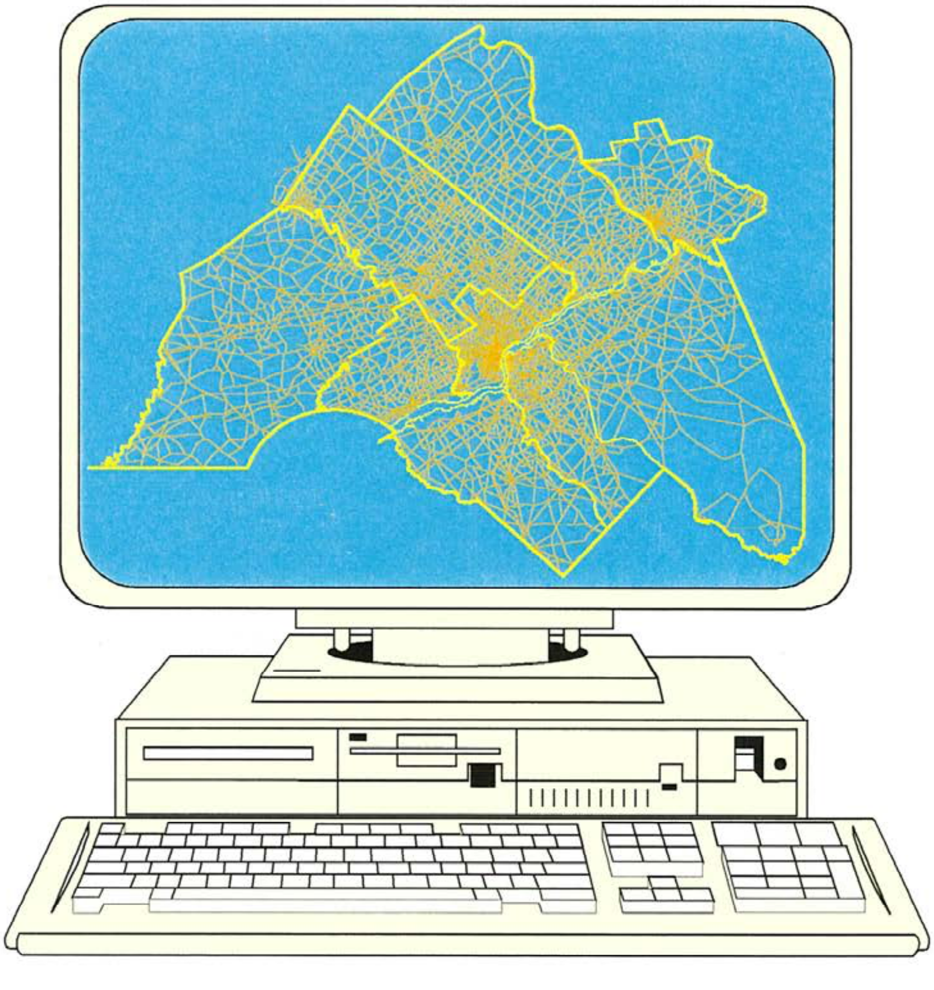
1997 ENHANCED TRAVEL SIMULATION MODEL FOR THE DELAWARE VALLEY REGION

Supplement No.1



DELAWARE VALLEY REGIONAL PLANNING COMMISSION

NOVEMBER 2002

1997 ENHANCED TRAVEL SIMULATION MODEL FOR THE DELAWARE VALLEY REGION

Supplement No.1

Delaware Valley Regional Planning Commission
The Bourse Building
111 South Independence Mall East
Philadelphia, PA 19106-2582

November 2002

-This report is printed on recycled paper -

Created in 1965, the Delaware Valley Regional Planning Commission (DVRPC) is an interstate, intercounty, and intercity agency which provides continuing, comprehensive and coordinated planning to shape a vision for the future growth of the Delaware Valley region. The region includes Bucks, Chester, Delaware, and Montgomery counties as well as the City of Philadelphia, in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer counties in New Jersey. DVRPC provides technical assistance and services; conducts high priority studies that respond to the request and demands of member state and local governments; fosters cooperation among various constituents to forge a consensus on diverse regional issues; determines and meets the needs of the private sector, and practices public outreach efforts to promote two-way communication and public awareness of regional issues and the commission.

Our logo is adapted from the official DVRPC seal, and is designed as a stylized image of the Delaware Valley. The outer ring symbolizes the region as a whole while the diagonal bar signifies the Delaware River. The two adjoining crescents represent the Commonwealth of Pennsylvania and the State of New Jersey.

DVRPC is funded by a variety of funding sources including federal grants from the U.S. Department of Transportation's Federal Highway Administration (FHWA) and Federal Transit Administration (FTA), the Pennsylvania and New Jersey departments of transportation, as well as by DVRPC's state and local member governments. This report was primarily funded by the Pennsylvania Department of Transportation and the Federal Highway Administration (FHWA). The authors, however, are solely responsible for its findings and conclusions, which may not represent the official views or policies of the funding agencies.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (CONTINUED)

LIST OF FIGURES

EXECUTIVE SUMMARY

Page intentionally left blank

I. INTRODUCTION

Refinement of DVRPC's travel simulation models was necessary to enhance the accuracy of DVRPC's travel forecasts and to respond to new forecasting requirements included in the Clean Air Act Amendments, ISTEA/TEA21 and the Transportation Conformity Rule. In FY 1995, a consultant group headed by Cambridge Systematics was hired to assist DVRPC staff in implementing the required model upgrades. The consultants completed the upgrades in FY 1998. DVRPC staff initiated work in FY 1999 on incorporating selected model enhancements prepared by the consultant group into the DVRPC travel simulation process so that these refinements are available for use in ongoing transportation and air quality modeling activities conducted by the commission staff and outside consultants. Beginning in FY 1999, a preliminary version of the new model became the basis for conformity determinations and in FY 2000 this conformity model was used in the Chester County Travel Simulation Model study. This was the first use the new enhanced model to estimate facility level highway and transit volumes.

Following the successful application of the new model to the Chester County Study, the new enhanced model was completed and put into general production for traffic and other studies in FY 2001. The following tasks were required to complete the implementation of the model.

- Three Time Period Travel Simulation

  The preliminary model contained two time periods, peak and off-peak. A third time period for evening/ night was implemented by splitting off-peak into midday and night. This improves the off-peak modal split and transit results while providing higher, more realistic travel speeds during evening/night time period for transportation and air quality modeling. During these hours, more than 30 percent of daily trips are made in most cases, with greatly reduced highway congestion and little or no transit service.

- Nested Modal Split Model

  Implement the nested modal split model used in ongoing transit studies into the Evans Process. Modal split parameters to model travel within each time period were refined.

- Non-Motorized Travel Simulation Model

  CSI's Non-Motorized travel model was implemented and applied to the Chester County Travel Simulation Study.

- Highway Speeds and Capacities

Alternative speed curves and capacity tables were reviewed and implemented for use in ongoing traffic studies. Calibrate the model for use in focused corridor studies.

- Implement additional gravity model improvements prepared by Cambridge Systematics. This involves dividing the combined arterial/local external-local gravity model included in the 1990 model validation into separate models. Preliminary estimates of friction factors and a trip attraction estimation methodology were prepared by the consultant as part of the model enhancement process. This exercise involves implementing this model enhancement into the Evans process.

- Complete the TRANPLAN software enhancements required for the Evans Process

  The selected link and turns computer code started by Jim Fennessy in FY 2000 must be tested and debugged. In addition, more user friendly software and procedures are required to execute the Evans Model process and weight together the Evans iterations of transit and other trip tables to form the composite trip tables.

All of these tasks, except for the implementation of the gravity model enhancements, have been completed as of the end of FY 2001. This technical supplement to the 1997 Travel Simulation report has been prepared to provide a comprehensive update to the technical documentation of new model.

II. BRIEF SYNOPSIS OF THE ENHANCED ITERATIVE TRAVEL SIMULATION PROCESS

Before the model enhancements and parameters are described in detail, this sections provides a brief overview of the model to place these enhancements within the context of the overall model. The enhanced DVRPC travel simulation process utilizes the Evans Algorithm to iterate the model see Figure 1. Evans re-executes the trip distribution and modal split models based on updated highway speeds after each iteration of highway assignment and assigns a weight (λ) to each iteration. This weight is then used to prepare a convex combination of the link volumes and trip tables for the current iteration and a running weighted average of the previous iterations. This algorithm converges rapidly to the equilibrium solution on highway travel speeds and congestion levels. About seven iterations are required for the process to converge to the approximate equilibrium state for travel patterns. After equilibrium is achieved, the weighted average transit trip tables are assigned to the transit networks to produce link and route passenger volumes.

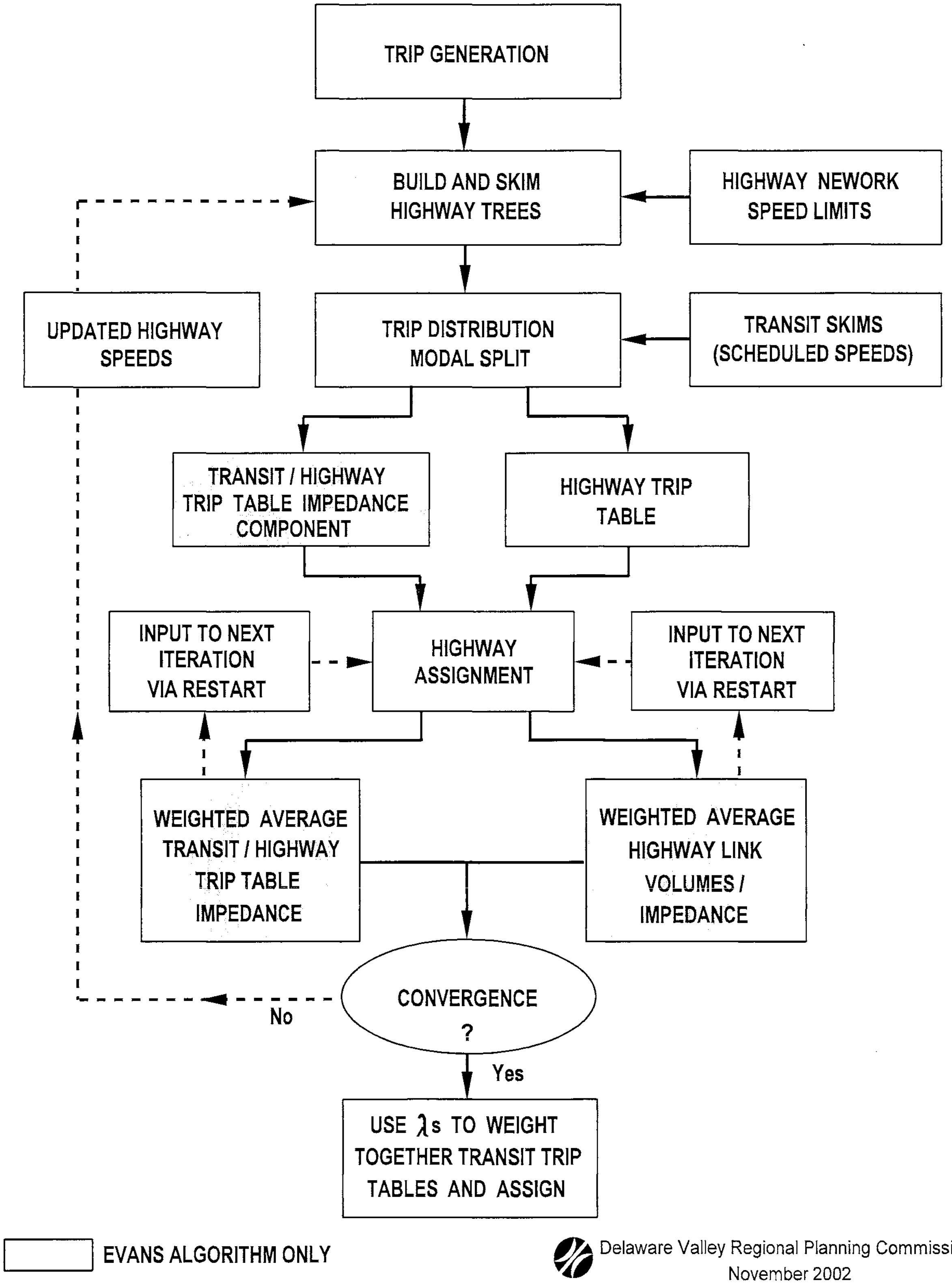
Urban Systems Inc. was retained by DVRPC to prepare a special extended version of TRANPLAN that supports the Evans Algorithm procedures. This required creation of special computerized feed back and weighting mechanisms between the trip distribution, modal split and highway assignment programs. These special features have been incorporated into TRANPLAN Version 9.1.

A. Separate Peak, Midday, and Evening Models

The enhanced DVRPC travel simulation models are disaggregated into separate peak period, midday, and evening time periods. This disaggregation begins in trip generation where factors are used to separate daily trips into peak, and midday travel. Evening travel is then defined as the residual after peak and midday travel are removed from daily travel. The enhanced process then utilizes completely separate model chains for peak, midday, and evening travel simulation runs. The peak period (combined AM and PM) is defined as 7:00 AM to 9:00 AM and 3:00 PM to 6:00 PM, midday is defined as 9:00 AM to 3:00 PM and evening (6:00 PM-7:00 AM). The separation of the models into three time periods proved to be relatively straight forward with few changes to the basic models or their parameters required. However, time of day sensitive inputs to the models such as highway capacities and transit service levels were disaggregated to be reflective of time-period specific conditions. Capacity factors were used to allocate daily highway capacity to the peak, midday, and evening time periods. Separate transit networks were required to represent the different levels of transit service that occur in the various time periods.

External-local productions at the nine-county cordon stations were disaggregated into peak, midday, and evening components using percentages derived from the temporal distribution of traffic counts taken at each cordon station.

Figure 1
EVANS ITERATIVE TRAVEL SIMULATION PROCESS



B. Free Flow Highway Speeds

Input highway operating speeds for the enhanced DVRPC model were estimated from a special highway travel time survey conducted as part of the Model Enhancement Study. The study, completed in 1997, surveyed about 2,000 miles of roadways within the DVRPC region using floating car techniques. Several additional changes were required to produce reasonably accurate estimates of highway traffic volumes and operating speeds directly from the highway assignment model. The number of functional classes in the highway link speed/capacity lookup table was increased from 9 to 27 to better account for detailed design capacity variations within the general functional class designations (freeway, parkway, principal arterial, etc.). The expanded link hourly capacity table stratified by functional class and area type are given in Section C 2 of Chapter III below. The initial highway network speeds were modified to reflect free-flow speeds (speed limits or measured operating speeds, which ever is higher). The input highway network free flow speeds are listed in Table 1. Finally, a formal toll plaza queuing model was implemented to better model the toll collection congestion and delay on the Turnpikes and Toll Bridges within the region. These changes improved the accuracy of the highway link volumes produced by the Evans process and brought the model into compliance with recent federal requirements.

Table 1. Free Flow Speeds (mph)

	Free-Flow Speeds (mph)				
	CBD (1)	Fringe (2)	Urban (3)	Suburban (4)	Rural (5)
Freeway	50.0	55.0	55.0	55.0	60.0
Parkway	45.0	45.0	50.0	60.0	55.0
Principal Arterial	30.0	30.0	35.0	40.0	50.0
Secondary Arteria	25.0	25.0	30.0	35.0	45.0
Collector / Local	15.0	15.0	20.0	35.0	35.0
Ramp	20.0	35.0	40.0	45.0	45.0

C. The Enhanced DVRPC Model Process

The enhanced iterative DVRPC model is charted in Figure 1. The first step in the process involves generating the number of trips that are produced by and destined for each traffic zone and cordon station throughout the nine-county region.

