Model Development Background

As part of the I-79 Access Study, HDR provided an update and revalidation of the Morgantown Monongalia Metropolitan Planning Organization (MMMPO) travel demand model (TDM). The model package received from the MMMPO was based on the 2012 model update provided by AECOM, documented in a memo dated October 2, 2012.

The base year of the model remains year 2010. This TDM 2015 update included adding new model features and a revalidation to year 2010 conditions. Unless otherwise stated in this document, the parameters used in the MMMPO TDM have been carried forward from previous model versions.

Model Features Added

Model Script and User Interface

No model script or documentation of the model steps were provided with the pervious version of the model. The TDM 2015 update involved recreating the model process with a new script and model graphic user interface (GUI). The advantage of using a model script and GUI are a streamlined model code and user-friendly application of the model, with the assurance of repeatable results. Many of the input files were reviewed from the previous model version, and those processes / parameters were carried forward into this version of the model including:

- Roadway Network (minor modifications as noted in this document)
- Zone Structure (modified as noted in this document)
- Socio-economic data for 2010 (minor modifications as noted in this document)
- Trip generation rates
- Trip distribution / gravity model parameters (using the exponential function)
- External-to-External travel

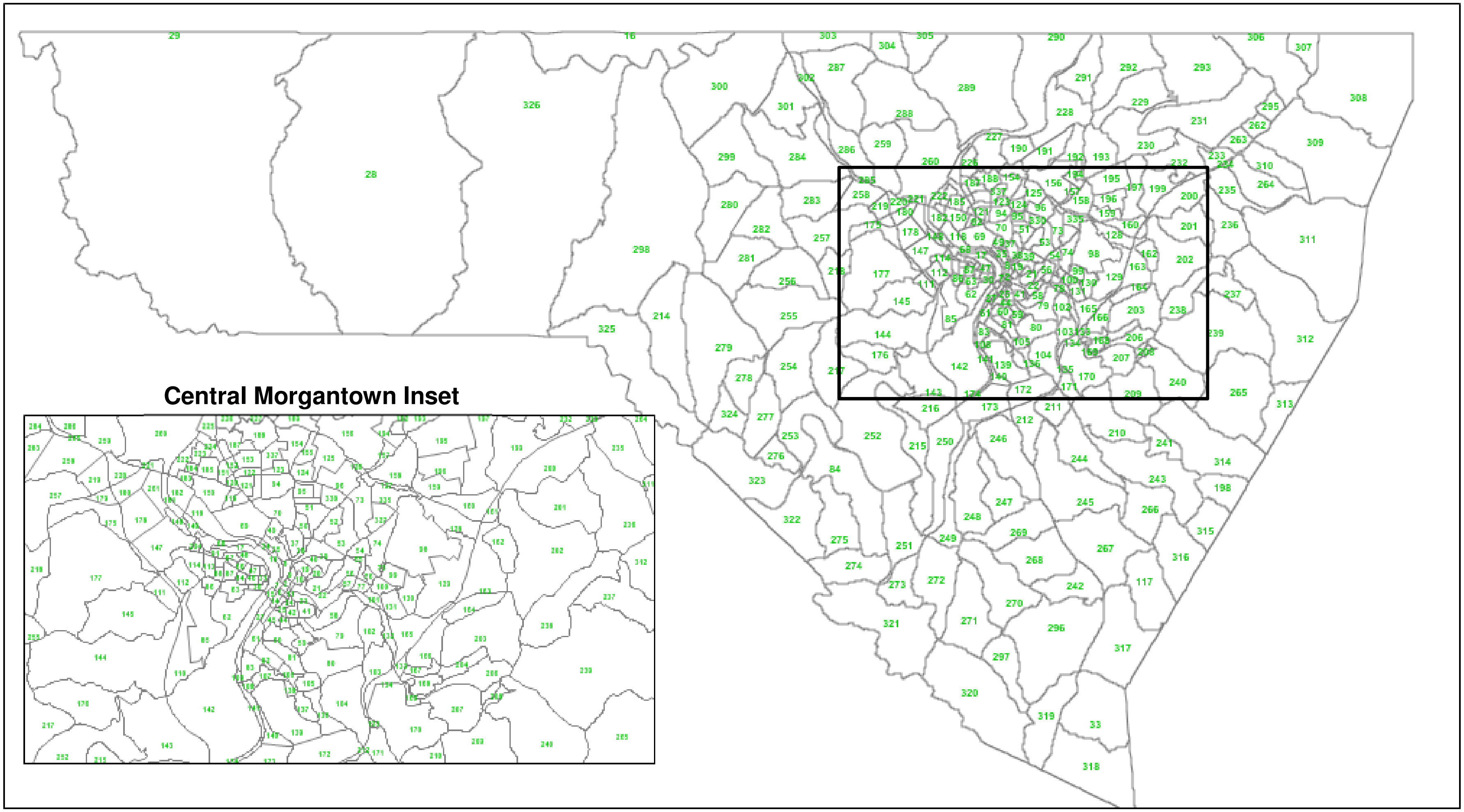
MMMPO TAZ Additions

MMMPO staff provided updates to the Traffic Analysis Zone (TAZ) structure, and socio-economic data. Three (3) new TAZs were added during this 2015 TDM update by MMMPO staff, along with socio-economic data reallocations to account for the new zone structure. These zonal additions increased the number of total model TAZs to 329. The updated TAZ structure is shown in **Figure 1**. The field “FIRST_TAZ” was carried forward as the unique TAZ name / identifier in the model.

Time-of-Day Model Component

The previous version of the MMMPO TDM had a single, daily time period considered for traffic assignment. The result of that approach was the model only considered a single set of travel costs (congested travel times on the network) when assigning all 24 hours of daily traffic. That approach did not recognize the temporally varying travel times across the MMMPO roadway network as travel patterns change throughout the course of a standard weekday.

Figure 1. TAZ Structure for MMMPO Model



By adding the time-of-day (TOD) component to the model, the 2015 TDM update has introduced a platform that reflects the varying travel time levels (congestion) that occur in Morgantown in peak- and off-peak periods. Thus, this component offers a more detailed simulation of travel path options during the traffic assignment phase.

Based on the data available, the following time periods were established as the MMMPO model TOD periods:

- **Morning (AM)**: 7:00 AM to 9:00 AM.
- **Mid Day (MD)**: 11:00 AM to 1:00 PM.
- **Afternoon (PM)**: 3:00 PM to 6:00 PM.
- **Off peak (OP)**: All other times:
    - 12:00 AM to 7:00 AM
    - 9:00 AM to 11:00 AM
    - 1:00 PM to 3:00 PM
    - 6:00 PM to 12:00 AM

A set of locally-tailored TOD parameters were developed using national household survey data (documented in NCHRP Report 716) as the starting point. These data were adjusted based on observed counts and validating model runs that iteratively compared peak period model output to cutlines of peak period traffic counts from 2015. When comparing local peak period travel volumes to the national averages in NCHRP Report 716, the analysis of local counts indicated:

- Approximately 5% to 15% less of daily travel occurs in the MMMPO area during the AM and PM peak periods than the national average.
- Off-peak and midday travel in the MMMPO area was a slightly higher percentage of daily travel than the national average.

The locally-estimated TOD parameters, broken out by trip purpose, are shown in **Table 1**.

Table 1. Time-of-Day Period Percentage Distribution of Daily Trips by Trip Purpose and Direction

Period	Home-Based Work		Home-Based Non-Work		Home-Based University		Non home-based
	From Home	To Home	From Home	To Home	From Home	To Home	
7-9 AM	19.5%	0.2%	8.7%	2.1%	38.6%	0.3%	9.1%
11 AM - 1 PM	2.8%	3.1%	5.9%	6.4%	2.1%	4.3%	22.5%
3-6 PM	2.5%	24.6%	9.3%	14.3%	2.9%	19.2%	23.8%
Off-Peak	29.2%	18.1%	24.3%	29.0%	11.4%	21.2%	44.6%
Total	54.0%	46.0%	48.2%	51.8%	55.0%	45.0%	100.0%

Sources: MMMPO Peak Hour Counts, 2015; *NCHRP 716: Travel Demand Forecasting Parameters and Techniques, Table C11.*

Note that these TOD parameters were developed to enhance model performance and sensitivity to roadway capacity, but the model was not extensively validated to peak conditions in this 2015 TDM update. The MMMPO region does have recent peak period counts in several portions of the urbanized area, and these data were used to develop the factors in Table 1. The region does not have a sufficiently wide and established set of peak period travel data or surveys to support full validation of the model to peak periods. Thus, the model has been validated to daily conditions.

West Virginia University Trip Distribution Application

To better reflect the travel patterns to and from WVU campuses, a set of district-based trip distribution factors were developed. The adjustment factors that were applied were based on AirSage data purchased for the Morgantown area. AirSage provides origin-destination data based on an anonymous aggregation and tracking of wireless signals from a sample of mobile phone carriers in the region. The AirSage data was statistically adjusted and expanded from their sample to estimate the travel (between origins and destinations) of all Morgantown regional residents.

From review of the AirSage data for Morgantown, the study team recognized the need for specific factors for WVU trip distribution to apply within the gravity model. WVU represents a significant special generator in the Morgantown area, and there is limited ability for the gravity model to accurately reflect the trip distribution patterns to a unique institution like WVU. Rather than replacing the trip distribution results of the TDM for WVU zones with AirSage values, TDM trip distribution output was factored to better reflect AirSage values. This approach allows the WVU trip distribution some degree of forecasting capability, while allowing changes in trip making levels from zones to be reflected in the WVU trip distribution routine.

A detailed description of the model development approach for this special WVU trip distribution application is provided at the end of this document as the Appendix.

Other Model Adjustments

Additional model validation adjustments were made to better reflect conditions in the MMMPO area. Model performance was examined through an iterative process at each step, with a particular focus on traffic assignment results and TOD factors. Those outlier locations where traffic volumes deviated the most from observed counts were those locations that received the most attention for additional model adjustments.

External Traffic Volumes

At the external stations, input traffic levels provided in the original Internal-External production / attraction files and External-External trip table deviated significantly from 2011 daily traffic counts at the model's external cordon. The traffic volumes in these input files ("IE-EI2010_input.bin" and "ThroughTrips10.mtx") were adjusted to better fit observed traffic volumes and patterns.

