COMPARING SHORT-TERM TRAFFIC PROJECTIONS WITH TRAFFIC COUNTS– THE JUATS 2015 MODEL

Final Report
Contract No. BD015-11

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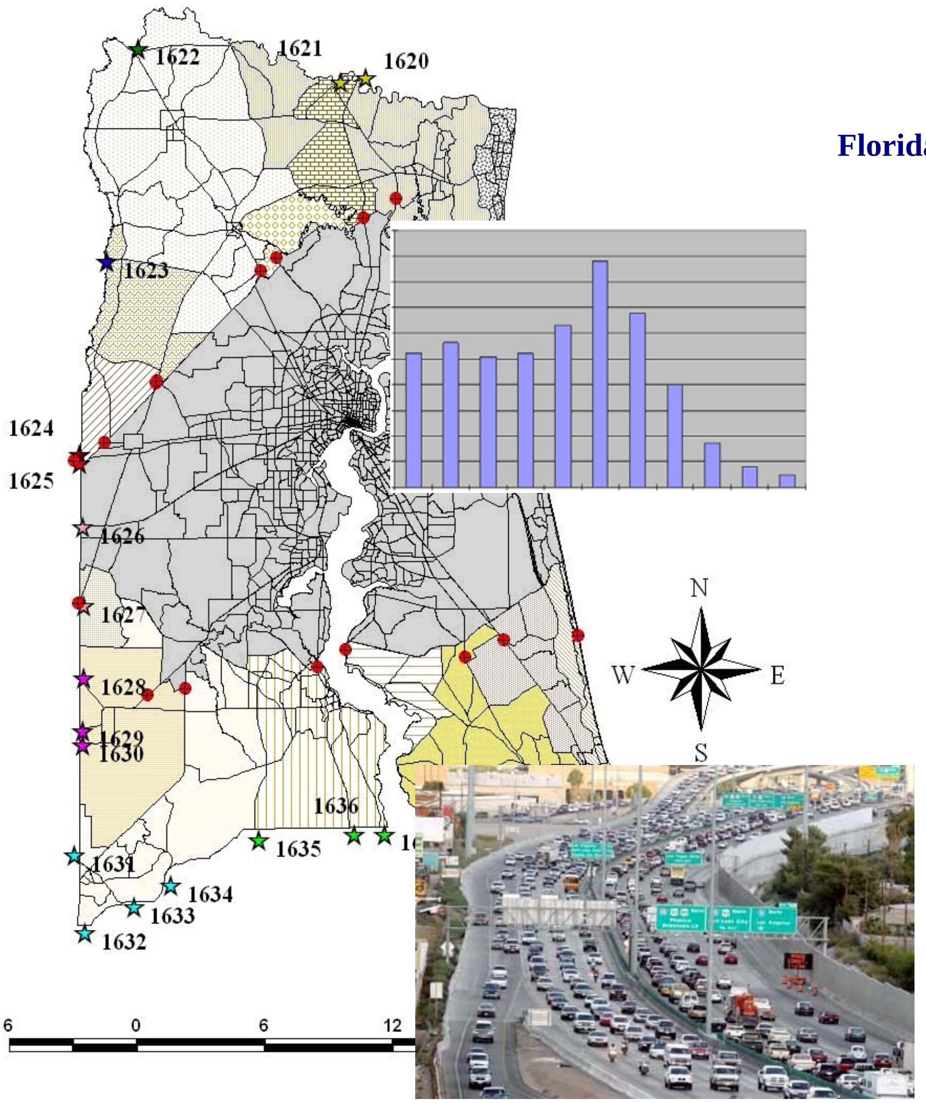

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July 2005

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FINAL REPORT

Prepared for
Florida Department of Transportation
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16. Abstract

Travel demand models are for the purpose of estimating future travel demand given changes in transportation infrastructure and socioeconomics/demographics. Given that the methodologies in a travel demand model are a controlled factor, the effect of input data on the accuracy of the traffic volumes projected for a short term horizon has not yet been thoroughly investigated. The purpose of this study is to investigate the performance of the FSUTMS four-step modeling process by examining the accuracy of short-term travel demand forecasts. The FSUTMS model developed in the Jacksonville Urban Area Transportation Study (JUATS) in 1995 is selected as the study case. Three factors, including ZDATA/EETRIP files, highway network, and two-digit coding, were investigated. The findings from this study show that the accuracy of a travel demand model in projecting traffic volumes may be improved with updated and accurate ZDATA/EETRIPS files. For However, a highway network that was updated to the projected year had a more significant effect on the model accuracy than the ZDATA/EETRIPS files. The study also found that two-digit coding of area and facility types improved the performance of the model. The three factors of ZDATA, network, and two-digit coding are not independent. In other words, they do not have a fixed effect on the model accuracy. Their effects on the model depend on their combinations. The presence of one factor enhances the effect of another. The findings from this study call for future studies to investigate other effects of parameters in travel demand models.

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ACRONYMS AND ABBREVIATIONS

(%RMSE)	Percent Root Mean Squared Error
AADT	Annual Average Daily Traffic
ADT	Average Daily Traffic
AF	Axle (correction) Factor
ASE	Automated Skyway Express
BPR	Bureau of Public Roads
CTPP	Census Transportation Planning Package
DRAM	Disaggregate Residential Allocation Model
E+C	Existing-Plus-Committed
E-E	External-External
EMPAL	Employment Allocation Model
FDOT	Florida Department of Transportation
FSUTMS	Florida Standard Urban Transportation Modeling Structure
FT	Facility Type
FTI	Florida Traffic Information
GIS	Geographical Information Systems
I-E	Internal-External
JUATS	Jacksonville Urban Area Transportation Study
LA	Los Angeles
MADT	Monthly Average Daily Traffic
MPO	Metropolitan Planning Organization
MSF	Monthly Seasonal Factors
PSWADT	Peak Season Weekday Average Daily Traffic
PTMS	Portable Traffic Monitoring Sites
RMSE	Root-Mean-Square Error
SF	Seasonal (correction) Factor
SIC	Standard Industrial Classification
SUE	Stochastic User Equilibrium
TAZ	Traffic Analysis Zone
TTMS	Telemetry Traffic Monitoring Sites
V/C	Ratios of Traffic Volume to Ground Count
VMT	Vehicle Miles Traveled

EXECUTIVE SUMMARY

The rapid pace of advancements in computer hardware and software has changed the landscape of travel demand forecasting. Geographically accurate networks, detailed employment databases, and population demographic profiles are available commercially. As a result, many users have taken advantage of these products in order to improve the accuracy of their travel demand model. However, given constraints of limited budgets, many users have wondered what product/ improvement provides the greatest return? Should the money be spent on obtaining a geographically accurate network or is it better to improve the socio-economic data? Questions like these prompted the Florida Department of Transportation to initiate a study to examine the relative effectiveness of each improvement in order to determine the best investment.

For this purpose, this study examined the TRANPLAN based model developed for the Jacksonville Urban Area Transportation Study (JUATS) in 1995. The base year of the JUATS model is 1990 and horizon year is 2015. Interim networks developed included the 2000 Existing-Plus-Committed (E+C) network, which included projected population and employment for 2000 and a proposed 2000 open-to-traffic network based on FDOT, City of Jacksonville construction schedules in 1995. The projected 2000 traffic on the 2000 E+C network was compared with traffic counts conducted by FDOT and City of Jacksonville.

Since 2000 is also a census year, the projected 2000 population demographics were also compared with census population tabulations. Additionally, two other factors, the accuracy of the 2000 highway network and the effect of two-digit coding, were also investigated to determine their relative impact on traffic volume projection accuracy.

The investigation involved the following comparisons of projected and actual traffic volumes:

1. Update the projected population and employment data with 2000 Census population and InfoUSA employment database to determine the impact of accurate demographic data on traffic projections.
2. Update the projected 2000 highway network to actual 2000 highway network to determine the impact of accurate highway network on traffic projections.
3. Update the projected network to 2000 and replace the one-digit facility codes of the network links with two-digit codes and determine whether two-digit coding scheme helps improve the model accuracy.
4. Combine all the updates above and determine the combined effects of all three factors on model accuracy.

The study results may be summarized as follows:

1. The socioeconomic and demographic statistics of the study area such as number of residents/employment for a given TAZ were underestimated and that the accuracy of the E+C model in projecting traffic volumes was improved with updated ZDATA/EETRIPS files that more accurately reflect the changes in the population and employment between 1990 and 2000. The %RMSE statistic for the E+C model was reduced from 0.2896 to 0.2833.
2. Not all committed highway improvements projected in 1995 were constructed as scheduled. After the highway network was updated, the %RMSE statistic calculated

from the observed and counted traffic volumes was reduced to 0.2610 without any modification to the original ZDATA/EETRIP files. This means that the updated highway network had a more significant effect on the model accuracy than the ZDATA/EETRIPS files.

3. The two-digit coding scheme improved the performance of the E+C model by producing smaller %RMSE values that the model with one-digit coding.
4. The three factors of ZDATA, network, and two-digit coding are not independent. In other words, they do not have a fixed effect on the model accuracy. Their effects on the model depend on their combinations and the presence of one factor enhances the effect of another. The results from this particular study suggest that correct network is most important. The benefit of updated ZDATA cannot be realized until network is updated. Therefore, special attention is needed to ensure the quality of network coding.

This research has identified network coding to be a key to the accuracy of the JUATS model because it increases the benefits of accurate ZDATA and quantified the improvements from having more accurate network and ZDATA. These results will help transportation modelers prioritize their efforts during model development, especially when resources are limited.

The 1990 JUATS model significantly underestimated the traffic volumes on freeway links. One major enhancement to the later versions of FSUTMS has been to allow the UROAD factor and the parameters for the BRP formula to be varied by facility type, which may have a significant effect on the assignment results. Other enhancements to FSUTMS may also help improve model performance in predicting future traffic flows. However, the effect of these enhancements in FSUTMS on the projected traffic flows is not investigated in this study. While progress has been made in our understanding of the effect of ZDATA and highway network on the accuracy of short term traffic projection, the findings from this study call for future studies to investigate other effects of parameters specified in a given travel demand models.

1. INTRODUCTION

Travel demand models are for the purpose of estimating future travel demand given changes in transportation infrastructure and socioeconomics/demographics. The Florida Standard Urban Transportation Modeling Structure (FSUTMS) is the modeling structure used by the Metropolitan Planning Organizations (MPOs) in Florida for projecting system traffic. The modeling process in FSUTMS is a four-step process, which includes trip generation, trip distribution, mode split, and trip assignment. The results or estimates from one step are inputs to subsequent steps. In the current practice, the model is first calibrated to replicate the traffic conditions in the base year for a given urban area. With projected changes in socioeconomic/demographic and network attributes in a future year, the calibrated model parameters are used to forecast the future travel demand.

With the aid of advanced computer technology, the landscape of travel demand forecasting has been changing. Detailed georeferenced socioeconomic and demographic data including parcel level data, household surveys, and transit surveys are now commonly incorporated in the process of travel demand forecast model development. As geographic information systems (GIS) become a mainstream technology in transportation demand modeling, a highway/transit network developed in a previous model validation effort may now be updated to a different year with limited time and resource available. With increasingly improved data quality and adoption of more sophisticated technology, modelers are pondering the most effective and efficient ways to improve model accuracy. What is the relative importance of the various approaches? Which give the best return of investment in model improvement? Are improvements in data collection strategies more important than geographically rectifying the network? In order to answer these questions, it is important to isolate each variable and determine what improvements result form correcting errors in each variable.

Zonal attributes that are closely associated with travel demand and the transportation network that reflects the travel supply are long recognized as the major factors contributing to the performance of a travel demand model. The methodologies implemented to develop a travel demand model also play an important role in model performance. Given that the methodologies are a controlled factor, the effect of input data on the accuracy of the traffic volumes projected for a short term horizon by a travel demand model has not yet been thoroughly investigated.

The purpose of this study is to investigate the performance of the FSUTMS four-step modeling process by examining the accuracy of short-term travel demand forecasts. The FSUTMS model developed in the Jacksonville Urban Area Transportation Study (JUATS) in 1995 is selected as a study case. The base year of the JUATS model is 1990. The end results of the 1995 JUATS model validation effort are the 1990 validated network, 2000 Existing-Plus-Committed (E+C) network, and 2015 Cost Feasible Plan. The 2000 E+C network and the projected year 2000 population and employment are used in this study to evaluate the performance of the travel demand model in estimating the traffic flows by comparing the projected traffic with that reported in the 2000 Florida Traffic Information (FTI) CD. Three factors, including ZDATA/EETRIP files, highway network, and two-digit coding, that may impact the accuracy of the traffic volume projection from the 2000 E+C JUATS model were investigated.

This report consists of ten chapters. A literature review is provided in Chapter 2, followed by a description of the procedure applied in this study to perform comparisons between the observed and estimated traffic flows in year 2000 in Chapter 3. Chapter 4 compares the output statistics from the E+C model given by different versions of FSUTMS. Chapter 5 examines the performance of the original E+C model without any modification to the required model input. Chapter 6 describes the process of updating the demographic, socioeconomic, and employment characteristics defined in the ZDATA1 and ZDATA2 files of the E+C model and the resulted projected traffic volumes estimated by FSUTMS. Chapter 7 discusses the effect of the updated highway network on model performance. Chapter 8 compares the outputs obtained from models with and without the two-digit coding scheme. The combined effect of the three factors (ZDATA/EETRIP files, highway network, and two-digit coding) is considered in Chapter 9. Finally, Chapter 10 provides conclusions and suggests directions for future research.

2. LITERATURE REVIEW

Predictions of future travel behavior are based on hypotheses about factors that influence travel behavior and the structure of their influences (Koppelman 1976). These hypotheses are carried through the model formulation and prediction process in the steps of model specification, data collection, estimation of model parameters, and prediction of future travel behavior. For example, disaggregate models that predict individual choice behaviors are commonly utilized to obtain group predictions in the travel demand modeling process (Koppelman 1975, McFadden and Reid 1975, Koppelman 1976, Ben-Akiva and Lerman 1985). Disaggregate choice models relate the probability of choosing one out of a set of available alternatives to the estimated utility of each alternative for an individual decision-maker. A theoretically consistent aggregation procedure is then applied to determine the proportion of the prediction group expected to choose an alternative. Due to the data requirement in the estimation of explanatory variables for each individual in the prediction group, a variety of alternative procedures with less extensive input data requirement have been proposed in the past. Each procedure reduces the problem of aggregating forecasts across individuals by making some simplifying assumptions about the choice model, the population, or both (Ben-Akiva and Lerman 1985). Presently, these assumptions are still difficult to validate due to the intensive data requirement. However, with the advanced technology in transportation planning and Geographic Information System (GIS), more data are available to assist the task of validation.

It is well known to the transportation professionals that input and model parameters may contribute to the discrepancies between the projected and observed traffic in a future year. Zhao and Kockelman (2002) identified three sources of uncertainties that contribute to such discrepancies: inherent, input, and propagated uncertainties. Inherent uncertainty stems from the use of samples to develop the parameters of a travel demand model. Consequently, these parameters should be considered as random variables estimated with variations and co-variations. Input uncertainty comes from the use of predicted socioeconomic and demographic data for a future year. Propagated uncertainty refers to uncertainties that are passed from one model to the subsequent models in sequential processes. Zhao and Kockelman performed an experiment of 100 Monte Carlo simulations on a 25-zone, 818-link traffic network extracted from the Dallas-Fort Worth metro regional model. Inputs to and parameters of the travel demand model for the selected study area were then varied randomly to approximate errors and uncertainties. In each simulation, a specific set of model parameters and inputs was used and the model outputs were examined. The study concluded that uncertainties were likely to be compounded over the four steps of the travel demand modeling process and were highly correlated with the outputs and that the effect of misspecifications at early stages such as trip generation appeared to be amplified in the later stages. The results from Zhao and Kockelman's study indicate that predictions from many travel demand models may be highly uncertain due to the uncertainties associated with the parameters and inputs to the travel demand models.

Other than the study by Zhao and Kockelman, the majority of the literature known to the researchers has focused on studying the effect introduced by the uncertainty in the sampled and estimated input data. For example, Pradhan and Kockelman (2002) investigated the uncertainty in demographic and other inputs on the outputs from a partially integrated land use-transportation modeling system known as UrbanSim and a traditional four-step travel demand model developed using TransCAD. In the study, UrbanSim and TransCAD were executed alternately in four iterations for 1980, 1985, 1990, and 1995, with the outputs from UrbanSim serving as the inputs into TransCAD and the travel times estimated by TransCAD fed into UrbanSim. This study concluded that population and employment growth rates had a significant and positive impact on aggregate as well as disaggregate outputs of the travel demand model. However, this impact decreased in each subsequent year that was modeled, possibly because of the increased congestion in the urban system. Outputs of the travel demand model appeared to be far less variable than outputs of the land use model. Pradhan and Kockelman suggested that such results might be a direct consequence of the stochastic user equilibrium (SUE) assignment.

Krishnamurthy and Kockelman (2003) extended Pradhan and Kockelman's previous work and examined the propagation of uncertainty by calibrating both a land use model and a transportation model based on the regional data collected from Austin, Texas. The predicted residence and work locations from a disaggregate residential allocation model (DRAM) and an employment allocation model (EMPAL) were used as inputs to the calibration of a four-step travel demand model. The resulted travel times were then fed to the future land used models. Different from Pradhan and Kockelman's previous work, the approach allowed model parameters and the corresponding covariance matrices to be jointly estimated. The results from this study indicated that output variations were most sensitive to the exponent of the BPR (Bureau of Public Roads) capacity restrained formula, the split of trips between peak and 12 off-peak periods, and several trip generation and attraction rates.

Giuliano (1984) compared the travel demand forecasts obtained from a model developed in the early 1960s and the actual outcomes in 1980 for the Los Angeles urban area. His analysis revealed that the population projected for 1980 was overestimated in every region in Los Angeles, resulting in an area-wide total estimated population that was 28 percent higher than the actual population. At the same time, regional employment forecasts were either significantly over- or under-estimated in different regions in Los Angeles. Giuliano’s research also showed that trip rates varied over time although the assumption that trip rates remain constant and unchanged over time is generally adopted in the current travel demand modeling process without further validation. The study concluded that the trip rates input into the model and the Vehicle Miles Traveled (VMT) per capita estimated by the model were higher than predicted. The average trip length was also less than the predicted. The discrepancies were largely attributed to the errors in the forecasts and distribution of population and employment. As highlighted in the Model Validation and Reasonableness Checking Manual (FHWA 1997), socioeconomic and transportation network data are the critical elements in travel demand analysis. Therefore, the accuracy of these elements is essential to the modeling process and input data should be verified carefully for model validation purposes. The same requirement applies to the population and employment projections for the forecast year, although this is much more difficult to achieve given the state-of-the-art of land use models.

According to the guidelines in the *Project Traffic Forecasting Handbook*, the process for using a travel demand model to project traffic is as follows (FDOT 2002):

1. Modify interim and forecast year network/land use;
2. Execute the model stream;
3. Evaluate model traffic output; and
4. Document the traffic forecast.

Model traffic assignments need to be converted from Peak Season Weekday Average Daily Traffic (PSWADT) to Annual Average Daily Traffic (AADT) before comparing them with ground counts and vice versa. In current practices, short-term traffic count data are collected from Portable Traffic Monitoring Sites (PTMSs), which are temporarily installed at designated roadway segments. The data collection is generally conducted from Tuesday to Thursday for 72 hours. The average traffic from such a short-term count is known as Average Daily Traffic (ADT). ADT is converted to AADT as follows:

$$AADT = ADT \times SF \times AF \tag{1}$$

where

SF = seasonal correction factor (SF); and
AF = axle correction factor.

The AF parameter is used to adjust vehicle axle sensor base data for the incidence of vehicles with more than two axles. The SF parameter is used to adjust the ADT collected at a PTMS by considering traffic fluctuations by day of week and month of year that are observed from a group of permanent Telemetry Traffic Monitoring Sites (TTMSs) operated year round. The SF parameter is derived for each week by interpolating the Monthly Seasonal Factors (MSFs) for every two consecutive months. The MSF is defined as

$$MSF = AADT / MADT \tag{2}$$

where MADT is the Monthly Average Daily Traffic. As suggested by Equations (1) and (2), the highest weekday volume would occur when the SF for a week is the lowest. Alternatively, AADT may also be calculated as follows:

$$AADT = PSWADT \times MOCF \tag{3}$$

where MOCF is the average of the 13 consecutive weeks during which the highest weekday volumes occur, i.e., when the sum of SFs for those 13 weeks is the lowest. MOCF used in validation to convert AADT to PSWADT for the base year model network should be used for adjusting future year model volume.

3. METHODOLOGY

This study compared the actual traffic counts from year 2000 against the projected traffic volumes from the 1995 JUATS model based on the 2000 E+C network, which will be referred to as the 2000 E+C model henceforth. The development of JUATS 2000 network included a number of assumptions:

- Scheduling of construction projects by the FDOT, City of Jacksonville, and Clay and St. Johns counties
- Population projections for year 2000
- Employment projection for year 2000

To test the effect of each assumption about future demographics, socioeconomics, and transportation network on the traffic volumes projected by the 2000 E+C model, the following research tasks were performed in this study:

1. Model Test Runs and Data Collection

   The 1990 base year model was run using the latest version of FSUTMS software program and the original script (control) files. Because major efforts have been made to enhance the modeling capabilities of FSUTMS after the original 1990 base year model was created, the results were examined to ensure that the model worked properly. The traffic volumes were extracted from the 2000 FTI CD for the TTMSs and PTMSs located in the study area. The MOCFs for the seasonal factor categories that were assigned to the PTMSs in the study were also collected from the FDOT Statistics Office.

2. Comparison of Traffic Counts

   The traffic volumes projected based on the 2000 E+C network were compared to the field collected traffic volumes in 2000. The differences in the traffic volumes were documented and investigated in the subsequent tasks to identify probable causes of the discrepancies, including the differences in socioeconomic/demographic and employment data, network configuration, network coding, and relevant model parameters in the two-digit coding scheme.

3. Comparison of Socioeconomic/Demographic and Employment Data

   The population and employment data projected in the 2000 E+C model were updated based on the 2000 Census and InfoUSA employment data. The 2000 E+C model with the updated data was run again and the traffic volumes were compared with the 2000 traffic counts. The discrepancies were documented and summarized.

4. Consideration of the Effect of Network Improvements

   The 2000 E+C network was compared with the 2000 base-year network developed during the 2002 model validation effort. It is assumed that the 2000 base year network reflects all the roadway improvements since 1990 and represents the true traffic network in 2000. Based on the 2000 base year network, the E+C network was modified to represent the traffic network in 2000 since some of the committed and/or cost feasible network improvements specified in the E+C model were not constructed as planned. The ZDATA3 and ZDATA4 files of the 2000 E+C model were also updated. The 2000 E+C model with the updated network was run and the traffic volumes were compared with the 2000 traffic counts. The discrepancies were summarized and documented.

5. Determination of the Effects of Network Double Digit Coding

   The area types and facility types in the 2000 E+C network were updated to two-digit coding after all the network improvements are incorporated. The definitions of the two-digit coding for area type and facility type are provided in Appendix A. The 2000 E+C model was rerun and the traffic volumes were compared with the 2000 traffic counts. The discrepancies between model output and observed data were summarized and documented.

6. Determination of Cumulative Effect

   The 2000 E+C model was run with the two-digit coding and the updated socioeconomic, demographic, and employment data. The traffic volumes were compared with the 2000 traffic counts. The main causes that led to the discrepancies between the projected and observed traffic volumes in 2000 were identified.

The procedures and results for each of the aforementioned tasks are described in detail in the following chapters.

4. MODEL TEST RUNS

The Jacksonville model was originally developed in 1995 in the FSUTMS Version 5.2 environment. Major efforts have been devoted to enhancing the modeling capabilities of FSUTMS. One of the tasks involved in this study is to examine the effect of two-digit coding of area and facility types, which requires the FSUTMS/TRANPLAN program Version 5.3 or later. Therefore, prior to run any particular model for the future years, the base year model was examined using the latest version of FSUTMS software program and the original script (control) files to ensure that the model works properly.

4.1 1990 Base Year Model

In this section, the results from the 1990 base year model as documented in *Technical Report No. 4, Model Validation for the JUATS Year 2015 Long Range Transportation Plan* are referred to as the Version 5.2 results. Due to a number of changes in the model specifications, several input files for FSUTMS Version 5.2 were updated. For example, the 1990 base year model, which was originally created with one-digit code format, was updated to two-digit code format by running the TWODIGIT.BAT file. The VFACTORS file with variable UROADF, CONFAC, BPR LOS, and BPR EXP values by facility type (FT) was also created using the VFACTORS.BAT file. The 1990 model was subsequently run using FSUTMS Versions 5.0 and 5.5. No discrepancy was detected in the results from Versions 5.0 and 5.5 at the trip generation stage. The trip distribution results from the two versions of FSUTMS models are given in Table 4.1, which shows only minor differences in the area-wide aggregate intrazonal trips. No noticeable differences are observed from the average trip length statistics.

Table 4.1 1990 Base Year Trip Distribution Statistics from FSUTMS 5.2 and 5.5

Trip Purpose	Model	Total Trips	Intrazonal Trips	Average Trip Length
HBW[1]	5.5	546,785	7,003	18.6
	5.2	546,785	6,998	18.6
HBW[2]	5.5	546,785	8,072	20.4
	5.2	546,785	8,202	20.0
HBS	5.5	355,934	11,667	12.8
	5.2	355,934	11,667	12.8
HBSR	5.5	356,355	5,063	15.0
	5.2	356,355	5,057	15.0
HBO	5.5	553,517	14,028	16.1
	5.2	553,517	14,029	16.1
NHB	5.5	601,760	29,206	14.7
	5.2	601,760	29,202	14.7
Truck/Taxi	5.5	261,866	15,734	13.9
	5.2	261,868	15,729	13.9
E-I	5.5	165,357	-	37.6
	5.2	165,357	-	37.6

[1] First pass for pre-loaded highway network

[2] Congested highway network.

Table 4.2 summarizes the results from the modal split stage for the three highway modes, i.e., drive alone, auto with two persons, and auto with three and more persons. It may be seen that the discrepancies between results obtained from Versions 5.2 and 5.5 were insignificant. Table 4.3 compares the daily transit usages of the three transit modes (local bus, express bus, and Automated Skyway Express (ASE) for work and non-work trips from FSUTMS version 5.2 and 5.5. The differences in the results from the two versions are again insignificant.

