National Capital Region
Transportation Planning Board

MEMORANDUM

TO: Feng Xie, Manager, Model Development Group, COG/TPB
FROM: Meseret Seifu, Principal Transportation Engineer, COG/TPB
SUBJECT: Year-2014 Validation of TPB Version 2.4 Travel Model
DATE: October 29, 2020

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1. Introduction

The staff of the National Capital Region Transportation Planning Board (TPB) maintains a series of travel demand forecasting models for use in regional planning activities. TPB's current, adopted, production-use travel demand forecasting model is called the Ver. 2.3.78 Travel Model. This model became the adopted model on March 18, 2020 when the TPB adopted the Air Quality Conformity (AQC) analysis of the 2020 Amendment to the Visualize 2045 and the FY 2021-2024 Transportation Improvement Program (TIP). This model is a member of a family of trip-based, "four-step" travel demand models, known as "Version 2.3," which, in turn, is a member of a series of trip-based models known as Generation 2 (or Gen2). The Version 2.3 Travel Model was calibrated and validated to year-2007 conditions.[1] It was later re-validated to both year-2010[2] and year-2014[3] conditions.

The most recent validation (to year-2014 conditions) for an official travel model was done in 2019 using the then production-use Ver. 2.3.75 Model to ensure that model was validated to recent data. According to federal regulations, specifically, 40 CFR 93.122(b)(1)(i), "network-based travel models must be validated against observed counts (peak and off-peak, if possible) <u>for a base year that is not more than 10 years prior to the date of the conformity determination</u>." That implies a regional travel demand model validated to year-2010 conditions, which was the case with the initial validation of the Ver. 2.3 Model, can be used for AQC determinations up to and including the year 2020. Thus, by re-validating the model to year-2014 conditions, we may now use the model for AQC determinations through 2024, which is around the time when the development of the Gen3 Model should be completed.

The TPB staff updates its regional travel demand forecasting model on a regular basis (typically annually). The Ver. 2.3.78 Model, which incorporates minor refinements to the Ver. 2.3.75 Model, is the adopted production-use model. The Ver. 2.3.82 Model was built directly from the Ver. 2.3.78 model and includes more substantial changes.[4] The primary change between these two models was

[1] Ronald Milone et al., "Calibration Report for the TPB Travel Forecasting Model, Version 2.3, on the 3,722-Zone Area System," Final Report (Washington, D.C.: Metropolitan Washington Council of Governments, National Capital Region Transportation Planning Board, January 20, 2012), https://www.mwcog.org/transportation/data-and-tools/modeling/model-documentation/.
[2] Ronald Milone to Files, "2010 Validation of the Version 2.3 Travel Demand Model," Memorandum, June 30, 2013, https://www.mwcog.org/transportation/data-and-tools/modeling/model-documentation/.
[3] Feng Xie to Dusan Vuksan and Mark Moran, TPB staff, "Year-2014 Validation of TPB's Version 2.3 Travel Demand Model," Memorandum, March 12, 2019.
[4] "Technical Updates in the V2.3.82 Model Application "Memorandum from Ron Milone and Meseret Seifu to DTP Technical Staff, December 12, 2019.

a revised treatment of external travel.[5] The Ver. 2.3.84 Model was built from the Ver. 2.3.82 Model and the primary change is re-calibration of the nested-logit mode choice model.[6] The Ver. 2.3.85 Model was built based on the Ver. 2.3.84 Model. The main change was reversion of the number of Trip Distribution iterations to the original number.[7] The Version 2.3.86 Model was built from the Ver.2.3.85 Model and the main change was increasing highway nodes range size from five digits to six digits. The Ver. 2.3.87 / Ver. 2.4 Model was built from the Ver.2.3.86 Model and the primary change is calibration of the existing toll searching process to determine the most suitable V/C toll-search stopping criteria range, closer to free-flow speeds, which can provide the best estimated tolls while simultaneously maintaining reasonable vehicle throughput on high-occupancy toll (HOT)/managed lanes.[8]

The year-2014 validation of the Ver. 2.3.84 Model and four sets of sensitivity tests which examined how the Ver. 2.3.84 Model responds to system changes (modifying highway and transit networks) and a policy change (modifying fare) were performed earlier this year.[9] The need to update the 2014 model validation using the Ver. 2.4 Model arose because of the model changes between the Ver. 2.3.84 and Ver. 2.4 models.

