DISPARATE IMPACT METRICS STUDY APPENDIX

This technical appendix describes how metrics analyzed for disparate impacts and disproportionate burdens (DI/DB) as part of this study were defined, and how the thresholds are applied to the metric impacts that are identified. In addition, the appendix discusses an analysis of the distribution of impacts by transportation analysis zone (TAZ).

1 METRICS ANALYZED FOR DISPARATE IMPACTS AND DISPROPORTIONATE BURDENS

The DI/DB analysis assesses the impacts of several metrics that are projected to occur in the outer year of the Long-Range Transportation Plan (LRTP) (2040 in the case of the most recent LRTP, *Destination 2040*). Using a travel demand model, impacts are analyzed for each TAZ in the Metropolitan Planning Organization (MPO) region, which are then aggregated for the entire region.[1]

1.1 Accessibility Metrics

Accessibility metrics determine the number of various types of destinations that are reachable within a given travel time by public transit. The metrics were

- jobs within a 60-minute public transit trip;
- retail within a 60-minute public transit trip;
- healthcare services within a 40-minute public transit trip; and
- two- and four-year institutions of higher education within a 40-minute public transit trip.

The average number of destinations was calculated for each of the four population groups, based on their respective share of the population within each TAZ. Access to jobs was determined by calculating the total number of jobs accessible by public transit. Access to retail opportunities was determined by calculating the total number retail jobs accessible by public transit. Access to higher education was determined by calculating the total available student seats (based on current student enrollment) accessible by public transit. Access to

[1] The TAZ is the unit of geography most commonly used in regional travel demand models. The spatial extent of TAZs typically ranges from very large (less densely developed) areas in suburban, rural, or undeveloped areas, to small areas in urban (more densely developed) central business districts. The MPO region is divided into 1,901 TAZs.

healthcare was determined by calculating the total number of hospital beds accessible by public transit.

1.2 Mobility Metrics

The mobility metrics evaluate the door-to-door travel time for trips starting or ending in MPO TAZs. The mobility metrics were

- average travel times for public transit trips starting in the MPO;
- average travel times for public transit trips ending in the MPO;
- average highway travel times for auto trips starting in the MPO; and
- average highway travel times for auto trips ending in the MPO.[2]

Average travel times were calculated for each of the population groups, based on their respective share of the population within each TAZ. Trips that end in TAZs were those generated by non-household land uses (such as retail, employment, health care, and education) within the MPO region. They originate either from households within or from outside of the region.[3] Trips that start in TAZs were those trips generated by households. The trips end either within another TAZ within or outside of the region.

1.3 Environmental Metrics

The two environmental metrics were congested vehicle-miles traveled (VMT) and carbon monoxide (CO) emissions. While the other metrics evaluated the impacts affecting users of the roadway or public transit system, these metrics assessed the VMT and CO impacts on residents in each TAZ. Both were calculated using highway trips only. The CO metric assessed the kilograms of CO emissions per square mile within each TAZ. The congested VMT metric assessed the volume-to-capacity ratio on the roads within or adjacent to each TAZ; those with a ratio of 0.75 or greater were considered congested.

2 APPLYING THRESHOLDS

The DI/DB Policy will consist of a three-test investigation that uses three thresholds to identify disparate impacts and disproportionate burden: (1) baseline uncertainty threshold, (2) practical impact threshold, and (3) disproportionality threshold.

[2] Highway trips consist of automobile and truck trips taken on any road in the MPO region. It does not include bus trips.

[3] Trips ending or originating outside of the MPO region are only those within the modeled area, which includes all of Massachusetts and Rhode Island, as well as southern New Hampshire. Only surface transportation trips are included—air travel is not.

2.1 Baseline Uncertainty Threshold

The baseline uncertainty threshold sets the sensitivity for detecting if a change between the no-build and build scenarios would likely exist, or whether it would likely be due to the inherent uncertainty in the modeling process.[4] It is applied to the no-build and build scenarios for each population group in a pair—minority/nonminority populations and low-income/non-low-income populations. A zero percent threshold indicates confidence that the impacts produced by the model would occur. A higher threshold indicates greater uncertainty about whether the impact would occur.

For a metric to pass the baseline uncertainty test and therefore be identified as an impact, it must exceed the threshold for one or more population groups in each pair. If neither population group is likely to experience an impact, then it would indicate that there would be no disparate impact or disproportionate burden, and no further analysis would be needed.