The previous model did not include an external station at County Road 73 near Smithtown. This roadway had 1,760 ADT counted in 2011. There was an external station on a local road near Cheat Lake, which had no traffic count and appeared to be a very low volume road following construction of the Mon-Fayette expressway. This external station (TAZ 1005) was moved and reassigned to represent County Road 73 near Smithtown and external traffic volume inputs for 1005 were adjusted to reflect adjacent ADT counts on Country Road 73.

Treatment of the Mon-Fayette Expressway

The Mon-Fayette Expressway opened in 2011. The current base year model represents 2010 conditions, but the available validation counts for the area were taken in 2011. The external station volume for CR 857 was adjusted (based on a nearby PennDOT count) to represent an estimated 2010 condition. The 2040 model will reflect the construction of the Mon-Fayette Expressway as a 4-lane freeway.

Traffic Assignment Parameters

The MMMPO TDM uses the Bureau of Public Roads (BPR) formula for capacity constraint during traffic assignment. An older script from Caliper, the software developer of TransCAD, (associated with the model before its 2012 revalidation) used alpha and beta parameters of 0.15 and 4.0, respectively. These parameters are traditionally associated with the manner in which traffic reacts when input capacities reflect LOS “C” conditions, which is not the case with the input capacities to the MMMPO TDM. To reflect the LOS “E/F” input capacities reflected in the MMMPO TDM, the BPR function alpha and beta parameters were adjusted to 0.83 and 5.5, respectively[1]. It appears that the previous version of the model had separate alpha and beta parameters for the arterial and freeway system, but did not provide information on how the traffic assignment parameters were applied. The alpha and beta parameters used in the TDM 2015 update are the same for all roadway types.

Western Panhandle Trip Generation Adjustment

The “western panhandle” portion of Monongalia County is not part of the urban area, and is coded with limited model details. This rural part of the County is over 100 square miles, and represented by a simple network and zone structure in the model; it includes five (5) large TAZs (16, 28, 29, 298 and 326) and the only roadway corridor modeled is WV 7. There are some minor roadway connections that exist and likely provide some low levels of connection between trip productions / attractions in this part of the county, but are not modeled. Thus, without modification to the trip rates, the model does not accurately represent travel along WV 7, the only continuous East-West road modeled in this part of the county. For the purposes of better reflecting trip making on the major roadway system in this part of the county, trip rates were reduced by 40% for these 5 TAZs in the model.[2]

Addition of 4H Camp Road Network Links

Model links to represent portions of the 4H Camp Road were added to the model to improve the zonal loadings for TAZs southeast of the I-68 / I-79 junction.

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[1] Based on “Delay-Volume Relations For Travel Forecasting”, Horowitz (1991).

[2] It is recommended that if future projects do more detailed planning and / or corridor studies in this portion of the county, the model detail of the “panhandle” should be enhanced, including more TAZ detail / subdivision, more local / county roads added to the network, and better modeling of external stations (potentially Daybrook Rd, Highway 218 in PA, and Toms Run Road that crosses between the WV / PA border).

Input Model Travel Speed Adjustments
Input travel times over a network link are calculated based on input (uncongested) model speeds and link length. Through the traffic assignment process, these link travel times can increase due to model-estimated congestion levels that are a product of traffic assignments and input capacity levels. In most instances, higher input speeds along a network link makes that link "cost" less to use, and makes it more attractive for some trips to use, and vice versa. Thus, as part of the validation process, travel speeds were inspected and adjusted on links where it made sense to do so from a validation perspective, and where it created input travel speeds more consistent with observed / posted speeds on the network.

Significant updates to network speeds, specifically input free-flow speeds (FFS) included the following corridors:

- All Interstate links were coded with a FFS of 70 mph, consistent with posted speeds. The previous version of the model had Interstate speeds ranging from 50 mph to 65 mph.
- Star City (US 19 / WV7) Bridge speeds were increased to FFS 45 mph, consistent with posted speeds.
- Westover (US 19 / Pleasant Street) Bridge speeds were increased to FFS 25 mph, consistent with posted speeds.
- Beechurst Avenue speeds south of 8th Street were lowered to FFS 25 mph, consistent with posted speeds.
- US 19 speeds between Garfield Avenue and Holland Avenue in Westover were lowered to FFS 25 mph, consistent with posted speeds.
- Dorsey Avenue speeds north of Green Bag Road were raised to FFS 35 mph, the posted speed limit. Speeds along Dorsey south of downtown were raised to FFS 25 mph, consistent with posted speeds.
- University Avenue north of downtown through the WVU campus area had speeds raised to FFS 20 mph, still lower than posted speeds, but at a level deemed reasonable given the level of pedestrian activity and potential lower travel speeds in the corridor.
- Willey Street northeast of downtown speeds set to FFS 25 mph, consistent with posted speeds.
- Mileground Road speeds southwest of the Vance Farm House – Bicentennial House reduced to FFS 25 mph, consistent with posted speeds.
- Patteson Drive east of Mon Boulevard and Van Voorhis Rod south of Chestnut Ridge Road reduced speeds to FFS 40 mph, consistent with posted speeds.
- Chestnut Ridge Road east of Van Voorhis set speeds at FFS 40 mph, the posted speed limit.
- WV 705 east of Mon General Drive raised speeds to FFS 50 mph, consistent with posted speeds.
- 8th Street northeast of Beechurst lowered speeds to FFS 20 mph, to reflect lower-speed travel on the hill along a narrow cross-section with on-street parking.
- Tower Lane in Westover had speeds reduced to FFS 15 mph, consistent with posted speeds.

Validation Results

To apply consistent metrics to model performance, the same validation checks were performed for the TDM 2015 update model dataset as were performed for the October 2012 model validation. These validation checks were based on the Travel Model Improvement Program (TMIP) *Travel Model Validation and Reasonableness Checking Manual, Second Edition*, September 24, 2010. It was the goal of the 2015 MMMPO model update to introduce new parameters and routines to improve model performance without "over calibrating" the model by introducing unreasonable input parameters that might improve base year performance, but reduce overall model forecasting capabilities.

Year 2011 daily traffic counts from WVDOH were available at 208 locations, and were used for the 2010 model validation. The previous validation document from 2012 referenced over 700 links with counts to validate against; it is not clear if that process used a single observed count across multiple travel model links, or had more daily traffic counts to use for validation. This TDM 2015 update validation used WVDOH daily traffic counts were from GIS-based on data received directly from WVDOH, and the online 2011 daily traffic count maps available for Monongalia County. Each count was only used on a single model link that best represented the location where WVDOH reported their count. For future use and review, the counts used in this validation effort are available in the TransCAD model network in the "Val_Count" field.

The model validation results are based on the summed total of all period traffic assignments (AM period + MD period + PM period + off-peak period) compared to WVDOH counts noted above. That daily, summed period traffic volume estimated by the model is available in the output file "PeriodFlowSums.bin" in the "Tot_Flow" field.

For consistency with the previous model validation, the following model checks were completed:

- Volume Comparisons
- Vehicle Miles Traveled Comparisons
- Percent Root Mean Squared Error (RMSE) Comparisons

Additionally, large cutlines were evaluated for the goodness-of-fit between peak period assignments and observed peak period counts.

Volume Comparisons

Three different validation checks were completed, comparing model-estimated to counted / observed daily traffic volumes for each of the 208 links that had a daily traffic count available for comparison. **Figure 2** provides an illustration of the ratio of model-estimated daily traffic volumes to counted (observed) traffic volumes, ranging from blue in color (low model estimation) to red in color (high model estimation). Data are only shown on those links that had a daily traffic count available (208 locations). As shown, the majority of links in the study area have model-estimated traffic volumes that are within 25% of counted traffic volumes.

HDR

Figure 2. Ratio of Model-Estimated Traffic Volumes to Counted Traffic Volumes

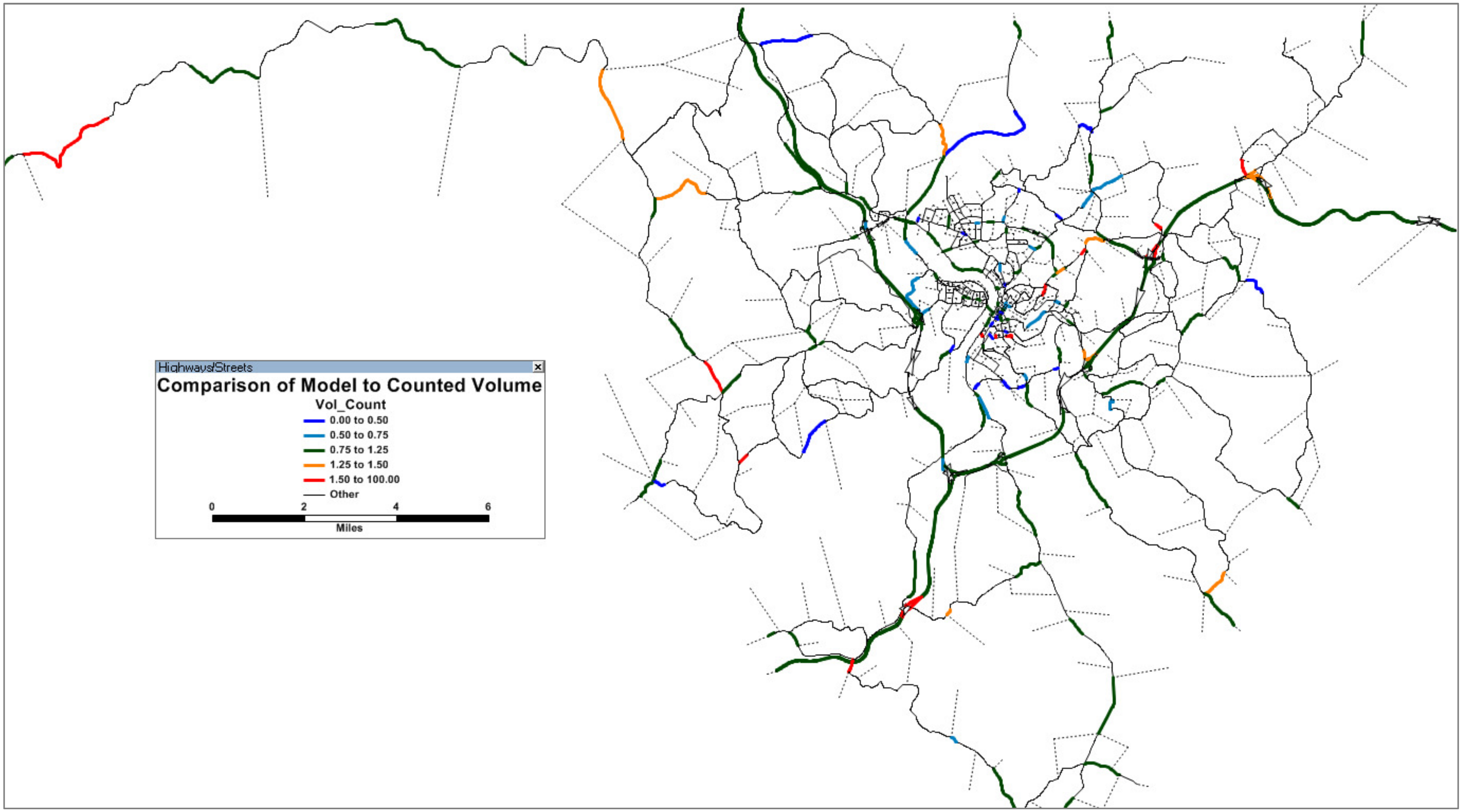


Table 2 compares the total amount of observed / counted daily traffic volumes to model-estimated daily traffic volumes at the 208 links with available counts, aggregated by functional classification groupings.

