Development of a Model for Truck Trips

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1. INTRODUCTION

1.1 Project Overview

The Metropolitan Washington Council of Governments (MWCOG) prepares travel forecasts for the metropolitan Washington region. For this purpose, MWCOG has developed a comprehensive travel forecasting model. This model estimates many different types of trips, including trips by the region's residents and non-residents, and by type of vehicle: private auto, public transportation, medium truck, and heavy truck, as well as by non-motorized travel modes (walk/bike).

Truck trips are an increasingly important element of urban travel forecasting. Perhaps the primary reason is that trucks make a disproportionately high contribution to the region's mobile source emission inventory, especially for NOx and particulates. The need to meet increasingly stringent regional emission budgets has caused most planning agencies to examine every possible emission source in greater detail. Another reason is an increasing emphasis on goods movement and the role of the region's transportation system in facilitating goods movement, and by implication, the economy.

The current MWCOG medium and heavy truck models are based on surveys performed in 1968. These models have been essentially unchanged in the past 40 years and have not been extensively validated during that time. As part of its program of continuous improvement of its travel models, MWCOG undertook the present project to develop new truck models.

For the purposes of this project, the definitions of medium and heavy trucks are as follows. A *medium truck* is a single-unit truck with two axles and six tires (i.e., dual rear wheels). Typical examples include RVs and small medium-duty delivery trucks. This matches the description of "class 5" (F5) trucks, using the FHWA 13-bin vehicle classification system (see Appendix A). A *heavy truck* is a single-unit truck with three or more axles, or a truck power unit pulling one or more trailers. This includes all vehicles in FHWA classes 6 through 13 (F6 – F13).

The purpose of this project is to develop a new model to estimate medium and heavy truck trips, write the Cube scripts to implement this model, and integrate those scripts into the existing MWCOG travel model chain.

1.2 General Approach

In many cases, travel models are developed from a survey of travel behavior. However, the nature of truck travel makes it difficult to obtain usable, reliable data on actual truck trip patterns. For example, a truck trip survey was conducted in the Washington area in 1996. This was a major effort, conducted jointly with the Baltimore Metropolitan Council (BMC) that included over 400 locations throughout the Washington/Baltimore region. More than 1,800 trips were covered by the survey. After the survey was completed, detailed examination of the data indicated that the variability in truck trip rates was so high that the data collected could not be used with reasonable confidence to develop new models. Problems with geocoding and identifying different types of trucks were also noted. Subsequent analysis disclosed that many of the factors that actually influence trip rates were beyond the scope of the survey. This has proven to be a common finding of truck surveys recently performed across the U.S. These findings caused MWCOG staff to reject the idea of updating the model with this data, or conducting a new survey.

Other cities faced with the need to update a model with little survey data have turned to an innovative approach that approaches this problem in a more indirect fashion. This new approach relies primarily on counts conducted throughout the region. The availability and relative accuracy of vehicle classification counts makes them a reliable and usable source of data for truck modelling. The new approach involves using these counts as a basis for synthesizing a truck trip table. That table is then used to ”inform” the model, providing a more credible basis for adjusting the model’s parameters. In addition, the method provides a systematic calibration adjustment that helps the model to achieve a relatively high accuracy of assigned truck volumes on a link-by-link basis.

This report documents the use of this new approach, called *adaptable assignment,* to develop a new truck model for MWCOG.

This report is organized into six chapters, including this Introduction:

2 Truck Modelling Issues
3 Count Data
4 Model Development
5 Forecasting
6 Application Notes

In addition, the reader is referred to a separate report describing the development of a new MWCOG model for Commercial trips: *Development of a Model for Commercial Vehicle Trips*, 4 May 2007, by William G. Allen, Jr., P.E. These include passenger cars, light trucks, SUV’s, vans, and other vehicles not defined under medium or heavy trucks, which are used for commercial purposes (i.e., not passenger transportation *per se*). The Commercial model was developed shortly before the new truck model and covers a type of trip that heretofore was not separately recognized in the MWCOG model.

2. TRUCK MODELLING ISSUES

2.1 State of the Art

As part of this project, the consultant made a brief review of the state of the art in truck trip modelling. Two recent reports greatly facilitated this effort: *Quick Response Freight Manual*, by Cambridge Systematics for the Travel Model Improvement Program, September 1996 and NCHRP Synthesis 298, *Truck Trip Generation Data*, by Cambridge Systematics and Jack Faucett Associates for the Transportation Research Board, 2001. These reports provide an excellent over-view of current practice and key issues concerning truck trip modelling.

The first issue is: what is the context of the model? There are three levels of analysis detail: 1) national or statewide analyses of tax payments, pavement condition, or general rail vs. truck movement; 2) regional analyses concerned with link volumes, emissions, and corridor facilities; and 3) local studies in which traffic engineers are looking at noise, geometrics, pavement, or loading facilities. These are very different kinds of analyses, calling for different kinds of models. Most of the focus of the literature is on regional truck models, and that is the level with which this report is concerned.

One of the most important issues is the definition of just what is a ”truck”. Models based on registration data use gross vehicle weight (GVW) definitions. Models based on classification counts use the number of axles as their criterion. These two definitions are not consistent with each other and create difficulties in comparing models and results. The selection of an appropriate definition also hinges on the purpose of the truck analysis: is it mainly for motor carrier/tax policy, pavement analysis, or emissions calculation?

Another key issue is the structure of the model. So-called *commodity flow models* attempt to analyze the movement of all goods from their source, through various transformations, and then on to the final consumer. This kind of analysis permits the explicit consideration of trade-offs among different freight modes (e.g., highway, air, rail, water). Many planners consider this the “ultimate” in freight modelling, but it is generally considered a goal that might be attained in the future, not something that is truly practical today. The alternative is a “vehicle-based” model, which simply estimates truck trips. This is the form taken by almost all operational truck trip models. Most planners consider this to be a reasonable interim approach until such time as commodity-based models become more widely used and accepted.

The difficulty in conducting truck trip surveys is well known. One problem is that almost all regional travel models consider the basic unit of travel to be the “trip” -- a movement between an origin and a destination. For many trucks, however, the unit of travel is instead a “tour” -- a series of connected trips throughout the day. This not only complicates the survey itself, but it makes it extremely difficult to translate tour movements into the origin/destination trip approach taken by most models. An even more significant problem is simply one of participation. Trucking firms treat travel data as proprietary information and are not willing to have this information made available to the public (or their competitors). These firms are not accustomed to working with public planning agencies and often distrust or misunderstand the purpose of the surveys. Even when the trucking company is cooperative, truck drivers themselves usually view surveys as nothing more than an unwarranted and unnecessary intrusion on their workday. Thus, it should come as no surprise that reliable, usable data is rarely achieved in trucking surveys. A possible exception is that roadside intercept surveys, if conducted in a safe and efficient manner, can be very useful in obtaining data on truck trip movements that are external or completely through the region.

Those analysts lucky enough to obtain usable data on truck trips are being confronted with another obstacle: the measures of land use that are causally related to truck activity are generally not among the data items that are available at the traffic zone level, or are forecasted. As a result, in almost all cases, planners try to relate truck travel to the variables that *are* available. The outcome is usually a relatively crude model that relates truck trips to employment and population. The results are usually less than satisfactory, but are justified by noting that "trucks are only 5% of all trips". While this may be true in total, trucks do account for a higher share of traffic on the major roadways and heavy trucks also utilize a greater share of roadway capacity than their volumes indicate.

In summary, the state of the art in truck trip models has been relatively dismal, but starting to improve. Substantial enhancements in these models will need to await the widespread acceptance and use of automated, non-intrusive data collection technology (perhaps GPS-based) and the development of traffic-zone-level data that is more closely related to goods movement. At least in recent years, more planning agencies are paying greater attention to these needs.

2.1 Factors Affecting Truck Forecasting

The above issues relate mainly to the development of a model which can adequately describe *today's* truck travel. Forecasting truck trips proves to be even more difficult than forecasting personal travel, for a number of reasons. Creating a model that accounts for all the factors that are likely to affect future truck travel would require a crystal ball. One needs only to look at the last 15 years to understand some of these factors.

One of the most important phenomena to affect truck travel over the past two decades is the change in goods movement technology. Containerization has affected practically all aspects of goods movement, including ship, rail, and truck. Containerized freight movement now represents the majority of goods moved at all U.S. ports, for example. In a related development, trailer on flat car (TOFC) and container on flat car (COFC) have created tremendous opportunities for intermodal coordination and efficiency that did not exist until recently. Another similar development (also related to the above) is the sharp rise in freight labor productivity. Over the past 15 years, the total tonnage of goods moved per trucking company employee has risen sharply. The nature of American industry has changed in recent years and improvements necessitated by international competition have practically revolutionized the freight industry. One example of this is *just-in-time* (JIT) delivery, in which industries reduce their warehousing space because they no longer stockpile materials used in production. These materials are delivered by suppliers on the day (sometimes at the hour) they are needed and they move directly from the loading dock onto the production line. JIT requires a veritable ballet of truck movements, organized and scheduled with great precision and timing. Obviously, it also increases the number of truck trips serving a manufacturing plant. This kind of operation barely existed 15 years ago and now it is commonly used throughout the manufacturing sector, particularly for motor vehicle assembly.

As if recent changes in technology and productivity weren't drastic enough, the past decade has also seen major political changes that affect goods movement. The increase in the global nature of the U.S. economy, aided by actions such as the North American Free Trade Agreement (NAFTA), has had a profound effect on all forms of freight movement. One of the earliest impacts of NAFTA was a sharp increase in truck traffic across the borders with Canada and Mexico, as U.S. companies sought to improve their operations by using facilities in those countries.

Many other external factors have been seen to strongly influence truck travel in recent years, including: deregulation, changes in weight and size limits, increased use of tandem trailers, fuel price fluctuations, trucking industry consolidation, and centralized warehousing. Competitive pressures within the industry will no doubt continue to drive innovation and changes that can barely be imagined today.

The above commentary serves to highlight how difficult truck forecasting can be, especially in light of the limited resources typically devoted to it. Forecasting freight is certainly no less challenging (and probably more so) than forecasting personal travel. While there will doubtless continue to be changes in technology and productivity in the future, it is not feasible to incorporate them into the model or to estimate their impact at this time. This suggests a need to continually revisit and update the truck model at regular intervals.

3. COUNT DATA

3.1 Counts

The principal source of truck counts for this project was the Maryland DOT (MDOT) program of vehicle classification counts. These counts are of two types, *permanent* and *program*. The permanent counts use sensors installed in the pavement to identify vehicles by type, from the weight and number of axles. This data was available for six locations for about 200 days in 2005. This was very helpful in providing day of week and seasonality adjustment factors. The program counts are performed using portable counting equipment and cover only 24-72 hours, but at many more locations (315).

Truck count data from VA and DC was much more limited. DC counts provided daily totals for 33 locations. VA counts provided both daily and hourly data, but at only seven locations. TPB staff provided 148 counts throughout the region as part of the Commercial vehicle count program conducted in the summer of 2005. Further details on that count program are available in the MWCOG memorandum *Data Collection for the Commercial Vehicle Model*, 19 April 2007. The Commercial program counts did include separate figures for MTK and HTK, but were conducted only for four hours and provide only the percentage of trucks by type. These percentages are assumed to be valid for an entire weekday and were applied to the 2000 AAWDT by direction with a growth factor of 1.089 applied to represent the growth from 2000 to 2005. (At the time of this analysis, 2005 AAWDT counts were not yet available.)

The MDOT permanent and program counts and the VDOT counts provided hourly data. This would permit the validation of the truck time of day models, for the first time.

Some of the count locations were on links that were not coded in the MWCOG network (such as 30 of the 33 DC counts). A few counts were duplicated among the sources mentioned above. A special effort was required to correctly post the counts on “dual-coded” links (two-way roads that are coded in the model as a separated pair of one-way links, with different node numbers in each direction). Actual directionality was provided for only a handful of counts. Daily counts were divided in two, with half being posted in each direction on the link. For the peak period counts, the directionality of the link was examined by looking at the peak period volume from the 2005 loaded network. The AM and PM peak period truck volumes were posted by direction based on the estimated loads. For example, if the estimated AM peak directionality on a two-way link was 70% northbound, 30% southbound, then the higher of the two AM peak truck volumes was posted in the northbound direction. In some cases, examination of the posted counts revealed values that appeared very illogical or unlikely to be accurate. Counts that were very questionable were dropped. In total, daily truck counts were posted on 674 links. Counts by period (AM peak, PM peak, off-peak) were posted on 394 links.

The MDOT permanent count stations provided a unique opportunity to compute truck day-of-week and seasonality factors. By analyzing the day to day and season to season patterns in the counts, it is possible to calculate factors that could be used to adjust the other counts, which were taken on known days of the year, to represent annual average weekday values, which are more suitable targets for travel model calibration. Table 3-1 shows these adjustments. They are applied by dividing them into the count. For example, an MTK count of 1,000 taken on a spring Tuesday would be converted to an annual average of 1,023 (=(1000/0.955)/1.024).

Table 3-1
Weekday/Season Adjustment Factors

Day	Medium	Heavy
Monday	0.906	0.928
Tuesday	0.955	0.951
Wednesday	1.089	1.158
Thursday	1.043	1.057
Friday	1.006	0.906

Season	Medium	Heavy
Dec-Feb	0.826	0.828
Mar-May	1.024	0.995
Jun-Aug	1.149	1.153
Sep-Nov	1.002	1.025

Values represent ratio of day or season shown to the average.

These figures mean that Monday is the lowest day of the week for medium truck travel, while Wednesday is the highest day for both types of trucks. However, Friday is the lowest day of the week for heavy trucks. Winter is the slowest season for both types of truck, while summer is the highest. All of the count data used in this project was adjusted as to day of week and seasonality, to represent an annual weekday average.

3.2 External Counts

In 2003, MWCOG staff conducted a survey of external travel at ten locations at the cordon of the modelled region, as documented in a 17 May 2007 memorandum from TPB staff Hamid Humeida and Ron Milone to Bill Allen, entitled *Transmittal of 2003 External Truck Survey File and Other Related Data*. This information was helpful in many ways. First, it provided a few additional counts. Second, it provided data on the observed pattern of through vs. external truck travel. Third, it was an essential source of data for the development of 2005 cordon truck trip volumes by station and vehicle type. This is very important data, as it is a major input to the modelling process and cannot be transferred from another area. These volumes are specifically related to the cordon definition and geography of the Washington region.

Unfortunately, the MWCOG survey covered only ten of the 47 external stations. Thus, data was obtained from other sources to complete this information. The VDOT "count book" contains values for the percent of vehicles that are trucks at numerous locations. These are broken down by "2-axle" and "3-axle truck plus single- and tandem-trailers". However, not all of the published data represent actual counts at the location indicated and in the year indicated. In many cases, this data is interpolated, extrapolated, or otherwise estimated. Also, it became apparent during the analysis that VDOT's truck categories did not align perfectly with this study's medium/heavy truck definitions. Notwithstanding, the VDOT data filled in some important gaps in the information.

Another source of data was information from the BMC model. This consultant developed a truck model for the Baltimore region in 2002. Twenty-seven of the MWCOG external stations are represented in the BMC model.

Table 3-2 shows how all this information was assembled for the purpose of identifying the 2005 MTK and HTK volumes at each cordon station. The consultant examined 2000 and 2003 AAWDT volumes provided by MWCOG, as well as VDOT 2005 data on percent trucks and the estimated percent trucks from a 2005 run of the BMC model (the BMC model uses the same definition of MTK and HTK as does MWCOG). This data was combined to produce an implied truck volume. Those figures were compared to data from the 2003 MWCOG cordon truck survey and to truck counts that were posted in the network on links near the external stations. As a result, the consultant revised the percent truck figures and used them to calculate a new set of 2005 truck volumes by station. The notes to Table 3-2 document this process. The consultant believes that these figures represent the most accurate picture possible of truck volumes at the MWCOG modelled cordon.

Table 3-2
Cordon Volumes

External Station	Facility Name	AADT 2000	AAWDT 2000	AADT 2003	AAWDT 2003	Quality Code '00 / '03	2000-2003 AAWDT Growth	AAWDT Growth per Year	AAWDT 2005 Est	VDOT Count or BMC Volume	VDOT or BMC Truck % MTK	VDOT or BMC Truck % HTK	Implied Truck Volume MTK	Implied Truck Volume HTK	MWCOG 2003 Truck Counts MTK	MWCOG 2003 Truck Counts HTK	Implied COG 2003 Truck % MTK	Implied COG 2003 Truck % HTK	Consultant's Revised % MTK	Consultant's Revised % HTK	Implied Revised 2005 Truck Vols MTK	Implied Revised 2005 Truck Vols HTK
Notes:		1	1	1	1	1,2	3	4	5	6	7	7	8	8	9	9	10	10	11	11	12	12
2145	VA 3 (East)	3,958	3,877	5,083	5,048	R7	1.302	1.092	6,020	5,400	2	7	110	380					4	8	230	460
2146	US 301 (South)	9,979	9,459	10,571	10,059	R7	1.063	1.021	10,480	12,000	2	10	240	1,200	292	1,754	3	17	3	**12**	340	1,350
2147	US 17	4,269	3,769	4,766	4,177	R7	1.108	1.035	4,470	4,400	1	6	40	260	172	336	4	8	4	8	180	350
2148	VA 2	5,184	5,134	4,872	4,897	R7	0.954	0.984	4,750	5,500	1	4	60	220					2	5	100	260
2149	I-95 (South)	72,000	63,000	79,000	67,000	R9G	1.063	1.021	69,810	67,000	1	17	670	11,390	2,242	14,766	3	22	3	**17**	2,050	11,630
2150	US 1(South)	10,168	10,174	9,672	9,714	R7	0.955	0.985	9,420	10,000	1	4	100	400					2	5	190	490
2151	VA 208/606	3,658	3,638	4,059	4,077	R7	1.121	1.039	4,400	4,700	2	5	90	240					3	6	140	270
2152	VA 612	3,175	3,156	3,307	3,323	R7	1.053	1.017	3,440	3,400	1	1	30	30					2	2	70	70
2153	VA 3(West)	16,865	16,766	19,656	19,753	R7	1.178	1.056	22,030	24,000	1	4	240	960					2	5	460	1,150
2154	US 15/29 (South)	20,409	19,758	22,352	21,661	R7	1.096	1.031	23,030	25,000	1	9	250	2,250	719	1,823	3	8	3	8	720	1,920
2155	US 211	13,748	13,484	16,887	16,784	R7	1.245	1.076	19,420	18,000	1	1	180	180					2	2	370	370
2156	I-66	26,126	23,013	33,308	30,296	R5	1.316	1.096	36,390	34,000	1	18	340	6,120	503	4,962	2	16	2	16	700	**4,200**
2157	VA 55	1,108	1,086	908	904	R7	0.832	0.941	800	1,000	1	2	10	20					2	2	20	20
2158	US 340	6,204	6,300	7,218	7,415	R6	1.177	1.056	8,270	7,900	1	7	80	550					2	8	160	650
2159	US 17/50	14,264	14,470	12,008	12,352	R6	0.854	0.949	11,120	12,000	1	3	120	360					2	4	230	460
2160	VA 7	20,466	21,499	23,372	25,295	R2 / R1	1.177	1.056	28,190	28,000	1	5	280	1,400					2	6	560	1,690
2161	WV 51	6,500	6,825	7,700	8,085	C9	1.185	1.058	9,050	9,050	*1*	*5*	90	450					2	6	180	540
2162	WV 9	16,049	16,851	17,500	18,375	C9	1.090	1.029	19,470	19,470	*1*	*10*	190	1,950					2	12	390	2,340
2163	WV 45	8,599	9,029	7,600	7,980	C9	0.884	0.960	7,350	7,350	*1*	*5*	70	370					2	6	150	440
2164	MD 34/WVA 480	5,926	6,222	5,800	6,090	C9	0.979	0.993	6,000	6,000	*1*	*5*	60	300					2	6	120	360
2165	Alt US 40	9,550	10,028	9,925	10,421	C7	1.039	1.013	*10,690*	*7,200*	*3*	*3*	250	250					2	3	180	270
2166	I-70 (West)	74,175	77,884	65,575	68,854	C6	0.884	0.960	63,420	68,230	*2*	*14*	1,460	9,240	1,717	7,423	2	11	2	**7**	1,320	4,610
2167	US 40	4,050	4,253	4,825	5,066	C7	1.191	1.060	5,690	6,450	*6*	*4*	360	290					4	4	240	240
2168	MD 77	2,500	2,625	3,150	3,308	C7	1.260	1.080	3,860	4,100	*4*	*2*	150	80					3	2	120	80
2169	MD 550	2,150	2,258	1,950	2,048	C7	0.907	0.968	1,920	2,300	*3*	*2*	80	50					2	2	**220**	**100**
2170	MD 140/PA16	9,650	10,133	8,450	8,873	C7	0.876	0.957	8,120	8,480	*4*	*6*	360	540					3	5	**310**	420
2171	US 15 (North)	15,175	15,934	15,875	16,669	C6	1.046	1.015	17,180	17,120	*4*	*16*	740	2,730	413	2,199	2	13	2	13	340	2,230
2172	MD 194 /PA194	4,325	4,541	5,125	5,381	C7	1.185	1.058	6,030	5,350	*5*	*5*	260	290					3	5	170	280
2173	MD 97/PA 97	7,975	8,374	7,575	7,954	C6	0.950	0.983	7,690	8,230	*4*	*6*	360	460					3	5	240	400
2174	MD 30 (North)/ PA 94	12,150	12,758	13,925	14,621	C7	1.146	1.046	16,010	13,500	*4*	*16*	590	2,150					3	14	440	2,070
2175	MD 86 / PA 516	1,999	2,099	3,325	3,491	C7	1.663	1.185	*4,900*	*3,440*	*7*	*6*	240	220					4	5	170	210
2176	MD 88	4,850	5,093	4,325	4,541	C7	0.892	0.962	4,210	4,230	*3*	*8*	130	330					2	7	80	300
2177	MD 30 (East)	21,800	22,890	21,175	22,234	C7 /C6	0.971	0.990	*21,810*	*16,520*	*3*	*8*	510	1,360					2	7	380	1,340
2178	MD 140/91	39,725	41,711	43,550	45,728	C7	1.096	1.031	48,620	46,310	*3*	*3*	1,520	1,580					2	3	**1,570**	**2,380**
2179	MD 26	18,250	19,163	21,125	22,181	C7	1.157	1.050	24,450	23,080	*3*	*5*	660	1,130					2	5	480	1,190
2180	I-70 (East)	68,975	72,424	80,075	84,079	C6	1.161	1.051	92,870	88,310	*3*	*9*	2,910	7,930	1,819	5,952	2	7	2	**5**	1,810	4,530
2181	US 40 (East) / MD 144	38,850	40,793	42,250	44,363	C7	1.088	1.028	*46,920*	*34,630*	*2*	*5*	760	1,630					2	4	**960**	**640**
2182	I-95 (North)	186,999	196,349	180,285	189,299	C6	0.964	0.988	*184,740*	*164,800*	*2*	*7*	4,100	11,780	4,915	15,600	3	8	3	8	5,240	13,980
2183	I-195 /US 1 (North)	23,150	24,308	26,425	27,746	C7	1.141	1.045	*30,300*	*92,440*	*3*	*5*	2,730	4,860					2	4	1,230	2,450
2184	Md 295 / B/W Pkwy	67,025	70,376	87,625	92,006	C7	1.307	1.093	*110,000*	*65,170*	*3*	*6*	1,920	3,980					0	0	0	0
2185	MD 648	11,650	12,233	12,250	12,863	C7	1.052	1.017	13,300	16,300	*3*	*8*	430	1,230					2	7	300	1,040
2186	MD 170	15,075	15,829	17,275	18,139	C6	1.146	1.046	19,860	16,340	*3*	*7*	510	1,150					2	6	360	1,090
2187	MD 3 / I-97	99,675	104,659	106,075	111,379	C6	1.064	1.021	*116,100*	*87,910*	*4*	*9*	3,690	7,580					3	8	**1,300**	**700**
2188	MD 2	43,525	45,701	44,250	46,463	C7	1.017	1.006	46,980	41,600	*3*	*4*	1,310	1,840					2	4	**1,520**	**780**
2189	MD 10	47,675	50,059	54,675	57,409	C6	1.147	1.047	*62,900*	*41,580*	*5*	*7*	1,890	2,760					3	6	1,570	3,130
2190	MD 710	16,500	17,325	15,150	15,908	C7	0.918	0.972	15,030	17,340	*6*	*7*	1,000	1,170					4	6	650	970
2191	US 50 (East) / 301	65,212	68,473	68,530	71,957	C8	1.051	1.017	74,380	82,800	*5*	*12*	3,890	9,870	1,709	7,252	2	10	2	**7**	1,570	5,500
Total:		1,181,290	1,215,781	1,260,379	1,296,266		1.066	1.022	1,361,890	1,287,930	3	8	36,060	105,510					2.3	6.0	30,130	79,950

Notes:
1 Source: MWCOG.
2 Quality Codes
R1 - Counts were taken at a permanent counting location, AAWDT was reported by VA.
R2 - Counts were taken at a permanent counting location, NB and SB AAWDT values reported by VA were summ
R5 - AAWDT based on short term counts taken in 2003. EB and WB AAWDT values reported by VA were summe
R6 - AAWDT reported by VA based on short term counts taken in 2003.
R7 - AAWDT reported by VA based on short term counts taken in a previous year.
R9G - AAWDT reported by VA based on short term counts taken in a previous year, all directions on facility reported as one.
C6 - AADT reported by MD based on short term counts taken in 2003. AAWDT calculated (AADT * 1.05).
C7 - AADT reported by MD based on short term counts taken in previous year. AAWDT calculated (AADT * 1.05).
C8 - AADT reported by MD based on counts at a toll facility. AAWDT calculated (AADT * 1.05).
C9 - AADT for Jefferson County WV is 2002 AADT. AAWDT calculated (AADT * 1.05).
3 Total change, AAWDT 2003 divided by AAWDT 2000.
4 Annual average change, AAWDT 2003 compared to AAWDT 2000.
5 AAWDT 2003, incremented by 2 years' worth of growth.
6 Values in italics are significantly different from the AAWDT 2005 Estimate.
7 VDOT Truck percentages: MTK = "2axle", HTK= "3axle + 1Trail + 2Trail". Values in italics are from the BMC 2005 model estimate (percent truck calculated from BMC est. truck volume and total volume).
8 VDOT count or BMC volume multiplied by VDOT or BMC truck % (result rounded to 10).
9 Source: MWCOG 2003 cordon truck survey.
10 MWCOG 2003 truck count divided by AAWDT 2003.
11 Estimated by consultant's judgment. Use Implied COG 2003 Truck %'s to modify VDOT/BMC Truck %'s to get new truck %'s. Zero percent trucks assumed for the Baltimore/Washington Parkway.
VDOT's MTK %'s appear to be too low and BMC's estimated MTK/HTK %'s appear too high. Assume COG %'s are correct; apply judgment to estimate MTK/HTK %'s for other stations.
12 Apply consultant's truck %'s to the average of the AAWDT 2005 Est. and the VDOT count/BMC volume.
Replace calculated value with posted count, if there is a count posted in the network nearby. Replaced values shown in bold. Round all calculated values to 10.

