Midtown Alternatives Analysis

Technical Memorandum 13 – Ridership Forecasting

Final Report

Prepared for

Memphis Area Transit Authority

Prepared by

Cambridge Systematics, Inc.

May 2016

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Date

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Table of Contents

List of Tables

List of Figures

1.0 Introduction

1.1 Project Overview

The purpose of this report is to summarize the ridership demand forecasting methodology and results in support of the Memphis Midtown Alternatives Analysis (AA). This ridership forecasting effort included: 1) calibration of the existing Memphis Area Transit Authority (MATA) transit system; 2) ridership forecasts for the seven alternatives selected through the Tier 2 screening process; and 3) documentation of findings and conclusions compliant with current Federal Transit Administration (FTA) reporting requirements.

Integrating the new high-capacity transit service with the existing MATA service and any future changes to MATA routes is important to ensure that appropriate levels of service are provided along the proposed alignments. In addition, a well-integrated network would allow passengers to easily connect to the service without significant penalties on travel time. As some of the proposed alignments do not follow existing bus routes, appropriate changes in service were made to ensure efficient use of resources and vehicles, as well as to provide better transfer opportunities between existing local bus routes and the new services.

In the interest of complying with the proposed project schedule and taking into consideration the nature of the Tier 2 alternative evaluation, the team agreed to use Simplified Trips-on-Project Software (STOPS) for screening the alternatives. Using STOPS, the impacts of the alternatives on the corridor boardings were examined using the existing land use and travel conditions (referred to as ‘existing year conditions’ in this report). All ridership and vehicle miles traveled (VMT) values presented in this report are current and horizon year forecasts. FTA guidance suggests using existing conditions which provide the most easily understood, most reliable, and most readily available information for decision-making. The FTA requires all sponsors to calculate the measure for evaluation based on current year inputs.

1.2 Description of Alternatives

The project team evaluated seven alternatives as part of the Memphis Midtown Alternatives Analysis. There were six bus rapid transit (BRT) route alignments (A6, A7, A8, A11, A23, and A26) and one alignment (A9) that considered the streetcar extension on Madison Avenue. The sections below briefly describe the evaluated alternatives and service changes associated with the implemented alternatives. For additional details on the alternatives, please refer to Draft Tier 2 Screening Operating Plan, dated November 2015. **Figure 1.1** below illustrates service alignments for the evaluated alternatives.

Figure 1.1 Service Pattern Options

Source: MATA Midtown Alternatives Analysis Operation Plan, November 2015.

1.2.1 Alignment 6: Airport via Poplar and Airways

Alignment 6 Airport via Poplar and Airways would operate along Poplar Avenue from downtown. This alignment would then travel south along East Parkway and Airways Boulevard to the Airways Transit Center before terminating at Memphis International Airport. The proposed weekday frequency under this scenario is 10 minutes during morning and afternoon peak, 15 minutes in the early morning and midday, and 30 minutes during the evening. Proposed Saturday service is every 30 minutes, and Sunday service every 60 minutes. The one-way travel time on this proposed route is 45 minutes and 23 seconds.

Because Alignment 6 largely duplicates the segment of Route 2 between the airport and Young Avenue on Airways Boulevard and East Parkway, this segment of Route 2 would be replaced by rapid bus service. Route 2 would, therefore, terminate at East Parkway and Young Avenue. Onward connections would be available at East Parkway via new rapid service. Similarly, Alignment 6 duplicates the segment of Route 32 on East Parkway and Airways Boulevard. Under this scenario, Route 32 would be replaced by rapid bus service on East Parkway and Airways Boulevard, and would terminate at Lamar Avenue. Service south of Lamar Avenue would be available with a connection to Alignment 6. On weekdays, a small frequency increase from 45 minutes to 40 minutes will occur, while on Saturdays, frequency will increase from 90 minutes to 70 minutes.

Alignment 6 also duplicates the segment of Route 50 that operates from downtown to East Parkway along Poplar Avenue. Route 50 would terminate at East Parkway, and the segment of Route 50 from downtown to East Parkway would be replaced by rapid bus service. Onward connections between Route 50 and downtown would continue to be available through convenient transfers to the new rapid transit service.

1.2.2 Alignment 7: Germantown via Poplar and University of Memphis

Alignment 7 would operate from downtown to Germantown via Poplar Avenue and the University of Memphis. Weekday frequency is assumed as 10 minutes during peak hours. During midday hours, frequency is assumed as 15 minutes on the inner portion between University of Memphis and Downtown and 30 minutes on long runs to Germantown. During evening hours, frequency is assumed as 30 minutes on the inner portion and 60 minutes on long runs to Georgetown. On Saturdays, Alignment 7 will operate from Downtown to Germantown at 30-minute frequencies throughout the day, and 60-minute frequencies during the evening. On Sundays, the route will operate from Downtown to Germantown at 60 minute frequencies throughout the day. The one-way travel time on this proposed route is 61 minutes and 55 seconds.

Alignment 7 only duplicates Route 50 service from downtown to Germantown. Under this scenario, Route 50 would be entirely replaced by rapid bus service, which would provide more frequent service for a longer service span on Poplar Avenue from downtown to Germantown.

1.2.3 Alignment 8: University of Memphis via Poplar, Cooper, and Union

Alignment 8 would operate from downtown on Poplar Avenue, deviating to serve Cooper Street and Union Avenue; before continuing again on Poplar Avenue and terminating at the University of Memphis. The weekday frequency under this scenario would be 10 minutes during morning and afternoon peak, 15 minutes in the early morning and midday, and 30 minutes during the evening. On Saturday, service would operate every 30 minutes; and on Sunday, service would operate every 60 minutes. The one-way travel time on this proposed route is 38 minutes and 16 seconds.

Because Alignment 8 duplicates Route 50 from downtown to Tucker Street on Poplar Avenue, Route 50 would be truncated at North Tucker Street/Overton Park, and the segment to downtown would be replaced by rapid bus service. Under this scenario, existing Route 50 passengers would transfer at Overton Park for continuing service to downtown. Frequency on Route 50 would not change on weekdays and Sundays. Route 50 frequency on Saturday would increase from 45 minutes to 60 minutes.

1.2.4 Alignment 9: Fairgrounds via Madison

Alignment 9 would travel along Madison Avenue from downtown, and then turn south on Cooper Street and east on Central Avenue. The weekday frequency for this alignment would be 10 minutes during morning and afternoon peak, 15 minutes in the early morning and midday, and 30 minutes during the evening. On Saturday, service would operate every 30 minutes, and on Sunday, service would operate every 60 minutes. The one-way travel time on this proposed route is 38 minutes and 55 seconds.

Alignment 9 parallels service of two routes. Alignment 9 would replace Route 2 service along Madison Avenue and portions of Cooper Street, and Route 32 also would replace Route 2 service from the airport to Young Street. As such, under this scenario, Route 2 would be eliminated. This scenario provides a transfer opportunity between Route 32 and Alignment 9 at the Fairgrounds. While deviations serving various medical facilities would no longer be served by Route 2, these areas would continue to be served within walking distance of the Madison streetcar line. Route 32 would increase frequency to 30 minutes on weekdays to compensate for the elimination of Route 2. Route 32 would replace Route 2 service to the airport on Airways Boulevard and East Parkway with 30 minute frequencies on weekdays and 60 minute frequencies on Saturdays.

1.2.5 Alignment 11: University of Memphis via Union and Poplar

Alignment 11 would operate from Downtown Memphis to the University of Memphis via Union and Poplar Avenues. The weekday frequency for this alignment would be 10 minutes during morning and afternoon peak, 15 minutes in the early morning and midday, and 30 minutes during the evening. On Saturday, service would operate every 30 minutes, and on Sunday, service would operate every 60 minutes. The one-way travel time on this proposed route is 30 minutes and 16 seconds.

Alignment 11 parallels the service of several local routes. However, a high-capacity transit line would only be able to replace sections of local bus routes. Route 32 would increase frequency to 30 minutes to compensate for the elimination of Route 2. Route 32 would replace Route 2 service to the airport on Airways Boulevard and East Parkway with 30-minute frequencies on weekdays and 60-minute frequencies on Saturdays. Route 34 would be truncated. Because Alignment 11 duplicates Route 34 on Union Avenue, in this scenario, Route 34 would be truncated at the Central Library, and the segment of Route 34 between downtown and Poplar Avenue would be replaced by rapid bus service. Under this scenario, riders boarding on Walnut Grove would be able to transfer to the new rapid service at the Central Library. Alignment 11 duplicates Route 56 service between downtown and McLean Boulevard along Union Avenue. As such, under this scenario, Route 56 would travel to McLean Boulevard via Jefferson Avenue and Madison Avenue, thereby, providing service to the various medical institutions located along this alignment. At McLean Avenue, Route 56 would continue south along its existing alignment. The adjusted Route 56 service would replace Route 2 on Madison Avenue, and Route 32 would replace Route 2 on East Parkway and Airways Boulevard. As such, under this scenario, Route 2 would be eliminated.

1.2.6 Alignment 23: Elvis Presley, Cleveland, Watkins Crosstown

Alignment 23 Elvis Presley, Cleveland, Watkins Crosstown is a north-south operating crosstown route that would travel along Watkins Street, N Cleveland Street, S Bellevue Boulevard, and Elvis Presley Boulevard. The alignment would continue to serve all areas currently served by Route 42. In this scenario, 10-minute service would be offered during weekday peak periods, and 15-minute service would be offered during weekday early mornings on the whole route. During midday and evening, service alternates between short runs between Frayser Boulevard and Raines Road, and long runs, which complete the entire Route 42 alignment. The core segment would have a frequency of 15 minutes during midday and evening, while the outer segment would have service every 30 minutes. The one-way travel time on the core segment of the route is 32 minutes and 12 seconds. The travel time on the northern loop is 34 minutes, and on the southern loop –33 minutes. Because Alignment 23 replicates Route 42, the existing local route would be replaced by rapid bus service.

