CAMBRIDGE SYSTEMATICS

KATS Travel Model

2016 Base Year Update

technical report

prepared for

KATS

prepared by

Cambridge Systematics, Inc.

July 6, 2021

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date

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1.0 Introduction

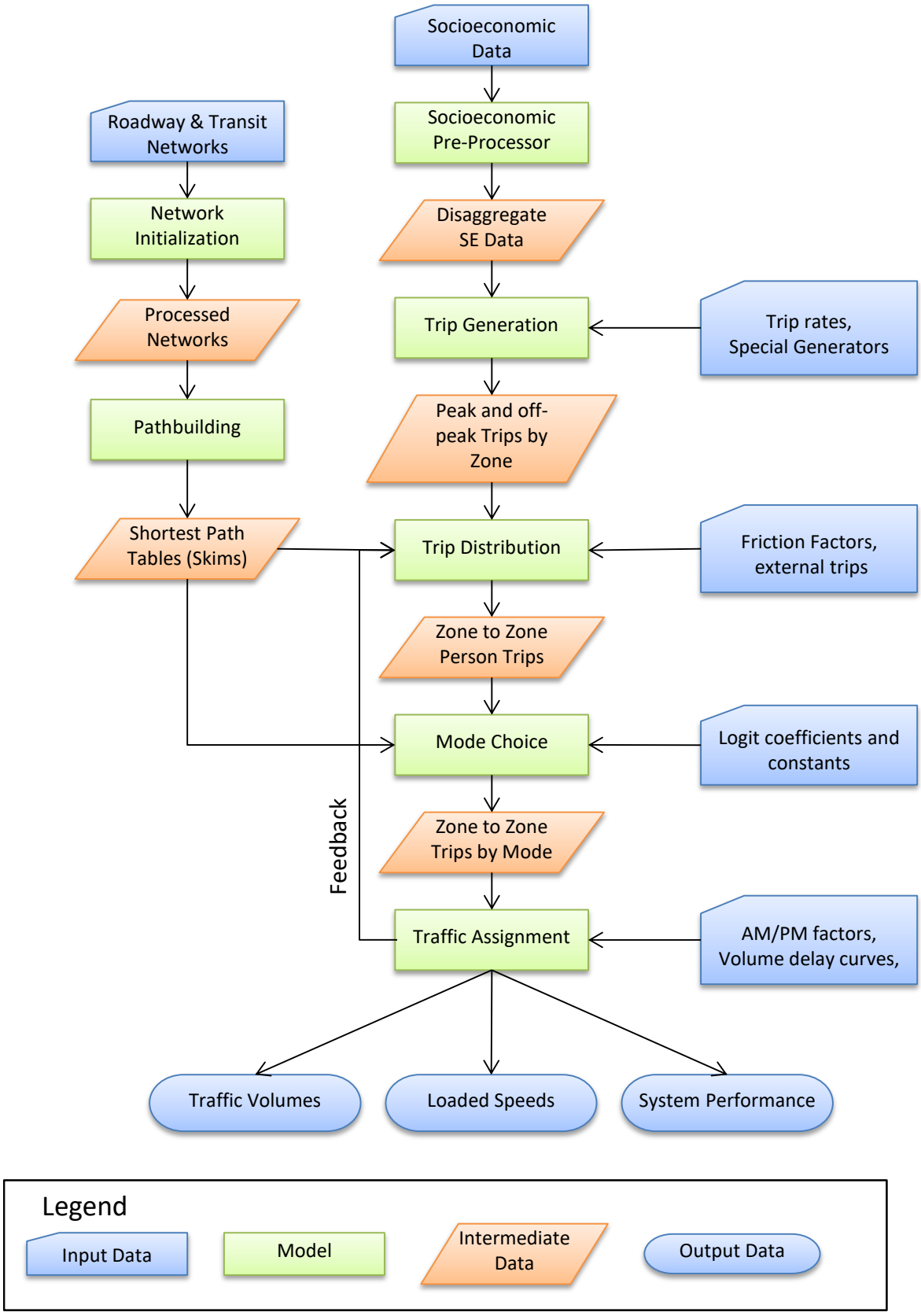
The Kalamazoo Area Transportation Study and member jurisdictions use the KATS Regional Travel Model (KATS Model) as a tool to forecast traffic and travel in Kalamazoo County and a portion of Van Buren County. The primary purpose of the travel model is to support the long range transportation plan (LRTP). In addition, the model can support evaluation of proposed roadway projects, help evaluate potential impacts of proposed development projects, and support various other studies of the region, subareas, corridors, and other planning activities.

