



Date: December 2, 2022
To: MBTA Board of Directors
From: Justin Antos, Senior Director of Bus Transformation
Steven Povich, Director of Fare Policy & Analytics
Re: Equity and Title VI Findings from the Bus Network Redesign Service Changes

Executive Summary

The CTPS equity analysis of the proposed Bus Network Redesign (BNRD) service changes finds that the service proposal raises no major Title VI concerns, and it passes the vast majority of the MBTA's tests designed to identify *potential* disparate impacts or disproportionate burden for our protected population of riders. We are encouraged by this finding, since an over-arching goal of the Bus Network Redesign has been to advance equity first. While Title VI focuses on low-income and minority riders specifically, from the start the Network Redesign has aimed to bring bus service to the transit-critical riders who depend the most on bus service – low-income riders and riders of color, plus those without easy access to a vehicle, seniors, and riders with a disability. For the past two years, the Bus Network Redesign has been prioritizing the travel needs of these populations, and consciously allocating new bus service and resources to them during the design of new services. BNRD calls for a net 25% increase in bus service in the coming years, and it brings those new investments to many transit-critical populations. We are pleased to see that the Title VI Service and Fare Equity Analyses largely confirm the intentions of the Redesign, that:

- While BNRD does not change fares explicitly, the redesign of bus service does change some riders' fares as they change modes or transfer to other routes, but those fare changes have no disparate impact or disproportionate burden on protected populations, specifically minority riders and low-income riders.
- BNRD's reallocation of bus service does not impact minority populations differently than other populations, and thus is not a disparate impact. BNRD passes all six of the Title VI numerical tests in this area as designated by MBTA policy.
- 50% of the new bus service in BNRD will go to minority populations, and 39% will go to low-income populations – slightly exceeding today's allocation of bus service.
- BNRD's proposed service changes do not impact low-income populations differently than other populations on five of the six numerical tests in this area, but it does result in a potential disproportionate benefit to non-low-income riders under one of the six tests required by MBTA policy.

Overall, BNRD passes eleven of the twelve of the Title VI numerical tests for service equity, and the findings confirm our intentional design to increase equity throughout the proposal. BNRD also passes the Title VI metrics for fare equity. We view the one particular ratio where BNRD did not pass as a weak indicator of service equity, and a further discussion is found below on this metric.

Nevertheless, in accordance with FTA Title VI Circular and the MBTA's Disparate Impact/Disproportionate Burden (DI/DB) Policy, MBTA staff have reviewed possible steps to avoid, minimize, or mitigate this potential disproportionate benefit. We are confident that the Bus Network Redesign process successfully incorporated equity throughout the planning process, but did so in a manner not easily quantified by the relatively prescriptive methodology of a Title VI service equity analysis.

MBTA staff recommend that the Board vote on December 15, 2022, to accept the CTPS Fare and Service Equity Analyses of the Bus Network Redesign changes.

Finding of Potential Disproportionate Benefit to Non-Low-Income Riders

In analyzing the equity of proposed service changes, per [MBTA policy](#), CTPS calculates 12 ratios on three different dimensions:

1. Ratios: Relative Change, Share of Change, and Absolute Change
2. Protected Rider Populations: Minority (Disparate Impact) and Low-Income (Disproportionate Benefit/Burden)
3. Service Metrics: Revenue Vehicle Hours (RVH) and Route Length

Of the 12 calculated ratios, CTPS found one non-passing result: a potential Disproportionate Benefit on the Absolute Change Ratio to Non-Low-Income Riders using the Revenue Vehicle Hours Metric.

The Absolute Change Ratio compares the nominal increase in RVH for low-income riders to the nominal increase in RVH for non-low-income riders. In the case of an increase in RVH (as here with BNRD), the Ratio is passing if greater than 0.80x. In other words, the policy states we ought not increase service for low-income riders any less than 80% of the amount of increase for non-low-income riders. Under the proposed plan, the increase in RVH is 4,792 for low-income riders, compared to 7,377 for non-low-income riders, a ratio of 0.65x and under the 0.80x threshold.

Unlike other ratios, the Absolute Change Ratio does not consider the proportions of current service provided to low-income riders or the proportion of service area population that is low-income.

MBTA Response to the Equity Analysis Finding

MBTA staff has reviewed the CTPS equity analysis and recommends the Board vote to accept the analysis for three key reasons: equity was sufficiently central to the BNRD planning process, the MBTA has enhanced our real-time monitoring for service equity, and the Absolute Change Ratio is a weak indicator of service equity that ought to be discounted when reviewing the analysis.

Equity in BNRD

The BNRD team considered equity from the earliest stages of the planning process. We used travel-demand data by low-income residents and people of color to prioritize corridors for

investment and promotion to high-frequency services, and we weighted trips by these populations more heavily to commit bus service to those transit-critical population. We reviewed trip-making using location-based services (LBS) data about where people travel using all modes and all types of trips. This data associated trip-making with a user's home region and demographics, so that as someone travels throughout the region chaining together multiple trips, the demographic data remained associated with those trips. This gave us a fuller understanding of how low-income people or people of color travel throughout the network, which we built into the Network Redesign. Additionally, this data was used to select corridors to upgraded to all-day high-frequency service, at the foundation of the Bus Network Redesign proposal.

Equity in Monitoring Ongoing MBTA Service

The MBTA's [Service Delivery Policy](#) is a public document that states the MBTA's objectives for quality transit service to riders and set standards for how success is measured, and the MBTA now releases an Annual Report these service metrics. The MBTA considers several key aspects of service in this evaluation, and most of these standards also incorporate equity checks, evaluating whether the MBTA met its service standards for all riders, for riders of color, and for low-income riders.