This memorandum documents the year-2014 validation performance of the Ver. 2.4 Model. Summary results of the Ver. 2.4 Model are also included, specifically: 1) A condensed summary of global modeling results; and 2) selected modeling performance summaries pertaining to year 2014; and 3) year-2014 transit ridership validation statistics. Please note that the comparison of the 2014 modeling and validation results in these summaries will be focused on the Ver. 2.4 Model vs. the Ver. 2.3.75 Model, since the latest 2014 model validation for an adopted, production-use model was conducted using the Ver. 2.3.75 Model.

2. Ver. 2.4 Model Overview

Relative to the Ver. 2.3.75 Model, the Ver. 2.4 Model incorporates seven (7) main refinements:

1. Updated external trip distribution process within the modeled area;[10]
2. Increased free-flow speed look-up values used in the traffic assignment process by 15%;
3. Removed Potomac River-crossing bridge penalties in the construction of path-building within the traffic assignment process;
4. Removed some trip production rate modification factors (P-mods) used in trip generation;
5. Re-calibrated the nested-logit mode choice (NLMC) model with updated calibration targets and modified commuter rail path-building parameters;

[5] "External Trip Distribution Model Update "Memorandum from Ron Milone and Meseret Seifu to DTP Technical Staff, December 4, 2019.

[6] Xie, Feng. Memorandum to Files, Mark Moran, Meseret Seifu, Jian (Jim) Yin, Ray Ngo, Sanghyeon Ko, Dusan Vuksan, and Jane Posey. "TPB Version 2.3 Travel Demand Model: Re-Calibrating the Nested-Logit Mode Choice Model Following the Updates to Commuter Rail Person Trip Targets." Memorandum, November 30, 2019.

[7] Meseret Seifu to Feng Xie, memorandum "Ver. 2.3.85 Travel Model: Technical Updates and Sensitivity Tests", April 14, 2020

[8] Anant Choudhary, Dusan Vuksan, memorandum to Files, "Toll Setting Process Recommendation for the Version 2.4 Travel Demand Model" October 16, 2020.

[9] Meseret Seifu to Feng Xie, memorandum "Year-2014 Validation and Sensitivity Tests of TPB Version 2.3.84 Travel Model", April 30, 2020

[10] "External Trip Distribution Model Update "Memorandum from Ron Milone and Meseret Seifu to DTP Technical Staff, December 4, 2019,

6. Restored the original number of iterations used in Trip Distribution for home-based shop (HBS) trips (changed from 9 to 27 iterations) and home-based other (HBO) trips (changed from 15 to 27 iterations); and
7. Changed toll setting Volume-to-Capacity ratio (V/C) toll-search stopping criteria range from (0.95-1.01) to (0.90-0.95). The toll searching algorithm utilizes only the higher-end value of the threshold range (0.95).

The refinements to the external trip distribution (TD) process and the mode choice re-calibration were the key changes in the Ver. 2.4 Model. The free-flow speed and p-mod changes were made to offset reductions in estimated vehicle miles of travel (VMT) caused by the revised external travel process. The bridge penalty change was meant to address under-estimations of Potomac River crossings that have been historically noted in recent models.[11] Reverting to the original number of iterations in TD resulted in more intuitive directionality of the VMT change. The lower toll-setting threshold is applied to adjust the estimated tolls in Ver. 2.4, which, previously, had been on the low side, to more closely match the observed tolls.

Summary tables providing both Version 2.3.75 and Version 2.4 global travel modeling results (Table A-1) and model validation performance results (Tables A-2 - A-6) for the year 2014 can be found in Appendix A at the end of this memorandum.

In Table A-1, the global travel modeling results from the Ver. 2.3.75 Model and the Ver. 2.4 Model are largely consistent. We also noticed an increase in households with zero vehicles ("VA0") and with one vehicle ("VA1") going from Ver. 2.3.75 to Ver. 2.4, which could be attributed to specific model refinements implemented in the Ver. 2.4 Model.[12]

- Compared to the Ver. 2.3.75 Model, the VMT performance for TPB member jurisdictions is mostly improved as shown in Table A-2. Frederick Co. over-estimation has been investigated and no modeling-related problems have been identified thus far. The over-estimation is perhaps attributed to land use problems (e.g., interpolated land activity for 2014) which is not something that can be easily fixed.
- As shown in Table A-3, the estimated-to-observed (E/O) ratios for daily VMT by facility type are based on a sample of ~6,700 directional daily link volumes. The ratios shown for the Ver. 2.3.75 and Ver. 2.3.84 models appear quite comparable and closely meet the "acceptable" standard cited in Florida DOT (FDOT), FHWA, and VDOT manuals.[13]
- As shown in Table A-4, screenline performance of the Ver. 2.4 Model is mostly comparable/slightly better than the Ver. 2.3.75 Model. Incremental improvements in the estimated-to-observed vehicle crossing ratios at the screenline level for the Ver. 2.4 Model

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[11] Ronald Milone to Files, "2010 Validation of the Version 2.3 Travel Demand Model," Memorandum, June 30, 2013; Feng Xie to Dusan Vuksan and Mark Moran, TPB staff, "Year-2014 Validation of TPB's Version 2.3 Travel Demand Model," Memorandum, March 12, 2019.

