National Capital Region Transportation Planning Board

Metropolitan Washington Council of Governments

FY-2006 Development Program for

TPB Travel Forecasting Models

June 30, 2006

The preparation of this report was financially aided through grants from the District of Columbia Department of Transportation, the Maryland Department of Transportation, the Virginia Department of Transportation, and the U.S. Department of Transportation (Federal Highway Administration and Federal Transit Administration) under the Urban Mass Transit Act of 1964, as amended. The material herein does not necessarily reflect the views of the sponsoring agencies.

Title	**Date**	June 30, 2006
FY-2006 Development Program for TPB Travel Forecasting Models	**Number of pages**	78
	Publication number	XXXXXXXX
	Price	$20.00

Agency

The Metropolitan Washington Council of Governments (COG) and the National Capital Region Transportation Planning Board (TPB).

COG serves as the regional planning organization for the Washington metropolitan area. COG works toward solutions to regional problems, especially those related to regional growth, transportation, housing, human services, and the environment. The TPB is the designated Metropolitan Planning Organization (MPO) for transportation for the Washington region. Members of the TPB include representatives of local governments; state transportation agencies; the Maryland and Virginia General Assemblies; the Washington Metropolitan Area Transit Authority; and non-voting members from the Metropolitan Washington Airports Authority and federal agencies.

Credits

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Abstract: This report describes work activities undertaken during FY-2006 supporting improved travel forecasting methods for the metropolitan Washington, D.C. region. This work represents a continuation of an ongoing models development plan that was formulated in FY-93 by the Travel Forecasting Subcommittee (TFS), a subcommittee of the TPB's Technical Committee.

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Chapter 1 Introduction

Transportation planning activities in the Washington region rely on technical methods used to forecast travel demand. The National Capital Region Transportation Planning Board (TPB) employs a travel modeling capability that supports a number of regional planning studies as well as local project planning studies conducted by state and local transportation agencies. The TPB recognizes that its travel modeling capability must be refined on a continuing basis if it is to remain viable. Ongoing improvements are necessary because the travel modeling practice is subject to regulatory and legislative requirements which evolve over time. The travel models require periodic modifications to address new questions being asked by decision makers. The research community continually provides practitioners with new travel forecasting techniques to consider. Element III.C (Models Development) in the COG/TPB Unified Planning Work Program is dedicated to the continued maintenance and improvement of the regional travel model. This report describes the activities undertaken in the area of Models Development during FY-2006 (July 1, 2005 to June 30, 2006).

The TPB's currently adopted travel forecasting process is known as the Version 2.1D #50 model. The model adheres to the conventional 'four-step' approach and is applied iteratively, using a restrained speed feedback linkage. The model is applied on microcomputer workstations using the TP+ software platform. It is currently designed to operate on a 2,191 transportation analysis zone (TAZ) system. The four-step modeling approach is quite common among the large metropolitan areas in the U.S.

Implementing travel modeling improvements presents some practical concerns. While readily available procedures are needed to serve regularly scheduled work activities during the year, there are inherent uncertainties about when proposed modeling improvements will be ready for production use. The Models Development program is designed to manage uncertainty by including both short-range and long-range model improvement activities. The program is structured along five concurrent 'tracks' as listed below:

- **Track 1 – Application:** Short-term improvements made to the currently adopted travel model while more advanced models remain in development. These improvements consist of, for example, updates to coefficients with newly collected data or building additional capabilities into the existing model structure.

- **Track 2 – Methods Development:** Longer-term improvements involving the incorporation of advanced forecasting methods that are not yet operational. Methods improvements may be associated with a structurally advanced four-step model or a 'next generation' model. The plan is that, at some point, one of the candidate 'methods' models would replace the application model.

- **Track 3 – Research:** Keeping abreast of advanced travel forecasting theory that has not yet made its way into accepted transportation planning practice.

- **Track 4 - Data Collection:** Collecting travel information to serve the needs of the above tracks.

- **Track 5 - Maintenance:** Promoting guidance on the model application through information sharing, documentation and training.

The Models Development program has proceeded along these five tracks since its inception in FY-1993. The multi-track approach allows for longer-term improvements to proceed off-line while the application model is maintained, with minor refinements, to support immediate planning needs in the mean time. The longer-term improvements are brought into application only when deemed appropriate by TPB staff and the designated oversight committee, the TPB Travel Forecasting Subcommittee (TFS). The TFS is a subcommittee to the TPB Technical Committee and is comprised of representatives from state and local transportation agencies in the Washington, D.C. region and the Washington Metropolitan Area Transit Authority (WMATA). The TFS also encourages the participation of consultants working in the region and various public interest groups. The TFS meets on a bi-monthly schedule.

Work activities associated with each track are mapped out over several fiscal years so that the necessary data is in place to serve short- and long-term improvement needs. Specific activities associated with each track are formulated by TPB staff based on recommendations of formal model reviews, emerging study needs, changes in federal guidance, and funding levels.

1.1 *FY-2006 Work Program Background*

The Version 2.1D #50 travel model was released in early FY-2005 (November 2004). It featured the incorporation of many refinements that were recommended by an expert review panel that audited the TPB's previous travel model release (Version 2.1/TP+, Release C). The refinements included improved highway link volume performance, an improved treatment of forecasted bus speeds, a reduction in the use of modeling adjustment factors, incorporating the mode choice model within the speed feedback loop, and improved consistency between the travel demand model and the mobile emissions post processor. The expert panel also recommended that the TPB develop an explicit commercial vehicle modeling capability. This particular travel market is substantial in the Washington region, but is not explicitly addressed in the existing travel model. The TPB was not in a position to implement that particular recommendation during FY-2005 given the absence of observed data to support such an effort. However, shortly thereafter, a commercial vehicle modeling technique was identified and a data collection effort was undertaken during late FY-2005 and early FY-2006. Considerable progress has been made in this area during FY-2006.

The TPB's transit modeling practice is another area that has been identified for refinement. At the present time, the TPB applies a sequential multinomial logit (SMNL) mode choice model which does not distinguish submodes of transit trips. The existing TPB travel model does not include the execution of transit assignments as a standard component of the regional modeling process (although the capability to do so exists with some additional effort). Given the wide variety of existing transit options in the Washington, D.C. area, and the desire to evaluate a variety of future transit options in greater detail, TPB has begun setting the stage for replacing the SMNL model with a nested logit (NL) model, which will enable transit submodes to be addressed explicitly. During FY-2005, TPB staff met periodically with consultants working in the Washington area using a newly formulated NL model to monitor its development and to assess its performance. This tool was transmitted to TPB during FY-2005 and some testing of the software was undertaken during FY-2006. The testing focused on executing the model as a 'post processor' to the regional travel model. The conclusion reached after testing in FY-2006 was that the NL process is sound and its performance shows promise. Staff work on incorporating the NL model into the Version 2.1D model framework is currently ongoing.

Transit model development in metropolitan areas across the country has been influenced by ongoing research that is currently being directed by the Federal Transit Administration (FTA). FTA is currently evaluating the state of the practice of transit forecasting in formulating guidance for the assessment of "New Starts." A considerable body of mode choice modeling research has resulted in recent years, and insights have been gained about improving the quality and validity of transit forecasts. TPB staff has, and continues, to monitor the FTA effort to inform the TPB's transit model work.

A number of modeling maintenance and refinement activities where undertaken during FY-2006 including a re-estimation of the demographic models, the development of a revised set of external and through trip forecasts, and the development of airport auto driver trip forecasts. These particular updates are particularly important to the models performance since they are (or affect) inputs to the four-step process. The traffic assignment procedure in the Version 2.1D model was also revisited during FY-2006 to address a problem noted in recent air quality work. There were a number of freeway links detected with excessive assignment loads, particularly in the 'out' simulation years (e.g., 2030). The selected treatment of this condition involved the several refinements to the traffic assignment procedure as well as the refinement of some inputs to the assignment process.

The Models Development program has benefited in recent years by allocating staff resources to investigate modeling practices of other agencies across the country. In order to more readily and efficiently obtain information on new and innovative techniques being applied by other planning organizations, TPB has decided in FY-2006 to retain a consultant to serve in this type of fact-finding capacity. Additionally, TPB staff has continued to meet with other travel modelers on a regular basis through a technical forum established by the Association of Metropolitan Planning Organizations (AMPO). The forum has proven valuable in recent years for facilitating peer-to-peer information exchange on specific modeling techniques and practice.

In the course of recent High Occupancy Toll (HOT) lane studies, TPB has recognized the importance of more effectively communicating alternative transportation futures to decision-makers. Towards this end, staff was training in the use of newly acquired traffic microsimulation software during FY-2006. The microsimulation essentially displays vehicles moving in real time at the subarea level and intersection level of analysis. This fine level of resolution has historically been viewed as too detailed for the regional modeling concerns, but there are several potential advantages of using this newly available technology. The major benefit of microsimulation is that it enables forecasts to be visually displayed in a realistic way, as vehicles moving along the transport system. Microsimulation has the potential to inform the regional model as regional patterns can be subject to the performance of major facility intersections.

TPB staff members attended a Transportation Research Board-sponsored conference in May (Innovations in Travel Demand Modeling) which provided an overview of the most advanced travel forecasting techniques that are becoming available to practitioners. These include tour-based or activity-based models which develop travel simulations on the basis of individual travelers as opposed to the conventional modeling approach which develops travel patterns as aggregate travel flows between zones. The advanced methods have not yet been embraced by the practice on a large scale, but many MPOs are planning data collection efforts that will support the development of activity models at a future point in time. During FY-2007, TPB is planning to conduct a travel survey which will support the development of both conventional four-step models in the short-term and activity models in the longer term. The last such regional travel survey was conducted in 1994.

1.2 *Structure of the Report*

The following chapters detail the key model development activities that were undertaken during FY-2006. The activities that will most immediately refine the regional travel model are described in Chapter 2 (Improvements to Application Model), Chapter 3 (Commercial Vehicle Model Implementation Status), and Chapter 6 (Airport Modeling Improvements and Status). The current status of the Nested Logit model work is described in Chapter 4. A review of microsimulation (and related) software that was examined during FY-2006 is provided in Chapter 5. The AMPO travel modeling group activities are presented in Chapter 7. The information on advanced modeling methods gained from the TRB conference on Innovations in Travel Demand Modeling are discussed in Chapter 8. The current arrangement for retaining consultant assistance to provide TPB with ongoing ‘scans’ of travel modeling practices in other metropolitan areas is discussed in Chapter 9. Finally, the future outlook of the TPB Models Development program is presented in Chapter 10.

Chapter 2 Improvements to Application Model

Several FY-2006 work activities were undertaken to improve the currently adopted travel forecasting process model, Version 2.1D #50. External and through trip files corresponding to base and future years were updated, the demographic models were re-estimated using the 2000 Census Transportation Planning Package (CTPP), and the traffic assignment process was adjusted to improve the model's estimation of freeway traffic. (Additionally, the treatment of modeled airport auto travel was also updated during FY-2006. This particular work item is presented in Chapter 6.) These improvements are described in greater detail in this chapter. It is anticipated that the improvements will be folded into the next model version, planned for release by the end of the 2006 calendar year.

2.1 *External and Through Travel Updates*

External and through travel in the TPB travel model is referenced among specific points of entry to the modeled region known as external stations. The 2191-TAZ system supporting the current TPB model includes 47 such external stations, numbered 2145 to 2191. External travel refers to those trips having one end outside of the modeled study area. External trips are generally distinguished by directionality: external-to-internal (X-I) and internal-to-external (I-X) trips. The TPB travel model requires that external productions (X-I trip-ends) and external attractions (I-X trip-ends) be provided as an input to the trip generation model. The automobile and light-duty vehicle trip-ends are specified by four purposes[1] and the truck trip-ends by two types[2]. Through travel refers to trips that traverse some portion of the modeled region without stopping. In other words, both trip-ends are located outside of the study area. The TPB model distinguishes through trips among two subgroups: automobile drivers and trucks.

External and through trips are prepared as exogenous inputs to the travel model by year. External trip-ends are developed as two text files corresponding to E-I travel (PEXT.ASC) and I-E travel (AEXT.ASC). Through trips are developed as two TP+ binary matrices corresponding to automobile drivers (XXAUT.VTT) and trucks (XXTRK.VTT) (COG/TPB 2004a, page 1-15).

The process of formulating external and through trip files has historically involved the development of base year files which would, in turn, be used as a basis for extrapolating to specific forecast years. The base year external and through trip formulation is based on observed travel patterns summarized from recent external travel surveys[3], and ultimately controlled to the observed traffic counts at the station level. The extrapolation has historically been based on a 3% annual growth rate at each external station (COG/TPB 2003, page 2).

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[1] There are four purposes in the currently adopted model: HBW, HBS, HBO, and NHB. The next model release will add a fifth purpose, Commercial Vehicle. This particular travel market is subsumed in the NHB purpose in the current model.
[2] Medium trucks are 2-axle vehicles with 6 or more tires, Heavy trucks refer to combination vehicles. Light duty trucks are subsumed in the modeled auto travel.
[3] The most recent automobile and truck external surveys were conducted in 1994 and 1996, respectively. A 2003 truck external survey has been conducted and is currently being processed.

The refinements to external and through trips undertaken during FY-2006 were made to address the following considerations:

1) The ground count definition has been updated: The base year (2000) average annual weekday traffic (AAWDT) figures currently coded to highway network links for the purposes of model validation work have been refined. The refinement affected traffic counts at external stations, and so, the base year control total of external and through travel was updated.

2) The traffic growth assumption at external stations has been refined: The assumption of 3% uniform annual traffic growth each external station has been changed. The growth now varies by station groups based on a more detailed review of historic traffic count trends, a review of projected land use growth, and an analysis of highway capacity constraints at individual stations.

The above refinements are discussed further below.

2.1.1 Refinement of Year 2000 Ground Counts at External Stations

Historically, AAWDT traffic counts coded on highway links have been developed by factoring AADT figures provided by the Virgina and Maryland DOTs by 1.10 (DC DOT has provided explicit AAWDT traffic counts).   An effort was made during FY-2005 to investigate the impact of improved traffic count quality on travel model performance statistics (COG/TPB 2005a, Chapter 2).   It was concluded that the traffic count quality does affect model performance. It was also concluded that traffic count quality should be taken into account and the location of specific counts should not be allocated to multiple links. As a result of these conclusions, traffic counts in the year 2000 network were comprehensively refined, including counts at external stations along the region's periphery. The refinements reflect the use of newly available AADWT counts in Virgina, as opposed to the use of 'adjusted' AADT counts. The refinements also reflect the use of a reduced AADT-to-AAWDT conversion factor (from 1.10 to 1.05) that is applied to Maryland counts. The reduced factor is presumed more appropriate based on a recent investigation of seasonal traffic counts in Maryland (See COG/TPB 2005c).   It should be noted that the TPB is currently planning to obtain AAWDT from Maryland in the future, as it currently obtains from Virginia.

Table 2-1 lists the year 2000 traffic counts before and after the refinement. In general, the refinements resulted in a 4% decline in average weekday traffic at external stations. The refined counts shown on the table served as the control for base year external and through traffic.   The total amounts to 1,215,800 weekday trips.

Table 2-1 Previous and Revised Year 2000 Counts at External Stations

		Previous Counts		Updated Counts	
Extl. Station	Facility Name	AADT 2000	AAWDT 2000	AADT 2000	AAWDT 2000
2145	VA 3 (East)	3,900	4,290	3,958	3,877
2146	US 301 (South)	9,900	10,890	9,979	9,459
2147	US 17	4,200	4,620	4,269	3,769
2148	VA 2	5,100	5,610	5,184	5,134
2149	I-95 (South)	72,000	79,200	72,000	63,000
2150	US 1(South)	7,500	8,250	10,168	10,174
2151	VA 208/606	4,400	4,840	3,658	3,638
2152	VA 612	1,679	1,846	3,175	3,156
2153	VA 3(West)	17,000	18,700	16,865	16,766
2154	US 15/29 (South)	20,000	22,000	20,409	19,758
2155	US 211	14,000	15,400	13,748	13,484
2156	I-66	24,000	26,400	26,126	23,013
2157	VA 55	1,100	1,210	1,108	1,086
2158	US 340	6,100	6,710	6,204	6,300
2159	US 17/50	14,000	15,400	14,264	14,470
2160	VA 7	20,000	22,000	20,466	21,499
2161	WV 51	6,617	7,278	6,500	6,825
2162	WV 9	16,049	17,654	16,049	16,851
2163	WV 45	8,599	9,459	8,599	9,029
2164	MD 34/WVA 480	5,926	6,518	5,926	6,222
2165	Alt US 40	7,600	8,360	9,550	10,028
2166	I-70 (West)	54,540	59,994	74,175	77,884
2167	US 40	3,800	4,180	4,050	4,253
2168	MD 77	2,450	2,695	2,500	2,625
2169	MD 550	2,150	2,365	2,150	2,258
2170	MD 140/PA16	9,650	10,615	9,650	10,133
2171	US 15 (North)	15,175	16,693	15,175	15,934
2172	MD 194 /PA194	4,325	4,758	4,325	4,541
2173	MD 97/PA 97	7,975	8,773	7,975	8,374
2174	MD 30 (North)/ PA 94	12,150	13,365	12,150	12,758
2175	MD 86 / PA 516	1,999	2,199	1,999	2,099
2176	MD 88	3,950	4,345	4,850	5,093
2177	MD 30 (East)	19,475	21,423	21,800	22,890
2178	MD 140/91	47,375	52,113	39,725	41,711
2179	MD 26	18,250	20,075	18,250	19,163
2180	I-70 (East)	85,375	93,913	68,975	72,424
2181	US 40 (East) / MD 144	38,850	42,735	38,850	40,793
2182	I-95 (North)	192,575	211,833	186,999	196,349
2183	I-195 /US 1 (North)	23,150	25,465	23,150	24,308
2184	Md 295 / B/W Pkwy	67,025	73,728	67,025	70,376
2185	MD 170	17,300	19,030	11,650	12,233
2186	MD 648	12,975	14,273	15,075	15,829
2187	MD 3 / I-97	99,675	109,643	99,675	104,659
2188	MD 2	56,725	62,398	43,525	45,701
2189	MD 10	47,675	52,443	47,675	50,059
2190	MD 710	38,150	41,965	16,500	17,325
2191	US 50 (East) / 301	74,075	81,483	65,212	68,473
Total:		1,152,408	1,267,648	1,181,290	1,215,781

2.1.2 Refinement of Growth Assumptions at External Stations

The assumption that traffic at external stations will grow at 3% annually is problematic on several accounts. First, the assumption that growth will occur uniformly at each external station is questionable given that the level of development at the periphery of the region varies substantially. External stations in Virginia will most likely experience higher-than-average growth because they serve largely undeveloped areas that are only beginning to experience development pressure. In contrast, the external facilities near the City of Baltimore serve areas that are well developed and so one would expect more moderate external traffic growth. Second, the 3% growth assumption translates into a more than doubling of traffic levels over 30 years. This growth rate is not realistic for facilities located in developed areas, many of which are near capacity today. Furthermore, the assumption of a constant growth rate over time is also problematic when one considers that land use forecasts indicate that growth in households and jobs will accelerate in the early years, and decelerate thereafter.

External traffic growth is usually formulated on the basis of historical traffic trends and/or on the basis of land use forecasts, both of which have inherent limitations. Traffic trends are subject to the volatility of the regional economy occurring during the count period. Extrapolating from traffic counts that are subject to short-term economic upturns or downturns is not entirely appropriate for a 30-year projection. Land use projections are made on a jurisdictional basis with limited knowledge about development occurring outside of the modeled area (although implicit assumptions regarding external in-commuting may be inferred from land use forecasts).

Given these considerations, the development of traffic growth was developed in three steps. First, initial annualized growth rates were developed for external station *groups* on the basis of both forecasted land use growth and historical traffic count growth. The initial growth rates were used to arrive at 2030 traffic projections. Second, the 2030 traffic figures were compared to a rough estimate of daily capacity at each station. The comparison lead to a modification of growth rates at a small number of locations where the projected traffic was significantly higher than the capacity. Finally, the apportioning of thirty year growth to individual years was not based on a constant, annualized growth rate, but instead, was based on the yearly employment growth pattern implied by the Round 7.0 employment forecasts.

A summary of annualized growth based on historical traffic trends and projected land use at the county level is shown on Table 2-2. The historical traffic growth reflects the annual growth rate in traffic counts at external locations over a 10-year period, from 1993 to 2003. As expected, the traffic counts on facilities in the Baltimore area are shown to have a moderate annual traffic growth rate, from 1.53% to about 2.64%. In contrast, the remaining external facilities (with the exception of facilities in King George County) have experienced a higher rate of traffic growth, from 3.13% to 6.34% per year. The future annual growth rates implied by the Round 7.0 Cooperative Land Use forecasts are more moderate in magnitude in comparison to the count-based rates, ranging from 0.79% to 2.89% per year in household growth and from 0.60% to 3.83% per year in employment growth. Again, the land use growth associated with Baltimore area counties is shown to be lower in magnitude in comparison to the planned growth in the remaining outer counties. The annualized job growth and household growth for the modeled region are both about 1.30% per year.

Table 2-2 Annualized Growth at County Level Based on Traffic Trends and Land Use Forecasts

Outer - Jurisdiction	TAZ Range	Historical AADT Counts (1993-2003)	Rnd 7.0 HH Forecasts (2000 - 2030)	Rnd 7.0 Job Forecasts (2000 - 2030)	Assumed Annualized Growth Assumption
Anne Arundel	2191 - 2184	2.28%	0.79%	0.93%	1.50%
Howard	2183 - 2180	2.64%	1.15%	1.63%	1.50%
Carroll	2179 - 2172	1.53%	1.05%	0.60%	1.50%
Frederick	2171 - 2165	6.34%	1.89%	1.86%	2.00%
Jefferson	2164 - 2161	3.27%	2.41%	2.20%	2.50%
Clarke	2160 - 2158	3.13%	1.56%	1.26%	2.50%
Fauquier	2157 - 2154	4.66%	2.89%	2.43%	2.50%
N. Spotsylvania	2153 - 2149	3.78%	2.56%	2.54%	2.50%
Fredericksburg			1.82%	3.51%	2.50%
King George	2148 - 2145	-1.13%	2.11%	3.83%	2.50%
Total / Regional		**2.88%**	**1.32%**	**1.36%**	

Reference: Ext_Counts_93_03.xls

The shaded area on Table 2-2 shows the 'initial' annual growth rates used to formulate future external and through trips over the next 30 years. It was expected that further station-specific adjustments would be in order to account for potential capacity limitations. The primary considerations behind these selected annual growth rates are as follows:

- The rate of growth shown in historical traffic counts can not be sustained over the next 30 years. Traffic growth rates will moderate due, in part, to demographic trends (i.e., the declining average household size and the increasing elderly population segment), and due to capacity constraints at external stations.
- The 'baseline' external traffic growth should be about 1.5% per year given that both households and jobs are expected to grow at about that rate over the next 30 years.
- The growth in external auto traffic around the Baltimore area will continue to be less than that of the remaining external stations.

