Technical Memorandum

STATEWIDE TRAVEL DEMAND MODEL DOCUMENTATION

Prepared for:

LOUISIANA DEPARTMENT OF TRANSPORTATION & DEVELOPMENT

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1. INTRODUCTION

The State of Louisiana has a statewide travel demand model that was initially developed in 2004 (2000 base year and 2030 forecast year) and updated in 2012 (2010 base year and 2040/2044 forecast years) and in 2018 (2016 base year and 2040/2044 forecast years). As part of the preparation of the Louisiana statewide transportation plan in 2012, the initial travel demand model was updated; and with more recent available data, the travel demand model was updated again. There are multiple reasons that make this update necessary. First, the model had a dated base year and needed to be updated to reflect more recent travel patterns. Second, the forecast year for the model needed to be consistent with the statewide transportation plan for the years 2040 and 2044. Thirdly, a lot of new transportation related data is available from sources such as Census, NHTS 2009 and ACS that provide more recent inputs to the travel demand model. Certain components of the model use data based on older versions of the Census and this update serves as a good opportunity to take advantage of these new available data.

Keeping these advantages in mind, subsequent chapters document the updates made to the Louisiana Statewide Model (LASTM) and its validation results. The current model has a 2016 base year and 2040/2044 forecast years.

2. DATA SOURCES

Most important to the development of mathematical models is the capability of replicating current traffic patterns and demonstrating sufficient sensitivity to project future travel demand based on available data. Sources of the data used for the LASTM development included:

- 2010 US Census
- American Community Survey (ACS, 2012 and 2015 5-yr Estimate)
- Longitudinal Employment Household Data (LEHD, 2014)
- Woods and Poole (W&P)
- Transearch
- LADOTD Traffic Counts

2.1 Base and Forecast Years

The LASTM was designed to replicate traffic conditions in Louisiana on an average weekday, in base year 2016 and forecast year 2040/2044.

For the model update, 2017 LADOTD estimated Annual Average Daily Traffic (AADT) Routine Traffic Counts and Highway Performance Monitoring System (HPMS) count data were used. 2017 LADOTD's AADT data were used primarily and HPMS AADT data were used for verification purpose. Counts collected prior to 2016 were projected to 2016 (base year) based on the annual growth rate published in Federal Highway Administration's Highway Statistics 2016.

2.2 Zonal Data

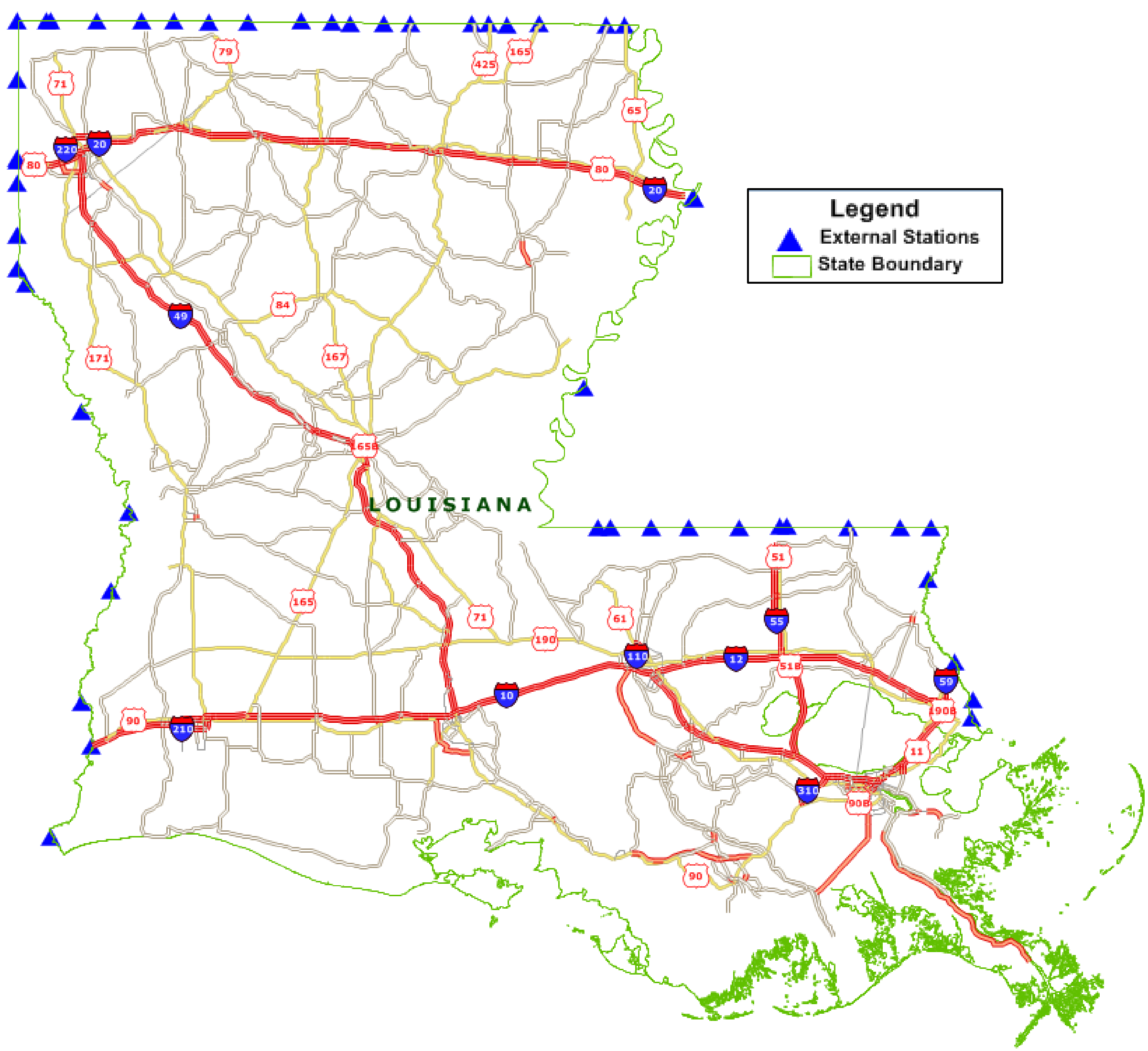
The updated LASTM uses a single unified zone structure, making the entire zone system easier to maintain and update. The socioeconomic data were developed by CDM Smith using Census/ACS data for demographics and by GCR & Associates under the supervision of CDM Smith for employment, adjusted by Woods and Poole datasets for 2016 and 2044. Particular scrutiny has been applied to those parishes and regions that have experienced tremendous population upheaval since the hurricanes of 2005 and 2008. The following fields are major attributes included in the zone file:

- POP_xx: Population (xx is the last two digits of the year, that is, 16, 40 or 44)
- HH_xx: Total occupied households
- hhsize1_xx: Households with one occupant
- hhsize2_xx: Households with two occupants
- hhsize3_xx: Households with three occupants
- hhsize4+_xx: Households with 4 occupants and more
- INC_1_xx: Less than $14,999

- INC_2_xx: $14,999 to $49,999
- INC_3_xx: Greater than $50,000
- TOTEMP_xx: Total employment
- Retail_xx: Retail employment (NAICS code 44-45)
- Industrial_xx: Industrial employment (NAICS code 21-33)
- Recreational_xx: Recreational employment (NAICS code 71-72)
- Others_xx: Other employment (NAICS code 42, 48-62, 81-92)

In addition to refined internal zones within Louisiana, 49 external stations at the state boundary were defined to serve as locations with controlling total traffic going into and out of the state. **Figure 2-1** shows the location of 49 external stations.

