

Development of Commercial Vehicle Travel Model

Prepared for

Baltimore Metropolitan Council
Baltimore, Maryland

Prepared by

William G. Allen, Jr., P.E.
Transportation Consultant
Mitchells, Virginia

June 2002

Consultant Report C02-9

Executive Summary

This report documents the development of a new set Commercial trip forecasting model for the Baltimore Metropolitan Council (BMC). BMC, along with many other agencies, has included trucks in its regional modelling for many years. However, it has not specifically included a fairly important category of non-personal travel that uses passenger cars, light trucks, and other vehicles not included in the "Truck" model. BMC recently retained a consultant to develop a new set of Medium and Heavy Truck trip models. As part of this effort, a completely new Commercial trip model has also been developed.

The principal challenge in estimating Commercial trips is to define them and obtain any kind of data on observed trip patterns. Traditional surveys are unlikely to be useful, so the consultant and staff devised an innovative way to estimate Commercial vehicle counts at those locations where Maryland DOT classification count data already existed.

The consultant has refined the practical application of a methodology to synthesize a trip table from count data. Working "backwards" from the count data, the consultant not only created such a trip table, but then used it to develop a Commercial trip forecasting model that would produce link-level volumes with reasonable accuracy.

BMC staff conducted new manual counts at a representative sample of locations throughout the region. They used this to create a database of various link characteristics. The consultant used this database to calibrate a "count model", which was then applied to synthesize daily Commercial counts at the 550+ classification count locations for 2000.

A Commercial model from the Lehigh Valley (PA) was adapted as a starting point. The consultant then applied a procedure called "adaptable assignment" to systematically adjust the interim model so as to better match the counts. This process resulted in a number of changes to the interim model and also produced a calibration adjustment table. This adjustment table is then multiplied by the output of the model, producing a new table whose assignment comes much closer to matching the count data.

The result is a process that both exhibits reasonable sensitivities to the key input variables (employment by type and households) and has been shown to match the synthesized counts to a fairly high degree of accuracy. A 2025 forecast was made with this new process and the results found to be reasonable. The consultant has also provided the staff with a set of TP+ setups with which to apply the new model.

Table of Contents

	<u>Page</u>
1 Introduction	1
2 Count Model	3
3 Interim Model	10
4 First Adaptable Runs	19
5 Final Adaptable Run	22
6 Forecasting	30
7 Final Model	34
References	43
Appendix A - Count Model Results	44
Appendix B - 2000 Through Commercial Trips	47

List of Tables

	<u>Page</u>
1 Count Model Evaluation.....	4
2 Detailed Logit Commercial Count Model.....	5
3 Final Count Model Results	6
4 TP+ Setup to Apply Count Model.....	8
5 Truck Zones	11
6 Interim Generation Model	12
7 Interim External Commercial Model	13
8 Commercial External Shares by Road Type.....	14
9 Configuration of Commercial Trip End File	14
10 2000 External Commercial Trip Ends.....	15
11 Revised Interim Generation Model.....	21
12 Final Delta Trip Table.....	23
13 Starting and Final Trip Lengths.....	26
14 Assignment Report	28
15 2025 Forecast Summary	30
16 2000 and 2025 Trip Tables.....	31
17 Recommended Commercial Time of Day Factors.....	34
18 Final Commercial Trip F Factors	36

List of Figures

	<u>Page</u>
1 Interim External Commercial Model	13
2 Interim Commercial F Factors.....	17
3 TP+ Setups	37

1 Introduction

This report documents the development of a new Commercial trip forecasting model for the Baltimore Metropolitan Council (BMC). In recent years, BMC has been updating various parts of its regional travel forecasting model. Because of a new emphasis on planning for goods movement, BMC wanted to update its old (1960's based) Truck models. At the same time, the staff saw a need to include a type of trip that was heretofore not specifically estimated by its travel demand model.

"Commercial" trips, as the term is used here, refers to those trips that are mainly business-oriented and are not personal transportation, but do not involve a Medium or Heavy Truck. Truck trips are defined based on the Federal Highway Administration's (FHWA) "F-13" classification scheme. "Heavy" trucks are defined as vehicles with three or more axles (F6 - F13 in the FHWA scheme). "Medium" trucks are vehicles with two axles and six tires (FHWA's F5). The Commercial category includes a wide range of light trucks: pickups, vans, minivans, and sport-utility vehicles (SUVs), as well as passenger cars that are used for business purposes. Light trucks, vans, and SUVs used for personal transportation are not included here.

This is a new category of trip that has not been commonly recognized in regional travel demand models but which is currently becoming the focus of attention in several urban areas. It includes package delivery vehicles, postal vehicles, couriers, equipment repair and service technicians, craftsmen (carpenters, plumbers, etc.), government workers, taxis, and many other types of light-duty vehicles. Planners are beginning to realize that business-related travel is very poorly identified in home-interview surveys. In fact, the extreme difficulty in identifying such trips and surveying their travel patterns has doubtless kept many planners from including these trips in the modelling process. (In some other urban areas, the Commercial category includes Medium Trucks, making this an even more important group. Since the BMC model already estimates Medium Trucks separately, Commercial trips are defined differently than elsewhere. This means that they are a somewhat smaller, although still important, group.)

Simple observation of the traffic stream on any roadway will reveal the basic fact that Commercial trips represent a category of travel that is too large to ignore. Exclusion of these trips will result in either underestimating traffic volumes, or (perhaps worse) implicitly incorporating their volume within some other category, most likely non-home-based travel. Since Commercial trips obviously have different

travel characteristics than most personal travel, accounting for these trips in a separate category will improve the accuracy of the model.

As noted above, the major hindrance to modelling Commercial trips is the difficulty in surveying them. Since much of this category consists of delivery people and others who spend much of their workday either outdoors or in their vehicle, capturing their travel pattern data is a particular challenge. A workplace survey might identify some of these trips, but the consultant believes that a comprehensive Commercial trip survey is probably not feasible. Thus, an alternative method has been developed to estimate the model parameters.

This method relies on a procedure that works “backwards” to develop a trip table from count data. There are many such procedures available; the consultant has developed a relatively simple one called “adaptable assignment”. This procedure assigns a starting trip table, systematically compares the resulting assigned link volumes to the counts, and adjusts the trips so as to produce a closer match between assigned volumes and counts. The starting trip table is usually based on a model borrowed from another urban area. Adaptable assignment produces a set of trip table adjustments. Examination of these adjustments can identify areas in which the starting model can be improved and the process re-applied.

In the end, the Commercial model will consist of a trip generation and distribution model, external and X/X table procedures, and a calibration adjustment table that is carried into the forecasting phase.

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

- 2 Count Model
- 3 Interim Model
- 4 First Adaptable Runs
- 5 Final Adaptable Run
- 6 Forecasting
- 7 Final Model

In addition, the reader is referred to a separate report describing the development of a new BMC model for Truck trips. These include Medium and Heavy Trucks, which are not included under the BMC definition of Commercial trips. However, the Truck models were developed at the same time as the new Commercial model, so as to ensure that there is no overlap or gap in the definition of the various types of business-related trips. The reader is strongly encouraged to refer to that Truck report, as many of the same parameters and techniques used there have also been used to create the Commercial trip model.

2 Count Model

Count Data

The basic methodology of this study relies on developing a trip table from counts. The main problem is that counts of Commercial traffic are not commonly available. Worse, it is difficult to obtain such counts due to the difficulty in defining just what is a Commercial vehicle, in a manner that is suitable for traffic counting.

The consultant developed a procedure that leverages the relatively large database of classification counts conducted by the Maryland Department of Transportation (MDOT). These counts identify the daily volume on a roadway link, stratified by the 13 FHWA categories based on the size and type of vehicle. These counts were available at approximately 550 locations throughout the BMC modelled area for 2000.

For this project, BMC staff conducted new counts of Commercial traffic at 113 of those 550 locations. The consultant and staff agreed that the best way to define "Commercial" for the purposes of these counts was that a Commercial vehicle is any vehicle that displays any text, logo, or trademark, or that is transporting equipment of an obviously commercial nature. This definition was coordinated with the FHWA commercial vehicle category descriptions so as to avoid duplication with the Medium and Heavy Truck categories.

The counts were conducted during January-April 2002, at a variety of locations around the BMC modelled area. Staff attempted to achieve a representative sample of links stratified by functional class group (freeway, arterial, collector) and area type (CBD, urban, suburban, rural). Counts were conducted for 30 minutes at a time, between 10 AM and 3 PM. Test counts indicated that 30 minutes' worth of this kind of data is, in general, sufficiently representative of a typical weekday's activity.

The BMC staff's data resulted in 113 observations of the total Commercial traffic volume. In addition, a total vehicle count was made at the same time. This permits the calculation of a "percent Commercial" value on each link. Additional data for each link was assembled from the MDOT classification data and the year 2000 coded network. This included the daily counts for vehicle types F1 - F13, as well as the jurisdiction, speed class, capacity class, functional type, area type, number of lanes, year 2000 weekday count, and whether the road is one- or two-way.

Model

The premise of this analysis was that it should be possible to use this data to develop a model of the percent Commercial traffic. For each

observation, the dependent variable is the percent Commercial traffic and the independent variables are as described above. If a model could be developed to estimate the percent Commercial, it could then be applied to the approximately 550 classification count links. This would produce a count database that could be used in the adaptable assignment process.

The consultant developed three different types of models:

- 1) basic logit
- 2) cross-classification table
- 3) detailed logit

Since the dependent variable is a fraction (0.0 to 1.0), the logit structure is well-suited for this purpose. The cross-classification table was considered as a simpler alternative, in the event the logit model proved unworkable. The logit function is $p = 1/(1+e^U)$, where p is the probability to be estimated (in this case, the percent Commercial) and U is the "utility" of Commercial traffic, expressed as a linear function of the available independent variables, plus a constant term ("bias coefficient"). The "basic" logit uses a single bias coefficient, while the "detailed" logit uses separate bias coefficients for each jurisdiction and for each facility type/area type combination. Although logit models are most commonly developed using discrete choice data, it is possible to estimate coefficients using aggregate data such as in this case.

The results for the best model of each of these three types are shown in Table 1.