2.2 Practical Impact Threshold

The practical impact threshold is applied to the difference (or impact) between the no-build and build scenarios for each of the four population groups. The change between the no-build and build scenarios for each population group is compared to the practical impact threshold, calculated as a percent change:

$$\%\,\boldsymbol{change} = \frac{(\boldsymbol{build} - \boldsymbol{nobuild})}{\boldsymbol{nobuild}} \times \mathbf{100}$$

A positive percent change indicates a benefit when an increase results in a beneficial impact, as is the case for the accessibility metrics. For the environmental and mobility metrics, a positive percent change is considered a burden, as an increase would be harmful.

This calculation does not account for the baseline uncertainty from the first step. It uses the build and no-build scenario results regardless of the uncertainty associated with them. A percent change of zero indicates there would be no difference between the build and no-build scenarios. To pass the practical impact test, the impact must exceed the threshold for at least one population group in a pair.[5] If neither of the population groups exceeds the threshold, there would be

[4] The no-build scenario is where the projects under analysis are not included in the travel scenario that is analyzed for impacts; the build-scenario is where the projects under analysis are included in the travel scenario that is analyzed.

[5] There are two cases in which a disparate impact or disproportionate burden is identified by the practical impact threshold without having to use the disproportionality threshold: when the

no disparate impact or disproportionate burden and no further analysis would be needed.

2.3 Disproportionality Threshold

Disproportionality is calculated as a ratio comparing the absolute value of the percent change for the protected population to the absolute value of the percent change for the non-low-income population. For example,

$$\boldsymbol{ratio} = \frac{|\%\ \boldsymbol{change}_{\boldsymbol{minority}}|}{|\%\ \boldsymbol{change}_{\boldsymbol{nonminority}}|}$$

When the ratio equals one, the impacts to the two populations are projected to change at the same rate. At a ratio greater than one, the protected population changes more than the non-protected population. At a ratio less than one, the protected population changes less than the non-protected population. The threshold allows for a percentage range surrounding a ratio of one such that within this range, it does not indicate a potential disparate impact or disproportionate burden. For example, a disproportionality threshold of 10 percent would mean that ratios between 0.90 to 1.10 would not be flagged as a disparate impact or disproportionate burden. For the accessibility metrics, ratios above that range would be flagged. For the mobility and environmental metrics, ratios below that range would be flagged.

3 ANALYSIS OF THE DISTRIBUTION OF IMPACTS BY TAZ

Staff developed an application to facilitate the exploration of how different thresholds would affect the identification of disparate impacts and disproportionate burdens. Using the results from the 10 metrics analyzed in *Destination 2040,* users can vary each of the three thresholds to visualize the effect on the identification of disparate impacts and disproportionate burdens.

The application is modeled after the three-step investigation described above: would there be an impact; if so, would the impact be significant; and if it would be significant, would the protected population be more disproportionately affected than the non-protected population? Users can adjust the threshold that accompanies each step, allowing them to sort through potential DI/DB outcomes to help decide which thresholds should be used in the DI/DB Policy.

---

protected population burdens are beyond the threshold and the non-protected population benefits are either beyond the threshold or within the threshold.

