# Memorandum

Date: June 30, 2013

To: Files

From: Ronald Milone, COG/TPB

Re: 2010 Validation of the Version 2.3 Travel Demand Model

## 1. Introduction

This technical memorandum describes the 2010 TPB travel model validation that was undertaken by TPB staff during FY 2013. TPB's currently adopted travel forecasting process is known as the Version 2.3 travel demand model which is a trip-based travel model that operates on a 3,722-zone area system. The Version 2.3 model was initially calibrated using the 2007/08 Household Travel Survey.[1] Since its adoption by the TPB in November 2011, it has evolved with periodic updates. The validation effort focused on the analysis of the most recent update (or "build") of the model, known as Version 2.3.39.

A model validation is essentially a comparison between the travel model outputs and observed data, ideally observed data that is more recent than that used to support the model calibration. The comparison enables the model's overall performance to be assessed and provides an objective basis for implementing technical adjustments to the model. The Version 2.3 model validation effort resulted in several modifications to the Version 2.3.39 model. In addition to validation-related modifications, other updates were also applied to the model, including enhancements to reduce running times, enhance stability, and improve the model's internal consistency. The updated model that resulted is known as the Version 2.3.52 travel model (or Build 52 of the Version 2.3 model).

[1] *Calibration Report for the TPB Travel Forecasting Model, Version 2.3, on the 3,722-Zone Area System*. Final Report. National Capital Region Transportation Planning Board, January 20, 2012. http://www.mwcog.org/transportation/activities/models/documentation.asp.

The validation effort was undertaken from September 2012 through March 2013 and was overseen by the TPB Travel Forecasting Subcommittee which is the designated forum for monitoring the TPB's travel forecasting activities. A more detailed description of the validation process and results is presented below.

## 2. Travel Model Development and Validation

Travel model development efforts are typically comprised of three phases: estimation, calibration, and validation. The phases are undertaken sequentially in order to progressively "hone in" on a final model specification that is acceptable for forecasting. The *estimation* phase involves the use of statistical analysis techniques to develop parameters and coefficients for individual modeling steps. While most modeled coefficients are developed using data from the household travel survey, other surveys may also be used (e.g., transit on-board surveys), and some parameters may be asserted (or borrowed) where local data is missing or insufficient. The model *calibration* phase occurs after estimation has occurred and involves the adjustment of the estimated coefficients and/or constants in order to achieve a more reasonable match between the modeled outputs and "real-world" data. Calibration data usually consists of transit ridership, traffic counts, or aggregate vehicle-miles-of-travel "targets." The data used to support estimation and calibration phases of model development typically represents a common base-year condition. The estimation and calibration phases of the Version 2.3 model were conducted primarily with 2007/08 data, along with American Community Survey (ACS) data and an assortment on-board transit survey data from 2007 or 2008.

The *validation* phase occurs after estimation and calibration steps and involves comparing the calibrated model outputs against a comprehensive set of observed data. Validation data is usually more recent than that used to support the original model calibration. The validation is a demonstration of the travel model's performance with respect to current conditions and a demonstration of its ability to function as a sound forecasting tool. The results of the validation may suggest a need to refine certain parameters of the travel model. Modifications may be warranted because of misspecifications in the model that were not detected during the earlier calibration phase or because of changes in traveler behaviors that were not observed during the model calibration. Another important component of the validation phase is sensitivity analysis. This type of analysis involves the applying the model with altered input

assumptions to reflect a specific hypothetical scenario, such has expanding the capacity of a roadway segment or altering land activity for a specific location. Sensitivity analysis serves as another demonstration of the model's ability to respond logically and reasonably to input changes. TPB staff's validation effort made use of 2010 data.

While validation tests may be used to assess a wide range of travel modeling inputs and outputs, all such tests are subject to the availability of observed information. Table 1 lists the observed data that was assembled for the 2010 validation analysis.

Table 1 Validation Data Assembled

| **Data Source** | **Data Elements Assembled** | **Level of Analysis** |
|---|---|---|
| 2010 Census | Households and Household Population | Jurisdiction level |
| 2010 American Community Survey (ACS) | Share of households by size and vehicles available | Jurisdiction and state level |
| 2010/11 TPB Geographically-Focused Household Travel Survey (HTS) | Share daily trips made by mode | Geographically-focused areas |
| 2010 HPMS reports | Vehicle-miles traveled (VMT) | Jurisdiction level |
| 2010 HPMS traffic counts | Daily link volumes | Screenline and facility levels |
| 2010 Metrorail faregate counts | Station Boardings | Metrorail station level |

The Census data was used to check household and population inputs to the travel model at the jurisdiction level (TAZ-level data was not available). The American Community Survey data was used to evaluate the proportions of households by socio-economic dimensions (size, income, and vehicle availability levels) that are produced by the demographic sub-models. Both of these comparisons were made at the jurisdiction and state level of analysis.

TPB staff consulted Highway Performance Monitoring System (HPMS) documents published by the state DOTs to obtain observed VMT summaries by jurisdiction. The Maryland and Virginia HPMS reports were obtained off the web at the following URLs:

- http://www.virginiadot.org/info/2010_traffic_data_daily_vehicle_miles_traveled.asp
- http://www.roads.maryland.gov/oppen/Vehicle_Miles_of_Travel.pdf

The District of Columbia VMT report was obtained by TPB staff members who are currently responsible for traffic monitoring activities in that jurisdiction.[2] VMT reports at the jurisdiction level are presented as either average annual weekday traffic (AAWT) or average annual daily traffic (AADT) values. TPB uses reported AAWT values when evaluating modeled VMT. For instances where AADT figures are reported, TPB staff computes the AAWT figure based on the following conversion:

AAWT = AADT * 1.05

Traffic counts used in the validation effort were taken directly from the TPB's Regional Transportation Data Clearinghouse, which contains geo-referenced ground counts collected each year by the state DOTs. The clearinghouse yielded approximately 6,400 directional traffic counts for the year 2010. The counts were obtained from permanent traffic counters and from 48-hour tube counts at standard programmed locations. Finally, 2010 Metrorail station boardings were available from electronic faregate counts.

Unfortunately, the validation effort did not include use of observed trip table data that would ideally exist by trip purpose and mode of travel. This model's ability to replicate recent observed trip patterns is always a desired objective and a useful way for solving validation problems.

# 3. Recent Travel Conditions

The Version 2.3 travel model was calibrated to year-2007 conditions, a time period time when national vehicle-miles traveled (VMT) reached peak levels, about 3 trillion miles. Figure 1 shows the historical U.S. VMT and VMT per capita between 1987 and 2012.

[2] 3/4/12 email from Robert Griffiths to Ronald Milone, Re; DC HPMS VMT 2007 and 2008

