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SYNTHETIC MODELS FOR THROUGH TRIPS

IN SMALL URBAN AREAS

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Meenakshisundaram Raja

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ABSTRACT

This research studied the usefulness of using synthetic models for through trip end estimation and distribution for small urban areas. Three sets of models--NC1, NC2, and KY--which were previously developed in North Carolina and Kentucky respectively were evaluated as a part of this study. All the three models were essentially two stage models. The first stage estimated the number of through trip ends at each Cordon station. The second stage distributed the through trip ends calculated in the stage one from each origin station to all other destination stations.

The basic features of all the models were compared to bring out their similarities and differences. The models were then tested with the help of data obtained from fourteen small urban areas in North Carolina. The trip end estimation stage was tested on all the fourteen urban areas and the trip distribution stage was tested on six of these urban areas. Later the estimated through trips were compared with the actual through trips obtained from O-D surveys to assess the accuracy of the models. RMS and percent RMS errors were calculated to measure the extent of the deviation. The models were applied and tested using a computer program.

Based on their performance the models were ranked in order of preference. It was found that the NC1 model performed better than the other two models in predicting the through trip flows. An analysis was performed to determine the sensitivity of functional classification for

all the three models, and the sensitivity of route continuity on the NC2 model. The results obtained showed that the NC1 Model was the most sensitive to changes in functional classification. Further it was observed that all three models were more sensitive to changes with respect to a higher level functional classification compared to a change of a lower level functional classification. A similar pattern was also observed for sensitivity to changes in route continuity.

The accuracy of the models in predicting large volumes of through trips was found to be acceptable. It was finally concluded that the models could be used as an useful tool for quick estimation of through trip patterns in a small urban area.

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INTRODUCTION

Transportation Planning for Urban Areas

Transportation engineers responsible for determining when and where to construct new urban highways and streets, or to improve existing facilities must consider many factors in the decision-making process. A major factor is the travel desires and volumes of traffic which can be expected to use the facilities in the future. So highway planners have to estimate travel, and typically the process involves the derivation of mathematical models that can replicate current travel demand. Once satisfactory models are developed based on observed data, projected values of model parameters are utilized to predict future travel demands. The future travel demand is then used to recommend improvements to the existing transportation network. The input data involved in the process is land use, socio-economic and origin-destination data.

The external origin-destination survey, in which drivers of vehicles are interviewed at the study area boundary, provides data for the internal-external and the external-external (or through) trips. Internal-internal trip data are generally obtained by home interview surveys, truck surveys and taxi surveys. The cost associated with conducting an origin-destination survey is very high. Given the limited resources available the prospect of conducting comprehensive O-D surveys for urban areas is low. At the same time it is not possible to neglect comprehensive transportation planning in urban areas as these may be areas of potential growth. The absence of comprehensive transportation planning at the initial growth period may lead to imbalance and improper growth in the future. Hence there is a need for developing tools and special methods for comprehensive transportation planning for urban areas taking into consideration the constraints imposed due to lack of financial resources.

It is with this background that transportation planning for urban areas have become an area of considerable interest to transportation planners and engineers. Also in the recent years there has been a trend among transportation planners and engineers to recognize the unique characteristics of these urban communities and to adjust planning procedures and models accordingly. The use of synthetic models to predict network flows in these urban areas is an on-going effort by engineers and planners to evolve low cost tools for transportation planning in urban areas.

Synthetic Models-An Introduction

Synthetic models are very useful tools. They eliminate the need for collecting large amounts of data, which may be expensive and time consuming. Although it is doubtful whether synthetically derived models can duplicate the reliability of those based on extensive O-D surveys, they may be reliable enough to serve as a valid tool for systems testing at significantly lower costs. This method of transportation planning may prove beneficial to those urban areas where there is a lack of high level technical expertise. Given this framework transportation planning for urban areas may be successfully done using synthetic models without much loss of accuracy, and at the same time saving time and money. Reviews of the studies completed in the past have indicated that there are many similarities in the models involving internal-internal trips developed for both trip generation and trip distribution. For this reason it has been possible in the past several years to synthesize internal-internal trips by modeling. A brief review of a few selected work done in this area by various researchers is given in the Annotated Bibliography in Appendix 1. It has been the approach initially to synthesize internal-internal travel, and to conduct a Cordon type O-D survey for external trips. It is generally easier to synthesize internal-internal trips because most of these are made by the residents of the urban area and the majority of these are home-based trips. In contrast the synthesis of external trips is relatively difficult because it involves trips made by non-residents. Usually the external-internal flows are estimated using models like the gravity model. The through trips are predicted using growth factor techniques like Fartar method. Mathematical modeling of through trips is difficult because these trips are not related to the urban area directly.

Development of Through Trip Models

Pioneering work in developing new techniques for synthesizing through trip was done in North Carolina. Initially work was directed towards simulation of internal travel using trip generation data from either a small sample of home interviews or data obtained from other similar urban areas. By 1970 a procedure for synthesis of internal travel had been perfected to the extent that its use had become standard operating procedure. In 1970 Modlin, working with the North Carolina Department of Transportation, was successful in synthesizing internal-external and through travel patterns for small urban areas (2). One of the models developed by Modlin dealt specifically with through trips. The estimating procedure utilized three models. The first dealt with the estimation of the percentage of through trips in the AADT at each external station given the functional classification of the facility external to the Cordon, the current AADT, the percentage of panel and pickup trucks, the percentage of other trucks, and the urban area population. The second was a composite model composed of distribution models for each functional classification which produced a triangular through trip table. A third model estimated the percentage of total external trips by vehicles garaged inside the Cordon as a function of employment available within the urban area.

In 1978 Pigman of Kentucky State DOT (3) working on similar lines developed synthetic models for both internal-external and through trips. He used both regression and cross-classification models for estimating internal external trips. Regression models were developed for various population groups and they predicted the internal-external trips by zone using population, commercial employment, public employment, and industrial employment by zone as independent variables. The cross-classification scheme used total employment and population as the independent variables. For through trips Pigman also included the results of cross-classification for through trip estimation purposes. Pigman concluded that the regression analysis technique provided fewer data problems and provided sufficient accuracy to make its use appropriate for planning purposes. He also confirmed the importance of urban area population, average daily traffic at the external station and the percent of trucks for estimating through trips. The significance of the impact of functional classification was not proved in the estimation of through trip productions. However the distribution models were based on the functional classification of the origin station. The models developed by Pigman were considerably simpler and consequently less tedious to use than that used by Modlin. This was because he used lesser number of independent variables in both the models and used fewer levels of functional classification. In 1980 Modlin (4) following his earlier work modified his through trip models to enhance its accuracy. He discarded the functional classification as an independent variable in the trip end estimation phase and included route continuity as an independent variable in the distribution models.

Objective

The objective of this thesis is to compare the available through trip models so far developed by Modlin (2, 4) and Pigman (3) and to apply these models to urban areas to study their accuracy and usefulness in predicting through trips in those areas. As an input data source for testing these models O-D data was obtained for fourteen small urban areas in North Carolina. These areas had a population ranging from 6,500 to 50,500 and the number of Cordon stations ranging from 7 to 30. The origin and destination data from some of the above areas were also used by Modlin in developing his models. The actual through trip movements are to be compared with the predicted through trips to gauge the accuracy of these models and also to study the usefulness of these models as a planning tool.

Table 1 in the following page gives a list of the urban areas and the Figure 1 following it shows the location of these areas.

Table 1

Urban Areas From Where O-D Data was Used
in Testing the Models

No.	Urban Areas	Urbanized Area Population	Number of Cordon Stations
1	Hickory	50,500	30
2	Morganton	16,500	18
3	Shelby	31,500	23
4	Statesville	37,000	24
5	Mount Airy	22,900	19
6	Tarboro	13,500	9
7	Elizabeth City	6,500	10
8	Boone	16,000	8
9	Dunn	17,300	21
10	Monroe	15,900	20
11	Ahoskie	6,500	8
12	Sanford	21,900	23
13	Canton	10,000	12
14	Farmville	6,600	7

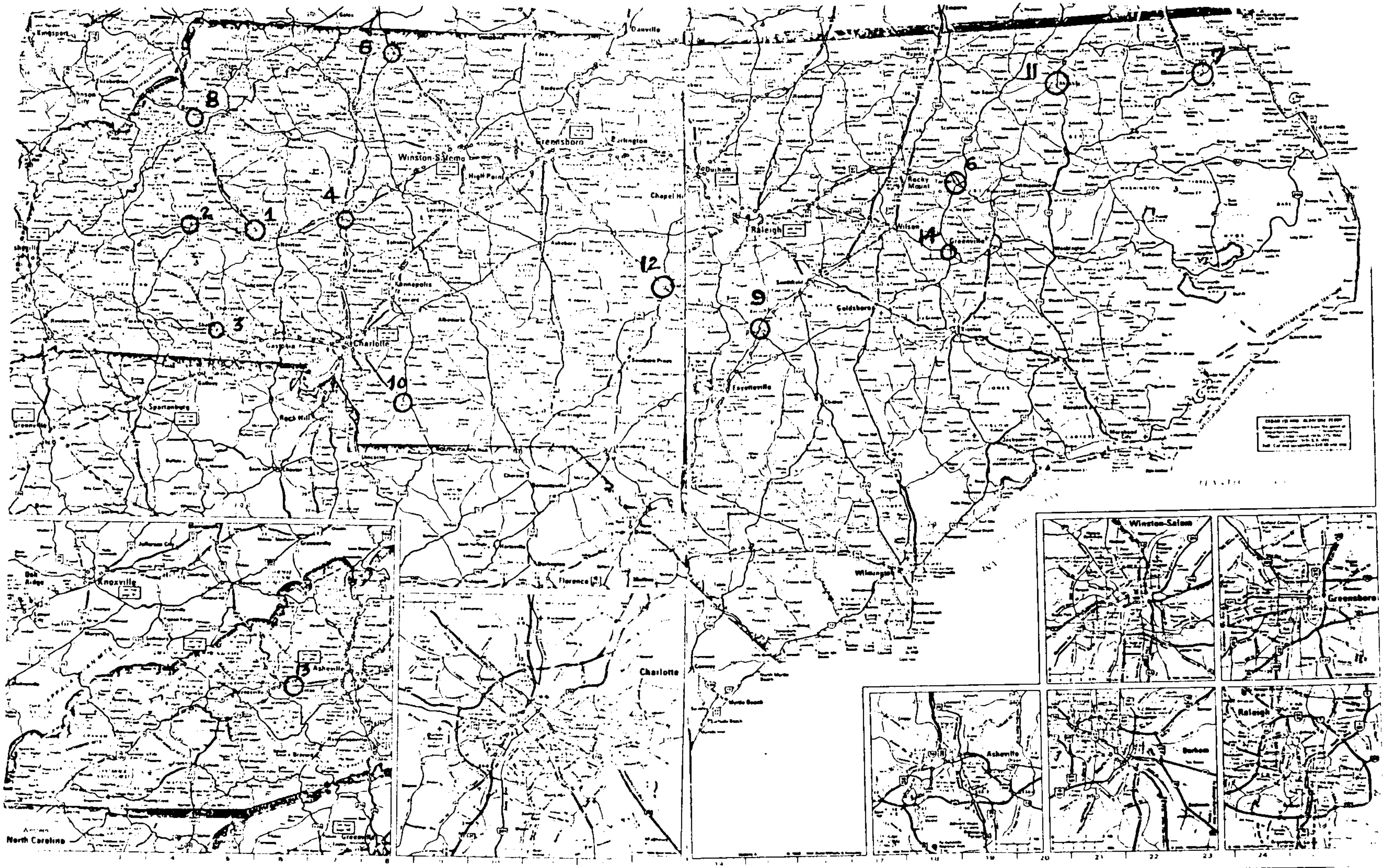

Figure 1

Location of the Urban Areas Shown in Table 1

CHAPTER 2

THROUGH TRIP MODELS

Introduction

The main use of synthetic through trip models is to estimate the through trip patterns within a small urban area without the help of O-D data. The models under discussion--Modlin (2, 4) and Pigman (3)--are described in detail here. Later the basic features of these models are compared to bring out their similarities and differences.

Through Trip Model-NC 1

The model developed by Modlin in 1975 is essentially a two-stage process. A set of parameters was made available in 1969 that suggested a solution to the problem of predicting through trips. The 1968 National Highway Functional Classification study required by the 1968 Federal-Aid Highway Act provided a classification system for highways that possessed important qualities. The system was intuitively hierarchial with respect to through trip generation. The classification was conducted under same guidelines in each state. These qualities then provided an excellent opportunity to seek a method of synthesizing through trip patterns. The 1968 National Highway Functional Classification (1) study provided for the following functional classes of roads:

(1) Interstate

(2) Interstate travelway

(3) Other principal arterial

(4) Minor arterial

(5) Major collector

(6) Minor collector

(7) Local

This classification system implies a heirarchial system of roads which compares traffic service versus land access service. Consequently the functional classification relates to the through trips on a facility. The functional classification was developed on a statewide basis, considering such parameters as travel characteristics, service to an urban area, size and socio-economic factors and system continuity. An individual facility's classification is assumed to remain reasonably stable over time, barring major shifts in the urban development of a given city. Using the above mentioned classification and other variables associated with through trip generation and distribution like ADT, percentage of trucks, and population, the percentage of through trip ends at each Cordon station is calculated using the following regression equation:

Equation for through trip end estimation NC1 model

$$\begin{aligned} Y(I) = {} & 76.76+11.22(INT)-25.74(OPA)-42.18(MINA) \\ & -51.22(MAJC)-53.40(MINC)+0.00012(ADT) \\ & +0.59(PTKS)-0.48(PPS)-0.000417(POP) \end{aligned}$$

where

Y(I) = percentage of through trip ends of the ADT at external station I

INT = interstate

OPA = other principal arterial

MINA = minor arterial

MAJC = major collector

MINC = minor collector

ADT = average daily traffic at the external station

PTKS = percentage of trucks excluding panels and pickups

PPS = percentage of panels and pickups

POP = population inside the Cordon area

An analysis of the statistical properties of all the models are presented in the latter part of the chapter.

The inclusion of functional classification as an independent variable in the model required the use of dummy variables. The variables representing the functional classification of a facility form a set of dummy variables. The presence of a particular classification is indicated by a value of one (1) for the corresponding variable, and its absence is marked by a value of zero (0). Consequently at any given station, only one of the dummy variables may be coded 1 and all others must necessarily be 0.

The second stage involves the distribution of the through trip ends predicted at each Cordon station in the first stage. Depending upon the functional classification of the origin station a different equation is used to distribute the through trip ends from the origin station to all other destination stations. The models used are given below.

Equations for through trip end distribution NC1 Model

Interstate

Y(I,J) =-2.28(INT) +83.75(INT)+1.66(OPA)+1.35(MINA)

+0.191 (SQDADT)-0.00378(DADT)+0.00000039(DADT2)

Interstate Travelway

Y(I,J) =189.95-68.34(INT)+110.29(OPA)-15.43(MINA)

-3.190(POEE)+1.445(PDEE)+0.0105(DADT)

-0.000000195(DADT2)

Other Principal Arterial

Y(I,J) =-10.00-67.01(INT)+13.95(OPA)+2.923(PTKS)

-0.138(PTKS2)-0.267(PDEE)+0.0127(PDEE2)

Minor Arterial

Y(I.J) =39.73-43.71(INT)-30.92(MINC)-26.91(OPA)-19.51(MINA)

-30.58(MAJC)+0.0513(SQDADT)+0.00169(DADT)-1.221(LPOP)

+0.0633(PTKS)-0.262(POEE)+0.586(SQPDEE)

Major Collector

Y(I,J) =-0.16-4.04(INT)+2.00(MAJC)-0.000130(POP)

+0.303(PDEE)-0.00414(PDEE2)+0.00316(DADT)

Minor Collector

Y(I,J) =-0.81-3.88(INT)+3.28(OPA)+0.00233(DADT)

-0.0216(SQPOP)+0.945(PTKS)-0.0354(PTKS2)

Y(I,J) = percentage distribution of through trips ends from the origin station "I" to destination station "J".

where

INT = interstate

OPA = other principal arterial

MINA = minor arterial

MAJC = major collector

MINC = minor collector

ADT = average daily traffic at the external station

PTKS = percentage of trucks excluding panels and pickups

PPS = percentage of panels and pickups

POP = population inside the Cordon area

PTKS2 = square of PTKS

SQDADT = square root of DADT

ODADT = average daily traffic from origin destination survey

PDEE = percentage of through trip ends at destination station predicted by Model 1

POEE = percentage of through trip ends at origin station predicted by Model 1

SQPOP = square root of population

SQPDEE = square root of PDEE

The distribution procedure produces two estimates for each station to station interchange since the model distributes two way trips from one station to all other stations. The two values for a station pair are averaged to arrive at the estimated trip interchange between any two stations. This averaging process produces trip end totals at individual stations that may be different from the totals predicted by Model 1. These differences are adjusted by utilizing a fratar balancing technique. For the purpose of this study this model hereafter will be referred as the NC1 Model.

Through Trip Model-KY

The model developed by Pigman (3) is also a two-stage process. In the first stage regression equations are used to estimate the through trip ends at each Cordon station. The equation is as follows

Equation for through trip end estimation at the Cordon stations KY Model

$$Y=.003(ADT)+1.49(PTADT)-0.0007(POP) + 17.43$$

where

Y = percentage of through trip ends of the ADT at the external station

POP = population of the urban area

ADT = average daily traffic at the external station

PTADT = percent trucks of ADT at the external station

The second stage involves distribution of the through trip ends predicted at each Cordon station in the first stage. Depending upon the functional classification of the origin station a different set of equation is used to distribute the through trip ends from each origin station to all the destination stations. Models used are given below. The independent variables used for these equations were:

1. AADT at the destination station.
2. Percent trucks at the destination station.
3. Percentage through trips at the destination station.
4. The ratio of destination station ADT to the combined ADT at all stations.

For the purpose of this study this model will hereafter be referred to as KY Model.

Equations for through trip distribution KY Model

Primary Arterial

$$Y(I,J)=0.0001(A)+0.11(T)+0.22(TT) +385.83(R)-2.58$$

Minor Arterial

$$Y(I,J)=0.0008(A)-0.08(T)-0.03(TT) +228.14(R)+6.20$$

Collector

$$Y(I,J)=-0.00001(A)+0.11(T)+0.05(TT) \quad 295.06(R)+3.10$$

Local

$$Y(I,J)=-0.01(A)-0.03(T)+0.83(TT) +2704.73(R)+1.95$$

Y(I,J)=percentage distribution of through trip ends from origin station "I" to destination station "J"

where

A = AADT at the destination station

T = percent trucks of AADT at destination station

TT = percent through trips of AADT at destination station

R = square of ratio of destination AADT to total AADT

Through Trip Model-NC 2

Modlin (4) continued to examine his original models and later developed a new set of models using multiple regression analysis. The selected variables for the new models are routinely available. The first stage model estimates the percentage of through trip ends at each external Cordon station. The model is as given below.

Equation for through trip end estimation at the Cordon stations NC2 Model

$$Y=9.29-0.00031(UP)+0.0026(ADT)+1.48(TRK)$$

where

Y = percentage of through trip ends at the ADT at the external station

UP = urban area population

ADT = average daily traffic at the external station

TRK = percentage of trucks excluding panels and pickups at the external station

The second stage model developed is a composite model wherein equations for each of five functional classifications were developed. The independent variables utilized are:

1. ADT at the destination station

2. Percent of trucks excluding panels and pickups.

3. Percent through trips at the destination.

4. Route continuity (as a dummy variable)

For the purpose of this study this model will hereafter be referred as the NC2 Model. The final equations are given below.

Equations for through trip distribution NC2 Model

Interstate

$$Y(I,J)=-2.70+0.21(PTTDES)+67.86(RTECON)$$

Principal Arterial

$$Y(I,J)=-7.40+0.55(PTTDES)+24.68(RTECON)+45.62(ADT/CD)$$

Minor Arterial

$$Y(I,J)=-0.63+86.68(ADT/CD)+30.04(RTECON)$$

Major Collector

$$Y(I,J)=-1.08+0.00079(DESADT)+0.47(PTKDES)$$
$$+31.78(ADT/CD)$$

Minor Collector
/Local $Y(I,J)=-0.40+109.42(ADT/CD)$

where

Y(I,J)=percentage distribution of through trip ends from origin station "I" to destination station J"

PTTDES=percentage through trips ends at the origin station

RTECON=route continuity: 1=Yes, 0=No

ADT/CD=average daily traffic at the destination station divided by the sum of average daily traffic at all stations

DESADT=average daily traffic at destination station

PTKDES=percentage trucks excluding panels and pickups at the destination station

Comparison of the Models

The models developed by Jerry J. Pigman for the Kentucky State DOT and David Modlin for the NC State DOT are similar in structure. Both essentially use regression equations for estimating through trip ends as well as distributing the through trips. The sample sizes used to develop the model are given in Table 2.

Through Trip End Estimation Models. The dependent variables for all the models are essentially the same. The independent variables for the first model developed by Modlin (2) have two additional variables. They are the functional classification and percent of panels and pickups. The independent variables used in the trip end estimation stage is

Table 2

Sample Sizes Used in Developing the Models

	Trip End Estimation Model		Trip Distribution Model	
	Number of Urban Areas	Total Number of Observations(1)	Number of Urban Areas	Total Number of Observations(2)
NC1	10	144	10	--
NC2	14	241	14	768
KY	17	177	17	1,331

1. Refers to total number of external stations.

2. Refers to total number of trip interchanges.

given in Table 3. The statistical comparison of the trip end estimation models are given in Table 4. Comparing the statistical parameters of the three models for the trip end estimation stage, it is observed that the NC1 Model has a higher value for the multiple correlation coefficient and a lower value for the standard error of estimation. It thus appears that the NC1 model has better explainatory variable compared to the other two models for the trip end estimation stage. A comparison between the KY Model and the NC2 Model demonstrates better statistical values for the latter thus making the KY Model appear the least attractive.

Trip Distribution Models. All the three models under study have used different categories of functional classification for the trip distribution models. These are given in Table 5.

A brief comparison of the independent variables used in the three models is presented in Table 6.

