MEMO

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CC:	Jay Evans (RSG), Steve Tuttle (RSG)
DATE:	October 15, 2020
SUBJECT:	KRTM Model Revalidation for 2018

This memo outlines the RSG team's revalidation of the Knoxville Regional Travel Model (KRTM) for the base year of 2018. The previous version of the KRTM was implemented in TransCAD 6.0 and was calibrated/validated for 2010. As part of this contract, RSG upgraded the model from TransCAD 6.0 to TransCAD 8.0 for the base year of 2018.

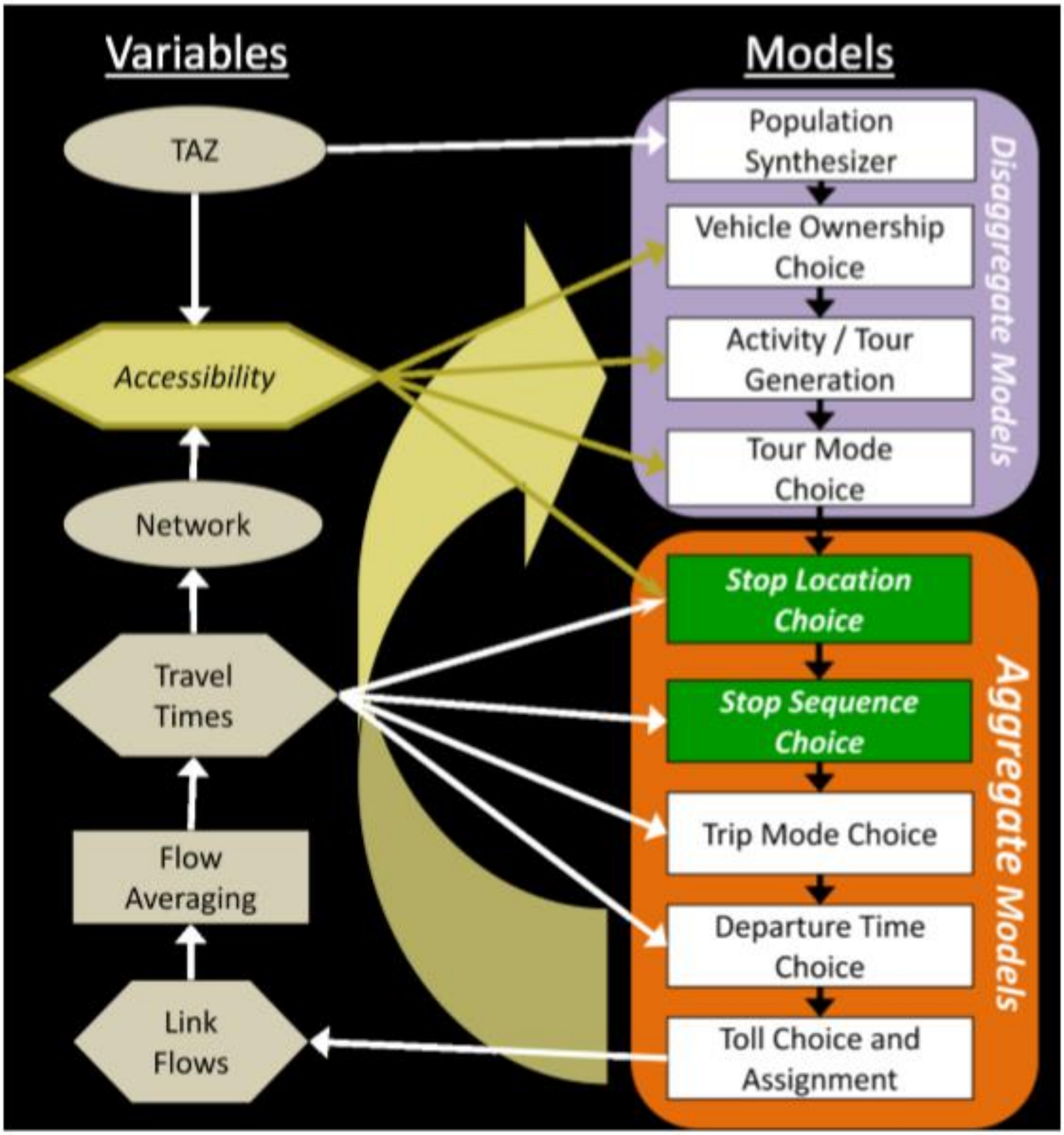
Although the results of the previous version for 2018 were also acceptable (the overall loading error was close to 0%), the upgraded model showed global underloading by more than 6%. Major inconsistencies also exist between TransCAD 6.0 and TransCAD 8.0 such as highway and transit skimming. For example, left-turn penalties are not considered in highway path building in TransCAD 8.0, but these affect path choices in TransCAD 6.0.

Moreover, some parameters such as weights for different legs of transit trips are not read when TransCAD 6.0 creates transit networks. Different skims (highway and transit) in the two TransCAD versions are the main source of different final loading errors as they influence components of the model such as tour generation, tour mode choice, stop location choice, stop sequence choice, and traffic assignment. Hence, the model recalibration and revalidation in TransCAD 8.0 was necessary.

Since no new survey data exist for 2018 for the study area, RSG revalidated the model based on current calibrated components of the model. The revalidation, therefore, did not involve all model components. This is because some still produced reasonable outputs compared with the observed data (all surveys and data used in the latest model calibration/validation in 2012). In contrast, there are other parts of the model that need updates as their results do not follow the observed patterns in the surveys.