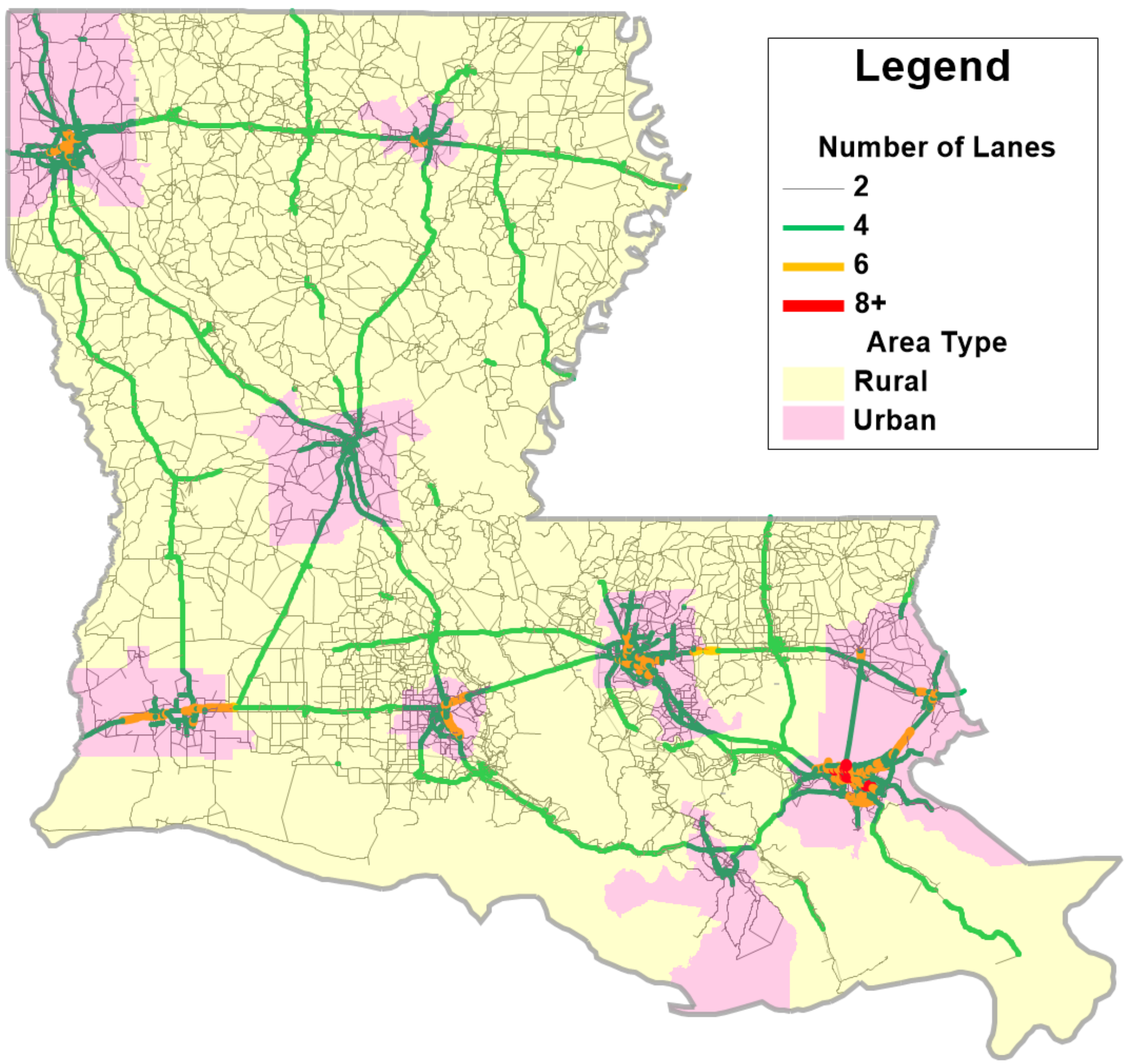
Figure 2-1: External Stations



2.3 Highway Data

The highway network is the representation of roads (links) and intersections (nodes) in Louisiana, their capacities, classification, directionality, lanes, and speed (**Figure 2-2**). Note that the model only assigns trips for the network within Louisiana, but the full micro/macro network is maintained and required for the model functionality.

Figure 2-2: Existing Model Highway Networks



3. MODEL ESTIMATION

3.1 Trip Generation Model

3.1.1 Trip Production Inputs

LASTM uses cross classification for trip productions. Trip rates are estimated using the 2009 National Household Travel Survey data (NHTS 2009) and are classified by area type, household income and household size. Three internal trip purposes of Home-Based-Work (HBW), Home-Based-Others (HBO) and Non-Home-Based (NHB) are assumed.

The trip production rates for short-distance internal trips in the LASTM are shown in **Table 3-1** and **Table 3-2**.

Table 3-1: LASTM Trip Production Rates (Urban)

Trip Purpose	HH Income	HH Size			
		1	2	3	4+
HBW	Less than $14,999	0.26	0.72	1.02	1.39
	$14,999 to $49,999	1.20	1.96	2.01	2.20
	Greater Than $50,000	1.79	2.38	2.82	3.32
HBO	Less than $14,999	2.07	2.33	2.49	5.66
	$14,999 to $49,999	3.29	4.95	7.49	8.41
	Greater Than $50,000	4.53	7.81	9.62	12.66
NHB	Less than $14,999	0.90	1.67	1.70	1.96
	$14,999 to $49,999	2.86	3.28	4.03	4.26
	Greater Than $50,000	1.99	3.84	5.57	7.70

Table 3-2: LASTM Trip Production Rates (Rural)

Trip Purpose	HH Income	HH Size			
		1	2	3	4+
HBW	Less than $14,999	0.17	0.48	0.54	0.58
	$14,999 to $49,999	0.79	1.30	1.33	1.45
	Greater Than $50,000	1.01	1.57	1.86	2.19
HBO	Less than $14,999	1.27	1.43	1.53	2.72
	$14,999 to $49,999	3.04	3.04	4.60	5.17
	Greater Than $50,000	3.55	4.84	6.65	7.41
NHB	Less than $14,999	0.56	1.05	1.49	2.09
	$14,999 to $49,999	1.80	2.34	2.54	4.28
	Greater Than $50,000	1.55	2.42	3.50	4.85

3.1.2 Trip Attraction Inputs

NHTS data and parameters from NCHRP 716 were used to derive the rates for trip attractions. Then, the ratio of total attractions to productions was reviewed and provided the basis to adjust the trip attraction rates. In other words, efforts were made to ensure that the total attractions are as close, within 20 percent, to the total productions as possible before the balancing procedure.

Table 3-3 shows the trip attraction rates for short-distance internal trips used in the LASTM model.

Table 3-3: LASTM Trip Attraction Rates

	Household	Retail Employment	Other Employment	Total Employment
HBW	-	-	-	1.45
HBO	1.7	8.4	3.5	-
NHB	1.4	6.9	0.9	-

3.1.3 Trip Generation Outputs

Initial outputs from the trip generation models are unbalanced trips between production and attraction. The LASTM model subsequently balanced the trip production and attraction to make sure trip production is equal to trip attraction before trip distribution. **Table 3-4** documents the unbalanced trip productions and attractions by trip purpose. The ratio of attraction over production is at least 0.84 (within 20 percent) for all trip purposes.

Table 3-4: Trip Production and Attraction before Balancing

Purpose	Production	Attraction	Attraction/Production
HBW	3,192,561	2,850,475	0.89
HBO	10,757,171	9,153,365	0.85
NHB	6,256,578	5,250,961	0.84
Total	20,206,310	17,254,802	0.85

Table 3-5 reports the overall trip production rates per household by trip purpose. The overall trip production rates for the updated LASTM model are higher than the 2009 NHTS rates and slightly lower than 2010 model rates.

Table 3-5: Trip Production Rates

Purpose	2016 Model Rates Per Household	2009 NHTS Rates Per Household	2010 Model Rate Per Household
HBW	1.74	1.45	1.68
HBO	5.86	5.39	6.13
NHB	3.41	3.12	3.35
Total	11.00	9.97	11.17

3.2 Trip Distribution Model

A gravity model is used to distribute the trips throughout the network. A friction factor characterizes how the attractiveness between zones decreases with travel time, as calculated by the gamma function shown below:

$$F_{ij} = a \times t_{ij}^{b} \times \exp(c \times t_{ij})$$

Where

$$F_{ij} = the\ friction\ factor\ between\ zone\ i\ and\ j,$$
$$a, b\ and\ c = model\ coefficients,$$
$$t_{ij} = travel\ time\ between\ zone\ i\ and\ j.$$

Table 3-6 shows the coefficients used in the friction factor calculation:

Table 3-6: Trip Distribution Parameters

Gamma function parameters\trip purpose	HBW	HBO	NHB
a	1.0000	1.0000	1.0000
b	-0.0200	-0.7515	-0.3000
c	-0.1230	-0.2900	-0.1200

The resulting trip length distribution curves based on the gamma function from the LASTM model and NHTS data are illustrated in **Figure 3-1** through

Figure 3-6**.** They are checked to ensure the reasonableness of trip distribution results. The trip distribution outputs from the LASTM have been summarized and compared with the 2010 model and 2009 NHTS data in **Table 3-7.** The average trip length results from the 2016 model are mostly consistent with 2010 model and 2009 NHTS data.