1.2.7 Alignment 26: University of Memphis via Union and Central

Alignment 26 University of Memphis via Union and Central would operate from Downtown Memphis to the University of Memphis via Union and Poplar Avenues. The weekday frequency for this alignment would be 10 minutes during morning and afternoon peak, 15 minutes in the early morning and midday, and 30 minutes during the evening. Service would operate every 30 minutes on Saturdays, and every 60 minutes on Sundays. The one-way travel time on this proposed route is 32 minutes and 56 seconds.

Alignment 26 University of Memphis via Union and Central parallels the service of several local routes. However, a high-capacity transit line would only be able to replace sections of local bus routes. Route 32 would replace Route 2 service to the airport on Airways Boulevard and East Parkway with 30-minute frequencies on weekdays and 60-minute frequencies on Saturdays. Alignment 26 would replace Route 34 from downtown to Cooper Street on Union Avenue. As such, under this scenario, Route 34 would operate via Madison Avenue and Jefferson Avenue to downtown, replacing the eliminated Route 2. Alignment 26 duplicates Route 56 from downtown to Cooper Street along Union Avenue. As such, under this scenario, Route 56 would travel along its existing alignment, but would use MLK Jr. Avenue to access downtown, replacing Route 5 service.

1.3 Purpose and Methodology

The travel demand modeling component of this study consisted of the following elements:

1. Coding and analysis of the existing No Build system;
2. Coding and analysis of the existing (2015) Build Alternatives;
3. Coding and analysis of the future (2035) Build Alternatives; and
4. Documentation of findings compliant with current FTA reporting requirements.

To estimate trips on the proposed BRT system, the project team utilized FTA's national model, STOPS. The STOPS model is designed to estimate transit project ridership using a streamlined set of procedures. STOPS includes many of the same computations of transit level of service and market share found in regional travel demand models. STOPS produces all of the reporting needed by project sponsors to review ridership forecasts in detail, and to support grant applications to the FTA New and Small Starts program.

When using STOPS, the FTA review of forecasts can be focused on the inputs, assumptions, and forecasts produced rather than on the modeling tool being used.

The focus of the forecasting effort for this study was on performing analysis and refining the results of the existing conditions first, followed by forecasting ridership for the horizon year build alternatives, once the team was comfortable with the results that STOPS produced for the base year.

2.0 STOPS Model Inputs

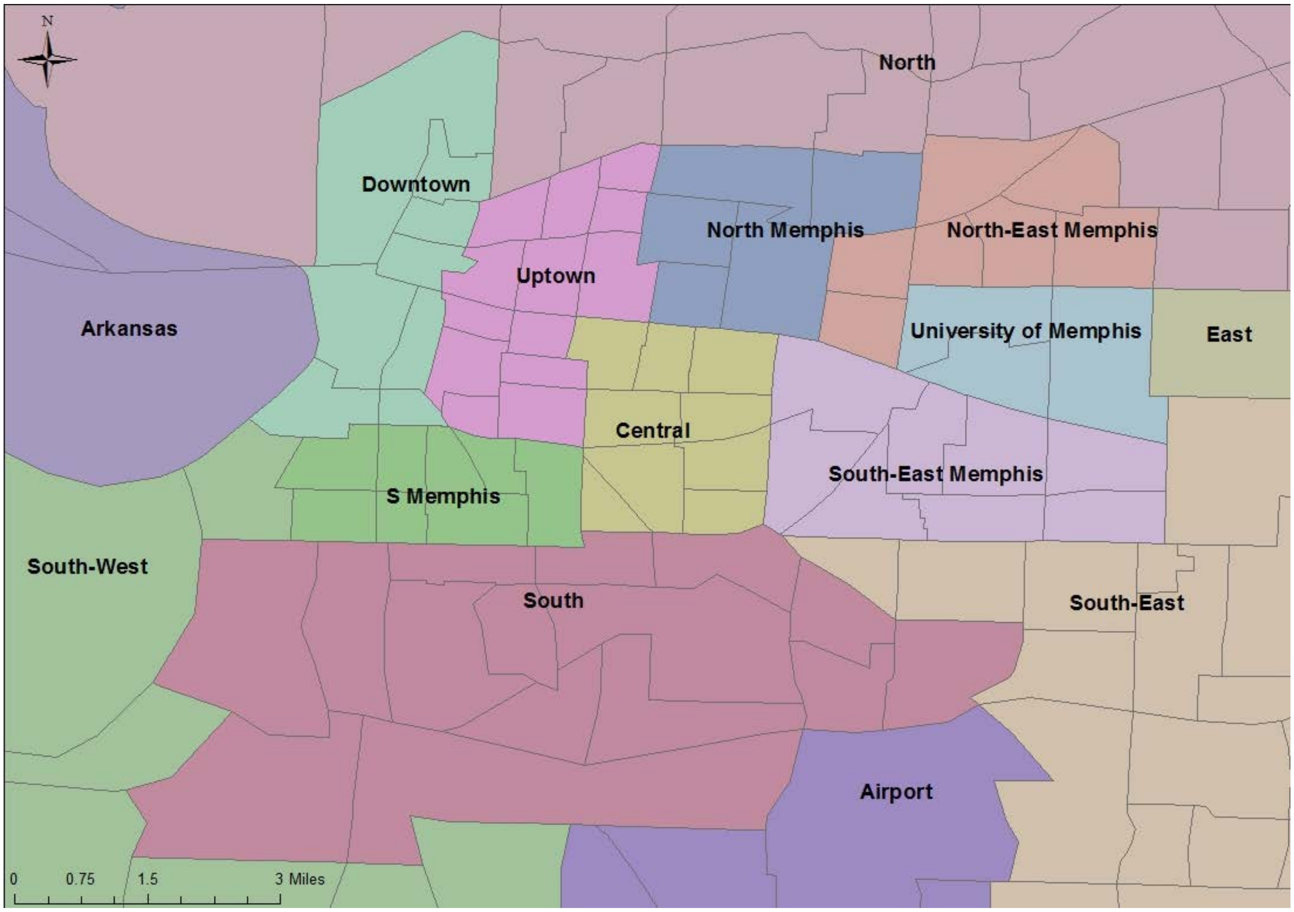
The following sections describe how STOPS was configured and calibrated to address the project corridor forecasting and multiple alternative build scenarios.

2.1 Study Area and District System

A district system can help: 1) in understanding and interpreting model results, 2) in growth factoring of the 2000 Census Transportation Planning Package (CTPP) trips to estimate forecast year trips using Metropolitan Planning Organization (MPO) forecasts, and 3) summarizing and mapping STOPS model output with a logical rationale. Census Traffic Analysis Zones (TAZ) are aggregated into larger geographic areas, forming districts to assist in the interpretation of results and mapping of travel markets in the corridor. These districts were created primarily using the boundaries of the Census TAZs, and do not represent municipality boundaries. The 15 districts that the study area was divided into 15 districts, shown in **Figure 2.1**. The districts used in STOPS modeling, listed below, are based on the guidelines outlined in the STOPS documentation.

1. Downtown
2. Uptown
3. North Memphis
4. North-East Memphis
5. Central
6. University of Memphis
7. South-East Memphis
8. University of Memphis
9. Airport
10. South
11. South-East
12. South-West
13. Arkansas
14. North
15. East

Figure 2.1 Districts Developed for STOPS Modeling



2.2 Population and Employment Data

STOPS uses existing population and employment data to factor 2000 CTPP journey-to-work (JTW) data to the existing and horizon years. STOPS does this by applying the 2015 to 2035 growth to the JTW data. Socioeconomic data obtained from Memphis area regional model indicates that population in the Memphis region will grow from 1,316,100 in 2015 to 1,629,467 in 2035, which is approximately a 24-percent increase over the 20 year period. The socioeconomic data from the model also suggests that employment will grow from 638,082 in 2015 to 906,228 in 2035, which is approximately a 42-percent increase.

In addition, STOPS needs to be fed the ratios between current work and nonwork trips on the transit system. Users may choose to compute these ratios from current rider-survey data or rely on the average default values in STOPS computed from six metro areas. These ratios of various trip purposes are prepopulated with national averages from on-board transit surveys obtained from the STOPS calibration cities. Since STOPS-supplied ratios have been well-calibrated for BRT specific analysis, for the purposes of this study, the team used the default ratios. **Table 2.1** presents the ratios used in this study.

Table 2.1 Modeled Ratios of Work to Nonwork Purposes

Auto Ownership Class	Parameter	STOPS Default
0 Car Households	HBO: HBW Ratio	1.098
1 Car Households	HBO: HBW Ratio	0.535
2+ Car Households	HBO: HBW Ratio	0.503
0 Car Households	NHB: HBW+HBO Ratio	0.199
1 Car Households	NHB: HBW+HBO Ratio	0.193
2+ Car Households	NHB: HBW+HBO Ratio	0.234

2.3 Transit Network

STOPS uses General Transit Feed Specification (GTFS) to represent existing and scenario-specific transit services. GTFS consists of a series of files that represent the stops, routes, and scheduled operations of a transit system. MATA is the primary provider of public transit services in the Memphis area. As the largest transit operator in the State of Tennessee, it transports nearly 11 million riders a year in the City of Memphis, other parts of Shelby County, and the City of West Memphis on fixed-route bus, paratransit, and vintage rail trolleys.

The modeling team downloaded 2015 MATA GTFS data. However, since Trolley service at the time was replaced by the bus service, the team requested an earlier version of GTFS data from the time when the Trolley was still in operation. Once the team received Trolley GTFS files for the year 2013, Trolley service characteristics (stop locations, trips, and stops times) were incorporated into the most recent 2015 GTFS data, which represent current bus service in the study region. For the purposes of developing existing and future year demand, the alternatives use this combined GTFS data set. The project team coded BRT service by creating new sets of alternative-specific GTFS files. Each alternative-specific GTFS set also reflected the changes made to the existing bus service compliant with the Draft Tier 2 Screening Operating Plan, dated November 2015.

