0.09	4.4 to 7.9	0.07
Parking	-0.4 to -0.1	-0.9 to -0.2	0.3	-0.01 to -0.06	-0.9 to -0.2	0.05
Total System	$21.1 to 27.5	3.5% to 4.6%*	$6.4	-1.69 to -5.95	-1.5% to -0.4%*	4.26

*These values refer to the percentage increase for the total changes in revenue or ridership systemwide compared to the existing systemwide values. That is, the 4.6% revenue increase means the total revenue increase for the low elasticity iteration of the spreadsheet model represents a 4.6% increase systemwide in revenue over the existing systemwide revenue. The 4.6% relative increase corresponds to a $27.5 million increase.
In this table, "Fare Revenue" includes revenue generated from parking at lots where the MBTA retains the revenue. "Ridership" includes the number of vehicles that parked at these lots.

Where applicable, the MBTA also accounts for the cost of changing the levels of service provided on the system. While the MBTA recognizes the inherent value to its customers of each trip made on its system, it is necessary to consider the cost associated with increased utilization of THE RIDE—a significant item in the MBTA's budget. Table 4-3 explores the change in the cost of operating the RIDE based on riders' reaction to the fare changes.

Although we account for increased operating costs for the additional ridership on THE RIDE, we do not account for decreased operating costs resulting from decreased ridership on other modes. Decreased demand on the other modes would only translate to savings in operating costs if the MBTA reduces service levels, which the MBTA does not plan to do.[11]

[11] It is relatively easy to save on operating costs with THE RIDE: If a trip is not taken, the MBTA does not pay for the service. On the MBTA's other modes, given constant service levels, if a passenger does not take a trip, the bus, train, or boat must still operate to serve the remaining passengers.

TABLE 4-3.
Spreadsheet Model Estimates of Annual Ridership and Fare Revenue Impacts Using Low, Base, and High Elasticities (THE RIDE)

Analysis Category	Low Elasticity	Base Elasticity	High Elasticity
Change of Ridership	85,156	119,219	153,281
Change of Revenue	-$1,101,196	-$1,002,010	-$902,823
Additional Operating Costs	3,632,767	5,085,874	6,538,980
Net Impact (Revenue-Operating Costs)	**-$4,733,963**	**-$6,087,884**	**-$7,441,804**

4.3 Regional Travel Demand Model Set Estimates

Projections

Table 4-4 presents estimates of the annual fare revenue and ridership impacts of the proposed changes using the regional travel demand model set. The travel demand model set projects that the greatest *absolute* increase in fare revenue would occur on heavy rail, and the greatest relative increase would occur on *bus*—comparatively few riders leave the bus system because its fares are low relative to the other modes. The greatest percentage decreases in ridership are on ferry and commuter rail. Riders on these modes already pay relatively high fares and pass prices. Given the relatively large absolute fare increase, the travel demand model predicts that riders on these modes would be much more likely to switch to a less expensive mode. Some riders might switch to the heavy or light rail system, offsetting some of those modes' ridership losses.

TABLE 4-4.
Travel Demand Model Set Estimates of Annual Revenue and Ridership Impacts

Mode	SFY 2013 Existing Fare Revenue	Revenue Change	Revenue Change	SFY 2013 Existing Ridership	Ridership Change	Ridership Change
Bus	$105,816,930	$6,215,418	5.9%	117,087,612	-439,573	-0.4%
Heavy Rail	185,661,914	9,015,380	4.9	162,113,109	-1,115,992	-0.7
Light Rail	73,156,619	3,569,269	4.9	78,532,906	-525,366	-0.7
Commuter Rail	183,512,995	2,714,341	1.5	35,323,276	-744,964	-2.1
Ferry	8,504,104	-282,075	-3.3	1,256,705	-102,552	-8.2
THE RIDE	*see spreadsheet model results*			*see spreadsheet model results*		
Parking	39,109,795	-169,021	0.4	7,166,047	-40,071	-0.6
Total System	$602,759,591	$20,061,301	3.3%	403,415,753	-2,849,299	-0.7%

Notes: This table does not show the additional cost to operate the additional trips on THE RIDE—approximately $5 million.
Total system values include the spreadsheet model's results (Table 4-1) for the effects on THE RIDE users; the regional travel demand model set does not account for trips made on THE RIDE.
In this table, "Fare Revenue" includes revenue generated from parking at lots where the MBTA retains the revenue. "Ridership" includes the number of vehicles that parked at these lots.

The results from the regional travel demand model set suggest that the proposed fare increase has a significantly greater impact on ferry customers compared to other riders.

4.4 Comparison of Model Results: Ranges of Projected Impacts

Table 4-5 and Table 4-6 present the projected ranges of ridership impacts and fare revenue impacts resulting from the proposed SFY 2015 fare increase. By using both the spreadsheet and travel demand model set, we created a range of probable impacts. Tables 4-5 and 4-6 show that the travel demand model set estimates a smaller loss of ridership and a smaller increase in revenue compared to the spreadsheet model using the base elasticities.

Using the travel demand model set, CTPS projects a decrease of 2.8 million unlinked trips, or a 0.7 percent decrease, compared to a decrease of 3.8 million unlinked trips, or a 0.9 percent decrease, using the spreadsheet model. The projections from the travel demand model set show similar ridership decreases in the heavy rail, light rail, and bus modes and larger ridership decreases in the commuter rail and ferry categories compared to the spreadsheet model.

While the travel demand model set appears to estimate a less elastic response of riders overall to the fare increase than the spreadsheet model, on a mode-by-mode basis, the results are quite similar for the heavy and light rail systems. The regional travel demand model set predicts a smaller shift away from the bus system. These riders have less choice and few cheaper modes to which they can switch.

The regional travel demand model set predicts a large decrease in commuter rail and ferry ridership partly because the already high cost of these modes makes driving a relatively more competitive option than it is for users of other transit modes.

TABLE 4-5.
Spreadsheet Model and Travel Demand Model Set Ridership Impacts

Mode	Existing Ridership	Spreadsheet Model			Travel Demand Model Set		
		Projected	Change	Change	Projected	Change	Change
Bus	117,087,612	115,919,936	-1,167,676	-1.0%	116,648,039	-439,573	-0.4%
Heavy Rail	162,113,109	160,540,065	-1,573,044	-1.0	160,997,117	-1,115,992	-0.7
Light Rail	78,532,906	77,701,821	-831,085	-1.1	78,007,541	-525,366	-0.7
Commuter Rail	35,323,276	35,075,750	-247,526	-0.7	34,578,312	-744,964	-2.1
Ferry	1,256,705	1,237,004	-19,701	-1.6	1,154,153	-102,552	-8.2
THE RIDE	1,936,098	2,055,317	119,219	6.2	*see spreadsheet model results*		
Parking	7,166,047	7,130,229	-35,818	-0.5	7,125,975	-40,071	-0.6
Total System	403,415,753	399,660,121	-3,755,632	-0.9%	400,566,454	-2,849,299	-0.7%

Notes: Total system values include the spreadsheet model's results (Table 4-1) for the effects on THE RIDE users; the regional travel demand model set does not account for trips made on THE RIDE.
In this table, "Fare Revenue" includes revenue generated from parking at lots where the MBTA retains the revenue. "Ridership" includes the number of vehicles that parked at these lots.

TABLE 4-6.
Spreadsheet Model and Travel Demand Model Set
Fare Revenue Projections

Mode	Existing Revenue	Spreadsheet Model			Travel Demand Model Set		
		Projected	Change	Change	Projected	Change	Change
Bus	$105,816,930	$111,509,507	$5,692,577	5.4%	$112,032,348	$6,215,418	5.9%
Heavy Rail	185,661,914	194,285,196	8,623,282	4.6	194,677,294	9,015,380	4.9
Light Rail	73,156,619	76,480,527	3,323,908	4.5	76,725,888	3,569,269	4.9
Commuter Rail	183,512,995	191,187,684	7,674,689	4.2	186,227,336	2,714,341	1.5
Ferry	8,504,104	8,894,163	390,059	4.6	8,222,029	-282,075	-3.3
THE RIDE	6,997,234	5,995,224	-1,002,010	-14.3	*see spreadsheet model results*		
Parking	39,109,795	38,906,872	-202,923	-0.5	38,940,774	-169,021	-0.4
Total System	$602,759,591	$627,259,173	$24,499,582	4.1%	$622,820,893	$20,061,301	3.3%

Notes: Total system values include the spreadsheet model's results (Table 4-1) for the effects on THE RIDE users; the regional travel demand model set does not account for trips made on THE RIDE.
In this table, "Fare Revenue" includes revenue generated from parking at lots where the MBTA retains the revenue. "Ridership" includes the number of vehicles that parked at these lots.

In terms of annual fare revenue, projections from the travel demand model set show a gain of $20.0 million, or a 3.3 percent increase, compared to a gain of $24.5 million, or a 4.1 percent increase, from the spreadsheet model. Comparing modes, the travel demand model set and the spreadsheet model arrive at similar results for the bus, heavy rail, and light rail systems. The bus revenue estimate from the travel demand model set is slightly higher than those for the other modes; we primarily attribute this to fewer bus riders leaving the system.

While the results from the travel demand model set and the spreadsheet model are similar for the bus, heavy rail, and light rail systems, their projected revenues are notably different for the ferry system: the travel demand model set predicts that revenue will decrease, and the spreadsheet model predicts that revenue will increase. The spreadsheet model provided a more accurate representation of the change in ferry ridership resulting from the SFY 2013 fare increase than the regional travel demand model, which predicted a significantly higher loss in ridership for the ferry system than actually occurred. Given the results from the previous fare increase, we are more confident in the spreadsheet model's projections for the ferry system. Regardless, the MBTA will pay close attention to the revenue from the ferry system to inform the assessment of future fare increases.

As was the case in the ridership projections, it appears that the differences between the models' revenue estimates can be at least partly explained by the travel demand model set's projected diversion of commuter rail and ferry riders to other, cheaper transit modes. Overall, this diversion represents a loss in fare revenue, as riders switch from a higher-priced travel option to a lower-priced option. Further, the travel demand model set projects that riders on higher-priced modes are more likely to switch modes. When riders switch from high-priced modes, they contribute a greater loss in revenue per passenger than riders switching from less expensive modes. Indeed, the revenue estimates projected by the travel demand model set for the commuter rail and ferry modes result in the travel demand model set's overall projection of total fare revenue being less than that of the spreadsheet model.

Taken together, the projections shown in these tables provide a range of outcomes from the proposed fare increase in terms of ridership and fare revenue impacts.

CHAPTER 5. AIR QUALITY IMPACTS

5.1 Background

The Boston Region MPO's travel demand model set can determine air quality impacts resulting from the proposed fare increase. Typically, CTPS uses the travel demand model set to estimate future traffic characteristics—traffic volumes, average highway speeds, vehicle-miles and vehicle-hours traveled—within the region's transportation network. Since the amount of air pollution emitted by highway traffic depends on the prevailing highway speeds, vehicle-miles traveled, and other factors, it is possible to estimate these air quality impacts with reasonable accuracy.