Figure 1 illustrates the hybrid design of the KRTM. As noted, not all elements shown in Figure 1 need to be modified as part of this revalidation. **This memo describes only parts of the model that have been updated as part of the revalidation**.

FIGURE 1. KRTM DESIGN



Source: Knoxville Regional Travel Model Update 2012 (Model Development and Validation Report)

1.1 TOUR AND STOP GENERATION

The KRTM had been calibrated in 2012 based on the 2010 Decennial Census and the 2005–2009 American Community Survey (ACS) along with combined regional household travel surveys conducted in 2000 and 2008. The 2007–2009 economic recession (Great Recession), therefore, has influenced the data used in the KRTM calibration. The model was underloaded for 2018. The underrepresented tours/trips could be attributable to the economy recovery that continued between 2013 and 2015, during which time more trips were observed across regions. Hence, a slight observed increase in tour generation for 2018 is a reasonable update to the model and addresses the underloading issue. Here are the updates to the tour and stop generation component of the model:

1. Increase in work tour generation by 1%.
2. Increase in work stop generation by 1%.
3. Increase in other tour generation by 1%.
4. Increase in other stop generation by 1%.
5. Increase in visitor tour generation by 2.5%.
6. Increase in visitor stop generation by 2.5%.
7. Increase in small commercial vehicle trips by 1%.

The new tour and stop generation models produce slightly more tours and stops than the previous version. However, the changes are minimal. Growth by 1% for work and other tours and stops in eight years is reasonable because the survey data that was used in the calibration may reflect the Great Recession. The same rates as the previous version were used for the school tours and stops generation because school trips were likely not influenced by the recession. Table 1 shows the household generation rates in the updated KRTM and the corresponding rates from the surveys.

TABLE 1. HOUSEHOLD GENERATION RATES

RATE	NCHRP 365 AVERAGE	KNOXVILLE COMBINED HH SURVEY FROM 2000 & 2008	OLD KNOXVILLE MODEL BASE YEAR 2006	NHTS 2009 TN STATEWIDE	NHTS 2009 ADD-ON FOR KNOXVILLE AREA	KRTM 2010	KRTM 2020
Tours/HH/Day	3.47	2.86	2.87	2.99	2.66	2.98	3.02
Stops/HH/Day	5.54	5.51	5.52	6.20	5.27	5.81	6.05
Trips/HH/Day	9.00	8.37	8.49	9.18	7.93	8.79	9.07
Stops/Tour	1.60	1.93	1.96	2.07	1.98	1.95	2.00

As shown in Table 1, the updated model shows slightly higher rates than local surveys—but still lower than statewide rates. Based on the 2012 model update documentation, the National Household Travel Survey (NHTS) sample size for the Knoxville area is less than 300 households, which might lead to errors in the estimates. These observations indicate the new rates in the updated model are within the acceptable range. Table 2 reports the number of generated tours and stops by type tour in the updated KRTM.

TABLE 2. NUMBER OF GENERATED TOURS AND STOPS BY PURPOSE

TRIP TYPE	OBSERVED	MODEL
Work Tours		429,732
Work Tours	Work Stops (Low-Income)	72,463
	Work Stops (Other)	476,253
	College Stops	9,586
	Other Stops	412,814
School Tours		193,218
School Tours	School Stops	197,700
	Other Stops	91,679
Other Tours		646,995
Other Tours	Short Maintenance Stops	533,132
	Long Maintenance Stops	336,003
	Discretionary Stops	412,961

1.2 STOP LOCATION CHOICE MODEL

The trip distribution in the KRTM is conducted through two steps:

1. Step location choice model.
2. Stop sequence choice model.

Since no new survey is available for recalibration of these models, RSG reviewed the outputs of these models and compared them with the observed measures such as mean travel time from home, percentage of intrazonal tours/trips, and average trip length by purpose from the survey data used in the calibration of the previous model version. The goal was to approximate observed measures since the 2018 metrics were somewhat far from targets. The utility function used in the destination choice model for stop location choice model includes several terms and most of them remained unchanged; however, two variables' parameters were adjusted. The first one is applying to the term comprised of travel time interacted with residential accessibility. The second one is applied to the intrazonal bias term. Table 3 shows the previous values of these coefficients in the original model and the updated values. Table 4 reports the mean travel time from home and the percentage of intrazonal trips in the survey and updated model.

TABLE 3. STOP LOCATION CHOICE MODEL PARAMETERS

TOUR TYPE	STOP TYPE	TRAVEL TIME X RESIDENCE ACCESSIBILITY		INTRAZONAL BIAS	
		KRTM 2012	KRTM 2020	KRTM 2012	KRTM 2020
Work Tours	Work (Low-Income) Stops	-0.01560	-0.01160	0.5615	1.2415
	Work Stops	-0.01078	-0.00928	0.7909	1.1009
	College Stops	-0.01128	-0.01128	0.0000	0.0000
	Nonwork Stops	-0.01544	-0.01384	0.2870	0.6570
UT Tours	Other Stops	-0.00553	-0.00253	2.5000	3.2000
School Tours	School Stops	-0.02837	-0.02337	1.4144	2.1144
	Other Stops	-0.02215	-0.02075	0.4335	0.7335
Other Tours	Short Maintenance Stops	-0.01981	-0.01281	-0.2101	1.1101
	Long Maintenance Stops	-0.02170	-0.02070	0.1771	0.1871
	Discretionary Stops	-0.03002	-0.03002	0.4284	0.4254