2.4 Highway Skims

STOPS uses the zone-to-zone existing and horizon year peak-period automobile travel times (skims) from the regional travel demand forecasting model. The project team obtained these skims from the Memphis Area Regional Model.

In addition to using highway skims, the National Environmental Policy Act (NEPA) analysis for the project can rely on usage of the regional model as part of the overall planning process, including review of traffic impacts that may be associated with build alternatives. For transit projects, typical traffic impacts include those caused by the introduction of park-and-ride and other station facilities, as well as potential "disruption" to No Build traffic operations. These potential impacts may be studied through the use of a representative build scenario in the regional model and supplemental traffic analysis rather than nuanced treatment of a multitude of transit options. Output from STOPS also is used to help inform these traffic analyses (e.g., travel demand at the stations).

2.5 System-wide and Station-Level Boardings

For the Memphis region, the team used locally-reported 2015 regionwide ridership of approximately 29,000 total weekday transit boardings for the system-level calibration. This represents the average weekday boardings on all fixed-route bus and fixed-guideway services in the study region. Fixed-route boardings were obtained from the 2014 regional on-board survey, considered the most comprehensive data source for route boardings.

2.6 Mode and Visibility Factor

The visibility factor indicates the degree to which the project is more visible to the traveling public than the local bus. Typically, a bus would have a visibility factor of 0 and a highly visible rapid transit system, such as subway system would have a visibility factor of 1. After careful consideration, consultation with FTA staff, and sensitivity testing runs, the modeling team adapted a visibility factor of 0.08 for BRT alternatives and a visibility factor of 0.25 for the fixed-guideway Alternative 9. In STOPS, a route type "0" indicates "fixed-guideway" and a route type "3" indicates bus. Alternative 9 was coded as a route type "0," since it represents an extension to the existing fixed-guideway Madison Trolley line. All other alternatives were coded as route type "3", as they closely replicate bus operations.

3.0 Model Calibration and Validation

3.1 Model Calibration

STOPS utilizes data from a variety of sources to represent travel flows and transit supply, bypassing the need to calibrate these challenging model elements. It utilizes relatively conventional procedures for estimating mode shares, and then auto-calibrates these results to match estimated home-to-work transit shares attracted to each zone (from the CTPP), local regional transit boardings (from the National Transit Database or other sources), and station-level (aggregated to groups) ridership data in cities where fixed guideway transit is already present. GTFS (General Transit Feed Specification) files are used to develop zone-to-zone transit, access, and wait times. A traditional nested logit mode choice model computes the transit shares stratified by access mode (walk, kiss-and-ride, and park-and-ride) and submode (fixed guideway-only, fixed guideway and bus, and bus-only). In addition, modeled station group boardings and observed group boardings are used to derive adjustment factors. STOPS requires the user to define station groups that represent groups of similar stations. STOPS uses these groups for internal calibration. A station group must be defined for both the existing and new stations. The project team developed station groups to calibrate the station-level boardings in the Memphis region system. Both Trolley and Bus stops were used in the station group development process.

Table 3.1 provides station group boarding adjustment factors applied in STOPS for the No Build scenario. These adjustment factors are based on the calibration using the observed boarding counts at the existing fixed-guideway stops in the region. Since STOPS utilizes census tract geography to develop the forecasts, it is expected that the stop-level estimated boardings may not be as accurate as regional model estimates. STOPS utilized an average boarding adjustment factor of 1.3 to match overall boardings to the observed boardings. The boarding adjustment factors that STOPS generated are significantly higher than 1.0 for some of the stops in order to calibrate to the observed boarding counts. It means that without the boardings adjustment process or without observed counts at the stations, STOPS would significantly underestimate the boardings. Therefore, STOPS is sensitive to the observed data counts as it tries to match estimated boardings totals to the observed boardings totals, by applying the adjustment growth.

Table 3.1 Boardings Adjustment Factors

Origin Group	Main	Mad	NMem	Centr	CentrM	NEMem	SEMem	EMem	Univ	South	Aerop	Arkan	North	East	SEast
1-Main	7.54	3.9	2.31	2.24	1.8	2.33	2.77	2.31	2.41	2.41	2.74	12.7	2.29	2.54	2.67
2-Mad	3.9	2.02	1.19	1.16	0.93	1.2	1.43	1.19	1.25	1.25	1.42	1	1.18	1.32	1.38
3-NMem	2.31	1.19	0.71	0.68	1	0.71	0.85	0.71	0.74	0.74	1	1	0.7	0.78	1
4-Centr	2.24	1.16	0.68	0.66	0.54	0.69	0.82	0.69	0.72	0.72	0.81	1	0.68	0.76	0.79
5-CentrM	1.8	0.93	1	0.54	0.43	1	0.66	1	0.58	0.58	0.66	1	1	0.61	0.64
6-NEMem	2.33	1.2	0.71	0.69	1	0.72	0.86	0.71	0.74	0.74	1	1	0.71	0.79	1
7-SEMem	2.77	1.43	0.85	0.82	0.66	0.86	1.02	0.85	0.89	0.89	1.01	1	0.84	0.94	0.98
8-EMem	2.31	1.19	0.71	0.69	1	0.71	0.85	0.71	0.74	0.74	1	1	0.7	0.78	1
9-Univ	2.41	1.25	0.74	0.72	0.58	0.74	0.89	0.74	0.77	0.77	1	1	0.73	0.81	0.85
10-South	2.41	1.25	0.74	0.72	0.58	0.74	0.89	0.74	0.77	0.77	0.88	1	0.73	0.81	0.85
11-Aerop	2.74	1.42	1	0.81	0.66	1	1.01	1	1	0.88	1	1	0.83	0.93	0.97
12-Arkan	12.7	1	1	1	1	1	1	1	1	1	1	19.73	1	1	1
13-North	2.29	1.18	0.7	0.68	1	0.71	0.84	0.7	0.73	0.73	0.83	1	0.7	0.77	1
14-East	2.54	1.32	0.78	0.76	0.61	0.79	0.94	0.78	0.81	0.81	0.93	1	0.77	0.86	1
15-SEast	2.67	1.38	1	0.79	0.64	1	0.98	1	0.85	0.85	0.97	1	1	1	0.95

3.2 Model Validation

As part of the validation process, the project team compared STOPS estimated boardings to the existing MATA transit system utilization. To do this, the team compared the boardings on the bus routes that operate in the project corridor. The STOPS model represents the aggregate corridor ridership well, with a 1-percent deviation over the observed boardings for the collection of routes reviewed (approximately 28,942 boardings estimated versus 28,611 boardings observed). At the individual route level, as is typical in transit assignment results, the model exhibited a mix of over- and under-estimation. Overall, the positive and negative deviations balanced out in the corridor. **Table 3.2** below presents the comparison of observed versus calibrated No Build boardings data.

Table 3.2 Observed versus Estimated Route-Level Boardings

Route Group	Observed	Final Calibrated	% Difference
East-West	16,789	16,008	-4.7%
North-South	9,542	10,673	11.9%
Trolley	2,280	2,261	-0.8%
Total	**28,611**	**28,942**	**1.2%**

4.0 STOPS Forecasts

4.1 Summary of Forecasts

This section summarizes ridership estimates for the Build alternatives, under 2015 and 2305 conditions, produced by STOPS. Figures 4.1 and 4.2 illustrate the projected 2015 and 2035 daily ridership for each alternative. The model estimates the highest ridership on Alternatives 11 and 23 (approximately 3,000 to 3,500 in the year 2035), and the lowest on Alternatives 8 and 9 (approximately 1,200 to 1,300 in the year 2035). These projections do not include trips generated by special generators. During our review of the results, several questions were raised regarding the validity of the results. For example, in Alternative 7, which has more robust service compared to Route 50 that it replaces, why does ridership decrease, compared to the No Build Route 50 ridership. In this particular case, as further explained below, it had to do with how STOPS addresses the consolidation of stops. In the case of Alternative 23, the travel times modeled could be higher than the scheduled time due to the way it was coded in the model. **Figures 4.3** and **4.4** illustrate ridership normalized by distance for 2015 and 2035. When normalized, Alternatives 11, 26, and 9 are amongst the top performers.