1. Trip Generation

Both internal trips (those made within the DVRPC region) and external trips (those which cross the boundary of the region) must be considered in the simulation of regional travel. Internal trip generation is based on zonal forecasts of population and employment, whereas external trips are estimated from cordon line traffic counts. The latter also include trips which pass through the Delaware Valley region. Estimates of internal trip productions and attractions by zone are established on the basis of trip rates applied to the zonal estimates of demographic and employment data. This part of the DVRPC model is not iterated on highway travel speed. rather, estimates of daily trip making by traffic zone are calculated and then disaggregated into peak, midday, and evening time periods.

2. Evans Iterations

The iterative portion of the Evans forecasting process involves updating the highway network restrained link travel speeds, rebuilding the minimum time paths through the network, and skimming the inter-zonal travel time for the minimum paths. Then the trip distribution, modal split, and highway assignment models in sequence for each pass through the model chain (see Figure 1). After convergence is reached, the transit trip tables for each iteration are weighted together and the weighted average table assigned to the transit network. The highway trip tables are loaded onto the network during each Evans iteration. A composite highway trip table is not required to perform the highway assignment. For each time period, seven iterations of the Evans process are performed to ensure that convergence on travel times is reached.

3. Trip Distribution

Trip distribution is the process whereby the zonal trip ends established in the trip generation analysis are linked together to form origin-destination patterns in the trip table format. Peak, midday, and evening trip ends are distributed separately. For each Evans iteration, a series of seven gravity-type distribution models were applied at the zonal level. These models follow the trip purpose and vehicle type stratifications established in trip generation. Documentation of the trip distribution models is included in the commission report entitled, "1997 Travel Simulation Model for the Delaware Valley Region."

4. Modal Split

The modal split model is also run separately for the peak, midday and evening time periods. The modal split model calculates the fraction of each person-trip interchange in the trip table which should be allocated to transit, and then assigns the residual to highway. The choice between highway and transit usage is made on the basis of comparative cost, travel time, and frequency of service, with other aspects of modal choice being used to modify this basic relationship. In general, the better the transit service, the higher the fraction assigned to transit, although trip purpose and auto ownership also affect the allocation. The model subdivides highway trips into auto drivers and passengers. Auto driver trips are added to the truck, taxi, and external vehicle trips in preparation for assignment to the highway network. See "1990 Travel Simulation Model for the Delaware Valley Region" for a detailed description of the model parameters.

5. Highway Assignment

The final step in the simulation process is the assignment of vehicle trips to the highway network. For peak, midday, and evening travel, this assignment model produces the future traffic volumes for individual highway links that are required for planning analyses. The regional nature of the highway network and trip table underlying the assignment process allow the diversion of travel into and through the study area to various points of entry and exit in response to the characteristics of the transportation system.

For each Evans iteration, highway trips are assigned to the network by determining the best (minimum time) route through the highway network for each zonal interchange and then allocating the interzonal highway travel to the highway facilities along that route. This assignment model is "capacity restrained" in that congestion levels are considered when determining the best route. The Evans equilibrium assignment method is used to implement the capacity constraint. When the assignment and associated trip table reach equilibrium, no path faster than the one actually assigned can be found through the network, given the capacity restrained travel times on each link.

6. Transit Assignment

After equilibrium is achieved, the weighted average transit trip tables (using the Lambda's calculated from the overall Evans process as weights) are assigned to the transit network to produce link and route passenger volumes. The transit person trips produced by the modal split model are "linked" in that they do not include any transfers that occur either between transit trips or between auto approaches and transit lines. The transit assignment procedure accomplishes two major tasks. First, the transit trips are "unlinked" to include transfers, and second, the unlinked transit trips are associated with specific transit facilities to produce link, line, and station volumes. These tasks are accomplished simultaneously within TRANPLAN, which assigns the transit trip matrix to minimum impedance paths built through the transit network. There is no capacity restraining procedure in the transit assignment model.

Page intentionally left blank

III. THREE TIME PERIODS TRAVEL SIMULATION

The version of the new DVRPC model implemented in FY 99 and documented in the commission report entitled, "1997 Travel Simulation Model for the Delaware Valley Region" had two time periods: peak which covered the time periods from 7:00 AM to 9:00 AM and 4:00 PM to 6:00 PM, and off-peak, which included the remainder of the day. A major shortcoming of this temporal division is that the midday and night time periods have vastly different characteristics in terms of highway congestion and transit service levels. This leads to underestimated highway VMT and travel speeds. In addition, transit ridership is overestimated when mid-day operating speeds and transit service patterns are taken as representative for night time travel. Splitting the off-peak period into midday and evening travel requires:

- Developing additional factors to divide the trip generation output and external-local/through trips into the midday and evening time periods.
- Coding separate transit networks for the midday and evening time periods. Service levels vary significantly between midday and evening.
- Refining and updating the highway link capacities used in the capacity restraint. Also, developing separate "CONFAC" settings to allocate the daily capacity to the mid-day and evening time periods.
- Developing separate "K" factors (i.e. the percent of the time period volume that occurs in the peak hour) for midday and evening for use in the toll queuing model.
- Fine tuning the modal split model to produce accurate transit results for each time period. The parameters and results of the modal split model fine tuning are documented in the nested modal split section below.
- Fine tuning the gravity model parameters and other simulation model parameters to achieve highway screenline validation.

A. Trip Generation Time Periods Factors

1. Person Trips

The off-peak person trip factors by purpose were disaggregated into midday (9:00 AM to 3:00 PM) and evening (6:00 PM-7:00 AM) using the percentage of midday to evening travel obtained from the DVRPC 1988-89 home interview survey. These percentages summarized by trip purpose (Home Based Work (HBW), Home-based Non-work (HBNW) and Non-home based (NHB) were as follows:

	Trip Purpose			
Time Period	**HBW**	**HBNW**	**NHB**	**Total**
Midday	32.0 %	49.9 %	80.7 %	54.7 %
Evening	68.0	50.1	19.3	45.3 %
Total	**100.0 %**	**100.0 %**	**100.0 %**	**100.0 %**

Applying these percentages to dissagregate the consultant recommended off-peak percentages, the following time period breakdown was obtained (the peak percentages are taken directly from the consultants recommendations):

	Trip Purpose		
Time Period	**HBW**	**HBNW**	**NHB**
Midday	52.8 %	31.4 %	26.7 %
Evening	15.1	32.4	59.2
Total	**100.0 %**	**100.0 %**	**100.0 %**

As an approximate check on the percentages given above, the 1997 trip generation model output was disaggregated by time of day using the above factors and the results in percentage terms compared to the time period breakdown of traffic counts taken at 1,953 locations randomly selected throughout the Region. The results of the trip generation disaggregation are shown below:

	Trip Purpose			
Time Period	**HBW Trips (000)**	**HBNW Trips (000)**	**NHB Trips (000)**	**Total Trips (000)**
Midday	2,234	2,895	1,073	6,202
Evening	639	3,153	2,379	6,171
Total	**4,231**	**9,219**	**4,019**	**17,469**

The comparison between the percent of total person trips generated by time period and the percent of daily traffic counts tabulate by the same time periods is shown below:

	Percent of Daily Travel	
Time Period	**Generated Person Trips**	**Traffic Counts**
Midday	35.0 %	36.3 %
Evening	35.3	33.0
Total	**100.0 %**	**100.0 %**

There is a close correspondence between the trip generation results and the aggregated traffic count data by time period. The differences are always less than 3 percent. This is strong evidence that the time period disaggregation factors given above are correct.

2. Truck Trips

Commercial vehicles (trucks and taxis) were disaggregated by time period using the hourly percentages given in Table 4-4 of the Quick Response Freight Manual prepared by Cambridge Systematics for the Federal Highway Administration. This is the same source used by Cambridge Systematics for their peak and off-peak factors and the disaggregation of the off-peak factor into midday and evening is a straight forward extension of the consultants recommendation. In this study separate factors are given for light trucks (four-tire) and heavy trucks (average of 6+tire and combinations). Taxis are assumed to have the temporal distribution as light trucks. The three time period truck/taxi factors are as follows:

	Percent of Daily Travel	
Time Period	**Light Truck**	**Heavy Truck**
Peak	36.5	29.7
Midday	34.0	41.8
Evening	29.5	28.5
Total	**100.0**	**100.0**

3. External-Local Trips

As in the consultant's recommendations, external local trips are disaggregated by time of day based on the temporal distribution of the traffic counted at that location. For cordon stations where traffic counts are not available, the temporal distribution of traffic is taken from a comparable location where a traffic count was available. This is the same methodology recommended by the consultant, except that off-peak is split into midday and evening time periods. The percentage distribution utilized to split down traffic into peak, midday and evening external trip productions is given in Table 2. See the "1997 Travel Simulation Model for the Delaware Valley Region" for a correspondence between cordon station number and station description.

Table 2. 1997 Peak Period Factors for External Local Trips

Cordon Station	Time Peroid Percentage Peak	Mid-Day	Evening	Total
1396	41.6	29.4	29.0	100.0
1397	36.9	33.6	29.5	100.0
1398	39.3	32.5	28.2	100.0
1399	33.5	18.5	48.0	100.0
1400	37.3	29.2	33.5	100.0
1401	40.8	32.2	27.0	100.0
1402	36.6	36.2	27.2	100.0
1403	35.3	27.8	36.9	100.0
1404	40.2	32.2	27.6	100.0
1405	34.7	32.9	32.4	100.0
1406	52.4	25.8	21.8	100.0
1407	43.5	31.5	25.0	100.0
1408	38.5	33.5	28.0	100.0
1409	42.1	33.5	24.4	100.0
1410	34.3	33.8	31.9	100.0
1411	39.8	33.3	26.9	100.0
1412	38.4	28.9	32.7	100.0
1413	39.2	28.5	32.3	100.0
1414	36.0	31.9	32.1	100.0
1415	34.0	33.9	32.1	100.0
1416	34.9	31.4	33.7	100.0
1417	38.5	33.5	28.0	100.0
1418	35.8	33.7	30.5	100.0
1419	37.4	33.8	28.8	100.0
1420	39.1	27.6	33.3	100.0
1421	36.4	36.2	27.4	100.0
1422	30.4	36.2	33.4	100.0
1423	35.5	35.4	29.1	100.0
1424	38.5	33.5	28.0	100.0
1425	34.2	38.8	27.0	100.0
1426	34.8	36.9	28.3	100.0
1427	38.5	38.5	23.0	100.0
1428	35.3	27.8	36.9	100.0
1429	38.4	36.4	25.2	100.0
1430	35.6	32.9	31.5	100.0
1431	38.5	32.9	28.6	100.0
1432	38.5	32.9	28.6	100.0
1433	41.4	30.5	28.1	100.0
1434	35.6	33.9	30.5	100.0
1435	36.9	30.5	32.6	100.0
1436	38.5	32.9	28.6	100.0
1437	36.4	38.8	24.8	100.0
1438	31.0	34.5	34.5	100.0
1439	36.6	36.2	27.2	100.0
1440	38.5	32.9	28.6	100.0
1441	38.5	32.9	28.6	100.0
1442	38.5	33.5	28.0	100.0
1443	36.9	32.0	31.1	100.0
1444	35.3	27.8	36.9	100.0
1445	42.7	23.6	33.7	100.0
1446	38.5	23.6	37.9	100.0
1447	34.1	32.7	33.2	100.0
1448	34.1	31.4	34.5	100.0
1449	38.5	31.5	30.0	100.0
1450	37.7	31.6	30.7	100.0
1451	35.3	33.1	31.6	100.0
1452	38.5	31.5	30.0	100.0
1453	38.5	33.1	28.4	100.0
1454	36.4	33.1	30.5	100.0

Cordon Station	Time Peroid Percentage Peak	Mid-Day	Evening	Total
1455	36.9	33.1	30.0	100.0
1456	35.3	31.5	33.2	100.0
1457	36.9	33.1	30.0	100.0
1458	35.3	32.9	31.8	100.0
1459	36.4	29.0	34.6	100.0
1460	36.4	29.0	34.6	100.0
1461	31.5	34.7	33.8	100.0
1462	38.5	26.7	34.8	100.0
1463	39.4	27.7	32.9	100.0
1464	38.5	28.0	33.5	100.0
1465	31.0	36.3	32.7	100.0
1466	33.2	35.2	31.6	100.0
1467	36.1	33.5	30.4	100.0
1468	38.5	27.2	34.3	100.0
1469	36.4	27.7	35.9	100.0
1470	39.4	32.1	28.5	100.0
1471	36.9	27.2	35.9	100.0
1472	35.3	27.8	36.9	100.0
1473	39.3	32.1	28.6	100.0
1474	38.5	28.4	33.1	100.0
1475	36.9	23.6	39.5	100.0
1476	39.0	32.7	28.3	100.0
1477	36.9	33.4	29.7	100.0
1478	38.5	23.6	37.9	100.0
1479	38.5	28.8	32.7	100.0
1480	36.4	32.6	31.0	100.0
1481	36.4	34.8	28.8	100.0
1482	36.4	32.8	30.8	100.0
1483	36.4	36.5	27.1	100.0
1484	36.6	39.3	24.1	100.0
1485	38.5	34.0	27.5	100.0
1486	36.4	31.7	31.9	100.0
1487	38.5	39.8	21.7	100.0
1488	38.5	33.1	28.4	100.0
1489	35.1	33.6	31.3	100.0
1490	36.4	30.3	33.3	100.0
1491	34.5	34.4	31.1	100.0
1492	38.5	30.5	31.0	100.0
1493	35.3	27.8	36.9	100.0
1494	36.9	35.1	28.0	100.0
1495	36.1	30.8	33.1	100.0
1496	34.6	33.5	31.9	100.0
1497	36.9	35.5	27.6	100.0
1498	36.5	34.1	29.4	100.0
1499	36.6	34.9	28.5	100.0
1500	34.3	37.0	28.7	100.0
1501	36.4	32.8	30.8	100.0
1502	38.5	32.1	29.4	100.0
1503	38.5	35.3	26.2	100.0
1504	36.4	32.2	31.4	100.0
1505	36.4	31.7	31.9	100.0
1506	35.3	27.8	36.9	100.0
1507	36.9	32.1	31.0	100.0
1508	33.0	28.9	38.1	100.0
1509	36.9	32.1	31.0	100.0

4. Through Trips

Through trips were disaggregated into the peak, midday, and evening time periods based on the average time period factors from the cordon traffic count data presented above. The factors used to disaggregate through travel were 0.367 in the peak, 0.329 for the midday time period, and 0.304 during the evening.