The growth assumptions on Table 2-2 were used to estimate 2030 traffic volumes which were then compared to an estimate of daily capacity at each individual station. The daily capacities where based on the hourly LOS E lookup capacity and peaking factors ranging from 6% on freeways to 10% on collectors. The comparison yielded inordinately high volume-to-capacity ratios at some locations such as VA Route 3 (Spotsylvania County) and I-95 north (near Baltimore). Annualized growth factors were therefore reduced at these locations and growth on parallel facilities with ample spare capacity were increased to make up for the 'spillover' volume. The final growth factors used at each external station are shown on Table 2-3. The table indicates that average annual growth rate for all external stations is 1.8%. The annualized growth rates vary by external station, ranging from 1.1% to 2.7%

Table 2-3 2000 / 2030 Traffic Volumes, V/C Ratios, and Final Growth Rates by External Station

Ext. Station No.	County	Facility Name	(a) 2000 AAWDT	(b) 2030 Est. AAWDT	(c) *Estimated Max. Capacity*	2030 V/C Ratio	Assumed Annual Growth Rate
2145	King George	VA 3 (East)	3877	8,132	*20,000*	0.41	2.5%
2146	King George	US 301 (South)	9459	19,841	*63,000*	0.31	2.5%
2147	King George	US 17	3769	7,906	*40,000*	0.20	2.5%
2148	King George	VA 2	5134	10,769	*40,000*	0.27	2.5%
2149	Spotsylvania	I-95 (South)	63000	140,105	*210,000*	0.67	2.7%
2150	Spotsylvania	US 1(South)	10174	22,626	*31,500*	0.72	2.7%
2151	Spotsylvania	VA 208/606	3638	8,091	*20,000*	0.40	2.7%
2152	Spotsylvania	VA 612	3156	7,019	*16,000*	0.44	2.7%
2153	Spotsylvania	VA 3(West)	16766	23,279	*16,000*	1.45	1.1%
2154	Fauquier	US 15/29 (South)	19758	41,444	*63,000*	0.66	2.5%
2155	Fauquier	US 211	13484	28,284	*63,000*	0.45	2.5%
2156	Fauquier	I-66	23013	48,271	*210,000*	0.23	2.5%
2157	Fauquier	VA 55	1086	2,278	*16,000*	0.14	2.5%
2158	Clarke	US 340	6300	13,215	*20,000*	0.66	2.5%
2159	Clarke	US 17/50	14470	30,352	*63,000*	0.48	2.5%
2160	Clarke	VA 7	21499	45,096	*63,000*	0.72	2.5%
2161	Jefferson	WV 51	6825	14,316	*20,000*	0.72	2.5%
2162	Jefferson	WV 9	16851	35,346	*63,000*	0.56	2.5%
2163	Jefferson	WV 45	9029	18,939	*31,500*	0.60	2.5%
2164	Jefferson	MD 34/WVA 480	6222	13,051	*20,000*	0.65	2.5%
2165	Frederick	Alt US 40	10028	18,164	*31,500*	0.58	2.0%
2166	Frederick	I-70 (West)	77884	141,076	*140,000*	1.01	2.0%
2167	Frederick	US 40	4253	7,704	*20,000*	0.39	2.0%
2168	Frederick	MD 77	2625	4,755	*20,000*	0.24	2.0%
2169	Frederick	MD 550	2258	4,090	*20,000*	0.20	2.0%
2170	Frederick	MD 140/PA16	10133	18,355	*31,500*	0.58	2.0%
2171	Frederick	US 15 (North)	15934	28,862	*75,000*	0.38	2.0%
2172	Carroll	MD 194 /PA194	4541	7,098	*31,500*	0.23	1.5%
2173	Carroll	MD 97/PA 97	8374	13,089	*31,500*	0.42	1.5%
2174	Carroll	MD 30 (North)/ PA 94	12758	19,942	*31,500*	0.63	1.5%
2175	Carroll	MD 86 / PA 516	2099	3,281	*20,000*	0.16	1.5%
2176	Carroll	MD 88	5093	7,961	*31,500*	0.25	1.5%
2177	Carroll	MD 30 (East)	22890	35,779	*31,500*	1.14	1.5%
2178	Carroll	MD 140/91	41711	65,198	*63,000*	1.03	1.5%
2179	Carroll	MD 26	19163	29,953	*31,500*	0.95	1.5%
2180	Howard	I-70 (East)	72424	113,205	*210,000*	0.54	1.5%
2181	Howard	US 40 (East) / MD 144	40793	63,763	*60,000*	1.06	1.5%
2182	Howard	I-95 (North)	196349	272,624	*280,000*	0.97	1.1%
2183	Howard	I-195 /US 1 (North)	24308	37,995	*63,000*	0.60	1.5%
2184	Anne Arundel	Md 295 / B/W Pkwy	70376	156,508	*210,000*	0.75	2.7%
2185	Anne Arundel	MD 170	12233	19,121	*31,500*	0.61	1.5%
2186	Anne Arundel	MD 648	15829	24,742	*31,500*	0.79	1.5%
2187	Anne Arundel	MD 3 / I-97	104659	163,590	*180,000*	0.91	1.5%
2188	Anne Arundel	MD 2	45701	63,454	*63,000*	1.01	1.1%
2189	Anne Arundel	MD 10	50059	78,246	*140,000*	0.56	1.5%
2190	Anne Arundel	MD 710	17325	27,080	*31,500*	0.86	1.5%
2191	Anne Arundel	US 50 (East) / 301	68473	107,029	*210,000*	0.51	1.5%
			1,215,783	2,071,024	*3,209,500*	0.65	1.8%

Reference: Ext_Capacity.xls

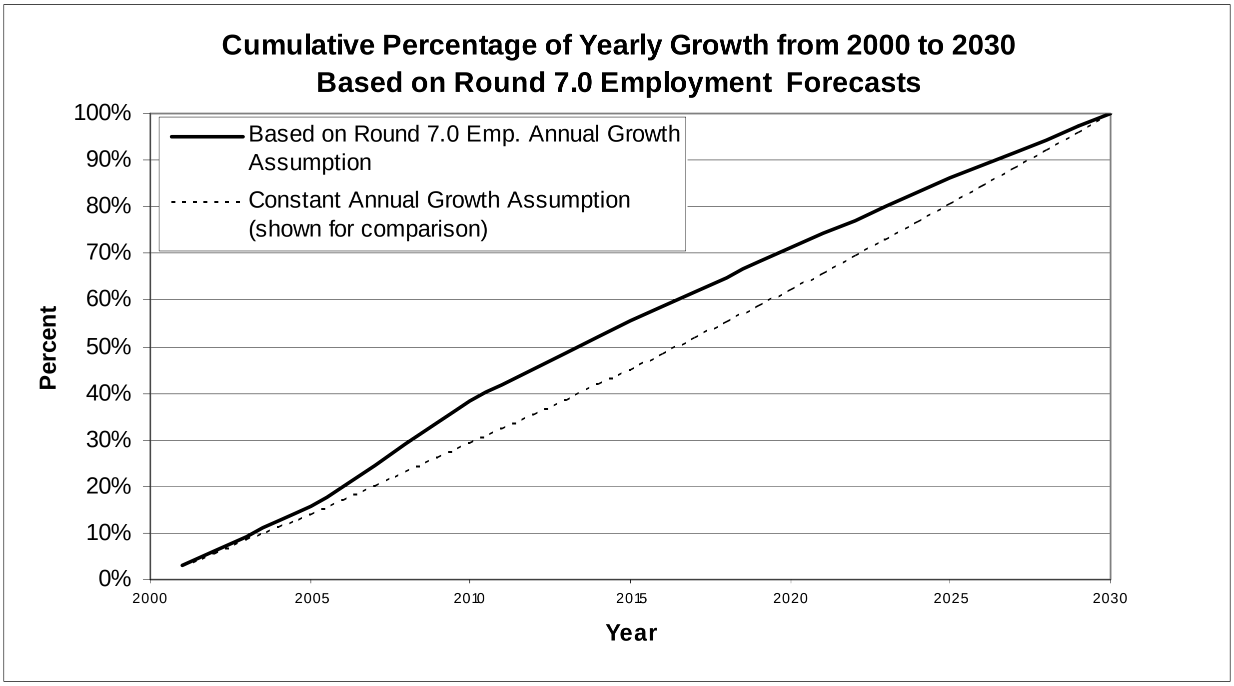
After the long term traffic growth at each external station was established, attention was given to how the growth will occur on a yearly basis. It was assumed that regional job forecasts would serve as a reasonable indicator of traffic growth at external stations. A review of the Round 7.0 employment forecasts over time indicated that the previous assumption of a constant growth rate over time was decidedly inappropriate. Table 2-4 indicates Round 7.0 employment growth on a year-to-year basis. (Since the Cooperative Forecasts figures are provided in 5-year increments, an average yearly growth rate was computed within each increment). Table 2-4 indicates that job growth will accelerate during the beginning of the 30-year period, particularly between 2005 and 2010 where the growth will occur at 2% per year. Thereafter, job growth is shown to decelerate steadily from 1.41% to less than 0.95% per year. The table also includes a cumulative yearly distribution of added jobs. This distribution was used to apportion the 30-year external traffic growth traffic to individual years. A graphic depiction of the cumulative growth distribution is shown on Figure 2-1.

Table 2-4 Annual Regional Employment Growth Pattern Implied by the Round 7.0 Cooperative Forecasts

Year	Round 7.0 Employment	5-Year Emp. Chg.	5-Year Emp. %Chg.	Avg. Annual. Growth Pct. Based on 5-Yr. Emp. Chg.	Annual Emp. Based on Avg. Growth Rate	Annual Change in Employment	Cumulative Jobs Added Over Time	Cumulative % of Jobs Added Over Time	Annual % Change in Employment
2000	3,438,100				3,438,100	0	0	0	0
2001				1.53%	3,490,555	52,455	52,455	3.05%	3.05%
2002				1.53%	3,543,810	53,255	105,710	6.15%	3.10%
2003				1.53%	3,597,877	54,068	159,777	9.30%	3.15%
2004				1.53%	3,652,770	54,893	214,670	12.50%	3.20%
2005	3,708,500	270,400	7.86%	1.53%	3,708,500	55,730	270,400	15.74%	3.24%
2006				2.00%	3,782,815	74,315	344,715	20.07%	4.33%
2007				2.00%	3,858,619	75,804	420,519	24.48%	4.41%
2008				2.00%	3,935,943	77,323	497,843	28.98%	4.50%
2009				2.00%	4,014,816	78,873	576,716	33.57%	4.59%
2010	4,095,269	386,769	10.43%	2.00%	4,095,269	80,453	657,169	38.26%	4.68%
2011				1.41%	4,152,947	57,678	714,847	41.61%	3.36%
2012				1.41%	4,211,438	58,491	773,338	45.02%	3.41%
2013				1.41%	4,270,753	59,315	832,653	48.47%	3.45%
2014				1.41%	4,330,903	60,150	892,803	51.97%	3.50%
2015	4,391,900	296,631	7.24%	1.41%	4,391,900	60,997	953,800	55.53%	3.55%
2016				1.20%	4,444,772	52,872	1,006,672	58.60%	3.08%
2017				1.20%	4,498,280	53,508	1,060,180	61.72%	3.11%
2018				1.20%	4,552,432	54,152	1,114,332	64.87%	3.15%
2019				1.20%	4,607,236	54,804	1,169,136	68.06%	3.19%
2020	4,662,700	270,800		1.20%	4,662,700	55,464	1,224,600	71.29%	3.23%
2021				1.07%	4,712,562	49,862	1,274,462	74.19%	2.90%
2022				1.07%	4,762,957	50,395	1,324,857	77.13%	2.93%
2023				1.07%	4,813,892	50,934	1,375,792	80.09%	2.97%
2024				1.07%	4,865,371	51,479	1,427,271	83.09%	3.00%
2025	4,917,400	254,700	5.46%	1.07%	4,917,400	52,029	1,479,300	86.12%	3.03%
2026				0.95%	4,964,196	46,796	1,526,096	88.84%	2.72%
2027				0.95%	5,011,438	47,242	1,573,338	91.59%	2.75%
2028				0.95%	5,059,129	47,691	1,621,029	94.37%	2.78%
2029				0.95%	5,107,275	48,145	1,669,175	97.17%	2.80%
2030	5,155,878	238,478	4.85%	0.95%	5,155,878	48,603	1,717,778	100.00%	2.83%

Note: CTPP Adjustments used
Reference: Ext_Growth_Assumption.xls

Figure 2-1 Cumulative Percentage of Yearly Job Growth Over Time (Rnd 7.0 Coop. Forecasts)



A TP+ script (Ext_Thru.s) was prepared to produce a series of yearly external and through files through time (2000 to 2030) respecting the above established growth assumptions. The script uses a lookup table (template.asc) detailing revised year 2000 control counts, auto and truck through/external proportions, auto trip purpose proportions at each external station, and car occupancies for each modeled purpose. The proportions were developed using information from the 1994 Auto External Survey and the 1996 Truck External Survey. The proportions are assumed to remain constant through time. Table 2-5 shows the resulting regional number of auto and truck through/external trips by year. Table 2-6 and Table 2-7 show more detailed regional external trip totals by year for X-I and I-X trips respectively. The filenames are shown on Figure 2-2.

2.1.3 Conclusions

A revised set of external and through trips has been created for the years 2000 through 2030 using updated base year ground counts at external stations and modified growth assumptions. The growth rate has been moderated in comparison with the TPB's prior assumptions. The net effect of the revision will be a reduced amount of simulated VMT in both the base year and in the future. The amount of future traffic growth at external stations is largely a matter of judgment. Traffic count trends and land use projections near external stations have been used to inform the external traffic growth assumptions as part of this work effort. The relative proportions of through / external auto and truck traffic, as well as the proportion of auto trips by purpose, are assumed to remain fixed over time, based on observed survey data.

Table 2-5 Auto Driver and Truck External Station Summary by Year:

Yr	AAWDT	Auto Drv Control	Truck Control	Auto XX Trip-Ends	Auto XI Adr Trips	Auto IX Adr Trips	TruckXX Trip-Ends	Truck XI Trips	Truck IX Trips
2000	1215783	1003776	114016	75345	486084	442347	59702	27157	27157
2001	1241868	1025617	116596	77040	496841	451736	61065	27765	27765
2002	1268380	1047815	119218	78763	507774	461279	62450	28384	28384
2003	1295320	1070372	121883	80513	518883	470976	63857	29013	29013
2004	1322688	1093287	124590	82291	530169	480827	65287	29651	29651
2005	1350398	1116488	127330	84092	541596	490801	66735	30298	30298
2006	1387429	1147495	130993	86498	556867	504130	68670	31162	31162
2007	1425145	1179074	134723	88948	572420	517706	70640	32042	32042
2008	1463631	1211298	138530	91449	588291	531558	72651	32940	32940
2009	1502887	1244166	142413	94000	604479	545688	74702	33856	33856
2010	1542997	1277751	146380	96606	621019	560125	76797	34791	34791
2011	1571648	1301740	149214	98468	632834	570438	78294	35460	35460
2012	1600811	1326158	152098	100362	644861	580935	79818	36140	36140
2013	1630317	1350863	155017	102280	657028	591556	81359	36829	36829
2014	1660251	1375926	157977	104225	669372	602330	82923	37527	37527
2015	1690697	1401419	160989	106203	681927	613289	84514	38238	38238
2016	1716953	1423403	163586	107909	692755	622739	85885	38850	38850
2017	1743636	1445745	166225	109643	703758	632344	87279	39473	39473
2018	1770576	1468302	168890	111393	714868	642041	88687	40101	40101
2019	1797858	1491145	171588	113166	726118	651861	90112	40738	40738
2020	1825483	1514274	174320	114961	737510	661804	91555	41383	41383
2021	1850285	1535041	176774	116572	747738	670731	92851	41961	41961
2022	1875429	1556094	179260	118206	758106	679782	94165	42548	42548
2023	1900744	1577290	181764	119851	768546	688894	95487	43139	43139
2024	1926401	1598773	184302	121518	779126	698129	96828	43737	43737
2025	1952314	1620470	186865	123201	789812	707456	98182	44342	44342
2026	1975577	1639948	189166	124713	799405	715829	99397	44885	44885
2027	1999096	1659640	191492	126241	809104	724295	100626	45433	45433
2028	2022872	1679547	193844	127786	818909	732853	101868	45988	45988
2029	2046818	1699598	196212	129342	828784	741472	103119	46547	46547
2030	2071022	1719863	198606	130914	838765	750184	104383	47111	47111

Table 2-6 Auto Driver and Truck XI Trips by Purpose

Yr	HBWXI AutoDrvs	HBSXI Auto Drvs	HBOXI AutoDrvs	NHBXI AutoDrvs	ComvXI AutoDrv	HBWXI AutoPsns	HBSXI Auto Psns	HBOXI AutoPsns	NHBXI AutoPsns	ComvXI AutoPsns	MedTkXI	HeavyTkXI	AutoXI Drv Totl	TruckXI Total
2000	236559	42352	117778	89395	0	272043	69457	189623	114426	0	3637	23520	486084	27157
2001	241902	43183	120471	91284	0	278187	70821	193959	116844	0	3718	24047	496841	27765
2002	247332	44029	123208	93205	0	284432	72207	198365	119302	0	3802	24583	507774	28384
2003	252850	44888	125989	95156	0	290777	73616	202843	121800	0	3886	25127	518883	29013
2004	258455	45760	128815	97139	0	297223	75047	207392	124337	0	3972	25679	530169	29651
2005	264131	46644	131675	99146	0	303750	76496	211997	126907	0	4059	26239	541596	30298
2006	271716	47825	135498	101828	0	312473	78432	218152	130340	0	4175	26987	556867	31162
2007	279440	49027	139392	104560	0	321357	80405	224421	133837	0	4293	27748	572420	32042
2008	287323	50254	143365	107348	0	330422	82417	230818	137405	0	4414	28526	588291	32940
2009	295363	51506	147418	110191	0	339668	84470	237343	141045	0	4537	29318	604479	33856
2010	303579	52785	151559	113097	0	349116	86567	244010	144764	0	4663	30128	621019	34791
2011	309447	53699	154517	115172	0	355864	88066	248772	147420	0	4753	30707	632834	35460
2012	315420	54628	157527	117285	0	362733	89591	253619	150124	0	4844	31296	644861	36140
2013	321464	55569	160573	119422	0	369683	91134	258523	152860	0	4937	31892	657028	36829
2014	327595	56524	163664	121590	0	376734	92699	263498	155635	0	5031	32496	669372	37527
2015	333831	57495	166807	123796	0	383905	94291	268559	158458	0	5126	33111	681927	38238
2016	339208	58332	169517	125697	0	390089	95664	272923	160893	0	5209	33641	692755	38850
2017	344674	59183	172272	127630	0	396375	97059	277358	163367	0	5293	34180	703758	39473
2018	350191	60042	175053	129582	0	402720	98468	281836	165865	0	5377	34724	714868	40101
2019	355779	60911	177870	131558	0	409146	99895	286370	168394	0	5463	35275	726118	40738
2020	361437	61792	180722	133559	0	415653	101339	290962	170955	0	5549	35833	737510	41383
2021	366517	62583	183282	135355	0	421495	102636	295084	173255	0	5627	36334	747738	41961
2022	371667	63385	185878	137177	0	427417	103951	299263	175586	0	5706	36842	758106	42548
2023	376852	64192	188491	139010	0	433380	105275	303471	177933	0	5785	37353	768546	43139
2024	382107	65010	191140	140869	0	439423	106617	307735	180312	0	5866	37871	779126	43737
2025	387415	65836	193815	142746	0	445527	107972	312043	182715	0	5947	38395	789812	44342
2026	392179	66578	196217	144431	0	451006	109188	315909	184872	0	6020	38864	799405	44885
2027	396997	67328	198645	146135	0	456546	110418	319818	187052	0	6094	39339	809104	45433
2028	401866	68086	201099	147857	0	462146	111661	323770	189257	0	6169	39820	818909	45988
2029	406771	68850	203572	149591	0	467787	112914	327750	191477	0	6244	40303	828784	46547
2030	411728	69622	206070	151345	0	473488	114179	331773	193721	0	6320	40792	838765	47111