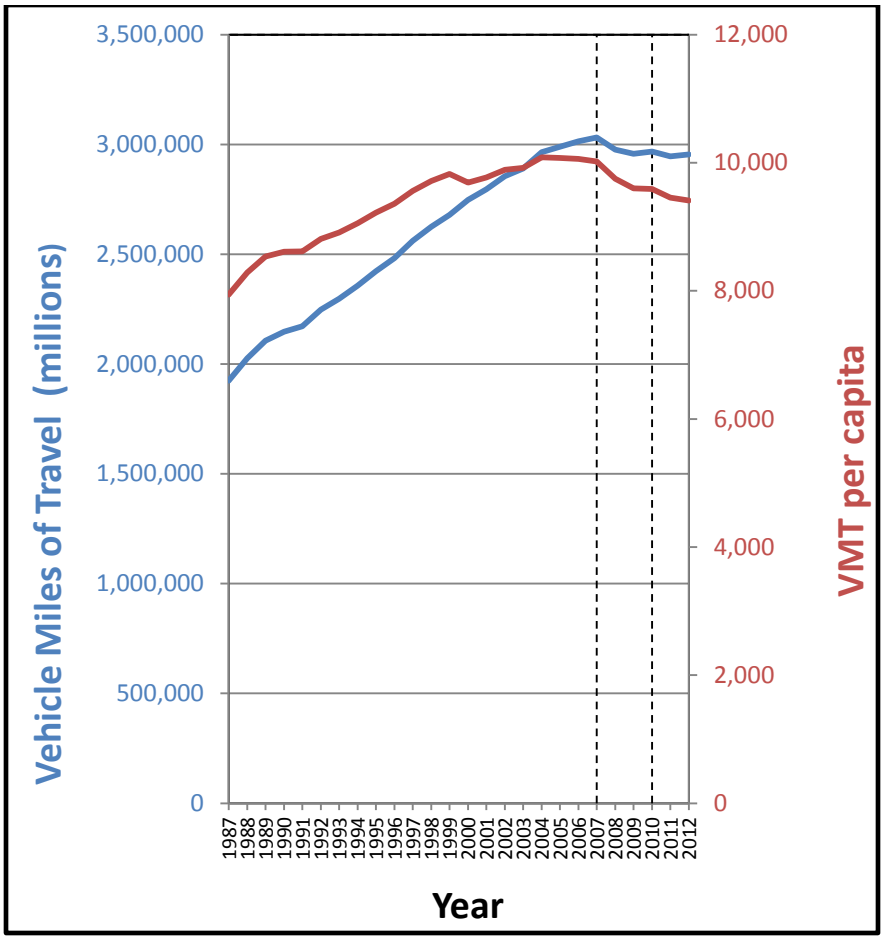



Figure 1 US Total Vehicle-Miles Travel and Vehicle-Miles per Capita

The figure indicates that both of these metrics have waned between 2007 and 2012. National VMT growth has, with a few temporary exceptions, been steady from year to year since the end of World War II, so the sustained leveling off of VMT since 2007 is unprecedented. VMT growth in the TPB planning area, shown in Figure 2, has been essentially "flat" between 2007 and 2010, despite an 11% increase in population for the modeled area (from 5,980,000 to 6,625,000).[3] This inconsistency explains the downward trend in VMT per capita shown in Figure 3.

[3] Based on 2007 Pseudo-Round 8.0 land activity and 2010 Round 8.2 Cooperative Forecasting Land Use.

Figure 2: VMT Growth in the TPB Planning Area, 2005 to 2011

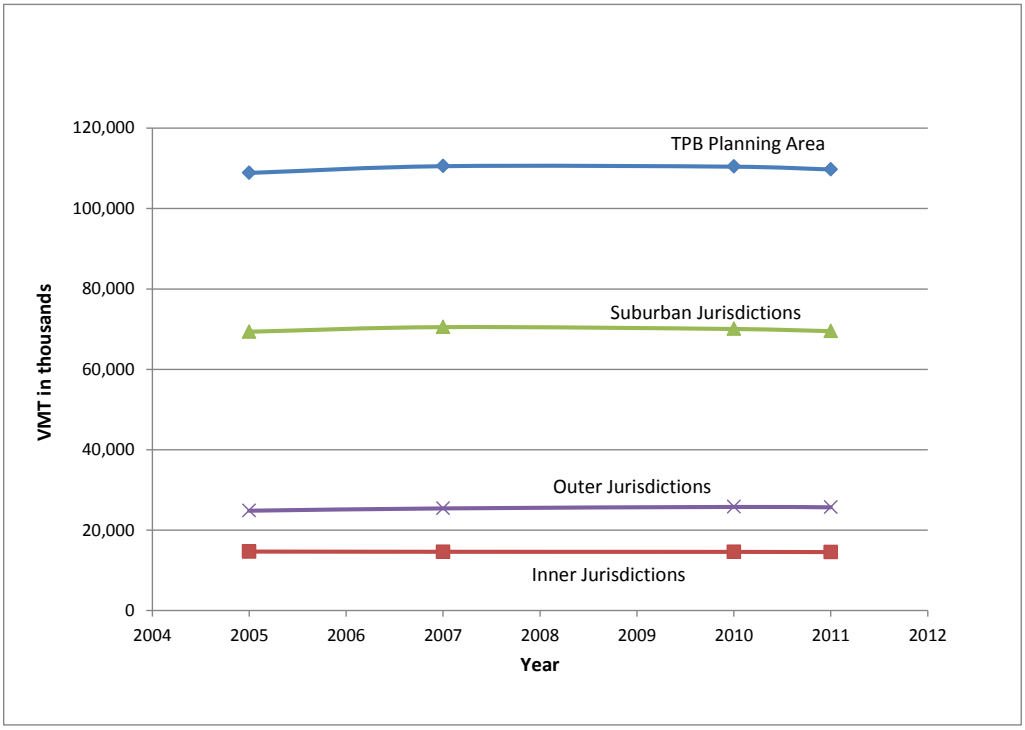
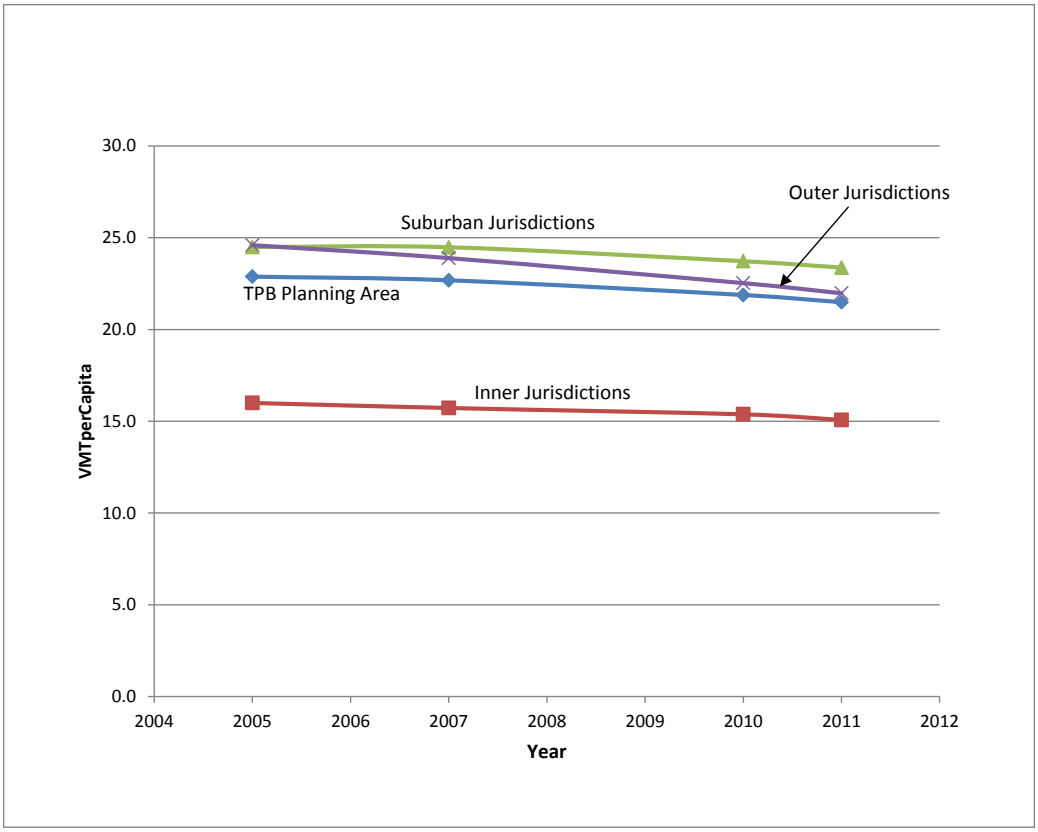



Figure 3: VMT per Capita in the TPB Planning Area, 2005 to 2011



It is not clear whether the decline in the region's VMT per capita is a short-term phenomenon or the beginning of a longer-term change in traveler behavior. Several potential causes can be suggested for the recent downturn in miles traveled per person:

- The global economic recession that began during 2008 has led to a slowing of the national economy and an overall reduction in household travel and commercial travel.
- Periods of fuel price volatility in recent years, particularly during the spring and summer of 2008 when prices spiked locally and nationally, have caused travelers to economize on discretionary travel.
- Internet-based telecommuting and communication technologies are increasingly serving as substitutes for motorized travel. Internet-based commerce is also emerging as an efficient and convenient alternative to motorized shopping trips.
- Residential location and travel preferences of the population segment aged 18-34 (also known as the "Millennials") are quite different than the older "Baby Boomers." Many of the Millennials are attracted to urbanized areas and are more inclined to use non-motorized and transit modes.

Given the recent changes in VMT growth and VMT per capita, it is evident that the TPB's 2010 validation work comes at a time when driving behavior is not following historical patterns. TPB staff will need to continue monitoring existing trends in order to gauge whether longer term changes to the travel model are warranted.