Table 1
Count Model Evaluation

Statistic	Model Type		
	Simple Logit	Cross-Classification	Detailed Logit
Percent RMSE	185%	28%	25%
R ²	.05	.28	.43
Rho ² w/r/t zero	0.4552	N/A	0.5935
Rho ² w/r/t constant	0.1800	N/A	0.0066
Percent overestimated	48%	53%	50%
Total error	15%	2%	0%

Percent RMSE = square root of the mean squared error/sum of the observed COM volume

R² = square of the correlation coefficient, estimated vs. observed

Rho² w/r/t zero = fraction of base likelihood explained by model, compared to a model with zero coefficients (for logit models only)

Rho² w/r/t constant = fraction of base likelihood explained by model, compared to a model with only constant terms (for logit models only)

Percent overestimated = percent of cases where error > 0

Total error = (estimated total COM volume/observed total COM volume) - 1

As this table shows, the simple logit model did not do a very good job explaining the variation in the data. The cross-classification model performed much better. The detailed logit model performed slightly better than the cross-classification model, at the cost of somewhat greater complexity. The consultant believes that this is an acceptable trade-off in this particular case. Table 2 shows the detailed logit model.

Table 2
Detailed Logit Commercial Count Model

$$\text{Percent Commercial} = 1/(1 + e^U)$$

$$U = c_{\text{Jur}} + c_{\text{FD}} + 0.0042 * \text{CAPCLASS} - 0.0058 * \text{SPDCLASS} - 0.0111 * \text{LANES} - 0.0472 * p_{\text{Bus}} + 0.0004 * F1 - 0.00015 * F7 + 0.0005 * F11 - 0.0005 * F12$$

where:

CAPCLASS = network capacity class

SPDCLASS = network speed class

LANES = number of lanes (each way)

pBus = percent of traffic count that is buses

F1 = classification count (motorcycle), both directions

F7 = classification count (4 axle, single unit truck), both directions

F11 = classification count (5 axle, multiple unit truck), both directions

F12 = classification count (6 axle, multiple unit truck), both directions

cJur = bias coefficient by jurisdiction

Jurisdiction	
Baltimore City	-0.32
Anne Arundel Co	-0.02
Baltimore Co	0.15
Carroll Co	0.06
Harford Co	-0.06
Howard Co	-0.01
Washington area	0.00

cFD = bias coefficient by facility group and density code

Facility Group*	Density Code			
	Rural	Suburban	Urban	City Ctr.
Freeway	2.62	2.62	2.68	2.30
Arterial	2.52	2.62	2.68	2.43
Collector	2.41	2.65	2.71	2.19

* Freeway = FT 1, 2, 12

Arterial = FT 3

Collector = FT 4-11, 14

According to the utility equation (U) in Table 2, the percent Commercial increases as:

- the capacity class decreases
- the speed class increases
- the number of lanes increases
- the percent bus increases
- the daily F1 or F11 count decreases
- the daily F7 or F12 count increases

The city center tends to have a higher Commercial share, while Rural and Suburban areas have lower shares. Freeways have a slightly lower share than other roadway types. It makes sense that Commercial traffic is higher on downtown arterial and collector streets, since much of this traffic is probably relatively short trips between business establishments.

Table 3 presents the estimated and observed Commercial count shares by various stratifications. The overall observed Commercial share of 7.7% was matched exactly by the model. The 113 individual link values are shown in Appendix A.

Table 3
Final Count Model Results

Jurisdiction	Commercial Share	
	Obs	Est
Baltimore City	10.5%	10.8%
Anne Arundel Co	8.0	7.9
Baltimore Co	6.6	6.2
Carroll Co	8.2	7.9
Harford Co	6.5	7.5
Howard Co	6.6	7.1

Facility Group	Commercial Share Density Code							
	Rural		Suburban		Urban		City Center	
	Obs	Est	Obs	Est	Obs	Est	Obs	Est
Freeway	6.9	7.2	6.6	6.3				
Arterial	7.9	8.4	8.0	7.8	9.0	9.6	11.1	11.7
Collector	8.4	8.5	7.5	7.3			14.6	14.4

Application

The consultant wrote a TP+ setup file (see Table 4) to apply this model to the version of the 2000 highway network containing all of the classification count data. The model produced a count in the COMCNT00 field for 1,161 directional links, with a total count of 2,002,813. Interestingly, by coincidence, this is very close to the total of the Medium and Heavy Truck counts in the same network (2,083,409, excluding buses). The range of estimates for percent Commercial by link was 3.7% - 14.2%.

Once the percent Commercial is calculated, it is multiplied by the total weekday counted volume to obtain the (weekday) Commercial count.

The consultant reviewed the resulting estimated counts and discovered that in a few cases, the values on adjacent links were somewhat inconsistent. In these cases, the estimated count was removed. This is necessary because inconsistent counts have the potential to disrupt the adaptable assignment process.

Table 4
TP+ Setup to Apply Count Model

```
run pgm=hwyntet

; BMC Regional Model
; Apply Commercial model to estimate Commercial volume counts
; commdl.job

id = "Estimate Commercial link counts, 2000

neti = sp0020.net
neto = sp0020c.net

; Lookup tables for bias constants. First set are based on
; Jurisdiction.
lookup interpolate = n, fail = 0,0,0, name = biasjur,
  lookup[1] = 1, result = 2,
  r = ` 1 -0.32',
      ` 2 -0.02',
      ` 3 0.15',
      ` 4 0.06',
      ` 5 -0.06',
      ` 6 -0.01',
      ` 7 0.00',
      ` 8 0.00',
      ` 9 0.00',
      `10 0.00',
      `11 0.00'

; Second set are based on FC Group and Link Density codes.
lookup interpolate = n, fail = 0,0,0, name = biasfgld,
  lookup[1] = 1, result = 2,
  r = `11 2.62',
      `12 2.62',
      `13 2.68',
      `14 2.30',
      `21 2.52',
      `22 2.62',
      `23 2.68',
      `24 2.43',
      `31 2.41',
      `32 2.65',
      `33 2.71',
      `34 2.19'

; Table to convert network FT (Functional Type) into Functional
; Group.
lookup interpolate = n, fail = 1,1,1, name = ft2fg,
  lookup[1] = 1, result = 2,
  r = ` 1 1',
      ` 2 1',
      ` 3 2',
      ` 4 3',
      ` 5 3',
      ` 6 3',
      ` 7 3',
      ` 8 3',
      ` 9 3',
      `10 3',
      `11 3',
      `12 1',
      `14 3'

; If there's no weekday count, assume this means there's no
; other classification count data. Can't estimate a Commercial
; count for this link, so skip it.
if (CNTWKD00 = 0) break
```

Table 4 (continued)

```
; Look up the bias constant based on JUR.
_cJur = biasjur(1,JUR)

; Look up the FGroup based on FT.
_fg = ft2fg(1,FT)

; Use FGroup and Density codes to construct a new index.
_ind = _fg*10 + LINKDC

; Use that new index to look up the FGroup/Link Density bias constant.
_cFD = biasfgld(1,_ind)

; Compute the percent bus.
_pbus = (HTBUSCNT00 - HTCNT00)/CNTWKD00

; COM utile for the logit model.
_u = _cJur + _cFD + 0.0042*CAPCLASS - 0.0058*SPDCLASS - 0.0111*LANES -
    0.0472*_pbus + 0.0004*F1 - 0.00015*F7 + 0.0005*F11 - 0.0005*F12

; Percent COM.
_p = 1/(1+exp(_u))

; COM link volume (estimated count -- this variable already existed
; in the network, but was previously empty)
COMCNT00 = round(_p * CNTWKD00)

print form=12.4, list=a(6),b(6),_cJur(6.2),_fg(3),_ind(4),_cFD(6.2),
    _pbus,_u,_p,COMCNT00(6)

endrun
```

3 Interim Model

Approach

As noted above, a key aspect of this modelling approach is the development of a starting, or interim, model of Commercial trips. The consultant believes this can best be developed by borrowing a generation model from another urban area and adapting the new BMC Medium Truck distribution model's F factors so as to produce a fairly short average trip length. Although the true average Commercial trip length is unknown, it is very likely similar to the 17.5 minutes for I/I Medium Trucks.

Interim Model

The consultant's experience with adaptable assignment has shown that the better the starting trip table, the better the final results. There are only a few other Commercial trip models in existence that use a definition of Commercial trips that is compatible with BMC's. One is a model that the consultant recently developed for the Lehigh Valley in Pennsylvania. This was used as the starting point for the new BMC model.

Truck Zones

The interim model accounts for zones in which there is strong reason to believe that the commercial 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 interim model to account for them. Although no data are available to specifically determine the increase in commercial trips for such areas, a reasonable estimate can be made and confirmed in the adaptable assignment process.

Six types of facilities have been identified. In most cases, there is only one such facility in each zone. When there are more than one, the zone is classified according to the most important facility. In addition to the six types, this classification scheme divides the facilities according to their relative scale: smaller vs. larger. BMC staff have determined that the level of 300 truck trips per day should generally be used to distinguish smaller from larger facilities. This results in 12 possible categories. Each "truck zone" is classified into one of these categories.

Although these classifications are rather general and simplistic, the consultant believes that this is a reasonable trade-off against the need to maintain and forecast this data item. Table 5 lists the classifications and

the zones that BMC staff have classified for 2000. The six truck zone types are defined below:

- Business District: core area of central business districts, major retail areas (shopping malls), college campuses
- Warehouse/Manufacturing: warehousing, manufacturing, and processing facilities, industrial parks
- Intermodal Transfer: facilities where freight transfers between trucks and another mode - mainly the port areas
- Airport: BWI (a special category)
- Institutional/Other: landfills, quarries
- Delivery/Medium Truck: facilities that process mail or express delivery packages

Although these truck zones were developed originally for the Medium and Heavy Truck trip models and relates more specifically to truck trips, the consultant believes that this information might be of use for the Commercial model as well.