Table 2-7 Auto Driver and Truck IX Trips by Purpose

Yr	HBWIX AutoDrvs	HBSIX Auto Drvs	HBOIX AutoDrvs	NHBIX AutoDrvs	ComvIX AutoDrvs	HBWIX AutoPsns	HBSIX Auto Psns	HBOIX AutoPsns	NHBIX AutoPsns	ComvIX AutoPsns	MedTkIX	HeavyTkIX	AutoIX Drv Totl	TruckIX Total
2000	146581	41644	164738	89384	0	168568	68297	265229	114411	0	3637	23520	442347	27157
2001	149570	42509	168383	91273	0	172006	69715	271097	116830	0	3718	24047	451736	27765
2002	152609	43388	172088	93193	0	175501	71157	277062	119287	0	3802	24583	461279	28384
2003	155697	44281	175853	95144	0	179052	72621	283123	121785	0	3886	25127	470976	29013
2004	158834	45189	179677	97127	0	182659	74109	289281	124322	0	3972	25679	480827	29651
2005	162010	46107	183550	99133	0	186312	75616	295515	126891	0	4059	26239	490801	30298
2006	166255	47335	188725	101815	0	191193	77630	303846	130324	0	4175	26987	504130	31162
2007	170578	48586	193995	104547	0	196164	79681	312332	133820	0	4293	27748	517706	32042
2008	174989	49862	199373	107334	0	201237	81773	320991	137388	0	4414	28526	531558	32940
2009	179488	51163	204859	110178	0	206412	83908	329822	141027	0	4537	29318	545688	33856
2010	184086	52493	210464	113083	0	211699	86089	338847	144746	0	4663	30128	560125	34791
2011	187370	53443	214468	115158	0	215475	87647	345293	147402	0	4753	30707	570438	35460
2012	190713	54410	218543	117270	0	219319	89232	351854	150105	0	4844	31296	580935	36140
2013	194094	55388	222666	119407	0	223209	90837	358492	152841	0	4937	31892	591556	36829
2014	197525	56381	226849	121575	0	227154	92464	365227	155616	0	5031	32496	602330	37527
2015	201015	57390	231104	123780	0	231168	94120	372077	158438	0	5126	33111	613289	38238
2016	204025	58261	234773	125681	0	234628	95547	377984	160872	0	5209	33641	622739	38850
2017	207083	59145	238501	127614	0	238146	96998	383987	163346	0	5293	34180	632344	39473
2018	210171	60039	242266	129565	0	241697	98463	390048	165843	0	5377	34724	642041	40101
2019	213298	60943	246079	131541	0	245293	99947	396186	168373	0	5463	35275	651861	40738
2020	216464	61859	249939	133542	0	248934	101449	402402	170933	0	5549	35833	661804	41383
2021	219307	62681	253405	135338	0	252203	102797	407982	173233	0	5627	36334	670731	41961
2022	222189	63515	256918	137159	0	255517	104165	413639	175564	0	5706	36842	679782	42548
2023	225091	64354	260456	138993	0	258854	105541	419334	177911	0	5785	37353	688894	43139
2024	228032	65205	264041	140851	0	262236	106936	425107	180289	0	5866	37871	698129	43737
2025	231002	66064	267663	142728	0	265652	108345	430937	182691	0	5947	38395	707456	44342
2026	233668	66835	270913	144412	0	268718	109610	436170	184848	0	6020	38864	715829	44885
2027	236364	67615	274200	146116	0	271818	110889	441462	187028	0	6094	39339	724295	45433
2028	239089	68403	277522	147838	0	274952	112182	446811	189232	0	6169	39820	732853	45988
2029	241834	69197	280869	149572	0	278109	113484	452199	191452	0	6244	40303	741472	46547
2030	244608	70000	284251	151325	0	281299	114800	457644	193696	0	6320	40792	750184	47111

Figure 2-2 External Trip Data Processing

External Trip Development
SubDirect: I:\ateam\mod_inputs\externals\2005-12-01
12/19/2005
Programmer: RM

ext_counts_93_03.xls
2000_2003_ext_aadt_aawdt_rev.xls
2000_ext_ctl2.xls
Ext_Capacity.xls

probability template
template.asc →

pre-existing 1994 X-X trip files auto & truck →
XXADAP94.BAL →
94XXTRK.FIN

→ **Ext_Thru.s** →

↓

Ext_Thru.rpt
ExtAutTrk.txt
ExtXIpurp.txt
ExtIXpurp.txt

Thru Auto/Truck Files by year	*Extl attractions by purpose*	*Extl productions by purpose*	*Extl Ps/As by purpose in DBF Fmt.*
XX2000AD.FIN	AEXT2000.ASC	PEXT2000.ASC	2000Station.DBF
XX2000TK.FIN	AEXT2001.ASC	PEXT2001.ASC	2001Station.DBF
XX2001AD.FIN	AEXT2002.ASC	PEXT2002.ASC	2002Station.DBF
XX2001TK.FIN	AEXT2003.ASC	PEXT2003.ASC	2003Station.DBF
XX2002AD.FIN	AEXT2004.ASC	PEXT2004.ASC	2004Station.DBF
XX2002TK.FIN	AEXT2005.ASC	PEXT2005.ASC	2005Station.DBF
XX2003AD.FIN	AEXT2006.ASC	PEXT2006.ASC	2006Station.DBF
XX2003TK.FIN	AEXT2007.ASC	PEXT2007.ASC	2007Station.DBF
XX2004AD.FIN	AEXT2008.ASC	PEXT2008.ASC	2008Station.DBF
XX2004TK.FIN	AEXT2009.ASC	PEXT2009.ASC	2009Station.DBF
XX2005AD.FIN	AEXT2010.ASC	PEXT2010.ASC	2010Station.DBF
XX2005TK.FIN	AEXT2011.ASC	PEXT2011.ASC	2011Station.DBF
XX2006AD.FIN	AEXT2012.ASC	PEXT2012.ASC	2012Station.DBF
XX2006TK.FIN	AEXT2013.ASC	PEXT2013.ASC	2013Station.DBF
XX2007AD.FIN	AEXT2014.ASC	PEXT2014.ASC	2014Station.DBF
XX2007TK.FIN	AEXT2015.ASC	PEXT2015.ASC	2015Station.DBF
XX2008AD.FIN	AEXT2016.ASC	PEXT2016.ASC	2016Station.DBF
XX2008TK.FIN	AEXT2017.ASC	PEXT2017.ASC	2017Station.DBF
XX2009AD.FIN	AEXT2018.ASC	PEXT2018.ASC	2018Station.DBF
XX2009TK.FIN	AEXT2019.ASC	PEXT2019.ASC	2019Station.DBF
XX2010AD.FIN	AEXT2020.ASC	PEXT2020.ASC	2020Station.DBF
XX2010TK.FIN	AEXT2021.ASC	PEXT2021.ASC	2021Station.DBF
XX2011AD.FIN	AEXT2022.ASC	PEXT2022.ASC	2022Station.DBF
XX2011TK.FIN	AEXT2023.ASC	PEXT2023.ASC	2023Station.DBF
XX2012AD.FIN	AEXT2024.ASC	PEXT2024.ASC	2024Station.DBF
XX2012TK.FIN	AEXT2025.ASC	PEXT2025.ASC	2025Station.DBF
XX2013AD.FIN	AEXT2026.ASC	PEXT2026.ASC	2026Station.DBF
XX2013TK.FIN	AEXT2027.ASC	PEXT2027.ASC	2027Station.DBF
XX2014AD.FIN	AEXT2028.ASC	PEXT2028.ASC	2028Station.DBF
XX2014TK.FIN	AEXT2029.ASC	PEXT2029.ASC	2029Station.DBF
XX2015AD.FIN	AEXT2030.ASC	PEXT2030.ASC	2030Station.DBF
XX2015TK.FIN			
XX2016AD.FIN			
XX2016TK.FIN			
XX2017AD.FIN			
XX2017TK.FIN			
XX2018AD.FIN			
XX2018TK.FIN			
XX2019AD.FIN			
XX2019TK.FIN			
XX2020AD.FIN			
XX2020TK.FIN			
XX2021AD.FIN			
XX2021TK.FIN			
XX2022AD.FIN			
XX2022TK.FIN			
XX2023AD.FIN			
XX2023TK.FIN			
XX2024AD.FIN			
XX2024TK.FIN			
XX2025AD.FIN			
XX2025TK.FIN			
XX2026AD.FIN			
XX2026TK.FIN			
XX2027AD.FIN			
XX2027TK.FIN			
XX2028AD.FIN			
XX2028TK.FIN			
XX2029AD.FIN			
XX2029TK.FIN			
XX2030AD.FIN			
XX2030TK.FIN			

2.2 *Re-Estimation of the Demographic Models*

This section describes the update of demographic models used in the Version 2.1D #50 model. The demographic models are essentially used to apportion the total number of households in a given TAZ among cross-classes, corresponding to household size, income, and vehicles-available groups. The existing set of models were developed using the 1990 CTPP and the 1994 Household Travel Survey. The revised demographic models have been re-estimated using the 2000 CTPP.

2.2.1 Demographic Models Background

The demographic model process is comprised of three sub-models, all of which operate at the TAZ level. The first sub-model is used to estimate the number of households in four size groups (1, 2, 3, 4 or more persons per household). The second sub-model is used to estimate the number of households in four income groups corresponding to income quartiles. The third sub-model estimates the number of households by various levels of vehicle availability (i.e., households with 0, 1, 2, and 3 or more vehicles available). The result of the demographic modeling process is the apportionment of total households to four size groups by four income groups by four vehicle availability groups: 64 cross-classes in all.

The household size sub-model is an 'aggregate share' model. This type of model presumes that the proportion of households in each size group can be related to the average household size of a given TAZ. The model requires that non-linear curves relating the proportion of each size group to the average household size be 'fitted' to the average household size data summarized and grouped by average household size increments. The household income sub-model is conceptually similar to the size model. It presumes that the proportion of each income group can be developed from a regional income index for each TAZ. The index is defined as the ratio of the median TAZ income to the regional median income. The model consists of a family of non-linear curves relating to the proportion of each income group to the income index.

In application, an iterative proportional fitting routine is used to combine the results of the size and income sub-models so that a joint distribution of households can be formulated. It is necessary to develop households jointly by size and income classes for the operation of the final sub-model. The vehicle availability model is a multinomial logit model that determines the share of households in each vehicle availability group based on the household size, income, transit accessibility to jobs, and area.

The 2000 CTPP demographic data was used to re-estimate the size and income models (i.e., the fitted curves). The vehicle availability (multinomial logit) model was originally estimated using disaggregate household records from the 1994 Household Travel Survey. Ideally a revised household travel survey would be used to re-estimate the model, but TPB did not have this option during FY-2006. Instead the existing vehicle model was maintained, but the alternative specific constants were adjusted to better match the regional vehicle availability totals summarized from the 2000 CTPP, subsequent to the updating of the size and income sub-models.

2.2.2 2000 CTPP Data

The 2000 CTPP demographic data by place of residence (Part 1) were obtained on a CD from the U.S. Census Bureau to support the re-estimation work. Five CTPP tables containing national demographic data were retrieved:

1. Total number of households (Table 1-060)
2. Household size by vehicle available (Table 1-063)
3. Household size by household income in 1999 (Table 1-064)
4. Vehicles available by household income in 1999 (Table 1-067), and
5. Median household income by vehicles available (Table 1-089).

The CTPP Access Tool (CAT) program was used to extract data from the above tables for the District of Columbia and the portions of Maryland, Virginia, and West Virginia that comprise the modeled study area. Table 2-8 displays the CTPP demographic totals for the TPB modeled area. The extracted data were available at several levels of geography, including the Census Tract level (1,188 units within the modeled study area) and the Census Zone level (4,215 units).

Table 2-8 2000 CTPP Regional Totals by Household Size, Income, and Vehicle Availability Groups

Households by Size Groups	1 Psn. HHs.	2 Psn. HHs.	3 Psn. HHs	4+Psn. HHs.
	546,700	661,500	368,500	565,500

Households by Income Quartile	Inc. Quartile 1	Inc. Quartile 2	Inc. Quartile 3	Inc. Quartile 4
	509,500	494,000	597,400	541,300

Households by Vehicles Available	HHs/ w/ 0Vehs.	HHs w/ 1 Vehs.	HHs w/ 2 Vehs.	HHs w/ 3+ Veh.
	210,600	709,700	825,900	396,100
Total Households	**2,142,200**			

2.2.3 Household Size Sub-Model

The steps for developing the household size sub-model were as follows:

1) The total number of household population, households, and households of the four size groups (i.e, households with 1, 2, 3, and 4 or more persons) were assembled at the CTPP Tract level. The data was initially assembled at the geographically finer Census zone level, but it was decided that the Tract level data yielded a minimum of reporting suppression and more stable data for aggregate curve fitting purposes.
2) The average household size was computed at the Census Tract level as the total household population divided by the total households. The average household size was rounded to the nearest tenth (i.e., to one decimal place).
3) The total number of households and the households in each of the four size groups were grouped and summarized for each average household size groups, in increments of tenths.

The average household sizes ranged from 1.0 to 3.9, and so, 30 discrete groups were summarized.

4) The percentage of households in each size group was computed at each of the 30 average household size groups. This resulted in percentage curves for each of the four household size groups. The curves were reviewed for overall logic and consistency with the prior model. The curves were found to be very consistent with the earlier work.
5) Each household size curve was manually adjusted to ensure that the curve surface was reasonably smooth and the sum of the four percentages, at each average size increment, equaled 100.0%.

The final size sub-model curves are shown on Figure 2-3 and in tabular form on Table 2-9.

Figure 2-3 Household Size Sub-Model: Graphical Form

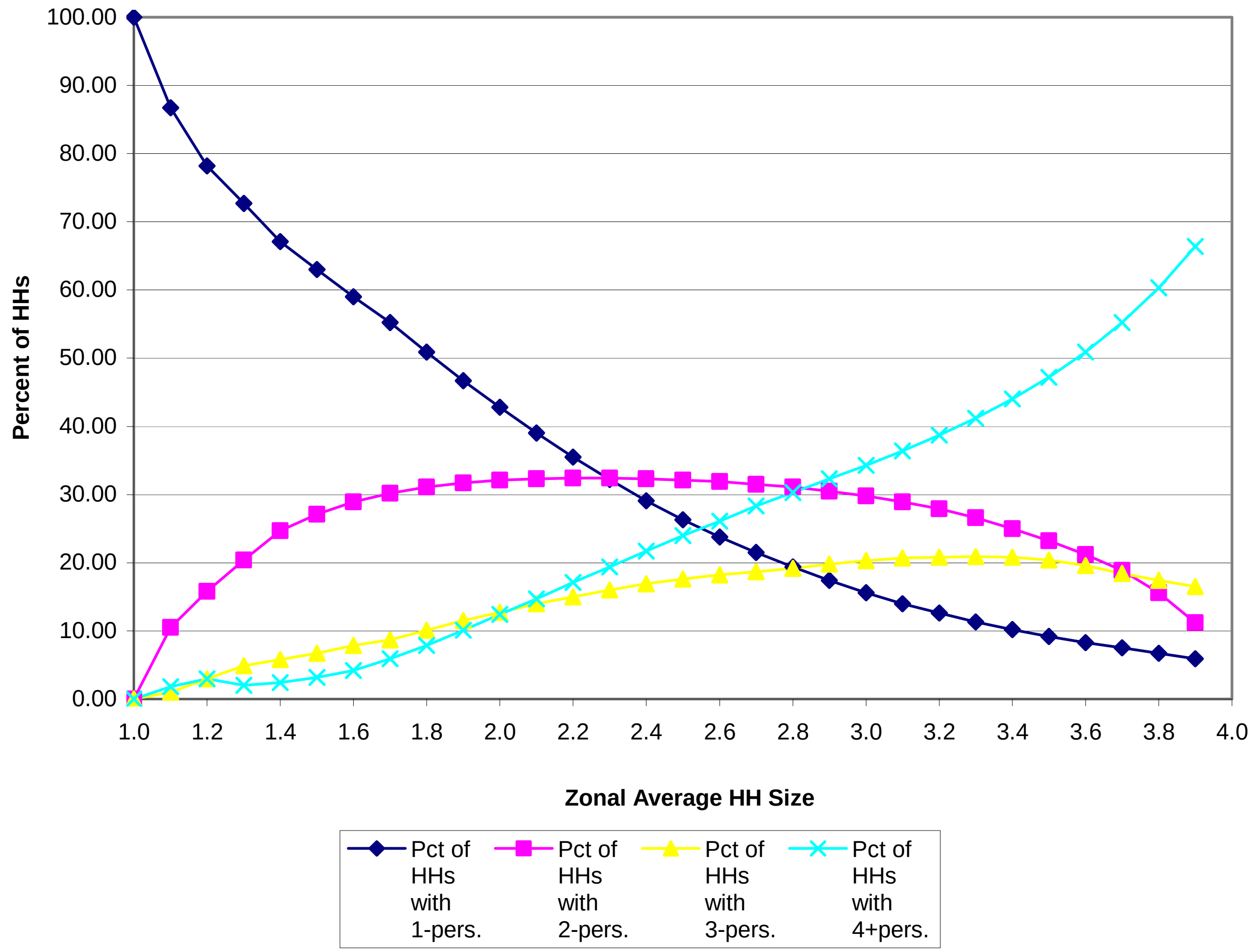


Table 2-9 Household Size Sub-Model: Tabular Form

Ave zonal HH size	Pct of HHs with 1-pers.	Pct of HHs with 2-pers.	Pct of HHs with 3-pers.	Pct of HHs with 4+pers.	
1.0	100.00%	0.00%	0.00%	0.00%	100.00%
1.1	86.70%	10.50%	1.00%	1.80%	100.00%
1.2	78.20%	15.80%	3.00%	3.00%	100.00%
1.3	72.70%	20.40%	4.90%	2.00%	100.00%
1.4	67.10%	24.70%	5.80%	2.40%	100.00%
1.5	63.00%	27.10%	6.70%	3.20%	100.00%
1.6	59.00%	28.90%	7.90%	4.20%	100.00%
1.7	55.20%	30.20%	8.70%	5.90%	100.00%
1.8	50.90%	31.10%	10.10%	7.90%	100.00%
1.9	46.70%	31.70%	11.50%	10.10%	100.00%
2.0	42.80%	32.10%	12.70%	12.40%	100.00%
2.1	39.00%	32.30%	14.00%	14.70%	100.00%
2.2	35.50%	32.40%	15.00%	17.10%	100.00%
2.3	32.20%	32.40%	16.00%	19.40%	100.00%
2.4	29.10%	32.30%	16.90%	21.70%	100.00%
2.5	26.30%	32.10%	17.60%	24.00%	100.00%
2.6	23.80%	31.90%	18.20%	26.10%	100.00%
2.7	21.50%	31.50%	18.70%	28.30%	100.00%
2.8	19.40%	31.10%	19.20%	30.30%	100.00%
2.9	17.40%	30.50%	19.80%	32.30%	100.00%
3.0	15.60%	29.80%	20.30%	34.30%	100.00%
3.1	14.00%	28.90%	20.70%	36.40%	100.00%
3.2	12.60%	27.90%	20.80%	38.70%	100.00%
3.3	11.30%	26.60%	20.90%	41.20%	100.00%
3.4	10.20%	25.00%	20.80%	44.00%	100.00%
3.5	9.20%	23.20%	20.40%	47.20%	100.00%
3.6	8.30%	21.20%	19.60%	50.90%	100.00%
3.7	7.50%	18.90%	18.40%	55.20%	100.00%
3.8	6.70%	15.60%	17.40%	60.30%	100.00%
3.9	5.90%	11.20%	16.50%	66.40%	100.00%

2.2.4 Household Income Model

According to an earlier analysis of the 2000 CTPP (COG/TPB, 2005, Chapter 6), the median annual household income for the TPB modeled area is approximately $63,800 (in 1999 dollars). The range of each quartile is shown below:

Quartile	Income Interval
1st Quartile (25%)	< $ 36,100
2nd Quartile (50%)	$36,100 - $ 63,800
3rd Quartile (75%)	$63,800 - $100,700
4th Quartile (100%)	> $100,700

The steps for developing the household income sub-model were similar to those undertaken above.

1) The CTPP income data at the Census Tract level of geography was used for this analysis. The CTPP provides household summaries for 25 discrete income ranges at the Census Tract level. The 25 ranges were combined to approximate the quartile ranges defined above as closely as possible. Subsequently, the total number of households and the households associated with the four income quartiles were assembled at the CTPP Tract level. The CTPP also provides the median income figure at the CTPP Tract level.
2) The median income index was computed for each CTPP Tract. The index is defined as the ratio of the median CTPP Tract income to the regional median income. The index was rounded to the nearest tenth (i.e., to one decimal place).
3) The total number of households and the households in each quartile group where grouped and summarized for each income index value, in increments of tenths. The index values ranged from 0.0 to 3.1, and so, 32 discrete groups were summarized.
4) The percentage of households in each quartile was computed at each of the 32 income index ranges. This resulted in percentage curves for each of the four income groups. As before, the curves were reviewed for reasonableness and consistency with the prior income model. Again, the curves were found to be very consistent with the earlier work.
5) The income quartile curves were manually adjusted to ensure that the curve surface was reasonably smooth and the sum of the four percentages at each average size increment equaled 100.0%.

The final size sub-model curves are shown on Figure 2-4 and in tabular form on Table 2-10.