Figure 4.1 2015 Daily Trips on Project
Build Scenario

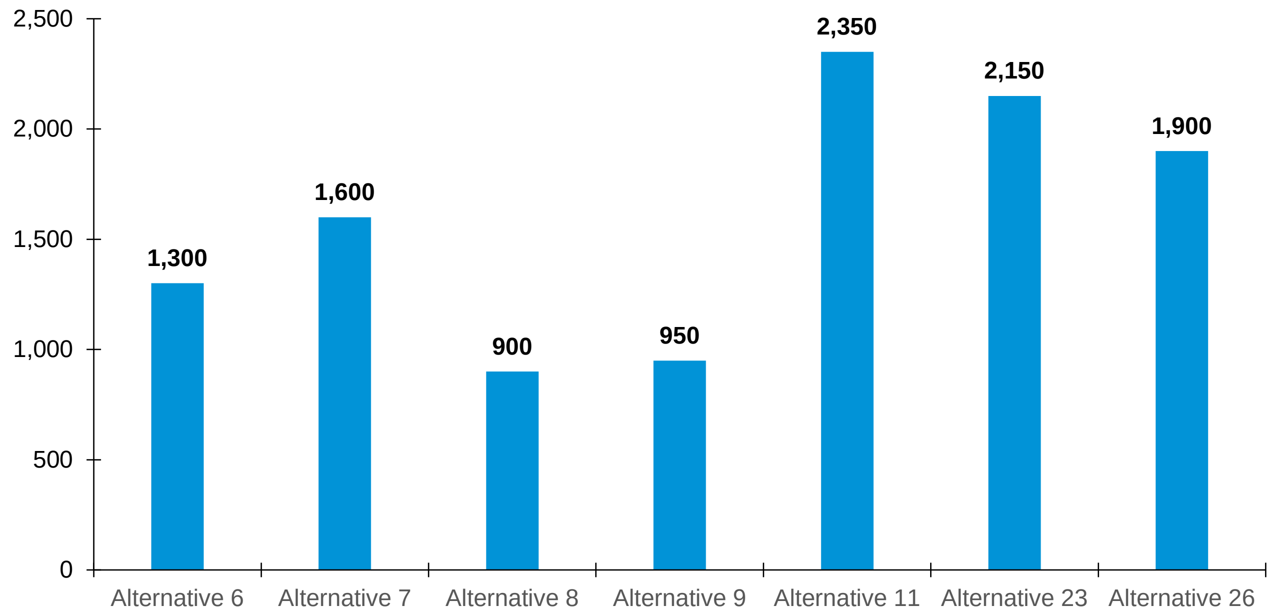


Figure 4.2 2035 Daily Trips on Project
Build Scenario

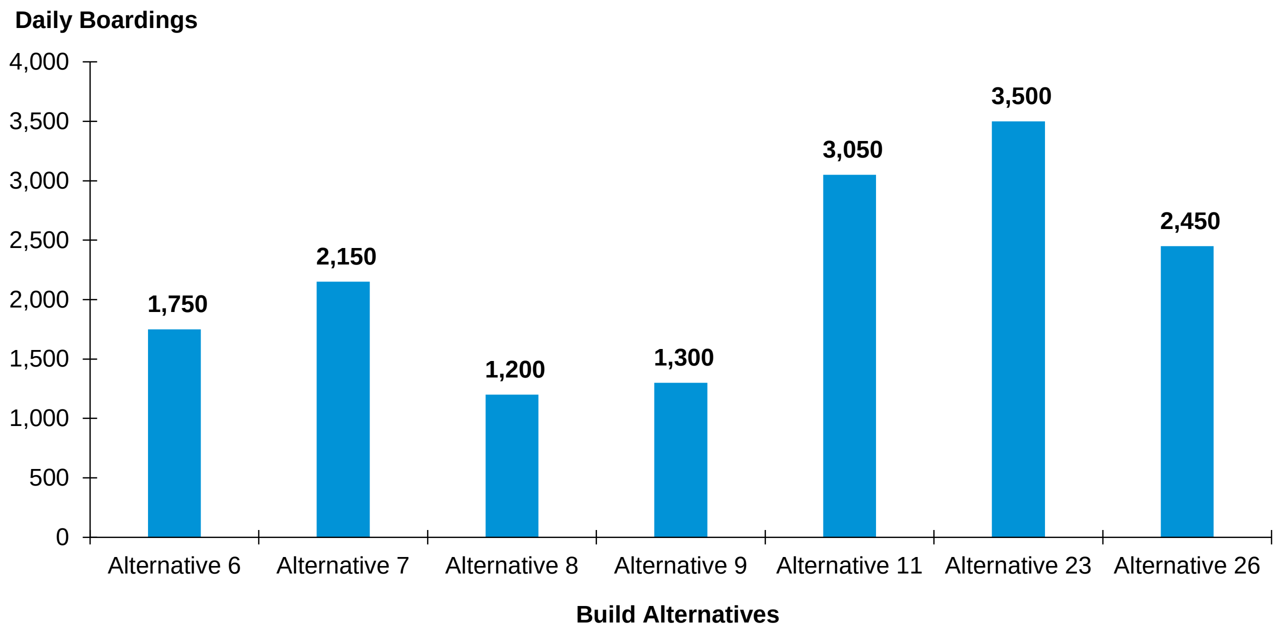


Figure 4.3 2015 Daily Project Boardings per Mile
Build Scenario

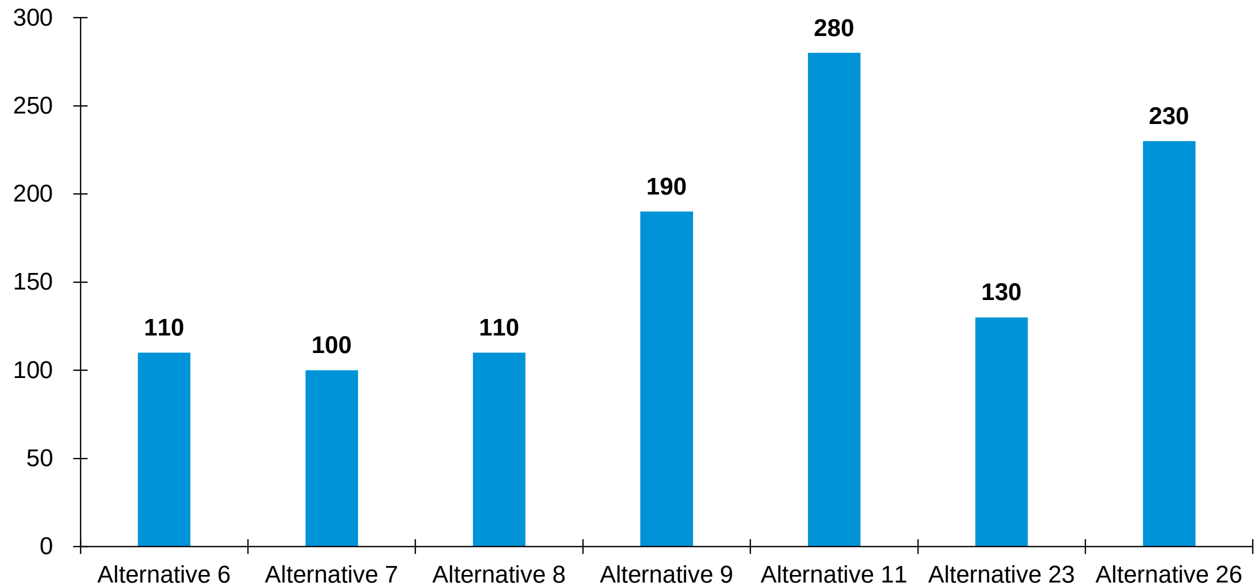
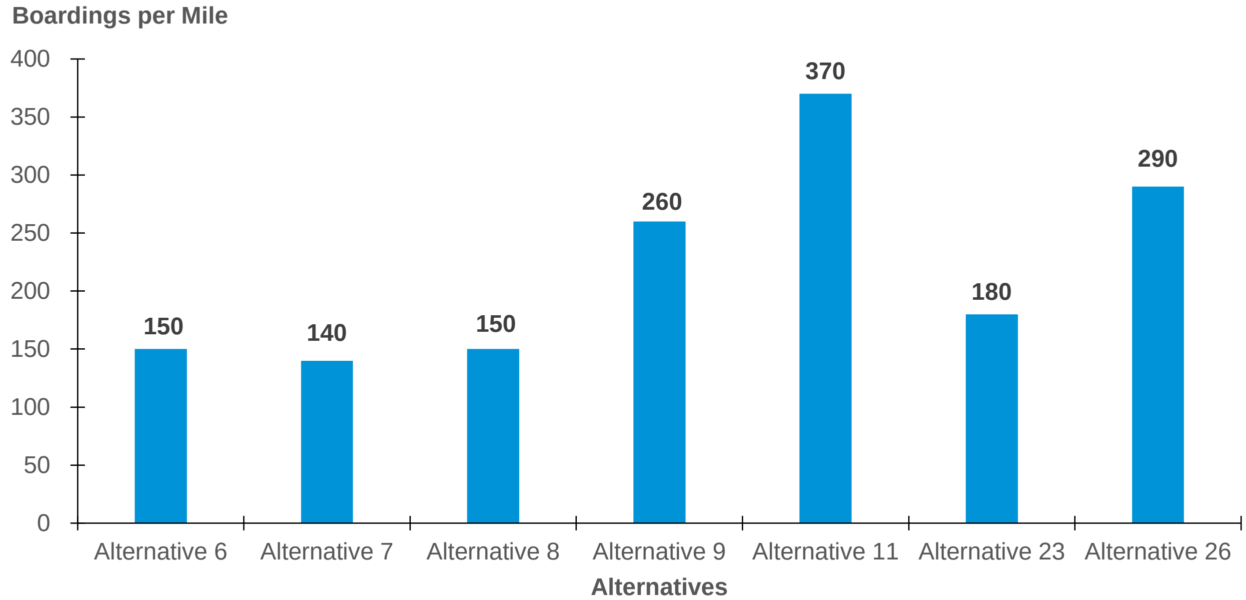


Figure 4.4 2035 Daily Project Boardings per Mile
Build Scenario



4.2 2015 & 2035 New Riders

As indicated in **Figures 4.5 and 4.6**, the system-wide ridership drops under most build alternatives, compared to the No Build, except under Alternatives 7 and 8. This outcome can most likely be attributed to system-wide reductions in service (i.e., truncation of existing service routes or the replacement by the project). Two possible explanations for why Alternatives 7 and 8 undergo an increase in new riders: 1) more robust service compared to the service they are replacing; and 2) the routes undergo the least amount of alteration to existing service, and operate under faster conditions compared to older routes, such as Route 50, albeit small in magnitude. Alternatives 11 and 26 undergo the biggest changes in current bus schedules, which could explain the largest drops in new system-wide riders.

In the case of Route 7, however, the STOPS projections indicated a reduction in Alternative 7 boardings (2,150 in the year 2035), compared to No-Build Route 50 boardings (2,500 in the year 2035) that it replaced, which was counterintuitive, given that frequencies and speeds had been enhanced. The only other logical explanation was that STOPS perceived the consolidated number of bus stops in Alternative 7 negatively, perhaps as reduced accessibility.