3.3 Count Synthesis Model

As noted above, the truck count coverage was fairly reasonable in Maryland. However, there were too few counts in DC and Virginia for the purposes of this study. The proposed approach requires a broader base of count coverage than is usually seen. Thus, the consultant chose to leverage the actual data to develop a count synthesis model. This is a procedure to estimate "counts" on many more links than there is actual count data for.

The theory behind this approach is that it is possible to relate the percent of traffic that is medium truck and heavy truck to various characteristics of the roadway link. This was done successfully for the Commercial vehicle trip model developed recently for MWCOG. As noted above, MWCOG staff have assembled a database containing the counts of medium and heavy trucks and total vehicles at various locations distributed across the region. This database also contains some characteristics of the highway at each count location from the coded network: facility type, area type, number of lanes, and annual average weekday traffic volume (AAWDT).

The dependent variables in this model are %MTK, the percent of total traffic that is medium trucks, and %HTK, the percent that is heavy trucks. The %MTK and %HTK resulting from MWCOG's 6-hour classification counts is assumed to be reasonably representative of the 24-hour actual %MTK and %HTK values. Table 3-3 shows a crosstab of the counted %MTK and %HTK by jurisdiction from the MWCOG counts.

Table 3-3
Counted Percent Truck by Jurisdiction

Jurisdiction	%MTK	%HTK	% Truck
DC	3.1%	1.2%	4.3%
Montgomery	3.1	2.6	5.7
Prince George's	3.1	3.2	6.3
Fairfax	0.7	1.8	2.5
Frederick	3.4	5.0	8.4
Howard	3.5	5.0	8.5
Anne Arundel	4.2	2.6	6.8
Charles	4.8	4.1	8.9
Carroll	3.4	4.2	7.6
Calvert	3.5	2.1	5.6
St. Mary's	4.0	2.4	6.4
Total	3.3	3.2	6.5

The overall share of 6.5% is slightly higher than the 5% value that is commonly assumed. The more heavily urbanized areas have the lowest shares, which probably means that the concentration of personal (auto) travel is higher there. In the outer jurisdictions, the higher shares are probably related to the higher level of construction activity (and probably the lower level of traffic) in those areas.

The first effort was to develop a simple look-up table, with %MTK and %HTK as a function of the link's facility type and area type, as shown in Table 3-4.

Table 3-4
%MTK/%HTK Look-Up Table

MTK	Urban	Suburban	Rural	Total
Freeway	3.1%	3.6%	3.3%	3.3%
Arterial	2.7%	3.7%	4.7%	3.4%
Collector	2.5%	3.8%	4.2%	3.1%
Total	3.0%	3.7%	4.1%	3.3%

HTK	Urban	Suburban	Rural	Total
Freeway	3.3%	5.5%	4.5%	4.0%
Arterial	1.6%	2.6%	4.1%	2.3%
Collector	1.5%	2.7%	3.8%	2.1%
Total	2.6%	3.8%	4.3%	3.2%

Note:
“Freeway” includes Expressways and Ramps.

This table says that there are not huge differences in %MTK or %HTK by link type, except that heavy truck traffic tends to stay on the Freeways, which seems logical.

Arterials tend to have a slightly higher share and Freeways the lowest share, which seems logical. This is consistent with similar findings from Baltimore, Atlanta, and Ohio.

Applying this look-up table to the observed data points produces a model with error statistics as shown in Table 3-5.

The next effort was to develop a logit model. The logit function is well suited to this kind of model, since it estimates a percentage that must be between 0 and 100%. A logit model was estimated that related % truck to the number of lanes, jurisdiction, area type, and facility type. This model is as follows:

$\%TRK = 1/(1+e^{U})$
(model is applied separately for MTK and HTK)

Where:
U(MTK) = -0.0116 * lanes + FT/AT bias + jur bias
U(HTK) = 0.0144 * lanes + FT/AT bias + jur bias

FT/AT bias = bias constant related to link facility type and area type
jur bias = bias constant related to jurisdiction

	MTK				HTK			
	CBD	Urban	Suburb	Rural	CBD	Urban	Suburb	Rural
Freeway	3.8	3.5762	3.2914	3.4682	3.3	3.0775	2.8493	3.1781
Arterial	3.9	3.6588	3.2656	3.0408	4.5	4.0406	3.5444	3.1336
Collector	4.0	3.6536	3.1564	3.1410	4.5	4.1438	3.5524	3.2086

jur	mtk	htk
dc	-0.1596	0.2946
mtg	-0.0869	0.2648
pg	0.0600	-0.1880
arl	0.15	0.30
alx	0.15	0.30
ffx	1.1991	0.4217
ldn	-0.18	-0.2
pw	0.1	-0.2
frd	0.1431	-0.1520
how	-0.0936	-0.0885
aa	-0.1811	0.2455
chs	-0.1852	-0.2655
car	0.2127	-0.2590
cal	0.2016	0.6092
stm	-0.1311	0.2100
kg	-0.1	-0.2
fbrg	-0.1	-0.2
sta	-0.1	-0.2
spt	-0.1	-0.2
fau	-0.1	-0.2

The shaded areas in these tables represent situations for which no observed data was available. Values for these bias coefficients were approximated from those of surrounding jurisdictions. In the above tables, it should be remembered that algebraically higher values of the bias coefficient mean a lower % truck share.

Based on similar work for the Commercial model, the only variables tested were number of lanes and AAWDT, and bias coefficients for facility type, area type, and jurisdiction. Including the AAWDT did not help the model's accuracy. The coefficients on the number of lanes means that wider roads have higher %MTK values but lower %HTK values, all else being equal. That seems logical.

The logit model has the statistics shown in Table 3-5. The model was estimated using the Excel Solver function, so more detailed statistics are not available. The higher accuracy of the logit model compared to the look-up table outweighs its additional complexity and makes it the preferred approach. This model is easily applied to all links with a count, using a TP+ script. The product of % truck and AAWDT is the synthesized Truck count. This produces as many Truck count values as there are AAWDT values, which provides a database that is sufficient for model development.

Table 3-5
Count Model Statistics

	Look-Up Table		Logit Model	
Measure	MTK	HTK	MTK	HTK
r-squared	0.001	0.004	0.271	0.222
% RMSE	55%	102%	45%	82%
total % error	14%	32%	0%	0%
rho-squared w/r/t zero			0.778	0.827
rho-squared w/r/t constants			0.000	0.000

After the logit model was applied, the consultant reviewed the resulting synthesized MTK and HTK counts and manually deleted those that appeared illogical or inconsistent. In calibrating the model, the actual Truck counts (not the estimates) are used where they are available.

A few other notes on the application of this model:

- No truck counts were calculated for truck-restricted or HOV roadways.
- The synthesized counts were multiplied by -1 before posting, to distinguish them from the actual counts. This was accounted for in subsequent processing.
- Subsequent analysis of the estimated truck volumes suggested that the count synthesis model did not produce sufficiently reasonable-looking volumes on the freeways. There were too many discontinuities between the actual counts and synthesized counts. Thus, the synthesized freeway counts were dropped.
- Only daily counts were synthesized.

The count synthesis model produced MTK counts on 4,921 links (by direction) and HTK counts on 4,598 links (by direction). The consultant judged this to be a sufficient sample for model development.

4. MODEL DEVELOPMENT

4.1 Overview

Most truck models, like the current MWCOG model, estimate trip ends using relatively simple trip rate equations based on the available socioeconomic variables. Straightforward F-factor curves are used for the gravity model and fixed factors for the time of day split. Simpler models are easier to develop and to understand and in this particular case, the available observed data does not support the development of a very sophisticated approach. That will have to await the development of technology (probably involving GIS-based vehicle tracking) that provides more information on truck travel patterns. More sophisticated truck models will also require more detailed land use data at the zonal level, e.g., specification of employment by more than four categories.

The proposed approach relies on finding a starting model that is likely to be suitable. Two candidates are the current MWCOG truck model and a model that was recently developed for the Baltimore area. The consultant chose the Baltimore model as the starting point for this project. That model uses the same definition of truck types and is based on the same type of land use variables as exist in this project. In fact, the Baltimore model is not substantially different from the current MWCOG model.

The consultant’s modelling approach relies on borrowing a similar model from another urban area and adjusting it, based on local count data, so as to make it more reflective of conditions in the Washington region.

This report documents the process used to arrive at the recommended model.

4.2 Existing MWCOG Truck Model

The existing MWCOG truck model had not been validated in several years. The consultant obtained a 2005 loaded network from TPB staff and compared the total truck volume (MTK+HTK) to the total counts. That network represents “Version 2.2V60” of the model and the file is named I624HRHWY.NET, dated 31 Oct 07. This represents the assignment of 530,800 total daily truck trips. Table 4-1 shows the volume/count ratio and %RMSE by facility type and area type.

The overall result is that the estimated volume exceeds the total count by 16% (this includes the synthesized counts). The overestimation is more pronounced for the higher facility types, with the lower facility types being underestimated. The more urbanized areas also see a relatively higher overestimation. The %RMSE is 104%, which is not very good. The error is worse in the more urbanized areas and on the lower facility types.

Table 4-1
Accuracy of Existing Truck Model

Volume/Count Ratio

Facility Type	Area Type 1	2	3	4	5	6	7	All
Freeway	0	1.24	1.21	1.47	1.13	1.61	1.34	1.27
Maj Art	3.55	1.71	1.46	0.88	0.96	1.00	1.03	1.32
Min Art	2.24	1.02	1.28	0.50	0.76	0.78	1.10	0.96
Collect.	1.52	0.74	0.51	0.29	0.53	0.63	0.65	0.59
Exprswy.	0	0.51	1.06	0.65	0.78	1.27	1.22	0.85
All	3.15	1.41	1.32	0.77	0.92	0.99	1.05	1.16

% RMSE

Facility Type	Area Type 1	2	3	4	5	6	7	All
Freeway	0	0.397	0.292	0.624	0.140	0.697	0.703	0.439
Maj Art	3.329	1.509	1.029	0.558	0.485	0.555	0.762	0.983
Min Art	1.431	1.165	1.481	1.237	0.748	0.694	0.930	1.125
Collect.	1.385	0.749	1.073	1.222	1.029	1.201	0.930	1.125
Exprswy.	0	0.635	0.334	0.712	0.477	0.584	0.226	0.598
All	3.188	1.362	0.987	0.998	0.531	0.890	1.060	1.044

Note: %RMSE is expressed as a fraction of 1.0, so 1.044 is equivalent to 104.4% RMSE.

4.3 Starting Model

Trip Generation

The starting trip end model is a similar model the consultant developed for the Baltimore area, which is in turn based on data in the TMIP *Quick Response Freight Manual* (QRFM). The basic trip end equations are shown below:

MTK productions = 0.125 * [indemp + retemp] + 0.034 * [offemp + othemp] + 0.048 * HH
HTK productions = 0.179 * indemp + 0.026 * [offemp + othemp] + 0.127 * retemp
+ 0.061 * HH
(attractions are set equal to productions, by zone)

Where:
indemp = industrial employment
offemp = office employment
retemp = retail employment
othemp = other employment
HH = households

External Trips

The above models estimate the total number of productions by zone (the number of attractions is defined as being equal to the number of productions). An external model estimates the proportion of those trip ends that are external, as a function of the zone's distance to the cordon, based on the relationship shown in Figure 4-1 (also adapted from the Baltimore model). The percent of trip ends in a zone that are external (I/X or X/I) is inversely proportional to the distance from that zone to the nearest external cordon station (d). The initial MTK equation is %ext = max(0.65*$d^{-0.9}$, 0.6) and the HTK equation is %ext = max(0.27*$d^{-0.5}$, 0.9). In application, external trips are extracted and treated as a separate trip purpose, defined as productions at the internal zones and attractions at the external stations. The productions are normalized to match the attraction total.

External attractions by station are a basic input to the model. Table 3-2 shows the cordon total for each truck type and station. These must be divided into external (I/X + X/I) and through (X/X) trip ends. The consultant applied a look-up table to split these trip ends into external and through, based on facility type and relationships from other models (see Table 4-2).

Table 4-2
External Trip Share

Percent of Cordon Trip Ends that are External (I/X & X/I)

FTYPE	MTK	HTK	
1	60%	30%	Freeway
2	60%	30%	Maj Arterial
3	80%	50%	Min Arterial
4	90%	60%	Collector
5	60%	50%	Expressway

These percentages were estimated by the consultant, based on experience in other areas. They reflect the logic that a lower proportion of through travel (thus a higher proportion of external travel) should be expected on the lower facility types, and vice-versa for the higher facility types. These values were also adjusted to more closely reflect the results of the MWCOG 2003 cordon truck survey.

Application of the external shares in Table 4-2 to the cordon totals in Table 3-2 produces the values shown in Table 4-3, in the columns "Initially Calculated External Trip Ends". The "Initially Calculated X/X Trip Ends" are the total, minus the externals. These X/X trip ends are then input to a process that synthesizes the X/X truck trip tables (see below). That process produces the figures shown in the "Final X/X Trip Ends" columns. Subtracting these from the total produces the final columns, "Final External Trip Ends".

Through Trips

The current X/X truck trip tables were based on 1968 survey data and have been growth factored over the years, to represent forecast year trips. Although a cordon truck survey was conducted in

2003, the sample size was too small to permit the creation of an X/X truck table directly from this data. However, the data were reliable at the trip end level and were used to influence this process.

In recent years, the consultant has had reasonable success with an innovative method of synthesizing an X/X table and this approach was used in this project. It consists of the following steps (all performed separately for MTK and HTK):

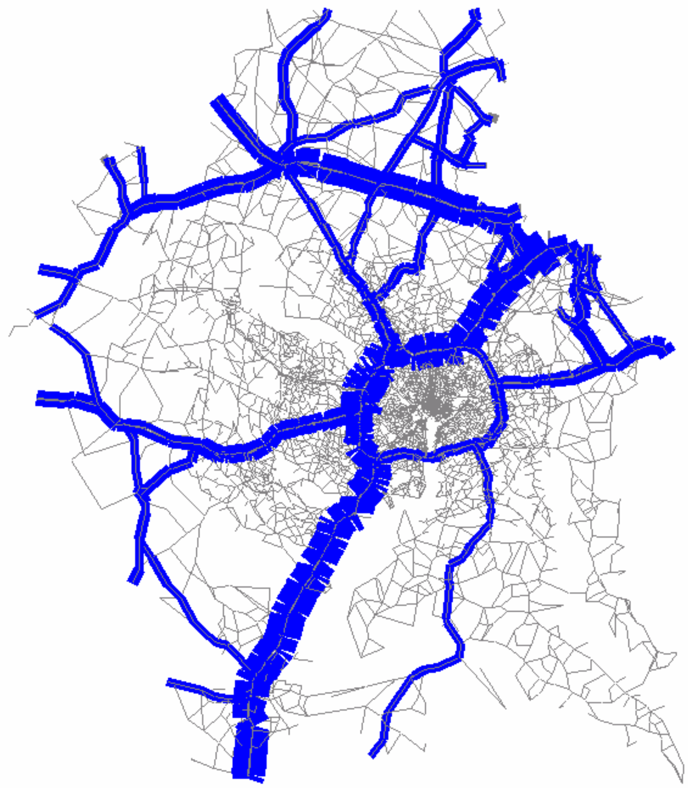
- Build a matrix showing illogical X/X connections
  Simple examination of the external station geography discloses the fact that certain station-to-station movements are highly unlikely. The consultant identified all such X/X movements and created a matrix with the value 1 in every cell that was judged to be illogical.
- Convert “illogical” matrix to “feasible” matrix
  Subtracting the above matrix from 1, cell by cell, produces a matrix that has the value 1 in every cell that is considered feasible.
- Fratar feasible matrix
  The matrix of feasible X/X movements is fratared to match the “Initially Calculated X/X Trip Ends” shown in Table 4-3. Examination of the resulting MTK table indicated that it did not balance properly. Thus, an additional non-iterative proportional fitting step was inserted to create a better starting table for MTK trips.
- Adjust table for through routes
  Common sense (and the 2003 survey) suggests that certain O/D pairs will have higher travel than the above process calculates. This involves external stations that are on the same through route. In the Washington area, the principal examples are I-95 and I-70. For example, a trip heading north at station 2149 (I-95 in Spotsylvania) is slightly more likely to stay on I-95, exiting the region at station 2182 (I-95 in Baltimore). The affected O/D pairs are increased and the Fratar step is repeated. The final X/X trips are integerized.
- Assign X/X trips to check
  The resulting X/X tables are assigned to the network in a one-pass, all-or-nothing assignment to see what the resulting volume patterns look like. Figure 4-1 shows this plot for HTK volumes. Bearing in mind that this is a non-capacity restrained assignment using paths based on off-peak time (OPHTIME), these patterns appear reasonable.

Because the Fratar process does not match the desired input volumes exactly, there is a small difference between the input and output trip ends. The output X/X trip ends are shown in Table 4-3 as the “Final X/X Trip Ends”. Thus, the final external trip ends are the total, minus those X/X trip ends. The X/X trip total for 2005 is 5,714 MTK and 27,058 HTK.

Table 4-3
External/Through Volumes

			2005 2-way tot vol		Initially Calculated External trip ends		Initially Calculated X/X trip ends (input to MAKEXX.S)		Final X/X trip ends (from MAKEXX.S)		Final External trip ends (cordon - final X/X)	
Station	Route	Facility Type	MTK	HTK	MTK	HTK	MTK	HTK	MTK	HTK	MTK	HTK
2145	VA 3	3	230	460	184	230	46	230	44	225	186	235
2146	US 301 (S)	2	340	1,350	204	405	136	945	140	947	200	403
2147	US 17	3	180	350	144	175	36	175	35	172	145	178
2148	VA 2	2	100	260	60	78	40	182	41	184	59	76
2149	I-95 (VA)	1	2,050	11,630	1,230	3,489	820	8,141	819	8,141	1,231	3,489
2150	US 1 (VA)	2	190	490	114	147	76	343	83	341	107	149
2151	VA 208	3	140	270	112	135	28	135	25	138	115	132
2152	VA 612	4	70	70	63	42	7	28	8	26	62	44
2153	VA 3	4	460	1,150	414	690	46	460	45	455	415	695
2154	US 15/29	2	720	1,920	432	576	288	1,344	283	1,344	437	576
2155	US 211	4	370	370	333	222	37	148	39	148	331	222
2156	I-66	1	700	4,200	420	1,260	280	2,940	280	2,938	420	1,262
2157	VA 55	4	20	20	18	12	2	8	2	8	18	12
2158	US 340	3	160	650	128	325	32	325	36	328	124	322
2159	US 17/50	2	230	460	138	138	92	322	88	320	142	140
2160	VA 7	2	560	1,690	336	507	224	1,183	225	1,181	335	509
2161	WVA 51	3	180	540	144	270	36	270	36	269	144	271
2162	WVA 9	2	390	2,340	234	702	156	1,638	157	1,637	233	703
2163	WVA 45	2	150	440	90	132	60	308	63	305	87	135
2164	WVA 480	3	120	360	96	180	24	180	23	182	97	178
2165	US 40 Alt	2	180	270	108	81	72	189	66	189	114	81
2166	I-70 (W)	1	1,320	4,610	792	1,383	528	3,227	534	3,223	786	1,387
2167	US 40 (W)	3	240	240	192	120	48	120	46	121	194	119
2168	MD 77	3	120	80	96	40	24	40	24	43	96	37
2169	MD 550	3	220	100	176	50	44	50	44	51	176	49
2170	MD 140 (N)	2	310	420	186	126	124	294	124	290	186	130
2171	US 15	5	340	2,230	204	1,115	136	1,115	133	1,112	207	1,118
2172	MD 194	2	170	280	102	84	68	196	69	196	101	84
2173	MD 97	2	240	400	144	120	96	280	96	280	144	120
2174	MD 30 (N)	2	440	2,070	264	621	176	1,449	176	1,447	264	623
2175	MD 86	3	170	210	136	105	34	105	37	104	133	106
2176	MD 88	2	80	300	48	90	32	210	32	208	48	92
2177	MD 30 (E)	2	380	1,340	228	402	152	938	149	938	231	402
2178	MD 140 (E)	2	1,570	2,380	942	714	628	1,666	629	1,663	941	717
2179	MD 26	2	480	1,190	288	357	192	833	192	835	288	355
2180	I-70 (E)	1	1,810	4,530	1,086	1,359	724	3,171	726	3,176	1,084	1,354
2181	US 40 (E)	5	960	640	576	320	384	320	379	321	581	319
2182	I-95 (MD)	1	5,240	13,980	3,144	4,194	2,096	9,786	2,107	9,809	3,133	4,171
2183	I-195	2	1,230	2,450	738	735	492	1,715	493	1,718	737	732
2184	MD 295	1	0	0	0	0	0	0	0	0	0	0
2185	MD 170	2	300	1,040	180	312	120	728	118	729	182	311
2186	MD 648	2	360	1,090	216	327	144	763	140	761	220	329
2187	MD 3	5	1,300	700	780	350	520	350	520	348	780	352
2188	MD 2	2	1,520	780	912	234	608	546	606	550	914	230
2189	MD 10	1	1,570	3,130	942	939	628	2,191	628	2,193	942	937
2190	MD 710	2	650	970	390	291	260	679	258	678	392	292
2191	US 50 (MD)	1	1,570	5,500	942	1,650	628	3,850	630	3,844	940	1,656
total trip ends			30,130	79,950	18,706	25,834	11,424	54,116	11,428	54,116	18,702	25,834

Figure 4-1
HTK X/X Patterns



Truck Skims

The consultant originally planned to use the standard off-peak pump-prime skims as normally calculated by the MWCOG model. However, those skims are based on SOV paths and do not reflect truck restrictions or value of time. Thus, the consultant created a new setup file that calculates off-peak travel times for trucks, taking into account truck restrictions and basing the paths on impedance that is calculated using the truck value of time. This setup uses the OPHTIME variable and increases that by the equivalent time calculated from the off-peak truck toll, to produce the truck impedance. Paths are built minimizing this impedance, but the value skimmed from the path is the actual time. In addition, these paths are built by excluding links representing HOV2, HOV3, truck-prohibited roads (parkways), the Dulles Airport Access Road, and all transit-only links.

The resulting skim table is updated with terminal and intrazonal times. Also, the value of 100,000 is inserted in cells which represent unconnected O/D pairs, to prevent the gravity model from estimating any trips for such movements. These steps are taken from the standard MWCOG skim process.

In addition, it turned out that numerous zone centroids are connected only to truck-restricted roads in the network. In the early stages of model development, trips were being estimated for such zones but could not be assigned to the network, creating a discrepancy in the assignment report. In order to avoid this situation, the consultant added a “connectivity check”. As part of the truck skim process, a file is output containing the skim total by zone (i.e., the sums of the travel time from that zone to all other zones and to that zone from all other zones). The trip generation setup includes a step that checks that file. If the zone is inaccessible by trucks in either direction, no truck trip ends are estimated for that zone.

In the case of some zones, truck inaccessibility may be an artifact of the way the network is coded in certain areas. That is, a zone might actually be accessible by trucks, but the network coding doesn’t reflect that. The consultant judged that that is the lesser of the two types of error.

Trip Distribution

Trip distribution is performed using a standard gravity model. The principal component of gravity model calibration is the F factor curve, which translates travel time into the effective impedance separating each zone-zone pair. The consultant considered several sources of F factors and tested a few different formulas, examining the resulting average trip lengths and convergence (equivalence of input and calculated attractions by zone). Figures 4-2 and 4-3 show the curves that were considered for MTK and HTK, respectively.