Table 3-7: Average Trip Length Distributions

Purpose	Average Trip Length (minutes)		Average Trip Length (miles)	
	2016 Model	2010 Model	2016 Model	2009 NHTS
HBW	17.7	18.4	11.7	13.4
HBO	11.4	12.0	7.4	7.3
NHB	13.0	14.9	8.5	6.3

Figure 3-1: HBW Trip Length Distribution (minutes)

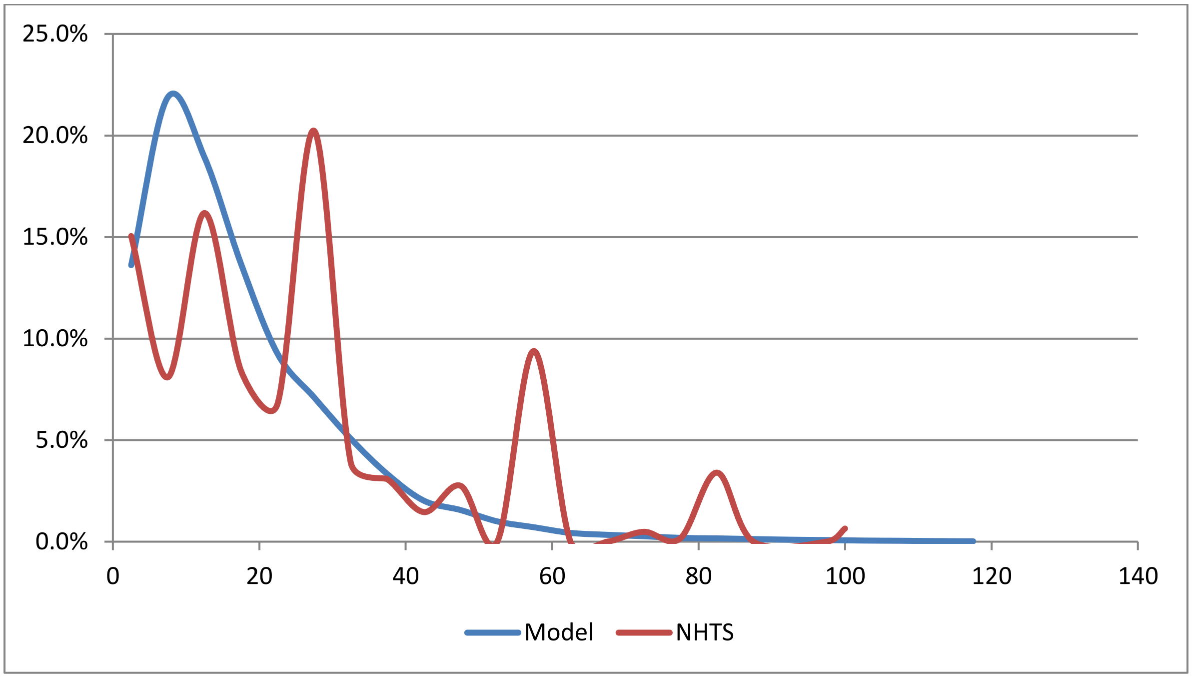


Figure 3-2: HBO Trip Length Distribution (minutes)

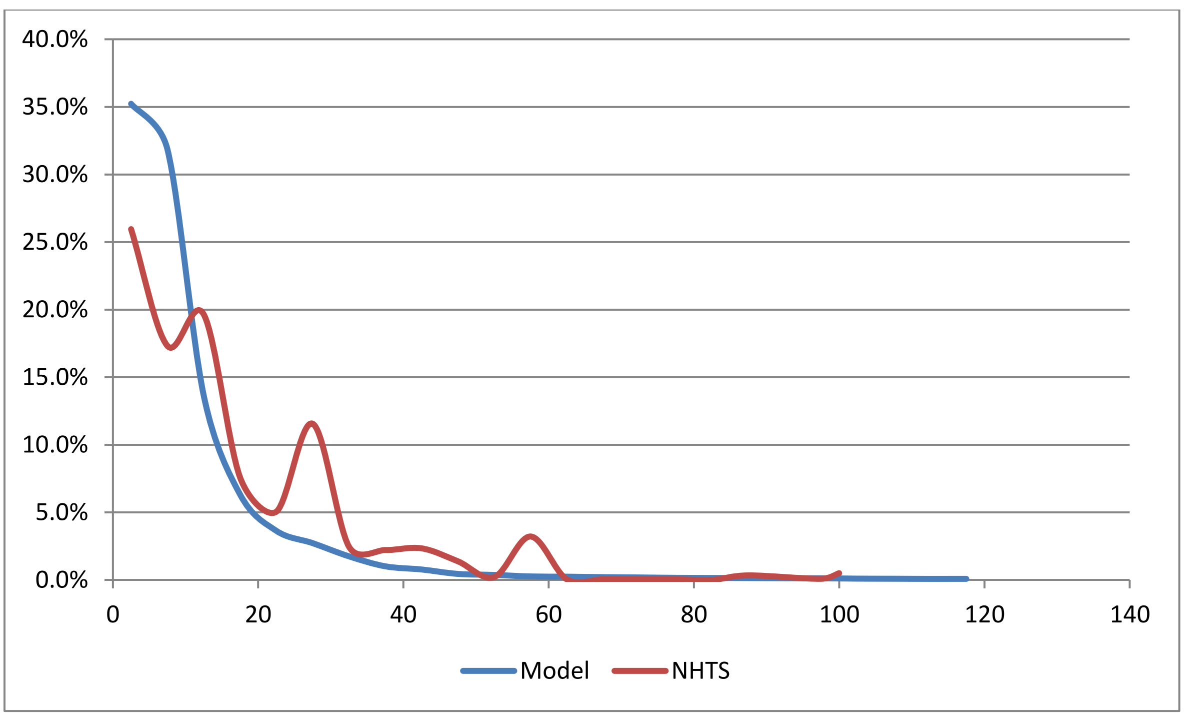


Figure 3-3: NHB Trip Length Distribution (minutes)

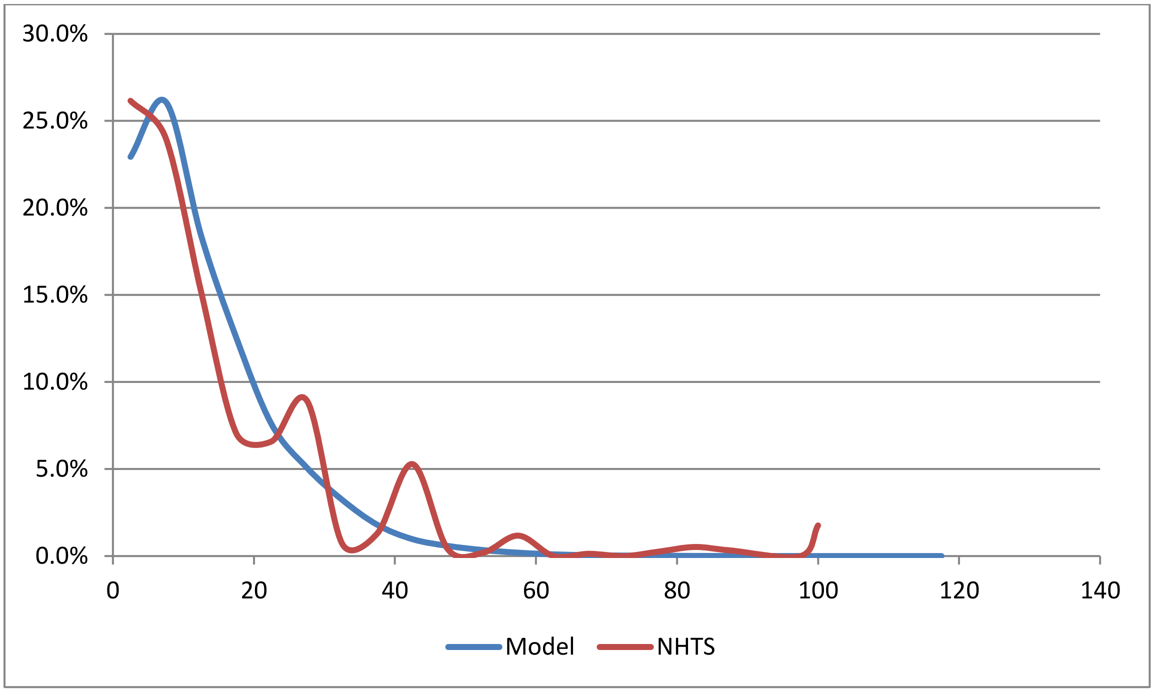


Figure 3-4: HBW Trip Length Distribution (miles)