In order to test this theory, Cambridge Systematics ran a sensitivity test by revising Route 50 service to have frequencies and speeds similar to Alternative 7 values, maintaining Route 50 stop spacing and number of stops similar to No-Build levels, in 2035. The result was an increase in Route 50 riders by approximately 8 percent. It must be noted here that there also was one more difference between the way Alternative 7 and Route 50 were coded, which relates to a particular model setting called the *visibility factor.* In this test scenario, since Route 50 was coded as a regular bus route and not a BRT project, it had a lower-than-suggested visibility factor, and therefore will likely attract more riders than the 8 percent increase projected, if coded with a visibility factor comparable to that of Alternative 7.

Figure 4.5 2015 System-wide New Riders
Build versus No-Build

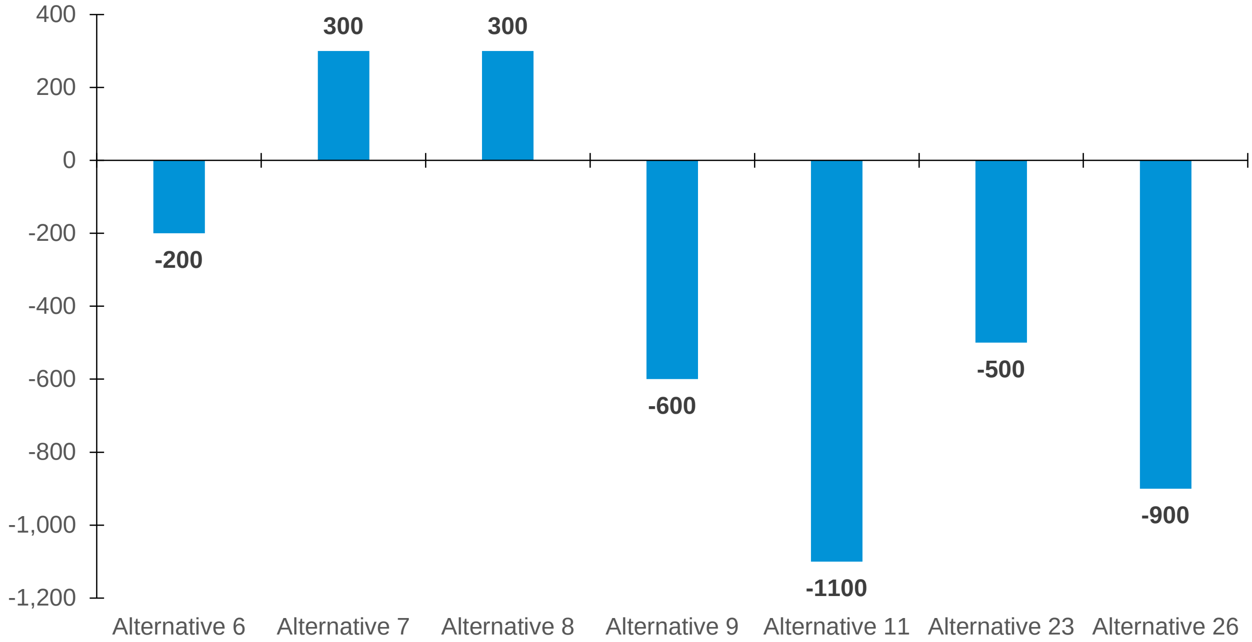
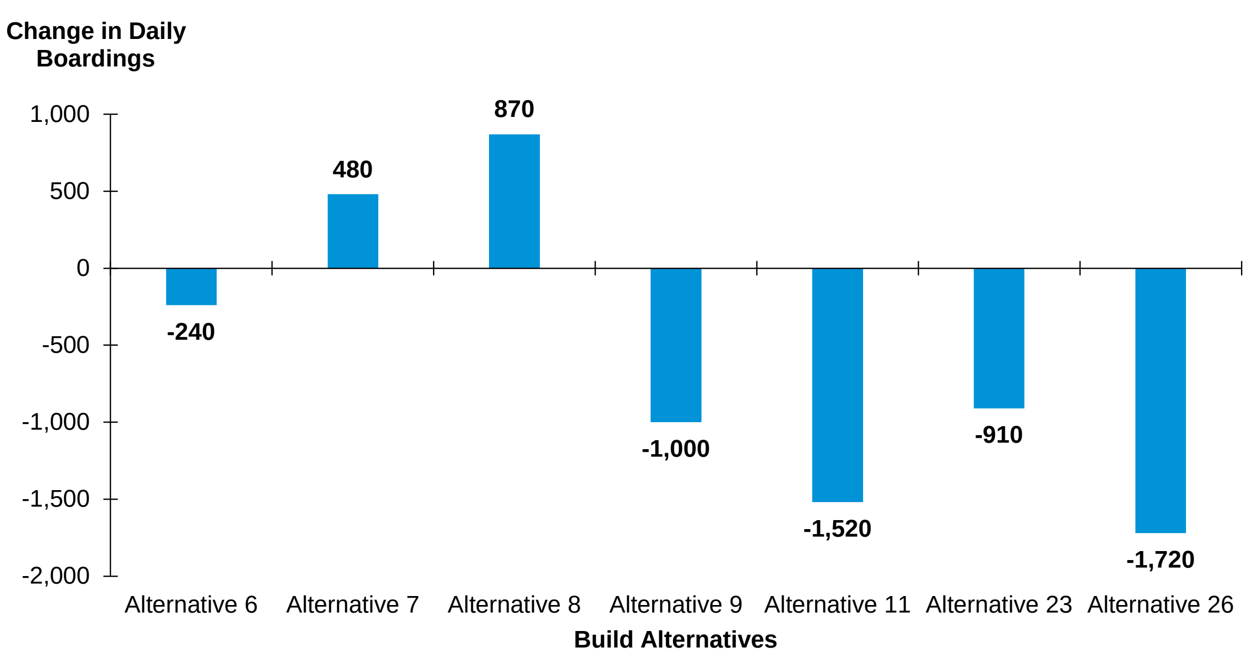


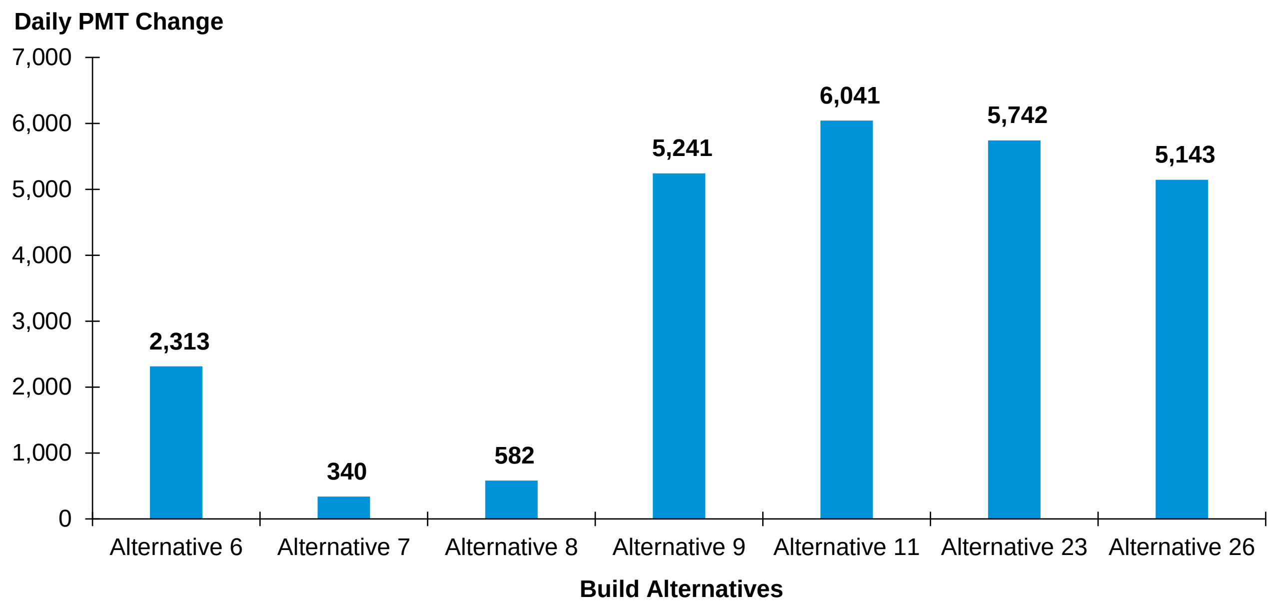
Figure 4.6 2035 System-wide New Riders
Build versus No-Build



4.3 Automobile Passenger Miles Traveled

All 2035 alternatives experience an increase in automobile person miles traveled (PMT) (Figure 4.7). The increase could be attributed to the reduction in service (i.e., truncation/alteration of existing bus routes as well). As discussed earlier, Alternatives 7 and 8 undergo the least change in service, reflected in smaller increases in PMT compared to other alternatives.

Figure 4.7 2035 Automobile PMT Change
Build versus No-Build



4.4 2035 Ridership by STOP

Figures A.1 through A.7 in Appendix A illustrate the range of projected riders, by stop, across alternatives. Despite the variation in overall project ridership and the alignment of alternatives, there are some clear trends that emerge from the stop-level ridership.

- Alternatives 11 and 26 attract the highest number of riders at Union Avenue compared to any other stop across alternatives;
- The intersection of the east-west alignments and Cleveland Street attracts a high number of riders;
- Alternatives 9, 11, and 26 attract a significant percentage of riders at Pauline Street;
- Other stops that are projected to attract a significant number of riders are S. Alicia Drive, Deloach Street, and McLean Boulevard; and
- North Main Terminal appears to attract a sizeable number of riders under Alternatives 11 and 26.