Table 4.2 1990 Base Year Highway Person Trips from FSUTMS 5.2 and 5.5

Highway Mode	Model	Trip Purpose			Total
		HBW	HBNW	NHB	
Drive Alone	5.5	448,912	524,452	375,987	1,349,351
	5.2	448,906	524,474	375,991	1,349,371
Drive w/ 1 Passenger (2 persons)	5.5	62,649	290,689	121,003	474,341
	5.2	62,651	290,696	121,002	474,349
Drive w/ 2 Passenger (3+ persons)	5.5	17,283	408,346	70,224	495,853
	5.2	17,289	408,351	70,222	495,862
Total	5.5	528,844	1,223,487	567,214	2,319,545
	5.2	528,846	1,223,521	567,215	2,319,582

Table 4.3 1990 Base Year Daily Transit Usage Statistics from FSUTMS 5.2 and 5.5

Trip Purposes		Source	Passengers		
			Trips	Miles	Hours
Work Trips	Local Bus	5.5	11,403	43,304	2,006
		5.2	11,407	43,325	2,013
	Express Bus	5.5	729	5,820	264
		5.2	680	5,479	243
	ASE	5.5	482	249	17
		5.2	497	253	17
	Subtotal	5.5	12,614	49,373	2,287
		5.2	12,584	49,057	2,273
Non-Work Trips	Local Bus	5.5	22,013	66,454	2,650
		5.2	22,026	66,284	2,646
	ASE	5.5	496	206	14
		5.2	483	195	13
	Subtotal	5.5	22,509	66,660	2,664
		5.2	22,509	66,479	2,659
Total		5.5	35,123	116,033	4,951
		5.2	35,093	115,536	4,932

Table 4.4 shows the results produced by FSUTMS versions 5.2 and 5.5 from the traffic assignment stage in terms of the ratios of traffic volume to ground count (V/C) by facility type and number of lanes. Significantly lower V/C ratios were observed for eight-lane divided arterials and three-lane undivided arterials from the Version 5.2. The discrepancies in the V/C ratios for other facility type and lane combinations were insignificant. Since there are no noticeable differences between the ratio for either divided or undivided arterials as a group from these two versions (see the last column), it appears that the results from traffic assignment might have been recorded incorrectly in the Technical Report No. 4. Table 4.4 indicates that the 1990 JUATS model underestimated the traffic flows on freeway links with the exception of 5-lane freeways and overestimated volumes on one-way streets.

Table 4.4 1990 Base Year Volume to Count Ratios from FSUTMS 5.2 and 5.5

FT	Source	Lanes									Total
		1	2	3	4	5	6	7	8	9	
Freeway	5.5	-	0.95	0.88	1.06	1.40	0.99	-	-	-	0.94
	5.2	-	0.93	0.92	1.07	1.41	0.99	-	-	-	0.94
Divided Arterial	5.5	-	0.98	-	0.99	-	1.07	-	1.19	-	1.01
	5.2	-	0.95	-	0.99	-	1.04	-	1.07	-	1.00
Undivided Arterial	5.5	0.77	1.02	1.01	0.99	-	0.57	-	-	-	1.00
	5.2	0.82	1.10	0.95	1.00	-	0.57	-	-	-	1.02
Collector	5.5	-	1.00	-	0.83	-	-	-	-	-	0.99
	5.2	-	1.01	-	0.82	-	-	-	-	-	1.01
One-way Streets	5.5	-	1.09	0.99	1.06	-	-	-	-	-	1.04
	5.2	-	1.03	1.03	1.06	-	-	-	-	-	1.04
Total	5.5	0.77	0.97	0.88	0.99	1.40	1.06	-	1.19	-	0.97
	5.2	0.82	0.97	0.92	1.00	1.41	1.03	-	1.07	-	0.99

Figure 4.1 illustrates the differences between the assigned traffic flows from the base year model and the ground counts. The locations of the freeway sections with underestimated and overestimated traffic flows in comparison with the ground counts are highlighted. The differences range from –22,583 to 18,292 vehicles per day.

Table 4.5 provides a summary of the V/C ratios in terms of vehicle miles of travel (VMT) by facility type and number of lanes. Typographic errors were suspected in the statistics for the facility types of three-lane undivided arterials and seven-lane divided arterials from Technical Report No. 4. No significant difference was observed in the other cells in the table.

Table 4.5 1990 Base Year Volume to Count VMT Ratios from FSUTMS 5.2 and 5.5

FT	Source	Lanes									Total
		1	2	3	4	5	6	7	8	9	
Freeway	5.5	-	0.95	0.88	1.06	1.40	0.99	-	-	-	0.94
	5.2	-	0.95	0.88	1.06	1.40	0.99	-	-	-	0.94
Divided Arterial	5.5	-	0.98	-	0.99	-	1.07	-	1.19	-	1.01
	5.2	-	0.97	-	0.98	-	1.06	1.19	-	-	1.00
Undivided Arterial	5.5	0.77	1.02	1.01	0.99	-	0.57	-	-	-	1.00
	5.2	0.77	1.03	0.95	0.99	-	0.57	-	-	-	1.00
Collector	5.5	-	1.00	-	0.83	-	-	-	-	-	0.99
	5.2	-	1.00	-	0.82	-	-	-	-	-	1.00
One-way Streets	5.5	-	1.09	0.99	1.06	-	-	-	-	-	1.04
	5.2	-	1.09	0.99	1.06	-	-	-	-	-	1.04
Total	5.5	0.77	0.97	0.88	0.99	1.40	1.06	-	1.19	-	0.97
	5.2	0.77	0.97	0.88	0.99	1.40	1.05	1.19	-	-	0.97

The results of comparisons between the outputs from Versions 5.2 and 5.5 at the various stages of the four-step model indicate that the 1990 model may be executed using either of the FSUTMS versions as long as the model of an older version is converted correctly to the newer one. The procedure described at the beginning of Section 4.1 was thus applied to convert the 2000 JUATS' model from Version 5.2 to Version 5.5.

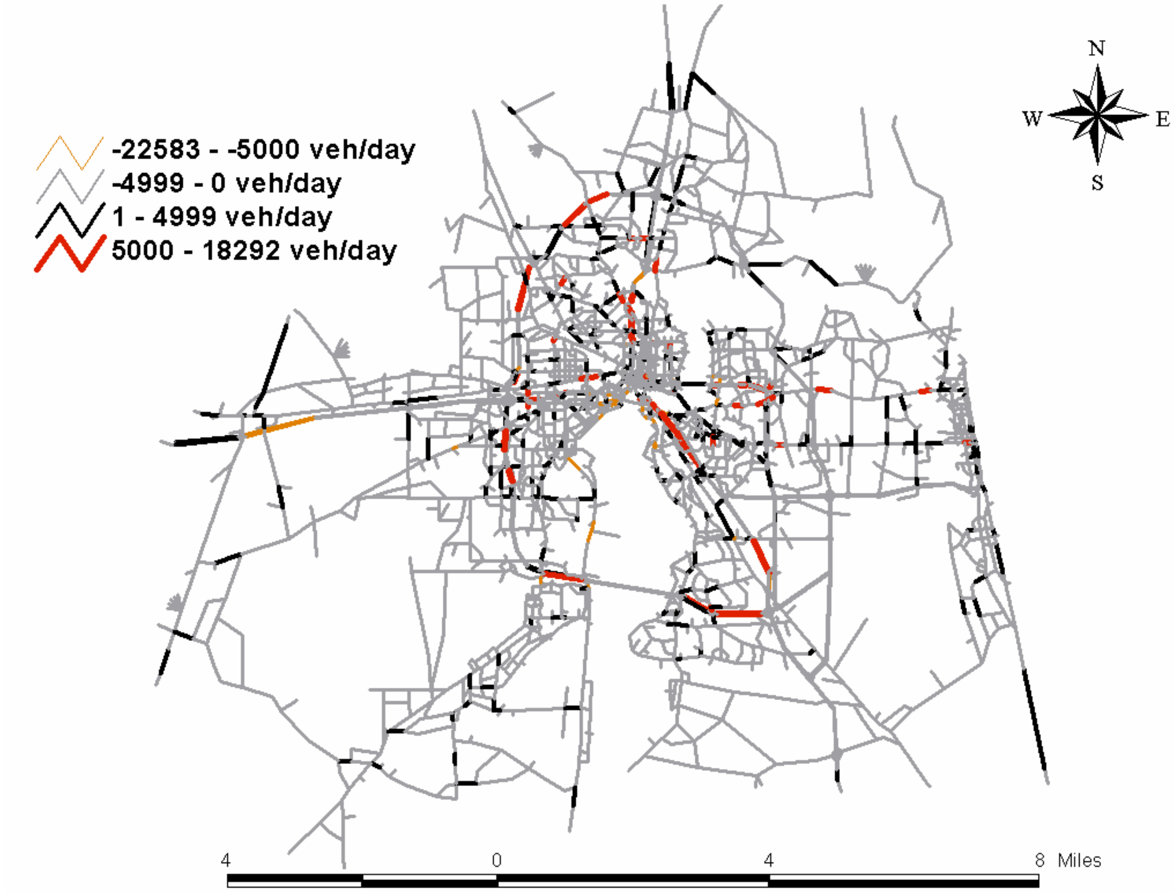

Figure 4.1 Differences between Counts and Volumes from the 1990 JUATS Network

4.2 2000 E+C Model

This section summarizes the results for the 2000 E+C model based on FSUTMS Versions 5.2 (using the original script files) and 5.5 (after model conversion using the procedure described in Section 4.1). Table 4.6 provides the total number of trips, intrazonal trips, and average trip length by purpose from the 2000 model. No differences in these statistics were observed from the two versions of FSTUMS. However, the results show that the 2000 model predicted a longer average trip length for each purpose compared with that calculated from the 1990 model.

Table 4.6 Forecast 2000 Trip Distribution Statistics from FSUTMS 5.2 and 5.5

Trip Purpose	Model	Total Trips	Intrazonal Trips	Average Trip Length
HBW[1]	5.5	620,492	8,110	19.425
	5.2	620,492	8,110	19.425
HBW[2]	5.5	620,492	9,048	21.260
	5.2	620,492	9,048	21.260
HBS	5.5	402,640	15,272	13.510
	5.2	402,640	15,272	13.510
HBSR	5.5	403,714	6,597	15.376
	5.2	403,714	6,597	15.376
HBO	5.5	630,293	18,011	16.665
	5.2	630,293	18,011	16.665
NHB	5.5	673,538	32,688	14.985
	5.2	673,538	32,688	14.985
T/T	5.5	292,768	18,630	14.191
	5.2	292,768	18,630	14.191
E-I	5.5	219,542	-	38.578
	5.2	219,542	-	38.578

1 First pass for pre-loaded highway network

2 Congested highway network.

Table 4.7 gives the number of trips for the three highway modes. The results show a total increase of nearly 300,000 person trips for the three highway modes. More than one half of the increased trips were HBNW trips. No significant difference for the results obtained from the two versions of FSUTMS was observed.

Table 4.7 Forecast 2000 Highway Person Trips from FSUTMS 5.2 and 5.5

Highway Mode	Model	Trip Purpose			Total
		HBW	HBNW	NHB	
Drive Alone	5.5	504,420	585,199	411,140	1,500,759
	5.2	504,466	585,189	411,134	1,500,788
Drive w/ 1 Passenger (2 persons)	5.5	74,672	329,325	133,517	537,513
	5.2	74,638	329,322	133,517	537,478
Drive w/ 2 Passenger (3+ persons)	5.5	21,221	466,092	77,794	565,107
	5.2	21,206	466,093	77,795	565,094
Total	5.5	611,290	1,396,691	640,015	2,647,996
	5.2	611,290	1,396,679	640,012	2,647,982

Table 4.8 gives the daily transit usage by trip purpose. There was an increase of close to 100% in the number of transit trips between 1990 and 2000. Tables 4.9 and 4.10 show the V/C ratios and ratio of volume to count VMT from the 2000 E+C model, respectively. Note that the ground counts in the LINKS file for the 2000 E+C networks were not updated to those collected in 2000. In the original model, these ground counts were the same as those specified in the 1990 base year network. It may be seen from Table 4.9 that freeway facilities may require more improvements to meet the future needs since the overall V/C ratio was the highest among all the facilities. The same observation may be made based on V/C's VMTs from Table 4.10. There is no noticeable discrepancy between the results from Versions 5.2 and 5.5 in either of the tables.

Table 4.8 Forecast 2000 Daily Transit Usage Statistics from FSUTMS 5.2 and 5.5

Trip Purposes		Source	Passengers		
			Trips	Miles	Hours
Work Trips	Local Bus	5.5	12,406	47,916	2,152
		5.2	12,445	48,199	2,161
	Express Bus	5.5	1,044	8,666	401
		5.2	1,034	8,609	393
	ASE	5.5	1,761	1,393	95
		5.2	1,751	1,386	93
	Subtotal	5.5	15,211	57,975	2,648
		5.2	15,230	58,194	2,647
Non-Work Trips	Local Bus	5.5	38,056	106,885	4,266
		5.2	38,065	106,955	4,269
	ASE	5.5	18,007	15,633	1,061
		5.2	18,003	15,626	1,061
	Subtotal	5.5	56,063	122,518	5,327
		5.2	56,068	122,581	5,330
Total		5.5	71,274	180,493	7,975
		5.2	71,298	180,775	7,977

Table 4.9 Forecast 2000 Volume to Count Ratios from FSUTMS 5.2 and 5.5

FT	Source	Lanes									Total
		1	2	3	4	5	6	7	8	9	
Freeway	5.5	-	1.15	1.06	1.10	1.48	0.99	-	-	-	1.11
	5.2	-	1.15	1.06	1.10	1.48	0.99	-	-	-	1.11
Divided Arterial	5.5	-	0.93	1.13	1.07	-	1.11	-	1.05	-	1.08
	5.2	-	0.92	1.13	1.07	-	1.11	-	1.05	-	1.08
Undivided Arterial	5.5	0.33	1.35	-	1.04	-	0.81	-	-	-	1.09
	5.2	0.33	1.35	-	1.04	-	0.81	-	-	-	1.09
Collector	5.5	-	1.12	-	0.84	-	-	-	-	-	1.10
	5.2	-	1.12	-	0.84	-	-	-	-	-	1.10
One-way Streets	5.5	-	1.01	0.94	1.16	-	-	-	-	-	1.03
	5.2	-	1.09	0.96	1.16	-	-	-	-	-	1.06
Total	5.5	0.33	1.16	1.06	1.06	1.48	1.10	-	1.05	-	1.09
	5.2	0.33	1.16	1.06	1.06	1.48	1.09	-	1.05	-	1.09

Table 4.10 Forecast 2000 Volume to Count VMT Ratios

FT	Source	Lanes									Total
		1	2	3	4	5	6	7	8	9	
Freeway	5.5	-	1.19	1.10	1.11	1.48	0.99	-	-	-	1.14
	5.2	-	1.19	1.10	1.11	1.48	0.99	-	-	-	1.14
Divided Arterial	5.5		0.91	1.12	1.10	-	1.11	-	1.18	-	1.09
	5.2	-	0.90	1.12	1.10	-	1.11	-	1.18	-	1.09
Undivided Arterial	5.5	0.33	1.29	-	1.06	-	0.84	-	-	-	1.13
	5.2	0.33	1.29	-	1.06	-	0.84	-	-	-	1.13
Collector	5.5	-	1.10	-	0.84	-	-	-	-	-	1.09
	5.2	-	1.10	-	0.84	-	-	-	-	-	1.09
One-way Streets	5.5	-	1.06	0.87	1.16	-	-	-	-	-	1.00
	5.2	-	1.13	0.88	1.16	-	-	-	-	-	1.03
Total	5.5	0.33	1.17	1.10	1.09	1.48	1.09	-	1.18	-	1.12
	5.2	0.33	1.17	1.10	1.09	1.48	1.09	-	1.18	-	1.12

4.3 Summary

In this chapter, the results from both the 1990 base-year and 2000 E+C models using FSUTMS Versions 5.2 and 5.5 are compared. There are some discrepancies between different FSUTMS versions even when the model structure and parameters remained unchanged. Although the discrepancies are generally insignificant, the changes to the FSUTMS engine during the past decade have some effects on the results obtained from Version 5.5. In the remaining analysis, Version 5.5 was used in the analysis to eliminate the effect of different FSUTMS versions. Unless specified otherwise, the original FSUTMS input files for the 2000 E+C model were used in the model runs to control other factors that may have an effect on the model output.

5. COMPARISON OF TRAFFIC COUNTS

To evaluate the performance of 2000 E+C model in projecting the traffic volumes, the traffic volumes projected by the JUATS travel demand model based on the 2000 E+C network were compared with those collected from the field by the FDOT. To obtain the traffic volumes observed on the roadways in 2000, the links in the E+C network that may have traffic count information available in 2000 were first identified. The traffic count data for these identified network links were then converted from AADTs to PSWADTs, as described in Chapter 2, before comparing them against with the assignment results from the E+C model.

In this study, the 2000 FSUTMS E+C network was first converted to a shapefile using the GIS-TM software developed by the FDOT. The converted network was not completely aligned with the locations of PTMSs and TTMSs defined in the shapefiles from the 2000 Florida Traffic Information (FTI) CD. Special effort was made to manually locate the PTMSs and TTMSs onto the 2000 network links. In this process, the links where the counts are available were first identified. The midpoints of the links were then selected to represent the locations of the count stations. Figure 5.1 illustrates the 2000 FSUTMS network and the approximated locations of the permanent and portable count stations. A total of 321 TTMS and 513 PTMS locations were identified.

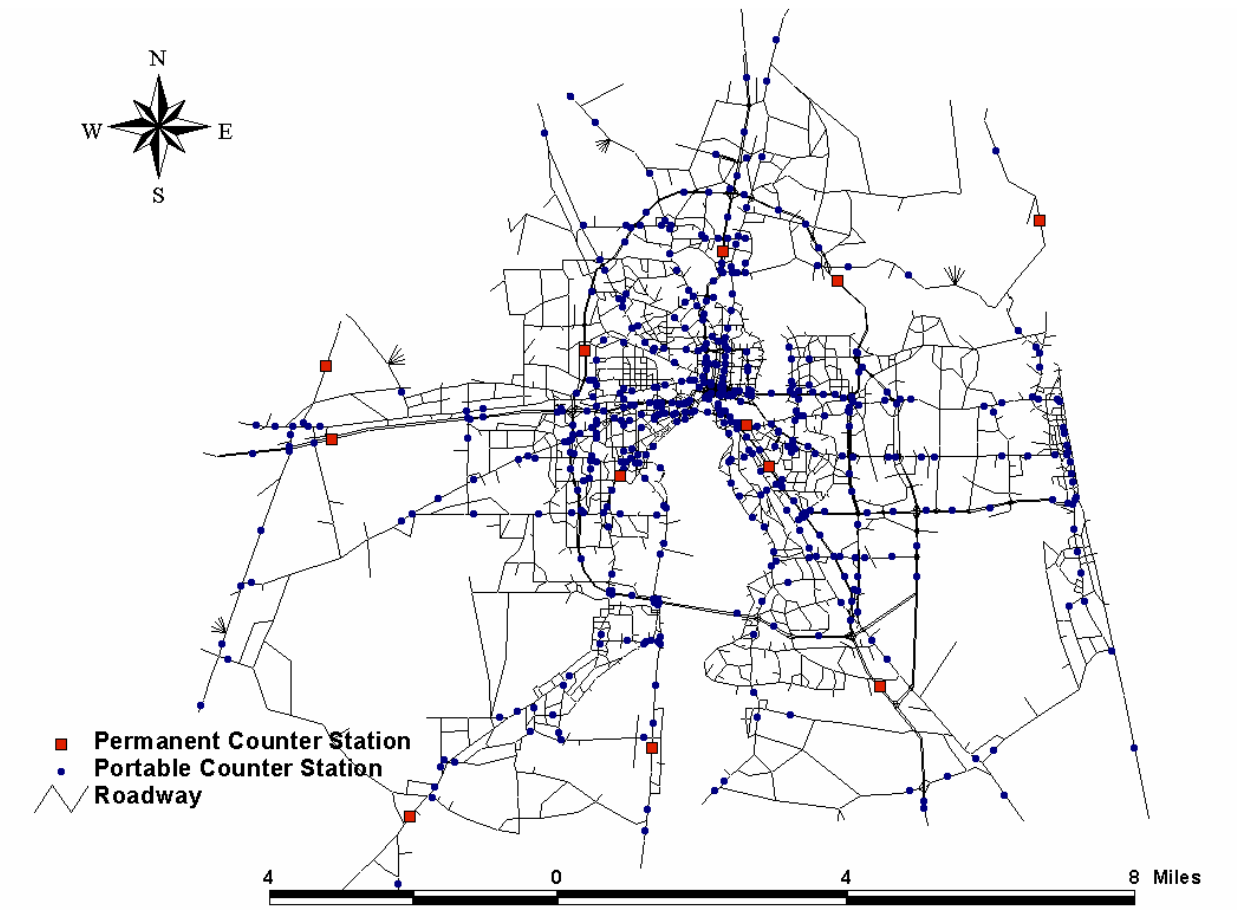

Figure 5.1 Approximated PTMS and TTMS Locations in the 2000 JUATS Network

In addition to the locations of the PTMSs and TTMSs, the SF category for each count station in the study area is also needed for the calculation of the PSWADT for a given network link. The JUATS study area is comprised of three counties, i.e., Clay, Duval, and St. Johns, with Duval County making up the majority of the study area. Several links near the boundaries of the study area are located in the adjacent counties such as Baker and Nassau. Table 5.1 lists the TTMSs and the corresponding MOCF factors for the SF categories in the counties with at least one count station in the study area. The MOCF data for the year of 2000 were obtained from the FDOT Statistics Office.

Table 5.1 SF Categories for Counties within and Adjacent to the JUATS Study Area

County	Category	Description	TTMS	2000 MOCF
Baker	2700	Countywide	270232, 290037	0.98
	2710	I-10	290269, 720109	0.97
Clay	7100	Countywide	280018, 280073, 710189, 710233, 720062, 729923, 740047	0.97
	7130	U.S. 301	280018	0.95
Duval	7200	Countywide	720062, 720161, 720171, 720172, 720235, 729914, 729923, 740047	0.98
	7201	Beaches Jax.	720062	0.96
	7210	I-10	290269, 720109	0.97
	7230	U.S. 301	280018, 720235	0.95
	7295	I95 & I295	720121, 720171, 720216, 729923, 740132	0.98
Nassau	7400	Countywide	720235, 720236, 740047, 740182	0.94
	7410	I-10	290269, 720109	0.97
	7430	U.S. 301	720235, 740047	0.95
	7495	I95	720121, 729923	0.96
St. Johns	7800	Countywide	720062, 760105, 780311, 780329	0.95
	7895	I95	720121, 730292	0.95

For the links with TTMS counts, directional AADTs were easily retrieved from the FTI CD. For links with PTMS counts, however, AADTs were given as the sum of traffic volumes from both directions of a given link. In this study, the traffic count data, typically 72-hour directional traffic counts, contained in the synopsis reports on the 2000 FTI CD were extracted to calculate the directional AADTs for links associated with a PTMS. The directional AADT for a PTMS link was computed by multiplying the average of the daily directional counts with the corresponding seasonal and axle adjustment factors. The directional PSWADT was then obtained by dividing the directional AADT by the corresponding MOCF. A GIS program was written to extract the traffic count information from the 2000 FTI CD, perform the calculation, and then place the resulted directional PSWADT on each link in the 2000 E+C highway network. With the help of GIS, the links with PTMS counts were easily identified after the locations of PTMS were determined. Additional effort was made to assign directional PSWADTs to the network links using an automatic process since the direction information was not available in the FSUTMS highway network. In the program, the general direction (e.g., east-west or north-south) of the alignment of a FSUTMS highway link is first determined and compared with the direction of a given PTMS from the FTI CD. For a link aligned in the northwest direction, for example, the program identifies the link's general direction as north and west. A match is then established when a directional PTMS count is labeled as N or W. The assignment results were verified to assure directional PSWADTs were accurately allocated.

After the PSWADTs were computed for the network links, the HTP2DBF utility program in FSUTMS was used to convert the traffic volumes estimated by the 2000 E+C model from TRANPLAN binary format to dBase format. The results from the FSUTMS model and the 2000 FTI CD were compared. The difference between model output and field observations were obtained by first calculating the absolute difference between the model estimate and the corresponding PSWADT for each direction on a given link. The average of the absolute differences from both directions was then used to quantify the discrepancy. Tables 5.2 and 5.3 give the number of links with a given range of difference by area and facility types, respectively. Figure 5.2 shows the differences by direction between the traffic volumes projected from the 2000 E+C network and the PSWADT counts converted from the 2000 AADTs. Figure 5.3 displays the differences as percentages of the average of the PSWADTs for both directions on a given link.

Table 5.2 Volume Differences by Area Type for the 2000 E+C Model

Difference	Area Type				
	1x	2x	3x	4x	5x
0~5,000	8	30	128	16	33
5,001~10,000	-	15	44	9	8
10,001~15,000	1	6	17	3	1
15,001~17,400	-	-	1	1	-

Table 5.3 Volume Differences by Facility Type for the 2000 E+C Model

Difference	Facility Type				
	1x	2x	3x	4x	6x
0~5,000	51	120	29	5	10
5,001~10,000	22	41	13	-	-
10,001~15,000	12	16	-	-	-
15,001~17,400	1	1	-	-	-

There are significant differences in traffic volumes on the links in the JUATS E+C network, especially those of area types 3x (residential) or facility types 1x (freeways and expressways) and 2x (divided arterials). Some are nearly four times of the average of the PSWADTs. Further analysis is thus necessary to identify the sources that may have introduced such differences between the projected and actual traffic volumes.