Figure 2-4 Final Household Income Sub-Model: Graphical Form

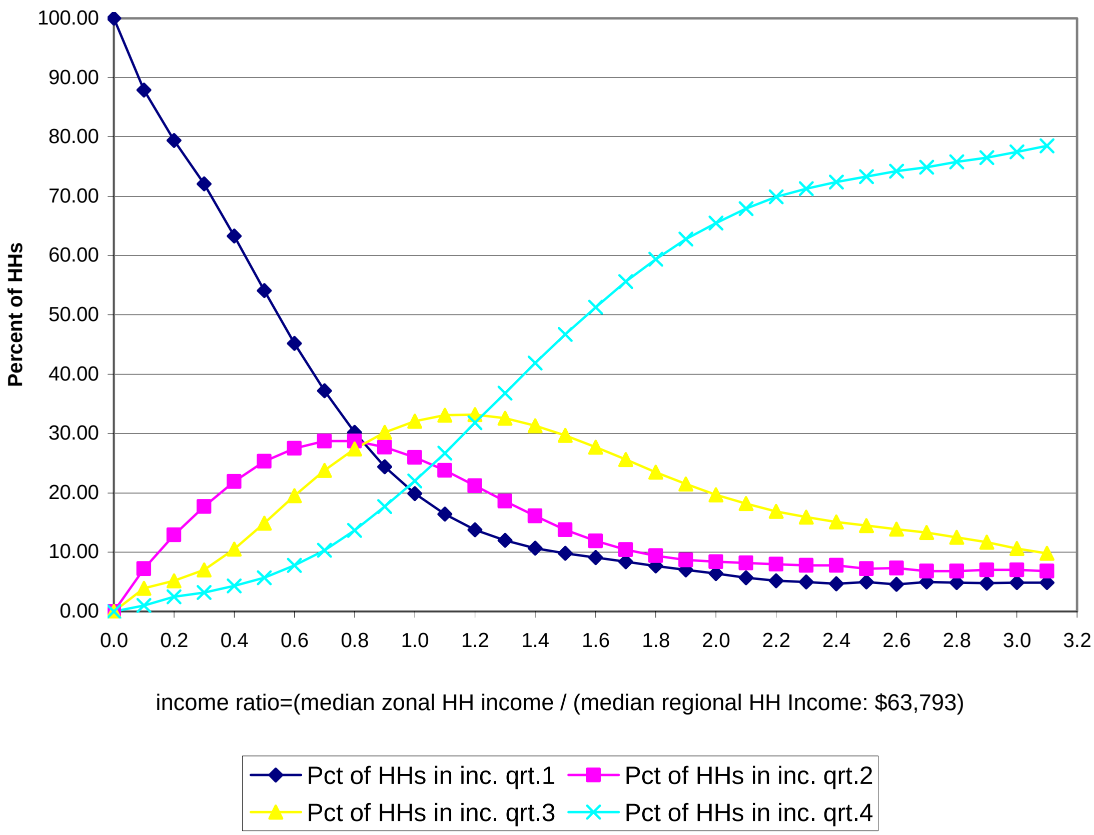


Table 2-10 Household Income Sub-Model: Tabular Form

Income ratio	Pct of HHs in inc. qrt.1	Pct of HHs in inc. qrt.2	Pct of HHs in inc. qrt.3	Pct of HHs in inc. qrt.4	
0.0	100.00%	0.00%	0.00%	0.00%	100.00%
0.1	87.90%	7.20%	3.90%	1.00%	100.00%
0.2	79.40%	12.90%	5.20%	2.50%	100.00%
0.3	72.10%	17.70%	7.00%	3.20%	100.00%
0.4	63.30%	21.90%	10.50%	4.30%	100.00%
0.5	54.10%	25.30%	14.90%	5.70%	100.00%
0.6	45.20%	27.50%	19.50%	7.80%	100.00%
0.7	37.20%	28.70%	23.80%	10.30%	100.00%
0.8	30.20%	28.70%	27.40%	13.70%	100.00%
0.9	24.40%	27.70%	30.20%	17.70%	100.00%
1.0	19.90%	26.00%	32.10%	22.00%	100.00%
1.1	16.40%	23.80%	33.10%	26.70%	100.00%
1.2	13.80%	21.20%	33.20%	31.80%	100.00%
1.3	12.00%	18.60%	32.60%	36.80%	100.00%
1.4	10.70%	16.10%	31.30%	41.90%	100.00%
1.5	9.80%	13.80%	29.70%	46.70%	100.00%
1.6	9.10%	11.90%	27.70%	51.30%	100.00%
1.7	8.40%	10.40%	25.60%	55.60%	100.00%
1.8	7.70%	9.40%	23.50%	59.40%	100.00%
1.9	7.00%	8.70%	21.50%	62.80%	100.00%
2.0	6.40%	8.40%	19.70%	65.50%	100.00%
2.1	5.70%	8.20%	18.20%	67.90%	100.00%
2.2	5.20%	8.00%	16.90%	69.90%	100.00%
2.3	5.00%	7.80%	15.90%	71.30%	100.00%
2.4	4.70%	7.80%	15.10%	72.40%	100.00%
2.5	5.00%	7.20%	14.50%	73.30%	100.00%
2.6	4.60%	7.30%	13.90%	74.20%	100.00%
2.7	5.00%	6.80%	13.30%	74.90%	100.00%
2.8	4.90%	6.80%	12.50%	75.80%	100.00%
2.9	4.80%	7.00%	11.70%	76.50%	100.00%
3.0	4.90%	7.00%	10.60%	77.50%	100.00%
3.1	4.90%	6.80%	9.80%	78.50%	100.00%

2.2.5 Household Vehicle Availability Model

Following the re-estimation of the household size and income sup-models, an application program was written in TP+ to apply the new curves and to evaluate the performance of the existing vehicle availability model against the 2000 CTPP figures. In order to apply the model at the TAZ level using Round 7.0 land use, a revised median income index based on the 2000 CTPP had to be formulated at the TAZ level (COG/TPB, 2006). In applying the revised size and income curves together with the existing vehicle availability model (COG/TPB 2004b, page 3-11), it was determined that minor refinements to the vehicle availability model were necessary to fine tune its performance, and the alternative specific constants were adjusted slightly. The final structure and coefficient specification of the revised vehicle availability model is shown on Table 2-11.

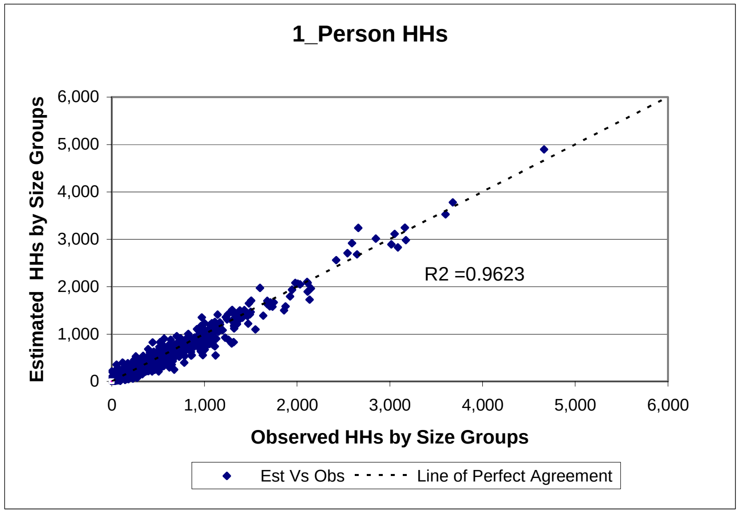
Table 2-11 Vehicle Availability Model (with updated Constants)

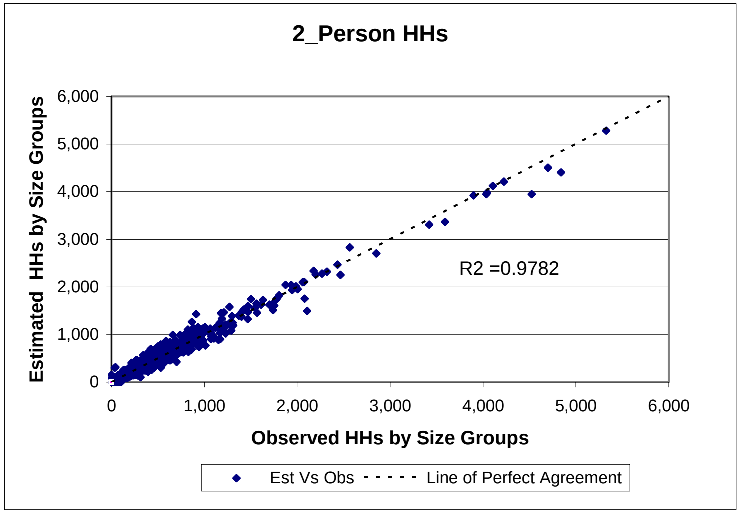
No. of vehicles 0	1	2	3+	Variable name	Coeff.
	x			Constant	1.0138
		x		Constant	-2.3381
			x	Constant	-5.1710
		x		HH size	0.8700
			x	HH size	1.3026
	x			Income level 2 dummy	1.2376
		x		Income level 2 dummy	1.7892
			x	Income level 2 dummy	1.8221
	x			Income level 3 dummy	1.3285
		x		Income level 3 dummy	2.4831
			x	Income level 3 dummy	2.7395
	x			Income level 4 dummy	1.9991
		x		Income level 4 dummy	3.7372
			x	Income level 4 dummy	4.1987
	x			Tot emp w/in 40 min transit (AM pk)	-1.10E-06
		x		Tot emp w/in 40 min transit (AM pk)	-1.82E-06
			x	Tot emp w/in 40 min transit (AM pk)	-2.05E-06
	x			Area type, 1994 (1 to 7)	0.0668
		x		Area type, 1994 (1 to 7)	0.2783
			x	Area type, 1994 (1 to 7)	0.4093
	x			DC dummy	-0.9246
		x		DC dummy	-1.0751
			x	DC dummy	-1.6334

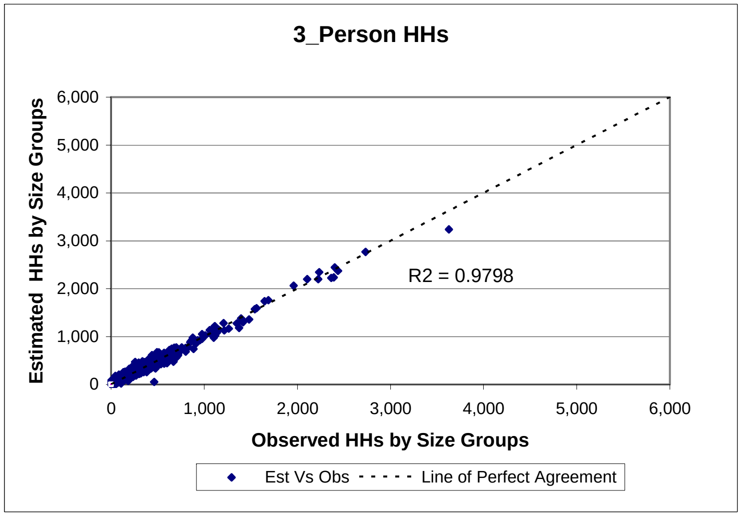
2.2.6 Application and Validation

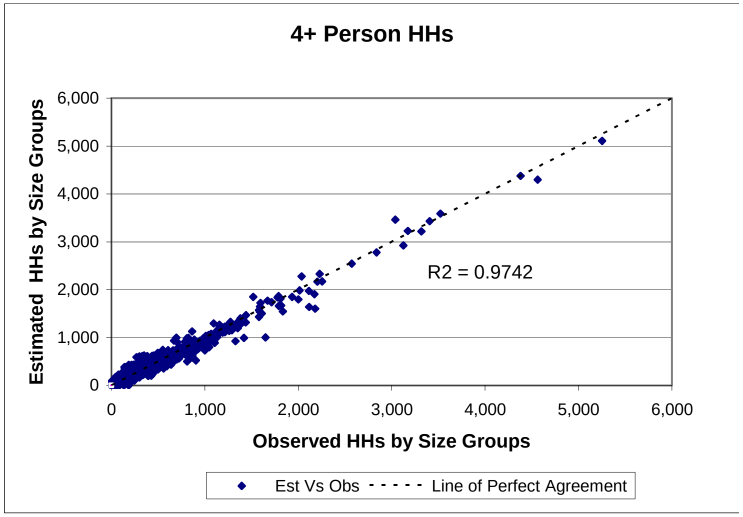
Scatterplots of estimated and observed values at the TAZ level are shown on the following figures. These indicate that the revised demographic models are matching the CTPP data reasonably well. More detailed performance measures can be found in other technical documentation (COG/TPB, 2006).

Exhibit 2-1 Observed and Estimated Zone Level Households by Household Size Groups



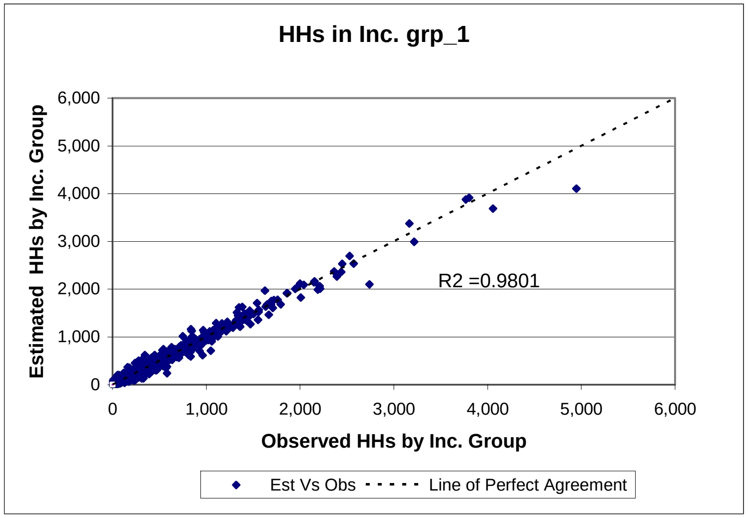


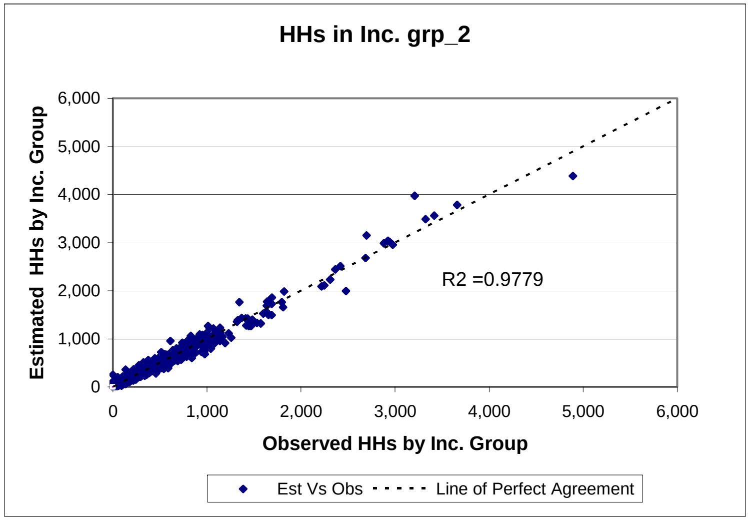


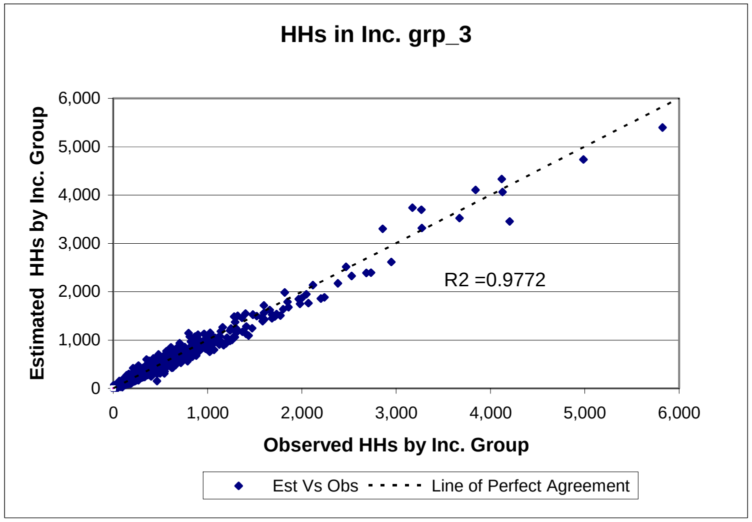


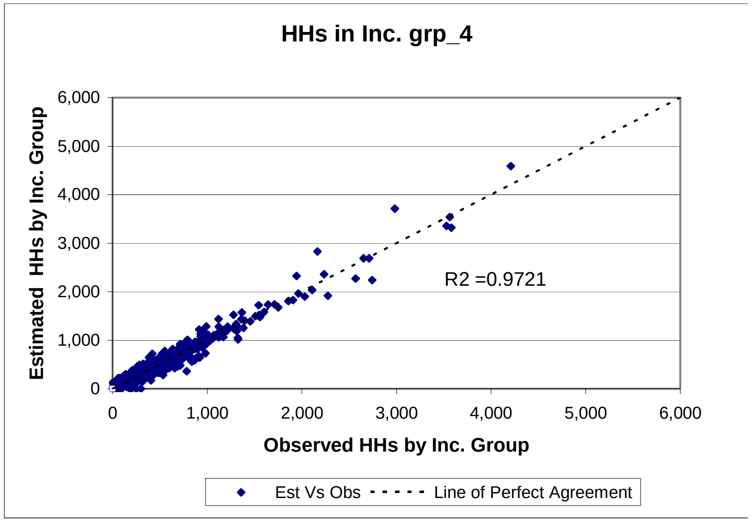
Ref: 2000_Est_Zonal_Summary_Adj.xls Adj_Zonal_HH_Size

Exhibit 2-2 Observed and Estimated Zone Level Households by Income Groups



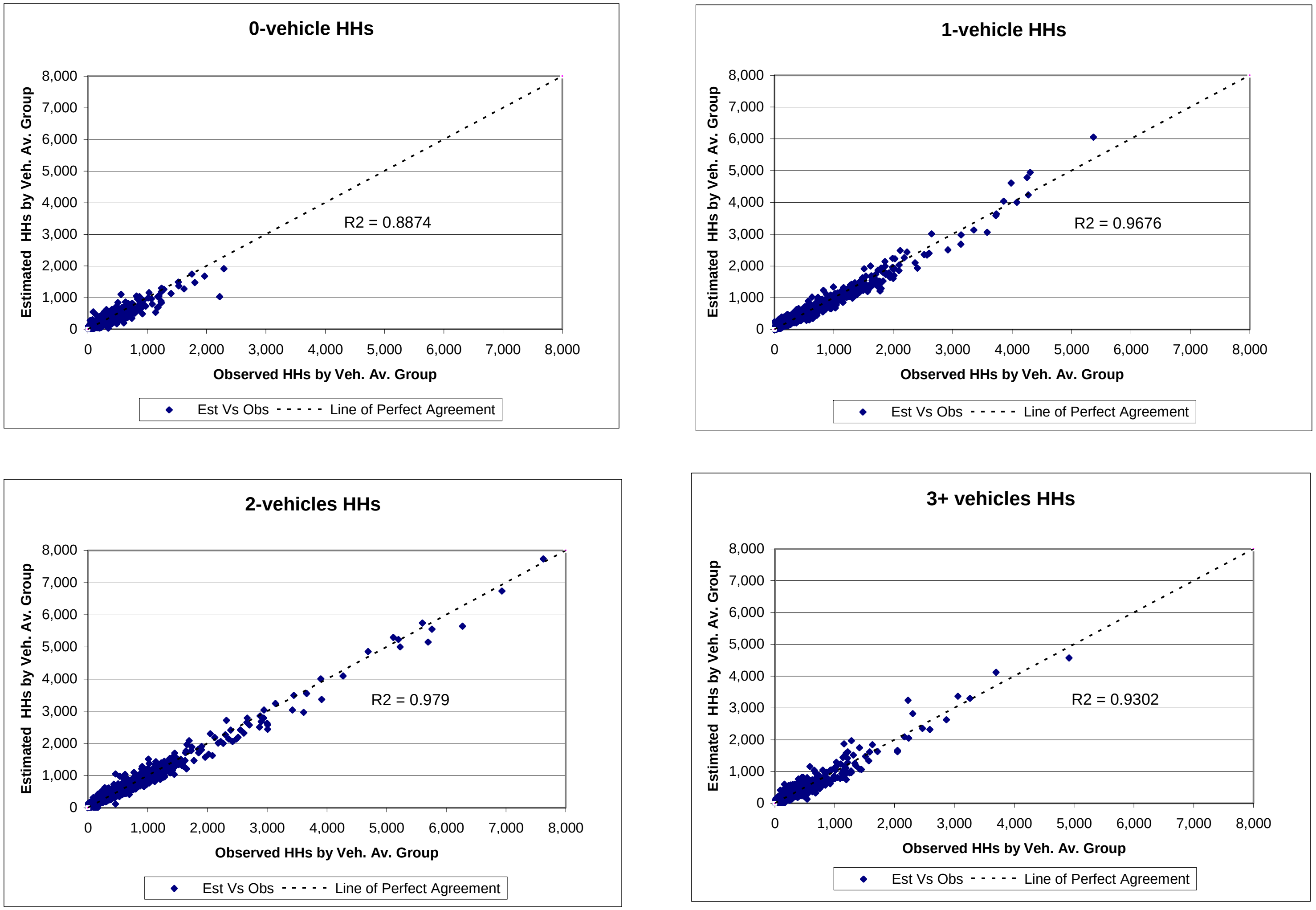






Ref: 2000_Est_Zonal_Summary_Adj.xls Adj_Zonal_HH_Inc

Exhibit 2-3 Observed and Estimated Zone Level Households by Vehicle Available Groups



Ref: 2000_Est_Zonal_Summary_Adj.xls Adj_Zonal_HH_Size

2.3 *Traffic Assignment Refinement*

One of the key issues researched during the last expert review of TPB models, conducted by the TRB, was the presence of freeway links with excessively large simulated daily volumes resulting from the highway assignment, particularly in the out-years. This issue was identified in the course of reviewing the mobile emissions post processor which essentially uses the final loaded links file produced by the Version 2.1D #50 model and distributes link volumes from three time-of-day periods to 24 hourly periods. It was determined that a small number (less than 1%) of highway links were assigned a simulated volume that exceeded the physical capacity of the facility. During FY-2006, considerable time was spent studying the extent of so called ‘overloading’ on the freeway system, investigating potential reasons for this condition, and identifying a solution to this problem. This section describes the activities undertaken.

2.3.1 Background

The mobile emissions post processor is used to distribute simulated highway volumes from the travel model by time period (AM peak, PM peak and off-peak time periods) among hourly intervals. This is necessary because emission calculations are generally sensitive to highway speeds which fluctuate during the day. As the gross volumes are apportioned to hourly periods, the post processor checks that the apportioned hourly volume is within the capacity of the highway link. If the condition arises that an allotted volume exceeds the capacity, steps are taken to compute the ‘excess volume’, or the portion of volume that exceeds capacity, and to move it into an adjacent hourly period (or in some cases periods). In this way, the post processor simulates peak-spreading. It is rare, but possible, that a simulated daily link volume from the travel model may be so large that, even when it is spread over the 24 hours in a day, it exceed the daily capacity of all 24 hourly periods assumed by the post processor. In this event, the ‘excess’ link volume is not eliminated, but rather, is simply ‘stacked’ in one of three hourly periods: hour 1 (the first hour of the day), hour 13 (the noon hour), or hour 24 (the last hour of the day). The amount of excess volumes in any one or more of these ‘boundary’ periods depends on the treatment of the volume spreading mechanism in the post processor with respect to each individual link. However, overloaded links are most often reflected by an excessive volume at hour 13.

Earlier investigations of link overloading indicated that the highest frequency of link overloading occurred on the low level facilities, i.e. collectors and minor arterials. This finding was not met with surprise. It was felt that collectors should be overloaded (and most poorly simulated with respect to the higher facilities) because they are actually simulating traffic that uses the collector system as well as traffic on the local street system, which is not included in the regional highway network.