Figure 4-2
Candidate MTK F Factor Curves

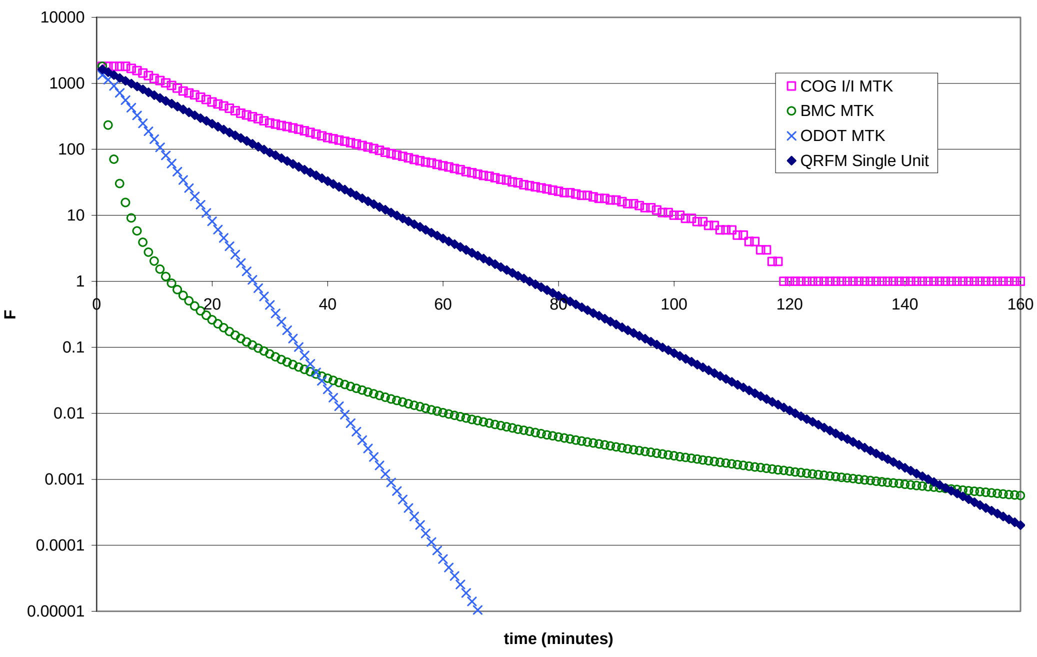
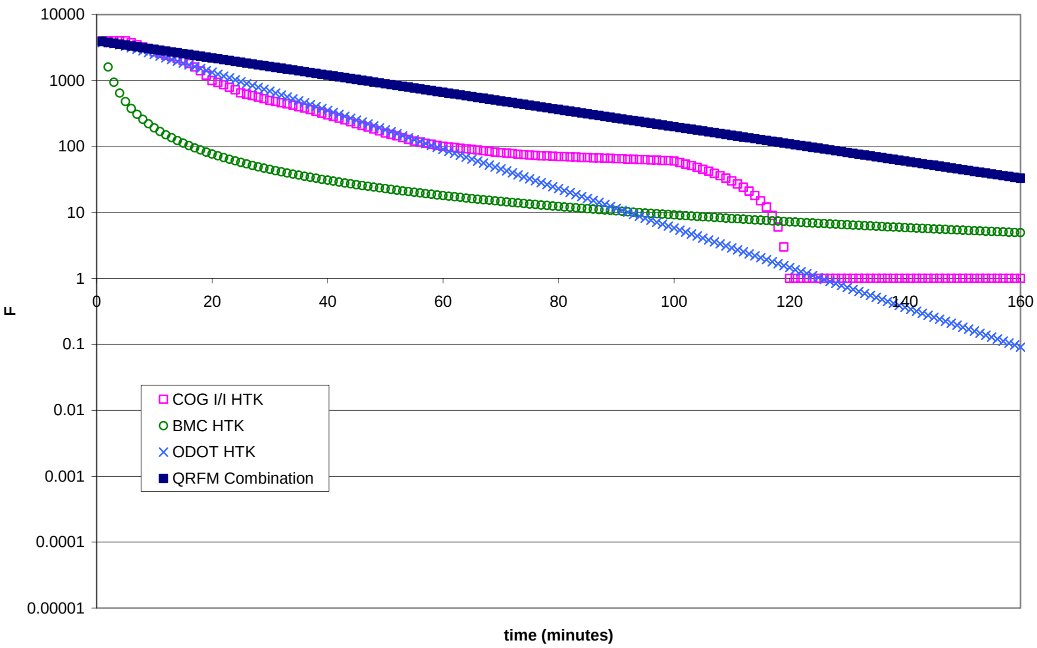


Figure 4-3
Candidate HTK F Factor Curves



These included the original MWCOG F factors and curves developed by the consultant for similar models in Baltimore and several urban areas in Ohio. For reference, the generic curves listed in the Quick Response Freight Manual (QRFM) for Single Unit and Combination trucks are shown. For the MWCOG model, the following functions were selected:

- MTK I/I: The QRFM Single Unit F factors, but with a different scale.
  $F = 4{,}500{,}000 * e^{-0.1t}$. (The Baltimore F factors were used initially, but were found to produce very odd-looking trip length frequency distributions and did not converge in a reasonable fashion.)
- HTK I/I: The Baltimore HTK F factors, but with a different scale.
  $F = 4{,}000{,}000 * t^{-1.32}$.
- MTK External: A power function using an exponent roughly halfway between that of the Baltimore MTK and HTK F factor models (-2.95 and -1.32, respectively), and with a different scale.
  $F = 4{,}000{,}000 * t^{-1.9}$.
- HTK External: A power function using an exponent slightly less powerful than the Baltimore HTK F factor model, and with a different scale.
  $F = 4{,}000{,}000 * t^{-1.0}$.

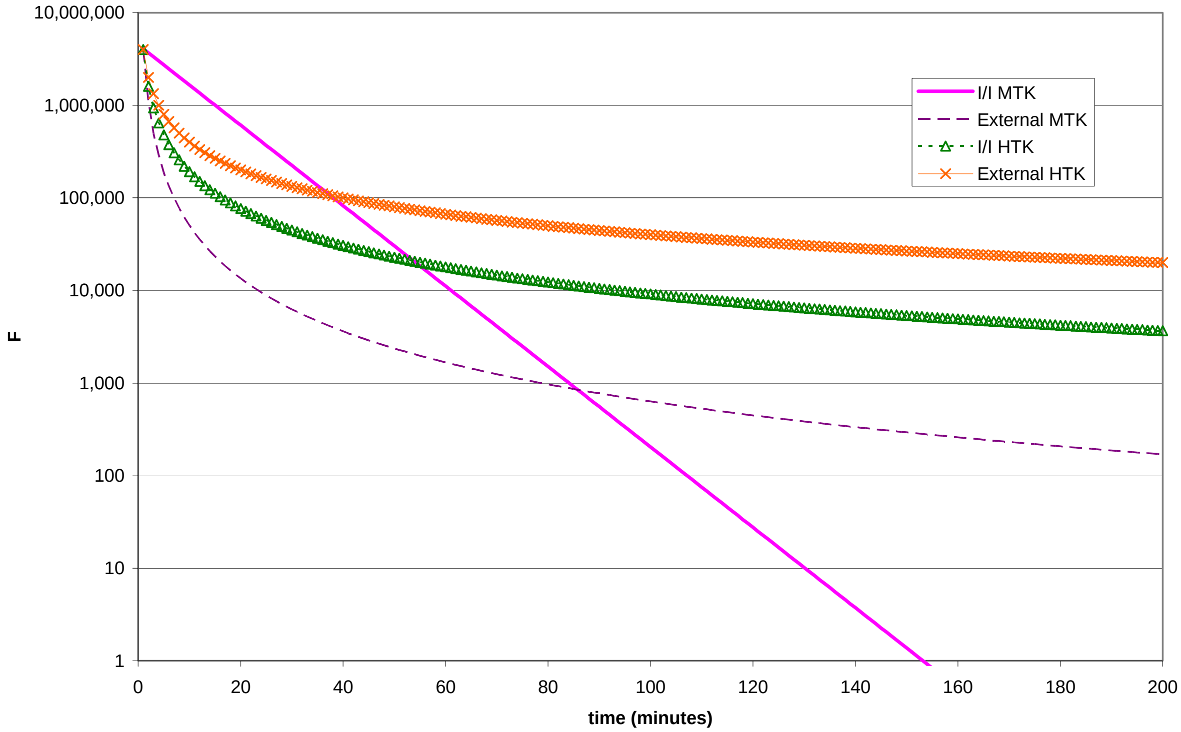
All four curves are scaled such that integer values can be used for all F values; i.e., there is no need to resort to fractional values. For the MTK I/I F factors, the factor drops to zero for travel times above 160 minutes. This means that the MTK model can estimate no I/I trips with a travel time of more than 160 minutes. The selected F factor curves are shown in Figure 4-4.

Separate gravity models are applied for I/I trips and external trips. In the gravity model setup file (TP+ program TRIPDIST), a maximum of 20 iterations of the gravity model are used, unless the %RMSE for both trip types is less than 10%. The resulting trip tables are not integerized and are output using single precision accuracy. In TP+, single precision format stores numbers with six digits to the right of the decimal point. Although single precision causes the file sizes to be much larger, its use is necessary because the TP+ default of two decimal places was causing too many trips to be lost to round-off error.

The resulting average trip lengths in minutes are as follows:

MTK I/I	24.2
MTK Ext	57.4
HTK I/I	48.8
HTK Ext	76.1

Figure 4-4
Final Truck F Factor Curves



Time of Day

For the time of day fractions, the consultant analyzed the MDOT hourly count data, as described in Chapter 3. Although in theory the temporal distribution summed from count data is not *exactly* the same as the temporal distribution of the trip table, they are usually considered to be close enough. Table 4-4 compares the current MWCOG truck model trip fractions by time period with the fractions derived from the MDOT counts. These sets of fractions are surprisingly similar. Thus, the consultant recommends using the MDOT count-derived fractions.

Table 4-4
Temporal Fractions

Source	AM	OP	PM
Current MWCOG MTK	19.5%	65.3%	15.2%
Current MWCOG HTK	15.4%	71.6%	13.0%
MDOT Count MTK	20.8%	63.4%	15.8%
MDOT Count HTK	18.0%	67.2%	14.8%

Assignment

For assignment, the existing MWCOG Highway_Assignment.s setup was adopted, with these changes:

- MTK and HTK trips are assigned using the truck usage restrictions. It is assumed that trucks cannot legally use any HOV lanes or truck-restricted roads (parkways).
- The network used for assignment is the year 2005 ZONEHWY.NET, with additional fields, MTKCNT and HTKCNT, added to hold the truck counts. Actual count data are used where available (mostly in Maryland) and mostly synthesized counts are used elsewhere.

Validation

Based on the initial model, Table 4-5 shows the total estimated/observed ratio by facility and area type and Table 4-6 shows the %RMSE by facility and area type. The initial model is fairly close for MTK trips, but severely overestimates HTK trips.

Table 4-5
Link Estimated/Observed Crosstab – Initial Model

Medium Truck

CROSSTAB ROW=FTYPE COL=AREATP COMP=_vol/_cnt

	1	2	3	4	5	6	7	1 7
1 - 1	0	0.94	0.89	1.02	0.80	1.00	1.01	0.91
2 - 2	2.05	1.14	1.11	0.77	0.68	0.67	0.53	0.88
3 - 3	9.54	0.70	0.79	0.57	0.68	0.68	0.66	0.70
4 - 4	1.12	0.54	0.43	0.10	0.24	0.46	0.52	0.39
5 - 5	0	0	0.90	0.63	0.68	0.97	0.68	0.78
0 - 6	2.13	1.01	0.98	0.74	0.72	0.79	0.70	0.85

Heavy Truck

CROSSTAB ROW=FTYPE COL=AREATP COMP=_vol/_cnt

	1	2	3	4	5	6	7	1 7
1 - 1	0	2.85	2.63	2.26	2.30	3.15	3.10	2.68
2 - 2	7.81	4.16	3.63	2.54	2.73	3.25	2.83	3.22
3 - 3	36.19	2.36	2.05	1.02	2.03	2.29	3.06	2.24
4 - 4	3.00	1.49	0.75	0.21	0.48	0.94	1.11	0.80
5 - 5	0	0	2.33	1.24	1.86	2.29	2.61	1.89
0 - 6	8.00	3.22	2.86	1.92	2.35	2.94	2.88	2.72

Table 4-6
Percent RMSE Crosstab – Initial Model

Medium Truck

CROSSTAB ROW=FTYPE COL=AREATP COMP=sqrt(_sqerr/_links)/(_cnt/_links)

	1	2	3	4	5	6	7	1 7
1 - 1	0	0.27	0.26	0.37	0.34	0.41	0.35	0.32
2 - 2	1.66	0.77	0.68	0.63	0.56	0.56	0.78	0.67
3 - 3	8.73	0.74	0.74	0.76	0.83	0.68	0.81	0.78
4 - 4	0.62	0.80	0.91	1.82	0.90	0.88	0.92	1.41
5 - 5	0	0	0.44	0.52	0.43	0.51	0.32	0.49
0 - 6	1.98	0.61	0.56	0.67	0.54	0.63	0.74	0.62

Heavy Truck

CROSSTAB ROW=FTYPE COL=AREATP COMP=sqrt(_sqerr/_links)/(_cnt/_links)

	1	2	3	4	5	6	7	1 7
1 - 1	0	2.26	1.94	1.54	1.48	2.65	2.72	2.05
2 - 2	7.30	4.33	3.51	2.64	2.48	3.44	2.85	3.21
3 - 3	36.21	2.73	2.09	1.23	2.10	2.65	3.84	2.63
4 - 4	2.66	3.01	1.37	1.86	0.94	1.34	1.67	1.91
5 - 5	0	0	1.61	0.77	1.06	1.82	1.61	1.31
0 - 6	8.71	4.62	3.80	2.12	2.43	4.41	4.02	3.59

Note: values are %RMSE as a fraction of 1.0, e.g., 1.11 = 111% RMSE

4.4 Adjusted Model

The basic premise of the consultant's approach to this project is that it is possible for the counts to "inform" the model. That is, the initial model would be applied and the resulting assignments compared to the counts in such a way as to suggest changes to the initial model, that would make the assignments closer to the counts. In effect, this customizes the model to the situation at hand.

Following the initial assignment, a matrix estimation procedure is applied to calculate a new trip matrix that would produce link volumes closer to the counts. Several techniques are available for this purpose, including commercially available software such as Cube ME. However, the consultant has had very good experience using his proprietary method, called *adaptable assignment (AA)*. This is actually not a specialized software package, but a set of TP+ scripts that are applied in iterative fashion at the user's direction (see Appendix B).

The resulting "after" trip table is compared to the "before" (starting) table, providing useful information to the calibration process. Specifically, comparison of the "before" and "after" trip ends and examination of the correlation of their difference with various socioeconomic data items available from the ZONE.ASC file, at the zone level, should disclose any bias of the model with respect to the socioeconomic data.

In theory, if the difference in trip ends has any reasonable correlation with, say, retail employment, then that would suggest that the starting model is biased with respect to that variable. This would mean that the starting model's coefficient on that variable should be changed and the process re-applied. After 29 iterations of this kind of testing, the consultant arrived at the following new trip generation model:

MTK productions = (0.125 * [indemp + retemp] + 0.005 * offemp + 0.020 * othemp
+ 0.100 * HH) * ATfac(m) * TZfac(m)
HTK productions = (0.078 * indemp + 0.039 * retemp + 0.002 * offemp + 0.003 * othemp
+ 0.015 * HH) * ATfac(h) * TZfac(h)

The basic variables are as described above. These equations include two new sets of adjustment factors, for area type and truck zones:

ATfac = area type adjustment factor:

Area type	MTK Factor	HTK Factor
1 (CBD)	0.7	0.7
5	1.2	1.1
6	1.2	1.1
7 (rural)	1.2	1.1

Note: no factor is applied to area types 2-4.

TZfac = truck zone adjustment factor: 2.7 (MTK), 5.3 (HTK) if the zone is a truck zone (see below).

Compared to the initial model, the MTK coefficients are reduced for office and other employment, but increased for HHs. The HTK coefficients are reduced for all variables, but especially for office and other employment. The area type adjustments indicate that the model was overestimating trips in the CBD, but slightly underestimating them in the exurban and rural areas. The truck zone factors are very strong adjustments, reflecting the importance of the "truck zone" designation on the trip rate per employee.

Compared to the initial model, the revised model suggests that employment (especially office employment) is less important, and households are more important, in generating truck trips. One can interpret this to mean that the trip rate *per employee* is higher for non-office than for office jobs, which probably makes sense. Even though a great many truck trips are indeed associated with office employment, the rate per employee is lower. This also helps correct a problem that occurred during model development, of overestimating volumes in the CBD. Reducing the coefficient on office employment and the lower factor on area type 1 obviously helped that.

As noted above, the main purpose of these adjustments is to remove any potential bias in the estimate, with respect to these variables. So when this model and the AA process are applied, one should expect there to be very little correlation between the trip end difference (*after* minus *before*) and these variables, at the zone level. As Table 4-7 shows, this was achieved.

Table 4-7
Final Trip End Correlations

Zonal Variable	Correlation with Trip End Difference MTK	HTK
hh	-0.012	0.040
hhpop	0.002	0.049
gqpop	-0.022	-0.001
totpop	0.000	0.048
totemp	-0.014	0.064
indemp	-0.004	0.107
retemp	0.028	0.121
offemp	-0.023	0.022
othemp	-0.019	0.005
final/starting ratio	1.018	1.204
final/starting correlation	0.825	0.877

Table 4-8 shows the ratios of the "after" trip ends to the "before" trip ends, stratified by area type and truck zone status. This table indicates very little difference for MTK trips, but a slight increase for HTK trips. The consultant considered further changes to the area type and truck zone adjustments, but concluded that the truck zone adjustment factors were already fairly high. Increasing the area type factors beyond the values shown above runs the risk of creating a more serious “cliff effect” problem, producing a disproportionate response in tripmaking when a zone changes area type in the future.

Table 4-8
Area Type/Truck Zone Analysis

area type	ratio of final trips to starting trips MTK	HTK
1	1.02	0.64
2	0.92	1.04
3	0.85	1.14
4	1.09	1.38
5	1.24	1.36
6	1.16	1.41
7	1.35	1.27
all	1.02	1.20

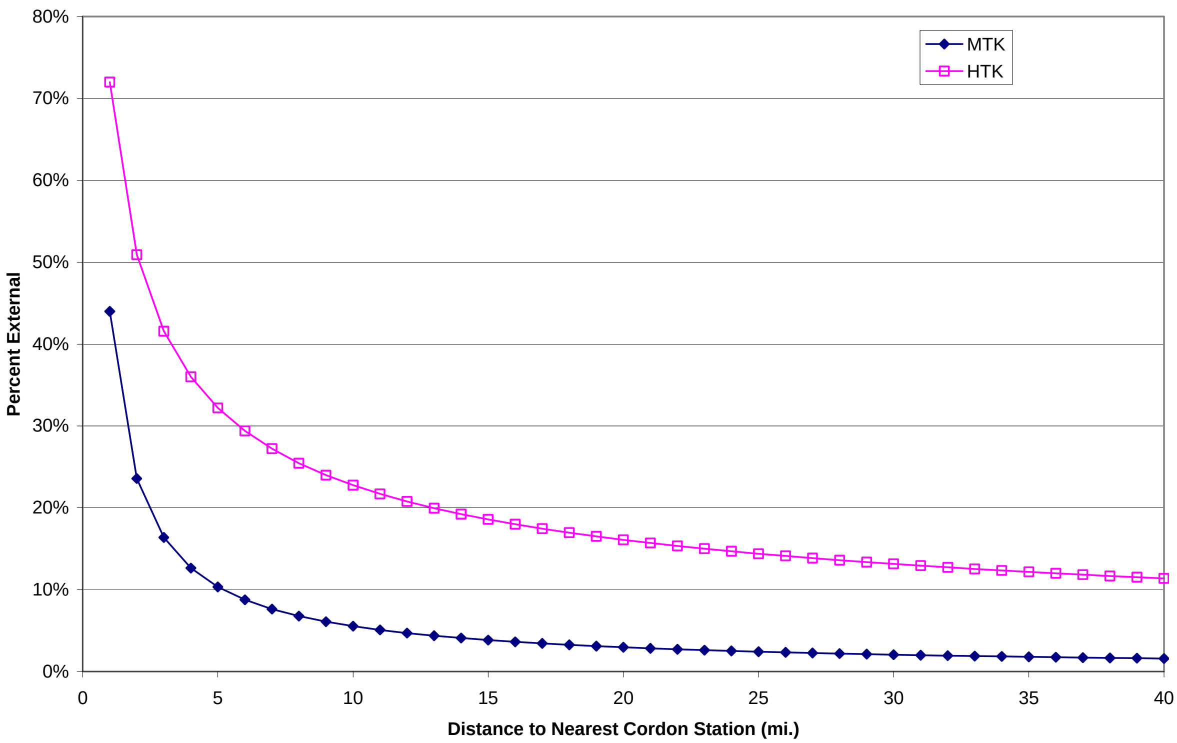
truck zone	ratio of final trips to starting trips MTK	HTK
no	1.01	1.22
yes	1.08	1.16
all	1.02	1.20

Another change in the revised model is that the external share equations were modified slightly, in order to maintain the balance between external trip ends at the internal zones and at the cordon. The revised equations are: MTK %ext = $\max(0.44*d^{-0.9}, 0.6)$ and HTK %ext = $\max(0.72*d^{-0.5}, 0.9)$. Figure 4-5 shows the final external model. No other changes were made to the initial model’s trip distribution or time of day steps.

The only other change in the revised model is that a calibration adjustment matrix is added to the output of the trip distribution step. The calibration matrix (a.k.a. “delta table”) is a set of cell values that adjust the basic model’s cell values in a way that produces link volumes that more closely match the counts. These adjustments are related to the specific locations of counts and the assignment methodology, but are otherwise random-looking values. Table 4-9 shows the “before”, “after”, and delta tables, and the delta ratio, compressed to jurisdictions.

As this table shows, the delta table adds a net 2% more MTK trips and 15% more HTK trips to the “before” trip tables. These changes are typical of those seen when using the AA process.

Figure 4-5
Final External Share Model



Detailed examination of the delta matrices identified a few O/D pairs that had especially large increases in truck trips. These mostly involved BWI, the Pentagon, and the Sterling/Ashburn area. This should not be too surprising.

The adaptable assignment process, like all matrix estimation procedures, tends to add more short trips than longer ones. This is because in the process of trying to influence the trips on a link, these algorithms find it more efficient to change the short trips than the longer ones. Also, shorter trips generally affect only a few counts, while longer trips affect several counts. On longer trips, the individual link errors tend to even each other out, which means that such trips don't need to be adjusted by very much. Thus in Table 4-9, higher positive delta values tend to be seen for the intra-jurisdictional movements.

In the early AA runs, this tendency was extremely pronounced for HTK trips. In fact, AA added so many short trips that it severely distorted the HTK trip length frequency distribution (TLFD). While this led to improved %RMSE values, the consultant judged that it was not an acceptable result and modified the AA process for HTK trips so that they would more closely reflect the starting TLFD. This resulted in lower accuracy (higher %RMSE) for the HTK estimates, but this trade-off was judged to be necessary.