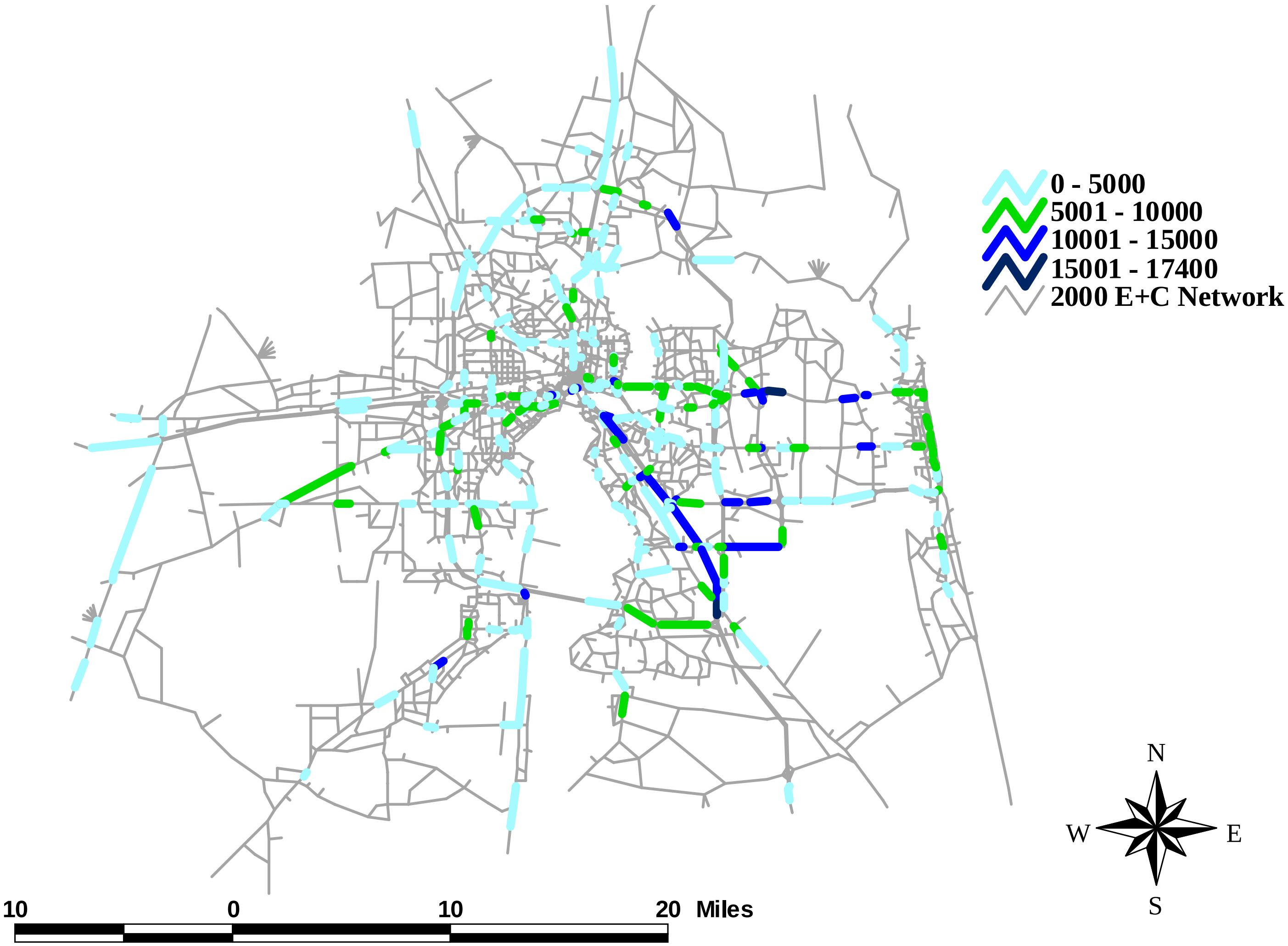

Figure 5.2 Differences between Assigned Volumes in 2000 E+C Network and PSWADTs Converted from AADTs

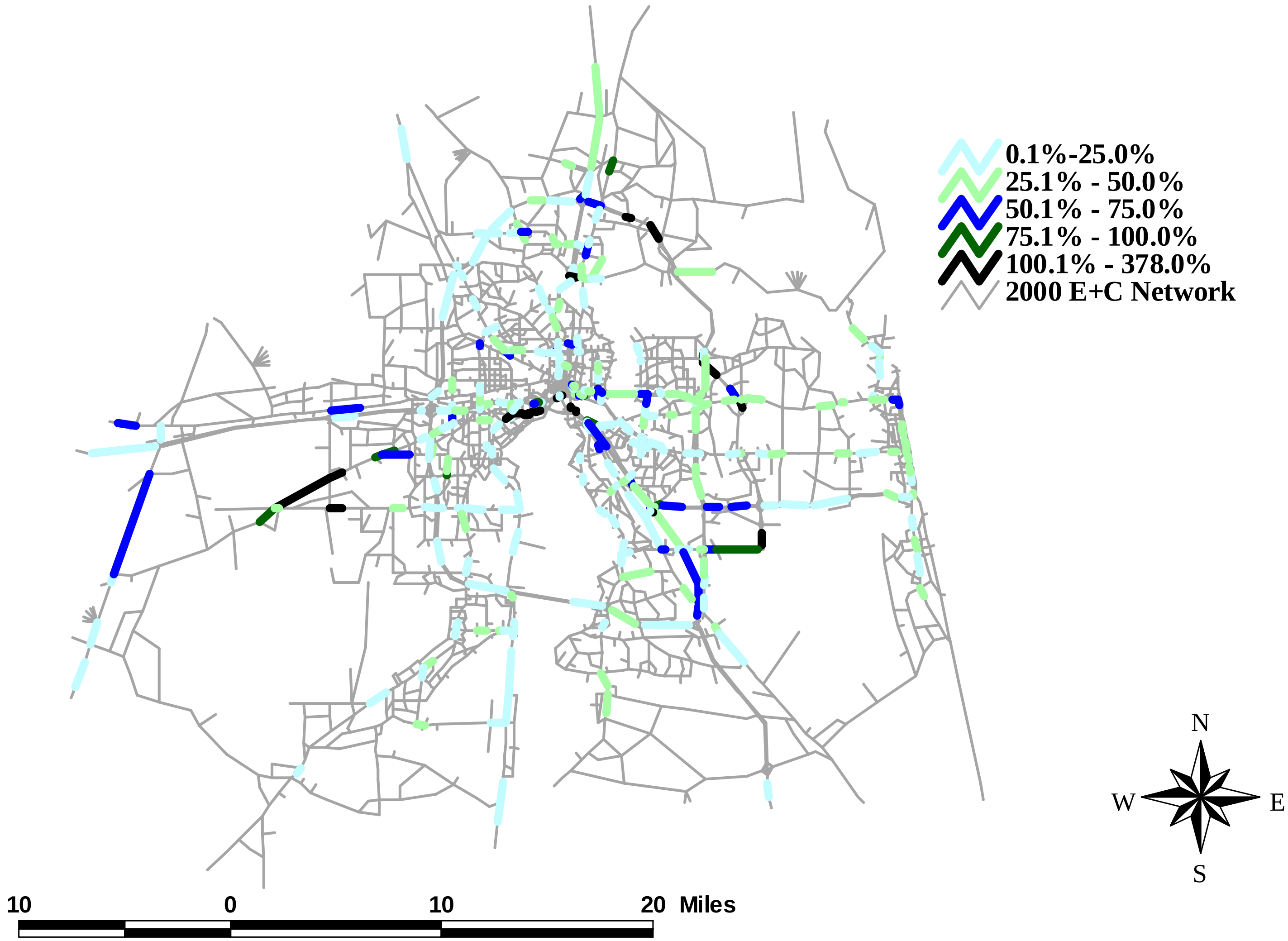

Figure 5.3 Volume Differences as Percentages of PSWADTs for the Original 2000 E+C Model

6. COMPARISON OF DEMOGRAPHIC AND SOCIOECONOMIC DATA

One of the causes of the predicted deviating from the observed traffic volumes may be the differences in the projected and the actual demographic and socioeconomic data. Trip generation is typically estimated by considering the characteristics of an area such as land use, population, employment, and other economic activity measures. In FSUTMS, these data are provided in the ZDATA1, ZDATA2, ZDATA3, and ZDATA4 files. In this study, these data were first verified with reliable data sources and the discrepancies were identified. The ZDATA files were then updated based on the data from the 2000 base-year model validated in 2002, which are considered accurate without further validation. The EETRIPS file was also updated to better reflect the traffic condition in year 2000.

6.1 Demographic Data

To determine the effect of demographic data on the performance of the JUATS model in forecasting short term traffic, the population, housing units, and households of each traffic analysis zone (TAZ) in the 2000 E+C model, which were projected in the 1995 model validation effort, were compared with the Census Transportation Planning Package (CTPP) Part 1 (residence) data. CTPP is a set of special tabulations from the decennial census designed for transportation planning purposes. CTPP Part 1 includes data on demographics at residence locations and provides statistics of total numbers of housing units and households by TAZ.

According to the definition by Census Bureau, a housing unit and a household are defined as follows:

- Housing unit – "A house, an apartment, a mobile home or trailer, a group of rooms, or a single room occupied as separate living quarters, or if vacant, intended for occupancy as separate living quarters."
- Household – "A household includes all the people who occupy a housing unit as their usual place of residence."

The difference between these two definitions is that a housing unit might not be occupied and a household is always non-vacant. No further information from the CTPP is available to segment the households in a TAZ into single- and multi-families. This study therefore compared the total housing units in a TAZ from the CTPP with the sum of SF and MF families in the ZDATA1 file. Similarly, the total number of households in a given TAZ was compared with the sum of non-vacant SF and MF families. The total number of internal TAZs from the 2000 JUATS model is 826, with zones 807 to 826 being dummy zones. The TAZ structure in the CTPP, however, is not consistent with that in the 1995 model. As a result, the two TAZ structures were compared and a look-up table was created for a total of 767 TAZs to associate one structure with the other. Figures 6.1, 6.2, and 6.3 are histograms that show distribution of the differences between the numbers of housing units, households, and population, respectively, from the ZDATA1 file and the CTPP. From the figures it may be seen that the differences for more than one half of all the TAZs are within ±25%. Table 6.1 provides the mean and median values of the differences in percentages. It may be seen that while more TAZs have overestimated demographic indicators as indicated by the positive median values, the underestimations are more significant as indicated by the negative mean values.

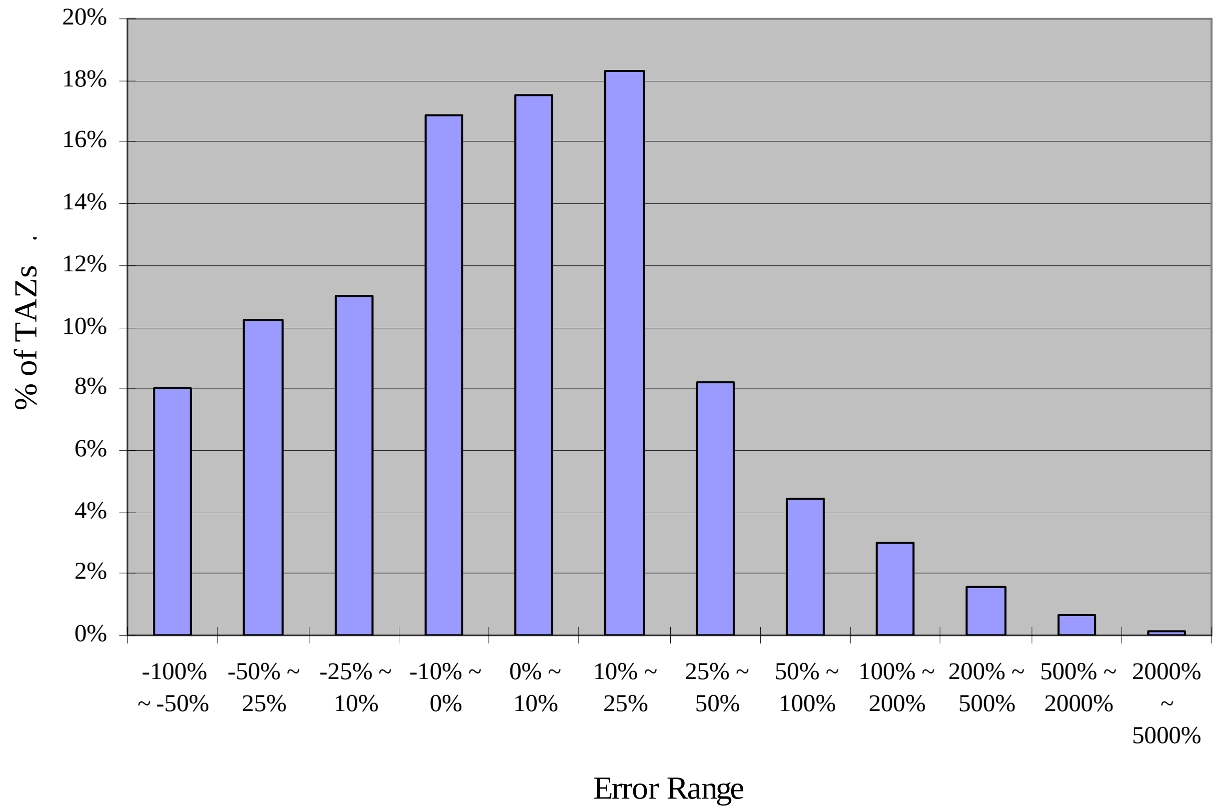

Figure 6.1 Histogram of Differences in Number of Housing Units by TAZ

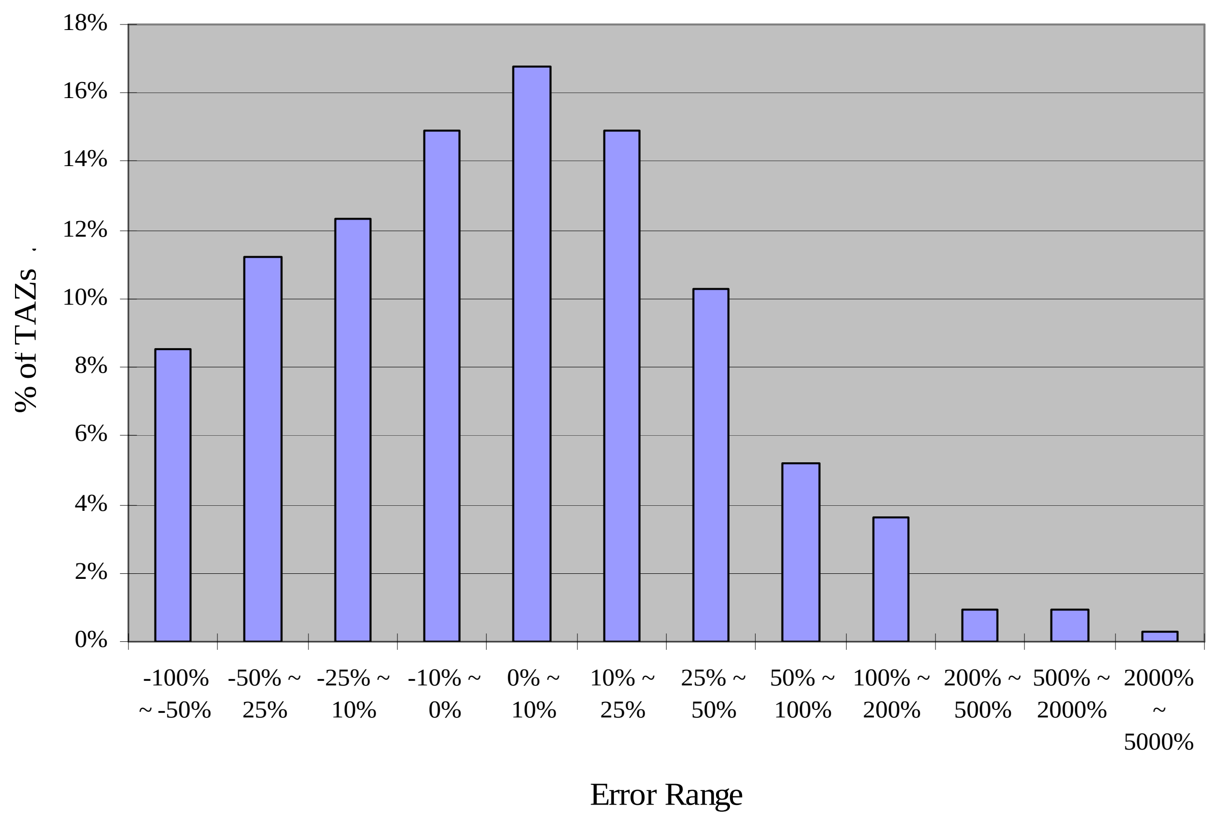

Figure 6.2 Histogram of Differences in Number of Households by TAZ

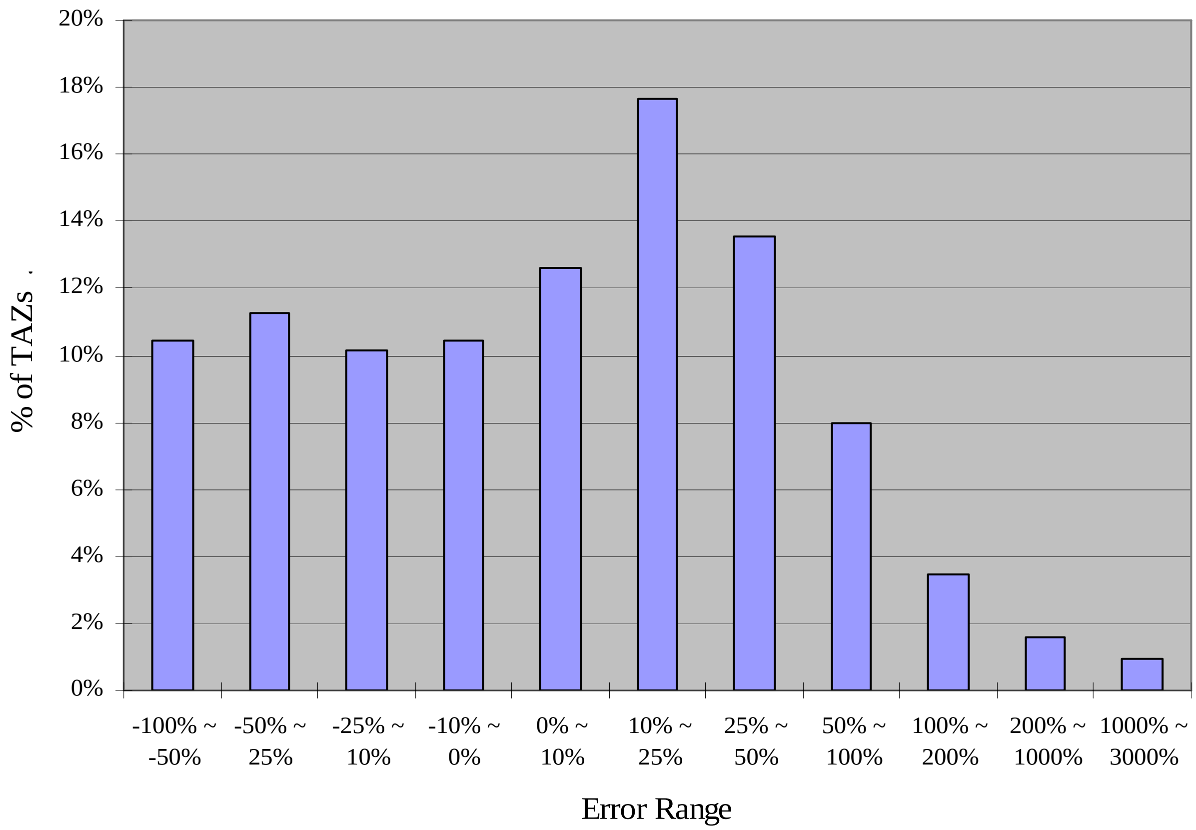

Figure 6.3 Histogram of Difference in Population by TAZ

Table 6.1 Statistics of Differences in Demographic Characteristics

	Number of TAZs*	Mean (%)	Median (%)
Housing Units	632	22.2	1.4
Households	632	28.2	2.0
Population	642	27.5	6.6

* TAZs with no housing units, households, or population are excluded from the calculations.

Table 6.2 summarizes the differences in the demographic data from the ZDATA1 file and the CTPP in absolute values. The total area-wide demographic estimates for the 2000 JUATS network were fairly consistent with the Census 2000 statistics. The differences between the estimated and observed demographic attributes at the zonal level, however, are significant. As indicated in Figures 6.1 to 6.3, some of the zonal housing units and population were either significantly over- or under-estimated. As a result, zonal travel demands estimated by the 2000 transportation model are expected to be significantly different from the true values.

Table 6.2 Area-wide Differences in Demographic Characteristics

Data Source	Housing Units	Households	Population
ZDATA1 (1)	363,336	332,580	876,896
CTPP (2)	383,029	354,410	919,135
(2) – (1)	19,693	21,830	42,239
[(2) – (1)] / (1) × 100	5.42%	6.56%	4.82%
[(2) – (1)] / (2) × 100	5.14%	6.16%	4.60%

To depict the spatial pattern of growth between 1990 and 2000 and differences between the 1990 and projected 2000 growth, population, household, housing units, and employment were aggregated to 20 Traffic Analysis Districts (TADs) as shown in Figure 6.4. For each attribute *a*, which may be population, households, house units, total employment, service employment, commercial employment, and industrial employment, the change and percentage of change in *a* between 1990 and 2000 and the difference between the 2000 statistics and the E+C model estimations are computed for each TAD as follows:

$$D_{2000}(a) = a_{2000} - a_{1990} \quad (4)$$
$$P_{2000}(a) = (a_{2000} - a_{1990})/a_{1990} \quad (5)$$
$$D_{e+c}(a) = a_{2000} - a_{e+c} \quad (6)$$
$$P_{e+c}(a) = (a_{2000} - a_{e+c})/a_{2000} \quad (7)$$

where

$D_{2000}(a)$	=	difference of attribute *a* between 1990 and 2000 base year model ZDATA files
$P_{2000}(a)$	=	percentage of difference of attribute *a* between 1990 and 2000 base year model ZDATA files
$D_{e+c}(a)$	=	difference of attribute *a* between 1990 base year and E+C model ZDATA files
$P_{e+c}(a)$	=	percentage of difference of attribute *a* between 2000 base year and E+C model ZDATA files
a_{2000}	=	value of *a* according to ZDATA file of the 2000 base year model
a_{1990}	=	value of *a* according to ZDATA file of the 1990 base year model
a_{e+c}	=	value of *a* according to ZDATA file of the E+C model

Figures 6.5 through 6.7 depict the spatial distribution of growth between 1990 and 2000 in housing units, households, and population, computed using Equations (4) and (5). It may be seen that significant growth occurred in most parts the study area, with the exception of TAD 11 and TAD 32. It is also interesting to note that while all TADs except TADs 11 and 32 had a positive growth in housing units and house holds, TADs 12, 23, and 24 had a negative population growth. The consequence is that, for instance, the average household size in TAD 12 decreased from about 2.9 in 1990 to 2.5 in 2000.