A review of loaded links files generated during the most recent air quality conformity study (COG/TPB 2005b) was undertaken to better quantify the extent of overloading. As part of this review the loaded links files were passed through the post processor to analyze overloading for the three boundary hours. A count of hourly ‘overloads’ for the years 2002, 2010, and 2030 are shown on Table 2-12.

Table 2-12 Number of Hourly Overloading Instances on Freeways

Year	Hour 1	Hour 13	Hour 24
2002	0	83	14
2010	0	107	15
2030	18	270	30

It should be pointed out that the above summary does not necessarily indicate the number of physical links affected by the overloading. It is not clear from the table whether or not the count of overloaded links in hour 13 are mutually exclusive of the links counted in hour 24 (most likely there is some overlap).

2.3.2 Investigation

To formulate explanations for the link overloading on the freeway system, the overloaded links from the 2030 network were plotted on a map. Several conclusions were drawn:

1) Not surprisingly, overloading occurred on most of the typical choke-points of the freeway system: I-95 at Springfield, the Wilson Bridge and other Potomac River bridge crossings, locations along I-395, and I-66 inside the Beltway, portions of the Capital Beltway, and the I-270 spur.
2) There was a cluster of overloading on facilities in the vicinity of Baltimore.
3) There were other overloaded freeway sections for which no apparent explanation was obvious.

Several explanations were formulated for the overloading patterns on the freeway system shown on the map.

1) The external volume on I-95 in the Baltimore area was found to be quite high in relation to the available capacity of the facility. This observation ultimately led to a complete revisiting of out-year external and through traffic assumptions (mentioned earlier in this Chapter).
2) The volume delay function (VDF) does not adequately account for queuing delays at various chokepoints that occur regularly during peak periods. It was speculated that a capability for addressing queuing delay as part of the highway assignment process should be added.
3) The Version 2.1D #50 VDFs used for freeways include a speed ‘floor’ of 11 to 13 mph, depending on the area type of the link. The speed floor engages at links with V-C ratios of greater than 1.17. There was some speculation that the speed floor was inadvertently ‘encouraging’ highly congested links to become overloaded.
4) Some of the overloaded links were found to contain incorrect lane codes which resulted in inordinately low capacities. A comprehensive review of the freeway system using aerial photographs was undertaken to correct lane coding errors.

2.3.3 Changes Implemented

Several changes were implemented to rectify link volume overloading on the freeway system. First, the external and through traffic forecasts were revised, as explained earlier. One of the key refinements was the moderation of assumed external traffic growth for external stations in the Baltimore area. Second, the 11-13 mph speed floor used in the existing freeway volume delay function was effectively removed. The refined freeway VDF is very similar to the existing function except it now enables congested speeds to drop to as low as 1 mph at a V-C ratio value of 3.0. Third, a queuing function was added to the VDF function. Previously, the congested time (T_c) calculation in the traffic assignment was computed based on the free flow time (T_0) and the VDF function:

(1) $T_c = T_0 * \text{VDF } f(V/C)$

The queuing function is now combined with the volume delay function in the formulation of congested time, as follows:

(2) $T_c = [\, T_0 * \text{VDF } f(V/C) \,] + \text{Queuing Time } f(V/C)$

The queuing function, which is applied to only freeways and ramps, is shown below:

V/C Ratio	Queuing Time (min)
< 0.7	0.0
0.8	0.1
0.9	0.2
1.0	0.8
1.1	2.8
1.2	7.0
1.3	11.2
1.4	13.2
1.5	13.8
1.6	13.9
1.7 >	14.0

Besides reducing the occurrence of overloaded freeways, it is expected that a marginal reduction of VMT will result due to these changes.

2.4 *References*

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Chapter 3 Commercial Vehicle Model Implementation Status

One of the key recommendations resulting from the last expert review of the TPB's modeling practice was that an explicit commercial vehicle (CV) model should be developed as part of the regional model. This particular travel market is currently subsumed in the NHB travel purpose. Past experience at other locations has shown that traditional O-D surveys to develop commercial vehicle and truck models are excessively expensive and difficult to conduct. What's more, the assumption that a 'standard' trip generation and distribution model can adequately simulate real-world commercial vehicle patterns is arguably weak.

TPB has recently learned of a practical technique which enables the development of commercial vehicle and truck models. The technique requires a modest amount of data and resources to install and has been successfully implemented at other cities. TPB has retained William Allen to implement the CV modeling technique which will be integrated with the regional travel model. The data collection phase of this project began at the end of FY-2005.

During FY-2006, the data collection was completed. The collected information will support a commercial vehicle modeling capability as well as a truck modeling effort (to be undertaken in FY-2007). Progress has been made in FY-2006 in calibrating a CV model, but the project has not yet been completed. TPB decided to refine its traffic assignment procedure during much of FY-2006, and the traffic assignment step is an integral component of the CV model calibration. A finalized version of the CV model is planned for completion in early FY-2007. Nonetheless, a 'dry-run' calibration has been undertaken during FY-2006 using the existing traffic assignment process. It has been demonstrated that the CV approach is viable. This chapter briefly reviews the progress made during FY-2006 and details the next steps for completing the CV model in early FY-2007.

3.1 *Background*

It is important to point out that the definition of a commercial vehicle, for the purposes of this modeling technique, is any light-duty vehicle that is *visually distinguished* as one that is engaged in a business enterprise (Allen 2004). This includes vehicles marked with a business name or logo, as well as vehicles carrying equipment that is clearly indicative of a commercial venture, e.g., a ladder or construction supplies. This definition can be construed as subjective and does not entail the entire universe of commercial vehicles on the highway system, but, it is practical for data collection purposes. It most assuredly captures the vast majority of vehicles in this travel market.

The general procedure for developing the proposed CV model may be summarized as the following steps (Allen 2005a):

1) Data Collection: Traffic counts are collected from a sample of highway network link locations that are representative of facility types and area types used by the regional model. Each location surveyed has an associated AAWDT count. The objective of the

survey is to accurately measure the percentage of commercial vehicles occurring at each location.

2) Count Model: A model is formulated, relating the observed CV percentage to highway link attributes. The model enables CV counts to be synthetically generated for the universe of highway links for which an associated ground count exists. The generation of these counts is necessary for later steps. A number of mathematical model forms may be considered for this purpose.
3) Initial Model: An initial trip generation and trip distribution model is specified in order to arrive at 'first-cut' trip tables. The model parameters are typically borrowed from pre-existing CV models. External and through trips are estimated, again, using borrowed shares.
4) Calibration of Initial Model: The trip tables generated from Step 3 are assigned and compared to the synthetic counts generated at Step 2. The parameters are iteratively adjusted after estimated link volumes are compared to observed counts, so that the match is as close as possible.
5) Develop Calibration Adjustment Matrix: The initial trip table produced by the final model specification resulting from Step 4 is assigned. A process known as an 'Adaptable Assignment' (AA) is used to modify the initial trip table in order to refine the assignment accuracy (i.e., the comparison of estimated and observed link volumes). The AA process may be used to refine the initial model specified in Step 4. The end result of this step is a 'delta table', or a trip table of adjustments (either additive or multiplicative) that are used to refine the initial trip table so that reasonably acceptable matches between estimated and observed link volumes are achieved (Allen 2005b). The calibrated delta table is essentially an integral component of the final application model.

Subsequent to the CV model development, adjustments must be made to the regional model to avoid double-counting. At minimum, the adjustments would address:

1) A reduction in NHB trip generation rates since commercial trips are now explicitly generated, and;
2) A further apportionment of what is currently known as NHB external and through trips among commercial and non-commercial categories.

3.2 *Commercial Vehicle Survey*

A commercial vehicle survey was conducted in the spring and summer of 2005, in accordance with specifications established by the consultant. Directional classification counts were collected at 148 locations in the region, being representative of facilities and locations distinguished by the regional model. The availability of reasonable ground counts were also considered in the selection of survey locations. The consultant was provided the data, along with the existing traffic assignment process and inputs corresponding to the year 2000 (COG/TPB, 2005). The overall share of commercial traffic observed on all links was 7.9%. Highway network link attributes associated with the count locations were also related to the surveyed count data.

3.3 *Count Model*

A logit model formulation relating the observed commercial vehicle percentage to highway link attributes was calibrated from the CV survey data. The independent variables included the number of lanes, the AAWDT, and bias coefficients relating to the facility type, area type, and jurisdiction (Allen 2005 and 2005d). The synthesized count provided a basis by which base year commercial traffic at external stations could be estimated (Allen 2005f).

3.4 *Commercial Vehicle Model*

A number of sources where considered as starting points for the initial trip generation and trip distribution parameters. The default Quick Response Freight Manual (QRFM) F-curve was ultimately selected for distributing internal commercial trips. The F-curve used for the external commercial trips was similar to that used in the existing TPB model for medium trucks (Allen 2005f).

Several trip generation model specifications were considered and tested. The final model is applied at the TAZ level. The specification of the model is shown below (Allen 2006a):

Daily Commercial Vehicle Trip Productions/Attractions =
(0.205 * IND + 0.154 * OFF + 0.452 * RET + 0.075 * OTH + 0.119 * HH) * ATFAC

Where:

IND = industrial employment
OFF = office employment
RET = retail employment
OTH = other employment
HH = households
ATFAC = area type adjustment factor:

Area type	Factor
1	0.95
2	0.90
6	1.20
7	1.15

Note: no factor is applied to area types 3-5.

The above specification was developed in concert with an *additive* delta matrix which was developed using the adaptable assignment process. As explained above, the delta matrix is used to refine the simulated trip table so that the estimated link volumes match observed counts well.

3.5 *Initial Results*

The commercial vehicle model produces a total of 932,600 trips (internal, external and through) for the year 2000, about 5% of the total vehicle trips simulated by the TPB travel model (Allen 2006a). The simulated year 2000 VMT amounts to 10.3 million. A 2030 test run of the final CV model was executed using Round 6.4a land use. The resulting 2030 commercial trips totaled

1.3804 million (reflecting a 48% increase). The resulting VMT for 2030 totaled approximately 14.5 million (reflecting a 41% increase and a marginal reduction in the average trip length). In view of the demographic and congestion dynamics, these results are reasonable.

3.6 *Conclusions and Next Steps*

Progress has been made in the development of a commercial vehicle model for the Washington region, the first of its kind in this area. It has been demonstrated that the proposed technique for modeling commercial travel is viable and reasonable.   TPB has recently updated its traffic assignment process (see Chapter 2) and is planning to revisit network coding issues in early FY-2007. The consultant will be provided updates necessary to finalize the commercial vehicle calibration. It is anticipated that the final commercial vehicle model specification will not deviate substantially in form from what has been described above.

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Chapter 4 Status of Nested Logit Mode Choice Model Implementation

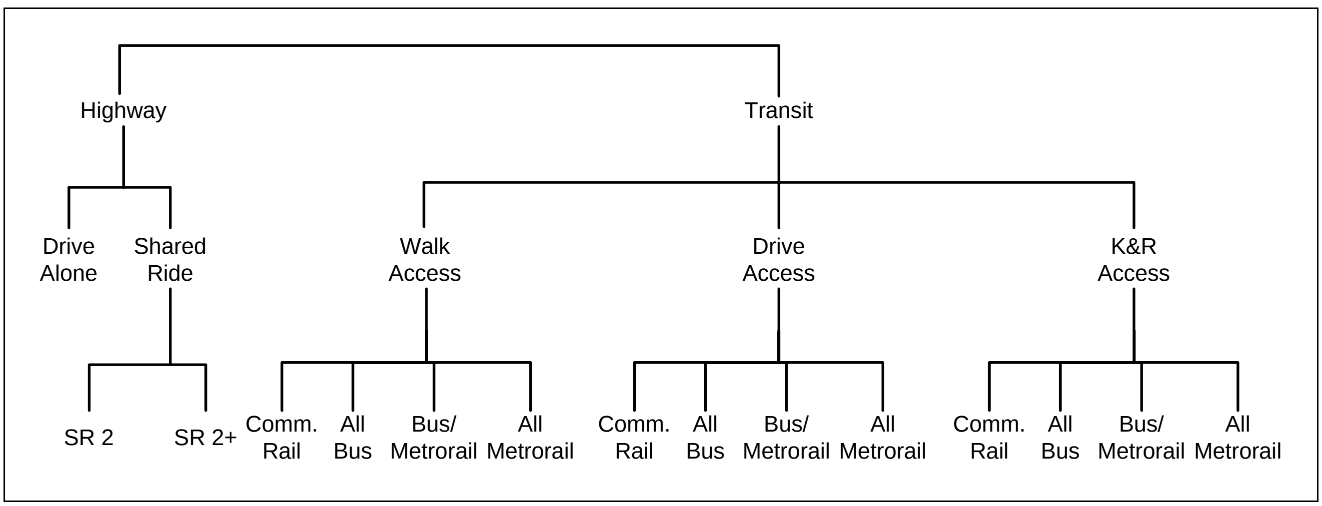
4.1 *Introduction*

In 2004 and 2005, AECOM Consult, Inc. developed a new nested logit mode choice model for use in two light rail project planning studies it was conducting in Arlington County, Virginia and Washington, D.C. for the Washington Metropolitan Area Transit Authority (WMATA). The starting point for the AECOM/WMATA mode choice model was the TPB mode choice model, Version 2.1D #50. Despite its progeny, the AECOM/WMATA model is fundamentally different from the COG/TPB model in three major ways. First, the AECOM/WMATA model is a nested-logit (NL) model that explicitly includes transit mode of access as part of its nesting structure. Specifically, as shown in Figure 4-1, the model has 15 choices, comprised of:

- Three auto modes (drive alone, shared ride 2, and shared ride 3+ persons)
- Four transit modes
    - Commuter rail
    - Bus only
    - Bus and Metrorail
    - Metrorail only
- Three access modes to transit
    - Walk-access
    - Drive-access (park)
    - Kiss-and-ride access (drop off passenger)

The "commuter rail" designation includes commuter rail only, commuter rail with Metrorail, and commuter rail with bus.

Figure 4-1 AECOM mode choice model structure



Ref: NestedChoice_Struct3.vsd

By contrast, the TPB mode choice model is a sequential multinomial logit (MNL) model with only five modes: transit, drive alone, shared ride 2, shared ride 3, and shared ride 4+ person.[4]

The second major difference between the COG/TPB and the AECOM/WMATA mode choice models is the number of models used. The COG/TPB mode choice model consists of four models:

- Home-based work (HBW), using peak period (AM) travel times (skims),
- Home-based shop (HBS), using off-peak travel times,
- Home-based other (HBO), using off-peak travel times, and
- Non-home-based (NHB), using off-peak travel times.

The AECOM/WMATA model consists of six models. In the AECOM model, home-based shop (HBS) and home-based other (HBO) have been combined into one purpose, called home-based other (HBO), but peak and off-peak skims are used for each of the three trip purposes. Consequently, the AECOM/WMATA mode choice model is made up of the following six models:

- HBW peak
- HBW off-peak
- HBO peak
- HBO off-peak
- NHB peak
- NHB off-peak

The third major difference between the COG/TPB and the AECOM/WMATA mode choice models is that the AECOM mode choice model is applied as a "post-process" to the recursive four-step model, i.e., it is run directly after running the COG/TPB travel model (including the COG/TPB mode choice model). By contrast, the TPB mode choice model is run within the speed feedback loop, which is used to feed congested link speeds from the traffic assignment back to both trip distribution and mode choice. The speed feedback loop is run six times, so the TPB mode choice model is run six times for each transportation network alternative analyzed. For each of the six times that trip distribution is run, a revised person trip table is created. The Federal Transit Administration (FTA) has indicated that projects being reviewed for "New Starts" funding,[5] should use fixed trip tables. AECOM's solution to this dilemma was to create a post-process mode choice model, i.e., one that is run after the TPB travel demand model (including its six loops of speed feedback) is run. For purposes of brevity, the post-processed AECOM/WMATA mode choice model developed for Arlington and Washington, D.C. will be

[4] In the first implementation of the Version 2 model (using MINUTP) in 2001, there was a transit sub-mode choice model and transit mode of arrival model (COG/TPB 2001, Chapter 9). The sub-mode model was used to apportion total transit trips among "bus-only" (including commuter rail) and Metrorail-related trips. The mode of arrival (MOA) model was then used to apportion Metrorail trips among access mode (walk, bus, auto passenger, and auto driver) and Metrorail station. When the Version 2 model was converted from MINUTP to TP+ in July 2002, these two models were not re-estimated, and, thus have not been a part of the regional travel model since that time.

[5] The Federal Transit Administration's (FTA) discretionary New Starts program is the federal government's primary financial resource for supporting locally-planned, implemented, and operated transit "guideway" capital investments, e.g., light rail, heavy rail, commuter rail, and bus rapid transit.

referred to simply as the AECOM post-process mode choice (PP MC) model, or simply the AECOM mode choice model.

The AECOM PP MC model is applied with a program called AEMS (AECOM Mode Split). AEMS is a Fortran program that allows one to apply any mode choice model with any nesting structure. It allows one to apply mode choice models with up to 15 different choices (AECOM 2005c, p. 13).

This last fiscal year, FY 2006, COG/TPB staff decided to use both the AEMS application program and also the AECOM mode choice model (structure and coefficients) for the first implementation of a COG/TPB nested logit mode choice model. The first step would be for COG/TPB staff to apply the AECOM mode choice model as is, i.e., as a post-process model and with the existing structure and coefficients. This has been done for the years 2000, 2002, and 2030. The base years (2000 and 2002) have been selected due to the availability of observed transit data for those two years:

- 2000 Regional Bus Survey, conducted by WMATA
- 2002 Metrorail Survey, conducted by WMATA

This chapter documents region-level modeling results for these the two base years: 2000 and 2002.

The second step, in the implementation of a COG/TPB nested logit mode choice model, would be to perform a "static calibration" of the AECOM mode choice model. In the static calibration, the AECOM mode choice model is applied using AEMS in the standard post-processed way, but for four models (HBW peak, HBS off peak, HBO off peak, and NHB off peak), not the six that were used by AECOM. Additionally, the static calibration would be done using the AECOM market segmentation of four household income categories, not the exiting COG/TPB market segmentation of three car ownership categories (0, 1, 2+ vehicles). The third and final step, "dynamic calibration," would be to re-calibrate the statically calibrated nested logit mode choice model by placing the model within the speed feedback loop (after trip distribution, but before traffic assignment).

4.2 *Year 2002*

The year-2002 model run was performed before the year-2000 model run, since it was one of the two years tested by AECOM for WMATA. Table 4-1 compares estimated and observed year-2002 "Metrorail-related" trips on an average weekday for the COG/TPB modeled area. A "Metrorail-related" trip includes Metrorail only trips and Metrorail with bus trips, but excludes trips using both commuter rail and Metrorail (this last category is grouped under the commuter rail mode and cannot be broken out). The AECOM/WMATA mode choice model groups home-based shop and home-based other together, so that has been done in the table below. At the regional level, for the Metrorail mode, the AECOM/WMATA post-process mode choice model matches the observed travel quite well. The model predicts 606,000 daily Metrorail trips, which is less than 1% over the 602,000 observed Metrorail trips.

Table 4-1 Estimated and observed year-2002 Metrorail-related trips for the COG/TPB modeled area

	Estimated	Observed	Absolute Difference (Est-Obs)	Percent Difference (Est/Obs)
HBW	417,537	410,356	7,181	1.75%
HBS & HBO	82,397	86,853	-4,456	-5.13%
NHB	105,802	104,339	1,463	1.40%
Total	605,736	601,548	4,188	0.70%

Notes:

1. Estimated Metrorail-related trips include the following modes from the AECOM/WMATA mode choice model (mode number and mode): 7) WK-MR, 13) PNR-MR, 14) KNR-MR, 6) WK-BU/MR, 11) PNR-BU/MR, and 12) KNR-BU/MR. It does not include the commuter rail modes [4) WK-CR, 8) PNR-CR and KNR-CR], even though these modes could include some Metrorail travel, too.
2. Observed data is from the 2002 WMATA Metrorail Survey and is for an average weekday.
    a. Commuter rail access trips have been removed from observed Metrorail trips
    b. HBW & HBO include only travel by residents of the region.
    c. NHB includes both resident and non-resident.
    d. Source: v21d50_aecom_transitByMode.xls, met02cont1.xls.
3. Travel model: COG/TPB, Version 2.1D #50
4. Land use: Round 6.4a, interpolated, 2000 and 2005
5. Network: 2002 from air quality conformity work
6. AECOM MC version: AECOM post-process MC, Feb 2006, DC PHBW MODE SPLIT - #DATE: 2/24/2005 #VER: 22
7. TP+ Version: 3.2.1
8. Model output locations:
    a. I:\ateam\model_dev\nest_log\MWCOG_2002_Model\2002_COG
    b. I:\ateam\model_dev\nest_log\MWCOG_2002_Model\2002_Transit\Run
9. Estimated data is from aecom_mc_summary3.s
10. Above table from regSum_cogMcAecomMc.xls

4.3 *Year 2000*

4.3.1 Network coding

When it developed its new post-process mode choice model, AECOM made several changes to transit access coding and pathbuilding. The changes were in five main areas: 1) the station database; 2) sidewalk links and zonal walk links; 3) zonal auto access links; 4) station links; and 5) zonal percent walk to transit. These coding changes are detailed in last year's end-of-year report (COG/TPB 2005d, page 4-5).

Given the new transit coding developed and adopted by AECOM for its nested logit mode choice model, COG/TPB staff needed to develop a new year-2000 transit network that incorporated this enhanced coding. There were two options:

1. Start with an existing year-2000 COG/TPB network. Add all of the transit enhancements needed in the AECOM model, or

2. Start with the year-2002 network from AECOM that already included the transit enhancements. Make all necessary changes to transit routes to reflect changes in transit service between 2000 and 2002.