TABLE 4. STOP LENGTHS AND INTRAZONAL SHARES

TOUR TYPE	STOP TYPE	MEAN TRAVEL TIME FROM HOME (MIN)		PERCENTAGE INTRAZONAL	
		OBSERVED	KRTM 2020	OBSERVED	KRTM 2020
Work Tours	Work (Low-Income) Stops	15.3	15.5	3.3	3.3
	Work Stops	18.5	18.5	3.0	2.8
	College Stops	20.8	20.7	0.0	0.6
	Nonwork Stops	14.6	14.4	4.2	4.3
UT Tours	Other Stops	15.9	16.3	4.2	4.2
School Tours	School Stops	10.1	10.1	11.3	11.2
	Other Stops	12.4	12.4	8.8	8.9
Other Tours	Short Maintenance Stops	11.7	11.7	7.6	7.5
	Long Maintenance Stops	15.0	14.9	3.4	3.1
	Discretionary Stops	14.2	14.6	6.6	6.5

As shown in Table 4, the average travel time from home and intrazonal percentage in the updated model are in good agreement with the observed measures. RSG also compared county-to-county work flows from the model with 2010 Census journey-to-work data that exist in the original model documentation. Because flows represented trips in different years, RSG compared the percentage of total trips for each pair of counties. Table 5 presents the ACS 2006–2008, Table 6 shows the 2010 Census journey-to-work, and Table 7 reports the model county-to-county flow percentages. The differences between the model and ACS percentages are shown in Table 8, and the differences between the model and Census data are reported in Table 9. According to Table 8 and Table 9, the updated destination choice model accurately captured the patterns in the observed data.

TABLE 5. CENSUS JOURNEY-TO-WORK FLOW PERCENTAGES FROM ACS 2006–2008

COUNTY	ANDERSON	BLOUNT	GRAINGER	HAMBLEN	JEFFERSON	KNOX	LOUDON	ROANE	SEVIER	UNION	TOTAL
Anderson	4.6	0.1	0.0	0.0	0.0	2.2	0.0	0.2	0.0	0.0	**7.1**
Blount	0.2	8.8	0.0	0.0	0.0	3.3	0.2	0.0	0.4	0.0	**13.0**
Grainger	0.0	0.0	0.8	0.5	0.1	0.6	0.0	0.0	0.1	0.0	**2.1**
Hamblen	0.0	0.0	0.1	4.9	0.4	0.2	0.0	0.0	0.1	0.0	**5.7**
Jefferson	0.0	0.0	0.0	0.9	2.4	1.1	0.0	0.0	0.6	0.0	**5.1**
Knox	2.8	1.6	0.0	0.1	0.1	42.3	0.5	0.2	0.5	0.0	**48.2**
Loudon	0.2	0.4	0.0	0.0	0.0	1.4	2.5	0.1	0.0	0.0	**4.6**
Roane	1.0	0.1	0.0	0.0	0.0	0.9	0.3	2.6	0.0	0.0	**4.9**
Sevier	0.1	0.2	0.0	0.1	0.1	1.8	0.0	0.0	7.1	0.0	**9.4**
Union	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Total	**8.9**	**11.3**	**0.9**	**6.4**	**3.2**	**53.8**	**3.5**	**3.2**	**8.8**	**0.0**	**100**

TABLE 6. 2010 COUNTY-TO-COUNTY WORK FLOW PERCENTAGES FROM CENSUS JOURNEY-TO-WORK DATA

COUNTY	ANDERSON	BLOUNT	GRAINGER	HAMBLEN	JEFFERSON	KNOX	LOUDON	ROANE	SEVIER	UNION	TOTAL
Anderson	4.8	0.1	0.0	0.0	0.0	2.2	0.0	0.3	0.0	0.0	**7.4**
Blount	0.2	8.4	0.0	0.0	0.0	3.2	0.2	0.0	0.4	0.0	**12.4**
Grainger	0.0	0.0	0.8	0.5	0.1	0.6	0.0	0.0	0.1	0.0	**2.1**
Hamblen	0.0	0.0	0.1	5.0	0.4	0.2	0.0	0.0	0.1	0.0	**5.9**
Jefferson	0.0	0.0	0.0	0.9	2.3	1.0	0.0	0.0	0.6	0.0	**4.9**
Knox	2.9	1.5	0.0	0.1	0.1	40.8	0.5	0.2	0.5	0.1	**46.8**
Loudon	0.2	0.3	0.0	0.0	0.0	1.4	2.6	0.1	0.0	0.0	**4.5**
Roane	1.1	0.1	0.0	0.0	0.0	0.9	0.3	2.9	0.0	0.0	**5.2**
Sevier	0.1	0.2	0.0	0.1	0.1	1.7	0.0	0.0	6.9	0.0	**9.2**
Union	0.1	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.6	**1.6**
Total	**9.4**	**10.7**	**0.9**	**6.6**	**3.1**	**52.7**	**3.6**	**3.5**	**8.6**	**0.8**	**100**

TABLE 7. MODEL COUNTY-TO-COUNTY WORK FLOW PERCENTAGES (2018)