The initial model (NC1) developed by Modlin had three independent variables which were absent in the other two models. These are:

1. Percent through trips at origin
2. Functional classifications (as a dummy variable)
3. Population of urban area.

In his second model (NC2) Modlin introduced a new dummy variable in the form of route continuity. This has enhanced the accuracy of the model as shown by the statistical results in Tables 7, 8, and 9. The NC2 Model shows higher values for the multiple correlation coefficient

Table 3

Independent Variables Used in the Trip End
Estimation Stage

Model	NC1	NC2	KY
ADT at the External Station	Yes	Yes	Yes
Percentage of Trucks of ADT at the External Station	Yes	Yes	Yes
Population of the Urban Area	Yes	Yes	Yes
Percentage of Panels and Pickups at the External Station	Yes	No	No
Functional Classification of External Station	Yes	No	No

Table 4

Comparison of the Statistical Parameters for the Through Trip End Estimation Models

	NC1	NC2	KY
Standard Error of Estimate	7.47	9.66	15.53
Multiple Correlation Coefficient	0.9214	0.74	0.53

Table 5

Categories of Functional Classification Used
in the Trip Distribution Stage

No 1	NC2	Kentucky
Interstate	Interstate	Primary Arterial
Interstate Travelway	Principal Arterial	Minor Arterial
Other Principal Arterial	Minor Arterial	Collector
Minor Arterial	Major Collector	Local
Major Collector	Minor Collector/Local	
Minor Collector		

Table 6

Independent Variables Used at the Trip Distribution Stage

Model	NC1	NC2	KY
ADT at the External Station	Yes	Yes	Yes
Percentage of Trucks (of ADT) at the External Station	Yes	Yes	Yes
Percentage Through Trip Ends at Destination Station	Yes	Yes	Yes
Percent Through Trip Ends at the Origin Station	Yes	No	No
Population of the Urban Area	Yes	No	No
Route Continuity (as dummy variable)	No	Yes	No
Functional Classification of Destination Station (as dummy variable)	Yes	No	No

Table 7

Statistical Results of Trip Distribution
Stage for NC1 Model

Origin Facility	Calcualted F-Ratio	Theoretical F(05) Ratio	Standard Error	RSquare
Interstate	1597.65	2.2	2.22	0.9903
Interstate Travelway	8.3	2.61	10.44	0.7737
Other Principal Arterial	38.9	2.1	11.92	0.4879
Minor Arterial	13.91	1.79	9.08	0.4679
Major Collector	44.2	2.1	7.61	0.4846
Minor Collector	32.57	2.1	8.01	0.3843

Table 8

Statistical Results of Trip Distribution
Stage for NC2 Model

Origin Facility	Total Observations	Mean of Dependent Variable	Standard Error	RSquare	Coefficient of Variation
Interstate	134	5.22	5.36	0.92	103
Principal Arterial	179	8.95	9.35	0.76	104
Minor Arterial	85	8.24	6.63	0.74	80
Major Collector	166	7.22	7.74	0.48	107
Minor Collector	204	6.46	6.83	0.53	106

Table 9

Statistical Results of Trip Distribution
Stage for KY Model

Origin Facility	Total Observations	Mean of Dependent Variable	Standard Error	RSquare	Coefficient of Variation
Primary Arterial	478	11.6	12.85	0.54	111
Minor Arterial	733	11.61	11.13	0.43	97
Collector	79	11.74	12.64	0.35	108
Local	42	7.03	7.93	0.63	113

and lower values for the standard error of estimation as compared to the NC1 Model and the KY Model for the trip distribution stage. The KY Model has the lowest value for the multiple correlation coefficient and the highest values for the standard error of estimation compared to the other two models. This makes the KY Model inferior to the other two models.

On basis of the statistical results presented by the authors it can be concluded that of the three models under analysis the NC1 model is preferable to the other two models. Also the NC2 Model is preferable to the KY Model.

In the following chapter the application of the models is illustrated with O-D data from Boone, NC, and using the KY Model.

CHAPTER 3

APPLICATION OF MODEL-A DETAILED EXAMPLE

The three models so far analyzed are similar in nature although the independent variables are slightly different. In this chapter the application of the models is fully illustrated by a step-by-step approach. As has been shown before, all the three models discussed so far involve two stages of calculation. In the first stage the percentage of through trip ends at each station is calculated based on a single equation for all the stations. Depending on the input variables at each Cordon station various values are obtained for the percentage of through trip ends. These percentages multiplied by the corresponding ADT at each Cordon station gives the number of through trip ends at each station. These trip ends represent two way trips at each station.

The second stage involves the calculation of the percentage of through trips at each station to be distributed to each of the other Cordon stations respectively. At this stage the functional classification of the origin station plays an important role in determining the particular equation to be used. The percentage of through trips from an origin station to a destination station when multiplied by the total number of through trip ends at the origin station gives the number of through trips from the origin station to the destination station. It is observed that at the end of the trip distribution phase the total percentage of through trips from each origin station does not add up to a hundred percent. To rectify this deviation the through trip percentages from each origin station are factored to make the sum a hundred percent. When this process is completed for all origin stations there are two values of through trip movements for each pair of stations, each value obtained when one of the two stations is used as an origin station. As explained earlier the output from the first stage represents two way trips at each station, and hence the distribution of through trips ends is actually the distribution of two way trips from each station to all the other destination stations. Thus between any pair of stations we have two values of two way through trips. This is twice the number of trips that can be accounted for. Hence to rectify this anomoly the two values of the through trips between a pair of stations are averaged to arrive at the appropriate value. Thus at the end of stage two we have as output, the number of through trips between all pairs of stations. However, the trip distribution process does not guarantee that the trip ends at each station resulting from the trip movements would match the original trip end estimates of the stage one model. To correct any discrepancy, a fratar adjustment is done to bring the value of the new trip ends to that estimated after the end of stage one. The following example illustrates the procedure in detail, using the Kentucky Model.

Table 10 on the following page shows the input variables used in the trip end estimation stage. The equation used for calculating the percentage of through trip ends at each station is

$$Y(I) = 17.43+0.003(\text{ADT})+1.49(\text{percent of trucks excluding panels and pickups})-0.0007\ (\text{urban population})$$

Table 10

Input Variables for Through Trip End Estimation
For Boone, NC Using the Kentucky Model

St No	ADT	Population	% Trucks Excluding Panels and Pickups
1	7,680	16,000	9.07
2	6,270	16,000	5.741
3	7,690	16,000	9.271
4	7,580	16,000	6.306
5	12,220	16,000	5.621
6	1,220	16,000	5.655
7	1,500	16,000	4.2
8	880	16,000	3.636

where

Y(I) = percentage of through trip ends of the ADT at external station I.

Of the three input variables used, the ADT and the percent trucks varies from station to station whereas the urban population is a constant. Table 11 shows the result of the trip end estimation stage, which is the total number of through trip ends at each station.

The calculation for the trip distribution phase is more exhaustive and time consuming compared to the trip end estimation phase. Here the equations involve more input variables, and the calculation for each station is done as many times as the total number of stations in the Cordon. The equation for each station is selected based on the functional classification of the station. Tables 12 through 17 on the following pages give the results obtained at the various stages of the trip distribution phase as shown in the flow chart, in Figure 2.

Table 11

Results of the Trip End Estimation Stage for Boone, NC Using the Kentucky Model

St No	ADT	% Through Trip Ends	Total Through Trip Ends
1	7,680	42.78	3,285
2	6,270	33.59	2,106
3	7,690	43.114	3,315
4	7,580	38.36	2,908
5	12,220	51.26	6,264
6	1,220	18.31	223
7	1,500	16.998	255
8	880	14.287	125.7

Table 12

Input Data for Through Trip Distribution
For Boone, NC Using the Kentucky Model

St No	ADT	% Through Trip Ends	% Trucks Excluding Panels and Pickups	Functional Classification
1	7,680	42.78	9.07	Primary Arterial
2	6,270	33.59	5.741	Minor Arterial
3	7,690	43.114	9.271	Primary Arterial
4	7,580	38.36	6.306	Primary Arterial
5	12,220	51.26	5.621	Primary Arterial
6	1,220	18.31	5.655	Local
7	1,500	16.998	4.2	Collector
8	880	14.287	3.636	Local

Note: The percentage of through trip ends as shown above is the output from the trip end estimation model.

Table 13

Results of Trip Distribution Phase Showing Percentage of Through Trip Ends to be Distributed from Each Station for Boone, NC Using the Kentucky Model

	To								
From	1	2	3	4	5	6	7	8	Total
1	0	12.92	19.94	18.24	38.94	2.47	2.196	1.197	95.90
2	16.97	0	16.96	17.07	30.78	6.34	6.80	6.27	101.92
3	19.8	12.92	0	18.24	38.94	2.475	2.196	1.197	95.768
4	19.8	12.92	19.94	0	38.94	2.475	2.196	1.197	97.47
5	19.8	12.92	19.941	18.24	0	2.475	2.196	1.197	76.77
6	39.03	19.37	39.40	34.40	121.2	0	3.91	5.92	263.26
7	14.74	11.066	39.40	13.933	27.87	4.84	0	4.519	91.83
8	39.03	19.37	39.40	34.40	121.2	0	3.917	0	257.34

Table 14

Results of Trip Distribution Phase After Factoring, Showing the Percentages of Through Trip Ends to be Distributed from Each Station for Boone, NC Using the Kentucky Model

From	To 1	2	3	4	5	6	7	8	Total
1	0	13.47	20.78	19.02	40.6	2.58	2.29	1.25	100
2	16.77	0	16.76	16.87	30.42	6.27	6.72	6.2	100
3	20.67	13.49	0	19.05	40.66	2.58	2.29	1.25	100
4	20.314	13.26	20.46	0	39.95	2.54	2.25	1.23	100
5	25.79	16.83	25.98	23.76	0	3.23	2.86	1.56	100
6	14.82	7.35	14.97	13.07	46.05	0	1.48	2.25	100
7	16.05	12.05	16.12	15.28	30.35	5.27	0	4.92	100
8	15.165	7.527	15.31	15.37	47.10	0	1.52	0	100

Table 15

Station to Station Distribution of Through Trips
for Boone, NC Using the Kentucky Model

To From	1	2	3	4	5	6	7	8	Total
1	0	443	683	625	1,334	85	75	41	3,285
2	353	0	353	355	641	132	142	131	2,106
3	685	447	0	631	1,348	86	76	42	3,315
4	591	386	595	0	1,162	74	66	36	2,908
5	1,616	1,054	1,627	1,488	0	202	179	98	6,264
6	33	16	33	29	103	0	3	5	223
7	41	31	41	39	77	13	0	13	255
8	19	10	19	17	59	0	2	0	126

Table 16

Station to Station Distribution of Through Trips Obtained by Averaging the Through Trips Between Stations for Boone, NC Using the Kentucky Model

	1	2	3	4	5	6	7	8
1	0							
2	398	0						
3	684	400	0					
4	608	370	613	0				
5	1,475	847	1,487	1,325	0			
6	59	74	60	52	152	0		
7	58	86	59	52	128	8	0	
8	30	70	30	26	79	3	7	0
Total	3,312	2,245	3,333	3,046	5,493	408	398	245
Desired Total	3,285	2,106	3,315	2,908	6,264	223	255	125

Table 17

Station to Station Distribution of Through Trips Obtained
After Fratar Balancing for Boone, NC
Using the Kentucky Model

	1	2	3	4	5	6	7	8
1	0							
2	345	0						
3	603	347	0					
4	512	307	518	0				
5	1,748	988	1,768	1,505	0			
6	29	36	30	25	101	0		
7	34	50	35	29	102	3	0	
8	14	33	14	12	50	1	2	0
Total	3,285	2,106	3,315	2,908	6,262	225	255	126
Desired Total	3,285	2,106	3,315	2,908	6,264	223	255	125

*This is the final output of the trip distribution stage.

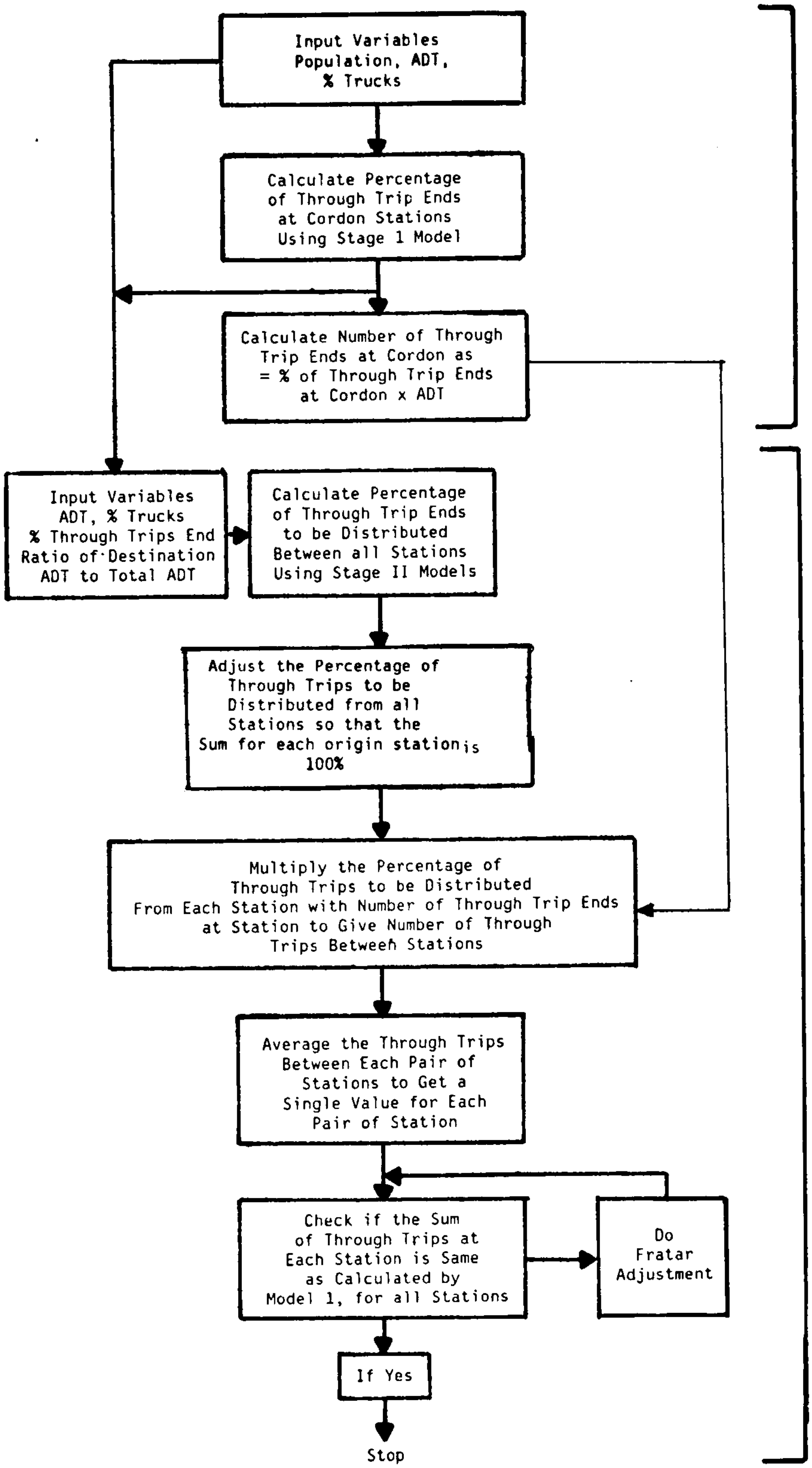

Figure 2

Flow Chart of the Trip End Estimation and Distribution Models

CHAPTER 4

THROUGH TRIP END ESTIMATION

Introduction

The through trip end estimation process is the first stage in the two stage process for synthesizing the through trip pattern for an urban area. The input variables used in this stage varies for each model under consideration as shown in Chapter 2. The models were tested initially on fourteen small urban areas located in North Carolina. These are the same urban areas that are listed in Table 1. The input data used were obtained from actual origin and destination surveys conducted in these areas. Data from some of the above mentioned areas were also used by Modlin (2, 4) in developing his models. These areas are listed in Table 18. Of these 13 areas are common with those used in testing the models.

As a part of this study the through trip end estimation models are tested by applying them to the fourteen urban areas listed in Table 1. The output is compared with the observed number of through trip ends at each Cordon station.

Estimation of Through Trip Ends

The through trip end estimation model estimates the percentage of through trip ends at each Cordon station. The percentage of through trip ends multiplied by the average weekday traffic at the Cordon station gives the total number of through trip ends at each Cordon station. The through trip end estimation for each urban area was

Table 18

List of Urban Areas from Which O&D Data was Used in Developing NC1 and NC2 Models

Urban Area	Population of Urban Area	Number of Stations	NC1	NC2
Elizabeth City	13,700	11	Yes	No
Sanford	16,549	19	Yes	Yes
Washington	13,600	10	Yes	No
Monroe	13,700	18	Yes	Yes
Lumberton	20,800	18	Yes	No
Smithfield	8,250	11	Yes	No
Henderson	20,400	17	Yes	No
Kinston	31,000	12	Yes	No
Asheboro	24,000	18	Yes	No
Greenville	35,000	15	Yes	No
Linconton	18,500	17	No	Yes
Dunn-Erwin	17,300	21	No	Yes
Tarboro	13,500	9	No	Yes
Mount Airy	22,900	19	No	Yes
Statesville	37,000	24	No	Yes
Hickory	50,500	30	No	Yes
Farmville	6,600	7	No	Yes
Boone	16,000	8	No	Yes
Shelby	31,500	23	No	Yes
Canton	10,000	12	No	Yes
Morganton	16,500	18	No	Yes
New Bern	25,350	10	No	Yes

performed with the help of a computer program for each of the three models separately. The listing of the computer program is presented in Appendix 2. In the following pages results obtained from a few of the urban areas for the trip end estimation stage is presented in Tables 19 through 24. The results represent the best and the worst cases for each model. The results obtained for all the other cases are presented in Appendix 3.

Comparison of Through Trip End Estimation Results

As a part of the Origin and Destination Survey the total number of through trip ends observed at each Cordon station are recorded for a twenty-four hour period on an average weekday. For comparing the results obtained from the trip end estimation stage, the observed through trip ends were matched with the estimated through trip ends, and the root mean square error was calculated for each area as follows:

$$R.M.S. = \sqrt{\frac{\sum_{i}^{n} (Oi-Ei)^2}{N}}$$

where R.M.S. in the root mean square error for each urban area.

Oi - the observed number of through trip ends at Cordon station i.

Ei - Estimated number of through trip ends at Cordon station i

N - The number of Cordon stations in the urban area.

The percent R.M.S. error which is the R.M.S. error expressed as a percent of the average number of through trips ends per station was also calculated for each area for all the three models. Table 25 gives

Table 19

Results of Through Trip End Estimation for Dunn, NC Using the NC1 Model
(Lowest RMS Error)

ADT	POP	% Through Trip Ends (Model)	Through Trip Ends (Model)	Actual Trip Ends (O&D)	Diff	Diff.Sqr	Functional Classification
3470	17,300	15.81	548.79	847	298.20	88928.68	Maj. Col
500	17,300	15.82	79.10	36	-43.10	1858.42	Min. Col
1130	17,300	8.69	98.24	82	-16.24	263.99	Min. Col
520	17,300	10.58	55.02	52	-3.02	9.16	Min. Col
920	17,300	14.10	129.77	85	-44.77	2004.57	Min. Col
430	17,300	5.85	25.18	51	25.81	66.40	Min. Col
3380	17,300	15.32	518.13	513	-5.13	26.38	Maj. Col
280	17,300	9.41	26.35	28	-1.64	2.71	Min. Col
14940	17,300	90.57	13531.26	14381	849.73	722051.8	Int
1390	17,300	6.33	87.99	117	-29.00	841.51	Min. Col
2660	17,300	14.88	395.93	433	37.06	1373.76	Maj. Col
4250	17,300	31.38	1333.92	2055	721.07	519947.3	Maj. Col
1920	17,300	10.64	204.46	228	23.53	553.8	Min. Art
470	17,300	8.89	41.81	40	-1.81	3.28	Min. Col
15210	17,300	90.10	13704.99	14128	423.01	178940.6	Int
2050	17,300	12.23	250.89	224	-26.89	723.47	Min. Col
630	17,300	6.91	43.56	26	-17.56	308.48	Min. Col
530	17,300	14.68	77.82	144	66.17	4378.96	Maj. Col
4680	17,300	17.20	805.09	839	33.90	1149.50	Maj. Col
410	17,300	9.27	38.01	39	.98	.96	Min. Col
4700	17,300	48.62	2285.39	1796	-489.38	239502	Pri. Art

Root Mean Square = 289.7894

Table 20

Results of Through Trip End Estimation for Hickory, NC Using the NC1 Model
(Highest RMS Error)

ADT	POP	% Through Trip Ends (Model)	Through Trip Ends (Model)	Actual Trip Ends (O&D)	Diff	Diff.Sqr	Functional Classification
28190	50,500	11.92	3361.46	13562	10200.54	$1.04x10^8$	Maj. Col
3890	50,500	.00	.19	436	435.80	189926.4	Maj. Col
470	50,500	.00	.02	70	69.97	4896.71	Min. Col
4570	50,500	3.06	140.19	635	494.80	224828.5	Maj. Col
620	50,500	.00	0.31	40	39.96	1597.52	Min. Col
860	50,500	.00	.04	45	44.95	2021.13	Min. Col
430	50,500	.00	.02	24	23.97	594.96	Min. Col
4150	50,500	7.49	310.89	321	10.10	102.06	Maj. Col
2060	50,500	.00	.10	156	155.89	24303.88	Min. Col
1410	50,500	.00	.07	194	193.92	37608.65	Min. Col
850	50,500	.00	.04	151	150.95	22788.17	Min. Col
2070	50,500	.00	.10	134	133.89	17928.27	Min. Col
380	50,500	.00	.01	28	27.98	782.93	Min. Col
17500	50,500	73.79	12914.53	9494	-3420.52	1.17E+07	Int
4520	50,500	.00	.22	509	508.77	258851	Maj. Col
1200	50,500	.00	.06	55	54.94	3018.40	Min. Col
1150	50,500	.00	.05	56	55.94	3129.56	Min. Col
1050	50,500	.00	.05	42	41.94	1759.59	Min. Col
1670	50,500	.00	.08	103	102.91	10591.81	Min. Col
16230	50,500	30.01	4871.19	4324	-547.19	299419	Pri. Art
770	50,500	.00	.03	61	60.96	3716.30	Min. Col
340	50,500	.00	.01	24	23.98	575.18	Min. Col

Table 20 (continued)

ADT	POP	% Through Trip Ends (Model)	Through Trip Ends (Model)	Actual Trip Ends (O&D)	Diff	Diff.Sqr	Functional Classification
450	50,500	.00	.02	17	16.97	288.23	Min. Col
4780	50,500	.00	.23	731	730.76	534011.6	Maj. Col
1340	50,500	.00	.05	132	131.93	17406.32	Min. Col
1010	50,500	.00	.05	157	156.94	24633.14	Min. Col
6040	50,500	1.41	85.55	441	355.44	126339.9	Maj. Col
370	50,500	.00	.01	25	24.98	624.07	Min. Col
2760	50,500	.00	.13	196	195.86	38361.92	Min. Col
2180	50,500	.00	.10	275	274.89	75565.06	Min. Col

Root Mean Square = 1980.713

Table 21

Results of the Through Trip End Estimation for Boone, NC Using the NC2 Model
(Lowest RMS Error)

ADT	POP	% Through Trip Ends (Model)	Through Trip Ends (Model)	Actual Trip Ends (O&D)	Diff	Diff.Sqr	Functional Classification
7860	16,000	37.32	2866.32	3350	483.67	233937.3	Pri. Art
6270	16,000	29.21	1831.84	1590	-241.84	58488.11	Maj. Col
7690	16,000	38.08	2928.96	2982	53.03	2812.52	Pri. Art
7580	16,000	33.36	2528.84	2651	122.16	14923.16	Pri. Art
12220	16,000	44.41	5428.07	4235	-1193.07	142348	Pri. Art
1220	16,000	15.86	193.54	230	36.45	1329.27	Min. Col.
1500	16,000	14.44	216.69	272	55.31	3059.19	Min. Col
880	16,000	11.99	105.51	140	34.48	1189.17	Min. Col

The root mean square is 466.2573

Table 22

Result of the Through Trip End Estimation for Hickory, NC Using the NC2 Model
(Highest RMS Error)