Absolute Change Ratio as a Weak Indicator of Service Equity

While CTPS outlines drawbacks with the Absolute Change Ratio in their memo, we elaborate on their discussion below and in the appendix.

The Absolute Change Ratio is a weak indicator of service equity, as it compares nominal increases (or decreases) in service, without taking into account the proportion of the ridership or service area population that is low-income vs. non-low-income. Specifically, the Absolute Change Ratio requires the increase in service to be nearly equal (no less than 80% for an increase) for low-income riders, *even if* they make up a minority of riders or existing service. In the analysis for BNRD, Low-Income riders represent 38% of existing service and 39% of the increase in service. While this appears appropriate, and passes our other ratio tests, this minor increase is not sufficient to pass the Absolute Change Ratio. Please see the appendix for a simplified example.

Unrelated to BNRD, MBTA staff are in the process of revising the DI/DB Policy. The Absolute Change Ratio is a key area we intend to improve upon in the revisions. MBTA staff will return to the board early in calendar year 2023 to review and approve an updated DI/DB Policy, following a public comment process.

Conclusion

MBTA staff recommend that the Board vote on December 15, 2022, to accept the CTPS Fare and Service Equity Analyses of the Bus Network Redesign changes.

Appendix: Example of Absolute Change Ratio

To provide a simpler example to understand the Absolute Change Ratio, MBTA staff have this example, outlined below, which is instructive to understand the weakness in this metric.

Example Scenario

	Low-Income	Non-Low-Income	Low-Income % of Total
RVH Pre-Change	A: 20	E: 80	I: 20%
Change in RVH	B: 10	F: 20	J: 33%
RVH Post-Change	C: 30	G: 100	K: 23%
% Change in RVH	D: 50%	H: 25%	

In this scenario, Low-Income riders represent 20% of service before the change (I), receive 33% of the increase in service (J), and represent 23% of service after the change (K). Low-income riders see a 50% increase in service (D), double the 25% increase seen by non-low-income riders (H). We calculate the three key ratios:

1. Relative Change: Compares percent change in service for low-income or minority riders to percent change in service for all other riders. Passing at >0.80x for a service increase.
 - a. $D/H: 50\% / 25\% = 2.00x$
2. Share of Change: Compares the share of the total change for low-income or minority riders to the share of existing service for low-income or minority riders. Passing at >0.80x for a service increase.
 - a. $J/I: 33\% / 20\% = 1.67x$
3. Absolute Change: Compares nominal change in service for low-income or minority riders to nominal change in service for all other riders. Passing at >0.80x for a service increase.
 - a. $B/F: 10 / 20 = 0.50x$ – does not pass

This result holds the MBTA to an unrealistic standard, as it suggests service increases ought to be equal even in cases where the compared groups are not equivalent. While the ratios are slightly less extreme in the BNRD analysis, we continue to believe that the outcome is an unhelpful indicator of equity in service changes.



TECHNICAL MEMORANDUM

DATE: December 2, 2022
TO: Massachusetts Bay Transportation Authority
FROM: Blake Acton, Central Transportation Planning Staff
Steven Andrews, Central Transportation Planning Staff
Emily Domanico, Central Transportation Planning Staff
RE: Bus Network Redesign: Title VI Service and Fare Equity Analysis

Over the next five years, the Massachusetts Bay Transportation Authority (MBTA) will implement Bus Network Redesign (BNRD) representing a comprehensive redesign of the MBTA's bus network to better align service to where current and potential riders are traveling. This memorandum presents the results of service and fare equity analyses performed by the Central Transportation Planning Staff (CTPS) that fulfill the MBTA's Title VI obligations as outlined in the Federal Transit Administration (FTA) Circular 4702.1B.¹ As a major redesign of the bus network, BNRD qualifies as a "major service change" prompting the completion of a service equity analysis (SEA). While the BNRD does not directly modify fare prices, it could affect the average fares paid by riders representing a de facto fare change for riders who may need to switch to higher or lower fare transit service to access the MBTA network. As a result, this SEA is accompanied by a fare equity analysis (FEA) that identifies and measures the equity impact of secondary changes to average fares from BNRD.

Summary of Title VI Results

CTPS performs Title VI SEAs by evaluating the impact of service changes on minority and low-income populations using two analysis methods: revenue vehicle hours (RVH) and route length. For each method CTPS calculates three ratios to test whether the proposed service change would result in a potential disparate impact to minority populations or disproportionate burden to low-income populations. These ratios are Relative Change, Share of Change, and Absolute Change which each test different metrics to evaluate the ratio of change between protected and non-protected populations. The results are twelve ratios: six evaluating impacts on minority populations and six evaluating impacts on low-income populations.

¹ FTA. 2012. "Title VI Requirements and Guidelines for Federal Transit Administration Recipients." FTA Circular 4702.1B. Federal Transit Administration.
<https://www.transit.dot.gov/regulations-and-guidance/fta-circulars/title-vi-requirements-and-guidelines-federal-transit>.

Civil Rights, nondiscrimination, and accessibility information is on the last page.

The results of the service equity analysis indicate that implementation of the combined changes associated with BNRD do not result in disparate impacts to minority populations with all six ratios below their respective thresholds. Results for low-income populations show five of the six ratios indicating no disproportionate burden (or benefit); however, one of the six ratios indicates a potential disproportionate benefit to non-low-income populations. More specifically, this result is indicated by the Absolute Change ratio under the RVH analysis method that tests whether low-income and non-low-income populations are receiving approximately equal share of the additional RVH. In the context of this analysis, Absolute Change is the least informative ratio, because it concludes that non-low-income populations are receiving more RVH than low-income populations although non-low-income populations comprise a majority of existing RVH (62 percent). Further discussion of these results is located in the *Discussion* subsection of Section 3.3.