B. Toll Plaza "K" Factors

The toll queing statistical model is registered to hourly travel and requires estimates of the percentage of time period volume that occurs in the peak hour. This factor is used to convert the total assigned volume for that time period into the equivalent peak hour for the toll plaza delay calculation. This differs from the normal K factor which relates peak hour traffic to daily traffic volumes. But, as in the daily K factor calculation, these percentages are based on hourly tabulations for traffic counts. Available 1997 hourly toll collection tabulations were used to calculate the "K" factor for the highway toll collection facilities within the DVRPC region (Pennsylvania, New Jersey, and Atlantic City turnpike toll plazas and the Delaware River bridge toll plazas). These "K" factors were taken for the most part from hourly toll booth counts by direction where available. In cases where the toll collection data was not available, the peak, midday, and evening "K values from similar facilities were substituted. The "K" values for the toll plaza queing model used in the 1997 peak, midday, and evening simulations are given in Table 4 below:

Table 3. "K" Factors for Highway Toll Collection Facilities

	------ "K" Value -------		
Location	Peak	Midday	Evening
PA TPKE DOWNINGTOWN IN	0.25	0.23	0.15
PA TPKE DOWNINGTOWN OUT	0.25	0.23	0.15
PA TPKE VALLEY FORGE IN	0.26	0.25	0.14
PA TPKE VALLEY FORGE OUT	0.26	0.25	0.14
PA TPKE NORRISTOWN IN	0.25	0.23	0.14
PA TPKE NORRISTOWN OUT	0.25	0.23	0.14
PA TPKE MID-COUNTY IN	0.25	0.22	0.14
PA TPKE MID-COUNTY OUT	0.25	0.22	0.14
PA TPKE FT WASHINGTON IN	0.22	0.23	0.18
PA TPKE FT WASHINGTON OUT	0.22	0.23	0.18
PA TPKE WILLOW GROVE IN	0.22	0.23	0.17
PA TPKE WILLOW GROVE OUT	0.22	0.23	0.17
PA TPKE PHILADELPHIA IN	0.25	0.23	0.17
PA TPKE PHILADELPHIA OUT	0.25	0.23	0.17
PA TPKE DELAWARE VALLEY IN	0.25	0.23	0.17
PA TPKE DELAWARE VALLEY OUT	0.25	0.23	0.17
PA TPKE LANSDALE IN	0.31	0.20	0.15
PA TPKE LANSDALE OUT	0.31	0.20	0.15
PA TPKE QUAKERTOWN IN	0.31	0.20	0.15
PA TPKE QUAKERTOWN OUT	0.31	0.20	0.15
NJ TPKE SWEDESBORO IN	0.52	0.13	0.13
NJ TPKE SWEDESBORO OUT	0.33	0.21	0.13
NJ TPKE WOODBURY IN	0.33	0.25	0.15

Table 3. "K" Factors for Highway Toll Collection Facilities (Continued)

Location	Peak	Midday	Evening
NJ TPKE WOODBURY OUT	0.36	0.20	0.15
NJ TPKE CAMDEN IN	0.26	0.21	0.18
NJ TPKE CAMDEN OUT	0.25	0.20	0.18
NJ TPKE BURLINGTON IN	0.34	0.37	0.17
NJ TPKE BURLINGTON OUT	0.29	0.23	0.20
NJ TPKE FLORENCE IN	0.27	0.20	0.19
NJ TPKE FLORENCE OUT	0.24	0.21	0.18
NJ TPKE BORDENTOWN IN	0.25	0.22	0.16
NJ TPKE BORDENTOWN OUT	0.28	0.19	0.19
NJ TPKE ALLENTOWN IN	0.36	0.30	0.18
NJ TPKE ALLENTOWN OUT	0.31	0.19	0.20
NJ TPKE HIGHTSTOWN IN	0.43	0.18	0.14
NJ TPKE HIGHTSTOWN OUT	0.30	0.20	0.16
AC EXPWY WILLIAMSTOWN IN	0.35	0.23	0.18
AC EXPWY WILLIAMSTOWN OUT	0.35	0.23	0.20
AC EXPWY WINSLOW IN	0.35	0.23	0.18
AC EXPWY WINSLOW OUT	0.35	0.23	0.20
COMMODORE BARRY BRIDGE	0.31	0.21	0.27
COMMODORE BARRY BRIDGE	0.31	0.21	0.27
WALT WHITMAN BRIDGE	0.29	0.24	0.22
WALT WHITMAN BRIDGE	0.29	0.24	0.22
BEN FRANKLIN BRIDGE	0.29	0.23	0.20
BEN FRANKLIN BRIDGE	0.29	0.23	0.20
BETSY ROSS BRIDGE	0.32	0.23	0.27
BETSY ROSS BRIDGE	0.32	0.23	0.27
TACONY-PALMYRA BRIDGE	0.29	0.23	0.27
TACONY-PALMYRA BRIDGE	0.29	0.23	0.27
BURLINGTON-BRISTOL BRIDGE	0.29	0.23	0.20
BURLINGTON-BRISTOL BRIDGE	0.29	0.23	0.20
TRENTON FREEWAY BRIDGE	0.35	0.23	0.27
TRENTON FREEWAY BRIDGE	0.35	0.23	0.27
US 202 BRIDGE	0.35	0.23	0.27
US 202 BRIDGE	0.35	0.23	0.27
PA TPKE BRIDGE	0.28	0.23	0.17
PA TPKE BRIDGE	0.28	0.23	0.17

C. Highway Network and Toll Facility Coding

The highway network and toll facility coding conventions generally follow TRANPLAN conventions included in TRANPLAN Version 9.1. For purposes of creating a "build" alternative, highway network coding is accomplished by editing the link and node records in the highway network cards file. By convention, this file has a ".cds" extension. The cards file contains a file name for the built highway network in binary, TRANPLAN format, header records to describe the alternative to be modeled, a speed/capacity lookup table, node records, and link records.

The node records, have an "N" in column 1, followed by the node number in columns 2-6, the X-coordinate in columns 13-17, and the Y-coordinate in columns 24-28. X and Y coordinates are expressed in hundredths of miles and are taken from the USGS "Quads" using the 1927 UTM scale. The X-coordinate is simply miles*100, the Y-coordinate is in (miles-2000)*100.

The link records are comprised of A and B node numbers, area type, distance, direction codes, functional class, number of lanes, and DVRPC's county planning area codes. Sample link records have the form:

```
11333110364  19S      0 2 4 120           01
11333113323  13S      0 3 4 120           01
11333113343  23S      0 4 4 120           01
11334  6033  25S1875  0 3 7 020     0     01
11334113333  23S      0 2 4 120           01
11334113383  84S      0 4 4 121           01
11335  6033  25S1875  0 2 7 020     0     01
11335113323  37S      0 2 4 120           01
11335113373  33S      0 4 4 121           01
```

where:

Columns 1 - 5	A-Node
Columns 6 -10	B-Node
Column 11	Area Type 1 - CBD 2 - CBD fringe 3 - Urban 4 - Suburban 5 - Rural 6 - Open Rural
Columns 12-15	Distance, in hundredths of miles
Column 16	"S" or "T" (for speed or time)
Columns 17-20	Hardcoded speed (or time) to override speed/capacity lookup table value. Centroid connectors have hardcoded speeds (18.75 mph) in this example.
Column 24	Not used
Column 26	Direction Code 1 - Northbound 2 - Eastbound 3 - Southbound 4 - Westbound
Columns 27- 28	Functional Class 11 - High Freeway/Expressway 1 - Medium Freeway/Expressway 21 - Low Freeway/Expressway 12 - High Parkway 2 - Medium Parkway 22 - Low Parkway 13 - High Major Arterial 3 - Medium Major Arterial 23 - Low Major Arterial

	14 - High Minor Arterial 4 - Medium Minor Arterial 24 - Low Minor Arterial 16 - High Collector/Local 6 - Medium Collector/Local 26 - Low Collector/Local 7 - Centroid Connector 18 - High Ramp 8 - Medium Ramp 28 - Low Ramp 38 - Turnpike Ramp 9 - Dummy or Toll Link
Column 30	Number of lanes (centroid connectors have 0 lanes)
Columns 31-32	County Planning Area identifier
Columns 33-38	Hard Coded Capacity (to override lookup value; centroid connectors and dummy links have 0 capacity)
Column 58	One or two-way link (all DVRPC links are one-way, with separate link records for each direction).

More information on highway network coding conventions and procedures can be found on pages 81-96 of *1990 Validation of DVRPC Travel Simulation Models*, and pages 81-86 of *1997 Travel Simulation for the Delaware Valley Region.* Note that the toll charges on page 89 of *1990 Validation* have since been updated to 2000 values. Also note that the number of functional classes has been increased and that the location of the area type and functional class fields have been switched from what is listed in *1990 Validation.*

Once the highway network cards file has been edited, run TRANPLAN to build the network in binary format, then run the highway macro update file (MACROUP25.IN) to insert toll values on the appropriate links. Note that a customized version of the TRANPLAN module EQUILB.EXE must be used with DVRPC's toll/queuing model.

D. Toll Facility Coding Specifications

The DVRPC Evans process minimizes the weighted sum of out of vehicle, in-vehicle, and dollar cost to achieve the equilibrium solution. This time and cost includes both transit and highway. Highway costs include vehicle operating, parking, and toll. And highway times also include delay at toll collection facilities.

The toll facility coding specifications involve two aspects of the model.

1. Toll cost
2. Toll collection facility delay because of deceleration, queing at booth, and acceleration.

Following TRANPLAN conventions, the dollar cost for toll facilities is inserted from a lookup table given in the EQUILB program control cards. This lookup value is indexed through a number inserted into the cost field using the macro highway update program. For fixed cost toll facilities (bridges), the toll charge is inserted through the dummy link representing the toll booth. For distance based toll charges (turnpikes) the toll charge is inserted on a dummy link along the turnpike roadway approximately halfway in between the toll plazas. For turnpike toll booths, a zero toll must be inserted using cost codes on the toll booth link. For new toll facilities, you will need to enter an index into the COST field. The index will range from 1 to 20, and corresponds to one of the 20 toll values listed in the equilibrium highway assignment portion of the *.in file:

TOLLS = 0.05, 0.10, 0.15, 0.20, 0.25, 0.30, 0.00, 0.40, 0.45, 0.50,
0.55, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90, 1.00, 2.00

These are one-way toll values in dollars. For facilities where a toll is collected in one direction only, assign half of the toll to each direction. These tolls represent cost in 1990 constant dollars. For future conditions we (necessarily) assume that tolls will increase at approximately the rate of inflation and therefore remain constant in 1990 dollars.

E. Toll Collection Facility Queuing Model

The Evans model formulation also includes the travel time delay associated with vehicle deceleration, toll booth queuing delay, and vehicle acceleration. This queuing model is implemented through an adaptation of the Florida Turnpike Model included in the EQUILB computer program. The application of the Florida model to the DVRPC Evans process involved two customizations, 1) "K Factor" to convert time period (Peak, Midday, or Night) traffic volumes into the maximum hour volume within each time period. - the Florida model was a peak hour assignment model - and 2), convert the time based delay calculations into Evans impedances. These enhancements are included in TRANPLAN version 9.1 and require a "DVRPC" code in the options section of the control cards.

The toll booth queuing model requires a control card to describe the characteristics of the toll collection facility. These cards are included in the "TOLDATAP.CDS. TOLDATAM.CDS, AND TOLDATAN.CDS data sets in the SIM25PK, SIM25MID, and SIM25NIT directories. The format of these cards follows the Tranplan conventions described in the EQUILB documentation except that the last column is a "K factor" as described above. Please note that this K is not peak hour over daily traffic as usually defined, but rather maximum volume within a given time period divided by total traffic volume for that time period.

Examples of TOLDATA cards follow. See the TRANPLAN manual for the format. The 0.23 in the last column of the first card represents a time period K of 23%.

```
1 4  2313 14316 PA TPKE DOWNINGTOWN IN    4           0:06 1 1        0.09 0.23
1 4 14316  2313 PA TPKE DOWNINGTOWN OUT   6           0:12 1 1        0.09 0.23
1 4  2314 14317 PA TPKE VALLEY FRGE IN    5           0:06 1 1        0.10 0.25
1 4 14317  2314 PA TPKE VALLEY FRGE OUT   9           0:12 1 1        0.09 0.25
1 4 14319 14318 PA TPKE NORRISTOWN IN     4           0:06 1 1        0.10 0.23
1 4 14318 14319 PA TPKE NORRISTOWN OUT    6           0:12 1 1        0.06 0.23
```

A few other coding conventions:

- Turnpike acceleration and deceleration ramps get a functional class (FC) of 18.
- Toll booth links and mid-interchange links for accessing turnpike tolls should be given a FC of 9.
- As per the Tranplan documentation, acceleration or deceleration links must have a dummy link separating them from the outside network.

D. Gravity Model and Trip Assignment Factors

1. Gravity Model Parameters.

The gravity model utilizes a system of "River Penalties" to accurately model the number of highway and transit trips crossing the Delaware River. Without the river penalties, the gravity model would produce too many trips crossing the river. In the non-iterative DVRPC model, a penalty of ten minutes was found to give good results. In the two time-period (peak and off-peak) iterative Evans model, a Delaware River Penalty of 20 minutes was required. For the three period model, a Delaware River penalty of 16 minutes gives acceptable results. In both the two and three period models, the same river penalty was applied to all time periods. In all other respects, the gravity model was run in an identical fashion to that described in Chapter XI of the 1997 Travel Simulation Report. This produces acceptable results for the temporal distribution of river crossings as is shown by Table 4 for the DRPA bridges. This comparison is limited to the DRPA bridges because hourly distribution of toll collections was not available for the other bridges on the Delaware River Screenline.

Table 4. Westbound Time Period Distribution of River Crossings for the DRPA Bridges

Time Period	Counted Traffic	Percent of Total	Simulated Traffic	Percent of Total
Peak	49,584	39.8	46,132	39.4
Midday	36,176	29.0	34,534	29.5
Evening	38,973	31.2	36,560	31.2
Total	**124,733**	**100.0**	**117,226**	**100.1**

It is clear from the above table that the temporal breakdown of DRPA bridge crossings is reasonably correct in both absolute and percentage terms. These results verify both the temporal trip generation factors and the gravity model river penalties. However, the reader should be aware the trip generation person trip factors represent a grand average for the region and only work well in the center of the region. The quality of the time period highway assignment results varies significantly by highway functional class and area of the region. To produce accurate time period assignments everywhere, the trip generation factors, at a minimum, should be disaggregated by area type. With the present factors, the highway assignment results should be tabulated on a daily basis and then re-disaggregated by time period using localized k factors from traffic counts.

2. Refinement of Highway Network Link Capacities

The new travel simulation models will employ three "per lane hourly capacities" for each functional class (at Level of Service "E"), corresponding to a high, medium, and low value. This will reflect the wide range of capacities that are observed on the various highway types due to differences in lane width; lateral clearance; truck use; density of ramps, signals, and/or driveways; median treatment, sub-standard geometry, etc. that cannot be completely accounted for simply by varying capacity by area type. Employing three values for each functional classification will allow for easier and more accurate model calibration. Also, the number of lanes was changes from the number of intersection approach lanes to the number of mid-block lanes in the base network. The designation of high, medium or low capacity is intended to represent the type of intersection treatment at the approach end of each link.

Note that the "high" and "low" values do not correspond to absolute maximum and minimum values, but rather to values that are representative of very favorable or very poor conditions for the given functional classification and area type.

This section documents the assumptions and procedures used to calculate these capacities. Attempts were made to 1.) use the existing value as the "medium" capacity, 2.) base the calculations for the various facility types on the methods in the *Highway Capacity Manual* (HCM), and 3.) only vary capacities by area type where the existing values vary (e.g. since urban and suburban parkways currently have the same hourly capacity, they will have the same range of values).

In addition, some capacity values were taken from *Enhancement of DVRPC's Travel Simulation Models: Task 1. Highway Network and Assignment Revisions*. These included "high" values for Freeways, Collectors/Locals, and Ramps. *Task 1* values were used for freeways because it was desirable to have "high" values somewhat higher than 2,300 vphpl, which is the maximum value possible in the HCM. For Collectors/Locals and Ramps, *Task 1* values were used in the high range because these values were found to produce reasonable results in the context of the travel simulation models, and it is not possible to use the HCM methods to derive capacities this low.

All values were rounded to the nearest ten.

