Appendix C
Model Development and Documentation

A key component of the ESMPO 2045 LRTP Update was to refine the previous 2010 base year model used during the MPO's inaugural 2040 LRTP. For the 2045 Update, the model is updated to a new base year of 2015 and model forecasts are extrapolated to the new horizon year of 2045. The earlier 2010/2040 model could be described as a simplified vehicle trip model while the vast majority of MPO models generate person trips, rather than vehicle trips. Since there has never been a household travel survey conducted in Baldwin County, the updated 2015/2045 model has to make use of nationally recognized transferable model parameters (e.g., person trip rates) and benchmarks (e.g., average trip lengths), in combination with established ALDOT standard area types, facility types and capacities.

This appendix is divided into the following sections:

- Data refinement
- Model development
- Model validation
- Model forecasting

Cube/Voyager software is the modeling platform used for all MPO models in the state of Alabama.

1.1. Data Refinement

In the wisest use of study resources, available 2010 model files were used as a starting point to develop similar files for the updated 2015 base year. Thus, the 2010/2040 traffic analysis zone (TAZ) system was maintained for the base year 2015 and horizon year 2045 and the 2015 model network was built directly from the previous 2010 network. While sections 2.1 and 2.2 of this report describe and depict 2015 socioeconomic and network conditions, respectively, this section provides additional background on how these estimates were achieved.

1.1.1. Year 2015 Population, Household, and Employment Estimates By TAZ

A control total for the ESMPO region was developed by using the Alabama Center for Business and Economic Research (CBER) 2015 population estimates for the cities and towns in Baldwin County and the county total population. The share of unincorporated county population that is within the MPO boundary was assumed to remain constant between 2010 and 2015. This produces a population control total for the MPO of 110,006 for 2015. The household (HH) control total is based on this figure divided by 2.52 persons per household (the 2010 value), producing a 2015 control total of 43,589 households in the MPO area.

Year 2015 population for each TAZ is estimated by interpolating between the 2010 TAZ population and the 2040 forecast TAZ population. This method produces a total population slightly lower than the control total. The initial estimate is factored to match the control total more closely. Based on this population growth estimate, each TAZ is characterized as having No/Low/Medium/High five-year growth. No growth is 0.0% or lower, Low is 0.5% or less, Medium is 0.5 to 2.0%, and High is above 2%.

These categories divide the TAZs into relatively even numbers of No/Low/Medium/High growth. The population growth in each TAZ for the 2010 to 2015 period is then converted to HHs by dividing the incremental population growth by 2.52 and adding that to the actual 2010 households for each TAZ.

Retail employment and non-retail employment for 2015 is estimated using a method similar to population. A 2015 value is interpolated from the 2010 and 2040 values for each TAZ. A reasonableness check is applied by calculating the ratio of employees to population for each year in the forecast, as well as a rate for the incremental change in population and employment from 2010 to 2015. In 2010, the ESMPO region had 13.4 retail employees per 100 population and 28.5 non-retail employees per 100 residents. The 2015 estimates increase these ratios to 13.6 and 28.8, respectively. Comparing change in population with change in employment for the 2010 to 2015 period, the ratio of employees to residents rises to 15.6 new retail employees per new resident and 31.4 non-retail employees per new resident. These ratios are consistent with typical trends in rapidly growing, affluent suburbs of metropolitan areas.

1.1.2. Year 2015 Highway Network Characteristics

A number of steps were taken to update the 2010 network to represent base year 2015 conditions. The first of these was to disaggregate the LINKGROUP1 codes from the 2010 model into separate attributes representing network facility type, number of lanes, and a flag to distinguish divided highways from undivided streets. This change was important to properly incorporate ALDOT's standard capacity lookup table, update characteristics to 2015 conditions, estimate roadway level-of-service (LOS) and map out network characteristics more efficiently. Table C.1 below is an equivalency between 2010 LINKGROUP1 codes and 2015 facility type/lane/divided categories.

Table C.1 ESMPO Model Network LINKGROUP1 Definitions

#	LINKGROUP1	Functional Classification	Facility Type	Divided	Number of Lanes
1	11	Freeway	1	1	4
2	32	Divided Principal Arterial	3	1	4
3	35	Undivided Principal Arterial	3	0	2
4	36	Undivided Principal Arterial	3	0	4
5	42	Divided Minor Arterial	4	1	4
6	45	Undivided Minor Arterial	4	0	2
7	46	Undivided Minor Arterial	4	0	4
8	54	Undivided Collector	5	0	2
9	61	One-Way Principal Arterial	6	0	2
10	91	Ramp	9	0	1
11	99	Centroid Connector	99	0	0

In addition to the 2010 network lacking unique attributes for facility type, lanes, and divided highways, this network did not include area types. Area types reflect generalized land uses adjacent to the roadways and are used in the model to assign capacities and terminal times. A generic area type code

was first assigned to all links in the model network using Cube attribute calculations. Then, specific area type codes were assigned to each link in the model network through the use of Cube polygons, Google Maps' satellite view, urban and MPO boundary maps, and a sample of field checks and notations.

Each TAZ was subsequently assigned a dominant area type code for the purposes of estimating terminal times, a measure of walk time between origin or destination and the vehicle used for travel. Terminal times tend to be longest in central business districts (i.e., CBD or downtown areas), moderate in outlying business districts (i.e., suburban commercial areas/activity centers), and lowest in residential and rural areas. In order to keep the number of capacity categories to a minimum, the model collapses the area type codes into area type groups. Table C.2 is a listing of area type codes and groups used in the ESMPO 2015/2045 models.