Finally, results of the FEA show that the effects of the service changes on the average fares would not result in disparate impacts to minority populations or disproportionate burdens to low-income populations.

1 PLANNED SERVICE CHANGES

BNRD is a major reconfiguration of the bus system that aims to provide more frequent and consistent service along key corridors throughout the region by increasing service by 25 percent.² The goals of BNRD are the following:

- 1) Equity first, prioritizing the needs of those who depend on buses and need frequent, reliable service. During the planning of the network, the MBTA defined equity as improving access and quality of service for transit-critical populations (low-income populations, people of color, seniors, people with disabilities, or people who live in households with few or no vehicles)
- 2) More frequent service in busy neighborhoods
- 3) More all-day service
- 4) New connections to more places (including non-downtown centers)
- 5) A network that is simpler and easier to use

BNRD will significantly improve service for riders traveling during non-peak travel periods, on weekends, and between locations outside of downtown Boston. This is accomplished by connecting the most heavily traveled origins and destinations with a grid-like network of “high-frequency corridors” defined as routes that

² MBTA. 2022. “Bus Network Redesign” Massachusetts Bay Transportation Authority. <https://www.mbta.com/projects/bus-network-redesign>.

provide 15-minute or better frequency all day, seven days per week. BNRD will provide more residents with access to the expanded high-frequency network, which offers greater accessibility to more destinations with a more consistent and reliable transfer experience. Riders can expect to wait fewer than 15 minutes to transfer to other high-frequency routes regardless of when or where along the network they travel. To expand the high-frequency network, BNRD is paired with a systemwide 25 percent increase in service coupled with the consolidation of some parallel or lower-frequency routes. Figure 1 shows the high-frequency bus routes before and after the implementation of BNRD. In summary, BNRD modifies the service of 69 bus routes, consolidates 32 routes, eliminates 14 routes, and creates six new routes reducing the total number of MBTA bus routes from 168 to 128.

2 TITLE VI EQUITY ANALYSIS FRAMEWORK

2.1 The MBTA's Disparate Impact/Disproportionate Burden Policy

As a recipient of federal funds through the FTA, the MBTA is required to comply with Title VI of the Civil Rights Act of 1964 (Title 49, part 21, Code of Federal Regulations). The FTA's Title VI Circular 4702.1B, issued in October 2012, under the authority of Title VI of the Civil Rights Act of 1964, directs transit providers to study proposed major service changes and all fare changes for possible disparities in impacts on minority and low-income riders and communities.

This requirement is part of the MBTA's Title VI assurance that no person shall, on the basis of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity receiving federal financial assistance.

The MBTA's Disparate Impact/Disproportionate Burden (DI/DB) Policy describes the general procedure for conducting service and fare equity analyses.³ This service equity analysis was performed in accordance with the MBTA's DI/DB Policy.

2.2 The Need to Conduct a Service and Fare Equity Analysis

According to the FTA's Title VI Circular 4702.1B, a transit provider must conduct a SEA prior to implementing a proposed service change if it qualifies as a "major service change" as defined by the transit provider in accordance with the FTA. According to the MBTA's DI/DB Policy, a service change is "major" if it meets one or more of the following conditions:

Major Service Change at the Modal Level

- A change in RVH per week of at least 10 percent by mode.

Major Service Change at the Route-Level

- For all routes, a change in route length of at least 25 percent or three miles; or for routes with at least 80 RVH per week, a change in RVH per week of at least 25 percent.

The changes associated with BNRD meet all the above conditions, so it qualifies as a "major service change."

³ MBTA. 2017. "Disparate Impact/Disproportionate Burden (DI/DB) Policy." Massachusetts Bay Transportation Authority. <https://cdn.mbta.com/sites/default/files/2017-11/1-30-17%20-%20MBTA%20DIDB%20Policy%20-%20Final.docx>.

The FTA Circular requires a FEA prior to “all fare changes regardless of the amount of increase or decrease.” The restructuring of bus routes combined with the MBTA’s multitiered fare policy may affect travel costs for some riders. Some riders could be left with a more expensive trip as their only option while others gain additional, lower-priced options. While BNRD does not directly change fares, these secondary effects could be interpreted as a fare change. However, there is no guidance in the FTA Circular 4702.1B or the MBTA’s DI/DB Policy on whether a FEA is necessary in these situations or how to conduct such an analysis. However, the FTA has provided guidance that the MBTA must conduct a FEA in this circumstance.

3 TITLE VI SERVICE EQUITY ANALYSIS

3.1 Methods

Data and Analysis

Following are the steps taken to develop Title VI DI/DB ratios:

- 1) Find percent minority and percent low-income by Census Tract with US Census data.^{4,5}
 - a. “Percent minority” is defined as the percent of individuals in a Census Tract who report as not being “White alone, not Hispanic or Latino”
 - b. “Percent low-income” is defined as the percent of occupied households that report an annual household income below 60 percent of the median household income for the MBTA service area (\$55,340).
- 2) Extract route and stop geometry of the baseline and BNRD schedules from General Transit Feed Specification (GTFS) generated by the MBTA using the Remix Data Platform.
- 3) Generate buffers around stops/stations that represent the approximate walkshed or driveshed around transit services. These are one-quarter mile for bus, one-half mile for rapid transit, one mile for non-terminal commuter rail stations, and five miles for terminal commuter rail stations.
- 4) Use stop buffers with demographic data from step one to find the percent minority and low-income by route.
- 5) Calculate the weekly route length miles by route of the baseline and BNRD schedules using route geometry.

⁴ US Census. 2021. “2020 United States Decennial Census.” US Census Bureau.

⁵ US Census. 2022. “2016–2020 American Community Survey (ACS) 5-Year Estimates.” US Census Bureau.

