APPENDIX G
DRAFT 2040 REGIONAL TRANSPORTATION PLAN
NETWORK MODELING SUPPORT
Draft 2014 Regional Transportation Plan
Network Modeling Support

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This document was prepared as a cooperative effort of the U.S. Department of Transportation, the Federal Highway Administration-Alabama Division, the Federal Transit Administration, the Alabama Department of Transportation, the Environmental Protection Agency, and the local governments in partial fulfillment of requirements of Title 23 USC 134 and 135, amended in MAP-21 Sections 1201 and 1202, July 2012. The Contents of this report do not necessarily reflect the official views or policy of the U.S. Department of Transportation.
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1.0 TRAFFIC ANALYSIS ZONE DEVELOPMENT AND DATASETS

1.1 SOCIOECONOMIC DATA COLLECTION AND ANALYSIS METHODOLOGY

Based on US 2010 Census Data, the Birmingham metropolitan planning urbanized area is expended into Blount County and St. Clair County. The Birmingham Metropolitan Planning Area now includes portions of Blount and St. Clair Counties next to Jefferson and Shelby Counties. The Traffic Analysis Zone (TAZ) for the Birmingham MPA is redeveloped based on the US 2010 Census data as part of the US Census Participant Statistical Areas Program (PSAP) and coordinated through the American Association of State Highway and Transportation Officials (AASHTO). The development utilized specified criteria defined by the Program related to permitted boundaries and population/employment densities. The geography of the TAZ’s was delineated with MAF/TIGER Partnership software provided by the Program. The TAZ geography was developed to “nest” within 2010 Census block group geography.

The RPC develops several estimated and projected data variables. However, not all variables are reported due to the relevance of the data. Since the ultimate purpose of the data is for use as inputs into the regional traffic assignment model, only seven variables exist for use in the model. These primary variables include the following:

- Total households
- Occupied households
- Total employment
- Retail employment
- Median household income
- School enrollment
- University enrollment

In the course of developing these variables other variables are projected as well though they are not always included in the published projections report, nor are they included in the datasets for modeling. These variables are necessary, however, in the course of the projections methodology in order to accurately calculate the reported variables. These variables are reported at the county level, though not sub-county, and they are as follows:

- Total population
- Group quarters (institutionalized) population
- Housing occupancy rates
- Housing vacancy rates
- Household size

1.2 BASE COUNTS

The base year dataset for the 2040 Projections is 2010 and utilizes the 2010 Census block data (PL 94-171) for the population and housing totals. For the intermediate year estimates, the RPC typically utilizes a residual component methodology for estimation. This basic process uses known population and housing data provided by the Census and other sources, and makes adjustments based on changes in housing stock and land use. At the county level, total population and household estimates are based on reports produced by the Census Bureau, and in some cases, by state demographers or secondary data vendors. At the sub-county level, change is estimated based on sources including local estimates, trends in issued housing permits, market trends, land use changes, and trends in demographic counts derived from US Census counts.
The base year dataset for the year 2010 was developed in the geographic information system (GIS) by overlaying the 2010 TAZ geography over the 2010 Census block layer. Using a spatial join analysis, the necessary data variables were then extracted from the block data into the zonal layer. Once the block statistics were, in effect, converted into zonal statistics, the resulting zonal attribute table was exported from the GIS into a database for continued analysis. The base year employment data was determined in a similar manner utilizing specific business data produced for local area employment geographies. This data, published through the U.S. Census Longitudinal Employer-Household Dynamics (LEHD) program, is developed utilizing a variety of state and federal sources.

1.3 PROJECTED COUNTS

Future year counts are modeled using a detailed method of trend extrapolation and a comprehensive review process incorporating GIS. Historical growth patterns, known residential and commercial developments, land use trends, projected market trends, and probable areas of residential and commercial growth are the primary components used to model future year patterns. Source data specific to these components is collected and analyzed in the GIS system in order to determine trend, density, build out, and changes in land use. Where county and sub-county forecasts are available through primary and secondary data sources, comparisons are made to ensure that the accuracy and relative continuity of the data is consistent.

1.4 POPULATION AND HOUSING

For 2010, county population and housing estimates were based on Woods & Doole and Claritas Demographics, Inc. estimates at census block level. The block data was aggregated to county totals and compared with census produced county estimates and housing permit data collected at the street address level. Totals between these sources were weighed for accuracy against the housing permit data, and likely county “target totals” were identified. Sub-county level estimates are based on local estimates using the collected housing permit data by geocoding each address in the GIS with the Census TIGER-Line street files, then overlaying the resulting point coverage with the planning district, census tract, and TAZ geographic layers and calculating the totals for each geographic unit. The resulting total gives an estimated total housing unit count.