[12] In the Ver. 2.3 Model, vehicle availability is inversely related to transit accessibility. Due to the external trip and subsequent model refinements (such as the higher free-flow speeds) in the Ver. 2.4 Model, drive access links that are part of the park-and-ride (PNR) and kiss-and-ride (KNR) transit trips show travel time improvements. As a result, transit accessibility increases and shares of households with lower vehicle availability (i.e., VA0 and VA1 households) go up.

[13] See, for example, the appendices of Cambridge Systematics, Inc., "FSUTMS-Cube Framework Phase II: Model Calibration and Validation Standards: Final Report" (Tallahassee, Florida: Florida Department of Transportation, Systems Planning Office, October 2, 2008), http://www.fsutmsonline.net/images/uploads/reports/FR2_FDOT_Model_CalVal_Standards_Final_Report_10.2.08.pdf.

relative to the Ver. 2.3.75 Model are observed: 23 out of 34 or 68% are better, 8 screenlines or 24% got worse, and 3 remain flat.

- In Figure A-1, screenlines are colored according to their daily volume E/O ratios. Many screenlines located in the regional core and inner suburbs validate well (shown in green). Screenlines near external count stations, especially those in Maryland, are over-estimated (shown in red or orange), though Screenline #35, near Baltimore, is well validated (shown in green on the map). The less satisfactory validation results of these outer screenlines can be attributed to the many missing observed counts associated with those screenlines as well as the suboptimal forecasting accuracy associated with large zone sizes in the outer areas.
- As shown on the inset map (Figure A-2), screenline #20 (Potomac River Screenline) validates fairly well. The two Virginia screenlines (#1 and #3) intersecting with Screenline #20 from the Ver. 2.3.75 Model are both under-estimated. By contrast, the Ver. 2.4 Model shows improvement (#1 remains the same and #3 becomes a good fit -- shown in green). The two DC screenlines (#2 and #4) are both over-estimated in both models, but, for the Ver. 2.4 Model, Screenline #2 is a better fit than for the Ver. 2.3.75 Model.
- In Table A-5, the percent root mean squared error (RMSE) values were developed from the E/O link volumes for a sample of approximately 6,700 network links. Historically, the percent RMSE statistics for TPB models have been observed to be around 20% for freeways and around 40% for all sampled links. Overall, compared to the Ver. 2.3.75 Model, the percent RMSE values from the Ver. 2.4 Model by facility type and by volume group are slightly better. The reference to the VDOT standard in Table A-5 refers to a 2014 VDOT report.[14]
- Year-2014 Average Weekday Transit Ridership by Sub-Mode (Table A-6) can be found in Appendix A at the end of this memorandum. The estimation of transit ridership has been significantly improved related to Ver. 2.3.75 transit ridership. Metrorail ridership validates very well to the 2014 conditions with an E/O ratio of 1.01. Bus ridership is overestimated by 9% with an E/O ratio of 1.09. Commuter rail ridership is underestimated by 24% (specifically, MARC ridership is underestimated by 14% and VRE by 36%), but the validation statistics have significantly improved as compared to the Version 2.3.75 Model, which underestimated commuter rail ridership by 40% (specifically, MARC ridership was underestimated by 22% and VRE by 78%).[15] More discussions on the transit validation can be found in a prior technical memorandum.[16]

Although the above comparison was focused on the model validations conducted using Ver. 2.3.75 Model and Ver. 2.4 Model, TPB staff also examined the differences between the 2014 model validation statistics from the Ver. 2.4 Model and those from the Ver. 2.3.84 Model and found them largely comparable.

For internal reference, the locations of the model executions may be found at the following LAN locations:

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[14] Cambridge Systematics, Inc., "Travel Demand Modeling Policies and Procedures, Ver. 2.00" (Virginia Department of Transportation, June 2014), http://www.virginiadot.org/projects/resources/vtm/vtm_policy_manual.pdf.

[15] Page B-1, Xie, Feng. Memorandum to Dusan Vuksan and Mark Moran. "Year-2014 Validation of TPB's Version 2.3 Travel Demand Model", MWCOG/TPB Memorandum, March 12, 2019.