Table 4-9
Calibration Adjustment Tables

Date: 6/19/2008
Time: 16:56

MWCOG Truck Trip Model
Starting Model Trips
Medium Truck

Destination District

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	1 DC	20472	4274	9464	3137	1573	3111	61	254	41	337	582	149	4	38	2	0	2	35	3	7	0	1	478	44025
	2 Mont Co	4315	36503	5568	635	260	3265	261	203	2001	2175	702	24	210	8	1	1	0	9	2	13	2	24	741	56923
	3 PG Co	9634	5398	29028	1187	1373	2844	57	241	47	2543	3697	1164	19	258	28	5	1	27	5	4	0	1	802	58363
	4 Arlingtn	3151	626	1186	3725	1464	3467	74	258	13	33	64	29	3	3	0	0	1	24	3	1	0	1	143	14269
O	5 Alxndria	1582	267	1219	1517	2152	3409	36	342	3	15	58	57	2	7	3	0	2	38	4	6	0	0	99	10818
r	6 Fairfax	3383	3224	3004	3586	3391	40022	4790	5725	80	111	130	152	5	19	2	0	26	339	47	255	3	4	631	68929
i	7 Loudoun	75	283	59	81	51	5084	14283	691	275	14	3	3	7	0	0	0	1	3	1	132	156	124	230	21556
g	8 PrWillam	292	232	274	276	362	6052	639	15158	3	7	6	26	0	2	1	4	75	935	136	672	4	1	322	25479
i	9 Fredrick	51	2466	73	17	5	111	264	5	16511	487	28	0	682	0	0	0	0	1	0	1	13	186	596	21497
n	10 Howard	334	2232	2597	32	19	114	11	4	407	14238	4549	5	458	3	0	0	0	2	1	0	0	5	1296	26307
	11 AnnArndl	593	700	3754	73	58	130	4	8	22	4527	27394	41	32	241	1	0	0	1	0	1	0	0	2020	39600
D	12 Charles	233	29	1468	42	90	177	0	14	0	6	59	6640	0	166	300	90	1	2	1	0	0	0	112	9430
i	13 Carroll	9	295	29	0	0	5	6	0	822	602	46	0	9767	0	0	0	0	0	0	1	0	5	533	12120
s	14 Calvert	50	15	407	6	17	28	0	3	0	6	348	222	0	4426	484	4	0	0	0	0	0	0	63	6079
t	15 St Marys	7	0	64	3	3	2	0	0	0	1	4	484	0	607	6042	35	0	3	0	0	0	0	81	7336
r	16 King Geo	1	0	7	0	1	1	0	7	0	0	0	114	0	2	29	828	29	62	42	3	0	0	48	1174
i	17 Frdckbrg	4	2	3	3	5	42	0	111	0	0	0	1	0	0	0	18	710	805	720	24	0	0	108	2556
c	18 Stafford	37	17	34	34	46	419	4	1126	0	0	2	2	0	1	0	36	756	4904	1168	179	0	0	230	8995
t	19 Spotsylv	8	2	6	6	8	73	0	197	0	0	1	1	0	0	0	26	749	1253	4684	41	0	0	444	7499
	20 Fauquier	5	12	4	8	4	302	124	749	2	0	0	0	0	0	0	0	21	172	38	2500	14	2	146	4103
	21 Clarke	0	3	2	0	0	9	218	11	20	0	1	0	0	0	0	0	0	0	0	26	496	188	45	1019
	22 Jeffrson	3	45	0	0	0	7	173	1	291	7	0	0	8	0	0	0	0	0	0	4	210	2299	147	3195
	23 External	464	740	817	140	103	627	231	329	596	1298	2017	107	538	63	85	48	109	230	446	147	43	150	5728	15056
	Total	44703	57365	59067	14508	10985	69301	21236	25437	21134	26407	39691	9221	11735	5844	6978	1095	2483	8845	7301	4017	941	2991	15043	466328

Date: 6/19/2008
Time: 16:56

MWCOG Truck Trip Model
Adaptable Assignment Revised Trips
Medium Truck

Destination District

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	1 DC	26028	3291	6248	1303	678	1116	28	169	47	242	452	230	0	36	0	1	4	13	6	1	0	0	482	40375
	2 Mont Co	3267	50777	4636	285	115	1122	169	64	1904	1552	712	24	213	6	1	0	1	5	0	3	4	18	747	65625
	3 PG Co	5889	4883	33529	881	661	866	26	86	49	1779	3874	2264	7	498	81	5	1	11	2	0	0	0	836	56228
	4 Arlingtn	1148	301	765	7375	2750	1790	19	584	5	14	61	29	0	5	0	0	2	26	7	2	0	0	136	15019
O	5 Alxndria	581	98	498	1264	3082	1641	6	636	1	7	45	37	0	6	0	0	2	23	10	3	0	0	99	8039
r	6 Fairfax	1023	1201	981	1494	1173	20126	3836	2908	47	72	91	61	4	14	1	2	31	243	69	174	3	1	642	34197
i	7 Loudoun	31	185	27	21	4	4175	41519	792	180	5	5	0	1	0	0	0	0	2	0	280	256	247	242	47972
g	8 PrWillam	113	67	72	316	57	2789	780	22916	4	3	9	2	1	2	0	3	83	994	263	1179	7	0	333	29993
i	9 Fredrick	51	1792	67	10	3	55	196	6	11637	314	20	1	643	0	0	0	1	0	0	1	6	81	603	15487
n	10 Howard	230	1541	1697	15	7	75	8	5	303	16097	4314	10	219	3	0	0	0	0	0	0	0	1	1308	25833
	11 AnnArndl	448	751	3760	57	51	89	2	7	14	4166	32101	74	19	299	5	1	0	0	0	0	0	0	2035	43879
D	12 Charles	255	37	2127	42	60	43	0	6	0	10	84	10940	0	275	1153	124	1	5	3	0	0	0	110	15275
i	13 Carroll	3	232	16	0	0	3	3	0	689	211	30	1	9354	0	0	0	0	0	0	0	0	1	541	11084
s	14 Calvert	46	12	572	5	12	14	0	0	0	4	314	290	0	4771	800	3	0	0	0	0	0	0	63	6906
t	15 St Marys	6	1	113	2	4	1	0	0	0	0	7	1083	0	798	6966	33	0	4	0	0	0	0	86	9104
r	16 King Geo	1	1	11	0	0	1	0	7	0	0	1	131	0	2	25	1233	47	97	73	1	0	0	48	1679
i	17 Frdckbrg	2	2	1	3	2	33	1	105	0	0	0	2	0	0	0	45	710	531	575	10	0	0	108	2130
c	18 Stafford	19	6	11	22	11	254	1	1003	0	0	1	4	0	0	0	93	548	5395	1575	441	0	0	232	9616
t	19 Spotsylv	4	3	2	6	5	69	0	305	0	0	1	2	0	0	0	59	627	1554	7401	39	0	0	446	10523
	20 Fauquier	1	6	2	1	1	196	250	1205	0	0	0	1	0	0	0	1	10	445	35	3850	43	2	146	6195
	21 Clarke	0	2	0	0	0	6	262	15	7	0	0	0	0	0	0	0	0	0	0	41	435	179	46	993
	22 Jeffrson	0	30	2	0	0	2	264	2	93	2	2	0	3	0	0	0	0	0	0	2	195	2296	151	3044
	23 External	490	749	830	134	102	638	238	329	608	1310	2034	111	543	63	83	50	108	233	451	144	53	154	5530	14985
	Total	39636	65968	55967	13236	8778	35104	47608	31150	15588	25788	44158	15297	11007	6778	9115	1653	2176	9581	10470	6171	1002	2980	14970	474181

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MWCOG Truck Trip Model
Delta Trips
Medium Truck

Destination District

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	1 DC	5556	-983	-3216	-1834	-895	-1995	-33	-85	6	-95	-130	81	-4	-2	-2	1	2	-22	3	-6	0	-1	4	-3650
	2 Mont Co	-1048	14274	-932	-350	-145	-2143	-92	-139	-97	-623	10	0	3	-2	0	-1	1	-4	-2	-10	2	-6	6	8702
	3 PG Co	-3745	-515	4501	-306	-712	-1978	-31	-155	2	-764	177	1100	-12	240	53	0	0	-16	-3	-4	0	-1	34	-2135
	4 Arlingtn	-2003	-325	-421	3650	1286	-1677	-55	326	-8	-19	-3	0	-3	2	0	0	1	2	4	1	0	-1	-7	750
O	5 Alxndria	-1001	-169	-721	-253	930	-1768	-30	294	-2	-8	-13	-20	-2	-1	-3	0	0	-15	6	-3	0	0	0	-2779
r	6 Fairfax	-2360	-2023	-2023	-2092	-2218	-19896	-954	-2817	-33	-39	-39	-91	-1	-5	-1	2	5	-96	22	-81	0	-3	11	-34732
i	7 Loudoun	-44	-98	-32	-60	-47	-909	27236	101	-95	-9	2	-3	-6	0	0	0	-1	-1	-1	148	100	123	12	26416
g	8 PrWillam	-179	-165	-202	40	-305	-3263	141	7758	1	-4	3	-24	1	0	-1	-1	8	59	127	507	3	-1	11	4514
i	9 Fredrick	0	-674	-6	-7	-2	-56	-68	1	-4874	-173	-8	1	-39	0	0	0	1	-1	0	0	-7	-105	7	-6010
n	10 Howard	-104	-691	-900	-17	-12	-39	-3	1	-104	1859	-235	5	-239	0	0	0	0	-2	-1	0	0	-4	12	-474
	11 AnnArndl	-145	51	6	-16	-7	-41	-2	-1	-8	-361	4707	33	-13	58	4	1	0	-1	0	-1	0	0	15	4279
D	12 Charles	22	8	659	0	-30	-134	0	-8	0	4	25	4300	0	109	853	34	0	3	2	0	0	0	-2	5845
i	13 Carroll	-6	-63	-13	0	0	-2	-3	0	-133	-391	-16	1	-413	0	0	0	0	0	0	-1	0	-4	8	-1036
s	14 Calvert	-4	-3	165	-1	-5	-14	0	-3	0	-2	-34	68	0	345	316	-1	0	0	0	0	0	0	0	827
t	15 St Marys	-1	1	49	-1	1	-1	0	0	0	-1	3	599	0	191	924	-2	0	1	0	0	0	0	5	1768
r	16 King Geo	0	1	4	0	-1	0	0	0	0	0	1	17	0	0	-4	405	18	35	31	-2	0	0	0	505
i	17 Frdckbrg	-2	0	-2	0	-3	-9	1	-6	0	0	0	1	0	0	0	27	0	-274	-145	-14	0	0	0	-426
c	18 Stafford	-18	-11	-23	-12	-35	-165	-3	-123	0	0	-1	2	0	-1	0	57	-208	491	407	262	0	0	2	621
t	19 Spotsylv	-4	1	-4	0	-3	-4	0	108	0	0	0	1	0	0	0	33	-122	301	2717	-2	0	0	2	3024
	20 Fauquier	-4	-6	-2	-7	-3	-106	126	456	-2	0	0	1	0	0	0	1	-11	273	-3	1350	29	0	0	2092
	21 Clarke	0	-1	-2	0	0	-3	44	4	-13	0	-1	0	0	0	0	0	0	0	0	15	-61	-9	1	-26
	22 Jeffrson	-3	-15	2	0	0	-5	91	1	-198	-5	2	0	-5	0	0	0	0	0	0	-2	-15	-3	4	-151
	23 External	26	9	13	-6	-1	11	7	0	12	12	17	4	5	0	-2	2	-1	3	5	-3	10	4	-198	-71
	Total	-5067	8603	-3100	-1272	-2207	-34197	26372	5713	-5546	-619	4467	6076	-728	934	2137	558	-307	736	3169	2154	61	-11	-73	7853

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MWCOG Truck Trip Model
Delta Trip Ratio
Medium Truck

Destination District

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	1 DC	1.27	.77	.66	.42	.43	.36	.46	.67	1.15	.72	.78	1.54	.00	.95	.00	.00	2.00	.37	2.00	.14	.00	.00	1.01	.92
	2 Mont Co	.76	1.39	.83	.45	.44	.34	.65	.32	.95	.71	1.01	1.00	1.01	.75	1.00	.00	.00	.56	.00	.23	2.00	.75	1.01	1.15
	3 PG Co	.61	.90	1.16	.74	.48	.30	.46	.36	1.04	.70	1.05	1.95	.37	1.93	2.89	1.00	1.00	.41	.40	.00	.00	.00	1.04	.96
	4 Arlingtn	.36	.48	.65	1.98	1.88	.52	.26	2.26	.38	.42	.95	1.00	.00	1.67	.00	.00	2.00	1.08	2.33	2.00	.00	.00	.95	1.05
O	5 Alxndria	.37	.37	.41	.83	1.43	.48	.17	1.86	.33	.47	.78	.65	.00	.86	.00	.00	1.00	.61	2.50	.50	.00	.00	1.00	.74
r	6 Fairfax	.30	.37	.33	.42	.35	.50	.80	.51	.59	.65	.70	.40	.80	.74	.50	.00	1.19	.72	1.47	.68	1.00	.25	1.02	.50
i	7 Loudoun	.41	.65	.46	.26	.08	.82	2.91	1.15	.65	.36	1.67	.00	.14	.00	.00	.00	.00	.67	.00	2.12	1.64	1.99	1.05	2.23
g	8 PrWillam	.39	.29	.26	1.14	.16	.46	1.22	1.51	1.33	.43	1.50	.08	.00	1.00	.00	.75	1.11	1.06	1.93	1.75	1.75	.00	1.03	1.18
i	9 Fredrick	1.00	.73	.92	.59	.60	.50	.74	1.20	.70	.64	.71	.00	.94	.00	.00	.00	.00	.00	.00	1.00	.46	.44	1.01	.72
n	10 Howard	.69	.69	.65	.47	.37	.66	.73	1.25	.74	1.13	.95	2.00	.48	1.00	.00	.00	.00	.00	.00	.00	.00	.20	1.01	.98
	11 AnnArndl	.76	1.07	1.00	.78	.88	.68	.50	.88	.64	.92	1.17	1.80	.59	1.24	5.00	.00	.00	.00	.00	.00	.00	.00	1.01	1.11
D	12 Charles	1.09	1.28	1.45	1.00	.67	.24	.00	.43	.00	1.67	1.42	1.65	.00	1.66	3.84	1.38	1.00	2.50	3.00	.00	.00	.00	.98	1.62
i	13 Carroll	.33	.79	.55	.00	.00	.60	.50	.00	.84	.35	.65	.00	.96	.00	.00	.00	.00	.00	.00	.00	.00	.20	1.02	.91
s	14 Calvert	.92	.80	1.41	.83	.71	.50	.00	.00	.00	.67	.90	1.31	.00	1.08	1.65	.75	.00	.00	.00	.00	.00	.00	1.00	1.14
t	15 St Marys	.86	.00	1.77	.67	1.33	.50	.00	.00	.00	.00	1.75	2.24	.00	1.31	1.15	.94	.00	1.33	.00	.00	.00	.00	1.06	1.24
r	16 King Geo	1.00	.00	1.57	.00	.00	1.00	.00	1.00	.00	.00	.00	1.15	.00	1.00	.86	1.49	1.62	1.56	1.74	.33	.00	.00	1.00	1.43
i	17 Frdckbrg	.50	1.00	.33	1.00	.40	.79	.00	.95	.00	.00	.00	2.00	.00	.00	.00	2.50	1.00	.66	.80	.42	.00	.00	1.00	.83
c	18 Stafford	.51	.35	.32	.65	.24	.61	.25	.89	.00	.00	.50	2.00	.00	.00	.00	2.58	.72	1.10	1.35	2.46	.00	.00	1.01	1.07
t	19 Spotsylv	.50	1.50	.33	1.00	.63	.95	.00	1.55	.00	.00	1.00	2.00	.00	.00	.00	2.27	.84	1.24	1.58	.95	.00	.00	1.00	1.40
	20 Fauquier	.20	.50	.50	.13	.25	.65	2.02	1.61	.00	.00	.00	.00	.00	.00	.00	.00	.48	2.59	.92	1.54	3.07	1.00	1.00	1.51
	21 Clarke	.00	.67	.00	.00	.00	.67	1.20	1.36	.35	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1.58	.88	.95	1.02	.97
	22 Jeffrson	.00	.67	.00	.00	.00	.29	1.53	2.00	.32	.29	.00	.00	.38	.00	.00	.00	.00	.00	.00	.50	.93	1.00	1.03	.95
	23 External	1.06	1.01	1.02	.96	.99	1.02	1.03	1.00	1.02	1.01	1.01	1.04	1.01	1.00	.98	1.04	.99	1.01	1.01	.98	1.23	1.03	.97	1.00
	Total	.89	1.15	.95	.91	.80	.51	2.24	1.22	.74	.98	1.11	1.66	.94	1.16	1.31	1.51	.88	1.08	1.43	1.54	1.06	1.00	1.00	1.02

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MWCOG Truck Trip Model
Starting Model Trips
Heavy Truck

Destination District

Origin District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 DC	2493	1048	1938	400	301	1336	346	385	301	533	635	175	107	93	96	8	33	108	96	45	7	29	849	11362
2 Mont Co	1051	3600	1530	234	190	1525	553	458	843	840	732	142	243	102	93	18	40	122	107	51	24	42	1105	13645
3 PG Co	1866	1518	4590	344	338	1596	476	468	417	1157	1265	282	186	194	141	17	41	142	118	58	9	50	1432	16705
4 Arlingtn	399	240	341	236	134	547	136	135	76	98	133	43	30	20	33	2	6	37	33	16	2	6	204	2907
5 Alxndria	310	195	325	146	210	587	114	134	71	85	122	43	24	29	28	3	12	39	28	11	4	9	180	2709
6 Fairfax	1350	1516	1588	537	576	5926	1465	1319	550	578	696	252	178	145	146	29	69	275	214	116	30	63	1233	18851
7 Loudoun	346	540	457	113	113	1388	2814	415	321	224	251	70	98	49	54	8	26	71	58	59	29	45	567	8116
8 PrWillam	384	455	473	129	139	1323	459	1841	186	190	234	87	60	53	55	14	39	163	112	88	11	24	574	7093
9 Fredrick	303	806	433	79	65	541	300	182	2637	345	296	61	231	44	42	7	13	53	45	30	19	68	905	7505
10 Howard	475	809	1076	96	88	578	233	195	351	2807	1185	88	191	65	60	6	17	55	48	27	10	30	1791	10281
11 AnnArndl	619	728	1263	131	125	699	257	236	298	1188	2800	133	157	121	102	10	18	77	64	32	15	28	2021	11122
12 Charles	173	142	295	42	51	243	72	84	58	88	130	400	24	57	75	14	6	28	31	8	2	8	167	2198
13 Carroll	111	240	186	27	24	180	92	66	233	190	158	27	789	20	9	2	5	21	17	11	5	17	476	2906
14 Calvert	101	101	183	26	27	141	50	48	44	65	122	56	19	272	96	9	5	16	17	8	0	9	104	1519
15 St Marys	95	101	154	25	27	146	49	57	43	65	99	72	14	98	552	9	10	23	27	7	1	1	134	1809
16 King Geo	14	13	22	3	5	24	9	13	7	8	12	11	2	5	11	7	5	7	11	0	0	3	40	232
17 Frdckbrg	29	31	37	9	11	66	20	39	14	15	20	7	5	5	9	4	116	67	73	6	1	2	116	702
18 Stafford	113	122	142	38	38	274	77	172	54	54	77	29	20	17	24	9	68	390	136	22	4	8	260	2148
19 Spotsylv	95	101	118	30	30	209	62	117	48	46	68	28	19	17	25	10	72	139	721	19	3	5	514	2496
20 Fauquier	42	61	58	13	14	131	63	90	26	28	32	13	12	7	7	2	6	24	19	71	4	5	128	856
21 Clarke	10	19	13	3	2	25	27	13	20	10	10	3	5	2	0	0	1	2	2	3	15	9	39	233
22 Jeffrson	30	63	41	9	7	56	47	25	72	31	30	5	16	5	3	1	2	6	5	5	8	89	115	671
23 External	818	1094	1434	193	180	1235	562	575	907	1787	2021	165	476	109	131	35	116	256	521	123	39	105	27082	39964
Total	11227	13543	16697	2863	2695	18776	8283	7067	7577	10432	11128	2192	2906	1529	1792	224	726	2121	2503	816	242	655	40036	166030

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MWCOG Truck Trip Model
Adaptable Assignment Revised Trips
Heavy Truck

Destination District

Origin District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 DC	1685	637	1567	362	210	894	200	546	236	500	628	167	55	110	139	8	15	76	61	42	4	28	890	9060
2 Mont Co	650	5323	1352	115	83	761	301	264	604	829	910	212	116	75	151	15	21	72	68	43	13	40	1105	13123
3 PG Co	1501	1373	7798	471	414	1804	735	833	327	1346	1294	421	120	153	235	23	27	119	102	63	22	35	1457	20673
4 Arlingtn	219	106	383	752	252	867	66	465	58	73	159	44	11	31	38	7	8	47	30	14	1	3	207	3841
5 Alxndria	116	96	346	244	410	633	289	364	46	55	161	40	14	35	17	3	5	36	35	9	8	8	183	3153
6 Fairfax	691	788	1687	738	540	6363	3842	2237	334	543	878	214	127	199	121	20	52	236	189	146	66	85	1248	21344
7 Loudoun	344	306	782	103	210	3752	11051	931	121	198	279	74	38	69	42	6	19	88	58	102	121	78	568	19340
8 PrWillam	426	267	780	436	292	2347	1048	5510	155	153	344	97	52	73	51	20	56	262	142	194	9	19	576	13309
9 Fredrick	222	554	337	55	45	335	124	161	2281	161	190	70	198	41	48	7	11	41	32	21	1	7	908	5850
10 Howard	464	791	1214	75	80	527	191	161	145	3227	1426	139	53	56	83	14	9	39	36	25	4	11	1793	10563
11 AnnArndl	595	938	1337	149	156	864	270	356	171	1445	3445	114	85	107	80	6	16	79	63	39	6	15	2027	12363
12 Charles	142	208	426	47	47	214	82	97	74	161	111	1201	33	65	170	6	5	18	17	7	4	8	171	3314
13 Carroll	56	108	99	15	12	129	48	49	237	67	103	33	875	8	15	2	2	14	13	8	2	6	476	2377
14 Calvert	113	75	152	35	39	201	79	79	32	55	95	74	11	220	101	3	4	16	12	9	0	5	108	1518
15 St Marys	110	116	217	29	28	142	52	53	48	76	77	176	13	97	626	8	3	20	20	7	0	0	132	2050
16 King Geo	11	16	25	5	3	19	7	13	8	14	8	6	1	6	8	10	3	7	5	2	0	0	41	218
17 Frdckbrg	18	20	31	10	7	53	18	47	11	9	21	5	4	4	5	3	116	114	119	5	0	1	116	737
18 Stafford	72	79	133	51	37	247	97	263	41	36	84	20	12	14	22	8	128	730	412	100	2	2	257	2847
19 Spotsylv	59	71	106	34	26	176	62	145	35	32	70	16	13	11	19	4	178	378	2092	17	1	2	519	4066
20 Fauquier	33	42	65	11	12	161	118	175	18	25	40	11	5	9	4	3	5	122	17	58	0	1	132	1067
21 Clarke	12	11	21	3	6	74	136	9	2	3	6	3	2	2	1	0	1	1	1	0	13	7	39	353
22 Jeffrson	25	40	40	6	9	87	74	19	8	11	19	7	6	2	2	0	1	2	3	0	8	87	118	574
23 External	842	1102	1444	202	177	1246	563	581	901	1788	2022	166	481	109	130	32	114	257	520	126	42	119	26982	39946
Total	8406	13067	20342	3948	3095	21896	19453	13358	5893	10807	12370	3310	2325	1496	2108	208	799	2774	4047	1037	327	567	40053	191686

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MWCOG Truck Trip Model
Delta Trips
Heavy Truck

Destination District

Origin District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 DC	-808	-411	-371	-38	-91	-442	-146	161	-65	-33	-7	-8	-52	17	43	0	-18	-32	-35	-3	-3	-1	41	-2302
2 Mont Co	-401	1723	-178	-119	-107	-764	-252	-194	-239	-11	178	70	-127	-27	58	-3	-19	-50	-39	-8	-11	-2	0	-522
3 PG Co	-365	-145	3208	127	76	208	259	365	-90	189	29	139	-66	-41	94	6	-14	-23	-16	5	13	-15	25	3968
4 Arlingtn	-180	-134	42	516	118	320	-70	330	-18	-25	26	1	-19	11	5	5	2	10	-3	-2	-1	-3	3	934
5 Alxndria	-194	-99	21	98	200	46	175	230	-25	-30	39	-3	-10	6	-11	0	-7	-3	7	-2	4	-1	3	444
6 Fairfax	-659	-728	99	201	-36	437	2377	918	-216	-35	182	-38	-51	54	-25	-9	-17	-39	-25	30	36	22	15	2493
7 Loudoun	-2	-234	325	-10	97	2364	8237	516	-200	-26	28	4	-60	20	-12	-2	-7	17	0	43	92	33	1	11224
8 PrWillam	42	-188	307	307	153	1024	589	3669	-31	-37	110	10	-8	20	-4	6	17	99	30	106	-2	-5	2	6216
9 Fredrick	-81	-252	-96	-24	-20	-206	-176	-21	-356	-184	-106	9	-33	-3	6	0	-2	-12	-13	-9	-18	-61	3	-1655
10 Howard	-11	-18	138	-21	-8	-51	-42	-34	-206	420	241	51	-138	-9	23	8	-8	-16	-12	-2	-6	-19	2	282
11 AnnArndl	-24	210	74	18	31	165	13	120	-127	257	645	-19	-72	-14	-22	-4	-2	2	-1	7	-9	-13	6	1241
12 Charles	-31	66	131	5	-4	-29	10	13	16	73	-19	801	9	8	95	-8	-1	-10	-14	-1	2	0	4	1116
13 Carroll	-55	-132	-87	-12	-12	-51	-44	-17	4	-123	-55	6	86	-12	6	0	-3	-7	-4	-3	-3	-11	0	-529
14 Calvert	12	-26	-31	9	12	60	29	31	-12	-10	-27	18	-8	-52	5	-6	-1	0	-5	1	0	-4	4	-1
15 St Marys	15	15	63	4	1	-4	3	-4	5	11	-22	104	-1	-1	74	-1	-7	-3	-7	0	-1	-1	-2	241
16 King Geo	-3	3	3	2	-2	-5	-2	0	1	6	-4	-5	-1	1	-3	3	-2	0	-6	2	0	-3	1	-14
17 Frdckbrg	-11	-11	-6	1	-4	-13	-2	8	-3	-6	1	-2	-1	-1	-4	-1	0	47	46	-1	-1	-1	0	35
18 Stafford	-41	-43	-9	13	-1	-27	20	91	-13	-18	7	-9	-8	-3	-2	-1	60	340	276	78	-2	-6	-3	699
19 Spotsylv	-36	-30	-12	4	-4	-33	0	28	-13	-14	2	-12	-6	-6	-6	-6	106	239	1371	-2	-2	-3	5	1570
20 Fauquier	-9	-19	7	-2	-2	30	55	85	-8	-3	8	-2	-7	2	-3	1	-1	98	-2	-13	-4	-4	4	211
21 Clarke	2	-8	8	0	4	49	109	-4	-18	-7	-4	0	-3	0	1	0	0	-1	-1	-3	-2	-2	0	120
22 Jeffrson	-5	-23	-1	-3	2	31	27	-6	-64	-20	-11	2	-10	-3	-1	-1	-1	-4	-2	-5	0	-2	3	-97
23 External	24	8	10	9	-3	11	1	6	-6	1	1	1	5	0	-1	-3	-2	1	-1	3	3	14	-100	-18
Total	-2821	-476	3645	1085	400	3120	11170	6291	-1684	375	1242	1118	-581	-33	316	-16	73	653	1544	221	85	-88	17	25656