FREEWAYS

Freeway capacities are calculated as (refer to HCM chapter 3):

capacity/lane $= MSF * f_w * f_{HV} * f_p$

where:
- MSF = Maximum capacity (service flow) under ideal conditions,
- f_w = Lane width/lateral clearance factor
- f_{HV} = Heavy vehicle factor
- f_p = Recreational/unfamiliar driver population factor

Rural Freeways

Rural freeways are characterized by large distances between interchanges and therefore capacities are determined by the basic freeway segment. The availability of right-of-way in rural areas usually permits wide lane and shoulder widths.

High range: capacity/lane = *Task 1* value = 2,493 = 2,490 vehicles.

Medium range: capacity/lane = existing value = 2,100 vehicles.

Low range:
- MSF = 2,300 (per HCM)
- f_w = 0.95 (twelve foot lanes, two foot lateral clearances)
- f_{HV} = 0.833 (ten percent trucks, rolling terrain)
- f_p = 0.95 (some unfamiliar drivers)
- capacity/lane = (2300)(0.95)(0.833)(0.95) = 1,729 = 1,730 vehicles.

Suburban Freeways

Suburban freeways typically have much closer interchange spacing than rural freeways. It is assumed that the interchange capacity restricts the ultimate capacity of suburban freeways. Rather than assume typical on/off ramp volumes, acceleration/deceleration lane lengths, and mainline volumes, suburban freeway capacities were calculated with the same formula as rural freeways, but with the MSF value decreased to account for the interchange effects. A value of 2,233 was used [4,400 ("max V_{12}" from HCM table 5-1) plus 2,300 (the MSF of a hypothetical third lane) divided by 3]. The low range for suburban freeways also includes slightly narrower lanes/lateral clearances than rural freeways.

High range: capacity/lane = *Task 1* value = 2,431 = 2,430 vehicles.
Medium range: capacity/lane = existing value = 2,000 vehicles.
Low range:
- MSF = 2,233
- f_w = 0.90 (eleven foot lanes, two foot lateral clearances)

f_{HV} = 0.833 (ten percent trucks, rolling terrain)
f_p = 0.95 (some unfamiliar drivers)
capacity/lane = (2233)(0.90)(0.833)(0.95) = 1,590 = 1,590 vehicles.

Urban/Fringe/CBD Freeways

Freeways in these three area types currently have the same capacity; therefore, the same high, medium, and low values will be used for these area types (except for "high" Urban freeways). Per lane capacities for these freeways are calculated like the suburban freeways, although slightly smaller lane widths and lateral clearances are assumed due to the limited right-of-way available in urban areas.

High range: capacity/lane = *Task 1* value = 2,332 = 2,330 vehicles for Urban areas.
= 2,315 = 2,320 vehicles for CBD/Fringe areas.

Medium range: capacity/lane = existing value = 1,950 vehicles.

Low range: MSF = 2,233 (per HCM)
f_w = 0.82 (eleven foot lanes, no lateral clearance)
f_{HV} = 0.833 (ten percent trucks, rolling terrain)
f_p = 0.95 (some unfamiliar drivers)
capacity/lane = (2233)(0.82)(0.833)(0.95) = 1,449 = 1,450 vehicles.

PARKWAYS

Parkways refer to a very high-type arterial with very few curb cuts or traffic signals. They may also include some grade separations and are typically divided with only a limited number of median openings. Parkway capacity would approach that of a freeway as the number of median openings, access points, and at-grade intersections approached zero. The capacity ranges for parkways were calculated in the same manner as for freeways, except that the MSF term was reduced to account for partial (rather than full) access control. The values used for MSF were taken from HCM table 7-11, which provides service flow rates for multi-lane rural and suburban highways. This is the HCM facility that most closely matches the travel simulation models parkways[1].

[1]The methods in Chapter 7 cannot be used to directly calculate capacity ranges for parkways. These procedures determine only the expected reduction in travel speeds from the free flow speed that occur do to non-ideal conditions (narrow lane widths, median openings, driveways, etc). Although it is possible to convert these speeds to resultant flow rates (i.e. using Figure 7-4) they would be only slightly lower than those for freeways. Parkways, however, represent facilities with significantly lower capacity than freeways. Additionally, the current model includes parkways in both urban and CBD fringe area types, for which the Multi-lane Rural and Suburban Highway procedures would not be applicable.

Rural Parkways

High range:

MSF = 1,800 (55 mph free-flow speed; interpolated from Table 7-11)
f_w = 0.86 (twelve foot lanes, no lateral clearance)
f_{HV} = 0.99 (two percent trucks, level terrain)
f_p = 1.00 (few unfamiliar drivers)
capacity/lane = (1800)(0.86)(0.99)(1.00) = 1,533 = 1,530 vehicles.

Medium range:

MSF = 1,800 (55 mph free-flow speed; interpolated from Table 7-11)
f_w = 0.82 (eleven foot lanes, no lateral clearance)
f_{HV} = 0.93 (four percent trucks, rolling terrain)
f_p = 1.00 (few unfamiliar drivers)
capacity/lane = (1800)(0.82)(0.93)(1.00) = 1,372 = 1,370 vehicles.

Low range:

MSF = 1,800 (55 mph free-flow speed; interpolated from Table 7-11)
f_w = 0.82 (eleven foot lanes, two foot lateral clearances)
f_{HV} = 0.833 (ten percent trucks, rolling terrain)
f_p = 0.90 (some unfamiliar drivers[2])
capacity/lane = (1800)(0.82)(0.833)(0.90) = 1,107 vehicles = 1,120 (since the calculated value is close to the existing value, that value will be used).

Suburban Parkways

High range:

MSF = 1710 (50 mph free-flow speed; from HCM Table 7-11)
f_w = 0.82 (eleven foot lanes, no lateral clearance)
f_{HV} = 0.99 (two percent trucks, level terrain)
f_p = 1.00 (few unfamiliar drivers)
capacity/lane = (1710)(0.82)(0.99)(1.00) = 1,388 = 1,390 vehicles.

Medium range:

MSF = 1710 (50 mph free-flow speed; from HCM Table 7-11)
f_w = 0.78 (ten foot lanes, no lateral clearance)
f_{HV} = 0.93 (four percent trucks, rolling terrain)
f_p = 1.00 (few unfamiliar drivers)
capacity/lane = (1710)(0.78)(0.93)(1.00) = 1,240 vehicles.

Low range:

MSF = 1,710 (50 mph free-flow speed; from Table 7-11)
f_w = 0.78 (ten foot lanes, no lateral clearances)
f_{HV} = 0.833 (ten percent trucks, rolling terrain)
f_p = 0.90 (some unfamiliar drivers)

---

[2]This value is lower than that of a freeway due to the greater effect unfamiliar drives have on capacity (due to the developed roadside – people looking for businesses, cross streets, etc).

capacity/lane = (1710)(0.78)(0.833)(0.90) = 1,000 vehicles = 960 (since the calculated value is close to the existing value, that value will be used).

Urban Parkways

High range:

MSF = 1590 (estimated from HCM Table 7-11)
f_w = 0.82 (eleven foot lanes, no lateral clearance)
f_{HV} = 0.99 (two percent trucks, level terrain)
f_p = 1.00 (few unfamiliar drivers)
capacity/lane = (1590)(0.82)(0.99)(1.00) = 1,291 = 1,290 vehicles.

Medium range:

MSF = 1590 (estimated from HCM Table 7-11)
f_w = 0.78 (ten foot lanes, no lateral clearance)
f_{HV} = 0.99 (four percent trucks, rolling terrain)
f_p = 1.00 (few unfamiliar drivers)
capacity/lane = (1590)(0.78)(0.93)(1.00) = 1,153 = 1,150 vehicles.

Low range: capacity/lane = existing value = 960 vehicles

Fringe/CBD Parkways

High range:

MSF = 1465 (estimated from HCM Table 7-11)
f_w = 0.82 (eleven foot lanes, no lateral clearance)
f_{HV} = 0.99 (two percent trucks, level terrain)
f_p = 1.00 (few unfamiliar drivers)
capacity/lane = (1465)(0.82)(0.99)(1.00) = 1,189 = 1,190 vehicles.

Medium range:

MSF = 1465 (estimated from HCM Table 7-11)
f_w = 0.78 (ten foot lanes, no lateral clearance)
f_{HV} = 0.93 (four percent trucks, rolling terrain)
f_p = 1.00 (few unfamiliar drivers)
capacity/lane = (1465)(0.78)(0.93)(1.00) = 1,063 = 1,060 vehicles.

Low range: capacity/lane = existing value = 960 vehicles

PRINCIPAL ARTERIALS

Capacities for Principal Arterials are calculated by combining the procedures in HCM Chapters 9 (Signalized Intersections) and 11 (Urban and Suburban Arterials). A saturation flow rate for the through movement is calculated with the method proscribed in Chapter 9. The per lane arterial capacity is then determined by multiplying the saturation flow rate by a representative g/C (green time/cycle length) value, per Chapter 11). This value may also include an adjustment to account for signal spacing. For example, a "high" range rural principal arterial will have a g/C ratio approaching 1.00 since there will be few signalized intersections to impede traffic flow, and those intersections will have the majority of the green time assigned to the principal arterial, rather than the cross streets. Assumptions regarding lane width, parking, bus operations, pedestrian volumes, and right and left turn treatments vary by area type. The basic equation is given by:

$$\text{capacity/lane} = (g/C)(s_0)(f_w)(f_{HV})(f_g)(f_p)(f_{bb})(f_a)(f_{RT})(f_{LT})$$

where:

g/C	=	through movement green time to cycle length ratio
s_0	=	ideal saturation flow rate = 1,900 cars/hour of green/lane
f_w	=	lane width adjustment factor
f_{HV}	=	heavy vehicle adjustment factor
f_g	=	grade adjustment factor
f_p	=	parking maneuver adjustment factor
f_{bb}	=	bus blockage adjustment factor
f_a	=	area type adjustment factor
f_{RT}	=	right turn treatment adjustment factor
f_{LT}	=	left turn treatment adjustment factor

Generally, as area types move from rural to urban to CBD, g/C ratios decrease (due primarily to higher volumes on the cross streets), lane widths decrease, parking and bus maneuvers increase, and the number of pedestrians increases which affects the right and left turn adjustment factors. To simplify calculations, values for f_{RT} where chosen from HCM Table 9-11B, using the entries for $P_{RTA} = 0$ (cases 2 and 5) and $P_{RT} = 0.2$ and 0.4. These cases represent the most common right turn treatments with typical turning movement proportions, and were found to provide a reasonable range of f_{RT} values for the various area types. The special procedures to calculate values for f_{LT} can not be directly applied to this type of hypothetical analysis. Rather, typical values were assumed, which decrease as left turn movements become more difficult.

Rural Principal Arterials

High range:	g/C	=	0.85
	s_0	=	1,900
	f_w	=	1.00 (twelve foot lanes)
	f_{HV}	=	0.98 (two percent heavy vehicles)
	f_g	=	1.00 (level grade)
	f_p	=	1.00 (no on-street parking)

	f_{bb}	= 1.00 (less than 5 bus stops/hr)
	f_a	= 1.00 (non-CBD)
	f_{RT}	= 0.97 (no pedestrians, P_{RT} = 0.2)
	f_{LT}	= 0.98
	capacity/lane = 1,504 = 1,500 vehicles	
Medium range:	capacity/lane = existing value = 1,100 vehicles	
Low range:	g/C	= 0.60
	s_0	= 1,900
	f_w	= 1.00 (twelve foot lanes)
	f_{HV}	= 0.909 (ten percent heavy vehicles)
	f_g	= 0.99 (two-percent grade)
	f_p	= 1.00 (no on-street parking)
	f_{bb}	= 0.98 (five to ten bus stops/hr)
	f_a	= 1.00 (non-CBD)
	f_{RT}	= 0.94 (no pedestrians, P_{RT} = 0.4)
	f_{LT}	= 0.96
	capacity/lane = 907 = 910 vehicles	

Suburban Principal Arterials

High range:	g/C	= 0.75
	s_0	= 1,900
	f_w	= 1.00 (twelve foot lanes)
	f_{HV}	= 0.98 (two percent heavy vehicles)
	f_g	= 1.00 (level grade)
	f_p	= 1.00 (no on-street parking)
	f_{bb}	= 0.98 (five to ten bus stops/hr)
	f_a	= 1.00 (non-CBD)
	f_{RT}	= 0.965 (low pedestrians, P_{RT} = 0.2)
	f_{LT}	= 0.98
	capacity/lane = 1,294 = 1,290 vehicles	
Medium range:	capacity/lane = existing value = 950 vehicles	
Low range:	g/C	= 0.55
	s_0	= 1,900
	f_w	= 1.00 (twelve foot lanes)
	f_{HV}	= 0.909 (ten percent heavy vehicles)
	f_g	= 0.99 (two-percent grade)
	f_p	= 1.00 (no on-street parking)
	f_{bb}	= 0.96 (ten bus stops/hr)
	f_a	= 1.00 (non-CBD)
	f_{RT}	= 0.93 (low pedestrians, P_{RT} = 0.4)

f_{LT} = 0.96
capacity/lane = 806 = 810 vehicles

Urban Principal Arterials

High range:

g/C = 0.70
s_0 = 1,900
f_w = 1.00 (twelve foot lanes)
f_{HV} = 0.98 (two percent heavy vehicles)
f_g = 1.00 (level grade)
f_p = 0.925 (10 parking maneuvers/hr)
f_{bb} = 0.96 (twenty bus stops/hr)
f_a = 1.00 (non-CBD)
f_{RT} = 0.951 (moderate pedestrians, P_{RT} = 0.2)
f_{LT} = 0.96
capacity/lane = 1,056 = 1,060 vehicles

Medium range: capacity/lane = existing value = 820 vehicles

Low range:

g/C = 0.60
s_0 = 1,900
f_w = 0.967 (eleven foot lanes)
f_{HV} = 0.909 (ten percent heavy vehicles)
f_g = 0.99 (two-percent grade)
f_p = 0.90 (20 parking maneuvers/hr)
f_{bb} = 0.95 (25 bus stops/hr)
f_a = 1.00 (non-CBD)
f_{RT} = 0.864 (high pedestrians, P_{RT} = 0.4)
f_{LT} = 0.94
capacity/lane = 688 = 690 vehicles

Fringe Principal Arterials

High range:

g/C = 0.65
s_0 = 1,900
f_w = 0.933 (ten foot lanes)
f_{HV} = 0.98 (two percent heavy vehicles)
f_g = 1.00 (level grade)
f_p = 0.90 (20 parking maneuvers/hr)
f_{bb} = 0.95 (25 bus stops/hr)
f_a = 0.95 (average of CBD and non-CBD)
f_{RT} = 0.932 (high pedestrians, P_{RT} = 0.2)
f_{LT} = 0.94
capacity/lane = 804 = 800 vehicles

Medium range: capacity/lane = existing value = 640 vehicles

Low range:

g/C = 0.60
s_0 = 1,900
f_w = 0.933 (ten foot lanes)
f_{HV} = 0.909 (ten percent heavy vehicles)
f_g = 0.99 (two-percent grade)
f_p = 0.875 (30 parking maneuvers/hr)
f_{bb} = 0.94 (30 bus stops/hr)
f_a = 0.95 (average of CBD and non-CBD)
f_{RT} = 0.788 (very high pedestrians, P_{RT} = 0.4)
f_{LT} = 0.92
capacity/lane = 542 = 540 vehicles

CBD Principal Arterials

High range:

g/C = 0.65
s_0 = 1,900
f_w = 0.967 (eleven foot lanes)
f_{HV} = 0.98 (two percent heavy vehicles)
f_g = 1.00 (level grade)
f_p = 0.90 (20 parking maneuvers/hr)
f_{bb} = 0.95 (25 bus stops/hr)
f_a = 0.90 (CBD area type)
f_{RT} = 0.894 (very high pedestrians, P_{RT} = 0.2)
f_{LT} = 0.94
capacity/lane = 757 = 760 vehicles

Medium range: capacity/lane = existing value = 600 vehicles

Low range:

g/C = 0.60
s_0 = 1,900
f_w = 0.933 (ten foot lanes)
f_{HV} = 0.909 (ten percent heavy vehicles)
f_g = 0.99 (two-percent grade)
f_p = 0.875 (30 parking maneuvers/hr)
f_{bb} = 0.94 (30 bus stops/hr)
f_a = 0.90 (CBD area type)
f_{RT} = 0.711 (extremely high pedestrians, P_{RT} = 0.4)
f_{LT} = 0.92
capacity/lane = 463 = 460 vehicles

SECONDARY ARTERALS

Secondary Arterials are similar to Principal Arterials with the most significant difference being a lower g/C value. This is due to both less green time available at signalized intersections and also many stop-controlled approaches at intersections with Principal Arterials, which significantly reduces the capacity of the approach.