Air pollutants produced by vehicles generally fall into two groups: gaseous and particulate. Examples of gaseous pollutants include carbon monoxide (CO), volatile organic compounds (VOC) (or compounds that easily evaporate at room temperature), nitrogen oxides (NOx), and carbon dioxide (CO_2). In addition, there are the photochemical oxidants (such as ozone), which are not directly emitted from vehicles but form when VOC and NOx chemically react in the presence of sunlight and warm temperatures. Particulate pollutants produced by vehicles are commonly broken into two categories: fine particulates—those with a diameter of 2.5 micrometers or less (particulate matter (PM)-2.5); and coarse particulates—those with a diameter between 2.5 and 10 micrometers (PM-10).

Under the Clean Air Act, the US Environmental Protection Agency (EPA) sets standards for various types of emissions. Historically, the EPA has regulated particulates, CO, and ground-level ozone, all of which are hazardous to human health. The Boston Region MPO is currently required to report the amount of CO, NOx, and VOC produced by the regional transportation system in such documents as the Transportation Improvement Program and the Long-Range Transportation Plan. Because of its contribution to climate change, CO_2 also is an important type of emission to measure.

CTPS employs emission rates for the year 2012 from the EPA Motor Vehicle Emission Simulator (MOVES) 2010b model for calculating amounts of pollutants. For each link within the highway network, the travel demand model set applies the MOVES emission factors corresponding to the link's average speed, land use (urban or rural), and roadway type (freeway or arterial), and estimates the emissions of pollutants based on the vehicle-miles traveled on that link by vehicle type. We obtain the total amount of emissions of a pollutant in the entire region by summing the quantities associated with the individual links in the system.

5.2 Estimated Air Quality Impacts

With respect to the proposed fare increase, transit users who switch to private automobiles are a primary cause of negative air quality impacts. A reduction in transit trips and an escalation of automobile trips generally increases CO, VOC, NOx, CO_2, and particulate matter, which we quantify in the manner described in the previous section. Note that as the numbers of automobile trips and vehicle-hours increase, the congestion on area roadways also increases. This additional congestion results in lower travel speeds, which are associated with higher emissions of most pollutants, for all vehicles—not just those of former transit users.

After calculating the ridership impacts as described earlier in this report, CTPS used the model set to estimate the change in regional vehicle-miles traveled and average speed for automobiles and transit vehicles. Specifically, for automobiles, the path of each automobile trip made by a former transit user was identified and the travel times for all automobile trips were estimated. CTPS applied emission factors provided by the EPA to these data.

Table 5-1 shows the results of the model set's air quality analysis. We expect automobile vehicle-miles and vehicle-hours traveled to increase and average speeds to decrease. The projected regional change in emissions of each of the selected pollutants is the sum of automobile and transit emissions.

The proposed scenario results in extremely small increases in all pollutant emissions—none of the emissions increase by more than one-tenth of one percent. Air quality should remain fundamentally unchanged.

TABLE 5-1.
Projected Average Weekday Changes in Selected Pollutants (MBTA Service Area)

Indicator/Pollutant	Initial Value	Absolute Change	Percent Change
Automobile vehicle-miles traveled	680,450,717	39,228	0.04%
Automobile vehicle-hours traveled	2,266,007	2,681	0.09
Automobile average miles-per-hour	30.21	-0.02	-0.05
Carbon monoxide (kg)	265,470	167	0.04
Nitrogen oxides (kg)	40,138	20	0.03
Volatile organic compounds (kg)	7,963	6	0.06
Carbon dioxide (kg)	31,623,622	24,471	0.05
Fine particulates, PM-2.5 (kg)	1,102.9	0.4	0.03
Coarse particulates, PM-10 (kg)	1,163.0	0.4	0.02

CHAPTER 6. FARE EQUITY ANALYSIS

6.1 Requirements

Title VI of the Civil Rights Act of 1964 prohibits discrimination, either intentionally or unintentionally, by recipients of federal financial assistance on the basis of race, color or national origin. To comply with 49 CFR Section 21.5(b) (2), 49 CFR Section 21.5(b) (7), and Appendix C to 49 CFR Part 21, the MBTA must evaluate any fare changes to *fixed-route* modes prior to implementing them to determine if the proposed changes would have a discriminatory effect. This requirement applies to any fare change. The FTA provides guidance for conducting fare equity analyses in FTA Circular 4702.1B ("Circular"), Section IV.7.b. Prior to a fare change, the MBTA must analyze any available information generated from ridership surveys that indicates whether minority and/or low-income riders are disproportionately more likely to use the mode of service, payment type, or payment media that would be subject to fare change. In addition, the MBTA must describe the datasets and collection methods used in its analysis.

The Circular states that the transit provider shall:

1. Determine the number and percentage of users of each fare media subject to change
2. Review fares before and after the change
3. Compare the relative cost burden impacts of the proposed fare change between minority and overall users for each fare media
4. Compare the relative cost burden impacts of the proposed fare change between low-income and overall users for each fare media

Under Title VI of the Civil Rights Act of 1964 and other directives, the FTA requires that transit agencies develop a policy to assess whether a proposed fare change would have a “disparate impact” on minority populations or “disproportionate burden” on low-income populations. The FTA Title VI guidelines define “disparate impact” as “a facially neutral policy or practice that disproportionately affects members of a group identified by race, color, or national origin, where the recipient’s policy or practice lacks a substantial legitimate justification and where there exists one or more alternatives that would serve the same legitimate objectives, but with less disproportionate effects on the basis, of race, color, or national origin,” and “disproportionate burden” as “a neutral policy or practice that disproportionately affects low-income populations more than non-low income populations. A finding of disproportionate burden requires the recipient to evaluate alternatives and mitigate burdens where practicable.

6.2 Proposed Disparate-Impact and Disproportionate-Burden Policies *Policies*

The MBTA has proposed the following policy thresholds for determining a disparate impact or disproportionate burden from a fare increase:

- A disparate benefit would be found if minority riders receive less than 80 percent of the benefit that all riders receive.
- A disproportionate benefit would be found if low-income riders receive less than 80 percent of the benefit that all riders receive.
- A disparate burden would be found if minority riders sustain more than 20 percent additional burden than the total burden that all riders sustain.
- A disproportionate burden would be found if low-income riders sustain more than 20 percent additional burden than the total burden that all riders sustain.

The draft policy is encapsulated in the following equations:

A disparate impact would be found if:

- Minority Benefit < 80% × All-Rider Benefit
- Minority Burden > 120% × All-Rider Burden

A disproportionate burden would be found if:

- Low-income Benefit < 80% × All-Rider Benefit
- Low-income Burden > 120% × All-Rider Burden

Upon finding a disparate impact or disproportionate burden based on a Title VI evaluation using the above proposed threshold policy definition, the MBTA shall consider modifying the proposed changes in order to avoid, minimize, or mitigate the disparate impacts or disproportionate burdens of the proposed changes.

Demographics and Definitions

Demographics

The systemwide demographic profile in Table 6-1 below shows how the MBTA's ridership characteristics in terms of minority and income status vary by mode. Minority and low-income profile data of the MBTA's ridership is from the MBTA 2008–09 Systemwide Passenger Survey report published in July 2010.

TABLE 6-1.
Demographic Profile of MBTA Riders by Mode

Mode	Minority	Nonminority	Low-Income	Non-Low-Income
Rapid Transit	27.5%	72.5%	24.1%	75.9%
Bus and Trackless Trolley	46.5	53.5	41.5	58.5
Commuter Rail	13.9	86.1	7.2	92.8
Commuter Ferry and Boat	5.7	94.3	4.5	95.5
Total	**33.0%**	**67.0%**	**28.5%**	**71.5%**

Minority- and Low-Income Populations

The MBTA uses both United States Census data and passenger survey data to define minority- and low-income populations. The census data is used when considering impacts on area residents. The survey data is used to assess impacts on riders.

Using the census data, the MBTA defines minority- and low-income populations based on the average percentage of minority residents and average income levels for the service area. For the MBTA service area, these were identified for each census tract and TAZ. Minority census tracts and TAZs were defined as those in which the percentage of the non-white population (including the Hispanic population) was greater than the average for the MBTA service area. The average percentage of minority residents is 26.2 percent in the service area. A census tract or TAZ is classified as low-income if its income level is at or below 60 percent of the median household income in the service area. For the 175-community MBTA service area 60% of household median income is $41,636.[12]

When using the MBTA Systemwide Passenger Survey as a basis for analysis, the definition of a minority rider mirrors the definition provided above: a minority rider is a person who is non-white or Hispanic. A low-income individual is a person whose household income is less than $40,000—the income category from the survey that most closely matched the census-defined low-income threshold.

Please see Appendix D for a sample application of the proposed disparate-impact policy.

Public-Engagement Process

It is the MBTA's policy that a proposed fare increase would be developed with extensive public input and would be adopted only after consultation with the Rider Oversight Committee (ROC), public comment, public meetings/hearings, MBTA Advisory Board review, and MBTA Board of Directors approval. The MBTA met with an MBTA stakeholder group, which consists of various community groups, transit advocacy groups (including the ROC), and other parties in early December 2013, to discuss the upcoming fare increase.

The MBTA plans to conduct an outreach program to inform the public about the proposed fare increase and solicit comment. During this period, the MBTA will hold public meetings and a hearing and accept written comments via mail, email, telephone, and the MBTA website. The MBTA will send a press release to area newspapers, announce the proposed fare increase on the MBTA and MassDOT websites, and send a blast email message to the MBTA, MassDOT, and Boston Region MPO's contact lists.

The MBTA will post documents relevant to the proposed fare increase on its website, including an informational brochure that describes the reasons for the need to increase fares; summarizes the impact of the proposed fare increase; and invites members of the public to attend public meetings, a public hearing, and comment via email or the MBTA website. The brochure will be posted in

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[12] Median household income was determined based on the 2007-2011 American Community Survey. Minority percentages were determined based on the 2010 US Census.

English and in the languages of the largest limited-English-proficiency populations in the MBTA service area. The MBTA will also post notices about the proposed fare increase and opportunities for public engagement throughout the system, which will be in languages other than English as determined by the four-factor analysis.

As stipulated in the MBTA's public process for changing fares, the MBTA must hold at least five public meetings for fare increases of less than 10%.[13] One or more of these meetings may be designated as a public hearing, which will be held in a central location within the MBTA service district. At these meetings, interpreters will be present and translated documents will be available.

The MBTA will hold five meetings at the following dates and locations:

- April 7 Roxbury Community College
- April 9 Lynn City Council Chambers
- April 16 Braintree Town Hall
- April 16 Shriners Auditorium
- April 22 State Transportation Building (public hearing)

The MBTA chose these meeting locations to offer access to stakeholders through the MBTA service area and to include locations with significant minority, low-income, and limited-English proficiency (LEP) populations. All of the meeting locations are accessible to people with disabilities, and assistance such as handouts in alternate formats and interpretation (American Sign Language or other non-English languages) will be provided as needed.

While the trigger for these meetings is the minor fare increase, the MBTA also will use them as an opportunity to engage the public in the decision-making process to develop the disparate-impact and disproportionate-burden policies.