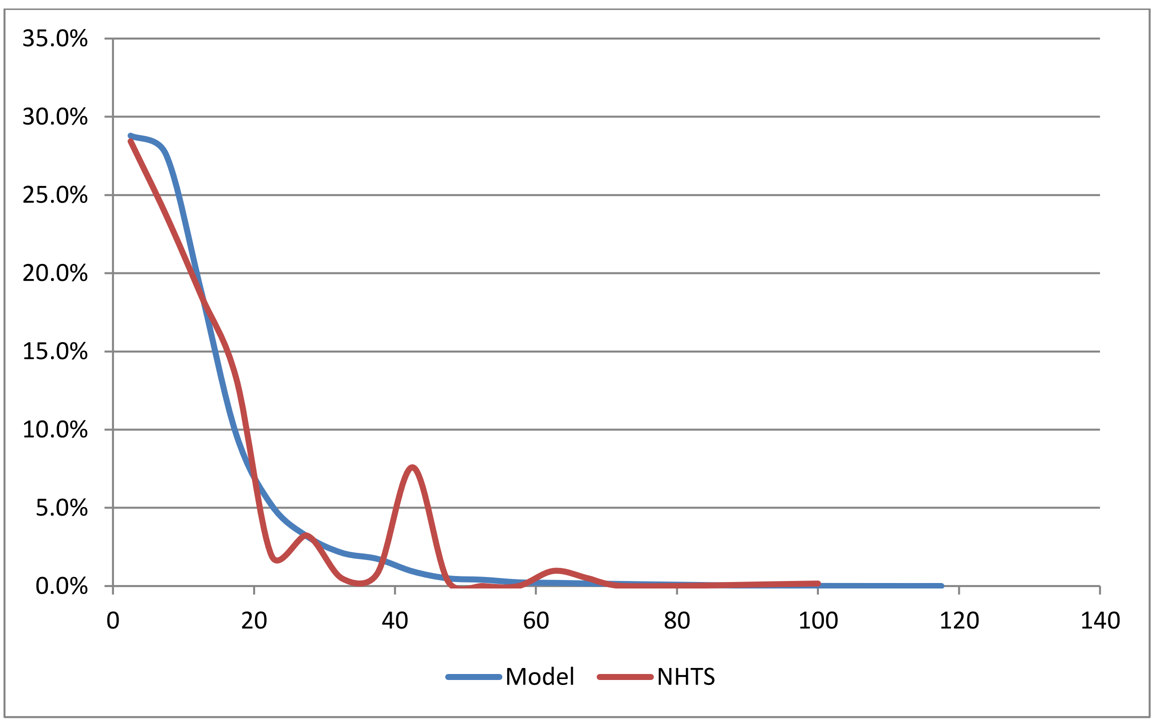


Figure 3-5: HBO Trip Length Distribution (miles)

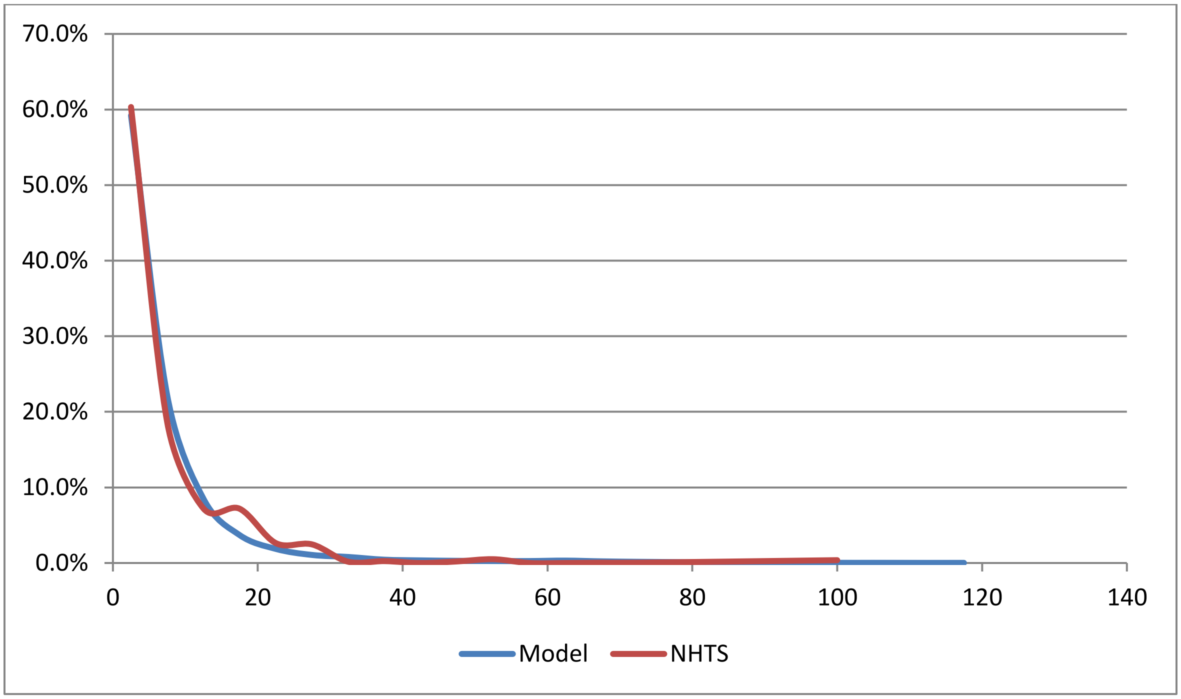
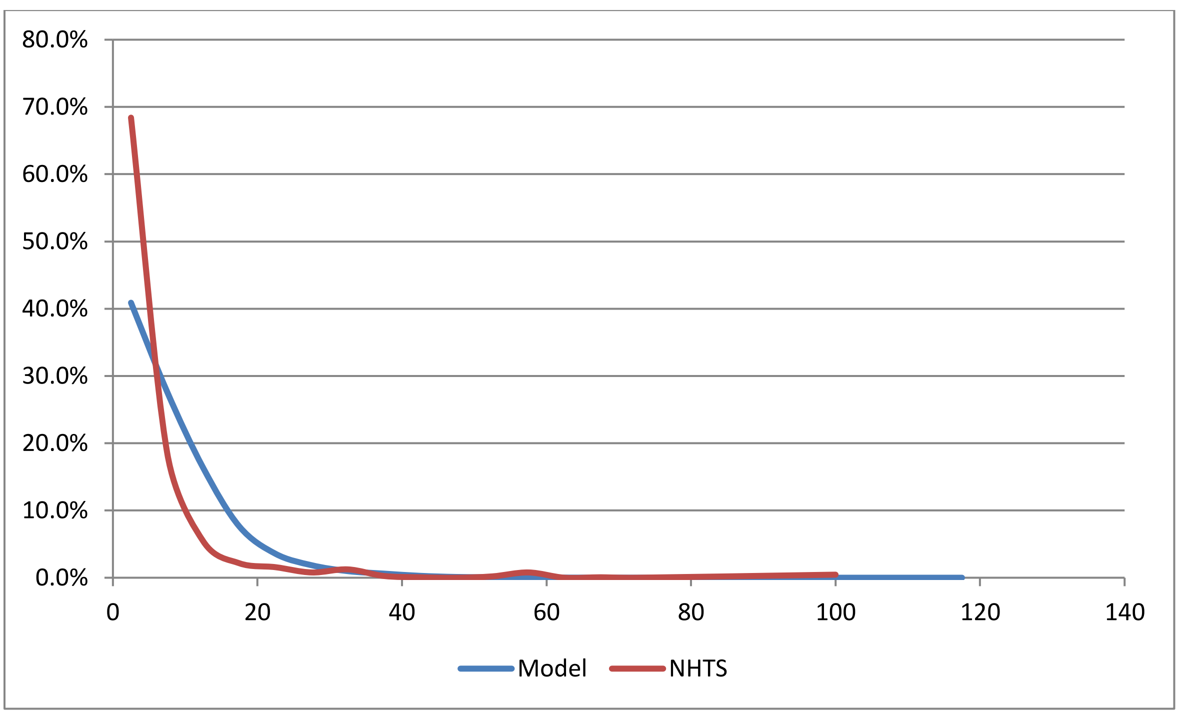


Figure 3-6: NHB Trip Length Distribution (miles)



3.3 Mode Split and Auto Occupancy

In this step, the person trips generated and distributed in trip generation and distribution are split into three different modes of transportation: auto, transit and others. Based on NHTS data, LASTM model assumes the following distribution among three modes (**Table 3-8**). The area type is associated with the destination zone of the trips.

Table 3-8: Shares for Three Modes

Mode\trip purpose	Urban			Rural		
	HBW	HBO	NHB	HBW	HBO	NHB
Auto	89.0%	89.7%	93.9%	86.6%	87.4%	91.5%
Transit	4.8%	5.0%	2.0%	3.6%	2.3%	0.7%
Others	6.2%	5.3%	4.1%	9.8%	10.3%	7.8%

Trips by transit and others are not within the scope of this modeling effort. The person trips by auto are further converted into vehicle trips by assuming the average occupancy shown in **Table 3-9.**

Table 3-9: Occupancy for Auto Trips

Automobile Trips	HBW	HBO	NHB	Total
Person Trips	2,563,257	9,436,773	5,397,785	17,397,815
Vehicle Trips	2,002,545	5,046,403	3,352,662	10,401,609
Average Occupancy – Model	1.28	1.87	1.61	1.67
Average Occupancy – NHTS	1.16	1.87	1.61	1.59

3.4 Time of Day Model

Based on NHTS data, the LASTM model uses the time of day factors shown in **Figure 3-7**. Three time periods are defined in the model, they are:

- AM (6:00 -9:00)
- PM (16:00-19:00)
- Off Peak (9:00-16:00, 19:00-0:00 and 0:00-6:00)

Aggregated time of day factors are shown in **Table 3-10**. In the assignment stage, OD matrices from each time period are loaded to the network. The daily traffic flow is the sum of traffic flows of each time periods.