Rural Secondary Arterials

High range:

$g/C = 0.65$
$s_0 = 1{,}900$
$f_w = 1.00$ (twelve foot lanes)
$f_{HV} = 0.98$ (two percent heavy vehicles)
$f_g = 1.00$ (level grade)
$f_p = 1.00$ (no on-street parking)
$f_{bb} = 1.00$ (less than 5 bus stops/hr)
$f_a = 1.00$ (non-CBD)
$f_{RT} = 0.97$ (no pedestrians, $P_{RT} = 0.2$)
$f_{LT} = 0.98$
capacity/lane = 1,151 = 1,150 vehicles

Medium range: capacity/lane = existing value = 800 vehicles

Low range:

$g/C = 0.45$
$s_0 = 1{,}900$
$f_w = 1.00$ (twelve foot lanes)
$f_{HV} = 0.909$ (ten percent heavy vehicles)
$f_g = 0.99$ (two-percent grade)
$f_p = 1.00$ (no on-street parking)
$f_{bb} = 0.98$ (five to ten bus stops/hr)
$f_a = 1.00$ (non-CBD)
$f_{RT} = 0.94$ (no pedestrians, $P_{RT} = 0.4$)
$f_{LT} = 0.96$
capacity/lane = 680 = 680 vehicles

Suburban Secondary Arterials

High range:

$g/C = 0.55$
$s_0 = 1{,}900$
$f_w = 1.00$ (twelve foot lanes)
$f_{HV} = 0.98$ (two percent heavy vehicles)
$f_g = 1.00$ (level grade)
$f_p = 1.00$ (no on-street parking)
$f_{bb} = 0.98$ (five to ten bus stops/hr)

	f_a	= 1.00 (non-CBD)
	f_{RT}	= 0.965 (low pedestrians, P_{RT} = 0.2)
	f_{LT}	= 0.98
	capacity/lane = 920 = 920 vehicles	
Medium range:	capacity/lane = existing value = 680 vehicles	
Low range:	g/C	= 0.40
	s_0	= 1,900
	f_w	= 1.00 (twelve foot lanes)
	f_{HV}	= 0.909 (ten percent heavy vehicles)
	f_g	= 0.99 (two-percent grade)
	f_p	= 1.00 (no on-street parking)
	f_{bb}	= 0.96 (ten bus stops/hr)
	f_a	= 1.00 (non-CBD)
	f_{RT}	= 0.93 (low pedestrians, P_{RT} = 0.4)
	f_{LT}	= 0.96
	capacity/lane = 586 = 590 vehicles	

Urban Secondary Arterials

High range:	g/C	= 0.50
	s_0	= 1,900
	f_w	= 1.00 (twelve foot lanes)
	f_{HV}	= 0.98 (two percent heavy vehicles)
	f_g	= 1.00 (level grade)
	f_p	= 0.925 (10 parking maneuvers/hr)
	f_{bb}	= 0.96 (twenty bus stops/hr)
	f_a	= 1.00 (non-CBD)
	f_{RT}	= 0.951 (moderate pedestrians, P_{RT} = 0.2)
	f_{LT}	= 0.96
	capacity/lane = 755 = 760 vehicles	
Medium range:	capacity/lane = existing value = 570 vehicles	
Low range:	g/C	= 0.40
	s_0	= 1,900
	f_w	= 0.967 (eleven foot lanes)
	f_{HV}	= 0.909 (ten percent heavy vehicles)
	f_g	= 0.99 (two-percent grade)
	f_p	= 0.90 (20 parking maneuvers/hr)
	f_{bb}	= 0.95 (25 bus stops/hr)
	f_a	= 1.00 (non-CBD)
	f_{RT}	= 0.864 (high pedestrians, P_{RT} = 0.4)

f_{LT} = 0.94
capacity/lane = 459 = 460 vehicles

Fringe Secondary Arterials

High range:

g/C = 0.50
s_0 = 1,900
f_w = 0.933 (ten foot lanes)
f_{HV} = 0.98 (two percent heavy vehicles)
f_g = 1.00 (level grade)
f_p = 0.90 (20 parking maneuvers/hr)
f_{bb} = 0.95 (25 bus stops/hr)
f_a = 0.95 (average of CBD and non-CBD)
f_{RT} = 0.932 (high pedestrians, P_{RT} = 0.2)
f_{LT} = 0.94
capacity/lane = 618 = 620 vehicles

Medium range: capacity/lane = existing value = 460 vehicles

Low range:

g/C = 0.40
s_0 = 1,900
f_w = 0.933 (ten foot lanes)
f_{HV} = 0.909 (ten percent heavy vehicles)
f_g = 0.99 (two-percent grade)
f_p = 0.875 (30 parking maneuvers/hr)
f_{bb} = 0.94 (30 bus stops/hr)
f_a = 0.95 (average of CBD and non-CBD)
f_{RT} = 0.788 (very high pedestrians, P_{RT} = 0.4)
f_{LT} = 0.92
capacity/lane = 361 = 360 vehicles

CBD Secondary Arterials

High range:

g/C = 0.45
s_0 = 1,900
f_w = 0.967 (eleven foot lanes)
f_{HV} = 0.98 (two percent heavy vehicles)
f_g = 1.00 (level grade)
f_p = 0.90 (20 parking maneuvers/hr)
f_{bb} = 0.95 (25 bus stops/hr)
f_a = 0.90 (CBD area type)
f_{RT} = 0.894 (very high pedestrians, P_{RT} = 0.2)
f_{LT} = 0.94
capacity/lane = 523 = 520 vehicles

Medium range:	capacity/lane = existing value = 410 vehicles
Low range:	g/C = 0.40
	s_0 = 1,900
	f_w = 0.933 (ten foot lanes)
	f_{HV} = 0.909 (ten percent heavy vehicles)
	f_g = 0.99 (two-percent grade)
	f_p = 0.875 (30 parking maneuvers/hr)
	f_{bb} = 0.94 (30 bus stops/hr)
	f_a = 0.90 (CBD area type)
	f_{RT} = 0.711 (extremely high pedestrians, P_{RT} = 0.4)
	f_{LT} = 0.92
	capacity/lane = 309 = 310 vehicles

The remaining entries were chosen to result in a "continuum" of values and to minimize overlap. These values were calculated from the existing values as follows:

COLLECTORS / LOCALS

High range:	Equal to *Task 1* values.
Medium range:	Equal to existing values.
Low range:	Equal to 80 percent of the Collector / Local "medium range."

RAMPS

High range:	Equal to *Task 1* values.
Medium range:	Equal to the approximate mid-point of High and Low ranges.
Low range:	Equal to existing values.

Tables 5A, 5B summarizes the high, medium, and low capacities employed by the enhanced travel simulation models.

Table 5A. Per Lane Hourly Capacities Assuming "E" Service Level

Functional Classification			Area Type CBD (1)	Fringe (2)	Urban (3)	Suburban (4)	Rural (5)
1	Freeway	High	2,320	2,320	2,330	2,430	2,490
		Medium	1,950	1,950	1,950	2,000	2,100
		Low	1,450	1,450	1,450	1,590	1,730
2	Parkway	High	1,190	1,190	1,290	1,390	1,530
		Medium	1,060	1,060	1,150	1,240	1,370
		Low	960	960	960	960	1,120
3	Principal Arterial	High	760	800	1,060	1,290	1,500
		Medium	600	640	820	950	1,100
		Low	460	540	690	810	910
4	Secondary Arterial	High	520	620	760	920	1,150
		Medium	410	460	570	680	800
		Low	310	360	460	590	680
6	Collector / Local	High	560	630	700	840	980
		Medium	400	450	500	600	750
		Low	320	360	400	480	600
8	Ramps	High	590	610	700	810	910
		Medium	460	490	540	680	800
		Low	330	370	390	540	680

These capacities are converted to daily capacities through "2KD" factors, given in the following table:

Table 5B. Standard (2KD) Conversion Factors

Functional Classification			Standard (2KD) Conversion Factors CBD (1)	Fringe (2)	Urban (3)	Suburban (4)	Rural (5)
1	Freeway	High	0.081	0.081	0.084	0.087	0.094
		Medium	0.081	0.081	0.084	0.087	0.094
		Low	0.081	0.081	0.084	0.087	0.094
2	Parkway	High	0.081	0.081	0.092	0.094	0.096
		Medium	0.081	0.081	0.092	0.094	0.096
		Low	0.081	0.081	0.092	0.094	0.096
3	Principal Arterial	High	0.083	0.083	0.084	0.086	0.090
		Medium	0.083	0.083	0.084	0.086	0.090
		Low	0.083	0.083	0.084	0.086	0.090
4	Secondary Arterial	High	0.085	0.085	0.094	0.098	0.100
		Medium	0.085	0.085	0.094	0.098	0.100
		Low	0.085	0.085	0.094	0.098	0.100
6	Collector / Local	High	0.076	0.089	0.089	0.114	0.120
		Medium	0.076	0.089	0.089	0.114	0.120
		Low	0.076	0.089	0.089	0.114	0.120
8	Ramps	High	0.058	0.068	0.075	0.082	0.089
		Medium	0.058	0.068	0.075	0.082	0.089
		Low	0.058	0.068	0.075	0.082	0.089

The new model uses free-flow speeds as inputs in the speed-capacity table. Free-flow speeds are taken to be the larger of the posted speed limit or the measured speeds from the travel time survey. Free flow speeds are as follows:

3. CONFAC Factors by Time Period

The DVRPC highway network has daily capacities inserted. These values are too large to represent the capacity for a peak, midday, or evening time period. In order to conduct a capacity restrained time period assignment, the daily capacity is divided by the CONFAC factor which converts daily to time period capacity. The CONFAC is included in the parameter set of the TRANPLAN equilibrium traffic assignment program. These values are determined in part by the output time period speeds and VMT resulting from the assignment and in part by the hourly distribution of traffic within each time period and the magnitude of time period traffic versus the daily total.

The CONFAC parameter settings for each time period and the resulting VMT and speeds from the traffic assignment are given in Table 6 below:

Table 6. CONFAC Factors by Time Period

Time Period	CONFAC	VMT	Average "Speeds"
Peak	2.490	35,421,468	28.3
Midday	2.857	30,760,280	36.06
Evening	1.538	31,506,172	36.94
Total	-	**97,687,920**	**32.31**

The reader should note that the speeds given above resulted from the BPR curve which represents cumulative travel time on each link rather than average travel time and cannot be directly interpreted in terms of observed travel behavior. These values approximate average speeds except for high V/C ratios where they are much lower than the average link speed. The values given above are a vast improvement over the results from the non-iterative model which produces an average speed of 17.91 MPH. The 1997-98 travel time survey produced similar average speeds (weighted by volume) in the peak and midday time periods. The improvement over the non-iterative model resulted principally from the redirection of trips away from congested areas of the region by the gravity model and modal split components of the Evans process when run with congested speeds.

The input table lookup speeds and capacities used in the networks are the same as those used for the two period model - see tables 1 and 2 and Chapter XI of the 1997 Travel Simulation Report.

4. Traffic Assignment Results by Highway Screenline

The daily calibration results for the regional system of highway screenlines is shown in Table 7. All except inner cordon segment 4 have less than 10 percent error. These results are generally better than those for the two period model shown in the 1997 Travel Simulation Model Report.

Table 7. 1997 Regional Highway Assignment Three Time Period Enhanced Model Summary of Screenlines

Screenline	Number of Crossings	1995 Counted Volume (000)	1997 Simulated Volume (000)	Percent Diff	R^2
Inner Cordon Seg. 1 (Bucks County)	21	259.4	259.4	0.0%	0.70
Inner Cordon Seg. 2 (Montgomery Co.)	34	508.5	529.3	4.1	0.78
Inner Cordon Seg. 3 (Chester Co.)	14	214.3	228.4	6.6	0.90
Inner Cordon Seg. 4 (Delaware Co.)	17	218.6	253.2	15.8	0.99
Inner Cordon Seg. 5 (Mercer Co.)	26	415.0	382.2	-7.9	0.81
Inner Cordon Seg. 6 (Burlington Co.)	28	311.7	323.2	3.7	0.96
Inner cordon Seg. 7 (Camden Co.)	11	150.9	154.6	2.4	0.66
Inner Cordon Seg. 8 (Gloucester Co.)	21	223.3	218.6	-2.1	0.87
Delaware River (ABCD)	18	554.6	520.3	-6.2	0.89
Schuylkill River (EFG)	40	1,318.0	1,239.1	-6.0	0.63
Center City Phila. (GHI)	60	977.5	993.4	1.6	0.80
N. Phila. RR (J)	26	491.6	463.9	-5.6	0.82
Crosswicks Creek (PQ)	7	220.3	229.6	4.2	0.85
Camden-Burlington Co. Boundary (TU)	32	513.7	558.1	8.6	0.84
Total	**355**	**6,377.4**	**6,353.3**	**-0.4%**	**0.83**

E. Nested Modal Split Model

As part of the simulation model upgrade, DVRPC staff implemented a nested modal split model (nested on mode of approach) within the non-iterative daily travel simulation model. The non-iterative daily version of the nested modal split model has been utilized successfully in a number of ongoing transit studies including the Schuylkill Valley Metro, Wawa Rail Extension, Roosevelt Boulevard, Quakertown Rail Reactivation, and the Eastwick Rail study. In FY 2000, this nested modal split model was incorporated into the three time period Evans iterative model described above. This model differs from old DVRPC model in that the model structure is now nested by mode of approach (see Figure 2). Walk/bus approach transit trips are modeled separately from auto approach transit trips in the modal split/transit assignment model each using separate transit networks. Following the separate transit assignments, the transit volumes are merged together and summarized to reflect total transit riding.

Incorporating the Nested modal split model into the Evans Process required three major work items:

- Incorporate the nested model structure into the three period model job control setups.
- Create a transit network reflective of 1997 evening headways, service patterns, and fares to complement the existing 1997 peak and midday networks.
- Fine tune the calibration to produce accurate transit assignment for each time period.