6.3 Datasets, Data Collection Efforts, and Descriptions

CTPS used several datasets in the fare equity analysis:

- 2010 census and 2007–11 American Community Survey demographic data
- Boston Region MPO travel demand model set
- CTPS spreadsheet model
- MBTA 2008–09 Systemwide Passenger Survey, published in July 2010
- The Rhode Island Commuter Rail Service Passenger Surveys Summary Report

[13] www.mbta.com/about_the_mbta/news_events/?id=17437

The US Census provides a count of total population and population by ethnicity every 10 years; the most recent Census occurred in 2010. Data on population by income level is no longer collected as part of the decennial Census. Instead, we used more recent estimates from the American Community Survey (ACS)—which has replaced the long form of the decennial US Census, and provides estimates of total population as well as population by ethnicity and income level. We used ACS five-year estimates for the 2007–11 period—the most recently available data at the time we began our Title VI analysis. We used data from these sources to determine whether the units of analysis (census tracts or TAZs) were minority, nonminority, low-income, or non-low-income.

The Boston Region MPO travel demand model set simulates travel on the transportation network in eastern Massachusetts, including both the transit and highway systems—which includes all express highways, principal arterial roadways, and many minor arterial and local roadways. It also covers all MBTA commuter rail, rapid transit, and bus services, as well as all private express bus services. The model set reflects service frequency, routing, travel time, and fares for these services. The travel demand model set uses a traditional four-step, sequential process: trip generation, trip distribution, mode choice, and trip assignment. The results of this process are used to estimate average daily transit ridership and projected highway travel conditions, among other measures. We used the model set to analyze MBTA ridership and revenue impacts as a result of the proposed fare increase. (See Chapter 2 for more detailed information about this process.)

The CTPS spreadsheet model is elasticity based. CTPS has used this model in the past to provide inputs to the fare-increase analysis process. The spreadsheet model takes existing ridership in the form of unlinked trips by mode, fare-payment type, and fare media as inputs. The MBTA provides CTPS with ridership data from the automated fare collection system. For modes that are not yet part of the AFC system, the MBTA provides data (most notably, sales data for transit passes) to estimate ridership. Using these input data, the spreadsheet model employs elasticities and diversion factors to model a range of possible impacts resulting from changes to the MBTA's fares. (See Appendix A and Chapter 2 for further detail.)

The MBTA 2008–09 Systemwide Passenger Survey report, published in July 2010, included all of the modes operated by the MBTA—the Red, Blue, Orange, and Green Lines; the commuter rail system; the bus system; and the ferry system. The questions asked for each mode varied based on the specific characteristics of the given mode; but common among all of the surveys were questions regarding origins, destinations, frequency of travel, and most important to this equity analysis, fare payment method, usage frequency, race, and income.

In general, CTPS staff distributed the surveys from early morning until midafternoon. Each survey result was expanded to represent typical boardings during the survey hours. The systemwide survey was used in conjunction with the CTPS spreadsheet model to estimate the number of riders using each fare type and the fare changes for low-income, minority, and all riders.

The Rhode Island Department of Transportation (RIDOT) published the Rhode Island Commuter Rail Service Passenger Surveys Summary Report in August 2012.[14] RIDOT conducted the survey in June 2012. It distributed 245 surveys containing questions regarding race, ethnicity, and income at two MBTA stations (Wickford Junction and T.F. Green); 195 surveys were returned. Assuming the agency attempted to hand a survey to each rider, this represents an 80% return rate.

6.4 Equity Analysis and Results

We used two approaches to project the impacts of the proposed fare increase on MBTA riders. One approach utilized the elasticity-based spreadsheet model to evaluate projected changes in fares for minority and low-income riders versus those for all riders. The second approach consisted of applying the Boston Region MPO's regional travel demand model set to evaluate the impacts on these same classifications of riders.

Analysis Using the Spreadsheet Model

CTPS used the MBTA Systemwide Survey in conjunction with the spreadsheet model to determine the number of riders using each fare type and the price change by fare type for minority, low-income, and all riders. Because the model's ridership values are in trips and the survey's values are in riders, CTPS used the survey responses for the frequency of travel, fare type, and minority status to translate surveyed riders into trips per surveyed rider by fare type by minority status and income status.

We used the equation below to determine the number of days per week a fare is used by a demographic classification by weighting each survey response by the number of days per week the pass is used—data we also obtained from the systemwide survey. If 1,000 minority riders use monthly passes five days per week and 200 minority riders use monthly passes seven days per week, the average weighted usage per week for the minority riders using passes is equal to 5.33 days per week:

[14] Rhode Island Commuter Rail Service Passenger Surveys: Summary Report. Aug. 2012 www.dot.ri.gov/documents/intermodal/2012_Commuter_Rail_Survey.pdf.

$$\text{Minority Pass Usage} = \frac{1{,}000 \times 5 + 200 \times 7}{1{,}000 + 200} = 5.33$$

If minority riders used passes 5.33 days per week, and nonminority riders used passes 4.25 days per week, and minority riders made up 25% of the total pass fares, the percentage of minority riders using that fare type is:

$$\text{Minority Pass Percentage} = \frac{5.33 \times 25\%}{(5.33 \times 25\%) + (4.25 \times 75\%)} = 29.5\%$$

We used this procedure for each of the pass types to estimate the share of riders by demographic classification who use each fare type. We multiplied the resulting percentage by the total number of trips made using a fare type to estimate the number of riders by classification by fare. If the MBTA recorded 50 million total trips made using passes, the minority usage would be:

$$\text{Total Minority Usage} = 29.5\% \times 50 \text{ million trips} = 14.8 \text{ million trips}$$

Table 6-2 provides a data snapshot of fare type usage by demographic group.[15] Low-income riders are somewhat more likely to use single-ride fares. When using a single-ride fare, minority riders and low-income riders are more likely to be on a bus and paying a student or senior fare. In an effort to minimize the impact of the fare increase on minority and low-income riders, the MBTA increased senior and student bus fares as little as possible—$0.05. While the single-ride bus fare was increased $0.10, which is slightly more than average on a relative basis, riders who currently use a CharlieTicket can obtain a CharlieCard to gain access to lower single-ride fares.

[15] Minority and low-income riders share some of the same payment characteristics; however, the difference between how low-income riders and all riders pay is significantly more notable than the difference between payment trends of minority riders and all riders.

TABLE 6-2.
Minority, Low-Income, and All Riders Using Each Principal Fare-Payment Type

	Price		Change		Annual Usage by Group: Total Trips			Annual Usage by Group: Percent of Group Total		
Fare-Payment Type	Existing	Proposed SFY 2016	Absolute	Percent	Minority	Low-Income	All Riders	Minority	Low-Income	All Riders
SINGLE-RIDE FARES								26.9%	30.0%	27.2%
CharlieCard										
Adult										
Local Bus	$1.50	$1.60	$0.10	6.7%	8,983,000	7,725,000	17,090,000	6.4%	5.9%	4.4%
Rapid Transit	2.00	2.10	0.10	5.0%	10,436,000	10,263,000	38,134,000	7.4%	7.9%	9.8%
Bus + Rapid Transit	2.00	2.10	0.10	5.0%	3,553,000	3,193,000	8,715,000	2.5%	2.4%	2.2%
Inner Express	3.50	3.65	0.15	4.3%	226,000	201,000	540,000	0.2%	0.2%	0.1%
Outer Express	5.00	5.25	0.25	5.0%	24,700	12,400	102,000	0.0%	0.0%	0.0%
Senior										
Local Bus	$0.75	$0.80	$0.05	6.7%	1,718,000	3,449,000	4,582,000	1.2%	2.6%	1.2%
Rapid Transit	1.00	1.05	0.05	5.0%	1,032,000	2,283,000	4,179,000	0.7%	1.7%	1.1%
Bus + Rapid Transit	1.00	1.05	0.05	5.0%	533,000	1,104,000	1,645,000	0.4%	0.8%	0.4%
Inner Express	2.25	2.35	0.10	4.4%	4,400	38,300	75,700	0.0%	0.0%	0.0%
Outer Express	3.25	3.40	0.15	4.6%	NR	NR	13,700	0.0%	0.0%	0.0%
Student										
Local Bus	$0.75	$0.80	$0.05	6.7%	1,522,000	1,477,000	1,979,000	1.1%	1.1%	0.5%
Rapid Transit	1.00	1.05	0.05	5.0%	807,000	658,000	1,252,000	0.6%	0.5%	0.3%
Bus + Rapid Transit	1.00	1.05	0.05	5.0%	333,000	309,000	456,000	0.2%	0.2%	0.1%
Inner Express	2.25	2.35	0.10	4.4%	19,800	30,600	32,600	0.0%	0.0%	0.0%
Outer Express	3.25	3.40	0.15	4.6%	NR	NR	500	0.0%	0.0%	0.0%
CharlieTicket										
Adult										
Local Bus	$2.00	$2.10	$0.10	5.0%	2,001,000	2,016,000	3,406,000	1.4%	1.5%	0.9%
Rapid Transit	2.50	2.65	0.15	6.0%	5,288,000	5,501,000	14,442,000	3.8%	4.2%	3.7%
Bus + Rapid Transit	4.50	4.75	0.25	5.6%	7,600	7,600	14,100	0.0%	0.0%	0.0%
Inner Express	4.50	4.75	0.25	5.6%	40,600	46,800	90,200	0.0%	0.0%	0.0%
Outer Express	6.50	6.80	0.30	4.6%	4,900	NR	8,700	0.0%	0.0%	0.0%
Commuter Rail										
Zone 1A–10	$2.00–$11.00	$2.10–$11.50	$0.10–$0.50	3.4%–6.3%	1,092,000	774,000	8,324,000	0.8%	0.6%	2.1%
InterZone 1–9	$2.50–$6.00	$2.75–$6.25	$0.25	4.2%–10.0%	20,600	14,600	157,400	0.0%	0.0%	0.0%
Ferry										
F1: Hingham	$8.00	$8.50	$0.50	6.3%	19,100	7,300	541,000	0.0%	0.0%	0.1%
F2: Boston	8.00	8.50	0.50	6.3%	1,400	31,500	205,000	0.0%	0.0%	0.1%
F2: Cross Harbor	13.00	13.75	0.75	5.8%	200	500	1,900	0.0%	0.0%	0.0%
F2: Logan	16.00	17.00	1.00	6.3%	3,100	8,300	28,800	0.0%	0.0%	0.0%
F4: Inner Harbor	3.00	3.25	0.25	8.3%	20,900	14,700	220,000	0.0%	0.0%	0.1%
PASSES								50.3%	46.4%	49.1%
Local Bus	$48.00	$50.00	$2.00	4.2%	3,243,000	2,527,000	5,498,000	2.3%	1.9%	1.4%
LinkPass	70.00	75.00	5.00	7.1%	30,072,000	20,774,000	91,766,000	21.5%	15.9%	23.5%
Senior/TAP	28.00	29.00	1.00	3.6%	3,919,000	7,561,000	11,532,000	2.8%	5.8%	2.9%
Student 5-Day	25.00	26.00	1.00	4.0%	5,943,000	5,383,000	9,007,000	4.2%	4.1%	2.3%
Student 7-Day	28.00	29.00	1.00	3.6%	622,000	564,000	943,000	0.4%	0.4%	0.2%
1-Day	11.00	12.00	1.00	9.1%	665,000	494,000	799,000	0.5%	0.4%	0.2%
7-Day	18.00	19.00	1.00	5.6%	21,249,000	21,505,000	44,721,000	15.2%	16.5%	11.4%
Inner Express	110.00	115.00	5.00	4.5%	639,000	351,000	2,190,000	0.5%	0.3%	0.6%
Outer Express	160.00	168.00	8.00	5.0%	107,000	30,100	375,000	0.1%	0.0%	0.1%
Commuter Boat	262.00	275.00	13.00	5.0%	8,000	7,400	265,000	0.0%	0.0%	0.1%
Commuter Rail										
Zone 1A–10	$70.00–$345.00	$75.00–$362.00	$5.00–$17.00	4.7%–7.1%	4,074,000	1,430,000	24,644,000	2.9%	1.1%	6.3%
Zone 1A	$70.00	$75.00	$5.00	7.1%	706,000	394,000	2,261,000	0.5%	0.3%	0.6%
Zone 1	173.00	182.00	9.00	5.2%	247,000	82,400	1,609,000	0.2%	0.1%	0.4%
Zone 2	189.00	198.00	9.00	4.8%	471,000	156,000	3,871,000	0.3%	0.1%	1.0%
Zone 3	212.00	222.00	10.00	4.7%	558,000	150,000	3,931,000	0.4%	0.1%	1.0%
Zone 4	228.00	239.00	11.00	4.8%	671,000	215,000	3,646,000	0.5%	0.2%	0.9%
Zone 5	252.00	265.00	13.00	5.2%	285,000	89,700	2,035,000	0.2%	0.1%	0.5%
Zone 6	275.00	289.00	14.00	5.1%	561,000	139,000	3,689,000	0.4%	0.1%	0.9%
Zone 7	291.00	306.00	15.00	5.2%	323,000	104,000	1,762,000	0.2%	0.1%	0.5%
Zone 8	314.00	330.00	16.00	5.1%	245,000	93,400	1,782,000	0.2%	0.1%	0.5%
Zone 9	329.00	345.00	16.00	4.9%	5,800	4,900	45,200	0.0%	0.0%	0.0%
Zone 10	345.00	362.00	17.00	4.9%	900	1,000	12,700	0.0%	0.0%	0.0%
InterZone 1–9	$82.00–$201.00	$86.00–$211.00	$4.00–$10.00	4.6%–5.3%	18,300	5,400	113,800	0.0%	0.0%	0.0%
FREE TRANSFERS AND OTHER FARES								22.8%	23.7%	23.8%