ADT	POP	% Through Trip Ends (Model)	Through Trip Ends (Model)	Actual Trip Ends (O&D)	Diff	Diff.Sqr	Functional Classification
28190	50,500	91.20	25709.56	13562	-12147.56	1.47×10^{8}	Maj. Col
3890	50,500	9.07	353.09	436	82.90	6873.18	Maj. Col
470	50,500	.5	2.35	70	67.65	4576.52	Min. Col
4570	50,500	19.73	902.10	635	-267.10	71347.13	Maj. Col
620	50,500	1.46	9.07	40	30.92	956.62	Min. Col
860	50,500	4.01	34.49	45	10.50	110.36	Min. Col
430	50,500	4.07	17.53	24	6.46	41.84	Min. Col
4150	50,500	16.26	674.99	321	-353.99	125314.2	Maj. Col
2060	50,500	4.88	100.55	156	55.44	3073.94	Min. Col
1410	50,500	1.91	27.05	194	166.94	27871.55	Min. Col
850	50,500	5.06	43.05	151	107.94	11651.93	Min. Col
2070	50,500	5.82	120.57	134	13.42	180.16	Min. Col
380	50,500	1.63	6.22	28	21.77	474.14	Min. Col
17500	50,500	65.80	11515.81	9494	-2021.80	4087694	Int
4520	50,500	13.37	604.73	509	-95.73	9164.38	Maj. Col
1200	50,500	.5	.6	55	49	2401	Min. Col
1150	50,500	2.84	32.67	56	23.32	544.21	Min. Col
1050	50,500	.5	5.25	42	36.75	1350.56	Min. Col
1670	50,500	3.21	53.71	103	49.28	2429.45	Min. Col
16230	50,500	49.98	8112.04	4324	-3788.04	1.43E+07	Pri. Art
770	50,500	1.60	12.33	61	48.66	2368.69	Min. Col
340	50,500	.5	1.7	24	22.3	497.29	Min. Col

Table 22 (continued)

ADT	POP	% Through Trip Ends (Model)	Through Trip Ends (Model)	Actual Trip Ends (O&D)	Diff	Diff.Sqr	Functional Classification
450	50,500	.5	2.25	17	14.75	217.56	Min. Col
4780	50,500	14.70	702.95	731	28.04	786.44	Maj. Col
1340	50,500	2.44	32.78	132	99.21	9842.66	Min. Col
1010	50,500	9.58	96.76	157	60.23	3627.88	Min. Col
6040	50,500	17.89	1080.76	441	-639.76	409294.8	Maj. Col
2760	50,500	9.09	251.13	196	-55.13	3039.58	Min. Col
2180	50,500	6.48	141.28	275	133.71	17879.49	Min. Col
370	50,500	3.77	13.96	25	11.03	121.88	Min. Col

The root mean square is 2357.374

Table 23

Results of the Through Trip End Estimation for Canton, NC Using the Kentucky Model
(Lowest RMS Error)

ADT	POP	% Through Trip Ends (Model)	Through Trip Ends (Model)	Actual Trip Ends (O&D)	Diff	Diff.Sqr	Functional Classification
90	10,000	20.53	18.48	26	7.51	56.54	Local
950	10,000	19.24	182.78	214	31.22	974.68	Local
1160	10,000	20.33	235.85	225	-10.85	117.72	Collector
18000	10,000	91.39	16451.82	17548	1096.18	1201610	Pri. Art
7100	10,000	40.96	2908.72	4118	1209.27	1462339	Min. Art
950	10,000	22.07	209.67	155	-54.67	2989.30	Local
3150	10,000	26.43	832.73	1120	287.26	82521.71	Collector
1650	10,000	22.83	376.69	427	50.30	2530.59	Collector
8130	10,000	42.86	3485.00	3922	436.99	190963.9	Min. Art
1250	10,000	19.99	249.88	94	-155.88	24300.92	Collector
240	10,000	14.13	33.91	16	-17.91	320.83	Local
18000	10,000	91.10	16398.18	17379	980.82	962008.5	Pri. Art

The root mean square is 572.3296

Table 24

Results of the Through Trip End Estimation for Hickory, NC Using the Kentucky Model
(Highest RMS Error)

ADT	POP	% Through Trip Ends (Model)	Through Trip Ends (Model)	Actual Trip Ends (O&D)	Diff	Diff.Sqr	Functional Classification
28190	50,500	91.08	25677.14	13562	-12115.14	1.46×10^8	Pri. Art
3890	50,500	.5	19.45	436	416.55	173513.9	Collector
470	50,500	.5	2.35	70	67.65	4576.52	Local
4570	50,500	10.10	461.97	635	173.02	29937.03	Collector
620	50,500	.5	3.1	40	36.9	1361.61	Local
860	50,500	.5	4.3	45	40.7	1656.49	Local
430	50,500	.5	2.15	24	21.85	477.42	Local
4150	50,500	6.45	267.67	321	53.32	2843.55	Collector
2060	50,500	.5	10.3	156	145.7	21228.55	Collector
1410	50,500	.5	7.05	194	186.95	34950.3	Collector
850	50,500	.5	4.25	151	146.75	21535.56	Local
2070	50,500	.5	10.35	134	123.65	15289.32	Collector
380	50,500	.5	1.9	28	26.1	681.21	Local
17500	50,500	61.42	10750.22	9494	-1256.21	1578076	Pri. Art
4520	50,500	3.68	166.60	509	342.39	117232.7	Collector
1200	50,500	.5	.6	55	.49	2401	Collector
1150	50,500	.5	5.75	56	50.25	2525.06	Collector
1050	50,500	.5	5.25	42	36.75	1350.56	Collector
1670	50,500	.5	8.35	103	94.65	8958.62	Collector
16230	50,500	45.0	7350.83	4324	-2981.83	8891354	Pri. Art
770	50,500	.5	3.85	61	57.15	3266.12	Local
340	50,500	.5	1.7	24	22.3	497.29	Local

Table 24 (continued)

ADT	POP	% Through Trip Ends (Model)	Through Trip Ends (Model)	Actual Trip Ends (O&D)	Diff	Diff.Sqr	Functional Classification
450	50,500	.5	2.25	17	14.75	217.56	Local
4780	50,500	5.12	244.81	731	486.18	236378.3	Min. Art
1340	50,500	.5	6.7	132	125.3	15700.09	Local
1010	50,500	.5	5.05	157	151.95	23088.8	Collector
6040	50,500	8.81	532.25	441	-91.25	8327.84	Min. Art
370	50,500	.5	1.85	25	23.15	525.92	Local
2760	50,500	.5	13.8	196	182.2	33196.84	Collector
2180	50,500	.5	10.9	275	264.1	69748.81	Collector

The root mean square is 2295.485

Table 25

Root Mean Square Error and Percent Root Mean Square Error
for Through Trip End Estimation

Urban Area	Number of Stations	Average Number of Through Trips Per Station	NC1 Model		NC2 Model		KY Model	
			R.M.S.	Percent R.M.S.	R.M.S.	Percent R.M.S.	R.M.S.	Percent R.M.S.
Mount Airy	19	695	392	56.29	444	63.76	518	74.4
Statesville	24	1,126	514	45.6	978	86.8	1,036	92
Tarboro	9	643	424	65.9	412	64.06	516	80.23
Farmville	7	1,250	394	31.52	585	46.8	449	35.92
Morganton	18	1,240	685	55.24	675	54.4	628	50.6
Elizabeth City	10	659	631	95.8	639	97.02	990	150.3
Hickory	30	1,081	1,980	183.2	2357	218	2295	212.3
Ahoskie	8	472	369	78.3	127	26.88	150	31.29
Boone	8	1931	471	24.4	466	24.13	756	39.15
Sanford	23	1,042	395	37.9	520	49.93	605	58.09
Canton	12	3,770	1,180	31.3	1,411	37.42	572	15.17
Monroe	20	1,461	927	63.45	415	28.40	619	42.37
Shelby	23	880	495	56.25	283	32.15	302	34.31
Dunn	21	1,721	289	16.78	1,080	62.73	745	43.2
Average				60.17		63.7		68.3

the R.M.S. error and the percent R.M.S. error for all the areas and models under consideration.

To further estimate the accuracy of the through trip end estimation models, the R.M.S. values were calculated on basis of volume groups of through trip ends for all of the fourteen urban areas combined together. The results are given in Tables 26 through 28 and the corresponding bar graph is shown in Figure 3.

Analysis of Results

On analyzing the results obtained from the through Trip End Estimation stage of the through trip models the following results are obtained.

1. The R.M.S. values obtained from the NC1 model was the lowest in seven out of fourteen areas.

2. The R.M.S. values obtained from the NC2 model was the lowest in five out of fourteen areas.

3. The R.M.S. values obtained from the KY model was the lowest in two out of fourteen areas.

The percentage R.M.S. varies widely among all the urban areas for each model under consideration. The average percentage R.M.S. is the lowest for NC1 model and highest for the KY model. Also while analyzing the estimated and the observed number of through trip ends on the basis of volume groups, it was observed that the NC1 model gives the lowest percent R.M.S. values in three out of five volume groups. The NC2 and and the KY models give the lowest R.M.S. value in one volume group each.

Table 26

Comparison of RMS Values by Volume Group
for Through Trip End Estimation-NC1 Model

	Vol Group	Number of Observations	Summation of Deviation Square	RMS Error	Percent RMS Error
1.	0-1999	128	2094694	127.925	12.79%
2.	1999-4999	58	12769020	469.2	13.40%
3.	5000-7999	21	24480290	1079.7	16.61%
4.	8000-9999	7	14480150	1438.3	15.98%
5.	10000-14999	11	11610570	1027.4	8.21%
6.	15000-29999	6	26694388	2109.2	12.05%

Note: Observations does not include trip ends greater than 19,999.

Table 27

Comparison of RMS Values by Volume Group
for Through Trip End Estimation-NC2 Model

	Vol Group	Number of Observations	Summation of Deviation Square	RMS Error	Percent RMS Error
1.	0-1999	128	2769868	147.104	14.71%
2.	1999-4999	58	15391310	515.13	14.7%
3.	5000-7999	21	14509430	831.21	12.79%
4.	8000-9999	7	6932238	995.14	11.06%
5.	10000-14999	11	47542360	2078.95	16.63%
6.	15000-19999	6	48535874	2844.2	16.25%

Note: Observation does not include trip ends greater than 19,999.

Table 28

Comparison of RMS Values by Volume Group
for Through Trip End Estimation-KY Model

	Vol Group	Number of Observations	Summation of Deviation Square	RMS Error	Percent RMS Error
1.	0-1999	128	2733307	146.12	14.61%
2.	1999-4999	58	14290800	496.38	14.18%
3.	5000-7999	21	15334660	854.53	13.14%
4.	8000-9999	7	10948320	1250.618	13.89%
5.	10000-14999	11	48387290	2097.342	16.78%
6.	15000-19999	6	18667773	1763.8	10.08%

Note: Observations does not include trip ends greater than 19,999.

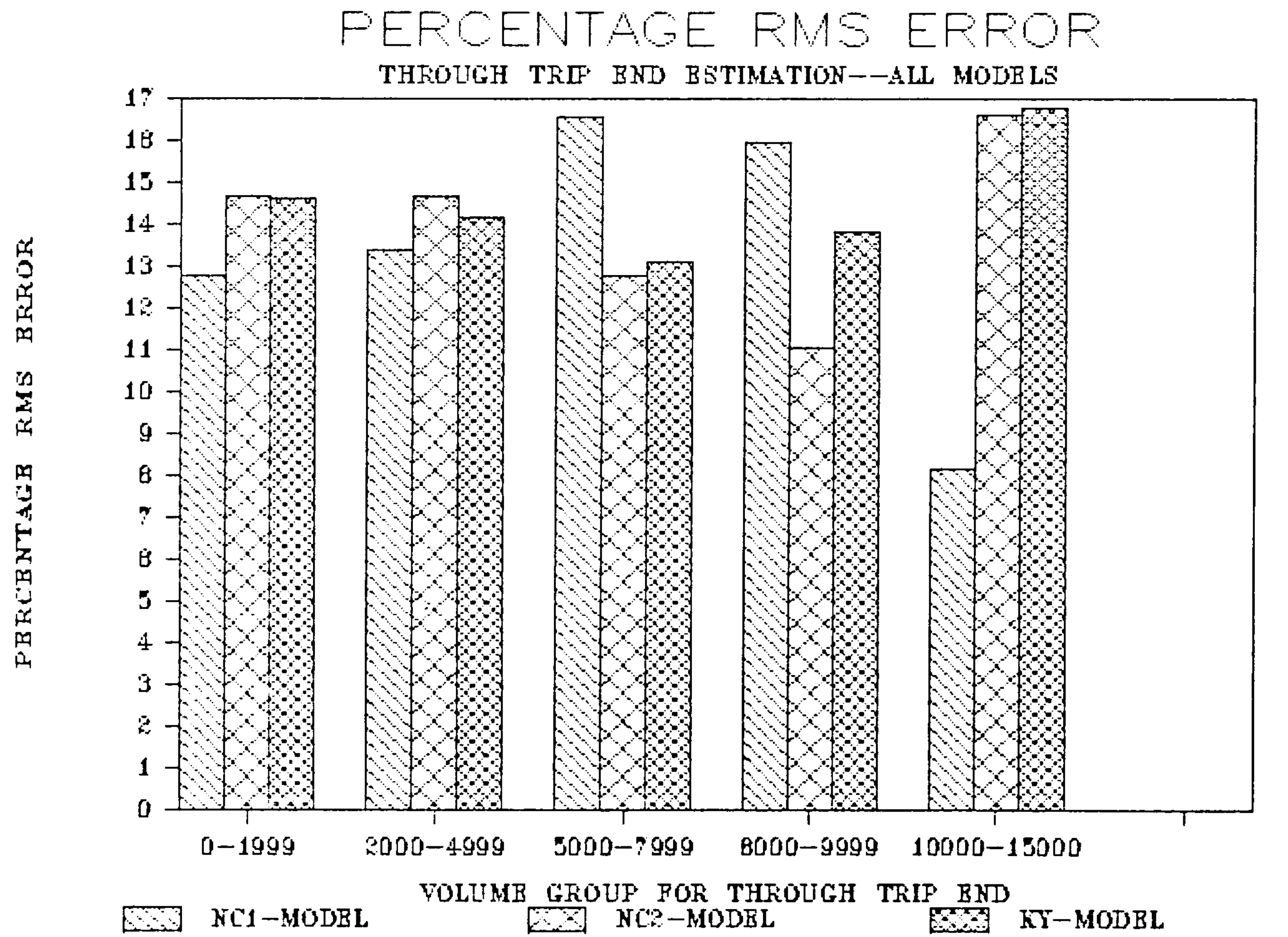

Figure 3

Percentage RMS Error for Through Trip End Estimation on Basis of Volume Group

Based on the above results it can be concluded that the NC1 model is able to predict the number of through trip ends more accurately relative to the other two models. The average percent R.M.S. error which is greater than fifty percent for all three models seems to be rather high. The percent R.M.S. error obtained while analyzing the results on the basis of volume groups seems to be within reasonable limits.

CHAPTER 5

THROUGH TRIP DISTRIBUTION

Introduction

The through trip distribution forms the second stage of the through trip estimation process. In this stage the through trip ends estimated at each station in the first stage are distributed to all the other stations. This second model calculates the percentage of through trip ends from origin station to all other destination stations. The model consists of a set of equations, and the particular equation to be used depends upon the functional classification of the origin station.

For this investigation, two alternative values of the through trip ends at each origin station were available. They were:

1. The number of through trip ends at each external station as calculated with the model of the first stage.

2. The number of through trip ends at each external station as observed in the origin and destination survey.

The accuracy of the trip distribution model was assessed using both these values respectively. The logic or purpose of using the observed trip ends is to judge the merit of the second stage model without any influence of the first stage model. As observed in the trip end estimation stage there are significant differences between the observed number of through trip ends and the estimated through trip ends in some cases. By using the estimated values the errors generated in the trip end estimation stage are propagated to the distribution stage. Hence to avoid this occurrence the observed values of the through trip ends were introduced into the distribution stage. This approach was tried only to measure the success of the distribution models in replicating the through trip movements between stations.

The practical usefulness of using the observed number of through trip ends as input to the distribution stage is, of course, limited because such data are available only from an origin and destination survey. As the purpose of using these models is to eliminate the need for origin and destination surveys, the use of the estimated number of through trip ends from the first stage model as input to the distribution stage is essential.

The trip distribution models were applied on six urban areas. The analysis was done with the help of a computer program shown in Appendix 2. These urban areas were selected because of their small size and limited number of Cordon stations. This was done partly to simplify the analysis at the trip distribution stage and partly because of memory (data storage) limitations of the computer system used. It is felt that the selection of small urban areas would not induce much bias in testing the models under study, because the models themselves were originally developed with the help of data from small urban areas of varying sizes.

The model generated through trip movements between stations were compared with the corresponding values from the origin and destination survey, and the RMS and percent RMS values for each urban area were calculated. Tables 29 through 34 show the triangular Trip Table of those areas with the best and the worst results of the trip distribution stage for the three models--NC1, NC2, and KY--using the estimated number of

Table 29

Through Trip Interchanges Estimated Using NC1 Through-Trip Distribution Model for Boone, NC (Area with the lowest RMS Error)

	1	2	3	4	5	6	7	8
1	0 0							
2	106 331	0 0						
3	727 933	104 342	0 0					
4	709 854	107 279	679 368	0 0				
5	1631 1151	285 545	1563 1250	1517 1061	0 0			
6	19 21	24 33	18 33	18 36	48 82	0 0		
7	17 27	47 32	17 33	16 43	41 113	5 21	0 0	
8	11 33	31 28	11 25	10 13	26 34	3 4	5 3	0 0
Total	3219	704	3119	3057	5112	134	148	96

Root mean square is 180.341.
Within each block the predicted values are at the top and the actual values are in the bottom.

Table 30

Through Trip Interchanges Estimated Using NC1 Through-Trip
Distribution Model for Elizabeth City, NC
(Area with the Highest R.M.S. Error)

	1	2	3	4	5	6	7	8	9	10
1	0									
	0									
2	765	0								
	444	0								
3	2	14	0							
	5	9	0							
4	120	231	3	0						
	315	220	4	0						
5	34	25	0	3	0					
	9	8	0	3	0					
6	71	99	1	11	1					
	52	16	0	4	0	0				
7	17	142	1	16	1	7	0			
	25	21	0	30	1	1	0			
8	2	3	0	3	0	1	1	0		
	3	2	0	0	0	0	0	0		

Table 30 (continued)

	1	2	3	4	5	6	7	8	9	10
9	2238	889	3	138	39	81	20	2	0	
	1254	609	1	155	8	7	3	0	0	
10	6	67	1	9	1	3	5	1	8	0
	5	3	0	17	0	1	0	2	57	0
Total	3255	2234	25	533	105	275	211	13	3417	100

Root mean square is 164.9781.
Within each block the predicted values are at the top and the actual values are in the bottom.

Table 31

Through Trip Interchanges Estimated Using NC2 Through-Trip Distribution Model for Boone, NC (Area with the lowest RMS Error)

	1	2	3	4	5	6	7	8
1	0 0							
2	440 331	0 0						
3	541 933	302 342	0 0					
4	451 854	245 279	515 368	0 0				
5	1375 1151	824 545	1537 1250	1305 1061	0 0			
6	7 21	10 33	7 33	7 36	163 82	0 0		
7	37 27	9 32	7 33	6 43	158 113	0 21	0 0	
8	15 33	2 28	20 25	1 13	67 34	0 4	0 3	0 0
Total	2866	1832	2929	2529	5428	194	217	106

Root mean square is 150.9239.
Within each block the predicted values are at the top and the actual values are in the bottom.

Table 32

Through Trip Interchanges Estimated Using NC2 Through-Trip Distribution Model for Canton, NC (Area with the Highest R.M.S. Error)

	1	2	3	4	5	6	7	8	9	10	11	12
1	0											
	0											
2	0	0										
	1	0										
3	0	1	0									
	1	13	0									
4	2	32	40	0								
	4	86	25	0								
5	1	16	18	761	0							
	5	10	20	4	0							
6	0	0	1	31	14	0						
	0	0	0	4	59	0						
7	0	4	4	170	54	3	0					
	1	7	13	76	663	17	0					
8	0	1	2	66	25	1	6	0				
	1	1	8	21	168	3	15	0				
9	1	10	12	1834	120	9	34	16	0			
	1	9	33	115	3163	72	313	204	0			

Table 32 (continued)

	1	2	3	4	5	6	7	8	9	10	11	12
10	0	0	0	176	2	0	0	0	1	0		
	4	3	24	31	18	0	11	3	2	0		
11	0	0	0	23	0	0	0	0	0	0	0	
	7	4	1	1	0	0	0	1	1	0	0	
12	10	73	103	11224	1390	105	382	177	834	10	0	0
	3	79	87	17180	8	1	9	3	9	1	0	0
Total	15	139	181	14360	2402	165	658	295	2872	190	24	14307

Root mean square is 884.0781.
Within each block the predicted values are at the top and the actual values are in the bottom.

Table 33

Through Trip Interchanges Estimated Using KY Through-Trip Distribution Model for Ahoskie, NC (Area with the lowest RMS Error)

	1	2	3	4	5	6	7	8
1	0							
	0							
2	13	0						
	0	0						
3	72	0	0					
	20	6	0					
4	77	0	4	0				
	33	7	2	0				
5	694	13	70	75	0			
	1031	0	17	19	0			
6	79	1	4	5	77	0		
	35	2	11	4	16	0		
7	290	3	20	22	285	23	0	
	270	3	11	27	88	2	0	
8	209	2	13	15	205	15	69	0
	50	0	17	45	133	16	26	0
Total	1434	33	184	197	1420	202	712	528

Root mean square is 85.19121.
Within each block the predicted values are at the top and the actual values are in the bottom.

Table 34

Through Trip Interchanges Estimated Using KY Through-Trip Distribution Model for Elizabeth City, NC (Area with the Highest R.M.S. Error)

	1	2	3	4	5	6	7	8	9	10
1	0 0									
2	1347 444	0 0								
3	10 5	30 9	0 0							
4	253 315	314 220	4 4	0 0						
5	41 9	62 8	0 0	10 3	0 0					
6	125 52	163 16	2 0	31 4	4 0	0 0				
7	57 25	123 21	1 0	18 30	2 1	9 1	0 0			
8	7 3	27 2	0 0	3 1	0 0	1 0	1 0	0 0		

Table 34 (continued)

	1	2	3	4	5	6	7	8	9	10
9	1436	1591	12	298	49	148	67	9	0	
	1254	609	1	155	8	7	3	0	0	
10	29	68	0	9	1	4	2	0	35	0
	5	3	0	17	0	1	0	2	57	0
Total	3305	3725	58	942	171	488	279	49	3643	148

Root mean square is 206.6286.
Within each block the predicted values are at the top and the actual values are in the bottom.

through trip ends. Results from the other remaining areas are shown in Appendix 4. Tables 35 and 36 present the results of the RMS and Percent RMS Values of all the three models. The RMS values were estimated for both approaches using the estimated number of through trip ends and observed number of through trip ends as input to the distribution model. The use of "observed" through trip ends yielded better results as may be expected, and reflects the accuracy of the trip distribution model by itself. The results based on the combined use of two sets of model, however, indicates the accuracy of the overall approach of synthesizing through trips.