COUNTY	ANDERSON	BLOUNT	GRAINGER	HAMBLEN	JEFFERSON	KNOX	LOUDON	ROANE	SEVIER	UNION	TOTAL
Anderson	4.4	0.1	0.0	0.0	0.0	2.0	0.1	0.4	0.0	0.0	**7.0**
Blount	0.2	8.0	0.0	0.0	0.0	3.3	0.4	0.1	0.7	0.0	**12.7**
Grainger	0.0	0.0	0.6	0.6	0.2	0.5	0.0	0.0	0.0	0.0	**1.9**
Hamblen	0.0	0.0	0.2	4.7	0.5	0.1	0.0	0.0	0.0	0.0	**5.6**
Jefferson	0.0	0.0	0.1	1.2	2.0	0.7	0.0	0.0	0.6	0.0	**4.7**
Knox	2.5	2.0	0.2	0.1	0.2	40.7	0.9	0.5	0.7	0.2	**48.0**
Loudon	0.1	0.4	0.0	0.0	0.0	1.5	1.9	0.4	0.0	0.0	**4.4**
Roane	0.8	0.1	0.0	0.0	0.0	0.5	0.4	2.7	0.0	0.0	**4.5**
Sevier	0.0	0.4	0.0	0.1	0.3	1.0	0.0	0.0	7.8	0.0	**9.7**
Union	0.2	0.0	0.1	0.0	0.0	0.7	0.0	0.0	0.0	0.5	**1.5**
Total	**8.3**	**11.0**	**1.2**	**6.7**	**3.2**	**51.1**	**3.7**	**4.0**	**9.9**	**0.8**	**100**

TABLE 8. DIFFERENCE BETWEEN THE MODEL AND ACS COUNTY-TO-COUNTY WORK FLOW PERCENTAGES

COUNTY	ANDERSON	BLOUNT	GRAINGER	HAMBLEN	JEFFERSON	KNOX	LOUDON	ROANE	SEVIER	UNION	TOTAL
Anderson	-0.2	0.0	0.0	0.0	0.0	-0.2	0.0	0.1	0.0	0.0	**-0.1**
Blount	0.0	-0.8	0.0	0.0	0.0	-0.1	0.3	0.0	0.3	0.0	**-0.3**
Grainger	0.0	0.0	-0.2	0.1	0.0	-0.1	0.0	0.0	-0.1	0.0	**-0.2**
Hamblen	0.0	0.0	0.2	-0.2	0.1	-0.1	0.0	0.0	-0.1	0.0	**-0.1**
Jefferson	0.0	0.0	0.1	0.3	-0.4	-0.4	0.0	0.0	0.0	0.0	**-0.3**
Knox	-0.3	0.4	0.1	0.0	0.1	-1.6	0.3	0.3	0.2	0.2	**-0.2**
Loudon	0.0	0.0	0.0	0.0	0.0	0.1	-0.6	0.3	0.0	0.0	**-0.2**
Roane	-0.2	0.0	0.0	0.0	0.0	-0.4	0.1	0.1	0.0	0.0	**-0.4**
Sevier	0.0	0.2	0.0	0.0	0.2	-0.7	0.0	0.0	0.7	0.0	**0.3**
Union	0.2	0.0	0.1	0.0	0.0	0.7	0.0	0.0	0.0	0.5	**1.5**
Total	**-0.5**	**-0.2**	**0.3**	**0.3**	**0.0**	**-2.7**	**0.2**	**0.9**	**1.1**	**0.8**	**0.0**

TABLE 9. DIFFERENCE BETWEEN THE MODEL AND CENSUS COUNTY-TO-COUNTY WORK FLOW PERCENTAGES

COUNTY	ANDERSON	BLOUNT	GRAINGER	HAMBLEN	JEFFERSON	KNOX	LOUDON	ROANE	SEVIER	UNION	TOTAL
Anderson	-0.5	0.0	0.0	0.0	0.0	-0.2	0.0	0.1	0.0	0.0	**-0.5**
Blount	0.0	-0.3	0.0	0.0	0.0	0.1	0.3	0.0	0.3	0.0	**0.3**
Grainger	0.0	0.0	-0.2	0.1	0.0	-0.1	0.0	0.0	-0.1	0.0	**-0.2**
Hamblen	0.0	0.0	0.2	-0.3	0.1	-0.1	0.0	0.0	-0.1	0.0	**-0.2**
Jefferson	0.0	0.0	0.1	0.3	-0.3	-0.3	0.0	0.0	0.0	0.0	**-0.2**
Knox	-0.3	0.4	0.1	0.0	0.1	0.0	0.3	0.2	0.2	0.1	**1.2**
Loudon	-0.1	0.1	0.0	0.0	0.0	0.2	-0.6	0.3	0.0	0.0	**-0.2**
Roane	-0.3	0.0	0.0	0.0	0.0	-0.4	0.1	-0.2	0.0	0.0	**-0.7**
Sevier	0.0	0.2	0.0	0.0	0.2	-0.7	0.0	0.0	0.9	0.0	**0.5**
Union	0.1	0.0	0.1	0.0	0.0	-0.2	0.0	0.0	0.0	-0.2	**-0.1**
Total	**-1.0**	**0.3**	**0.3**	**0.1**	**0.1**	**-1.7**	**0.1**	**0.5**	**1.3**	**-0.1**	**0.0**

1.3 STOP SEQUENCE CHOICE MODEL

The second destination choice model used in the KRTM is the stop sequence choice model. This model links the stops to form trips and tours. Travel time sensitivity is the parameter used in this destination choice model and controls the relative length of home-based and non-home-based trips. This parameter varies by tour type (work, UT, school, and other) and trip type (home-based trips and non-home-based trips). Table 10 shows the value of this parameter in the previous version and the updated KRTM. Table 11 presents the average travel time by tour/trip type in the survey and the updated model. According to Table 11, the model has a good agreement with the survey.