Table C.2 ESMPO Model Network Area Type Definitions

Area Type Code	Area Type Code Definition	Additional Guidance Used for ESMPO Area Type Assignment	Area Type Group	Area Type Group Definition
1	CBD Major	No Major CBD in study area	1	Urban
2	CBD Minor	Downtown Fairhope	1	Urban
3	CBD Fringe	Areas adjacent to Fairhope CBD	1	Urban
4	Urban Stable	Established residential areas	2	Suburban
5	Urban Activity Center	Suburban business districts	2	Suburban
6	Urban Growth	Recent/ongoing suburban residential	2	Suburban
7	Urban Transitioning	Growth next to/outside urban boundary	2	Suburban
8	Rural Developed	Small cities outside transitioning area	3	Fringe
9	Rural Undeveloped	Undeveloped areas/outside MPO area	4	Rural

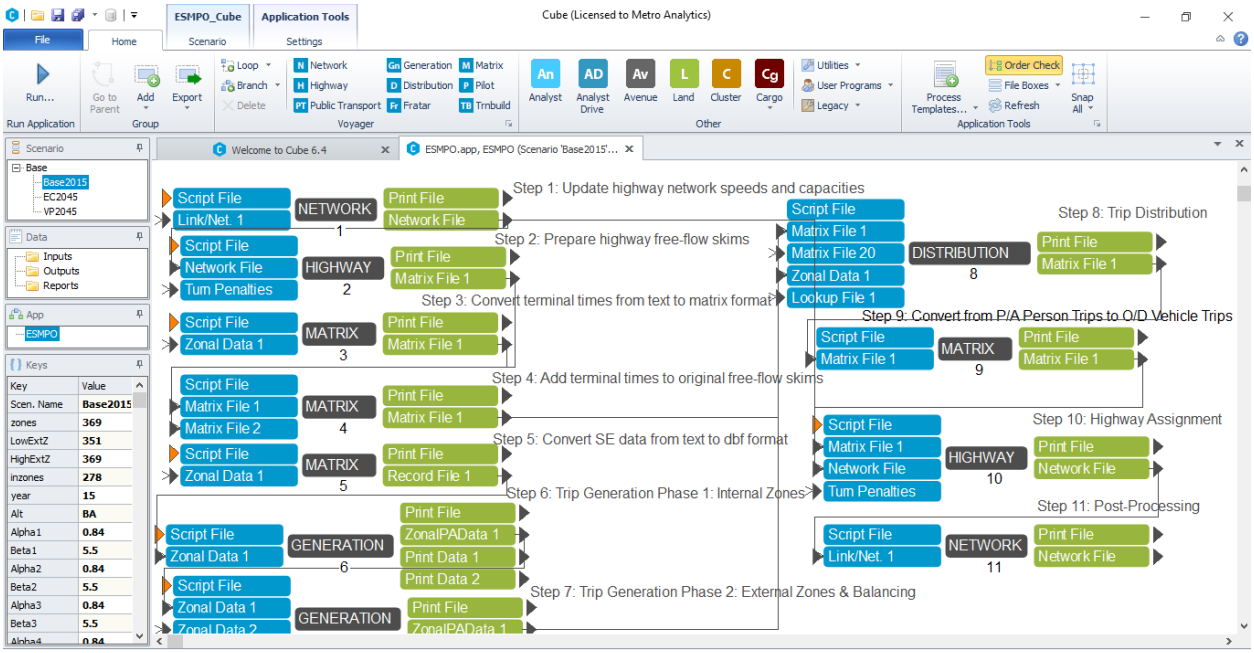
A comprehensive set of base year traffic counts is also needed to validate any travel demand forecasting model. In the case of ESMPO, year 2015 traffic counts were obtained from the Alabama Traffic Data website maintained by ALDOT and manually added to relevant links in the highway network. There are some low volume ALDOT traffic counts that appear to be estimates as the same number appears on multiple links in the network. It is very difficult to validate highway assignment volumes to low volume traffic counts so a few of these estimates were later removed from the model network. Some of these hard to validate counts also pinpoint locations where TAZs should be split for the next model update.

Screenlines are typically included in a model network to summarize traffic counts and volumes along parallel roadways that cross natural and manmade features of significance. Since these were not identified in the 2010 network, new screenlines were identified and added to the 2015 network. Locations with traffic counts on parallel roadways were identified as potential screenlines, including all roadways crossing the Fish River and I-10. A cordon line (a circular screenline) was added to cover every roadway location along the model boundary to ensure that the model properly simulated external trips – those beginning and/or ending outside the model study area. A table is provided later in the Appendix to summarize screenline locations, model volumes, and traffic counts.

A final check on the model network was to review all zone centroids and centroid connectors. Centroids represent the center of trip activity within a TAZ while centroid connectors represent locations where trips are loaded to the highway network from each TAZ. A checklist was prepared and filled in for every TAZ to confirm centroid locations, centroid connectors, and area type codes. The checklist also includes notations on changes made, including moving centroid locations, adding/deleting centroid connectors, previous and revised area types, splitting roadway links to accommodate new connectors, etc.

1.2. Model Development

The 2015/2045 ESMPO model is categorized as a four-step travel demand model while the previous 2010/2040 model was a three-step model. A step was added to the new model that applies auto occupancy factors to previously generated and distributed person trips. Since the region has never been covered by a large sample household travel survey, the study team felt it was important to use person trip rates from a national source. The use of person trip rates, as opposed to the vehicle trip rates used in the previous model, necessitated the application of auto occupancy factors prior to trip assignment. As depicted below in Figure C.1, a set of 11 individual Cube/Voyager program steps are required to run the ESMPO model. Each of these steps is described in the following subsections.



1.2.1. Step 1: Update highway network speeds and capacities

As implied, this step in the model chain performs an update of highway network speeds and capacities. This step is necessary because speeds and capacities are assigned to network links based on the previously described area types and facility types. Thus, if either of these attributes is modified, this step will replace previously assigned speeds and capacities with those intended for the updated attributes. Free-flow speeds were iteratively adjusted during model validation to minimize the difference between traffic counts and modeled traffic assignment volumes. These values and adjustments are discussed further in the section on model validation. Capacities are consistent with official values provided by ALDOT.