The model was originally developed with a 2010 base year and has been updated and recalibrated to reflect a base year of 2016. The model is regularly kept up to date by KATS to reflect current conditions and the most recent available data. This memo describes the changes to the model to create the 2016 model base year. Major aspects of this update include:

- Use of the MI Travel Counts household travel survey to develop new trip generation rates and mode share and trip distribution calibration targets.
- Updates to the transit and roadway networks to reflect changes between 2010 and 2016.
- Use of 2016 socioeconomic data from the Census American Community Survey (ACS).
- Incorporation of traffic counts representing the 2016 base year.
- Calibration of model components.
- Validation to 2016 traffic counts and transit boarding data.

The KATS Model process and functions are shown in the model flow diagram in **Figure 1.1**. It is an adaptation of the standard 4-step modeling process that has dominated travel models in small and medium-sized communities in the U.S. for several decades.

Figure 1.1 Model Flow Chart



2.0 Network Updates

The roadway network is based on version 11a of the Michigan Geographic Framework (MGF), which represents 2010 conditions. The roadway network has been modified to represent changes between 2010 and 2016.

The KATS model utilizes a master network structure that allows maintenance of attributes representing different years and scenarios within a single file. Input network attributes used by the travel model include facility type, area type, number of lanes, speed limit, and direction of flow. Values for these attributes were populated on the roadway network file for the year 2010 in the prior update. New columns were added for each attribute for the 2016 base year. As the vast majority of roadways had the same conditions in 2010 and 2016, the columns are mostly identical between the years. Changes were made as directed by KATS and MDOT staff based on the changes to roadways.

2.1 Traffic Counts

KATS maintains an online traffic count database that served as the source of traffic count data for non-state roadways. The database contains latitude and longitude coordinates for each traffic count, as well as 24-hour traffic count data. A subset of the data features volumes by 15-minute increments. This database was joined to the roadway network using the geographic coordinates corresponding to each count location. MDOT also provided traffic count data for state facilities. This information was provided as a data table that included network link IDs. Between these two sources, traffic count values were matched to 741 links as summarized by facility type and area type in **Table 2.1**.

Table 2.1 Summary of Traffic Counts

	CBD	Urban	Suburban	Fringe	Rural	Total
Freeway	0	0	16	0	10	**26**
Expressway	0	0	2	0	2	**4**
Principal Arterial	4	41	94	0	3	**142**
Minor Arterial	10	45	154	0	68	**277**
Collector	3	15	83	0	107	**208**
Minor Collector	0	2	6	0	9	**17**
Ramp	0	4	36	0	15	**55**
Fwy to Fwy Ramp	0	0	12	0	0	**12**
Total	**17**	**107**	**403**	**0**	**214**	**741**

3.0 Socioeconomic and Household Survey Data

The 2016 model includes updated population and employment data for each traffic analysis zone (TAZ). Population data was retrieved from the 2013-2017 5-year American Community Survey (ACS) dataset. Employment data was developed based on detailed employment records provided by MDOT and broken out by industry type.

3.1 Population

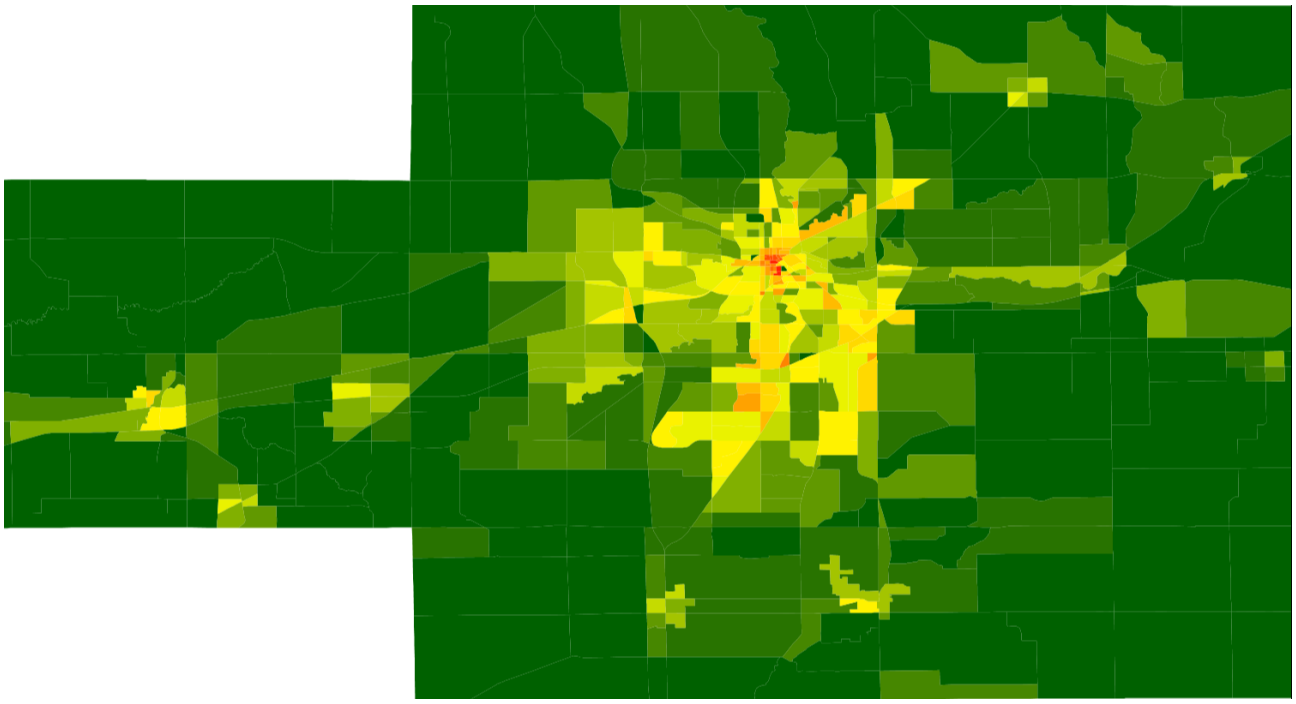
The Census population of households saw an increase of just under 6 percent, while the average size fell. As a result the number of people grew by less than 4 percent, as shown in **Table 3.1**. Median income rose in dollars but tracked with inflation, as per the consumer price index (CPI) provided by the Bureau of Labor Statistics (BLS). The model income categories were adjusted to match the income groups in the HTS and Census. Household density by TAZ, shown in **Figure 3.1**, rose slightly overall but did not change significantly from the 2010 model.