Figure 3-7: Time of Day Factors

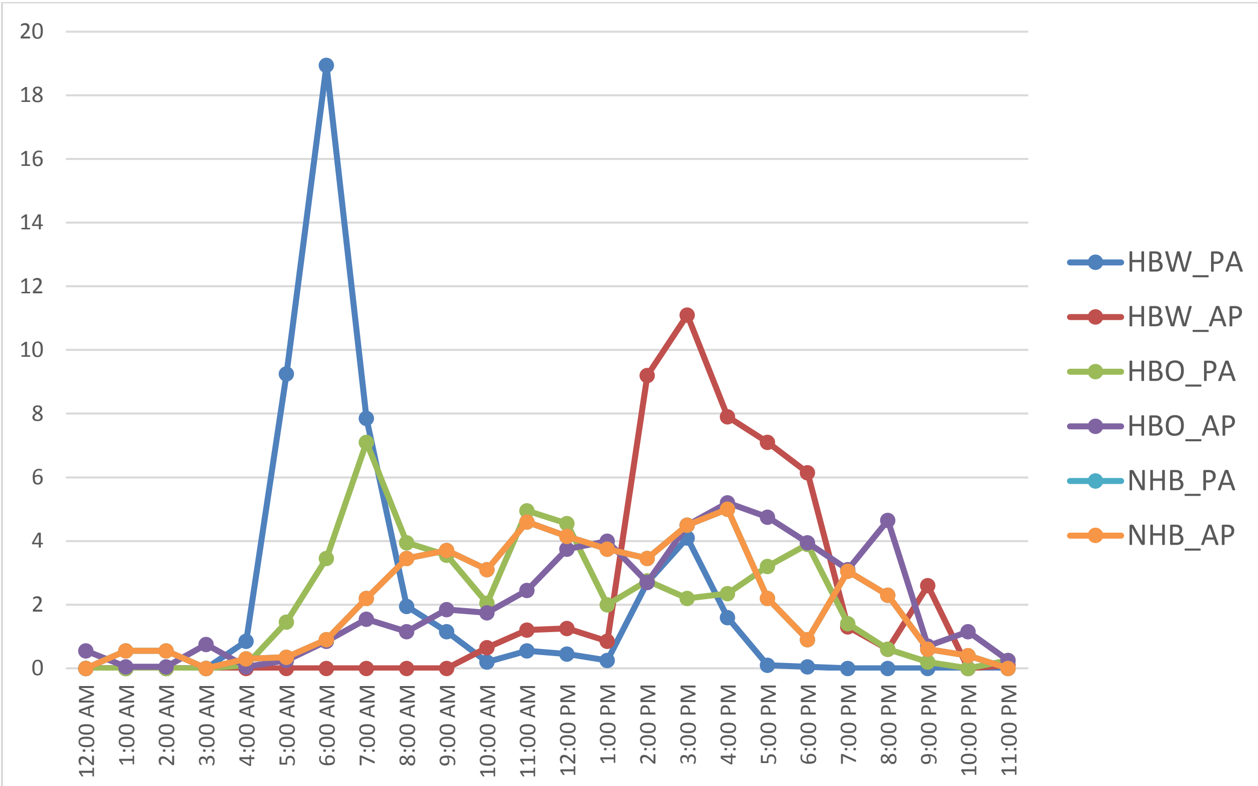


Table 3-10: Aggregated Time of Day Factors

Time of Day	HBW	HBO	NHB
Off Peak	48.35	58.6	70.7
AM	28.75	18.05	13.1
PM	22.9	23.35	16.2
Total	100	100	100

3.5 Truck Model

Truck trips in LASTM model comprise three categories: long distance truck trips, local medium truck trips and local heavy truck trips. Detailed information regarding the development of long distance truck trips will be deferred to the external trip section because of its close ties with the development of long distance auto trips.

The Quick Response Freight Manual II was consulted to produce the initial local truck production rates. Local truck production and attraction rates are assumed to be the same (**Table 3-11**).

Table 3-11: Local Truck Production Rates

Trip Type	Agriculture, Mining and Construction	Manufacturing, Transportation, Utilities and Wholesale	Retail	Office and Service	Household
Local Medium Truck	0.130	0.109	0.114	0.031	0.045
Local Heavy Truck	0.078	0.047	0.029	0.004	0.017

The impedance function used for local trucks during the trip distribution is based on the Quick Response Freight Manual II and are different from the Gravity Model used for the auto trip purpose. The impedance function for local trucks is:

$$P_{t=}\exp(a - b \times T)$$

Where

$$P_t = the\ impedance\ for\ local\ truck\ trips$$
$$a, b = the\ coefficients\ for\ local\ truck\ trips$$
$$T = the\ travel\ time\ during\ off\ peak$$

Table 3-12 shows the parameters used in the impedance function for local truck trips.

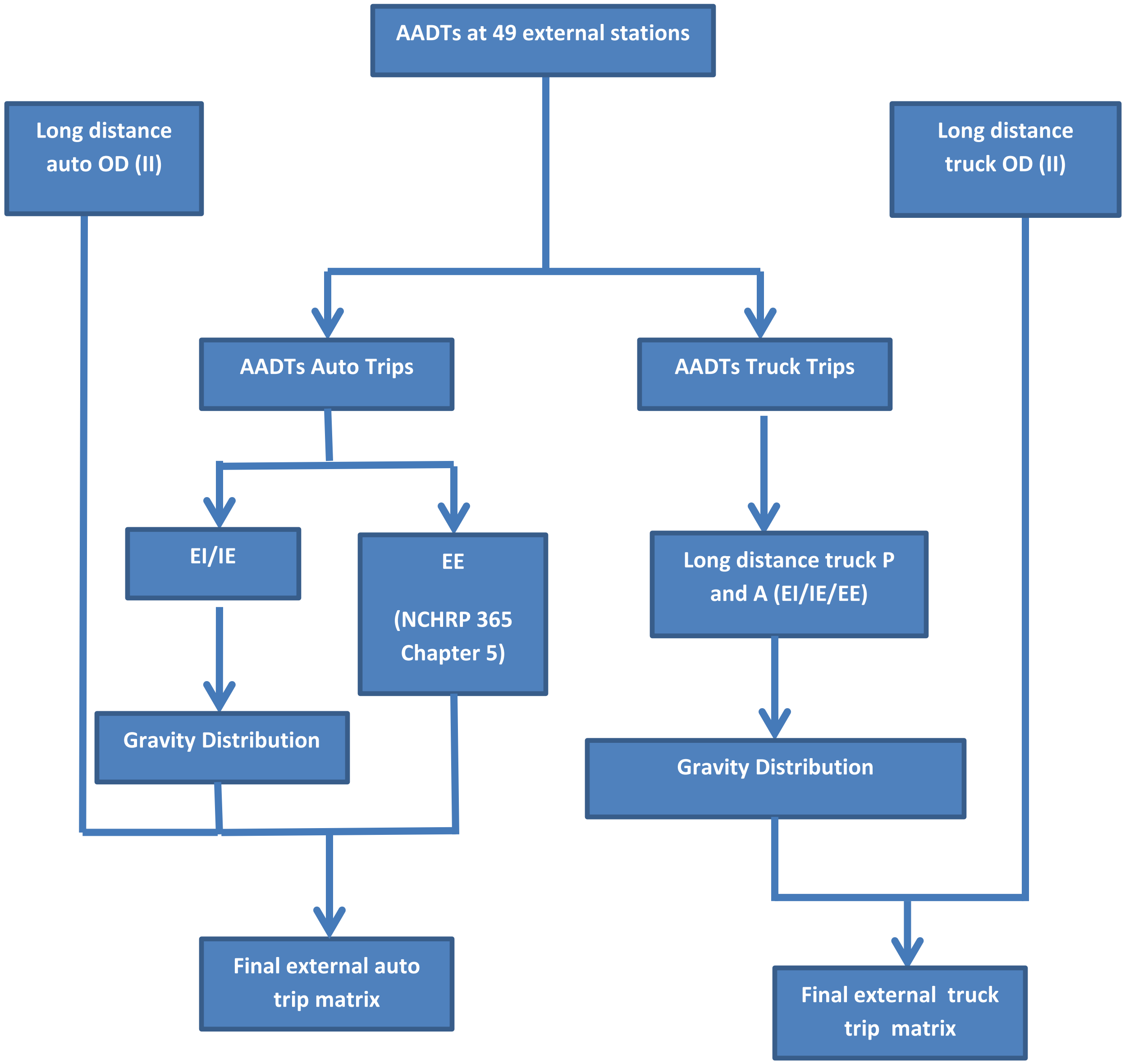
Table 3-12: Local Truck Impedance Parameters

Trip Category\Coefficient Trip Distance		a	b
Medium Truck Trips	< 27 miles	4.750	-0.050
	≥ 27 miles	4.85	-0.050
Heavy Truck Trips	< 7.5 miles	1.000	0.000
	≥ 7.5 miles	5.500	-0.045

3.6 External Trip Model

As mentioned earlier, 49 external stations are defined at the state boundary. The AADTs at those 49 external stations serve as the controlling total of external-external (EE), external-internal (EI) and internal-external (IE) trips. **Figure 3-8** illustrates the process of developing external auto and truck trips. The long-distance truck OD matrix was developed by Transearch data. The long-distance auto OD was derived from a nation-wide county-to-county long distance trip database.