To further study the accuracy of the trip distribution models, the observed and the estimated through trips were compared on the basis of volume group for all the six areas combined together. The RMS and percent RMS error was calculated for each model as shown in Table 37.

Analysis of Results

The RMS and the percent RMS values calculated for the through trip distribution process give an indication of the relative accuracies of each model for the six areas tested. The RMS error obtained from the NC1 model is the lowest in three out of six areas, when distributing estimated number of through trip ends at the origin station based on the trip end estimation model. The NC2 model and the KY models reported the lowest RMS errors in two and one area respectively in a similar analysis.

A similar trend is observed in the RMS values obtained from the trip distribution model using the observed number of through trip ends

Table 35

RMS and Percent RMS Error for Station to Station Through Trip Distribution Using Estimated Through Trip Ends at Cordon Stations

	NC1		NC2		KY	
Area	RMS Error	Percent RMS Error	RMS Error	Percent RMS Error	RMS Error	Percent RMS Error
Ahoskie	135.5	200	92.75	137.4	85.2	126
Canton	456	133	884	257.8	752.11	219.4
Elizabeth City	164.97	225	154.64	211.3	206.6	282.3
Tarboro	79.55	101.53	173.35	221.3	178.14	227.4
Farmville	281.85	135.3	443.2	212.8	418	200.64
Boone	180.34	65.34	150.92	54.68	213.41	188.8
Average		143.4		182.5		188.8

Table 36

RMS and Percent RMS Error for Station to Station Through Trip Distribution Using Observed Through Trip Ends at Cordon Stations

	NC1		NC2		KY	
Area	RMS Error	Percent RMS Error	RMS Error	Percent RMS Error	RMS Error	Percent RMS Error
Ahoskie	49.3	73.03	58.58	86.8	39.4	58.3
Canton	454.5	132.6	813.4	237.4	765	223.7
Elizabeth City	43.11	58.91	21.64	29.58	32.08	43.84
Tarboro	58.06	74.1	92.98	118.6	109.04	139.2
Farmville	143.7	68.9	215.84	103.6	234.31	112.5
Boone	76.73	27.8	83.7	30.3	74.02	26.81
Average		72.55		101.3		100.6

Table 37

RMS Error and Percent RMS Error by Volume Group for Through Trip Distribution

Volume Group	Number of Observations	NC1		NC2		KY	
		RMS Error	Percent RMS Error	RMS Error	Percent RMS Error	RMS Error	Percent RMS Error
0-250	202	81.5	65.2	191.2	153	202	172
250-500	9	246.9	65.8	278.5	74.2	209	53.97
500-1000	5	325.19	43.3	541	72.16	595.6	79.42
1000-2000	6	566.9	37.8	418	27.88	508.9	33.9
Average			53.02		81.81		85.32

at each station. While comparing the RMS values obtained from using the estimated number of through trip ends and observed number of through trip ends it is seen that the RMS values in the latter case are connsistently lower in all areas. This can easily be accounted for because the errors induced by the trip end estimation process is not carried over to the second phase.

The results of the percent RMS errors show that the NC1 model is relatively more accurate than the other two models in predicting the through trip flows. The percent RMS error averaged for all the six areas shows that the NC1 model has a value of 143.4 percent while the NC2 and the KY model have a value of 182.5 and 188.8 percent respectively. Corresponding values obtained when using observed through trip ends at the Cordon station shows that the NC1 model has a percentage RMS error of 72.55 while the NC2 and the KY models have a percentage RMS of 101.3 and 100.6 percent respectively. It can be concluded from a comparison of the above results, the additional error of 70.85 percent which represents 49.4 percent of the total error is introduced at the trip end estimation stage while 50.6 percent of the total error is introduced at the trip distribution stage. For the NC2 and the KY models the corresponding values are 44.5 and 46.7 percent due to the trip end estimation stage and 55.5 and 53.2 percent due to the trip distribution stage respectively.

On analyzing the results obtained while comparing the observed and estimated through trips, it is seen that higher the volume group, lower is the percent RMS error for all the three models. It is seen that the

NC1 model has the lowest percent RMS values in two volume groups. While the NC2 and the KY models have the lowest percent RMS value in one volume group. Further the NC1 model has an average percent RMS of 53.02 while the NC2 and the KY model have a corresponding value of 81.81 and 85.32 respectively. This shows that the NC1 model is relatively better than the NC2 and the KY models in estimating through trip flows in an urban area.

CHAPTER 6

SENSITIVITY ANALYSIS

A sensitivity analysis was performed to study the effects of the change of functional classification of a station and the route continuity between stations on the through trip distribution pattern. The sensitivity analysis for functional classification was done independent of the analysis for route continuity.

Functional Classification

The sensitivity analysis for functional classification was done for each of the three models. The analysis was done as described below for Boone, NC. The functional classification of a particular station or a group of stations was altered by changing it to the next higher or lower level of classification. A complete run of the two-stage models was done to generate the station to station through trip interchanges. The RMS was calculated for the station or group of stations for which the functional classification was changed. The RMS was compared with the RMS error for the same station or stations before the functional classification was changed. The percentage change in RMS error gave an indication of the sensitivity of the model to a change of that particular level of functional classification. The results of the three models are tabulated in Tables 38 through 40.

Route Continuity

Route continuity as an independent variable was used in NC2 model. It was essentially a "dummy" variable that was coded either "1" or "0"

Table 38

Results of Sensitivity Analysis of Functional Classification for Boone, NC-NC1 Model

Station Number	Classification Old	Classification New	RMS Error Old	RMS Error New	Percnet Change in RMS
1	Primary Arterial	Minor Arterial	222	321.27	44.7
2	Major Collector	Minor Arterial	171	77.6	54.6
5	Primary Arterial	Interstate Travelway	294.2	822.5	179
1, 3, 5	Primary Arterial	Minor Arterial	221	443	100.4
6, 7, 8	Collector	Collector	22.75	21.8	4.17

Table 39

Results of Sensitivity Analysis of Functional Classification for Boone, NC-NC2 Model

Station Number	Functional Classification Old	Functional Classification New	RMS Error Old	RMS Error New	Percent Change in RMS
1	Principal Arterial	Minor Arterial	232.4	234.38	0.85
2	Major Collector	Minor Arterial	116.2	115.7	0.39
5	Principal Arterial	Interstate	199.75	193.8	2.98
7	Minor Collector/ Local	Major Collector	27.03	26.9	0.48
1, 3, 4	Principal Arterial	Minor Arterial	177.85	186.41	4.6
6, 7, 8	Minor Collector	Major Collector	29.97	29.8	0.56

Table 40

Results of Sensitivity Analysis of Functional Classification for Boone, NC-KY Model

Station Number	Functional Classification		RMS Error		Percent Change in RMS
	Old	New	Old	New	
1	Primary Arterial	Minor Arterial	286.09	274.8	3.94
2	Minor Arterial	Collector	170.16	175. 2	2.96
2	Minor Arterial	Primary Arterial	170.16	186.2	9.43
1, 3, 4, 5	Primary Arterial	Minor Arterial	240.7	234.5	2.57
6, 8	Local	Collector	11.4	9.53	16.40
7	Collector	Local	11.71	10.77	8.02

depending upon whether there was a route continuity between any pair of stations or not. To study the sensitivity of this variable the route continuity for stations which included different levels of functional classification, was changed from either 0 to 1 or vice-versa. The sensitivity of the model for a given functional classification was obtained by observing the change in the number of through trips between the pair of stations before and after the route continuity was changed. Table 41 in the following page shows the results of the sensitivity analysis for Boone, NC.

Conclusions

On analyzing the results of the sensitivity analysis the following findings were obtained.

1. The NC1 model is the most sensitive to changes in functional classification, among all the three models. Also the KY model is more sensitive than the NC2 model to changes in functional classification.

2. Higher the functional classification of a station greater is the sensitivity to a change in the classification level.

3. The sensitivity to route continuity was greater when the pair of Cordon stations connected by that particular route was on a higher level of functional classificaion.

Table 41

Results of the Sensitivity Analysis for Route Continuity for Boone, NC-NC2 Model

O-D Pair	Functional Classification	Route Continuity Changes From	Tij Old	Tij New	Percent Change
2, 7	2 - Major Collector 7 - Minor Collector/ Local	0 to 1	9	9	0
3, 5	3 - Primary Arterial 5 - Primary Arterial	1 to 0	1536	1411	8.13
1, 3	1 - Primary Arterial 3 - Primary Arterial	1 to 0	541	423	21.8
7, 8	7 - Minor Collector 8 - Minor Collector/	1 to 0	0	0	0
2, 4	2 - Major Collector 4 - Principal Arterial	1 to 0	245	238	2.85
5, 6	5 - Principal Arterial 6 - Minor Collector	1 to 0	163	86	47.2
5, 1	5 - Principal Arterial 1 - Principal Arterial	1 to 0	1374	1269	7.64
2, 3	2 - Major Collector 3 - Principal Arterial	1 to 0	302	301	0.33
1, 4	1 - Principal Arterial 4 - Principal Arterial	1 to 0	451	350	22.4

CHAPTER 7

CONCLUSIONS

The main purpose of this thesis was to study the feasibility of using synthetic models to estimate through trip flows in an urban area. As a part of this study, three models developed previously--NC1, NC2, and KY-- were used to estimate through trip flows in six urban areas in North Carolina. On completing the study it was concluded that the three models that were tested for this study have exhibited similar tendencies in predicting through trip flows in urban areas, and on the basis of the overall results it was observed that the NC1 model is relatively more accurate in predicting through trip flows. Further, the results of the NC2 and KY models, although not as accurate as the NC1 models, compares well with the results of the NC1 model.

On analyzing the results it is found that the through trip flows between stations having high volumes of trips are predicted more accurately by all the three models, in comparison to those between stations with low volumes of trips. On facilities with very low volumes of traffic, the results predicted by the models do not follow a realistic pattern and are rather erratic. The above mentioned fact is supported by the percentage RMS error at the end of the trip distribution stage.

The main advantage of using these models is the estimation of through trip flows in an urban area without the use of expensive O&D

data. The use of these models would greatly simplify the travel analysis and forecasting process. One of the benefits of using these models is in testing different transportation related scenarios and predicting the effect of such changes on the through trip distribution pattern. These models would be helpful in throughfare planning in urban areas.

Although the use of these models would be a great benefit to transportation planning, it should not be overlooked that this approach would require the expertise of technical people who are well versed in the use of mathematical models, and who are also aware of the limitations of using these models. Only then is it possible to interpret the results produced by these models in their proper perspective. While using these models it is important to have input data which are as accurate as possible. This is especially important for the functional classification of facilities under consideration. As has been shown in the sensitivity analysis, the NC1 model is quite sensitive to changes in the functional classification of highways. If the through trip distribution between stations is to be predicted for a future time period it is essential to project as accurately as possible the input variables such as population, ADT, percentage trucks, etc. The difficulties associated with the prediction of the functional classification of a facility at a future time period, would vary from case to case, and it is here that the availability of experienced analysts is necessary.

It is observed that because of the substantial amount of work done in synthesizing internal-internal and internal-external trips by various researchers in the past, the use of synthetic models in that area has become standard procedure in planning. But a similar situation does not exist in the case of synthetic models for through trips. Apart from the three models reported in this study there does not appear to be any other work done in developing through trip models. This may be because of the perceived difficulties in developing synthetic models for through trips and also because the origin and destination surveys which provides the basic data source for developing such models are not being conducted widely these days. However, through trip models can become universally acceptable only if more and more researchers develop such models, and this in turn will lead to more knowledge about the use of such models. This will also help in further understanding of the merits and limitations of such models, and also aid in establishing the use of these models on a routine basis.

In the final analysis it can be concluded that the models follow a logical process in predicting the through trip flows in an area. Its results are realistic although not very accurate at the micro-level. The models do predict the through trip movements between stations where volumes are high rather accurately. It should be noted that for planning purposes, the larger or heavier traffic flows are of more interest than the small or lighter flows. Thus it can be concluded that the models are a good long-range planning tool, and these can be used for a quick estimation of through trip flows where a high level of accuracy in predicting the flows is not intended. The results obtained from these models are consistent with the time and cost of using these models.

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8. Bates, J.W., "Synthetic Derivation of Internal Trips for Small Cities," Transportation Research Record No. 526, Transportation Research Board, Washington, DC, 1974, pp. 93-103.

9. Rhodes, D., Hillegass, T., "Demonstration of a Simplified Traffic Model for Small Urban Area," Transportation Research Record No. 677, Transportation Research Board, Washington, DC, January 1978, pp. 76-81.

10. Smith, Robert L., "Examination of a Simplified Travel Demand Model," Transportation Engineering Journal of ASCE; Proceedings of the American Society of Civil Engineers, Vol. 104; No. TEL, January 1978, pp. 31-41.

APPENDIXES

APPENDIX 1

ANNOTATED BIBLIOGRAPHY

TITLE: Examination of a Simplified Travel Demand Model

AUTHOR: Robert L. Smith

SOURCE: Transportation Engineering Journal of ASCE, Proceedings of the American Society of Civil Engineers, Vol. 104, No. TE1, January 1978, pp. 31-41.

In this paper titled "Examination of a Simplified Travel Demand Model" the author Robert L. Smith has tried to evaluate an internal volume forecasting model as a replacement for the Conventional Urban Travel Demand Models in small- and medium-sized urban areas. The internal volume forecasting model uses traffic counts rather than home interview survey data for model calibration. By eliminating the need for a home interview survey the internal volume forecasting model provides an inexpensive travel demand forecasting technique for small-sized urban areas.

In the Internal Volume Forecasting Model the interzonal trip probability factors perform the trip generation and trip distribution functions of a conventional UTPS Package.

The interzonal trip proability factors are

$$F(I,J,K,) = \frac{P(I) \times A(J)}{T(1,J)^{12}}$$

In which

F(IJK) = interzonal trip probability factor between zones I and J for the Kth set of P(I) and A(J) characteristics.

P(I) = characteristic of Internzonal Zone I related to trip production

A(J) = characteristics of Interzonal Zone J related to trip attraction

T(I,J) = Interzonal travel impedence such as travel time.

N = Exponent related to the importance of travel time.

The trip probability factor provides a measure of the magnitude of the trip between zones. The relationship between the trip probability factors and link volumes on a transportation network is determined by assigning the matrices of trip probability factors to the network and then estimating a regression equation of the form

$$V = Ao + A_1F_1 + A_2F_2 + \ldots + A_mF_m$$

where

V = observed volume on a link

A_k = Kth computed regression coefficient

F_k = link loading of the trip probability factors based on the kth set of Pi and Aj characteristics

Because the trip probability factors are only between zones within the study area, the volume used as independent variable must be the internal traffic volume, on the link. To obtain internal traffic volumes from observed counts, a trip table of external trips is built and assigned to the network. The resulting volumes are then subtracted from total counts to leave internal volumes.

The application of the Internal Volume Forecasting model to forecasting Future Traffic Volumes requires only projections of the future socio-economic and land-use variables by zone and a future highway network. Using these forecasts, future trip probability factor matrics are computed and assigned to the network. The link loads of probability factors can then be converted to future internal volume by using the regression equation developed from base year data. Finally external trips can be forecast through use of a fratar technique and be assigned to the network and added to the internal volumes to arrive at the link by link estimates of the future year traffic volume.

TITLE: Transportation Planning for Small Urban Areas

AUTHOR: Grecco, W.L.; Wegmann, F.J.; Spencer, J.A; Chatterjee, A.

SOURCE: NCHRP Report No. 167, Transportation Research Board 1978.

It has been recommended in the above paper that it is possible to reduce the time and cost requirements of network simulation procedures through the use of synthetic travel models, when it is complimented with a selectively chosen small sample home interview survey. Also the use of synthetic or borrowed household category models for trip productions and zonal equations for trip attractions is recommended for use in synthesizing the internal household travel patterns in small urban areas. For trip distribution the use of gravity model with either borrowed or synthesized friction factor is recommended. Finally for external trips the use of external O-D survey has been suggested.

TITLE: Synthetic Derivation of Internal Trips for Small Cities

AUTHOR: Bates, J. W.

SOURCE: Transportation Research Record No. 526, Transportation Research Board, 1974, pp. 93-103.

In the above mentioned paper the author has introduced a method of estimating internal trip movements without interviews or surveys. The methodology followed by the author was essentially as described below.

Trip generation equations were developed from data obtained from four cites similar in size and nature. The model was then tested on eight other cities of similar standing. It was found that there was not much difference in friction factor estimates for various cities of similar sizes as above. By using friction factor of one of the cities as base new friction factors were estimated and a gravity model distribution was made. Finally the trips were assigned on the network and it was found that there was not significant error between observed results and the assigned results, even though the error was greater than that could be obtained from an elaborate study.

TITLE: Evaluation of Estimated Vehicle Trip Productions and Atractions in a Small Urban Area

AUTHOR: Goode, L.R.

SOURCE: Transportation Research Record No. 638, Transportation Research Board, 1977, pp. 21-25.

The author has demonstrated that a gravity model calibration that used estimates of trip productions and attractions rather than expanded O-D trips productions and attractions from a ten percent home interview survey was more successful in duplicating street volumes in Greensboro, NC. The author has recommended that for small urban areas, gravity model should be calibrated on the basis of estimated production and attractions rather than productions and attractions from the O-D survey.

TITLE: Demonstration of a Simplified Traffic Model for Small Urban Areas

AUTHORS: Rhodes, D.; Hillegass, T.

SOURCE: Transportation Research Record No. 677, Transportation Research Board, Washington, DC, January 1978, pp. 76-81.

The method suggested by the author requires no home interview survey or demand model calibration. The approach combines a fratar expansion of external trip tables with a factoring of internal travel on a link by link basis to produce a forecast of total automobile travel by link. A brief description of the method is as follows.

1. On the basis of an external O-D survey assign the external Cordon trip tables on the highway network.

2. Do volume counts for all the links for the base year. Subtract the external assigned trips on the network from the base ADT to get internal volumes.

3. Factor the external trip table to the future year with the help of fratar method. Assign the future external trip table to highway network.

4. By using base year zonal population as a proxy for productions and employment similarly for attractions run a gravity model using borrowed friction factors.

   Similarly by using future year zonal population and employment the gravity model is again solved.

5. Assign both base year and future internal tables to the highway network and compute a growth factor for the internal travel, as the link by link ratio of the future load divided by the base load.

6. Finally forecast the link traffic by factoring the base year internal volume on the link (the difference between assigned external trip table and full link count) by the internal growth factor, and add to this the future external trip.

TITLE: Synthsziging Travel Patterns for a Small Urban Area

AUTHORS: Khasnabis, S. and Poole, M.R

SOURCE: Traffic Engineering, pp. 28-30, August 1975.

The authors have tried to synthesize the travel pattern for a small urban area without the benefit of either an internal home Interview Origin Destination survey or a similar traffic sruvey.

The study essentially consisted of the following steps.

1. Determination of zonal trip productions using generation rates from home interviews from other similar urban areas.

2. Determination of zonal attraction factors using multiple regression equations as determined from other studies.

3. Determination of trip distribution using a three purpose gravity model with trip length frequently curves developed in similar areas.

4. Assignment of traffic to existing network and making accuracy checks on the procedures.

The study uses synthetic models for the determination of through trips in the network. The accuracy of the synthetic method was tested through the assignment of estimated internal, external and through travel to the existing major street network, and by comparison of assigned volumes with ground counts along established screen lines. The Chi-Square test showed the absence of any significant difference between the distribution of the observed ADT's and the assigned traffic volumes suggesting that the method could be used effectively in small urban areas.