Table 3.1 Census Population Summary

Year	Households	People	Average HH Size	Average Workers/HH	Median Income
2010	114,684	289,717	2.53	1.14	$49,800
2016	120,995	300,403	2.48	1.25	$54,688

Source: 2010 KATS Model, American Community Survey 5-Year Estimates for 2013-2017

Figure 3.1 Density of Total Households (2016)



3.2 Employment

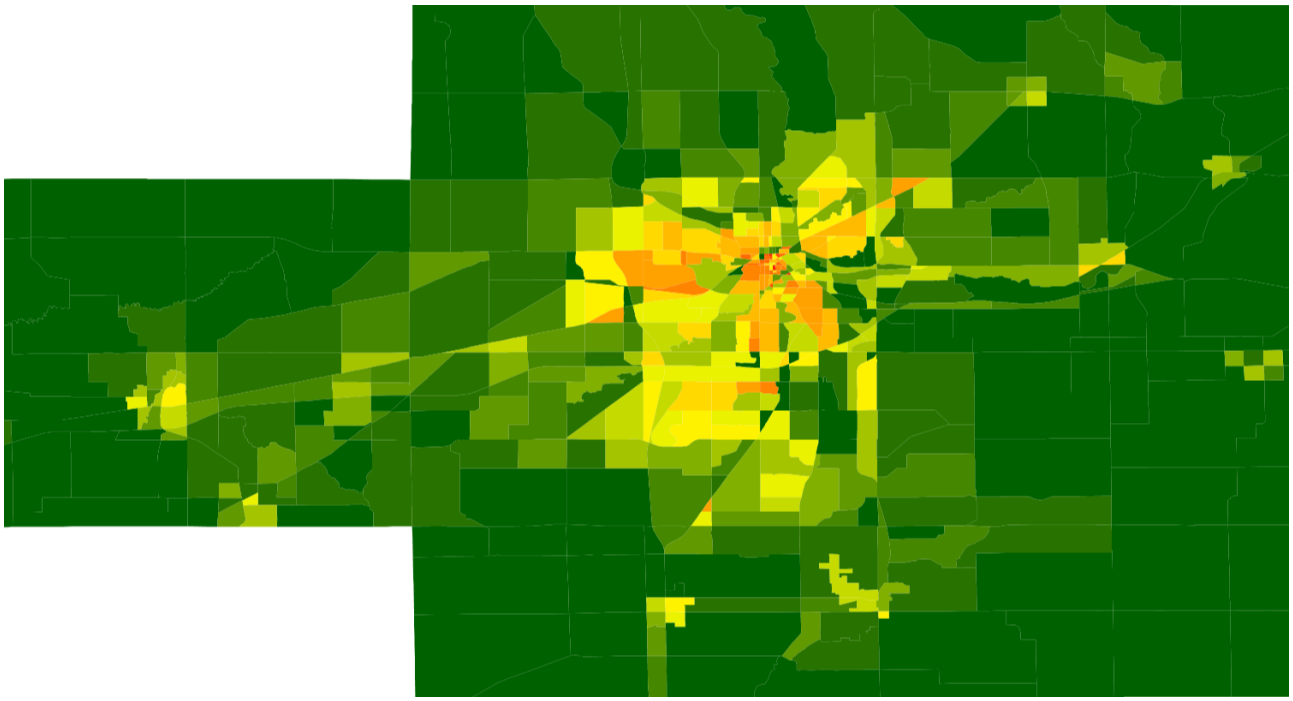
The model requires employment categorized into 4 employment types as a model input, with 2010 and 2016 values shown in **Table 3.2**. This update shows growth of almost 4% overall with medical jobs rising the most, and service adding the fewest jobs. While the changes were not completely uniform, the spatial distribution of employment shown in **Figure 3.2** is generally consistent with the 2016 dataset.