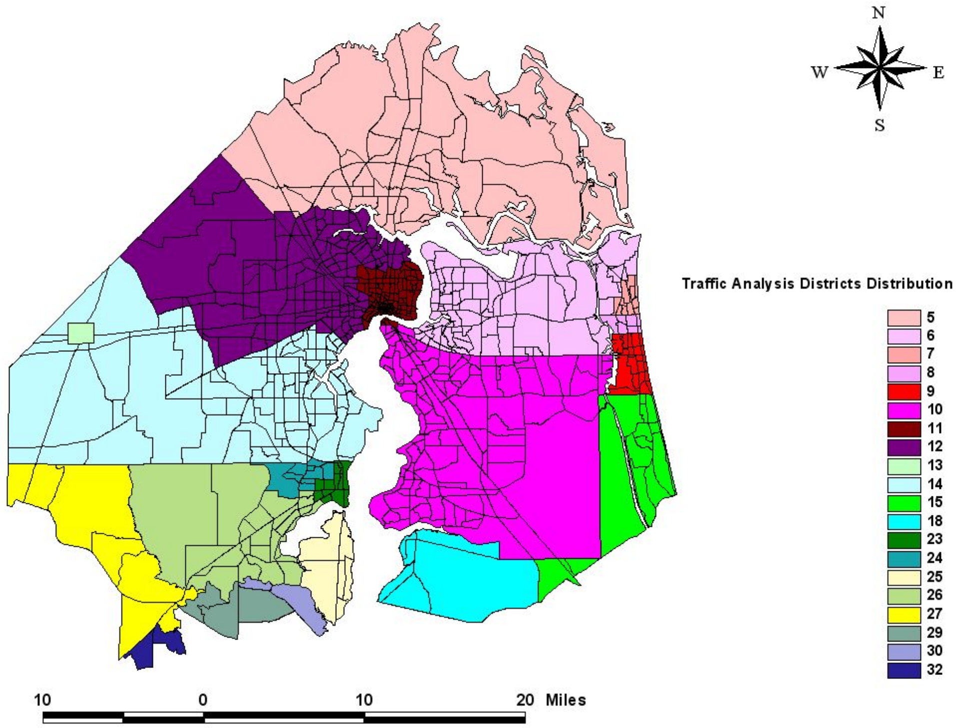

Figure 6.4 TAD Structures for the 2000 E+C Model

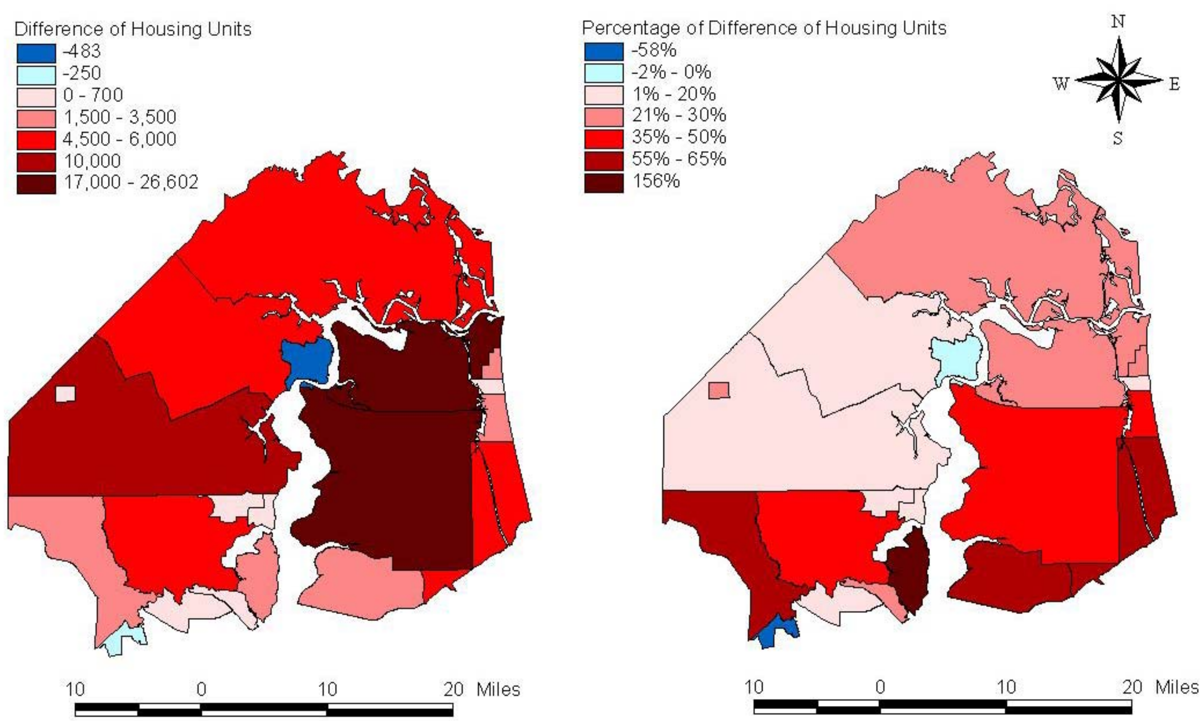

Figure 6.5 Differences in Housing Units between 1990 and 2000

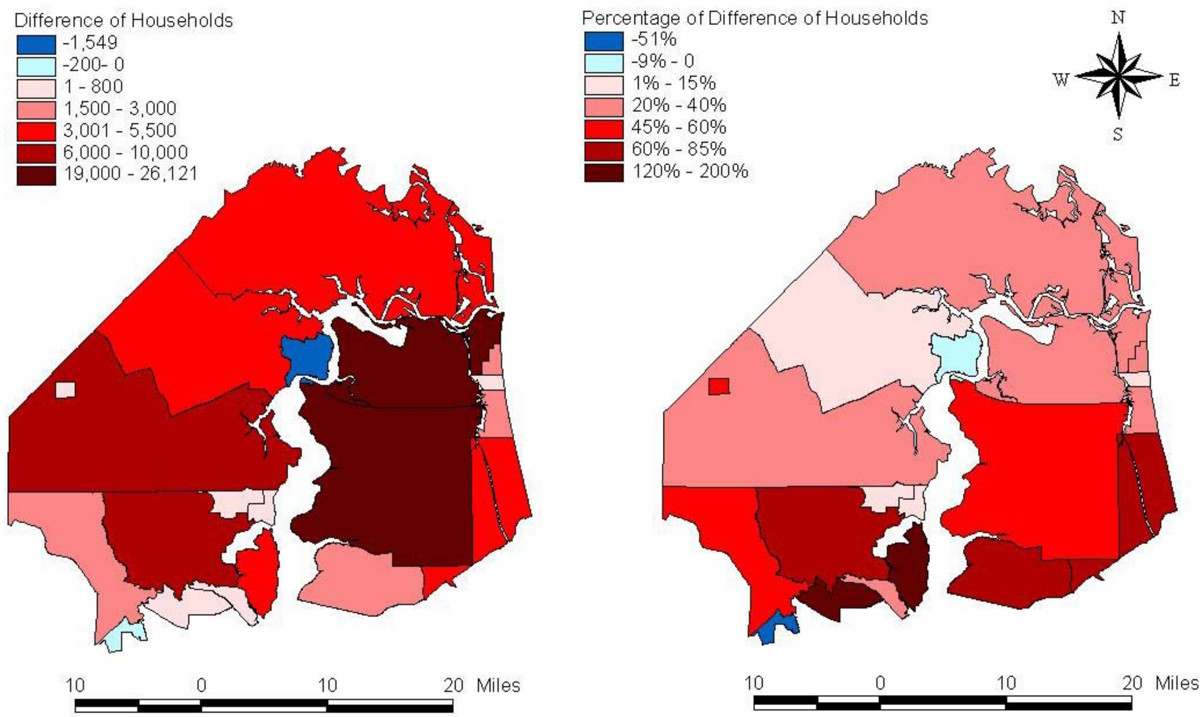

Figure 6.6 Differences in Households between 1990 and 2000

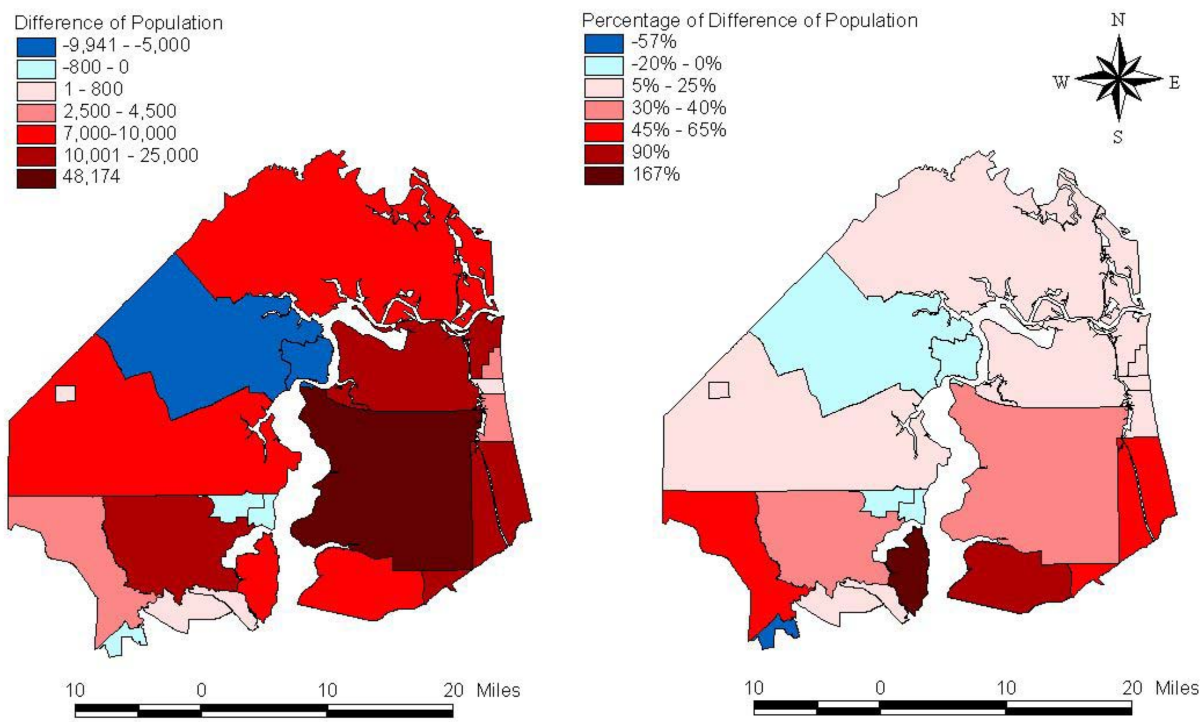

Figure 6.7 Differences in Population between 1990 and 2000

Figures 6.8 through 6.110 illustrate the spatial distribution of differences between the E+C model estimations and 2000 base year model ZDATA statistics, computed using equations (6) and (7). Note that in some of the legends, the value ranges are not continuous because the values for the

20 TADs are discrete. The differences in housing units and households range from about -1,200 to +17,000. The largest positive differences in terms of percentage occurred in TADs 10, 11, 15, and 27 (between 24% and 53%), while the largest negative differences occurred in TADs 29 and 32 (-50% to -60%). The distribution of differences in households has similar pattern but more significant, especially in TAD 15 and 25. The differences in population estimations range between about -10,000 and 25,000 in numbers and -60% and +60% in percentages. The population estimation is generally overestimated in the eastern part of the study area while underestimated in the western part of the study area.

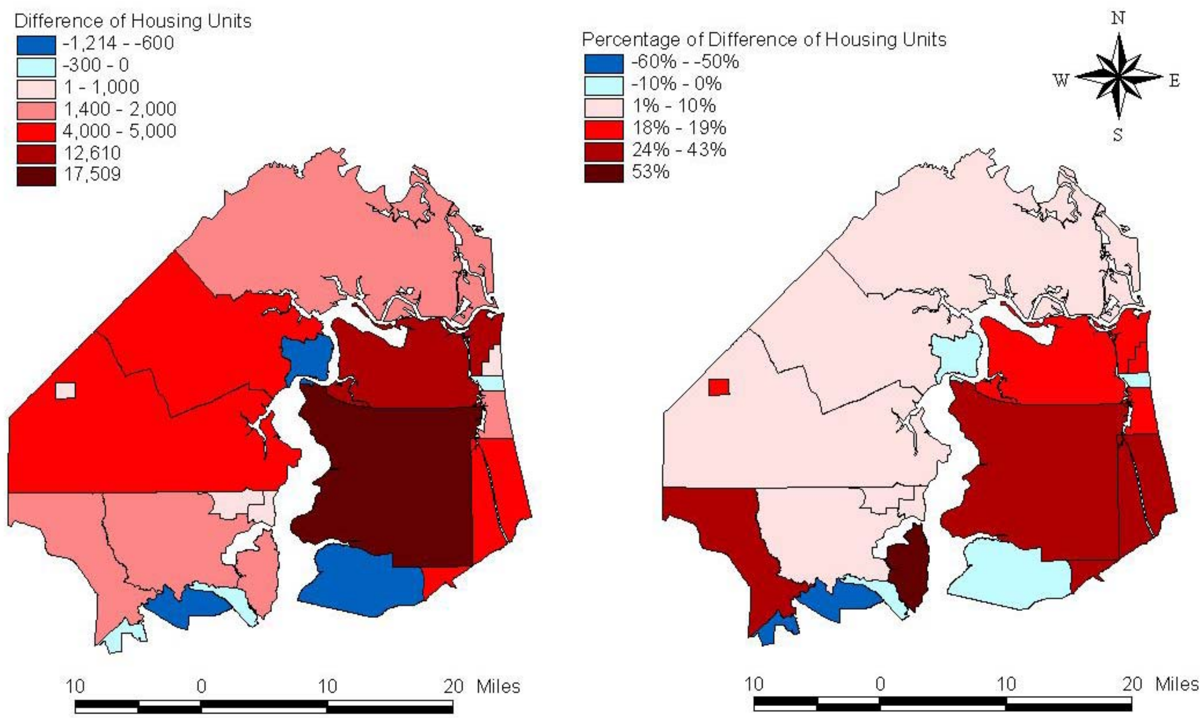

Figure 6.8 Differences in Housing Unit Estimations for E+C and 2000 Base Year Models

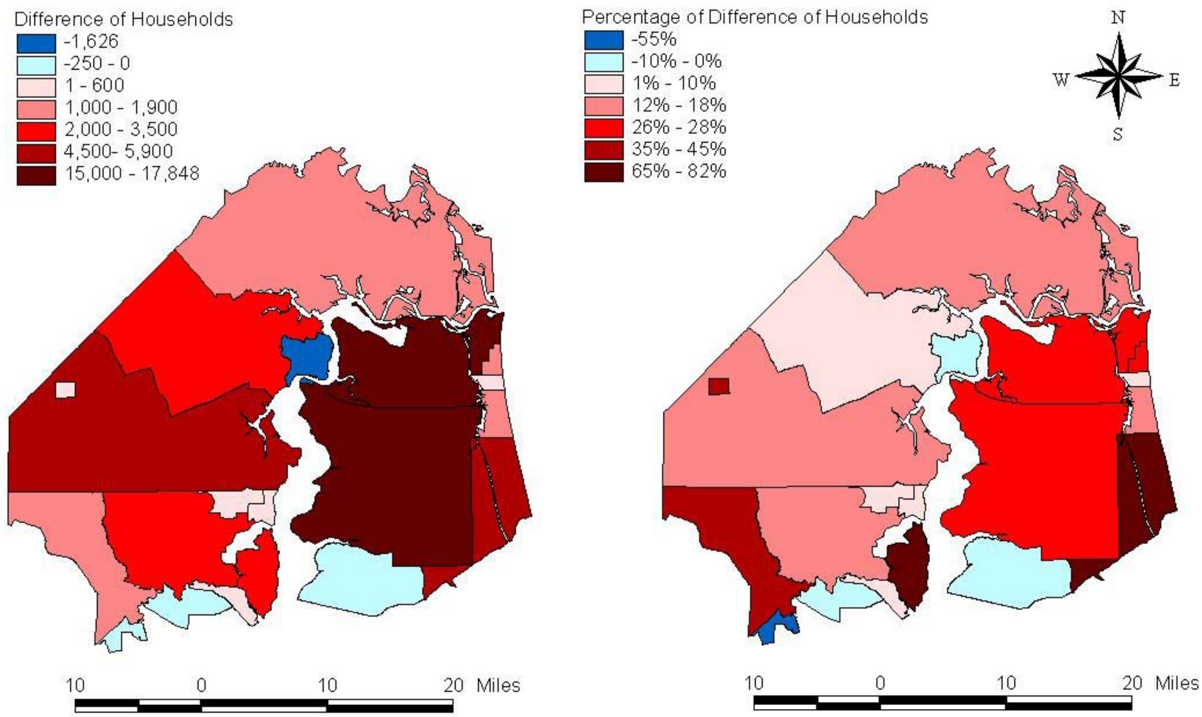

Figure 6.9 Differences in Household Estimations for E+C and 2000 Base Year Models

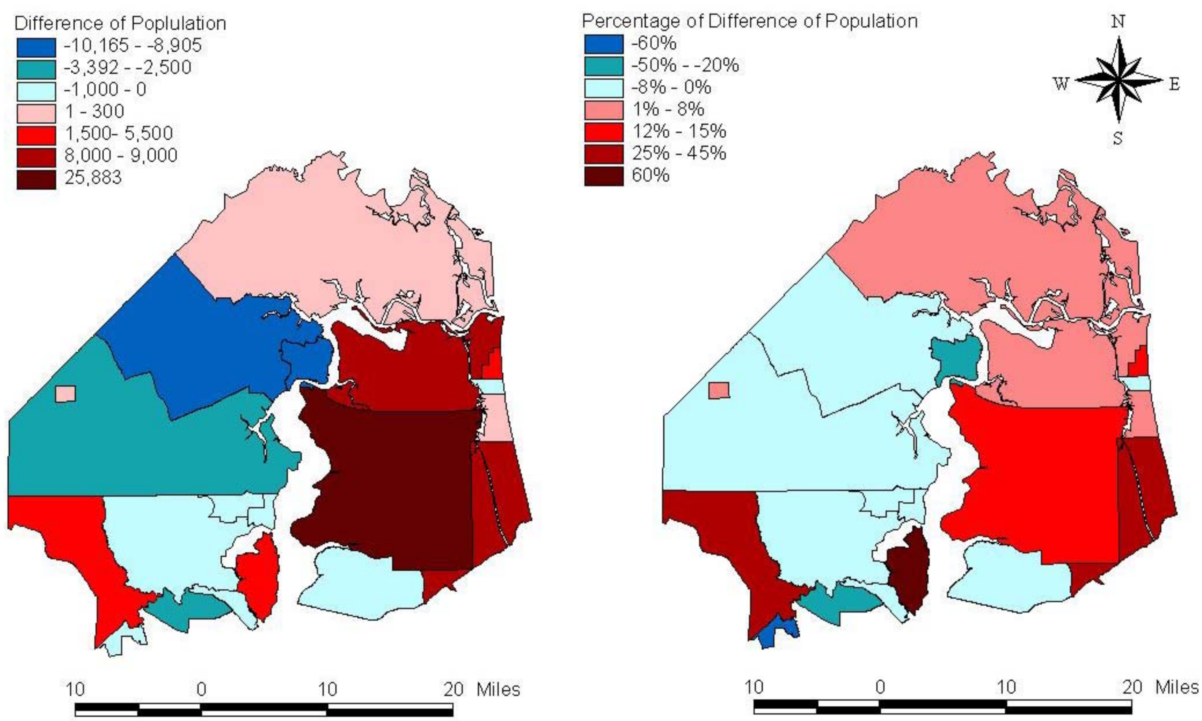

Figure 6.10 Differences in Population Estimations for E+C and 2000 Base Year Models

6.2 Employment Data

The employment data from the 2000 ZDATA2 file, CTPP Part 2 (place of work data), and InfoUSA (2001) were compared. The CTPP 2000 Part 2 data include the characteristics of workers at place of work. The InfoUSA database provides information such as employee size, annual sales, and SIC codes of employers. These data sources classify employment differently. In the ZDATA2 file, employment data are classified into commercial, industry, and service categories. Employment types in the CTPP Part 2 data are defined by industry as follows:

1. All Industries
2. Agriculture, forestry, fishing and hunting, and mining
3. Construction
4. Manufacturing
5. Wholesale trade
6. Retail trade
7. Transportation and warehousing, and utilities
8. Information
9. Finance, insurance, real estate and rental and leasing
10. Professional, scientific, management, administrative and waste management services
11. Educational, health and social services
12. Arts, entertainment, recreation, accommodation and food services
13. Other services (except public administration)
14. Public administration
15. Armed forces

Table 6.3 gives the equivalent employment categories based on the definitions of the employment types from the three data sources. The area-wide numbers of employment by category from the three data sources were then compared and the results are shown in Table 6.4. It may be seen from Table 6.4 that the numbers of area-wide commercial and industrial employment from the ZDATA2 file are relatively close to those from the CTPP. The service employment from the ZDATA2 file, however, was significantly underestimated according to the CTPP. Additionally, InfoUSA database appears to be inconsistent with the CTPP and should not be used without careful verification. The discrepancies in the size of employment by category will influence the number of trips estimated at an attraction end in the trip generation step. The effect will be propagated to the trip distribution step when the trips of a production zone are allocated to the attraction zones.

Table 6.3 Definition of Employment Variables

Employment	SIC Codes*	CTPP
Industrial	01-39	2-4
Commercial	50-59	5-6
Service	40-49, 60-93	7-15

* Source: FDOT FSUTMS Trip Generation Model, 1997

Table 6.4 Area-wide Differences in Numbers of Employment

Data Source	Employment Type			
	Commercial	Industrial	Service	Total
ZDATA1 (1)	81,060	70,645	256,660	408,356
InfoUSA (2)	117,636	85,772	242,821	446,229
CTPP (3)	74,413	68,343	320,476	463,723
(1) – (2)	-36,576	-15,127	13,839	-37,864
(1) – (3)	6,647	2,302	-63,816	-55,358

Similar to the housing, household, and population data, the spatial distributions of employment growth by three categories as well as the total employment are plotted in Figures 6.11 through 6.14. Between 1990 and 2000, the largest growth in industrial employment occurred in TADs 5, 6, 8, 10, 11, and 12 (ranging from 5,000 to about 18,000). In terms of percentage, the eastern part of the study area saw growth between 100% to about 1,500%. Note that TAD 12 had a small increase in housing units and households, but lost a small percentage of population in the decade. This area also gained over 16,000 industrial jobs in the same period.

For commercial employment, there were gains in some areas and losses in others. For instance, TAD 10 added the most commercial employment in absolute numbers. However, in terms of percentage, the TADs to the south boundary of the study area had the most significant changes.

The most significant loss of service employment happened in TAD 11, 12 and 14 in the central-western part of the study area while the rest of the region saw a gain in service employment. The largest number of service jobs (around 30,000) was added to TAD 10 and the southern part of the region saw the most significant growth in percentages.

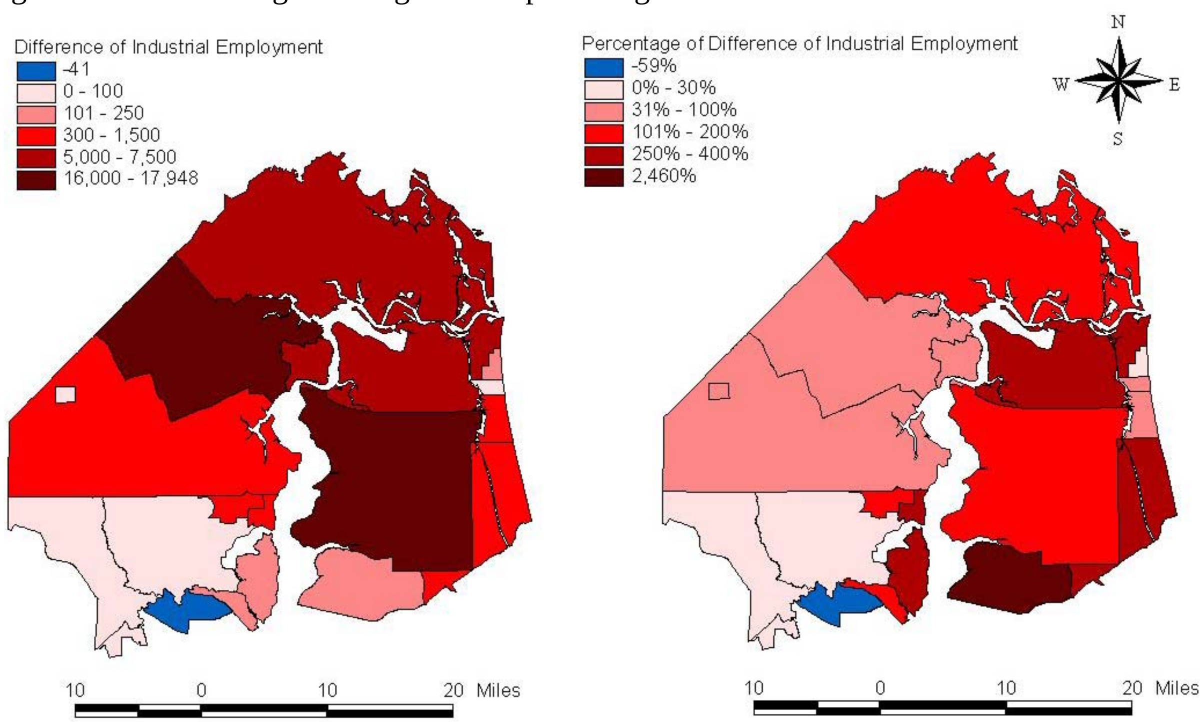

Figure 6.11 Growth of Industrial Employment between 1990 and 2000

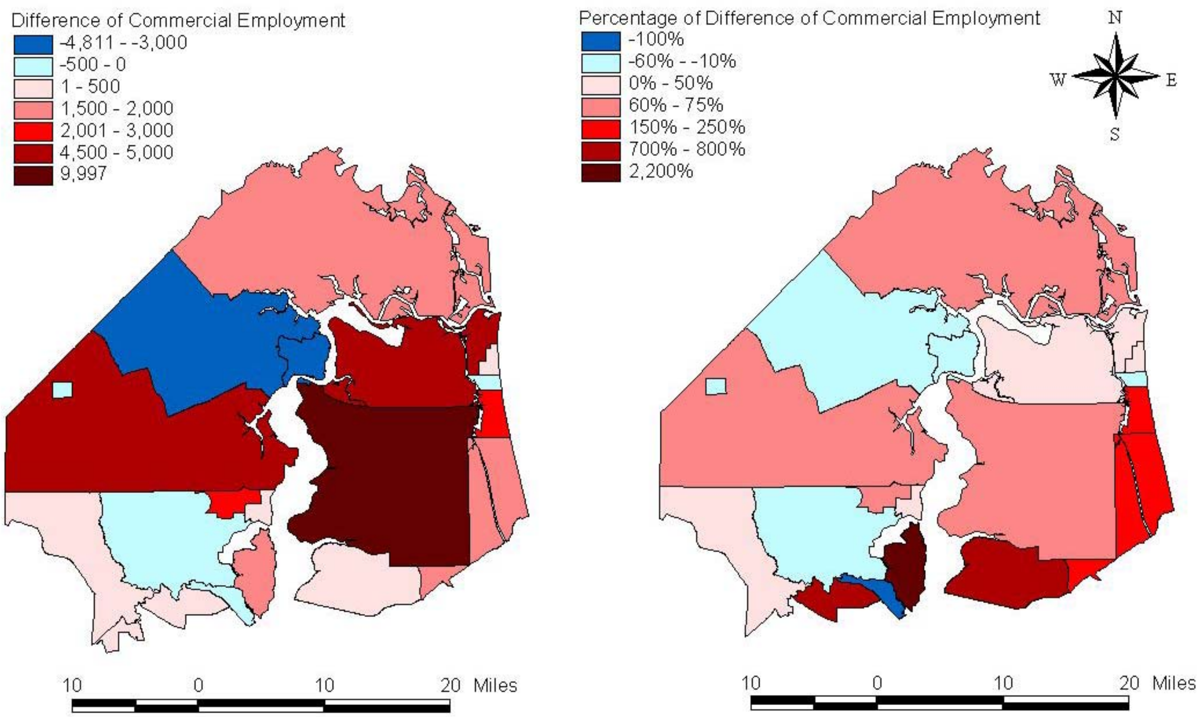

Figure 6.12 Growth of Commercial Employment between 1990 and 2000 Year

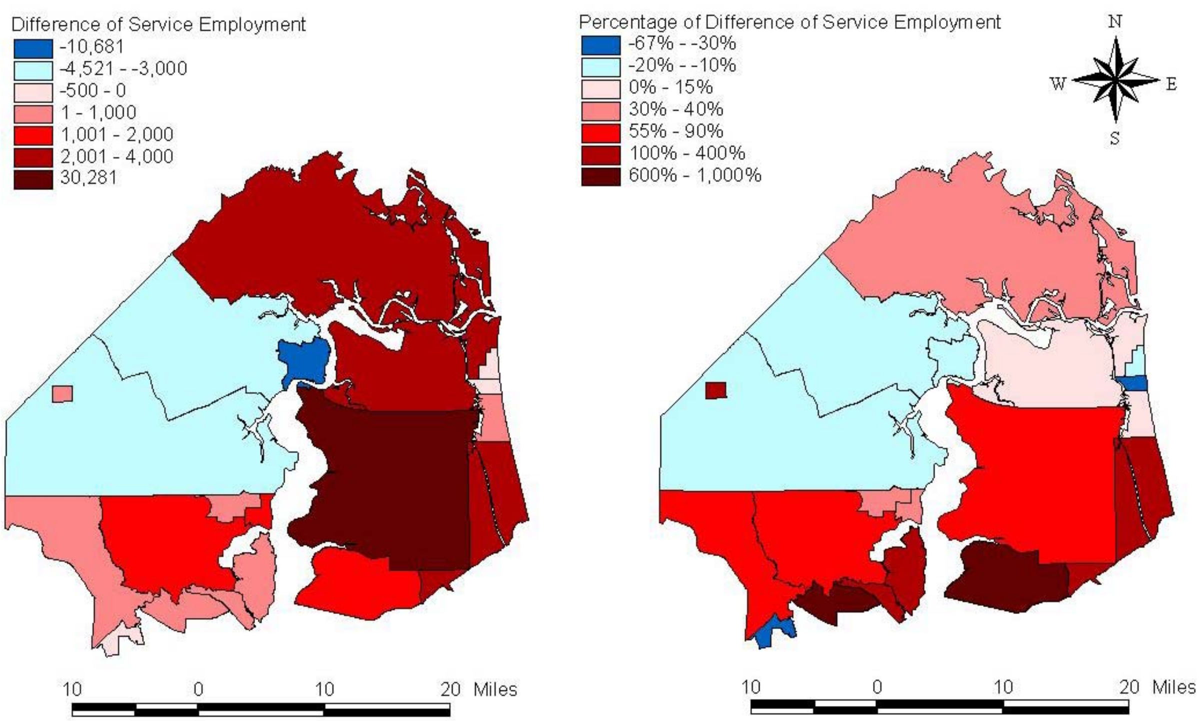

Figure 6.13 Growth of Service Employment between 1990 and 2000

Although growth of employment by categories was uneven in the region, overall the region gained employment with a few exceptions for three small TADs (11, 8, 32).