APPENDIX 2

```
1 OPEN "B:TEXT.FLE"
FOR APPEND AS#1
2 OPEN "B:TRANS.DAT" FOR APPEND AS#2
3 PRINT#1,
4 PRINT#1,
5 PRINT#1,
6 PRINT#1,
7 OPEN  "B:DIST.DAT" FOR APPEND AS#3
8 OPEN  "B:DOST.DAT" FOR APPEND AS#4
10 DIM A(40),C(40),IN(40),OP(40),MI(40),MA(40),MN(40),PTKS(40),PPP(40) ,X(40),Y(
40),N(40),XI(40),Z(40,40),X2(40),TPS(40),O(40),OO(40),M(40,40),RAN(40,40),P(40,4
0),GF(40),W(30,30),RA(30),T(10,10),QQ(30,30),QM(40),QL(30,30),QN(30,30),S(40),LL
(9),  DS(10)
11 PRINT#1,  "THROUGH TRIP ESTIMATION FOR BOONE   N.C (KY    MODEL)
12 PRINT#1,
13 PRINT#1,
14 PRINT#1,
15 PRINT#1, "ADT" TAB(12)"POP" TAB(18)  "%THROUGH"  TAB(30) "THROUGH" TAB(39) "A
CTUAL" TAB(50)  "DIFF"  TAB(62)  "DIFF.SQR "
16 PRINT#1,TAB(19)                     "TRIPS"  TAB(29)"TRIP ENDS" TAB(40)    "TRI
PS"
17 PRINT#1, TAB(19) "(MODEL)" TAB(29) "(MODEL)" TAB(40) "(O&D)"
18 U=0
20 FOR I= 1 TO 8
21 U=U+1
22 WIDTH "lpt1:",240
30 READ A(I),C(I),PTKS(I),TPS(I),S(I)
40 LET Y(I)=.003*A(I) +1.49*PTKS(I) -.0007*C(I) + 17.43
50 X(I)=(Y(I)*A(I))/100
51 LET XI(I)=TPS(I)-X(I)
52 XO=XO+(XI(I)^2)
53 X2(I)=(XI(I)^2)
54 LET  RMS=SQR(XO/U)
55 TI=450401
60 NEXT
61 PRINT XO
70 PRINT
80 FOR I= 1 TO  8
81 IF  S(I)=1 GOTO 90
82 IF  S(I)=2 GOTO 93
83 IF  S(I)=3 GOTO 94
84 IF  S(I)=4 GOTO 95
90 PRINT#1, A(I) TAB(10)  C(I) TAB(18)        Y(I) TAB(29)  X(I) TAB(40)  TPS(I
)TAB(48)   XI(I) TAB(60)  X2(I) TAB(73) "PRIMARY.ART":GOTO 100
91 TI=687101
92 PRINT#1, A(I)  TAB(10) C(I) TAB(18) Y(I) TAB(30) X(I)  TAB(45) TPS(I) TAB(55)
  XI(I)  TAB(70)  X2(I)
93 PRINT#1, A(I) TAB(10)  C(I) TAB(18)        Y(I) TAB(29)  X(I) TAB(40)  TPS(I
)TAB(48)   XI(I) TAB(60)  X2(I) TAB(73) "MIN.ART":GOTO 100
94 PRINT#1, A(I) TAB(10)  C(I) TAB(18)        Y(I) TAB(29)  X(I) TAB(40)  TPS(I
)TAB(48)   XI(I) TAB(60)  X2(I) TAB(73)    "COLLECTOR":GOTO 100
95 PRINT#1, A(I) TAB(10)  C(I) TAB(18)        Y(I) TAB(29)  X(I) TAB(40)  TPS(I
)TAB(48)   XI(I) TAB(60)  X2(I) TAB(73)            "LOCAL":GOTO 100
100 PRINT#2, A(I) TAB(10)  C(I) TAB(18)        Y(I) TAB(30)  X(I) TAB(45)  TPS(
I)TAB(55)   XI(I) TAB(70)  X2(I)
101 PRINT    A(I) TAB(10)  C(I) TAB(18)        Y(I) TAB(30)  X(I) TAB(45)  TPS(
I)TAB(55)   XI(I) TAB(70)  X2(I)
102 NEXT I
103 PRINT#1,
110 PRINT#1,
111 PRINT#1, "THE ROOT MEAN SQUARE IS";RMS
150 FOR J= 1 TO  8
```

```
170 NEXT J
180 FOR J= 1 TO  8
190 FOR I = 1 TO 8
220 NEXT I
230 PRINT
240 NEXT J
260 GOTO 670
270 FOR I = 1 TO 8
280 POP=8000
290 Z(J,I)=.0001*A(I)+.11*PTKS(I)+.22*Y(I)+385.83*((A(I)/TI)^2)-2.58
292 IF Z(J,I)<0 THEN Z(J,I)=0
300 NEXT I
320 RETURN
330 FOR I = 1 TO 8
340 Z(J,I)=.0008*A(I)-.08*PTKS(I)-.03*Y(I)+228.14*((A(I)/TI)^2)+6.2
342 IF Z(J,I)<0 THEN Z(J,I)=0
350 NEXT I
360 RETURN
370 FOR I = 1 TO 8
380 Z(J,I)=-.00001*A(I)+.11*PTKS(I)+.05*Y(I)+295.06*((A(I)/TI)^2)+3.1
390 IF Z(J,I)<0 THEN Z(J,I)=0
400 NEXT I
410 RETURN
420 FOR I = 1 TO 8
430 Z(J,I)= -.01*A(I)-.03*PTKS(I)+.83*Y(I)+2704.73*((A(I)/TI)^2)+1.95
440 IF Z(J,I)=<0 THEN Z(J,I)=0
450 NEXT I
460 RETURN
670 FOR J = 1 TO 8
680 FOR I = 1 TO 8
685 ' PRINT Z(J,I) '
690 K=K+Z(J,I)
700 ' PRINT K;J;I'
710 NEXT I
720 MK=K-Z(J,J)
740 FAC=100/MK
750 FOR I = 1 TO 8
760 Z(J,I)=Z(J,I)*FAC
761 PRINT J,I,Z(J,I)
780 M(J,I)=(X(J)*Z(J,I))/100
800 NEXT I
810 PRINT:K=0:NEXT J
811  PRINT#3, " THROUGH TRIP DISTRIBUTION FOR BOONE    N.C.(KY  MODEL  )
812  PRINT#3, "FROM" TAB(12)"TO  "                    TAB(20) "THROUGH" TAB(39
) "ACTUAL" TAB(50)  "DIFF"  TAB(80)  "DIFF.SQR "
813      PRINT#3, TAB(19)                          TAB(19)"TRIP ENDS" TAB(40)
  "TRIPS"
814      PRINT#3,                 TAB(20)  "(MODEL)" TAB(40) "(O&D)"
820 FOR J= 1 TO 8
830 FOR I = 1 TO 8
835  M(I,I)=0
840 RAN(J,I)=(M(J,I)+M(I,J))/2
850 O(J)=O(J)+RAN(J,I)
870 P(J,I)=RAN(J,I)
900 NEXT I
905 KT=0
910 K=0
911 DS(J)=O(J)
912 O(J)=0
913 GF(J)=X(J)/DS(J)
914 NEXT J
915 FOR J=1 TO 8:DS(J)=0
916 NEXT J
917 FOR J= 1 TO 8
918 FOR I=1 TO 8
```

```
920 NEXT I
921 GF(J)=X(J)/DS(J)
922 'PRINT GF(J) '
923 NEXT J
930 DATA 7680,16000,8.8 ,3350 ,1
940 DATA 6270,16000,5.741,1590 ,2
950 DATA 7690,16000,9.271,2982 ,1
960 DATA 7580,16000,6.306,2651 ,1
970 DATA 12220,16000,5.62,4235,1
980 DATA 1220,16000,5.655,230 ,4
990 DATA 1500,16000,4.2,272 ,3
991 DATA 880,16000,3.636,140 ,4
9000 KT=KT+1
9110 FOR J = 1 TO 8
9111 LL(J)=0
9120 FOR I = 1 TO 8
9130 LL(J)=LL(J)+P(J,I)*GF(I)
9135 NEXT I
9136 FOR I= 1 TO 8
9140 T(J,I)=X(J)*P(J,I)*GF(I)/LL(J)
9141 NEXT I
9142 NEXT J
9145 FOR J= 1 TO 8
9146 FOR I=1 TO 8
9150 P(J,I)=(T(I,J)+T(J,I))/2
9155 NEXT I
9156 NEXT J
9157 IF KT>50 THEN 9302
9160 GOTO 915
9302 FOR J= 1 TO 8
9303 FOR I = 1 TO 8
9305 READ QQ(J,I)
9306 QL(J,I)=QQ(J,I)-P(J,I):QM =QM+((QL(J,I)^2)/2)
9307 QN(J,I)=(QL(J,I)^2):RRS= SQR(QM/28)
9340 DATA 0,331,933,854,1151,21,27,33,331,0,342,279,545,33,32,28
9341 DATA 933,342,0,368,1250,33,33,25,854,279,368,0,1061,36,43,13
9342 DATA 1151,545,1250,1061,0,82,113,34,21,33,33,36,82,0,21,4
9343 DATA 27,32,33,43,113,21,0,3,33,28,25,13,34,4,3,0
9371 PRINT#3, J    TAB(12)  I                          TAB(19)    P(J,I) TAB(40)
  QQ(J,I) TAB(48)  QL(J,I) TAB(80) QN(J,I)
9372 PRINT#4, J    TAB(12)  I                          TAB(19)    P(J,I) TAB(40)
  QQ(J,I) TAB(48)  QL(J,I) TAB(80) QN(J,I)
9380 NEXT I
9390 NEXT J
9400 FOR J=1 TO 8
9500 PRINT L(J)
9600 NEXT
9700 PRINT#3, "ROOT MEAN SQUARE IS";RRS
9770 N=0
9772 LPRINT CHR$(27);"W";CHR$(1);
9773 LPRINT            "THROUGH TRIP DISTRIBUTION FOR BOONE N.C.(KY MODEL)
9774 LPRINT CHR$(27);"W";CHR$(0);
9775 LPRINT
9776 LPRINT
9800  LPRINT CHR$(15);" ",:FOR P= 1 TO 8:LPRINT P,
9810 NEXT P
9820 LPRINT:LPRINT
9830 FOR J = 1 TO 8
9840 LPRINT J,
9841 N=N+1
9850 FOR I = 1 TO N
9855   LPRINT  CHR$(15); P(J,I),:IF I=N  THEN LPRINT CHR$(13)
9856 NEXT I
9860 LPRINT " ",:FOR I = 1 TO N
9865                 LPRINT QQ(J,I),:IF I=N  THEN LPRINT CHR$(13)
```

```
9866 NEXT I
9867 LPRINT:NEXT J
9868 LPRINT "=================================================================
==============================================================================
====="
9869 LPRINT "TOTAL":LPRINT " ",
9871 FOR J = 1 TO 8
9873          LPRINT DS(J),
9874 NEXT J
9875 LPRINT "=================================================================
==============================================================================
====="
9876 LPRINT
9877 LPRINT
9900 LPRINT    "ROOT MEAN SQUARE IS";RRS
9901 LPRINT
9902 LPRINT "WITHIN EACH BLOCK THE PREDICTED VALUES ARE AT THE TOP AND "
9903 LPRINT "THE ACTUAL VALUES ARE IN THE BOTTOM"
```

APPENDIX 3

THROUGH TRIP END ESTIMATION FOR SHELBY N.C. (NC 1 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
12370	31500	39.93691	4940.195	5757	816.8052	667170.7	PRI.ART
750	31500	1.543202	11.57401	77	65.42599	4280.56	MIN.COL
6050	31500	9.526401	576.3473	1945	1368.653	1873210	MAJ.COL
2750	31500	7.960701	218.9193	395	176.0807	31004.42	MAJ.COL
460	31500	2.166701	9.966826	16	6.033174	36.39918	MIN.COL
4590	31500	21.7773	999.5782	1165	165.4218	27364.38	MIN.ART
3080	31500	7.011103	215.942	1039	823.0581	677424.6	MAJ.COL
370	31500	12.4407	46.03059	106	59.96941	3596.33	MAJ.COL
240	31500	.005	.012	27	26.988	728.3521	MIN.COL
2340	31500	6.3603	148.831	226	77.169	5955.053	MIN.COL
10030	31500	37.8107	3792.413	4936	1143.587	1307791	PRI.ART
500	31500	8.112501	40.56251	55	14.4375	208.4413	MAJ.COL
3500	31500	8.457399	296.009	423	126.991	16126.72	MAJ.COL
5100	31500	8.6602	441.6702	1130	688.3298	473798	MAJ.COL
920	31500	3.830801	35.24337	41	5.75663	33.13879	MIN.COL
1000	31500	4.585503	45.85503	87	41.14498	1692.909	MIN.COL
220	31500	.9040003	1.988801	15	13.0112	169.2913	MIN.COL
150	31500	1.7425	2.613751	21	18.38625	338.0542	MIN.COL
4830	31500	12.1381	586.2702	1081	494.7298	244757.6	MAJ.COL
2650	31500	9.778101	259.1197	568	308.8804	95407.06	MAJ.COL
920	31500	5.117701	47.08285	77	29.91715	895.036	MIN.COL
4410	31500	9.326002	411.2767	855	443.7234	196890.4	MAJ.COL
2400	31500	5.555102	133.3224	202	68.67757	4716.608	MIN.COL

ROOT MEAN SQUARE IS 494.913

THROUGH TRIP END ESTIMATION FOR SANFORD N.C. (NC 1 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
9140	21900	44.9905	4112.132	4771	658.8682	434107.3	PRI.ART
7630	21900	43.11431	3289.621	4521	1231.379	1516293	PRI.ART
5370	21900	13.4851	724.1497	1301	576.8503	332756.3	MAJ.COL
2300	21900	9.114698	209.6381	313	103.362	10683.69	MIN.COL
990	21900	3.763299	37.25666	46	8.743339	76.44598	MIN.COL
300	21900	.005	.015	39	38.985	1519.83	MIN.COL
380	21900	2.186702	8.309466	11	2.690534	7.238971	MIN.COL
430	21900	.005	.0215	11	10.9785	120.5275	MIN.COL
10600	21900	41.3597	4384.128	3315	-1069.128	1143035	PRI.ART
1410	21900	7.266702	102.4605	95	-7.460488	55.65887	MIN.COL
600	21900	3.674401	22.04641	34	11.95359	142.8884	MIN.COL
8450	21900	39.3617	3326.064	3632	305.9363	93597.01	PRI.ART
790	21900	6.011501	47.49085	44	-3.490852	12.18605	MIN.COL
2580	21900	9.516102	245.5155	310	64.48456	4158.258	MAJ.COL
480	21900	6.636899	31.85712	29	-2.857115	8.163105	MIN.COL
1020	21900	21.7947	222.306	46	-176.3059	31083.78	MIN.COL
270	21900	1.112701	3.004291	30	26.99571	728.7683	MIN.COL
11170	21900	42.1841	4711.964	4819	107.0361	11456.73	PRI.ART
1540	21900	5.924501	91.23731	171	79.7627	6362.088	MIN.COL
400	21900	.005	.02	27	26.98	727.9204	MIN.COL
660	21900	3.607101	23.80686	65	41.19314	1696.875	MIN.COL
1880	21900	9.102601	171.1289	297	125.8711	15843.53	MAJ.COL
320	21900	4.290101	13.72832	27	13.27168	176.1374	MIN.COL

ROOT MEAN SQUARE IS 395.8837

THROUGH TRIP END ESTIMATION FOR MONROE N.C. (NC 1 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
16110	15900	50.37251	8115.011	11666	3550.989	1.260952E+07	PRI.ART
1340	15900	12.1655	163.0177	130	-33.0177	1090.169	MAJ.COL
5720	15900	17.6306	1008.47	1550	541.5296	293254.3	MAJ.COL
2620	15900	12.8721	337.249	297	-40.24899	1619.982	MAJ.COL
620	15900	18.7091	115.9964	87	-28.99643	840.7929	MIN.COL
1120	15900	12.5241	140.2699	94	-46.26992	2140.905	MAJ.COL
14270	15900	48.20611	6879.011	8500	1620.989	2627605	PRI.ART
300	15900	7.703701	23.1111	36	12.8889	166.1237	MIN.COL
770	15900	9.908102	76.29238	133	56.70762	3215.754	MAJ.COL
750	15900	9.328701	69.96526	136	66.03475	4360.588	MIN.COL
6000	15900	48.27671	2896.603	4160	1263.398	1596173	PRI.ART
450	15900	8.757702	39.40966	78	38.59034	1489.215	MIN.COL
2490	15900	10.8784	270.8722	419	148.1278	21941.85	MAJ.COL
1450	15900	9.904701	143.6182	165	21.38184	457.1829	MIN.COL
4170	15900	14.8365	618.6821	748	129.3179	16723.13	MAJ.COL
2860	15900	14.0909	402.9998	406	3.000183	9.001099	MAJ.COL
590	15900	9.223301	54.41748	118	63.58253	4042.737	MIN.COL
1240	15900	13.6275	168.981	131	-37.98102	1442.558	MAJ.COL
850	15900	10.6562	90.57768	41	-49.57768	2457.947	MIN.COL
3270	15900	14.6419	478.7902	323	-155.7902	24270.58	MAJ.COL

ROOT MEAN SQUARE IS 927.7075

THROUGH TRIP END ESTIMATION FOR STATESVILLE N.C. (NC 1 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
4480	37000	8.814201	394.8762	1481	1086.124	1179665	MAJ.COL
600	37000	5.769601	34.6176	42	7.382397	54.49978	MIN.COL
10700	37000	81.7792	8750.374	9312	561.626	315423.8	INT
470	37000	8.3054	39.03538	36	-3.035378	9.213516	MIN.COL
2730	37000	6.869401	187.5347	402	214.4654	45995.39	MAJ.COL
3380	37000	35.6843	1206.129	1051	-155.1294	24065.13	PRI.ART
560	37000	4.1112	23.02272	56	32.97728	1087.501	MIN.COL
400	37000	.005	.02	24	23.98	575.0404	MIN.COL
7100	37000	79.651	5655.221	3510	-2145.221	4601974	INT
550	37000	.9468012	5.207407	39	33.7926	1141.94	MIN.COL
90	37000	.005	.0045	6	5.9955	35.94602	MIN.COL
5680	37000	7.074302	401.8204	481	79.17966	6269.418	MAJ.COL
840	37000	3.199901	26.87917	13	-13.87917	192.6312	MIN.COL
1180	37000	4.711599	55.59686	35	-20.59686	424.2306	MIN.COL
170	37000	2.139199	3.636639	4	.3633611	.1320313	MIN.COL
2360	37000	6.293201	148.5195	166	17.48047	305.5668	MAJ.COL
11200	37000	78.57881	8800.826	8811	10.17383	103.5068	INT
570	37000	.005	.0285	24	23.9715	574.6328	MIN.COL
4200	37000	10.0872	423.6626	693	269.3375	72542.68	MAJ.COL
280	37000	.9380007	2.626402	22	19.3736	375.3363	MIN.COL
3000	37000	7.367301	221.019	545	323.981	104963.7	MAJ.COL
600	37000	2.931001	17.586	33	15.414	237.5913	MAJ.COL
520	37000	1.937703	10.07606	24	13.92394	193.8762	MAJ.COL
1750	37000	2.616002	45.78004	24	-21.78003	474.3699	MAJ.COL

ROOT MEAN SQUARE IS 514.6474

THROUGH TRIP END ESTIMATION FOR HICKORY N.C. (NC 1 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
28190	50500	11.9243	3361.46	13562	10200.54	1.04051E+08	MAJ.COL
3890	50500	.005	.1945	436	435.8055	189926.4	MAJ.COL
470	50500	.005	.0235	70	69.9765	4896.711	MIN.COL
4570	50500	3.067801	140.1985	635	494.8015	244828.5	MAJ.COL
620	50500	.005	.031	40	39.969	1597.521	MIN.COL
860	50500	.005	.043	45	44.957	2021.132	MIN.COL
430	50500	.005	.0215	24	23.9785	574.9685	MIN.COL
4150	50500	7.491499	310.8972	321	10.10278	102.0662	MAJ.COL
2060	50500	.005	.103	156	155.897	24303.88	MIN.COL
1410	50500	.005	.0705	194	193.9295	37608.65	MIN.COL
850	50500	.005	.0425	151	150.9575	22788.17	MIN.COL
2070	50500	.005	.1035	134	133.8965	17928.27	MIN.COL
380	50500	.005	.019	28	27.981	782.9363	MIN.COL
17500	50500	73.7973	12914.53	9494	-3420.526	1.17E+07	INT
4520	50500	.005	.226	509	508.774	258851	MAJ.COL
1200	50500	.005	.06	55	54.94	3018.403	MIN.COL
1150	50500	.005	.0575	56	55.9425	3129.563	MIN.COL
1050	50500	.005	.0525	42	41.9475	1759.593	MIN.COL
1670	50500	.005	.0835	103	102.9165	10591.81	MIN.COL
16230	50500	30.01351	4871.192	4324	-547.1919	299419	PRI.ART
770	50500	.005	.0385	61	60.9615	3716.304	MIN.COL
340	50500	.005	.017	24	23.983	575.1843	MIN.COL
450	50500	.005	.0225	17	16.9775	288.2355	MIN.COL
4780	50500	.005	.239	731	730.761	534011.6	MAJ.COL
1340	50500	.005	.067	132	131.933	17406.32	MIN.COL
1010	50500	.005	.0505	157	156.9495	24633.14	MIN.COL
6040	50500	1.416502	85.55672	441	355.4433	126339.9	MAJ.COL
370	50500	.005	.0185	25	24.9815	624.0753	MIN.COL
2760	50500	.005	.138	196	195.862	38361.92	MIN.COL
2180	50500	.005	.109	275	274.891	75565.06	MIN.COL

ROOT MEAN SQUARE IS 1980.713

THROUGH TRIP END ESTIMATION FOR MORGANTON N.C. (NC 1 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
5290	16500	26.2141	1386.726	1455	68.27393	4661.329	MIN.ART
1020	16500	10.8005	110.1651	82	-28.16512	793.2738	MIN.COL
8150	16500	16.1236	1314.074	1115	-199.0735	39630.26	MAJ.COL
450	16500	11.2218	50.49811	43	-7.498112	56.22168	MIN.COL
12400	16500	87.1519	10806.84	8179	-2627.835	6905517	INT
700	16500	8.863801	62.04661	106	43.95339	1931.901	MIN.COL
2500	16500	16.9983	424.9576	598	173.0424	29943.68	MAJ.COL
750	16500	5.745502	43.09126	92	48.90874	2392.065	MIN.COL
980	16500	9.803701	96.07626	131	34.92374	1219.667	MIN.COL
1400	16500	9.3462	130.8468	206	75.1532	5648.003	MIN.COL
3330	16500	26.32411	876.5926	728	-148.5927	22079.78	MIN.ART
450	16500	8.501502	38.25676	64	25.74324	662.7145	MIN.COL
1750	16500	11.5344	201.852	191	-10.85199	117.7657	MIN.COL
10000	16500	87.8071	8780.71	7649	-1131.71	1280767	INT
4600	16500	14.9479	687.6033	627	-60.60334	3672.764	MAJ.COL
570	16500	12.2115	69.60556	118	48.39444	2342.022	MAJ.COL
4000	16500	13.0886	523.5441	915	391.4559	153237.8	MAJ.COL
210	16500	6.465701	13.57797	35	21.42203	458.9033	MIN.COL

ROOT MEAN SQUARE IS 685.3682

THROUGH TRIP END ESTIMATION FOR CANTON N.C.(NC 1 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
90	10000	.005	.0045	26	25.9955	675.766	MIN.COL
950	10000	12.5784	119.4948	214	94.50519	8931.231	MAJ.COL
1160	10000	11.0201	127.8332	225	97.16682	9441.392	MAJ.COL
18000	10000	91.705	16506.9	17548	1041.1	1083888	INT
7100	10000	18.2336	1294.586	4118	2823.415	7971670	MAJ.COL
950	10000	11.121	105.6495	155	49.35048	2435.47	MIN.COL
3150	10000	14.1056	444.3265	1120	675.6735	456534.7	MAJ.COL
1650	10000	14.0245	231.4043	427	195.5958	38257.7	MAJ.COL
8130	10000	17.3284	1408.799	3922	2513.201	6316180	MAJ.COL
1250	10000	13.4234	167.7925	94	-73.7925	5445.333	MIN.COL
240	10000	11.8068	28.33632	16	-12.33632	152.1849	MIN.COL
18000	10000	91.5102	16471.84	17379	907.1641	822946.6	INT

ROOT MEAN SQUARE IS 1180.274

THROUGH TRIP END ESTIMATION FOR TARBORO N.C. (NC 1 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
3950	13500	18.2855	722.2772	529	-193.2772	37356.06	MAJ.COL
2220	13500	26.2597	582.9654	574	-8.965393	80.37828	MIN.ART
1480	13500	15.5615	230.3103	201	-29.31024	859.0902	MAJ.COL
3660	13500	45.67451	1671.687	1612	-59.68689	3562.525	PRI.ART
1190	13500	14.1467	168.3457	103	-65.34572	4270.063	MAJ.COL
2720	13500	27.66391	752.4582	553	-199.4582	39783.57	MIN.ART
3540	13500	20.3563	720.6131	232	-488.6131	238742.8	MAJ.COL
1460	13500	15.3267	223.7698	107	-116.7698	13635.19	MAJ.COL
5800	13500	46.72251	2709.905	1577	-1132.905	1283474	PRI.ART

ROOT MEAN SQUARE IS 424.495

THROUGH TRIP END ESTIMATION FOR BOONE N.C.(NC 1 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
7680	16000	41.91761	3219.272	3350	130.7278	17089.75	PRI.ART
6270	16000	11.2344	704.3971	1590	885.6029	784292.6	MAJ.COL
7690	16000	40.5578	3118.895	2982	-136.8948	18740.18	PRI.ART
7580	16000	40.3346	3057.363	2651	-406.3628	165130.7	PRI.ART
12220	16000	41.8342	5112.139	4235	-877.1392	769373.1	PRI.ART
1220	16000	10.9999	134.1988	230	95.80121	9177.871	MIN.COL
1500	16000	9.842002	147.63	272	124.37	15467.89	MIN.COL
880	16000	10.8713	95.66746	140	44.33254	1965.374	MIN.COL

ROOT MEAN SQUARE IS 471.863

THROUGH TRIP END ESTIMATION FOR ELIZABETH CITY N.C. (NC 1 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
6660	6600	48.8748	3255.062	2113	-1142.062	1304305	PRI.ART
8320	6600	26.8532	2234.187	1333	-901.1865	812137.1	MIN.ART
300	6600	8.426801	25.2804	19	-6.280403	39.44346	MIN.COL
2760	6600	19.3055	532.8318	749	216.1682	46728.7	MAJ.COL
630	6600	16.6524	104.9101	27	-77.91013	6069.988	MIN.COL
1570	6600	17.4972	274.706	80	-194.706	37910.44	MAJ.COL
1290	6600	16.3456	210.8583	83	-127.8583	16347.73	MAJ.COL
270	6600	4.9803	13.44681	5	-8.44681	71.3486	MIN.COL
7300	6600	46.80981	3417.116	2094	-1323.116	1750635	PRI.ART
690	6600	14.4746	99.87476	83	-16.87476	284.7574	MAJ.COL