1.2.2. Step 2: Prepare highway free-flow skims

This step is a process that builds a matrix of minimum travel times and paths between each TAZ, known as "skims". This includes the estimation of intrazonal times, an estimate of travel time to traverse each TAZ in the model network. Turn prohibitors are placed in the TURNPEN file to identify locations where intersection movements are not permitted (e.g., left turn restriction). The TURNPEN file can also include travel time penalties, ideally where physical barriers exist (e.g., river crossing) and assignment screenline volumes are excessive when compare to traffic counts. Turn penalties are described further during model validation. Zone-to-zone travel times are subsequently updated with terminal times during another step and used to distribute trips between pairs of TAZs.

1.2.3. Step 3: Convert terminal times from text to matrix format

As described earlier in this appendix, terminal times represent walk times from the point of origin to vehicular travel mode (e.g., auto) and from the vehicle to the final destination. An AREATYPE text file is used to assign terminal times to each TAZ in the model network. For this study, the consultant team first edited terminal times in Excel and then exported the contents to a text file format. Step 3 subsequently takes terminal times listed by zone and converts these values to a matrix of origin and destination terminal times for each pair of TAZs.

1.2.4. Step 4: Add terminal times to original free-flow skims

Step 4 simply adds the terminal times from Step 3 to the initial free-flow skims from Step 2 so that travel times between zones account for walk times to and from vehicles. The resulting updated skims are those used during Step 8, trip distribution.

1.2.5. Step 5: Convert SE data from text to dbf format

Socioeconomic data, described elsewhere in this report, were initially prepared in a spreadsheet, and exported to a text file format. During Step 5, this text file is converted to a .dbf format for input to Step 6, trip generation.

1.2.6. Step 6: Trip Generation Phase 1: Internal Zones

Trip generation is required in all four-step travel demand models to estimate the number of trips, generally produced by homes, and attracted to businesses and schools. This first phase of trip generation takes the modified socioeconomic data file from Step 5 and first runs a series of diagnostic checks to identify syntax/math errors that could lead to erroneous results (e.g., school enrollment in a zone with zero employment). After this demographic check, the model uses input data on zonal income to estimate the number of households in six income groups and four auto availability categories using guidance from *NCHRP 716, Travel Demand Forecasting: Parameters and Techniques*. Then the model calculates trip productions and trip attractions using trip rates from the same report. In addition to the summary of diagnostic checks, this model step generates an estimate of households by auto availability in each TAZ, along with a preliminary file containing zonal productions and attractions in a dbf format.

1.2.7. Step 7: Trip Generation Phase 2: External Zones & Balancing

The second trip generation phase largely focuses on external trips, those with at least one trip end outside the model study area. An input text file called EXTERNALCOUNTS is required for input, along with the socioeconomic data from Step 5 and internal productions and attractions from Step 6. As with

other text files, the external count file was generated by exporting data from a spreadsheet containing 2015 traffic counts at each external zone in the model, along with a code that provides a percent of through trips at each external zone. Instead of 2015 traffic counts, the 2045 EXTERNALCOUNTS file contains forecasted external volumes. As described later in this appendix, 2045 external forecasts were derived using available data on traffic count trends and population growth. This step outputs a final set of trip productions and attractions that are subsequently used as input to Step 8, trip distribution.

1.2.8. Step 8: Trip Distribution

In addition to trip generation, all four-step models include a trip distribution step that produces a production/attraction (P/A) matrix of person trips between each pair of internal and external zones. Inputs to this step include the updated set of travel time skims from Step 4, final set of trip productions and attractions from Step 7, a friction factor file and K-factor matrix. The FRICTIONFACTORS file provides a set of trip attenuation curves for each trip purpose in the model. The initial set of friction factors was derived from both the 2010 ESMPO and Huntsville MPO models, iteratively adjusted in a spreadsheet and then exported to a text file format. A Cube model script was used to generate a K-factor matrix aimed at encouraging the distribution of external trips between predominant external zones (e.g., I-10 west to I-10 east) and discouraging the distribution of external trips between illogical pairs of zones (e.g., trips between I-10 crossing Mobile Bay and US 90/98 crossing Mobile Bay… essentially a U-Turn movement). K-Factors were also adjusted iteratively during model validation to achieve the desired impacts.

1.2.9. Step 9: Convert from P/A Person Trips to O/D Vehicle Trips (Auto Occupancy)

Step 9 represents the auto occupancy phase of the ESMPO model. While some four-step models include a logit mode choice model to convert person trips to vehicle trips, an auto occupancy model is sufficient to use in regions where the percent share of transit trips is small. Auto occupancy factors, also derived from NCHRP 716, are applied to the person trip matrices from Step 8 to achieve a vehicle trip matrix. The resulting vehicle origin-destination (O/D) trip matrix is also “balanced” during this step such that the number of trips entering a zone is equal to the number of trips exiting a zone.

1.2.10. Step 10: Highway Assignment

Step 10, highway assignment, is also required of all travel demand models, both four-step and the most advanced activity-based models. During this step, the updated highway network from Step 1 is used, in conjunction with the vehicle O/D trip table from Step 9, and the TURNPEN file described earlier in Step 2 to load trips onto the highway network and generate congested travel time skims. During highway assignment, skims are iteratively adjusted based on volume/capacity ratios resulting from trip loadings. Using an equilibrium algorithm, travelers strive to find the shortest path from origin to destination, and network equilibrium occurs when no traveler can decrease travel effort by shifting to a new path. The output from this step is a loaded highway network with volumes, volume/capacity ratios, congested speeds, and other attributes.

1.2.11. Step 11: Post-Processing

This final step updates the loaded highway network to compute, summarize and add attributes such as volume/count ratio, root mean square error, vehicle-miles traveled, and vehicle-hours traveled. It

includes the majority of attributes in the original loaded network, though a few unimportant attributes are removed. This “post-processing” step also produces summary tables of the newly computed attributes to provide an assessment of model validity. This final loaded and updated highway network is titled HWYEVAL as it includes the additional evaluation statistics.

The next section describes some of these files in greater detail, how model validation was achieved, and compares model results to a series of benchmarks and accuracy standards.

1.3. Model Validation

Model validation is the process of taking a model from a recent base year, comparing model results against traffic counts and other available data on travel patterns, and iteratively refining the model to minimize error. Once a model is validated, it is then applied to forecasted socioeconomic data, network conditions, and other trend data to identify future potential transportation projects. A comprehensive worksheet was prepared to monitor progress during the validation process. Model validation is described for each component of the four-step modeling process, starting with trip generation, and ending with highway assignment, along with tables from the validation worksheet.