Table 3.2 Employment by Type

	Retail	Service	Basic	Medical	All
2010	32,393	56,026	41,503	16,928	146,850
2016	33,794	56,933	43,079	18,595	152,401

Source: 2010 KATS Model, 2016 Employment data provided by MDOT.

Figure 3.2 Density of Total Employment (2016)



4.0 Trip Generation

4.1 Production Rates

The KATS Model produces trips using rates classified by household income, size, and number of workers. Work trip rates including home-based work (HBW) and work-based other (WBO) trips are produced using household income and number of workers. All other trips are produced based on household size and income.

Income categories are defined based on ranges available in the MI Travel Counts HTS. **Table 4.1** demonstrates grouping of categories available in the survey data into the low, medium, and high income categories used by the model, with annual incomes shown in 2015 dollars. Trip rates increase for higher income groups, while transit share is highest for the lower income groups. A low to medium income cutpoint of $25,000 isolates households more likely to use transit, while a medium to high income cutpoint of $75,000 is placed where the number of daily trips per household increases from 8.9 to 11.2.

Table 4.1 Overall Trip Summary

Income Range	Total Trips per Household	HBW Trips per Household	Transit Share	Income Group
Less than $15,000	6.0	0.5	10.0%	Low
$15,000 to $24,999	7.9	0.9	1.1%	
$25,000 to $34,999	7.1	1.1	0.3%	Medium
$35,000 to $49,999	8.1	1.3	0.8%	
$50,000 to $74,999	8.9	1.6	0.0%	
$75,000 to $99,999	11.2	1.8	0.0%	High
$100,000 to $124,999	12.8	2.2	0.5%	
$125,000 to $149,999	10.3	1.8	0.8%	
$150,000 or more	12.8	2.1	0.0%	
All Income Levels	**8.9**	**1.4**	**1.4%**	

Source: MI Travel Counts Household Travel Survey

Trip rates for each purpose were calculated by dividing the number of weighted and expanded trips made by the number of households in each category. In cases where limited HTS records were available segments were combined to create more reliable results. The resulting production rates are shown in **Table 4.2** through **Table 4.6**. Home-based school and home-based university have been retained from the previous model.

Table 4.2 HBW Trip Production Rates

Income Group	0 Workers	1 Worker	2 Workers	3+ Workers	All Worker Groups
Low Income	0	1.12	2.33	3.53	**0.70**
Medium Income	0	1.30	2.33	3.53	**1.33**
High Income	0	1.37	2.33	3.53	**1.95**
All Incomes	**0**	**1.26**	**2.33**	**3.53**	**1.35**

Table 4.3 HBS Trip Production Rates

Income Group	1 Person	2 People	3 People	4 People	5+ People	All Sizes
Low Income	0.45	0.79	1.04	0.93	0.83	**0.64**
Medium Income	0.45	0.79	1.04	0.93	0.83	**0.75**
High Income	0.45	0.79	1.04	0.93	0.83	**0.84**
All Incomes	**0.45**	**0.79**	**1.04**	**0.93**	**0.83**	**0.75**

Table 4.4 HBO Trip Production Rates

Income Group	1 Person	2 People	3 People	4 People	5+ People	All Sizes
Low Income	1.60	2.98	3.53	5.91	7.08	**2.60**
Medium Income	1.60	2.98	3.53	5.91	7.08	**3.14**
High Income	1.60	2.98	4.27	5.91	7.08	**4.28**
All Incomes	**1.60**	**2.98**	**3.79**	**5.91**	**7.08**	**3.34**

Table 4.5 WBO Trip Production Rates

Income Group	0 Workers	1 Worker	2 Workers	3+ Workers	All Worker Groups
Low Income	0.08	1.12	2.33	2.94	**0.73**
Medium Income	0.08	1.30	2.33	2.94	**1.33**
High Income	0.08	1.37	2.33	4.05	**1.99**
All Incomes	**0.08**	**1.26**	**2.33**	**3.53**	**1.37**