Date: 6/19/2008
Time: 16:56

MWCOG Truck Trip Model
Delta Trip Ratio
Heavy Truck

Destination District

Origin District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 DC	.68	.61	.81	.91	.70	.67	.58	1.42	.78	.94	.99	.95	.51	1.18	1.45	1.00	.45	.70	.64	.93	.57	.97	1.05	.80
2 Mont Co	.62	1.48	.88	.49	.44	.50	.54	.58	.72	.99	1.24	1.49	.48	.74	1.62	.83	.53	.59	.64	.84	.54	.95	1.00	.96
3 PG Co	.80	.90	1.70	1.37	1.22	1.13	1.54	1.78	.78	1.16	1.02	1.49	.65	.79	1.67	1.35	.66	.84	.86	1.09	2.44	.70	1.02	1.24
4 Arlingtn	.55	.44	1.12	3.19	1.88	1.59	.49	3.44	.76	.74	1.20	1.02	.37	1.55	1.15	3.50	1.33	1.27	.91	.88	.50	.50	1.01	1.32
5 Alxndria	.37	.49	1.06	1.67	1.95	1.08	2.54	2.72	.65	.65	1.32	.93	.58	1.21	.61	1.00	.42	.92	1.25	.82	2.00	.89	1.02	1.16
6 Fairfax	.51	.52	1.06	1.37	.94	1.07	2.62	1.70	.61	.94	1.26	.85	.71	1.37	.83	.69	.75	.86	.88	1.26	2.20	1.35	1.01	1.13
7 Loudoun	.99	.57	1.71	.91	1.86	2.70	3.93	2.24	.38	.88	1.11	1.06	.39	1.41	.78	.75	.73	1.24	1.00	1.73	4.17	1.73	1.00	2.38
8 PrWillam	1.11	.59	1.65	3.38	2.10	1.77	2.28	2.99	.83	.81	1.47	1.11	.87	1.38	.93	1.43	1.44	1.61	1.27	2.20	.82	.79	1.00	1.88
9 Fredrick	.73	.69	.78	.70	.69	.62	.41	.88	.86	.47	.64	1.15	.86	.93	1.14	1.00	.85	.77	.71	.70	.05	.10	1.00	.78
10 Howard	.98	.98	1.13	.78	.91	.91	.82	.83	.41	1.15	1.20	1.58	.28	.86	1.38	2.33	.53	.71	.75	.93	.40	.37	1.00	1.03
11 AnnArndl	.96	1.29	1.06	1.14	1.25	1.24	1.05	1.51	.57	1.22	1.23	.86	.54	.88	.78	.60	.89	1.03	.98	1.22	.40	.54	1.00	1.11
12 Charles	.82	1.46	1.44	1.12	.92	.88	1.14	1.15	1.28	1.83	.85	3.00	1.38	1.14	2.27	.43	.83	.64	.55	.88	2.00	1.00	1.02	1.51
13 Carroll	.50	.45	.53	.56	.50	.72	.52	.74	1.02	.35	.65	1.22	1.11	.40	1.67	1.00	.40	.67	.76	.73	.40	.35	1.00	.82
14 Calvert	1.12	.74	.83	1.35	1.44	1.43	1.58	1.65	.73	.85	.78	1.32	.58	.81	1.05	.33	.80	1.00	.71	1.13	.00	.56	1.04	1.00
15 St Marys	1.16	1.15	1.41	1.16	1.04	.97	1.06	.93	1.12	1.17	.78	2.44	.93	.99	1.13	.89	.30	.87	.74	1.00	.00	.00	.99	1.13
16 King Geo	.79	1.23	1.14	1.67	.60	.79	.78	1.00	1.14	1.75	.67	.55	.50	1.20	.73	1.43	.60	1.00	.45	.00	.00	.00	1.02	.94
17 Frdckbrg	.62	.65	.84	1.11	.64	.80	.90	1.21	.79	.60	1.05	.71	.80	.80	.56	.75	1.00	1.70	1.63	.83	.00	.50	1.00	1.05
18 Stafford	.64	.65	.94	1.34	.97	.90	1.26	1.53	.76	.67	1.09	.69	.60	.82	.92	.89	1.88	1.87	3.03	4.55	.50	.25	.99	1.33
19 Spotsylv	.62	.70	.90	1.13	.87	.84	1.00	1.24	.73	.70	1.03	.57	.68	.65	.76	.40	2.47	2.72	2.90	.89	.33	.40	1.01	1.63
20 Fauquier	.79	.69	1.12	.85	.86	1.23	1.87	1.94	.69	.89	1.25	.85	.42	1.29	.57	1.50	.83	5.08	.89	.82	.00	.20	1.03	1.25
21 Clarke	1.20	.58	1.62	1.00	3.00	2.96	5.04	.69	.10	.30	.60	1.00	.40	1.00	.00	.00	1.00	.50	.50	.00	.87	.78	1.00	1.52
22 Jeffrson	.83	.63	.98	.67	1.29	1.55	1.57	.76	.11	.35	.63	1.40	.38	.40	.67	.00	.50	.33	.60	.00	1.00	.98	1.03	.86
23 External	1.03	1.01	1.01	1.05	.98	1.01	1.00	1.01	.99	1.00	1.00	1.01	1.01	1.00	.99	.91	.98	1.00	1.00	1.02	1.08	1.13	1.00	1.00
Total	.75	.96	1.22	1.38	1.15	1.17	2.35	1.89	.78	1.04	1.11	1.51	.80	.98	1.18	.93	1.10	1.31	1.62	1.27	1.35	.87	1.00	1.15

The resulting trip length frequency diagrams, shown in Table 4-10, bear this out. For both type of truck trips, the "after" trip length is about 9% less than the "before". This is not *too* bad – it is common to see trip length differences of 20-30% in such analyses. Since the starting average trip length is itself only an estimate, this is not a major concern. Also, note that the distributions themselves are not too much different, before vs. after.

Table 4-11 shows the resulting estimated trip length frequency distribution and average trip length for all truck trips (MTK + HTK, I/I + external + X/X, after AA). The only data to which this can be compared is the TLFD for the current MWCOG truck trips (using the same highway times). This is shown in Table 4-12. The new initial estimate average travel time is 21% shorter than that of the current trips: 33.6 minutes vs. 42.8. This is probably due to fewer trips of longer than 90 minutes (7.1% of the total vs. 10.6% currently).

Validation

Table 4-13 shows the assignment validation results for the final model. These results can be compared directly with Tables 4-5 and 4-6 from the initial model. For MTK trips, the estimated/observed ratios are much better for the final model, with no real bias by area type and the overall %RMSE is down from 62% to 31%. For HTK trips, the results are not quite as encouraging. The estimated/observed ratios are unfortunately higher than desired, although still considerably better than the initial model. The %RMSE shows sharp improvement, from 359% to 80%. Table 4-13 also indicates that the final model's total truck estimate is improved over the current model: estimated/observed went from 1.16 to 1.07 and %RMSE went from 104% to 51%.

The final model produced 10.8 million total daily regional truck VMT, as shown in Table 4-14. This is about 5% less VMT than the current model produces. The biggest percentage increases are in the rural areas and the largest percentage decreases are in the heavily urbanized areas.

Time of Day Validation

For the first time ever, a comparison can be made between the estimated and counted truck trips by time of day. Although the number of links with hourly counts is limited in number and almost all of them are in Maryland, this is still a useful opportunity to check the assignments by time of day. As Table 4-15 shows, the results are very good for MTK, with estimated/observed ratios very close to 1.0 and %RMSE values in the 30's for all three periods. For HTK, the results are not so good, but are not substantially worse than the daily evaluation statistics. The estimated/observed ratio exceeds 1.0 for all periods, suggesting that the HTK model may be estimating too many trips all day and particularly in the peak periods.

Still, these results do not demonstrate the need for changes to the time of day fractions shown in Table 4-4.

Table 4-10
Trip Length Frequency Distributions – Before vs. After AA

Medium Truck Before

```
FREQUENCY (Iter=1) Starting Total MTK Trips vs. Off-Pk Highway Time
  BASEMW=9 VALUEMW=31 RANGE=0,90,3
  MW[9]                            Accum
>=  -  <   Obs      Sum    Pct  Pct
-------------------------------------------------------------------
  0 -  3     840  2,538.53 0.5   0.5 |
  3 -  6   4,201 29,695.29 6.4   6.9 |======
  6 -  9  10,407 32,587.99 7.0  13.9 |======
  9 - 12  20,244 27,541.17 5.9  19.8 |=====
 12 - 15  33,718 37,675.71 8.1  27.9 |========
 15 - 18  50,148 43,736.47 9.4  37.3 |=========
 18 - 21  69,740 41,394.63 8.9  46.1 |========
 21 - 24  89,282 39,659.16 8.5  54.6 |========
 24 - 27 108,097 34,586.19 7.4  62.1 |=======
 27 - 30 123,661 31,040.79 6.7  68.7 |======
 30 - 33 136,434 26,632.38 5.7  74.4 |=====
 33 - 36 145,966 20,794.48 4.5  78.9 |====
 36 - 39 153,057 17,492.59 3.8  82.6 |===
 39 - 42 159,743 14,732.84 3.2  85.8 |===
 42 - 45 164,155 11,890.33 2.5  88.3 |==
 45 - 48 169,881  9,676.01 2.1  90.4 |==
 48 - 51 170,411  7,709.98 1.7  92.1 |=
 51 - 54 168,386  6,392.31 1.4  93.4 |=
 54 - 57 163,788  4,788.23 1.0  94.5 |=
 57 - 60 158,598  3,874.21 0.8  95.3 |
 60 - 63 154,076  3,087.10 0.7  96.0 |
 63 - 66 146,864  2,494.43 0.5  96.5 |
 66 - 69 138,335  1,928.28 0.4  96.9 |
 69 - 72 128,007  1,507.20 0.3  97.2 |
 72 - 75 118,986  1,284.34 0.3  97.5 |
 75 - 78 108,782  1,205.17 0.3  97.8 |
 78 - 81  98,581    881.69 0.2  98.0 |
 81 - 84  88,688    688.37 0.1  98.1 |
 84 - 87  80,171    649.99 0.1  98.2 |
 87 - 90  73,073    613.70 0.1  98.4 |
 90+     606,353  7,549.43 1.6 100.0 |=
-------------------------------------
Total Obs = 3,842,673
Total Sum = 466,329
Mean      = 26.33
@I=J      = 46,948.89
```

Medium Truck After

```
FREQUENCY (Iter=1) Revised Total MTK Trips vs. Off-Pk Highway Time
  BASEMW=9 VALUEMW=33 RANGE=0,90,3
  MW[9]                          Accum
>=  -  <   Obs      Sum     Pct  Pct
------------------------------------------------------------------
  0 -  3      841  2,538.32  0.5   0.5 |
  3 -  6    4,205 32,240.66  6.8   7.3 |======
  6 -  9   10,407 37,187.29  7.8  15.2 |=======
  9 - 12   20,244 37,215.64  7.8  23.0 |=======
 12 - 15   33,719 47,265.57 10.0  33.0 |=========
 15 - 18   50,151 51,113.60 10.8  43.8 |==========
 18 - 21   69,741 53,361.46 11.3  55.0 |===========
 21 - 24   89,285 38,644.94  8.2  63.2 |========
 24 - 27  108,098 30,836.82  6.5  69.7 |======
 27 - 30  123,667 25,962.24  5.5  75.2 |=====
 30 - 33  136,434 22,228.80  4.7  79.8 |====
 33 - 36  145,967 16,632.75  3.5  83.4 |===
 36 - 39  153,059 13,805.02  2.9  86.3 |==
 39 - 42  159,745 11,657.36  2.5  88.7 |==
 42 - 45  164,156  9,502.58  2.0  90.7 |==
 45 - 48  169,883  7,582.61  1.6  92.3 |=
 48 - 51  170,412  5,978.74  1.3  93.6 |=
 51 - 54  168,389  5,158.05  1.1  94.7 |=
 54 - 57  163,788  3,793.08  0.8  95.5 |
 57 - 60  158,600  3,094.48  0.7  96.1 |
 60 - 63  154,078  2,516.09  0.5  96.7 |
 63 - 66  146,867  2,090.34  0.4  97.1 |
 66 - 69  138,338  1,618.67  0.3  97.4 |
 69 - 72  128,009  1,274.79  0.3  97.7 |
 72 - 75  118,988  1,118.35  0.2  97.9 |
 75 - 78  108,784  1,056.02  0.2  98.2 |
 78 - 81   98,583    741.20  0.2  98.3 |
 81 - 84   88,689    616.65  0.1  98.5 |
 84 - 87   80,176    577.17  0.1  98.6 |
 87 - 90   73,076    539.85  0.1  98.7 |
 90+      606,486  6,211.99  1.3 100.0 |=
--------------------------------------
Total Obs = 3,842,865
Total Sum = 474,161.12
Mean      = 23.89
@I=J      = 46,948.89
```

Heavy Truck Before

```
FREQUENCY (Iter=1) Starting Total HTK Trips vs. Off-Pk Highway Time
  BASEMW=9 VALUEMW=32 RANGE=0,90,3
  MW[9]                         Accum
>=  -  <   Obs      Sum     Pct  Pct
------------------------------------------------------------------
  0 -  3     832    913.62  0.6   0.6 |
  3 -  6   4,156  6,478.83  3.9   4.5 |===
  6 -  9  10,278  4,450.66  2.7   7.1 |==
  9 - 12  19,996  2,904.77  1.7   8.9 |=
 12 - 15  33,259  4,583.43  2.8  11.6 |==
 15 - 18  49,437  5,121.94  3.1  14.7 |===
 18 - 21  68,726  4,711.40  2.8  17.6 |==
 21 - 24  87,941  4,732.83  2.9  20.4 |==
 24 - 27 106,566  4,673.16  2.8  23.2 |==
 27 - 30 121,901  4,722.09  2.8  26.1 |==
 30 - 33 134,569  4,503.77  2.7  28.8 |==
 33 - 36 143,943  4,266.27  2.6  31.4 |==
 36 - 39 150,992  4,318.59  2.6  34.0 |==
 39 - 42 157,371  4,697.39  2.8  36.8 |==
 42 - 45 161,711  4,578.37  2.8  39.5 |==
 45 - 48 167,110  6,040.93  3.6  43.2 |===
 48 - 51 167,459  4,994.95  3.0  46.2 |===
 51 - 54 165,369  4,336.80  2.6  48.8 |==
 54 - 57 160,722  4,257.65  2.6  51.4 |==
 57 - 60 155,483  3,868.02  2.3  53.7 |==
 60 - 63 151,000  3,805.48  2.3  56.0 |==
 63 - 66 143,449  3,713.07  2.2  58.2 |==
 66 - 69 135,225  3,512.51  2.1  60.3 |==
 69 - 72 124,839  3,411.50  2.1  62.4 |==
 72 - 75 116,150  3,750.68  2.3  64.6 |==
 75 - 78 106,500  3,806.59  2.3  66.9 |==
 78 - 81  96,745  2,963.47  1.8  68.7 |=
 81 - 84  87,112  2,890.53  1.7  70.5 |=
 84 - 87  78,789  3,160.82  1.9  72.4 |=
 87 - 90  71,756  2,550.03  1.5  73.9 |=
 90+     608,624 43,325.84 26.1 100.0 |==========================
--------------------------------------
Total Obs = 3,788,010
Total Sum = 166,046
Mean      = 64.26
@I=J      = 9,967.56
```

Heavy Truck After

```
FREQUENCY (Iter=1) Revised Total HTK Trips vs. Off-Pk Highway Time
  BASEMW=9 VALUEMW=34 RANGE=0,90,3
  MW[9]                          Accum
>=  -  <   Obs      Sum     Pct  Pct
------------------------------------------------------------------
  0 -  3     832    913.62  0.5   0.5 |
  3 -  6   4,156  6,831.17  3.6   4.0 |===
  6 -  9  10,278  5,449.64  2.8   6.9 |==
  9 - 12  19,996  4,926.18  2.6   9.5 |==
 12 - 15  33,259  8,442.76  4.4  13.9 |====
 15 - 18  49,437  8,723.28  4.6  18.4 |====
 18 - 21  68,726  8,029.32  4.2  22.6 |====
 21 - 24  87,941  6,711.10  3.5  26.1 |===
 24 - 27 106,566  7,306.49  3.8  29.9 |===
 27 - 30 121,901  6,914.06  3.6  33.5 |===
 30 - 33 134,569  6,467.28  3.4  36.9 |===
 33 - 36 143,943  5,190.40  2.7  39.6 |==
 36 - 39 150,992  5,705.73  3.0  42.6 |==
 39 - 42 157,372  5,596.79  2.9  45.5 |==
 42 - 45 161,711  4,885.64  2.5  48.0 |==
 45 - 48 167,110  6,467.07  3.4  51.4 |===
 48 - 51 167,459  5,223.52  2.7  54.1 |==
 51 - 54 165,370  4,584.97  2.4  56.5 |==
 54 - 57 160,723  4,818.39  2.5  59.0 |==
 57 - 60 155,485  4,192.71  2.2  61.2 |==
 60 - 63 151,002  4,010.60  2.1  63.3 |==
 63 - 66 143,449  3,735.33  1.9  65.3 |=
 66 - 69 135,226  3,712.37  1.9  67.2 |=
 69 - 72 124,841  3,551.21  1.9  69.1 |=
 72 - 75 116,150  3,588.09  1.9  70.9 |=
 75 - 78 106,501  3,653.88  1.9  72.8 |=
 78 - 81  96,746  2,741.97  1.4  74.3 |=
 81 - 84  87,113  2,758.64  1.4  75.7 |=
 84 - 87  78,791  3,027.46  1.6  77.3 |=
 87 - 90  71,759  2,307.94  1.2  78.5 |=
 90+     608,697 41,238.32 21.5 100.0 |====================
--------------------------------------
Total Obs = 3,788,101
Total Sum = 191,705.96
Mean      = 57.6
@I=J      = 9,967.56
```

Table 4-11
Total Truck Trip Length Frequency Distribution – Final Trips

FREQUENCY (Iter=1) Revised Total TRK Trips vs. Off-Pk Highway Time
BASEMW=9 VALUEMW=35 RANGE=0,90,3
MW[9]

>=	<	Obs	Sum	Pct	Accum Pct	
0	3	841	3,451.94	0.5	0.5	|
3	6	4,205	39,071.83	5.9	6.4	|=====
6	9	10,407	42,636.93	6.4	12.8	|======
9	12	20,244	42,141.82	6.3	19.1	|======
12	15	33,719	55,708.33	8.4	27.5	|========
15	18	50,153	59,836.87	9.0	36.5	|========
18	21	69,743	61,390.78	9.2	45.7	|=========
21	24	89,285	45,356.04	6.8	52.5	|======
24	27	108,098	38,143.31	5.7	58.2	|=====
27	30	123,667	32,876.30	4.9	63.2	|====
30	33	136,434	28,696.08	4.3	67.5	|====
33	36	145,968	21,823.16	3.3	70.8	|===
36	39	153,060	19,510.76	2.9	73.7	|==
39	42	159,748	17,254.16	2.6	76.3	|==
42	45	164,160	14,388.22	2.2	78.4	|==
45	48	169,888	14,049.67	2.1	80.5	|==
48	51	170,418	11,202.26	1.7	82.2	|=
51	54	168,397	9,743.02	1.5	83.7	|=
54	57	163,800	8,611.47	1.3	85.0	|=
57	60	158,622	7,287.19	1.1	86.1	|=
60	63	154,094	6,526.68	1.0	87.1	|
63	66	146,892	5,825.67	0.9	87.9	|
66	69	138,368	5,331.04	0.8	88.7	|
69	72	128,046	4,826.01	0.7	89.5	|
72	75	119,025	4,706.43	0.7	90.2	|
75	78	108,811	4,709.89	0.7	90.9	|
78	81	98,627	3,483.18	0.5	91.4	|
81	84	88,735	3,375.29	0.5	91.9	|
84	87	80,234	3,604.63	0.5	92.4	|
87	90	73,126	2,847.79	0.4	92.9	|
90+		618,132	47,450.31	7.1	100.0	|=======

Total Obs = 3,854,947
Total Sum = 665,867.07
Mean = 33.6
@I=J = 56,916.45

Table 4-12
Total Truck Trip Length Frequency Distribution – Current Model

```
FREQUENCY (Iter=1) Original Total Truck Trips vs. Off-Peak Hwy Time
  BASEMW=5 VALUEMW=1 RANGE=0,90,3
  MW[5]                          Accum
>=  -  <   Obs     Sum     Pct  Pct
-------------------------------------------------------------------
  0 -  3    689  1,695.35  0.3   0.3 |
  3 -  6  1,799 19,178.25  3.7   4.0 |===
  6 -  9  3,548 21,316.97  4.1   8.0 |====
  9 - 12  6,438 19,114.11  3.6  11.7 |===
 12 - 15  9,945 27,087.60  5.2  16.8 |=====
 15 - 18 13,799 36,244.29  6.9  23.8 |======
 18 - 21 16,841 36,808.56  7.0  30.8 |=======
 21 - 24 17,162 32,626.61  6.2  37.0 |======
 24 - 27 16,613 28,726.79  5.5  42.5 |=====
 27 - 30 15,829 26,657.45  5.1  47.5 |=====
 30 - 33 14,767 22,948.42  4.4  51.9 |====
 33 - 36 13,812 20,070.25  3.8  55.7 |===
 36 - 39 12,726 17,815.27  3.4  59.1 |===
 39 - 42 11,858 16,247.04  3.1  62.2 |===
 42 - 45 10,981 14,591.35  2.8  65.0 |==
 45 - 48  9,954 13,670.44  2.6  67.6 |==
 48 - 51  9,332 16,980.93  3.2  70.9 |===
 51 - 54  8,543 11,746.23  2.2  73.1 |==
 54 - 57  7,673 10,064.76  1.9  75.0 |=
 57 - 60  7,226 11,102.04  2.1  77.1 |==
 60 - 63  6,873  9,252.31  1.8  78.9 |=
 63 - 66  6,272  8,817.13  1.7  80.6 |=
 66 - 69  5,907  7,572.57  1.4  82.0 |=
 69 - 72  5,292  6,953.52  1.3  83.3 |=
 72 - 75  4,988  6,381.46  1.2  84.6 |=
 75 - 78  4,318  5,546.66  1.1  85.6 |=
 78 - 81  4,019  5,245.26  1.0  86.6 |
 81 - 84  3,755  5,138.57  1.0  87.6 |
 84 - 87  3,519  4,958.94  0.9  88.5 |
 87 - 90  3,181  4,356.36  0.8  89.4 |
 90+     25,444 55,804.17 10.6 100.0 |==========
-------------------------------------
Total Obs = 283,103
Total Sum = 524,719.66
Mean      = 42.78
@I=J      = 31,826.21
```

Table 4-13
Validation Statistics – Final Model

Medium Trucks

CROSSTAB ROW=FTYPE COL=AREATP COMP=_vol/_cnt

	1	2	3	4	5	6	7	17
1 - 1	0	1.01	1.01	1.06	0.96	0.87	1.16	1.01
2 - 2	0	1.02	0.96	1.10	0.90	1.05	0.90	0.97
3 - 3	0	0.96	0.98	0.97	0.93	0.81	0.88	0.94
4 - 4	0	0.00	1.15	0.33	0.77	0.82	0.49	0.71
5 - 5	0	0	1.04	1.06	1.25	1.45	0	1.12
0 - 6	0	1.00	1.00	0.99	0.94	0.96	0.98	0.98

CROSSTAB ROW=FTYPE COL=AREATP COMP=sqrt(_sqerr/_links)/(_cnt/_links)

	1	2	3	4	5	6	7	17
1 - 1	0	0.150	0.126	0.059	0.068	0.343	0.287	0.167
2 - 2	0	0.408	0.363	0.349	0.313	0.352	0.450	0.370
3 - 3	0	0.093	0.247	0.234	0.413	0.585	0.612	0.358
4 - 4	0	1.013	0.341	1.159	0.411	0.669	0.947	0.884
5 - 5	0	0	0.232	0.214	0.263	0.579	0	0.265
0 - 6	0	0.220	0.218	0.352	0.266	0.539	0.491	0.309

Heavy Trucks

CROSSTAB ROW=FTYPE COL=AREATP COMP=_vol/_cnt

	1	2	3	4	5	6	7	17
1 - 1	0	1.29	1.24	1.21	0.94	1.41	1.41	1.25
2 - 2	0	0.49	0.91	1.43	1.43	1.75	1.46	1.29
3 - 3	0	0.70	0.54	0.64	0.99	0.97	0.62	0.69
4 - 4	0	0.00	0.94	0.07	0.48	0.57	0.67	0.53
5 - 5	0	0	1.90	1.39	3.49	15.55	0	2.48
0 - 6	0	1.21	1.17	1.01	1.15	1.59	1.36	1.24

CROSSTAB ROW=FTYPE COL=AREATP COMP=sqrt(_sqerr/_links)/(_cnt/_links)

	1	2	3	4	5	6	7	17
1 - 1	0	0.356	0.338	0.206	0.109	0.527	0.536	0.373
2 - 2	0	0.588	0.655	0.848	0.825	1.391	0.956	0.914
3 - 3	0	0.388	0.579	0.880	0.466	1.060	0.666	1.091
4 - 4	0	1.021	0.585	1.386	0.629	0.931	0.696	1.231
5 - 5	0	0	1.041	1.117	2.487	18.194	0	2.271
0 - 6	0	0.533	0.583	0.934	0.539	1.524	1.036	0.799

Note: values are %RMSE as a fraction of 1.0, e.g., 0.799 = 79.9% RMSE

Total Trucks

CROSSTAB ROW=FTYPE COL=AREATP COMP=_vol3/_cnt3

	1	2	3	4	5	6	7	17
1 - 1	0	1.10	1.09	1.17	1.00	1.28	1.12	1.10
2 - 2	1.38	1.11	1.13	1.02	1.10	1.09	1.14	1.11
3 - 3	1.04	0.93	1.05	0.80	0.99	0.97	1.17	1.00
4 - 4	0.91	0.79	0.90	0.70	0.89	0.94	1.10	0.90
5 - 5	0	0.67	1.03	0.86	0.97	1.32	1.00	0.97
0 - 6	1.29	1.04	1.09	0.94	1.04	1.08	1.14	1.07

CROSSTAB ROW=FTYPE COL=AREATP COMP=sqrt(_sqerr3/_links3)/(_cnt3/_links3)

	1	2	3	4	5	6	7	17
1 - 1	0	0.178	0.170	0.324	0.101	0.308	0.288	0.214
2 - 2	0.769	0.525	0.401	0.315	0.371	0.348	0.517	0.433
3 - 3	0.196	0.397	0.685	0.553	0.554	0.459	0.577	0.572
4 - 4	0.605	0.563	1.001	0.695	0.713	0.709	0.823	0.776
5 - 5	0	0.367	0.290	0.304	0.247	0.634	0.008	0.356
0 - 6	0.757	0.524	0.462	0.490	0.366	0.557	0.597	0.506

Table 4-14
2005 Truck VMT

Jurisdiction	Previous	Revised	Difference	Pct Diff.
District of Columbia	507,600	317,700	-189,900	-37%
Montgomery Co	1,137,800	1,119,900	-17,900	-2%
Prince George's Co	1,734,800	1,620,000	-114,800	-7%
Arlington	173,000	133,300	-39,700	-23%
Alexandria	102,300	94,000	-8,300	-8%
Fairfax Co	1,580,100	1,287,500	-292,600	-19%
Loudoun Co	375,700	585,400	209,700	56%
Prince William Co	692,400	704,700	12,300	2%
Frederick Co	1,004,400	782,800	-221,600	-22%
Howard Co	1,065,000	1,020,700	-44,300	-4%
Anne Arundel Co	812,700	895,800	83,100	10%
Charles Co	214,800	277,300	62,500	29%
Carroll Co	303,100	315,900	12,800	4%
Calvert Co	87,100	119,800	32,700	38%
St Mary's Co	79,600	131,600	52,000	65%
King George Co	100,600	98,700	-1,900	-2%
Fredericksburg	48,700	45,900	-2,800	-6%
Stafford Co	535,600	453,300	-82,300	-15%
Spotsylvania Co	272,300	243,200	-29,100	-11%
Fauquier Co	298,900	335,900	37,000	12%
Clarke Co	105,200	81,700	-23,500	-22%
Jefferson Co	134,700	143,800	9,100	7%
region	11,366,400	10,808,900	-557,500	-5%

Note: excludes centroid connectors.