Table 2. Observed and Model-Estimated Daily Volumes by Functional Classification Group

Functional Classification Group	Sum of Counted Volumes	Sum of Modeled Volumes	Total Difference	Percentage Difference
Arterial	1,209,937	1,145,602	-64,335	-5.6%
Freeway	359,338	354,301	-5,037	-0.4%
Ramp	119,943	125,910	5,967	0.5%
Grand Total	1,689,218	1,625,813	-63,405	-3.8%

Table 3 compares the total amount of observed / counted daily traffic volumes to model-estimated daily traffic volumes, aggregated by counted volume range.

As shown in both **Table 2** and **Table 3**, the overall summary of model-estimated daily traffic is within 3.8% of counted daily volumes. All volume categories are well within the acceptable range of national validation guidelines[3].

- Arterials have the highest level of count and model deviation (at 5.6%). The level of deviation seen among the functional classifications generally indicates a good replication of observed levels.
- In general, higher-frequency volume ranges and the higher volume ranges are closer to 0% (model counts equal to observed counts) than the lower-frequency and lower volume ranges. Thus, overall model performance is good from this perspective.

[3] Table 9.2, *Travel Model Validation and Reasonableness Checking Manual, 2nd Edition*.

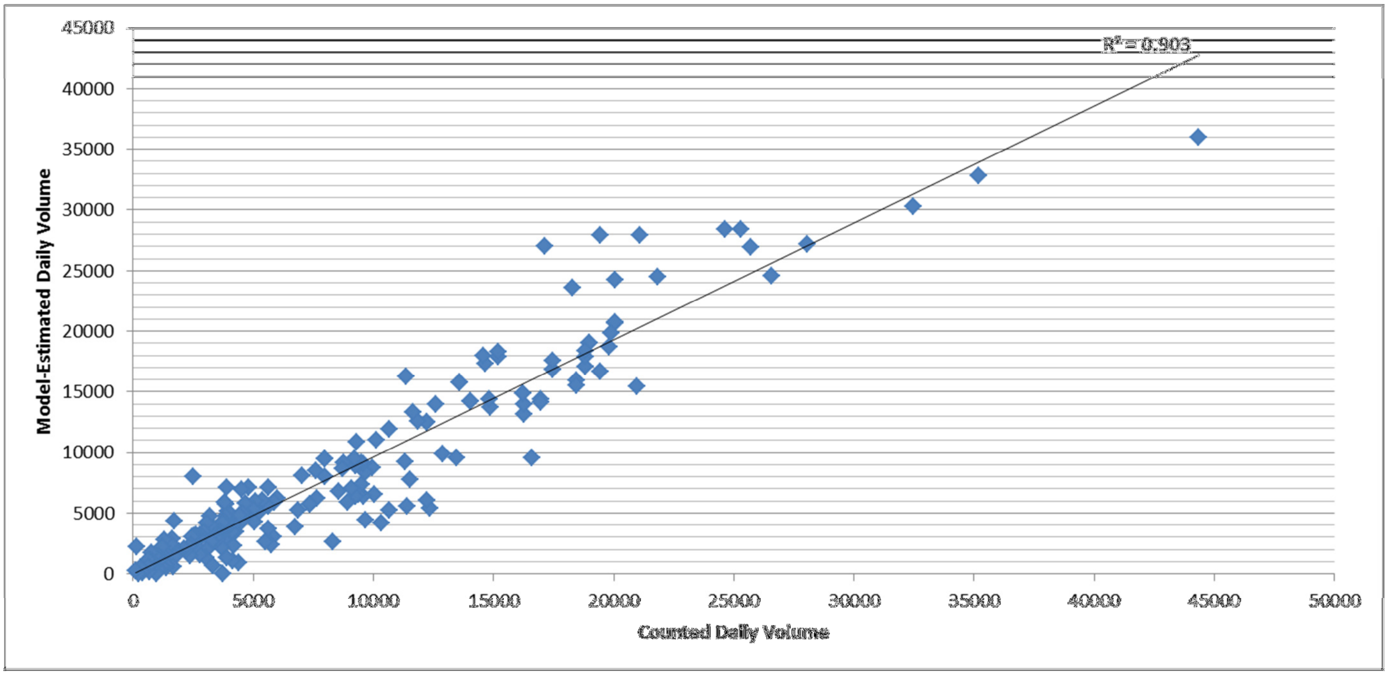
Table 3. Observed and Model-Estimated Daily Volumes by Counted Volume Range

Counted Volume Range	Sum of Counted Volumes	Sum of Modeled Volumes	Total Difference	Percentage Difference
0 - 500	1595	3,535	1,940	122%
500 - 1,500	24,524	26,572	2,048	8%
1,500 - 2,500	27,682	30,169	2,487	9%
2,500 - 3,500	63,262	66,884	3,622	6%
3,500 - 4,500	109,143	99,598	-9,545	-9%
4,500 - 5,500	67,529	74,695	7,166	11%
5,500 - 7,000	59,511	45,588	-13,923	-23%
7,000 - 8,500	69,333	63,991	-5,342	-8%
8,500 - 10,000	167,184	142,614	-24,570	-15%
10,000 - 12,500	169,931	140,080	-29,851	-18%
12,500 - 15,000	153,121	156,778	3,657	2%
15,000 -17,500	181,773	177,725	-4,048	-2%
17,500 - 20,000	228,318	229,493	1,175	1%
20,000 - 25,000	148,690	161,982	13,292	9%
25,000 - 35,000	138,090	137,304	-786	-1%
35,000 - 45,000	79,532	68,804	-10,728	-13%
Grand Total	1,689,218	1,625,813	-63,405	-3.8%

Figure 3 shows a scatterplot of model-estimated daily volumes compared to counted volumes, with each data point representing a single modeled link. As shown, the data generally congregate along the line defining a one-to-one trend of model-estimated volumes equal to counted volumes.

The R-squared statistic measures the strength of the relationship between observed traffic volumes and model-estimated traffic volumes, with 1.0 representing a model that fully explains the relationship, and 0.0 representing a model that explains none of the relationship. R-squared describes correlation, but not necessarily explanatory value. While the r-squared statistic is not a crucial determinant of overall model performance, it is one piece of information that describes overall model goodness-of-fit. Through the TDM 2015 update, the MMMPO model now achieves an **R-squared value of 0.903**, well within established guidelines, indicating a close fit between counts and assignments.

Figure 3. Scatterplot of Model-Estimated Volumes and Counted Volumes



Vehicle Miles Traveled Comparisons

Vehicle miles traveled (VMT) estimated by the model was compared to observed VMT for those links that had associated observed count data. VMT is simply the amount of vehicles on each segment multiplied by that segment's length, and then all segments with counts in the MMMPO area summarized. **Table 4** compares the level of observed / counted VMT and the level of model-estimated VMT for the 208 links with available counts, aggregated by functional classification groupings.

Table 4. Observed and Model-Estimated Daily VMT by Functional Classification Group

Functional Classification Group	Sum of Counted Volumes	Sum of Modeled Volumes	Total Difference	Percentage Difference
Arterial	338,192	328,198	-9,994	-3.0%
Freeway	752,030	754,265	2,235	0.3%
Ramp	31,563	33,993	2,430	7.7%
Grand Total	1,121,784	1,116,456	-5,328	-0.5%

Table 5 compares the level of observed / counted VMT to model-estimated daily VMT, aggregated by counted volume range.

Table 5. Observed and Model-Estimated Daily VMT by Counted Volume Range

Counted Volume Range	Observed / Counted VMT	Model-Estimated VMT	Total Difference	Percentage Difference
0 - 500	735	926	191	21%
500 - 1,500	13,988	16,820	2,832	20%
1,500 - 2,500	13,770	14,421	651	5%
2,500 - 3,500	40,197	33,888	-6,309	-16%
3,500 - 4,500	47,867	49,230	1,362	3%
4,500 - 5,500	18,274	20,294	2,019	11%
5,500 - 7,000	11,975	10,859	-1,116	-9%
7,000 - 8,500	22,562	24,441	1,880	8%
8,500 - 10,000	114,471	110,845	-3,626	-3%
10,000 - 12,500	41,405	40,087	-1,318	-3%
12,500 - 15,000	273,245	281,997	8,752	3%
15,000 - 17,500	147,249	137,557	-9,691	-7%
17,500 - 20,000	213,283	210,841	-2,443	-1%
20,000 - 25,000	128,988	131,778	2,789	2%
25,000 - 35,000	24,346	24,230	-117	-0%
35,000 - 45,000	9,428	8,244	-1,184	-13%
Grand Total	**1,121,784**	**1,116,456**	**5,328**	**0.5%**

As shown in both **Table 4** and **Table 5**, the overall summary of model-estimated daily VMT is within 0.5% of counted daily volumes.

- Ramps have the highest level of deviation (at 7.7%), but are also by far the lowest VMT facility and as a result most prone to deviation. The level of deviation seen among the functional classifications generally indicates a good replication of observed levels.
- In general, higher-frequency volume ranges and the higher volume ranges are closer to 0% (model VMT equal to observed VMT) than the lower-frequency and lower volume ranges. Thus, overall model performance is good from this perspective.