[16] Page 19, Xie, Feng. Memorandum to Files, Mark Moran, Meseret Seifu, Jian (Jim) Yin, Ray Ngo, Sanghyeon Ko, Dusan Vuksan, and Jane Posey. "TPB Version 2.3 Travel Demand Model: Re-Calibrating the Nested-Logit Mode Choice Model Following the Updates to Commuter Rail Person Trip Targets." Memorandum, November 30, 2019.

Ver. 2.3.75: L:\modelRuns\fy19\Ver2.3.75_Visualize2045_CLRP_Xmittal_Model_Validation
Ver. 2.4: Z:\ModelRuns\fy21\CGV2_4_2020_Amendment_Visualize2045_Xmittal

Note about drive mappings: L: (\\tms6\ateam); Z: (\\tms8\F)

3. Conclusions

The performance of the Ver. 2.4 Model is largely comparable to that of the Ver. 2.3.75 Model. The model performance has significantly improved in some areas, such as external trip distribution and commuter rail ridership. Year-2014 validation statistics largely met federal or state standards. TPB Staff will continue refining the model and investigating. In general, the performance of TPB's Ver. 2.4 Model is both reliable and acceptable for regional planning purposes.

Appendix:

Appendix A:

Table A-1 Control Totals 2014 Demographic and Travel Statistics

		Ver. 2.3.75	Version2.4	Difference	% Diff.
1	Households	2,584,936	2,584,936	0	0.0%
2	Jobs	3,982,930	3,982,930	0	0.0%
3	HH Population	6,851,243	6,851,243	0	0.0%
4	HH & GQ Population	6,983,525	6,983,525	0	0.0%
5	HH_Inc1	709,973	709,974	1	0.0%
6	HH_Inc2	800,949	800,949	0	0.0%
7	HH_Inc3	531,816	531,816	0	0.0%
8	HH_Inc4	542,228	542,228	0	0.0%
9	HH_All_Incs	2,584,966	2,584,966	0	0.0%
10	HH_Siz1	650,926	650,926	0	0.0%
11	HH_Siz2	780,830	780,830	0	0.0%
12	HH_Siz3	452,946	452,946	0	0.0%
13	HH_Siz4	700,264	700,265	1	0.0%
14	HH_ALL_Sizs	2,584,966	2,584,966	0	0.0%
15	HH_VA0	228,800	233,255	4,455	1.9%
16	HH_VA1	779,937	783,784	3,847	0.5%
17	HH_VA2	989,314	985,234	-4,080	-0.4%
18	HH_VA3+	586,914	582,692	-4,222	-0.7%
19	HH_All_VAs	2,584,966	2,584,966	0	0.0%
20	HBWAutoPsnXI	302,152	302,152	0	0.0%
21	HBSAutoPsnXI	67,719	67,719	0	0.0%
22	HBOAutoPsnXI	228,528	228,528	0	0.0%
23	NHWAutoPsnXI	31,158	31,158	0	0.0%
24	NHOAutoPsnXI	60,590	60,590	0	0.0%
25	AutoPsnXI	690,146	690,146	0	0.0%
26	HBWAutoPsnIX	190,556	190,556	0	0.0%
27	HBSAutoPsnIX	68,958	68,958	0	0.0%
28	HBOAutoPsnIX	323,821	323,821	0	0.0%
29	NHWAutoPsnIX	31,153	31,153	0	0.0%
30	NHOAutoPsnIX	60,582	60,582	0	0.0%
31	AutoPsnIX	675,070	675,070	0	0.0%
32	NonMotr_HBW Trips	150,741	150,650	-91	-0.1%
33	NonMotr_HBS_Trips	318,213	320,722	2,509	0.8%
34	NonMotr_HBO_Trips	907,396	909,301	1,905	0.2%
35	NonMotr_NHW_Trips	476,815	476,505	-310	-0.1%
36	NonMotr_NHO_Trips	371,531	371,157	-374	-0.1%
37	NonMotr_ALL_Trips	2,224,696	2,228,335	3,639	0.2%