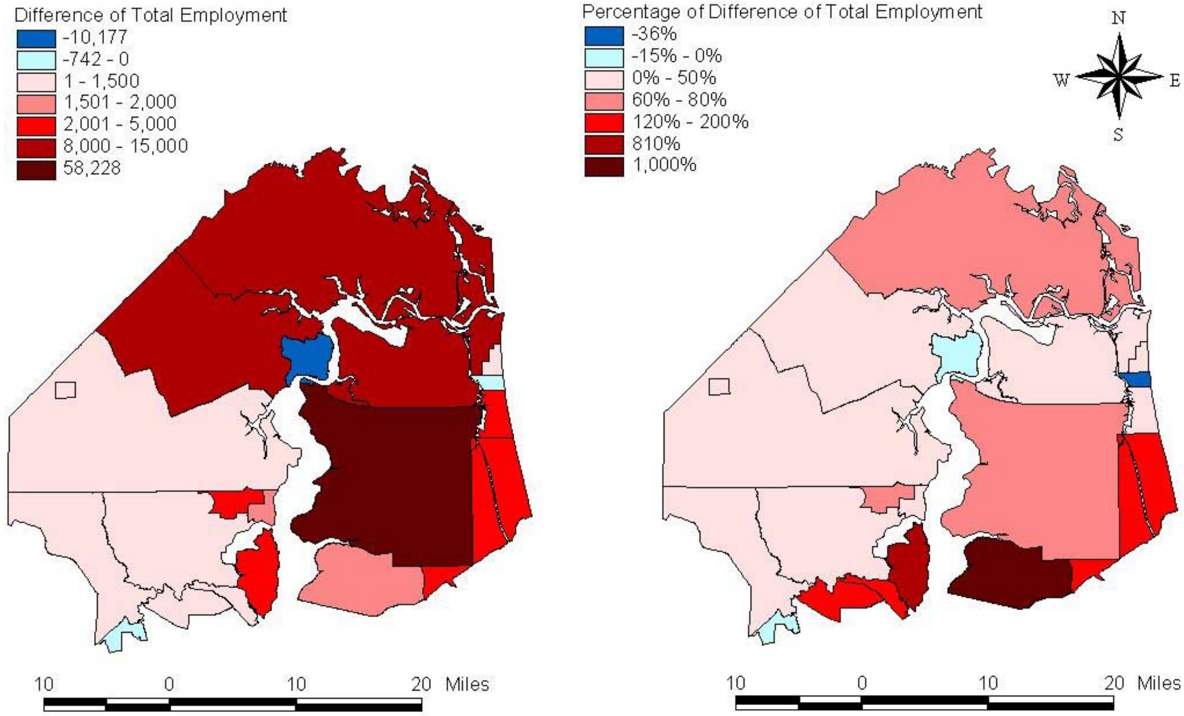

Figure 6.14 Growth of Total Employment between 1990 and 2000

The differences in the employment estimations for the 2000 E+C model and the 2000 base year model are illustrated in Figures 6.15 through 6.18. Industrial employment was underestimated for TADs 13 and 29 while most significant overestimations occurred in the northern part of the region (TADs 5, 6, 10, and 12) in numbers and northeastern part in percentages. At the TAD level, commercial employment estimations were less accurate, with most TADs under- or overestimated by both a large number and a large percentage. Estimations of service employment are more accurate than those of the commercial employment, although in the southern part of the region it was generally overestimated. The estimations of total employment are similar to those of service employment, with TADs covering a large portion of the region having moderate errors between ±20% and TADs to the south having larger errors.

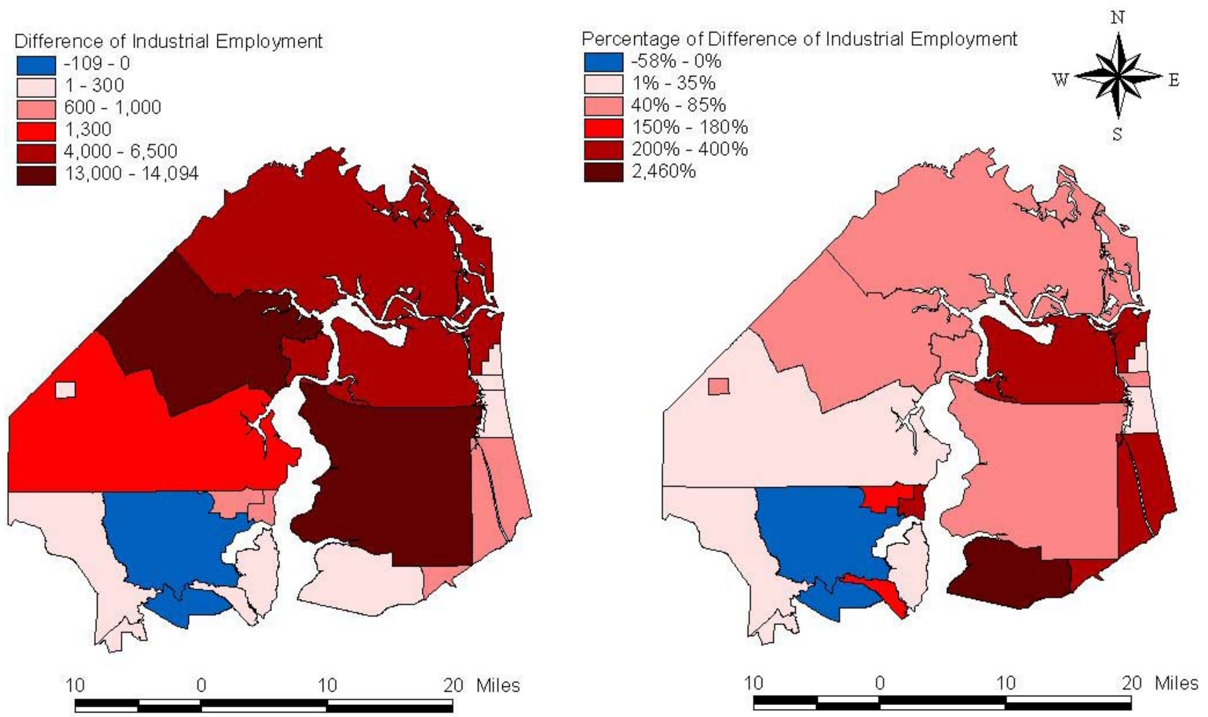

Figure 6.15 Differences in Industrial Employment Estimations for E+C and 2000 Base Year Models

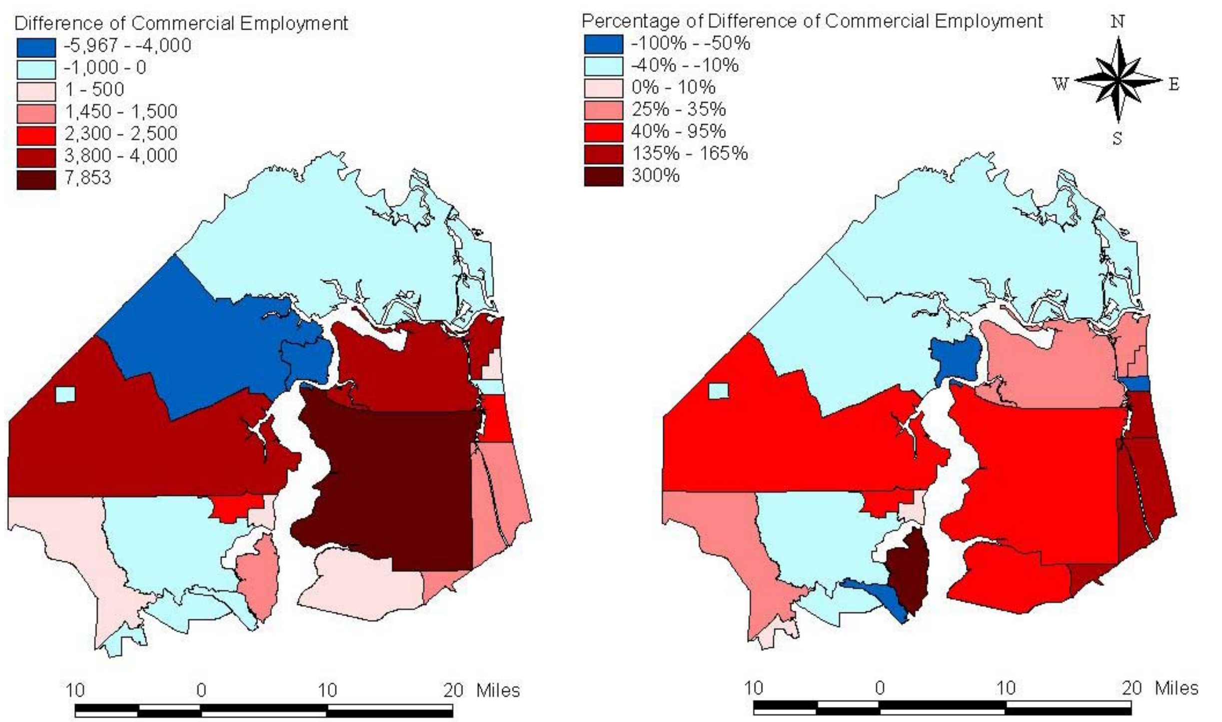

Figure 6.16 Differences in Commercial Employment Estimations for E+C and 2000 Base Year Models

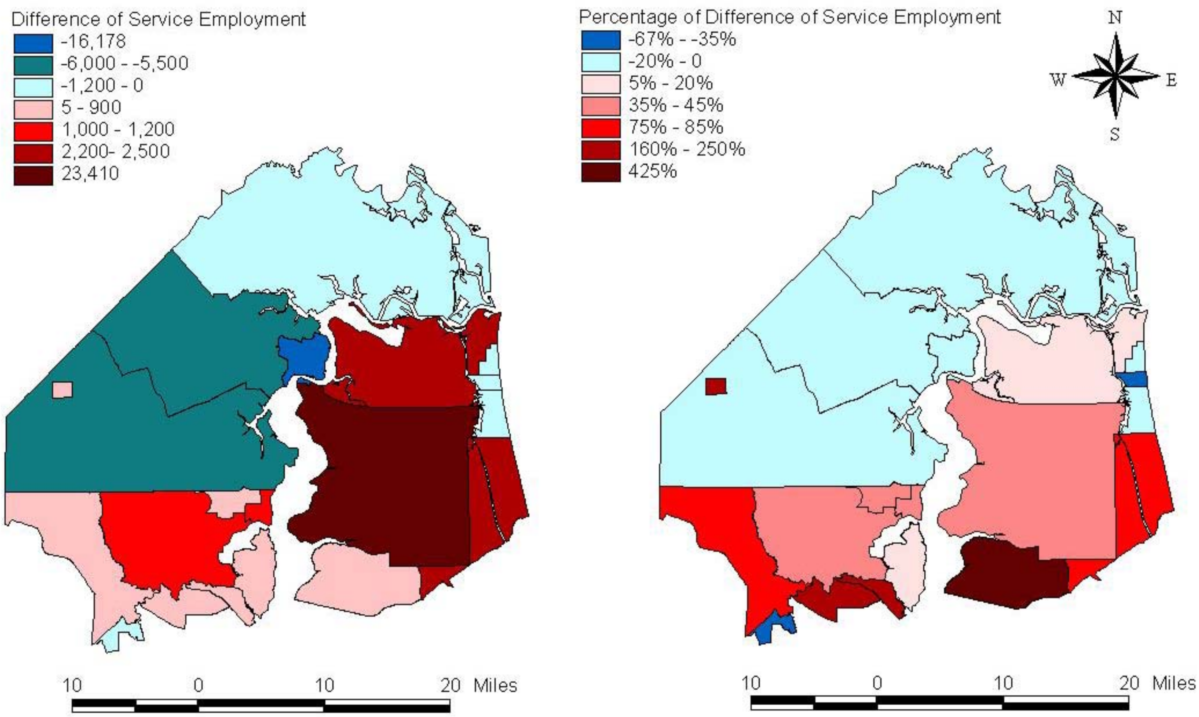

Figure 6.17 Differences in Service Employment Estimations for E+C and 2000 Base Year Models

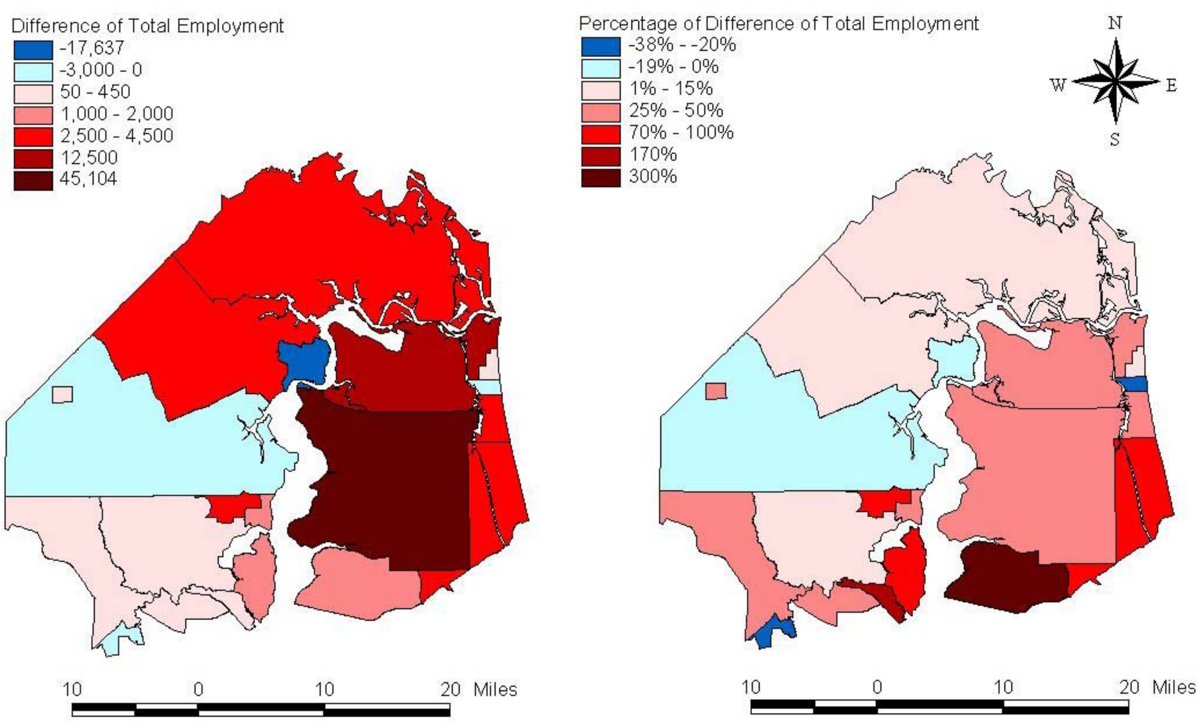

Figure 6.18 Differences in Total Employment Estimations for E+C and 2000 Base Year Models

6.3 Trip Generation Data Update

To better understand the effect of demographic, socioeconomic, and employment data on trip generation, the ZDATA files from the 2000 base year model validated in 2002 were used as the data source to update the corresponding input files in the 2000 E+C model. It was assumed that the data reflected accurately the characteristics of the study area in year 2000 and no additional verification was necessary. The data structures of the ZDATA files mostly remained the same in the 2000 E+C and 2000 base year models. The major difference was that the trip production rate of a household having three and more (3+) cars was explicitly specified in the 2000 base year model. However, as mentioned before, the TAZ structures for these two models differ significantly, which is depicted in Figure 6.19. In the process to convert the data from one zonal structure to the other, the 826 internal TAZs (TAZs 804 to 826 were dummy zones) in the E+C model were matched with those in the 2000 base year model. For the external TAZs (827 to 843), a different approach was developed to compile data associated with the external stations in the E+C model. In the following subsections, the process to compile the data for external-external (E-E) trip, internal-internal (I-I) productions and attractions, and internal-external (I-E) trips are described in detail.

6.3.1 External-external trips

As shown in Figure 6.20, there are 17 external stations in the 2000 E+C model. Because the study area has changed, some of the trips entering/exiting these external stations have become internal trips in the base year model. To take advantage of the numbers of trips modeled in the 2000 base year model for the areas outside the study area of the 2000 E+C model, the traffic volumes from the 2000 base year model were used to develop a more accurate estimate of the E-E trip table. The process involved first identifying the external stations in the 2000 E+C model in the network of the 2000 base year model. Due to the differences in the highway networks, the external stations from the 2000 E+C network were not connected to the network in the 2000 base year model. Therefore, the junctions in the 2000 base year highway network adjacent to the external stations in the 2000 E+C model were considered as the new locations of the external TAZs in this study. The links of facility type 2x or 3x with one end connecting to the identified junctions were designated as the centroid connectors to connect external stations to the 2000 base year highway network. After the external stations were defined, the shortest paths between every 2000 base year model's TAZ located outside the 2000 E+C study area and each of the 17 newly designated external stations were constructed based on the highway congested travel times obtained from the base year model's traffic assignment step. The path with the least travel time determined the external stations to which a given TAZ would be aggregated. Figure 6.21 shows the resulted designations of TAZs as external stations. Note that external station 837 was merged with 842 since they were adjacent to each other and a shortest path for station 837 could not be established without passing through station 842.

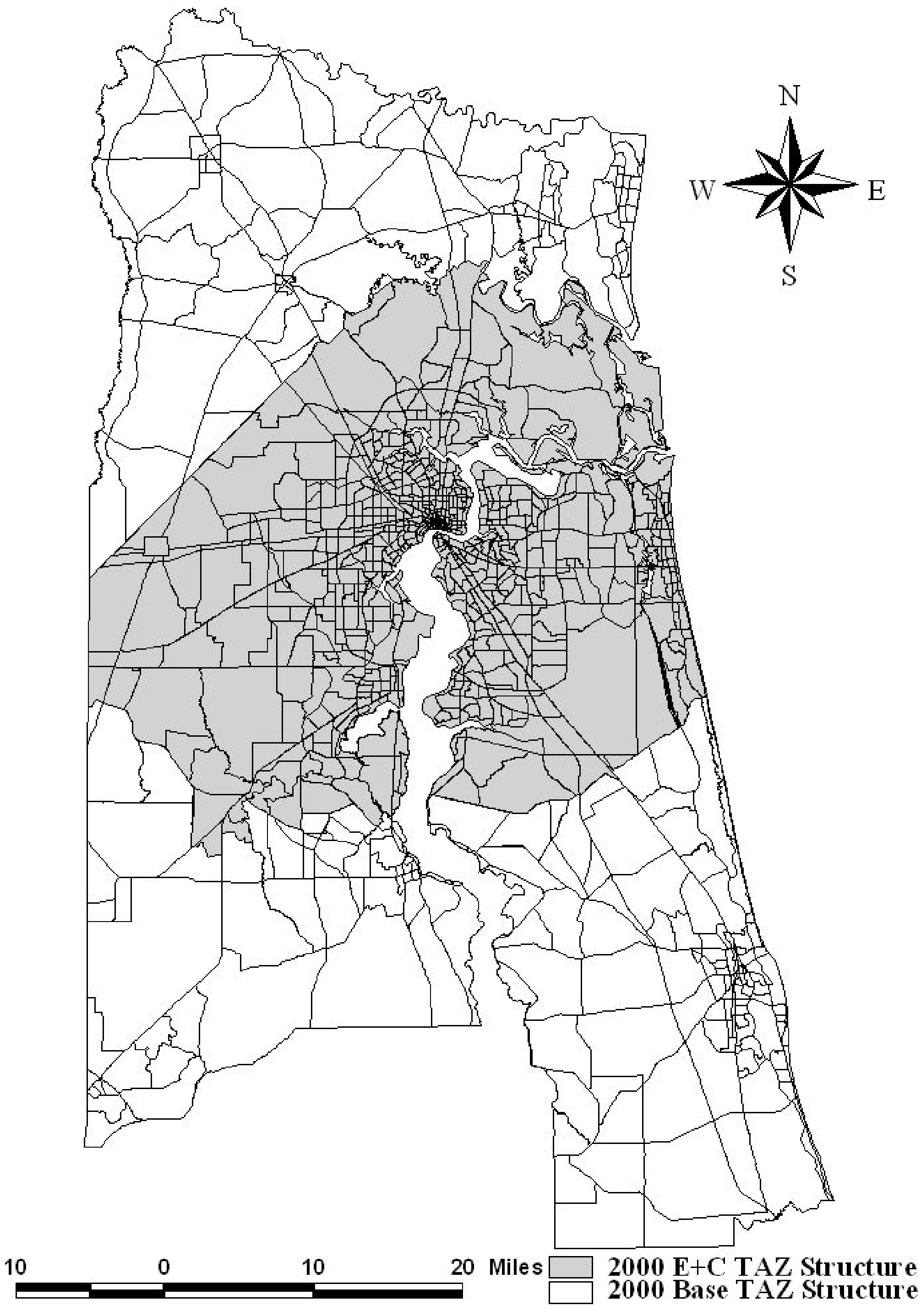

Figure 6.19 TAZ Structures for the 2000 E+C and Base Year Models

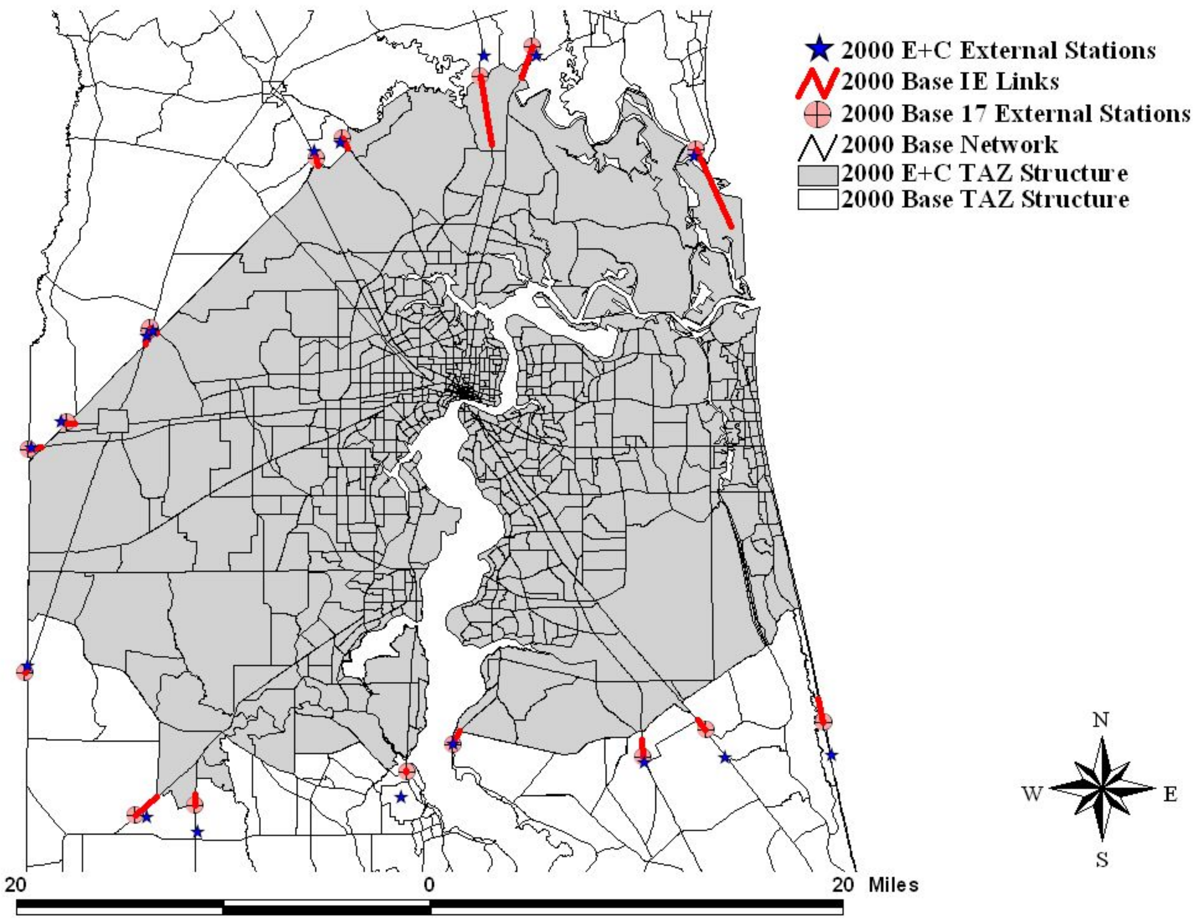

Figure 6.20 External Stations and Links Selected from the 2000 Base Year Model for Compiling IE Trips