Table 5
Truck Zones

Type	Scale	
	Larger	Smaller
Business District	116-121,124,125,139,140,161,1015-1020,1026,1027,1038	63,258,342,346,347,368,429,461,462,473,484,529,530,536,541,610,611,630,653,755,759,762,793,828,829,955,973,975,1053,1054,1056,1059,1081,1097,1138,1202,1203,1273,1274
Warehouse/Mfgr.	167,413,725,881,1009,1145,1197,1249,1265	180,184,658,734,746,750,767,869,872,994,995,1013,1144,1192,1205,1258
Intermodal Transfer	168,177,178,195,207,709,1010	94
Airport	224	N/A
Institutional/Other	206,265,464,841	190,314,319,463,570,768,769,770,900,910,915,1096,1269,1270
Delivery/Medium Truck	(none identified)	1034,1098,1146,1148

Generation

The recommended interim Commercial vehicle trip generation model is shown in Table 6. This is the Lehigh Valley model, adjusted to use the new BMC categories of employment by zone. This interim model has been applied to BMC's year 2000 zonal socioeconomic data. The consultant has developed initial factors that increase the estimated Commercial trips for the truck zones, by type.

Table 6
Interim Generation Model

$$\text{COM} = 0.454 * \text{INDEMP} + 0.501 * \text{RETEMP} + 0.454 * \text{OFFEMP} + 0.146 * \text{HH}$$

INDEMP is Industrial Employment
RETEMP is Retail Employment
OFFEMP is Office Employment
HH is Households

Factor for truck zone type:

Type	Scale	
	Larger	Smaller
Business District	2.0	1.5
Warehouse/Mfgr.	1.2	1.1
Intermodal Transfer	1.2	1.1
Airport	3.0	N/A
Institutional/Other	1.2	1.1
Delivery/Medium Truck	4.0	2.0

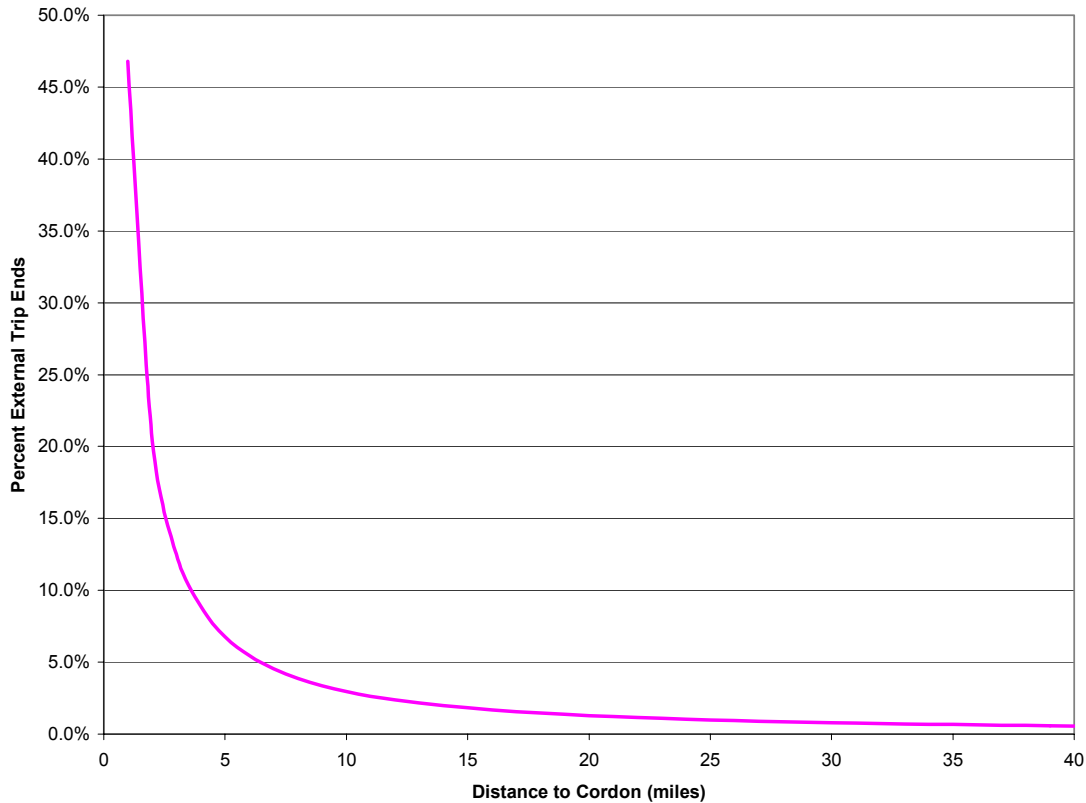
As applied to BMC's new 2000 zonal data, this model estimates 910,000 daily Commercial vehicle trips. Of these, about 828,000 are I/I and 82,000 are external. These trip rates and the truck zone factors constitute the interim model, that serves as the starting point for the adaptable assignment process. All of the coefficients and factors in Table 6 are subject to being modified as a result of subsequent analyses.

External Model

The consultant proposes a new procedure for estimating external Commercial trips. This is identical to the new procedure the consultant has used for estimating external Medium and Heavy Truck trips. This method assumes that the generation model estimates total trip ends, both I/I and external (which includes I/X and X/I). The external share of the total trip ends is then modelled as a function of the zone's distance to the model's cordon, along the highway network. Zones that are closer to the edge of the modelled region will generally have a higher share of external trips than other zones.

In addition, the external trip ends at the internal zones that are calculated in this manner are balanced to match the total external trip ends at the external stations. In this way, the external trip volumes at the cordon are conserved and are assumed to be the "correct" volumes.

Figure 1
Interim External Commercial Model



The proposed external share model is shown in Figure 1 and Table 7. This calculation is performed for each internal zone. This is very similar to the external share model developed for the Medium Truck model.

Table 7
Interim External Commercial Model

$$\text{Percent External} = 0.468 * D^{-1.2}$$

Where D = distance to nearest external station (via highway net), miles

At the external stations, the consultant split the Commercial trips into external vs. through. This analysis was based on 2000 total weekday volumes posted on the network and a preliminary 2000 total through trip table provided by BMC. The consultant first calculated the percentage of total through-trips by station. As with Medium Trucks, it is estimated that Commercial trips are less likely to make through-trips than the general stream of traffic.

In addition, the through-trip percentage (through-trips/total trips at cordon) logically varies by facility type. Freeways have by far the largest through-trip percentage, because they are the major routes through the region. However, local roads typically have few, if any, through-trips. Based on the relationships and assumptions described above, the consultant developed a look-up table to estimate the external trip share (= 100% - through-trip share) for each station, as shown in Table 8. These are the same as the Medium Truck values used in the new Truck model.

Table 8
Commercial External Shares by Road Type

Road Type	COM External %	Description
1	87%	Freeway
2	92%	Multilane divided
3	92%	center turn lane
4	98%	undivided
5	98%	urb/sub arterial
6	100%	rural hwy
7	100%	substandard
8	100%	Local
9	100%	ramp 1
10	100%	ramp 2
11	100%	ramp 3
12	100%	ramp 4
13	100%	ramp 5
14	100%	cent connector

Applying this table to the Commercial trip volumes at the external stations produces the estimated external trip ends as shown in Table 10. The internal and external trip ends are configured as shown in Table 9.

Table 9
Configuration of Commercial Trip End File

Zone	I/I Prod	I/I Attr	Ext Prod	Ext Attr
1	A	A	D	O
...	B	B	E	O
1284	C	C	F	O
1285	O	O	O	G
...	O	O	O	H
1326	O	O	O	I

Note: Letters represent non-zero values.

Table 10
2000 External Commercial Trip Ends

TAZ	Road	COM Ext Vol
1285	MD 2	794
1286	MD 4	2,278
1287	MD 381	412
1288	MD 5/US 301	5,462
1289	MD 210	1,848
1290	I-495/I-95	11,460
1291	I-395/US 1	13,334
1292	Arl. Mem Bridge	4,496
1293	I-66	5,718
1294	Key Bridge	3,600
1295	Chain Bridge	1,374
1296	I-495	14,774
1297	US 15	1,022
1298	MD 478/MD 79	412
1299	US 340	1,004
1300	US 40 Alt.	584
1301	I-70	3,628
1302	US 40	286
1303	MD 17/MD 77	188
1304	MD 550	136
1305	MD 140	670
1306	US 15/US 15 Bus	954
1307	Harney Rd	94
1308	MD 194	334
1309	MD 97	618
1310	Old Hanover Rd	202
1311	MD 30	834
1312	MD 86	224
1313	Middletown Rd	234
1314	MD 45	710
1315	I-83	1,286
1316	MD 23	190
1317	MD 24	70
1318	MD 624	260
1319	MD 165	504
1320	Old Pylesville Rd	104
1321	MD 646	22
1322	MD 623	76
1323	US 1	644
1324	I-95	4,152
1325	US 40	1,578
1326	US 50/US 301	3,902
Total		90,472

Distribution

Creating a reasonable interim Commercial distribution model is problematic. Due to the different sizes of network and modelled area, and other differences, it is not feasible to transfer the Lehigh Valley Commercial distribution model. The consultant believes, however, that Commercial trips are similar enough to Medium Truck trips that it should be feasible to transfer the new BMC Medium Truck F factors for use with the Commercial model. The consultant expected that this would produce an average trip length that is similar to, but slightly shorter than, that of Medium Truck trips, and that this would be appropriate.