It was decided that the latter approach – start with the enhanced 2002 network and modify it so that it reflects year-2000 conditions – was the most expeditious. The main change made to the 2002 transit network was the editing of transit line/route files (mode*.tb). For example, in 2001, Metro's Green Line was extended from Anacostia to Branch Avenue, and bus service was changed accordingly. But, in addition to this change, there were hundreds of changes made to transit route itineraries, headways, and run times, so that the service would correspond to the year-2000 paper schedules archived at COG/TPB. The inputs needed for a travel model run are shown on page 1-14 of the COG/TPB Travel Model (Version 2.1D #50) User's Guide (COG/TPB 2004). One of the inputs to the travel model is the share of each zone that is within walking distance to transit service, known as the "percent walk to transit." For each zone, the model needs to know the share of the zone that is within a short walk to transit, a long walk to transit, and beyond walking distance ("must drive"). The definition of "short" walk is different for the COG/TPB mode choice model and the AECOM mode choice model: In the COG/TPB model a short walk is defined as less than 1/3 mile; in the AECOM model, a short walk is defined as less than ½ mile (Both models define a long walk as less than 1 mile). Each of the two models has its own, off-line process to calculate percent walk to transit. The COG/TPB percent walk process was developed several years ago; uses a combination of SAS, ArcInfo, and manual editing of text files; and includes a number of additional calculations beyond percent walk, which tends to make the overall process slow and cumbersome. By contrast, the AECOM percent walk process has fewer requirements, so it can be run more quickly. After reviewing the AECOM process for calculating percent walk, COG/TPB staff from the GIS unit decided to develop its own new process (described later in this chapter). It should be noted that for the year-2000 model run, due to time limitations, the AECOM percent walk to transit process was not re-run. Consequently, the year-2000 model run uses the year-2002 percent walk to transit for the AECOM model and the year-2000 percent walk to transit file for the COG/TPB mode choice model.

4.3.2 Results

Table 4-2 compares estimated and observed year-2000 bus only trips on an average weekday for the WMATA Compact area.[6] Observed data comes from the 2000 WMATA and NVTC bus surveys. Estimated data comes from the AECOM/WMATA post-process mode choice model. The AECOM model overestimates the total number of bus-only trips by about 6% (359,000 estimated versus 338,000 observed). For the three trip purposes, the AECOM model ranges from 34% too high (HBW) to 32% too low (NHB). As can be seen from Table 4-1 and Table 4-2, tt is much more difficult to accurately predict bus trips than Metrorail trips.

In the upcoming fiscal year, we will conduct the static and dynamic calibration of the AECOM nested logit mode choice model, and will present jurisdiction-level summaries of results.

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[6] Washington, D.C., Montgomery County, Prince George's County, Fairfax County, Arlington County, Alexandria, and Loudoun County.

Table 4-2 Estimated and observed year-2000 bus-only trips for the WMATA Compact area

	Estimated	Observed	Absolute Difference (Est-Obs)	Percent Difference (Est/Obs)
HBW	229,491	171,149	58,342	34.09%
HBS & HBO	85,816	101,437	-15,621	-15.40%
NHB	44,167	65,402	-21,235	-32.47%
Total	359,474	337,988	21,486	6.36%

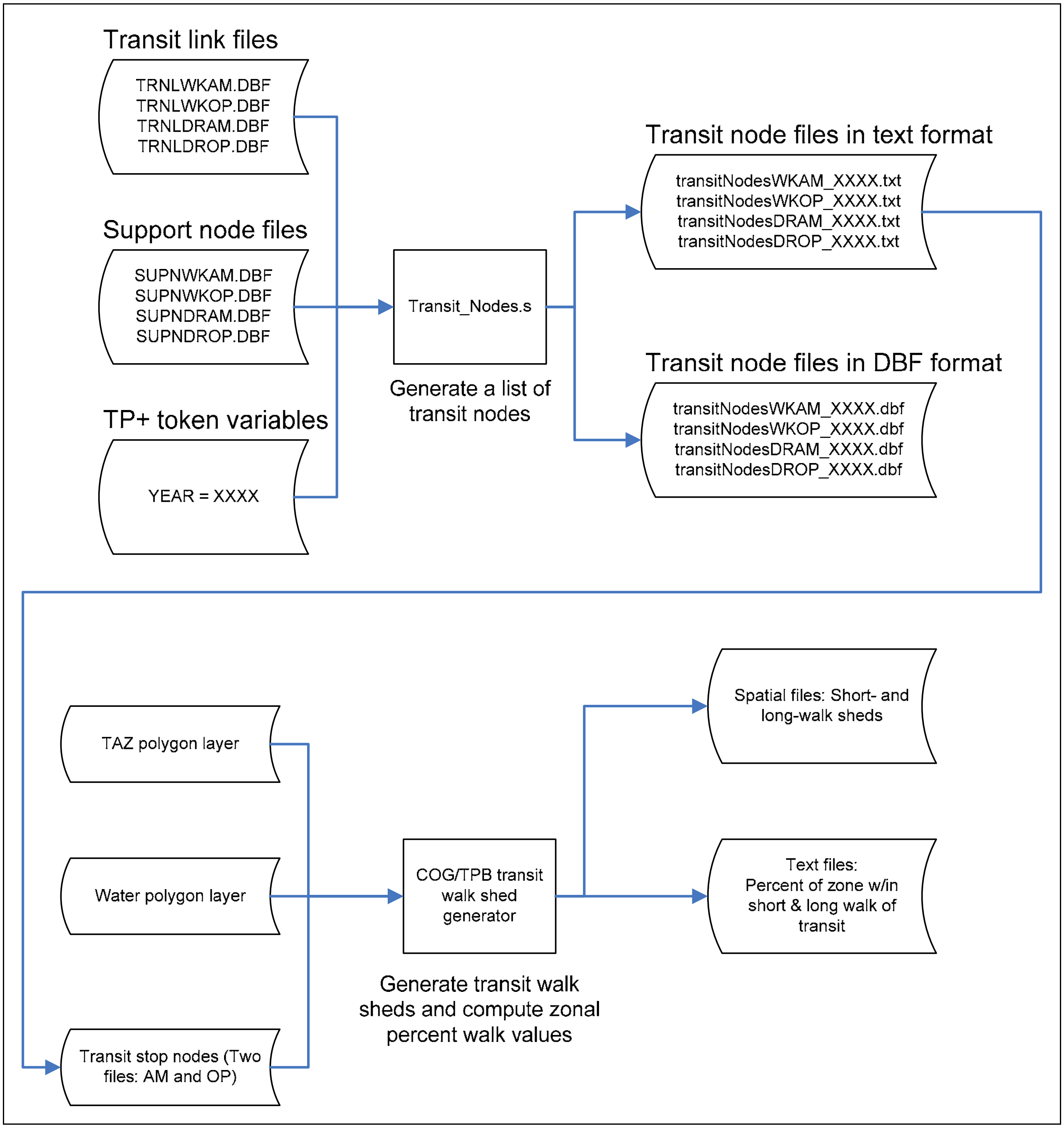
Notes:

1. Estimated bus-only trips include the following modes from the AECOM/WMATA mode choice model (mode number and mode): 5) WK-BUS, 9) PNR-BUS, and 10) KNR-BUS.
2. Observed data is from the 2000 WMATA & NVTC Bus Surveys (documented in a 2/5/04 memo by Hamid Humeida) and is for an average weekday.
3. Travel model: COG/TPB, Version 2.1.054 (TB route files in inputs)
4. Land use: Round 7.0, 2000
5. Network: 2000, derived from AECOM 2002 with enhanced transit access coding
6. AECOM MC version: AECOM post-process MC, Feb 2006, DC PHBW MODE SPLIT - #DATE: 2/24/2005 #VER: 22
7. TP+ Version: 3.2.1
8. Model output locations:
   a. I:\ateam\model_dev\nest_log\aecomppmc_2.1.054_2000\2000_cog_rnd70
   b. I:\ateam\model_dev\nest_log\aecomppmc_2.1.054_2000\2000_transit\Run
9. Estimated data is from aecom_mc_summary3.s, aecom_mc_summaryBusOnly.s
10. Above table from regSum_cogMcAecomMc.xls
11. AECOM MC model does not include external trips.

4.4 *Percent walk to transit*

This section describes a procedure developed by COG/TPB GIS staff to generate zonal walk percents in support of the AECOM nested logit model. (The percent walk process was described earlier, in section 4.3.1). The process for generating transit walk sheds and computing zonal percent walk to transit is shown in schematic form in the bottom half of Figure 4-2. Before this process can be executed, one must generate a list of transit nodes, which is shown in the top half of Figure 4-2.

Figure 4-2 COG/TPB process for generating a list of transit nodes, transit walk sheds, and zonal percent walk to transit values



Source: pctWalkTransitYY.vsd

To generate a list of transit nodes, the Transit_Nodes.s TP+ script needs three inputs: 1) A set of "transit link" files, 2) a set of "support node" files, and 3) a four-digit token variable representing the year of interest. The "transit link" files and the "support node" files are both generated as a matter of course from the travel model. The output of the Transit_Nodes.s program is a set of transit node files, in both text and DBF format. For example, using a text file format, the program outputs:

- transitNodesDRAM_2002.TXT (Drive-access transit, AM peak period)
- transitNodesDROP_2002.TXT (Drive-access transit, off peak period)
- transitNodesWKAM_2002.TXT (Walk-access transit, AM peak period)
- transitNodesWKOP_2002.TXT (Walk-access transit, off peak period)

Each output file contains the node number, the x and y coordinates, a flag to indicate whether a node is a Metrorail station (1=> yes, 0=>no), and a flag to indicate whether a transit node is a stop node (1=> yes, 0=>no), or simply a node through which the transit route passes.

The second half of Figure 4-2 shows a schematic representation of the process used to generate transit walk sheds and compute zonal percent walk values. The inputs to this second process are 1) a TAZ polygon layer, 2) a water polygon layer, and 3) two transit stop node files – AM and off peak. The output of the walk shed process is 1) a set of spatial files (short and long walk sheds to different transit markets), and 2) Text files containing the calculated zonal percent of a zone within short and long walk to transit. This walk shed process is implemented in ArcGIS (Version 9) and Visual Basic (COG/TPB 2006a). The process will be tested in the upcoming fiscal year.

4.5 *FTA's Summit user benefits computer program*

Summit is the Federal Transit Administration's software program for calculating user benefits and producing cost-effectiveness information needed as part of FTA's "New Starts" program. Summit enables various benefit measures to be calculated in tabular and graphical form for very detailed sub-markets. In addition to being used for FTA's New Starts program, the detailed program output of Summit can be used to reveal problems associated with mode choice model specifications, network coding, and even traffic assignments. In the previous fiscal year (FY-2005), COG/TPB was one of several MPOs taking part in an FTA working group, known as Working Group on Travel Forecasting for New Starts Projects. FTA asked several of the MPOs in this working group, including COG/TPB, to undertake some sensitivity testing to better understand the equilibrium assignment issue as pertains to Summit. This work was completed in FY-2005 and submitted to the FTA, but, has not yet been published. This fiscal year (2006), COG/TPB staff has not run Summit, but has continued to keep abreast of developments with the Summit computer program. There were two main developments this fiscal year. First, in April 2005, a Summit User's Guide was released. Second, in June, the FTA offered a two-day workshop entitled Travel Forecasting for New Starts Proposals, held June 15 and 16 in Minneapolis, Minnesota.

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Chapter 5 Traffic Microsimulation Training

5.1 *Motivation*

Recently, in the Washington area, there have been a number of proposals for new toll roads, including high-occupancy toll (HOT) roads, where single-occupant vehicles pay a toll to use the facility, but high-occupancy vehicles are allowed on for free or for a reduced toll. In Northern Virginia, the private sector has proposed constructing HOT lanes on the Beltway and on I-95/I-395. Given the importance and preponderance of these types of proposals, it was felt that COG/TPB staff should have the ability to analyze the feasibility of new HOT lane facilities, particularly regarding issues such as the development of traffic queues and congestion due to traffic blocking back over multiple links or road segments. Unfortunately, the macroscopic-scale, four-step travel models normally used by COG/TPB do not have the ability to represent traffic queues. To represent such queuing phenomena, one must use either a mesoscopic traffic model, such as dynamic traffic assignment (DTA), or a microscopic traffic model, such as Citilabs' Cube Dynasim, PTV's VISSIM, or Quadstone Paramics. It was decided to purchase one copy each of Cube Dynasim and Cube Avenue (Citilabs' implementation of dynamic traffic assignment), along with five days of training. The Citilabs products were selected because it was thought that, since COG/TPB staff already uses Citilabs software for travel demand modeling and network development, the Citilabs products would be the easiest to integrate with existing work and, consequently, the quickest to get up and running. In May and June of 2006,[7] COG/TPB staff received five days of training in the following Citilabs software packages:

- Cube Dynasim (Traffic microsimulation)
- Cube Analyst (Matrix estimation & adjustment), formerly called Cube ME
- Cube Avenue (Dynamic traffic assignment), formerly called Cube DTA
- Cube Applications Manger (Flowcharting modeling processes)

5.2 *Macroscopic, mesoscopic, and microscopic traffic models*

Conceptually, one can think of traffic modeling as occurring at three different scales: Macroscopic, mesoscopic, and microscopic. The term macroscopic is used to describe the largest scale of modeling traditionally employed by planners to model all of the travel over a large regional area. To run such a model for a large area in a reasonable amount of time, a macroscopic model makes many aggregations and simplifications of the system being modeled. The four-step, trip-based travel model used by planners all over the world is a good example of a macroscopic travel model. Macroscopic traffic models are generally used for making long-range forecasts for large areas (e.g., an entire urban area, state, or country). Consequently, they rely on relatively simple models of the traffic, with a minimum of operational detail. Limitations of macroscopic traffic models include (Citilabs 2006):

- Usually consider only link-based volume delay functions (i.e., no delay at nodes or intersections);
- Does not consider queuing effects of congested links;
- Does not consider delay through intersections, merge/diverge areas, and weaving areas;

[7] May 11, 12, and 26; June 20 and 21, 2006.

- Assumes that there is no variation in demand through the analysis period, generally a peak period, off-peak period, or a peak hour.

In a macroscopic traffic model, a vehicle trip follows a specific origin-destination path through a network, and can be though of as existing on all links in that path simultaneously (during the analysis period).

By contrast, mesoscopic traffic models are more detailed than macroscopic travel demand models, but less detailed than microscopic traffic microsimulation models. Cube Avenue or DTA (dynamic traffic assignment) is the Citilabs software package for developing a mesoscopic traffic model. With mesoscopic models, it is still possible to analyze large urban areas, but its more detailed representation of traffic, allows for the following enhancements over a macroscopic analysis:

- Takes into account intersection configurations and controls;
- Includes more detailed estimates of delay, travel time, and capacities;
- Enforces capacity limitations and the effects of queues;[8]
- Can incorporate demand and volume-delay functions that vary through the analysis period;
- Allows vehicles to respond to traffic conditions and change their route through the network.

A mesoscopic traffic model represents traffic as platoons of vehicles traveling through the network. A platoon can exist on one or several connected links, but would rarely exist on all links in a path simultaneously (as is the case with the macroscopic model).

Lastly, a microscopic traffic model is the most detailed representation of a vehicle's movement through a network, typically including the following elements (Citilabs 2006):

- The roadway geometry (lanes, turning lanes, weaving areas, exclusive lanes);
- The physical size of different types of vehicles;
- Details of traffic control (signal timing, phasing, geometric configurations).

Whereas macroscopic traffic models are generally deterministic, microscopic traffic models are generally stochastic (random), which means that every time one runs a traffic microsimulation, one could get a slightly different answer. Consequently, when performing traffic microsimulation, one should make multiple runs and average the results. There are generally two types of traffic microsimulation models: 1) Discrete time and 2) Discrete event ("event-driven"). In a discrete-time model, the system is updated at discrete time intervals. Most discrete-time models employ a 0.1-second time interval. TRANSIMS is a suite of traffic microsimulation software developed by the federal government and is also a discrete-time model, but it uses 1-second time intervals, since it is designed to simulate an entire urban area. In a "discrete-event" model, time intervals vary – the system is updated each time an event occurs,

[8] In a macroscopic traffic model, there is no limit to the amount of traffic that can pass through a link. In other words, volume-to-capacity ratios above 1.0 are common. In the four-step model, as the V/C ratio gets larger, the congested link speed goes down (often approaching zero asymptotically), which acts a signal that fewer and fewer vehicles should be loaded onto that link, but there is nothing inherent in the model that keeps the volume from surpassing the capacity.

i.e., something changes in the system. In a discrete-event model with lots of objects that are changing frequently, the model generally approaches a discrete-time model. Dynasim is an example of a discrete-event model.

Outputs from a traffic microsimulation include:

- Speeds
- Travel times across user defined sections of the network
- Delays at junctions, by movement, approach, and for the junction overall
- Speed-flow curves
- Speed-density information
- Summaries of traffic control indications and responses

Because of its high level of detail, traffic microsimulation models are able to produce an animation of individual vehicles moving through the network. These animations can be a very compelling way to show the public or decision makers what is likely to happen in the scenario.

The main drawbacks to traffic microsimulation include:

- Due to the detailed nature of the traffic simulation, microsimulation models run slowly, and cannot generally be run for an entire urban area (with the exception of TRANSIMS, which is still, in many respects, under development).
- These models are even more data hungry than the four-step, regional, trip-based model. It can be difficult to get all the data needed. Networks need much more detail, in terms of geometry, lane trajectories, turning movements, and traffic control devices (signalized or unsignalized, signal phasing and timing).

In the upcoming fiscal year, FY-2007, COG/TPB staff hopes to use the new traffic microsimulation software to analyze feasibility of one or more proposed HOT lane projects. Given the fact that several of these proposed projects are quite long (over ten miles in both the case of I-495 and I-395/95) and the fact that staff is just beginning to work with this new software, an initial approach might be to model and simulate only one or two critical sections of the facility, such as the 14th Street Bridge section of I-395 or the Tysons Corner area of I-495, to examine queue formation and its ramification on the proposed facility and surrounding roads.

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Chapter 6 Airport Modeling Improvements and Status

Airport auto driver travel is addressed in the Version 2.1D #50 model as exogenous trip tables that are prepared individually for base and future years. Trip tables represent ground vehicle trips that are associated with daily air passenger travel to and from the three primary commercial airports in the Washington region: Dulles International Airport (IAD), Baltimore/Washington International Thurgood Marshall Airport (BWI), and Ronald Reagan Washington National Airport (DCA).

The base-year, airport-passenger, auto-driver trips are developed from air passenger surveys. Future year trip tables are developed using the base year trip patterns and a Fratar-type extrapolation technique. The last such trip table was developed with a 1998 base year air passenger survey (COG/TPB, 2001, Chapter 6). During FY-2006 a revised set of airport auto driver trip tables was produced as before using the COG 2000 Regional Air Passenger Survey as a basis for base year patterns. This chapter describes that effort and discusses plans for further work in this area.

6.1 *Refinement of Existing Airport Auto Driver Trips*

The COG 2000 Air Passenger Survey was used to develop base-year auto driver trip patterns as a basis for formulating future trip tables. The survey was conducted from October 15-28 at the three major airports serving the Washington region, including both weekday and weekend travel. A total of 7,723 departing passengers were survey interviewed. Approximately 78% of these air passengers began their trips as local originations from the modeled region. The information obtained from the survey included the type of airport trip (i.e., whether it was a local origination versus a connecting flight), place of residence, ground access mode, and the local place of origination.

The survey weighting factor is designed to reflect annualized air passenger travel. Because the travel model is designed to reflect average weekday travel, two special processing steps were undertaken in the development of daily auto driver trips:

1) Weekday trip records were selected from the survey. Weekend travel records were not considered.
2) The annualized weighting factor on each weekday record was adjusted to arrive at a weighted weekday figure. The annualized weighting factor was divided by the number of weekdays in the year: 260.

Automobile driver trips relating to private car, rental car, and taxi modes were developed as one-way trips to the airport by purpose: Home-Base (HB) and Non-Home-Based (NHB). Although both residents and non-residents of the modeled area are distinguishable from the survey, they were combined for the purposes of this work. Therefore HB travel includes both residents and non-residents.

Air travel was geographically coded to 160 Aviation Analysis Zones (AAZs). The AAZ system extends well beyond the TPB modeled area, into Baltimore area counties. 131 of the 160 AAZs are located within the TPB modeled area.