# 4. Validation Preparation

Prior to the validation analysis, staff spent a considerable amount of time refining the highway network, specifically revisiting facility type and lane coding, and refining centroid connections with respect to the 3,722 TAZ system.[4] During later stages of the validation, additional highway network refinements were implemented. The most prominently network update was a change in the facility type coding for freeways in the District of Columbia. TPB staff noted that the Version 2.3.39 model overestimated vehicle-miles traveled and speculated the speed and capacities associated with freeway facilities in the District were excessive with respect to actual conditions in the District. For example, sections of I-395 in

[4] Initial modifications were documented in a 9/18/12 memorandum from Meseret Seifu to files on the subject: Refinement of facility type codes in the base-year 2010 highway network.

the District are subject to posted speed limits of 40 mph, which is clearly lower than the free-flow freeway speed assumed by the model. Staff decided to code many of the freeways in or near the District as expressways as a means of more accurately reflecting actual operating conditions and for improving VMT performance.

## 5. Land Activity Validation

Round 8.1 is the currently adopted land activity forecast that is input to the regional travel model. The U.S. Census provides household and population information at fine levels of geography every ten years. At the time of the validation effort, 2010 Census information was available only at the jurisdiction level. Staff obtained Census data from the web,[5] and prepared a comparison of 2010 Round 8.1 households against the 2010 Census (Table 2). The table indicates reasonable agreement for most of the TPB planning members. Larger differences are noted in the Baltimore-area jurisdictions and in some of the exurban Virginia counties, where it is likely that the 2010 Census has not yet been considered in the preparation of local land use data. Overall, the comparison shown in Table 2, and graphically in Figure 4, is reasonable.

[5] American Fact Finder, http://factfinder2.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t

Table 2: 2010 Round 8.1 and Census Households, Household Population and Household Size

| | 2010 Round 8.1 | | | 2010 Census | | | HH Diff. | Pop. Diff. | Size Diff. |
|---|---|---|---|---|---|---|---|---|---|
| Juris. | HHs | HH Pop. | HH Size | HHs | HH Pop. | HH Size | R81 - Cen | R81 - Cen | R81 - Cen |
| DC | 266,707 | 561,702 | 2.11 | 266,707 | 561,702 | 2.11 | 0 | 0 | 0.00 |
| Mtg | 361,030 | 959,695 | 2.66 | 357,086 | 962,877 | 2.70 | 3,944 | -3,182 | -0.04 |
| PGeo | 304,042 | 844,092 | 2.78 | 304,042 | 844,092 | 2.78 | 0 | 0 | 0.00 |
| Arl | 98,050 | 204,735 | 2.09 | 98,050 | 204,735 | 2.09 | 0 | 0 | 0.00 |
| Alx | 68,131 | 138,131 | 2.03 | 68,082 | 138,139 | 2.03 | 49 | -8 | 0.00 |
| Ffx | 399,514 | 1,075,041 | 2.69 | 405,075 | 1,106,770 | 2.73 | -5,561 | -31,729 | -0.04 |
| Ldn | 104,583 | 311,139 | 2.98 | 104,583 | 311,139 | 2.98 | 0 | 0 | 0.00 |
| PW | 147,819 | 451,524 | 3.05 | 147,819 | 451,524 | 3.05 | 0 | 0 | 0.00 |
| Frd | 84,800 | 229,203 | 2.70 | 84,800 | 229,203 | 2.70 | 0 | 0 | 0.00 |
| How | 107,502 | 279,983 | 2.60 | 104,749 | 284,763 | 2.72 | 2,753 | -4,780 | -0.11 |
| AnnAr | 202,314 | 516,054 | 2.55 | 199,378 | 523,523 | 2.63 | 2,936 | -7,469 | -0.08 |
| Chs | 50,950 | 143,049 | 2.81 | 51,214 | 145,146 | 2.83 | -264 | -2,097 | -0.03 |
| Car | 61,592 | 171,740 | 2.79 | 59,786 | 163,815 | 2.74 | 1,806 | 7,925 | 0.05 |
| Calv | 32,046 | 91,026 | 2.84 | 30,873 | 88,087 | 2.85 | 1,173 | 2,939 | -0.01 |
| StM | 38,870 | 101,278 | 2.61 | 37,604 | 102,225 | 2.72 | 1,266 | -947 | -0.11 |
| KGeo | 8,370 | 23,257 | 2.78 | 8,376 | 23,283 | 2.78 | -6 | -26 | 0.00 |
| Stf | 41,769 | 125,355 | 3.00 | 41,769 | 125,368 | 3.00 | 0 | -13 | 0.00 |
| Spots_Fbrg | 43,175 | 119,749 | 2.77 | 51,447 | 143,563 | 2.79 | -8,272 | -23,814 | -0.02 |
| Fau | 26,871 | 74,194 | 2.76 | 23,658 | 64,814 | 2.74 | 3,213 | 9,380 | 0.02 |
| Clk_Jeff | 26,496 | 65,153 | 2.46 | 25,440 | 65,886 | 2.59 | 1,056 | -733 | -0.13 |
| Total | 2,474,631 | 6,486,100 | 2.62 | 2,470,538 | 6,540,654 | 2.65 | 4,093 | -54,554 | -0.03 |

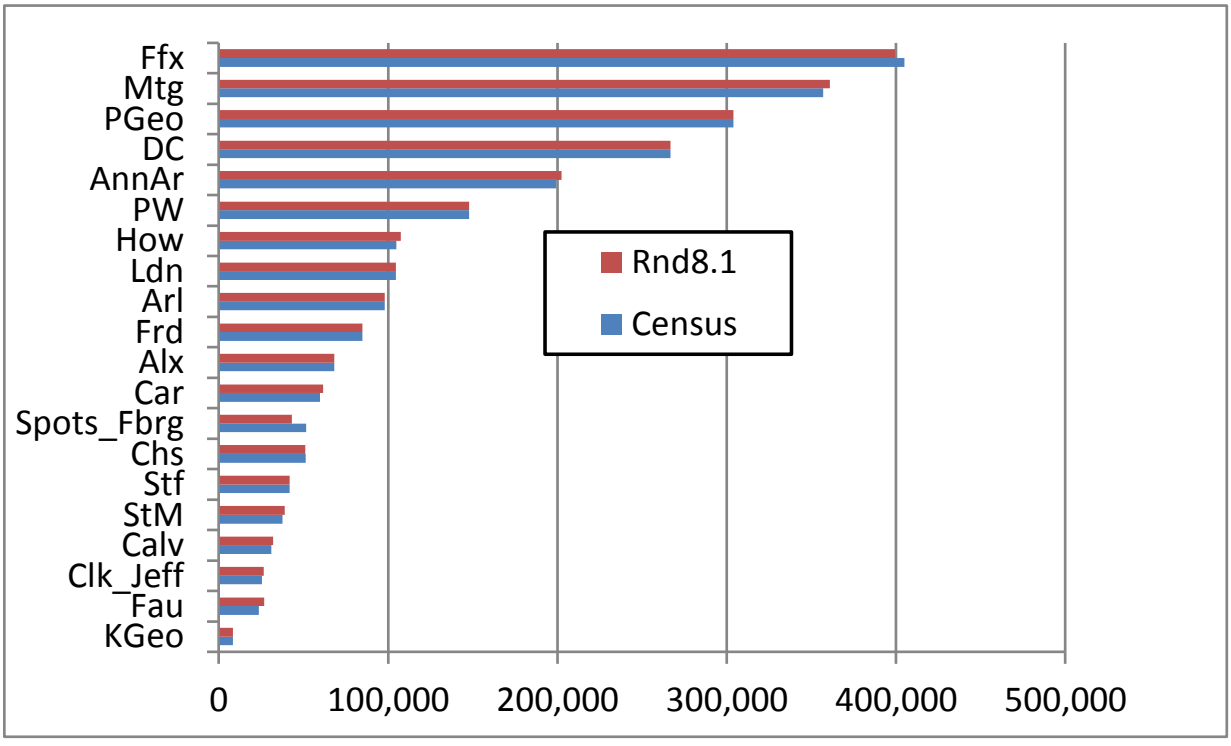


Figure 4: 2010 Households by Jurisdiction: Census vs. Round 8.1 Cooperative Forecasts

TPB staff assembled ACS data to evaluate households by size, income level, and vehicles available. Comparisons of ACS and estimated results are shown on Tables 3 through 5 and Figures 5 through 7.