The new Medium Truck model uses a gamma function to define its F factors. The gamma function has become a popular way to define F factors in many areas, because it has the proper shape and is easy to calibrate. This function was adopted for use in this model. Its equation is as follows:

$$F = \alpha * t^{\beta} * e^{(\gamma t)}$$

where:

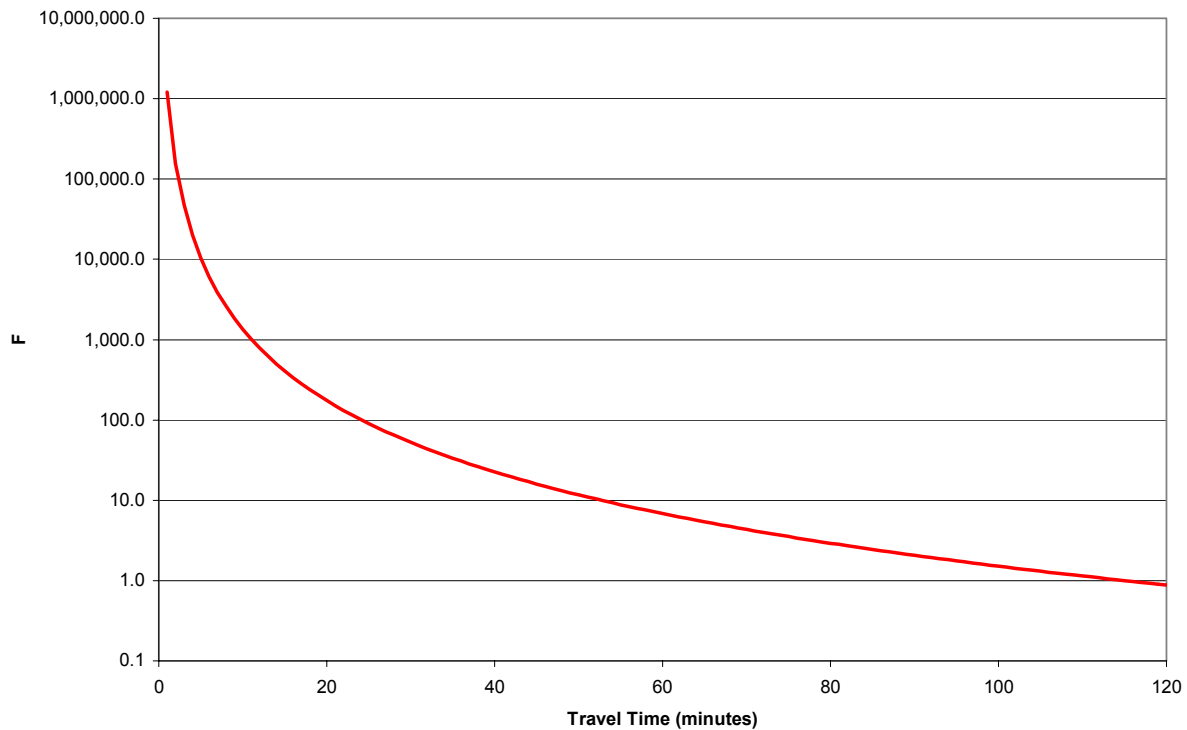
t = travel time, minutes

α , β , γ = calibrated coefficients

The Medium Truck coefficients of exp(14) for α , -2.95 for β , and 0.0 for γ were used. (The gamma value of zero effectively converts this into an exponential model.) The same F factors were applied to I/I and external trips and then the resulting tables were summed to determine the overall average trip length. F factors were computed for travel times from 1 to 120 minutes. Figure 2 shows the resulting F factor curve. The interim estimated trip length is 16.2 min, which is 7% lower than the Medium Truck value of 17.4 min. This seemed reasonable.

For through (X/X) trips, the consultant started by examining the 2000 total X/X daily vehicle trip table provided by BMC. This was found to be inadequate for describing Commercial X/X movements. Instead, the consultant examined the external station locations where X/X Commercial trips should be expected. Then, by inspecting the external station geography and making assumptions about likely X/X patterns, the consultant developed an "X/X pattern file". This was used to create a seed matrix, which was then Fratared to match the estimated number of daily X/X Commercial trip ends at each station. The resulting tables were assigned to the network and the loading patterns examined to confirm that they represent a reasonable set of X/X volume patterns on the roadways. The final X/X 2000 daily Commercial total is 4,229. This volume is not significant in the context of the entire model, but it becomes

Figure 2
Interim Commercial F Factors



somewhat more important for analyses that focus on the major through roadways in the region. The through-trip table is shown in Appendix B.

Assignment

In the case of the new Truck models, the consultant proposed a revised assignment methodology that both prohibits trucks from using certain roadways and temporarily multiplies their volumes for the purpose of calculating the V/C ratio, to account for their impact on traffic flow. However, no such conditions are assumed to apply to Commercial trips, so no specific changes to the assignment process are necessary in this case.

BMC performs traffic assignments for five time periods of the day: night, AM peak, midday, PM peak, and evening. This is helpful in modelling system features that vary by time of day (such as HOV operation and reversible roadways) and generally leads to the development of more accurate peak period or peak hour volumes. However, prior BMC analysis has shown that on a regional basis, the difference between a standard daily assignment's volumes and the sum of

the five period volumes is not large. Thus, for the purposes of the interim Commercial model, only a daily assignment procedure is used. For the final model, new time of day factors are developed.

Validation

The interim model described above was applied to year 2000 conditions, using the 1998 zone structure. This included newly developed external station commercial volumes and the newly created split of employment by four types: retail, industrial, office, and other as shown in Appendix A. The resulting daily assigned Commercial volumes were compared to the synthesized counts posted in the network.

The total error was +8.7% and the percent root-mean-square error (%RMSE) was 70%. These figures represent a slightly worse-than-average degree of accuracy, although they are better than the interim Truck models at this same stage. In any case, it was clear that this could be improved upon.

This completes the development of the interim Commercial model. This model is then applied for 2000 to develop the trip tables to be used as the starting point for the adaptable assignment process. This is described in the next chapter.

4 First Adaptable Runs

Approach

As noted above, the premise of adaptable assignment is that it is possible to systematically compare the traffic counts to the assigned volumes and then use that comparison to adjust the starting trip table for each O/D pair. The resulting O/D volumes will produce assignments that more closely match the counts. However, it is entirely possible that the adjustment for some O/D pairs will counteract the adjustment for other O/D pairs. Thus, the process must be iterated several times until a balance has been achieved and little additional assignment accuracy can be expected. The details of this process are described in reference 1.

Having applied the adaptable assignment procedure to several different models, the consultant has discovered that its use is not a deterministic process. In particular, the appropriate number of iterations must be ascertained by trial and error. Typically, the iterations are increased until the improvement in accuracy between iterations is very small and the trip table changes stabilize.

In addition, the output trip table must be examined carefully to determine how it differs from the input trip table. If these differences can be understood, it should be possible to use them to develop adjustments to the starting model, so that its estimates will better reflect the count data.

The consultant ran various tests of the adaptable assignment process to determine suitable values for its various parameters and options. The best results were achieved by using 10 iterations. The adapted trip table is fratered after the 5th and 10th iterations, so that the external station totals will match the counts. Links in the Baltimore region are given a higher priority than Washington area links, so as to try to match those counts more closely.

Feedback

As noted above, the adaptable assignment process produces a new trip table. The difference between this table and the starting trip table is called the "delta table". In effect, the delta table is an O/D matrix of calibration adjustments that, when added to the starting trip table, produce a table that matches the counts fairly closely. Analysis of this delta table can provide clues as to how to modify the interim model, so as to make it more accurate.

Specifically, the consultant examined the trip end summary of this delta table. This was then compared to the land use data to see if there

was a systematic employment- or household-based adjustment that would improve the model. None was found.

Next, the consultant cross-tabulated the delta trip ends and the starting (interim model) trip ends by various factors, including truck zone type, jurisdiction, and density code. This analysis was more fruitful and strongly indicated a number of modifications to the truck zone factors. In addition, it suggested a need for jurisdiction- and density code-based adjustment factors.

After several iterations of this analysis, the consultant arrived at some adjustments to the interim trip generation model to make it more suitable. The revised interim model is shown in Table 11.

This revised model incorporates adjustment factors based on the density code and jurisdiction of the zone. In general, these adjustments reduce the number of trips in the city center areas. This is logical -- since those areas have many more employees, it would make sense that the Commercial trip rate per employee might be less there. However, the Washington area is seen to have a lower Commercial rate than the Baltimore area counties (except for Prince George's County). No explanation can be found for this outcome. It may be related to a similar finding from the Heavy Truck model, or it may be simply because there are fewer counts in the Washington portion of the BMC network.

In addition, this analysis indicated that the initially assumed truck zone factors shown in Table 5 were too high. The revised factors, shown in Table 11, suggest that only in the larger Business District and Delivery/Medium Truck zones are the Commercial trips per employee higher than elsewhere. In both those cases, the factors for the "Larger" zones exceed those for the "Smaller" zones, which is logical.

The revised interim model estimates 1,124,000 total Commercial trips (1,038,000 I/I, 82,000 external, 4,000 X/X). The assignment statistics for the revised interim model are: total error of +21.3% and %RMSE of 80%. Oddly, these results are worse than for the original interim model. As part of the model development, the consultant discovered that the final results were improved if the interim model overestimated the counts.

Table 11
 Revised Interim Generation Model

$$\text{COM} = 0.80 * (0.454 * \text{INDEMP} + 0.501 * \text{RETEMP} + 0.454 * \text{OFFEMP} + 0.146 * \text{HH})$$

Factor for truck zone type:

Type	Scale	
	Larger	Smaller
Business District	1.2	1.0
Warehouse/Mfgr.	1.0	1.0
Intermodal Transfer	1.0	1.0
Airport	1.0	N/A
Institutional/Other	1.0	1.0
Delivery/Medium	3.0	2.5
Truck		

Factor for density code:

Type	COM
Rural	0.8
Suburban	1.0
Urban	1.5
City Center	0.7

Factor for jurisdiction:

Type	COM
Baltimore City	1.0
Anne Arundel	1.5
Baltimore County	1.2
Carroll	1.7
Harford	2.1
Howard	1.2
D.C.	0.5
Montgomery	0.7
Prince George's	1.2
Frederick	0.6

5 Final Adaptable Run

Although adaptable assignment helped identify a number of changes that make the interim model more accurate, the resulting accuracy is still not as good as one would like to see. One must recognize the limitations of all relatively simplistic regional travel models, which use fairly basic, available zone-level variables. It is the consultant's experience that *no* travel forecasting model can replicate the millions of individual decisions that take place each day, so as to estimate link-level volumes that match the counts with a very high degree of accuracy. Traffic counts may be somewhat consistent from day to day, but they do include a certain degree of randomness that cannot be reproduced perfectly by a travel model that is limited to relatively simple inputs and relatively simple relationships. However, that observation does not invalidate the use of this model, or any regional travel model, for planning purposes.

As described in Chapter 4, adaptable assignment can be used to "inform" a model, to make it more accurate with respect to the counts. However, no matter how accurate the starting model becomes, the adaptable process will always create a non-zero delta table. This final delta table represents a set of calibration adjustments that are necessary in order to match the counts with a higher degree of accuracy.

This adjustment table then becomes an integral part of the model. It is always added to the model output, to become the "final" trip table for assignment purposes. The consultant believes that this method of assignment calibration is superior to most other techniques and produces results that are not only more accurate in the base year, but more credible in the forecast years.