- a. A route length is the total length of a line that the transit vehicle follows including inbound and outbound directions. Final weekly route miles represent weekday miles multiplied by five plus Saturday and Sunday to account for route differences on weekends.
- 6) Calculate weekly RVH by route using schedules from the MBTA that represent the total number of hours per week a vehicle is in service including layover and recovery time, across all vehicles for each route.
- 7) Multiply route demographic data with the route length and RVH data for the baseline and BNRD schedules to find the ratio of route miles and RVH allocated to protected groups by route.
- 8) Compare aggregate baseline and BNRD values and generate Title VI DI/DB ratios.

Determining an Adverse Impact

The MBTA defines adverse effects as disproportionate changes to the amount of service scheduled, by route and by mode, as measured by changes to weekly RVH and access to the service, by route, as measured by changes to route length. Once CTPS calculates how the RVH or route length will be affected by a service proposal, the results are used to generate three change ratios. The values of these ratios determine whether a service proposal would have an adverse impact on protected populations.

- 1) Relative Change
 - a. Ratio of the percent change of the protected group divided by the percent change of the nonprotected group. This ratio compares the percent change between the protected and nonprotected group.
- 2) Share of Change
 - a. Ratio of the protected share of net change divided by the protected share of existing hours/miles. This ratio compares the share of change received by protected groups relative to their existing share and is referred to as “Protected Share of Change/Protected Share of Existing” in prior Title VI analyses.
- 3) Absolute Change
 - a. Ratio of the net change of the protected group divided by the net change of the nonprotected group. This ratio serves as a direct comparison of absolute change between the protected and nonprotected group without considering any existing shares or values.

A change ratio of 1.0 or 100 percent indicates equal impact between protected and nonprotected groups. The ratio threshold that indicates an adverse impact depends on whether there is a net increase or decrease of a particular metric. When RVH or route miles decline, a ratio above 1.20 or 120 percent indicates a potential disparate impact on minority and/or potential disproportionate burden on low-income populations. If there is an overall increase of RVH or route miles, then a ratio below 0.80 or 80 percent indicates a potential disparate benefit to nonminority and/or potential disproportionate benefit to non-low-income populations. In the case of this analysis, BNRD will lead to a decline in systemwide route miles with an increase in RVH. As a result, a ratio above 1.20 would indicate a DI/DB for the route length metric, and a ratio below 0.80 would indicate a DI/DB for the RVH metric.

3.2 Summary of Changes

Change in Weekly Revenue-Vehicle Hours

Net change in weekly RVH by population group is presented in Table 1, which shows that BNRD will add 12,169 additional weekly RVH systemwide, representing an increase of 17.4 percent compared to the existing network. When this increase is evaluated only within the bus system, BNRD represents a 24.4 percent increase in systemwide bus RVH that closely reflects the commonly cited 25 percent increase in service for BNRD. Between minority and nonminority populations this increase is evenly shared with both groups receiving approximately 50 percent of the additional RVH. Minorities currently receive 47 percent of the existing RVH, so this change slightly favors minority groups relative to the status quo. Changes in RVH between low-income and non-low-income populations exhibit a similar pattern to changes between minority and nonminority groups. Low-income populations are allocated about 39 percent of additional RVH, which is slightly above their existing share of 38 percent. This indicates that the changes to RVH associated with BNRD largely reflect the current ratios while slightly favoring low-income groups.

TABLE 1
Net Change in Weekly Revenue-Vehicle Hours by Population Group

Population Group	Existing Hours	Share of Existing Hours	Net Change	Share of Net Change	Percent Change
Minority	32,845	47%	6,045	50%	18%
Nonminority	37,071	53%	6,124	50%	17%
Low-Income	26,422	38%	4,792	39%	18%
Non-Low-Income	43,494	62%	7,377	61%	17%

Low-income households are those with an annual income of less than \$55,340.
Sources: Baseline and BNRD MBTA schedule files as processed by CTPS and 2020 US Census and 2016–20 ACS.

Change in Weekly Route Length

Net change in weekly route length by demographic is presented in Table 2. The existing network is 21,670 route miles with 43 percent allocated to minority populations compared to 57 percent to nonminority populations. Furthermore, 36 percent of route miles are allocated to low-income populations compared to 64 percent to non-low-income populations. Changes resulting from BNRD will reduce the total route miles of the MBTA system by 3,062 to 18,608 miles representing a 14 percent reduction from the baseline. This decline of route miles is expected because BNRD expands bus service by consolidating and simplifying routes and the route length metric is sensitive to the number of total routes rather than the service offered by those routes. For example, in a scenario where two 10-mile routes that share the same corridor are consolidated into one 10-mile route, there would be a 50 percent reduction in total route length even if the service offered on the corridor remains the same. Many of the proposed changes in BNRD involve consolidating service into fewer high-frequency routes, thereby resulting in fewer total route miles.

TABLE 2
Net Change in Weekly Route Length by Population Group

Population Group	Existing Miles	Share of Existing Miles	Net Change	Share of Net Change	Percent Change
Minority	9,296	43%	-1,415	46%	-15%
Nonminority	12,373	57%	-1,647	54%	-13%
Low-Income	7,821	36%	-1,172	38%	-15%
Non-Low-Income	13,849	64%	-1,890	62%	-14%

Low-income households are those with an annual income of less than \$55,340.
Sources: Baseline and BNRD MBTA schedule files as processed by CTPS and 2020 US Census and 2016–20 ACS.