The ACS is now a replacement to the Census "long form" which has been used in the past to collect detailed household, job, and commuting travel data every ten years. It is important to point out that the ACS data is developed from a continuous data collection process whereby 250,000 households are sampled each month. While this type of collection results in a constant stream of yearly data, there are a few definitional limitations:

1. Whereas the U.S. Census has historically been conducted every ten years during the spring using a substantial sampling rate (1 in 6), the ACS represents data that is collected throughout the year using a lower much lower sampling rate.
2. An implication of the ACS's lower sampling rate is that the yearly data cannot be used to supply household information at fine levels of geography. Yearly data is significant only for areas with a population of 65,000 or more. Jurisdictions with lower population levels must rely on multiple years of ACS data to ensure that the sampled information is meaningful.

Given these limitations, the regional matches shown between modeled distributions and observed ACS appear to be within reasonable tolerances.

Table 3 2010 HH Size Distribution at State Level – Estimated vs. Observed (ACS)

| State | Size | 1 Psn HHs | 2 Psn HHs | 3 Psn HHs | 4+Psn HHs | Sum |
|---|---|---|---|---|---|---|
| DC | estimated | 41.1% | 30.4% | 13.2% | 15.3% | 100.0% |
| | observed | 48.0% | 27.8% | 11.9% | 12.3% | 100.0% |
| | Diff. | -6.9% | 2.5% | 1.3% | 3.0% | |
| MD | estimated | 23.1% | 30.9% | 18.2% | 27.8% | 100.0% |
| | observed | 24.5% | 32.0% | 17.3% | 26.1% | 100.0% |
| | Diff. | -1.4% | -1.2% | 0.9% | 1.7% | |
| VA | estimated | 24.4% | 30.1% | 17.7% | 27.8% | 100.0% |
| | observed | 23.9% | 31.3% | 16.5% | 28.2% | 100.0% |
| | Diff. | 0.5% | -1.2% | 1.2% | -0.4% | |
| Total | estimated | 25.6% | 30.5% | 17.5% | 26.4% | 100.0% |
| | observed | 26.7% | 31.3% | 16.4% | 25.5% | 100.0% |
| | Diff. | -1.2% | -0.8% | 1.0% | 0.9% | |

Table 4 2010 HH Income Distribution at State Level – Estimated vs. Observed (ACS)

| State | Income | Inc. 1 | Inc. 2 | Inc. 3 | Inc. 4 | Sum |
|---|---|---|---|---|---|---|
| DC | Estimated | 47.0% | 29.1% | 13.4% | 10.6% | 100.0% |
| | Observed | 42.2% | 27.3% | 13.1% | 17.4% | 100.0% |
| | Diff. | 4.8% | 1.9% | 0.3% | -6.9% | |
| MD | Estimated | 26.3% | 32.1% | 21.2% | 20.4% | 100.0% |
| | Observed | 27.8% | 31.6% | 20.4% | 20.2% | 100.0% |
| | Diff. | -1.5% | 0.4% | 0.9% | 0.2% | |
| VA | Estimated | 23.0% | 30.2% | 21.9% | 24.9% | 100.0% |
| | Observed | 21.7% | 29.0% | 22.4% | 26.8% | 100.0% |
| | Diff. | 1.3% | 1.1% | -0.5% | -1.9% | |
| Total | Estimated | 27.2% | 31.0% | 20.6% | 21.1% | 100.0% |
| | Observed | 26.9% | 30.2% | 20.4% | 22.5% | 100.0% |
| | Diff. | 0.4% | 0.8% | 0.2% | -1.4% | |

Table 5 2010 HH Vehicle Availability Distribution at State Level – Estimated vs. Observed (ACS)

| State | | 0 Vehs. | 1 Veh. | 2 Vehs. | 3+ Vehs. | Sum |
|---|---|---|---|---|---|---|
| DC | Estimated | 38.9% | 39.3% | 17.4% | 4.3% | 100.0% |
| | Observed | 35.0% | 45.3% | 15.7% | 4.0% | 100.0% |
| | Diff. | 3.9% | -6.0% | 1.7% | 0.4% | |
| MD | Estimated | 5.0% | 28.6% | 40.9% | 25.5% | 100.0% |
| | Observed | 6.7% | 30.3% | 39.1% | 23.8% | 100.0% |
| | Diff. | -1.7% | -1.7% | 1.8% | 1.7% | |
| VA | Estimated | 5.2% | 29.8% | 40.2% | 24.8% | 100.0% |
| | Observed | 4.7% | 30.6% | 41.0% | 23.6% | 100.0% |
| | Diff. | 0.4% | -0.8% | -0.8% | 1.2% | |
| Total | Estimated | 8.7% | 30.2% | 38.1% | 23.0% | 100.0% |
| | Observed | 8.9% | 32.0% | 37.4% | 21.7% | 100.0% |
| | Diff. | -0.2% | -1.7% | 0.6% | 1.3% | |

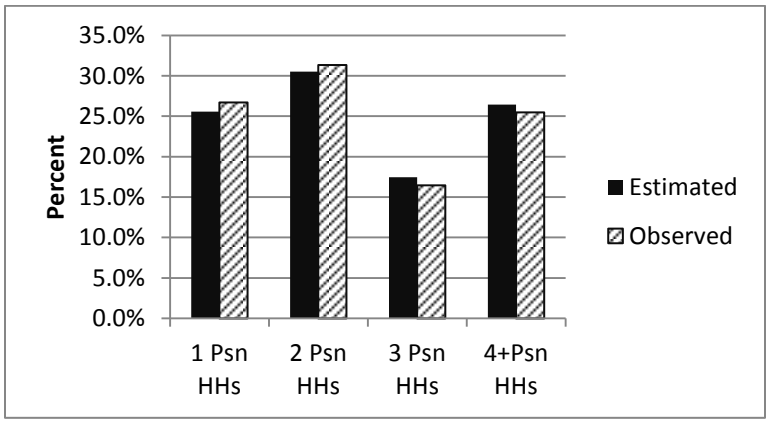


Figure 5 2010 Regional HH Size Distribution – Model vs. ACS Total

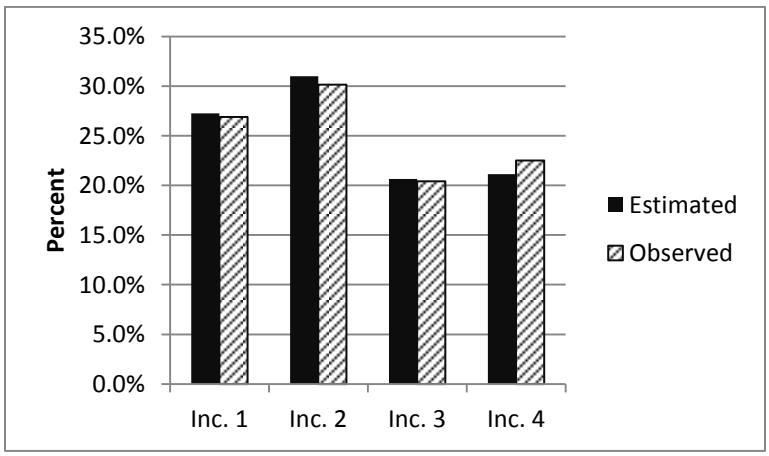


Figure 6 2010 Regional HH Income Distribution - Model vs. ACS Total

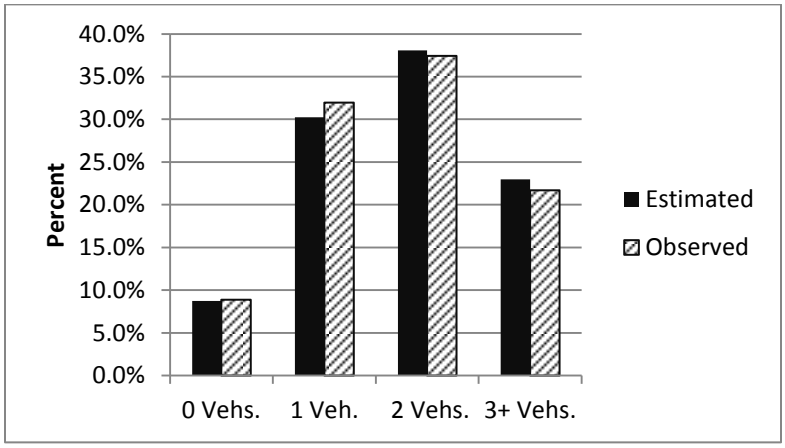


Figure 7 2010 Regional HH Vehicle Availability Distribution - Model vs. ACS Total

## 6. Non-Motorized Travel Validation

During the spring of 2010 and the fall of 2011, TPB staff began a special ongoing data collection program intended to supplement the TPB's household travel survey (HTS) that was collected during 2007 and 2008. The special data collection effort is known as the Geographically Focused Household Travel Surveys (GFHTS). The data collection program was initiated by the TPB and is currently intended to:

1. Permit more intensive analysis of travel behavior for a wide variety of communities in terms of physical design, land activity density, and travel options at the neighborhood level of analysis;
2. Supply regional planners with information to facilitate land use and transportation planning efforts; and
3. Build a database that permits "before and after" data analysis opportunities for locations that are undergoing major transportation improvements or major shifts in land activity patterns

TPB staff presented an overview of the data collection effort[6] and preliminary results of the surveys to the TPB in May of 2012.[7] The presentation focused on ten areas that had been thus far surveyed and analyzed. The ten areas, listed in Table 6, range in size from about 0.5 to 20 square miles.