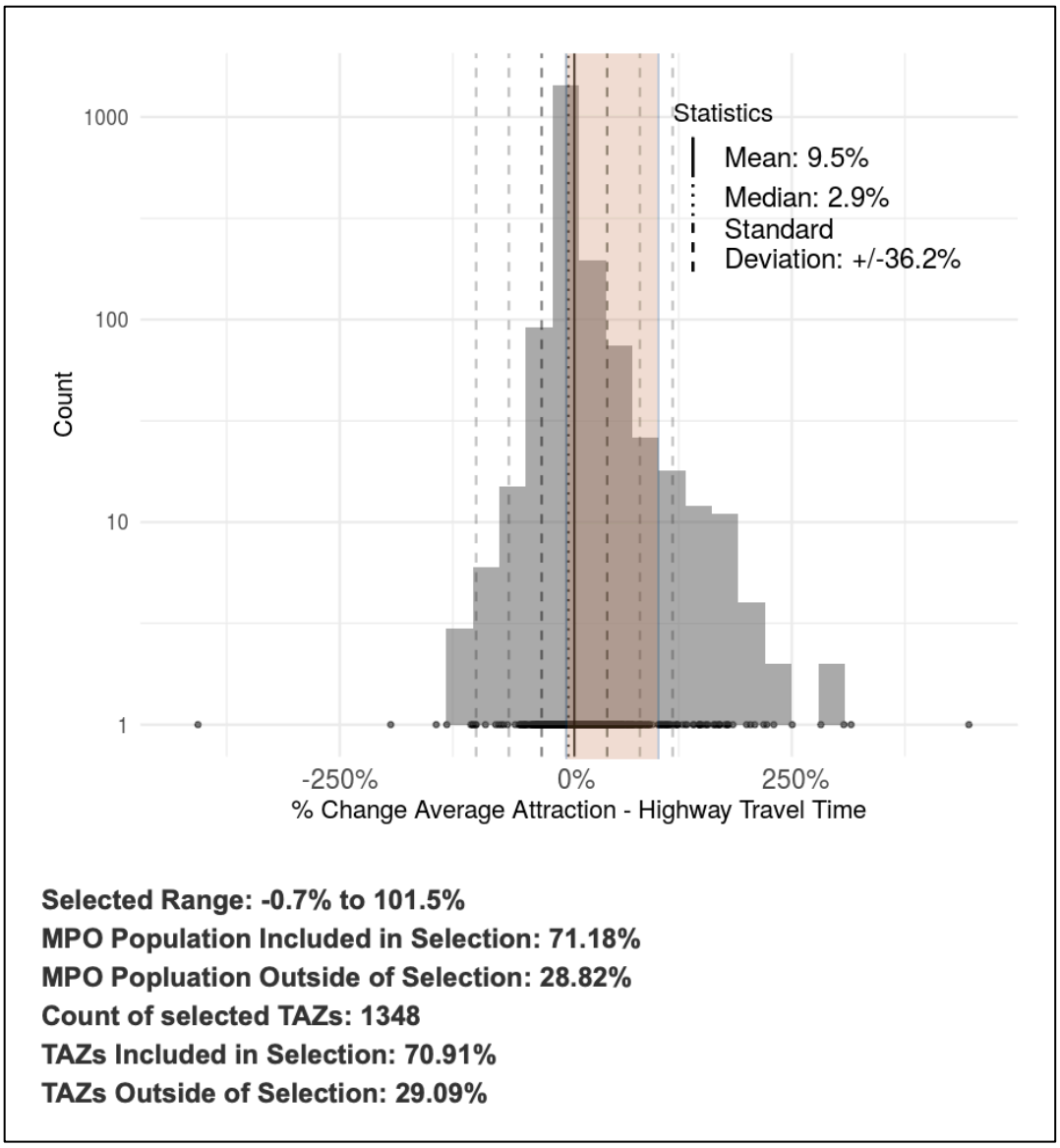
The application also allowed staff to explore other options for the practical impact threshold. The practical impact threshold described above uses weighted averages for the MPO region. Using the application, staff explored if there was an alternative method for setting an impact threshold by analyzing the distribution of the model results for each TAZ in the MPO region. Instead of using the regionwide averages for each population, staff used the model results for each TAZ.

Staff investigated the distribution of the impact for each metric by TAZ to determine whether there appeared to be a logical point in the distribution at which impacts changed significantly. To do so, staff used the same percent change formula as described above for the practical impact threshold.

Figure 1 shows the results, produced with the DI/DB threshold application, using the percent change for the average attraction for highway travel time metric. The Y axis shows the count of TAZs, represented by each bar in the histogram, on a logarithmic scale.[6] The dots below the histogram represent the percent change for each individual TAZ. To characterize the spread of the change across MPO TAZs, the summary statistics for each metric are reported as well. The user can select a range values on the histogram; the histogram reports the population included in the selection, the count of selected TAZs, and the number of TAZs included in the selection. The orange selection box represents the range associated with the selected percent change.

Figure 1
Distribution of the Percent Change in Average Attraction Highway Travel Times, by MPO TAZ

[6] A logarithmic scale is a way of displaying data over a wide range of values. Instead of each number on the scale being equally spaced, each is 10 times that of the preceding number.



MPO = metropolitan planning organization. TAZ = transportation analysis zone.