Table 12 presents the final delta trip table. The total delta is 55,077 trips. The most desirable characteristic of a delta trip table is that it is small, relative to the starting table. The total delta is 5% of the starting trip table, which is a very acceptable value. Another desirable feature is that the relative delta should be more or less consistent across the region. In this case, the relative delta is a little high in Baltimore City and Carroll County. No explanation could be found for this.

The fact that the external stations have a net delta of zero is not a coincidence. The Fratar step referred to earlier ensures that this will be the case.

Table 12
 Final Delta Trip Table

Date: 6/30/02
 Time: 15:23

Baltimore Metropolitan Council Travel Model
 2000 Daily Trip Calibration Adjustment Table
 Commercial Vehicles

		Destination District								
		1	2	3	4	5	6	7	8	Total
Origin District	1 BaltCity	20000	-3516	3481	-326	-728	-2367	-2590	-408	13546
	2 AnnArndl	-4112	16392	-2273	-241	-278	-1948	-3686	-242	3612
	3 BaltmrCo	4273	-1261	9892	-827	-65	-663	-2136	15	9228
	4 Carroll	-253	-269	-849	4083	-48	-70	201	426	3221
	5 Harford	-825	-313	-119	-89	3540	-164	-479	265	1816
	6 Howard	-2269	-839	-762	15	-157	8949	-1114	-75	3748
	7 DC Area	-2420	-2643	-2174	354	-420	-1594	28146	596	19845
	8 External	-369	-251	74	551	350	-87	546	-753	61
Total		14025	7300	7270	3520	2194	2056	18888	-176	55077

Date: 6/30/02
 Time: 15:23

Baltimore Metropolitan Council Travel Model
 2000 Daily Original Trip Table
 Commercial Vehicles

Destination District

		1	2	3	4	5	6	7	8	Total
O	1 BaltCity	95762	9949	27812	1016	2133	4152	4735	1080	146639
r	2 AnnArndl	9948	96228	7736	696	857	7703	12839	2177	138184
i	3 BaltmrCo	27828	7726	123778	2764	5140	4956	4741	1700	178633
g	4 Carroll	1016	695	2768	24302	281	1087	1823	824	32796
i	5 Harford	2129	870	5133	289	54733	409	997	2569	67129
n	6 Howard	4149	7706	4963	1089	411	33913	8160	472	60863
	7 DC Area	4733	12834	4754	1818	989	8154	389306	32199	454787
D	8 External	1070	2173	1694	828	2573	475	32209	4229	45251
	Total	146635		178638		67117		454810		1124282
			138181		32802		60849		45250	

Date: 6/30/02
 Time: 15:23

Baltimore Metropolitan Council Travel Model
 2000 Daily Delta/Original Trip Ratio
 Commercial Vehicles

		Destination District								
		1	2	3	4	5	6	7	8	Total
O	1 BaltCity	.21	-.34	.13	-.31	-.33	-.56	-.54	-.37	.09
r	2 AnnArndl	-.40	.17	-.28	-.34	-.31	-.24	-.28	-.10	.03
i	3 BaltmrCo	.15	-.15	.08	-.29	.00	-.12	-.44	.01	.05
g	4 Carroll	-.24	-.38	-.30	.17	-.16	-.05	.11	.52	.10
i	5 Harford	-.38	-.35	-.01	-.30	.06	-.39	-.47	.10	.03
n	6 Howard	-.54	-.10	-.14	.01	-.37	.26	-.13	-.15	.06
	7 DC Area	-.50	-.20	-.45	.19	-.41	-.19	.07	.02	.04
D	8 External	-.33	-.11	.04	.67	.14	-.17	.02	-.17	.00
Total		.10	.05	.04	.11	.03	.03	.04	.00	.05

It is also clear from these tables that the intra-jurisdictional cells are always positive, while most of the inter-jurisdictional cells are negative. This reflects the tendency of adaptable assignment to add more short trips than long trips. Mechanically, this is because adaptable assignment factors the starting trips to match the counts, and the majority of the trips from any zone tend to go to nearby zones. Thus, the process tends to magnify these close trips. However, this may make some rational sense also, since very short trips tend to be undercounted in trip surveys.

The average Commercial trip length is reduced, when the delta table is included, as shown in Table 13. The slight drop in trip length is typical and is of no great concern.

Table 13
Starting and Final Trip Lengths

	COM
Starting Trip Table	15.4
Final Trip Table	14.3
Percent Change	-7%

Note: all figures include External and X/X trips.
Starting value represents revised interim model.

It should also be noted that in the delta trip matrix, the individual cell values include fractional amounts of trips (to the nearest 0.01 trip) and in many cases, are negative. Special care must be taken in forecasting to ensure that when these delta values are added to the model's initial estimates, that the resulting value does not become negative for any cell. Such values should be re-set to zero. Also, both delta tables include all matrix cells, including I/I, I/X, X/I, and X/X values. Both the interim model and the delta tables represent 24-hour travel on a typical weekday.

As noted above, the Commercial delta table now becomes an integral part of the model. It must always be added to the results of the starting model, in order to produce the final trip table.

Accuracy

As the final step in the development of the Commercial model, the Commercial delta table was added to the table from the revised interim model and the resulting table was assigned to the BMC 2000 network. This procedure used the new Medium and Heavy Truck trip tables, as well as the modified Truck assignment procedure, so as to:

- 1) maintain Medium and Heavy Truck volumes separately by link,
- 2) prevent Medium and Heavy Trucks from using truck-prohibited links, and

- 3) factor Medium Truck volumes by 1.5 and Heavy Truck volumes by 2.0, for the purposes of the V/C calculation

The resulting assigned volumes were compared to the synthesized Commercial counts, producing the report shown in Table 14. The total error is -1.9%, while the %RMSE value is 13%. This is a *substantial* improvement over both the interim model and the revised interim model. The consultant believes this should be considered acceptable.

There is little difference in the estimated/observed ratio, when stratified by the various fields shown in these reports. The %RMSE values tend to be better (lower) for the higher-type, higher-volume facilities, but this is to be expected.

There is a small discrepancy in the External station volumes that bears clarification. As part of the adaptable assignment process, the external station trip ends are Frated to match the starting totals, which are in turn derived from counts. Thus, these totals should match very closely. As Table 14 indicates, the external station volumes appear to be underestimated. This is because the BMC assignment process assigns through-trips separately and the through-trips (auto + truck + commercial) are output on a separate link volume field. The volume field used to create these reports excludes those through volumes. This explains why the Commercial external station counts appear to be underestimated.

The consultant believes that the adaptable assignment process is at least as valid as the count data. The result of this process is a model that both matches the counts and displays reasonable sensitivity to changes. The new model's coefficients and the inclusion of special factors for truck zones produces logical and defensible trip patterns.

Most other regional travel models do not specifically account for Commercial vehicle trips. In most cases, these trips are counted as Truck or NHB trips. Counting them as Truck trips is incorrect, since the trip patterns and average trip lengths are so different. Counting them as NHB is incorrect, since Commercial trips are not personal travel and are not subject to changes in mode choice. Counting these trips in this new category of travel represents an improvement in accuracy and credibility, compared to the old model.

Table 14
Assignment Report

BMC Commercial Model Adaptable Evaluation Results 2000 6/30/02 15:26:43

County	Count	Vol Est/Obs	%RMSE	Links	Obs VMT	Est VMT	
External	90472	83633	0.92	0.19	84	27138	25089
BaltCity	133376	133739	1.00	0.13	111	34515	34767
AnnArndl	409880	399052	0.97	0.14	209	343244	336454
BaltmrCo	545202	543956	1.00	0.12	288	345769	340274
Carroll	39864	39421	0.99	0.05	70	42184	41832
Harford	132616	128452	0.97	0.16	144	175273	167454
Howard	226280	223248	0.99	0.09	110	176891	173480
Montgomery	114159	113015	0.99	0.12	38	112201	109490
PG	228631	222362	0.97	0.06	60	287201	277825
Frederick	27124	24287	0.90	0.16	22	71970	63656

Vol Class	Count	Vol Est/Obs	%RMSE	Links	Obs VMT	Est VMT	
<= 999	260935	260205	1.00	0.23	539	185446	182292
1000-2499	542055	538528	0.99	0.12	341	349070	340215
2500-4999	613740	603638	0.98	0.08	173	603590	587671
5000-9999	530874	508794	0.96	0.08	83	478280	460143

Area Type	Count	Vol Est/Obs	%RMSE	Links	Obs VMT	Est VMT	
Rural	656429	634338	0.97	0.16	539	752272	720063
Suburban	1171150	1155918	0.99	0.11	515	831522	817617
Urban	79314	80781	1.02	0.13	62	26578	26743
City Ctr	40711	40128	0.99	0.06	20	6014	5898

Roadway Type	Count	Vol Est/Obs	%RMSE	Links	Obs VMT	Est VMT	
Freeway	1231181	1199476	0.97	0.08	339	1229499	1188380
>2 Ln Div	113233	115083	1.02	0.07	78	65425	65753
2WCLTL	31640	31517	1.00	0.03	28	21586	21390
Undivided	70628	72234	1.02	0.25	60	36622	37057
Arterial	210696	213030	1.01	0.14	175	61969	62671
Rural Hwy	65067	64819	1.00	0.07	101	69841	68883
Substndrd	84746	82936	0.98	0.25	188	73876	71864
Local	39728	40953	1.03	0.25	76	26370	26236
Ramp 1	2326	2647	1.14	0.15	2	744	834
Ramp 2	6455	3928	0.61	0.43	3	3001	1964
Ramp 5	1432	909	0.63	0.36	2	315	200
Cent Conn	90472	83633	0.92	0.19	84	27138	25089

Table 14 (continued)

Cong Spd Range	Count	Vol Est/Obs	%RMSE	Links	Obs VMT	Est VMT	
0	1757	1873	1.07	0.13	3	120	128
5	973	1069	1.10	0.10	1	58	64
10	5872	6404	1.09	0.14	3	1539	1762
15	25363	25412	1.00	0.06	8	21956	21990
20	141767	141084	1.00	0.06	65	89167	88129
25	138876	138210	1.00	0.18	130	70641	69028
30	156199	148754	0.95	0.18	98	102941	99637
35	104589	105037	1.00	0.16	103	73384	72120
40	353921	356303	1.01	0.15	355	230424	230295
45	155990	155498	1.00	0.07	95	119493	118973
50	157881	152547	0.97	0.10	54	196644	189537
55	161934	158080	0.98	0.06	31	115338	112498
60	389159	376543	0.97	0.08	133	329509	315757
65	153323	144351	0.94	0.17	57	265172	250403