1.3.1. Trip Generation

Key trip generation parameter sources and assumptions used in the ESMPO model are listed below:

- Trip production rates – NCHRP 716 (Urban Area less than 500,000 population)
- Trip productions by purpose – NCHRP 716 (Initial trip production reasonableness check)
- Trip attraction rates – NCHRP 716 (Motorized Person Trips, Interpolation of Models 1 and 3)
- Truck trip attraction rates – NCHRP 716 (Sample Total Truck Trip Rates, Huntsville adjustments)
- Autos per household targets – NCHRP 716 (Mobile, AL MSA)
- External traffic counts – Alabama Traffic Data website (ALDOT)

The previous 2010 ESMPO model was missing some of the area's external zones. These same external zones were missing from initial 2015 model runs. As validation progressed, a clearer picture evolved on the location of these external zones and the roadways that feed them. Iterative adjustments were also made to external zones along the Bay Crossing to offset the impact of trips attracted to new zone 278. Table C.3 provides 2015 base year model external trip estimates based on ALDOT traffic counts, along with a comparison to the 2010 model. Final 2015 external trips are found in the column "2015Adj".

Table C.3 ESMPO 2015 External Trip Summary

Zones	Location	2010	2015	Rev 2015	2015 Adj	2015/Direction
351	CR 1, South of Alt US 98	944	*1,051*	**1,440**	**1,440**	720
352	CR 27/Mary-Ann Beach Road, South of Alt US 98	1,374	*1,529*	**1,430**	**1,430**	715
353	US 98, east of CR 9	7,907	9,490	**9,490**	**9,490**	4,745
354	Underwood Road, east of CR 9	2,881	*3,207*	**1,130**	**1,130**	565
355	CR 71/College Avenue, north of CR 32	656	*730*	**1,000**	**1,000**	500
356	*Disconnected External Zone - now CR 68*	-	-	**720**	**720**	360
357	AL 59, north of CR 32	23,167	27,010	**27,010**	**27,010**	13,505
358	CR 32, west of AL 59	7,721	*2,910*	**2,910**	**2,910**	1,455
359	*Disconnected External Zone - now Beach Express*	-	8,400	**8,400**	**8,400**	4,200
360	US 90, east of Baldwin Beach Express	4,522	4,850	**4,850**	**4,850**	2,425
361	I-10, east of Baldwin Beach Express	26,121	36,050	**36,050**	**36,050**	18,025
362	CR 64, east of Baldwin Beach Express	1,853	*2,062*	**2,300**	**2,300**	1,150
363	*Not displayed in network - now CR 36*	-	-	**660**	**660**	330
364	*Not displayed in network - now CR 38*	-	-	**850**	**850**	425
365	US 31, south of Holly Hills	15,770	15,810	**15,810**	**15,810**	7,905
366	CR 39 at Whitehouse Fork Road	958	*1,066*	**1,000**	**1,000**	500
367	SR 225, north of Whitehouse Fork Road	3,013	4,680	**4,680**	**4,680**	2,340
368	I-10, east of Baldwin/Mobile County Line	57,871	75,500	**75,500**	***70,500***	37,750
369	US 90/98, east of Baldwin/Mobile County Line	14,940	16,580	**16,580**	***9,500***	8,290
	Totals	169,698	210,925	211,810	199,730	105,905

Validation of trip generation included a series of iterative adjustments focused on achieving NCHRP trip allocation by purpose, matching benchmarks for aggregate trip rates (i.e., trips per household, person, and employee), and minimizing the difference between trip productions and unadjusted attractions by purpose. Since the ESMPO area is somewhat of a bedroom community to Mobile, it was important to attract some portion of work and shop trips to locations across Mobile Bay and beyond the model boundary. Thus, a new zone 278 was added to the model to attract a portion of these trips that otherwise, would be forced to remain with the model boundaries.

Table C.4 provides a summary of trip productions by purpose, compared to the previous ESMPO model and NCHRP 716 targets. The model does a good job of matching the NCHRP targets for person-trip purposes, as noted in the table. In addition to the three person-trip purposes in the table, the model also includes three vehicle-trip purposes for trucks and external trips.

Table C.4 ESMPO Trip Generation Purpose Summary

TRIP GENERATION - Trip Purpose Summary										
	2010 Model		2015 Model							
Trip Purpose	Trips	% Total Productions	Prior Run Trips	Prior Run % Prods	Prior Run % Person Trips	Trips (New Run)	% Total Productions	Including Truck Trips	% Person Trips	NCHRP 716 Targets
Home-Based Work (HBW)	53,630	13%	59,226	10%	14%	59,226	10%	14%	15%	15%
Home-Based Other (HBO)	129,211	31%	215,752	37%	51%	215,752	37%	51%	54%	54%
NonHome-Based (NHB)	60,955	15%	122,683	21%	29%	122,683	21%	29%	31%	31%
Truck Trips	37,547	9%	25,383	4%	6%	25,383	4%	6%		
Internal-External (I-E)	97,737	24%	119,277	20%		119,277	20%			
External-External (E-E)	35,973	9%	40,227	7%		40,227	7%			
Total	415,053	100%	582,548	100%	100%	582,548	100%	100%	100%	100%

Table C.5 provides a summary of aggregate trip rates and balancing of productions and attractions. As indicated, the ESMPO model falls within the NCHRP acceptable range of trips per person, household, and employee. Likewise, the ESMPO model meets established targets on the ratio of productions and attractions. Thus, it was felt that the ESMPO trip generation model was validated to acceptable levels.