The 2040 projection focuses on housing. Comparisons between primary and secondary data suppliers of county projections were used to access probable target totals. Secondary variables, such as household size, and vacancy and occupancy rates, were projected using trend extrapolation at sub-county geographies and applied to the projected housing totals to obtain totals for occupied households and non-group quarter’s population. Increased housing unit removal, in areas where the trend extrapolation method reflected slow demolition rates, was calculated by first comparing municipal demolition trends with the age of the housing stock, and a formula applied to units over sixty years old where median household income was particularly low.

1.5 SCHOOL AND UNIVERSITY ENROLLMENT

Enrollment totals indicate primary areas of continued vehicle trip generation in transportation modeling. School enrollment totals are collected directly from the area school systems, as was the enrollment totals for the local universities. The data was first collected into a spreadsheet, then geocoded in the GIS system using the TIGER-Line files. The resulting point coverage was then overlaid with the TAZ layer, joined with TAZ attribute table in order to ensure accurate zonal coding, then exported and joined with the population and housing data. In addition to both public and private schools and universities, large preschools and adult education centers were included in the dataset for trip generation purposes within the regional traffic assignment model.

The projected number of school and university enrollment totals was computed by applying a traditional cohort-component analysis based on county population trends published by secondary sources and Reviewed by RPC. The resulting data reflects an increase in the senior population and a relatively constant percentage of school age population. The percentages were compared with other data sources for projected school age population for verification. University enrollment projections were tallied from university sources. School and university data was geocoded in the GIS to assign appropriate TAZ numbers then exported into the dataset. Future school locations were determined based on known developments and probable future locations identified by county officials.
1.6 MEDIAN HOUSEHOLD INCOME

Income estimates and projections reflect the census money income definition, and are produced for both current dollar values and future year values. The current estimates are collected from purchased data sources that use estimates based on a combination of:

- Change in consumer financial information from an external Consumer Marketing Database,
- Change in income summarized from an external consumer household database, and
- Estimates and projections of trends occurring between decennial census years.

All data is reported by census tract. Therefore, each zone within a tract is assigned the median income total for that tract.

Median household income projections were calculated by applying the rate of increase from other projected income categories reported in primary data sources for counties, and applying that percentage change to median household income by census tract. The data is reported in both constant dollars and projected dollars, which reflect expected changes due to inflation and cost of living. The tract level projections are then applied to each zone within individual census tracts.

1.7 EMPLOYMENT DATA

The 2010 employment data is developed by the US Census Longitudinal Employment Household Dynamics program. Employment statistics are updated continuously by the RPC and maintained in an Employment File Database, which contains information, including employment totals and industry type, on over 32,000 businesses within Jefferson and Shelby counties. The information is collected and maintained in order to track business trends and place-of-work employment statistics for transportation planning. This data is easily manipulated within a spreadsheet and is reported at all geographic levels used by the regional traffic assignment model.

Total and retail employment projections were calculated using the trend extrapolation method and applying data pertaining to known and probable commercial developments. Much of the developments information was reported in square feet or acres, and was converted to employment totals through a standard formula of employment densities as published in the Trip Generation Studies Report by the Institute of Transportation Engineers. The county totals were compared to historical ratios of population and housing in order to verify the accuracy and consistency of employment change.
2.0 TRAVEL DEMAND MODEL

2.1 HIGHWAY NETWORK DEVELOPMENT

**Base Year** = Roadways existed in 2010 and functional classified from Minor collector to Interstate highways consist of the base year network with all the social economic datasets in 2010. The base year is used for the calibrations and validations of modeling of 2040 RTP. The base year network is as an initial highway network to be coded for all other intermediate years.  

**E+C** = Existing + Committed, a network that includes projects opened to traffic and construction phase of projects fully committed to funding in the current TIP FY2012-2015.  

**Improved** = Model year networks coded with all system improvements planned in 2040 RTP.  

**No Build** = E+C Model year networks with appropriate socio-economic data in 2040 but without highway improvements.

The modeling networks are developed to include the existing functional classified roadways and/or future new roadways from minor Collectors to Interstate highways in the Birmingham MPA based on US 2010 Census. The network is formatted for use with the Voyager under Citilab CUBE modeling, a four-step travel forecasting model. The Voyager model is used as analysis screen tools in the 2040 RTP.