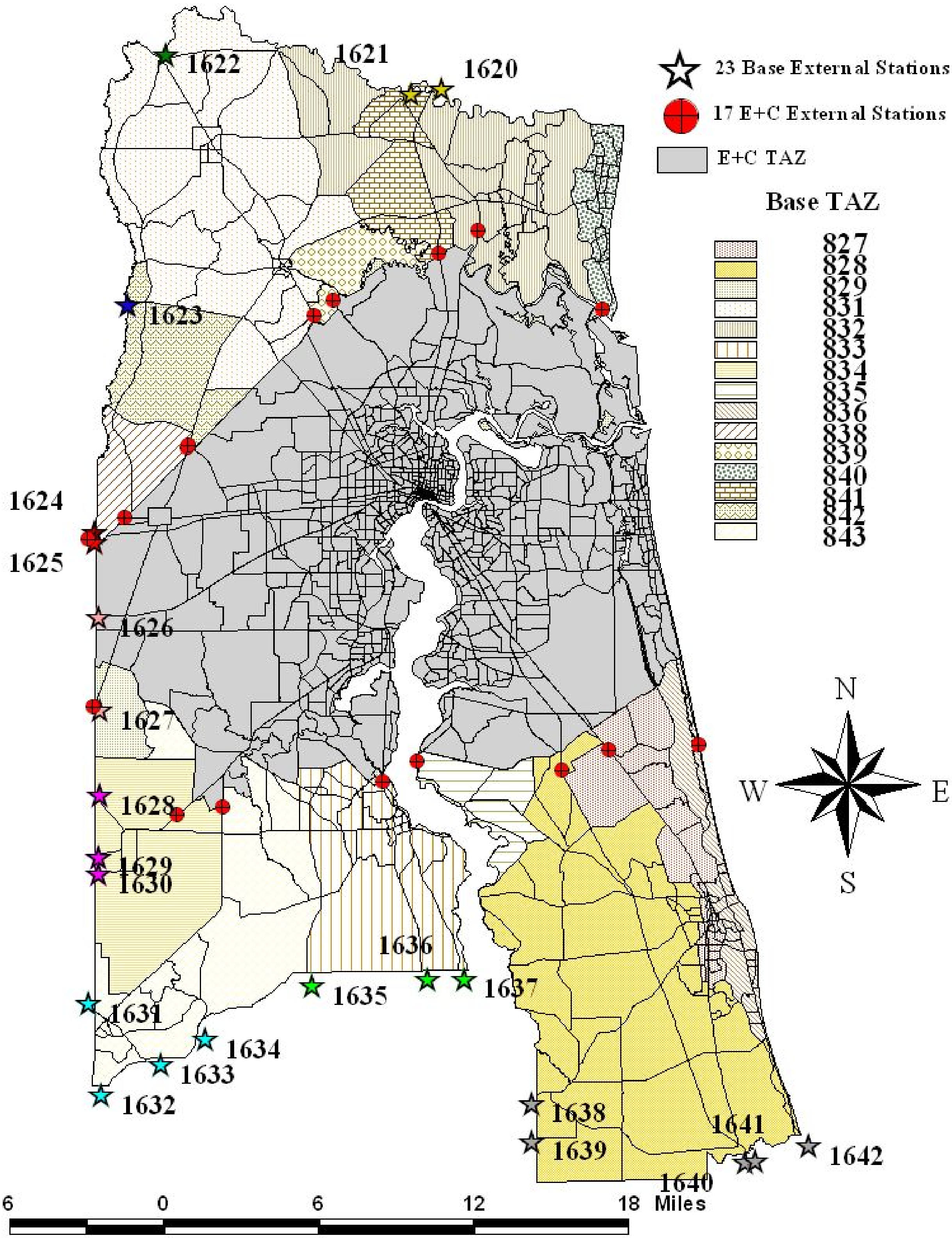

Figure 6.21 Results from TAZ Aggregation

A selected link analysis was performed to identify the origin and destination zones for all trips traversing through the external centroid connectors to enter/exit the E+C study area. First, a set of external centroid connectors was defined in the Equilibrium Highway Load function in the HASSIGN script file. A trip table was then created for these links using the Build Selected Link Trip Table function. The trip table was subsequently compressed from a 1642×1642 matrix to a 17×17 matrix. The region enclosed by the first TAZ in the newly created 17 zone structure represents the area enclosed by the E+C study boundary. Each of the remaining 16 TAZs represents a specific external station previously defined. Finally, the EETRIPS file was updated based on the zonal trips from the trip matrix with TAZ region 1 at neither of the trip ends. The original and updated numbers of EE trips for each external station are shown in Table 6.5.

Table 6.5 Original and Updated EE Trips

Zone	Production/Attraction	
	Original	Updated
827	82	92
828	12,146	20,361
829	2,870	5,241
830	2,376	8,621
831	335	1,832
832	202	48
833	267	447
834	209	6
835	150	46
836	0	0
837	1,163	0
838	171	129
839	118	16
840	0	0
841	13,719	25,960
842	0	0
843	0	0
Total	33,808	62,799

6.3.2 ZDATA1 and ZDATA2 File Update

For every TAZ located within the 2000 E+C study area boundary in the 2000 base year model, a density were calculated for each zonal attribute defined in the ZDATA1 and ZDATA2 files. The attributes for a given zone in the 2000 E+C model were then estimated by multiplying the size of the 2000 base year model TAZs within the 2000 E+C TAZ boundary with the density. For attributes expressed as percentages, such as car ownership, the values were first converted to the original numerical units (e.g., in number of vehicles) before the above procedure was applied.

6.3.3 ZDATA3 File Update

In FSUTMS, the ZDATA3 file defines special generator trips by TAZ. The boundaries of the TAZs in the ZDATA3 file remained basically unchanged in the 2000 E+C and 2000 base year models. Therefore, the special generator trips in the base year model were used directly to update the ZDATA3 file of the E+C model. Table 6.6 shows the number of trips from the ZDATA3 file for the 2000 E+C (i.e., original) and 2000 base year model (i.e., updated). As shown in Table 6.6, several TAZs such as 99 and 149 are no longer in the list of special generators in the base year model, while TAZs such as 193 and 569 have been added as new special generators. Significantly different numbers of trips were specified for TAZs such as 294, 348, and 482.

Table 6.6 Original and Updated Number of Trips in ZDATA3 in the 2000 E+C Model

E+C TAZ Structure		P/A*	HBW	HBS	HBSR	HBO	NHB	Total
99	Original	A	214	214	214	785	0	1,428
	Updated							
149	Original	A	0	12,498	0	0	0	12,498
	Updated							
193	Original	A	2,243	2,243	2,243	8,225	0	14,954
	Updated	A	0	0	0	3,785	1,622	5,407
	Original							
	Updated	P	336	840	840	1,176	168	3,360
294	Origin	A	2,297	2,297	2,297	8,423	0	15,314
	Updated	A	7,763	0	7,763	7,763	7,763	31,050
318	Original	A	0	8,527	0	0	0	8,527
	Updated							
336	Original	A	0	0	0	8,511	0	8,511
	Updated							
348	Original	A	-1,953	0	-977	-977	-15,624	-19,530
	Updated	A	-12,889	0	-6,186	-11,857	-20,622	-51,554
	Original							
	Updated	P	390	390	312	390	78	1,560
482	Original	A	-1,783	0	-892	-892	-14,264	-17,830
	Updated	A	-11,514	0	-4,871	-9,743	-18,157	-44,285
	Original							
	Updated	P	1825	1,825	1,460	1,825	365	7,300
569	Original							
	Updated	P	680	1,700	1,700	2,380	340	6,800
	Original							
	Updated	A	0	0	0	18,403	7,887	26,290
604	Original	A	0	20,475	0	0	0	20,475
	Updated							

* Productions (P) and Attractions (A)

6.3.4 ZDATA4 File Update

In FSUTMS, the ZDATA4 file contains internal-external (IE) trip productions for external traffic analysis zones. Internal-external trips are trips with one trip end inside the study area and the other outside. The ZDAT4 file was updated with the trips between internal zones (i.e., region one) and the external stations from the trip matrix of the E-E trips. Table 6.7 provides the original and updated IE trips for the E+C model. IE trips were significantly reduced when the study area was expanded.

Table 6.7 Original and Updated IE Trips

TAZ in E+C Model	Original IE Trips	Updated IE Trips
827	13,892	12,558
828	32,484	19,614
829	14,356	7,160
830	27,843	29,724
831	13,432	16,422
832	8,436	15,120
833	23,486	16,406
834	13,612	6,712
835	3,824	1,332
836	12,828	14,018
837	1,726	0
838	4,261	2,376
839	7,694	1,294
840	2,122	13,938
841	33,214	11,718
842	1,574	1,416
843	4,758	7,096
Total	219,542	176,904

6.4 Results from FSUTMS Version 5.5

Table 6.8 presents the number of trips estimated by the 2000 E+C model after the ZDATA and EETRIPS files were updated and by the 2000 base year model for each trip purpose. More trips were predicted from the E+C model for every trip purpose other than the IE trips once the input files associated with trip generation were updated. As previously mentioned, the study area for the 2000 E+C model was much smaller than that defined in the 2000 base year model. The reduction in IE trips may be due to two possible causes. One is that population and employment growth has occurred within the original urban boundary as defined in the E+C model and the employment growth or redistribution has resulted in people making more trips within the original urban boundary. The other possibility is that growth in population and employment has occurred mostly outside the original urban boundary, resulting in increased trip destinations outside the original urban boundary. Instead of traveling to the urban area for work, shopping, etc., roadway users may find alternative locations outside the original urban area boundary to meet their daily needs. The results in Table 6.8 also suggest that there may be significantly more HBO and NHB trips after the study area was expanded.

Table 6.8 Number of Trips by Trip Purpose from the 2000 E+C Model and 2000 Base Year Model

Trip Purpose	2000 E+C Model		2000 Base Year Model
	Updated Input	Original Input	
HBW	701,954	620,492	734,188
HBS	452,975	402,640	472,020
HBSR	447,983	403,714	457,769
HBO	697,366	630,293	994,955
NHB	737,512	673,538	1,023,960
Truck/Taxi	336,175	292,768	345,477[1]
I-E	176,904	219,542	88,431[2]
Total Trips	3,550,869	3,242,987	4,116,800

1. 4-wheel trucks + single unit truck + combination truck
2. SOIE-P + HOIE-P + LDIE-P + HDIE-P

With the updated ZDATA files, the 2000 E+C model estimated 300,000 more trips. It is clear that the data in the ZDATA and EETRIPS files significantly impacted the results from a travel demand analysis when other influential factors such as network coding and model parameters were controlled. For a fast growing urban area in Florida like Jacksonville, the transportation demand models developed in the past are likely to underestimate the overall number of trip produced since socioeconomic, demographic, and employment data may be underestimated.

The results from trip distribution before and after the input files for trip generation were updated are given in Table 6.9. There is an increase in the number of intrazonal trips and a decrease in the average trip length. The reduction in the average trip length suggests that the 2000 E+C model allowed more trips to reach their destinations with less time. One probable explanation to this interesting finding is that the gravity model relies on the productions and attractions estimated for TAZs in the study area. After the ZDATA and EETRIPS files were updated, the number of trips allocated by the gravity model to a given zone pair changed as well. A significantly different travel pattern may thus be obtained from the E+C model. Note that the traffic network for the 2000 E+C model was not updated; therefore the effect of the network on trip distribution was not considered.

Table 6.9 Forecast 2000 Trip Distribution Statistics with Updated ZDATA

Trip Purpose	2000 Model	Total Trips	Intrazonal Trips	Average Trip Length
HBW[1]	Updated	701,954	13,672	19.194
	Original	620,492	8,110	19.425
HBW[2]	Updated	701,954	17,072	21.203
	Original	620,492	9,048	21.260
HBS	Updated	452,975	23,892	12.351
	Original	402,640	15,272	13.510
HBSR	Updated	447,983	10,635	14.821
	Original	403,714	6,597	15.376
HBO	Updated	697,366	26,788	16.115
	Original	630,293	18,011	16.665
NHB	Updated	737,512	36,486	14.943
	Original	673,538	32,688	14.985
T/T	Updated	336,175	22,869	14.217
	Original	292,768	18,630	14.191
E-I	Updated	176,904	-	38.917
	Original	219,542	-	38.578

1 First pass for pre-loaded highway network

2 Congested highway network.

Table 6.10 shows the number of person trips that traveled by cars. As expected, more auto trips were observed from the updated 2000 E+C model since more trips were derived from the trip generation step. Table 6.11 summarizes the transit usage statistics of the daily work trips and non-work trips for the local and express bus modes. The results indicate a decrease in the number of transit trips estimated by the mode choice model. One may tend to reach the conclusion that the mode choice model in FSUTMS was not calibrated properly. However, since highway travel time is a major factor in determining the proportion of trips allocated to the transit mode, a decrease in average trip length from the trip distribution step suggests that more trips may be allocated to the auto mode.

Table 6.10 Forecast 2000 Highway Person Trips with Updated ZDATA

Highway Mode	2000 E+C Model	Trip Purpose			Total
		HBW	HBNW	NHB	
Drive Alone	Updated	572,161	650,131	453,816	1,676,108
	Original	504,420	585,199	411,140	1,500,759
Drive w/ 1 Passenger (2 persons)	Updated	82,162	362,483	148,196	592,841
	Original	74,672	329,325	133,517	537,513
Drive w/ 2 Passenger (3+ persons)	Updated	22,949	510,772	86,545	620,266
	Original	21,221	466,092	77,794	565,107
Total	Updated	684,780	1,537,261	700,768	2,922,809
	Original	611,290	1,396,691	640,015	2,647,996

Table 6.11 Forecast 2000 Daily Transit Usage Statistics with Updated ZDATA

Trip Purposes	Transit Mode	2000 E+C Model	Passengers		
			Trips	Miles	Hours
Work Trips	Local Bus	Updated	8,361	32,095	1,381
		Original	12,406	47,916	2,152
	Express Bus	Updated	706	5,359	233
		Original	1,044	8,666	401
	ASE	Updated	1,229	988	67
		Original	1,761	1,393	95
	Subtotal	Updated	10,296	38,442	1,681
		Original	15,211	57,975	2,648
Non-Work Trips	Local Bus	Updated	29,390	86,841	3,465
		Original	38,056	106,885	4,266
	ASE	Updated	14,275	12,799	870
		Original	18,007	15,633	1,061
	Subtotal	Updated	43,665	99,640	4,335
		Original	56,063	122,518	5,327
Total		Updated	53,961	138,082	6,016
		Original	71,274	180,493	7,975

Figure 6.22 illustrates the average differences between the traffic volumes projected from the updated E+C model and the PSWADT counts. Again, the volume discrepancy was first calculated in absolute value for each direction on a bi-directional roadway segment. The average of the absolute differences from both directions was then calculated, as shown in Figure 6.22. The largest discrepancy was 17,813 vehicles per day, which was about the same as the original E+C model. Compared with Figure 5.2, Figure 6.22 reveals a better match between the projected traffic volumes and PSWADTs since fewer links exhibited large traffic volume discrepancies. Figure 6.23 shows the differences in percentage by dividing the volume discrepancies illustrated in Figure 6.22 by the average of the PSWADTs for both directions on a given link. Compared with Figure 5.3, Figure 6.23 also shows a better match of the projected traffic volumes with the PSWADTs. Therefore, the performance of the E+C model improved when the associated ZDATA and EETRIPS files were updated. The results shown in Figures 6.22 and 6.23 suggest that future growth in population and employment as well as land use development in an urban area should be accurately estimated during model validation. The data should also be updated frequently to better consider the effect of socioeconomic and demographic characteristics on travel demand modeling.

Tables 6.12 and 6.13 give the number of links for categorized difference in volume discrepancy shown in Figure 6.23 by area and facility type, respectively. The results show that fewer links exhibited large discrepancies between observed and modeled traffic volumes after the ZDATA and EETRIPS files were updated.

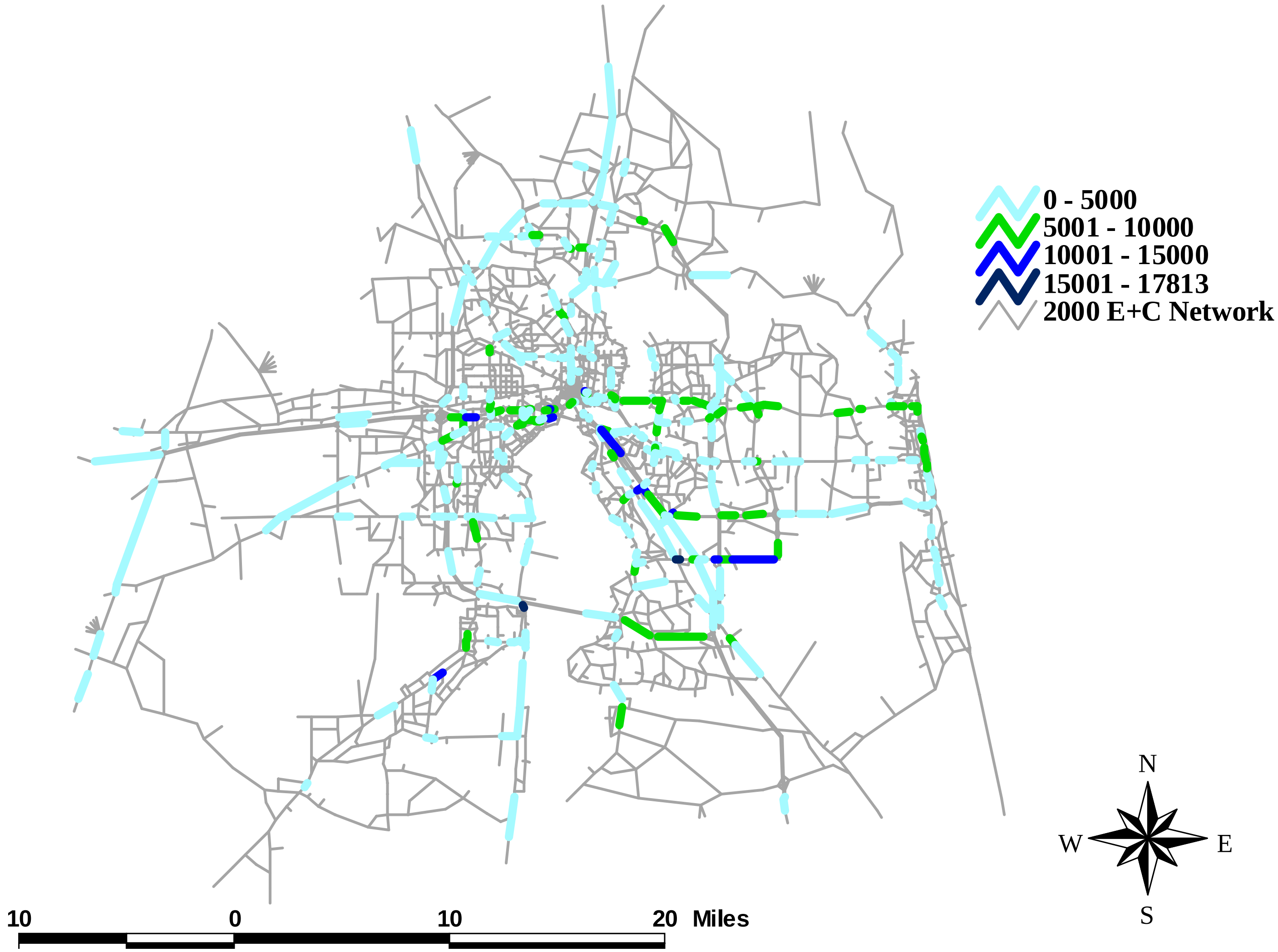

Figure 6.22 Volume Difference over PSWADT for the 2000 E+C Model with Updated ZDATA Files

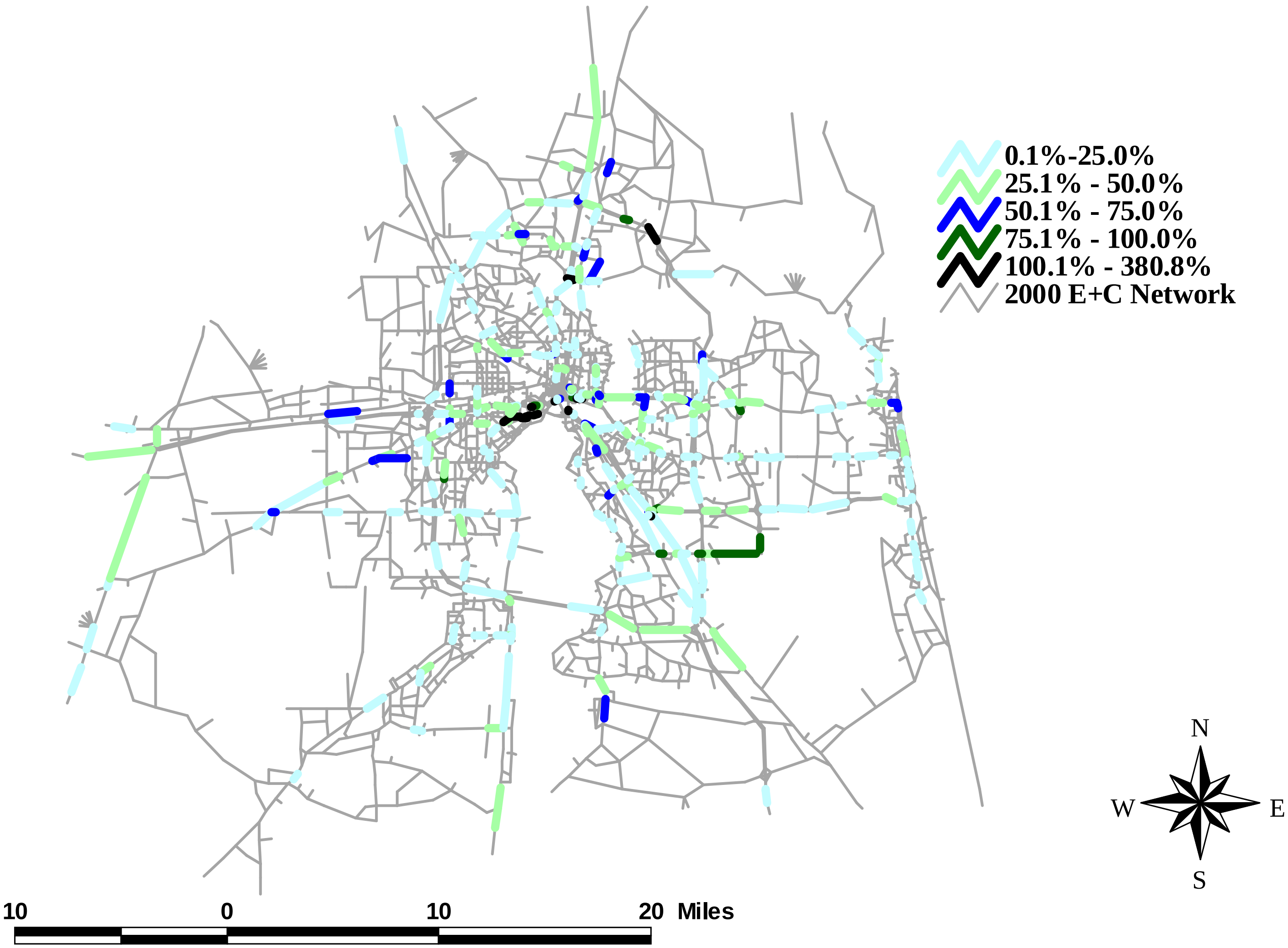

Figure 6.23 Volume Differences as Percentages of PSWADTs for the 2000 E+C Model with Updated ZDATA Files

Table 6.12 Volume Discrepancies by Area Type for the 2000 E+C Model with Updated ZDATA

Difference	Area Type				
	1x	2x	3x	4x	5x
0~5,000	9	26	142	22	39
5,001~10,000	-	19	42	6	3
10,001~15,000	-	6	4	1	-
15,001~17,813	-	-	2	-	-

Table 6.13 Volume Discrepancies by Facility Type for the 2000 E+C Model with Updated ZDATA

Difference	Facility Type				
	1x	2x	3x	4x	6x
0~5,000	59	133	31	5	10
5,001~10,000	23	37	10	-	-
10,001~15,000	4	6	1	-	-
15,001~17,813	-	2	-	-	-

6.5 Summary

There were some significant differences between the socioeconomic, demographic, and employment data projected for the 2000 E+C model and Census 2000. These zonal attributes were updated based on the data compiled from the 2000 base year model. Also updated were the IE and EE trips to better reflect the travel patterns in year 2000 due to the changes in the boundary of the urban area. The results from the 2000 E+C model before and after revising the necessary input data were then compared. The results from the comparison show that the number of trips was underestimated in the 2000 E+C model for every trip purpose except the IE and EE trips. It is typical to find a transportation demand model developed in the past that would underestimate the overall number of trip generated since the relevant socioeconomic, demographic, and employment data were likely underestimated for a fast growing urban area in Florida like Jacksonville. The effect of the zonal attributes specified in the ZDATA and EETRIPS files yielded a reduction in average trip length after they were updated. Consequently, fewer transit trips were estimated by the 2000 E+C model. It is not sufficient, however, to reach the conclusion that the mode choice model in FSUTMS was not calibrated properly.

7. INCORPORATION OF COMMITTED IMPROVEMENTS

This task is to determine whether all committed highway improvements projected in the 2000 E+C network have been implemented as scheduled and whether the network realistically reflects the actual highway network in 2000. The 2000 E+C highway network was compared with the 2002 validated model network. Because the study area of the 2002 validated model is much larger than that of the 1995 model, only the links within the study area of the 2000 E+C network are considered.

7.1 Network Update

A total of 5,965 one-way links were examined manually on a link by link basis. Figure 7.1 shows the links in the 2000 E+C network that could not be identified in the network from the 2002 study, which may represent highway improvements that were projected but were never implemented. Links that were added to the 2000 E+C network during the 2002 model validation were also identified. Figures 7.2 and 7.3 illustrate these additional links using the 2000 E+C and the 2000 base year networks as the background layers, respectively. These links may represent projects that were not in the 2000 E+C network but were implemented. Some of these additional links may also represent the roadway segments that already existed prior to the 1995 model validation but have been intentionally excluded. Figure 7.4 identifies the links with changed number of lanes in the network developed for the 2000 base year model validated in 2002. These links were updated to reflect the traffic network condition in 2000.