Note: Values greater than 100,000 are rounded to the nearest 1,000. Values less than 100,000 are rounded to the nearest 100. Percentages are calculated using unrounded values.
NR indicates that no riders from a given classification responded to the survey.

Minority and low-income riders are more likely to use a 7-Day LinkPass than a monthly LinkPass compared to all riders.[16] The MBTA added the 7-Day LinkPass during the 2007 fare structure changes to allow passengers who cannot afford to —or for some other reason do not—purchase a monthly pass at the beginning of the month to spread their purchases out over a longer period. Four 7-Day LinkPasses essentially cost the same as a monthly LinkPass ($76 compared to $75, respectively), unless an individual purchases a 7-Day LinkPass for all 52 weeks of the year. The 7-Day LinkPass is also somewhat more flexible—if someone knows s/he is not going to make enough trips in a given week for the pass to be worthwhile (say, during the winter holidays or school vacation), s/he can choose not to purchase it for that week. Further, the MBTA proposal includes relatively low fare increases to the monthly bus, senior, and student pass prices—fare products that likely would be used by minority and low-income riders.

At the beginning of SFY 2013, the MBTA introduced a monthly student pass that is valid seven days a week, in addition to the existing five-day student pass. This fare product was designed to provide more access at the lower pass prices for minority- and low-income students. However, sales of the seven-day student monthly pass appear to be lower than expected.[17] The MBTA is reviewing ways to improve access to the seven-day student pass.

Minority Riders Compared to All Riders and Low-income Riders Compared to All Riders

Table 6-3 presents the existing and proposed average fares, the absolute price changes, and the relative price changes for minority riders, low-income riders, and all riders. As the Circular indicates, fare equity analyses are only applicable to fixed-route modes; neither THE RIDE nor parking is included in the following analysis. Minority and low-income riders pay lower average fares compared to the overall average fare for all riders. This is largely because nonminority and non-low-income riders use the commuter rail system and other more expensive modes more than minority and low-income riders. At the proposed fare levels, minority and low-income riders would continue to pay lower average fares.

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[16] The 7-Day LinkPass and the monthly LinkPass provide unlimited access to all local bus and rapid transit services.

[17] The seven-day student pass was, and is proposed to remain, $3 more than the five-day student pass. Many of the students likely would make at least three trips in a given month—the extra cost of the seven-day pass.

TABLE 6-3.
Existing and Proposed Average Fares and Price Changes
(Weighted by Fare Usage Frequency)

Rider Classification	Existing Average Fare	Proposed Average Fare	Absolute Price Change	Percentage Price Change
Minority	$1.14	$1.20	$0.06	5.3%
Low-income	$1.01	$1.06	$0.05	5.1%
All Riders	**$1.41**	**$1.48**	**$0.07**	**5.3%**

Note: The values in this table are rounded to the nearest cent or the nearest tenth of a percent. All calculations were performed using unrounded values.

Results from Applying the Proposed Disparate-Impact and Disproportionate-Burden Policies

The results of the analysis show that there is no disparate impact on minority riders and no disproportionate burden on low-income riders when considering both the absolute and relative fare changes.

Application of the proposed disparate-impact policy shows:
The **absolute increase** in the average fare for minority riders is **81%** of the **absolute increase** in the average fare for all riders.

The **relative increase** (or the change taken as a percentage if the initial fare) in the average fare for minority riders is **101%** of the **relative increase** in the average fare for all riders.

Application of the proposed disproportionate-burden policy shows:
The **absolute increase** in the average fare for low-income riders is **69%** of the **absolute increase** in the average fare for all riders.

The **relative increase** in the average fare for low-income riders is **96%** of the **relative increase** in the average fare for all riders.

The fare changes affect the overall ridership more severely than minority or low-income riders when considering the absolute changes in fares; and affect overall ridership more than low-income riders when considering the relative changes in fares. While the relative change in fares is greater for minority riders than for all riders, the relative increase for minority riders is 1% greater than the increase for all riders. Because this is less than the 20% threshold in the disparate-impact policy, we do not find a disparate impact.

Analysis Using the MPO Travel Demand Model Set

CTPS used the regional travel demand model set to evaluate the impacts of the fare changes on minority and low-income populations for all modes except THE RIDE. There are three important issues to note concerning this analysis:

- The fares reported in Tables 6-4 and 6-5 are greater than the average fares quoted in other places in this report because they are linked rather than unlinked trips.
- The regional travel demand model set uses Census-based demographic data. As mentioned in the Circular, this is *not* FTA's preferred method of analysis. The regional travel demand model accounts for ridership by mode for each TAZ.
- Parking utilization and revenue is included in this analysis; a fare equity analysis does not generally include parking. Isolating parking revenue from the rest of the fares was not possible at the time of analysis.

Minority Riders Compared to All Riders and Low-income Riders Compared to All Riders

Table 6-4 presents the average prices, the absolute price changes, and the relative price changes for minority riders, low-income riders, and all riders. Minority- and low-income riders pay lower average fares compared to all riders. This is largely because nonminority and non-low-income riders use the commuter rail system and other more expensive modes more than minority and low-income riders. At the proposed fare levels, minority- and low-income riders would continue to pay lower average fares.

TABLE 6-4.
Existing and Proposed Average Fares and Price Changes
(as Calculated by the Regional Travel Demand Model Set in Linked Trips)

Rider Classification	Existing Average Fare	Proposed Average Fare	Absolute Price Change	Percent Price Change
Minority	$2.26	$2.34	$0.08	3.7%
Low-income	$2.14	$2.22	$0.08	3.8%
All Riders	$2.59	$2.68	$0.09	3.4%

Note: The values in this table are rounded to the nearest cent or the nearest tenth of a percent. All calculations were performed using unrounded values.

Results from Applying the Proposed Disparate-Impact and Disproportionate-Burden Policies

The results of the analysis show that there is no disparate impact on minority riders and no disproportionate burden on low-income riders when considering both the absolute and relative fare changes.

Application of the proposed disparate-impact policy shows:
The **absolute increase** in the average fare for minority riders is **93%** of the **absolute increase** in the average fare for all riders.

The **relative increase** (or the change taken as a percentage if the initial fare) in the average fare for minority riders is **107%** of the **relative increase** in the average fare for all riders.

Application of the proposed disproportionate-burden policy shows:
The **absolute increase** in the average fare for low-income riders is **93%** of the **absolute increase** in the average fare for all riders.

The **relative increase** in the average fare for low-income riders is **112%** of the **relative increase** in the average fare for all riders.

The relative fare increase for minority riders is 7% greater than the increase for all riders. Because this is less than the 20% threshold in the proposed disparate-impact policy, we do not find a disparate impact. We also do not find a disproportionate burden. The relative fare increase on low-income riders is 12% that of all riders. Because this is less than the 20% threshold in the MBTA's disparate-impact policy, we do not find a disparate impact. If parking revenue and ridership were removed from this analysis, the relative fare increases would be more similar. This is because people who park then take transit are more likely to be nonminority and non-low-income and parking costs did not increase.

Consideration of Off-Model Stations

Seven MBTA commuter rail stations are outside of the model region. The ridership associated with these stations is therefore not included in the preceding analysis. These stations are Grafton Station and Worcester Station on the Framingham-Worcester Line; North Leominster Station and Fitchburg Station on the Fitchburg Line; and Providence Station, T.F. Green Station, and Wickford Junction on the Providence-Stoughton Line. Because these stations are outside of what CTPS is able to directly model, we conducted a separate analysis for them. The MBTA's most recent systemwide survey and a RIDOT commuter rail survey serve as sources of data for this section. Table 6-5 and Table 6-6 present demographic data for these stations.

According to the MBTA Systemwide Survey and the RIDOT commuter rail survey, riders who use these stations tend to have higher income and be nonminority.

TABLE 6-5.
Off-Model Station Characteristics: Income Status

Station Name	Total Riders	Less than $40k	Percent of Total	More than $40K	Percent of Total	Community Type
Grafton	406	16	3.9%	390	96.1%	Non-low-income
Worcester	559	45	8.1%	514	91.9%	Non-low-income
North Leominster	263	29	11.0%	234	89.0%	Non-low-income
Fitchburg	212	31	14.6%	181	85.4%	Non-low-income
Providence	1,219	124	10.2%	1,095	89.8%	Non-low-income
T.F. Green*	164	18	11.0%	146	89.0%	Non-low-income
Wickford Junction*	241	19	8.0%	222	92.0%	Non-low-income
Total	**3,064**	**282**	**9.2%**	**2,782**	**90.8%**	—

* RIDOT's 2012 commuter rail survey provided the data for T.F. Green and Wickford Junction Stations. Ridership data for those stations comes from counts made by the conductors.

