Appendix B

2050 **Metropolitan Transportation Plan**

KYOVA Interstate Planning Commission

Memo

Date: Monday, November 01, 2021

Project: KYOVA 2050 MTP

To: KYOVA Interstate Planning Commission

From: HDR

Subject: Travel Model Adjustments

Background

The KYOVA Interstate Planning Commission has embarked on the process of updating the Metropolitan Transportation Plan (MTP). An important early step is to review the travel demand model (TDM) and provide recommendations for improvements calibrated to the current transportation conditions.

The TDM is an important tool used to support the MTP. The TDM estimates and distributes trips across its transportation network. The travel modeling process attempts to replicate existing travel patterns and traffic levels. Once the model does a reasonable job of replicating existing conditions ("calibrated"), it can be used to forecast future traffic volumes based on anticipated population and employment growth through the MTP's planning horizon of 2050. It can be used to identify potential deficiencies in the transportation network, and to estimate the impacts of various scenarios such as adding new roads, changing the capacity of existing roads or removing roads.

The KYOVA TDM was evaluated in detail and adjustments to various components were tested with the goal of improving the model's outputs compared to observed conditions for the 2015 base year. The calibration process also aims to not over-calibrate or constrain the model's ability to react to scenario changes.

Trip Generation Model Adjustments

Prior to reviewing the trip generation outputs, the input socioeconomic data were reviewed in detail. The first check involved comparing the model totals versus observed data as shown in **Table 1**. Slight differences are natural since data estimate methods and study area boundaries vary. Yet, model input socioeconomic data does not show a large amount of error compared to observed data, suggesting the data is overall very accurate.

The totals were also compared with sums of the household cross-classification data (household size by vehicles owned, household workers by vehicles owned, and household size by number of children), and employment by individual categories. One minor modification was made to total employment totals in the TDM to ensure the sum of all individual employment category matched the total employment value. During trip generation, the total employment value is multiplied by 1.2 to generate home-based work (HBW) trip attractions. The updated TOTAL_EMP value for the region is 121,580, up from 121,559.

Table 1 – Model Socioeconomic Data Totals Compared to Observed Data

	Model	Observed	Percent Difference
Population	292,048	286,591[1]	2%
Households	119,669	114,192[1]	5%
Employment	121,580	118,552[2]	3%
School Enrollment	60,926	61,860[3]	-2%

No changes were made to the trip purposes, which are shown in **Table 2**. Ideally, the number of productions and attractions would be equal since each trip has a beginning and an end. Yet, TDMs calculate productions and attractions separately using different data sources so the result will rarely, if ever, be identical. Typically, a ratio between 0.90 and 1.10 for production-to-attraction ratios from a trip generation model is considered acceptable, which suggests that there are not significant flaws in the socioeconomic data or the trip generation rates. If ratios are close, then trips can be balanced at the end of trip generation without large adjustments to either the productions or attractions. **Table 3** shows that the unbalanced production and attraction ratios are all between 0.90 and 1.10.

[1] Block Group 5-Year Estimate data, US Census, 2011 - 2015
[2] On the Map data, Longitudinal Employer-Household Dynamics, 2015
[3] Census Transportation Planning Products data, US Census, 2012-2016

Table 2 - Trip Purpose Descriptions

Trip Purpose	Description
HBW	Home-Based Work
HBS	Home-Based School
HBO	Home-Based Other
NHB	Non-Home Based
IE_AUTO	Internal to External Auto
LT_TRK	Light Truck
IE_SU	Internal to External Single Unit Truck
SU_TRK	Single Unit Truck
IE_CU	Internal to External Combination Truck
CU_TRK	Combination Truck

Table 3 - Unbalanced Production to Attraction Ratios

Trip Purpose	Productions	Attractions	P:A Ratios
HBW	132,261	145,896	0.91
HBS	71,400	73,111	0.98
HBO	408,903	395,744	1.03
NHB	191,559	189,249	1.01
IE_AUTO	116,318	116,915	0.99
LT_TRK	109,396	109,396	1.00
IE_SU	8,539		
SU_TRK	31,117	31,117	1.00
IE_CU	8,794		
CU_TRK	12,946	12,946	1.00
Total	1,091,233	1,074,374	1.02
Internal Only	957,582	957,459	1.00

Trips per household are another common validation check. **Table 4** shows the average trips per household compared to the Travel Model Improvement Program (TMIP) Validation and Reasonableness Checking Manual, Second Edition Table 5.2 trips per household by MSA population groups. The KYOVA model trips per household is lower than the average US urban area. The KYOVA model was tested with higher trip rates to match the TMIP trips per household, which resulted in poorer calibration results for the model. This, combined with the accurate socioeconomic data and excellent production to attraction ratios, led to the decision to not change trip rates.