3.3 Title VI Results

Results by Revenue-Vehicle Hours

Table 3 summarizes the results of the service equity analysis relating to the systemwide increase in RVH associated with BNRD. The final service equity analysis results indicate no disparate benefit to nonminority populations and a potential disproportionate benefit to non-low-income populations. This conclusion is determined through three analysis methods as presented in Table 3, which result in three ratios for each demographic (for a total of six). Relative Change (first row of Table 3) and Share of Change (second row of Table 3) are relative metrics that account for change relative to pre-existing service. Absolute Change (third row of Table 3) is a ratio of additional service hours by population group. The Absolute Change ratio describing impacts on low-income populations, one of the six ratios, is equal to 0.65 (4,792 / 7,377), which is below the DI/DB threshold of 0.80. This indicates a potential disproportionate benefit to non-low-income populations.

TABLE 3
Summary of DI/DB Results Relating to Revenue-Vehicle Hour Changes

Analysis Method	Impacts on Minority Populations	Impacts on Low-Income Populations
Relative Change (Protected/Nonprotected)	No Disparate Benefit Ratio: 1.06 > 0.80 → Pass	No Disproportionate Benefit Ratio: 1.06 > 0.80 → Pass
Share of Change (Protected Share of Change/Protected Share of Existing)	No Disparate Benefit Ratio: 1.06 > 0.80 → Pass	No Disproportionate Benefit Ratio: 1.03 > 0.80 → Pass
Absolute Change (Protected/Nonprotected)	No Disparate Benefit Ratio: 0.99 > 0.80 → Pass	Disproportionate Benefit Ratio: 0.65 < 0.80 → Does Not Pass

Note: Values correspond to Table 1.
DI/DB = disparate impact/disproportionate burden.
Source: Central Transportation Planning Staff.

Results by Route Length

The final DI/DB metrics presented in Table 4 indicate no disparate impact to minority populations and no disproportionate burden to low-income populations. These results can be understood by observing changes in route length by population group in Table 2 which shows that the systemwide decline in route length is shared roughly proportionally to existing ratios with 46 percent of decline in route length experienced by minority populations and low-income groups experiencing 38 percent of total decline. Both minority and low-income populations experience a reduction of route length of approximately 15 percent, while nonminority and non-low-income populations experience slightly lower reductions of 13 percent and 14 percent, respectively. While this metric shows that protected groups experience a greater reduction in route miles than nonprotected groups, the differences are minor; they do not exceed the thresholds set by the MBTA’s DI/DB policy.

TABLE 4
Summary of DI/DB Results Relating to Route Length Changes

Analysis Method	Impacts on Minority Populations	Impacts on Low-Income Populations
Relative Change (Protected/Nonprotected)	No Disparate Impact Ratio: 1.15 < 1.20 → Pass	No Disproportionate Burden Ratio: 1.07 < 1.20 Pass
Share of Change (Protected Share of Change/Protected Share of Existing)	No Disparate Impact Ratio: 1.07 < 1.20 → Pass	No Disproportionate Burden Ratio: 1.06 < 1.20 → Pass
Absolute Change (Protected/Nonprotected)	No Disparate Impact Ratio: 0.86 < 1.20 → Pass	No Disproportionate Burden Ratio: 0.62 < 1.20 → Pass

Note: Values correspond to Table 2.
DI/DB = disparate impact/disproportionate burden.
Source: Central Transportation Planning Staff.

Discussion

The results of this Title VI service equity analysis have two outcomes that appear to disagree: (1) Low-income groups will receive slightly more RVH from BNRD than their existing share and (2) the Absolute Change DI/DB ratio indicates a potential disproportionate benefit to non-low-income populations. Every proposed service change is different, and the MBTA DI/DB policy cannot anticipate every possible outcome, so it is important that we examine the context of these results. This outcome is the result of how MBTA’s Title VI Service Equity Analysis evaluates the equity of service changes using three different ratios (described in Section 3.1) that each rely on different values. Out of the six ratios used to test for a disproportionate burden (or benefit) to low-income populations only one ratio, the absolute change by RVH metric indicates a potential disproportionate benefit. This outcome by itself may not be too concerning considering how the Absolute Change ratio is calculated and how it interacts with the low-income threshold.

- 1) The Absolute Change ratio does not consider existing shares.
 - a. Unlike the other two DI/DB ratios, the Absolute Change ratio misses important context by not incorporating the share of existing RVH or route length into its calculation. The Absolute Change ratio essentially asks if the proposed change is roughly even (50/50) between groups. This makes the Absolute Change ratio more sensitive to changes as the difference between each group’s share of the existing hours or route miles increases. In the case of this

analysis, low-income populations comprise 38 percent of existing RVH and under BNRD low-income populations will receive about 39 percent of the additional RVH. The 39 percent share of additional RVH is too far below 50 percent causing the Absolute Change ratio to indicate a potential a DI/DB.

- 2) The low-income threshold guarantees an imbalance in the existing share.
 - a. The MBTA's DI/DB policy defines a low-income household as one with an income that is less than 60 percent of the median household income for the MBTA service area. This definition guarantees that low-income will almost always be a minority of the existing share of RVH or route length, which increases the probability of a disproportionate benefit to non-low-income populations under the Absolute Change metric. For example, if the low-income threshold were set to 80 percent of the median household income for the MBTA service area, there would not be a DI/DB because the low-income populations would be closer to a 50 percent share of the population.

4 TITLE VI FARE EQUITY ANALYSIS: SPATIAL ANALYSIS OF THE 2015-17 RIDER CENSUS

CTPS, in partnership with the MBTA, developed a spatial analysis to identify the demographics and travel patterns of rider survey respondents who started or ended their trip in locations where they would have the choice to change modes. This analysis follows FTA's guidance to use ridership surveys to complete fare equity analyses. The fundamental question this analysis answers is "what are the equity implications if riders who remain in the MBTA's service area and gain or lose mode options choose the least expensive option available to them?".

As the MBTA updates its DI/DB Policy and continues investigating and refining the methodologies in this subject area, the methodologies, tools, and interpretations of results may evolve.