Table C.5 ESMPO Trip Generation Purpose Summary

TRIP GENERATION - Aggregate Trip Rate Comparisons											
	Total HB+NHB Productions					Total Attractions			Actual Values		
Validation Measure	2010 Model	2015 Model Run	*Total Households 2010/2015	*Total Population 2010/2015	*Total Employees 2010/2015	2010 Model	2015 Model Run	NCHRP Target Range	2010 Model	2015 New Model Run	Prior 2015 Model Run
Person Trips Per Household	*243,796*	*397,661*	*38,976*					8.0 - 10.0	6.25	9.13	9.11
Person Trips Per Person	*243,796*	*397,661*	*43,575*	*98,220*				3.3 - 4.0	2.48	3.64	3.61
HBW Trips Per Employee	*53,630*	*59,226*		*109,236*	*41,095*			1.2 - 1.55	0.77	1.23	1.28
P/A Ratio (HBW)	*53,630*	*59,226*			*48,023*	*n/a*	*57,647*	0.9 - 1.1	n/a	1.03	1.03
P/A Ratio (HBO)	*n/a*	*215,752*				*n/a*	*218,894*	0.9 - 1.1	n/a	0.99	0.99
P/A Ratio (NHB)	*n/a*	*122,683*				*n/a*	*121,561*	0.9 - 1.1	n/a	1.01	1.01
Trips per TAZ (277)							*11,411*	<15k Trucks	880	1,436	1,436

1.3.2. Trip Distribution

Key trip distribution parameter sources and assumptions used in the ESMPO model are listed below:

- Highway network speeds – Huntsville MPO model validated speeds used as starting point
- Highway network capacities – ALDOT standard model network capacities (unchanged)
- Highway network prohibitors – SB US 98 to WB I-10 loop ramp and mid-bay zones to Mobile
- Highway network penalties – iteratively added and adjusted at mid-bay crossing
- Terminal times – 4 minutes for CBDs, 2 minutes for activity centers, and 1 minute elsewhere
- Friction factors – started with prior ESMPO FFs; mostly replaced with Huntsville; then adjusted
- K-Factors – set to 1 for most zones; set to zero for select external to external zone pairs

Validation of trip distribution included a series of iterative adjustments to network speeds, penalties, terminal times, friction factors and K-factors. Iterative adjustments were also made to socioeconomic estimates of employment and school enrollment in new zone 278 to achieve a proper balance of trips leaving Baldwin County for Mobile County.

Table C.6 provides a comparison of average trip lengths by trip purpose for the 2015 model vs. targets from NCHRP 716 and the 2012-2016 American Community Survey (ACS). Average trip lengths from the earlier 2010 model were unavailable for comparison. Average trip lengths from the model were lower than benchmark statistics from NCHRP and the ACS, the latter specific to Baldwin County. While these model estimates are lower than desired, much effort was expended during validation to increase these.

Table C.6 ESMPO Average Trip Length Summary

TRIP DISTRIBUTION: Avg Trip Lengths (Minutes)					
Purpose	2010 ESMPO Model	Prior 2015 ESMPO Model Run	New 2015 ESMPO Model Run	2012-2016 ACS	NCHRP 716 Target Trip Times
HBW	N/A	18.29	18.18	27.23	20-21
HBO	N/A	11.93	11.96		18
NHB	N/A	11.02	11.05		18-19
Truck	N/A	11.65	11.68		N/A
I-E	N/A	18.97	18.97		N/A
E-E	N/A	27.35	27.35		N/A
All	N/A	14.88	14.89		N/A

Another metric commonly used in model validation is the percentage of trips distributed within the same zone, known as intrazonal trips. General guidance is a target of roughly five percent of home-based trips being distributed internally, with higher percentages for nonhome-based and truck trips, due to more frequent stops. External zones, with their pass-through nature should not have any intrazonal activity. Table C.7 provides intrazonal percentages by trip purpose, excluding external purposes.

Table C.7 ESMPO Intrazonal Summary

TRIP DISTRIBUTION: Intrazonal Trips: Number & Percent						
Purpose	2010 ESMPO Model No. INTZ	2010 ESMPO Model Pct. INTZ	2015 ESMPO Prior Model Run No. INTZ	2015 ESMPO Prior Model Run Pct. INTZ	2015 ESMPO New Model Run No. INTZ	2015 ESMPO New Model Run Pct. INTZ
HBW	924	1.7%	488	0.8%	486	0.8%
HBO	21,964	17.0%	18,760	8.7%	18,657	8.6%
NHB	10,575	17.3%	16,800	13.7%	16,736	13.6%
Truck	2,477	6.6%	2,230	8.8%	2,224	8.8%
All	35,940	8.7%	38,278	6.6%	38,103	6.5%

1.3.3. Auto Occupancy

Auto occupancy factors by trip purpose were derived from NCHRP 716, applied to the three person-trip purposes, and all zone-to-zone movements balanced, resulting in a vehicle trip table for highway assignment. ALDOT purchased a statewide license for Streetlytics data, a product that uses a combination of model estimates and GPS data to estimate existing travel flows. A series of corrections were made to the EXTERNALCOUNTS file as validation progressed, along with Iterative adjustments to the K-Factors, to direct changes to the external-external (through) trip table, consistent with Streetlytics flows. Changes to the number of trips in trip generation also had an impact on this step. With each model run, it was confirmed that the desired ratios of person to vehicle trips remained intact. Table C.8 provides a summary of auto occupancy rates, person trips and resulting balanced vehicle trips.