[6] May 16, 2012 presentation to the TPB on 2011 TPB Geographically Focused Household Travel Surveys/ Initial Results (Item #9), https://www.mwcog.org/uploads/committee-documents/k11dXlle20120517145044.pdf

Table 6 Geographically-Focused Household Travel Survey Areas

| | Geo-Focused Area | Jurisdiction | When Surveyed | Total HHs in Area | Land Area (Sq mi) | No. of TAZs |
|---|---|---|---|---|---|---|
| 1 | Shirlington | Arlington | Spring 2010 | 4,200 | 0.6 | 3 |
| 2 | Crystal City Area | Arlington | Spring 2010 | 9,600 | 0.7 | 8 |
| 3 | Columbia Pike Corridor | Arlington | Spring 2010 | 15,000 | 2.5 | 12 |
| 4 | Frederick City | Frederick Co. | Fall 2011 | 26,500 | 19.8 | 22 |
| 5 | Largo | Prince Geo. | Fall 2011 | 12,200 | 9.4 | 20 |
| 6 | Logan Circle | DC | Fall 2011 | 23,900 | 1.1 | 17 |
| 7 | Purple Line | Montgom./Prince Geo. | Fall 2011 | 16,100 | 4.9 | 21 |
| 8 | Reston | Fairfax County | Fall 2011 | 15,700 | 8.2 | 19 |
| 9 | White Flint | Montgomery Co. | Fall 2011 | 12,500 | 4.6 | 11 |
| 10 | Woodbridge | Pr. William | Fall 2011 | 12,900 | 8.0 | 19 |

TPB staff reviewed the daily modal share information from the GFHTS and determined that it was a reasonable basis for assessing modeled mode shares in the ten areas. TPB staff first developed zonal equivalences for each of the focus areas surveyed. In most cases, the zonal alignments corresponded reasonably well to the surveyed boundaries. Table 6 indicates that the number of TAZs associated with the surveyed areas range from 3 to 22. In summarizing the daily mode shares from the model, staff computed shares based on home-based trip purposes only, to ensure that the modeled data reflected strictly the residents of the areas.

A comparison of observed and estimated daily trip shares by focus area is shown in Table 7. In reviewing the data numerically and graphically, the following observations were made:

- While the modeled shares did not match the observed shares perfectly, the overall share graphical patterns were quite similar for each area, within plus or minus 10%.
- Given that the Version 2.3 mode choice model is calibrated to large district-to-district interchanges, the match between estimated and observed transit shares at a sub-area level could not realistically be expected to match exactly. Nonetheless, most of the transit share differences fell within 5%, which was reasonable in the staff's view.
- Staff noted that auto and transit share differences were, in most areas, slightly over-estimated while non-motorized shares were generally under-estimated.

[7] Memorandum, dated May 9, 2012, to the TPB from Robert Griffiths, https://www.mwcog.org/uploads/committee-documents/l11dXl9c20120510093110.pdf.

- Substantial under-estimations in the non-motorized shares were noticed for the Logan Circle, Crystal City, and Purple Line focus areas (each under-estimated by about 15%). These areas are quite diverse in location, density, and socio-economic profile.
- Staff also reviewed the observed non-motorized shares by purpose (work vs. non-work) and determined that the under-estimation of non-motorized trip shares was most pronounced for non-work purposes.

Staff ultimately decided to adjust the Version 2.3 sub-models so that the estimated daily non-motorized shares aligned more closely with the GFHTS shares. The adjustment was applied to all non-work purposes and in higher-density areas (Area Types 1 and 2) which are largely inclusive of the GFHTS study areas. The adjustment to the non-motorized shares was determined using a trial-and-error method. The ultimate adjustment involved raising non-work shares by 30%. So, for example, if an existing non-motorized share for a given non-work trip was 15%, the adjusted share was increased to 19.5% (15% * 1.30).

The comparison of observed and adjusted/estimated daily trip shares by focus area is shown in Table 8. The adjusted model has improved that regional average share of non-motorized trips from -3% to 0%. The 15% under-estimation non-motorized shares noted earlier for the Logan Circle area has been reduced to about a 5%. Unfortunately the adjustment did not improve the non-motorized shares for two of the ten focus areas (Crystal City and Columbia Pike).

Table 7 Estimated and Observed Modal Shares by Focus Area – Before Model Adjustments

| | Estimated Shares | | | | Observed Shares | | | | Difference (E-O) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Focus Area** | **Auto** | **Transit** | **NonMotr** | **Sum** | **Auto** | **Transit** | **NonMotr** | **Sum** | **Auto** | **Transit** | **NonMotr** |
| **Logan Circle** | 0.29 | 0.21 | 0.50 | 1.00 | 0.20 | 0.15 | 0.65 | 1.00 | 0.09 | 0.05 | -0.15 |
| **Crystal city** | 0.56 | 0.25 | 0.18 | 1.00 | 0.46 | 0.22 | 0.32 | 1.00 | 0.11 | 0.04 | -0.14 |
| **Shirlington** | 0.73 | 0.14 | 0.13 | 1.00 | 0.71 | 0.13 | 0.16 | 1.00 | 0.01 | 0.01 | -0.02 |
| **Columbia Pike** | 0.69 | 0.15 | 0.16 | 1.00 | 0.79 | 0.10 | 0.11 | 1.00 | -0.10 | 0.04 | 0.05 |
| **Purple Line** | 0.73 | 0.15 | 0.12 | 1.00 | 0.66 | 0.07 | 0.27 | 1.00 | 0.08 | 0.07 | -0.15 |
| **White Flint** | 0.79 | 0.11 | 0.10 | 1.00 | 0.72 | 0.08 | 0.20 | 1.00 | 0.07 | 0.03 | -0.09 |
| **Largo** | 0.89 | 0.06 | 0.05 | 1.00 | 0.86 | 0.04 | 0.10 | 1.00 | 0.03 | 0.02 | -0.05 |
| **Reston** | 0.87 | 0.05 | 0.08 | 1.00 | 0.82 | 0.03 | 0.15 | 1.00 | 0.05 | 0.02 | -0.07 |
| **Woodbridge** | 0.92 | 0.03 | 0.05 | 1.00 | 0.85 | 0.02 | 0.13 | 1.00 | 0.08 | 0.01 | -0.08 |
| **Frederick** | 0.93 | 0.01 | 0.05 | 1.00 | 0.86 | 0.02 | 0.12 | 1.00 | 0.08 | -0.01 | -0.07 |
| **Regional Average** | 0.86 | 0.07 | 0.07 | 1.00 | 0.84 | 0.06 | 0.10 | 1.00 | 0.02 | 0.00 | -0.03 |