4.1 Methodology, Datasets, Assumptions, and Simplifications

This methodology uses a combination of a spatial analysis with the MBTA's 2015–17 Rider Census (the MBTA's rider survey) to find locations where survey respondents must switch or would likely switch to a mode with a different fare structure.

The following outlines the general workflow:

- 1) Create 0.5-mile circular buffers around “base” stops/stations and “BNRD” stops/stations. The distance was selected based on the coverage standard described in the June 2021 MBTA Service Delivery Policy.⁶
- 2) Identify the areas where there is a change of bus network coverage.
- 3) Buffer these areas by an extra 0.10 miles to account for error associated with asking for locations “to the nearest intersection.” This buffer, in effect, increases the sample sizes associated with the areas that may be affected.
- 4) Identify where the changes in coverage coincide with rapid transit, commuter rail, or ferry service areas.
- 5) Identify survey respondents who started or ended their trips in these areas.
- 6) Identify the fare payment, travel patterns, and demographics of those survey respondents.
- 7) Calculate the share of respondents who would be affected on a daily and weekly basis.
- 8) Evaluate whether those impacts present a significant disparity between groups.

Datasets

CTPS used a set of MBTA-derived base and Fall 2022 Bus Network Redesign GTFS schedules to perform these analyses. The rapid transit, commuter rail, and ferry stop locations, the critical part of the analysis, are the same in each dataset. The base file is mostly representative of current service, but does not contain all changes that have been implemented since the planning process for BNRD began.

The GTFS files did not contain the Green Line Extension stops, but CTPS manually added the stop locations based on a Fall 2022 GTFS file.

The 2015–17 Rider Census is used to identify the travel pattern and demographics of riders who may be affected by service changes in the spatial analysis. More information about the survey may be found at the survey website.⁷

⁶ MBTA. June 2021. Service Delivery Policy <https://cdn.mbta.com/sites/default/files/2021-06/2021-service-delivery-policy.pdf>

⁷ CTPS. May 2018. MBTA 2015-2017 Systemwide Passenger Survey. <https://www.ctps.org/dv/mbtasurvey2018/>.

The rider survey's sampling plan was focused on gaining sufficient sample sizes at the route at station levels—representation beyond those levels was not a goal. Area- and subroute-centric summaries may not be representative of the true ridership in an area. Further, the vast majority (95 percent) of survey respondents described a weekday trip. The Saturday and Sunday spatial analyses use the trip patterns from the largely weekday trip making behavior.

For reference, the survey indicated that 34 percent of the riders can be classified as riders who are minority and 29 percent as riders who live in low-income households. Based on a prior MBTA Title VI service equity analysis, riders who can be classified as minority riders contribute approximately 25 percent of the MBTA's fare revenue; riders classified as low-income contribute 19 percent of the MBTA's fare revenue.⁸ These values are a useful comparator when evaluating fare equity implications because they account for how each demographic group's collective fare product and travel pattern choices within the available transit network affect the groups' average fares.

The MBTA is currently in the process of updating its ridership survey.

Definition of a Disparate Impact or Disproportionate Burden

CTPS would identify a potential DI or DB if the ratio between a protected group's share of the new revenue and the protected groups' share of the existing revenue, an analogue to the average fare, is greater than 1.10 for a net fare increase or less than 0.90 for a net fare decrease.⁹

Assumptions and Limitations

The fare impact for riders in areas that lose or gain bus service depends on what modes and fare products are used. Tables 5A and 5B summarize the combinations of modes and fare types and how they are treated in the analysis.

⁸ CTPS. July 2022 MBTA Boston Free Bus: Fare Equity Analysis Results.

<https://cdn.mbta.com/sites/default/files/2022-07/Free-Bus-Fare-Equity-Analysis-June-22.pdf>

⁹ Appendix 1 contains an example showing how the ratio between the change in the average fare between a protected group and all riders (the metric required by the MBTA's DI/DB Policy) and the ratio between a protected groups' share of the new revenue and the protected groups' share of the existing revenue produce the same value.

TABLE 5
Summary of Mode–Fare Product Combinations and Whether the Riders’
Fares are Affected by Service Changes

A: Riders who lose access to bus service, but are within 0.5 miles of a rapid transit, commuter rail, or ferry service.

Modes used by passenger	Reported fare product	Potential Impact on fare payment to make trip
Only Bus	Single-ride/ Monthly Bus Pass	Affected Have to switch to more expensive fare
Only Bus	Monthly/Weekly/ One-Day LinkPass	Not affected Already pay more expensive fare
Bus and Rapid Transit, Commuter Rail, and/or Ferry	Any fare	Not affected Already pay more expensive fare. This is a simplification of the MBTA fare structure.

Note: If a rider is using a pass product, they are not typically going to be affected by bus network changes because they already are paying using a fare product that provides access to higher priced modes. Surveyed riders who lose service must have used bus service to be affected by the loss of bus service.

B: Riders who gain access to bus service, and are within 0.5 miles of a rapid transit, commuter rail, or ferry service.

Modes used by passenger	Reported fare product	Potential Impact on fare payment to make trip
Bus	Monthly Bus Pass	Not affected Already pay bus fares
Only Bus	Any fare	Not affected Already use only bus system
Commuter Rail	Any fare	Not affected Trips are not typically possible
Rapid Transit	Any fare	Affected Can switch to cheaper fare
Ferry	Any fare	Affected Can switch to cheaper fare

In this analysis, riders may lose access to their bus service, but may be within the service area of some other bus service. This replacement service may not provide service levels or patterns that they experienced on their initial mode, but it would provide access to the system at the same price. This assumption holds for the areas that gain new bus service. If riders can access a less expensive mode despite nonoptimal service levels or patterns, we assume that they do (within the bounds of the previous assumptions about modes and fare product choices). In both cases, riders losing service and riders gaining service, the fact that a service exists means people switch to it is a coarse simplification. In practice, some people who lose service would choose to take the more expensive option (for example, a convenient rapid transit transfer) rather than take a potentially onerous replacement bus trip. Other people would certainly choose the least expensive option. Some people would choose a mix of each day-to-day depending on their specific needs. For people who gain service, it seems highly unlikely that the mere presence of a new bus option would cause all riders boarding near a service to shift to a bus trip. For example, most riders in Kendall Square who gain access to new weekend Route 64 service will likely continue using the Red Line to access their destination.