4.5 Summary (2035 Results)

- Alternatives 11 and 23 are projected to generate the highest daily boardings (approximately 3,000 to 3,500), and Alternatives 8 and 9 are projected to generate the lowest daily boardings (approximately 1,200 to 1,300).
- System-wide ridership drops under most Build alternatives, compared to the No-Build, except under Alternatives 7 and 8. The drop is attributable to a combination of factors, including the reduction in current service serving key markets, consolidation of stops that the STOPS model could be overreacting to, and the replacement of key routes with better speeds and frequencies. However, other changes such as the introduction of transfers could have a negative impact on ridership. All alternatives are projected to experience an increase in PMT.
- Based on the service plans developed, several stop locations were identified as high-ridership locations.
- Based on the ridership results, the team recommends revising service plans to reflect less aggressive service cuts to existing bus routes, compared to the original Tier 2 service plans.

4.6 Sensitivity Tests

As part of the validation and quality assurance process, the project team also conducted sensitivity tests on the 2035 alternatives to evaluate the sensitivity of the model to change.

The first test conducted was to identify the reason for the system-wide decrease in ridership compared to the No-Build scenario. The assumed hypothesis was that system-wide ridership decreased compared to the No-Build scenario because local bus service was reduced across many of the Build alternatives. This was confirmed when the team ran a variation of Alternative 23 by only enhancing the frequency of the Route 42 bus compared to the No-Build. As expected, the model projected an increase in overall system-wide boardings. In addition, one of the reasons that the original Alternative 23 BRT was estimated to have a lower ridership than competing Route 42 (which was removed in the Build scenario), despite more robust service, is that the proposed travel times were significantly slower for Alternative 23 compared to Route 42, when the end loops were included (68 versus 99 minutes).

The second sensitivity test was conducted to determine if the decrease in ridership projected by STOPS in Alternative 7, compared to Route 50 in the No-Build, is attributable to stop spacing. To test this theory, the modeling team assumed that there would be no BRT alternative, but there would be service upgrade on Route 50. This test run considered that:

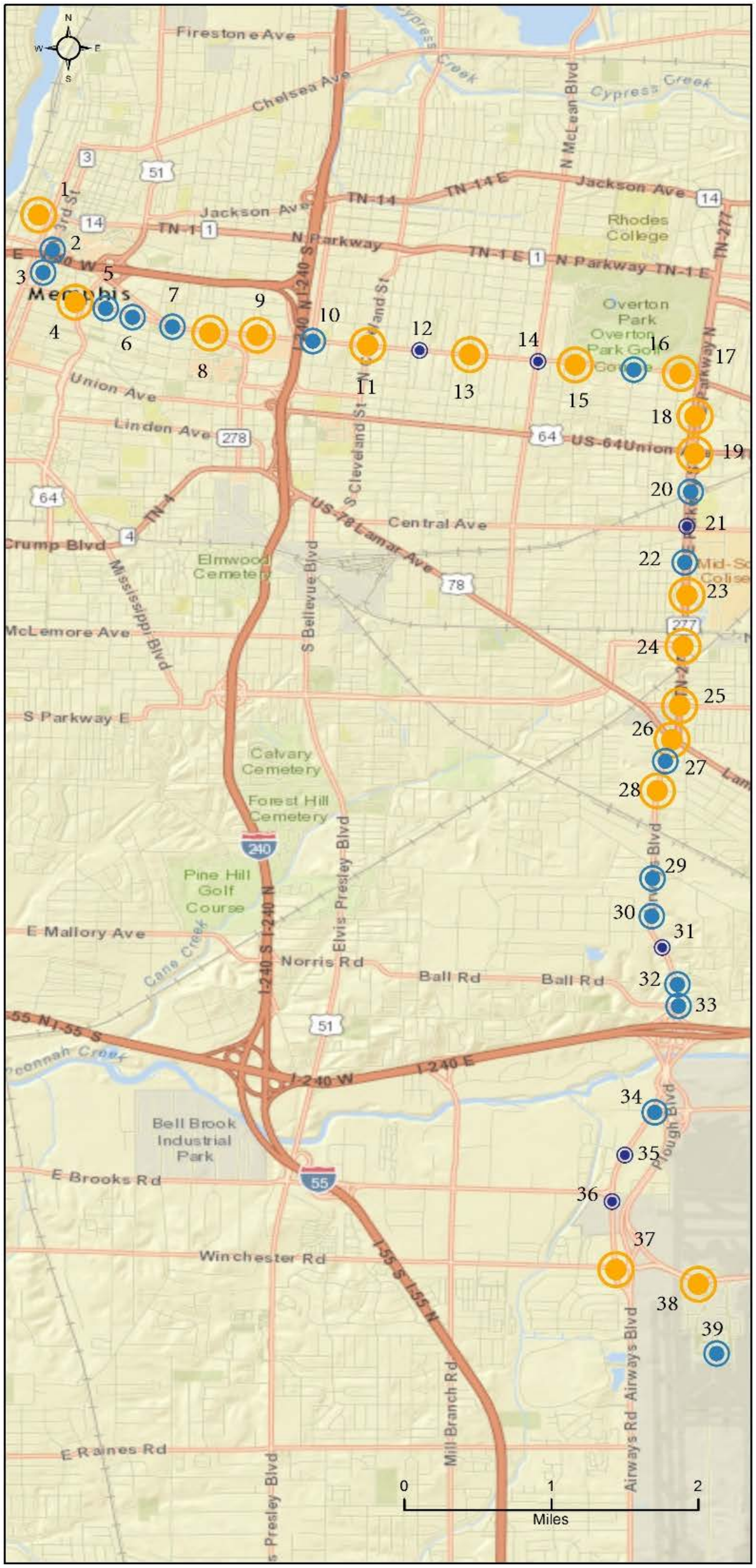
- All routes remain the same, except for Route 50;
- Route 50 assumes the service frequency of the proposed Alternative 7;
- Travel time on Route 50 is consistent with proposed Alternative 7 travel time; and
- Route 50 has more stops than Alternative 7.

The sensitivity test resulted in 8 percent increase in Route 50 boardings, which implies that the model is likely increasing ridership when there are shorter walks involved. In addition, since Route 50 was not coded as a STOPS Build project (as in the case of the BRT in Alternative 7 were), certain parameters could not be applied to it. If it was coded as a Build project, the projected boardings on Route 50 would likely have been even higher than 8 percent.

The main conclusions from these model sensitivity testing exercises are: 1) system-wide ridership in the Build alternatives is affected by substantial service cuts to the existing local bus service; 2) the model is sensitive to travel times on the Build alternatives, especially in comparison to the competing routes in the corridor; and 3) the model is sensitive to stop spacing, and longer walk distances translate into slower door-to-door travel times.

Appendix A. 2035 Average Weekday Boardings by Stop

Figure A.1 Alignment 6 Ridership by Stop

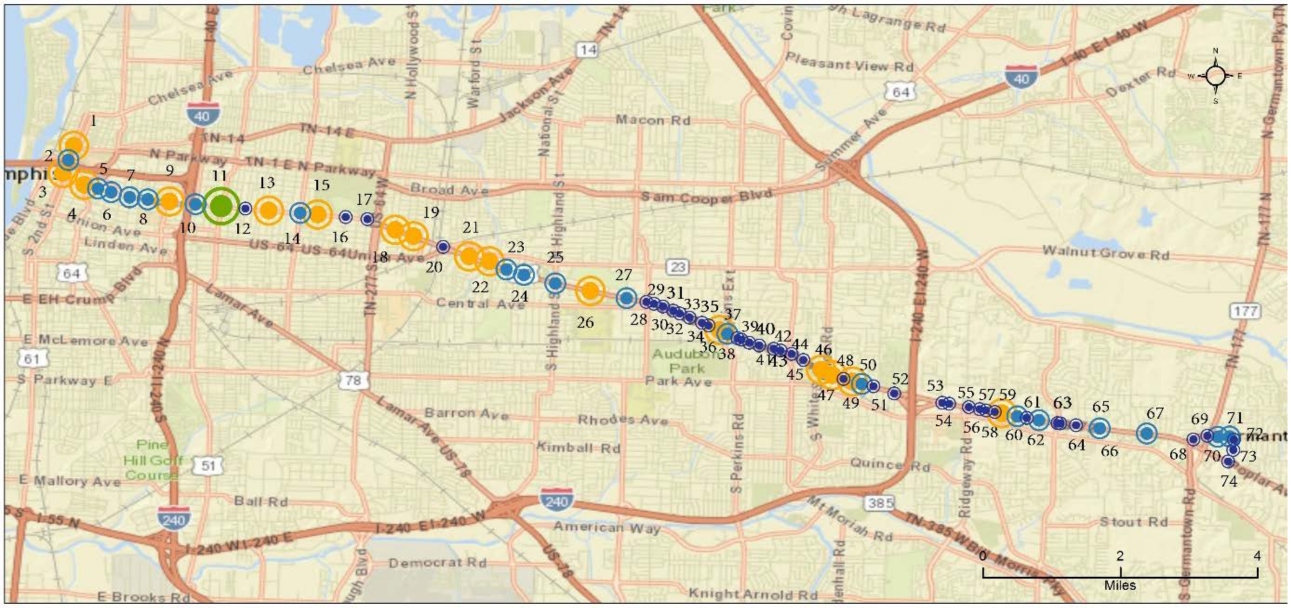


2035 Avarage Weekday Boardings

- < 10
- 11 - 50
- 51 - 200
- 201 - 300
- > 300

1 North Main Terminal
2 Jackson Ave
3 Poplar
4 N Lauderdale St
5 High St
6 Hamplin Pl
7 Manassas Street
8 Le Bonheur Hospital (Ashland Street)
9 VA Medical
10 N Bellevue Boulevard
11 N Cleveland Blvd
12 Stonewall St
13 Center City Shopping Ctr / Angelus Str
14 McLean Blvd
15 Overton Park
16 Cooper St
17 Edgewood
18 Court Ave
19 Union Ave
20 Christian Brother's University
21 Central Ave
22 Evelyn Ave
23 Young Ave
24 South Parkway
25 Park Ave
26 Lamar Ave
27 Malone Ave
28 Lowell Ave
29 Dunn Ave
30 Memphis Depot
31 Dwight Rd
32 Ball Rd
33 Ketchum Rd
34 Democrat Rd
35 Director's Row
36 Airways Transit Center
37 Winchester Rd
38 Jim McGhee
39 Memphis International Airport