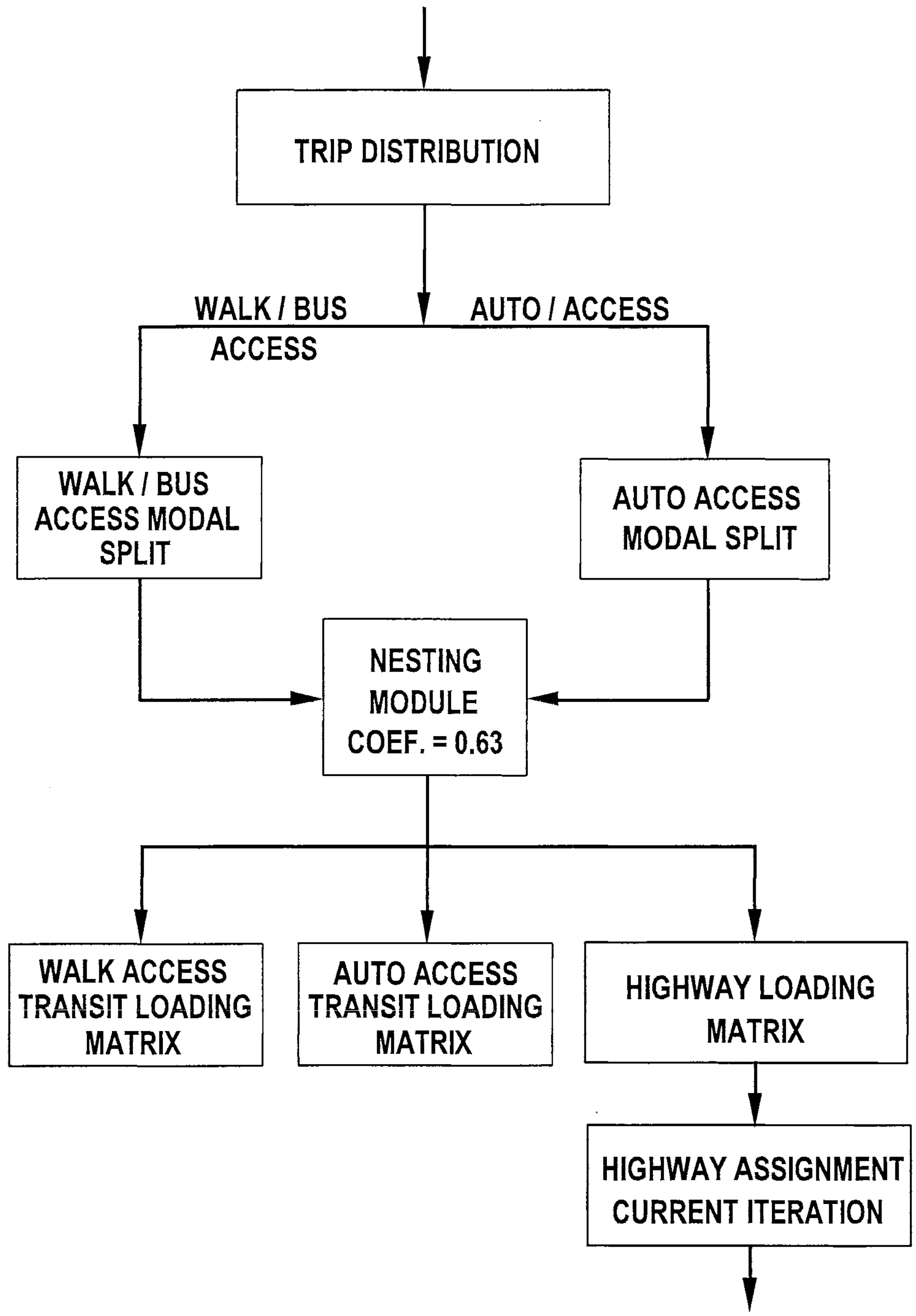
F. Incorporating the Nested Model Structure into the Evans Process

This nested process is operated in a straight forward way within the Evans iterative execution job stream. The modal split portion of the control files are similar in scope to the old DVRPC model except that the Modal Split/Transit Assignment control file is now more complex. There is one aspect of the transit assignment that has been omitted from Figure 2 for simplicity. External-Local transit trips are added to the walk/bus approach trip table prior to the walk/bus approach assignment step of the simulation process.

1. Transit Person Trip Bias Correction

The old DVRPC model incorporated a transit/highway person trip interchange bias correction as an explicit step in the modeling chain. The bias correction eliminated the underestimation of person trips in corridors with good transit service relative to the auto using a curve calibrated with home interview data.. The person trip gravity model distribution is based on highway travel times only and does not consider transit service. In the Evans process, this correction was included directly into the modal split model to streamline the model execution process.

Figure 2
TRIP DISTRIBUTION / NESTED MODAL SPLIT PROCESS



Delaware Valley Regional Planning Commission
November 2002

2. Walk/Bus and Auto Approach Transit Networks

The nested modal split process starts with a base focused transit network, coded to the same specifications as the old DVRPC model. The walk and auto approach sub-networks are specified parametrically by utilizing delete access and egress modes parameters in UPATH as follows:

3. Walk Approach Network

The walk approach transit network is generated by removing all the auto approach links (mode 3) for both access and egress.

4. Auto Approach Network

The auto approach network is also specified within UPATH In this case the walk links (mode 1) connecting transit facilities to centroids are made one-way away from the transit lines with the delete egress parameter. This prevents walk access to the transit system on the home end of the trip, but allows walk egress at the non-home end. It is important to note that walk links not connected to a centroid are not altered. As with the walk approach network, the actual time period network built in DVFARE using unmodified link, coordinate, and line files is not altered.

From an operational point of view, this is a significant improvement in that the separation of the transit network into auto approach and walk/bus approach sub-networks that is achieved parametrically through enhanced path building and skimming procedures, rather than through the use of separate transit networks. This reduces the number of transit networks required from six to three to run the three period model.

The each time period model within the Evans iterative process is defined as an independent computer process from the gravity model through the highway and transit assignments. This facilitates multi-processor operations in that each time period can be run in parallel in a separate computer thereby reducing the overall computing time to one-third of the time required to run the three period model on a single computer. Incorporation of the nested modal split model into the Evans iterative model job stream was straight forward, although it greatly increased the complexity of the process.

Another significant improvement in executing the transit assignment results from the enhanced computer program. In the two period Evans model, the lambdas from the convergence table had to be transcribed manually into a separate job stream to weight together the individual iteration transit trip tables into the weighted average for loading into the network. The nested iterative model would have required that this be done six times (3 time periods times 2 approach modes). This is now done automatically by the enhanced Evans TRANPLAN computer program and the entire job stream including the transit assignment proceeds through iterative process including transit assignment without human intervention. For this reason, the three period model is significantly easier to run than the two period model.

G. Evening Transit Network

Implementation of the three time period model required development of an evening service transit network. The Peak and Midday transit networks were already available from the two time period Evans model. (See the 1997 Travel Simulation Report for a description of these networks and the coding conventions). Creation of the evening transit network followed the same coding conventions, but was based on transit service levels that operate weekdays between 8:00 PM and 10:00 PM. Transit service levels vary widely during evening and nighttime hours; from near peak service levels between 6:00 and 7:00 PM to virtually no service after mid-night. The service levels that exist between 8:00 and 10:00 PM represent "average" or typical service levels over the evening/night time period. A listing of the correspondence between company, route, and line card is given in Table 8.

Table 8. 1997 Evening Transit Line Card/Route # Correspondence by Company

Co. 1 - SEPTA City Transit Division

Route #	Mode	Line Cards	Route #	Mode	Line Cards
C	4	1,2	36	4	55,56
G	4	3,4	37	4	57
H	4	5	38	4	58
XH	4	6	39	4	59
J	4	7	40	4	60
K	4	8	42	4	61,62
L	4	9,10	43	4	63
R	4	11,12	44	4	64,65
Fox-Newt	4	13	46	4	66
2	4	14	47	4	67,68
3	4	15	48	4	69
5	4	16	52	4	70,71
6	4	17	53	4	72
7	4	18	54	4	73
9	4	19	55	4	74,75
10	4	20	56	4	76
11	4	21	57	4	77
12	4	22	58	4	78,79
13	4	23	59	4	80
14	4	24,25,26	60	4	81
15	4	27	61	4	82
17	4	28,29	64	4	83
18	4	30,31,32,33	65	4	84
20	4	34,35	66	4	85
21	4	36,37	67	4	86
22	4	38,39	68	4	87,88

Co. 1 - SEPTA City Transit Division

Route #	Mode	Line Cards	Route #	Mode	Line Cards
23	4	40	70	4	89,90
24	4	41	73	4	91
25	4	42	75	4	92
26	4	43,44	79	4	93
27	4	45,46	84	4	94
28	4	47	88	4	95
29	4	48	89	4	96
30	4	49	90	4	97
31	4	50	BSS	6	2,3,4
32	4	51	MFSE	6	5
33	4	52			
34	4	53			
35	4	54			

Co. 2 - SEPTA Suburban Victory Division

101	4	106	110	4	115,116
102	4	107	113	4	117
103	4	108	114	4	118
104	4	109,110	117	4	119,120
107	4	111	119	4	121
108	4	112,113	120	4	122
109	4	114			
100	6	1			

Co. 3 - SEPTA Suburban Frontier Division

93	4	98	98	4	103,104
94	4	99	99	4	105
96	4	100,101	124	4	123,124
97	4	102	125	4	125

Co. 4 - New Jersey Transit Mercer Division

600	5	100	606	5	107
601	5	101,102,103	607	5	108
602	5	104	608	5	109
603	5	105,106	609	5	110,111,112

Co. 6 - PATCO (D.R.P.A. Lindenwold Line)

Local	8	1

Co. 7 - New Jersey Transit Southern Division

Route #	Mode	Line Cards	Route #	Mode	Line Cards
313/315	5	1	410	5	18
317	5	2	412	5	19
400	5	3,4	413	5	20
401	5	5	419	5	21
402	5	6,7	450	5	22
403	5	8,9	455	5	23,24
404	5	10	457	5	25
405	5	11	459	5	26
406	5	12,13	463	5	27
407	5	14	551	5	28
408	5	15	554	5	29
409	5	16,17			

Co. 8 - New Jersey Transit Railroad Division

Corridor	7	50,51
Princ. Jct	7	52,53
Atlantic City	7	54

Co. 9 - SEPTA Regional Rail Division

R1	7	1,2	R6	7	10
R2	7	3	R7	7	11
R3	7	4,5,6	R8	7	12,13
R5	7	7,8,9			

1. Fine Tuning the Modal Split Model Calibration by Time Period

The DVRPC modal split model is calibrated to produce estimates of total daily transit riding. The three period model estimated total daily ridership within 5 percent, however, it did not produce accurate ridership estimates by time period (peak 14 percent overestimated, midday 30 percent underestimated and evening 53 percent overestimated). Several options were considered to fine tune the calibration by time period. The two most acceptable methods to correct this situation were to (1) adjust the constant portion of the modal split model equations and recalibrate the model for each time period or (2) adjust the transit and auto captivities embedded within the modal split model to accurately replicate the results by time period. It was decided to use captivities to adjust the model output rather than adjust the equation constants for two basic reasons. First, since the modal split model errors represented less than two percentage points of mode share and the adjustments to the equation constants would be very small. Second, many of the differences between time periods are explainable in terms of captivities. For instance, the lower modal splits in the evening/night time periods can be explained in terms of higher auto captivity resulting from fear of riding transit at night. The transit and auto captivities by time period were set by trial and error until a reasonably accurate assignment by transit operator and submode was obtained. The final captivities by time period are given in Table 9.

Table 9. Transit Captivities Used in the Three Time Period Model

Transit Service/	Peak		Midday		Evening	
Submode	Auto	Transit	Auto	Transit	Auto	Transit
Commuter Rail	0.0	1 %	40 %	0.0	45 %	0.0
Subway Elevated	0.0	0.0	0.0	0.0	40 %	0.0
Philadelphia City	20 %	0.0	0.0	17.4 %	15 %	0.0
Pennsylvania Suburban Bus	20 %	0.0	0.0	1.1 %	15 %	0.0
PATCO	0.0	7 %	30 %	0.0	50 %	0.0
South Jersey Bus	50 %	0.0	40 %	0.0	15 %	0.0
Mercer County Bus	20 %	0.0	0.0	1.1 %	15 %	0.0

2. Public Transit Assignment Results

Tables 10, 11, 12, and 13 compare assigned with actual transit boardings by transit operation and submode for the peak, midday, and night time periods, and for the daily total. The assignment results include the effect of the transit and auto capacities listed above. Overall, the transit assignment results are acceptable for model validation both by time period and in total. However, there several minor problems that may be addressed in the future.

First, the SEPTA Frontier division is severely underestimated for all time periods. This is primarily a network coding problem because the Frontier Division service patterns have unique service characteristics not easily modeled in TRANPLAN. In the current model calibration, the Victory Division bus and trolley was overestimated by a compensating amount. If the network coding problems in the Frontier Division are resolved we may want to reset the captivities for suburban Pennsylvania buses.

Second, NJT Mercer Division buses tend to be overestimated, but to a much smaller degree (about 12 percent). This could be corrected with a higher auto captivity. The Southern Division, although correctly estimated required a very high auto captivity in the peak and midday time periods. The significant overestimation of NJT southern division in the base model may have also resulted from network coding problems.

Finally, simulation errors for night travel are significantly larger than for the other time periods. This is natural given the very small modal splits and ridership levels occurring in the night time period.

Table 10. Comparison of 1997 Passenger Counts and Enhanced Model Assigned Volumes for all Time Periods by Transit Operating Companies

Company/Division	Submode	1997 Assigned Volumes	1997 Passenger Counts	% Difference
SEPTA City Transit	Subway-Elevated	283,933	275,812	2.94%
	Bus & Trolley	580,423	580,395	0.00%
Total		**864,356**	**856,207**	**0.95%**
SEPTA Suburban				
Victory Division	Heavy Rail	6,519	6,720	-2.99%
Victory Division	Bus & Light Rail	36,528	29,479	23.91%
Fronier Division	Bus	10,674	18,358	-41.86%
Total		**53,721**	**54,557**	**-1.53%**
SEPTA Regional Rail	Commuter Rail	84,967	86,065	-1.28%
SEPTA Total		**1,003,044**	**996,829**	**0.62%**
NJT Southern Division	Bus	34,628	33,691	2.78%
NJT Mercer Division	Bus	16,392	14,560	12.58%
Total NJ Transit		**51,020**	**48,251**	**5.74%**
DRPA	High Speed Rail	34,254	32,390	5.75%
Grand Total		**1,088,318**	**1,077,470**	**1.01%**

Table 11. Comparison of 1997 Passenger Counts and Enhanced Model Assigned Volumes for Peak Time Period by Transit Operating Companies

Company/Division	Submode	1997 Assigned Volumes	1997 Passenger Counts	% Difference
SEPTA City Transit	Subway-Elevated	160,533	148,553	8.06%
	Bus & Trolley	251,204	246,630	1.85%
Total		**411,737**	**395,183**	**4.19%**
SEPTA Suburban				
Victory Division	Heavy Rail	4,176	3,901	7.05%
Victory Division	Bus & Light Rail	19,780	14,201	39.29%
Fronier Division	Bus	4,600	8,107	-43.26%
Total		**28,556**	**26,209**	**8.95%**
SEPTA Regional Rail	Commuter Rail	54,271	55,485	-2.19%
SEPTA Total		**494,564**	**476,877**	**3.71%**
NJT Southern Division	Bus	17,423	15,705	10.94%
NJT Mercer Division	Bus	8,066	7,099	13.62%
Total NJ Transit		**25,489**	**22,804**	**11.77%**
DRPA	High Speed Rail	22,198	21,375	3.85%
Grand Total		**542,251**	**521,056**	**4.07%**

Table 12. Comparison of 1997 Passenger Counts and Enhanced Model Assigned Volumes for Midday Time Period by Transit Operating Companies