Table C.8 ESMPO Auto Occupancy Summary

2015 MODE CHOICE/AUTO OCCUPANCY						
Trip Purpose	Person or Vehicle Trips Generated	Person Trips Generated	Prior Model Run Vehicle Trips	New Model Run Vehicle Trips	Person/ Vehicle Trip Ratio	NCHRP 716 Auto Occupancies
HBW	person trips	59,226	53,840	53,840	1.100	1.10
HBO	person trips	215,752	125,355	125,354	1.721	1.72
NHB	person trips	122,683	73,859	73,858	1.661	1.66
Truck	vehicle trips	25,383	25,382	25,382	1.000	n/a
I-E	vehicle trips	119,277	119,277	119,277	1.000	n/a
E-E	vehicle trips	40,227	40,227	40,227	1.000	n/a
All	combination	582,548	437,940	437,938	1.330	n/a

1.3.4. Highway Assignment

As the final step in the "four-step" model chain, the assignment model is influenced by all of the validation adjustments, corrections, and refinements described earlier under the other model steps. An assortment of calculations and comparisons between assignment volumes and counts are critical to an assessment of model validity. Assignment metrics used to validate the ESMPO model include these:

- 2015 Volume-over-Count by Facility Type
- 2015 Percent Root Mean Square Error (RMSE) by Facility Type
- 2015 Volume-over-Count by Number of Lanes
- 2015 Volume-over-Count by Screenline
- 2015 Vehicle-Miles Traveled (VMT)
- 2015 Vehicle-Hours Traveled (VHT)
- 2015 Volume-over-Count by Bay Crossing Location

Table C.9 presents volume/count and RMSE by facility type. For each facility type category, information is provided on FHWA recommended percent assignment error targets; volume/count ratios for the current model run, previous model run, and the older 2010 model run; and percent RMSE. For the year 2015 model, volumes, counts, and the number of links with counts in each facility type category are also provided. The green numbering under "FHWA Percent Error Target" means that the 2015 model meets all facility type targets for this measure. For the "FHWA Percent RMSE Target" all facility types meet these standards except for collector streets, which achieve an RMSE of 80.9 percent vs. the target of 77.48 percent (depicted in red numbers).

Table C.9 ESMPO Volume-over-Count Ratios and RMSE by Facility Type

2010 Volume-over-Count and PERCENT RMSE BY FACILITY TYPE						2015 Volume-over-Count and PERCENT RMSE BY FACILITY TYPE						
NAME	FACTYPE	FHWA % Error Target	VOL/ AADT	FHWA % RMSE Target	% RMSE	# of LINKS	Prior Model Run VOL/AADT	Prior Model Run % RMSE	AADT (New Model Run)	VOLUME (New Model Run)	New Model Run VOL/AADT	New Model Run % RMSE
Interstate	1	+/- 7%	1.05	18.33	7.41	10	1.06	10.7	321,650	343,714	1.07	10.9
Principal Arterial	3	+/- 10%	0.80	36.77	30.01	58	0.96	18.0	623,950	616,425	0.99	16.5
Minor Arterial	4	+/- 15%	0.85	43.90	41.48	202	1.16	45.7	846,196	920,645	1.09	43.4
Collector	5	+/- 25%	1.24	77.48	52.22	416	0.74	85.1	491,940	410,510	0.83	80.9
One-way P Arterial	6		0.00		n/a	2	0.73	27.2	26,950	20,113	0.75	25.4
Ramps	9		-	74.85	27.96	17	0.99	57.8	88,795	90,223	1.02	59.4
Total		n/a	n/a	36.77	31.95	705	1.00	44.6	2,399,481	2,401,630	1.00	42.6

Table C.10 presents another summary of volume-over-count ratios by number of lanes categories. The typical standard of accuracy here is to have assignment error within plus or minus 15 percent. As depicted, all lane categories meet this standard. Incidentally, green numbers for results indicate improvement over the previous model run.

Table C.10 ESMPO Volume-over-Count Ratios by Number of Lanes

Volume/Count Ratios by No. of Lanes per Direction		
# Lanes/	Volume/Count	
Directio	Previous	Current
1	1.02	1.03
2	0.96	0.97
3	1.16	1.14
Total	1.00	1.00

Table C.11 depicts volume/count ratios for the two Mobile Bay bridge crossings at the Baldwin/Mobile County Line. As indicated, the overall volume/count ratio is a perfect 1.00 for the combined I-10 and US 90/98 bridge crossings. The table provides directional volumes, counts, and ratios for both highways.

Table C.11 ESMPO Volume-over-Count Ratios by Bay Crossing

Final	Bay Crossing Summary		
	Ratio	Count	Volume
I-10 WB	0.98	37,750	36,814
I-10 EB	1.00	37,750	37,629
I-10 Total	0.99	75,500	74,443
US 90/98wb	1.12	8,290	9,281
US 90/98eb	1.02	8,290	8,465
US 90/98	1.07	16,580	17,746
Sum	1.00	92,080	92,189
Diff			(109)

Table C.12 provides volumes, counts, volume/count ratios, percent error, and accuracy standards for all screenlines in the model. A summary of non-screenline links is also provided. As indicated by the green

numbers under the "Maximum Desirable Deviation" volume/count ratios meet established standards for all except 3 of 12 screenlines. The sum of all non-screenline links achieve a perfect average 1.00 volume/count ratio, accounting for the vast majority of volumes. A sum of all roadway links across the model also shows an error margin of zero.

Table C.12 ESMPO Volume-over-Count Ratios by Screenline

Screenline Updates		Prior ESMPO 2015 Model Run					New ESMPO 2015 Model Run			
Screenline	Name	Count	Volume	Volume to Count Ratio	Percent Deviation from Base	Maximum Desirable Deviation	Count	Volume	Volume to Count Ratio	Percent Deviation from Base
1	EXTERNAL CORDON LINE	211,810	211,950	1.00	0%	(+/-) 10%	211,810	211,949	1.00	0%
2	E/W Flows, Daphne/Spanish Fort	91,260	93,118	1.02	2%	(+/-) 10%	91,260	91,435	1.00	0%
3	N/S Flows, north of I-10	66,880	69,530	1.04	4%	(+/-) 15%	66,880	67,465	1.01	1%
4	N/S Flows, north of CR 64	107,180	101,604	0.95	-5%	(+/-) 10%	107,180	102,167	0.95	-5%
5	E/W Flows, east of US 98	108,066	114,079	1.06	6%	(+/-) 10%	*108,066*	114,354	1.06	6%
6	N/S Flows, south of AL 104	92,350	84,943	0.92	-8%	(+/-) 10%	*92,350*	84,739	0.92	-8%
7	N/S Flows, south of Fairhope	47,040	39,160	0.83	-17%	(+/-) 15%	47,040	37,720	0.80	-20%
8	E/W Flows, Fish River Crossing	91,730	116,121	1.27	27%	(+/-) 10%	*91,730*	115,630	1.26	26%
9	N/S Flows, north of US 98	13,940	14,290	1.03	3%	(+/-) 20%	13,940	14,096	1.01	1%
10	N/S, north of Spanish Fort	19,060	19,807	1.04	4%	(+/-) 20%	19,060	20,090	1.05	5%
11	Arc north of Spanish Fort Core	24,160	24,723	1.02	2%	(+/-) 20%	24,160	23,301	0.96	-4%
12	E/W Flows, west of US 98	58,504	36,461	0.62	-38%	(+/-) 15%	*58,504*	38,397	0.66	-34%
0	*Non-Screenline Links*	1,467,501	1,468,831	1.00	0%	*(+/-) 5%*	*1,467,501*	*1,480,288*	1.01	1%
TOTAL		2,399,481	2,394,617	1.00	0%	(+/-) 5%	**2,399,481**	**2,401,631**	1.00	0%