TABLE 6-6.
Off-Model Station Characteristics: Minority Status

Station Name	Total Riders	Minority	Percent of Total	Non-minority	Percent of Total	Community Type
Grafton	511	99	19.4%	412	80.6%	Nonminority
Worcester	675	222	32.9%	453	67.1%	Minority
North Leominster	295	47	15.9%	248	84.1%	Nonminority
Fitchburg	266	48	18.0%	218	82.0%	Nonminority
Providence	1,341	400	29.8%	941	70.2%	Nonminority
T.F. Green*	164	21	13.0%	143	87.0%	Nonminority
Wickford Junction*	241	17	7.0%	224	93.0%	Nonminority
Total	**3,493**	**854**	**24.5%**	**2,639**	**75.5%**	—

* RIDOT's 2012 commuter rail survey provided the data for T.F. Green and Wickford Junction Stations. Ridership data for those stations comes from counts made by the conductors.

Except for Providence and Worcester Stations, relatively few riders use these stations. The ridership of these stations represents about five percent of the commuter rail system's total ridership, and it represents less than one-hundredth of a percent of the total trips made on the MBTA system. Because not many riders use these stations, and the fare increases at these stations are similar to those of the rest of the system, it is highly unlikely that our conclusions would change if the regional travel demand model set included these stations.

CTPS is presently working to incorporate these stations into the regional travel demand model set.

6.5 Summary of Equity Analysis

Our analysis of the SFY 2015 fare increase, using the spreadsheet model and the MBTA Systemwide Passenger Survey, estimated that not only are minority- and low-income riders currently paying a lower existing average fare than all riders, but the absolute change in the average fare also is less for minority- and low-income riders. A greater percentage of riders paying with single-ride fares—especially on the bus and with senior and student fares—or a 7-Day LinkPass are minority and low-income.

Using the spreadsheet model coupled with the MBTA systemwide survey and the regional travel demand model set, we calculated the absolute and relative fare increases for minority riders, low-income riders, and all riders. Our analysis indicates that neither a disparate impact on minority riders nor a disproportionate burden on low-income riders should occur if the MBTA enacts the proposed fare changes.

CHAPTER 7. CONCLUSION

CTPS conducted two analyses of the impacts of the fare changes on ridership and revenue, each using a methodology based on established data inputs. These analyses show that the MBTA fare proposal would generate approximately $20–$25 million of additional revenue, with an anticipated ridership decrease by 3-to-4 million trips annually. Additional trips made on THE RIDE system, induced by the January 2014 reduction in the ADA paratransit fare, should increase annual operating costs by approximately $5 million. The fare increase would cause a small number of transit riders to divert to other transportation modes; riders who switch to driving would minimally degrade air quality and increase congestion on the roadway network.

Staff applied the MBTA's draft disparate-impact and disproportionate-burden policy thresholds in assessing the estimated regional equity impacts of the proposed fare changes. We do not expect the fare increase to cause disparate impacts or disproportionate burdens.

CTPS also measured the effects of the fare increase in terms of several environmental-justice metrics. The details, which can be found in Appendix B, show that all of the differences between the minority and nonminority riders (and communities) and between low-income and non-low-income riders (and communities) are fundamentally very minor.

Throughout SFY 2015, the MBTA intends to conduct a thorough review of its fare structure and fare-collection policies, including whether it is feasible or desirable in SFY 2016 to:

- Offer means-tested fares
- Simplify the fare structure
- Establish incentives for more efficient payment methods on buses
- Implement a university pass program
- Broaden the availability of student fares
- Introduce time-of-day pricing
- Change the parking pricing structure
- Assimilate new fare payment technologies

The MBTA will be leading continuous dialogues and civic engagements with customers and service-area residents concerning these fare policy issues in the coming year.

Because the proposed 5% fare increase is minor, as defined by the MBTA, fare or fare structure changes in SFY 2016 likely would generate the additional revenue required to meet the legislated own-source revenue benchmark mandated for SFY 2016 of 33.25%. Another reason the MBTA has been considering a move toward smaller, more regular fare increases, in addition to limiting the impact on riders, is to facilitate planning and budgeting. The MBTA will make final decisions regarding changes to fare levels in SFY 2016 based, in part, on operating revenue received in SFY 2015. Appendix C presents one set of potential SFY 2016 fares—in this scenario, fares increase by approximately 5% roughly evenly across all modes.

APPENDIX A: SPREADSHEET MODEL METHODOLOGY

A.1 Apportionment of Existing Ridership

One of the first steps in starting a new iteration of the spreadsheet model is the collection of new AFC and pass sales data—this data represents the largest share of the MBTA's ridership and revenue—and revenue and ridership reports for the ferries, THE RIDE, and the MBTA's parking lots.

The MBTA provides CTPS with AFC data summarized by hour, by day for the various combinations of fare type, fare mode, and fare media (Table A-1). After processing, the AFC data can be attributed to each mode, fare type, and station (or Green Line branch). The fares for approximately 85% of all trips made on the system are paid using the AFC system.

The remaining trips are made using modes on which fares are not paid using the AFC system: commuter rail, commuter boat, THE RIDE, and parking. For these modes, we rely on fare-mix reports (that indicate how riders pay), various passenger surveys CTPS has conducted, and other ridership and revenue reports provided by the MBTA.

TABLE A-1.
AFC Fare Categories

Fare Type	Fare Mode	Fare Media
Adult/Senior/TAP/Student/Free	Single-Ride	CharlieCard CharlieTicket Onboard Cash
Adult/Senior/TAP/Student	Transfer	CharlieCard CharlieTicket
Short (fares below the full value)	Single-Ride	Onboard Cash
Bus/Inner Express/Outer Express	Pass	CharlieCard CharlieTicket
LinkPass: Monthly/1-Day/7-Day	Pass	CharlieCard CharlieTicket
Commuter Rail Zone and InterZone/Commuter Boat	Pass	CharlieTicket
Senior/TAP/Student	Pass	CharlieCard CharlieTicket

A.2 Price Elasticity

Price elasticity is the measure of the rate of change in ridership relative to a change in fares if all other factors remain constant. On a traditional demand curve that describes the relationship between price, on the y-axis, and demand, on the x-axis, elasticities are equivalent to the slope along that curve. Therefore, price elasticities are generally expected to be negative, meaning that a positive price increase would lead to a decrease in demand (with a price decrease having the opposite effect). The more negative (farther from zero) the value of a price elasticity, the larger the projected decrease in demand. More negative price elasticities are said to be relatively "elastic," while smaller negative values, closer to zero, are said to be relatively "inelastic." Thus, if the price elasticity of the demand for transit is assumed to be elastic, a given fare increase would cause a greater loss of ridership than if demand were assumed to be inelastic.

At its most elemental level, the spreadsheet model is based on this simple price elasticity relationship, and requires four inputs: original demand, original fare, new fare, and price elasticity. The formula for calculating new demand is:

$$\text{New Demand} = \text{Original Demand} \times [1 + \text{Price Elasticity} \times (\text{New Fare} \div \text{Old Fare} - 1)]$$

As an example, assume that original demand equals 100 and that the impact we are modeling is a 10 percent fare increase from $1.00 to $1.10. Also assume that the price elasticity is -0.25.

$$\text{New Demand} = 100 \times [1 + -0.25 \times (\$1.10 \div \$1.00 - 1)] = 97.50$$

Thus, using an elasticity of -0.25, a simple price elasticity model projects that a 10 percent increase in price will lead to a 2.50 percent decrease in demand. With the fare increased from $1.00 to $1.10, this simplified example projects a 7.25 percent increase in revenue ($100.00 to $107.25).

A.3 Diversion Factors

The spreadsheet model's calculations are more comprehensive than a simple elasticity calculation. Its greater detail lies in its use of ridership diversion factors. Diversion factors reflect estimates of the likelihood of a switch in demand for one type of good to another resulting from a change in the relative prices of those goods. In the spreadsheet model, we use such factors to estimate the number of riders who would choose to divert from one fare/mode category to another. Using cash tickets and passes as an example, assume that original ridership equals 100 cash riders and 1,000 pass riders. Also assume that original prices for cash tickets and passes equal $2.00 and $100.00, respectively, and that the new prices are set at $1.50 for cash tickets and $50.00 for passes, representing price decreases of 25 percent and 50 percent. Assume that the cash price elasticity equals -0.35 and the pass price elasticity equals -0.25. Finally, assume a cash-to-pass diversion factor of 0.05 and a pass-to-cash diversion factor of 0.00.

In these calculations of diversion, one of the diversion factors must always equal zero, indicating that the diversion is expected to occur in one direction only. The direction of the diversion, and thus the diversion factor value, depends on the respective price changes of the two types of goods. The category with the greater relative price decrease (or the smaller relative price increase)—in this case, pass, for which the price decrease is 50 percent, compared to 25 percent for cash tickets—would gain riders from the diversion, while the other category, with the smaller relative price decrease (or the greater relative price increase), would lose riders from the diversion. One would therefore expect that cash customers would switch to passes, but not that pass customers would switch to cash tickets, resulting in the 0.05 cash-to-pass and 0.00 pass-to-cash diversion factors.

The diversion factors essentially work to redistribute demand between the two categories after the respective price elasticities have been applied. For instance, after the cash fare is decreased from $2.00 to $1.50, the projected effect of price elasticity is that cash demand grows to 108.75 riders. Similarly, the pass price decrease from $100 to $50 leads to a projected increase in pass demand, because of price elasticity, to 1,125, for a total ridership of 1,233.75. However, the percentage decrease in the pass price is larger than that in cash fares (50 percent versus 25 percent); thus, one would expect some customers to switch from cash to pass.

This diversion is estimated by taking the ratio of new-to-original cash prices ($1.50÷$2.00, or 75 percent), dividing that ratio by the ratio of new-to-original pass prices ($50÷$100, or 50 percent), subtracting 1, and multiplying this result by the 0.05 diversion factor and the price-elasticity-estimated cash ridership (108.75). The number of riders “diverted” from cash to pass equals 2.72, giving final ridership estimates of 106.03 for cash and 1,127.72 for pass (still summing to a total ridership of 1,233.75).

New Cash Demand (Price Effect),

$$Cp = 100 \times [1 + -0.35 \times (\$1.50 \div \$2.00 - 1)] = 108.75$$

New Pass Demand (Price Effect),

$$Pp = 1{,}000 \times [1 + -0.25 \times (\$50 \div \$100 - 1)] = 1{,}125.00$$

Total Demand = 108.75 + 1,125.00 = 1,233.75

$$\text{Diverted Riders from Cash to Pass} = \left(\frac{\$NewCash/\$OldCash}{\$NewPass/\$OldPass} - 1\right) \times \text{Diversion} \times C_P$$

$$\text{Diverted Riders from Cash to Pass} = \left(\frac{\$1.50/\$2.00}{\$50/\$100} - 1\right) \times 0.05 \times 108.75 = 2.72$$

New Cash Demand = C_p − Diverted Riders from Cash to Pass = 106.03
New Pass Demand = P_p + Diverted Riders from Cash to Pass = 1,127.72
Total Demand = 106.03 + 1,127.72 = 1,233.75

We used diversion factors to estimate diversions between:

- Cash and pass categories (for example, bus cash versus bus pass, subway cash versus subway pass)
- Bus and rapid transit (in other words, bus cash versus subway cash, bus pass versus subway pass)
- CharlieTicket/onboard cash and CharlieCard (for example, bus onboard cash versus bus CharlieCard, subway CharlieTicket versus subway CharlieCard)

We initially developed a range of diversion factors based on results of the 2007 Post-Fare Increase Impacts Analysis. We used these factors in the SFY 2013 fare increase analysis, and continued to use them in the SFY 2015 analysis. After reviewing the impacts of the SFY 2013 fare increase, we found sufficient evidence to slightly increase the willingness of people to divert between passes and cash on the subway and light rail system.