Cap/Lane Range	Count	Vol Est/Obs	%RMSE	Links	Obs VMT	Est VMT	
500	15696	15083	0.96	0.19	20	3604	3479
750	80947	83788	1.04	0.15	90	34150	34152
1000	4000	3529	0.88	0.23	6	1266	1163
1250	64216	67153	1.05	0.21	72	21886	23273
1500	259794	256619	0.99	0.24	324	140444	137169
1750	150912	147739	0.98	0.08	95	118955	115503
2000	164062	163172	0.99	0.06	136	158568	156873
2250	1117505	1090449	0.98	0.09	309	1110375	1073620
3000	90472	83633	0.92	0.19	84	27138	25089

Totals:

Count	1947604.000
Assigned Vol	1911165.000
Est/Obs Vol	0.981
RMS Error	52581053.000
Avg RMS Error	215.142
% RMS Error	0.125488
Links	1136.000
Obs. VMT	1616386.000
Est. VMT	1570321.000
Est/Obs VMT	0.972
Corr Coef R	0.996
Coef Var Rsq	0.992589

6 Forecasting

2025 Run

The consultant believes that a model is not complete until it has been used to make a forecast. As the final step in the development of the Commercial model, BMC staff provided the consultant with data and setups for a 2025 forecast, labelled "SP25". The consultant applied the model to that scenario, with the results as shown in Table 15. The final Commercial trip tables, including the calibration adjustment, are shown in Table 16.

Table 15
2025 Forecast Summary

	2000	2025	% Change
Commercial Trips	1,179,800	1,545,600	31%
Avg. Trip Length	7.2	8.4	17%
Commercial VMT (000)	8,479.7	13,011.6	53%

Includes multiplicative calibration adjustment.

These figures reflect a fairly modest growth in Commercial travel to 2025. Most of this is due to an increase in total Commercial trips, while some is due to increased trip length. These estimates do not appear unreasonable.

Table 16
 2000 and 2025 Trip Tables

Date: 6/30/02
 Time: 17:23

Baltimore Metropolitan Council Travel Model
 2000 Final Daily Trip Table (w/Mult. Calib. Adj.)
 Commercial Vehicle Trips

		Destination District								Total
		1	2	3	4	5	6	7	8	
Origin District	1 BaltCity	115769	6409	31276	710	1371	1781	2144	674	160134
	2 AnnArndl	5787	112701	5346	430	572	5769	9186	1935	141726
	3 BaltmrCo	32066	6446	133612	1962	5083	4257	2606	1769	187801
	4 Carroll	726	425	1922	28443	181	1006	2048	1252	36003
	5 Harford	1239	554	5026	197	58305	207	512	2903	68943
	6 Howard	1867	6897	4179	1128	227	42882	7024	398	64602
	7 DC Area	2149	10283	2487	2213	534	6571	417505	32850	474592
	8 External	658	1928	1762	1395	2913	392	32765	4229	46042
Total		160261		185610		69186		473790		1179843
			145643		36478		62865		46010	

Date: 6/30/02
 Time: 17:23

Baltimore Metropolitan Council Travel Model
 2025 Final Daily Trip Table (w/Mult. Calib. Adj.)
 Commercial Vehicle Trips

		Destination District								
		1	2	3	4	5	6	7	8	Total
O	1 BaltCity	120744	7932	30065	1111	2460	3859	4816	1201	172188
r	2 AnnArndl	7537	123915	6842	777	1047	9838	13039	3103	166098
i	3 BaltmrCo	30528	7787	152101	2824	6967	6626	5457	2916	215206
g	4 Carroll	1104	788	2793	35243	379	1623	2797	1918	46645
i	5 Harford	2429	1032	6956	387	82271	602	1340	4852	99869
n	6 Howard	3911	11827	6314	1852	593	70764	11920	879	108060
	7 DC Area	4831	13964	5377	3046	1350	11406	574333	51795	666102
D	8 External	1186	3018	2819	2030	4837	871	51361	5338	71460
Total		172270		213267		99904		665063		1545628
			170263		47270		105589		72002	

Date: 6/30/02
 Time: 17:23

Baltimore Metropolitan Council Travel Model
 2025/2000 Daily Trip Ratio
 Commercial Vehicle Trips

		Destination District								
		1	2	3	4	5	6	7	8	Total
O	1 BaltCity	1.04	1.24	.96	1.56	1.79	2.17	2.25	1.78	1.08
r	2 AnnArndl	1.30	1.10	1.28	1.81	1.83	1.71	1.42	1.60	1.17
i	3 BaltmrCo	.95	1.21	1.14	1.44	1.37	1.56	2.09	1.65	1.15
g	4 Carroll	1.52	1.85	1.45	1.24	2.09	1.61	1.37	1.53	1.30
i	5 Harford	1.96	1.86	1.38	1.96	1.41	2.91	2.62	1.67	1.45
n	6 Howard	2.09	1.71	1.51	1.64	2.61	1.65	1.70	2.21	1.67
	7 DC Area	2.25	1.36	2.16	1.38	2.53	1.74	1.38	1.58	1.40
D	8 External	1.80	1.57	1.60	1.46	1.66	2.22	1.57	1.26	1.55
Total		1.07		1.15		1.44		1.40		1.31
			1.17		1.30		1.68		1.56	

7 Final Model

The final recommended Commercial trip model includes the following components:

- trip generation model (as described in Table 11)
- trip distribution model (F factors as calculated by the gamma function, as described on page 17 and shown in Figure 2 and Table 18)
- procedure to calculate external trips (Figure 3)
- base year through-trip table (Appendix B)
- calibration adjustment table ("delta table")

Figure 3 contains the TP+ setups used to apply the new Commercial trip model. This consists of a trip generation setup and a trip distribution setup. The new F factors are shown in Table 18. As developed for this project, the new Commercial model estimates average weekday trips for a 24-hour period.

There is no specific process for forecasting through-trips. The consultant recommends that BMC staff develop a setup to Fratar the through-trips. It should also be clear that BMC must adjust its current through-trip table to remove through Commercial trips.

In order to split these trips by period for the period-based assignments, the consultant recommends the use of a revised set of factors, derived from Reference 3. This uses data for "4 tire single unit" commercial vehicles. These factors are shown in Table 17. These factors have not been validated at the link level.

Table 17
Recommended Commercial Time of Day Factors

Period	COM
Night (12 M - 6 AM)	4.5%
AM Peak (6 - 10)	25.1
Midday (10 AM - 3 PM)	28.9
PM Peak (3 - 7)	29.4
Evening (7 PM - 12 M)	12.1

During the development of the Truck model, the consultant discovered that in the case of the BMC model, treating the delta trip calibration adjustment matrix as a table of trips to be added to the model output could result in an overestimation of future trips, due to integer rounding error at the O/D cell level. It is thus recommended that the calibration adjustment be applied as a “multiplicative delta”, i.e., the adjustment table consists of factors for each O/D cell that are multiplied by the model’s initial output table. Please refer to Chapter 7 of the Truck model report for more details.

Table 18
Final Commercial Trip F Factors

Time	COM F	Time	COM F	Time	COM F
1	1202604	41	21.0	81	2.8
2	155627	42	19.6	82	2.7
3	47056	43	18.3	83	2.6
4	20139	44	17.1	84	2.5
5	10427	45	16.0	85	2.4
6	6089	46	15.0	86	2.4
7	3864	47	14.0	87	2.3
8	2606	48	13.2	88	2.2
9	1841	49	12.4	89	2.1
10	1349	50	11.7	90	2.1
11	1019	51	11.0	91	2.0
12	788	52	10.4	92	1.9
13	622	53	9.9	93	1.9
14	500	54	9.3	94	1.8
15	408	55	8.8	95	1.8
16	337	56	8.4	96	1.7
17	282	57	7.9	97	1.7
18	238	58	7.6	98	1.6
19	203	59	7.2	99	1.6
20	175	60	6.8	100	1.5
21	151	61	6.5	101	1.5
22	132	62	6.2	102	1.4
23	116	63	5.9	103	1.4
24	102	64	5.6	104	1.3
25	90	65	5.4	105	1.3
26	81	66	5.2	106	1.3
27	72	67	4.9	107	1.2
28	65	68	4.7	108	1.2
29	58	69	4.5	109	1.2
30	53	70	4.3	110	1.1
31	47.9	71	4.2	111	1.1
32	43.6	72	4.0	112	1.1
33	39.9	73	3.8	113	1.1
34	36.5	74	3.7	114	1.0
35	33.5	75	3.5	115	1.0
36	30.8	76	3.4	116	1.0
37	28.4	77	3.3	117	1.0
38	26.3	78	3.2	118	0.9
39	24.3	79	3.0	119	0.9
40	22.6	80	2.9	120	0.9