A model with estimated and observed VMT levels that nearly match indicate general overall good model performance.

Root Mean Square Error

Root mean square error (RMSE) and percent RMSE (%RMSE) are statistical checks that compare the overall amount of difference between model-estimated and observed traffic levels for each link. RMSE provides a calculation of overall model accuracy, and unlike the volume and VMT comparisons above, a series of positive and negative differences do not cancel each other out with the RMSE measure. The lower the RMSE and %RMSE, the better the model accuracy.

RMSE and %RMSE are calculated as:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}[(Count_i - Model_i)^2]}{N}}$$

$$\%RMSE = \frac{RMSE}{\left(\frac{\sum_{i=1}^{N} Count_i}{N}\right)} * 100$$

Where:

$Count_i$ = The observed traffic count for link *i*;

$Model_i$ = The model-estimated traffic volume for link *i*; and

N = The number of links with counts in the model, including link *i*[4]

Table 6 provides the RMSE and % RMSE by functional classification group[5]. As shown in Table 6, the %RMSE is within and below those levels, indicating relatively low levels of overall model deviation and high levels of model fit.

Table 6. RMSE and Percent RMSE by Functional Classification Group

Functional Classification Group	Number of Count Locations	RMSE	%RMSE
Arterial	155	2,634	34%
Freeway	24	1,419	9%
Ramp	29	1,342	32%
Grand Total	**208**	**2,378**	**29.3%**

Table 7 provides the RMSE and %RMSE by counted volume range. Florida DOT / Florida Standard Urban Transportation Model Structure (FSUTMS) standards, which are widely recognized as a national best practice, are provided for reference.

[4] *Travel Model Validation and Reasonableness Checking Manual, 2nd Edition*
[5] Typical targets for %RMSE range from 30% to 50%.

Table 7. RMSE and Percent RMSE by Counted Volume Range

Counted Volume Range	Number of Count Locations	RMSE	%RMSE	FSUTMS Standard (Acceptable – Desirable)
0 - 500	6	877	330%	-
500 - 1,500	25	581	59%	-
1,500 - 2,500	14	912	46%	-
2,500 - 3,500	21	1,536	51%	-
3,500 - 4,500	28	1,609	41%	45 - 100%
4,500 - 5,500	14	1,019	21%	35 - 45%
5,500 - 7,000	10	2,111	35%	35 - 45%
7,000 - 8,500	9	2,265	29%	35 - 45%
8,500 - 10,000	18	2,138	23%	35 - 45%
10,000 - 12,500	15	4,062	36%	27 - 35%
12,500 - 15,000	11	2,240	16%	27 - 35%
15,000 - 17,500	11	4,228	26%	25 - 30%
17,500 - 20,000	12	3,271	17%	25 - 30%
20,000 - 25,000	7	4,100	19%	15 - 27%
25,000 - 35,000	5	2,025	7%	15 - 27%
35,000 - 45,000	2	6,150	15%	15 - 25%
Grand Total	**208**	**2,378**	**29.3%**	30 - 50%

As shown in **Table 6** and **Table 7**, the overall level of model deviation from observed counts is relatively low and generally within the “desirable” guidelines set forth in other states.

Cutlines

Cutlines were added as a general method of evaluating modeled flows across major areas. Four cutlines were established, based on the availability of counts and logical locations:

- Cutline 1: Monongahela River
- Cutline 2: Downtown Morgantown Boundary
- Cutline 3: Northwest of I-68
- Cutline 4: West of I-79

Model validations often aim for cutline model volumes to be within 10% to 15% of counted volumes. **Table 8** shows the daily model-estimated and observed volume comparison across each of those cutlines.

Table 8. Observed and Model-Estimated Daily Traffic Volumes by Cutline

Cutline	Segment Name	Model Link ID	Observed Daily Count Volume	Model-Estimated Daily Volume	Percentage Deviation
Cutline 1: Monongahela River Crossing Cordon Check					
	US119 EB	405	16,276	13,157	
	US119 WB	406	16,276	13,988	
	US19	1176	19,811	18,729	
	I79 NB	1831	18,821	18,408	
	I79 SB	2112	18,821	17,872	
Cutline 1 Total			**90,005**	**82,153**	**-8.7%**
Cutline 2: Downtown Morgantown Crossing Cordon Check					
	Beechurst Ave	1079	20,042	24,273	
	US 19	1176	19,811	18,729	
	Willey St	1211	11,522	7,795	
	University Ave	1275	21,823	24,517	
	High St	1301	5,503	2,625	
	Pleasant St	1303	4,661	4,745	
	Brockway Ave	1318	9,680	8,321	
Cutline 2 Total			**93,042**	**91,006**	**-2.2%**
Cutline 3: NW of I-68					
	US 119	1740	18,824	17,046	
	Kingwood Pike	1695	4,115	4,218	
	State Route 7	1579	11,353	16,237	
	Canyon Rd	575	3,837	5,933	
	Point Marion Rd	652	12,598	13,998	
	Hartmann Run Rd	724	7,991	7,984	
	Hwy 857 EB	725	12,237	12,538	
	Hwy 857 WB	726	12,237	12,514	
Cutline 3 Total			**83,192**	**90,469**	**8.7%**
Cutline 4: West of I-79					
	Mason Dixon Hwy	2520	7,038	8,114	
	Chaplin Rd	590	5,037	4,220	
	Fairmont Rd	1374	7,373	5,726	
	Fairmont Rd	1375	7,373	5,744	
	Halleck Rd	2049	748	1,716	
Cutline 4 Total			**27,569**	**25,521**	**-7.4%**

As noted earlier in this document, part of the validation process used available peak period traffic counts to create the appropriate temporal factors in use of the time-of-day element of the model. Due to the nature of the available peak period data, the peak periods themselves were validated only on a limited basis. **Table 9** represents the high-level cutline comparisons completed for the peak hour model "pseudo-validation". The bottom three rows provide a total/ combined assessment of goodness-of-fit for all three cutlines.

Table 9. Comparison of Peak Period Observed Volumes and Model-Estimated Volumes by Cutline

Cutline	Segment Name	Peak Observed Volume			Peak Model-Estimated Volume		
		AM Period	Midday Period	PM Period	AM Period	Midday Period	PM Period
Cutline 1: NW of I-68							
	Cheat Rd Eastbound	1,664	1,765	4,716	1,353	1,414	3,043
	Cheat Rd Westbound	2,662	1,783	2,820	2,044	1,444	2,474
	WV 7 / Earl Core	2,316	2,357	4,527	2,409	1,997	4,050
	Dorsey Ave	787	374	1,161	648	484	1,080
	Cutline 1 Total	7,429	6,279	13,224	6,454	5,339	10,647
Cutline 1 Model Deviation from Observed					-13%	-15%	-19%
Cutline 2: North of WV 705							
	VanVoorhis	1,895	1,980	3,277	1,785	1,593	3,019
	Steweartstown	2,280	1,766	3,916	2,199	1,870	3,842
	Mileground	3,202	2,965	4,597	3,445	3,128	5,351
	Hartman Run	1,095	1,270	2,024	891	910	1,647
	Cutline 2 Total	8,472	6,711	11,790	8,319	7,500	13,859
Cutline 2 Model Deviation from Observed					-2%	12%	18%
Cutline 3: Downtown							
	Beechurst	2,700	2,892	5,109	3,826	3,122	5,956
	Willey	1,328	1,602	2,978	1,156	1,028	1,948
	Walnut	1,490	1,329	2,347	1,369	1,009	2,025
	Pleasant	582	415	1,074	848	567	1,100
	University	3,460	3,039	6,047	3,598	3,173	5,986
	Westover Bridge	2,373	2,391	4,943	3,305	2,442	5,293
	Cutline 3 Total	11,933	11,668	22,498	14,102	11,341	22,309
Cutline 3 Model Deviation from Observed					18%	-3%	-1%
TOTAL OF ALL 3 CUTLINES		27,834	24,658	47,512	28,874	24,180	46,815
Total of All 3 Cutlines Model Deviation from Observed					4%	-2%	-1%
R-Squared Goodness of Fit Statistic: Model vs Observed					83.6%	91.4%	86.8%

Validation Conclusion

Through the model upgrades and adjustments in the TDM 2015 update, overall model performance has improved. Due to the introduction of a time-of-day element, the model will be more sensitive to capacity restraint, and due to the introduction of AirSage-based trip distribution factors, should better reflect travel patterns to and from the WVU campus.

The travel model should be applied in relative terms to understand and interpret patterns, with judgment used when interpreting results. Travel models are aggregated, imperfect representations of real-world land use conditions and transportation network representations. A certain perspective needs to be understood when evaluating modeling results. While it is anticipated that the model, in most cases, provides a reasonable, relative forecast of travel patterns and traffic growth levels, model output needs interpretation to produce traffic forecasts. This is often called "post-processing" travel model traffic assignments, with the assumption that the model reflects relative levels of growth by corridor, but there is always some level of deviation (or "error") seen in the base year model (2010) between model-estimated and observed / counted traffic. Post-processing corrects for this base year deviation when developing future year 2040 model traffic forecasts. This approach has its basis in NCHRP 255, "Highway Traffic Data for Urbanized Area Project Planning and Design".

Future Model Improvements

Through the validation and model development process, several opportunities for model improvements were identified. Those improvements include:

- **Subarea Count / Socioeconomic Investigations**: As outlier count-model comparisons were investigated during validation, two subareas of the model appeared to have inconsistent patterns of observed traffic counts and socio-economic levels (trip generation) that could not be easily rectified. In these two corridors, there are ADT counts that are significantly higher than those supported by local trip generation (given the input socio-economic data) and expected levels of pass-through traffic in those corridors. These two subareas are:
    - *Star City area* – model-estimated traffic volumes along University Avenue between Patteson Drive and the Star City US 19 bridge are significantly lower than WVDOH ADTs. On segments just beyond this subarea, model volumes fit observed counts much better. Thus, it appears that either socio-economic data inputs are low (as this area is not generating sufficient trip levels to achieve the counts along this portion of University Avenue), or reported traffic counts are higher than actual levels.
    - *Green Bag Road / Dorsey Avenue area* - Similar to the Star City area, model-estimated traffic volumes along this portion of Green Bag Road and Dorsey Avenue are significantly lower than WVDOH ADTs. On segments just beyond this subarea, model volumes fit observed counts much better. Thus, it appears to be either an issue of low socio-economic data inputs or high traffic counts.
- **Additional Time-of-Day validation**: A TOD component was added to the MMMPO TDM, and available counts were used to adjust TOD inputs. A more extensive peak hour

validation, with a wider set of corrected / normalized peak period counts would add some additional accuracy to the period-based assignments. Any additional survey data from a source such as an NHTS add-on survey could help with additional tailoring of period factors by trip purpose.