Table 4 - Average Trips per Household

	All Households	TMIP[4]
Unbalanced Trips per Household	9.12	10.84
Balanced Trips per Household	9.12	10.84

Trip Distribution Model Adjustments

Once trips are balanced, the model distributes trips between TAZs using a gravity model. Friction factor coefficients determine the impedance, or disutility, of trips of different lengths which tells the model how desirable trips are between nearby zones versus zones farther away.

Numerous tests were done with the friction factors to lengthen or shorten trips. **Figures 1, 3, 4 and 5** show the final proposed adjustments to the friction factors for auto trip purposes. National Cooperative Highway Research Program (NCHRP) 716, Travel Demand Forecasting: Parameters and Techniques Table 4.5 curves are shown as well where applicable using suggested values.

Without observed data on trip length frequency distributions it is difficult to confidently alter the friction factor curves. Yet, one overall guideline that was used is the total model Vehicle Miles Traveled (VMT) compared to the VMT of count data. This will be discussed in greater data later, but in general it was necessary to reduce the model VMT to be more in line with count data. Adjusting trip lengths is one of the key methods to impact overall VMT since shorter trips will yield less VMT.

As a result, the NHB trip purpose friction factor curve was adjusted down to be closer to the NCHRP 716 curve. The HBS curve was also adjusted down to get average school trip lengths shorter than average work trip lengths since work trips are typically the longest of all auto trip purposes as suggested by various friction factor curves shown in NCHRP 716. The HBO trip purpose curve was kept the same.

The HBW friction factors from the previous model showed curves that prefer shorter trip lengths compared to NCHRP 716 communities. Yet, some observed data is available for calibrating HBW trips via Census Journey-to-Work (JTW) data (**Figure 2**). The curve was adjusted to more closely match the Census data and approximate the NCHRP HBW curve better. **Figure 2** shows a very good match between the model and Census JTW data, with a coincidence ratio between the curves of 0.88, up from 0.74 from the previous model and well above the 0.70 recommended by the TMIP Validation Manual. A household travel survey or Location-Based-Service data could help guide changes to the other trip purpose curves in future model updates.

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[4] MSA population between 250,000 and 500,000. Based on 2001 National Household Travel Survey