Some riders lose or gain new service in areas that are not near the rapid transit, commuter rail, or ferry systems. While these riders may be able to travel a long distance to access a new mode and thus pay a higher priced fare, fundamentally they are losing access to the system because of impacts accounted for in the service equity analysis—revenue vehicle hours and route length. These riders are not included in the fare equity analysis.

We assume that riders who use the service on weekends match the demographics of riders who responded to the survey. Minority and low-income populations may be disproportionately more likely to ride on weekends than nonminority and non-low-income populations. This may mean that the weekend values in later tables show fewer riders classified as minority or low-income riders than there likely are on those days.

We also must acknowledge that the COVID-19 pandemic has shifted the demographics of who is using the MBTA's network. Throughout the pandemic, bus routes exhibited the most durable ridership.

4.2 Discussion of Results

Results can be grouped into two broad categories:

- 1) Impacts to those who must switch to a more expensive service—these riders lose bus service and are near a more expensive rapid transit or commuter rail service.
- 2) Impacts to those who gain the choice to switch to a new, less expensive service. These riders may choose to continue using their existing service, switch to a less expensive bus service, or make new trips that are served by the new bus route but do not serve as a replacement for their current travel patterns.

Table 6 presents the percentage of each demographic group within each category. The table also presents the number of surveys used to generate the results.

TABLE 6
Weighted Survey Responses for Riders Who Started or Ended Trips Near Rail Service, Gained New Bus Service, and Paid with Certain Fare Products

Category	Group	Weekday	Saturday	Sunday	Weekly
Lost Existing Bus Service					
Minority Status:	Minority	25% (1)	10% (1)	13% (1)	23%
Minority Status:	Nonminority	75% (1)	90% (4)	87% (3)	77%
Income Status:	Low-income	0% (0)	41% (1)	0% (0)	4%
Income Status:	Non-low-income	100% (1)	59% (2)	100% (2)	96%
Gained New Bus Service					
Minority Status:	Minority	26% (18)	22% (118)	25% (253)	26%
Minority Status:	Nonminority	74% (58)	78% (446)	75% (925)	74%
Income Status:	Low-income	36% (20)	17% (68)	24% (199)	33%
Income Status:	Non-low-income	64% (47)	83% (452)	76% (890)	67%

Notes:
Percentages are based on weighted survey results. The weekly percentage is based on a weighted average of each daily percentage. Weekdays were weighted by 83.7 percent, Saturdays by 9.7 percent, and Sundays by 6.6 percent. These percentages are based on weekly ridership shares by type of day based on the MBTA's Composite 2021 Automatic Passenger Counter summary. On Weekdays, Saturdays, and Sundays, the MBTA loses 0.7 percent, 0.5 percent, and 0.4 percent of its existing service area (including extra buffers) and gains 0.8 percent, 2.2 percent, and 3.8 percent of new area (including extra buffers), respectively. Many of the changes are in lower population density areas.
Values in parentheses indicate the number of district survey responses. For reference, nearly 35,000 distinct people responded to the survey. Sample sizes vary between groups because respondents could choose to independently decline to answer race/ethnicity questions and income questions.
All riders who lose service are within the extra buffer added to attempt to account for uncertainty in the starting or ending locations; no riders are within the base, 0.5-mile buffers. Appendix 2 contains a table with these results.

For riders who lost service, very few survey respondents were identified who would be affected. Despite identifying survey respondents who would be negatively affected, the more appropriate takeaway is that an exceedingly small number of riders would be affected at all. For riders who gained new service, we identified more responses, but the results, primarily derived from weekday results, are based on a small number of surveys. The weekend results are

complicated to interpret because the survey respondents were primarily weekday responses.

Title VI Results

Despite the limitations of a very small sample size, a survey that is mostly representative of weekday riders being used to generalize weekend travel, and simplifications to who would switch to a new mode, it still does not appear likely that the proposed service changes would result in fare inequities. CTPS finds that the effects of the service changes on the average fares would not result in either potential disparate impacts to minority populations or potential disproportionate burdens to low-income populations.

To develop a final estimate that CTPS can apply to the thresholds noted in the MBTA’s DI/DB policy, we assigned estimated cost changes to each set of weighted results. For riders who lost service, because the affected weekday riders were exclusively in the catchment area of Zone 2 commuter rail stations, we assumed their costs would change from the bus fare to the Zone 2 commuter rail fare (\$1.70 to \$7.00, an increase of \$5.30). For riders that gain service, we assumed fares will change from the rapid transit fare to the bus fare (\$2.40 to \$1.70, a decrease of \$0.70). While there is certainly more nuance to this—reduced fares and monthly passes will decrease the effects—these values are generally representative of the relative magnitudes of the effects.

Overall, the benefits of gaining access to less expensive options outweigh the effects of losing access to bus service. Because the change is a net benefit we test if the ratio is greater than or equal to 0.90 for both minority and low-income populations.

**TABLE 7
Final DI/DB Ratios**

Population Group	Existing Share of Revenue	Share of Saved Revenue	DI/DB Ratio
Minority	25%	26%	1.0 > 0.9
Low-Income	19%	34%	1.8 > 0.9

Note: Values are based on unrounded calculations.
DI/DB = disproportionate impact/disparate burden.