- **Mode Choice Element**: The MMMPO TDM currently does not consider non-automobile trips as a part of the modeling process. While this approach covers the vast majority of regional trip-making via automobile, it skips trip making for many non-motorized travelers, particular in central Morgantown. Future model enhancements should consider adding a mode-choice element to the model, looking at bus trips and PRT trips as a part of the modeling process.
- **WVU Trip Generation Study**: More investigation into the trip rates tailored to the WVU campus would be a potential future improvement to the MMMPO TDM. This would be a valuable locally-based validation check, and enhance the AirSage-based adjustments this model update provided.
- **Enhanced downtown Morgantown Model Detail**: the downtown street network is a simplification of the actual network – some one-way streets are not accurately represented, and as a result travel flows in and immediately adjacent to downtown are somewhat inaccurate.[6] For the purposes of the regional model, this is not a significant issue. However, for subarea studies and corridor studies these details can affect model output for a few blocks adjacent to downtown. This would likely require additional zonal subdivision to support the improved street network detail.
- **Enhanced "Western Panhandle" Model Detail**: As noted earlier in this document, this rural part of Monongalia County is coded with limited model details. If corridor studies or other model applications are required in this part of the County, it is recommended that the 40% trip generation reduction validation factor be removed, and additional network and zonal details, including new external stations, be added to more accurately reflect travel in this part of Mon County.

[6] University Ave between Willey and Beechurst is represented as a two-way street, and Chestnut Street downtown is not included in the model.

Appendix – AirSage Factor Development

The AirSage OD data illustrated the relative travel flows between various districts within and beyond the MMMPO planning boundary. The AirSage data add value to the MMMPO TDM by providing a point of reference that can either validate some of the model steps or identify needs for further TDM improvements. In this study, a review of AirSage data for travel flows between districts associated with the West Virginia University (WVU) campus suggested that the WVU area could be more appropriately modeled in the TDM as a special generator. Special generators are elements within a TDM that reflect trip making behavior different from the common behavior observed in the rest of the TDM, as they exhibit unique trip making behavior both terms in travel amounts and in trip distribution patterns. Based on the comparison of MMMPO TDM model output with AirSage data, HDR applied the AirSage data to develop a specialized trip distribution procedure for the WVU campus within the model.

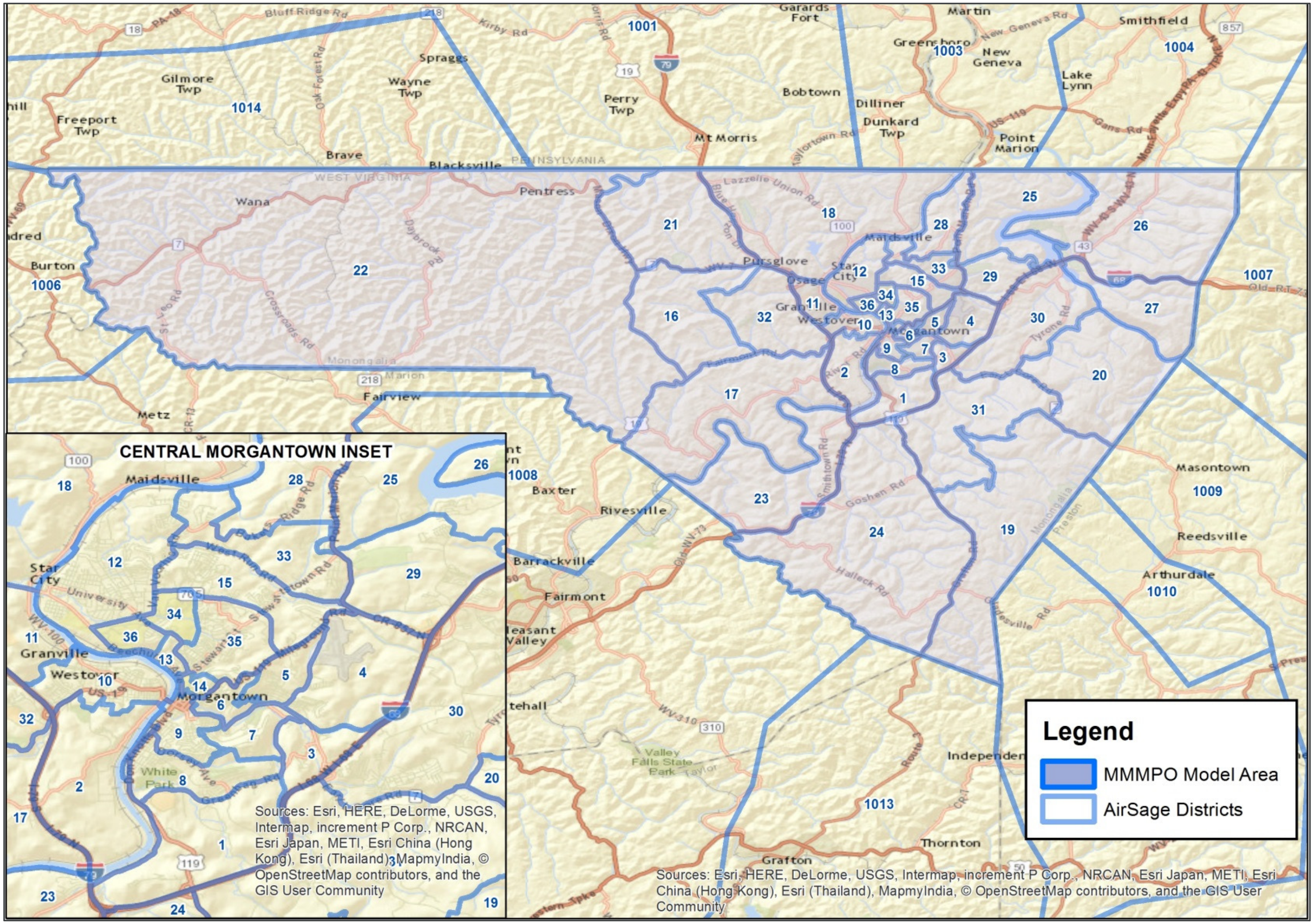
WVU Special Generator Trip Distribution Procedure

AirSage data was collected for 36 districts within the MMMPO model boundary and 14 districts external to the MMMPO model boundary. Districts were developed as groupings of traffic analysis zones (TAZs) that were likely to exhibit similar travel patterns. Of the 36 districts within the model boundary, 5 districts were identified as being associated with WVU. The AirSage districts are shown in Figure 1. The WVU districts were:

- District 12
- District 13
- District 14
- District 34
- District 36

Review of the AirSage data compared to the MMMPO TDM's gravity model output revealed unique characteristics in the distribution of traffic flows between these WVU districts and other districts. The project team determined that the best way to capture this unique distribution of traffic flows was to adjust the gravity model trip distribution for trips related to WVU zones (on either the origin or destination end) with a trip distribution procedure based on factors computed directly from the AirSage data.

Figure A1. Districts Used for AirSage / MMMPO TDM Analysis



The new WVU special generator trip distribution procedure is constructed as follows:

- Run the existing trip generation procedure in the MMMPO TDM. This develops the daily zone-by-zone productions and attractions for multiple trip types.
- Run the existing gravity model trip distribution procedure in the MMMPO TDM. This develops the daily zone to zone trip flow matrices for multiple trip types.
- Run the new WVU special generator trip distribution procedure:
  - Extract selections (sub-matrices) of the daily zone to zone trip flow matrices for 5 different types of zonal flows:
    - Trip flows between two WVU zones (Defined as Zone 1)
    - Trip flows from a non-WVU zone to a WVU zone (Defined as Zone 2)
    - Trip flows from an external zone to a WVU zone (Defined as Zone 3)
    - Trip flows from a WVU zone to a non-WVU zone (Defined as Zone 4)
    - Trip flows from a WVU zone to an external zone (Defined as Zone 5)
  - Runs an iterative (Fratar) balancing procedure on each selection (sub-matrix) that is constrained to both production totals by zone and attraction totals by zone. The balancing procedure uses the AirSage factor matrices (see "Development of AirSage Factor Matrices" section below) as a set of initial values for each zone to zone flow and then grows the zone to zone flows by a factor to match either total productions by zone or total attractions by zone. New factors are iteratively developed and applied to the zone to zone flows until the total productions and total attractions for each zone are within a tolerance of the target values. Outputs include:
    - Updated trip flows between two WVU zones
    - Updated trip flows between a WVU zone and a non-WVU zone
    - Updated trip flows between a WVU zone and an external zone
  - Replaces the selections of zone to zone trip flows back into the overall daily zone to zone trip flow matrices. At this stage no trip flows between two non-WVU zones (including external stations) will have changed, but all trip flows between a WVU zone and any other zone (WVU, non-WVU, or external) will have been updated from their value after running the gravity model distribution to the value calculated using the new AirSage Factor trip distribution procedure. Outputs include:
    - Updated daily zone to zone trip flow matrices for multiple trip types
- Sends the updated daily zone to zone trip flow matrices for multiple trip types to be converted from production and attraction matrices to origin-destination matrices separated into four time periods.

Development of AirSage Factor Matrices

AirSage data was converted from the original format provided by the data vendor to a format that allowed for direct use in the MMMPO TDM following the existing gravity model trip distribution procedure. The method to convert AirSage data into the model required AirSage factors is as follows.