The most recent modeling work was performed for the 2035 Birmingham Area Long Range Plan, this effort benefited by the work done for the Strategic Regional Multimodal Mobility Plan in 1998. This same modeling stream was updated in November of 2000 to include the addition of a capacity project on I-59, the resulting modeling output was the basis of the amended 2020 Long Range Plan Update adopted by the Birmingham MPO in February 2001 and continued with the plan updates for the 2025 LRTP in June 2002, 2030 LRTP in January 2006, and 2035 Regional Transportation Plan (RTP) in June 2010 with a build in Transit network. The adopted plan 2025 LRTP, 2030 LRTP, and 2035 RTP were reviewed by the United States Environmental Protection Agency (Region 4) and satisfied the requirements of 40 CFR Section 93.119.

The 2040 Birmingham Area Long Range Plan update was built upon the foundation of the existing modeling efforts. This modeling effort required additional efforts to bring the network connections up to date with the 2010 census Traffic Analysis Zones. The network data files were reviewed for accuracy and additional projects recommended by project sponsors where added to the future year scenarios. The whole model network includes Jefferson and Shelby Counties and portions of Blount and St. Clair Counties while keeping the same Transit network for Jefferson and Shelby Counties.

To be consistent with the regional air quality conformity requirements, the modeling networks are constructed for the years of 2010, 2014, 2024, 2030, and 2040. The model years are determined through negotiation with the conformity partners during their monthly conference call meetings. The model year results are the basis of analysis demonstrating that the implementation of the currently amended Transportation Improvement Program (TIP) and the draft 2040 RTP developed in compliance with Title 23 and Title 49 of United States Code meet the conformity requirements set forth in the Clean Air Act (CAA). The following Figure 1 illustrates the 2040 RTP projects in 2040. The project details are listed in the Appendix-A Capacity Project List of 2040 RTP.
Figure 1. Capacity Project Locations in the 2040 RTP

Source: RPCGB, 2014
The network link attributes include all roadway characteristic. For example, the following Table 1 lists FACTYPE, LANES, and DIVIDED, etc.

**Table 1. Network Attributes**

<table>
<thead>
<tr>
<th>FACTYPE</th>
<th>Facility Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Interstate/Freeway</td>
</tr>
<tr>
<td>2</td>
<td>Expressway</td>
</tr>
<tr>
<td>3</td>
<td>Principal Arterial</td>
</tr>
<tr>
<td>4</td>
<td>Minor Arterial</td>
</tr>
<tr>
<td>5</td>
<td>Collector/Local Road</td>
</tr>
<tr>
<td>6</td>
<td>One-Way Principal Arterial</td>
</tr>
<tr>
<td>7</td>
<td>One-Way Collector Arterial</td>
</tr>
<tr>
<td>8</td>
<td>One-Way Collector/Local Road</td>
</tr>
<tr>
<td>9</td>
<td>Ramp</td>
</tr>
<tr>
<td>97</td>
<td>Transit Transfer Link (manually assist automated support link generation)</td>
</tr>
<tr>
<td>98</td>
<td>Transit Only Link (Rail line, Exclusive Bus Lanes, etc.)</td>
</tr>
<tr>
<td>99</td>
<td>Centroid Connector</td>
</tr>
</tbody>
</table>

**LANES**

Number of through lanes in the A-B link direction

**DIVIDED**

Divided highway designator

0 = Undivided highway

1 = Divided highway
The following figures illustrate the lane configurations of base year network link in 2010, the E+C (No Build) in 2040, and 2040 with Plan respectively.

*Figure 2. Base Year Roadway Network*
Figure 3. 2040 Roadway Network with Plan

Source: RPCGB, 2014
2.2 MODEL SETUP

The four-step model includes the following components:

- Trip generation
- Trip distribution
- Mode choice
- Traffic assignment

As a screen tool for 2040RTP and the requirement of air quality conformity determination, the time-of-day model, volume-delay function consisted with travel time, and commercial truck assignments are fully incorporated in the model setup. The time of day includes four time periods. They are AM from 6 AM to 9 AM, MD from 9 AM to 3 PM, PM from 3 PM to 6 PM, and NT from 6 PM to 6 AM. The hourly traffic assignments for 24 hour-periods are obtained through those four time periods of day. The travel speed profile for each hour of an average weekday in the roadways is populated.

2.3 VMT BASED ON HPMS REPORTS AND OBSERVED TRAFFIC COUNTS

The forecasting of future roadway growths and deficiencies are processed through comparisons of the base year conditions, E+C (No Build) scenario, and horizon year of plan in 2040. The exercise produced volume-to-capacity ratios (VOC) for the levels of congestion of each scenario. For simplified purpose, the level of service (LOS) concept is used to measure the level of congestions through VOC.

The VMT in base year 2010 is about 30.5 million vehicle miles per day based on the modeling projections.