Company/Division	Submode	1997 Assigned Volumes	1997 Passenger Counts	% Difference
SEPTA City Transit	Subway-Elevated	77,993	82,749	-5.75%
	Bus & Trolley	242,232	245,202	-1.21%
Total		**320,225**	**327,951**	**-2.36%**
SEPTA Suburban				
Victory Division	Heavy Rail	1,669	1,798	-7.17%
Victory Division	Bus & Light Rail	12,845	11,360	13.07%
Fronier Division	Bus	5,067	6,825	-25.76%
Total		**19,581**	**19,983**	**-2.01%**
SEPTA Regional Rail	Commuter Rail	14,159	13,645	3.77%
SEPTA Total		**353,965**	**361,579**	**-2.11%**
NJT Southern Division	Bus	13,463	12,332	9.17%
NJT Mercer Division	Bus	5,865	6,039	-2.88%
Total NJ Transit		**19,328**	**18,371**	**5.21%**
DRPA	High Speed Rail	6,123	5,589	9.55%
Grand Total		**379,416**	**385,539**	**-1.59%**

Table 13. Comparison of 1997 Passenger Counts and Enhanced Model Assigned Volumes for Evening Time Period by Transit Operating Companies

Company/Division	Submode	1997 Assigned Volumes	1997 Passenger Counts	% Difference
SEPTA City Transit	Subway-Elevated	45,407	44,510	2.02%
	Bus & Trolley	86,987	88,563	-1.78%
Total		**132,394**	**133,073**	**-0.51%**
SEPTA Suburban				
Victory Division	Heavy Rail	674	1,021	-33.99%
Victory Division	Bus & Light Rail	3,903	3,918	-0.38%
Fronier Division	Bus	1,007	3,426	-70.61%
Total		**5,584**	**8,365**	**-33.25%**
SEPTA Regional Rail	Commuter Rail	16,537	16,935	-2.35%
SEPTA Total		**154,515**	**158,373**	**-2.44%**
NJT Southern Division	Bus	3,742	5,654	-33.82%
NJT Mercer Division	Bus	2,461	1,422	73.07%
Total NJ Transit		**6,203**	**7,076**	**-12.34%**
DRPA	High Speed Rail	5,933	5,426	9.34%
Grand Total		**166,651**	**170,875**	**-2.47%**

IV. IMPLEMENTATION OF THE NON-MOTORIZED TRAVEL MODEL

The calibration results reported above utilize the DVRPC trip generation model as validated with the 1990 data and do not incorporate non-motorized travel. The Non-Motorized travel model prepared by Cambridge Systematics was tested by rerunning the calibrated three period, nested modal split, Evans model substituting the non-motorized travel version of trip generation for the 1997 base model. The Non-Motorized travel version of trip generation differs significantly from the base model in that total trips including walk, bicycle, and other Non-Motorized travel are generated and the motorized portion of total travel is separated from the total using a logit pre-distribution modal split model. For a detailed description of the non-motorized travel model see Report 9 of the Model Enhancement Project series. The Non-Motorized travel was tested as delivered by CSI. No changes to the model were made by DVRPC staff.

Extensive comparisons between the Non-Motorized version of the enhanced model and the original model are given in Table 14. These include an ANOVA analysis of the differences in person trip productions and attractions, highway link volumes (entire network), the highway screenline validation, and transit ridership by operator and submode. The statistical impact of implementing the non-motorized travel model on trip productions and attractions by traffic zone and in terms of highway link volumes is summarized by functional class. At the traffic zone level, the generated person trip productions have virtually the same mean value (12,737 versus 12,617). The percent root mean squared (RMS) difference is about 8.4 percent and the Theil statistics show that 93 % of this difference is due to scatter. The Non-Motorized attraction model produced an even closer match with the existing person trip generation model results (about 3% percent RMS different) . These percent RMS differences are acceptable because they do not create a significant increase in error in the simulated highway and public transit volumes produced from the simulation.

A statistical summary of the highway link volume differences between the non-motorized travel and existing trip generation model is also shown in Table 15. As one might expect, the % difference varies inversely with the functional class because the traffic volumes, and hence the number of zonal interchanges using the link, varies with the functional class. Overall, the % RMS differences range from 11.5% for local streets to 4.4% for freeways with 7.2% overall. The Theil statistics clearly show that almost all of the differences are attributable to scatter.

The above regional statistics suggest that the implementation non-motorized travel does not significantly disturb the simulation model results. In order to verify this conclusion, the highway and transit validation statistics were rerun with the non-motorized travel model included in the model chain. The results for the highway screenlines are shown below. These results easily show FHWA validation and are very comparable to the three period model validation results shown above.

Table 14. Statistical Impact Due to Implementation of Non-Motorized Travel in the DVRPC Model: (Comparison of Results)

Impact By Functional Class							
Class	**Mean Existing Model**	**Mean Non-Motorized Prediction**	**% Root Mean Square - Diff**	**Value of R-squared**	**Theil UM Statistic**	**Theil US Statistic**	**Theil UC Statistic**
Freeway/ Parkway	38,385	38,278	4.446%	.9941	.0040	.0128	.9832
Major Arterial	21,305	21,214	5.174	.9950	.0068	.0005	.9899
Minor Arterial	8,431	8,396	7.609	.9898	.0031	.0060	.9907
Local Street	4,843	4,801	11.576	.9728	.0057	.0039	.9907
All Roads	11,327	11,283	7.157%	.9977	.0031	.0003	.9940

Impact By Production And Attraction							
	Mean Existing Model	**Mean Non-Motorized Prediction**	**% Root Mean Square - Diff**	**Value of R-squared**	**Theil UM Statistic**	**Theil US Statistic**	**Theil UC Statistic**
Productions	12,737	12,617	8.420%	.9954	.0130	.0556	.9312
Attractions	12,459	12,521	3.306%	.9991	.0225	.0002	.9773
Productions & Attraction	12,598	12,569	6.414%	.9961	.0013	.0331	.9653

Table 15. 1997 Regional Highway Assignment Three Time Period Enhanced Model Summary of Screenlines with Non-Motorized Travel Model Included

Screenline	1995 Number of Crossings	1995 Counted Volume (000)	1997 Simulated Volume (000)	Percent Diff	R^2
Inner Cordon Seg. 1 (Bucks County)	21	259.4	253.7	2.2%	0.72
Inner Cordon Seg. 2 (Montgomery Co.)	34	508.5	512.9	0.9	0.74
Inner Cordon Seg. 3 (Chester Co.)	14	214.3	223.3	4.2	0.89
Inner Cordon Seg. 4 (Delaware Co.)	17	218.6	253.3	15.9	0.99
Inner Cordon Seg. 5 (Mercer Co.)	26	415.0	375.9	-9.4	0.81
Inner Cordon Seg. 6 (Burlington Co.)	28	311.7	313.4	0.5	0.96
Inner cordon Seg. 7 (Camden Co.)	11	150.9	151.3	0.3	0.67
Inner Cordon Seg. 8 (Gloucester Co.)	21	223.3	209.8	-6.0	0.88
Delaware River (ABCD)	18	554.6	515.3	-7.1	0.89
Schuylkill River (EFG)	40	1,318.0	1,214.2	-7.9	0.62
Center City Phila. (GHI)	60	977.5	981.4	0.4	0.79
N. Phila. RR (J)	26	491.6	458.2	-6.8	0.82
Crosswicks Creek (PQ)	7	220.3	225.4	2.3	0.87
Camden-Burlington Co. Boundary (TU)	32	513.7	545.7	6.2	0.83
Total	**355**	**6,377.4**	**6,233.5**	**-2.3%**	**0.82**

This analysis was also run for the transit simulation errors by company and submode (see tables 16 through 19). As in the highway statistics, the inclusion of the Non-Motorized travel model had no significant on the extent or distribution of transit assignment errors.

This analysis has clearly shown that the Non-Motorized Travel Model can be implemented within the three time period process without disturbing the modal calibration or validation.

Table 16. Comparison of 1997 Passenger Counts and Enhanced Model Assigned Volumes for all Time Periods by Transit Operating Companies with Implementation of Non-Motorized Travel Module

Company/Division	Submode	1997 Assigned Volumes	1997 Passenger Counts	% Difference
SEPTA City Transit	Subway-Elevated	274,552	275,812	-0.46%
	Bus & Trolley	564,438	580,395	-2.75%
Total		**838,990**	**856,207**	**-2.01%**
SEPTA Suburban				
Victory Division	Heavy Rail	6,386	6,720	-4.97%
Victory Division	Bus & Light Rail	36,049	29,479	22.29%
Fronier Division	Bus	10,275	18,358	-44.03%
Total		**52,710**	**54,557**	**-3.39%**
SEPTA Regional Rail	Commuter Rail	83,575	86,065	-2.89%
SEPTA Total		**975,275**	**996,829**	**-2.16%**
NJT Southern Division	Bus	33,426	33,691	-0.79%
NJT Mercer Division	Bus	14,725	14,560	1.13%
Total NJ Transit		**48,151**	**48,251**	**-0.21%**
DRPA	High Speed Rail	34,502	32,390	6.52%
Grand Total		**1,057,928**	**1,077,470**	**-1.81%**

Table 17. Comparison of 1997 Passenger Counts and Enhanced Model Assigned Volumes for Peak Time Period by Transit Operating Companies with Implementation of Non-Motorized Travel Module

Company/Division	Submode	1997 Assigned Volumes	1997 Passenger Counts	% Difference
SEPTA City Transit	Subway-Elevated	155,448	148,553	4.64%
	Bus & Trolley	239,127	246,630	-3.04%
Total		**394,575**	**395,183**	**-0.15%**
SEPTA Suburban				
Victory Division	Heavy Rail	4,055	3,901	3.95%
Victory Division	Bus & Light Rail	19,346	14,201	36.23%
Fronier Division	Bus	4,203	8,107	-48.16%
Total		**27,604**	**26,209**	**5.32%**
SEPTA Regional Rail	Commuter Rail	53,699	55,485	-3.22%
SEPTA Total		**475,878**	**476,877**	**-0.21%**
NJT Southern Division	Bus	16,460	15,705	4.81%
NJT Mercer Division	Bus	7,626	7,099	7.42%
Total NJ Transit		**24,086**	**22,804**	**5.62%**
DRPA	High Speed Rail	22,575	21,375	5.61%
Grand Total		**522,539**	**521,056**	**0.28%**

Table 18. Comparison of 1997 Passenger Counts and Enhanced Model Assigned Volumes for Midday Time Period by Transit Operating Companies with Implementation of Non-Motorized Travel Module

Company/Division	Submode	1997 Assigned Volumes	1997 Passenger Counts	% Difference
SEPTA City Transit	Subway-Elevated	74,710	82,749	-9.71%
	Bus & Trolley	239,838	245,202	-2.19%
Total		**314,548**	**327,951**	**-4.09%**
SEPTA Suburban				
Victory Division	Heavy Rail	1,666	1,798	-7.34%
Victory Division	Bus & Light Rail	12,774	11,360	12.45%
Fronier Division	Bus	5,063	6,825	-25.82%
Total		**19,503**	**19,983**	**-2.40%**
SEPTA Regional Rail	Commuter Rail	13,449	13,645	-1.44%
SEPTA Total		**347,500**	**361,579**	**-3.89%**
NJT Southern Division	Bus	13,339	12,332	8.17%
NJT Mercer Division	Bus	5,725	6,039	-5.20%
Total NJ Transit		**19,064**	**18,371**	**3.77%**
DRPA	High Speed Rail	5,922	5,589	5.96%
Grand Total		**372,486**	**385,539**	**-3.39%**

Table 19. Comparison of 1997 Passenger Counts and Enhanced Model Assigned Volumes for Evening Time Period by Transit Operating Companies with Implementation of Non-Motorized Travel Module

Company/Division	Submode	1997 Assigned Volumes	1997 Passenger Counts	% Difference
SEPTA City Transit	Subway-Elevated	44,394	44,510	-0.26%
	Bus & Trolley	85,473	88,563	-3.49%
Total		**129,867**	**133,073**	**-2.41%**
SEPTA Suburban				
Victory Division	Heavy Rail	665	1,021	-34.87%
Victory Division	Bus & Light Rail	3,929	3,918	0.28%
Fronier Division	Bus	1,009	3,426	-70.55%
Total		**5,603**	**8,365**	**-33.02%**
SEPTA Regional Rail	Commuter Rail	16,427	16,935	-3.00%
SEPTA Total		**151,897**	**158,373**	**-4.09%**
NJT Southern Division	Bus	3,627	5,654	-35.85%
NJT Mercer Division	Bus	1,374	1,422	-3.38%
Total NJ Transit		**5,001**	**7,076**	**-29.32%**
DRPA	High Speed Rail	6,005	5,426	10.67%
Grand Total		**162,903**	**170,875**	**-4.67%**

A. Highway Speeds

The free flow speeds were adjusted slightly to better conform with the DVRPC 1996-97 travel time survey. **(See Table 1 Chapter II)** for the free flow speed lookup tables. In FY 2001, the enhanced travel simulation model was applied to a number of studies in the I-95, US 422, Pennsylvania Turnpike and PA 41 corridors. In the conduct of these studies, the simulated outputs from the model were subjected to detailed link and facility level calibration exercises. As a result of these calibrations, the highway speed lookup tables were refined by increasing the speeds on freeways and adjusting speeds on other facilities by about 5 mph. This lookup table varied slightly from corridor calibration to corridor calibration. An example of this modified table lookup from the I-95 corridor studies in included in Table 20. The capacity table lookup included in the 1997 Simulation Report was not changed, although in corridor studies, special non-lookup values were placed on a few roadway links with special characteristics not adequately covered by the standard lookup table.

Table 20. Revised Highway Speed Lookup Table From the I-95 Enhancement Project

		Free Flow Speeds			
Functional Class\ Area Type	**CBD**	**CBD Fringe**	**Urban**	**Suburban**	**Rural**
Freeway	55	60	65	70	70
Parkway	35	35	40	45	50
Major Arterial	25	25	30	37	45
Minor Arterial	20	20	27	34	42
Local	15	20	24	31	37

B. Implement Additional Gravity Model Improvements

This involves dividing the combined arterial/local external-local gravity model included in the 1990 model validation into separate models. Preliminary estimates of friction factors and a trip attraction estimation methodology were prepared by the Cambridge Systematics as part of the model enhancement process. However, additional calibration and refinement of these improvements is required before they can be input into the Evans model process. We were unable to complete incorporating these improvements into the Evans process in FY 2001. This work involves separating arterial from local travel in the external-local trip generation and distribution models and calibrating the model to replicate observed trip totals and trip length frequency distributions. This work will be completed in FY 2002 using the data from the new external-local travel survey currently underway at DVRPC.

C. Complete the Evans Model Software

In FYs 2000 and 2001, the computer software used to execute the Evans travel simulation was improved significantly. These improvements included:

- Debugging of the procedures to accomplish turning movement and selected link analyses.
- Development of job control streams to execute the entire Evans process with minimal human intervention. These job streams have been refined to allow substitutable highway and transit network names, redirection of outputs to different subdirectories for each alternative tested, as well as centralized input of CONFACS, Frank-wolf Lambda values, turn location selections and other highway assignment parameters. This is a significant improvement in that these parameters are substituted into 7 separate job streams from a single parameter files. Operating instructions, sample parameter setups and a complete listing of the Evans Model job control language for the peak, midday, and evening time periods are given below.
- Development of procedures to automatically weight together the individual Evans iteration trip tables into the weighted average trip table for use in the transit assignment and other post processing applications. This trip table weighting is accomplished directly in the revised TRANPLAN Equilibrium Assignment program.