Table 8 Estimated and Observed Modal Shares by Focus Area – After Model Adjustments

| | Estimated Shares | | | | Observed Shares | | | | Difference (E-O) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Focus Area** | **Auto** | **Transit** | **NonMotr** | **Sum** | **Auto** | **Transit** | **NonMotr** | **Sum** | **Auto** | **Transit** | **NonMotr** |
| **Logan Circle** | 0.22 | 0.18 | 0.60 | 1.00 | 0.20 | 0.15 | 0.65 | 1.00 | 0.02 | 0.03 | -0.05 |
| **Crystal City** | 0.66 | 0.17 | 0.17 | 1.00 | 0.46 | 0.22 | 0.32 | 1.00 | 0.20 | -0.05 | -0.15 |
| **Shirlington** | 0.70 | 0.11 | 0.19 | 1.00 | 0.71 | 0.13 | 0.16 | 1.00 | -0.01 | -0.02 | 0.03 |
| **Columbia Pike** | 0.65 | 0.12 | 0.22 | 1.00 | 0.79 | 0.10 | 0.11 | 1.00 | -0.14 | 0.02 | 0.11 |
| **Purple Line** | 0.71 | 0.13 | 0.16 | 1.00 | 0.66 | 0.07 | 0.27 | 1.00 | 0.05 | 0.06 | -0.11 |
| **White Flint** | 0.80 | 0.08 | 0.12 | 1.00 | 0.72 | 0.08 | 0.20 | 1.00 | 0.08 | 0.00 | -0.08 |
| **Largo** | 0.87 | 0.05 | 0.08 | 1.00 | 0.86 | 0.04 | 0.10 | 1.00 | 0.01 | 0.01 | -0.02 |
| **Reston** | 0.86 | 0.04 | 0.10 | 1.00 | 0.82 | 0.03 | 0.15 | 1.00 | 0.04 | 0.01 | -0.05 |
| **Woodbridge** | 0.91 | 0.02 | 0.07 | 1.00 | 0.85 | 0.02 | 0.13 | 1.00 | 0.06 | 0.00 | -0.06 |
| **Frederick** | 0.92 | 0.01 | 0.07 | 1.00 | 0.86 | 0.02 | 0.12 | 1.00 | 0.06 | -0.01 | -0.05 |
| **Regional Average** | 0.84 | 0.05 | 0.10 | 1.00 | 0.84 | 0.06 | 0.10 | 1.00 | 0.00 | -0.01 | 0.00 |

# 7. Highway and Transit Travel Validation

Most of the validation effort focused on the investigation of model tests aimed at improving daily VMT performance at the jurisdiction level and improving screenline crossing performance of the model. The primary performance issues identified where:

1. VMT was over-estimated in the District of Columbia, the City of Alexandria and Loudoun County.
2. Traffic crossings over the Potomac River (Screenline #20) were substantially over-estimated
3. Radial highway screenline crossings within DC (screenline #2 and #4) were over-estimated
4. Several screenline crossings in the “outer ring” of the modeled study area where over-estimated

Some of these noted problems were partially resolved by the changes described above: 1) the adjustment of the non-motorized share sub-model and 2) the re-coding of freeway facility types in the District of Columbia as expressways. These changes, alone, did not result in a complete elimination of the performance issues, but they did move results in the right direction.

Staff undertook a series of sensitivity tests that focused on imposing time penalties on Potomac River bridges. The tests explored the use of time penalties on Potomac River crossings, ranging from 8 to 15 minutes. Staff also considered testing the time penalties with and without bridge-related K-factors and expanding the number of bridges to include bridge penalties (the existing screenline #20 includes only those bridges between, and including, the Capital Beltway bridges). After evaluating the tests, staff decided to use 11-minute time penalties on all screenline-20 bridges and bridges between Loudoun County and Maryland (i.e., the Point of Rocks Bridge and the Route 340 Bridge). All bridge-related K-factors used in the Version 2.3.39 model were considered duplicative and were removed. The final model specification also included a number of refinements that were not validation-related, but were used to improve the model's accuracy, stability and internal consistency. All model tests are documented in a previous memorandum.[8]

Table 9 shows a comparison of estimated and observed (HPMS) VMT at the jurisdiction level. The table shows the modeled results both before and after modeling adjustments (both the non-motorized model update and the use of bridge penalties). The match between estimated and observed VMT at the jurisdiction level should ideally be within 15%. The observed VMT is based on sampled counts collected by the state DOTs, most of which is seasonally adjusted and is therefore subject to a margin of error. The validation effort resulted in a notable improvement to estimated VMT in the District of Columbia, e.g., the estimated–to-observed (E-O) ratio has changed from 1.13 to 0.98. VMT performance in the City of Alexandria has also been improved, from an E-O ratio of 1.25 to 1.14. VMT performance at the MSA level has improved from an E-O ratio of 1.04 to 1.00. VMT performance for the modeled regional has been improved from an E-O ratio of 1.02 to 1.00.

[8] Memorandum from Mark Moran to Ronald Milone, Subject: Updates made to the COG/TPB Version 2.3 Travel Model, from Build 38 to Build 52, May 30, 2013.

Table 9 Total Estimated and Observed (HPMS) VMT by Jurisdiction

| Jurisdiction | 2010 Observed[1] (a) | 2010 Estimate Before Adjust. (b) | 2010 Estimate After Adjust (c) | Existing E/O Ratio (b/a) | Validated E/O Ratio (c/a) |
|---|---|---|---|---|---|
| District of Columbia | 8,218,979 | 9,277,286 | 8,057,876 | 1.13 | 0.98 |
| Montgomery Co., Md. | 19,693,973 | 21,105,942 | 20,822,943 | 1.07 | 1.06 |
| Prince George's Co., Md. | 23,123,014 | 23,118,892 | 22,685,984 | 1.00 | 0.98 |
| Arlington Co., Va. | 4,256,249 | 4,529,161 | 3,876,314 | 1.06 | 0.91 |
| City of Alexandria, Va. | 2,122,476 | 2,642,544 | 2,414,208 | 1.25 | 1.14 |
| Fairfax Co., Va. | 27,221,807 | 26,320,633 | 25,418,571 | 0.97 | 0.93 |
| Loudoun Co., Va. | 6,212,516 | 6,802,826 | 6,906,894 | 1.10 | 1.11 |
| Prince William Co., Va. | 8,573,525 | 8,979,517 | 8,876,845 | 1.05 | 1.04 |
| Frederick Co., Md. | 7,738,356 | 8,630,040 | 8,460,471 | 1.12 | 1.09 |
| Charles Co., Md. | 3,253,562 | 3,129,606 | 3,101,335 | 0.96 | 0.95 |
| Stafford Co., Va. | 3,920,132 | 4,139,957 | 4,141,312 | 1.06 | 1.06 |
| Calvert Co., Md | 2,036,712 | 1,868,404 | 1,848,978 | 0.92 | 0.91 |
| MSA Subtotal | 116,371,301 | 120,544,808 | 116,611,731 | 1.04 | 1.00 |
| | | | | | |
| Howard Co., Md. | 10,491,370 | 10,400,008 | 10,575,990 | 0.99 | 1.01 |
| Anne Arundel Co., Md. | 14,984,795 | 14,578,753 | 14,742,784 | 0.97 | 0.98 |
| Carroll Co., Md. | 3,354,247 | 3,931,758 | 3,999,660 | 1.17 | 1.19 |
| City of Fredericksburg, Va. | 919,376 | 824,063 | 822,610 | 0.90 | 0.89 |
| Spotsylvania Co., Va.[2] | 3,303,754 | 2,202,562 | 2,212,010 | 0.67 | 0.67 |
| Clarke Co., Va. | 757,688 | 870,279 | 926,425 | 1.15 | 1.22 |
| Jefferson Co., WVa. | 1,094,762 | 1,245,818 | 1,213,570 | 1.14 | 1.11 |
| Fauquier Co., Va. | 3,331,811 | 3,162,081 | 3,187,848 | 0.95 | 0.96 |
| King George Co., Va. | 819,433 | 722,614 | 753,741 | 0.88 | 0.92 |
| St. Mary's Co., Md. | 2,192,055 | 2,075,399 | 2,050,833 | 0.95 | 0.94 |
| Non-MSA Subtotal | 41,249,289 | 40,013,335 | 40,485,471 | 0.97 | 0.98 |
| | | | | | |
| **Grand Total / Modeled Are** | **157,620,591** | **160,558,143** | **157,097,202** | **1.02** | **1.00** |

1- Source: County Level HPMS reports from the state DOTs; VMT does not include local facilities

2 - Observed VMT pertains to entire county; estimated VMT pertains to northern portion of county o

The screenline locations used to evaluate regional modeling performance are shown in Figure 8 and Figure 9. Screenline crossing performance is summarized in Table 10. The table includes model performance results for the pre-adjusted and post-adjusted travel model. Note that, although not shown in Table 10, the coverage of ground counts on highway links associated with screenlines is not complete. On average, only two-thirds of the links associated with each screenline include a ground

count. The table indicates notable improvements for screenlines 2, 3, 5, 6 and 20. For example, screenline 20 (Potomac River bridges within the Beltway) went from 42% overestimated to only 7% overestimated.