Based on Voyager modeling, vehicle miles traveled continues to grow, from 30.5 million plus miles in the base year to over 45.3 million miles in 2040, an increase of 67.6% over 30 years or 1.3% per year for the existing and committed highways, a no build scenario with the congested 2.31 million VMT at LOS F. With the 2040 regional transportation plan, the VMT in 2040 would be 45.8 million miles with the congested 1.64 million VMT for LOS F. Although there is a 1.1% VMT increases with the 2040 RTP, the congested VMTs could be reduced 29%.

Table 2 presents the relationship of VOC and LOS for the plan comparisons and indicates the VMT by LOS for each scenario. Table 3 indicates the percentages of those VMT. Figures 4 and 5 illustrate changes and percentages in bar charts respectively.

Table 2. VMT based on LOS by Volume/Capacity Ratio (VOC)

<table>
<thead>
<tr>
<th>LOS</th>
<th>LOS A &amp; B</th>
<th>LOS C</th>
<th>LOS D</th>
<th>LOS E</th>
<th>LOS F</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume/Capacity Ratio</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;=0.5</td>
<td>14,339,180</td>
<td>10,675,416</td>
<td>3,761,302</td>
<td>964,384</td>
<td>833,512</td>
<td>30,573,794</td>
</tr>
<tr>
<td>0.50 - 0.75</td>
<td>11,033,894</td>
<td>15,716,385</td>
<td>11,156,446</td>
<td>5,045,180</td>
<td>2,305,200</td>
<td>45,257,105</td>
</tr>
<tr>
<td>0.75 - 0.90</td>
<td>12,335,367</td>
<td>17,636,496</td>
<td>10,424,229</td>
<td>3,767,793</td>
<td>1,641,820</td>
<td>45,805,705</td>
</tr>
<tr>
<td>0.90 - 1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt; 1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base year 2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040 No Build</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040 with plan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Percentages of VMT based on LOS by Volume Capacity Ratio (VOC)

<table>
<thead>
<tr>
<th>LOS</th>
<th>LOS A &amp; B</th>
<th>LOS C</th>
<th>LOS D</th>
<th>LOS E</th>
<th>LOS F</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume/Capacity Ratio</td>
<td>&lt;=0.5</td>
<td>0.50 - 0.75</td>
<td>0.75 - 0.90</td>
<td>0.90 - 1.00</td>
<td>&gt;1.0</td>
<td></td>
</tr>
<tr>
<td>Base Year 2010</td>
<td>46.9%</td>
<td>34.9%</td>
<td>12.3%</td>
<td>3.2%</td>
<td>2.7%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2040 No Build</td>
<td>24.4%</td>
<td>34.7%</td>
<td>24.7%</td>
<td>11.1%</td>
<td>5.1%</td>
<td>100.0%</td>
</tr>
<tr>
<td>2040 with plan</td>
<td>26.9%</td>
<td>38.5%</td>
<td>22.8%</td>
<td>8.2%</td>
<td>3.6%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Figure 4. Projected Total VMT by base year 2010, 2040 No Build, and 2040 With Plan

Figure 5. Percentage of VMT at LOS F (VOC >= 1.0)
The following figures illustrate the roadway LOS and deficiencies based on VOC.

*Figure 6. LOS based on VOC for Base Year 2010*

Source: RPCGB, 2014
Figure 7. LOS based on VOC for E+C in 2040 (2040 No Build)
Figure 8. LOS based on VOC for 2040 Plan
2.4 VALIDATION PARAMETERS

To ensure the accuracy of the travel demand model, the highway assignments were validated using several widely used measures. The primary highway assignment validation measures are Vehicle Miles Traveled comparisons based on modeled volumes and observed traffic counts using Root Mean Squared Error (RMSE) by facility type and volume groups.

Target VMT values by County were estimated from HPMS reports and MPO observed Traffic counts. The VMT in base year 2010 is 28,481,172 vehicle miles per day based on the Federal Highway Performance Monitoring System (HPMS) report for Jefferson and Shelby counties. The VMT includes Interstates/Arterials and the estimated VMT of collectors/local roads. The VMT for lower functional classification roadways, i.e., collectors/ramps are based on MPO’s observed traffic counts. The base year Voyager modeling assigns 28,476,555 for the same functional classifications of highways. Table 4 summarizes general VMT comparisons for the HPMS and the base year model validation in 2010.