Figure 3-8: Development of External Trips



A method similar to what is descried in Chapter 5 of NCHRP Report 365 is used to estimate the percentages of through auto trips at 49 external stations. The equation from this report is as follows:

$$Y_i = \max(0{,}76.76 + 11.22 \times I - 25.74 \times PA - 42.18 \times MA + 0.00012 \times ADT_i - 0.000417 \times POP_i)$$

Where

$$Y_i = Percentages\ of\ through\ car\ trips$$
$$I = Interstate\ (0\ or\ 1)$$
$$PA = Principle\ arterial\ (0\ or\ 1)$$
$$MA = Minor\ arterial\ (0\ or\ 1)$$
$$ADT_i = Average\ daily\ traffic\ at\ Station\ i$$
$$POP_i = Population\ of\ the\ county\ which\ Station\ i\ belongs\ to$$

Table 3-13 summarizes the percentages of through car trips by volume.

Table 3-13: Summary of Percentages of Through Car Trips

ADT Groups	Count	Average (%)	Max (%)	Min (%)
<1,000	13	16.5	25.7	0.0
1k-5k	25	19.0	39.8	0.0
5k-10k	3	12.2	14.3	8.7
10k-20k	5	38.6	60.2	9.5
20k+	3	22.0	33.2	11.4
Grand Total	**49**	**19.9**	**60.2**	**0.0**

Equations 5-2, 5-3, and 5-4 in NCHRP Report 365 were used to obtain the initial distribution of through trips at each of the 49 external stations. The three equations resulted in some negative percentages between some externals stations. After revising the negative percentages to zero, the distribution percentages were re-calculated by their weights and used to obtain an asymmetrical through trip table. Lastly, a fratar method was applied to convert the asymmetrical through car trip table into a symmetrical one which is ready for traffic assignment.

3.7 PA to OD Conversion

Based on the previous steps, the PA to OD conversion generates the origin-destination (OD) matrices for assignment by trip category (auto and truck trips) and time of day (AM, PM and Off-Peak). The procedure is the standard process to convert the production-attraction matrices to OD matrices. **Table 3-14** summarizes the 2016 OD trips by time of day for both auto and truck trips. Note that an Origin-Destination-Matrix-Estimation (ODME) procedure is applied in calibration of the model and discussed in section 3.9 of this report.

Table 3-14: Pre-ODME Total Trip OD Summary (2016)

Trip Category		AM	PM	Off Peak	Daily
Auto	HBW	633,863	504,886	1,065,992	2,204,741
	HBO	924,673	1,196,184	3,001,985	5,122,842
	NHB	474,351	586,602	2,560,048	3,621,002
	EIIE	22,625	27,979	122,107	172,711
	EE	5,470	6,764	29,521	41,755
Truck	Medium	29,428	36,392	158,824	224,645
	Heavy	11,157	13,797	60,212	85,166
	Long Distance	7,142	8,833	38,547	54,522
Total Auto Trips		2,060,982	2,322,415	6,779,653	11,163,050
Total Truck Trips		47,728	59,022	257,583	364,332
Total Trips		2,108,710	2,381,437	7,037,236	11,527,382
Truck Percent		2.26%	2.48%	3.66%	3.16%

3.8 Highway Assignment and Feedback Loop

A Multi-Modal Multi-Class Assignment (MMA Assignment) is performed to assign trips to the LASTM network. In the initial MMA run, link free flow time is used as inputs to the Volume Delay Function (VDF). The VDF in the LASTM model is:

$$\boldsymbol{T_i = T_f[1 + \alpha(\frac{v}{c})^{\beta}]}$$

Where,

$$T_i = congested\ link\ travel\ time$$
$$T_f = free\ flow\ link\ travel\ time$$
$$\frac{v}{c} = link\ volume\ to\ capacity\ ratio$$
$$\alpha, \beta = \text{Coefficients}$$

The coefficients used in the volume delay function are shown in **Table 3-15**.

Table 3-15: Volume Delay Function Coefficients

Functional Classification	α	β
Rural Interstates	0.25	7
Rural Arterials	0.60	4
Rural Collectors and Local Roads	0.50	3
Urban Interstates and Expressway	0.25	7
Urban Arterials and Collectors	0.60	4
Urban Local Roads	0.50	3

A feedback mechanism using the Method of Successive Averages (MSA) is implemented in the LASTM model to feed the travel time from previous MMA run into the next MMA run until the difference of link travel times between each run satisfies the convergence criterion (MSA Root Mean Square Error <10%).

3.9 ODME Process

After the feedback loops converged, an Origin-Destination-Matrix-Estimation (ODME) process was applied to internal short distance trips. The ODME process used observed data to calibrate the model's OD matrix. The 2016 LADOTD estimated Annual Average Daily Traffic (AADT) Routine Traffic Counts and Highway Performance Monitoring System (HPMS) count data were used as the observed data for this ODME process. The ODME process adjusted the model's OD matrix to match the observed counts based on weights of the corresponding functional class, as shown in **Table 3-16**.

Table 3-16: Weights by Functional Class in ODME Process

Functional Classification	Weights
External Stations	100%
Interstate Freeways and Expressways	75%
Principal Arterials	50%
Other roadways with daily volume > 1,500	25%
Others (volume < 1,500)	0%

Based on the corresponding observed count weights, a Post-ODME matrix was generated for each trip purpose in each time of the day. This set of Post-ODME matrices were used for the final traffic assignment to the model network. **Table 3-17** shows the RMSE comparison of between Pre-ODME and Post-ODME traffic assignment. As the RMSE results show, Post-ODME has a lower RMSE than Pre-ODME overall and in all functional classes. This indicates that the ODME process indeed improved the model's fitness to observed data, resulting in more reliable model outputs.

Table 3-17: RMSE of Pre-ODME and Post-ODME Results

	Pre ODME		Post ODME	
Functional Classification	RMSE	%RMSE	RMSE	%RMSE
Rural Interstate	11,959	34.0	6,646	18.9
Rural Principal Arterial	9,559	94.5	3,468	34.3
Rural Minor Arterial	4,370	69.3	2,391	37.9
Rural Major Collector	2,574	80.4	1,347	42.1
Rural Minor Collector	1,685	105.0	1,083	67.5
Rural Local	1,088	106.3	983	96.0
Urban Interstate	24,880	31.7	13,191	16.8
Urban Freeway/Expressway	27,775	54.5	8,269	16.2
Urban Principal Arterial	10,598	44.4	6,228	26.1
Urban Minor Arterial	7,125	69.6	4,212	41.1
Urban Collector	4,680	84.4	3,828	69.1
Urban Local	3,520	99.2	3,147	88.7
TOTAL	**7,584**	**74.6**	**3,983**	**39.2**

Table 3-18 summarizes the 2016 Post-ODME OD trips by time of day for both auto and truck trips. Total trips increase by approximately 10 percent.

Table 3-18: Post-ODME Total Trip OD Summary (2016)

Trip Category		AM	PM	Off Peak	Daily
Auto	HBW	729,461	581,944	1,228,008	2,539,413
	HBO	937,967	1,211,776	3,041,518	5,191,261
	NHB	566,358	700,382	3,056,606	4,323,347
	EIIE	22,625	27,979	122,107	172,711
	EE	5,470	6,764	29,521	41,755
Truck	Medium	36,161	44,718	195,156	276,035
	Heavy	14,042	17,366	75,786	107,194
	Long Distance	7,142	8,833	38,547	54,522
Total Auto Trips		2,261,882	2,528,846	7,477,760	12,268,488
Total Truck Trips		57,345	70,916	309,490	437,751
Total Trips		2,319,227	2,599,761	7,787,250	12,706,238
Truck Percent		2.47%	2.73%	3.97%	3.45%

4. MODEL VALIDATION AND REASONABLENESS CHECK

4.1 Calibration and Validation

The LASTM model results have been validated via various reasonableness check measures. For validation purposes, AADT count data greater than 500 are used in the validation statistics:

The following statistics were computed in the LASTM validation:

- Root Mean Square Error (RMSE) by volume class and screen lines
- Volume Error by volume class and functional classification
- Volume vs. Count Scatter plot

Table 4-1 shows the overall RMSE by volume. The overall RMSE of the LASTM is 37%. The RMSE for links with counts higher than 50,000 and 25,000 is 16% and 20% respectively. Generally, it is expected that, higher the volume class, lower the RMSE. What's shown in **Table 4-1** is consistent with the expectation for a travel demand model.

Table 4-1: Percent Root Mean Square Error (RMSE)

Vol. Class	Number of Records	PRMSE	Counts	Flows	Diff. (%)
Overall	**3,679**	**37**	**40,736,534**	**41,133,391**	**1.0**
500-1,000	420	153	314,288	459,440	46.2
1,000-2,500	857	86	1,416,315	1,683,517	18.9
2,500-5,000	721	53	2,584,608	2,905,371	12.4
5,000-10,000	666	38	4,753,927	5,019,729	5.6
10,000-25,000	578	30	9,346,809	9,827,254	5.1
25,000-50,000	276	20	9,436,034	9,177,413	-2.7
50000	161	16	12,884,553	12,060,667	-6.4

Five screen lines have been established cutting the state largely through rural areas (**Figure 4-1**)**. Table 4-2** documents the screen line analysis results.