1. Computer Operating Instructions for the Enhanced Evans Travel Simulation Model

The Peak, Midday, and Evening travel simulation models from the trip distribution to highway and transit assignment are run in separate sub-directories. The iterative process is completely contained in a predefined job stream that is specialized for each time period. Separate trip production and attraction estimates from the trip generation model are prepared for each time period. The same highway network is the utilized for all time periods. The CONFAC parameters in the highway assignment step are used to define time period capacities from the daily table lookup capacities in the network. However, separate transit networks are usually coded for each time period to model differences in service frequencies and route configurations which can vary significantly by time of day. Since the model is defined in production-attraction format, AM peak transit service patterns are taken as representative for the combined AM/PM peak time period.

The following files are included in time period directory for insertion into the model. All data formats in these files follow regular TRANPLAN conventions. The "XX" portion of the file name denotes the year.

File Name	Function
GRAVIXXP.	Insert the trip generation peak period output into the gravity model.
GRAVIXXM.	Insert the trip generation midday period output into the gravity model.
GRAVIXXN.	Insert the trip generation night period output into the gravity model.
NETWORKS	Input the highway and transit network data set names into the job stream where needed. This file is present in all three time periods.
TITLE	Header file to identify the printed outputs - alternative number etc.
HASSIGNP	Highway assignment parameters inserted into the job stream. We customarily preset the first 17 Lambda values in the build alternatives to the values of the no-build. Turning movement selection or other unique parameter values may also be inserted here.
HASSIGNM	Highway assignment parameters inserted into the job stream. We customarily preset the first 17 Lambda values in the build alternatives to the values of the no-build. Turning movement selection of other unique parameter values may also be inserted here.
HASSIGNN	Highway assignment parameters inserted into the job stream. We customarily preset the first 17 lambda values in the build alternatives to the values of the no-build. Turning movement selection or other unique parameter values may also be inserted here.
OUTPUTP	This files contains the filename and directory information for the output from the last Evans iteration of the peak period run. These are the values that are posted and developed into the traffic forecasts. Ordinarily the output of each alternative tested is directed to a separate subdirectory.
OUTPUTM	This files contains the filename and directory information for the output from the last Evans iteration for the midday time period run.
OUTPUTN	This files contains the filename and directory information for the output from the last Evans iteration for the evening time period run.

After the filenames, data, and directory information is updated in each of the above files as appropriate for the alternative being tested the model is run by executing the batch file "MASTER.BAT " in each sub-directory.

Figures 3 through 7 give prototypical examples of each of the input files. A complete listing of the job control language needed to execute the model for each time period is given in the appendix.

Figure 3. The "NETWORKS" File

INPUT FILE = TOLDATA, USER ID = 'toldatap.cds'
INPUT FILE = HWYNET, USER ID = $..\2025nets\p412Levq.dat$
INPUT FILE = TRNET, USER ID = $..\2025nets\p41_25pk.DAT$

Figure 4. The "OUTPUTS" File

OUTPUT FILE=WTGOUT1, USER ID = $2Lane\tr25wt7a.vol$
OUTPUT FILE=WTGOUT2, USER ID = $2Lane\tr25wt7w.vol$
OUTPUT FILE=WTGOUT3, USER ID = $2Lane\tgm25w7.vol$
OUTPUT FILE=WTGOUT4, USER ID = $2Lane\hyld25w7.vol$
OUTPUT FILE=LOADHIST, USER ID = $2Lane\LODH97E7.d15$

Figure 5. The "HASSIGN" File

~ I95 Lambda's preset first 17 values
lambdapr=1.,.188,.148,.148,.133,.117,.117,.102,.070,.086,.055,
.070,.055,.070,.055,.758,.148

Figure 6. The "TITLE" File

PA 41 2025 Peak Period 2-Lane BPs /no 41 widening

Figure 7. The "GRAVIXXP" File

```
GF    1 1  16474223729921128790 206691 384482 100000 150000   2000
GF    2 1  1449591757097 847770 162923 317649  82000 130000   2500
GF    3 1  1277211309910 640866 128947 263208  56000  80000   2600
GF    4 1  112715 983118 487555 102467 218735  27500  40000   2800
GF    5 1   99608 742731 373274  81751 182302  13500  18800   2250
GF    6 1   88141 564807 287575  65482 152373   5200   8850   1800

ETC to 175 Below

GF  175 1      01      0      0     01     01      0      0      0
GP    1 1     159     98   1610      0      0    681    215    636
GP    2 1       0      0   1285      0      0    535    179    473
GP    3 1     110    239   1459      0      0    586    210    506
GP    4 1      74     94   2100      0      0    896    279    835
GP    5 1     173    277    199      0      0     89     39    103
GP    6 1     274    425    402      0      0    162     61    175

Etc to Last External Cordon Station 1562

GP 1562 1       0      0      0      0      0      0      0      0
GA    1 1   13475   4010   1610    202    108    681    215    636
GA    2 1   10296   3387   1285    158     83    535    179    473
GA    3 1   10655   4061   1459    178     91    586    210    506
GA    4 1   17959   5154   2100    264    142    896    279    835
GA    5 1    1439    521    199     28     15     89     39    103
GA    6 1    2767   1051    402     54     28    162     61    175

Etc to last External Cordons Station 1562

GA 1562 1       0      0      0      0      0      0      0      0
```

D. Procedure For Separate AM and PM Peak Period Highway Assignments

Put an explanation here. Need for assignments. Theory (post modal split) Overview of method.
Steps needed follow

E. Disaggregate Combined Peak into Separate AM and PM Highway Loading Matrices

1. Subtract combined peak period transit trips from person trips to get highway person trips.
2. Divide resulting highway person trips by the auto occupancy (Table 21) to get auto driver (vehicle) trips.

Table 21. Highway Auto Occupancies

Trip Purpose	Auto Occupancy
Home Based Work	1.153
Home-based Non-Work	1.560
Non-home Based	1.439

3. Multiply combined peak period auto driver trips by percent AM peak (Table 22) to get AM peak period auto driver trips by purpose.

Table 22. Percent of Combined Peak Period Trips in AM Peak

Trip Purpose	Auto Occupancy
Home Based Work	45.2 %
Home-based Non-Work	33.4 %
Non-home Based	25.1 %

4. Subtract AM peak from combined peak period trips to get PM peak period trips.
5. Sum the by purpose AM and PM peak period trips to get total AM and PM peak auto drivers.
6. Transpose the PM peak period auto driver matrices to get the work to home direction correct.
7. Add light and heavy truck trips together to get combined peak period total truck trips.
8. Estimate AM peak truck trips by using 0.358 of combined for the AM peak. Estimate PM truck trips by subtracting AM trucks from total.
9. Add up combined peak external-local and through trips to get total.
10. Multiply combined peak P/A inbound format external-local and through trips by the proportion of trips that occur in the AM peak by cordon station (Table 23).
11. Multiply the AM Peak proportion of trips the are oriented inbound by to percent inbound by cordon station (Table 24).
12. Subtract AM peak inbound trips from total AM peak trips to get AM Peak trips outbound.
13. Transpose the AM peak outbound trip matrix to orient direction outbound.
14. Subtract AM Peak form combined peak to get PM peak period external local trips.
15. Multiply PM Peak period external-local trips by an inbound factor (Table 25) to estimate inbound trips.
16. Subtract PM inbound external local from PM combined peak to get PM peak outbound trips.
17. Transpose PM peak outbound external trips to correct the direction.
18. Add together auto driver, truck, and external-local/through trips to get total AM and PM peak period highway loading Matrices.

F. Assign the Disaggregated AM and PM Highway Loading Matrices Separately to the Highway Network

1. Assign the AM peak highway loading matrix to the peak period highway network using a post-restraint methodology using 15 iterations of restraint.
2. Invert the direction of the link level congestion by flipping the A-B and B-A restrained travel speeds on the network.
3. Assign the PM peak highway loading matrix to the inverted peak period highway network using a post-restraint methodology using 15 iteration of restraint

Table 23. Proportion of Peak Period Trips that Occur in the AM Peak DVRPC Region

Cordon Zone	Proportion in AM Peak	Cordon Zone	Proportion in AM Peak	Cordon Zone	Proportion in AM Peak
1396	0.298	1434	0.371	1472	0.385
1397	0.263	1435	0.336	1473	0.356
1398	0.237	1436	0.356	1474	0.356
1399	0.391	1437	0.382	1475	0.336
1400	0.330	1438	0.326	1476	0.421
1401	0.343	1439	0.393	1477	0.336
1402	0.388	1440	0.356	1478	0.356
1403	0.314	1441	0.356	1479	0.356
1404	0.306	1442	0.356	1480	0.382
1405	0.303	1443	0.336	1481	0.382
1406	0.408	1444	0.385	1482	0.382
1407	0.414	1445	0.363	1483	0.382
1408	0.356	1446	0.356	1484	0.363
1409	0.352	1447	0.343	1485	0.356
1410	0.379	1448	0.302	1486	0.382
1411	0.387	1449	0.356	1487	0.356
1412	0.417	1450	0.361	1488	0.356
1413	0.347	1451	0.365	1489	0.373
1414	0.372	1452	0.356	1490	0.382
1415	0.341	1453	0.356	1491	0.342
1416	0.318	1454	0.382	1492	0.356
1417	0.356	1455	0.336	1493	0.385
1418	0.360	1456	0.385	1494	0.336
1419	0.294	1457	0.336	1495	0.349
1420	0.322	1458	0.385	1496	0.335
1421	0.382	1459	0.382	1497	0.336
1422	0.365	1460	0.382	1498	0.340
1423	0.301	1461	0.524	1499	0.383
1424	0.356	1462	0.356	1500	0.353
1425	0.345	1463	0.505	1501	0.382
1426	0.353	1464	0.356	1502	0.356
1427	0.356	1465	0.458	1503	0.356
1428	0.385	1466	0.440	1504	0.382
1429	0.367	1467	0.385	1505	0.382
1430	0.323	1468	0.356	1506	0.385
1431	0.356	1469	0.382	1507	0.336
1432	0.356	1470	0.409	1508	0.394
1433	0.565	1471	0.336	1509	0.336
				1510	0.365

Table 24. Proportion of AM Peak Period Trips that are Inbound to the DVRPC Region

Cordon Zone	Proportion in Inbound
1396	0.487
1397	0.487
1398	0.487
1399	0.475
1400	0.419
1401	0.392
1402	0.366
1403	0.392
1404	0.392
1405	0.392
1406	0.419
1407	0.419
1408	0.392
1409	0.392
1410	0.419
1411	0.419
1412	0.419
1413	0.392
1414	0.487
1415	0.523
1416	0.487
1417	0.392
1418	0.419
1419	0.419
1420	0.419
1421	0.419
1422	0.419
1423	0.419
1424	0.392
1425	0.419
1426	0.487
1427	0.392
1428	0.523
1429	0.487
1430	0.392
1431	0.392
1432	0.392
1433	0.392
1434	0.604
1435	0.487
1436	0.392
1437	0.419
1438	0.419
1439	0.419
1440	0.392
1441	0.392
1442	0.392
1443	0.487
1444	0.523
1445	0.392
1446	0.392
1447	0.547
1448	0.392
1449	0.392
1450	0.392
1451	0.419
1452	0.392
1453	0.392
1454	0.419
1455	0.487
1456	0.523
1457	0.487
1458	0.523
1459	0.419
1460	0.419
1461	0.419
1462	0.392
1463	0.419
1464	0.392
1465	0.419
1466	0.419
1467	0.480
1468	0.392
1469	0.419
1470	0.258
1471	0.487
1472	0.523
1473	0.631
1474	0.392
1475	0.487
1476	0.622
1477	0.487
1478	0.392
1479	0.392
1480	0.419
1481	0.419
1482	0.419
1483	0.419
1484	0.419
1485	0.392
1486	0.419
1487	0.392
1488	0.392
1489	0.419
1490	0.419
1491	0.487
1492	0.392
1493	0.523
1494	0.487
1495	0.487
1496	0.410
1497	0.487
1498	0.487
1499	0.469
1500	0.513
1501	0.419
1502	0.392
1503	0.392
1504	0.419
1505	0.419
1506	0.523
1507	0.487
1508	0.446
1509	0.487
1510	0.365

Table 25. Proportion of PM Peak Period Trips that are Inbound to the DVRPC Region

Cordon Zone	Proportion in Inbound	Cordon Zone	Proportion in Inbound	Cordon Zone	Proportion in Inbound
1396	0.526	1435	0.526	1474	0.596
1397	0.526	1436	0.596	1475	0.526
1398	0.526	1437	0.513	1476	0.42
1399	0.498	1438	0.513	1477	0.526
1400	0.513	1439	0.513	1478	0.596
1401	0.596	1440	0.596	1479	0.596
1402	0.552	1441	0.596	1480	0.513
1403	0.596	1442	0.596	1481	0.513
1404	0.596	1443	0.526	1482	0.513
1405	0.596	1444	0.493	1483	0.513
1406	0.513	1445	0.596	1484	0.513
1407	0.513	1446	0.596	1485	0.596
1408	0.596	1447	0.434	1486	0.513
1409	0.596	1448	0.596	1487	0.596
1410	0.513	1449	0.596	1488	0.596
1411	0.513	1450	0.596	1489	0.513
1412	0.513	1451	0.513	1490	0.513
1413	0.596	1452	0.596	1491	0.526
1414	0.526	1453	0.596	1492	0.596
1415	0.519	1454	0.513	1493	0.493
1416	0.526	1455	0.526	1494	0.526
1417	0.596	1456	0.493	1495	0.526
1418	0.513	1457	0.526	1496	0.522
1419	0.513	1458	0.493	1497	0.526
1420	0.513	1459	0.513	1498	0.526
1421	0.513	1460	0.513	1499	0.601
1422	0.513	1461	0.513	1500	0.545
1423	0.513	1462	0.596	1501	0.513
1424	0.596	1463	0.513	1502	0.596
1425	0.513	1464	0.596	1503	0.596
1426	0.526	1465	0.513	1504	0.513
1427	0.596	1466	0.513	1505	0.513
1428	0.493	1467	0.467	1506	0.493
1429	0.526	1468	0.596	1507	0.526
1430	0.596	1469	0.513	1508	0.504
1431	0.596	1470	0.641	1509	0.526
1432	0.596	1471	0.526	1510	0.526
1433	0.596	1472	0.493		
1434	0.413	1473	0.485		

1997 Enhanced Travel Simulation Model for the Delaware Valley Region - ***Supplement No. 1***

Publication No. : 02047

Date Published: November 2002

Geographic Area Covered: Delaware Valley region comprised of five counties in Pennsylvania (Bucks, Chester, Delaware, Montgomery, and Philadelphia); and four counties in New Jersey (Burlington, Camden, Gloucester and Mercer).

Key Words: 1997 Enhanced Travel Simulation Model, Highway Assignment, TRANPLAN, Evans Iteration, Trip Generation, Trip Distribution, Nested Modal Split, Model, Highway Speeds and Capacities, and Travel Speeds, Gravity Model, Non-Motorized Travel Simulation Model and Transit Assignment.

ABSTRACT

This Supplement report presents and updated refinement of the 1997 DVRPC's Travel Simulation Model.

Delaware Valley Regional Planning Commission
8th Floor - The Bourse Building
111 South Independence Mall East
Philadelphia, PA 19106-2582

Phone:	215-592-1800
Fax:	215-592-9125
Internet:	www.dvrpc.org

Staff contact:	John J. Coscia Jr.
Direct phone:	215-238-2859
E-mail:	twalker@dvrpc.org