Finally, Table C.13 provides a summary of VMT and VHT statistics, along with typical standards for VMT per person and household. VMT per person and household are slightly higher than typical FHWA statistics. This is likely explained by a higher than average percent of external trips, resulting from daily interactions between the ESMPO area and neighboring Mobile, Gulf Shores, Orange Beach and Pensacola. External trips are typified by longer average trip lengths and travel times than internal person trips.

Table C.13 ESMPO Vehicle-Miles Traveled and Vehicle-Hours Traveled

Trip Assignment	New 2015 VMT	VMT per Prior 2015 Run	New 2015 VHT	2015 Total HHs	2015 Total Pop		Typical VMT Statistics
VMT & VHT Total	3,853,255	3,846,177	94,748			per:	
VMT & VHT - Per HH	88.4	88.4	2.2	43,575		HH	45-82
VMT & VHT - Per Person	35.3	35.3	0.9		109,236	pop	17-33

1.4. Model Forecasting

Once the model accurately replicates base year 2015 traffic patterns, the focus can turn to preparing the model to forecast traffic for the year 2045 and using the model to identify future transportation needs. Earlier sections of this report described assumptions used in forecasting 2045 socioeconomic data, conducting the 2045 needs assessment, and use of the model in project prioritization. Thus, these topics will not be repeated here. Other key components of model forecasting are described in this section, focused on the following:

- Forecasting external travel
- Existing-plus-committed (E+C) highway network coding

1.4.1. Forecasting External Travel

While a majority of trip growth is accounted for by forecasting socioeconomic data such as households, population, employment, and school enrollment, growth in trips crossing the study area boundary requires additional analyses and assumptions. As noted in the validation discussion, the ESMPO area is influenced greatly by external trips due to its location relative to other nearby urban areas. Two alternate techniques were used to forecast traffic volumes at external zones. Historic ALDOT 2009-2018 traffic counts were used to compute compounded average annual growth rates (CAGR) for application in 2045 growth estimates. Another methodology was to use available 2045 population forecasts for Baldwin and Mobile Counties to estimate an alternate CAGR. After testing these alternate approaches, it was decided to proceed with CAGRs based on ALDOT counts for all external zones except the two Mobile Bay crossings. Final 2045 external trip forecasts are depicted in the last column of Table C.14.

Table C.14 ESMPO 2045 External Trip Summary

		First Cut	Refined External Trips		
Zones	Location	2045	2015 Adj	Rev 2045	2045 Adj
351	CR 1, South of Alt US 98	1,941	**1,440**	***2,284***	**2,284**
352	CR 27/Mary-Ann Beach Road, South of Alt US 98	1,928	**1,430**	***2,268***	**2,268**
353	US 98, east of CR 9	14,834	**9,490**	**11,731**	**11,731**
354	Underwood Road, east of CR 9	1,523	**1,130**	***1,792***	**1,792**
355	CR 71/College Avenue, north of CR 32	2,493	**1,000**	***1,586***	**1,586**
356	*Disconnected External Zone - now CR 68*	971	**720**	***1,142***	**1,142**
357	AL 59, north of CR 32	40,148	**27,010**	**41,635**	**41,635**
358	CR 32, west of AL 59	3,923	**2,910**	***4,615***	**4,615**
359	*Disconnected External Zone - now Beach Express*	889	**8,400**	***13,322***	**13,322**
360	US 90, east of Baldwin Beach Express	7,878	**4,850**	***7,692***	**7,692**
361	I-10, east of Baldwin Beach Express	52,798	**36,050**	***57,173***	**57,173**
362	CR 64, east of Baldwin Beach Express	3,099	**2,300**	***3,648***	**3,648**
363	*Not displayed in network - now CR 36*	n/a	**660**	***1,047***	**1,047**
364	*Not displayed in network - now CR 38*	n/a	**850**	***1,348***	**1,348**
365	US 31, south of Holly Hills	23,018	**15,810**	**30,504**	**30,504**
366	CR 39 at Whitehouse Fork Road	1,523	**1,000**	***1,586***	**1,586**
367	SR 225, north of Whitehouse Fork Road	7,993	**4,680**	**10,052**	**10,052**
368	I-10, east of Baldwin/Mobile County Line	98,345	***70,500***	**99,064**	***92,504***
369	US 90/98, east of Baldwin/Mobile County Line	28,229	***9,500***	***17,441***	***9,993***
	Totals	291,533	199,730	309,929	295,921

1.4.2. Existing-plus-Committed Highway Network Coding

The existing-plus-committed (E+C) highway network includes roadway projects completed or under construction since the base year of 2015 plus projects committed to construction in the ESMPO Transportation Improvement Program (TIP). Table C.15 provides a listing of roadway projects added to the 2015 base year highway network to generate the E+C network. The last column of the table indicates whether or not the additional capacity can be quantified in the travel demand model. Since the model includes through travel lanes, medians, and continuous turn lanes, these capacity projects can be included in the E+C network. Conversely, projects to add intersection turn lanes and signalization are not accounted for in model capacities and thus are not coded in the E+C network.