Table 4-2: Screen Line Analysis

Screen Line	Description	Flow	Count	Flow/Count	RMSE%
1	EW south of I-20	35,924	28,698	1.25	68.1
2	EW north of I-10	64,592	66,871	0.97	24.3
3	NS east of Shreveport	81,308	72,871	1.12	29.8
4	NS west of Baton Rouge	122,250	122,923	0.99	18.8
5	NS east of Baton Rouge	69,400	64,957	1.07	24.3

Figure 4-1: Screen Line Location

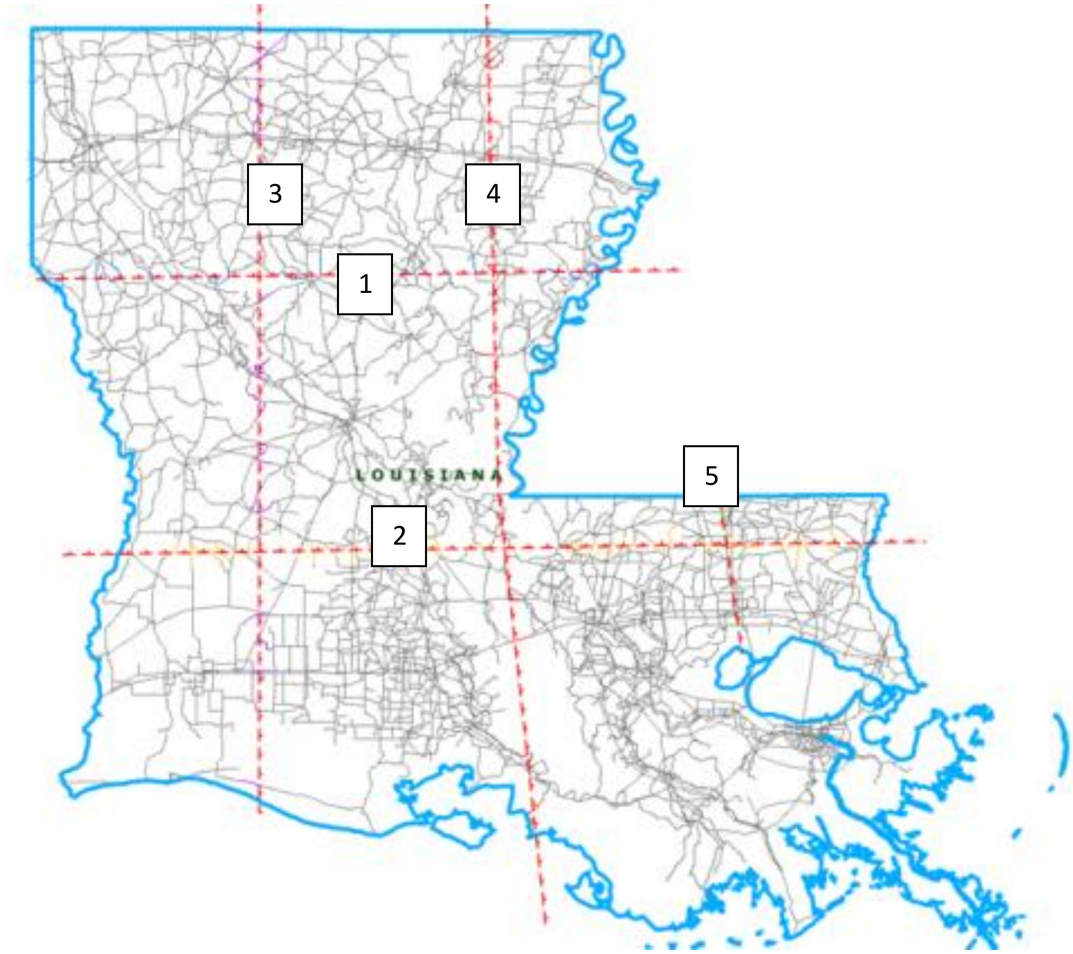


Table 4-3 compared all the counts in the network and model flows by functional classification.

Table 4-3: Volume vs. Count

Functional Class	Functional Description	Num. of Records	Length (mile)	COUNT	FLOW	Diff. (%)
1	Rural Interstate	116	265	4,045,653	4,155,737	2.72
2	Rural Principal Arterial	314	398	3,226,026	3,826,521	18.61
6	Rural Minor Arterial	488	670	3,121,324	3,546,460	13.62
7	Rural Major Collector	1,282	2,166	4,101,824	4,380,262	6.79
8	Rural Minor Collector	538	1,199	861,048	941,221	9.31
9	Rural Local Road	324	718	331,777	359,519	8.36
11	Urban Interstate	147	132	11,350,813	10,654,197	-6.14
12	Urban Arterial and Expressway	19	12	967,932	939,512	-2.94
14	Urban Other Principle Arterial	385	259	9,161,146	9,102,950	-0.64
16	Urban Minor Arterial	289	259	2,948,327	2,823,497	-4.23
17	Urban Collector	114	141	631,976	546,355	-13.55
19	Urban Local Road	27	33	95,838	49,933	-47.90
TOTAL		**4,043**	**6,252**	**40,843,684**	**41,326,165**	**1.18**

Figure 4-2 compares VMTs calculated based on counts and model flows by functional classification.

Figure 4-2: VMT by Functional Class (Count vs Model, 2016)