Table A-1: Continued

		Ver. 2.3.75	Version2.4	Difference	% Diff.
38	Ext_HBWAdr	428,447	428,438	-9	0.0%
39	Ext_HBSAdr	83,055	83,152	97	0.1%
40	Ext_HBOAdr	343,014	342,858	-156	0.0%
41	Ext_NHWAdr	48,552	48,548	-4	0.0%
42	Ext_NHOAdr	94,556	94,569	13	0.0%
43	Ext_ALLAdr	997,625	997,566	-59	0.0%
44	Ext_ComVeh	78,413	78,407	-6	0.0%
45	Ext_Medium_Trk	23,738	23,733	-5	0.0%
46	Ext_Heavy_Trk	28,542	28,541	-1	0.0%
47	MC_HBWPsn	3,920,757	3,916,186	-4,571	-0.1%
48	MC_HBSPsn	3,070,467	3,117,483	47,016	1.5%
49	MC_HBOPsn	7,199,469	7,221,594	22,125	0.3%
50	MC_NHWPsn	1,635,990	1,632,901	-3,089	-0.2%
51	MC_NHOPsn	3,295,257	3,288,896	-6,361	-0.2%
52	MC_ALLPsn	19,121,940	19,177,060	55,120	0.3%
53	MC_HBW_Trn	817,641	779,694	-37,947	-4.6%
54	MC_HBS_Trn	18,666	26,427	7,761	41.6%
55	MC_HBO_Trn	205,746	205,178	-568	-0.3%
56	MC_NHW_Trn	71,185	90,163	18,978	26.7%
57	MC_NHO_Trn	28,326	36,002	7,676	27.1%
58	**MC_All_Trn**	**1,141,564**	**1,137,465**	**-4,099**	**-0.4%**
59	HBW_TransitPct	20.85	19.91	-0.94	-4.5%
60	HBS_TransitPct	0.61	0.85	0.24	39.3%
61	HBO_TransitPct	2.86	2.84	-0.02	-0.7%
62	NHW_TransitPct	4.35	5.52	1.17	26.9%
63	NHO_TransitPct	0.86	1.09	0.23	26.7%
64	ALL_TransitPct	5.97	5.93	-0.04	-0.7%
65	MC_HBW_AutoPsn	3,103,116	3,136,492	33,376	1.1%
66	MC_HBS_AutoPsn	3,051,801	3,091,056	39,255	1.3%
67	MC_HBO_AutoPsn	6,993,722	7,016,416	22,694	0.3%
68	MC_NHW_AutoPsn	1,564,805	1,542,737	-22,068	-1.4%
69	MC_NHO_AutoPsn	3,266,931	3,252,893	-14,038	-0.4%
70	MC_ALL_AutoPsn	17,980,376	18,039,595	59,219	0.3%
71	Int_HBWAutoDrv	2,847,279	2,860,228	12,949	0.5%
72	Int_HBSAutoDrv	2,014,396	2,038,839	24,443	1.2%
73	Int_HBOAutoDrv	4,450,502	4,469,372	18,870	0.4%
74	Int_NHWAutoDrv	1,299,884	1,291,272	-8,612	-0.7%
75	Int_NHOAutoDrv	2,195,001	2,184,483	-10,518	-0.5%
76	Int_ALLAutoDrv	12,807,062	12,844,193	37,131	0.3%

Table A-1: Continued

		Ver. 2.3.75	Version2.4	Difference	% Diff.
77	HBW_OCC	1.09	1.10	0.01	0.9%
78	HBS_OCC	1.51	1.52	0.01	0.7%
79	HBO_OCC	1.57	1.57	0.00	0.0%
80	NHW_OCC	1.20	1.19	-0.01	-0.8%
81	NHO_OCC	1.49	1.49	0.00	0.0%
82	ALL_OCC	1.40	1.40	0.00	0.0%
83	Int_CommVeh	1,092,525	1,092,089	-436	0.0%
84	Int_Med_Truck	449,144	448,746	-398	-0.1%
85	Int_Hvy_Truck	106,292	106,298	6	0.0%
86	ALL_HBWAdr	3,275,727	3,288,666	12,939	0.4%
87	ALL_HBSAdr	2,097,452	2,121,991	24,539	1.2%
88	ALL_HBOAdr	4,793,516	4,812,230	18,714	0.4%
89	ALL_NHWAdr	1,348,436	1,339,820	-8,616	-0.6%
90	ALL_NHOAdr	2,289,557	2,279,052	-10,505	-0.5%
91	ALL_ALLAdr_MC	13,804,687	13,841,759	37,072	0.3%
92	ALL_CV	1,170,938	1,170,496	-442	0.0%
93	ALL_Mtk	472,881	472,480	-401	-0.1%
94	ALL_Htk	134,834	134,838	4	0.0%
95	THRU_Truck	34,149	34,149	0	0.0%
96	THRU_Auto&CV	43,198	43,198	0	0.0%
97	Taxi_AutoDrv	129,676	129,676	0	0.0%
98	Visitor/Tourist Adr	263,707	263,707	0	0.0%
99	School AutroDrv	303,248	303,248	0	0.0%
100	Final_Medium_Truck	527,037	525,397	-1,640	-0.3%
101	Final_Heavy_Truck	145,112	145,344	232	0.2%
102	AirPax_AutoDrv	67,597	67,597	0	0.0%
103	Final_Comm_Veh	1,367,252	1,362,066	-5,186	-0.4%
104	All_Veh_Trips_MC	16,685,663	16,716,141	30,478	0.2%
105	TRIPS_per_HH	7.41	7.43	0.02	0.3%
106	TRIPS_per_Pop	2.74	2.75	0.01	0.4%
107	**Total_VMT**	**163,214,084**	**159,691,204**	**-3,522,880**	**-2.2%**
108	VMTperCapita	23.37	22.87	-0.50	-2.1%
109	VMTperHH	63.14	61.78	-1.36	-2.2%
110	VMTperTrip	9.78	9.55	-0.23	-2.4%