After building one-way base-year auto driver trip tables by purpose, the trips were factored at the AAZ level using a Fratar-based approach. Growth at the airport-end of the trip was controlled to the passenger enplanement forecasts specific to each airport (COG/TPB, 2005a). Growth at the non-airport-end was based on Round 7.0 Cooperative Forecasts and differed based on the trip type. NHB travel was controlled to employment growth while HB travel was controlled to household growth. The resulting one-way trips were ultimately converted to daily format trips assuming directional symmetry (i.e., for each trip *to* the airport was an implied trip *from* the airport). The trip tables were subsequently 'split' from AAZ level to the TAZ level based on household- and job-based pro-ration. The resulting trip totals are shown on Table 6-1 (in tabular) and on Figure 6-1 (in graphical form). Data processing steps are shown in Figure 6-2

Table 6-1 Daily Auto Driver Air Passenger Trips by Airport– Base and Forecast Years

Year	National	Dulles	BWI	All
2000	18,746	16,585	14,486	49,723
2001	18,345	16,596	14,810	49,657
2002	17,942	16,606	15,134	49,588
2003	17,541	16,617	15,459	49,522
2004	17,139	16,627	15,783	49,453
2005	16,738	16,638	16,107	49,386
2006	17,225	18,415	17,332	52,871
2007	17,714	20,191	18,558	56,356
2008	18,204	21,968	19,784	59,844
2009	18,693	23,744	21,010	63,329
2010	19,181	25,521	22,236	66,814
2011	19,380	27,476	23,125	69,852
2012	19,579	29,431	24,015	72,891
2013	19,777	31,387	24,905	75,928
2014	19,977	33,342	25,795	78,967
2015	20,176	35,298	26,684	82,006
2016	20,372	36,782	27,344	84,343
2017	20,570	38,267	28,003	86,680
2018	20,770	39,752	28,664	89,021
2019	20,967	41,236	29,323	91,358
2020	21,164	42,721	29,983	93,695
2021	21,360	43,696	30,376	95,254
2022	21,557	44,671	30,769	96,815
2023	21,756	45,647	31,161	98,378
2024	21,953	46,622	31,554	99,938
2025	22,149	47,597	31,946	101,498
2026	22,345	48,682	32,338	103,166
2027	22,542	49,767	32,730	104,837
2028	22,742	50,852	33,123	106,512
2029	22,940	51,937	33,516	108,182
2030	23,135	53,022	33,907	109,851

Figure 6-1 Daily Auto Driver Air Passenger Trips by Airport– Base and Forecast Years

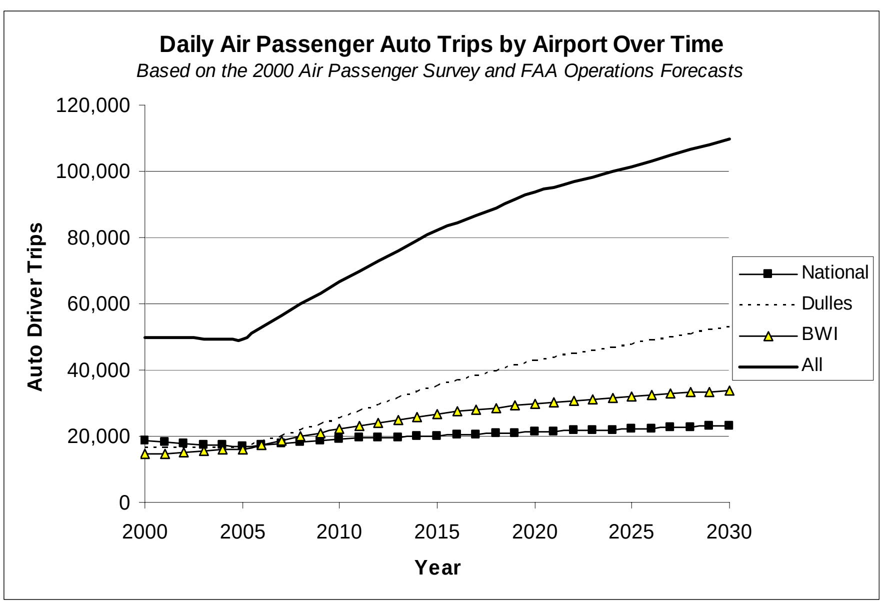
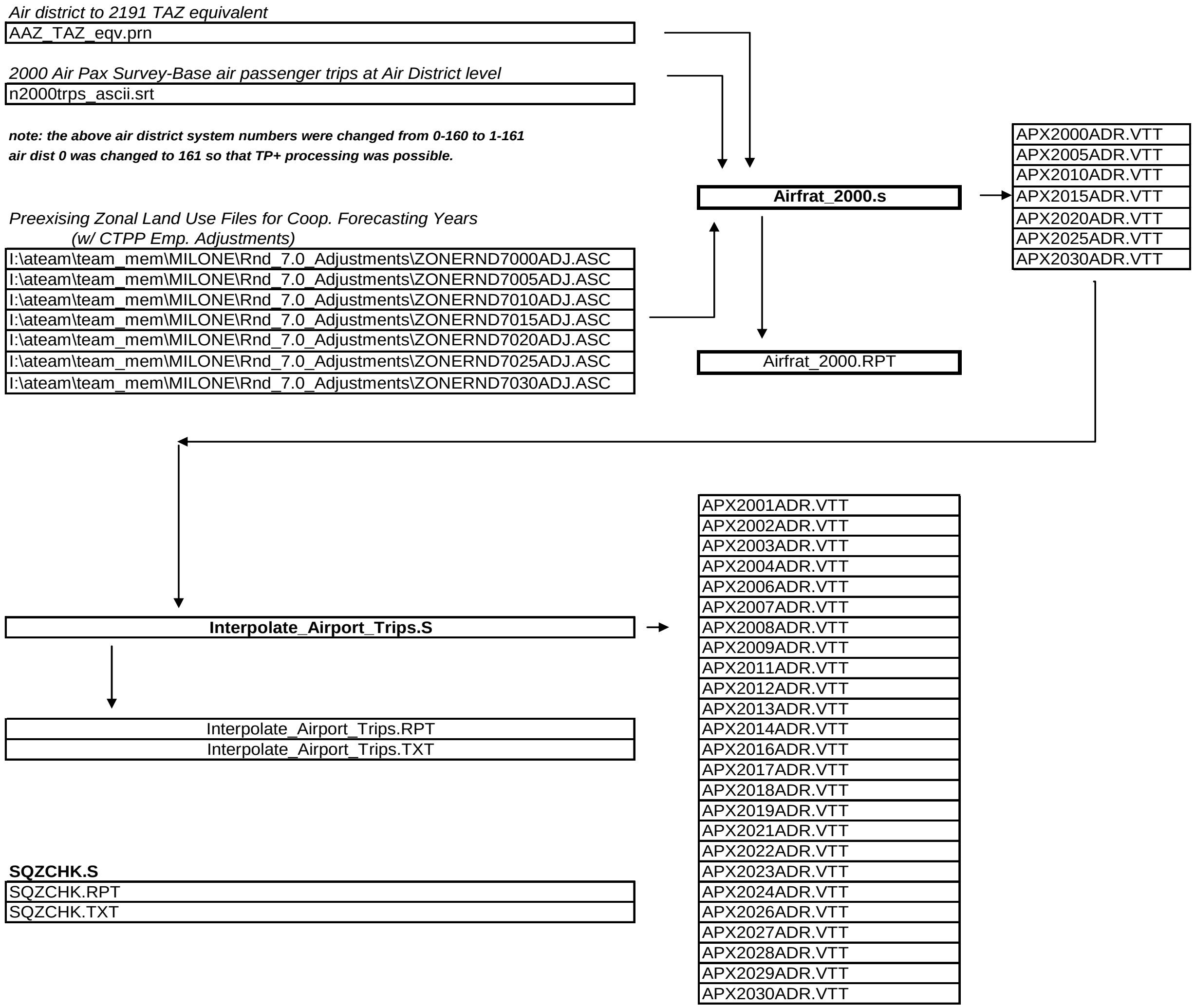


Figure 6-2 Airport Auto Driver Data Processing

Airport Auto Driver Trip Development
SubDirect: I:\ateam\mod_inputs\airport\2005-12-01
12/2/2005
Programmer: RM



6.2 *Future Airport Work*

The currently adopted approach for addressing airport ground access travel is one that takes advantage of recently collected data and one that works within the framework of the regional travel model. COG has reviewed more elaborate techniques to forecast airport access trips (COG/TPB, 2005b) but the data and resource requirements are substantial, particularly for an area with three viable airports to choose from. It is known that transportation considerations are important factors in the selection of an airport, but ticket price is frequently the key determinant of the airport choice. This item is difficult to collect and even more difficult to forecast. Nonetheless, TPB will commit to keep abreast of developments in the field of airport choice modeling.

6.3 *References*

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Chapter 7 National MPO Collaboration

TPB has assumed a prominent role in promoting an Association of Metropolitan Planning Organizations (AMPO) technical committee known as the AMPO Travel Modeling Working Group. It is comprised primarily of travel forecasters working at MPOs of varying size. The mission of the committee is to promote understanding between modelers regarding current methods being used in practice and to discuss issues relating to acceptable standards and practice. The committee also serves to promote communication between MPOs and federal representatives from the Department of Transportation and the Environmental Protection Agency. Meetings occur twice each year, usually at a mid-western location.

During FY-2006, the subcommittee met in Berkeley, California on September 8 and 9, and in Houston on March 20 and 21. This chapter touches on the areas of discussion addressed at the meetings.

7.1 *The September Meeting in Berkeley, California*

The September AMPO meeting in Berkeley California was a two-day meeting. The first day focused on a variety of topics, including:

- The status of the ongoing TRB study aimed at determining of the state-of-the practice in urban transportation planning;
- The use and current status of the U.S. Census;
- A description of an UrbanSim implementation for Houston;
- A status report on an activity modeling implementation in Denver;
- A status report on the Federally sponsored TRANSIMS study and the status of the TMIP program; and
- A discussion on the specification of speed feedback linkages in transportation models.

During the morning of the second day, a joint meeting of the AMPO group and the committee overseeing the TRB ‘determination’ study was held. A presentation on the preliminary findings of an MPO survey was made. Several MPOs representatives were asked to provide input to the committee, regarding the findings of the survey, and regarding the next steps of the study.

7.2 *The March Meeting in Houston, Texas*

The March AMPO meeting in Houston, Texas was a two-day meeting. This particular conference addressed a number of topics:

- The travel model improvement plans for the Washington and Baltimore metropolitan areas were presented;
- FHWA presented on the relationship between the new SAFETEA-LU reauthorization and the federal transportation research program;

- New developments in activity modeling were discussed; and
- Newly published TRB-TCRP reports on Travel Response to Transportation System Changes were presented.

7.3 *Outlook*

This forum has proved to be a well attended forum for sharing information within the travel forecasting community. It has become clear to TPB that MPOs can benefit substantially by participating in this group.

Chapter 8 Advanced Modeling Methods

The COG/TPB models development program is divided into five main tracks:

1. Application track
2. Methods development track
3. Research track
4. Data collection track
5. Maintenance track

It is this third track, the research track that is the subject of this chapter. The research track entails activities that keep staff abreast of the latest advances in modeling from academia and from research and development firms. It includes participation in conferences, research efforts supported by the TPB, and the review of technical publications and periodicals. COG/TPB staff attended two conferences that covered advanced modeling methods, and also state-of-the practice methods, both sponsored by the Transportation Research Board:

1. TRB 85th Annual Meeting, Washington, D.C., January 22-26, 2006
2. TRB Innovations in Travel Demand Modeling Conference, Austin, Texas, May 21-23, 2006

COG/TPB staff has also been following the White House Area Transportation Study (WHATS), a study being conducted by the U.S. Federal Highway Administration and its consultants to determine ways to mitigate the negative traffic impacts caused by street closures around the White House in 1995 and 2001, primarily Pennsylvania Avenue, NW and E Street, NW. The WHATS study is using the advanced TRANSIMS model and its second-by-second traffic microsimulation.

8.1 *TRB 85th Annual Meeting*

The 85th Annual Meeting of the Transportation Research Board was held January 22-26, 2006 in Washington, D.C. What follows are some of the lessons learned.

8.1.1 Activity-based models

<u>TRANSIMS</u>

TRANSIMS is currently being used in two places for real world studies: Portland, Oregon and the White House Area Transportation Study. This section discusses its use in Portland, as described at the TRB conference. The Portland TRANSIMS model is continuing to be validated. One of the lessons of the Portland work is that the transportation network can be coarser than was originally thought. The original concept for the network was:

- Network made of TIGER street centerlines;
- Actual transit schedules;
- Actual intersection control and timing plans;
- Actual lane connectivity through intersections.

The revised concept is that the coarser, EMME/2 networks can be used, provided the following updates and additions are made:

- Pocket lanes;
- Activity locations (generally two per link);
- Parking locations (generally two per link);
- Lane connectivity through intersections (start with synthetic data);
- Signal and sign warrants (start with synthetic data);
- Detailed transit coding (e.g., bus stops cannot be at nodes – there must be an offset);
- Synthetic transit schedules derived from the MPO travel model transit schedules.

The EMME/2 network has 1,260 zones, whereas the TRANSIMS model has 20,000 activity locations. The TRANSIMS "traffic assignment" is actually an iterative process of running the Router (building paths through the network) and running the Traffic Microsimulation (simulating vehicle interactions on these paths). Travel behavior emerges through feedback of the Router and Traffic Microsimulator. Peak spreading automatically goes on in the "assignment." As of January 2006, there were still some issues with the traffic microsimulation:

- Lost vehicles: Some vehicles get "lost" in the simulation, because they cannot complete a necessary turn or other movement. The lost vehicle rate was 10 to 15%, but now it is 1.3%, which is considered very good compared to other simulation models.
- Screenline validation: The model was 7 to 10% low, but now it is only 0.3% low.
- Simulation fidelity: The original fidelity of the simulation used default values: 1 second and 7.5 meters. TRANSIMS is hardwired so that this 1-second value cannot be changed. However, one can trick TRANSIMS into thinking it is working with 1/2-second resolution, by "re-scaling." This was done in Portland, so the effective values are now 0.5 second and 3.75 meters.

<u>NYMTC Best Practices Model</u>

The New York Metropolitan Transportation Commission (NYMTC) used a consultant to develop an activity-based travel model called the Best Practices Model or BPM. Development occurred from 1995 to 2002. The model includes three states, 10 MPOs (not just NYMTC), 28 counties, 4,000 TAZs, and 52,000 highway links. The main calibration data set was the 1997/1998 Household Travel Survey. Run times, which originally had been 10 days, dropped down to seven days, and are now around three days, which NYMTC hopes to further reduce using parallel processing. The basic unit of the model is "pairs of journeys," which is similar to tours, but not exactly the same. The model uses demand microsimulation, but not traffic microsimulation. The traffic assignment is done using TransCAD 4.0. The model was validated to a 1996 base year, and then was re-validated to 2002. Two components of the model take 99% of the run time: 1) Location choice: 23×10^6 tours x 4,000 zones; and 2) Multi-class assignment: 4,000 zones x 4,000 zones x 6 highway tables x 4 times of day. NYMTC plans to make model results available on its web page.

8.1.2 Cell phones and travel surveys

Cell phones are an issue that will need to be addressed in future household travel surveys, due, in part, to the fact that there are more and more households with no landline telephone. For example, in 2005, 9% of households in the U.S. had no landline telephone (7% were wireless only households; 2% had no phone service whatsoever). Wireless-only households are more likely to be renters and younger people. Mike Brick from WESTAT pointed out several issues regarding interviews conducted on cell phones:

- Cost to respondents (weekend minutes vs. weekday minutes);
- Safety and privacy concerns;
- Pre-notification (Use of text messaging?);
- Cell phone response rates are even lower than landline;
- Text messaging was not very successful in pretests. Offering $5 to $10 to reimburse for cost of call was more successful;
- Virtually all CDMA cell phones are GPS equipped, but few service providers offer services that use GPS (it is used mainly for 911 calls).

8.1.3 Vendor booths

Citilabs is introducing a new feature called "distributed processing." This will allow the processing of model runs to be distributed across two or more connected computers, reducing substantially the model run times. Each computer must have Voyager/TP+ installed on it. COG/TPB staff received a demonstration of distributed processing at TRB. (As of June 2006, COG/TPB staff has a copy of Voyager/TP+ with distributed processing, which we plan to test in the upcoming fiscal year.

8.2 *TRB Innovations in Travel Demand Modeling Conference*

The Innovations in Travel Demand Modeling Conference was held in Austin, Texas from May 21-23, 2006. This two-and-a-half day conference was sponsored by the Transportation Research Board and had about 200 attendees. The conference had two main goals:

- Explore the state of the art in travel demand forecasting techniques and survey data collection techniques;
- Focus on exchange of ideas between researchers and practitioners regarding recent advances in travel modeling, opportunities and challenges related to implementation, and directions for further research and development.

The following sessions were attended by the two COG/TPB staff:

- Sunday
    - Workshop 1 – Innovations in Practice
    - Workshop 2 – FTA Findings for Meaningful Forecasts
- Monday
    - Plenary Session 1 – Overview of the Policy Issues
    - Plenary Session 2 – Moving Innovative Models into Practice
    - Breakout session 1A – Tour Based Models
    - Breakout session 1B – Data and Synthetic Populations
    - Breakout session 2A – Activity Based Models
    - Breakout session 2C – Assignment Advances
- Tuesday
    - Breakout session 3A – Education and Outreach

- Breakout session 3C – Validation
- Breakout session 4A – The Secret is in the Segue…Transitioning to a New Model Framework
- Lunch and Plenary Session – Next Steps: Institutional Issues

What follows are some of the lessons learned.

8.2.1 TRANSIMS

The Federal Highway Administration (FHWA) has recently issued a Broad Agency Announcement (BAA), which is similar to a request for proposals (RFP), whose goal is to broaden the TRANSIMS user base and to provide for applications of TRANSIMS representing a diversity of populations, geographic regions and analytical methods. The idea is to get new agencies to try out TRANSIMS, offering some federal funding to help the agencies conduct the tests. The government anticipates $400,000 will be dedicated to this program, but it is also anticipated that no single proposal or organization will receive more than $200,000 of the federal funding. Details are available at the Federal Business Opportunities web site (www.fedbizopps.gov). TRANSIMS software is now available as open source code, for interested research organizations. The two main uses of TRANSIMS are in Portland, Oregon and for the White House Area Transportation Study. The Portland TRANSIMS model is still undergoing validation. The White House Area Transportation Study is described later in this chapter.

8.2.2 Data

Unfortunately, as travel models become more complex, observed data is becoming harder and harder to obtain. For example, there are no plans to continue the American Travel Survey (ATS), a survey about long-distance travel of persons living in the United States, conducted by the Bureau of Transportation Statistics (BTS). Funding is uncertain for the National Household Travel Survey (NHTS), formerly called the Nationwide Personal Transportation Survey (NPTS). The last NHTS was conducted in 2001. The American Community Survey (ACS) is the new survey designed to take the place of the Census long-form. Unlike the Census long-form, a one-in-six sample, conducted every ten years, the ACS is to be a smaller sample conducted annually. Unfortunately, there are concerns that, due to non-disclosure issues regarding confidentiality of survey information summarized for small geographic areas or market segments, transportation planners may not be able to get useful trip tables from the ACS. The foregoing raises the importance of the upcoming COG/TPB household travel survey, a survey of roughly 10,000 households, surveyed about a travel day occurring on a given weekday.

8.2.3 TRB Determination of the State of the Practice in Travel Forecasting

The FHWA, FTA and Office of the Secretary of Transportation have funded the National Academy of Sciences (NAS) to conduct a "Determination of the State of the Practice in Travel Forecasting." This project will gather information and determine the state of the practice of metropolitan travel demand modeling by metropolitan planning organizations and state departments of transportation (http://rip.trb.org/browse/dproject.asp?n=10824). Findings from the survey of MPOs are available on the web (http://onlinepubs.trb.org/onlinepubs/reports/BMI-SG-Sept2005-Draft.pdf), but the full study will not be available till January 2007. Marty Wachs, Director of the Transportation, Space, and Technology Program at the Rand Corporation presented some of the results and some of his own observations on the study. Of 381 MPOs, 228 responded to the survey. There were in-depth interviews conducted on 13 MPOs. According to Wachs, in 1993, Harvey and Deakin found that the travel models were not up to the tasks at hand (Deakin & Harvey 1993). Since that time, there have been many improvements, including greater use of GIS, better algorithms, more feedback loops, and more zones, but the modeling tasks have also become more complex and data inputs remain a problem. According to Wachs, the two biggest data problems are

- Many areas develop land use forecasts using a negotiated process;
- Sample sizes are small and data are out of date.

Mr. Wachs felt that progress in advancing the state of the art in modeling is slow, giving the following examples:

- Only 11 out of 228 MPOs are using destination-choice trip distribution models;
- Fewer than 50% of large MPOs distribute *person* trips (versus *vehicle* trips);
- Twenty-two MPOs are engaged in "New Starts" projects to seek federal funding for a new fixed-guideway transit project, but have no mode choice model;
- Truck trips are modeled by 80% of large MPOs, but the methods are often crude or outdated;
- Only one MPO reported that it is actually using an activity-based model set. Two MPOs had tried tour-based models, but then later abandoned them. The vast majority of MPOs stated that they have no interest in activity-based and/or tour-based approaches.

Mr. Wachs felt that the level of practice is unacceptable. For example, model validation is not done at all by most agencies. Where validation *is* conducted, it usually consisted of a screenline validation of just the traffic assignment step. Mr. Wachs listed the following "pressing issues":

- Error propagation through chains of models: It is not discussed, presented, or known by modelers;
- Poor representation of prices;
- Poor representation of goods movement;
- Point estimates support policy making poorly;
- Models are difficult to apply to new policy issues, e.g., evacuation, terrorism, hurricanes;
- Poor representation of non-resident travel, even though conventions & tourism account for a growing percentage of travelers.

Mr. Wachs concluded with three points: 1) MPOs need to advocate for more resources; 2) We need more federal leadership; 3) MPOs may want to consider a pooled funding effort.

8.2.4 Activity-based models

Mark Bradley, Principal Mark Bradley Research and Consulting, made a presentation summarizing the use of activity-based (AB) models in the U.S. There are currently ten areas in the U.S. that are either developing, have developed, or are using activity-based travel models (See Table 8-1). Typically, a model that is activity-based is also tour-based, but a tour-based travel model is not necessarily activity based. Six of these models could be categorized as in the developmental stages. Four of these models have been used in practice, though one area, San

Francisco County, is not an MPO and the model requires inputs from the MPO trip-based model. Additionally, Portland's AB model, developed in 1998 and not related to the MPOs work with TRANSIMS, is not currently being used. This leaves only two areas, the New York Metropolitan Transportation Council (NYMTC) and the Mid-Ohio Regional Planning Commission (MORPC), as MPOs that are using AB models in production work.

Table 8-1 Status of activity-based travel models in the U.S.

Area	**Status**
Portland Metro	Used in the past, but not currently being used
San Francisco County *	In use, but requires the MPO (MTC) model
NYMTC	In use
Columbus, OH (MORPC)	In use
Atlanta (ARC)	Under development
Sacramento (SACOG)	Under development
San Francisco MPO (MTC)	Under development
Denver (DRCOG)	Under development
Dallas (NCTCOG) CEMDAP	Under development
SE Florida FAMOS *	Under development

* Not an MPO.

Despite being activity-based models, all ten of these implementations rely on demand microsimulation, but static traffic assignment (the same assignment technique used by current-day, trip-based travel models). According to Mr. Bradley, the two main advantages of using demand microsimulation:

1. One is not limited to zone-level summaries. Trips are not stored in zone-to-zone trip tables. Data is stored in person-level lists.
2. One can use any market segmentation aggregation one wants, not simply items that were chosen at the start. For example, in a typical trip-based, four-step travel model, trips may be segmented by auto ownership (0, 1, 2+ vehicles per household). However, if one wants to get summaries by people over 16 years of age versus people 16 and under, one cannot do this, unless this was pre-designated in the trip-based model. The ability to choose all sorts of market segmentation schemes makes AB models ideal for equity analyses and Environmental Justice studies.