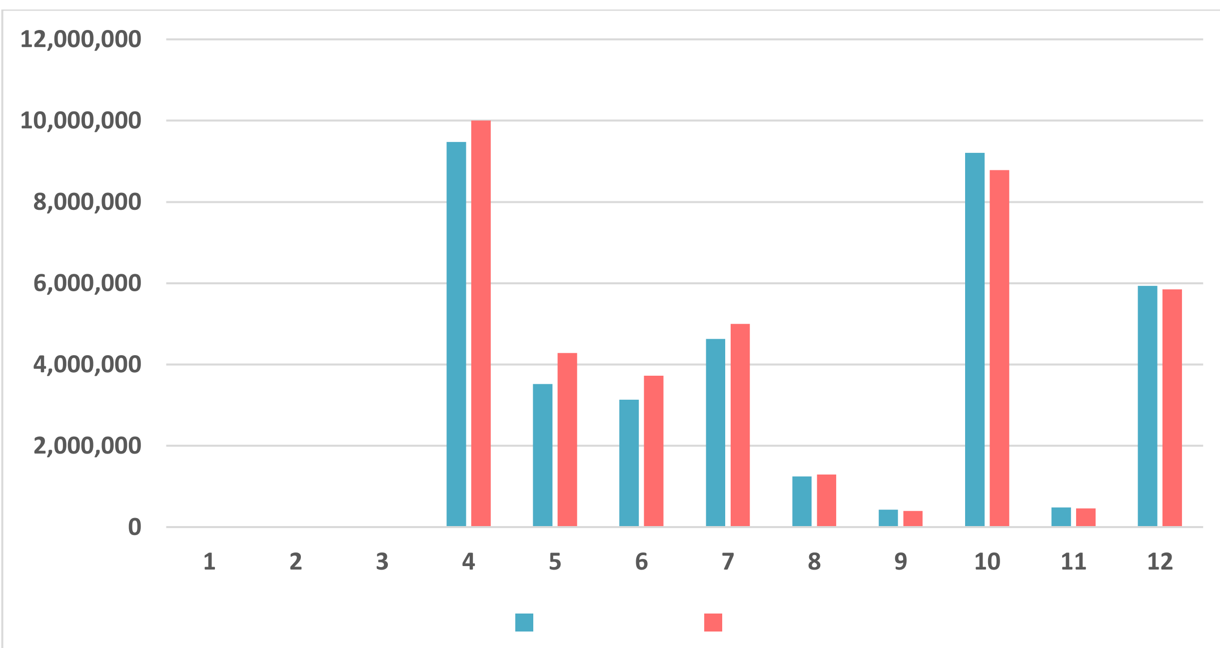


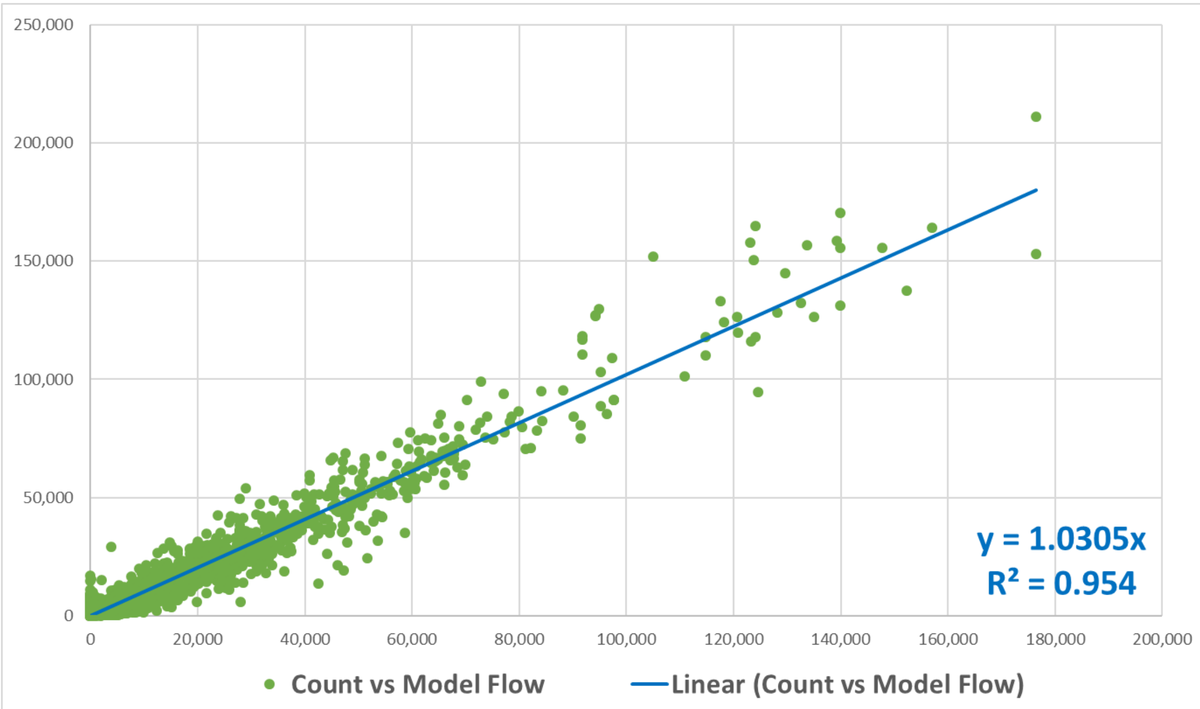
Table 4-4 contains the total VMT and VHT results by functional classification. In other words, **Table 4-4** covers all links except connectors whereas **Table 4-3** and **Figure 4-2** only takes links with counts into consideration. **Figure 4-2** is used to visually inspect that the model flow generated VMT is reasonably close to VMT calculated by counts. The total VMT and VHT in Error! Not a valid bookmark self-reference. can be utilized to calculate the average speed by functional class in the model, which will be particularly useful when comparing results with a future scenario.

Table 4-4: VMT and VHT (2016)

Functional Class	Functional Description	Num. of Records	Length (mile)	VMT	VHT	Average Speed (mph)
1	Rural Interstate	559	630	22,521,811	374,852	60
2	Rural Principal Arterial	1,571	1110	12,715,518	224,592	57
6	Rural Minor Arterial	2,352	1867	12,571,954	250,159	50
7	Rural Major Collector	5,315	5100	13,949,477	357,971	39
8	Rural Minor Collector	2,187	2984	4,349,588	109,453	40
9	Rural Local Road	1,260	1725	1,584,565	39,628	40
11	Urban Interstate	553	295	19,666,592	412,079	48
12	Urban Arterial and Expressway	109	52	2,203,387	75,135	29
14	Urban Other Principle Arterial	2,233	855	19,397,328	625,146	31
16	Urban Minor Arterial	1,580	860	7,988,556	289,657	28
17	Urban Collector	579	455	1,872,861	77,271	24
19	Urban Local Road	130	95	158,951	6,048	26
TOTAL		**18,428**	**16028**	**118,980,590**	**2,841,991**	**42**

The x-axis and y-axis in **Figure 4-3** represent model flows and link counts respectively. Ideally, all points should lie on the 45-degree line (slope=1), that is, y=x. The linear regression equation from the data points is y=1.0305x with a R-square of 0.954. This indicates the model flows are predicting actual counts in reasonably plausible manner at the statewide level.

Figure 4-3: Count vs Model Flow Scatter Plot



4.2 Model Management

The LASTM makes it easy to manage and develop different scenarios. The Model User's Guide gives detailed instructions for setting up the model, creating and running a scenario. The model consists of three major components:

- GISDK scripts
- Master files
- Parameter files

The GISKD scripts are contained in a folder called "interface". It generates the model interfaces and takes inputs from model users to create and run different scenarios.

The master files are stored in a folder called "master". It stores the master network and zone files as well as truck seed matrices. The files in the "master" should not be edited without careful consideration because each scenario after the change will always copy the files in it as a starting point. That is to say, changing the files in the "master" will affect all scenarios created subsequently. Each scenario folder is independent and will have both "input" and "output" sub-folders. The files in the "input" sub-folder are directly copied from selected files in the "master" folder. A recommended way is to modify the network and zone files in the "input" sub-folder of each scenario and avoid modifying the files in the "master" folder if possible.

The parameters files such as trip generation/attraction rates and gamma function coefficients are in the "parameters" folder. The script will extract values from it during each run.

5. FUTURE YEAR MODELS

5.1 Future Year Network

During this June 2018 model update, future year networks were updated and tested. All scenarios use the master network file in the "master" folder, which means the 2016, 2040 and 2044 model years share the same network file, but, with different attribute fields by network type. The network types are:

- Base year (BY)
- Existing plus Committed (EC)
- Alternative 1 (ALT1) – EC + Priority A
- Alternative 2 (ALT2) – EC + Priority B
- Alternative 3 (ALT3) – EC + Priority A&B
- Alternative 4 (ALT4) – EC + Priority A&B&C&D

Input roadway characteristic are represented by each of the network types. For example, the functional class for the 2016 base year is stored in a field called "FC_BY", whereas, the functional class for the future year Existing plus Committed network is stored in a field called "FC_EC". The priority projects are defined in the *Draft Final STP_8-31-15_Appendices A through I.pdf* document provided in the appendix of the LASTM User's Guide document.

5.2 Future Year Land Use Data

Similar to the master network file, the 2016, 2040 and 2044 land use data are stored in a master zone file with different attribute fields by year. **Table 5-1** shows the total population, employment and household assumed in 2016, 2040 and 2044.

Table 5-1: 2016, 2040 and 2044 Population, Household and Employment

Land Use Data	2016	2040	2044	2016-2044 Annual Growth
Population	4,787,043	5,930,053	5,729,560	0.64%
Household	1,836,984	2,248,571	2,194,198	0.64%
Employment	1,965,845	2,422,583	2,648,925	1.07%

5.3 Future Year Model Output

Table 5-2 and **Table 5-3** documents the VMT, VHT and average speed of the 2016, 2040 E+C and 2044 E+C runs. As expected, the average speed of the network decreases from 42 mph (2016) to 35 mph (2044), which suggests the proposed E+C improvements are not sufficient enough to maintain the current average traveling speed in 2044. This also confirms that the model is able to produce reasonable results based on different land use and network assumptions.

Table 5-2: 2016 and 2040 VMT and VHT

Functional Class	2016			2040		
	VMT	VHT	Average Speed	VMT	VHT	Average Speed
1	22,521,811	374,852	60	30,922,409	716,678	43
2	12,715,518	224,592	57	24,884,927	736,539	34
6	12,571,954	250,159	50	19,716,923	586,817	34
7	13,949,477	357,971	39	22,140,602	702,520	32
8	4,349,588	109,453	40	7,053,113	200,524	35
9	1,584,565	39,628	40	2,992,519	83,286	36
11	19,666,592	412,079	48	23,292,068	621,131	37
12	2,203,387	75,135	29	3,209,862	108,966	29
14	19,397,328	625,146	31	24,034,639	957,714	25
16	7,988,556	289,657	28	10,223,590	490,275	21
17	1,872,861	77,271	24	2,602,260	147,163	18
19	158,951	6,048	26	346,093	14,271	24
Total	**118,980,590**	**2,841,991**	**42**	**171,419,004**	**5,365,883**	**32**

Table 5-3: 2016 and 2044 VMT and VHT

Functional Class	2016			2044		
	VMT	VHT	Average Speed	VMT	VHT	Average Speed
1	22,521,811	374,852	60	30,075,952	670,299	45
2	12,715,518	224,592	57	21,134,433	558,446	38
6	12,571,954	250,159	50	17,895,116	455,892	39
7	13,949,477	357,971	39	20,240,610	593,552	34
8	4,349,588	109,453	40	6,377,551	173,560	37
9	1,584,565	39,628	40	2,477,694	67,783	37
11	19,666,592	412,079	48	23,135,210	598,766	39
12	2,203,387	75,135	29	3,058,695	91,502	33
14	19,397,328	625,146	31	23,223,179	863,952	27
16	7,988,556	289,657	28	9,710,168	417,564	23
17	1,872,861	77,271	24	2,460,759	121,768	20
19	158,951	6,048	26	286,465	12,369	23
Total	**118,980,590**	**2,841,991**	**42**	**160,075,831**	**4,625,456**	**35**