Table C.15 ESMPO 2045 Existing-plus-Committed Highway Network

Sponsor	Proj Fam ID	Project Description	Length	Project Scope	Capacity?
ALDOT	*under construction*	Additional Lanes on US 31, School Rd to East of SR 181		Add two lanes to existing two lane roadway	yes
ALDOT	*under construction*	Additional Lanes on SR 181, Milton Jones Rd to Mosley Rd		Add two lanes to existing two lane roadway	yes
ALDOT	*under construction*	Additional Lane on SR 181, US 90 to Eastern Shore Blvd+DDI		Add NB lane and construct DDI at I-10	yes
ALDOT	42459	Intersection Relocation and Signal US 90 at SR 59 Loxley	0.33	Add Left turn lanes and Realign roadway	no
ALDOT	22886	Additional Lanes on SR 181 from US 98 to CR 32	3.63	Add two lanes to existing two lane roadway	yes
TBD	43970	Intersection Improvement at US 90/US 31 and Spanish Main	0.24	undefined	no
ALDOT	33130	Widen I-10 from east end of Bayway to .5 mi east of SR-181	4.07	Add one lane each direction	yes
Additional	Resolution 2019-26	Gayfer Ave Turn Lanes		left turn lanes	no
Additional	Resolution 2019-26	CR 64 at Pollard Intersection		left turn lanes	no
Baldwin Co	USES	Widen and Add Ctr Turn Lane CR-64 from SR 181 to CR 54		TWLTL, roundabout at Austin Rd-Rigsby Rd	yes

Further discussions with MPO and County staff provided clarification on some of the above projects. After coding the SR 181 four-laning into the model network, it was later determined that the project was

only partially funded in the TIP and thus should not be coded into the E+C network. The team was also seeking clarity on the segment of SR 181 between CR 32 and Mosley Road, which also seemed to have a partial commitment. A similar situation arose with the continuous turn lane addition to CR 64, which is still awaiting construction funding. The latter was further complicated during the needs assessment, which identified the ultimate 2045 project is to four-lane this corridor.

Section 3 of this report further describes application of the E+C network in the model along with the 2045 socioeconomic forecasts and external trip projections. Table C.16, found on the next page, provides a listing of all loaded network attributes, along with definitions and the range of values found in the 2015 network. Some of these attributes are duplicative, used purely for calculation, or no longer needed. The consultant team will do some additional network cleanup to streamline these attributes.

Table C.16 ESMPO Loaded Highway Network Attributes

Name	Definition	Minimum	Maximum	Total	Non-Zero	Average	Ave(<>0)
Note: All are directional values unless noted otherwise		*These are minimum, maximum, total, etc. values (2015 network)*					
A	A-Node	1	2714	7585900	5134	1477.581	1477.5808
B	B-Node	1	2714	7584164	5134	1477.243	1477.2427
DISTANCE	Distance in Miles	0.005734	3.5240335	1653.285	5134	0.322027	0.3220268
LINKGROUP1	No Longer Used	11	99	336146	5134	65.47448	65.474484
SPEED	Speed in MPH	15	70	161081	5134	31.37534	31.375341
TIME	Travel Time in Minutes	0.014509	11.837009	3468.713	5134	0.675636	0.6756356
CAPACITY	Capacity in Vehicles per Hour per Lane	0	34000	36489100	3448	7107.343	10582.686
DISTANCE_MILES	Distance in Miles (duplicate attribute)	0.007608	3.2918	1702.821	5134	0.331675	0.3316752
DISTANCE_FT	Distance in Feet	40.1727	14517.68	8933181	5134	1740.004	1740.0041
LANES	Number of Lanes per Direction	0	3	4009	3449	0.780873	1.1623659
FACTYPE	Facility Type	1	99	182423	5134	35.53233	35.532333
AREATYPE	Area Type	2	9	29579	5134	5.761395	5.7613946
AADT	2015 Average Annual Daily Traffic Count	0	37750	2399481	689	467.3707	3482.5559
SCREENLINE	Screenline	0	12	1320	226	0.257109	5.840708
DIVIDED	Divided=1; Undivided=0	0	1	953	953	0.185625	1
TWOWAY	Two-Way=1; One-Way=0	0	1	4989	4989	0.971757	1
V_1	Assigned Traffic Volume	0	37629.406	13488924	4708	2627.371	2865.1071
TIME_1	Travel Time in Minutes (duplicate)	0.009224	12.437765	3981.402	5134	0.775497	0.7754971
VC_1	Volume/Capacity Ratio	0	1.1378669	967.483	3343	0.188446	0.2894056
CSPD_1	Congested Speed	12.41944	68.751076	156093.7	5134	30.40392	30.403921
VDT_1	Undefined	0	52616.563	4117635	4708	802.0325	874.60381
VHT_1	Vehicle-Hours Traveled	0	1331.2948	109142.7	4708	21.2588	23.182391
V1_1	Assigned Traffic Volume - HBW only	0	3683.574	1948841	4583	379.5951	425.23266
V2_1	Assigned Traffic Volume - HBO only	0	5346.0244	2570978	4583	500.7749	560.9815
V3_1	Assigned Traffic Volume - NHB only	0	3288.0933	1400422	4584	272.7741	305.50226
V4_1	Assigned Traffic Volume - Trucks only	0	1125.3851	528140.8	4584	102.8712	115.21397
V5_1	Assigned Traffic Volume - IE only	0	15862.556	4991898	4357	972.3215	1145.7192
V6_1	Assigned Traffic Volume - EE only	0	19387.074	2048643	658	399.0345	3113.4394
VT_1	Assigned Traffic Volume - Two-Way	0	70499.203	24153260	4716	4704.57	5121.5564
VMT	Vehicle-Miles Traveled	0	52616.563	4117635	4708	802.0325	874.60381
CNT	2015 AADT Count (duplicate)*	0	37750	2399481	689	467.3707	3482.5559
VOLCNT	Volume/Count Ratio*	0	32.41243	952.7452	679	0.185576	1.4031593
SQDIFF	Root Mean Square Error*	0	69878171	1.51E+09	689	294890.7	2197342.6
**These attributes only exist if traffic count is available*							