Figure 1 - HBW Friction Factor Curve

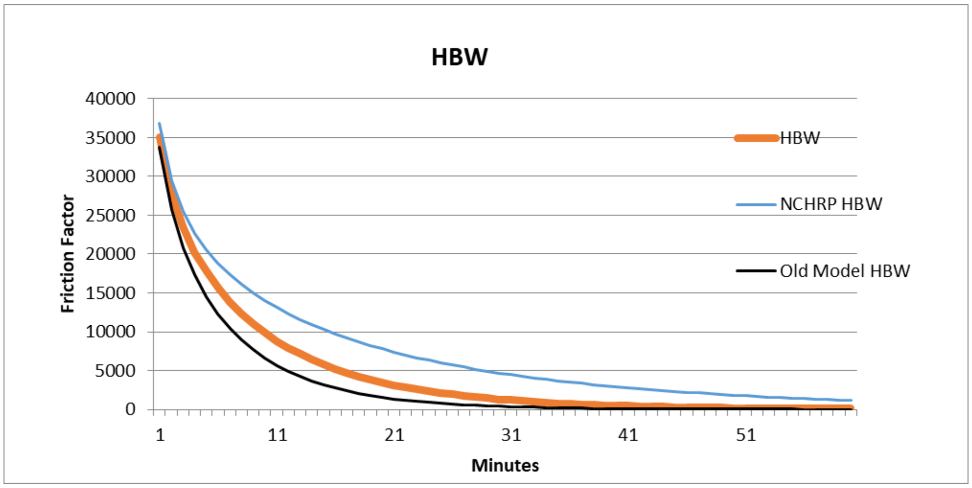


Figure 2 - Trip Length Distribution Curve

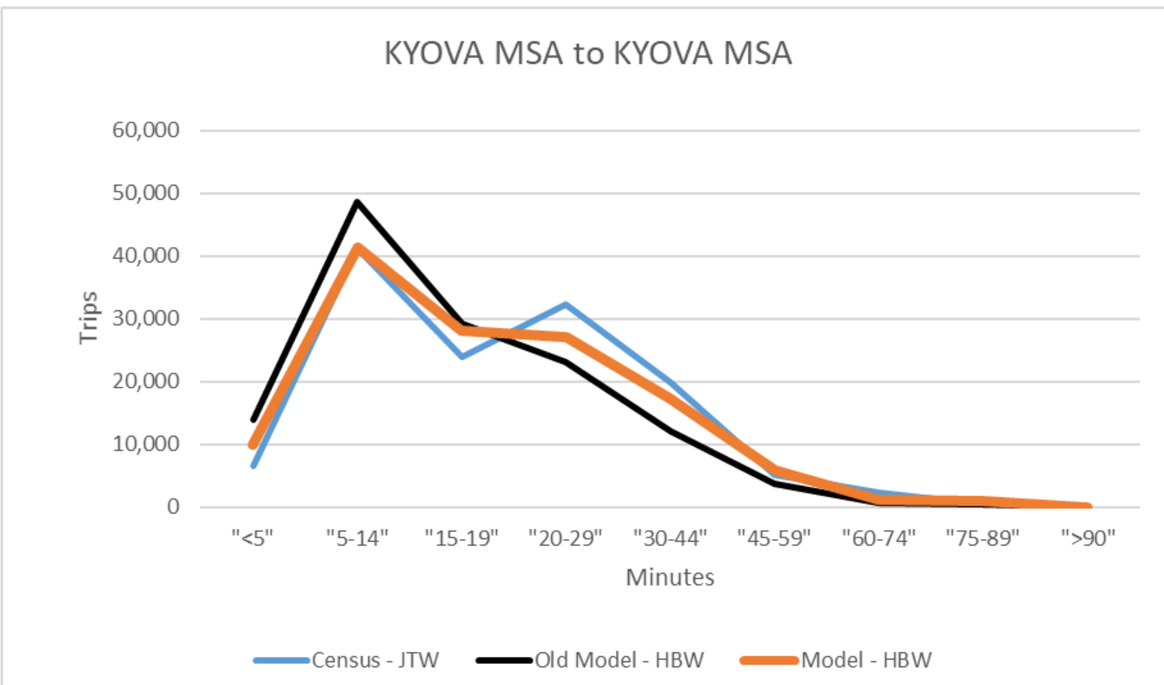


Figure 3 - HBS Friction Factor Curve

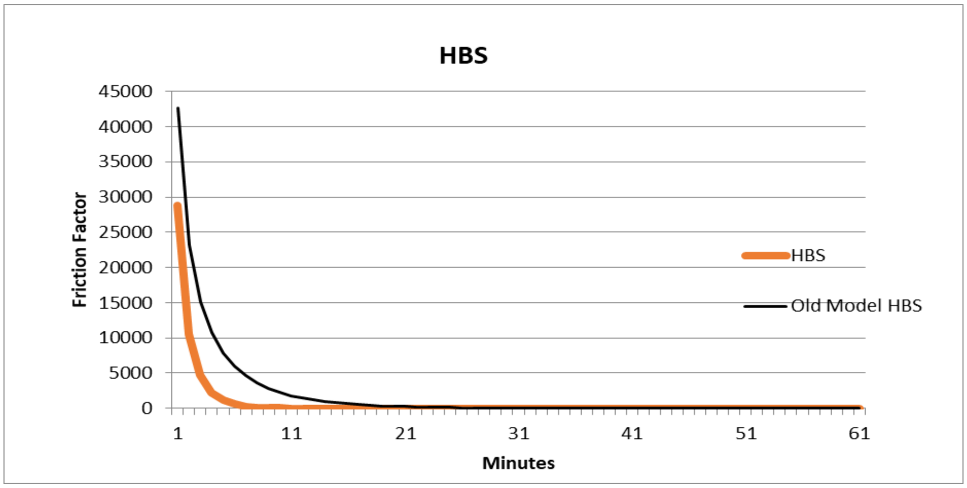


Figure 4 - HBO Friction Factor Curve

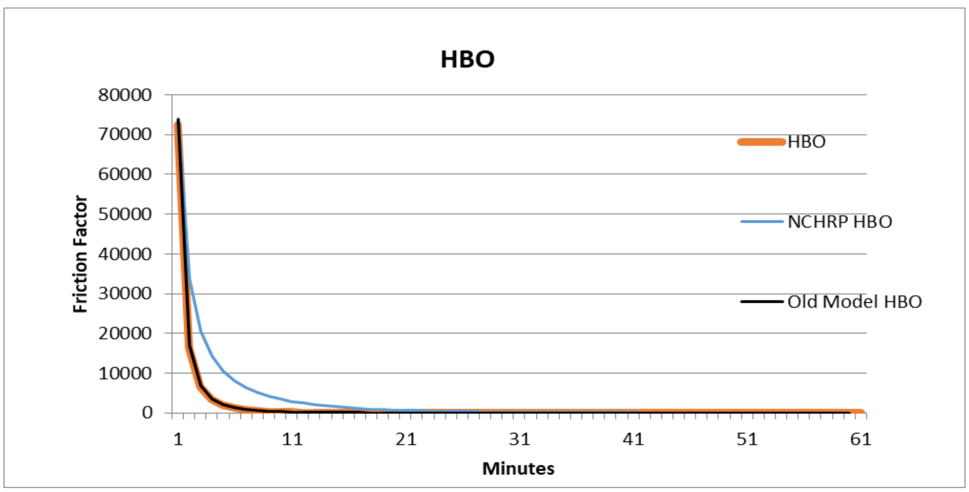
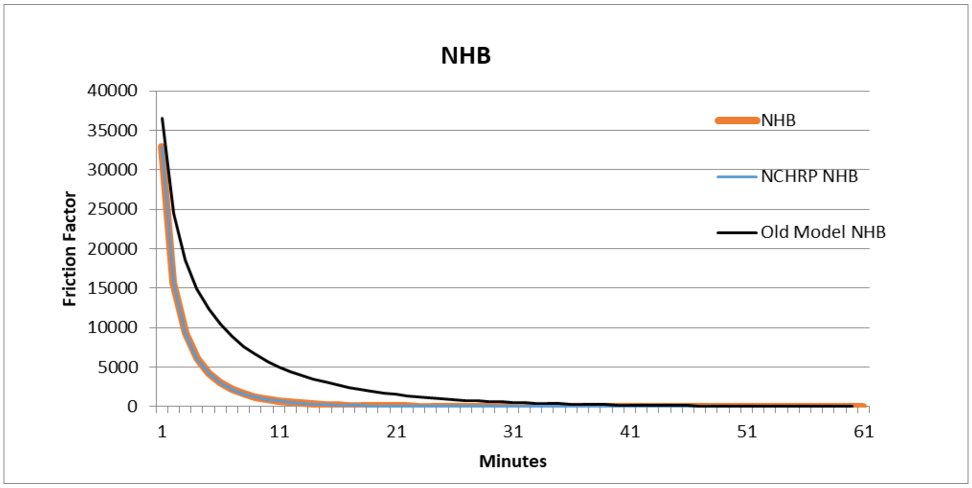


Figure 5 - NHB Friction Factor Curve



The average travel times by trip purpose are shown in **Table 5**. The updates to the HBW trip purpose are more in-line with Census JTW average trip lengths. HBS and NHB trip lengths have been shortened to allow the model to better match VMTs, but it is unclear what the target trip lengths should be without observed data. Truck trip lengths were not adjusted.