Table 11 and Table 12 show aggregate VMT performance based on the sampled counts on network links, by facility type and by area type. For about 6,400 directional ground counts (about 20% of all highway links), the E-O VMT ratio is 1.03. The error margins and the estimated and observed distributions by facility type and area type are quite reasonable. The percent Root Mean Square Error (%RMSE) statistics by facility type are shown in Table 13, and appear to be within reasonable tolerances.

Staff also compared estimated daily 2010 Metrorail boardings against daily faregate counts collected by WMATA. An estimated and observed plot of the station-level boardings is shown in Figure 10. The estimated boardings, shown below, are about 3% lower than the observed count. This finding is in line with staff expectations. Since the existing model does not currently include external transit trips, it is reasonable that the model would slightly under-estimate boarding counts. In fact, many of the under-estimated stations shown in Figure 10 are stations that serve a large number of external transit trips (e.g., Union Station, Smithsonian, and National Airport).

| Estimated | Observed | Diff. (E-O) | % Diff. |
|---|---|---|---|
| 724,021 | 743,396 | -19,375 | -3% |
| | | | |

Figure 8 Screenline Location Map: Inside of the Capital Beltway

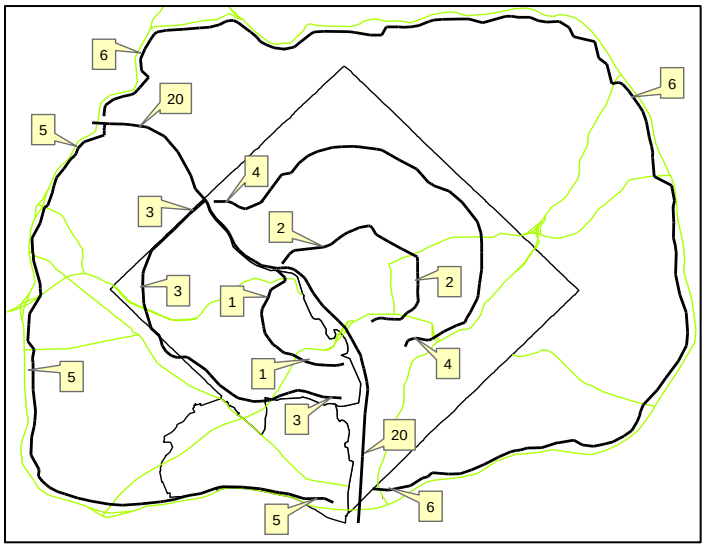


Figure 9 Screenline Location Map: Outside of the Capital Beltway

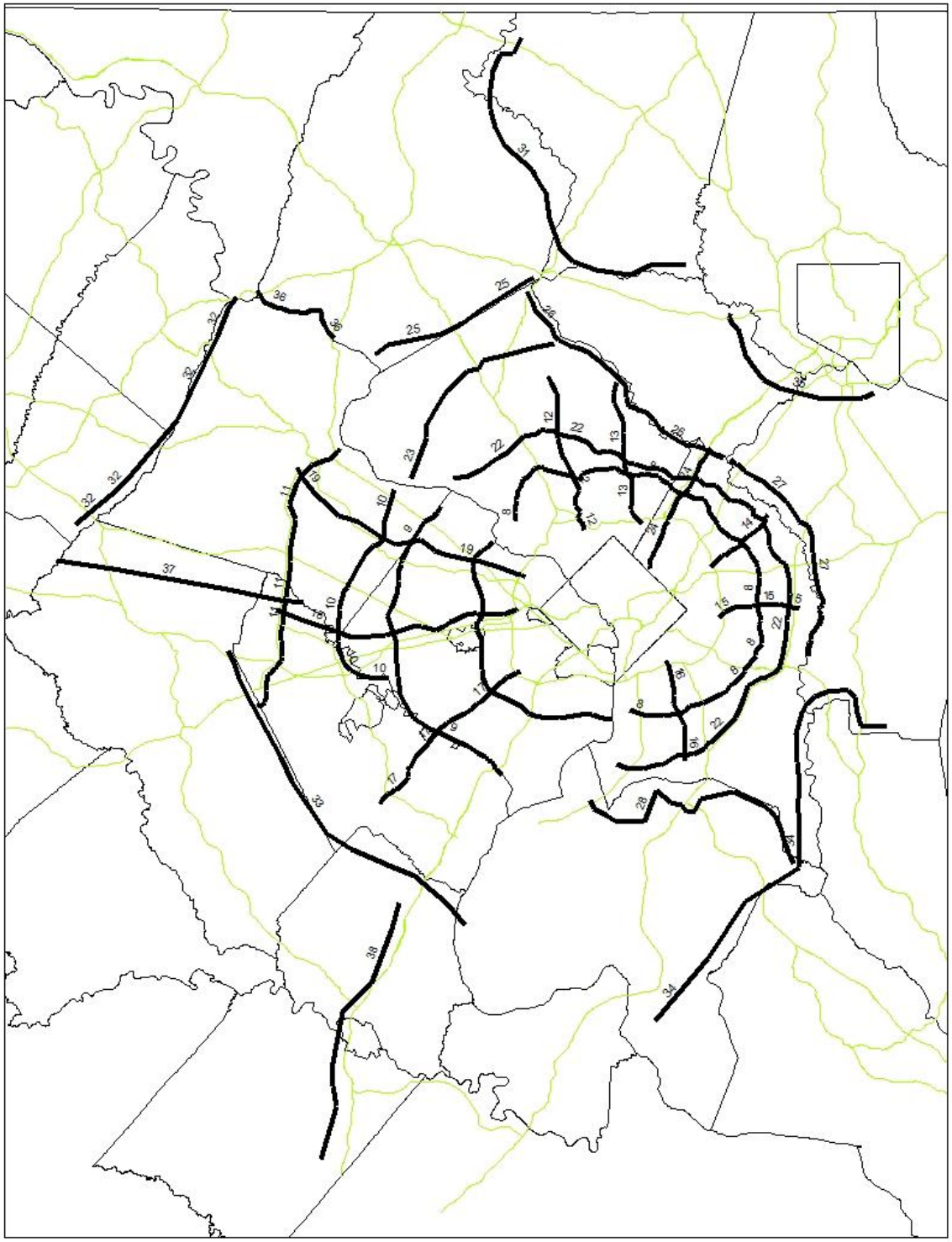


Table 10 Estimated and Observed Screenline Crossings (in thousands)

| Screenline | Observed | Estimated Before Adj | Estimated After Adj. | E/O Ratio (Before) | E/O Ratio (After) |
|---|---|---|---|---|---|
| 1 | 544 | 573 | 478 | 1.05 | 0.88 |
| 2 | 759 | 1,012 | 920 | 1.33 | 1.21 |
| 3 | 830 | 934 | 829 | 1.13 | 1.00 |
| 4 | 738 | 877 | 896 | 1.19 | 1.21 |
| 5 | 998 | 1,095 | 1,030 | 1.10 | 1.03 |
| 6 | 1,464 | 1,607 | 1,537 | 1.10 | 1.05 |
| 7 | 1,203 | 1,209 | 1,158 | 1.01 | 0.96 |
| 8 | 1,396 | 1,564 | 1,551 | 1.12 | 1.11 |
| 9 | 856 | 871 | 844 | 1.02 | 0.99 |
| 10 | 459 | 501 | 499 | 1.09 | 1.09 |
| 11 | 293 | 291 | 294 | 0.99 | 1.00 |
| 12 | 456 | 449 | 450 | 0.98 | 0.99 |
| 13 | 386 | 493 | 501 | 1.28 | 1.30 |
| 14 | 333 | 277 | 292 | 0.83 | 0.88 |
| 15 | 331 | 271 | 282 | 0.82 | 0.85 |
| 16 | 158 | 146 | 147 | 0.92 | 0.93 |
| 17 | 487 | 493 | 485 | 1.01 | 1.00 |
| 18 | 719 | 671 | 658 | 0.93 | 0.92 |
| 19 | 719 | 665 | 640 | 0.92 | 0.89 |
| 20 | 846 | 1,206 | 903 | 1.42 | 1.07 |
| 22 | 1,423 | 1,561 | 1,550 | 1.10 | 1.09 |
| 23 | 184 | 229 | 231 | 1.24 | 1.25 |
| 24 | 433 | 386 | 376 | 0.89 | 0.87 |
| 25 | 99 | 128 | 127 | 1.29 | 1.28 |
| 26 | 37 | 73 | 75 | 1.94 | 2.01 |
| 27 | 235 | 291 | 288 | 1.24 | 1.22 |
| 28 | 177 | 140 | 137 | 0.79 | 0.78 |
| 31 | 76 | 170 | 174 | 2.24 | 2.29 |
| 32 | 89 | 87 | 123 | 0.98 | 1.37 |
| 33 | 261 | 315 | 315 | 1.21 | 1.21 |
| 34 | 133 | 138 | 153 | 1.04 | 1.15 |
| 35 | 951 | 854 | 855 | 0.90 | 0.90 |
| 36 | 47 | 59 | 77 | 1.25 | 1.64 |
| 37 | 24 | 34 | 35 | 1.45 | 1.48 |
| 38 | 264 | 176 | 177 | 0.67 | 0.67 |
| | **18,409** | **19,845** | **19,090** | **1.08** | **1.04** |