Given that the fare increases are relatively level across all modes and fare media, these factors have a negligible effect on the results.

A.4 Price Elasticity Estimation

CTPS estimated the price elasticity of demand for the SFY 2015 version of the fare increase model based on a review of the changes in ridership, revenue, and price following the implementation of the SFY 2013 fare increase. We used the demonstrated elasticities—which we calculated following our analysis of the impact of the SFY 2013 fare increase—to guide our decisions about modifying the previously used set of elasticities. However, because the changes in ridership likely also were influenced by factors in addition to the fare changes, we did not directly use the demonstrated elasticities for the SFY 2015 iteration of the spreadsheet model.

The following sections explain the process CTPS used to modify the elasticities for the SFY 2015 iteration of the spreadsheet model using the SFY 2013 demonstrated elasticities.

A.5 Calculating the Demonstrated Elasticity of Each Fare Type

Before we performed projections using the latest iteration of the spreadsheet model, we reviewed how ridership changed after past price changes to calculate demonstrated elasticities.

To calculate the demonstrated elasticity for a given fare, we used two pieces of information: the percentage change in fares and the percentage change in ridership. For each fare payment type on each mode, we calculated the percentage change between full SFY 2012 (before the fare increase) and full SFY 2013 (after the fare increase) ridership and fares using the formula:

$$\text{Percentage Change} = \frac{X_2 - X_1}{\left(\frac{X_2 + X_1}{2}\right)}$$

Where:

X_1 = SFY 2012 value (the year before the fare changes)

X_2 = SFY 2013 value (the year after the fare changes)

This formula provides the percentage change between X_1 and X_2 relative to the midpoint of X_1 and X_2. If $X_1 = 10$ and $X_2 = 20$, the formula would indicate that the percentage change relative to the midpoint (15) is equal to 66%.

For example in SFY 2012, the single-ride bus ridership was 22,441,080. SFY 2013 ridership was 21,237,096. The percentage change in ridership between these two years is:

$$\text{Percentage Change} = \frac{21{,}237{,}096 - 22{,}441{,}080}{\left(\frac{21{,}237{,}096 + 22{,}441{,}080}{2}\right)} = -5.5\%$$

For each relevant fare payment type, we calculated the demonstrated elasticity with respect to fares using the following formula:

$$\text{Elasticity} = \frac{\Delta\text{Ridership (in \%)}}{\Delta\text{Fare (in \%)}}$$

For example, the percentage change in single-ride ridership on MBTA buses from SFY 2012 to SFY 2013 was -5.5%. The percentage change in the fare was 19.5%. The demonstrated elasticity is calculated as follows:

$$\text{Elasticity} = \frac{\Delta\text{Ridership (in \%)}}{\Delta\text{Fare (in \%)}} = \frac{-5.5\%}{19.5\%} = -0.28$$

As another example, the total change in LinkPass ridership was -0.3%. The change in the average LinkPass trip price was 17.4%. The demonstrated elasticity is calculated as follows:

$$\text{Elasticity} = \frac{\Delta\text{Ridership (in \%)}}{\Delta\text{Fare (in \%)}} = \frac{-0.3\%}{17.4\%} = -0.02$$

Modifying the Elasticities of Each Fare Type for the Current Projection

Because the demonstrated elasticity values only incorporate the changes in fares and do not account for other factors that affect transit ridership—such as gas prices, employment levels, and development—we do not advise using the elasticities calculated based on the results from the SFY 2013 fare increase in the SFY 2015 model. Some of the demonstrated elasticities indicate that other factors are affecting ridership, especially those with positive values that indicate ridership increased in response to the fare increase. Therefore, we only used the demonstrated elasticities, along with the following heuristics, to inform the modification of the SFY 2012 elasticities.

- If the value of a demonstrated elasticity was close to zero or positive, we modified the value to make it more inelastic (closer to zero)
- No elasticity was set to be greater than -0.10
- If an elasticity was used in SFY 2012 and the demonstrated elasticity was roughly similar, we did not modify the elasticity
- If the demonstrated elasticity was significantly more negative than the one we used in SFY 2012, we decreased the elasticity (made it more negative)

Table A-2 presents the elasticities we used to predict what might have happened following the SFY 2013 fare increase, the elasticities we calculated based on the actual changes between SFY 2012 and SFY 2013, and the elasticities we used to project the effects of the SFY 2015 fare changes.

TABLE A-2.
SFY 2012, Demonstrated, and SFY 2013 Elasticities

Modal Category	Estimated SFY 2013 Elasticity	Demonstrated SFY 2013 Elasticity	Estimated SFY 2015 Base Elasticity
Cash Elasticities			
Bus and Trackless Trolley			
Bus-Adult *(from example)*	-0.20	-0.28	-0.25
Bus-Senior	-0.15	-0.26	-0.20
Bus-Student	-0.15	0.30	-0.15
Subway			
Subway-Adult	-0.25	-0.26	-0.25
Subway-Senior	-0.15	-0.18	-0.15
Subway-Student	-0.15	1.80	-0.10
Surface Light Rail			
Surface Light Rail-Adult	-0.25	-0.29	-0.30
Surface Light Rail-Senior	-0.20	-0.19	-0.20
Surface Light Rail-Student	-0.20	1.96	-0.15
Commuter Rail			
Commuter Rail-Adult	-0.35	0.01	-0.20
Commuter Rail-Senior	-0.25	0.37	-0.15
Commuter Boat			
Commuter Boat-Adult	-0.30	-0.34	-0.30
Commuter Boat-Senior	-0.20	-0.75	-0.25
THE RIDE	-0.12	-0.39	-0.35
Parking	-0.20	-0.18	-0.20
Pass Elasticities			
Bus	-0.30	-0.09	-0.15
Inner Express	-0.20	-0.33	-0.25
Outer Express	-0.20	-0.33	-0.25
LinkPass *(from example)*	-0.30	-0.02	-0.15
1-Day LinkPass	-0.35	0.41	-0.15
7-Day LinkPass	-0.35	0.09	-0.15
Commuter Rail	-0.10	-0.17	-0.10
Commuter Boat	-0.25	-0.17	-0.20
Senior	-0.15	0.23	-0.10
Student	-0.15	-0.04	-0.10

Note: The estimated SFY 2013 elasticity is the elasticity we used to estimate the effects of the SFY 2013 fare increase.
The demonstrated SFY 2013 elasticity is the elasticity we calculated based on ridership changes following the SFY 2013 fare increase.
The estimated SFY 2015 base elasticity is the elasticity we used to estimate the effects of the SFY 2015 fare increase.

A.6 Examples of Ridership and Revenue Calculations

Simple Example: Price Elasticity Only

Given:
Original Demand: 100,000
Original Fare: $1.50
New Fare: $2.50
Price Elasticity: -0.05
New Demand =
Original Demand × [1 + Price Elasticity × (New Fare ÷ Old Fare − 1)]
New Demand = 100,000 × [1 + −0.05 × ($2.50 ÷ $1.50 − 1)] = 96,666.67

More Complex Example: Price Elasticity plus Ridership Diversion — Cash to Pass

Given:
Original Cash Demand: 10,000
Original Cash Fare: $2.25
New Cash Fare: $2.00
Cash Price Elasticity: -0.30
New Demand =
Original Demand × [1 + Price Elasticity × (New Fare ÷ Old Fare − 1)]
New Cash Demand (Price Effect),
C_p = 10,000 × [1 + −0.30 × ($2.00 ÷ $2.25 − 1)] = 10,333.33

Given:
Original Pass Demand: 5,000
Original Pass Price: $71.00
New Pass Price: $50.00
Pass Price Elasticity: -0.25
New Pass Demand (Price Effect),
P_p = 5,000 × [1 + −0.25 × ($50 ÷ $71 − 1)] = 5,369.72
Total Demand = 10,333.33 + 5,369.72 = 15,703.05
Percentage Change in Cash Price: $2.25 to $2.00: -11%
Percentage Change in Pass Price: $71 to $50: -30%

Given:
Cash-to-Pass Diversion Factor: 0.05
Pass-to-Cash Diversion Factor: 0.00

$$\text{Diverted Riders from Cash to Pass} = \left(\frac{\$NewCash/\$OldCash}{\$NewPass/\$OldPass} - 1\right) \times Diversion \times C_P$$

$$\text{Diverted Riders from Cash to Pass} = \left(\frac{\$2.00/\$2.25}{\$50/\$71} - 1\right) \times 0.05 \times C_p = 135.48$$

New Cash Demand = C_p – Diverted Riders from Cash to Pass = 10,197.85
New Pass Demand = P_p + Diverted Riders from Cash to Pass = 5,505.20
Total Demand = 10,197.85 + 5,505.20 = 15,703.05

Another Complex Example: Price Elasticity plus Two Ridership Diversions — Single-Ride CharlieCard (SR-CC) to Pass, and Single-Ride CharlieTicket (SR-CT) to Single-Ride CharlieCard (SR-CC)

Given:
Original Single-Ride CharlieCard Demand: 10,000
Original Single-Ride CharlieCard Fare: \$2.20
New Single-Ride CharlieCard Fare: \$3.50
Single-Ride CharlieCard Price Elasticity: -0.30
New SR-CC Demand (Price Effect),
CC_p = 10,000 × [1 + −0.30 × (\$3.50 ÷ \$2.20 − 1)] = 8,227.27

Given:
Original Pass Demand: 50,000
Original Pass Price: \$71.00
New Pass Price: \$90.00
Pass Price Elasticity: −0.25
New Pass Demand (Price Effect),
P_p = 50,000 × [1 + −0.25 × (\$90 ÷ \$71 − 1)] = 46,654.93

Given:
Original Single-Ride CharlieTicket Demand: 5,000
Original Single-Ride CharlieTicket Fare: \$2.50
New Single-Ride CharlieTicket Fare: \$4.50
Single-Ride CharlieTicket Price Elasticity: −0.30
New SR-CT Demand (Price Effect),
CT_p = 5,000 × [1 + −0.30 × (\$4.50 ÷ \$2.50 − 1)] = 3,800.00
Total Demand = 8227.27 + 46,654.93 + 3,800.00 = 58,682.20

Given:
Single-Ride CharlieCard-to-Pass Diversion Factor: 0.05
Pass-to-Single-Ride CharlieCard Diversion Factor: 0.00
Single-Ride CharlieCard to Single-Ride CharlieTicket Diversion Factor: 0.00
Single-Ride CharlieTicket to Single-Ride CharlieCard Diversion Factor: 0.25

Note:

Percentage Change in Single-Ride CharlieCard Fare: \$2.20 to \$3.50: 59.09%

Percentage Change in Pass Price: \$71 to \$90: 26.76%

Percentage Change in Single-Ride CharlieTicket Fare: \$2.50 to \$4.50: 80.00%

$$\text{Diverted Riders from SR-CC to Pass} = \left(\frac{\$3.50/\$2.20}{\$90/\$71} - 1\right) \times 0.05 \times CC_p = 104.92$$

$$\text{Diverted Riders from SR-CT to SR-CC} = \left(\frac{\$4.50/\$2.50}{\$3.50/\$2.20} - 1\right) \times 0.25 \times CT_p = 124.86$$

New Single-Ride CharlieCard Demand =
CC_p – Diverted Riders from SR-CC to Pass + Diverted Riders from SR-CT to SR-CC = 8,247.21

New Pass Demand = P_p + Diverted Riders from SR-CC to Pass = 46,759.85

New Single-Ride CharlieTicket Demand =
CT_p – Diverted Riders from SR-CT to SR-CC = 3,675.14

Total Demand = 8,202.15 + 46,759.85 + 3,720.20 = 58,682.20

Note that as we introduce additional ridership diversion factors, and more cells in the spreadsheet become linked, the complexity of the spreadsheet model increases significantly. However, the basics of the methodology explained above with regard to price elasticities and ridership diversion factors remain the same.