ROOT MEAN SQUARE IS 630.4388

THROUGH TRIP END ESTIMATION FOR MOUNT AIRY N.C. (NC 1 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
8700	22900	32.2417	2805.028	4428	1622.972	2634038	MIN.ART
340	22900	6.321302	21.49243	31	9.507576	90.394	MIN.COL
1300	22900	8.020101	104.2613	94	-10.26131	105.2944	MIN.COL
570	22900	5.669099	32.31386	46	13.68614	187.3104	MIN.COL
1110	22900	10.3705	115.1126	184	68.88744	4745.479	MAJ.COL
370	22900	.005	.0185	21	20.9815	440.2233	MIN.COL
1780	22900	12.9243	230.0526	191	-39.05258	1525.104	MAJ.COL
1980	22900	10.2293	202.5402	233	30.45981	927.7999	MAJ.COL
9010	22900	48.78151	4395.214	4905	509.7862	259881.9	PRI.ART
1100	22900	10.2787	113.0657	55	-58.06568	3371.623	MIN.COL
470	22900	8.504901	39.97304	82	42.02697	1766.266	MIN.COL
2070	22900	9.519901	197.0619	133	-64.06194	4103.932	MIN.COL
1220	22900	9.460103	115.4133	76	-39.41326	1553.405	MIN.COL
420	22900	9.498101	39.89203	49	9.107975	82.95521	MIN.COL
7620	22900	20.6061	1570.185	1539	-31.18506	972.5079	MIN.ART
560	22900	5.8349	32.67544	42	9.324562	86.94746	MIN.COL
6290	22900	14.2533	896.5326	940	43.46741	1889.416	MAJ.COL
620	22900	9.1573	56.77526	66	9.224743	85.09588	MIN.COL
1190	22900	6.2555	74.44045	115	40.55956	1645.078	MIN.COL

ROOT MEAN SQUARE IS 391.8578

THROUGH TRPI ESTIMATION FOR FARMVILLE N.C. (NC 1 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
1550	6600	13.5578	210.1459	190	-20.14594	405.8587	MAJ.COL
2200	6600	20.9268	460.3896	378	-82.38962	6788.05	MAJ.COL
1560	6600	15.372	239.8033	167	-72.80324	5300.312	MAJ.COL
4380	6600	51.5944	2259.835	3147	887.1651	787061.8	PRI.ART
3130	6600	28.8924	904.3321	746	-158.3322	25069.07	MIN.ART
5320	6600	51.46721	2738.055	3232	493.9448	243981.5	PRI.ART
2360	6600	31.477	742.8572	890	147.1428	21651.01	MIN.ART

ROOT MEAN SQUARE IS 394.6531

THROUGH TRIP END ESTIMATION FOR DUNN N.C. (NC 1 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
3470	17300	15.8153	548.7909	847	298.2091	88928.68	MAJ.COL
500	17300	15.8219	79.1095	36	-43.1095	1858.429	MIN.COL
1130	17300	8.694501	98.24786	82	-16.24786	263.9931	MIN.COL
520	17300	10.5823	55.02797	52	-3.027969	9.168598	MIN.COL
920	17300	14.1057	129.7724	85	-44.77243	2004.571	MIN.COL
430	17300	5.857001	25.1851	51	25.8149	666.409	MIN.COL
3380	17300	15.3295	518.1371	513	-5.137085	26.38964	MAJ.COL
280	17300	9.411801	26.35304	28	1.646957	2.712469	MIN.COL
14940	17300	90.57071	13531.26	14381	849.7363	722051.8	INT
1390	17300	6.330301	87.99118	117	29.00883	841.5121	MIN.COL
2660	17300	14.8848	395.9357	433	37.06427	1373.76	MAJ.COL
4250	17300	31.3865	1333.926	2055	721.0738	519947.3	MIN.ART
1920	17300	10.6493	204.4666	228	23.53343	553.8224	MIN.COL
470	17300	8.896099	41.81167	40	-1.811665	3.282129	MIN.COL
15210	17300	90.1051	13704.99	14128	423.0137	178940.6	INT
2050	17300	12.2389	250.8975	224	-26.89745	723.4726	MAJ.COL
630	17300	6.914902	43.56388	26	-17.56388	308.4899	MIN.COL
530	17300	14.6842	77.82627	144	66.17373	4378.963	MAJ.COL
4680	17300	17.2029	805.0957	839	33.9043	1149.501	MAJ.COL
410	17300	9.271999	38.0152	39	.9848022	.9698354	MIN.COL
4700	17300	48.62531	2285.39	1796	-489.3894	239502	PRI.ART

ROOT MEAN SQUARE IS 289.7894

THROUGH TRIP END ESTIMATION FOR AHOSKIE N.C. (NC 1 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
3770	6500	52.5977	1982.934	1439	-543.9335	295863.6	PRI.ART
220	6500	18.5909	40.89998	18	-22.89998	524.409	MIN.COL
1040	6500	20.6224	214.473	85	-129.473	16763.24	MIN.COL
1060	6500	22.3325	236.7245	136	-100.7245	10145.42	MAJ.COL
3990	6500	51.60591	2059.076	1304	-755.0757	570139.3	PRI.ART
1090	6500	21.2923	232.0861	86	-146.0861	21341.14	MIN.COL
2690	6500	20.7332	557.7231	428	-129.7231	16828.08	MAJ.COL
2380	6500	28.9324	688.5911	286	-402.5911	162079.6	MIN.ART

ROOT MEAN SQUARE IS 369.744

THROUGH TRIP END ESTIMATION FOR MONROE N.C. (NC 2 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
16110	15900	72.05821	11608.58	11666	57.42383	3297.496	PRIMARY.ART
1340	15900	15.689	210.2326	130	-80.23262	6437.274	MAJ.COLLECTOR
5720	15900	35.735	2044.042	1550	-494.042	244077.5	MAJ.COLLECTOR
2620	15900	20.645	540.8991	297	-243.8991	59486.75	MAJ.COLLECTOR
620	15900	34.833	215.9646	87	-128.9646	16631.87	MIN.COLLECTOR
1120	15900	13.193	147.7616	94	-53.7616	2890.309	MAJ.COLLECTOR
14270	15900	63.959	9126.949	8500	-626.9493	393065.3	PRIMARY.ART
300	15900	7.213	21.639	36	14.361	206.2383	MIN.COLLECTOR
770	15900	13.171	101.4167	133	31.5833	997.5047	MAJ.COLLECTOR
750	15900	12.083	90.6225	136	45.3775	2059.118	MIN.COLLECTOR
6000	15900	43.197	2591.82	4160	1568.18	2459189	PRIMARY.ART
450	15900	10.563	47.5335	78	30.4665	928.2078	MIN.COLLECTOR
2490	15900	15.5858	388.0864	419	30.91361	955.6509	MAJ.COLLECTOR
1450	15900	12.127	175.8415	165	-10.84151	117.5383	MIN.COLLECTOR
4170	15900	24.3198	1014.136	748	-266.1357	70828.21	MAJ.COLLECTOR
2860	15900	19.197	549.0343	406	-143.0342	20458.79	MAJ.COLLECTOR
590	15900	13.4134	79.13906	118	38.86094	1510.173	MIN.COLLECTOR
1240	15900	13.949	172.9676	131	-41.96759	1761.279	MAJ.COLLECTOR
850	15900	13.897	118.1245	41	-77.12449	5948.187	MIN.COLLECTOR
3270	15900	22.3646	731.3224	323	-408.3224	166727.2	MAJ.COLLECTOR

THE ROOT MEAN SQUARE IS 415.7869

THROUGH TRIP ESTIMATION FOR STATESVILLE N.C (N.C 2 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
4480	37000	23.084	1034.163	1481	446.8368	199663.1	MAJ.COLLECTOR
600	37000	13.44	80.64001	42	-38.64001	1493.05	MIN.COLLECTOR
10700	37000	55.092	5894.844	9312	3417.156	1.167696E+07	INT
470	37000	8.809999	41.407	36	-5.406998	29.23563	MIN.COLLECTOR
2730	37000	15.278	417.0894	402	-15.08939	227.6896	MAJ.COLLECTOR
3380	37000	22.814	771.1131	1051	279.8869	78336.68	PRIMARY.ART
560	37000	8.008001	44.8448	56	11.1552	124.4385	MIN.COLLECTOR
400	37000	3.3	13.2	24	10.8	116.64	MIN.COLLECTOR
7100	37000	43.512	3089.352	3510	420.648	176944.7	INT
550	37000	3.0092	16.5506	39	22.4494	503.9757	MIN.COLLECTOR
90	37000	4.714	4.2426	6	1.7574	3.088455	MIN.COLLECTOR
5680	37000	20.6836	1174.828	481	-693.8284	481397.8	MAJ.COLLECTOR
840	37000	8.809999	74.004	13	-61.004	3721.488	MIN.COLLECTOR
1180	37000	12.0472	142.157	35	-107.157	11482.61	MIN.COLLECTOR
170	37000	11.3156	19.23652	4	-15.23652	232.1515	MIN.COLLECTOR
2360	37000	13.1024	309.2167	166	-143.2167	20511.01	MAJ.COLLECTOR
11200	37000	50.176	5619.712	8811	3191.288	1.018432E+07	INT
570	37000	4.038	23.0166	24	.9834042	.9670838	MIN.COLLECTOR
4200	37000	23.984	1007.328	693	-314.3281	98802.13	MAJ.COLLECTOR
280	37000	10.1808	28.50624	22	-6.506237	42.33112	MIN.COLLECTOR
3000	37000	16.1724	485.1721	545	59.82797	3579.386	MAJ.COLLECTOR
600	37000	7.076	42.456	33	-9.455998	89.41589	MIN.COLLECTOR
520	37000	6.2908	32.71216	24	-8.712162	75.90176	MIN.COLLECTOR
1750	37000	13.5292	236.761	24	-212.761	45267.24	MAJ.COLLECTOR

THE ROOT MEAN SQUARE IS 978.6028

THROUGH TRIP END ESTIMATION FOR SANFORD N.C. (NC 2 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
9140	21900	52.609	4808.463	4771	-37.46289	1403.468	PRIMARY.ART
7630	21900	42.023	3206.355	4521	1314.645	1728292	PRIMARY.ART
5370	21900	31.115	1670.875	1301	-369.8753	136807.7	MAJ.COLLECTOR
2300	21900	19.285	443.555	313	-130.555	17044.61	MIN.COLLECTOR
990	21900	8.5086	84.23514	46	-38.23514	1461.926	MIN.COLLECTOR
300	21900	15.121	45.363	39	-6.362999	40.48776	MIN.COLLECTOR
380	21900	3.8738	14.72044	11	-3.72044	13.84167	MIN.COLLECTOR
430	21900	6.3718	27.39874	11	-16.39874	268.9187	MIN.COLLECTOR
10600	21900	47.821	5069.026	3315	-1754.026	3076607	MAJ.COLLECTOR
1410	21900	12.531	176.6871	95	-81.68711	6672.783	MIN.COLLECTOR
600	21900	7.5094	45.0564	34	-11.0564	122.2439	MIN.COLLECTOR
8450	21900	36.903	3118.304	3632	513.6966	263884.1	PRIMARY.ART
790	21900	10.919	86.26011	44	-42.26011	1785.917	MIN.COLLECTOR
2580	21900	20.0426	517.0991	310	-207.0991	42890.02	MAJ.COLLECTOR
480	21900	11.149	53.5152	29	-24.5152	600.9951	MIN.COLLECTOR
1020	21900	43.18901	440.5278	46	-394.5278	155652.2	MIN.COLLECTOR
270	21900	4.2982	11.60514	30	18.39486	338.3709	MIN.COLLECTOR
11170	21900	51.079	5705.524	4819	-886.5239	785924.7	PRIMARY.ART
1540	21900	12.425	191.345	171	-20.345	413.9191	MIN.COLLECTOR
400	21900	3.911	15.644	27	11.356	128.9588	MIN.COLLECTOR
660	21900	8.9234	58.89444	65	6.105561	37.27787	MIN.COLLECTOR
1880	21900	12.8206	241.0273	297	55.97272	3132.945	MIN.ART
320	21900	16.357	52.34241	27	-25.3424	642.2375	MIN.COLLECTOR

THE ROOT MEAN SQUARE IS 520.2076

THROUGH TRIP END ESTIMATION FOR MORGANTON N.C. (NC 2 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
5290	16500	30.0946	1592.004	1455	-137.0044	18770.2	MIN.ART
1020	16500	11.1782	114.0176	82	-32.01764	1025.129	MIN.COLLECTOR
8150	16500	33.0462	2693.266	1115	-1578.266	2490923	MAJ.COLLECTOR
450	16500	10.9246	49.1607	43	-6.160702	37.95425	MIN.COLLECTOR
12400	16500	59.207	7341.668	8179	837.3325	701125.8	INT
700	16500	9.798599	68.5902	106	37.40981	1399.494	MIN.COLLECTOR
2500	16500	21.7454	543.635	598	54.36499	2955.552	MAJ.COLLECTOR
750	16500	9.677	72.5775	92	19.4225	377.2335	MIN.COLLECTOR
980	16500	11.5478	113.1684	131	17.83157	317.9648	MIN.COLLECTOR
1400	16500	16.5914	232.2796	206	-26.2796	690.6175	MIN.COLLECTOR
3330	16500	27.189	905.3937	728	-177.3937	31468.52	MIN.ART
450	16500	7.713001	34.7085	64	29.2915	857.9919	MIN.COLLECTOR
1750	16500	14.2158	248.7765	191	-57.77651	3338.125	MIN.COLLECTOR
10000	16500	54.743	5474.3	7649	2174.7	4729321	INT
4600	16500	24.127	1109.842	627	-482.8421	233136.5	MAJ.COLLECTOR
570	16500	13.1754	75.09978	118	42.90023	1840.429	MAJ.COLLECTOR
4000	16500	20.865	834.6	915	80.40003	6464.164	MAJ.COLLECTOR
210	16500	11.085	23.2785	35	11.7215	137.3935	MIN.COLLECTOR

ROOT MEAN SQUARE IS 675.9433

THROUGH TRIP END ESTIMATION FOR SHELBY N.C. (NC 2 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
12370	31500	50.631	6263.054	5757	-506.0542	256090.9	PRIMARY.ART
750	31500	4.0354	30.2655	77	46.73451	2184.114	MIN.COLLECTOR
6050	31500	27.4058	1658.051	1945	286.9491	82339.78	MAJ.COLLECTOR
2750	31500	11.6774	321.1285	395	73.87149	5456.997	MAJ.COLLECTOR
460	31500	2.645	12.167	16	3.833003	14.69191	MIN.COLLECTOR
4590	31500	28.035	1286.807	1165	-121.8065	14836.83	MIN.ART
3080	31500	13.305	409.794	1039	629.206	395900.2	MAJ.COLLECTOR
370	31500	17.6846	65.43301	106	40.56699	1645.68	MAJ.COLLECTOR
240	31500	5.0774	12.18576	27	14.81424	219.4617	MIN.COLLECTOR
2340	31500	9.901	231.6834	226	-5.683396	32.30098	MIN.COLLECTOR
10030	31500	39.5446	3966.323	4936	969.6768	940273	PRIMARY.ART
500	31500	5.561	27.805	55	27.195	739.568	MAJ.COLLECTOR
3500	31500	17.5494	614.229	423	-191.229	36568.53	MAJ.COLLECTOR
5100	31500	20.8214	1061.891	1130	68.10865	4638.787	MAJ.COLLECTOR
920	31500	8.502999	78.2276	41	-37.22759	1385.894	MIN.COLLECTOR
1000	31500	7.305	73.05	87	13.95	194.6024	MIN.COLLECTOR
220	31500	6.1502	13.53044	15	1.469561	2.159608	MIN.COLLECTOR
150	31500	14.715	22.0725	21	-1.0725	1.150257	MIN.COLLECTOR
4830	31500	27.179	1312.746	1081	-231.7456	53706.03	MAJ.COLLECTOR
2650	31500	24.471	648.4815	568	-80.48151	6477.273	MAJ.COLLECTOR
920	31500	7.541	69.37719	77	7.622811	58.10724	MIN.COLLECTOR
4410	31500	22.9642	1012.721	855	-157.7212	24875.98	MAJ.COLLECTOR
2400	31500	14.497	347.928	202	-145.928	21294.99	MIN.COLLECTOR

ROOT MEAN SQUARE IS 283.5288

THROUGH TRIP END ESTIMATION FOR HICKORY N.C. (NC 2 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
28190	50500	91.20101	25709.56	13562	-12147.56	1.475633E+08	MAJ.COLLECTOR
3890	50500	9.077001	353.0953	436	82.9047	6873.188	MAJ.COLLECTOR
470	50500	.5	2.35	70	67.65	4576.523	MIN.COLLECTOR
4570	50500	19.7398	902.1088	635	-267.1088	71347.13	MAJ.COLLECTOR
620	50500	1.463	9.070599	40	30.9294	956.6279	MIN.COLLECTOR
860	50500	4.011001	34.49461	45	10.50539	110.3633	MIN.COLLECTOR
430	50500	4.077001	17.5311	24	6.468899	41.84665	MIN.COLLECTOR
4150	50500	16.265	674.9975	321	-353.9975	125314.2	MAJ.COLLECTOR
2060	50500	4.8814	100.5568	156	55.44316	3073.943	MIN.COLLECTOR
1410	50500	1.9186	27.05226	194	166.9477	27871.55	MIN.COLLECTOR
850	50500	5.0654	43.0559	151	107.9441	11651.93	MIN.COLLECTOR
2070	50500	5.825001	120.5775	134	13.4225	180.1635	MIN.COLLECTOR
380	50500	1.6382	6.225159	28	21.77484	474.1437	MIN.COLLECTOR
17500	50500	65.80461	11515.81	9494	-2021.805	4087694	INT
4520	50500	13.379	604.7308	509	-95.73078	9164.381	MAJ.COLLECTOR
1200	50500	.5	6	55	49	2401	MIN.COLLECTOR
1150	50500	2.841	32.6715	56	23.3285	544.2191	MIN.COLLECTOR
1050	50500	.5	5.25	42	36.75	1350.563	MIN.COLLECTOR
1670	50500	3.2162	53.71055	103	49.28945	2429.45	MIN.COLLECTOR
16230	50500	49.9818	8112.047	4324	-3788.047	1.43493E+07	PRIMARY.ART
770	50500	1.6014	12.33078	61	48.66922	2368.693	MIN.COLLECTOR
340	50500	.5	1.7	24	22.3	497.29	MIN.COLLECTOR
450	50500	.5	2.25	17	14.75	217.5625	MIN.COLLECTOR
4780	50500	14.7062	702.9563	731	28.0437	786.4492	MAJ.COLLECTOR
1340	50500	2.447	32.7898	132	99.2102	9842.663	MIN.COLLECTOR
1010	50500	9.580999	96.7681	157	60.23191	3627.882	MIN.COLLECTOR
6040	50500	17.8934	1080.762	441	-639.7615	409294.8	MAJ.COLLECTOR
370	50500	3.773	13.9601	25	11.0399	121.8794	MIN.COLLECTOR
2760	50500	9.099001	251.1324	196	-55.13242	3039.583	MIN.COLLECTOR
2180	50500	6.481001	141.2858	275	133.7142	17879.49	MIN.COLLECTOR

THE ROOT MEAN SQUARE IS 2357.374

THROUGH TRIP END ESTIMATION FOR DUNN N.C. (NC 2 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
3470	17300	21.681	752.3307	847	94.66931	8962.278	MAJ.COLLECTOR
500	17300	19.435	97.17501	36	-61.17501	3742.382	MIN.COLLECTOR
1130	17300	12.637	142.7981	82	-60.79811	3696.41	MIN.COLLECTOR
520	17300	13.863	72.0876	52	-20.0876	403.5117	MIN.COLLECTOR
920	17300	23.043	211.9956	85	-126.9956	16127.88	MIN.COLLECTOR
430	17300	16.071	69.1053	51	-18.1053	327.8019	MIN.COLLECTOR
3380	17300	22.483	759.9255	513	-246.9254	60972.16	MAJ.COLLECTOR
280	17300	10.4714	29.31992	28	-1.319922	1.742193	MIN.COLLECTOR
14940	17300	71.77901	10723.78	14381	3657.217	1.337524E+07	INT
1390	17300	12.9874	180.5249	117	-63.52486	4035.408	MIN.COLLECTOR
2660	17300	22.313	593.5258	433	-160.5258	25768.52	MAJ.COLLECTOR
4250	17300	40.581	1724.693	2055	330.3075	109103	MIN.ART
1920	17300	16.467	316.1664	228	-88.16641	7773.317	MIN.COLLECTOR
470	17300	12.697	59.67591	40	-19.6759	387.1412	MIN.COLLECTOR
15210	17300	71.593	10889.3	14128	3238.705	1.048921E+07	INT
2050	17300	17.693	362.7065	224	-138.7065	19239.5	MAJ.COLLECTOR
630	17300	12.225	77.0175	26	-51.0175	2602.786	MIN.COLLECTOR
530	17300	13.963	74.0039	144	69.9961	4899.454	MIN.COLLECTOR
4680	17300	31.339	1466.665	839	-627.6652	393963.6	MAJ.COLLECTOR
410	17300	7.879	32.3039	39	6.696099	44.83774	MIN.COLLECTOR
4700	17300	40.271	1892.737	1796	-96.73682	9358.012	PRIMARY.ART

THE ROOT MEAN SQUARE IS 1080.914

THROUGH TRIP END ESTIMATION FOR AHOSKIE N.C. (NC 2 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
3770	6500	30.841	1162.706	1439	276.2943	76338.55	PRIMARY.ART
170	6500	9.049	15.3833	18	2.6167	6.84712	MIN.COLLECTOR
1040	6500	11.681	121.4824	85	-36.4824	1330.966	MIN.COLLECTOR
1060	6500	12.547	132.9982	136	3.001801	9.010806	MAJ.COLLECTOR
3990	6500	28.305	1129.369	1304	174.6306	30495.85	PRIMARY.ART
1090	6500	12.477	135.9993	86	-49.9993	2499.93	MIN.COLLECTOR
2690	6500	19.7598	531.5386	428	-103.5386	10720.25	MAJ.COLLECTOR
2380	6500	15.6386	372.1987	286	-86.19867	7430.211	MIN.ART