1. Identify AirSage data as Home-Based flows or Non-Home-Based flows for internal districts. AirSage factors involving travel with an external district combine all trip purposes.
2. Select portions of the AirSage district-to-district trip flow matrix:
    a. Trip flows between WVU districts (Defined as Zone 1)
    b. Trip flows from non-WVU districts to WVU districts (Defined as Zone 2)
    c. Trip flows from external districts to WVU districts (Defined as Zone 3)
3. Normalize each selection of AirSage district-to-district trip flows by the sum of all origin trips for each zone.
4. Products of Steps 1 through 3 are reflected in the TransCAD model files:
    a. ASHB1_DISTRICT.mtx (AirSage Home-Based Zone 1)
    b. ASHB2_DISTRICT.mtx (AirSage Home-Based Zone 2)
    c. ASNHB1_DISTRICT.mtx (AirSage Non-Home-Based Zone 1)
    d. ASNHB2_DISTRICT.mtx (AirSage Non-Home-Based Zone 2)
    e. ASTOT3_DISTRICT.mtx (AirSage Total of all trip types Zone 3)
5. Overlay the AirSage district shapefile and TAZ layer in TransCAD.
6. Tag each TAZ with its overlying district.
7. Disaggregate each matrix of AirSage district-to-district trip flows described in Item 4 from row and column identifiers (IDs) of districts to row and column IDs of TAZs. Disaggregate row factor and column factor in TransCAD is 1, which means normalized flows from "TAZ A" to "TAZ B" and "TAZ C" will be the same if "TAZ B" and "TAZ C" share the same district.
8. Set all intrazonal flows (e.g. flow from "TAZ A" to "TAZ A") to zero for the matrices.

The AirSage Factor matrices created will need to have the same names as shown in Item 4 with the _DISTRICT portion removed (e.g. ASHB1.mtx) and placed in the proper folder structure. The AirSage factor matrices for Zone 2 and Zone 3 are transposed by the special generator procedure to create matrices for Zone 4 (WVU districts to non-WVU districts) and Zone 5 (WVU districts to external districts).

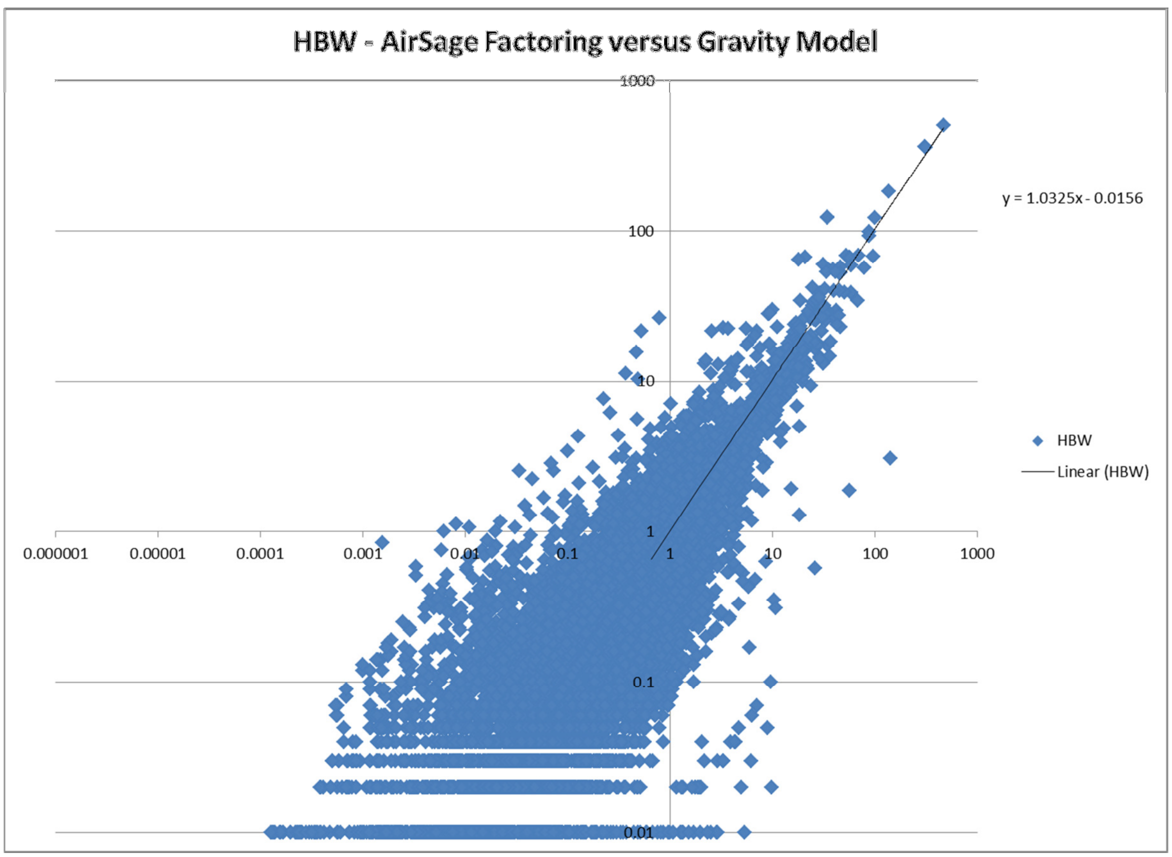
Any modifications to the MMMPO zone structure will require these steps be repeated to create new AirSage Factor matrices.

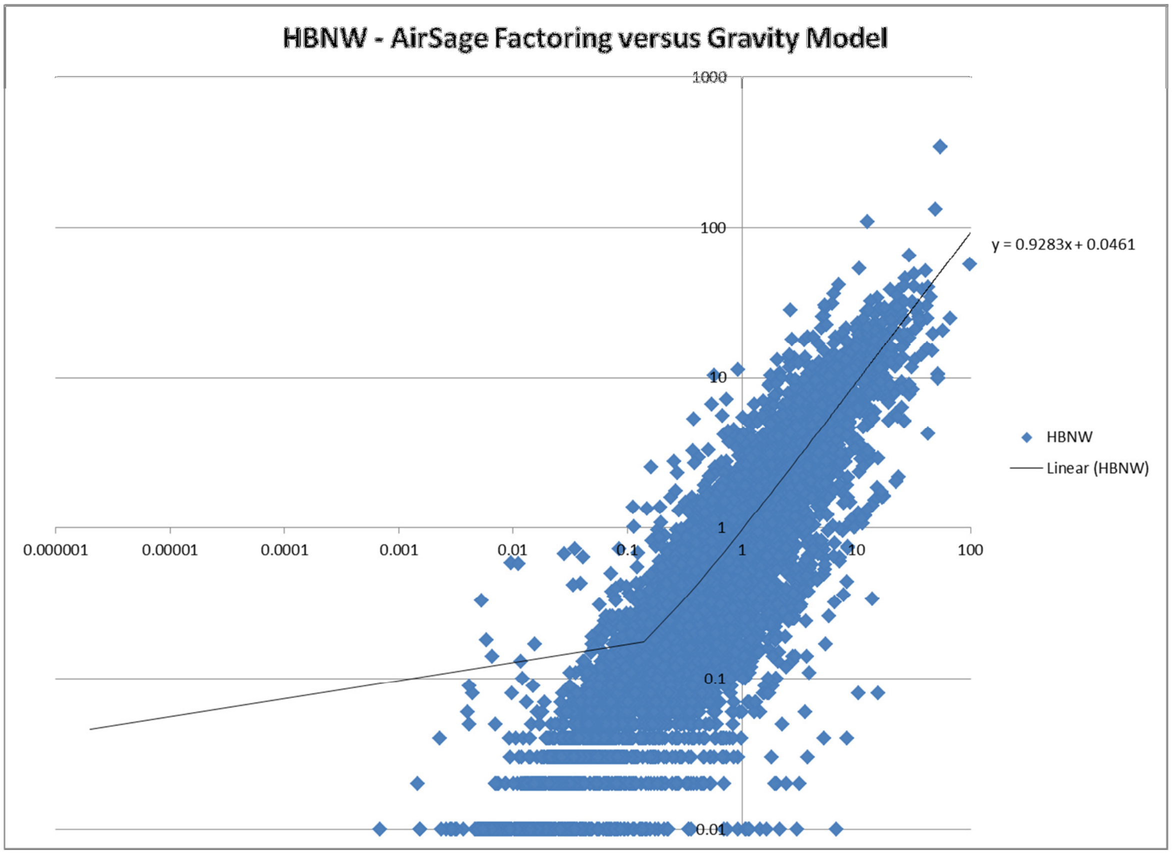
Evaluation of WVU Special Generator Trip Distribution

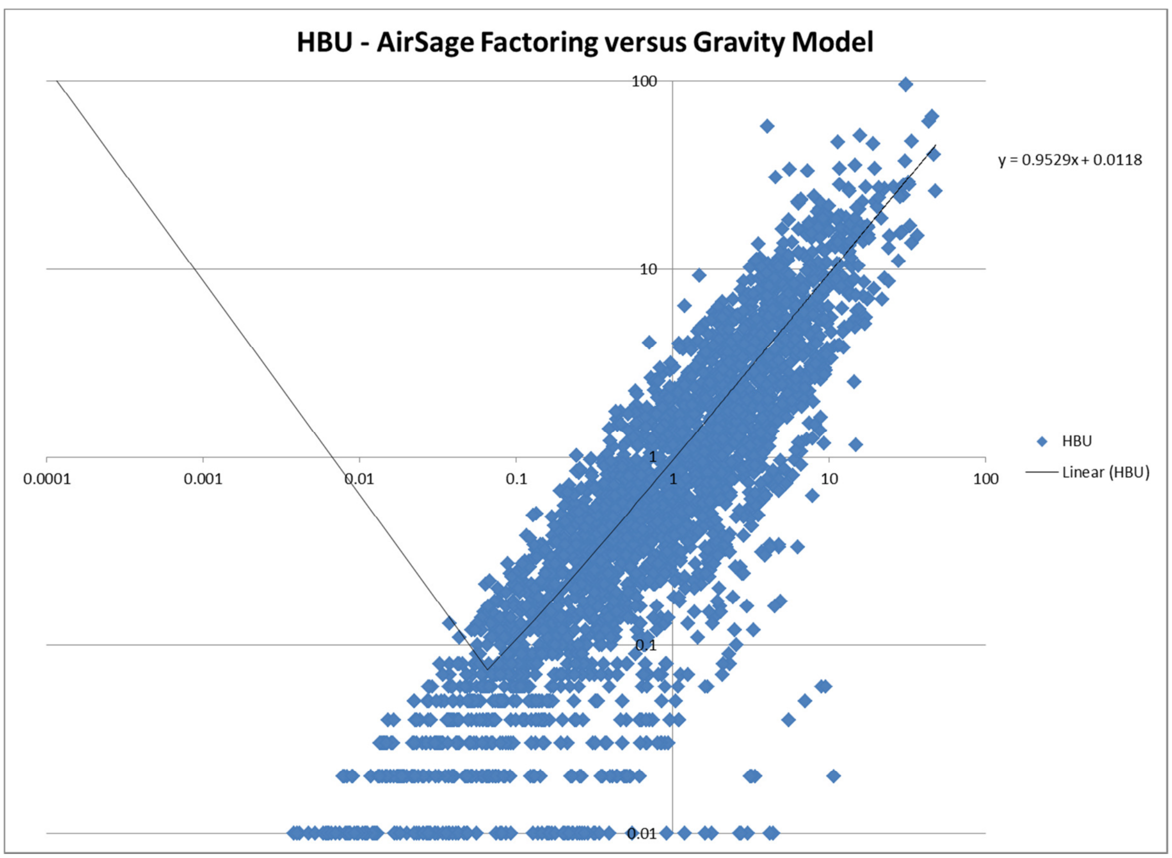
By design, the WVU Special Generator Trip Distribution procedure does not change the amount of total trips generated by a zone. The procedure instead re-distributes generated trips to the WVU area based on how AirSage data showed the relative flows between districts. In order determine what effect the change in trip distribution has for WVU, data analysis was conducted for model zone-to-zone trip flows with and without the WVU Special Generator Trip Distribution procedure.