TABLE 10. STOP SEQUENCE CHOICE MODEL PARAMETERS

TRIP TYPE	KRTM 2012	KRTM 2020
Work Tours—Home-Based Trips	0.069	0.069
Work Tours—Non-Home-Based Trips	-0.185	-0.175
UT Tours—Home-Based Trips	0.000	0.000
UT Tours—Non-Home-Based Trips	-0.055	-0.055
School Tours—Home-Based Trips	-0.080	-0.080
School Tours—Non-Home-Based Trips	-0.110	-0.110
Other Tours—Home-Based Trips	0.029	0.049
Other Tours—Non-Home-Based Trips	-0.117	-0.097

TABLE 11. AVERAGE TRIP TRAVEL TIME

TRIP TYPE	OBSERVED	MODEL
Work Tours	14.9	14.7
Home-based Trips	16.3	16.5
Non-Home-based Trips	12.4	11.7
UT Tours	15.0	11.2
Home-based Trips	16.3	11.4
Non-Home-based Trips	12.1	10.5
School Tours	10.5	10.5
Home-based Trips	10.3	10.3
Non-Home-based Trips	11.2	11.9
Other Tours	12.1	12.0
Home-based Trips	12.7	12.5
Non-Home-based Trips	10.6	9.5
Work Tours	14.9	14.7
Home-based Trips	16.3	16.5

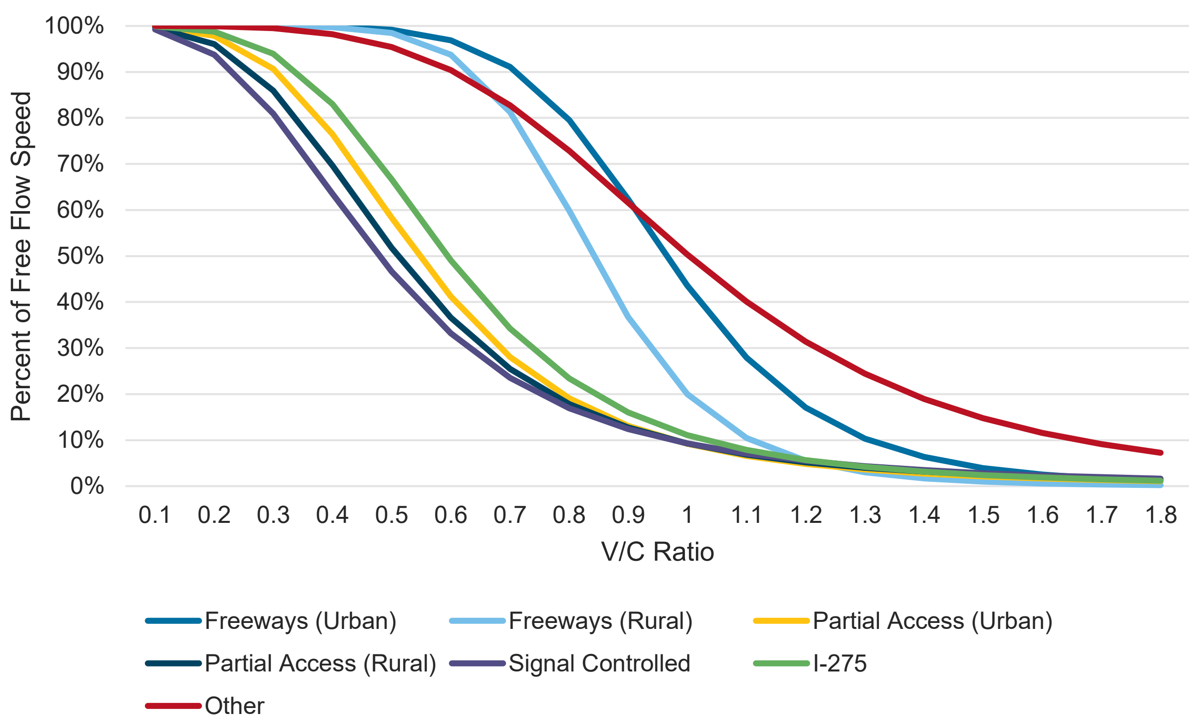
1.4 VOLUME-DELAY FUNCTIONS

The KRTM uses Bureau of Public Road (BPR) volume-delay functions (VDF) to calculate congested travel times. The coefficients of VDFs were estimated by the genetic algorithm in the previous version of the model. RSG reviewed the loaded network after running the model with all mentioned updates. This review included careful analysis of the loading error by facility type in urban and rural areas. Freeways and partial-access controlled facilities were divided to urban and rural groups with different sets of parameters for VDFs. Table 12 reports the original and updated values of VDF parameters by facility type and area type and Figure 2 shows the updated VDFs.