THE ROOT MEAN SQUARE IS 126.9014

THROUGH TRIP END ESTIMATION FOR MOUNT AIRY N.C. (NC 2 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
8700	22900	57.223	4978.401	4428	-550.4009	302941.1	MIN.ART
340	22900	11.807	40.1438	31	-9.143802	83.60913	MIN.COLLECTOR
1300	22900	12.231	159.003	94	-65.003	4225.389	MIN.COLLECTOR
570	22900	14.625	83.3625	46	-37.3625	1395.957	MIN.COLLECTOR
1110	22900	14.401	159.8511	184	24.1489	583.1691	MAJ.COLLECTOR
370	22900	10.405	38.49851	21	-17.49851	306.1977	MIN.COLLECTOR
1780	22900	19.843	353.2054	191	-162.2054	26310.59	MAJ.COLLECTOR
1980	22900	16.071	318.2058	233	-85.20578	7260.025	MAJ.COLLECTOR
9010	22900	56.99301	5135.07	4905	-230.0698	52932.13	PRIMARY.ART
1100	22900	14.523	159.753	55	-104.753	10973.19	MIN.COLLECTOR
470	22900	13.8026	64.87221	82	17.12779	293.361	MIN.COLLECTOR
2070	22900	15.1506	313.6174	133	-180.6174	32622.66	MIN.COLLECTOR
1220	22900	12.023	146.6806	76	-70.6806	4995.748	MIN.COLLECTOR
420	22900	14.975	62.895	49	-13.895	193.0711	MIN.COLLECTOR
7620	22900	38.135	2905.887	1539	-1366.887	1868381	MIN.ART
560	22900	12.971	72.63761	42	-30.63761	938.6628	MIN.COLLECTOR
6290	22900	33.9666	2136.499	940	-1196.499	1431610	MAJ.COLLECTOR
620	22900	11.943	74.04661	66	-8.046608	64.7479	MIN.COLLECTOR
1190	22900	11.501	136.8619	115	-21.86189	477.9424	MIN.COLLECTOR

THE ROOT MEAN SQUARE IS 444.0595

THROUGH TRIP END ESTIMATION FOR TARBORO N.C. (NC 2 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
3950	13500	25.883	1022.378	529	-493.3784	243422.3	MAJ.COLLECTOR
2220	13500	23.6642	525.3452	574	48.65479	2367.288	MIN.ART
1480	13500	16.4418	243.3387	201	-42.33864	1792.56	MAJ.COLLECTOR
3660	13500	31.2118	1142.352	1612	469.6482	220569.4	PRIMARY.ART
1190	13500	16.043	190.9117	103	-87.91168	7728.464	MAJ.COLLECTOR
2720	13500	27.421	745.8513	553	-192.8513	37191.61	MIN.ART
3540	13500	30.737	1088.09	232	-856.0899	732889.8	MAJ.COLLECTOR
1460	13500	15.265	222.869	107	-115.869	13425.63	MAJ.COLLECTOR
5800	13500	36.169	2097.802	1577	-520.8018	271234.5	PRIMARY.ART

THE ROOT MEAN SQUARE IS 412.3943

THROUGH TRIP END ESTIMATION FOR ELIZABETHCITY N.C. (NC 2 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
6660	6600	41.284	2749.515	2113	-636.5144	405150.6	PRIMARY.ART
8320	6600	35.832	2981.223	1333	-1648.222	2716637	MIN.ART
300	6600	13.5	40.5	19	-21.5	462.25	MIN.COLLECTOR
2760	6600	27.37	755.412	749	-6.411927	41.1128	MAJ.COLLECTOR
630	6600	21.166	133.3458	27	-106.3458	11309.43	MIN.COLLECTOR
1570	6600	24.794	389.2658	80	-309.2658	95645.34	MAJ.COLLECTOR
1290	6600	15.482	199.7178	83	-116.7178	13623.04	MAJ.COLLECTOR
270	6600	12.3712	33.40224	5	-28.40224	806.6873	MIN.COLLECTOR
7300	6600	41.32	3016.36	2094	-922.3599	850747.7	PRIMARY.ART
690	6600	15.55	107.295	83	-24.295	590.247	MAJ.COLLECTOR

THE ROOT MEAN SQUARE IS 639.9229

THROUGH TRIP END ESTIMATION FOR BOONE N.C. (NC 2 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
7680	16000	37.322	2866.329	3350	483.6707	233937.3	PRIMARY.ART
6270	16000	29.216	1831.843	1590	-241.8432	58488.11	MAJ.COLLECTOR
7690	16000	38.088	2928.967	2982	53.03321	2812.521	PRIMARY.ART
7580	16000	33.362	2528.84	2651	122.1604	14923.16	PRIMARY.ART
12220	16000	44.4196	5428.075	4235	-1193.075	1423428	PRIMARY.ART
1220	16000	15.864	193.5408	230	36.4592	1329.273	MIN.COLLECTOR
1500	16000	14.446	216.69	272	55.31003	3059.199	MIN.COLLECTOR
880	16000	11.9904	105.5155	140	34.48448	1189.179	MIN.COLLECTOR

THE ROOT MEAN SQUARE IS 466.2573

THROUGH TRIP END ESTIMATION FOR CANTON N.C. (NC 2 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
90	10000	16.192	14.5728	26	11.4272	130.5809	MIN.COLLECTOR
950	10000	14.58	138.51	214	75.49001	5698.741	MIN.COLLECTOR
1160	10000	15.5848	180.7837	225	44.21631	1955.082	MAJ.COLLECTOR
18000	10000	79.778	14360.04	17548	3187.96	1.016309E+07	INT
7100	10000	33.826	2401.646	4118	1716.354	2945871	MAJ.COLLECTOR
950	10000	17.392	165.224	155	-10.224	104.5302	MIN.COLLECTOR
3150	10000	20.892	658.098	1120	461.9021	213353.5	MAJ.COLLECTOR
1650	10000	17.88	295.02	427	131.98	17418.72	MAJ.COLLECTOR
8130	10000	35.32	2871.516	3922	1050.484	1103517	MAJ.COLLECTOR
1250	10000	15.212	190.15	94	-96.14999	9244.821	MIN.COLLECTOR
240	10000	9.774	23.4576	16	-7.4576	55.61579	MIN.COLLECTOR
18000	10000	79.482	14306.76	17379	3072.241	9438666	INT

THE ROOT MEAN SQUARE IS 1411.238

THROUGH TRIP END ESTIMATION FOR FARMVILLE N.C. (NC 2 MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
1550	6600	19.562	303.211	190	-113.211	12816.73	MAJ.COLLECTOR
2200	6600	23.768	522.896	378	-144.896	20994.85	MAJ.COLLECTOR
1560	6600	19.44	303.264	167	-136.264	18567.87	MAJ.COLLECTOR
4380	6600	42.756	1872.713	3147	1274.287	1623808	PRIMARY.ART
3130	6600	29.738	930.7994	746	-184.7994	34150.81	MIN.ART
5320	6600	45.2	2404.64	3232	827.3601	684524.8	PRIMARY.ART
2360	6600	34.692	818.7313	890	71.26874	5079.233	MIN.ART

THE ROOT MEAN SQUARE IS 585.5331

THROUGH TRIP END ESTIMATION FOR STATESVILLE N.C. (KENTUCKY MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
4480	37000	18.678	836.7745	1481	644.2255	415026.5	COLLECTOR
600	37000	7.485001	44.91001	42	-2.910004	8.468121	LOCAL
10700	37000	53.281	5701.067	9312	3610.933	1.303884E+07	PRIMARY.ART
470	37000	2.774	13.0378	36	22.9622	527.2626	COLLECTOR
2730	37000	10.15	277.095	402	124.905	15601.25	COLLECTOR
3380	37000	17.9855	607.91	1051	443.0901	196328.8	MIN.ART
560	37000	2.001001	11.20561	56	44.79439	2006.538	LOCAL
400	37000	.5	2	24	22	484	LOCAL
7100	37000	40.246	2857.466	3510	652.5337	425800.2	PRIMARY.ART
550	37000	.5	2.75	39	36.25	1314.063	COLLECTOR
90	37000	.5	.45	6	5.55	30.8025	LOCAL
5680	37000	16.7203	949.713	481	-468.713	219691.9	COLLECTOR
840	37000	2.915501	24.49021	13	-11.49021	132.0248	COLLECTOR
1180	37000	6.304601	74.39429	35	-39.39429	1551.91	COLLECTOR
170	37000	5.181801	8.809061	4	-4.809061	23.12707	COLLECTOR
2360	37000	7.818201	184.5096	166	-18.50955	342.6035	MIN.ART
11200	37000	48.523	5434.576	8811	3376.424	1.140024E+07	PRIMARY.ART
570	37000	.5	2.85	24	21.15	447.3225	LOCAL
4200	37000	19.477	818.0341	693	-125.0341	15633.52	COLLECTOR
280	37000	4.081401	11.42792	22	10.57208	111.7688	LOCAL
3000	37000	11.1537	334.611	545	210.389	44263.53	COLLECTOR
600	37000	1.077999	6.467994	33	26.53201	703.9473	LOCAL
520	37000	.2569008	1.335884	24	22.66412	513.6622	LOCAL
1750	37000	8.014601	140.2555	24	-116.2555	13515.34	COLLECTOR

THE ROOT MEAN SQUARE IS 1036.684

THROUGH TRIP END ESTIMATION FOR SHELBY N.C. (KENTUCKY MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
12370	31500	51.562	6378.219	5757	-621.2193	385913.4	PRIMARY.ART
750	31500	.2077007	1.557756	77	75.44225	5691.532	LOCAL
6050	31500	25.7629	1558.656	1945	386.3445	149262.1	MIN.ART
2750	31500	8.666201	238.3205	395	156.6795	24548.46	COLLECTOR
460	31500	.5	2.3	16	13.7	187.69	LOCAL
4590	31500	25.838	1185.964	1165	-20.96423	439.4991	MIN.ART
3080	31500	10.431	321.2749	1039	717.7252	515129.4	COLLECTOR
370	31500	13.8038	51.07407	106	54.92594	3016.858	LOCAL
240	31500	1.061701	2.548082	27	24.45192	597.8963	LOCAL
2340	31500	6.721001	157.2714	226	68.72858	4723.617	COLLECTOR
10030	31500	39.5058	3962.432	4936	973.5681	947834.9	PRIMARY.ART
500	31500	1.648001	8.240004	55	46.76	2186.497	COLLECTOR
3500	31500	14.8647	520.2645	423	-97.26446	9460.376	MIN.ART
5100	31500	18.7707	957.3058	1130	172.6942	29823.29	MIN.ART
920	31500	4.770501	43.88861	41	-2.888607	8.344051	LOCAL
1000	31500	3.595001	35.95001	87	51.04999	2606.101	COLLECTOR
220	31500	2.134101	4.695022	15	10.30498	106.1926	LOCAL
150	31500	10.73	16.095	21	4.905001	24.05903	LOCAL
4830	31500	25.068	1210.784	1081	-129.7844	16844	MIN.ART
2650	31500	21.508	569.962	568	-1.961975	3.849346	COLLECTOR
920	31500	3.802001	34.97841	77	42.02159	1765.814	COLLECTOR
4410	31500	20.6641	911.2869	855	-56.28687	3168.211	MIN.ART
2400	31500	11.371	272.904	202	-70.90403	5027.381	COLLECTOR

THE ROOT MEAN SQUARE IS 302.7676

THROUGH TRIP END ESTIMATION FOR SANFORD N.C. (KENTUCKY MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
9140	21900	56.042	5122.239	4771	-351.2388	123368.7	PRIMARY.ART
7630	21900	44.807	3418.774	4521	1102.226	1214902	PRIMARY.ART
5370	21900	32.961	1770.006	1301	-469.0056	219966.3	MIN.ART
2300	21900	19.877	457.171	313	-144.171	20785.28	COLLECTOR
990	21900	8.5268	84.41532	46	-38.41532	1475.737	LOCAL
300	21900	14.92	44.76	39	-5.759999	33.17758	LOCAL
380	21900	3.627401	13.78412	11	-2.784121	7.751328	LOCAL
430	21900	6.1614	26.49402	11	-15.49402	240.0646	LOCAL
10600	21900	51.78	5488.68	3315	-2173.68	4724886	PRIMARY.ART
1410	21900	12.737	179.5917	95	-84.59172	7155.76	COLLECTOR
600	21900	7.371701	44.2302	34	-10.2302	104.657	LOCAL
8450	21900	39.966	3377.127	3632	254.8728	64960.15	PRIMARY.ART
790	21900	10.877	85.9283	44	-41.9283	1757.982	PRIMARY.ART
2580	21900	20.7468	535.2675	310	-225.2675	50745.43	COLLECTOR
480	21900	10.99	52.752	29	-23.752	564.1575	LOCAL
1020	21900	43.45301	443.2206	46	-397.2206	157784.2	LOCAL
270	21900	4.0126	10.83402	30	19.16598	367.3349	LOCAL
11170	21900	55.278	6174.553	4819	-1355.553	1837523	PRIMARY.ART
1540	21900	12.68	195.272	171	-24.272	589.1301	COLLECTOR
400	21900	3.672501	14.69	27	12.31	151.536	LOCAL
660	21900	8.818201	58.20013	65	6.799874	46.23828	LOCAL
1880	21900	13.2083	248.3161	297	48.68396	2370.128	COLLECTOR
320	21900	16.172	51.7504	27	-24.7504	612.5823	LOCAL

THE ROOT MEAN SQUARE IS 605.4247

THROUGH TRIP END ESTIMATION FOR DUNN N.C. (KENTUCKY MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
3470	17300	24.521	850.8787	847	-3.878662	15.04402	COLLECTOR
500	17300	21.124	105.62	36	-69.62	4846.945	LOCAL
1130	17300	14.521	164.0873	82	-82.08731	6738.327	COLLECTOR
520	17300	15.522	80.7144	52	-28.7144	824.5169	LOCAL
920	17300	24.917	229.2364	85	-144.2364	20804.14	COLLECTOR
430	17300	17.7105	76.15515	51	-25.15515	632.7816	LOCAL
3380	17300	25.294	854.9372	513	-341.9372	116921.1	COLLECTOR
280	17300	12.0157	33.64397	28	-5.643967	31.85436	LOCAL
14940	17300	79.344	11853.99	14381	2527.006	6385759	PRIMARY.ART
1390	17300	14.9732	208.1275	117	-91.1275	8304.222	COLLECTOR
2660	17300	24.8475	660.9435	433	-227.9435	51958.23	COLLECTOR
4250	17300	43.847	1863.498	2055	191.5024	36673.18	MIN.ART
1920	17300	18.679	358.6368	228	-130.6368	17065.97	COLLECTOR
470	17300	14.329	67.34631	40	-27.34631	747.8205	LOCAL
15210	17300	79.26	12055.45	14128	2072.554	4295479	PRIMARY.ART
2050	17300	19.963	409.2415	224	-185.2415	34314.42	COLLECTOR
630	17300	13.915	87.66451	26	-61.66451	3802.511	LOCAL
530	17300	15.6265	82.82045	144	61.17955	3742.937	LOCAL
4680	17300	34.707	1624.288	839	-785.2876	616676.6	MIN.ART
410	17300	9.455501	38.76755	39	.2324486	5.403234E-02	LOCAL
4700	17300	43.707	2054.229	1796	-258.229	66682.22	PRIMARY.ART

THE ROOT MEAN SQUARE IS 745.527

THROUGH TRIP END ESTIMATION FOR CANTON N.C. (KENTUCKY MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
90	10000	20.534	18.4806	26	7.5194	56.54137	LOCAL
950	10000	19.24	182.78	214	31.22	974.6885	LOCAL
1160	10000	20.3319	235.85	225	-10.85004	117.7233	COLLECTOR
18000	10000	91.399	16451.82	17548	1096.18	1201610	PRIMARY.ART
7100	10000	40.968	2908.728	4118	1209.272	1462339	MIN.ART
950	10000	22.071	209.6745	155	-54.67452	2989.303	LOCAL
3150	10000	26.436	832.7341	1120	287.2659	82521.71	COLLECTOR
1650	10000	22.83	376.695	427	50.305	2530.592	COLLECTOR
8130	10000	42.866	3485.006	3922	436.9942	190963.9	MIN.ART
1250	10000	19.991	249.8875	94	-155.8875	24300.92	COLLECTOR
240	10000	14.13	33.912	16	-17.912	320.8399	LOCAL
18000	10000	91.101	16398.18	17379	980.8203	962008.5	PRIMARY.ART

THE ROOT MEAN SQUARE IS 572.3296

THROUGH TRIP END ESTIMATION FOR HICKORY N.C. (KENTUCKY MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
28190	50500	91.086	25677.14	13562	-12115.14	1.467767E+08	PRIMARY.ART
3890	50500	.5	19.45	436	416.55	173513.9	COLLECTOR
470	50500	.5	2.35	70	67.65	4576.523	LOCAL
4570	50500	10.1089	461.9768	635	173.0232	29937.03	COLLECTOR
620	50500	.5	3.1	40	36.9	1361.61	LOCAL
860	50500	.5	4.3	45	40.7	1656.49	LOCAL
430	50500	.5	2.15	24	21.85	477.4225	LOCAL
4150	50500	6.450001	267.6751	321	53.32495	2843.55	COLLECTOR
2060	50500	.5	10.3	156	145.7	21228.49	COLLECTOR
1410	50500	.5	7.05	194	186.95	34950.3	COLLECTOR
850	50500	.5	4.25	151	146.75	21535.56	LOCAL
2070	50500	.5	10.35	134	123.65	15289.32	COLLECTOR
380	50500	.5	1.9	28	26.1	681.21	LOCAL
17500	50500	61.4298	10750.22	9494	-1256.215	1578076	PRIMARY.ART
4520	50500	3.686003	166.6073	509	342.3927	117232.7	COLLECTOR
1200	50500	.5	6	55	49	2401	COLLECTOR
1150	50500	.5	5.75	56	50.25	2525.063	COLLECTOR
1050	50500	.5	5.25	42	36.75	1350.563	COLLECTOR
1670	50500	.5	8.350001	103	94.65	8958.623	COLLECTOR
16230	50500	45.0144	7305.838	4324	-2981.838	8891354	PRIMARY.ART
770	50500	.5	3.85	61	57.15	3266.123	LOCAL
340	50500	.5	1.7	24	22.3	497.29	LOCAL
450	50500	.5	2.25	17	14.75	217.5625	LOCAL
4780	50500	5.121601	244.8125	731	486.1875	236378.3	MIN.ART
1340	50500	.5	6.7	132	125.3	15700.09	LOCAL
1010	50500	.5	5.05	157	151.95	23088.8	COLLECTOR
6040	50500	8.812202	532.257	441	-91.25702	8327.844	MIN.ART
370	50500	.5	1.85	25	23.15	535.9225	LOCAL
2760	50500	.5	13.8	196	182.2	33196.84	COLLECTOR
2180	50500	.5	10.9	275	264.1	69748.81	COLLECTOR

THE ROOT MEAN SQUARE IS 2295.485

THROUGH TRIP END ESTIMATION FOR AHOSKIE N.C. (KENTUCKY MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
3770	6500	38.047	1434.372	1439	4.628174	21.41999	MIN.ART
170	6500	14.731	25.0427	18	-7.0427	49.59962	LOCAL
1040	6500	17.7135	184.2204	85	-99.22041	9844.691	COLLECTOR
1060	6500	18.593	197.0858	136	-61.0858	3731.475	COLLECTOR
3990	6500	35.578	1419.562	1304	-115.5624	13354.66	MIN.ART
1090	6500	18.534	202.0206	86	-116.0206	13460.78	COLLECTOR
2690	6500	26.4779	712.2556	428	-284.2556	80801.22	COLLECTOR
2380	6500	22.2103	528.6052	286	-242.6052	58857.27	COLLECTOR

THE ROOT MEAN SQUARE IS 150.0505

THROUGH TRIP END ESTIMATION FOR FARMVILLE N.C.(KENTUCKY MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
1550	6600	25.804	399.962	190	-209.962	44084.06	COLLECTOR
2200	6600	30.287	666.3141	378	-288.3141	83125.02	COLLECTOR
1560	6600	25.685	400.686	167	-233.686	54609.15	COLLECTOR
4380	6600	50.237	2200.381	3147	946.6194	896088.2	MIN.ART
3130	6600	36.653	1147.239	746	-401.2389	160992.6	COLLECTOR
5320	6600	53.057	2822.633	3232	409.3674	167581.7	MIN.ART
2360	6600	41.346	975.7656	890	-85.76562	7355.742	MIN.ART

THE ROOT MEAN SQUARE IS 449.4181

THROUGH TRIP END ESTIMATION FOR MONROE N.C.(KENTUCKY MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
16110	15900	80.61561	12987.18	11666	-1321.175	1745503	PRIMARY.ART
1340	15900	18.217	244.1078	130	-114.1078	13020.59	COLLECTOR
5720	15900	40.0735	2292.204	1550	-742.2041	550867	MIN.ART
2620	15900	23.696	620.8352	297	-323.8352	104869.2	COLLECTOR
620	15900	37.21501	230.733	87	-143.733	20659.18	LOCAL
1120	15900	15.62	174.944	94	-80.944	6551.931	COLLECTOR
14270	15900	71.75801	10239.87	8500	-1739.867	3027138	PRIMARY.ART
300	15900	9.286001	27.858	36	8.141996	66.29211	LOCAL
770	15900	15.464	119.0728	133	13.9272	193.9669	LOCAL
750	15900	14.361	107.7075	136	28.29248	800.4645	LOCAL
6000	15900	47.693	2861.58	4160	1298.42	1685894	MIN.ART
450	15900	12.716	57.22201	78	20.77799	431.725	LOCAL
2490	15900	18.5529	461.9673	419	-42.96726	1846.185	COLLECTOR
1450	15900	14.673	212.7585	165	-47.75852	2280.876	COLLECTOR
4170	15900	27.9884	1167.116	748	-419.1163	175658.5	COLLECTOR
2860	15900	22.33	638.638	406	-232.638	54120.44	COLLECTOR
590	15900	15.6392	92.27129	118	25.72872	661.9668	LOCAL
1240	15900	16.427	203.6948	131	-72.69483	5284.538	COLLECTOR
850	15900	16.2255	137.9168	41	-96.91676	9392.859	LOCAL
3270	15900	25.6758	839.5988	323	-516.5988	266874.3	COLLECTOR

THE ROOT MEAN SQUARE IS 619.3591

THROUGH TRIP END ESTIMATION FOR ELIZABETH CITY N.C.(KENTUCKY MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
6660	6600	49.62701	3305.159	2113	-1192.159	1421242	PRIMARY.ART
8320	6600	44.773	3725.114	1333	-2392.114	5722207	MIN.ART
300	6600	19.223	57.669	19	-38.669	1495.292	LOCAL
2760	6600	34.1275	941.9191	749	-192.9191	37217.77	COLLECTOR
630	6600	27.067	170.5221	27	-143.5221	20598.6	LOCAL
1570	6600	31.079	487.9404	80	-407.9404	166415.3	COLLECTOR
1290	6600	21.597	278.6013	83	-195.6013	38259.88	COLLECTOR
270	6600	18.0751	48.80277	5	-43.80277	1918.683	LOCAL
7300	6600	49.908	3643.284	2094	-1549.284	2400282	PRIMARY.ART
690	6600	21.436	147.9084	83	-64.9084	4213.101	LOCAL