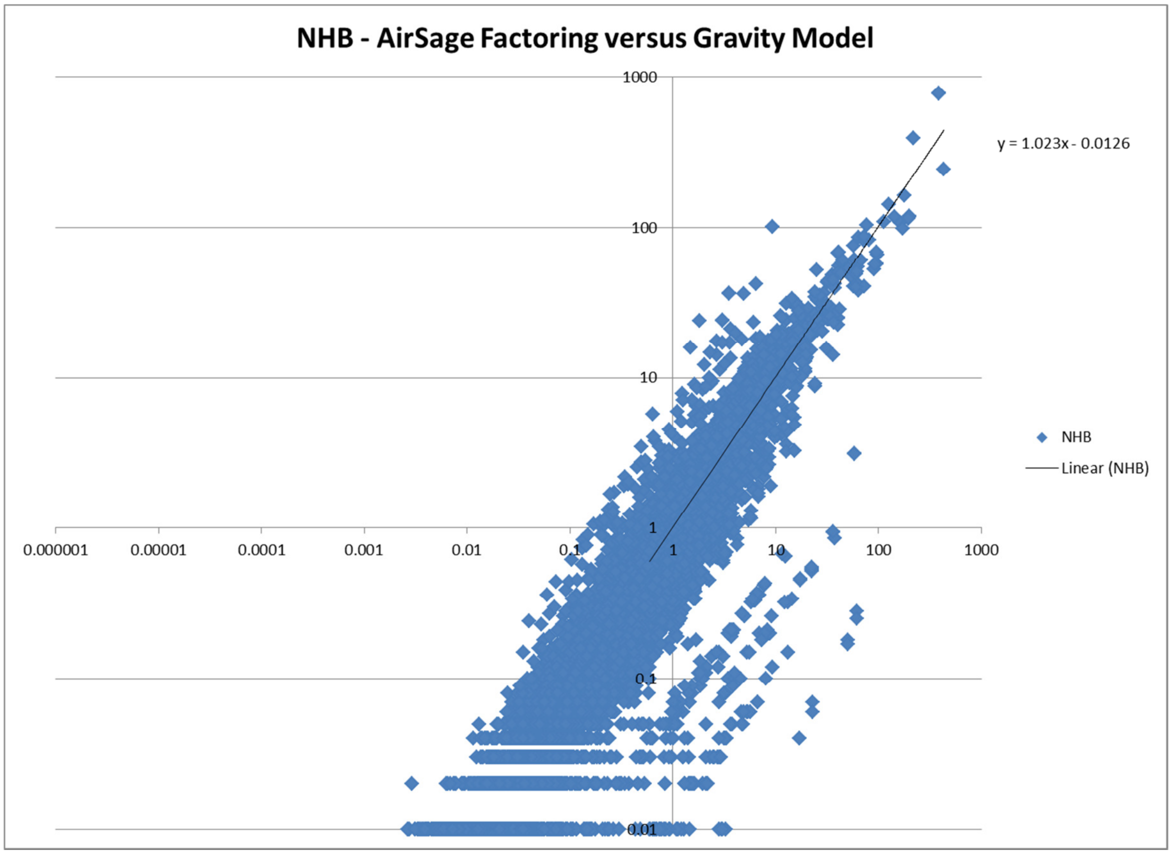
The data analysis began by comparing how the flow for each cell changed after introducing AirSage factors. This data comparison is plotted for each of four trip types in the model. The plots are shown on a log-log chart to show the changes in flows in a more balanced fashion for both zone pairs with high trip exchanges and zone pairs with low trip exchanges. The data in all four plots reflects similar trends. The most important trend is that there are zones exchanges where the gravity model and AirSage agreed on the amount of trips generated and there are zone exchanges where the two methods did not agree on the amount of trips generated.

The most obvious data to see in the plots are where the two methods did not agree on the number of trips generated. That data is in the lower right and upper left quadrant of the four data plots. In the lower right quadrant are zone exchanges where the gravity model distributed many trips, but AirSage flows show low trip making activity. In the top left quadrant are zone exchanges where the gravity model distributed few trips, but AirSage showed higher levels of trip making activity. The plots show that after the AirSage factoring has been applied that there are some of these zone exchanges where the gravity model and AirSage are not in agreement, but for most cases the two methods lead to an agreement of the general level of trip making. A linear trend line was added to the plot as an additional confirmation of this agreement between the two methods. The trend lines show that the distribution methods are more consistent for some trip types as compared to others. Home-based work trips and Non-home based trips on average tend to show the AirSage factoring method as slightly increasing the gravity model trips per zone exchange, whereas the home-based non-work and home-based university trips saw on average a slightly larger decrease in trips per zone exchange due to applying AirSage factors.