Table 4.6 OBO Trip Production Rates

Income Group	1 Person	2 People	3 People	4 People	5+ People	All Sizes
Low Income	1.31	1.91	2.02	2.95	2.95	**1.68**
Medium Income	1.31	1.91	2.02	2.95	2.95	**1.90**
High Income	1.61	1.91	2.02	3.31	3.31	**2.42**
All Incomes	**1.34**	**1.91**	**2.02**	**3.16**	**3.12**	**2.00**

Table 4.7 Trip Production Rate Summary

	HBW	HBS	HBO	WBO	OBO	All Home-Based	Total
Low Income	0.70	0.83	7.08	0.73	2.95	8.61	**12.28**
Medium Income	1.33	0.83	7.08	1.33	2.95	9.24	**13.52**
High Income	1.95	0.83	7.08	1.99	3.31	9.85	**15.15**
All Incomes	**1.35**	**0.83**	**7.08**	**1.37**	**3.12**	**9.26**	**13.75**

4.2 Attraction Rates

Trip attraction rates are primarily based on employment. A small number of trip attractions are also generated at households. Using trip information in the MI Counts data, including trip purpose and location name, each trip attraction was classified as occurring at a household (9%) or a location with retail (36%), basic (3%), service (45%), or medical (8%) employment. Total attractions by purpose and attraction variable are shown in **Table 4.8**, with resulting trip attraction rates shown in **Table 4.9**.

Table 4.8 Trips by Attraction Rate Variable

Attraction Variable	HBW	HBS	HBO	WBO	OBO	Total Attractions	SED Total*
Retail	21,906	79,520	88,740	40,038	112,998	343,202	343,202
Service	75,462	1,781	176,762	33,998	69,240	357,243	425,276
Medical	24,522	0	34,476	6,062	11,076	76,137	76,393
Basic	21,200	0	3,101	3,008	571	27,880	27,880
Households	3,764	529	52,722	6,703	18,742	82,459	82,459
Total Attractions	135,256	73,925	299,539	299,539	299,539	1,107,798	

*Totals employment by type or total households Source: MI Travel Counts Household Travel Survey

Table 4.9 Table 10: Trip Attraction Rates

	HBW	HBS	HBO	WBO	OBO	All Purposes
Retail	0.6	2.4	2.6	1.2	3.3	10.2
Service	1.3	0.0	3.1	0.6	1.2	7.5
Medical	1.3	0.0	1.9	0.3	0.6	4.1
Basic	0.5	0.0	0.1	0.1	0.0	0.6
Households	0.0	0.0	0.4	0.1	0.2	0.7
All Employees	0.5	0.3	1.3	0.3	0.8	3.5

5.0 Trip Distribution

Trip distribution matches production and attraction trip-ends from trip generation to make complete trips. The KATS Model uses a gravity approach that considers travel time and activity level to distribute trips. The gravity model has been recalibrated to trip length frequency distributions obtained from the MI Travel Counts HTS.