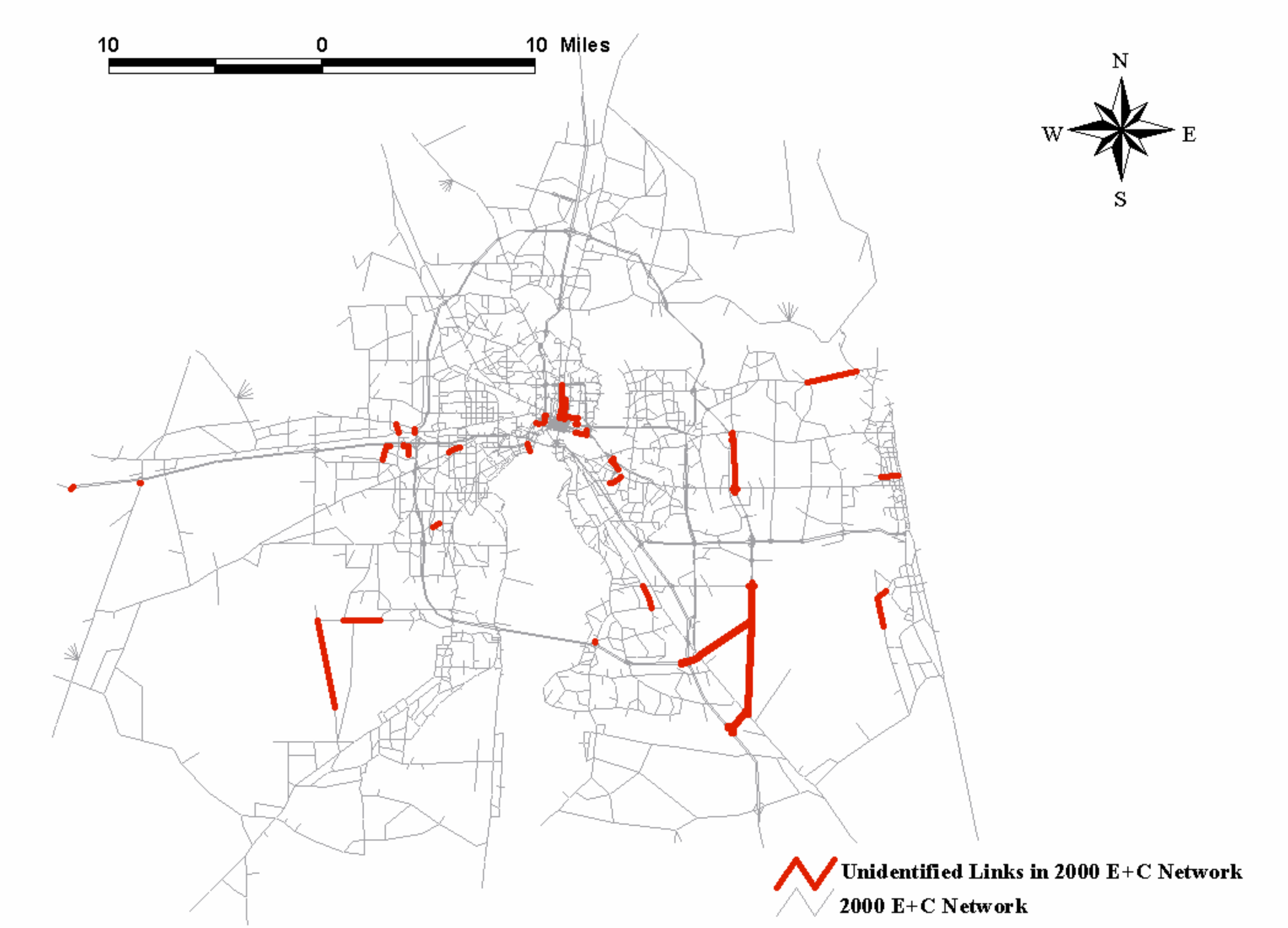

Figure 7.1 Unidentified Highway Links in the 2000 E+C Network

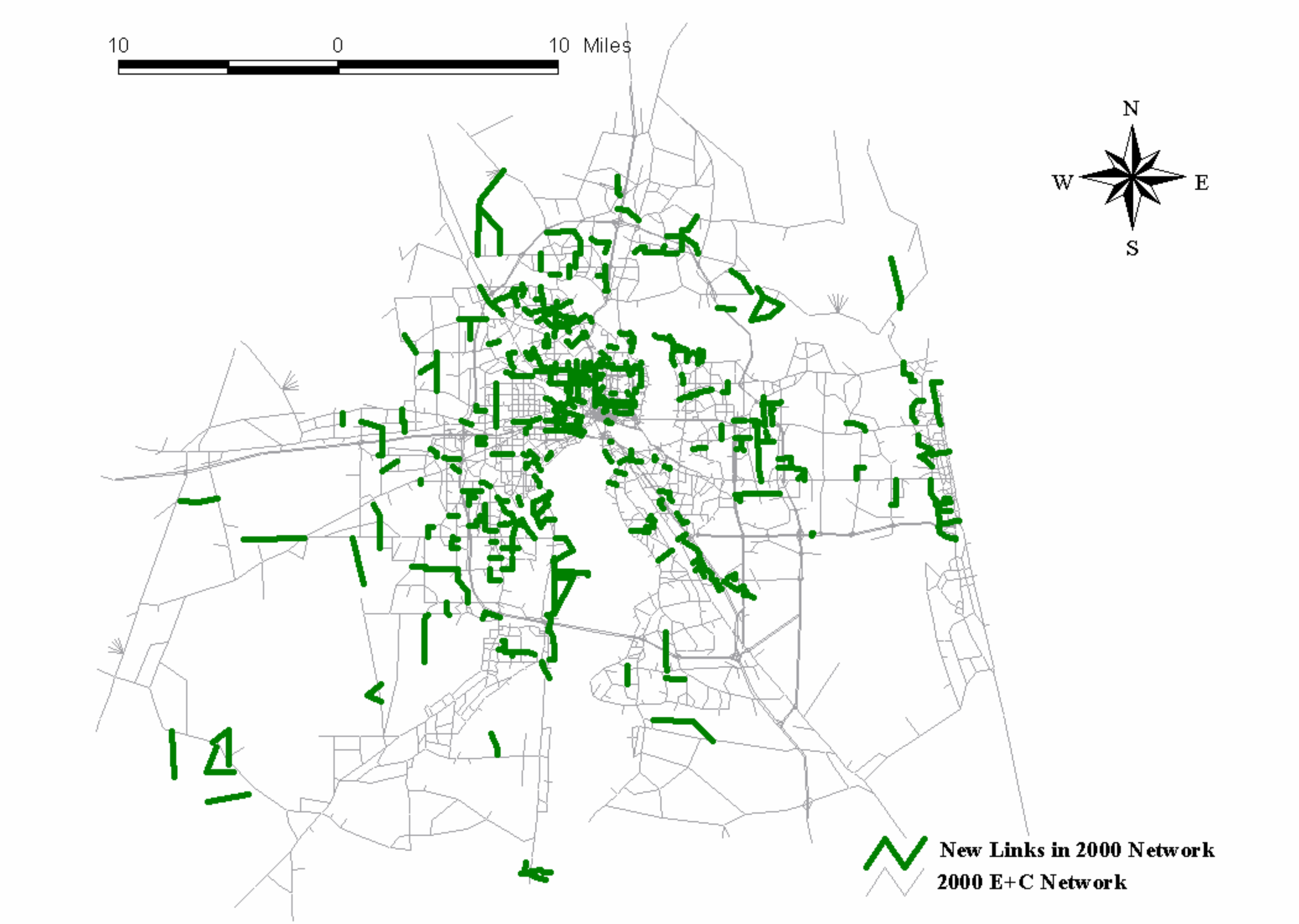

Figure 7.2 Additional Highway Links Identified in the 2000 E+C Network

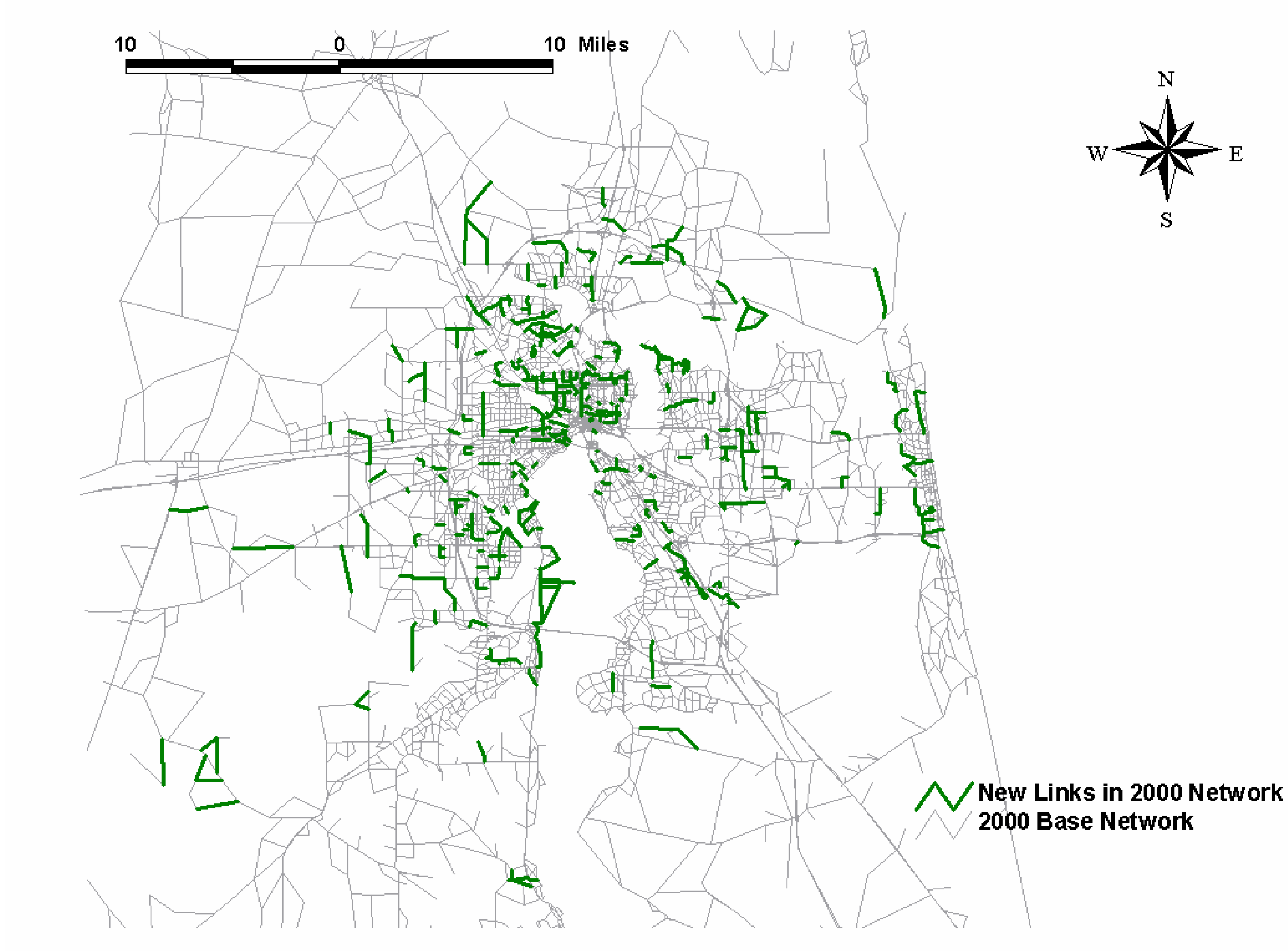

Figure 7.3 Additional Highway Links Identified in the 2000 Base Year Network

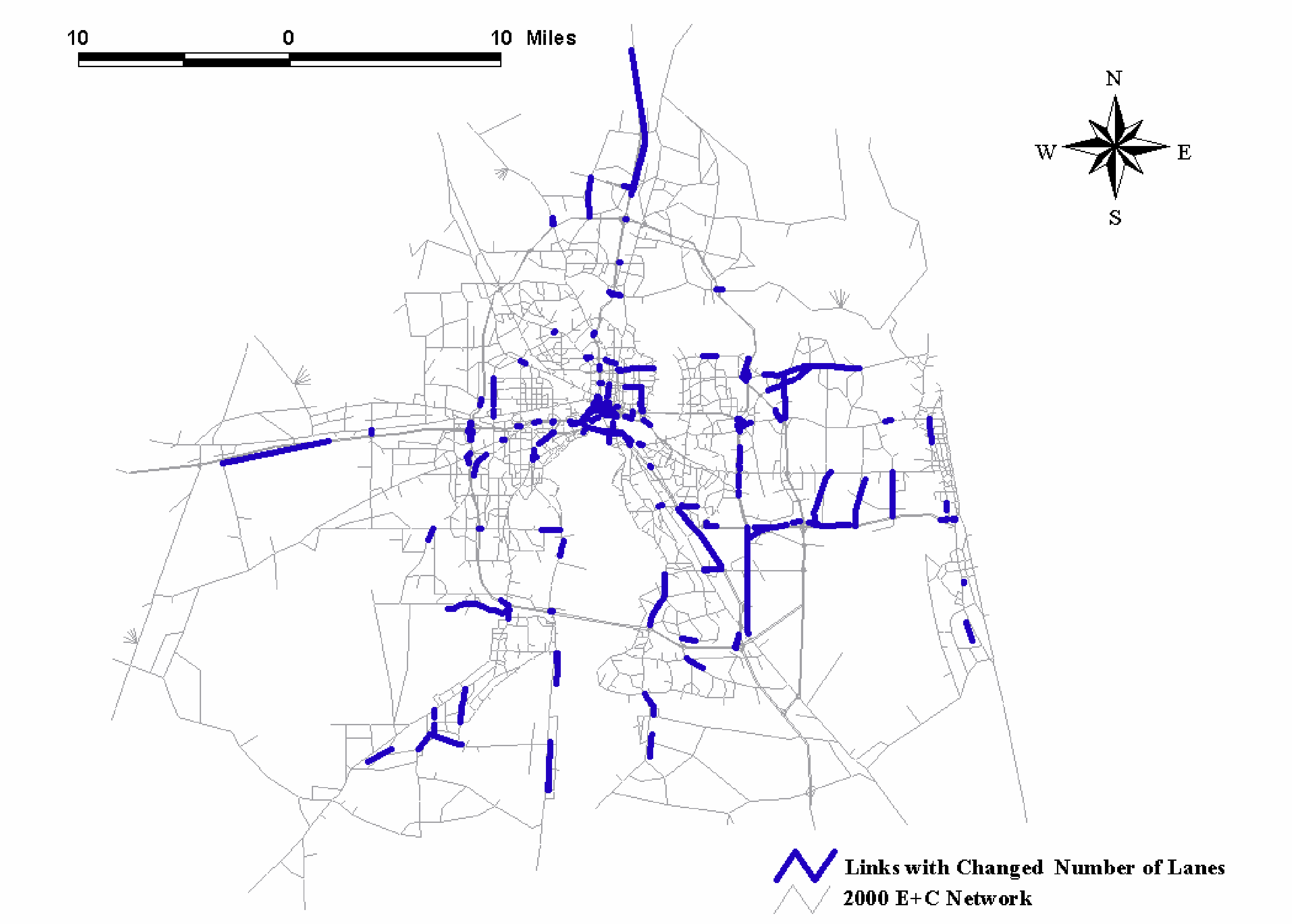

Figure 7.4 Links with Changed Number of Lanes in the 2000 E+C Network

Table 7.1 summarizes the number of links by facility type that differ between the 2000 E+C and 2000 base year networks as shown in Figures 7.1 to 7.4. The results from this task indicate that, in addition to zonal socioeconomic and demographic data, the highway network is also significantly different from the existing condition in the projected year.

Table 7.1 Number of Links by FT with Network Discrepancies

FT	Description	Number of Links		
		Undefined*	Additional**	Change in Number of Lanes
1	Freeway	35	0	66
2	Divided Arterial	12	0	162
3	Undivided Arterial	18	60	124
4	Collector	37	2,300	222
5	Centroid Connector***	0	0	0
6	One-way Street	0	52	52
7	Ramp	0	58	58

* Undefined in 2000 E+C network.
** Additional links in 2000 base year network.
*** FT 5 links were excluded from the comparison.

7.2 Results from FSUTMS Version 5.5

Table 7.2 shows the trip distribution results obtained from the 2000 E+C model after the highway network was updated. More introzonal trips and a higher average trip length were obtained for some trip purposes. This may be counterintuitive since a transportation system should provide better service when improvements were made and demand was fixed. However, since some of the projected improvements to the roadway did not take place as scheduled, the network was not truly improved but simply updated to better reflect the network existed in year 2000. The additional links that were not specified in the original E+C network are present in the 2000 base year network may either represent projects that were not included in the original roadway improvement plan or removed for the purpose of reducing the complexity of network coding during the 1995 model validation effort.

Table 7.2 Trip Distribution Statistics for Model with Updated Network

Trip Purpose	2000 Model	Total Trips	Intrazonal Trips	Average Trip Length
HBW[1]	Updated	620,492	8,344	19.512
	Original	620,492	8,110	19.425
HBW[2]	Updated	620,492	9,959	22.208
	Original	620,492	9,048	21.260
HBS	Updated	402,640	15,412	13.631
	Original	402,640	15,272	13.510
HBSR	Updated	403,714	6,933	15.370
	Original	403,714	6,597	15.376
HBO	Updated	630,293	18,585	16.714
	Original	630,293	18,011	16.665
NHB	Updated	673,538	33,130	14.998
	Original	673,538	32,688	14.985
T/T	Updated	292,768	19,029	14.202
	Original	292,768	18,630	14.191
E-I	Updated	219,542	-	39.114
	Original	219,542	-	38.578

1 First pass for pre-loaded highway network
2 Congested highway network.

The number of people that would travel by the auto mode is summarized in Table 7.3. The differences between the original and updated model estimates were not significant. Table 7.4 provides the number of transit trips estimated by the 2000 E+C model before and after the highway network was update. Table 7.4 also does not reveal any noticeable differences between the results obtained from the original and updated E+C models.

Table 7.3 Highway Person Trips for Model with Updated Network

Highway Mode	2000 Model	Trip Purpose			Total
		HBW	HBNW	NHB	
Drive Alone	Updated	503,875	585,340	411,083	1,500,299
	Original	504,420	585,199	411,140	1,500,759
Drive w/ 1 Passenger (2 persons)	Updated	74,358	328,959	133,303	536,620
	Original	74,672	329,325	133,517	537,513
Drive w/ 2 Passenger (3+ persons)	Updated	21,232	465,220	77,612	564,064
	Original	21,221	466,092	77,794	565,107
Total	Updated	610,373	1,395,635	639,573	2,645,581
	Original	611,290	1,396,691	640,015	2,647,996

Table 7.4 Daily Transit Usage Statistics for Model with Updated Network

Trip Purposes	Transit Mode	2000 Model	Passengers		
			Trips	Miles	Hours
Work Trips	Local Bus	Updated	12,349	46,980	2,350
		Original	12,406	47,916	2,152
	Express Bus	Updated	1,071	8,813	473
		Original	1,044	8,666	401
	ASE	Updated	1,762	1,386	94
		Original	1,761	1,393	95
	Subtotal	Updated	15,182	57,179	2,917
		Original	15,211	57,975	2,648
Non-Work Trips	Local Bus	Updated	38,021	106,796	4,272
		Original	38,056	106,885	4,266
	ASE	Updated	18,068	15,674	1,064
		Original	18,007	15,633	1,061
	Subtotal	Updated	56,089	122,470	5,336
		Original	56,063	122,518	5,327
Total		Updated	71,271	179,649	8,253
		Original	71,274	180,493	7,975

Figure 7.5 illustrates the average differences between the traffic volumes projected from the updated E+C model and the PSWADT counts. The largest discrepancy was 17,084 vehicles per day, which was about the same as the original E+C model. Compared with the results shown in Figure 5.2 from the original E+C model, Figure 7.5 reveals a better match between the projected traffic volumes and PSWADTs after the highway network was updated since fewer links had large traffic volume discrepancies. Figure 7.6 shows the differences as percentages of the PSWADTs for both directions on a given link. Compared with Figure 5.3, Figure 7.6 also shows a better match of projected traffic volumes with PSWADTs. Therefore, the performance of the 2000 E+C model improved when the highway network was updated. The results shown in Figures 7.5 and 7.6 suggest that future improvement on an urban area's highway infrastructure should be accurately specified. The network should also be updated promptly to reflect the up-to-date traffic conditions.

Tables 7.5 and 7.6 give the number of links with volume discrepancy in different ranges as by area and facility type, respectively. It may be seen that fewer links had large discrepancies between observed and modeled traffic volumes after the E+C highway network was updated.

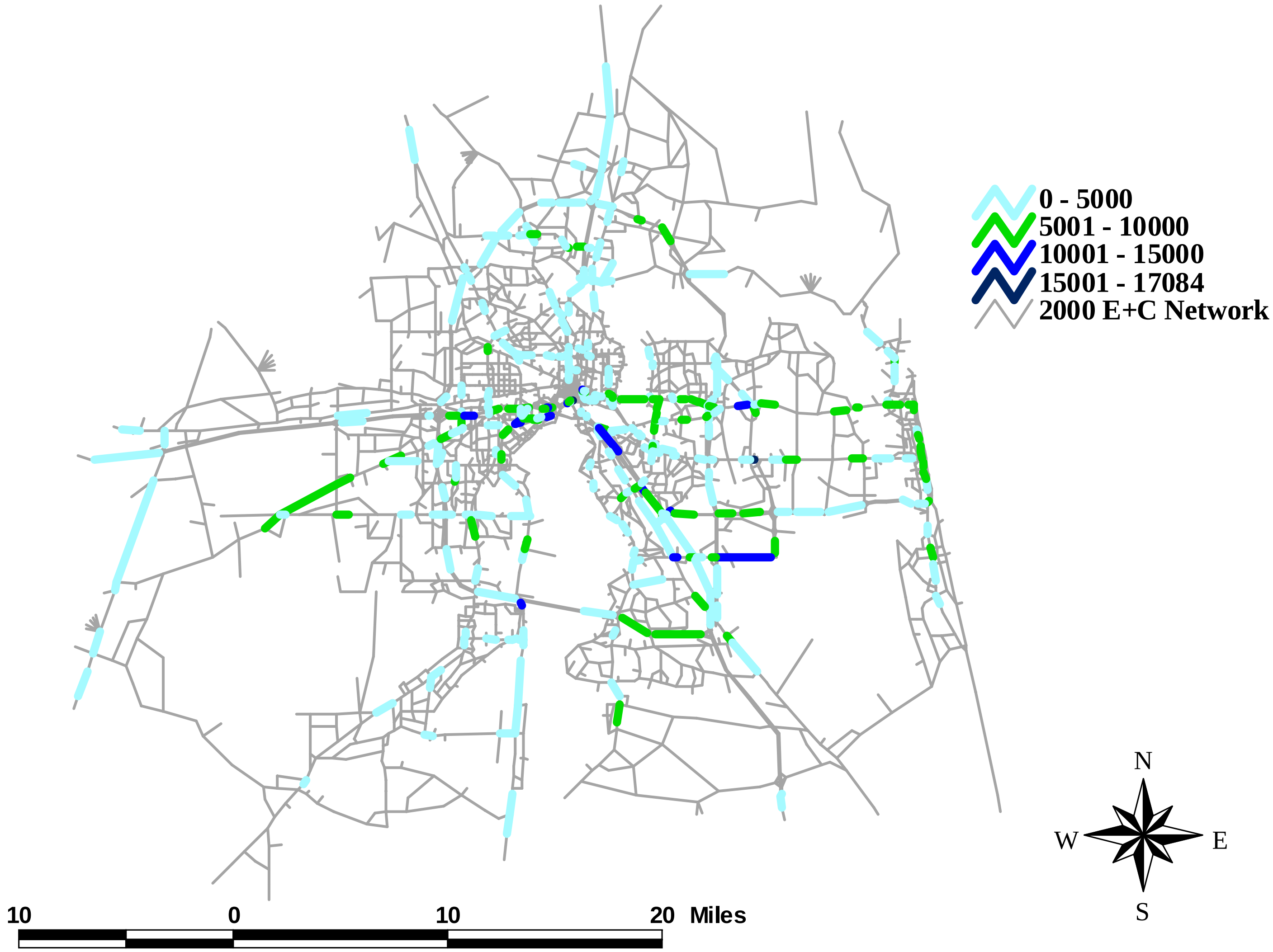

Figure 7.5 Difference between Predicted Volumes and PSWADTs for the 2000 E+C model with Updated Network

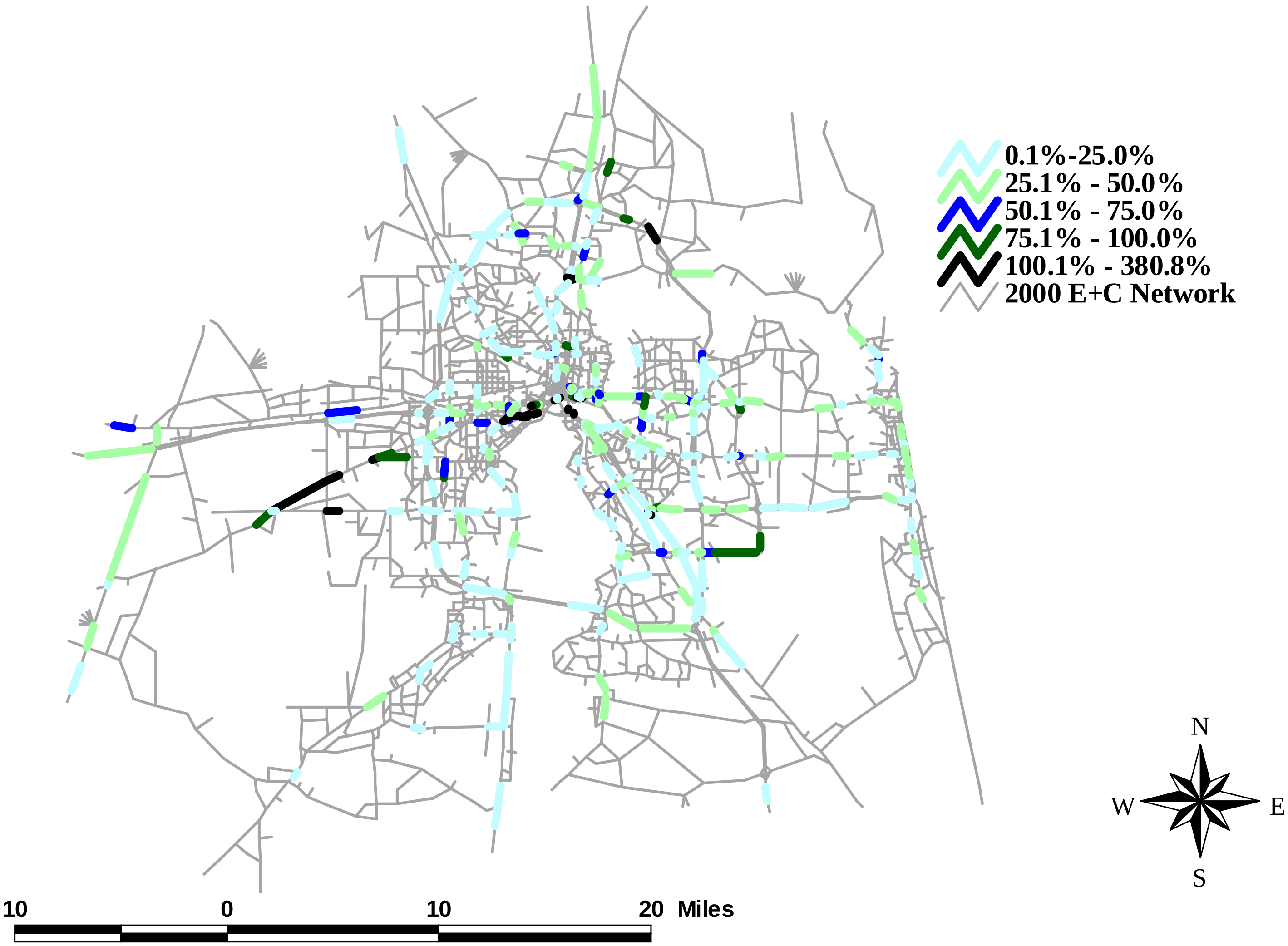

Figure 7.6 Difference between Predicted Volumes and PSWADTs in Percentage for the 2000 E+C Model with Updated Network

Table 7.5 Volume Discrepancies by Area Type for the 2000 E+C Model with Updated Network

Difference	Area Type				
	1x	2x	3x	4x	5x
0~5,000	8	27	135	25	32
5,001~10,000	-	17	46	4	10
10,001~15,000	-	7	8	-	-
15,001~17,084	1	-	1	-	-

Table 7.6 Volume Discrepancies by Facility Type for the 2000 E+C Model with Updated Network

Difference	Facility Type				
	1x	2x	3x	4x	6x
0~5,000	59	122	31	5	10
5,001~10,000	23	45	9	-	-
10,001~15,000	4	9	2	-	-
15,001~17,084	-	2	-	-	-

7.3 Summary

In this Chapter, the 2000 E+C network was updated based on the 2000 base year network constructed in the 2002 model validation effort. The results from the network comparison step indicate that some projected improvements to the highway networks were not completed as scheduled and the network effect on the distribution patterns varied among trips with different purposes. The updated highway network resulted in a decrease in transit trips and a better match between the modeled and observed traffic counts.