APPENDIX B: ENIVORNMENTAL JUSTICE ANALYSIS

B.1 Definition of Environmental Justice Communities

To assess the impacts of the proposed SFY 2015 fare increase on minority and low-income communities, CTPS conducted an environmental justice impact analysis. Environmental justice communities were identified based on definitions developed by the MBTA for their environmental justice and Title VI analyses. The methodology used is consistent with that employed by the Boston Region MPO in the Long-Range Transportation Plan. For the MBTA's service area, we identified the median household income and average percentage of minority residents for each TAZ. Minority census tracts and TAZs were defined as those in which the percentage of the non-white population (including the Hispanic population) was greater than the average for the MBTA service area. The average percentage of minority residents is 26.2 percent in the service area. A census tract or TAZ is classified as low-income if its income level is at or below 60 percent of the median household income in the service area; for the 175-community MBTA service area 60% of household median income is $41,636.[18]

B.2 Equity Determination

After identifying the environmental justice communities in the MBTA service area, CTPS analyzed areawide equity in terms of both the existing and proposed conditions—that is, conditions before and after the proposed fare changes—using the Boston Region MPO's travel demand model set. We estimated each TAZ's "score" in terms of various metrics (discussed below) using the model set for both the existing and projected system. To measure the areawide results, we calculated the averages across TAZs, by community classification—minority and nonminority communities; low-income and non-low-income communities. In this calculation, we weighted the scores for transit-based metrics according to each TAZ's existing number of transit trips; and we weighted the scores for regionally applicable metrics by each TAZ's existing population. We also used statistical tests to compare whether the estimated differences between the changes experienced by each pair of community classifications are significant. If there is a statistically significant difference, an area in one community classification is more likely to experience a larger change than an area in the other community classification; if there is not such a significant difference, an area is likely to experience about the same level of change no matter which community classification it falls under.[19] The difference between the pair of community

[18] Median household income was determined based on the 2007–2011 American Community Survey. Minority percentages were determined based on the 2010 US Census.

[19] CTPS used a two-sample t-test to determine if the samples of minority (and low-income) communities and nonminority (and non-low-income) communities in the MBTA service area

classifications is considered significant if the variations of the changes within the classifications are together smaller than the difference between the average changes experienced by the community classifications. For example, if the change experienced by Group A is expressed as 2% ±0.5% and the change experienced by Group B is expressed as 5% ±1.0%, there is a significant difference because the high end of the range in Group A (2.5%) is below the low end of the Group B range (4.0%).

We analyzed three general categories of metrics with respect to their projected equity impact.

For the first category*, transit equity*, the measures are the average fare (in dollars), the average total travel time—the total of the in- and out-of-vehicle travel times in minutes—and the average number of transfers. All averages are weighted by the number of trips produced in each TAZ.

The second category is *highway congestion and air quality*. We use congested vehicle-miles traveled (VMT) to represent local levels of congestion and average carbon monoxide (CO) emissions per square mile (in kilograms) to represent the local level of air pollution. The results are weighted by the population of each TAZ.

The third category is *accessibility*. We used the travel demand model set to estimate the number of jobs within the average transit commute time for the Boston region, 40 minutes. Again, the results are weighted by the population of each TAZ.

Transit – Equity Metrics

Tables B-1 and B-2 present the existing and projected values for the three transit equity metrics: average fare, average total travel time, and average number of transfers.

Compared to nonminority and non-low-income riders, minority riders and low-income riders pay lower average fares, have fewer transfers, and endure shorter travel times. Considerably more of the commuter rail riders are nonminority or non-low-income, which causes their average fares and travel times to be higher. While the absolute change in average fares is greater for nonminority riders and non-low-income riders, the relative changes are greater for minority riders and low-income riders.

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were different at the 95% confidence level. A t-test can be used to examine whether the difference between the averages of two groups is statistically significant.

When comparing both minority versus nonminority riders and low-income versus non-low-income riders, the difference in the comparative relative changes number of transfers and average travel times is very small. For both pairs of comparisons, the difference between the changes to the average fare and the difference between the changes to the number of transfers is statistically significant, but the difference in total travel time is not.

Accessibility to Jobs — Equity Metrics

Tables B-1 and B-2 present the existing and projected accessibility metric, access to jobs, which is measured by the number of jobs within a 40-minute transit commute (the average Boston-region transit commute time).
In Tables B-1 and B-2:

- Basic jobs are those for companies or organizations whose primary purpose is to create a product (such as manufacturing, agriculture, construction).
- Retail jobs are those for companies or organizations whose primary purpose is to sell a product to the public.
- Service jobs are those for companies or organizations whose primary purpose is to provide a service for the public (such as government, education, finance, health care).

As seen in the tables, there are more jobs within reasonable access to people who live in minority- or low-income communities than to people who live in nonminority or non-low-income communities—which largely is a function of these populations living in the urban core. The projected difference in both absolute and relative terms is very small, although nonminority and non-low-income communities benefit more than their counterparts from the access to jobs.

The differences between minority and nonminority communities and the differences between low-income and non-low-income communities are *not* statistically significant for the changes to this metric.

TABLE B-1.
Minority and Nonminority Equity Impacts

Category/ Metric	Existing Minority	Existing Non-minority	Projected Minority	Projected Non-minority	Absolute Change Minority	Absolute Change Non-minority	Percent Change Minority	Percent Change Non-minority
Transit Equity								
Average fare*	$2.26	$3.09	$2.34	$3.19	$0.08	$0.10	3.67%	3.15%
Transfers*	0.90	0.91	0.90	0.91	0.00	0.00	-0.07%	-0.26%
Total travel time (min.)	70.55	79.94	70.54	79.95	-0.01	0.00	-0.02%	0.00%
Accessibility to Jobs								
Total jobs	628,457	306,542	628,368	306,758	-88.93	216.34	-0.01%	0.07%
Basic	90,243	58,013	90,245	58,063	1.65	49.37	0.00%	0.09%
Retail	75,873	43,007	75,864	43,032	-8.31	24.41	-0.01%	0.06%
Service	462,341	205,522	462,259	205,664	-82.26	142.57	-0.02%	0.07%
Highway Congestion and Air Quality								
CO per square-mile*	140.3	67.1	140.6	67.1	0.27	0.03	0.19%	0.04%
Congested VMT	3,194.5	6,012.6	3,211.6	6,016.2	17.14	3.53	0.54%	0.06%

Notes: *Indicates that the difference in the percentage change in the metric resulting from the proposed fare increase for the minority population and the nonminority population is statistically significant.
Values shown in this table are rounded to the level of precision shown. Changes are calculated using unrounded values.

TABLE B-2.
Low-Income and Non-Low-Income Equity Impacts

Category/ Metric	Existing Low-income	Existing Non-low-income	Projected Low-income	Projected Non-low-income	Absolute Change Low-income	Absolute Change Non-low-income	Percent Change Low-income	Percent Change Non-low-income
Transit Equity								
Average fare*	$2.14	$2.79	$2.22	$2.88	$0.08	$0.09	3.84%	3.28%
Transfers*	0.80	0.95	0.80	0.94	0.00	0.00	-0.05%	-0.18%
Total travel time (min.)	64.09	78.66	64.08	78.65	-0.01	0.00	-0.02%	-0.01%
Accessibility to Jobs								
Total jobs	705,363	375,464	705,246	375,608	-116.90	144.20	-0.02%	0.04%
Basic	97,896	64,921	97,892	64,959	-4.64	38.38	0.00%	0.06%
Retail	83,889	50,019	83,874	50,036	-15.08	17.25	-0.02%	0.03%
Service	523,578	260,525	523,481	260,613	-97.18	88.57	-0.02%	0.03%
Highway Congestion and Air Quality								
CO per square-mile*	181.0	79.3	181.2	79.3	0.22	0.09	0.12%	0.12%
Congested VMT	2,090.6	5,474.3	2,102.7	5,482.0	12.07	7.70	0.58%	0.14%

Notes: * Indicates that the difference in the percentage change in the metric resulting from the proposed fare increase for the minority population and the nonminority population is statistically significant.
Values shown in this table are rounded to the level of precision shown. Changes are calculated using unrounded values.

Highway Congestion and Air Quality — Equity Metrics

Tables B-1 and B-2 present the existing and projected measures of average CO emissions per square mile and average congested VMT per square mile. The first metric represents impacts on local air pollution; the second represents impacts on local congestion.

Existing CO emissions per square-mile are greater for minority communities and low-income communities than their counterparts. Current congested VMT per square-mile are greater for nonminority communities and non-low-income communities than their counterparts, but the changes in the metric are very small. Projected congested VMT per square mile increases more for minority communities and for low-income communities than their counterparts. Projected CO increases per square mile are relatively similar for low-income and non-low-income communities, although the increases in the CO emission metric are greater for minority communities than nonminority communities.

The differences between minority and nonminority communities and the differences between low-income and non-low-income communities are statistically significant for the changes in CO emissions per square-mile, but not for the changes in congested VMT per square-mile. The changes in CO emission levels are well within the established CO emissions budget developed to ensure that the area maintains its attainment with the CO air quality standard. These levels will not affect the region's conformity status.

Summary of Equity Impacts

Before and after the fare increase, minority communities and low-income communities pay lower average fares, make fewer transfers, have shorter travel times, have more jobs within the average commute time, and have less congested roads than their counterparts; however, before and after the fare increase, CO emissions per square-mile are higher for minority communities and low-income communities than their counterparts.

The projected changes for most metrics are very small across all communities. The only metric that increases by more than 1% is the average fare for all communities. The only metrics for which the differences between the comparative projected changes are statistically significant are average fare and CO emissions per square-mile.

- For metrics where the difference between the changes to minority communities and nonminority communities is statistically significant, the model projects that with the fare increase proposed:

  - Minority riders might experience *slightly* higher rate of fare increases compared to nonminority riders.
  - Nonminority riders might make relatively fewer transfers compared to minority riders.
  - Carbon monoxide emissions might increase *slightly* more in minority communities compared to nonminority communities.

- For metrics where the difference between the changes to low-income communities and non-low-income communities is statistically significant, the model projects that with the proposed increase:
  - Low-income riders might experience slightly higher rate of fare increase compared to non-low-income riders.
  - Non-low-income riders might make relatively fewer transfers compared to low-income riders.
  - Carbon monoxide emissions might increase slightly more in low-income communities compared to non-low-income communities.