TABLE 12. VOLUME DELAY FUNCTION PARAMETERS

FACILITY TYPE	KRTM 2020		TNMUG STANDARD	
	ALPHA	BETA	ALPHA	BETA
Freeways—Urban	1.30	7.24	1.30	7.24
Freeways—Rural	1.30	7.24	4.00	8.00
Partial Access Controlled—Urban	9.90	3.79	9.90	3.79
Partial Access Controlled—Rural	9.90	3.79	9.82	3.40
Signal Controlled	9.80	3.10	9.80	3.10
Special—Bridges	8.89	3.15	8.89	3.15
Special—Curves	8.00	4.00	8.00	4.00
All Other	0.99	4.36	0.99	4.36

FIGURE 2. UPDATED VOLUME DELAY CURVES



Although VDFs compute the delay due to the congestion, the model considers another type of delay, which is due to the existence of signals. This delay is applied to the free-flow travel time, which is ultimately used by VDFs in the traffic assignment. Although the parameters related to the signal control delay have been determined in the last model calibration in 2012, general rules (not specific for each link) are used to assign these parameters. This approach is consistent with other assumptions and calculations in macroscopic modeling approaches that are used in travel demand forecasting models. The delays, therefore, may require revision. RSG reviewed the loaded network after traffic assignment and analyzed model flows on the links with annual average daily traffic (AADT) to determine areas potentially requiring control delay adjustments. These delays were slightly changed (no delay was canceled out after adjustment and links still have delays) for some links to affect path choice in the favor of observed traffic counts. “AB_Time_Adj_1” and “BA_Time_Adj_1” are the fields in the model network indicating adjustments to the delays.

1.5 TRAFFIC ASSIGNMENT RESULTS

The updated trip tables were assigned to the highway network. The resulting loaded network was then compared with the observed counts. RSG used the same measures as the previous version of the KRTM in the validation report. Table 13 to Table 18 report the assignment statistics by functional class and area type.

Table 13 to Table 15 illustrate that the KRTM meets the TNMUG standards. All reported statistics fall within the acceptable ranges and most fall within the preferred ranges. Table 14 indicates that the updated model far exceeds the minimum threshold for all volume groups. Moreover, Table 14 and Table 15 show smaller loading errors and root mean square errors (RMSE) for higher volume groups, which is desirable from a modeling perspective.

TABLE 13. VOLUME-TO-COUNT RATIOS BY FUNCTIONAL CLASS AND AREA TYPE (2018)

FUNCTIONAL CLASS	AREA	KRTM 2020	TNMUG STANDARD	
			ACCEPTABLE	PREFERABLE
Freeways	Urban	0.81%	+/- 7%	+/- 6%
	Rural	6.30%		
Principal Arterials	Urban	2.27%	+/- 15%	+/- 10%
	Rural	11.63%		
Minor Arterials	Urban	-9.68%		
	Rural	4.76%		
Collectors	Urban	-10.06%	+/- 25%	+/- 20%
	Rural Maj	15.89%		
	Rural Min	-2.32%		

TABLE 14. VOLUME-TO-COUNT RATIO BY VOLUME GROUP (2018)

AADT	KRTM 2020	TNMUG STANDARD	
		ACCEPTABLE	PREFERABLE
0–1000	41.71%	+/- 200%	+/- 60%
1001–2,500	7.05%	+/- 100%	+/- 47%
2,501–5,000	-5.81%	+/- 50%	+/- 36%
5,001–10,000	-3.00%	+/- 29%	+/- 25%
10,001–25,000	-0.46%	+/- 25%	+/- 20%
25,001–50,000	-0.04%	+/- 22%	+/- 15%
> 50,000	-1.14%	+/- 21%	+/- 10%

TABLE 15. ROOT MEAN SQUARE ERROR BY VOLUME GROUP (2018)

AADT	KRTM 2020	TNMUG STANDARD
0–5000	66.54%	115%
5001–9,999	40.49%	43%
10,000–19,999	26.67%	30%
20,000–39,999	20.68%	25%
40,000–59,999	14.07%	20%
> 60,000	11.43%	19%

Table 16 reports the loading error, RMSE, and vehicle miles traveled (VMT) error by functional class and area type. Table 16 indicates overloading in rural areas and underloading in urban areas. The overloading in rural areas is not uncommon because of the sparseness of the network. Local roads are also included in the reported statistics by area type, which affects the overall performance. According to Table 16, the model has greater accuracy on higher functional classes.

TABLE 16. ASSIGNMENT VALIDATION STATISTICS BY FUNCTIONAL CLASS AND AREA TYPE (2018)

LINK TYPE	LOADING ERROR (%)	RMSE (%)	VMT ERROR (%)
All Links	-0.78	29.84	1.56
Rural Interstates	6.30	11.61	5.37
Rural Principal Arterials	11.63	24.54	19.03
Rural Minor Arterials	4.76	27.11	8.72
Rural Major Collectors	15.89	58.35	25.27
Rural Links	7.54	30.63	8.78
Urban Interstates	0.81	14.52	2.26
Urban Other Freeways	1.77	26.51	9.63
Urban Principal Arterials	2.27	19.76	2.22
Urban Minor Arterials	-9.68	33.37	-13.00
Urban Collectors	-10.06	52.06	-16.33
Urban Link	-2.42	27.42	-1.84

Table 17 and Table 18 show the KRTM's performance on major highway corridors in the study area and on screenlines that had been designated in the previous model calibration/validation effort. According to Table 17, 9 out of 11 corridors have a loading error of less than 10%. The other two corridors (I-75 and SR62) are also close to 10%. Comparing the updated model and the previous version shows that the new model performs better since the previous model has a higher loading error and RMSE on I-75 and SR62.