Table A-2 Estimated and Observed Year 2014 Daily VMT by Jurisdiction

		Observed*	V2.3.75	V2.4	V2.3.75 / Obs	V2.4 / Obs
	District of Columbia	7,922,357	8,187,123	7,910,374	1.03	1.00
	Montgomery County	19,757,260	21,596,642	20,053,933	1.09	1.02
	Prince George's County	23,646,575	23,113,129	21,816,275	0.98	0.92
	Arlington County	4,046,638	3,866,042	4,004,099	0.96	0.99
	City of Alexandria	2,016,133	2,019,850	2,050,969	1.00	1.02
TPB Member Area	Fairfax County	26,663,007	26,631,226	26,910,009	1.00	1.01
	Loudoun County	6,623,699	7,343,767	6,681,249	1.11	1.01
	Prince William County	9,425,332	9,521,281	9,443,949	1.01	1.00
	Frederick County	7,798,767	8,785,986	8,716,957	1.13	1.12
	Charles County	3,276,575	3,020,140	3,065,323	0.92	0.94
	Total	***111,176,343***	***114,085,186***	***110,653,137***	***1.03***	***1.00***
	Stafford County	4,006,798	4,501,478	4,472,254	1.12	1.12
	Calvert County	1,987,808	1,729,059	1,637,084	0.87	0.82
	Howard County	10,546,027	11,317,730	10,963,782	1.07	1.04
	Anne Arundel County	15,493,973	15,431,752	15,653,162	1.00	1.01
Non-TPB Member Area	Carrol County	3,290,959	4,097,305	4,114,971	1.25	1.25
	St. Mary's County	2,246,712	2,176,268	2,156,753	0.97	0.96
	King George County	871,306	789,154	794,934	0.91	0.91
	City of Fredericksburg	929,927	864,641	857,116	0.93	0.92
	Spotsylvania County ɫ	3,442,058	2,246,698	2,296,448	0.65	0.67
	Fauquier County ǂ	3,439,861	3,520,312	3,620,994	1.02	1.05
	Clarke County	810,485	1,114,449	1,024,839	1.38	1.26
	Jefferson County	1,177,470	1,340,054	1,445,730	1.14	1.23
	Total	***48,243,384***	***49,128,900***	***49,038,067***	***1.02***	***1.02***
	Modeled Area Total: §	***159,419,727***	***163,214,086***	***159,691,204***	***1.02***	***1.00***

Notes:

* The observed VMT data is from HPMS.

ɫ Observed VMT is for the entire Spotsylvania County while Estimated is for northern portion of county only.

ǂ Fauquier County urbanized area is part of TPB Planning Area. Fauquier is not included as a TPB member in this summary as the HPMS VMT data is only available for the whole county.

§ **FDOT standard** for estimated-over-observed VMT Areawide is ±5% (acceptable) and ±2% (preferable).

Table A-3 Estimated and Observed Year 2014 Daily VMT by Facility Type

	E/O Ratio		Standard ɫ	
FTYPE	**V2.3.75**	**V2.4**	**Acceptable**	**Preferable**
Freeway	1.07	1.06	±7%	±6%
Major Arterial	1.07	1.08	±15%	±10%
Minor Arterial	1.13	1.10	±15%	±10%
Collector	0.74	0.74	±25%	±20%
Expressway	0.95	0.91	±15%	±10%
Total	**1.06**	**1.05**	***±5%***	***±2%***

ɫ **FDOT standards** for VMT by facility type, which are also cited in the FHWA and VDOT manuals