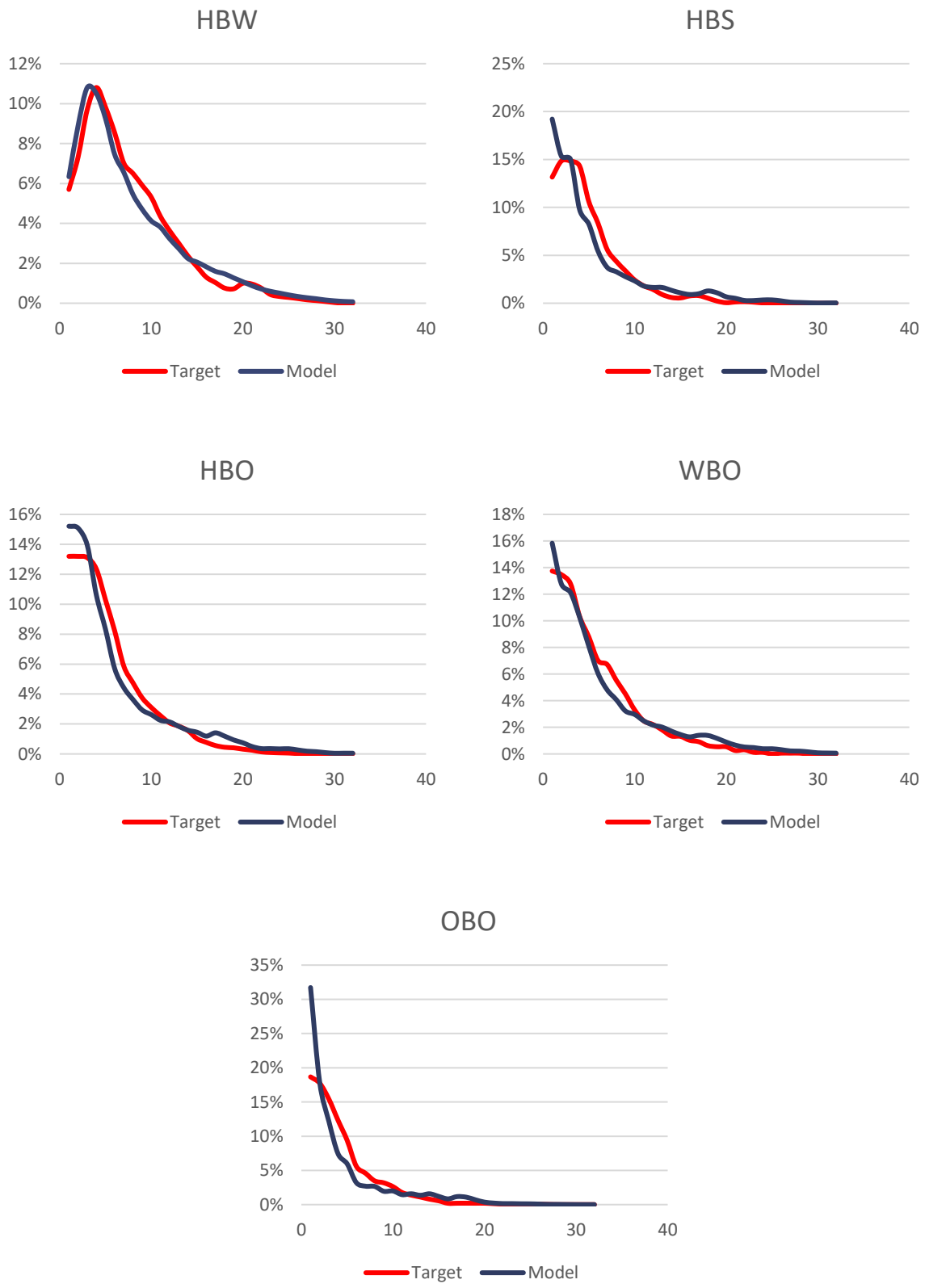
5.1 Calibration Targets

Updated calibration targets have been calculated using the weighted MI Counts 2015 HTS along with the shortest path ("skim") matrices generated from the travel model highway network. The two principal calibration targets the trip length frequency distribution and average trip length. The percent share of intrazonal trips is considered in calibration.

5.2 Calibration Results

The KATS model has been calibrated to match the survey-based targets. This was completed through an iterative process in which the model was first run with the previous parameter values and then updated until model outputs were reasonably consistent with calibration targets. This process resulted in distributions and average distances close to that of the HTS as shown in **Figure 5.1**. HBW was segmented by income group for this calibration, then results were combined for display in the figure below. Average length and the coincidence ratios are shown in **Table 5.1** below. Some differences between calibration targets and model calibration results remain, as it was important to balance this calibration with later validation to total VMT as represented by traffic counts.

Figure 5.1 Trip Length Distributions by Purpose



Source: MI Travel Counts Household Travel Survey and KATS model output

Table 5.1 Coincidence Ratios and Average Trip Lengths

Trip Purpose	Coincidence Ratio (of Distribution)	Observed Average Trip Length (Miles)	Modeled Average Trip Length (Miles)
HBW Income 1	96%	5.86	5.87
HBW Income 2	98%	6.82	6.91
HBW Income 3	94%	7.98	7.94
HBS	95%	4.40	5.01
HBO	98%	4.90	5.53
WBO	99%	5.19	6.00
OBO	91%	3.82	4.00

6.0 Mode Choice

6.1 Calibration Targets

Mode choice calibration targets have been developed using a combination of transit boarding data and mode shares reported in the HTS. Auto and non-motorized mode shares are obtained from the household travel survey. The survey did not capture a sufficient number of transit trips to develop reliable mode share targets. Transit calibration targets are instead based on boarding and transfer rate provided by transit operators. Transit trip totals have been separated by trip purpose using distributions retained from the previous model.

As shown in **Table 6.1**, drive alone dominates for work related travel (HBW and WBO) while other travel tends to involve more than one person. Non-auto travel holds a small share, mostly trips made by walking for non-HBW trips. HBW is broken out by income group to capture variations in commutes by different households. Lower income households tend to share rides or use transit more to get to work.