Table 11 Estimated and Observed VMT Based on Link Counts by Facility Type

| | Ground Count Coverage | | | VMT (Based on Count Sample) | | Error | | Distribution | |
|---|---|---|---|---|---|---|---|---|---|
| Facility Type | Hwy. Links | Links w/ Counts | Percent | Estimated | Observed | Diff. | Percent | Estimated | Observed |
| Freeway | 2,489 | 565 | 22.7% | 33,505,890 | 31,309,209 | 2,196,681 | 7.0% | 49.4% | 47.6% |
| Major Art | 6,828 | 1,919 | 28.1% | 16,421,719 | 15,966,098 | 455,621 | 2.9% | 24.2% | 24.3% |
| Minor Art | 11,376 | 2,753 | 24.2% | 11,657,746 | 11,290,670 | 367,076 | 3.3% | 17.2% | 17.2% |
| Collector | 10,383 | 926 | 8.9% | 1,553,639 | 2,319,733 | -766,094 | -33.0% | 2.3% | 3.5% |
| Expressway | 579 | 203 | 35.1% | 4,604,687 | 4,845,147 | -240,460 | -5.0% | 6.8% | 7.4% |
| Ramp | 744 | 2 | 0.3% | 23,045 | 31,223 | -8,178 | -26.2% | 0.0% | 0.0% |
| Total | 32,399 | 6,368 | 19.7% | 67,766,726 | 65,762,080 | 2,004,646 | 3.0% | 100.0% | 100.0% |

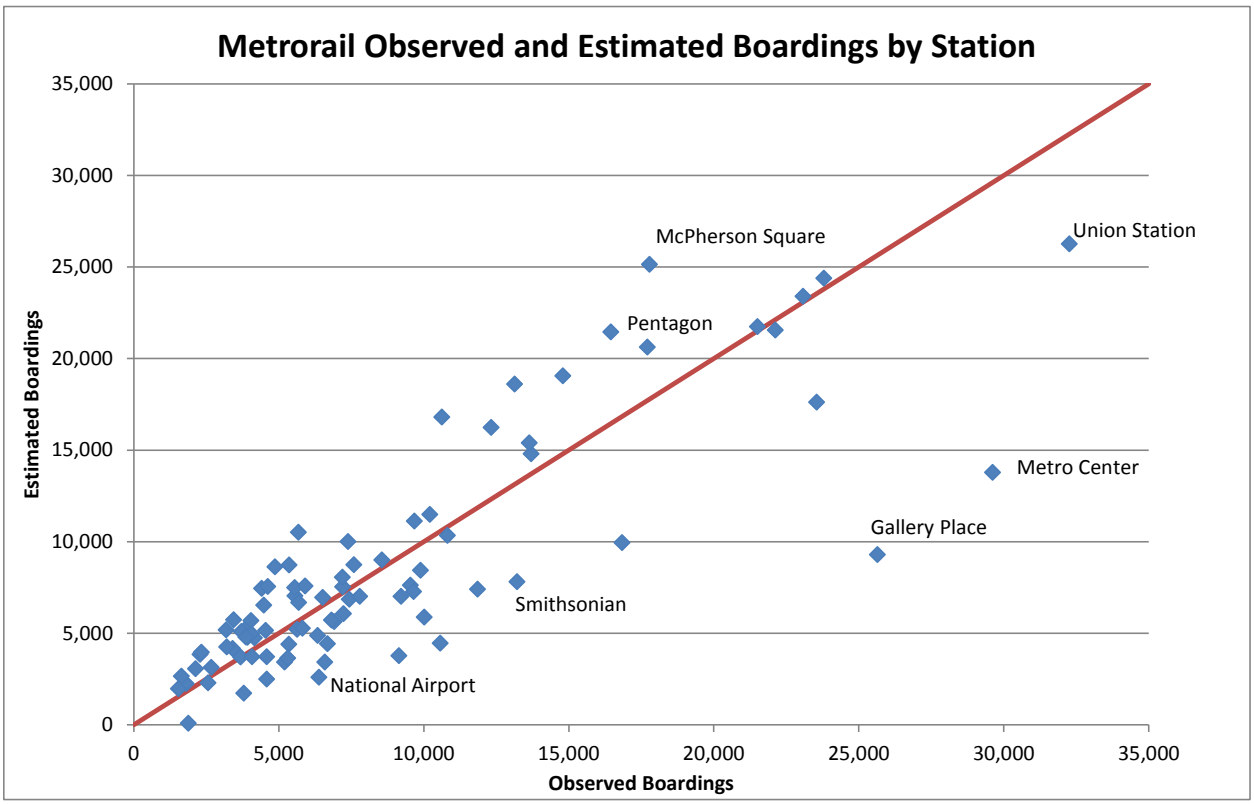
Table 12 Estimated and Observed VMT Based on Link Counts by Area Type

| | Ground Count Coverage | | | VMT | | Error | | Distribution | |
|---|---|---|---|---|---|---|---|---|---|
| Area Type | Hwy. Links | Links w/ Counts | Percent | Estimated | Observed | Diff. | Percent | Estimated | Observed |
| AT 1 (CBD) | 3,456 | 513 | 14.8% | 1,563,501 | 1,564,198 | -697 | 0.0% | 2.3% | 2.4% |
| AT 2 | 7,824 | 1,364 | 17.4% | 8,898,107 | 9,476,093 | -577,986 | -6.1% | 13.1% | 14.4% |
| AT 3 | 5,712 | 1,261 | 22.1% | 16,081,372 | 16,579,275 | -497,903 | -3.0% | 23.7% | 25.2% |
| AT 4 | 4,127 | 867 | 21.0% | 8,690,653 | 8,719,430 | -28,777 | -0.3% | 12.8% | 13.3% |
| AT 5 | 5,231 | 1,144 | 21.9% | 17,627,473 | 16,259,798 | 1,367,675 | 8.4% | 26.0% | 24.7% |
| AT 6 (Exurban) | 6,049 | 1,219 | 20.2% | 14,905,620 | 13,163,285 | 1,742,335 | 13.2% | 22.0% | 20.0% |
| Total | 32,399 | 6,368 | 19.7% | 67,766,726 | 65,762,079 | 2,004,647 | 3.0% | 100.0% | 100.0% |

Table 13 Percent Root Mean Square Error by Facility Type

| Facility Type: | No. Obs | Pct_RMSE |
|---|---|---|
| Freeway | 565 | 20.91 |
| Major Art | 1,919 | 37.93 |
| Minor Art | 2,753 | 50.33 |
| Collectors | 926 | 72.91 |
| Expressway | 203 | 29.4 |
| Ramp | 2 | 26.19 |
| | 6,368 | 39.56 |

Figure 10 2010 Estimated and Observed Daily Metrorail Boardings by Station




# 8. Conclusion

This memorandum has reviewed the validation process and results of the Version 2.3 Model using available 2010 data. The validation process has resulted in changes to the existing model, including modifications to increase the share of non-work, non-motorized travel and the use of time penalties imposed on Potomac River bridges. The highway network coding conventions have also been updated such that interstate-type facilities in the District of Columbia are now coded as expressways, in order to more closely represent actual operating conditions. This memorandum has also presented national and local traffic monitoring data that indicates that regional driving on a per capita basis has been decreasing in recent years. The reason for this decrease is not clear, but ongoing monitoring of VMT must continue to determine whether or not the drop in per capita driving is temporary or the beginning of a longer-term trend.