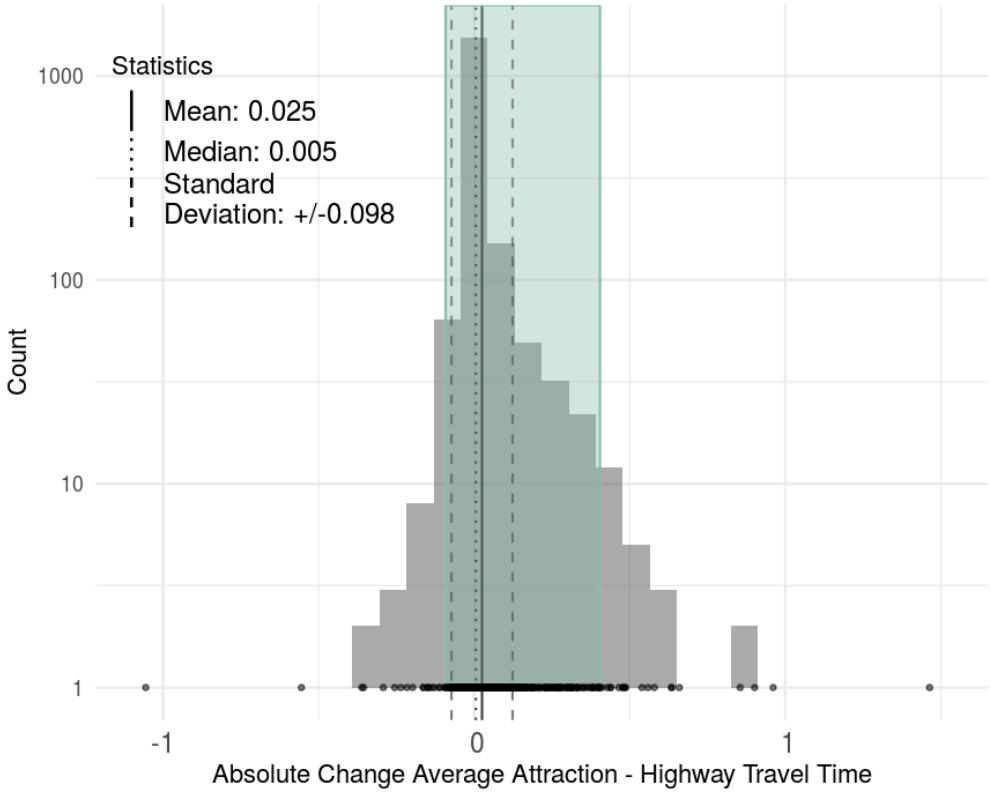
Staff also explored setting thresholds based on the absolute change between the build and no-build scenarios for every TAZ, exploring deriving threshold values based on the median change in a metric's value for a certain percentage of TAZs. For each TAZ, staff calculated the absolute change:

$$absolute\ change\ =\ build - nobuild$$

For example, the range that resulted from identifying the middle 50 percent of TAZs was calculated by finding the absolute change associated with the 25th percentile of TAZs and the 75th percentile of TAZs. Similarly, the middle 98 percent of TAZs was calculated by finding the absolute change associated with the first percentile and the 99th percentile. Figure 2 shows the absolute change

for all TAZs in the MPO region for the average attraction highway travel time metric using the DI/DB threshold application. The green selection box represents the range of absolute change derived from the middle percentile of TAZs associated with the selected radio button (98 percent). Below the histogram is a summary of statistics associated with the selection within the highlighted percentile.

Figure 2
Distribution of the Absolute Change in Average Attraction Highway Travel Times, by MPO TAZ



Selected Range: -0.092 to 0.405
MPO Population Included in Selection: 98.48%
MPO Popluation Outside of Selection: 1.52%
Count of selected TAZs: 1863
TAZs Included in Selection: 98%
TAZs Outside of Selection: 2%
Note: Selected range is inclusive.

MPO = metropolitan planning organization. TAZ = transportation analysis zone.

The distribution of the changes in travel time—both the absolute values and percent changes—was fairly widely distributed around the mean, while for the

environmental and accessibility metrics the values were much more tightly gathered around the mean. Staff also found that analyzing the distribution of changes by TAZ—both absolute values and percent change—identifies outliers rather than a point along the distribution that indicates a significantly larger impact. For metrics where the impacts are clustered around the mean, there simply was not a big enough variation to identify such a break point. For those metrics with more variation, if most of the TAZs had large changes, the metric would not move past the practical impact test regardless of the magnitude of the impacts. This approach would just show that most of the TAZs had similar impacts rather than identify meaningful changes.