Table 6.1 Mode Choice Calibration Targets

	Transit	Drive Alone	Shared Ride	Bike	Walk
HBW	2,054	78%	20%	1.0%	0.8%
HBS	381	47%	48%	0.0%	4.6%
HBO	2,207	35%	55%	0.6%	7.3%
OBO	381	33%	56%	0.7%	4.7%
WBO	1,522	70%	23%	0.2%	5.3%
non-HBW	4,491	40%	52%	0.5%	6.2%
HBW Income 1	1,674	71%	27%	1.1%	0.0%
HBW Income 2	228	78%	19%	0.9%	1.5%
HBW Income 3	152	82%	16%	0.9%	0.6%
All	7,611	44%	45%	0.6%	5.2%

Note: Targets for transit are shown as linked trips. Targets for all other modes are shown as shares of non-transit trips.
Source: MI Travel Counts Household Travel Survey and FTA 2016 KATS Agency Profile

6.2 Calibration Results

Alternative specific constants were updated to match the target mode shares using an automated calibration routine built into the KATS model system. The resulting alternative specific constants for each mode are provided in **Table 6.2**. School and University trip target mode shares were not changed in this update, but alternative specific constants were updated by the calibration routine to ensure that the updated model produces reasonable mode shares. All other aspects of the model choice model such as utility variable coefficients and the model structure remain unchanged from the previous model.

Table 6.2 Alternative Specific Constants

Trip Purpose	Drive Alone	Shared Ride	Transit	Walk	Bike
HBW (Low Income)	0	-1.1618	0.4396	-2.4896	-0.4136
HBW (Med Income)	0	-1.5206	-3.4972	-2.4896	-0.4136
HBW (High Income)	0	-1.8491	-3.6093	-2.4896	-0.4136
HBS	0	-0.3903	-3.1326	-2.1747	-1.7776
HBU	0	-1.3589	-0.896	-0.2229	2.2282
HBSc	0	1.182	-0.9323	0.1828	0.4504
HBO	0	0.1703	-2.8612	-1.3973	-0.8086
WBO	0	-1.1448	-4.2916	-2.1617	-2.2516
OBO	0	0.5287	-3.0397	-2.1215	-2.4601

7.0 External Travel

In addition to the internal-internal trips that occur entirely within the modeling area, the model must include external travel from outside of the region. Trips with one end inside the modeling area and the other outside of the area are called internal-external (IE) or external-internal (EI) trips. Through trips, or external-external (EE) trips, are those that pass through the modeling area without stopping or with only short convenience stops. The volume of entrances and exits are calibrated based on vehicle counts on roads crossing the model boundary at 24 specified external stations. These locations are mapped in **Figure 7.1**.

The update involved revising the model to make use of 2016 count data. Where possible, the counts shown in **Table 7.1** represent observed model volumes at the model boundary. In cases where traffic counts were not available at the model boundary, estimated external volumes were developed using the best available count data. In cases where no count data were available to develop a new estimate, values from the previous model were retained. Model methodology and parameters such pass-through shares, trip purpose shares for IE/EI trips, and the EE trip seed matrix were retained from the 2010 model.