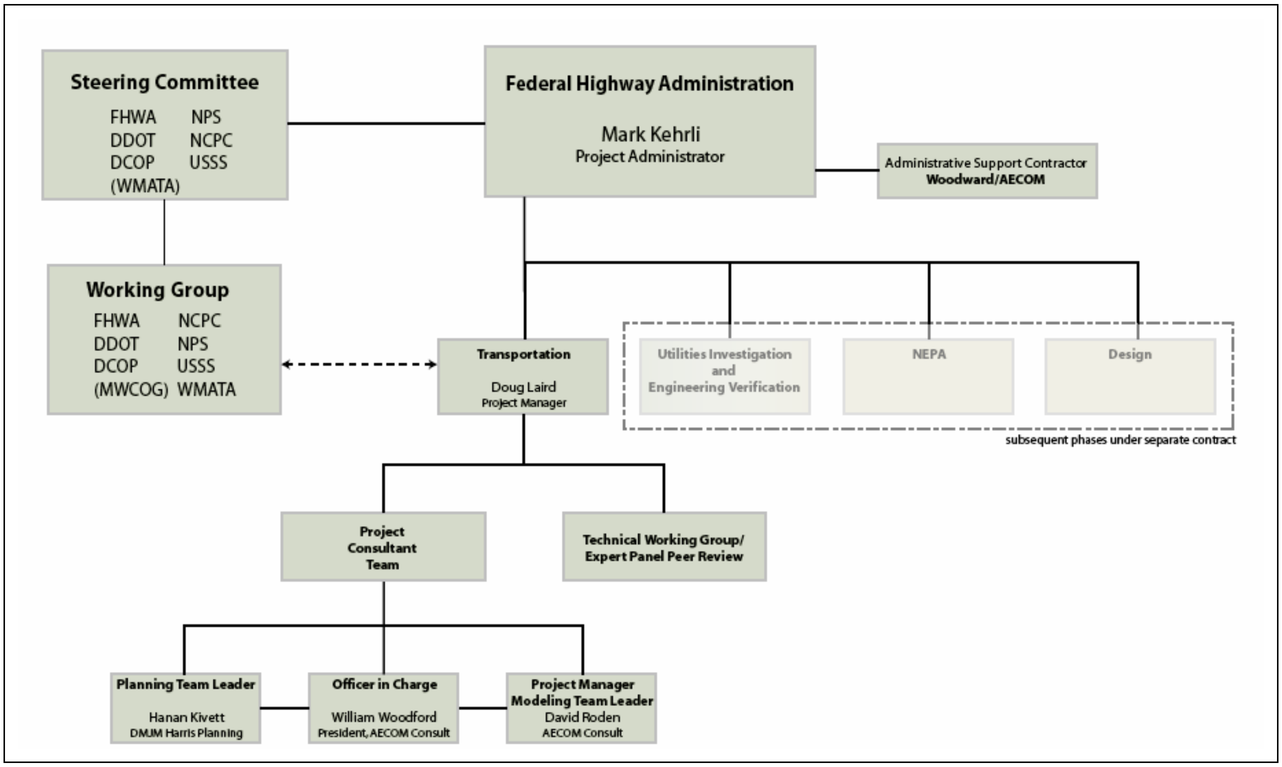
8.2.5 Traffic Assignment

For a long time, the user equilibrium (UE) assignment has been considered the best practice for performing static (as opposed to dynamic) traffic assignments. However, despite being touted as superior by academics, practitioners have found many difficulties with using UE assignment, in particular, the issue of stability. In many cases, it has been found that making even a small network change (e.g., adding a ramp, or adding a break point to a ramp), causes accessibility changes far away from, and out of proportion to, the network change made. Many people have argued that these instabilities are because the travel model has not been run with enough UE iterations. A typical MPO might use 20 or 30 UE iterations, but academics have argued that for a complex, congested network, as is found in most major cities, one should be using 2,000 or more iterations, which is rarely practical for practitioners running scenario studies or air quality conformity studies. Others have suggested that the fault lies less with the UE traffic assignment theory, and more with the algorithms used to implement that theory. The most common algorithm in use is known as Frank and Wolfe, or simply Frank-Wolfe (originally proposed by Marguerite Frank and Phil Wolfe in 1956 as a procedure for solving quadratic programming problems with linear constraints). Several researchers, such as David Boyce and Hillel Bar-Gera, have proposed new optimization algorithms, such as an "origin-based assignment" algorithm. Caliper Corporation, which makes TransCAD, and PTV, which makes VISUM, have both added non-Frank-Wolfe algorithms, such as origin-based assignment, which converge faster than Frank-Wolfe. However, Citilabs software has yet to offer anything beyond Frank-Wolfe for solving the UE assignment problem.

8.3 *White House Area Transportation Study (WHATS)*

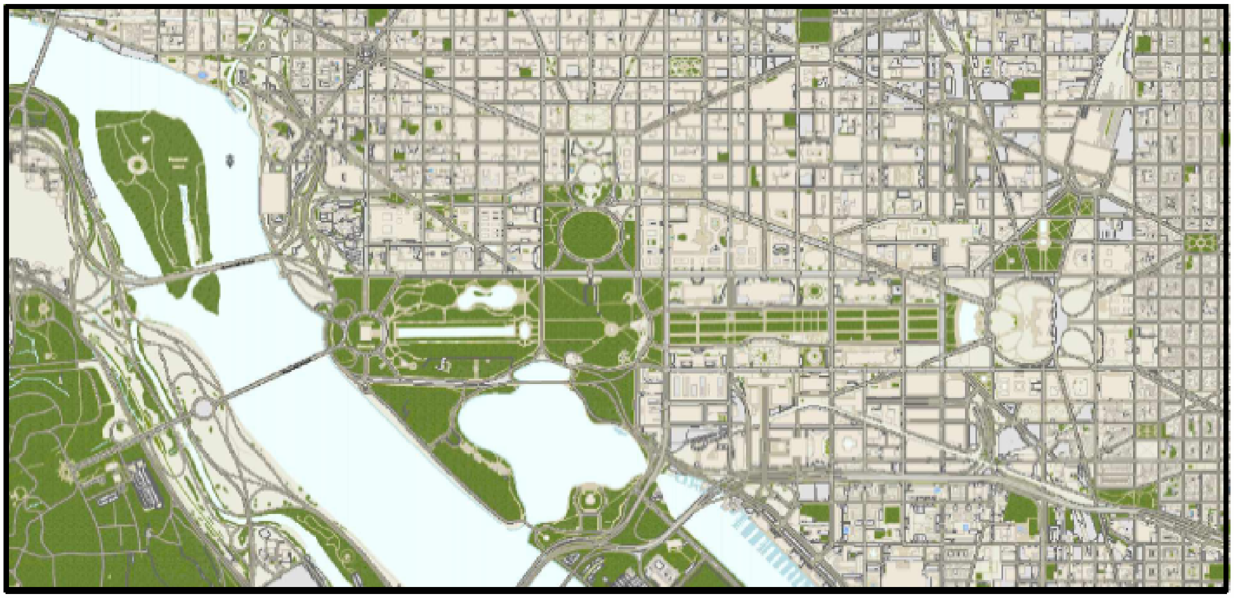
The purpose of WHATS is to determine ways to mitigate the negative traffic impacts caused by street closures around the White House in 1995 and 2001, primarily Pennsylvania Avenue, NW and E Street, NW. The study is being conducted by the Federal Highway Administration (FHWA), in conjunction with other federal and local agencies. WHATS represents one of two known examples where TRANSIMS is being used for a practical study (the other example is in Portland, Oregon). One member of the COG/TPB staff acts as a liaison to the study, attending the monthly working group meetings and facilitating information exchange. The 4.5 million dollar project, which started in 2003, should be completed by the end of 2007. The project is guided by a Steering Committee, which meets about twice a year, a Working Group, which meets monthly, and a Technical Working Group, which meets once or twice a year (See Figure 8-1).

Figure 8-1 White House Area Transportation Study: Organization chart



The basic modeling approach is to combine the trip generation, trip distribution, and mode choice elements of the COG/TPB travel model (including the AECOM/WMATA nested logit mode choice model), with the microscopic simulation of travel between each person's daily activities using the TRANSIMS Router and Traffic Microsimulator. The approach converts standard networks and trip tables from the regional modeling process to TRANSIMS network files and activity patterns. These data are used by the TRANSIMS Router and Traffic Microsimulator to evaluate the operational performance of detailed traffic and transit facilities. The simulation study ranges from the Potomac River crossings on the West, to 6th Street, NE/SE on the East, and M Street on the North to the Southeast Freeway (I-395) on the South (See Figure 8-2)

Figure 8-2 Study area for the White House Area Transportation Study



Source: AECOM 2005, page 1.

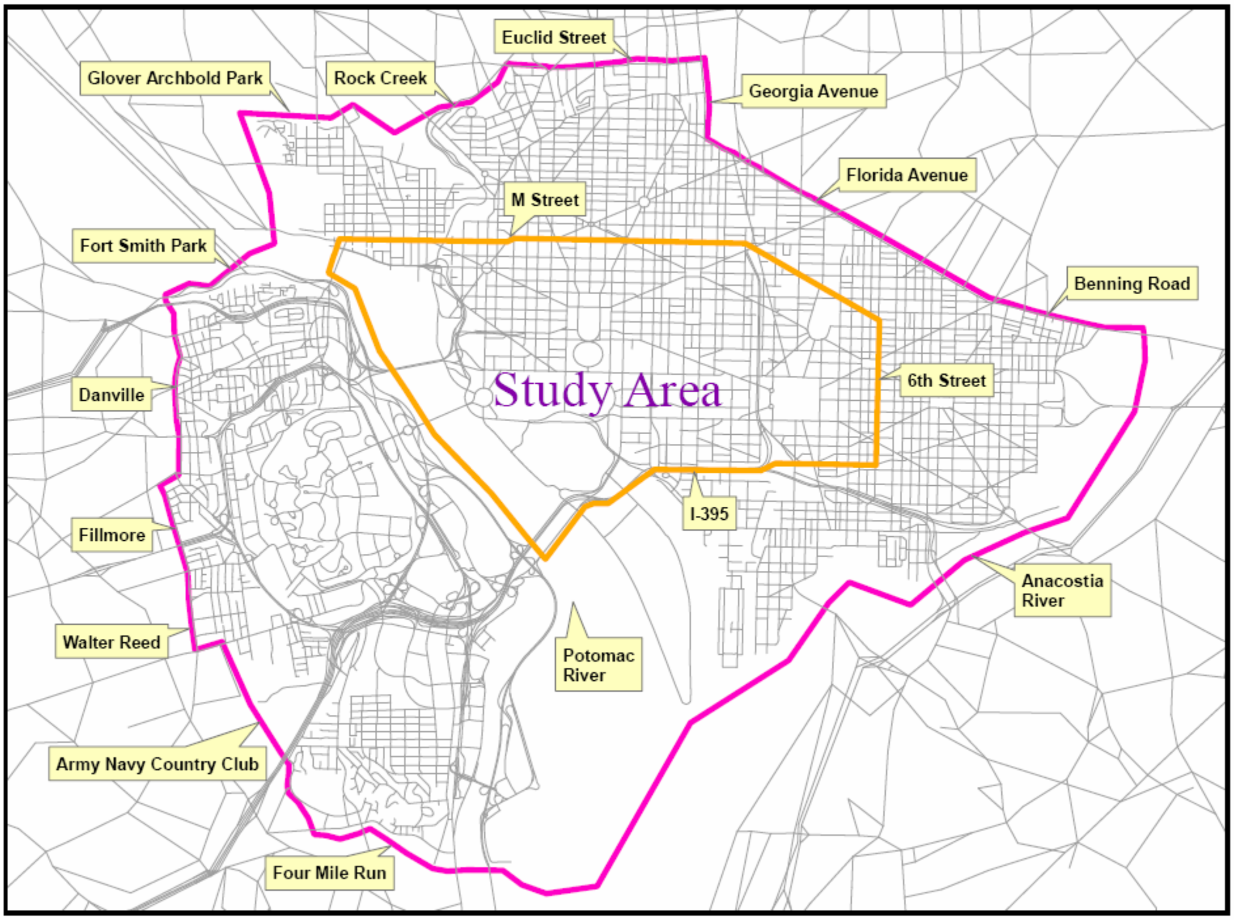
TRANSIMS requires significantly more detailed network information than is included in the COG/TPB regional travel model. AECOM had developed customized procedures to convert traditional networks into the detailed network representation required by TRANSIMS. This includes traffic signal phasing and timing plans, parking lots, activity locations, turn pockets, lane connectivity, and transit routes, schedules, and stops.

The model is currently being calibrated and validated. As noted by the consultant (AECOM 2005):

Since TRANSIMS uses a relatively low fidelity simulation (1 second time steps and 7.5 meter cells), it has some difficulty modeling dense, complex networks. Network and activity rescaling will be used to increase the simulation fidelity by reducing the size of the time steps and increasing the number of cells on each link. This provides the Microsimulator with more opportunities to make complex maneuvers. It also minimizes the number of special coding rules that will be required to calibrate the network. The validation process compares the results of a full model simulation to observed traffic counts and travel speeds by time of day. In order to be effective, the process needs a significant amount of observed data at the level of detail required by the analysis. For TRANSIMS this can be as detailed as 15 minute volumes on 30 meter segments. Unfortunately, it is rare to have observed data available at this level of detail.

The traffic microsimulation cordon is shown in Figure 8-3 as the outer cordon. The inner cordon is the study area. Beyond the simulation cordon, the COG/TPB network is used for region routing using the TRANSIMS Router.

Figure 8-3 Simulation cordon and study area



Source: AECOM 2005, page 8.

8.4 *References*

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Chapter 9 Assistance on TPB Travel Demand Model Development and Application

The TPB travel demand models have received increased scrutiny in recent years by environmental groups and other stakeholders. In 2003, the TPB commissioned the National Academy of Sciences Transportation Research Board (TRB) to conduct a peer review of the TPB models to comment on how well they measure up to the state of modeling practice. In a final letter report to the TPB, dated May 10, 2004, the TRB panel, comprised of members from academia, consulting firms, and other MPOs, made the following observation:

"As we noted in our first letter, despite some four decades of experience with the use of travel demand models in transportation planning, there are few universally accepted guidelines or standards of practice for these models or their application. Any assessment of these models, their performance, and the current state of transportation demand modeling practice relies primarily on professional experience and judgment."

The TRB is presently engaged in a nationwide assessment of modeling practice by MPOs, and is scheduled to report its findings shortly. These findings, together with the earlier TRB panel recommendations regarding the TPB models, will offer insight and guidance for the direction of the TPB models development program.

In September 2005 TPB announced that it was seeking to contract for the services of an individual or a firm that will be able to provide technical assistance on a task order basis for an ongoing assessment of the performance of the TPB travel demand models. Task orders might include the following activities:

- Attending all meetings of the TPB Travel Forecasting Subcommittee and other committees as appropriate;
- Providing written guidance to TPB staff on specific models development issues raised at either the TPB Travel Forecasting Subcommittee meetings or other forums, drawing upon knowledge of travel demand modeling practice in other MPOs;
- Conducting research focused on specific modeling issues raised by TPB staff.

A competitive bidding process ensued, involving several transportation consulting firms. The firm of Vanasse Hangen Brustlin, Inc (VHB) was selected by a review committee comprised of staff from the three state DOTs, WMATA, and TPB.

For FY2006 VHB was given the following five task orders under this contract:

Task 1 -- Attend Meetings and Assess TPB Work Program in Models Development and Data Collection

Task 2 – Review Managed Lanes Modeling in Other MPOs

Task 3 – External Trip Forecasts (both here at TPB and elsewhere)

Task 4 – Review Experience with Equilibrium Assignment

Task 5 – Review Current Use of Activity-Based Modeling

A report documenting the information developed through these task orders will be prepared for distribution and discussion at the September 22, 2006 meeting of the TPB Travel Forecasting Subcommittee.

Chapter 10 Looking Forward

Many of the Models Development activities undertaken during FY-2006 were concerned with isolated improvements to the current Version 2.1D #50 model which have not yet been combined. During early FY-2007, these improvements will be merged and formalized into a new travel model release: Version 2.2. FY-2007 will also feature improvements which will be brought into application beyond FY-2007. A major regional travel survey will also take place during the year. This data collection effort is planned to meet the needs of both conventional and advanced model development work for the next decade. This chapter outlines the anticipated activities of each program 'track' for the next fiscal year (FY-2007) and beyond. A multi-year timeline indicating the phasing of planned activities is shown on Figure 10-1.

10.1 *Applications Track*

The next model release, Version 2.2, will essentially include the following elements that were developed during FY-2006 or will be completed during early FY-2007, namely:

- Revised centroid coding and highway lane corrections to the highway network
- Revised external and through trips
- Revised airport trips
- Updated demographic models (year 2000 and beyond)
- Updated traffic assignment routine (including a queuing delay component)
- Commercial Vehicle Model
- Conversion of Fortran programs to TP+ scripts

TPB staff plans to review the highway network to add or refine centroid connectors during the beginning of FY-2007. In revisiting the TPB's traffic assignment procedures during FY-2006, it was noted that many of the link 'overloading' conditions on the arterial system where due to lack of, or a misplacement of, centroid connections. The lane-coding errors noted in the most recent traffic assignment work will also be entered into the highway network database which supports highway networks produced for each simulated year. Subsequently, the commercial vehicle model will be finalized and merged into the production model. With the inclusion of an explicit commercial vehicle model, the trip generation model will need to be adjusted to avoid double-counting. It is expected that the trip generation of NHB trips and medium trucks will need to be reduced with the inclusion of the commercial model.

Since the inclusion of these various refinements will not dramatically affect the base year simulation, a wholesale re-calibration will not be necessary. However, essential modeling statistics (trip-lengths, transit modal shares, screen line performance etc.) will be prepared and reviewed for reasonability.

Figure 10-1 Proposed TPB work program: Multi-year staging of models development activities

	FY - 2007				FY - 2008				FY - 2009			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1. APPLICATIONS TRACK												
A. Finalizing application model upgrade: **Version 2.2**												
- Centroid / network adjustments - regionwide	■											
- Conform transit lines to centroid/network changes	■											
- Finalize commercial vehicle model:												
Re-estimate commercial vehicle model with final model updates		■										
Adjust NHB model with respect to final commercial vehicle model		■										
"Fold in" the FY-2006 enhancements & commercial vehicle model		■										
Revise batch files / test		■										
Performance checks of the model / adjustments		■										
Forecast run test		■										
Documentation		■										
- Software/hardware testing - server & distributed processing	■	■	■	■	■	■	■	■				
- Testing of Cube 'Application Manager'	■	■	■	■	■	■	■	■				
B. Nested logit mode choice model development												
- Revise transit/highway network building scripts & batch files	■	■	■	■								
- Redesign of input file information / GIS databases	■	■	■	■								
- Redesign of station file	■	■	■	■								
- Revise/integrate new percent walk process into model	■	■	■	■								
- Observed trip summaries/processing	■	■										
- Model calibration in 'static mode'	■	■										
Linking transit speeds to highway congestion	■	■	■	■								
GIS aided analysis link highway links to transit lines?	■	■	■	■								
- Dynamic calibration: Integration into regional model with feedback; evaluation				■	■	■	■	■				
- Integration of MC model with SUMMIT				■	■	■	■	■				
C. Completion of medium/heavy truck models												
- Complete truck external survey processing/Create new truck extl/thru files			■	■								
- Documentation			■	■								
D. Consultant assistance on assessment of TPB model performance	■	■	■	■	■	■	■	■				
E. Testing microsimulation software	■	■	■	■	■							
F. National MPO Panel	■	■	■	■	■	■	■	■	■	■	■	■
G. Continue development of a more formal airport access demand model	■	■	■	■								
2. METHODS TRACK												
A. Begin efforts to develop framework for tour-based and/or activity-based travel modeling							■	■	■	■	■	■
B. Revisit Transportation Analysis Zone System					■	■	■	■	■	■	■	■
3. RESEARCH TRACK												
A. TRB Participation, TRANSIMS awareness, etc.	■	■	■	■	■	■	■	■	■	■	■	■
4. DATA COLLECTION TRACK												
A. Pre-Testing & Data Collection	■	■	■	■	■							
B. Processing & Cleaning					■	■	■	■				
C. Documentation								■	■	■		
5. MAINTENANCE TRACK												
A. Training	■	■	■	■	■	■	■	■	■	■	■	■
B. Documentation	■	■	■	■	■	■	■	■	■	■	■	■

Source: modelsDevTimeLine2006.xls

TPB will be exploring new model application opportunities that are now offered by Citilabs, Inc. First, there is now an alternative to the standard practice of executing a model application on a single workstation. The vendor now offers the option of distributed processing which allows the analyst to combine the computing speed of several CPUs in executing a single model execution. The benefit of this mode is a substantial reduction in the execution time of a given model run. Second, TPB will also explore the use of the Application Manager which allows one to execute the travel model with a Graphical User Interface (GUI). The use of the GUI may serve as a viable alternative to the current application which involves the use of batch files that are called from a 'command–prompt' window.

The implementation of a nested logit (NL) model into the regional model will continue during FY-2007. This effort will entail a static calibration of the nested logit model as well as a substantial amount of testing and evaluation in applying the NL in the speed feedback loop.

In the same approach used to develop a commercial vehicle model, TPB will use a consultant to develop new medium truck and heavy truck models. The data to develop the models have already been collected as part of the commercial vehicle model effort. Other work activities include: the use of a consultant to monitor and report on the state-of-the-practice across the country, the application of microsimulation software, and the ongoing participation of TPB staff on a national MPO panel.

10.2 *Methods Development*

The Methods Track addresses longer term improvements to the regional travel model. These activities will include the continued investigation into airport access modeling during FY-2007. Given that staff has kept abreast of advanced practices (Research Track) and data collection activities are underway (Data Collection Track) it is anticipated that the stage will be set in FY-2008 to explore activity based forecasting procedures. A revisiting of the zone system is also anticipated during FY-2008, given that the current 2191 TAZ system has been in use for over 10 years.

10.3 *Research Track*

TPB staff has been actively involved in conferences and forums concerned with advanced practices, most prominently, activity based models. The research track is a continuing effort to keep abreast of cutting-edge techniques regarding regional travel modeling.

10.4 *Data Collection*

TPB has allocated almost $2.4 million to conduct a regional household travel/activity survey for the TPB modeled area. Approximately 10,000 households living in 22 jurisdictions will be sampled. Given the large sample, the survey data will be collected over a 12-month period, from September 2006 through August 2007.

10.5 *Maintenance*

The Maintenance track relates to ongoing documentation of the travel forecasting model and training. Staff plans to provide documentation on the model performance, and on the general operation and use of the travel model, as it evolves.