TABLE 17. ASSIGNMENT VALIDATION STATISTICS BY CORRIDOR (2018)

CORRIDOR	LOADING ERROR (%)	RMSE (%)	VMT ERROR (%)
I-40	-0.22	12.19	1.73
I-75	11.39	14.25	9.80
I-275	1.60	5.82	2.2
I-640	-6.53	9.21	-6.45
I-81	7.94	9.45	9.64
I-140	7.92	9.42	8.47
Chapman Hwy	6.78	15.67	12.52
US129	-0.57	15.81	-1.47
SR66/US321	-6.79	8.77	-7.90
Pellissippi Pkwy	-1.35	1.36	-1.30
SR62	10.43	21.12	4.50

A total of 5 screenlines out of 16 (31%) show a loading error of more than 10%. However, the "Knox-Loudon Border" screenline, which has a loading error of 23%, includes only 2 links. The loading error on the other 4 screenlines is less than 17%. The previous version of the model also exhibits high loading errors on these screenlines. Moreover, the previous version of the model has a loading error of more than 10% on 7 screenlines. Although the current model still has room for improvement regarding screenlines, it is still better than the previous version.

TABLE 18. VOLUME-TO-COUNT RATIO BY SCREENLINE (2018)

SCREENLINE	LOADING ERROR (%)
Knox–Blount Border	7.72
Knox & Blount Boundary	8.96
Knox County Boundary	7.36
Blount County Boundary	4.38
Rivers	12.28
Inner Knoxville	5.26
East Counties	7.87
West Counties	15.33
North Counties	14.03
North West Counties	7.58
North East Counties	16.94
Old2	3.03
Old4	-8.94
Old6	-1.73
Old7	-0.49
Knox–Loudon Border	23.04

Figure 3 presents AADTs and the model volumes with the correlation coefficient of 0.95. Tennessee Department of Transportation (TNDOT) specified 0.88 as the threshold for the correlation coefficient. The graph illustrates that the updated model accurately captures the observed counts. The loading errors on the network are also seen in Figure 4.

FIGURE 3. OBSERVED COUNTS AND MODEL VOLUMES (2018)

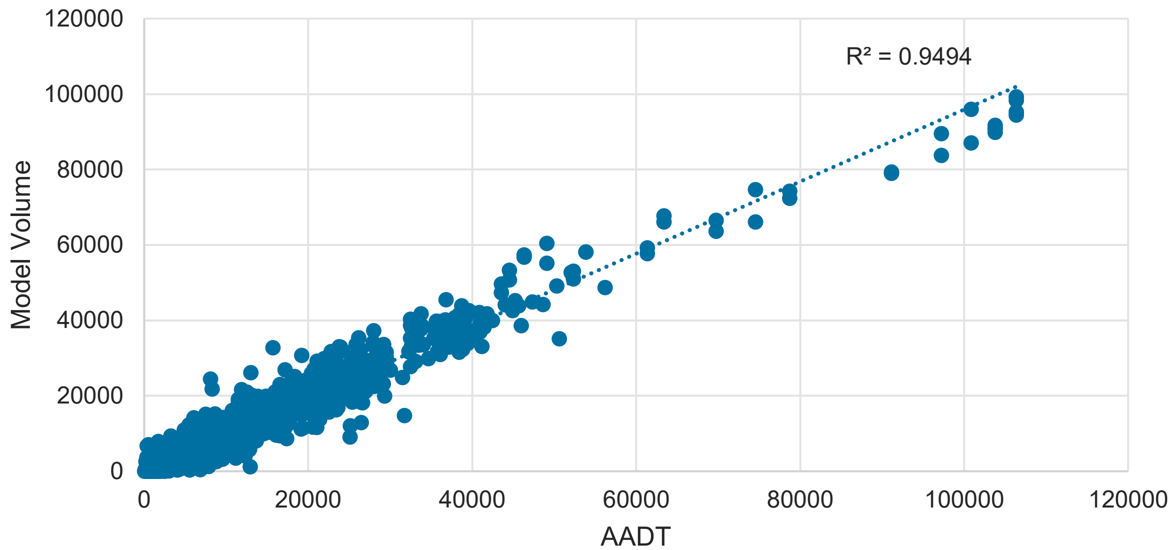
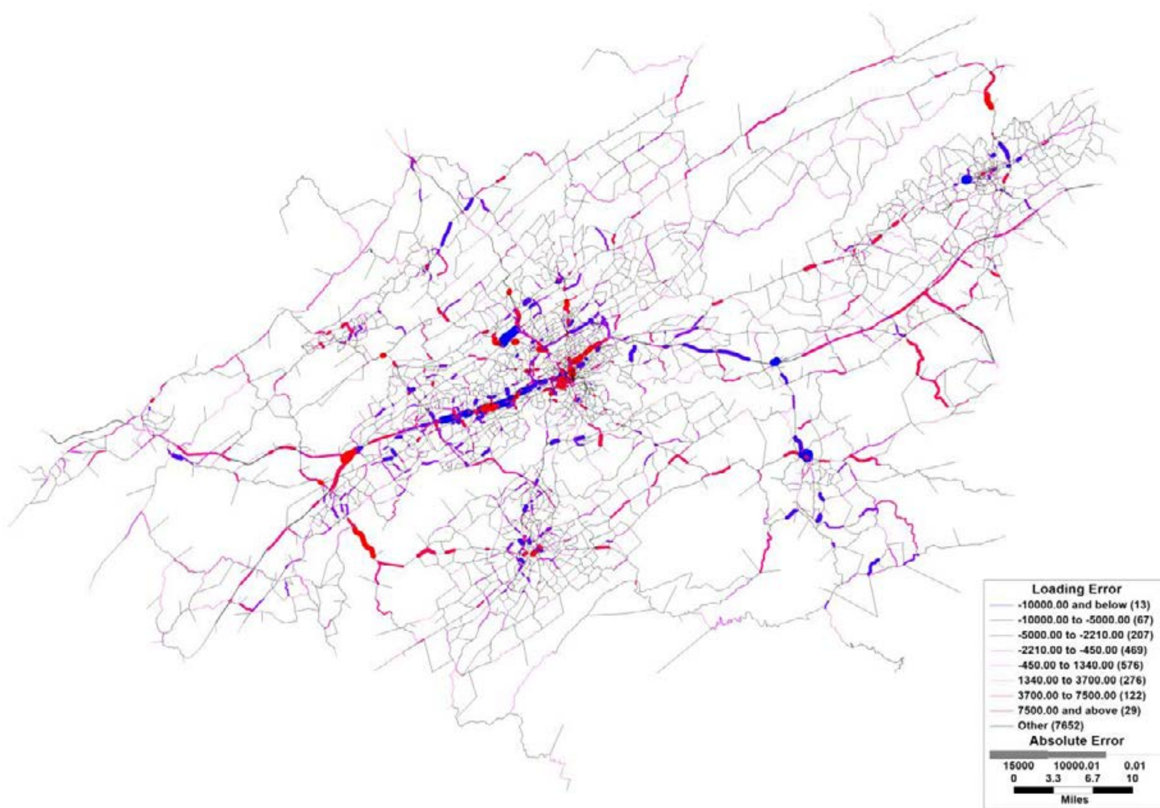