THE ROOT MEAN SQUARE IS 990.6487

THROUGH TRIP END ESTIMATION FOR MOUNT AIRY N.C. (KENTUCKY MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
8700	22900	60.13101	5231.398	4428	-803.3975	645447.5	PRIMARY.ART
340	22900	11.211	38.11741	31	-7.117409	50.65751	LOCAL
1300	22900	12.005	156.065	94	-62.065	3852.065	COLLECTOR
570	22900	14.136	80.57521	46	-34.57521	1195.445	LOCAL
1110	22900	14.117	156.6987	184	27.30129	745.3602	COLLECTOR
370	22900	9.811002	36.30071	21	-15.30071	234.1116	LOCAL
1780	22900	19.852	353.3656	191	-162.3656	26362.6	COLLECTOR
1980	22900	16.131	319.3939	233	-86.39386	7463.899	COLLECTOR
9010	22900	60.01801	5407.623	4905	-502.6226	252629.5	PRIMARY.ART
1100	22900	14.236	156.596	55	-101.596	10321.75	COLLECTOR
470	22900	13.2698	62.36807	82	19.63194	385.4129	COLLECTOR
2070	22900	15.2388	315.4432	133	-182.4432	33285.52	COLLECTOR
1220	22900	11.765	143.533	76	-67.53302	4560.709	COLLECTOR
420	22900	14.431	60.61021	49	-11.61021	134.7969	COLLECTOR
7620	22900	40.501	3086.176	1539	-1547.176	2393755	MIN.ART
560	22900	12.467	69.81521	42	-27.81521	773.6858	COLLECTOR
6290	22900	35.7958	2251.556	940	-1311.556	1720179	MIN.ART
620	22900	11.455	71.02101	66	-5.021004	25.21048	COLLECTOR
1190	22900	11.228	133.6132	115	-18.61322	346.452	COLLECTOR

THE ROOT MEAN SQUARE IS 518.1825

THROUGH TRIP END ESTIMATION FOR TARBORO N.C.(KENTUCKY MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
3950	13500	30.409	1201.156	529	-672.1555	451793.1	MIN.ART
2220	13500	27.5136	610.8019	574	-36.80188	1354.378	MIN.ART
1480	13500	19.9594	295.3991	201	-94.39911	8911.191	COLLECTOR
3660	13500	35.6629	1305.262	1612	306.7379	94088.15	MIN.ART
1190	13500	19.447	231.4193	103	-128.4193	16491.52	COLLECTOR
2720	13500	31.487	856.4464	553	-303.4464	92079.72	MIN.ART
3540	13500	35.139	1243.921	232	-1011.921	1023983	COLLECTOR
1460	13500	18.767	273.9982	107	-166.9982	27888.41	COLLECTOR
5800	13500	41.472	2405.376	1577	-828.376	686206.8	MIN.ART

THE ROOT MEAN SQUARE IS 516.6986

THROUGH TRIP END ESTIMATION FOR MORGANTON N.C.(KENTUCKY MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
5290	16500	33.9978	1798.484	1455	-343.4838	117981.1	MIN.ART
1020	16500	13.3206	135.8701	82	-53.87013	2901.991	COLLECTOR
8150	16500	38.0631	3102.143	1115	-1987.143	3948737	MIN.ART
450	16500	12.8473	57.81286	43	-14.81286	219.4207	LOCAL
12400	16500	66.026	8187.224	8179	-8.223633	67.62814	PRIMARY.ART
700	16500	11.8093	82.66511	106	23.33489	544.5172	LOCAL
2500	16500	24.5252	613.13	598	-15.13001	228.9171	COLLECTOR
750	16500	11.706	87.79501	92	4.204987	17.68191	LOCAL
980	16500	13.6774	134.0385	131	-3.038529	9.232654	LOCAL
1400	16500	18.9157	264.8198	206	-58.8198	3459.768	COLLECTOR
3330	16500	30.323	1009.756	728	-281.7559	79386.4	MIN.ART
450	16500	9.614001	43.26301	64	20.73699	430.0229	LOCAL
1750	16500	16.6579	291.5133	191	-100.5133	10102.92	COLLECTOR
10000	16500	60.614	6061.4	7649	1587.6	2520474	PRIMARY.ART
4600	16500	27.726	1275.396	627	-648.3961	420417.6	COLLECTOR
570	16500	15.1592	86.40744	118	31.59256	998.0899	LOCAL
4000	16500	24.2125	968.5001	915	-53.50006	2862.257	COLLECTOR
210	16500	12.917	27.12571	35	7.874296	62.00454	LOCAL

THE ROOT MEAN SQUARE IS 628.4416

THROUGH TRIP END ESTIMATION FOR BOONE N.C. (KENTUCKY MODEL)

ADT	POP	%THROUGH TRIP ENDS (MODEL)	THROUGH TRIP ENDS (MODEL)	ACTUAL TRIP ENDS (O&D)	DIFF	DIFF.SQR	
7680	16000	42.7843	3285.834	3350	64.16602	4117.277	PRIMARY.ART
6270	16000	33.59409	2106.349	1590	-516.3494	266616.7	MIN.ART
7690	16000	43.11379	3315.45	2982	-333.4502	111189	PRIMARY.ART
7580	16000	38.36594	2908.138	2651	-257.1382	66120.05	PRIMARY.ART
12220	16000	51.2638	6264.436	4235	-2029.436	4118611	PRIMARY.ART
1220	16000	18.31595	223.4546	230	6.54541	42.84239	LOCAL
1500	16000	16.988	254.82	272	17.18002	295.1532	COLLECTOR
880	16000	14.28764	125.7312	140	14.26876	203.5975	LOCAL

THE ROOT MEAN SQUARE IS 755.5789

APPENDIX 4

THROUGH TRIP DISTRIBUTION FOR AHOSKIE N.C. (NC 1 MODEL)

	1	2	3	4	5	6	7	8
1	0							
	0							
2	4.655111	0						
	0	0						
3	34.56613	.3754658	0					
	20	6	0					
4	21.4589	5.825077	16.88376	0				
	33	7	2	0				
5	1680.86	5.616876	41.69948	27.78351	0			
	1031	0	17	19	0			
6	38.10343	.5850343	7.43486	17.86683	45.96579	0		
	35	1	11	4	16	0		
7	63.60135	18.77114	60.95363	77.36068	82.31792	64.9775	0	
	270	3	11	27	88	2	0	
8	139.6887	5.071283	52.55961	69.54575	174.8322	57.15263	189.7409	0
	50	0	17	45	133	16	26	0
TOTAL	1982.934	40.89998	214.4729	236.7245	2059.076	232.0861	557.7231	688.5911

ROOT MEAN SQUARE IS 135.8625

WITHIN EACH BLOCK THE PREDICTED VALUES ARE AT THE TOP AND
THE ACTUAL VALUES ARE IN THE BOTTOM

THROUGH TRIP DISTRIBUTION FOR BOONE N.C. (NC 1 MODEL)

	1	2	3	4	5	6	7	8
1	0							
	0							
2	105.8901	0						
	331	0						
3	726.9768	104.3138	0					
	933	342	0					
4	709.5378	106.8854	678.9696	0				
	854	279	368	0				
5	1631.009	284.9583	1563.303	1517.428	0			
	1151	545	1250	1061	0			
6	18.54004	24.27563	18.046	17.82311	48.08269	0		
	21	33	33	36	82	0		
7	16.69996	47.39044	16.67995	16.33321	41.17241	4.799246	0	
	27	32	33	43	113	21	0	
8	10.61879	30.68339	10.60604	10.38576	26.18655	2.6321	4.554842	0
	33	28	25	13	34	4	3	0
TOTAL	3219.272	704.3971	3118.895	3057.363	5112.139	134.1988	147.63	95.66745

ROOT MEAN SQUARE IS 180.341

WITHIN EACH BLOCK THE PREDICTED VALUES ARE AT THE TOP AND
THE ACTUAL VALUES ARE IN THE BOTTOM

THROUGH TRIP DISTRIBUTION FOR ELIZABETH CITY N.C.(NC 1 MODEL)

	1	2	3	4	5	6	7	8	9	10
1	0									
	0									
2	764.945	0								
	444	0								
3	2.136558	14.0659	0							
	5	9	0							
4	119.7845	230.8295	2.949512	0						
	315	220	4	0						
5	34.38925	25.31551	.2540529	2.755363	0					
	9	8	0	3	0					
6	70.91719	98.56924	1.14457	10.66342	1.124672	0				
	52	16	0	4	0	0				
7	16.50868	141.7396	1.439338	16.49022	1.324356	6.811261	0			
	25	21	0	30	1	1	0			
8	1.867028	3.308852	.1519766	2.736562	.2163406	1.056333	1.338595	0		
	3	2	0	1	0	0	0	0		
9	2238.178	888.7921	2.513802	137.8642	38.91264	80.94034	20.03245	2.194016	0	
	1254	609	1	155	8	7	3	0	0	
10	6.335454	66.62082	.6246921	8.758558	.6179451	3.478962	5.173719	.5771055	7.687499	0
	5	3	0	17	0	1	0	2	57	0
TOTAL	3255.062	2234.187	25.2804	532.8318	104.9101	274.706	210.8582	13.44681	3417.116	99.8

ROOT MEAN SQUARE IS 164.9781

WITHIN EACH BLOCK THE PREDICTED VALUES ARE AT THE TOP AND
THE ACTUAL VALUES ARE IN THE BOTTOM

THROUGH TRIP DISTRIBUTION FOR FARMVILLE N.C. (NC1 MODEL)

	1	2	3	4	5	6	7
1	0						
	0						
2	34.58836	0					
	46	0					
3	23.99476	39.50823	0				
	21	10	0				
4	30.13092	94.8806	35.40838	0			
	25	3	4	0			
5	37.80586	63.1061	43.24346	205.5122	0		
	55	32	5	99	0		
6	57.67185	182.8803	67.72601	1729.891	388.5042	0	
	15	126	37	2906	101	0	
7	25.95419	45.42599	29.92238	164.0123	166.1603	311.382	0
	27	163	88	111	454	48	0
TOTAL	210.1459	460.3896	239.8033	2259.835	904.3321	2738.055	742.8572

ROOT MEAN SQUARE IS 281.8863

WITHIN EACH BLOCK THE PREDICTED VALUES ARE AT THE TOP AND
THE ACTUAL VALUES ARE IN THE BOTTOM

THROUGH TRIP DISTRIBUTION FOR TARBORO N.C. (NC 1 MODEL)

	1	2	3	4	5	6	7	8	9
1	0								
	0								
2	55.09244	0							
	32	0							
3	51.38452	18.77151	0						
	34	10	0						
4	65.2122	66.40973	12.09139	0					
	122	60	32	0					
5	35.68078	12.50209	12.31291	9.467068	0				
	20	15	1	5	0				
6	75.00166	86.8853	25.05315	89.24105	16.5053	0			
	139	233	11	32	13	0			
7	112.1746	46.01016	42.89052	72.38683	29.83775	62.51808	0		
	56	49	17	35	2	7	0		
8	53.12138	19.23201	18.71397	10.09099	12.69032	25.63122	44.35173	0	
	22	14	2	34	4	4	14	0	
9	274.6096	278.0621	49.09226	1346.788	39.3495	371.6225	310.4435	39.93822	0
	104	162	97	1295	44	114	52	12	0
TOTAL	722.2772	582.9653	230.3103	1671.687	168.3457	752.4581	720.6131	223.7698	2709.905

ROOT MEAN SQUARE IS 79.55213

WITHIN EACH BLOCK THE PREDICTED VALUES ARE AT THE TOP AND
THE ACTUAL VALUES ARE IN THE BOTTOM

THROUGH TRIP DISTRIBUTION FOR AHOSKIE N.C. (NC 2 MODEL)

	1	2	3	4	5	6	7	8
1	0							
	0							
2	6.385766	0						
	0	0						
3	39.86018	2.285059	0					
	20	6	0					
4	90.88243	.5025515	3.945528	0				
	33	7	2	0				
5	589.1798	5.921984	40.21368	21.59098	0			
	1031	0	17	19	0			
6	56.35012	.6917161	2.93473	1.234185	64.87929	0		
	35	1	11	4	16	0		
7	229.0144	1.777915	18.48122	8.944074	240.1669	5.801916	0	
	270	3	11	27	88	2	0	
8	151.033	2.62881	13.76201	5.898454	167.4167	4.107353	27.3523	0
	50	0	17	45	133	16	26	0
TOTAL	1162.706	20.1938	121.4824	132.9982	1129.369	135.9993	531.5386	372.1987

ROOT MEAN SQUARE IS 92.74837

WITHIN EACH BLOCK THE PREDICTED VALUES ARE AT THE TOP AND
THE ACTUAL VALUES ARE IN THE BOTTOM

THROUGH TRIP DISTRIBUTION FOR BOONE N.C. (NC 2 MODEL)

	1	2	3	4	5	6	7	8	
1	0								
	0								
2	440.2101	0							
	331	0							
3	541.3471	301.5173	0						
	933	342	0						
4	451.2415	244.7607	514.8471	0					
	854	279	368	0					
5	1374.677	824.2706	1536.833	1304.733	0				
	1151	545	1250	1061	0				
6	6.766177	9.534302	7.486721	6.593477	162.9294	0			
	21	33	33	36	82	0			
7	36.80658	9.064106	6.905267	5.979673	157.6964	.185925	0		
	27	32	33	43	113	21	0		
8	15.28147	2.485967	20.03048	.6841376	66.93665	4.477097E-02		5.206521E-02	0
	33	28	25	13	34	4	3	0	
TOTAL	2866.329	1831.843	2928.967	2528.84	5428.075	193.5408	216.69	105.5155	

ROOT MEAN SQUARE IS 150.9239

WITHIN EACH BLOCK THE PREDICTED VALUES ARE AT THE TOP AND
THE ACTUAL VALUES ARE IN THE BOTTOM

THROUGH TRIP DISTRIBUTION FOR ELIZABETH CITY N.C
. (NC 2 MODEL)

	1	2	3	4	5	6	7	8	9	10	
1	0										
	0										
2	994.9688	0									
	444	0									
3	10.49884	11.90257	0								
	5	9	0								
4	240.9558	245.0861	5.944458	0							
	315	220	4	0							
5	43.13297	27.85174	.3354867	12.13843	0						
	9	8	0	3	0						
6	214.0019	68.39534	1.645081	21.99268	3.356363	0					
	52	16	0	4	0	0					
7	70.17616	109.5136	.3894293	4.397128	.7950484	1.429803	0				
	25	21	0	30	1	1	0				
8 0	12.42009	20.48917	7.655664E-03		.2168748	1.436079E-02		5.999812E-02		1.443265E-02	
	3	2	0	1	0	0	0	0			
9	1158.433	1446.127	9.661579	222.9668	45.48679	77.84826	12.89423	.1754122	0		
	1254	609	1	155	8	7	3	0	0		
10	4.927448	56.88829	.1149064	1.713607	.2346136	.5364211	.1079919	4.254687E-03		42.76746	0
	5	3	0	17	0	1	0	2	57	0	
TOTAL	2749.515	2981.222	40.5	755.4119	133.3458	389.2658	199.7178	33.40224	3016.36	107.295	

ROOT MEAN SQUARE IS 154.8415

WITHIN EACH BLOCK THE PREDICTED VALUES ARE AT THE TOP AND
THE ACTUAL VALUES ARE IN THE BOTTOM

THROUGH TRIP DISTRIBUTION FOR FARMVILLE N.C. (NC 2 MODEL)

	1	2	3	4	5	6	7
1	0						
	0						
2	25.76963	0					
	46	0					
3	14.57638	25.77232	0				
	21	10	0				
4	76.35411	138.9343	76.28905	0			
	25	3	4	0			
5	29.58274	52.8049	29.76131	308.0014	0		
	55	32	5	99	0		
6	133.2755	238.2389	133.0516	1055.192	421.7918	0	
	15	126	37	2906	101	0	
7	23.65258	41.37599	23.81335	217.9419	88.85727	423.0902	0
	27	163	88	111	454	48	0
TOTAL	303.211	522.896	303.264	1872.713	930.7993	2404.64	818.7313

ROOT MEAN SQUARE IS 433.2054

WITHIN EACH BLOCK THE PREDICTED VALUES ARE AT THE TOP AND
THE ACTUAL VALUES ARE IN THE BOTTOM

THROUGH TRIP DISTRIBUTION FOR TARBORO N.C. (NC 2 MODEL)

	1	2	3	4	5	6	7	8	9
1	0								
	0								
2	66.3182	0							
	32	0							
3	40.60127	29.32758	0						
	34	10	0						
4	143.8507	59.85849	24.17467	0					
	122	60	32	0					
5	25.5266	19.86061	4.919944	53.2884	0				
	20	15	1	5	0				
6	95.13558	39.89735	16.95025	115.655	9.726306	0			
	139	233	11	32	13	0			
7	179.6938	85.36171	39.10027	208.2818	24.56762	85.63775	0		
	56	49	17	35	2	7	0		
8	25.14838	19.46745	4.951728	50.65406	3.050322	46.43916	24.22218	0	
	22	14	2	34	4	4	14	0	
9	446.1038	205.2539	83.31295	486.5886	49.9719	336.4099	441.2249	48.93572	0
	104	162	97	1295	44	114	52	12	0
TOTAL	1022.378	525.3452	243.3387	1142.352	190.9117	745.8513	1088.09	222.869	2097.802

ROOT MEAN SQUARE IS 173.3525

WITHIN EACH BLOCK THE PREDICTED VALUES ARE AT THE TOP AND
THE ACTUAL VALUES ARE IN THE BOTTOM

THROUGH TRIP DISTRIBUTION FOR ASHOKIE N.C.(KY MODEL)

	1	2	3	4	5	6	7	8
1	0							
	0							
2	13.33164	0						
	0	0						
3	72.02527	.4449576	0					
	20	6	0					
4	76.68061	.4985742	4.02566	0				
	33	7	2	0				
5	694.3807	12.88483	70.15758	74.74906	0			
	1031	0	17	19	0			
6	78.62719	.5157044	4.137882	4.548889	76.6575	0		
	35	1	11	4	16	0		
7	290.0809	3.093948	20.06966	21.9512	285.4459	22.51707	0	
	270	3	11	27	88	2	0	
8	209.2455	1.968546	13.35941	14.6318	205.2867	15.01636	69.09682	0
	50	0	17	45	133	16	26	0
TOTAL	1434.372	32.7382	184.2204	197.0858	1419.562	202.0206	712.2556	528.6052

ROOT MEAN SQUARE IS 85.19121

WITHIN EACH BLOCK THE PREDICTED VALUES ARE AT THE TOP AND
THE ACTUAL VALUES ARE IN THE BOTTOM

THROUGH TRIP DISTRIBUTION FOR BOONE N.C.(KY MODEL)

	1	2	3	4	5	6	7	8
1	0							
	0							
2	341.6095	0						
	331	0						
3	596.8819	347.7509	0					
	933	342	0					
4	506.6229	307.081	518.7024	0				
	854	279	368	0				
5	1733.087	993.8302	1773.422	1509.794	0			
	1151	545	1250	1061	0			
6	28.7307	35.17526	29.5145	24.40136	101.7315	0		
	21	33	33	36	82	0		
7	33.9789	48.93288	34.77015	29.61911	102.4975	2.793554	0	
	27	32	33	43	113	21	0	
8	14.02697	31.96964	14.40819	11.91732	50.0734	1.107777	2.227941	0
	33	28	25	13	34	4	3	0
TOTAL	3254.938	2106.349	3315.45	2908.138	6264.436	223.4546	254.82	125.7312

ROOT MEAN SQUARE IS 213.4134

WITHIN EACH BLOCK THE PREDICTED VALUES ARE AT THE TOP AND
THE ACTUAL VALUES ARE IN THE BOTTOM

THROUGH TRIP DISTRIBUTION FOR ELIZABETH CITY N. C.(KY MODEL)

	1	2	3	4	5	6	7	8	9	10
1	0									
	0									
2	1346.982	0								
	444	0								
3	9.506039	29.72748	0							
	5	9	0							
4	253.1737	314.3749	4.012006	0						
	315	220	4	0						
5	40.95468	62.46305	.2937893	10.24046	0					
	9	8	0	3	0					
6	125.4002	163.3693	1.693165	30.91856	4.484817	0				
	52	16	0	4	0	0				
7	56.58858	122.7317	.8121287	18.21267	2.174234	8.713579	0			
	25	21	0	30	1	1	0			
8	7.217958	26.83328	5.902886E-02		3.481546	.2447505	1.463879	.7013812	0	
	3	2	0	1	0	0	0	0		
9	1436.412	1590.697	11.31559	298.286	48.84448	147.8633	66.7122	8.592132	0	
	1254	609	1	155	8	7	3	0	0	
10	28.92326	67.93528	.2497783	9.219258	.8218563	4.033524	1.954852	.208816	34.56178	0
	5	3	0	17	0	1	0	2	57	0
TOTAL	3305.159	3725.113	57.669	941.9191	170.5221	487.9404	278.6013	48.80277	3643.284	147.9084

ROOT MEAN SQUARE IS 206.6286

WITHIN EACH BLOCK THE PREDICTED VALUES ARE AT THE TOP AND THE ACTUAL VALUES ARE IN THE BOTTOM

THROUGH TRIP DISTRIBUTION FOR FARMVILLE N.C.(KY MODEL)

	1	2	3	4	5	6	7
1	0						
	0						
2	19.1556	0					
	46	0					
3	10.1719	19.14565	0				
	21	10	0				
4	112.1148	188.3178	112.3693	0			
	25	3	4	0			
5	37.86374	69.13451	37.84186	337.8143	0		
	55	32	5	99	0		
6	181.4278	303.314	181.8468	1178.604	541.6021	0	
	15	126	37	2906	101	0	
7	39.22814	67.24655	39.31059	271.1603	122.9824	435.8377	0
	27	163	88	111	454	48	0
TOTAL	399.962	666.3141	400.686	2200.381	1147.239	2822.633	975.7656

ROOT MEAN SQUARE IS 418.0372

WITHIN EACH BLOCK THE PREDICTED VALUES ARE AT THE TOP AND
THE ACTUAL VALUES ARE IN THE BOTTOM

THROUGH TRIP DISTRIBUTION FOR TARBORO N.C.(KY MODEL)

	1	2	3	4	5	6	7	8	9
1	0								
	0								
2	86.84648	0							
	32	0							
3	39.9558	17.65488	0						
	34	10	0						
4	204.0319	96.22345	46.63508	0					
	122	60	32	0					
5	31.08399	13.6043	4.513265	36.38638	0				
	20	15	1	5	0				
6	125.4677	58.41529	27.33841	137.5339	21.20328	0			
	139	233	11	32	13	0			
7	188.8146	89.09656	38.16352	215.7357	29.80808	132.0022	0		
	56	49	17	35	2	7	0		
8	37.12049	16.32444	5.348256	43.38914	4.027479	25.35988	34.42922	0	
	22	14	2	34	4	4	14	0	
9	487.8347	232.6365	115.7899	525.3266	90.79252	329.1259	515.8707	107.9994	0
	104	162	97	1295	44	114	52	12	0
TOTAL	1201.156	610.8019	295.3991	1305.262	231.4193	856.4464	1243.921	273.9982	2405.376

ROOT MEAN SQUARE IS 178.1471

WITHIN EACH BLOCK THE PREDICTED VALUES ARE AT THE TOP AND
THE ACTUAL VALUES ARE IN THE BOTTOM

VITA

Meenakshisundaram Raja was born in Calcutta, India on September 8, 1957. He attended elementary school in that city. He graduated from Central School, Madurai, India in May 1974. The following July he entered the Indian Institute of Technology, Kharagpur. In May 1981 he received a Bachelor of Technology in Civil Engineering. In September 1981 he began working as a design engineer for Bharat Heavy Electricals Limited in Hyderabad, India. In Summer 1984 he entered The University of Tennessee and began study toward a Master's degree in Civil Engineering. In Fall 1984 he accepted a Research Assistantship from the Transportation Center at The University of Tennessee. In August 1986 he was awarded the Master of Science in Civil Engineering.

The author is a member of the Transportation Research Board, the Institute of Transportation Engineers, and Chi Epsilon.