Figure 3 TP+ Setups

```
zones=1326
inzones='1-1284'
exzones='1285-1326'

;-----
run pgm=matrix

; Distance to nearest external station
; (input to Truck and Commercial models)

; input off-peak highway skim
filei mati[1] = sp0011.dat

; skip entire calculation for external stations
if (i > @zones@) continue

; get distance matrix; exclude internal zones
mw[1] = mi.1.SOVDist, exclude = @inzones@

; Fill zero cells with large value.
jloop
  if (mw[1] < 0.01) mw[1] = 9999.
endjloop

; "Nearest" zone is the one with the minimum distance.
nearest = rowmin(1)

print list = i(5.0),nearest(7.2) file = tkextdst.dat print=y
endrun
;-----
run pgm=tripgen
;
; Commercial Trip Generation
; Purpose 1 = COM I/I, 2 = COM Ext

; Input Zonal Data
;   Type 2
;   z      1998 TAZ (2-5)
;   rpd    RPD (6-10)
;   pop    Population (11-16)
;   hh     Households (17-22)
;   gq     Persons in Group Quarters (23-26)
;   lf     Labor Force (27-31)
;   te     Total Employment (32-36)
;   sche   School Employment (K-12) (37-41)
;   re     Retail Employment (42-46)
;   nre    Non-Retail Employment (47-51); nre = off + ind + oth
;   off    Office Employment (52-56)
;   ind    Industrial Employment (57-61)
;   oth    Other NRE Employment (62-66)
;   dc     1998 TAZ Density Code (67-68): 1-Rural, 2-Suburban, 3-
Urban, 4-City Center; Updated regularly
```

```
;          pd          Proportion Developed in Tenths (69-71) ;Not updated recently
;
;          Ext Sta Vols
;          xmt          External MT Volume (2-way)
;          xht          External HT Volume (2-way)
;
;          Truck Zones
;          tztype       Truck Zone Type Code (1-12)
;
zdati[1]=sp0008.dat, select=2,1, z=2-5, rpd=6-10, pop=11-16, hh=17-22, gq=23-26,
          lf=27-31, te=32-36, sche=37-41, re=42-46,
          nre=47-51, off=52-56, ind=57-61,
          oth=62-66, dc=67-68

; Commercial external volumes and external share (0-100%) (100-PCTEXT is
; the Through share)
zdati[3]=cmextvol.prn, z=#1, xcom=#2, pctextcm=#3

; "Truck Zones"
zdati[4]=tkzones.prn, z=#1, tztype=#2

; Distance to nearest external station (created above)
zdati[5]=tkextdst.dat, z=#1, extdist=#2

; Output P/A file
pao=sp0010.com form=8.0 list= z(5.0), p[1], a[1], p[2], a[2],
          print=y

zones = @zones@

; Trip Rate Lookup Table
lookup name=trate,
lookup[1]=1, result=2,
list=y,
r='1  0.454',          ; Ind Emp
   '2  0.501',          ; Ret Emp
   '3  0.454',          ; Off Emp
   '4  0.146'          ; HH

; Truck Zone Factor Lookup Table
lookup name=frate,
lookup[1]=1, result=2,
list=y,
r=' 1  1.2',          ;Bus Dist,      Large
   ' 2  1.0',          ;Whse/Mfgr,   Lg
   ' 3  1.0',          ;Inter/Trans, Lg
   ' 4  1.0',          ;Airport,     Lg
   ' 5  1.0',          ;Inst/Othr,   Lg
   ' 6  3.0',          ;Exp/Pkg,     Lg
   ' 7  1.0',          ;Bus Dist,    Small
   ' 8  1.0',          ;Whse/Mfgr,   Sm
   ' 9  1.0',          ;Inter/Trans, Sm
  '10  1.0',          ; (N/A)
  '11  1.0',          ;Inst/Othr,   Sm
```

```
        '12  2.5'          ;Exp/Pkg,      Sm

; Density Code adjustment table
lookup name=dcfac,
  lookup[1]=1, result=2,
  list=y,
  r=' 1  0.8',          ;Rural
    ' 2  1.0',          ;Suburban
    ' 3  1.5',          ;Urban
    ' 4  0.7'          ;City Center

; Jurisdictional Factor Lookup Table
lookup name=jurfac,
  lookup[1]=1, result=2,
  list=y,
  r=' 1  1.0',          ;Balt City
    ' 2  1.5',          ;Anne Arundel
    ' 3  1.2',          ;Balt Co
    ' 4  1.7',          ;Carroll
    ' 5  2.1',          ;Harford
    ' 6  1.2',          ;Howard
    ' 7  0.5',          ;DC
    ' 8  0.7',          ;Montgomery
    ' 9  1.2',          ;PG
   '10  0.6'          ;Frederick

; Apply equations to internal zones
if (i=@inzones@)
  com = 0.8 * (trate(1,1)*ind + trate(1,2)*re + trate(1,3)*off + trate(1,4)*hh)

; Apply "truck zone" factors
if (tztype > 0)
  com = com * frate(1,tztype)
endif

; Density Code adjustment
if (dc > 0)
  com = com * dcfac(1,dc)
endif

; Jurisdictional adjustments
if (rpd > 0)
  jur = int(rpd/100)
  com = com * jurfac(1,jur)
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). This particular model is an
; amalgam of the Berks Co, PA purpose-specific models, modified
; to produce the correct number of BMC external trips in 2000. Use
; the MT model.
extpct = 0.0
if (extdist > 0)
```

```
    extpct = 0.468 * exp(-1.2 * ln(extdist))
endif
extpct = max(min(extpct,1.0),0)
intpct = 1.0 - extpct

; Apply internal trip end shares; set A's equal to P's
p[1] = com * intpct
a[1] = p[1]

; 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. Multiply by 2 because we're
; putting external P's and external A's in the same column.
p[2] = 2 * com * extpct

endif

; External trip ends. These are the input cordon volumes, which
; we then multiply by the External share. These are defined as
; Attractions, at the external stations.
if (i=@exzones@)
  p[1] = 0
  p[2] = 0
  a[1] = 0
  a[2] = xcom * pctextcm * 0.01
endif

; Debug
if (i = 63,100,117,200,300)
  print list=i(4), form=6, list=' IRO emp, HH: ',ind,re,off,
    hh,'\n',form=7.2,list=' Tot TE: ',com,' Dist to Ext, ext %s: ',
    extdist,extpct(8.4),'\n',
    list=' COMII: ',p[1],'\n'
endif

; Normalize the external Productions at the internal zones so that
; their total matches the external Attractions at the external
; stations. This keeps the external station volumes intact.
phase=adjust
  p[2] = p[2] * a[2][0]/p[2][0]

endphase

endrun



---



run pgm=tripdist

; Commercial Trip Distribution
; Distribute all trips on uncongested skims
; Purpose 1 = COM I/I, 2 = COM External

; Skims
mati[1]=sp0011.dat
```

```
; Trip ends
zdati[1]=sp0010.com z=#1,p1=#2,a1=#3,p2=#4,a2=#5

; Output
mato[1]=tempc.trp, mo=1-2
;
; Maximum 99 iterations, unless RMSE for all purposes is under 25
; (same as for other BMC TD models)
maxiters=99
maxrmse=25
;
;Set productions and attractions
setpa p[1]=p1 p[2]=p2
setpa a[1]=a1 a[2]=a2
;
;Look up friction factors
lookup file=comff.dat name=ff,
      lookup[1]=1, result=2,
      lookup[2]=1, result=2,
      interpolate=y,
      fail=1200000,0.5,0
;
;Distribute trips on skim time excluding HOV facilities
gravity purpose=1, los=mi.01.01, ffactors=ff
gravity purpose=2, los=mi.01.01, ffactors=ff
;
;Perform bucket rounding
bucket1=rowfix(1)
bucket2=rowfix(2)
;
endrun
;-----
run pgm=matrix

      id = "2000 Commercial: balance trips, add X/X, and do TLFs

; Input files: trips, skims, X/X
mati[1] = tempc.trp
mati[3] = sp0011.dat
mati[4] = sp00cmxx.trp

      mato      = sp00com.trp, mo=6,7, name = COM, COMXX

; Sum II and Ext trips.
mw[1] = mi.1.1 + mi.1.2

; Transpose
mw[4] = mi.1.1.t + mi.1.2.t

; Sum and round. Insert X/X trips as table 2.
mw[6] = 0.5 * (mw[1] + mw[4])
rnd6 = rowfix(6)
mw[7] = mi.4.1
```

```
; Time (w/o barrier penalties).
mw[3] = mi.3.1

; TLF (still in P/A format, excluding X/X).
frequency basemw=3, valuemw=1, range=0-90-2,
title='Est 2000 Commercial vs. Hwy Time'

endrun
*del temp*.trp
```

```
run pgm=matrix

; BMC Truck Model
; Calibration final production run w/mult. delta
; final.s

id = "Apply delta adjustments

mati[1] = sp00com.trp
mati[2] = sp00cmxx.trp
mati[3] = deltac.fac

mato    = sp00com.adj, mo = 1,2, name=COM, COMXX

; Apply multiplicative deltas and bucket round.
mw[1] = mi.1.1 * mi.3.1      ; COM int+ext
mw[2] = mi.2.1 * mi.3.1      ; COM XX

b1 = rowfix(1)
b2 = rowfix(2)
endrun
```

References

1. Allen, W.G., *Adaptable Assignment*, presented at the Sixth TRB Conference on the Application of Transportation Planning Methods, May 1997
2. List, G. and Turnquist, M., *Estimating Truck Travel Patterns in Urban Areas*, Transportation Research Record 1430, 1994
3. *Quick Response Freight Manual*, prepared by Cambridge Systematics for the Travel Model Improvement Program, September 1996

Appendix A Count Model Results

BMC COM Survey ID	BMC Commercial Vehicle Survey Description	Obs. COM Volume	Est. COM Volume
1	Boston Street - W of Kenwood Avenue (samples B thru F)	614	714
2	Eastern Avenue - W of Dundalk Avenue	209	186
3	Lombard Street - W of Calvert Street	254	187
4	Fleet Street - E of Broadway	95	94
5	Pratt Street - E of Greene Street (MD 295)	92	70
6	Interstate Avenue - E of Ponca Street	76	69
7	Kane Street - S of Eastern Avenue (MD 150)	75	100
8	Dundalk Avenue - N of Holabird Avenue	77	71
9	Lombard Street - W of IS 895 (Harbor Tunnel Thwy)	37	42
10	Ponca Street - S of Lombard Street	41	43
11	Martin Luther King Jr Blvd - N of Washington Blvd	134	160
12	Greene Street (MD 295) - N of Lombard Street	53	57
13	MD 2 Governor Ritchie Hwy - N of Marley Station Road	47	64
14	MD 170 Aviation Boulevard - N of MD 176 Dorsey Road	61	45
15	US 40 Pulaski Highway - E of MD 700 Martin Boulevard	106	61
16	US 1 Belair Road - N of IS 695 Beltway	116	88
17	US 1 Belair Road - S of IS 695 Beltway	88	93
18	Red Run Boulevard - E of Owings Mills Boulevard	24	37
19	Painters Mill Road - N of Red Run Boulevard	30	50
20	Boston Street - W of Ponca Street	42	36
21	Broening Highway - S of Holabird Avenue	24	21
22	IS 695 Beltway - W of Cromwell Bridge Road	276	251
23	MD 45 York Road - N of IS 695 Beltway	89	96
24	Green Spring Drive - N of Timonium Road	61	43
25	Old Court Road - W of MD 140 Reisterstown Road	24	31
26	INTERSTATE 70 - E of Baltimore-Howard County Line	164	118
27	MD 25 Falls Road - N of MD 131 Seminary Avenue	25	22
28	Deereco Road - S of Padonia Road	68	42
29	MD 45 York Road - N of Thornton Mill Road	62	47
30	President Street - N of Lombard Street	111	126
31	Reisterstown Road MD 140 - N of Northern Parkway	63	77
32	Erdman Avenue MD 151 - S of Pulaski Highway US 40	69	92
33	Moravia Road - E of I-895 Harbor Tunnel Thruway	84	77
34	IS 695/83 Beltway - E of Joppa Rd overpass	394	370
35	IS 83 Jones Falls Expressway - N of Old Pimlico Road	160	204
36	MD 140 Baltimore Blvd - W of Baltimore-Carroll Co L	103	76
37	MD 91 Gamber Road - S of MD 140 Baltimore Boulevard	26	23
38	Center Street - S of MD 140 Baltimore Boulevard	25	27