FIGURE 4. KRTM LOADING ERROR (2018)

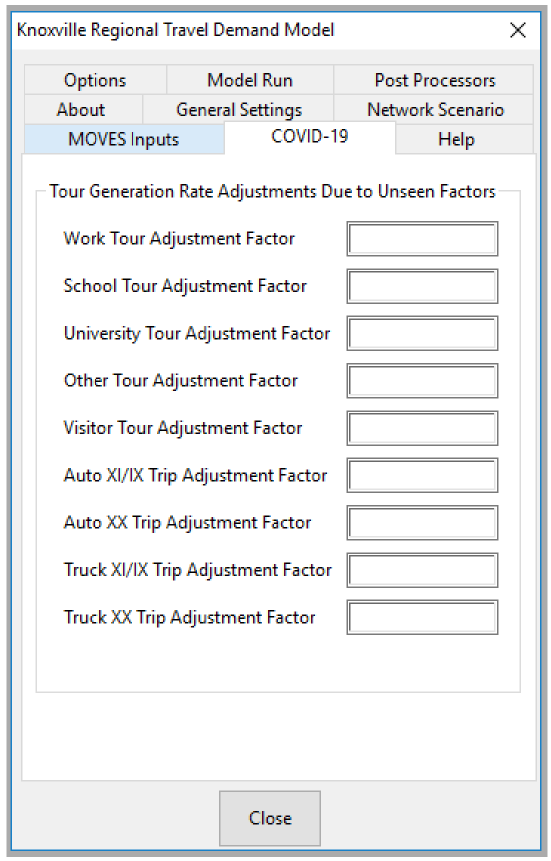


1.6 TOUR RATE CUSTOMIZATION

RSG enhanced the KRTM to allow for user-adjusted tour rates by purpose. This configuration is intended for Exploratory Model Analysis (EMA) of assumed COVID-19 travel impacts to trip making. Scenario planning is a structured way to think about the future using a limited number of scenarios such as best case, worst case, and most likely, etc. The EMA considers varied input assumptions across a wide range of future scenarios along key dimensions of uncertainty to explore potential outcomes, find critical input assumptions, and identify robust future policy directions in the face of deep uncertainty.

The KRTM first estimates number of tours (by purpose) and stops (by type) and then specifies the location of stops. Finally, it connects stops in a sequenced way to form trips and tours. In this version of the model, the user can specify adjustments to trip generation rates due to special circumstances such as COVID-19. In fact, the model has been developed for a typical and normal day; however, this feature enhances the model to take rare situations into account and to forecast traffic flows on the network. The user can adjust tour generation rates in the "COVID-19" tab in the model's user interface, which is shown in Figure 5.

FIGURE 5. COVID-19 TAB IN THE KRTM USER INTERFACE



As shown in Figure 5, tour generation adjustment can be conducted on household tour types such as work and school tours and visitor tours. The user can also change auto and truck external trips. The KRTM generates external trips (not tours) for passenger cars and trucks and adds them to household and visitor trips before assignment. The adjustment rates must be between 0 and 1 and show the reduction in tour/trip generation. For example, if the user wants to test a scenario with 20% decrease in work tours, the factor of 0.2 should be entered in the corresponding text box on the user interface. Any factor larger than 1 will crash the run as it forces the model to generate negative tours. Although the main goal of this feature is to analyze situations like COVID-19, which significantly decreases trips on the network, any negative factor (between -1 and 0) will increase tours (and consequently trip) in the model.