Table 4. Vehicle Miles Traveled Comparisons

<table>
<thead>
<tr>
<th>Road Type</th>
<th>2010 Weekday VMT based on HPMS</th>
<th>2010 Weekday VMT based on Modeling</th>
<th>VMT Adjustment Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jefferson County</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freeway - rural restricted</td>
<td>311,771</td>
<td>364,227</td>
<td>0.856</td>
</tr>
<tr>
<td>Arterial - rural unrestricted</td>
<td>251,797</td>
<td>230,041</td>
<td>1.095</td>
</tr>
<tr>
<td>Collector/local road - rural unrestricted</td>
<td>647,131</td>
<td>557,447</td>
<td>1.161</td>
</tr>
<tr>
<td>Ramp - rural restricted</td>
<td>3,727</td>
<td>3,206</td>
<td>1.163</td>
</tr>
<tr>
<td>Freeway/Expressway - urban restricted</td>
<td>9,825,621</td>
<td>10,405,555</td>
<td>0.944</td>
</tr>
<tr>
<td>Arterial - urban unrestricted</td>
<td>7,291,838</td>
<td>6,868,620</td>
<td>1.062</td>
</tr>
<tr>
<td>Collector/local road - urban unrestricted</td>
<td>3,574,291</td>
<td>3,587,488</td>
<td>0.996</td>
</tr>
<tr>
<td>Ramp - urban restricted</td>
<td>717,868</td>
<td>758,174</td>
<td>0.947</td>
</tr>
<tr>
<td>Sub-total for Jefferson County</td>
<td>22,624,045</td>
<td>22,774,758</td>
<td>99.3%</td>
</tr>
<tr>
<td>Shelby County</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freeway - rural restricted</td>
<td>0</td>
<td>0</td>
<td>1.000</td>
</tr>
<tr>
<td>Arterial - rural unrestricted</td>
<td>687,490</td>
<td>767709</td>
<td>0.896</td>
</tr>
<tr>
<td>Collector/local road - rural unrestricted</td>
<td>429,353</td>
<td>352568</td>
<td>1.218</td>
</tr>
<tr>
<td>Ramp - rural restricted</td>
<td>0</td>
<td>0</td>
<td>1.000</td>
</tr>
<tr>
<td>Freeway/Expressway - urban restricted</td>
<td>1,571,399</td>
<td>1714605</td>
<td>0.916</td>
</tr>
<tr>
<td>Arterial - urban unrestricted</td>
<td>2,081,389</td>
<td>1918863</td>
<td>1.085</td>
</tr>
<tr>
<td>Collector/local road - urban unrestricted</td>
<td>1,035,367</td>
<td>899551</td>
<td>1.151</td>
</tr>
<tr>
<td>Ramp - urban restricted</td>
<td>52,128</td>
<td>48501</td>
<td>1.075</td>
</tr>
<tr>
<td>Sub-total for Shelby County</td>
<td>5,857,127</td>
<td>5,701,797</td>
<td>102.7%</td>
</tr>
<tr>
<td>TOTAL for both Counties</td>
<td>28,481,172</td>
<td>28,476,555</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
The Root Mean Squared Error (RMSE) is commonly used to measure the overall accuracy of modeled volumes relative to counts. RMSE is used because it provides the ability to measure the overall percent difference, when differences may be positive or negative. It is generally not appropriate to use a simple percent difference measure when dealing with positive and negative differences since the overall error is masked due to cancelling effect of the positive and negative values. Table 5 shows a comparison of percent RMSE by facility type and volume group for the project model.

The results of the comparisons of VMT and RMSE indicated that the model is operating at an acceptable level for this plan update.

\textit{Table 5. Percent Root Mean Square Error (\%RMSE)}

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|}
\hline
\textbf{FACILITY TYPES} & \% RMSE & \textbf{TARGET} \\
\hline
%RMSE & & \\
\hline
Model & Target & \\
\hline
All Facility Types & 36.20\% & <38\% \\
Freeways & Expressways & 21.40\% & <25\% \\
Principal Arterials & 25.80\% & <50\% \\
Minor Arterials & 51.50\% & <75\% \\
Collectors & 75.40\% & <100\% \\
\hline
\end{tabular}
\end{table}

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|}
\hline
\textbf{VOLUME GROUP} & \% RMSE & \\
\hline
%RMSE & \textbf{TARGET} & \\
\hline
Model & & \\
Target & & \\
\hline
All Volume Groups & 36.20\% & <38\% \\
0 - 1000 & 280.80\% & <300\% \\
1001 - 2500 & 106.70\% & <200\% \\
2501 - 5000 & 54.60\% & <100\% \\
5001 - 10000 & 43.10\% & <50\% \\
>10000 & 24.30\% & <30\% \\
\hline
\end{tabular}
\end{table}