Table A-4 Estimated and Observed 2014 Daily Vehicular Screenline Crossings

Screenline	Obs (AAWDT)	Ver. 2.3.75	Ver. 2.4	Ver2.3.75/Obs	Ver2.4/Obs	Standard *
1	189,600	140,495	139,704	0.74	0.74	±10%
2	363,864	457,183	431,647	1.26	1.19	±10%
3	242,200	214,927	221,378	0.89	0.91	±10%
4	562,162	684,763	655,504	1.22	1.17	±10%
5	454,700	384,217	391,099	0.84	0.86	±10%
6	1,207,388	1,240,057	1,214,572	1.03	1.01	±10%
7	561,400	542,844	545,257	0.97	0.97	±10%
8	1,053,952	1,158,729	1,087,083	1.10	1.03	±10%
9	328,000	253,049	253,129	0.77	0.77	±10%
10	125,000	118,229	117,685	0.95	0.94	±10%
12	399,264	399,605	374,359	1.00	0.94	±10%
13	271,530	329,609	306,667	1.21	1.13	±10%
14	242,602	258,354	253,854	1.06	1.05	±10%
15	323,004	290,837	269,751	0.90	0.84	±10%
16	157,428	147,215	127,015	0.94	0.81	±10%
17	133,300	121,969	126,491	0.91	0.95	±10%
18	438,500	386,601	389,893	0.88	0.89	±10%
19	346,150	278,359	269,700	0.80	0.78	±10%
20	**905,074**	**837,437**	**812,890**	**0.93**	**0.90**	**±10%**
22	826,658	869,792	813,702	1.05	0.98	±10%
23	38,446	61,658	48,943	1.60	1.27	±20%
24	359,688	323,225	313,126	0.90	0.87	±10%
25	100,842	132,846	123,985	1.32	1.23	±10%
26	38,998	81,919	65,700	2.10	1.68	±20%
27	137,466	204,726	178,893	1.49	1.30	±10%
28	214,260	161,233	164,995	0.75	0.77	±10%
31	64,798	143,386	141,007	2.21	2.18	±10%
32	37,000	65,260	76,390	1.76	2.06	±20%
33	47,000	52,152	49,301	1.11	1.05	±20%
34	101,990	119,545	114,430	1.17	1.12	±10%
35	725,446	677,333	730,602	0.93	1.01	±10%
36	25,412	53,699	41,194	2.11	1.62	±20%
37	23,500	47,084	45,295	2.00	1.93	±20%
38	163,600	113,862	117,899	0.70	0.72	±10%
Total:	**11,210,222**	**11,352,198**	**11,013,141**	**1.01**	**0.98**	**N/A**
Note:						
* FDOT standard for screenline volumes is used (±10% for screenline volumes larger than						
50k and ±20% for screenline volumes smaller than 50k). VDOT standard is much more stringent.						