Table 5 - Average Travel Times by Trip Purpose

	Previous Model	Model Updates	Census JTW
HBW	17.64	20.47	21.39
HBS	17.70	15.41	N/A
HBO	15.54	15.27	N/A
NHB	15.29	9.15	N/A

The last change to the trip distribution portion of the model was the removal of all K-Factors. K-Factors are used to enhance origin and destination pairs that the gravity model does not represent accurately. It is preferable that they be avoided if possible and only added in justifiable circumstances where the gravity model does not account for certain unique travel characteristics, and not just to make results more accurate. The previous model included a K-Factor of 0.05 between Wayne and Boyd counties. The model results were tested with and without the K-Factor with no significant differences. Thus, the K-Factor was removed.

Trip Assignment Model Adjustments

The goal of a TDM is to replicate travel patterns as accurately as possible throughout each step of the model, without placing too many unreasonable constraints on its operation. Ultimately, the model-predicted volumes should have a strong correlation with observed traffic count data.

The traffic assignment step attempts to minimize a trip's travel time over the network between its origin and destination. Travel time is a function of congested speed and distance traveled.

A comparison of model-estimated and observed VMT by functional classification (for segments with observed counts) from the previous model is shown in **Table 6**. The results are generally acceptable according to FHWA goals from 1990.

Table 6 - Previous Model VMT by Functional Class Comparison with Counts

	Number of Counts	VMT		Error		Validation Goal[5]
Facility Type		Estimated	Observed	Difference	Percent	
Freeway/Expressway	65	780,105	740,600	39,505	5.3%	+/-7%
Principal Arterials	112	511,937	461,586	50,351	10.9%	+/-10%
Minor Arterials	155	629,797	584,659	45,138	7.7%	+/-15%
Collectors	358	527,954	475,805	52,148	11.0%	+/-20%
Total	690	2,449,792	2,262,650	187,142	8.3%	N/A

Percent Root Mean Squared Error (%RMSE) is a standard model validation check that measures the average error between the model-estimated and counted volumes. The lower the value, the less the difference there is between the model-estimated volumes and the traffic counts. The %RMSE by facility type and by volume group from the previous model are shown in **Tables 7 and 8**.

Table 7 - Percent RMSE by Facility Type from Previous Model

Facility Type	% RMSE
Freeways	16.58%
Principal Arterials	35.59%
Minor Arterials	32.51%
Collectors	49.66%
Total	37.60%

[5] FHWA-1990 goals

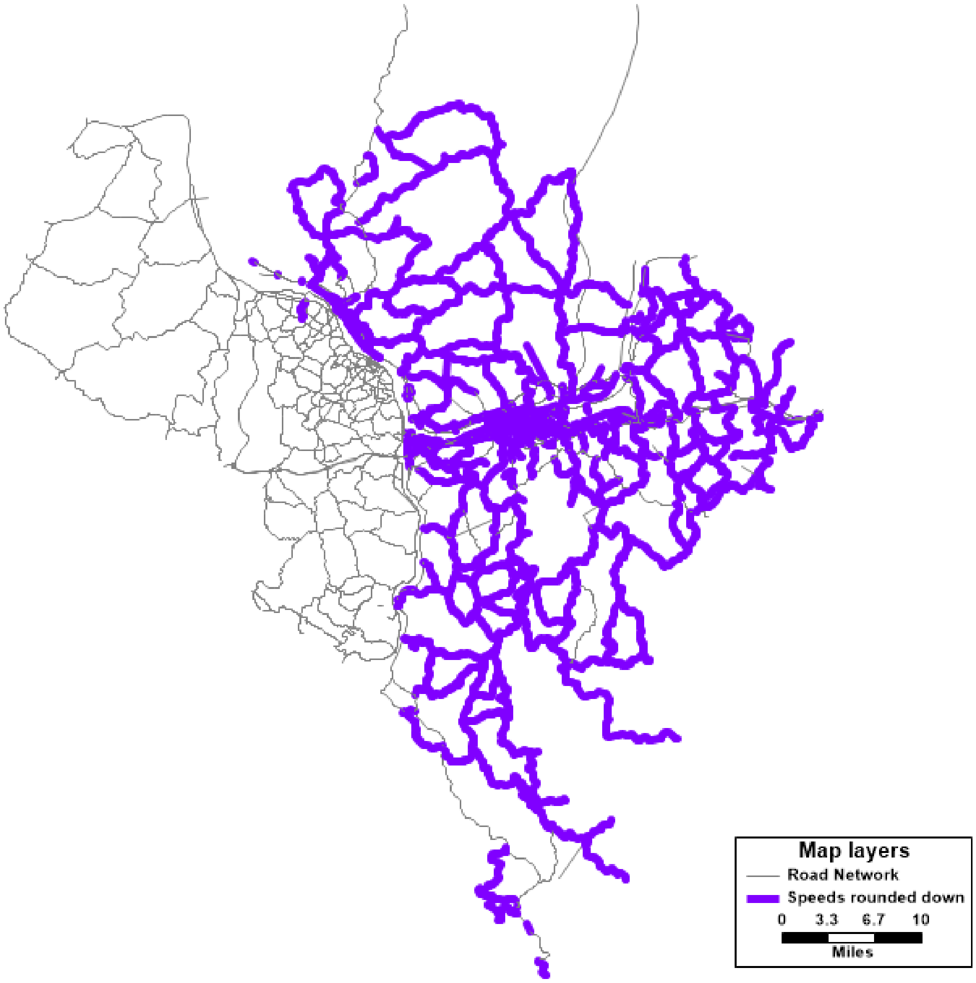
Table 8 - Percent RMSE by Volume Groups from Previous Model