Table 4-15
Validation Statistics by Time Period

AM Peak

Medium Trucks

CROSSTAB ROW=FTYPE COL=AREATP COMP=_vol/_cnt

	1	2	3	4	5	6	7	17
1 - 1	0	0.99	0.94	0.97	0.81	0.90	1.05	0.94
2 - 2	0	1.08	1.15	1.01	0.92	1.02	0.94	1.02
3 - 3	0	1.07	0.93	1.04	0.84	0.85	0.91	0.93
4 - 4	0	0.18	1.48	0.48	0.69	1.00	0.49	0.81
5 - 5	0	0	0.91	0.95	1.07	1.60	0	1.03
0 - 6	0	1.00	0.99	0.96	0.88	0.99	0.96	0.97

CROSSTAB ROW=FTYPE COL=AREATP COMP=sqrt(_sqerr/_links)/(_cnt/_links)

	1	2	3	4	5	6	7	17
1 - 1	0	0.152	0.184	0.032	0.256	0.237	0.306	0.204
2 - 2	0	0.293	0.563	0.467	0.577	0.609	0.514	0.558
3 - 3	0	0.543	0.413	0.407	0.673	0.841	0.786	0.585
4 - 4	0	0.956	0.546	1.277	0.420	0.665	0.820	1.103
5 - 5	0	0	0.290	0.293	0.487	0.653	0	0.379
0 - 6	0	0.232	0.325	0.465	0.555	0.550	0.544	0.418

Heavy Trucks

CROSSTAB ROW=FTYPE COL=AREATP COMP=_vol/_cnt

	1	2	3	4	5	6	7	17
1 - 1	0	1.36	1.37	1.40	1.10	2.11	1.72	1.47
2 - 2	0	0.34	1.19	1.27	1.36	1.52	1.77	1.38
3 - 3	0	0.68	0.58	0.89	1.01	1.06	0.93	0.83
4 - 4	0	0.61	0.95	0.19	0.45	0.49	0.56	0.49
5 - 5	0	0	1.21	1.33	2.46	12.27	0	2.28
0 - 6	0	1.17	1.26	1.06	1.23	2.06	1.66	1.39

CROSSTAB ROW=FTYPE COL=AREATP COMP=sqrt(_sqerr/_links)/(_cnt/_links)

	1	2	3	4	5	6	7	17
1 - 1	0	0.474	0.522	0.400	0.186	1.258	1.056	0.688
2 - 2	0	0.885	1.003	0.795	0.896	1.373	1.329	1.126
3 - 3	0	0.802	0.778	0.653	0.684	1.597	1.115	0.965
4 - 4	0	0.394	0.516	1.770	0.771	0.963	0.756	2.018
5 - 5	0	0	0.432	0.907	1.546	11.274	0	2.204
0 - 6	0	0.676	0.806	0.873	0.683	2.659	1.713	1.215

PM Peak

Medium Trucks

CROSSTAB ROW=FTYPE COL=AREATP COMP=_vol/_cnt

	1	2	3	4	5	6	7	17
1 - 1	0	0.94	0.95	1.18	0.84	0.88	1.08	0.95
2 - 2	0	1.41	1.03	1.19	0.81	0.90	0.84	0.95
3 - 3	0	1.00	1.04	1.30	0.95	0.88	0.86	1.01
4 - 4	0	0.69	1.12	0.86	0.53	0.64	0.44	0.78
5 - 5	0	0	0.69	1.11	0.89	1.93	0	0.99
0 - 6	0	0.98	0.97	1.16	0.84	0.92	0.90	0.95

CROSSTAB ROW=FTYPE COL=AREATP COMP=sqrt(_sqerr/_links)/(_cnt/_links)

	1	2	3	4	5	6	7	17
1 - 1	0	0.241	0.179	0.177	0.220	0.226	0.325	0.214
2 - 2	0	0.548	0.458	0.343	0.471	0.401	0.454	0.448
3 - 3	0	0.256	0.314	0.336	0.700	0.763	0.732	0.517
4 - 4	0	0.310	0.156	0.777	0.505	0.521	1.078	0.639
5 - 5	0	0	0.367	0.302	0.245	0.971	0	0.405
0 - 6	0	0.343	0.300	0.357	0.461	0.449	0.520	0.386

Heavy Trucks

CROSSTAB ROW=FTYPE COL=AREATP COMP=_vol/_cnt

	1	2	3	4	5	6	7	17
1 - 1	0	0.85	1.09	1.62	0.79	1.72	2.30	1.25
2 - 2	0	0.41	1.21	1.37	1.77	1.82	2.18	1.61
3 - 3	0	0.64	0.54	0.87	0.92	2.03	1.30	0.89
4 - 4	0	0.57	0.86	0.49	1.22	0.36	0.66	0.63
5 - 5	0	0	1.34	1.57	4.11	24.62	0	3.31
0 - 6	0	0.78	1.07	1.14	1.31	2.15	2.13	1.38

CROSSTAB ROW=FTYPE COL=AREATP COMP=sqrt(_sqerr/_links)/(_cnt/_links)

	1	2	3	4	5	6	7	17
1 - 1	0	0.293	0.271	0.624	0.299	1.032	1.918	0.737
2 - 2	0	0.809	0.882	0.744	1.543	1.938	2.090	1.554
3 - 3	0	0.489	0.778	0.571	0.996	2.193	1.674	1.012
4 - 4	0	0.440	0.312	1.031	0.477	0.943	1.057	1.180
5 - 5	0	0	0.686	1.301	3.171	23.762	0	3.947
0 - 6	0	0.438	0.508	0.823	1.154	2.830	2.789	1.400

Off-Peak

Medium Trucks

CROSSTAB ROW=FTYPE COL=AREATP COMP=_vol/_cnt

	1	2	3	4	5	6	7	17
1 - 1	0	1.01	1.01	1.06	0.96	0.87	1.16	1.01
2 - 2	0	1.02	0.96	1.10	0.90	1.05	0.90	0.97
3 - 3	0	0.96	0.98	0.97	0.93	0.81	0.88	0.94
4 - 4	0	0.00	1.15	0.33	0.77	0.82	0.49	0.71
5 - 5	0	0	1.04	1.06	1.25	1.45	0	1.12
0 - 6	0	1.00	1.00	0.99	0.94	0.96	0.98	0.98

CROSSTAB ROW=FTYPE COL=AREATP COMP=sqrt(_sqerr/_links)/(_cnt/_links)

	1	2	3	4	5	6	7	17
1 - 1	0	0.150	0.126	0.059	0.068	0.343	0.287	0.167
2 - 2	0	0.408	0.363	0.349	0.313	0.352	0.450	0.370
3 - 3	0	0.093	0.247	0.234	0.413	0.585	0.612	0.358
4 - 4	0	1.013	0.341	1.159	0.411	0.669	0.947	0.884
5 - 5	0	0	0.232	0.214	0.263	0.579	0	0.265
0 - 6	0	0.220	0.218	0.352	0.266	0.539	0.491	0.309

Heavy Trucks

CROSSTAB ROW=FTYPE COL=AREATP COMP=_vol/_cnt

	1	2	3	4	5	6	7	17
1 - 1	0	1.29	1.24	1.21	0.94	1.41	1.41	1.25
2 - 2	0	0.49	0.91	1.43	1.43	1.75	1.46	1.29
3 - 3	0	0.70	0.54	0.64	0.99	0.97	0.62	0.69
4 - 4	0	0.00	0.94	0.07	0.48	0.57	0.67	0.53
5 - 5	0	0	1.90	1.39	3.49	15.55	0	2.48
0 - 6	0	1.21	1.17	1.01	1.15	1.59	1.36	1.24

CROSSTAB ROW=FTYPE COL=AREATP COMP=sqrt(_sqerr/_links)/(_cnt/_links)

	1	2	3	4	5	6	7	17
1 - 1	0	0.356	0.338	0.206	0.109	0.527	0.536	0.373
2 - 2	0	0.588	0.655	0.848	0.825	1.391	0.956	0.914
3 - 3	0	0.388	0.579	0.880	0.466	1.060	0.666	1.091
4 - 4	0	1.021	0.585	1.386	0.629	0.931	0.696	1.231
5 - 5	0	0	1.041	1.117	2.487	18.194	0	2.271
0 - 6	0	0.533	0.583	0.934	0.539	1.524	1.036	0.799

Truck Zones

The revised model accounts for zones in which there is strong reason to believe that the truck trip activity is higher than the standard trip rates would indicate. The consultant believes that the most important zones are few enough in number that they can be identified individually and classified in a way that allows the model to account for them. Although no survey data are available to specifically determine the increase in truck trips for such areas, a reasonable estimate can be made and confirmed in the adaptable assignment process.

Several types of these facilities have been identified, such as the following:

- Business District: core area of major business districts, major retail areas (shopping malls)
- Warehouse/Manufacturing: warehousing, manufacturing, and processing facilities, industrial parks
- Intermodal Transfer: facilities where freight transfers between trucks and another mode – mainly the major rail yards
- Airports
- Institutional/Other: landfills, quarries, US mail processing centers
- Delivery: facilities that process mail or express delivery packages

Although these classifications are very general, the consultant believes that this is a reasonable trade-off against the need to maintain and forecast this data item. Based on guidance from the consultant, TPB staff identified a number of truck zones in 2005, as shown in Table 4-16.

Table 4-16
Truck Zones

TAZ	Name	Jurisdiction	Reason
144	Eckington	District of Columbia	FedEx
146	Brentwood	District of Columbia	Postal Service, Warehousing
480	Southlawn Lane	Montgomery	Heavy Industrial
482	Shady Grove	Montgomery	Postal Service, Trash Transfer Station
709	Tuxedo	Prince George's	Industrial, Pepsi plant
712	Landover	Prince George's	Warehousing
715	Cabin Branch	Prince George's	Warehousing
729	Ardwick Ardmore	Prince George's	Industrial Area
730	New Carrollton	Prince George's	Industrial, Warehousing, UPS terminal
748	Capitol Heights	Prince George's	Postal Service, Warehousing, Industrial
869	Konterra Business Park	Prince George's	Industrial Area
874	West Laurel	Prince George's	Warehousing, UPS terminal
882	Vansville	Prince George's	Industrial Area
934	Brown's Station	Prince George's	Landfill
943	Collington	Prince George's	Warehousing (incl. Safeway and Nordstrom), Wholesale
1239	National Airport	Arlington	Airport
1381	Eisenhower Avenue	Alexandria	UPS terminal, trash incinerator
1495	Southern Drive	Fairfax County	Warehousing
1515	Port Royal	Fairfax County	UPS terminal, dairy plant, industrial
1524	Merrifield	Fairfax County	Postal Service
1570	Newington	Fairfax County	Petroleum tank farm (Intermodal (pipeline <---> highway))
1611	Colonial Pipeline	City of Fairfax	Petroleum tank farm (Intermodal (pipeline <---> highway))
1687	Ox Road (west)	Fairfax County	Trash transfer station
1688	Ox Road (east)	Fairfax County	Industrial Area
1780	Dulles	Loudoun	Airport
1784	Dulles	Loudoun	Postal Service, airport-related warehousing
1973	Southern Industrial Park	Prince William	Martin Brower (McDonald's), other warehousing
1976	Manassas	Prince William	Petroleum tank farm (Intermodal (pipeline <---> highway))
1043	Frederick	Frederick	South Street Quarry
1048	Buckeystown Pike	Frederick	UPS terminal, Industrial area along Md. 85
1080	Jessup	Howard	Warehousing (incl. Giant), Wholesale, Truck Stop, Intermodal (rail <---> highway)
1096	Waterloo	Howard	Warehousing, Wholesale
1127	BWI	Anne Arundel	Airport
1060	Union Bridge	Carroll	Lehigh Cement Plant
2110	Fredericksburg	Spotsylvania	Warehousing (CVS)

5. FORECASTING

The consultant tested the final model by applying it to 2030 conditions, using the "Version_2.2V60" version of the MWCOG model and inputs dated 4 October 2007. The 2005 vs. 2030 external growth was estimated using growth factors provided by TPB staff (see Table 5-1). These were used to forecast both the external truck trip ends (as input to the trip generation step) and to Fratar the 2005 X/X truck trip tables.

This run produced the results shown in Table 5-2.

Table 5-3 shows the 2030 MTK and HTK trips and comparison to 2005. As might be expected, the largest percentage increases are in the areas that are not highly developed today. For MTK, DC and Montgomery have lower percentage increases, although the lowest percentage increase is in Anne Arundel, for some unknown reason. For HTK, the lowest percentage increase is in Carroll.

There is nothing in these results to suggest that the model is behaving abnormally.

Table 5-1
External Growth

station	growth rate	MTK Ext	HTK Ext
2145	2.1	390	490
2146	2.1	420	850
2147	2.1	300	370
2148	2.1	120	160
2149	2.2	2,710	7,680
2150	2.2	240	330
2151	2.2	250	290
2152	2.2	140	100
2153	1.4	580	970
2154	2.1	920	1,210
2155	2.1	700	470
2156	2.1	880	2,650
2157	2.1	40	30
2158	2.1	260	680
2159	2.1	300	290
2160	2.1	700	1,070
2161	2.1	300	570
2162	2.1	490	1,480
2163	2.1	180	280
2164	2.1	200	370
2165	1.8	210	150
2166	1.8	1,410	2,500
2167	1.8	350	210
2168	1.8	170	70
2169	1.8	320	90
2170	1.8	330	230
2171	1.8	370	2,010
2172	1.6	160	130
2173	1.6	230	190
2174	1.6	420	1,000
2175	1.6	210	170
2176	1.6	80	150
2177	1.6	370	640
2178	1.6	1,510	1,150
2179	1.6	460	570
2180	1.6	1,730	2,170
2181	1.6	930	510
2182	1.4	4,390	5,840
2183	1.6	1,180	1,170
2184	2.2	0	0
2185	1.6	290	500
2186	1.6	350	530
2187	1.6	1,250	560
2188	1.4	1,280	320
2189	1.6	1,510	1,500
2190	1.6	630	470
2191	1.6	1,500	2,650
total		31,760	45,820

Table 5-2
2030 Results

Statistic	MTK	HTK	Total TRK
I/I trips (before delta)	592,199	152,920	745,119
External trips (before delta)	31,760	45,820	77,580
X/X trips (before delta)	9,619	47,861	57,480
Average I/I travel time (min.)	24.6	49.3	29.7
Average Ext. travel time (min.)	57.7	75.9	68.5
Total trips (with delta)	643,517	272,400	915,917
VMT (excl. cent conn)			17,284,761
Cent conn VMT			1,281,275

Table 5-3
2030 TRK Trips

Date: 1/11/2008
Time: 11:47

MWCOG Truck Trip Model
2005 Medium Truck Trips
With Calibration Adjustment

Destination District

Origin District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 DC	26025	3289	6245	1303	678	1116	28	169	47	242	452	230	0	36	0	1	4	13	6	1	0	0	476	40361
2 Mont Co	3270	50774	4635	285	115	1122	169	64	1904	1552	712	24	213	6	1	0	1	5	0	3	4	18	730	65607
3 PG Co	5891	4883	33530	881	661	866	26	86	49	1780	3874	2263	7	498	81	5	1	11	2	0	0	0	818	56213
4 Arlingtn	1145	303	766	7372	2750	1790	19	584	7	11	58	32	0	8	0	0	2	26	7	2	0	0	134	15016
5 Alxndria	581	98	500	1263	3084	1641	6	636	1	8	44	38	0	5	0	0	2	23	10	3	0	0	96	8039
6 Fairfax	1018	1205	983	1499	1172	20128	3835	2908	52	68	94	56	4	11	1	2	31	243	69	174	3	1	627	34184
7 Loudoun	30	184	30	17	8	4175	41515	792	180	6	2	1	2	0	0	0	0	2	0	280	256	247	237	47964
8 PrWillam	117	68	71	316	60	2794	774	22918	2	2	5	4	0	0	0	3	83	994	263	1178	7	0	327	29986
9 Fredrick	52	1794	62	10	3	55	196	6	11636	314	20	1	642	0	0	0	1	0	0	1	6	81	590	15470
10 Howard	229	1542	1697	15	7	75	8	5	304	16103	4314	10	214	3	0	0	0	0	0	0	0	1	1283	25810
11 AnnArndl	449	752	3761	57	51	89	2	7	13	4166	32101	74	18	299	5	1	0	0	0	0	0	0	1994	43839
12 Charles	259	35	2130	42	60	43	0	6	0	8	85	10939	0	277	1151	124	1	5	3	0	0	0	104	15272
13 Carroll	4	232	16	0	0	3	3	0	690	211	30	1	9354	0	0	0	0	0	0	0	0	1	530	11075
14 Calvert	46	11	571	5	12	14	0	0	0	4	314	290	0	4772	800	3	0	0	0	0	0	0	63	6905
15 St Marys	6	1	113	2	4	1	0	0	0	0	7	1083	0	799	6964	33	0	4	0	0	0	0	84	9101
16 King Geo	1	0	11	0	1	1	0	7	0	0	1	131	0	2	25	1232	47	97	73	1	0	0	48	1678
17 Frdckbrg	3	2	1	2	3	33	0	106	0	0	0	2	0	0	0	45	710	530	575	10	0	0	105	2127
18 Stafford	17	4	13	22	12	252	1	1003	1	0	1	3	0	0	1	94	548	5394	1576	441	0	0	229	9612
19 Spotsylv	5	1	4	4	4	69	1	305	0	1	0	3	0	0	0	59	626	1554	7403	39	0	0	437	10515
20 Fauquier	1	5	1	3	0	196	251	1206	0	0	0	0	0	0	0	1	7	446	35	3851	43	2	144	6192
21 Clarke	0	2	0	0	0	6	262	15	7	0	0	0	0	0	0	0	0	0	0	41	435	179	45	992
22 Jeffrson	1	29	2	0	0	2	266	1	94	1	2	0	2	0	0	0	0	0	0	2	195	2295	148	3040
23 External	502	766	843	142	101	655	240	337	617	1330	2076	113	558	66	81	47	110	239	454	152	47	161	5531	15168
Total	39652	65980	55985	13240	8786	35126	47602	31161	15604	25807	44192	15298	11014	6782	9110	1650	2174	9586	10476	6179	996	2986	14780	474166

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MWCOG Truck Trip Model
2030 Medium Truck Trips
With Calibration Adjustment

Destination District

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	1 DC	30332	4003	8555	2056	997	1772	72	248	54	329	536	301	9	40	5	0	12	32	6	4	0	0	757	50120
	2 Mont Co	3932	60334	6202	401	179	1837	351	150	2957	2087	930	36	269	8	1	0	2	17	2	15	0	43	1164	80917
	3 PG Co	8209	6401	43094	1198	1171	1817	76	209	86	2634	4411	3020	49	619	94	12	4	35	3	3	0	1	1329	74475
	4 Arlingtn	1865	430	1083	8308	3025	2501	47	674	12	14	64	43	1	8	0	0	1	42	12	6	0	0	214	18350
O	5 Alxndria	902	147	940	1541	3509	2374	33	760	6	11	53	65	1	7	0	2	3	54	12	7	0	0	144	10571
r	6 Fairfax	1645	1893	1879	2182	1831	27564	8034	4997	79	95	125	106	5	18	0	4	41	445	109	409	16	7	1006	52490
i	7 Loudoun	66	344	65	54	38	8282	55880	2398	379	17	7	2	9	0	0	0	2	16	1	541	409	407	583	69500
g	8 PrWillam	213	125	198	393	160	4810	2442	29220	5	7	12	7	0	4	0	2	150	1628	374	1971	25	3	613	42362
i	9 Fredrick	62	2806	104	12	5	89	446	9	17424	555	76	2	782	0	0	0	0	0	0	1	12	249	1009	23643
n	10 Howard	316	2056	2544	22	14	112	16	6	555	18704	6051	11	402	5	0	0	0	0	0	0	2	11	2011	32838
	11 AnnArndl	532	957	4274	71	59	110	6	11	67	5902	33834	78	79	329	5	1	0	1	0	1	0	1	2816	49134
D	12 Charles	330	45	2928	57	98	113	0	17	0	16	86	13428	0	365	1293	228	1	9	2	0	0	0	197	19213
i	13 Carroll	8	274	60	1	0	3	7	0	837	380	97	1	9651	0	0	0	0	0	0	0	0	7	721	12047
s	14 Calvert	56	22	689	9	16	18	1	2	1	5	336	390	0	5781	923	5	0	1	0	0	0	0	97	8352
t	15 St Marys	10	0	140	1	1	5	0	2	0	1	9	1276	0	948	8926	80	0	3	0	0	0	0	137	11539
r	16 King Geo	2	0	23	0	1	4	0	9	0	0	0	270	0	8	62	3028	84	164	117	3	0	0	163	3938
i	17 Frdckbrg	3	2	4	5	4	54	2	176	0	1	0	1	0	0	0	67	1887	1337	1296	36	0	0	294	5169
c	18 Stafford	34	14	27	37	27	434	16	1636	0	2	1	7	0	0	2	133	1342	10087	2703	643	1	0	542	17688
t	19 Spotsylv	6	3	7	8	5	101	2	410	0	1	1	2	0	0	0	85	1357	2654	11367	80	0	0	1013	17102
	20 Fauquier	5	13	7	6	2	413	518	1986	1	0	1	0	0	0	0	0	30	633	73	6626	58	3	382	10757
	21 Clarke	0	4	0	0	0	23	431	22	11	0	0	0	0	0	0	0	0	0	0	55	645	299	86	1576
	22 Jeffrson	1	51	3	0	0	18	460	5	229	8	0	0	4	0	0	0	1	0	0	3	338	4516	352	5989
	23 External	781	1217	1390	223	148	1038	615	646	1057	2096	2935	204	752	104	137	169	305	567	1054	397	93	370	9441	25739
	Total	49310	81141	74216	16585	11290	53492	69455	43593	23760	32865	49565	19250	12013	8244	11448	3816	5222	17725	17131	10801	1599	5917	25071	643509

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MWCOG Truck Trip Model
2030 Minus 2005 Medium Truck Trips
With Calibration Adjustment

Destination District

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	1 DC	4307	714	2310	753	319	656	44	79	7	87	84	71	9	4	5	-1	8	19	0	3	0	0	281	9759
	2 Mont Co	662	9560	1567	116	64	715	182	86	1053	535	218	12	56	2	0	0	1	12	2	12	-4	25	434	15310
	3 PG Co	2318	1518	9564	317	510	951	50	123	37	854	537	757	42	121	13	7	3	24	1	3	0	1	511	18262
	4 Arlingtn	720	127	317	936	275	711	28	90	5	3	6	11	1	0	0	0	-1	16	5	4	0	0	80	3334
O	5 Alxndria	321	49	440	278	425	733	27	124	5	3	9	27	1	2	0	2	1	31	2	4	0	0	48	2532
r	6 Fairfax	627	688	896	683	659	7436	4199	2089	27	27	31	50	1	7	-1	2	10	202	40	235	13	6	379	18306
i	7 Loudoun	36	160	35	37	30	4107	14365	1606	199	11	5	1	7	0	0	0	2	14	1	261	153	160	346	21536
g	8 PrWillam	96	57	127	77	100	2016	1668	6302	3	5	7	3	0	4	0	-1	67	634	111	793	18	3	286	12376
i	9 Fredrick	10	1012	42	2	2	34	250	3	5788	241	56	1	140	0	0	0	-1	0	0	0	6	168	419	8173
n	10 Howard	87	514	847	7	7	37	8	1	251	2601	1737	1	188	2	0	0	0	0	0	0	2	10	728	7028
	11 AnnArndl	83	205	513	14	8	21	4	4	54	1736	1733	4	61	30	0	0	0	1	0	1	0	1	822	5295
D	12 Charles	71	10	798	15	38	70	0	11	0	8	1	2489	0	88	142	104	0	4	-1	0	0	0	93	3941
i	13 Carroll	4	42	44	1	0	0	4	0	147	169	67	0	297	0	0	0	0	0	0	0	0	6	191	972
s	14 Calvert	10	11	118	4	4	4	1	2	1	1	22	100	0	1009	123	2	0	1	0	0	0	0	34	1447
t	15 St Marys	4	-1	27	-1	-3	4	0	2	0	1	2	193	0	149	1962	47	0	-1	0	0	0	0	53	2438
r	16 King Geo	1	0	12	0	0	3	0	2	0	0	-1	139	0	6	37	1796	37	67	44	2	0	0	115	2260
i	17 Frdckbrg	0	0	3	3	1	21	2	70	0	1	0	-1	0	0	0	22	1177	807	721	26	0	0	189	3042
c	18 Stafford	17	10	14	15	15	182	15	633	-1	2	0	4	0	0	1	39	794	4693	1127	202	1	0	313	8076
t	19 Spotsylv	1	2	3	4	1	32	1	105	0	0	1	-1	0	0	0	26	731	1100	3964	41	0	0	576	6587
	20 Fauquier	4	8	6	3	2	217	267	780	1	0	1	0	0	0	0	-1	23	187	38	2775	15	1	238	4565
	21 Clarke	0	2	0	0	0	17	169	7	4	0	0	0	0	0	0	0	0	0	0	14	210	120	41	584
	22 Jeffrson	0	22	1	0	0	16	194	4	135	7	-2	0	2	0	0	0	1	0	0	1	143	2221	204	2949
	23 External	279	451	547	81	47	383	375	309	440	766	859	91	194	38	56	122	195	328	600	245	46	209	3910	10571
	Total	9658	15161	18231	3345	2504	18366	21853	12432	8156	7058	5373	3952	999	1462	2338	2166	3048	8139	6655	4622	603	2931	10291	169343