Appendices

The Boston Region Metropolitan Planning Organization (MPO) operates its programs, services, and activities in compliance with federal nondiscrimination laws including Title VI of the Civil Rights Act of 1964 (Title VI), the Civil Rights Restoration Act of 1987, and related statutes and regulations. Title VI prohibits discrimination in federally assisted programs and requires that no person in the United States of America shall, on the grounds of race, color, or national origin (including limited English proficiency), be excluded from participation in, denied the benefits of, or be otherwise subjected to discrimination under any program or activity that receives federal assistance. Related federal nondiscrimination laws administered by the Federal Highway Administration, Federal Transit Administration, or both, prohibit discrimination on the basis of age, sex, and disability. The Boston Region MPO considers these protected populations in its Title VI Programs, consistent with federal interpretation and administration. In addition, the Boston Region MPO provides meaningful access to its programs, services, and activities to individuals with limited English proficiency, in compliance with U.S. Department of Transportation policy and guidance on federal Executive Order 13166.

The Boston Region MPO also complies with the Massachusetts Public Accommodation Law, M.G.L. c 272 sections 92a, 98, 98a, which prohibits making any distinction, discrimination, or restriction in admission to, or treatment in a place of public accommodation based on race, color, religious creed, national origin, sex, sexual orientation, disability, or ancestry. Likewise, the Boston Region MPO complies with the Governor's Executive Order 526, section 4, which requires that all programs, activities, and services provided, performed, licensed, chartered, funded, regulated, or contracted for by the state shall be conducted without unlawful discrimination based on race, color, age, gender, ethnicity, sexual orientation, gender identity or expression, religion, creed, ancestry, national origin, disability, veteran's status (including Vietnam-era veterans), or background.

A complaint form and additional information can be obtained by contacting the MPO or at http://www.bostonmpo.org/mpo_non_discrimination.

To request this information in a different language or in an accessible format, please contact

Title VI Specialist
Boston Region MPO
10 Park Plaza, Suite 2150
Boston, MA 02116
civilrights@ctps.org

By Telephone:

857.702.3700 (voice)

For people with hearing or speaking difficulties, connect through the state MassRelay service:

- **Relay Using TTY or Hearing Carry-over:** 800.439.2370
- **Relay Using Voice Carry-over:** 866.887.6619
- **Relay Using Text to Speech:** 866.645.9870

For more information, including numbers for Spanish speakers, visit <https://www.mass.gov/massrelay>.

APPENDIX A

COMPARING THE CHANGE IN THE AVERAGE FARE TO THE SHARE OF THE CHANGE IN REVENUE AS IT RELATES TO THE SHARE OF THE BASE REVENUE

In the following example, the average fare for both increases by 20 percent. The disparate impact/disproportionate benefit ratio is $20\% \div 20\% = 1.0$ (the average fare increase for the protected group divided by the average fare increase for the entire population). We can also compare how the share of the change compares to the existing share of revenue by group: $20\% \div 20\% = 1.0$ (the protected group's share of the change divided by the protected group's existing share of revenue).

Population Group	Num. of Riders	Fare	Revenue	Share of Revenue	New Fare	New Revenue	Change in Revenue	Share of Change	Avg Fare Increase
Protected Group	100	\$0.50	\$50	20%	\$0.60	\$60	\$10	20%	20%
Nonprotected Group	200	\$1.00	\$200	80%	\$1.20	\$240	\$40	80%	20%
Total	300	\$0.83	\$250	100%	\$1.00	\$300	\$50	100%	20%

In this next example, we have increased the fare for the protected group by an additional \$0.05. Here, we can again compare the average fare increase, $30\% \div 22\% = 1.364$ (the average fare increase for the protected group divided by the average fare increase for the entire population). We can also compare how the share of the change compares to the existing share of revenue by group: $27\% \div 20\% = 1.364$ (the protected group's share of the change divided by the protected group's existing share of revenue). These values are identical. This means that we can compare the share of the change in revenue to the share of the existing revenue to estimate whether a change results in disparate impacts or disproportionate burdens.

Population Group	Num. of Riders	Fare	Revenue	Share of Revenue	New Fare	New Revenue	Change in Revenue	Share of Change	Avg Fare Increase
Protected Group	100	\$0.50	\$50	20%	\$0.65	\$65	\$15	27%	30%
Nonprotected Group	200	\$1.00	\$200	80%	\$1.20	\$240	\$40	73%	20%
Total	300	\$0.83	\$250	100%	\$1.02	\$305	\$55	100%	22%

APPENDIX B

RESULTS WITHOUT INCLUDING AN EXTRA 0.1-MILE BUFFER

Table B1 shows that no riders were identified using only 0.5-mile buffers without an extra buffering to account for the imprecision of their identified start and ending locations. The beneficiaries in the areas that gained service are disproportionately people in protected groups.

TABLE B1
Weighted Survey Responses for Riders Who Started or Ended Trips Near Rail Service, Gained New Bus Service and Paid with Certain Fare Products—No Extra Buffer

Category	Group	Weekday	Saturday	Sunday	Weekly
Lost Existing Bus Service					
Minority Status	Minority	0% (0)	0% (0)	0% (0)	NA
Minority Status	Nonminority	0% (0)	0% (0)	0% (0)	NA
Income Status	Low-income	0% (0)	0% (0)	0% (0)	NA
Income Status	Non-low-income	0% (0)	0% (0)	0% (0)	NA
Gained New Bus Service					
Minority Status	Minority	54% (4)	18% (50)	21% (94)	48%
Minority Status	Nonminority	46% (8)	82% (208)	79% (392)	52%
Income Status	Low-income	48% (3)	10% (19)	20% (72)	43%
Income Status	Non-low-income	52% (5)	90% (219)	80% (372)	57%