Figure A.2 Alignment 7 Ridership by Stop

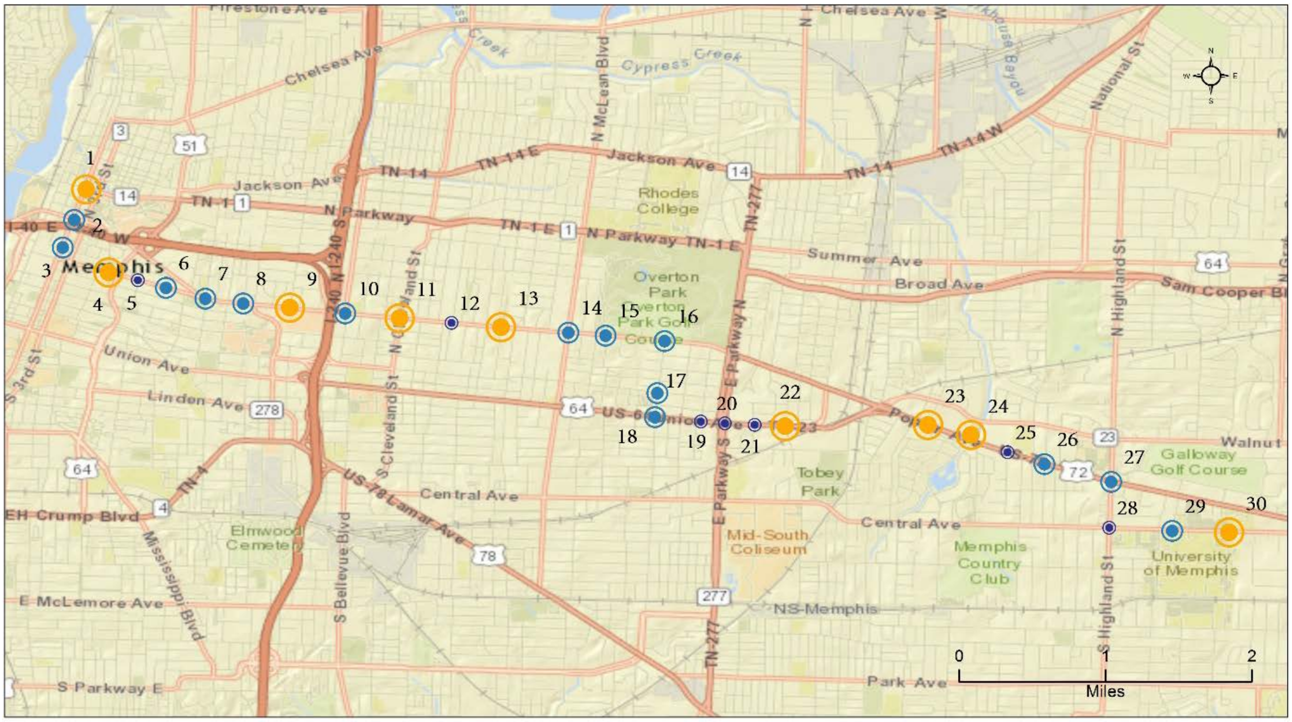


2035 Avarage Weekday Boardings

- < 10
- 11 - 50
- 51 - 200
- 201 - 300
- > 300

1 North End Terminal
2 2nd and Jackson
3 2nd and Market
4 N Lauderdale St
5 High St
6 Hamplin Pl
7 Manassas Street
8 Le Bonheur Hospital (Ashland Street)
9 VA Medical
10 N Bellevue Boulevard
11 Cleveland
12 Stonewall St
13 Center City Shopping Ctr / Angelus Stre
14 McLean Blvd
15 Overton Park
16 Cooper St
17 Edgewood
18 N Hollywood
19 Bingham
20 Scott
21 Tillmann St
22 Chicksaw Oaks Plaza
23 Marne Street / East High School
24 S Century St
25 Highland Street
26 Deloach / U of M
27 Poplar@Galloway
28 Poplar@Goodlet
29 Poplar@Williamsburg
30 Williamsburg@Poplar
31 Poplar@Woodmere
32 Poplar@Greenfield
33 Poplar@Cherry
34 Poplar@Oak Court
35 Poplar@Grove Park
36 Poplar@Perkins
37 Poplar-Perkins
38 Perkins@Poplar
39 Poplar Ave@Perkins Rd
40 Poplar@Colonial
41 Colonial@Poplar
42 Poplar@Erin
43 Poplar@Moss
44 Poplar@Mendelhall
45 Poplar@Truse Pkwy
46 Poplar@White Station
47 Poplar@Pelham Dr
48 Poplar@Estate Dr
49 Poplar@Valleybrook
50 Poplar@Reddoch
51 Poplar@June
52 Poplar@Brookfield
53 Poplar@Ridgeway Loop
54 Poplar@Ridgeway
55 Poplar@Ridgeway2
56 Poplar@Briarcrest
57 Poplar@Massey
58 Massey @Poplar
59 Poplar@International Pl
60 International Pl@Poplar
61 Poplar@Aaron Brenner
62 Poplar@Poplar Woods
63 Poplar Kirby
64 PoplarR@Kirby
65 Poplar@Hazelton Rd
66 Poplar@Val Verde
67 Poplar@Riverdale
68 Farmington rd@Germantown Rd
69 Germantown Rd@Farmington Rd
70 Farmington Rd@Exeter Rd
71 Exeter Rd@Farmington
72 Exeter Rd@Poplar Ave
73 Poplar Ave@Exeter Rd
74 Exeter-Farmington

Figure A.3 Alignment 8 Ridership by Stop



2035 Avarage Weekday Boardings

- < 10
- 11 - 50
- 51 - 200
- 201 - 300
- > 300

1 North Main Terminal
2 Jackson Ave
3 Market
4 N. Lauderdale
5 High
6 Hamplin
7 Manassas
8 Le Bonheur Hospital (Ashland)
9 VA Medical (Decatur)
10 N. Bellevue
11 N. Cleveland
12 Stonewall
13 Center City Shopping Center (Angelus)
14 McLean
15 Overton Park
16 Cooper
17 Madison (Overton Square)
18 Union
19 Edgewood
20 East Pkwy / Memphis Theological Seminary
21 Patricia
22 S. Alicia
23 Tillman
24 Chicksaw Oaks Plaza
25 Marne Street (East High School)
26 S. Century
27 Highland
28 Central
29 Deloach
30 U of M