Volume Range	Number of Counts	% RMSE	FSUTMS[6] - Acceptable	FSUTMS[6] - Preferable
0-5,000	382	65.86%	100%	45%
5,000-10,000	155	35.04%	45%	35%
10,000-15,000	79	30.89%	35%	27%
15,000-20,000	42	19.80%	35%	27%
20,000-30,000	27	16.55%	35%	27%
30,000-40,000	5	20.39%	35%	27%

Adjustments made to steps that impact the routing of traffic generally focused on changing travel times. Posted speeds for several corridors in the Ohio and West Virginia portions of the model included speed values that varied from posted speeds. The previous model documentation noted that average speeds were used rather than posted speeds. While this may be good justification for altering posted speeds, since speeds are in increments of 5 mph in Kentucky, they were rounded down to the nearest 5 mph in the other two states as well for consistency. The links that were impacted are shown in **Figure 6**. This change had a minor impact on assignment results in the model.

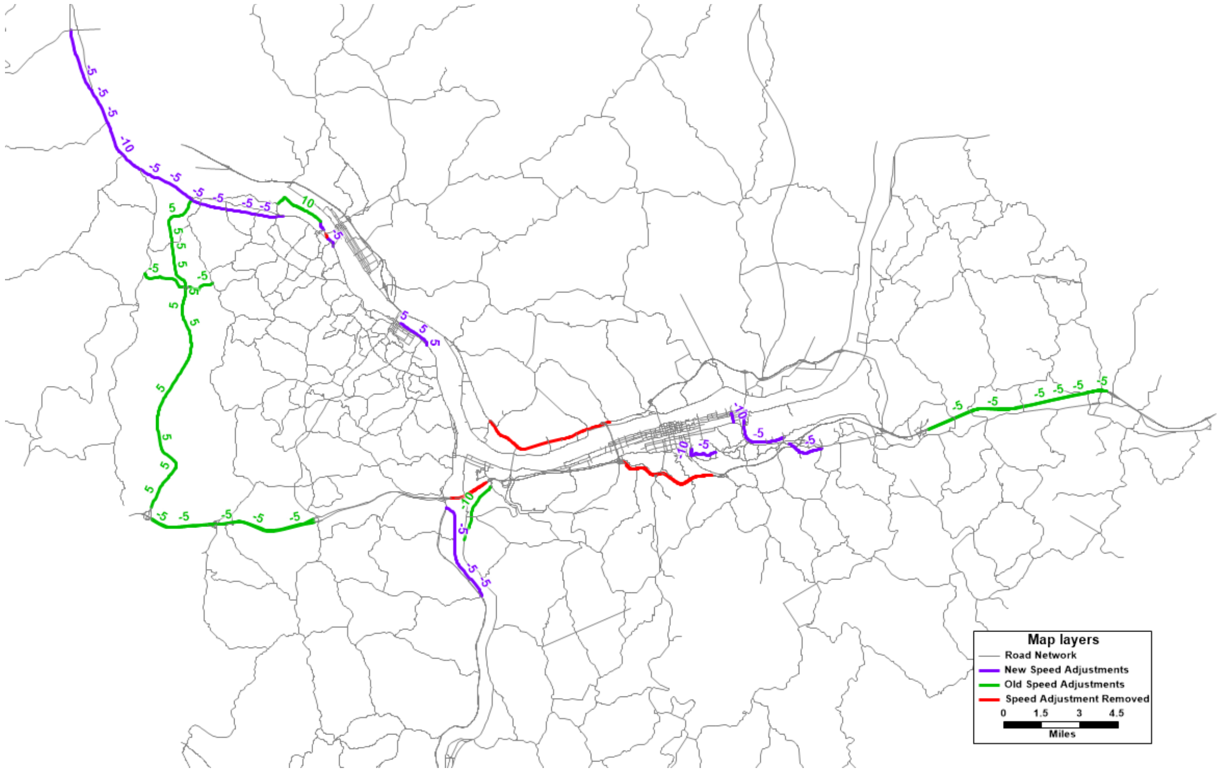
[6] Florida Standard Urban Transportation Model Structure