Figure 7.1 External Station Locations

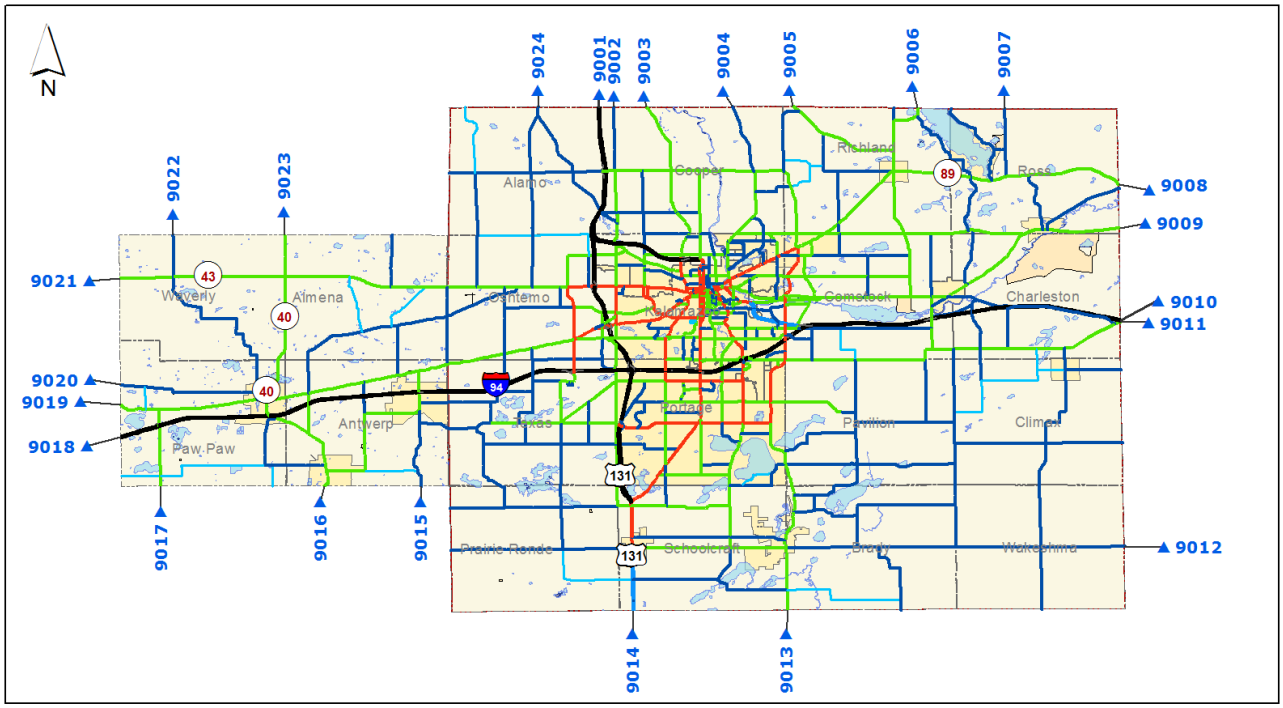


Table 7.1 External Station Volumes and IE/EE Splits

ID	Description	Count	Pass Through %
9001	131 N of County Line	42,479	21.1%
9002	12th St N of County Line	3,881	0.7%
9003	Douglas Ave N of County Line	3,924	0.0%
9004	Riverview Dr N of County Line		0.7%
9005	Richplain Rd N of County Line	8,388	27.8%
9006	M43 N of County Line	11,449	8.3%
9007	40th N of County Line	1,924	62.6%
9008	D Ave E of County Line	8,636	47.6%
9009	M96 E of County Line	9,374	1.4%
9010	I94 E of County Line	49,928	30.6%
9011	Mercury Drive E of County Line	4,858	0.7%
9012	W Ave W of County Line	579	0.8%
9013	24th S of County Line		0.9%
9014	US131 S of County Line	27,577	26.4%
9015	652 S of 72nd		11.9%
9016	M40 S of 72nd	7,577	22.6%
9017	M51 S of 72nd	7,759	41.9%
9018	I94 W of 46th St	37,613	49.0%
9019	Red Arrow Highway W of 56th Ave	5,218	20.2%
9020	CR374 W of 46th St	1,217	0.7%
9021	M43 W of 46th St	7,966	33.4%
9022	CR665 N of 24th Ave	3,658	33.4%
9023	M40 N of 24th Ave	7,202	28.8%
9024	Ravine Rd N of County Line	5,257	2.8%

Source: KATS and MDOT Traffic Counts, 2010 KATS Model assumptions where needed.

8.0 Validation

Traffic assignment results have been validated based on the traffic counts described in Section 2.1. Two measures of model calibration are presented in **Table 8.1**. The count/volume ratio demonstrates the model's ability to match overall regional activity levels. This ratio should be close to 100% overall, with increasing variation accepted for smaller facilities types such as minor arterials and collectors. The root mean square error (RMSE) and percent root mean square error (%RMSE) represent the model's ability to match specific count volumes. RMSE measures can overemphasize errors on low volume links, so they are expected to be higher for lower facility types.

The primary tools used in improving model validation were adjustments to trip rates through application of trip rate factors and adjustments to trip distribution calibration. Some localized network adjustments such as relocation of centroid connector loadings were also made to improve model validation. Trip rate factors resulting from the validation exercise are shown in **Table 8.2**.

Table 8.1 Assignment Validation

	Number of Counts	Model Volume / Count Volume	RMSE	% RMSE
Freeway	26	96%	3,514	16%
Expressway	4	110%	2,025	22%
Principal Arterial	142	104%	5,245	27%
Minor Arterial	277	104%	2,747	33%
Collector	225	203%	2,858	187%
CBD	17	109%	2,225	32%
Urban	107	109%	3,597	38%
Suburban	403	102%	3,401	31%
Rural	214	101%	2,588	52%
All Links	741	103%	3,189	36%

Table 8.2 Trip Rate Factors

	CBD	Urban	Suburban	Rural
HBW	0.71	0.78	1.7	1.38
HBS	0.82	0.84	1.92	1.38
HBU	0.71	0.78	1.7	1.38
HBSc	0.82	0.84	1.92	1.38
HBO	0.58	0.54	0.67	0.49
WBO Productions	1.1	1.1	1.38	1.65
WBO Attractions*	1.65	1.43	1.87	1.21
OBO Productions	1.1	1.1	1.38	1.65
OBO Attractions	1.65	1.43	1.87	1.21

* WBO attraction rate factors are applied to both WBO attraction rates and to WBO production allocation rates