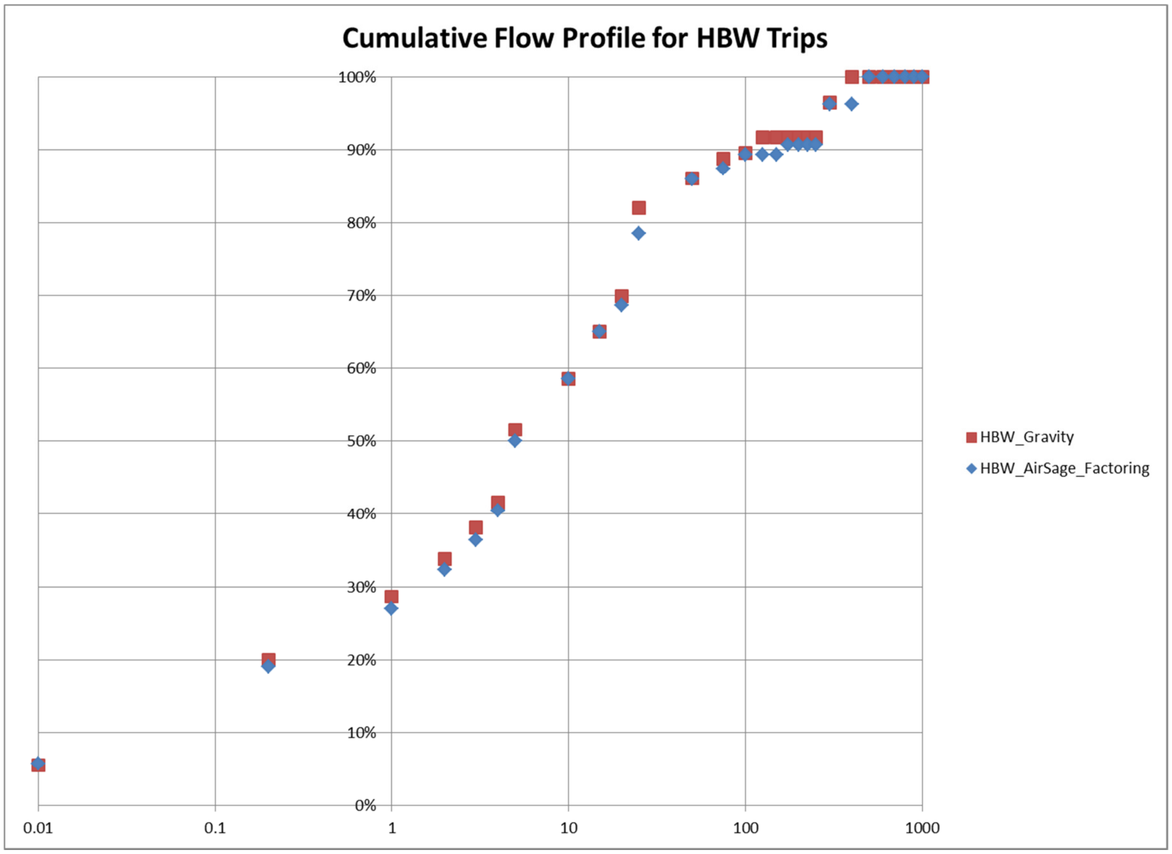


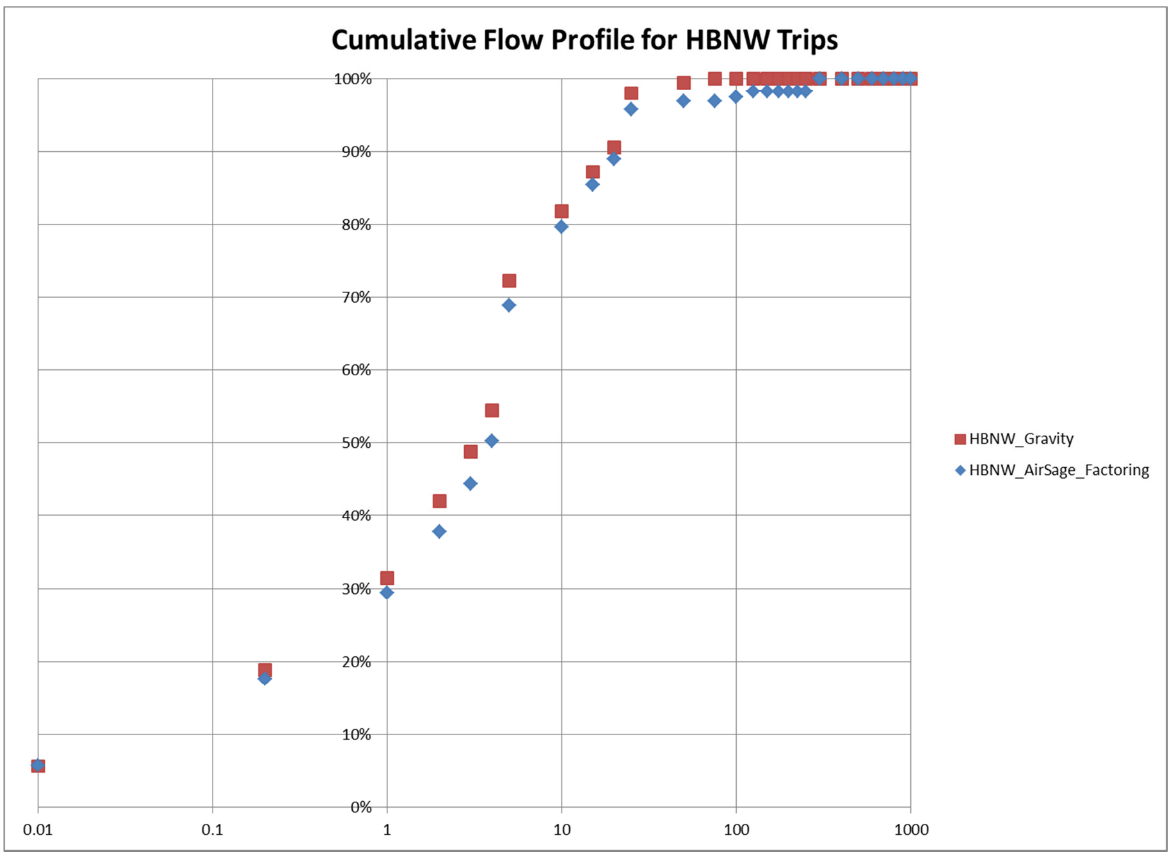

HBNW - AirSage Factoring versus Gravity Model
1000
100
10
1
0.1
0.01
0.000001
0.00001
0.0001
0.001
0.01
0.1
1
10
100
y = 0.9283x + 0.0461
HBNW
Linear (HBNW)

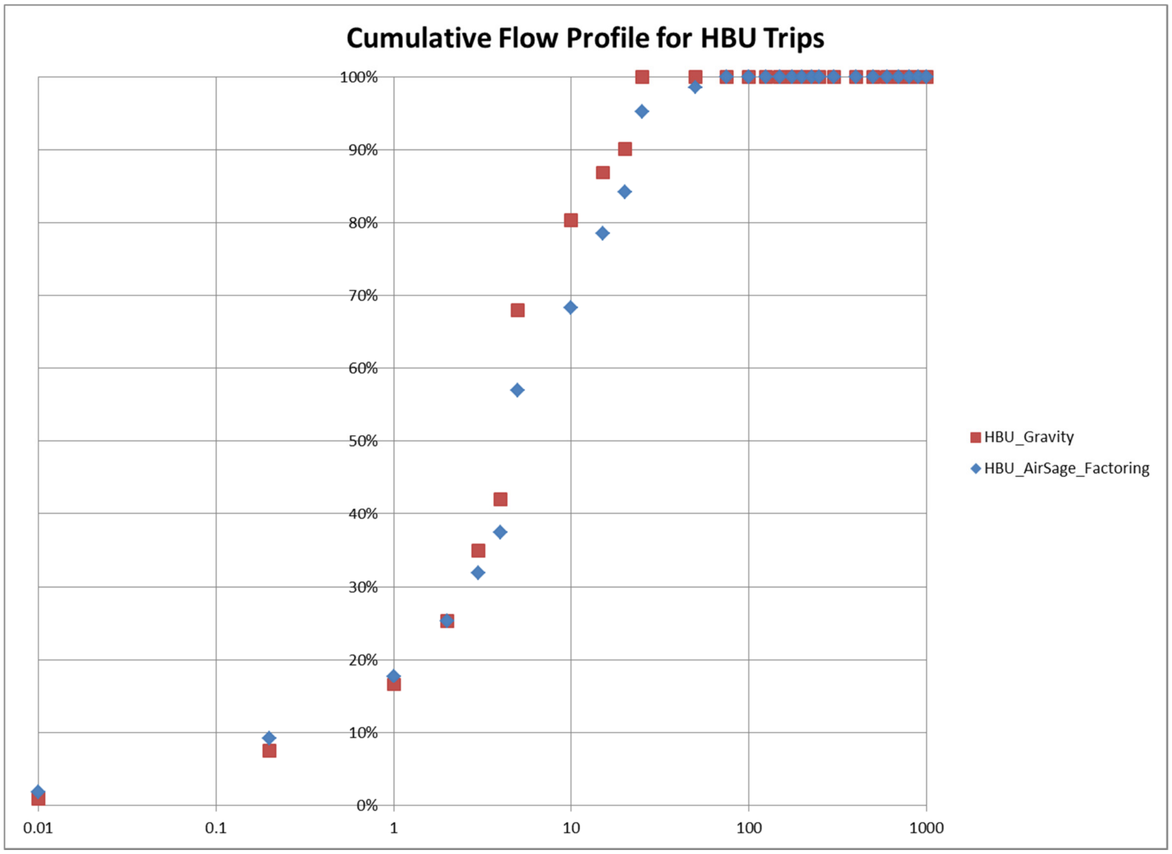

HBU - AirSage Factoring versus Gravity Model
100
10
1
0.1
0.01
0.0001
0.001
0.01
0.1
1
10
100
y = 0.9529x + 0.0118
HBU
Linear (HBU)

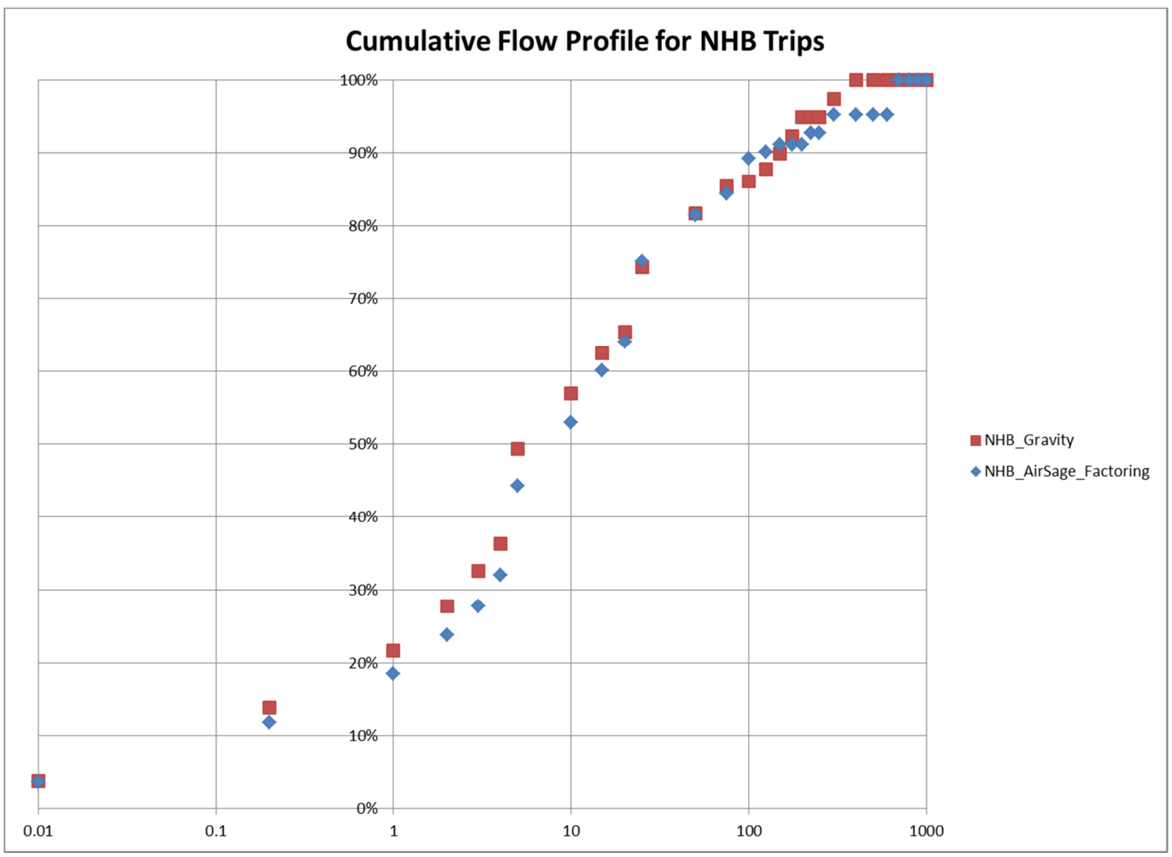


Additional data analysis was conducted by developing cumulative flow profiles by trip type. The cumulative flow profile displays information such as, "59% of all Home-based work flows come from zone exchanges with less than 10 trips exchanged". The cumulative flow profiles tell a similar story of how AirSage factoring changes trips per zone exchange. The plots for most trip types show that the gravity model has a higher volume of zone exchanges with one or less trips and that the gravity model leads to a smaller maximum number of trips exchanges between the most active zone pairs.


Cumulative Flow Profile for HBW Trips
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.01
0.1
1
10
100
1000
HBW_Gravity
HBW_AirSage_Factoring


Cumulative Flow Profile for HBNW Trips
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.01
0.1
1
10
100
1000
HBNW_Gravity
HBNW_AirSage_Factoring


Cumulative Flow Profile for HBU Trips
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.01
0.1
1
10
100
1000
HBU_Gravity
HBU_AirSage_Factoring


Cumulative Flow Profile for NHB Trips
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0.01
0.1
1
10
100
1000
NHB_Gravity
NHB_AirSage_Factoring

All of these data comparisons appear to be consistent the hypothesis that introducing cell phone-based origin-destination data to the trip distribution for the WVU special generator provides a better representation of travel activity than the gravity model used as a regional trip distribution method for the MMMPO TDM. The data show a general similarity between the gravity model the AirSage factoring results, with the primary differences being:

1. A small percentage of zone exchanges with drastically modified number of trips to better match the Airsage flows.
2. A large percentage of zone exchanges with minor modifications to the number of trips that show more concentrated flows for home-based work trips and non-home based trips between WVU districts.

Additional support of the hypothesis could be provided through review of trip length frequencies or mapping of select desire lines.