Figure A.4 Alignment 9 Ridership by Stop

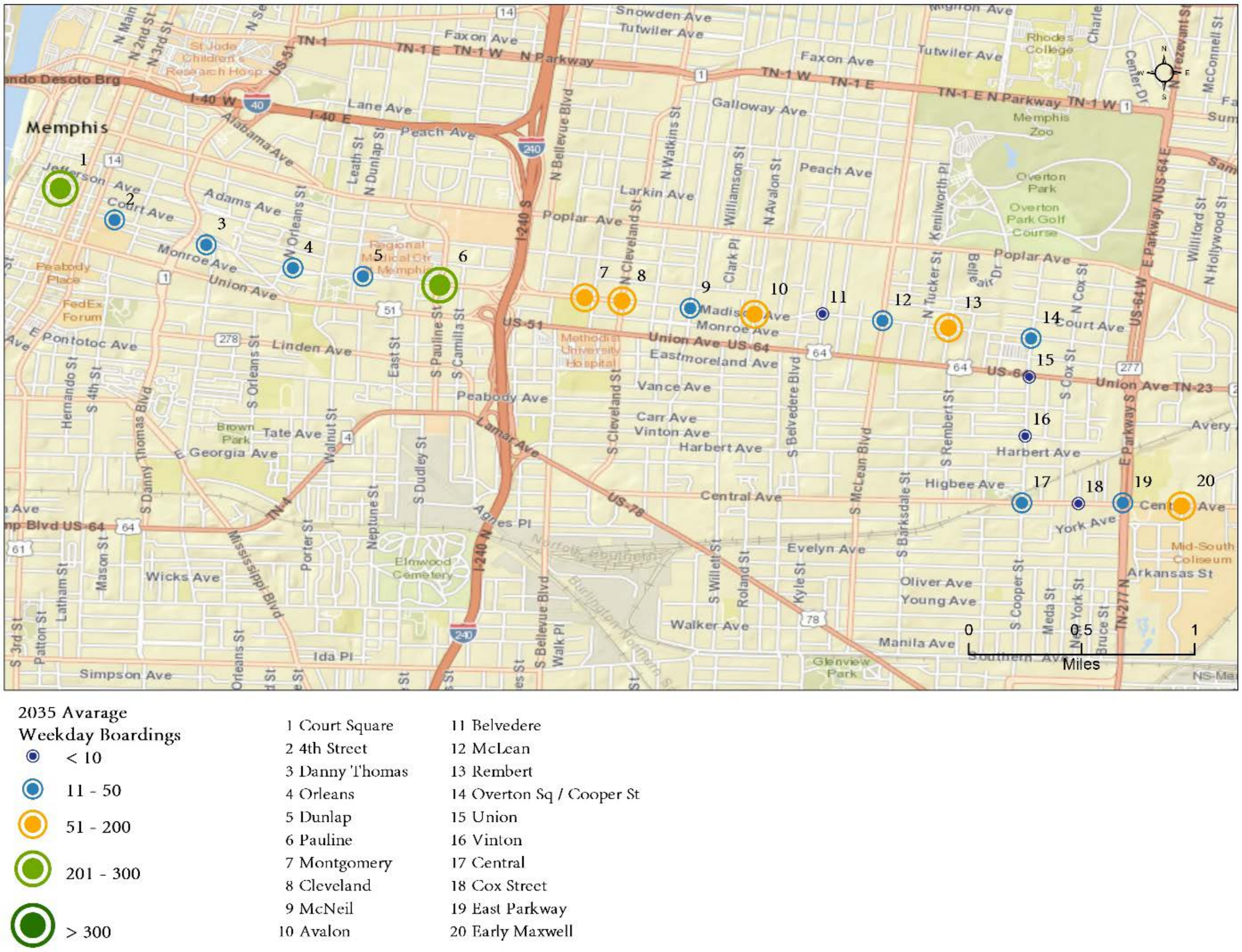
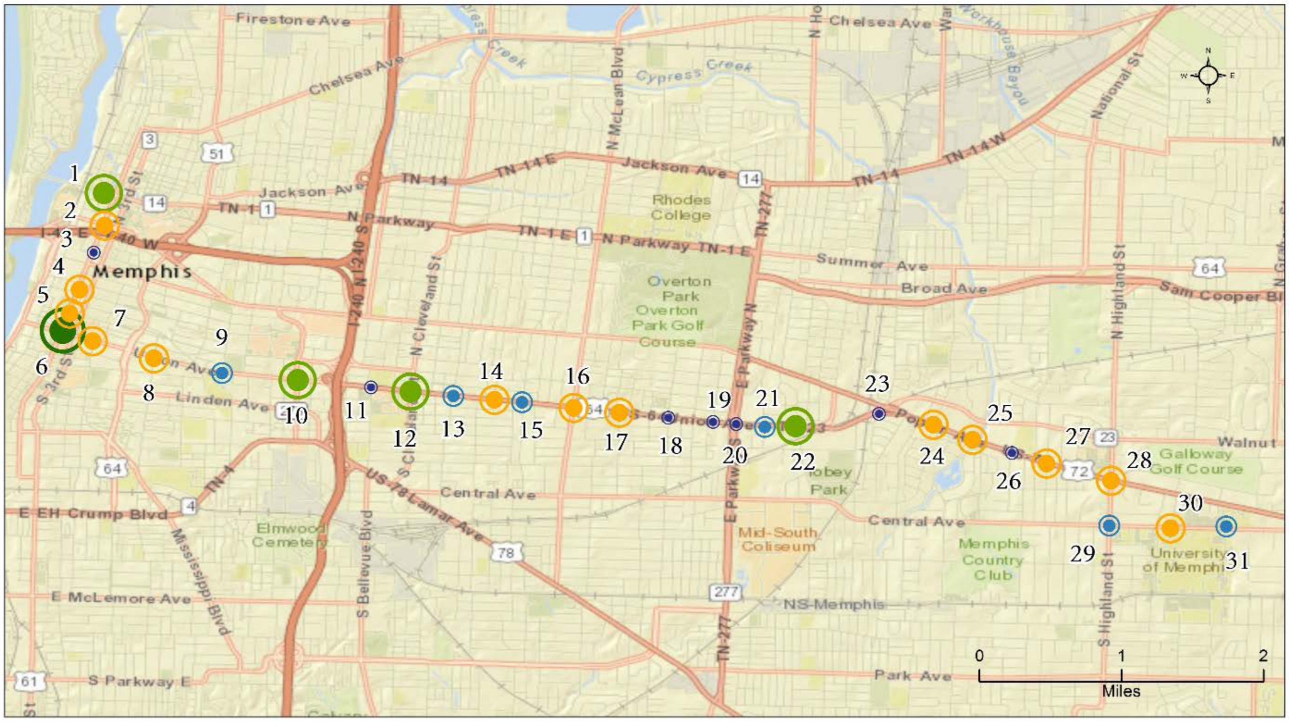


Figure A.5 Alignment 11 Ridership by Stop

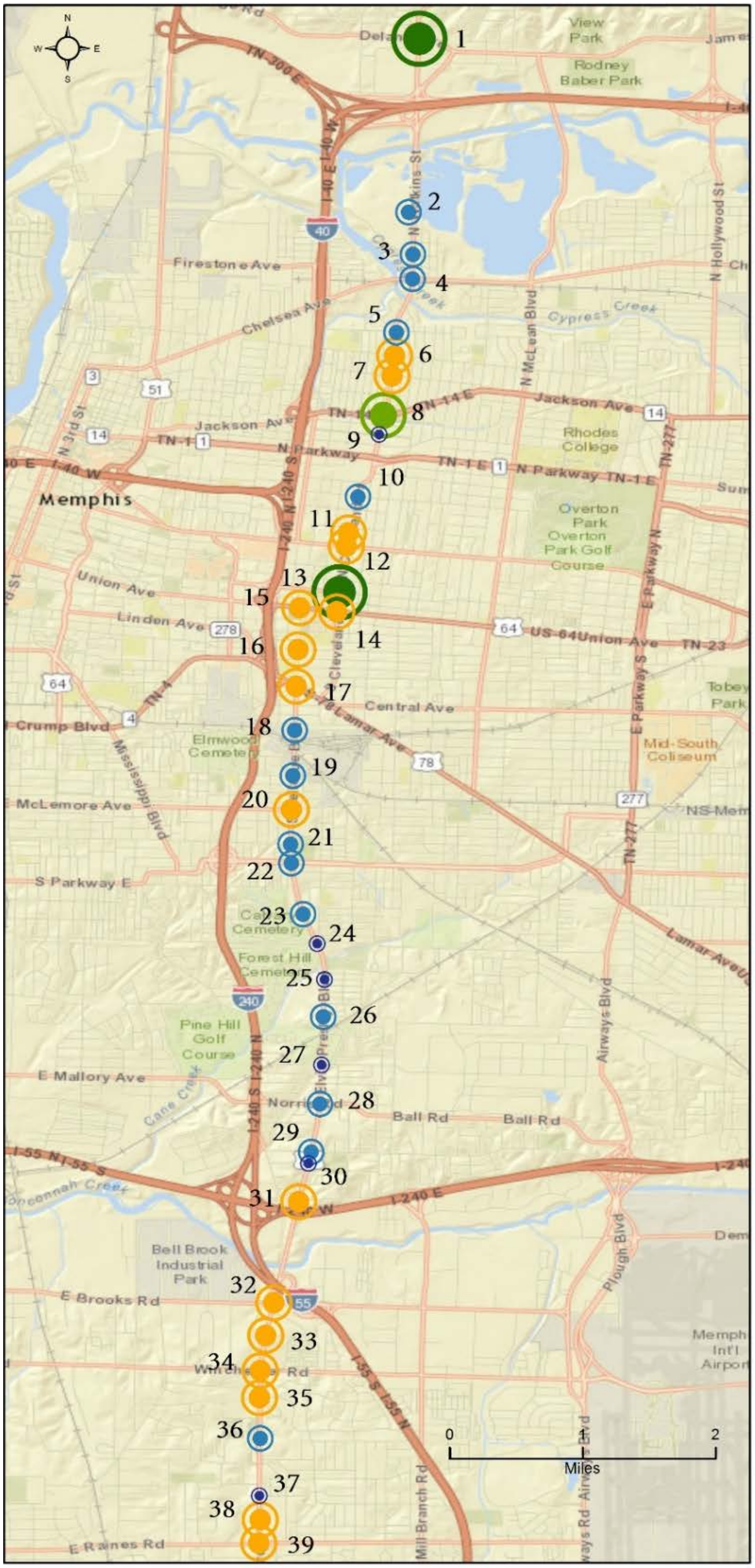


2035 Avarage Weekday Boardings

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 400
- 401 - 500

1 North Main St	9 Manassas St	17 S Rembert St	25 Chicksaw Oaks
2 Jackson Ave	10 Pauline St	18 Cooper St	26 Marne St
3 Market Ave	11 Bellevue Blvd	19 Edgewood	27 S Century St
4 Jefferson	12 Cleveland Blvd	20 Union Ave	28 Highland St
5 Madison Ave	13 McNeil St	21 Patricia Dr	29 S Highland St
6 Union Ave	14 S Avalon St	22 S Alicia Dr	30 Deloach St
7 4th St	15 Methodist Univ	23 Scott	31 Parking Lot
8 Lauderdale St	16 McLean Blvd	24 Tillmann St	

Figure A.6 Alignment 23 Ridership by Stop



2035 Avarage Weekday Boardings

- 0 - 10
- 11 - 50
- 51 - 200
- 201 - 300
- 301 - 500

1 Delano Ave
2 1515 N Watkins St
3 Levee Road
4 Chelsea Ave
5 Brown Ave (Saints Court Apt)
6 Vollintine Ave
7 Henry Ave
8 Jackson Ave
9 Tutwiler Ave
10 North Pkwy
11 Overton Park Ave
12 Poplar Ave
13 Madison Ave
14 Union Ave
15 Methodist University Hospital
16 Peabody Ave
17 Lamar Ave
18 Heistan Pl
19 Walker
20 McLemore Ave
21 E Trigg Ave
22 South Parkway
23 S Montgomery St
24 E Person Ave
25 Kimball Ave
26 Dunn Ave
27 Elliston Rd
28 Norris Rd
29 Alcy Rd
30 Carlton Rd
31 Clementine Rd
32 Brooks Rd
33 Gateway Dr
34 Winchester Rd
35 Bluebird Rd
36 Graceland (3734 Elvis Presley Blvd)
37 Laudeen Dr
38 Family Dollar (4045 Elvis Presley Blvd)
39 E Raines Road

Figure A.7 Alignment 26 Ridership by Stop