APPENDIX C. SFY 2016 FARE CHANGES

During SFY 2015, the MBTA intends to conduct a thorough review of fares, parking fees, fare structure, and fare-collection policies to examine possible changes for SFY 2016.

The MBTA has indicated it intends to review the feasibility and policy implications of:

- Offering means-tested fares
- Simplifying the fare structure
- Establishing incentives for more efficient payment methods on buses
- Implementing a university pass program
- Broadening the availability of student fares
- Introducing time-of-day pricing
- Changing the parking pricing structure
- Assimilating new fare payment technologies

While the MBTA plans to work on these topics throughout SFY 2015, the Authority also must start planning to present a balanced budget in SFY 2016. The SFY 2016 proposed fares in the next section represent a second year of roughly level across-the-board fare increases, using the proposed SFY 2015 fares as the base. These fares are highly tentative and will be revisited before the end of SFY 2015, with opportunity for public review and input.

C.1 Description of Potential SFY 2016 Fare Increase Scenario

SFY 2016 Proposed Fares

Table C-1 presents the key existing and proposed single-ride fares for each fare category, along with the percentage change in price from the existing to the proposed price. Table C-2 presents the same information for the pass prices. Table C-2 also presents the value of monthly passes in terms of their single-ride equivalents, a concept discussed at the end of this section. Neither Table C-1 nor C-2 reflect any potential fare structure changes that may be considered by the Authority. The proposed scenario for SFY 2016 also includes $1.00 increases in parking prices at stations that are near, at, or greater than capacity.[20] Until data exists that suggests raising fares on the commuter boat system will truly reduce revenue, the commuter boat system fares would increase at the same rate as the other fares.

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[20] These parking lots are, in alphabetical order: Alewife, Braintree, Chestnut Hill, Eliot, Forest Hills, Lechmere, Malden, Oak Grove, Suffolk Downs, Sullivan, Waban, Wellington, Wollaston, and Wonderland.

The overall price increase across all modes and fare/pass categories is 4.8%. This systemwide average is based on the percentage change between the existing average fare (total revenue divided by existing ridership) and the proposed average fare (total projected revenue divided by total projected ridership).

The percentage changes in prices are relatively consistent across fare payment types. The MBTA may elect to hold the following fares constant in SFY 2016 because in SFY 2015 they experienced a greater-than-average fare increase:

- Commuter rail interzone fares 1–3
- Inner harbor single-ride fares
- One-day link passes

Another factor the MBTA considers when raising fares is the pass-ride value, which is the number of trips required at the lowest-cost single-ride fare to expend the cost of the pass.[21] Lower pass-ride values indicate that a passenger needs to make fewer trips to make the pass financially worthwhile. Table C-2 presents the changes to the single-ride to-pass ratios. The changes in the single-ride to-pass ratios from the current fare structure are minimal, and the pass-ride values tend to be approximately 32 trips per month.

C.2 Potential Results

The results of this analysis will vary depending upon the impacts of the SFY 2015 fare changes. However, using the same base elasticities as used in the SFY 2015 analysis, revenue could reasonably be expected to increase by approximately $25 million (a 4% increase over projected SFY 2015 revenue), and ridership might decrease by 3 million unlinked passenger trips (slightly less than a 1% decrease from projected SFY 2015 ridership).

The potential fare increase might decrease THE RIDE usage by 30 thousand trips or 2%.

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[21] For example, the monthly bus pass would cost $52. The lowest-price single-ride bus fare is $1.70, which a passenger may obtain by using a CharlieCard. Thus, a $52 monthly bus pass would be equal to 30.59 single-ride CharlieCard bus trips.

TABLE C-1.
Key Single-Ride Fares: Proposed SFY 2015 and Potential SFY 2016

Fare Category	Proposed SFY 2015 Fare	Potential SFY 2016 Fare	Percent Change	Absolute Change
CharlieCard				
Adult				
Local Bus	$1.60	$1.70	6.3%	$0.10
Rapid Transit	2.10	2.20	4.8	0.10
Bus + Rapid Transit	2.10	2.20	4.8	0.10
Inner Express	3.65	3.85	5.5	0.20
Outer Express	5.25	5.50	4.8	0.25
Senior				
Local Bus	$0.80	$0.85	6.3%	$0.05
Rapid Transit	1.05	1.10	4.8	0.05
Bus + Rapid Transit	1.05	1.10	4.8	0.05
Student				
Local Bus	$0.80	$0.85	6.3%	$0.05
Rapid Transit	1.05	1.10	4.8	0.05
Bus + Rapid Transit	1.05	1.10	4.8	0.05
CharlieTicket or Cash				
Adult				
Local Bus	$2.10	$2.25	7.1%	$0.15
Rapid Transit	2.65	2.75	3.8	0.15
Bus + Rapid Transit	4.75	5.00	5.3	0.25
Inner Express	4.75	5.00	5.3	0.25
Outer Express	6.80	7.00	2.9	0.20
Commuter Rail				
Zone 1A	$2.10	$2.20	4.8%	$0.10
Zone 1	5.75	6.00	4.3	0.25
Zone 2	6.25	6.75	8.0	0.50
Zone 3	7.00	7.50	7.1	0.50
Zone 4	7.50	8.00	6.7	0.50
Zone 5	8.50	9.00	5.9	0.50
Zone 6	9.25	9.75	5.4	0.50
Zone 7	9.75	10.25	5.1	0.50
Zone 8	10.50	11.00	4.8	0.50
Zone 9	11.00	11.50	4.5	0.50
Zone 10	11.50	12.00	4.3	0.50
InterZone 1 *(no increase)*	$2.75	$2.75	0.0%	$0.00
InterZone 2 *(no increase)*	3.25	3.25	0.0	0.00
InterZone 3 *(no increase)*	3.50	3.50	0.0	0.00
InterZone 4	3.75	4.00	6.7	0.25
InterZone 5	4.25	4.50	5.9	0.25
InterZone 6	4.75	5.00	5.3	0.25
InterZone 7	5.25	5.50	4.8	0.25
InterZone 8	5.75	6.00	4.3	0.25
InterZone 9	6.25	6.50	4.0	0.25
Ferry				
F1: Hingham	$8.50	$9.00	5.9%	$0.50
F2: Boston	8.50	9.00	5.9	0.50
F2: Cross Harbor	13.75	14.50	5.5	0.75
F2: Logan	17.00	18.00	5.9	1.00
F4: Inner Harbor *(no increase)*	3.25	3.25	0.0	0.00
THE RIDE				
ADA Territory	$3.00	$3.15	5.0%	$0.15
Premium Territory	5.25	5.50	4.8	0.25

TABLE C-2.
Pass Prices: Proposed SFY 2015 and Potential SFY 2016

Pass Category	Proposed SFY 2015 Fare	Potential SFY 2016 Fare	Percent Change	Absolute Change	Proposed SFY 2015 Pass Ride	Potential SFY 2016 Pass Ride
Local Bus	$50.00	$52.00	4.0%	$2.00	31.25	30.59
LinkPass	75.00	78.00	4.0	3.00	35.71	35.45
Senior/TAP	29.00	30.00	3.4	1.00	27.62	27.27
Student 5-Day Validity	26.00	27.00	3.8	1.00	24.76	24.55
Student 7-Day Validity	29.00	30.00	3.4	1.00	27.62	27.27
1-Day *(no increase)*	12.00	12.00	0.0	0.00	5.71	5.45
7-Day	19.00	20.00	5.3	1.00	9.05	9.09
Inner Express	115.00	121.00	5.2	6.00	31.51	31.43
Outer Express	168.00	176.00	4.8	8.00	32.00	32.00
Commuter Rail						
Zone 1A	$75.00	$78.00	4.0%	$3.00	35.71	35.45
Zone 1	182.00	191.00	4.9	9.00	31.65	31.83
Zone 2	198.00	208.00	5.1	9.00	31.68	30.81
Zone 3	222.00	233.00	5.0	11.00	31.71	31.07
Zone 4	239.00	251.00	5.0	12.00	31.87	31.38
Zone 5	265.00	278.00	4.9	13.00	31.18	30.89
Zone 6	289.00	303.00	4.8	14.00	31.24	31.08
Zone 7	306.00	321.00	4.9	15.00	31.38	31.32
Zone 8	330.00	347.00	5.2	17.00	31.43	31.55
Zone 9	345.00	362.00	4.9	17.00	31.36	31.48
Zone 10	362.00	380.00	5.0	18.00	31.48	31.67
InterZone 1	$86.00	$90.00	4.7%	$4.00	31.27	32.73
InterZone 2	105.00	110.00	4.8	5.00	32.31	33.85
InterZone 3	114.00	119.00	4.4	5.00	32.57	34.00
InterZone 4	124.00	130.00	4.8	6.00	33.07	32.50
InterZone 5	141.00	148.00	5.0	7.00	33.18	32.89
InterZone 6	159.00	167.00	5.0	8.00	33.47	33.40
InterZone 7	175.00	184.00	5.1	9.00	33.33	33.45
InterZone 8	193.00	203.00	5.2	10.00	33.57	33.83
InterZone 9	211.00	222.00	5.2	11.00	33.76	34.15
Commuter Boat	$275.00	$289.00	5.1%	$14.00	32.35	32.11

APPENDIX D. EXAMPLE APPLICATION OF THE PROPOSED DISPARATE-IMPACT POLICY

Below is a sample application of the proposed disparate-impact policy for a fictitious fare increase.

Based on staff analysis, the estimated existing average fares for minority riders and all riders are:

Minority riders:	$2.00
All riders:	$2.25

Further analysis shows that the predicted average fares following the proposed fare increase would be:

Minority riders:	$2.25
All riders:	$2.50

The relative changes between the proposed and existing average fares are:

Minority riders:	12.50%	($2.25 - $2.00) ÷ $2.00
All riders:	11.11%	($2.50 - $2.25) ÷ $2.25

To calculate whether a disparate impact is present, one first needs to determine which part of the policy to use. A fare increase would cause a “burden,” so we use the burden portion of the proposed disparate-impact policy. We use the relative change in fare as the indicator of the burden.

The next step is to apply the disparate-impact policy. To calculate this, we multiply the all-rider relative change (the burden) by the proposed threshold, and check to see if the minority relative change is greater than or less than the result. If the following inequality is true, there is a disparate impact; otherwise, there is no disparate impact.

Minority Burden > 120% × All Rider Burden
12.50% > 120% × 11.11%
12.50% > 13.33%

Because 12.50% is not greater than 13.33%, the resulting statement is not true; the minority riders did not sustain more than 20% additional burden than the burden sustained by all riders. We do not find a disparate impact.

As an alternative, one could test whether the ratio of the burden to minority riders compared to the burden to all riders is greater than 120%. If so, then we would find that a disparate impact exists; otherwise no disparate impact exists:

$$\frac{\text{Minority Burden}}{\text{All Rider Burden}} > 120\%$$

$$\frac{12.50\%}{11.11\%} > 120\%$$

$$112.50\% > 120\%$$

Because 112.50% is not greater than 120%, the statement is false; we do not find a disparate impact.