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MWCOG Truck Trip Model
2030/2005 Medium Truck Trips
With Calibration Adjustment

Destination District

Origin District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 DC	1.17	1.22	1.37	1.58	1.47	1.59	2.57	1.47	1.15	1.36	1.19	1.31	.00	1.11	.00	.00	3.00	2.46	1.00	4.00	.00	.00	1.59	1.24
2 Mont Co	1.20	1.19	1.34	1.41	1.56	1.64	2.08	2.34	1.55	1.34	1.31	1.50	1.26	1.33	1.00	.00	2.00	3.40	.00	5.00	.00	2.39	1.59	1.23
3 PG Co	1.39	1.31	1.29	1.36	1.77	2.10	2.92	2.43	1.76	1.48	1.14	1.33	7.00	1.24	1.16	2.40	4.00	3.18	1.50	.00	.00	.00	1.62	1.32
4 Arlingtn	1.63	1.42	1.41	1.13	1.10	1.40	2.47	1.15	1.71	1.27	1.10	1.34	.00	1.00	.00	.00	.50	1.62	1.71	3.00	.00	.00	1.60	1.22
5 Alxndria	1.55	1.50	1.88	1.22	1.14	1.45	5.50	1.19	6.00	1.38	1.20	1.71	.00	1.40	.00	.00	1.50	2.35	1.20	2.33	.00	.00	1.50	1.31
6 Fairfax	1.62	1.57	1.91	1.46	1.56	1.37	2.09	1.72	1.52	1.40	1.33	1.89	1.25	1.64	.00	2.00	1.32	1.83	1.58	2.35	5.33	7.00	1.60	1.54
7 Loudoun	2.20	1.87	2.17	3.18	4.75	1.98	1.35	3.03	2.11	2.83	3.50	2.00	4.50	.00	.00	.00	.00	8.00	.00	1.93	1.60	1.65	2.46	1.45
8 PrWillam	1.82	1.84	2.79	1.24	2.67	1.72	3.16	1.27	2.50	3.50	2.40	1.75	.00	.00	.00	.67	1.81	1.64	1.42	1.67	3.57	.00	1.87	1.41
9 Fredrick	1.19	1.56	1.68	1.20	1.67	1.62	2.28	1.50	1.50	1.77	3.80	2.00	1.22	.00	.00	.00	.00	.00	.00	1.00	2.00	3.07	1.71	1.53
10 Howard	1.38	1.33	1.50	1.47	2.00	1.49	2.00	1.20	1.83	1.16	1.40	1.10	1.88	1.67	.00	.00	.00	.00	.00	.00	.00	11.00	1.57	1.27
11 AnnArndl	1.18	1.27	1.14	1.25	1.16	1.24	3.00	1.57	5.15	1.42	1.05	1.05	4.39	1.10	1.00	1.00	.00	.00	.00	.00	.00	.00	1.41	1.12
12 Charles	1.27	1.29	1.37	1.36	1.63	2.63	.00	2.83	.00	2.00	1.01	1.23	.00	1.32	1.12	1.84	1.00	1.80	.67	.00	.00	.00	1.89	1.26
13 Carroll	2.00	1.18	3.75	.00	.00	1.00	2.33	.00	1.21	1.80	3.23	1.00	1.03	.00	.00	.00	.00	.00	.00	.00	.00	7.00	1.36	1.09
14 Calvert	1.22	2.00	1.21	1.80	1.33	1.29	.00	.00	.00	1.25	1.07	1.34	.00	1.21	1.15	1.67	.00	.00	.00	.00	.00	.00	1.54	1.21
15 St Marys	1.67	.00	1.24	.50	.25	5.00	.00	.00	.00	.00	1.29	1.18	.00	1.19	1.28	2.42	.00	.75	.00	.00	.00	.00	1.63	1.27
16 King Geo	2.00	.00	2.09	.00	1.00	4.00	.00	1.29	.00	.00	.00	2.06	.00	4.00	2.48	2.46	1.79	1.69	1.60	3.00	.00	.00	3.40	2.35
17 Frdckbrg	1.00	1.00	4.00	2.50	1.33	1.64	.00	1.66	.00	.00	.00	.50	.00	.00	.00	1.49	2.66	2.52	2.25	3.60	.00	.00	2.80	2.43
18 Stafford	2.00	3.50	2.08	1.68	2.25	1.72	16.00	1.63	.00	.00	1.00	2.33	.00	.00	2.00	1.41	2.45	1.87	1.72	1.46	.00	.00	2.37	1.84
19 Spotsylv	1.20	3.00	1.75	2.00	1.25	1.46	2.00	1.34	.00	1.00	.00	.67	.00	.00	.00	1.44	2.17	1.71	1.54	2.05	.00	.00	2.32	1.63
20 Fauquier	5.00	2.60	7.00	2.00	.00	2.11	2.06	1.65	.00	.00	.00	.00	.00	.00	.00	.00	4.29	1.42	2.09	1.72	1.35	1.50	2.65	1.74
21 Clarke	.00	2.00	.00	.00	.00	3.83	1.65	1.47	1.57	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1.34	1.48	1.67	1.91	1.59
22 Jeffrson	1.00	1.76	1.50	.00	.00	9.00	1.73	5.00	2.44	8.00	.00	.00	2.00	.00	.00	.00	.00	.00	.00	1.50	1.73	1.97	2.38	1.97
23 External	1.56	1.59	1.65	1.57	1.47	1.58	2.56	1.92	1.71	1.58	1.41	1.81	1.35	1.58	1.69	3.60	2.77	2.37	2.32	2.61	1.98	2.30	1.71	1.70
Total	1.24	1.23	1.33	1.25	1.28	1.52	1.46	1.40	1.52	1.27	1.12	1.26	1.09	1.22	1.26	2.31	2.40	1.85	1.64	1.75	1.61	1.98	1.70	1.36

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MWCOG Truck Trip Model
2005 Heavy Truck Trips
With Calibration Adjustment

Destination District

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
	1 DC	1684	637	1565	362	210	894	200	546	236	501	628	167	55	110	139	8	15	76	61	42	4	28	879	9047
	2 Mont Co	652	5316	1354	115	83	761	301	264	604	831	910	212	116	75	151	15	21	72	68	43	13	40	1087	13104
	3 PG Co	1501	1371	7802	471	414	1804	737	833	327	1346	1294	421	120	153	235	23	27	119	102	63	22	35	1440	20660
	4 Arlingtn	217	107	384	752	252	867	66	465	56	74	159	46	12	32	35	7	8	47	30	14	1	3	206	3840
O	5 Alxndria	118	96	345	245	410	633	290	364	46	57	158	39	13	37	17	3	5	36	35	9	8	8	180	3152
r	6 Fairfax	694	786	1685	739	537	6364	3840	2238	335	535	884	216	129	206	116	20	52	236	189	146	66	85	1229	21327
i	7 Loudoun	341	312	779	105	207	3756	11049	931	120	196	284	74	38	66	43	6	19	88	58	102	121	78	561	19334
g	8 PrWillam	423	268	782	440	289	2343	1054	5512	150	150	344	94	55	75	53	20	56	262	142	194	9	19	571	13305
i	9 Fredrick	223	554	336	55	45	335	124	161	2282	161	190	70	198	41	48	7	11	41	32	21	1	7	896	5839
n	10 Howard	464	791	1215	75	80	527	191	161	141	3227	1426	139	58	56	83	14	9	39	36	25	4	11	1767	10539
	11 AnnArndl	603	935	1334	149	156	864	270	356	172	1445	3448	114	87	107	80	6	16	79	63	39	6	15	1996	12340
D	12 Charles	147	208	426	47	47	214	82	97	76	161	108	1203	33	66	167	6	5	18	17	7	4	8	164	3311
i	13 Carroll	58	107	101	15	12	129	48	49	237	67	103	33	873	8	15	2	2	14	13	8	2	6	469	2371
s	14 Calvert	112	76	150	35	39	201	79	79	34	53	96	74	12	219	101	3	4	16	12	9	0	5	107	1516
t	15 St Marys	111	119	214	29	28	142	52	53	49	75	75	176	15	98	626	8	3	20	20	7	0	0	128	2048
r	16 King Geo	10	17	25	4	2	20	7	14	8	14	7	6	1	6	9	10	3	7	5	2	0	0	41	218
i	17 Frdckbrg	18	22	30	9	9	52	17	48	10	10	20	6	4	4	5	3	116	113	120	5	0	1	114	736
c	18 Stafford	68	82	130	57	34	247	96	265	44	36	83	19	13	15	20	4	127	732	413	101	2	2	254	2844
t	19 Spotsylv	62	70	105	34	25	177	61	145	36	30	71	17	14	12	17	6	178	378	2092	17	1	2	510	4060
	20 Fauquier	34	42	63	11	11	161	119	174	18	26	39	12	6	9	4	2	6	122	16	58	0	1	130	1064
	21 Clarke	9	14	19	2	7	73	135	9	4	3	7	4	1	1	1	0	0	1	2	1	13	7	39	352
	22 Jeffrson	25	40	40	9	8	87	73	19	9	12	17	6	5	4	0	0	1	2	2	0	9	87	117	572
	23 External	853	1119	1459	200	181	1257	573	584	916	1811	2052	171	484	109	134	39	115	261	527	132	36	119	26984	40116
	Total	8427	13089	20343	3960	3086	21908	19464	13367	5910	10821	12403	3319	2342	1509	2099	212	799	2779	4055	1045	322	567	39869	191695

Date: 1/11/2008

Time: 11:47

MWCOG Truck Trip Model
2030 Heavy Truck Trips
With Calibration Adjustment

Destination District

Origin District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 DC	2109	855	2016	426	218	1124	454	638	296	618	669	212	60	127	156	48	45	149	122	77	13	53	1374	11859
2 Mont Co	848	6266	1835	166	115	1074	718	403	849	1082	1008	256	112	111	178	65	56	167	148	97	23	81	1832	17490
3 PG Co	1952	1808	9033	545	487	2200	1119	974	484	1705	1440	546	127	199	282	114	63	247	196	119	27	80	2425	26172
4 Arlingtn	302	159	467	768	256	930	140	504	73	89	167	58	15	37	37	14	17	73	52	23	4	9	311	4505
5 Alxndria	149	118	400	248	377	645	356	388	51	75	150	49	12	34	26	18	15	56	44	20	8	14	263	3516
6 Fairfax	893	1140	2072	813	567	6834	4980	2552	446	661	911	248	120	222	154	96	123	396	314	261	90	130	1967	25990
7 Loudoun	572	737	1159	174	268	4874	15009	1491	359	375	400	136	68	106	84	49	61	203	159	232	153	159	1527	28355
8 PrWillam	533	420	956	472	316	2686	1608	6219	216	210	392	115	44	84	71	50	104	401	244	295	16	39	1072	16563
9 Fredrick	287	803	476	70	53	449	366	221	2871	296	267	85	193	47	64	22	26	76	69	40	11	63	1500	8355
10 Howard	575	1015	1551	95	89	647	364	222	278	4127	1719	170	77	72	99	38	26	81	73	47	9	39	3047	14460
11 AnnArndl	637	1040	1480	155	152	899	411	384	255	1737	3359	123	84	106	89	42	37	110	97	60	7	39	2902	14205
12 Charles	189	253	540	58	48	275	139	122	87	183	124	1306	41	78	184	49	14	40	36	15	7	13	282	4083
13 Carroll	62	114	130	17	11	120	82	51	233	86	105	30	708	8	24	8	6	21	20	12	3	12	603	2466
14 Calvert	132	100	195	41	39	225	109	93	44	72	98	86	9	259	118	19	9	27	22	13	2	9	168	1889
15 St Marys	129	145	266	36	30	168	95	69	59	96	83	193	17	116	745	42	13	33	36	14	5	4	213	2607
16 King Geo	55	62	100	14	14	86	49	51	27	39	42	46	10	20	42	167	21	44	48	12	1	3	224	1177
17 Frdckbrg	49	58	76	20	16	121	62	95	28	26	39	14	7	8	15	22	308	211	240	17	1	5	358	1796
18 Stafford	145	166	240	78	53	413	214	400	77	73	120	39	20	25	35	47	221	1231	595	137	5	13	628	4975
19 Spotsylv	125	151	201	55	43	309	167	241	70	66	103	36	21	24	35	48	299	558	2990	46	3	10	1346	6947
20 Fauquier	70	100	121	25	19	272	244	280	41	50	61	19	9	15	12	12	18	157	46	185	5	11	350	2122
21 Clarke	15	21	28	7	7	88	169	18	11	9	9	4	2	3	1	1	1	5	2	5	20	15	88	529
22 Jeffrson	45	91	74	13	12	135	154	40	60	38	37	11	13	9	2	5	4	10	10	8	16	209	294	1290
23 External	1354	1866	2472	312	265	2006	1569	1094	1539	3129	2973	287	619	172	227	234	366	642	1388	357	88	300	47791	71050
Total	11227	17488	25888	4608	3455	26580	28578	16550	8454	14842	14276	4069	2388	1882	2680	1210	1853	4938	6951	2092	517	1310	70565	272401

Date: 1/11/2008
Time: 11:47

MWCOG Truck Trip Model
2030 Minus 2005 Heavy Truck Trips
With Calibration Adjustment

Destination District

Origin District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 DC	425	218	451	64	8	230	254	92	60	117	41	45	5	17	17	40	30	73	61	35	9	25	495	2812
2 Mont Co	196	950	481	51	32	313	417	139	245	251	98	44	-4	36	27	50	35	95	80	54	10	41	745	4386
3 PG Co	451	437	1231	74	73	396	382	141	157	359	146	125	7	46	47	91	36	128	94	56	5	45	985	5512
4 Arlingtn	85	52	83	16	4	63	74	39	17	15	8	12	3	5	2	7	9	26	22	9	3	6	105	665
5 Alxndria	31	22	55	3	-33	12	66	24	5	18	-8	10	-1	-3	9	15	10	20	9	11	0	6	83	364
6 Fairfax	199	354	387	74	30	470	1140	314	111	126	27	32	-9	16	38	76	71	160	125	115	24	45	738	4663
7 Loudoun	231	425	380	69	61	1118	3960	560	239	179	116	62	30	40	41	43	42	115	101	130	32	81	966	9021
8 PrWillam	110	152	174	32	27	343	554	707	66	60	48	21	-11	9	18	30	48	139	102	101	7	20	501	3258
9 Fredrick	64	249	140	15	8	114	242	60	589	135	77	15	-5	6	16	15	15	35	37	19	10	56	604	2516
10 Howard	111	224	336	20	9	120	173	61	137	900	293	31	19	16	16	24	17	42	37	22	5	28	1280	3921
11 AnnArndl	34	105	146	6	-4	35	141	28	83	292	-89	9	-3	-1	9	36	21	31	34	21	1	24	906	1865
12 Charles	42	45	114	11	1	61	57	25	11	22	16	103	8	12	17	43	9	22	19	8	3	5	118	772
13 Carroll	4	7	29	2	-1	-9	34	2	-4	19	2	-3	-165	0	9	6	4	7	7	4	1	6	134	95
14 Calvert	20	24	45	6	0	24	30	14	10	19	2	12	-3	40	17	16	5	11	10	4	2	4	61	373
15 St Marys	18	26	52	7	2	26	43	16	10	21	8	17	2	18	119	34	10	13	16	7	5	4	85	559
16 King Geo	45	45	75	10	12	66	42	37	19	25	35	40	9	14	33	157	18	37	43	10	1	3	183	959
17 Frdckbrg	31	36	46	11	7	69	45	47	18	16	19	8	3	4	10	19	192	98	120	12	1	4	244	1060
18 Stafford	77	84	110	21	19	166	118	135	33	37	37	20	7	10	15	43	94	499	182	36	3	11	374	2131
19 Spotsylv	63	81	96	21	18	132	106	96	34	36	32	19	7	12	18	42	121	180	898	29	2	8	836	2887
20 Fauquier	36	58	58	14	8	111	125	106	23	24	22	7	3	6	8	10	12	35	30	127	5	10	220	1058
21 Clarke	6	7	9	5	0	15	34	9	7	6	2	0	1	2	0	1	1	4	0	4	7	8	49	177
22 Jeffrson	20	51	34	4	4	48	81	21	51	26	20	5	8	5	2	5	3	8	8	8	7	122	177	718
23 External	501	747	1013	112	84	749	996	510	623	1318	921	116	135	63	93	195	251	381	861	225	52	181	20807	30934
Total	2800	4399	5545	648	369	4672	9114	3183	2544	4021	1873	750	46	373	581	998	1054	2159	2896	1047	195	743	30696	80706

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Time: 11:47

MWCOG Truck Trip Model
2030/2005 Heavy Truck Trips
With Calibration Adjustment

Destination District

Origin District	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
1 DC	1.25	1.34	1.29	1.18	1.04	1.26	2.27	1.17	1.25	1.23	1.07	1.27	1.09	1.15	1.12	6.00	3.00	1.96	2.00	1.83	3.25	1.89	1.56	1.31
2 Mont Co	1.30	1.18	1.36	1.44	1.39	1.41	2.39	1.53	1.41	1.30	1.11	1.21	.97	1.48	1.18	4.33	2.67	2.32	2.18	2.26	1.77	2.03	1.69	1.33
3 PG Co	1.30	1.32	1.16	1.16	1.18	1.22	1.52	1.17	1.48	1.27	1.11	1.30	1.06	1.30	1.20	4.96	2.33	2.08	1.92	1.89	1.23	2.29	1.68	1.27
4 Arlingtn	1.39	1.49	1.22	1.02	1.02	1.07	2.12	1.08	1.30	1.20	1.05	1.26	1.25	1.16	1.06	2.00	2.13	1.55	1.73	1.64	4.00	3.00	1.51	1.17
5 Alxndria	1.26	1.23	1.16	1.01	.92	1.02	1.23	1.07	1.11	1.32	.95	1.26	.92	.92	1.53	6.00	3.00	1.56	1.26	2.22	1.00	1.75	1.46	1.12
6 Fairfax	1.29	1.45	1.23	1.10	1.06	1.07	1.30	1.14	1.33	1.24	1.03	1.15	.93	1.08	1.33	4.80	2.37	1.68	1.66	1.79	1.36	1.53	1.60	1.22
7 Loudoun	1.68	2.36	1.49	1.66	1.29	1.30	1.36	1.60	2.99	1.91	1.41	1.84	1.79	1.61	1.95	8.17	3.21	2.31	2.74	2.27	1.26	2.04	2.72	1.47
8 PrWillam	1.26	1.57	1.22	1.07	1.09	1.15	1.53	1.13	1.44	1.40	1.14	1.22	.80	1.12	1.34	2.50	1.86	1.53	1.72	1.52	1.78	2.05	1.88	1.24
9 Fredrick	1.29	1.45	1.42	1.27	1.18	1.34	2.95	1.37	1.26	1.84	1.41	1.21	.97	1.15	1.33	3.14	2.36	1.85	2.16	1.90	11.00	9.00	1.67	1.43
10 Howard	1.24	1.28	1.28	1.27	1.11	1.23	1.91	1.38	1.97	1.28	1.21	1.22	1.33	1.29	1.19	2.71	2.89	2.08	2.03	1.88	2.25	3.55	1.72	1.37
11 AnnArndl	1.06	1.11	1.11	1.04	.97	1.04	1.52	1.08	1.48	1.20	.97	1.08	.97	.99	1.11	7.00	2.31	1.39	1.54	1.54	1.17	2.60	1.45	1.15
12 Charles	1.29	1.22	1.27	1.23	1.02	1.29	1.70	1.26	1.14	1.14	1.15	1.09	1.24	1.18	1.10	8.17	2.80	2.22	2.12	2.14	1.75	1.63	1.72	1.23
13 Carroll	1.07	1.07	1.29	1.13	.92	.93	1.71	1.04	.98	1.28	1.02	.91	.81	1.00	1.60	4.00	3.00	1.50	1.54	1.50	1.50	2.00	1.29	1.04
14 Calvert	1.18	1.32	1.30	1.17	1.00	1.12	1.38	1.18	1.29	1.36	1.02	1.16	.75	1.18	1.17	6.33	2.25	1.69	1.83	1.44	.00	1.80	1.57	1.25
15 St Marys	1.16	1.22	1.24	1.24	1.07	1.18	1.83	1.30	1.20	1.28	1.11	1.10	1.13	1.18	1.19	5.25	4.33	1.65	1.80	2.00	.00	.00	1.66	1.27
16 King Geo	5.50	3.65	4.00	3.50	7.00	4.30	7.00	3.64	3.38	2.79	6.00	7.67	10.00	3.33	4.67	16.70	7.00	6.29	9.60	6.00	.00	.00	5.46	5.40
17 Frdckbrg	2.72	2.64	2.53	2.22	1.78	2.33	3.65	1.98	2.80	2.60	1.95	2.33	1.75	2.00	3.00	7.33	2.66	1.87	2.00	3.40	.00	5.00	3.14	2.44
18 Stafford	2.13	2.02	1.85	1.37	1.56	1.67	2.23	1.51	1.75	2.03	1.45	2.05	1.54	1.67	1.75	11.75	1.74	1.68	1.44	1.36	2.50	6.50	2.47	1.75
19 Spotsylv	2.02	2.16	1.91	1.62	1.72	1.75	2.74	1.66	1.94	2.20	1.45	2.12	1.50	2.00	2.06	8.00	1.68	1.48	1.43	2.71	3.00	5.00	2.64	1.71
20 Fauquier	2.06	2.38	1.92	2.27	1.73	1.69	2.05	1.61	2.28	1.92	1.56	1.58	1.50	1.67	3.00	6.00	3.00	1.29	2.88	3.19	.00	11.00	2.69	1.99
21 Clarke	1.67	1.50	1.47	3.50	1.00	1.21	1.25	2.00	2.75	3.00	1.29	1.00	2.00	3.00	1.00	.00	.00	5.00	1.00	5.00	1.54	2.14	2.26	1.50
22 Jeffrson	1.80	2.28	1.85	1.44	1.50	1.55	2.11	2.11	6.67	3.17	2.18	1.83	2.60	2.25	.00	.00	4.00	5.00	5.00	.00	1.78	2.40	2.51	2.26
23 External	1.59	1.67	1.69	1.56	1.46	1.60	2.74	1.87	1.68	1.73	1.45	1.68	1.28	1.58	1.69	6.00	3.18	2.46	2.63	2.70	2.44	2.52	1.77	1.77
Total	1.33	1.34	1.27	1.16	1.12	1.21	1.47	1.24	1.43	1.37	1.15	1.23	1.02	1.25	1.28	5.71	2.32	1.78	1.71	2.00	1.61	2.31	1.77	1.42

Note: External trips are shown in O/D format.

5. APPLICATION NOTES

The Truck trip generation, distribution, and time of day models are fairly straightforward processes that can easily be incorporated into the current MWCOG travel model setup. However, there are a few other changes that need to occur elsewhere in the model chain.

One change is the identification of the truck zones. This should be considered an input file that could change by forecast year. Thus, it should either be in a separate file or incorporated into the basic socioeconomic data file, ZONE.ASC, as another field. The consultant recommends the latter. The value of this field would be zero, except for zones that are truck zones, where it would be 1.

Another change is that a separate set of truck skims must be created. These represent the off-peak period only and use the "pump prime" speeds. Only a travel time matrix is created (distance and toll are not created or used). The Cube script to create these skims is shown in Appendix C. It is based on the protocol in the existing MWCOG script Highway_Skims.s. The second step adds terminal times and intrazonal times. In addition, the second step outputs a zonal ASCII file called SKIMTOT.DAT. This file contains the zone number, total truck travel time from that zone to all other zones, and total truck travel time to that zone from all other zones. This file is used in trip generation to determine whether or not each zone is accessible by trucks and therefore capable of generating truck trips.

For trip generation, the only required new file is a file of *external* MTK and HTK daily vehicle trips at each cordon station, for the forecast year. This includes only the I/X and X/I trips, so it is equal to the cordon total minus the X/X trip ends. The generation model reads the land use file (basic input), the area type file (previously calculated elsewhere in the MWCOG model chain), and the truck connectivity file (described above). The output file contains the zone number and the zonal trip ends in the following format: MTK I/I productions, MTK I/I attractions, HTK I/I productions, HTK I/I attractions, MTK external productions, MTK external attractions, HTK external productions, HTK external attractions. The external attractions are defined as zero for the internal zones and the external productions are defined as zero for the external stations.

For trip distribution, a new set of F factors must be supplied, in the following format: MTK I/I, HTK I/I, MTK external, HTK external (the tables are created on the output file in that same order). This is a fairly standard gravity model application. One new feature is that trips are output as single-precision (fractional) values, which makes the resulting tables larger.