Figure 6 – Posted Speed Values Rounded Down to Nearest Five MPH



It is common for TDMs to assign an unreasonably large number of trips one corridor when there are multiple parallel routes with similar travel times. HERE speed data was used to help determine if posted speeds were unfairly prioritizing a route where actual travel times might be lower because of delay at intersections or other factors. A speed override was used to more accurately represent travel times on these identified routes, shown in **Figure 7**. Speed adjustments carried over from the previous model are also shown, as well as adjustments that were removed.

Figure 7 - Speed Adjustments



Localized adjustments to centroid connectors were also made during calibration to better represent how traffic flows in and out of neighborhoods, particularly around downtown Huntington. These, as well as changes made to earlier model steps are included in the updated results in **Tables 9 and 10**.

The changes noted in this document led to improved overall VMT error for most facility types. Principal arterial VMT error remains similar to the amount of error in the previous model but total VMT error is closer to 0% overall, suggesting that the model is neither systematically overestimating nor underestimating traffic.

Table 9 - Proposed Model VMT by Functional Class Comparison with Counts

	Number of	VMT		Error		Validation
Facility Type	Counts	Estimated	Observed	Difference	Percent	Goal[5]
Freeway/Expressway	65	762,345	740,600	21,745	2.9%	+/-7%
Principal Arterials	112	514,589	461,586	53,003	11.5%	+/-10%
Minor Arterials	155	592,703	584,659	8,043	1.4%	+/-15%
Collectors	358	472,121	473,345	-1,224	-0.3%	+/-20%
Total	690	2,341,757	2,260,190	81,567	3.6%	N/A

In terms of %RMSE, principal and minor arterial roadways have lower amounts of error, and overall %RMSE improved as well. Lower functional class roadways are less accurate than higher class roadways, which is typical. In terms of volume groups compared to the Florida Standard Urban Transportation Model Structure (FSUTMS) all are within the acceptable range and all except the lowest volume roads are within the preferable range.

Table 10 - Proposed Model %RMSE by Facility Type

Facility Type	% RMSE
Freeways	16.82%
Principal Arterials	29.70%
Minor Arterials	28.12%
Collectors	53.73%
Total	34.57%

Table 11 - Proposed Model %RMSE by Volume Groups

Volume Range	Number of Counts	% RMSE	FSUTMS[6] - Acceptable	FSUTMS[6] - Preferable
0-5,000	382	63.29%	100%	45%
5,000-10,000	155	34.43%	45%	35%
10,000-15,000	79	27.56%	35%	27%
15,000-20,000	42	16.25%	35%	27%
20,000-30,000	27	14.37%	35%	27%
30,000-40,000	5	18.68%	35%	27%

Summary and Recommendations

The KYOVA model was carefully reviewed and some minor adjustments were made with the goal of improving the model accuracy and ensuring the model is not too tightly calibrated to be able to successfully run scenarios. The validation results indicate that the KYOVA TDM is accurate compared to national standards. This suggests that the majority of the data are high quality and accurate. All adjustments were discussed and the model does not contain unreasonable calibration methods to achieve the reported results.