BMC COM Survey ID	BMC Commercial Vehicle Survey Description	Obs. COM Volume	Est. COM Volume
39	Englar Road - S of MD 140 Baltimore Boulevard	22	23
40	MD 97 Littlestown Pike - N of MD 140 Baltimore Blvd	59	71
41	MD 26 Liberty Road - E of MD 32 Sykesville Road	55	62
42	MD 26 Liberty Road - W of MD 32 Sykesville Road	49	49
43	MD 32 Sykesville Bypass - N of Howard-Carroll Co Line	32	30
44	MD 32 Sykesville Road - N of Bennett Road	34	27
45	MD 27 Ridge Road - N of INTERSTATE 70	75	48
46	INTERSTATE 70 - E of MD 27 Ridge Road	102	98
47	MD 97 New Washington Road - N of MD 26 Liberty Rd	29	35
48	MD 439 Old York Rd - E of IS 83 Harrisburg Expressway	12	13
49	IS 83 Harrisburg Exp - S of Pennsylvania State Line	51	47
50	MD 45 York Road - N of Freeland Road	11	11
51	IS 83 Harrisburg Exp - N of MD 137 Mount Carmel Rd	45	49
52	MD 45 York Road - N of Piney Hill Road	11	15
53	MD 137 Mount Carmel Road - W of MD 25 Falls Road	6	5
54	MD 25 Falls Road - S of Stringtown Road	9	12
55	MD 30 Hanover Pike - N of MD 496 Bachmans Valley Rd	22	37
56	IS 695 Beltway - S of MD 150 Eastern Avenue	98	79
57	IS 695 Beltway - N of Lillian Holt Drive overpass	180	177
58	MD 45 York Road - S of Stevenson Lane	65	61
59	MD 131 Seminary Avenue - E of Front Avenue	13	23
60	MD 129 Park Heights Avenue - S of IS 695 Beltway	37	73
61	MD 129 Park Heights Avenue - N of IS 695 Beltway	33	50
62	IS 695 Beltway - S of Windsor Mill Road overpass	308	224
63	MD 2 Governor Ritchie Highway - N of IS 695 Beltway	105	110
64	MD 2 Governor Ritchie Highway - S of MD 100	85	88
65	IS 195 Metropolitan Blvd - S of MD 170 Aviation Blvd	180	151
66	MD 175 Annapolis Road - E of AA-Howard County Line	47	41
67	MD 176 Dorsey Road - E of MD 713 New Ridge Road	34	39
68	Robinson Road - W of MD 2 Governor Ritchie Highway	25	37
69	MD 2 Governor Ritchie Hwy - S of Jones Station Road	124	136
70	MD 450 West Street - E of MD 2 Solomons Island Road	121	73
71	MD 70 Rowe Boulevard - S of US 50 / US 301	79	79
72	Bestgate Road - E of MD 178 Generals Highway	54	51
73	Jennifer Road - W of Admiral Drive	16	29
74	INTERSTATE 97 - N of MD 450 Defense Highway	198	169
75	Riva Road - W of Harry S. Truman Drive	66	91
76	Bay Ridge Road - E of Bay Ridge Avenue	78	65

BMC COM Survey ID	BMC Commercial Vehicle Survey Description	Obs. COM Volume	Est. COM Volume
77	MD 3 Robert Crain Highway - S of Waugh Chapel Road	129	117
78	MD 3 Robert Crain Hwy - N of MD 450 Annapolis Road	128	147
79	MD 424 Davidsonville Rd - S of US 50 John Hanson Hwy	41	42
80	MD 424 Davidsonville Rd - N of US 50 John Hanson Hwy	36	37
81	US 50 John Hanson Hwy - E of MD 424 Davidsonville Rd	117	178
82	IS 695 Beltway - E of MD 2 Governor Ritchie Highway	125	118
83	INTERSTATE 97 - S of Furnace Branch Road	214	169
84	US 1 Washington Boulevard - N of MD 100	85	91
85	MD 103 Meadowridge Road - S of Brightfield Road	20	22
86	MD 100 - W of MD 103 Meadowridge Road	113	131
87	MD 32 - N of MD 108 Clarksville Pike	64	63
88	MD 108 Clarksville Pike - E of Ten Oaks Road	68	61
89	MD 175 Little Patuxent Pky - W of MD 108 Waterloo Rd	86	154
90	US 29 Columbia Pike - N of MD 32	85	135
91	MD 216 - E of US 29 Columbia Pike	28	22
92	Gorman Road - W of Leishear Road	14	13
93	US 1 Balt-Wash Boulevard - S of Whiskey Bottom Road	90	65
94	INTERSTATE 95 - N of MD 216	250	198
95	MD 482 Hampstead Mexico Rd - E of MD 27 Westminster Manchester Rd	15	21
96	MD 97 Littlestown Pike - S of Pennsylvania State Line	10	12
97	MD 194 Francis Scott Key Hwy - S of Penna State Line	9	8
98	MD 194 Frederick Street - S of MD 140 Baltimore Street	22	19
99	MD 94 Woodbine Road - S of MD 144 Frederick Road	10	9
100	US 40 Baltimore National Pike - E of IS 70 (Exit 82)	24	32
101	MD 144 Frederick Road - E of MD 32	17	13
102	INTERSTATE 70 - E of MD 32	108	133
103	IS 83 Harrisburg Expressway - N of IS 695 Beltway	225	233
104	MD 136 Priestford Road - S of US 1 Conowingo Road	14	13
105	US 1 Conowingo Road - N of MD 161 Main Street	22	18
106	US 1 Hickory Bypass - S of MD 543 Fountain Green Rd	40	38
107	I-95 John F. Kennedy Hwy - N of MD 22 Aberdeen Thwy	89	150
108	MD 24 Vietnam Vets Hwy - N of MD 924 Emmorton Rd	85	101
109	US 1 Belair Road - N of Baltimore-Harford County Line	33	41
110	MD 23 Norrisville Road - W of MD 165 Baldwin Mill Rd	32	30
111	US 40 Pulaski Highway - W of Robin Hood Road	57	64
112	US 40 Pulaski Highway - W of MD 152 Mountain Road	71	61
113	MD 152 Mountain Road - N of I-95 John F Kennedy Hwy	60	59

Appendix B 2000 Through Commercial Trips

Orig	Dest	COM	Orig	Dest	COM	Orig	Dest	COM
1286	1293	126	1293	1326	59	1315	1293	21
1286	1294	12	1294	1286	12	1315	1294	2
1286	1296	10	1294	1299	1	1315	1296	2
1286	1301	2	1294	1301	5	1315	1326	1
1286	1315	1	1294	1306	1	1324	1286	2
1286	1324	2	1294	1315	2	1324	1288	6
1286	1326	2	1294	1324	6	1324	1289	2
1288	1296	29	1294	1325	1	1324	1290	87
1288	1299	1	1294	1326	6	1324	1291	102
1288	1301	6	1296	1286	10	1324	1292	5
1288	1315	2	1296	1288	32	1324	1293	68
1288	1324	6	1296	1289	10	1324	1294	7
1288	1325	1	1296	1290	429	1324	1296	5
1288	1326	6	1296	1291	500	1324	1301	1
1289	1296	9	1296	1292	25	1324	1315	1
1289	1299	1	1296	1299	1	1324	1326	1
1289	1301	2	1296	1301	5	1325	1288	2
1289	1324	2	1296	1315	1	1325	1290	21
1289	1325	1	1296	1324	6	1325	1291	24
1289	1326	2	1296	1325	1	1325	1292	1
1290	1296	401	1296	1326	5	1325	1293	16
1290	1299	20	1299	1288	2	1325	1294	2
1290	1301	72	1299	1290	21	1325	1296	1
1290	1306	3	1299	1291	26	1326	1286	1
1290	1315	25	1299	1292	1	1326	1288	6
1290	1324	82	1299	1293	16	1326	1289	2
1290	1325	19	1299	1294	2	1326	1290	82
1290	1326	76	1299	1296	1	1326	1291	96
1291	1296	467	1299	1326	1	1326	1292	5
1291	1299	23	1301	1286	2	1326	1293	64
1291	1301	83	1301	1288	6	1326	1294	6
1291	1306	3	1301	1289	1	1326	1296	5
1291	1315	30	1301	1290	76	1326	1299	1
1291	1324	95	1301	1291	89	1326	1315	1
1291	1325	22	1301	1292	5	1326	1324	1
1291	1326	89	1301	1293	59			
1292	1296	24	1301	1294	6			
1292	1299	1	1301	1296	4			
1292	1301	4	1301	1316	1			
1292	1315	2	1301	1324	1			
1292	1324	5	1301	1326	1			
1292	1325	1	1306	1290	3			
1292	1326	5	1306	1291	4			
1293	1286	120	1306	1293	2			
1293	1299	15	1306	1296	1			
1293	1301	56	1315	1288	2			
1293	1306	2	1315	1289	1			
1293	1315	20	1315	1290	27			
1293	1324	64	1315	1291	32			
1293	1325	15	1315	1292	1			