The calibration adjustment matrix, DELTA.TRP, must be input to the time of day step, which is where those adjustments are applied. In addition, the X/X trip table must be input to the time of day step. The user is responsible for forecasting X/X MTK and HTK trips, separately.

In assignment, the MTK and HTK trips are each loaded using the TRK paths. The "V" (volume) function is modified to include a passenger car equivalent (PCE) factor of 1.5 on MTK trips and 2.0 on HTK trips, as follows:

```
V    = vol[1] + vol[2] + vol[3] + 1.5*vol[4] + vol[5] + 2.0*vol[6]
```

These PCE values are the same as used in the Baltimore model and are the result of considerable research by BMC staff. The function of PCEs is to reflect the higher effect that trucks have on congestion. Due to their acceleration and braking characteristics, they effectively create a higher V/C ratio. Some analysts believe that using PCEs means that the network capacities should be adjusted, since in theory these capacities already reflect the presence of an "average" percentage of trucks in the traffic stream. After careful consideration, the consultant and TPB staff agreed that such adjustment would not be appropriate in this case and thus no changes were made to the link capacities. *The user must remember that the output total volumes in the loaded network (the V_1 field) contain the results of the above equation, i.e., autos plus truck PCEs. In order to get the <u>actual</u> vehicle volume, the user must re-sum the individual trip components in a subsequent step:*

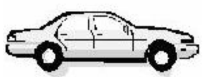
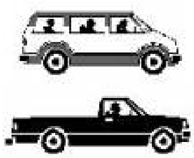
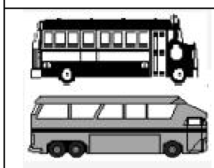
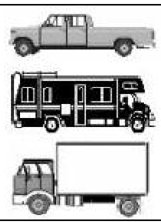
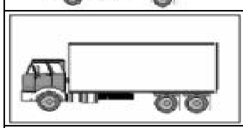
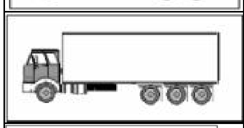
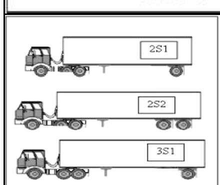
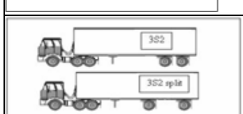
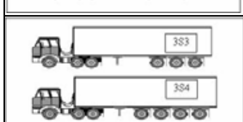
total vehicles = V1_1 + V2_1 + V3_1 + V4_1 + V5_1 +V6 _1

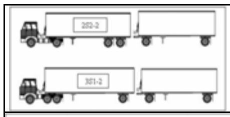
Appendix C shows the stand-alone Cube script file to apply the Truck model. The file names will need to be edited to be compatible with the MWCOG file naming and directory system.

The delta matrix is a matrix file with six tables: MTK I/I, MTK external, MTK X/X, HTK I/I, HTK external, HTK X/X. It is 2191 x 2191 zones, in single precision, so it occupies 32 Mb of disk space. One of the principal disadvantages of using a delta matrix is that if the zone system changes, the cells in this matrix have to be renumbered as well. Fortunately, this is not too difficult.

APPENDIX A DESCRIPTION OF VEHICLE CLASSES

The following chart describes the "13 bin" classification system used by the FHWA.

	**CLASS 1: *Motorcycles*** -- All two or three-wheeled motorized vehicles. Typical vehicles in this category have saddle type seats and are steered by handlebars rather than steering wheels. This category includes motorcycles, motor scooters, mopeds, motor-powered bicycles, and three-wheel motorcycles.
	**CLASS 2: *Passenger Cars*** -- All sedans, coupes, and station wagons manufactured primarily for the purpose of carrying passengers and including those passenger cars pulling recreational or other light trailers.
	**CLASS 3: *Other Two-Axle, Four-Tire Single Unit Vehicles*** -- All two-axle, four-tire vehicles, other than passenger cars. Included in this classification are pickups, panels, vans, and other vehicles such as campers, motor homes, ambulances, hearses, carryalls, and minibuses. Other two-axle, four-tire single-unit vehicles pulling recreational or other light trailers are included in this classification.
	**CLASS 4: *Buses*** -- All vehicles manufactured as traditional passenger-carrying buses with two axles and six tires or three or more axles. This category includes only traditional buses (including school buses) functioning as passenger-carrying vehicles. Modified buses should be considered to be a truck and should be appropriately classified.
	**CLASS 5: *Two-Axle, Six-Tire, Single-Unit Trucks --*** All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., with two axles and dual rear wheels.
	**CLASS 6: *Three-Axle Single-Unit Trucks*** -- All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., with three axles.
	**CLASS 7: *Four or More Axle Single-Unit Trucks*** -- All trucks on a single frame with four or more axles.
	**CLASS 8: *Four or Fewer Axle Single-Trailer Trucks*** -- All vehicles with four or fewer axles consisting of two units, one of which is a tractor or straight truck power unit.
	**CLASS 9: *Five-Axle Single-Trailer Trucks*** -- All five-axle vehicles consisting of two units, one of which is a tractor or straight truck power unit.
	**CLASS 10: *Six or More Axle Single-Trailer Trucks*** -- All vehicles with six or more axles consisting of two units, one of which is a tractor or straight truck power unit.
	**CLASS 11: *Five or fewer Axle Multi-Trailer Trucks*** -- All vehicles with five or fewer axles consisting of three or more units, one of which is a tractor or straight truck power unit.

	**CLASS 12:** ***Six-Axle Multi-Trailer Trucks*** -- All six-axle vehicles consisting of three or more units, one of which is a tractor or straight truck power unit.
	**CLASS 13:** ***Seven or More Axle Multi-Trailer Trucks*** -- All vehicles with seven or more axles consisting of three or more units, one of which is a tractor or straight truck power unit.

- Traffic Monitoring Guide - May 1, 2001; Section 4: Vehicle Classification Monitoring http://www.fhwa.dot.gov/ohim/tmguide/tmg4.htm#tab4a1
- Some pictures are taken from Texas Department of Transportation's website
- Some pictures are taken from Microsoft's clip arts.

NOTE: In reporting information on trucks the following criteria should be used:

a. Truck tractor units traveling without a trailer will be considered single-unit trucks.
b. A truck tractor unit pulling other such units in a "saddle mount" configuration will be considered one single-unit truck and will be defined only by the axles on the pulling unit.
c. Vehicles are defined by the number of axles in contact with the road. Therefore, "floating" axles are counted only when in the down position.
d. The term "trailer" includes both semi- and full trailers.

Source: MWCOG

APPENDIX B ADAPTABLE ASSIGNMENT

Adaptable assignment (AA) is the name given to the consultant's proprietary procedure to perform matrix estimation. Matrix estimation is generally defined as the process of creating a synthesized trip table based on traffic count data. The AA process requires a starting trip table of some kind and then implements a semi-automated process of adjusting this table, cell-by-cell, such that the resulting assignment of that trip table to the network produces estimated link volumes that are much closer to the count data than before. This process is documented in a paper, *Adaptable Assignment*, that was presented at the Sixth TRB Conference on the Application of Transportation Planning Methods, May 1997. The main features of the procedure are summarized below.

The AA process requires the following items to begin:

- a starting trip table (or starting model)
- a highway network with counts posted
- an assignment procedure

The process is applied through a batch file that runs the following steps:

- applies the starting model to get the starting trip table
- performs a trip end summary for external + through trips and saves these to a file
- runs the AA procedure a certain number of times (see below); generally 10-20 iterations are sufficient, but this figure must be determined for each project by trial-and-error (in this case, it ended up being seven for MTK and two for HTK)
- Fratar the final trip table's external zones so that the external + through totals match the starting values (this step implements the assumption that the starting cordon trip totals by external station are "correct" and should not be modified)
- subtract the starting table from the final table to get the delta matrix

The "AA procedure" is contained in a Cube setup, consisting of the following steps:

- apply time of day model to the daily Truck trips, to split them by time period (AM, PM, OP)
- assign <u>all</u> vehicle trips to the network by time period using the current MWCOG assignment protocol; output MTK and HTK volumes as separate values on each link
- merge the MTK and HTK volumes from the loaded networks by period; compute daily assigned vs. count statistics for MTK and HTK trips
- build paths through the network and then skim two fields: the (synthesized MTK and HTK) counts, and the assigned MTK and HTK volumes for links that have a count; this produces 2 zone-zone matrices for each truck type, one with the sum of the counts along each O/D path and one with the sum of the assigned volumes (only on links with counts) on each O/D path
- adjust the starting daily trip tables, cell-by-cell; use the above skims and the trip length frequency distributions to determine a ratio for each O/D: total count divided by total assigned volume; multiply the starting matrix trips by that ratio, cell-by-cell; check the absolute change in trips for each O/D cell, if too large, cap it; output a new daily trip table

The first pass of the AA procedure uses the starting model's trip table. Each subsequent pass uses the trip table that is output from the previous pass. On each of the AA iterations, the %RMSE usually decreases. The external Fratar step at the end always increases the assignment error, but this is judged to be a reasonable trade-off that is necessary to match the counts at the cordon. The final output of this process is a new trip table.

It bears emphasis that the counts used in this process must be very "clean", because they are actually *driving* the development of the trip table. Even with a process to synthesize counts (as used in this case), there were some MTK and HTK counts that looked inconsistent. The consultant examined the network carefully and removed such counts before proceeding.

There are several other commercially-available processes to do matrix estimation, such as Cube ME. The consultant believes that any such process could be substituted for the AA procedure in this analysis.

The consultant believes that in this case it is reasonable to use matrix estimation to calculate a calibration adjustment (delta) matrix. It bears emphasis that this model (indeed, all models) are relatively simplistic formulations, that cannot possibly account for all of the factors that influence the way actual travellers behave each day. Most travel researchers do not believe that we know enough about how individuals make personal travel decisions and it is reasonable to think that we know even less about how Truck travel decisions are made. It should not be surprising that there would be a substantial random component to the decision process for Truck travel. It makes sense to think of the calibration adjustment matrix as that random component. As long as that adjustment is small, relative to the total base of tripmaking, such adjustment should be acceptable.

Since the delta matrix is a count-based calibration adjustment, it does not change for forecasting. Some have argued that the delta matrix should change in the future, that it is in effect tied to the land use and is thus a relative change. This implies that the adjustments should be calculated as cell-by-cell *factors*: final trips/starting trips, instead of *differences* (final trips – starting trips). The consultant believes that the final delta matrix adjustments represent random changes relating to the topology of the network and count locations and are thus not related to land use. So, they should not be changed for future years and should be applied as additive differences.

APPENDIX C APPLICATION SCRIPT

Truck Skims

```
in_tskm = 'toll.skm'  ; read in toll param file
PRD =  'OP'
IDS =  'Off-Peak Pump Prime Skims'

RUN PGM = HWYLOAD

; build pump prime off-peak highway skims for truck models
; based on COG's PUMP_PRIME_SKIMS_V22V60.S
; MWCOG VERSION 2.2 Model

;

  NETI    = ..\Version_2.2V60.S\ZONEHWY.NET
  MATO[1] = PP_@PRD@.skm, MO=1
  ID      = @IDS@

  PHASE=LINKREAD
;-
  READ FILE = @in_tskm@

   ; Define AM /OP link level tolls by vehicle type here:
       LW.TRK@PRD@TOLL = LI.@PRD@TOLL * @PRD@_TFAC(4,LI.TOLLGRP)           ;  Truck
TOLLS in 1994 cents

   ; Define AM /OP Equivalent 'toll minutes' by vehicle type here:
       LW.TRK@PRD@_tm = (LW.TRK@PRD@TOLL / 100.0) *    TK@PRD@EQM  ;  Truck
Time(min) equiv. of toll value in 1994$

   ; Define AM /OP IMPEDANCE (HIGHWAY TIME + EQV.TIME) by vehicle type here:
       LW.TRK@PRD@IMP  = LW.TRK@PRD@_tm + LI.@PRD@HTIME            ; TRUCK  IMPEDANCE

; Limit Codes:
;  0/1 = No prohibitions
;  2   = prohibit 1/occ autos,trucks
;  3   = prohibit 1&2occ autos,trucks
;  4   = prohibit trucks
;  5   = prohibit non-airport trips (year 2000 and beyond)
;  6-8 = Ununsed
;  9   = prohibit all traffic use
;
    IF     (LI.@PRD@LIMIT==1)
      ADDTOGROUP=1
    ELSEIF (LI.@PRD@LIMIT==2)
      ADDTOGROUP=2
    ELSEIF (LI.@PRD@LIMIT==3)
      ADDTOGROUP=3
    ELSEIF (LI.@PRD@LIMIT==4)
      ADDTOGROUP=4
    ELSEIF (LI.@PRD@LIMIT==5)
      ADDTOGROUP=5
    ELSEIF (LI.@PRD@LIMIT==6-8)
      ADDTOGROUP=6
    ELSEIF (LI.@PRD@LIMIT==9)
      ADDTOGROUP=7
    ENDIF
;
  ENDPHASE
;
; Specify path skimming  Time, distance, & toll skims over minimum time paths
```

```
; Note that override values of 0 will be inserted for disconnected ijs
;
  PHASE=ILOOP
    PATHLOAD PATH=LW.TRK@PRD@IMP, EXCLUDEGRP=2,3,4,5,6,7,   ; TRK paths
             MW[1]=PATHTRACE(LI.@PRD@HTIME), NOACCESS=0    ;  excluding links

;----------------------------------------------------------------------
; scaling, rounding of skim tables
;----------------------------------------------------------------------

;     mw[1] = ROUND(MW[1])                    ; round time skims to whole min

;----------------------------------------------------------------------
; I will print selected rows of skim files
;----------------------------------------------------------------------


     IF (i = 920)                          ;  for select rows (Is)
         printrow MW=1              ;  print work matrices 1-3
     ENDIF                                 ;  row value to all Js.
  ENDPHASE
ENDRUN
endloop

;--------------------------------------------------------------------

RUN PGM=MATRIX

  id = "Update 2005 Off-peak hwy skims

zones=2191

; 2005 terminal time file
  ZDATI[1]= ztermtm.asc, Z=1-4,hterm=27-28

;  READ AM PEAK & OFF-PEAK SOV TIME SKIM FILE (IN WHOLE MIN)
  MATI[2] = pp_op.skm    ;  INPUT OFF-PK SKIM FILE

; WRITE OUT FINAL TIME SKIMS (file usually called SOVOPTT.SKF)
  MATO = trkop.skm, MO=4; output op time(min) w/ o&d term&intra times

  MW[2]   = MI.2.1       ;  INPUT OFF-PK SKIM FILE

;
; Now add the terminal times to the OP travel times below
;  (terminal times added only to connected interchanges)
;  Also put a big number in unconnected interchanges to prevent
;  gravity model from estimating trips for them.
;
JLOOP
    IF  (MW[2] > 0)
         MW[4] = MW[2] + zi.1.hterm[I] + zi.1.hterm[J]
    ELSE
         MW[4] = 100000
    ENDIF
ENDJLOOP

;
; Establish Intrazonal Values for Network Time Skims
; --  Values equal to 50% of single lowest nonzero interzonal value

JLOOP
 IF (I=J)
      MW[4]=ROUND(0.50 * LOWEST(4,1,0.0001,99999.9))
```

```
      if (mw[4] = 0) mw[4] = 100000
 ENDIF
ENDJLOOP

; print a row of I/O matrices for checking

   IF  (I =92)
     PRINTROW MW=2,4, form=5, maxperline=10, base1=y
   ENDIF

; Output skim total by zone as a connectivity check.
   report marginrec = y, file = skimtot.dat, form=15, list=j(5),r4,c4

ENDRUN
```

Truck Model

```
maxzone = 2191
maxint  = 2144

run pgm=tripgen

; trk.s
; MWCOG Medium/Heavy Truck Model 2008

  id = "Truck Trip Generation

; Input Zonal Data (2005 data used for model development)
  zdati[1] = zone.asc, z=1-4, hh=10-15, hhpop=16-23, gqpop=24-31,
    totpop=32-39, totemp=40-47, indemp=48-55, retemp=56-63,
    offemp=64-71, othemp=72-79, jur=80-81, area=82-92, incrat=93-95,
    extdist=96-98

; Final external trip ends, from TRK Externals.xls, tab "trkext".
  zdati[2] = trkext.prn, z = #1, mtkte = #2, htkte = #3

; Zonal area type
  zdati[3] = atype.asc, z = #1, atype = #11

; Truck skim summary
  zdati[4] = ..\hskim\skimtot.dat, z = #1, skimout = #2, skimin = #3

; Truck zones
  zdati[5] = tzfile.prn, z = #1, tzone = #2

; Output P/A file: 1 = I/I MTK, 2 = I/I HTK, 3 = External MTK,
;  4 = Ext HTK
  pao = trkte.dat form=8.0 list= z(5.0), p[1],a[1],p[2],a[2],
    p[3],a[3],p[4],a[4],  print=y

  zones = @maxzone@

; Look up area type factors
; AT 1,2 = urban, 6,7 = rural

  lookup interpolate=n, fail=1,1,1, name=attrk,
    lookup[1] = 1, result = 2,
    lookup[2] = 1, result = 3,
;       AT  MTK  HTK
    r = '1  0.7  0.7',
        '5  1.2  1.1',
```

```
        '6  1.2  1.1',
        '7  1.2  1.1'

; If the truck skim doesn't exist, out of or into the zone,
;  skip it.  This means the zone cannot be accessed by trucks
;  (i.e., it's surrounded by truck-prohibited roads).
  if (skimout/@maxzone@ > 90000 || skimin/@maxzone@ > 90000) break

; Apply equation to internal zones
  if (i <= @maxint@)

; AT-based adjustment factor.
    mfac = attrk(1,atype)
    hfac = attrk(2,atype)

; Calculate productions
; Use BMC model as the starting model.
;   Incorporate adjustments from the delta trip end analysis
    mtk = (0.125 * indemp + 0.005 * offemp +
           0.125 * retemp + 0.020 * othemp +
           0.100 * hh) * mfac
    htk = (0.078 * indemp + 0.002 * offemp +
           0.039 * retemp + 0.003 * othemp +
           0.015 * hh) * hfac

; Apply truck zone factor
    if (tzone = 1)
      mtk = mtk * 2.7
      htk = htk * 5.3
    endif

;  Apply external trip end share model.
;  External share is a declining function of the zone's distance to the
;   nearest cordon station (in miles).  Use power function,
;   modified to produce the correct number of external trips in 2005.
    extpctm = 0.0
    extpcth = 0.0
    if (extdist > 0)
      extpctm = 0.44 * extdist^-0.9
      extpcth = 0.72 * extdist^-0.5
    endif
    extpctm = min(extpctm,0.60)
    extpcth = min(extpcth,0.90)
    intpctm = 1.0 - extpctm
    intpcth = 1.0 - extpcth

; Apply internal trip end shares; set A's equal to P's
    p[1] = mtk * intpctm
    a[1] = p[1]
    p[2] = htk * intpcth
    a[2] = p[2]

; Define all external trip ends as "Productions" at the internal
;  zones and "Attractions" at the external stations.  Calculate
;  these (initially) for internal zones as what's left over
;  after the above calculation.
    p[3] = mtk * extpctm
    p[4] = htk * extpcth
  endif

; External trip ends.  These were calculated externally, in
;  TRK Externals.xls  These are defined as Attractions, at the
;  external stations.  They do not include X/X trip ends.
  if (i > @maxint@)
```

```
    p[1] = 0
    p[2] = 0
    p[3] = 0
    p[4] = 0
    a[1] = 0
    a[2] = 0
    a[3] = mtkte
    a[4] = htkte
  endif

  phase = adjust

; Normalize external trips to the attractions (input at the external
;  stations).
    p[3] = p[3] * a[3][0]/p[3][0]
    p[4] = p[4] * a[4][0]/p[4][0]

  endphase

endrun

;--------------------------------------------------------------------
run pgm=tripdist

  id = "Truck Trip Distribution

; Skims
  mati = ..\hskim\trkop.skm

; Trip ends
  zdati = trkte.dat z=#1,p1=#2,a1=#3,p2=#4,a2=#5,p3=#6,a3=#7,
    p4=#8,a4=#9

; Output
  mato = trk.trp, mo=1-4, name = MTKII,HTKII,MTKEXT,HTKEXT, dec=4*S

; Set maximum iterations, unless RMSE for all purposes is met.
  maxiters = 20, maxrmse = 10

; Set productions and attractions
  setpa p[1]=p1, a[1]=a1, p[2]=p2, a[2]=a2, p[3]=p3, a[3]=a3,
    p[4]=p4, a[4]=a4

; Get skims.
  mw[5] = mi.1.1

; Look up friction factors.
  lookup interpolate=y, fail=4000000,0,0, name=ff,
    lookup[1]=1, result=2,
    lookup[2]=1, result=3,
    lookup[3]=1, result=4,
    lookup[4]=1, result=5,
    file=truck.ffs

; Distribute trips on off-peak skim time.
  gravity purpose=1, los = mw[5], ffactors=ff
  gravity purpose=2, los = mw[5], ffactors=ff
  gravity purpose=3, los = mw[5], ffactors=ff
  gravity purpose=4, los = mw[5], ffactors=ff

; Trip end report
  report margins = 1,2,3,4

endrun
```

```
;-------------------------------------------------------------------
run pgm=matrix

  id = "Truck TLFDs

;  Input files: trips, skims
  mati[1] = trk.trp
  mati[2] = ..\hskim\trkop.skm

; Get trips.
  mw[1] = mi.1.1       ; MTK I/I
  mw[2] = mi.1.2       ; HTK I/I
  mw[3] = mi.1.3       ; MTK Ext
  mw[4] = mi.1.4       ; HTK Ext

; Time.
  mw[5] = mi.2.1

; Total
  mw[6] = mw[1] + mw[2] + mw[3] + mw[4]

; TLF
  frequency basemw=5, valuemw=1, range=0-90-2,
  title='Est Medium Truck I/I Trips vs. Off-Peak Hwy Time'
  frequency basemw=5, valuemw=2, range=0-90-2,
  title='Est Heavy Truck I/I Trips vs. Off-Peak Hwy Time'

  frequency basemw=5, valuemw=3, range=0-150-3,
  title='Est Medium Truck External Trips vs. Off-Peak Hwy Time'
  frequency basemw=5, valuemw=4, range=0-150-3,
  title='Est Heavy Truck External Trips vs. Off-Peak Hwy Time'
  frequency basemw=5, valuemw=6, range=0-90-2,
  title='Initial Est Total Truck Trips vs. Off-Peak Hwy Time'

endrun

;-------------------------------------------------------------------
run pgm=matrix

  id = "Truck time of day + delta

  mati[1] = ..\trk\trk.trp
  mati[2] = ..\trk\trkxx05.trp
  mati[3] = delta.trp

  mato    = tmtrk.trp, mo=11-16, name=AMMTK,PMMTK,OPMTK,AMHTK,
    PMHTK,OPHTK, dec = 6*S

; I/I trips are already balanced, so we can apply a single factor
;  to all trips.  Apply separate P/A and A/P factors to externals.
;  Assume externals are 70/30 inbound (X/I, or A/P) in the morning,
;  70/30 outbound (I/X, P/A) in the evening.  Off-peak is 50/50.
  mw[1] = mi.1.MTKII
  mw[2] = mi.1.MTKEXT           ; P/A (outbound)
  mw[3] = mi.1.MTKEXT.t         ; A/P (inbound)
  mw[4] = mi.1.HTKII
  mw[5] = mi.1.HTKEXT           ; P/A (outbound)
  mw[6] = mi.1.HTKEXT.t         ; A/P (inbound)

; Also add in the X/X's.
  mw[7] = mi.2.1
  mw[8] = mi.2.2
```

```
; Read and transpose the external delta.
  mw[21] = mi.3.mtkii
  mw[22] = mi.3.mtkext
  mw[23] = mi.3.mtkext.t
  mw[24] = mi.3.mtkxx
  mw[25] = mi.3.htkii
  mw[26] = mi.3.htkext
  mw[27] = mi.3.htkext.t
  mw[28] = mi.3.htkxx

; Add in the deltas.  First, for I/I and I/X.
  if (i = 1-@maxint@)
    jloop
      mw[31] = max(mw[1] + mw[21],0)
      mw[32] = max(mw[2] + mw[22],0)

      mw[35] = max(mw[4] + mw[25],0)
      mw[36] = max(mw[5] + mw[26],0)
    endjloop
  endif

  if (i > @maxint@)

; Now for X/I.
    mw[33] = max(mw[3] + mw[23],0), include = 1-@maxint@
    mw[37] = max(mw[6] + mw[27],0), include = 1-@maxint@

; Now for X/X.
    mw[34] = max(mw[7] + mw[24],0), include = @fext@-@maxzone@
    mw[38] = max(mw[8] + mw[28],0), include = @fext@-@maxzone@
  endif

; Use TOD factors derived from MdSHA count data.
;  MTK
  mw[11] = 0.208 * (mw[31] + mw[34] + 0.7 * mw[33] + 0.3 * mw[32])  ; AM
  mw[12] = 0.158 * (mw[31] + mw[34] + 0.3 * mw[33] + 0.7 * mw[32])  ; PM
  mw[13] = 0.634 * (mw[31] + mw[34] + 0.5 * mw[33] + 0.5 * mw[32])  ; OP

;  HTK
  mw[14] = 0.180 * (mw[35] + mw[38] + 0.7 * mw[37] + 0.3 * mw[36])  ; AM
  mw[15] = 0.147 * (mw[35] + mw[38] + 0.3 * mw[37] + 0.7 * mw[36])  ; PM
  mw[16] = 0.673 * (mw[35] + mw[38] + 0.5 * mw[37] + 0.5 * mw[36])  ; OP

endrun
```