Figure A-1 Screenline crossing performance (Est./Obs. ratios) Map, 2014

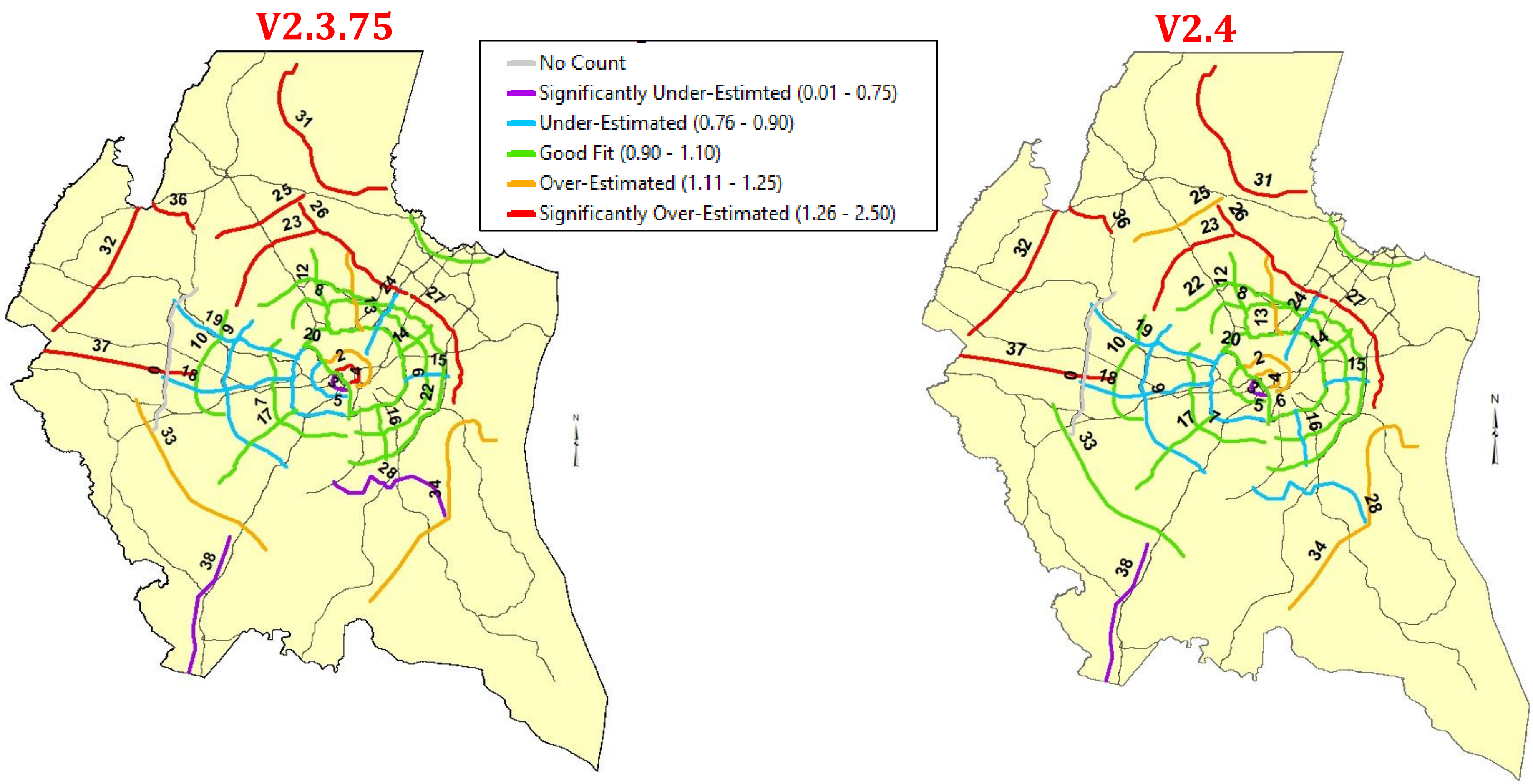

Figure A-2 Screenline crossing performance (Est./Obs. ratios) Map, 2014 (Inset Maps)

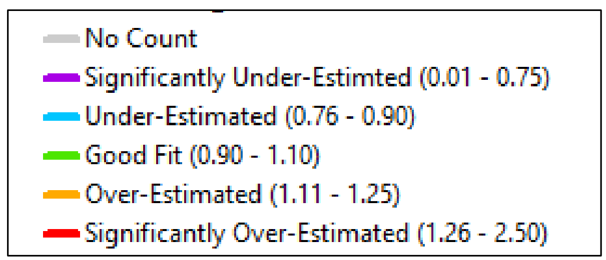

Table A-5 Daily Directional 2014 Volume percent RMSE by Facility Type and Volume Group

		% RMSE		
Facility Type	**Links w/ Counts**	**V2.3.75**	**V2.4**	
Freeway	517	21.89%	22.17%	
Major Arterial	1,867	38.43%	36.94%	
Minor Arterial	2,939	51.52%	49.05%	
Collector	1,139	76.01%	74.81%	
Expressway	224	33.95%	34.12%	
Ramp	2	13.38%	11.58%	
Total:	**6,688**	**42.60%**	**42.01%**	
Daily Directional Volume % RMSE by Volume Group*				
		% RMSE		
Volume Range	**Links w/ Counts**	**V2.3.75**	**V2.4**	**Standard ǂ**
Less than 5,000	2,045	110.11%	103.72%	100%
5,000-9,999	1,699	56.43%	53.03%	45%
10,000-14,999	1,049	43.79%	42.65%	35%
15,000-19,999	583	35.18%	33.96%	30%
20,000-29,999	622	29.44%	29.49%	27%
30,000-49,999	329	26.39%	27.11%	25%
50,000-59,999	94	22.16%	20.58%	20%
Greater than 60,000	267	19.43%	19.57%	19%
Total:	**6,688**	**42.6% ƚ**	**42.01%**	**40%**
Notes:				
* Based on 6,693 directional links with daily traffic counts				
ƚ VDOT standard for percent RMSE areawide; FDOT areawide standard is 45%				
(acceptable) and 35% (preferable)				
ǂ VDOT standard for percent RMSE by volume group				

Table A-6 2014 Observed and Estimated Average Weekday Transit Ridership by Mode in Modeled Area

	Updated Observed ("O")	**Estimated (E)**	**E/O Ratio**
Metrorail*	737,679	744,835	1.01
Commuter Rail	36,482	27,779	0.76
MARC**	20,171	17,298	0.86
VRE**	16,311	10,481	0.64
All Bus**	648,083	705,146	1.09
Total:	**1,422,244**	**1,477,759**	1.04

Notes: * Data Source: WMATA Crystal ReportsSystem (with adjustments related to Silver Line stations)
Since Silver Line opened in July 2014 and its 2014 ridership data is not available,
2015 Silver Line station counts are used instead.
** Data Source: Version 2.5 Model Development Report
adjusted to exclude boardings associated with external trips