8. EFFECT OF TWO-DIGIT CODING

The two-digit coding system, original recommended by the Florida Model Task Force, allowed more area and facility types to be specified in FSUTMS. Its effect on the performance of the 2000 E+C model was evaluated in this study. The SPDCAP file in the 2000 base year model was used to run the 2000 E+C model with FSUTMS Version 5.5. The area and facility types of each link in the 2000 E+C network that have been updated with the necessary improvements as described in Section 7 were modified based on those specified for the corresponding link in the 2000 base year model.

8.1 Results from FSUTMS 5.5

Table 8.1 presents the results from trip distribution before and after the two-digit coding was implemented in the E+C model. The results indicate an increase in both intrazonal trips and average trip length for every trip purpose. These were the result of a lower free-flow speed for most of the combinations of area and facility types in SPDCAP.

Table 8.1 Forecast 2000 Trip Distribution Statistics with Two-Digit Coding

Trip Purpose	2000 Model	Total Trips	Intrazonal Trips	Average Trip Length
HBW[1]	Updated	620,492	9,436	21.694
	Original	620,492	8,110	19.425
HBW[2]	Updated	620,492	11,758	25.365
	Original	620,492	9,048	21.260
HBS	Updated	402,640	20,911	16.059
	Original	402,640	15,272	13.510
HBSR	Updated	403,714	8,909	16.226
	Original	403,714	6,597	15.376
HBO	Updated	630,293	21,432	18.504
	Original	630,293	18,011	16.665
NHB	Updated	673,538	37,197	16.607
	Original	673,538	32,688	14.985
T/T	Updated	292,768	20,920	15.525
	Original	292,768	18,630	14.191
E-I	Updated	219,542	-	43.648
	Original	219,542	-	38.578

[1] First pass for pre-loaded highway network
[2] Congested highway network.

Table 8.2 gives, by trip purpose, the number of people travel by the auto mode with the network links coded according to the two-digit and one-digit coding schemes. Table 8.3 is similar to Table 8.2 except that the trips are transit trips instead of auto trips. Because of the reduction in the free-flow speed, more trips, especially the HBNW trips, were allocated to the transit mode.

Table 8.2 Forecast 2000 Highway Person Trips with Two-Digit Coding

Highway Mode	2000 Model	Trip Purpose			Total
		HBW	HBNW	NHB	
Drive Alone	Two-Digit Coding	503,671	583,145	408,691	1,495,507
	One-Digit Coding	504,420	585,199	411,140	1,500,759
Drive w/ 1 Passenger (2 persons)	Two-Digit Coding	72,892	325,503	131,806	530,201
	One-Digit Coding	74,672	329,325	133,517	537,513
Drive w/ 2 Passenger (3+ persons)	Two-Digit Coding	20,586	459,170	76,558	556,313
	One-Digit Coding	21,221	466,092	77,794	565,107
Total	Two-Digit Coding	608,555	1,385,318	635,794	2,629,667
	One-Digit Coding	611,290	1,396,691	640,015	2,647,996

Table 8.3 Forecast 2000 Daily Transit Usage Statistics with Two-Digit Coding

Trip Purposes		2000 Model	Passengers		
			Trips	Miles	Hours
Work Trips	Local Bus	Two-Digit Coding	12,586	46,386	2,693
		One-Digit Coding	12,406	47,916	2,152
	Express Bus	Two-Digit Coding	1,228	9,529	532
		One-Digit Coding	1,044	8,666	401
	ASE	Two-Digit Coding	1,982	1,600	108
		One-Digit Coding	1,761	1,393	95
	Subtotal	Two-Digit Coding	15,796	57,515	3,333
		One-Digit Coding	15,211	57,975	2,648
Non-Work Trips	Local Bus	Two-Digit Coding	41,561	113,629	4,969
		One-Digit Coding	38,056	106,885	4,266
	ASE	Two-Digit Coding	20,126	18,412	1,247
		One-Digit Coding	18,007	15,633	1,061
	Subtotal	Two-Digit Coding	61,687	132,041	6,216
		One-Digit Coding	56,063	122,518	5,327
Total		Two-Digit Coding	77,483	189,556	9,549
		One-Digit Coding	71,274	180,493	7,975

Figure 8.1 illustrates the average differences between the modeled and observed traffic volumes. Figure 8.2 shows the differences as a percentage of the PSWADTs for both directions on a given link. The largest difference was 17,254 vehicles per day, which was about the same as the original E+C model. Tables 8.4 and 8.5 list the number of links with volume discrepancies in different ranges by area and facility type, respectively. In Chapter 9, several test statistics were calculated to gain a better picture of the overall performance of the E+C model.

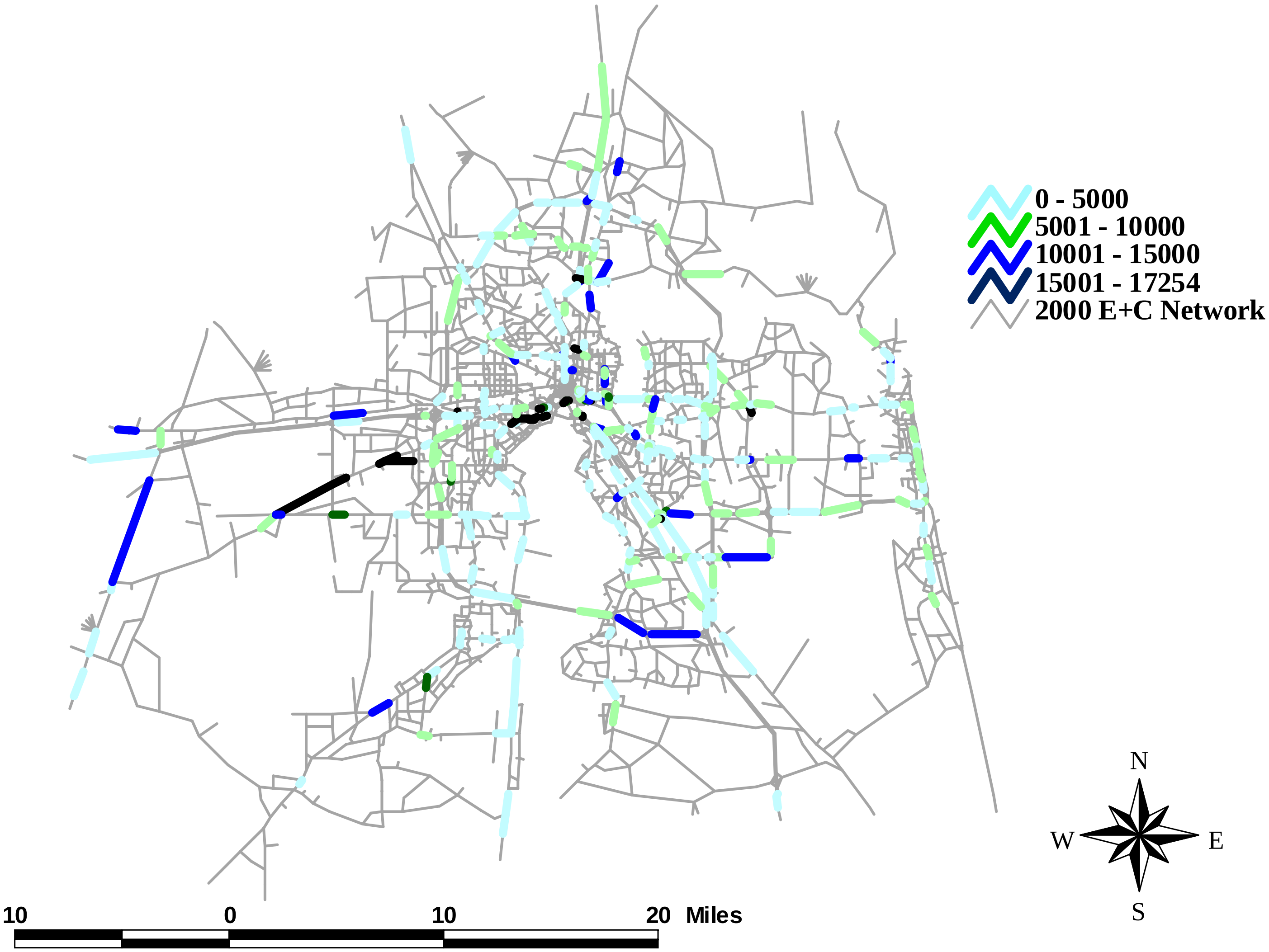

Figure 8.1 Volume Differences for the 2000 E+C Model with Two-Digit Coding

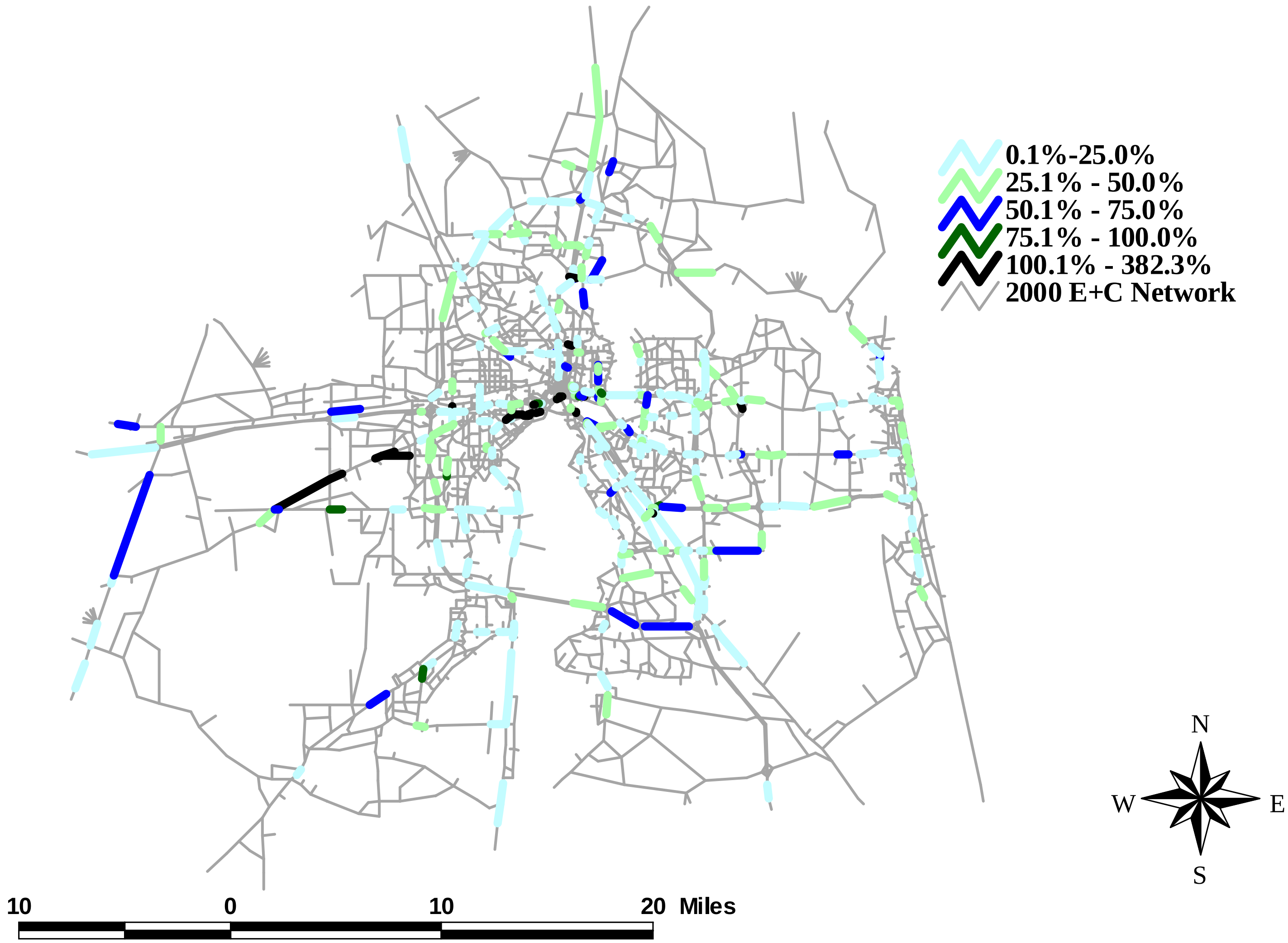

Figure 8.2 Volume Differences as Percentages of PSWADT for the 2000 E+C Model with Two-Digit Coding

Table 8.4 Volume Discrepancies by Area Type for the 2000 E+C Model with Two-Digit Coding

Difference	Area Type				
	1x	2x	3x	4x	5x
0~5,000	8	37	137	20	35
5,001~10,000	1	9	47	9	4
10,001~15,000	-	5	4	-	2
15,001~17,254	-	-	2	-	1

Table 8.5 Volume Discrepancies by Facility Type for the 2000 E+C Model with Two-Digit Coding

Difference	Facility Type				
	1x	2x	3x	4x	6x
0~5,000	62	126	35	4	10
5,001~10,000	18	44	7	1	-
10,001~15,000	4	7	-	-	-
15,001~17,254	2	1	-	-	-

8.2 Summary

In this chapter, the 2000 E+C network updated in Chapter 7 was used to test the effect of two-digit area and facility coding schemes on the model output. The effect of ZDATA files was not considered here as the original demographic/socioeconomic data were used to run the E+C model. The area and facility types of the E+C network links were first revised based on the 2000 base year model. The speed and capacity table in the 2000 base year model was assumed correct and used in running the E+C model without further verification.

The results from FSUTMS revealed a significant increase in the average trip lengths for all trip purposes, especially HBW trips, at the trip distribution step. This was due to the fact that a significant lower speed was specified in the SPDCAP file in the 2000 base year model for each combination of area and facility types. The trip lengths estimated by the updated E+C model were quite different from those obtained from the 2000 base year model. However, by comparing statistics from Tables 8.4 and 8.5 (based on results with two-digit coding) with those from Tables 7.5 and 7.6 (based on one-digit coding), it appears that the number of links with large errors is generally decreased. To further evaluate the effect of two-digit coding, it was incorporated into the model together with the updated ZDATA files and network in the next chapter. Various test statistics are also provided to illustrate that two-digit coding did play a positive role in improving the model accuracy.

9. COMBINED EFFECT OF NETWORK AND ZDATA

In this section, the combined effect of ZDATA, network, and one- and two-digit coding schemes was investigated. A model with updated ZDATA and network and one-digit coding was first run, followed by updating the model with the two-digit coding. To evaluate the overall effect of the ZDATA, network, and two-digit-coding on the projected traffic volumes and identify possible improvements to the transportation model to increase the accuracy in short-term traffic projection, six general test statistics were computed. The percent root mean squared error (%RMSE), which is currently adopted by the Florida Department of Transportation (FDOT) as a criterion for calibrating trip assignment results, was also used as the seventh test statistic for comparing the model generated link volumes and the actual ground counts.

9.1 Combined Effect of ZDATA, Highway Network, and One-Digit Coding

As discussed in Chapter 8, the two-digit coding schemes seem to improve the forecast accuracy of the 2000 E+C model. To further investigate the effect of two-digit coding, traffic volumes were obtained from the E+C model with updated ZDATA files and network and one-digit coding. Table 9.1 shows the statistics from trip distribution. The model predicted more intrazonal trips than the original 2000 E+C model for every trip purpose. Longer average trip lengths were obtained for trip purposes such as HBW, T/T, and EI, while shorter average trip lengths were observed for HBS, HBSR, HBO, and NHB trips. The differences in average trip lengths between the updated and original E+C models, however, were relatively insignificant. Note that the difference in total intrazonal trips shown in Table 9.1 between the updated and original models was 41,722.

Table 9.1 Trip Distribution Statistics for Model with Combined Effect (One-Digit Coding)

Trip Purpose	2000 Model	Total Trips	Intrazonal Trips	Average Trip Length
HBW[1]	Updated	701,954	14,036	19.290
	Original	620,492	8,110	19.425
HBW[2]	Updated	701,954	18,907	22.112
	Original	620,492	9,048	21.260
HBS	Updated	452,975	24,108	12.506
	Original	402,640	15,272	13.510
HBSR	Updated	447,983	10,672	14.811
	Original	403,714	6,597	15.376
HBO	Updated	697,366	27,594	16.146
	Original	630,293	18,011	16.665
NHB	Updated	737,512	37,303	14.959
	Original	673,538	32,688	14.985
T/T	Updated	336,175	23,384	14.213
	Original	292,768	18,630	14.191
E-I	Updated	176,904	-	39.496
	Original	219,542	-	38.578
Total	Updated	3,550,869	141,968	
	Original	3,242,987	100,246	

[1] First pass for pre-loaded highway network
[2] Congested highway network.

Table 9.2 gives the number of person trips by auto modes for each trip purpose estimated by the 2000 E+C model with the updated ZDATA files and highway network. Table 9.3 summarizes the transit usage statistics for the daily work trips and non-work trips for the local and express bus modes. The total number of auto trips was increased from 2,647,996 (see Table 4.7) to 2,884,716, a nearly 240,000 increase. As previously described in Section 6.4, additional 300,000 trips were estimated by the E+C model with the updated ZDATA files. The increase in the number of trips at the trip generation step may be classified approximately as follows: 14% intrazonal trips; 80% auto trips; and 6% transit trips. The majority of the transit trips, however, were associated with the walk mode since the transit ridership given in Table 9.3 was reduced in comparison with the results presented in Table 4.8.

Table 9.2 Highway Person Trips for Model with Combined Effect (One-Digit Coding)

Highway Mode	Trip Purpose			Total
	HBW	HBNW	NHB	
Drive Alone	570,221	650,513	453,753	1,674,488
Drive w/ 1 Passenger	81,703	361,981	147,804	591,488
Drive w/ 2 Passenger	22,999	509,529	86,212	618,740
Total	674,923	1,522,023	687,769	2,884,716

Table 9.3 Daily Transit Usage Statistics for Model with Combined Effect (One-Digit Coding)

Trip Purposes	Transit Mode	Passengers		
		Trips	Miles	Hours
Work Trips	Local Bus	8,354	31,365	1,430
	Express Bus	745	5,714	273
	ASE	1,722	1,254	86
	Subtotal	10,821	38,333	1,789
Non-Work Trips	Local Bus	29,331	86,647	3,456
	ASE	14,257	12,781	868
	Subtotal	43,588	99,428	4,324
Total		54,409	137,761	6,113

Figures 9.1 and 9.2 identify the differences in number and percentage, respectively, between the modeled and observed traffic volumes. As shown in Figure 9.1, the largest discrepancy was 20,687 vehicles per day, 4,000 more than that estimated by the original E+C model. Tables 9.4 and 9.5 give the number of links with volume discrepancies within given ranges by area and facility types, respectively.

The results from this model will be compared with those from the same model but with two-digit coding instead of one-digit coding, which is presented in the next section.

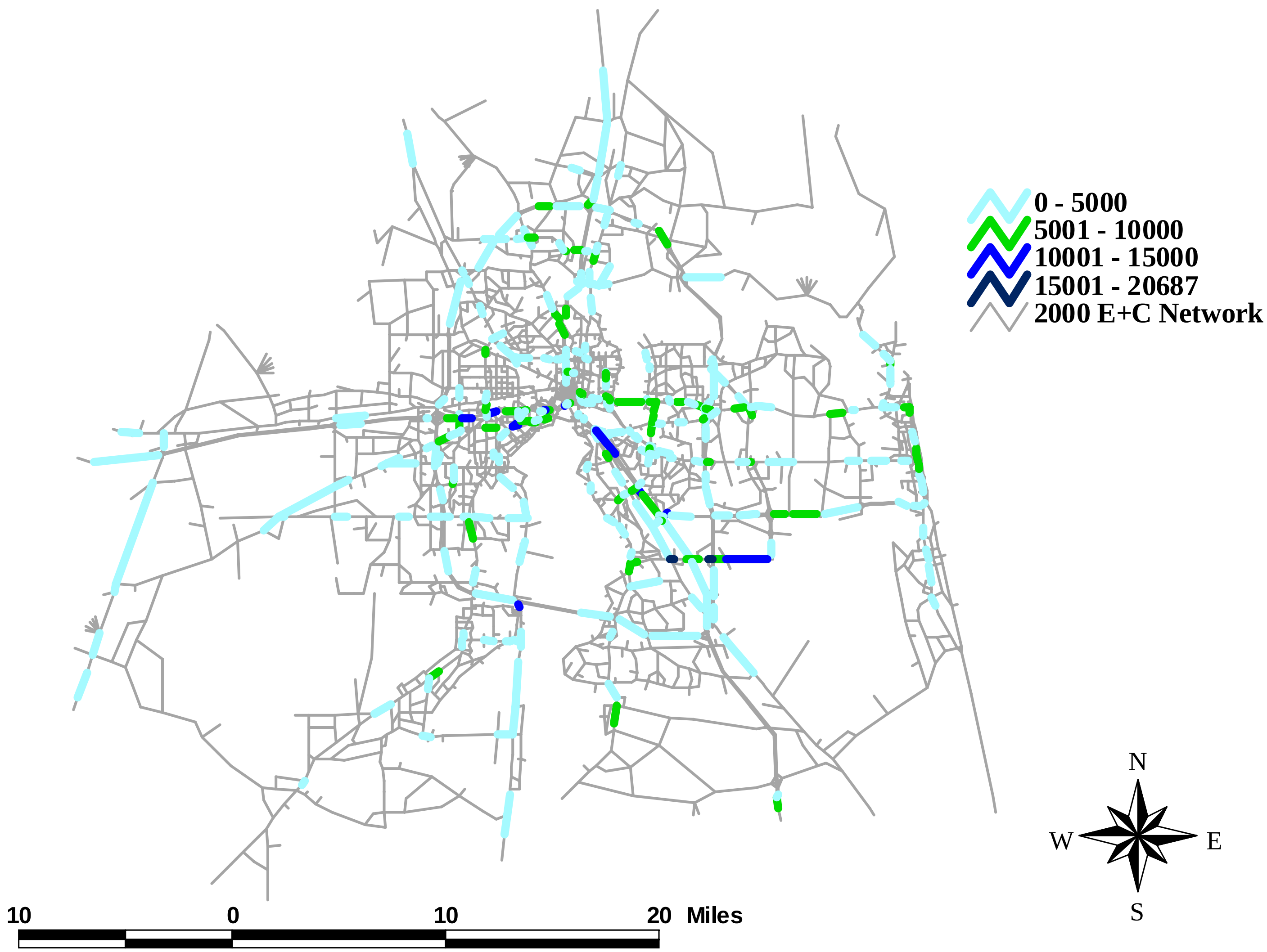

Figure 9.1 Volume Difference over PSWADT for the 2000 E+C Model with Combined Effect (One-Digit Coding)

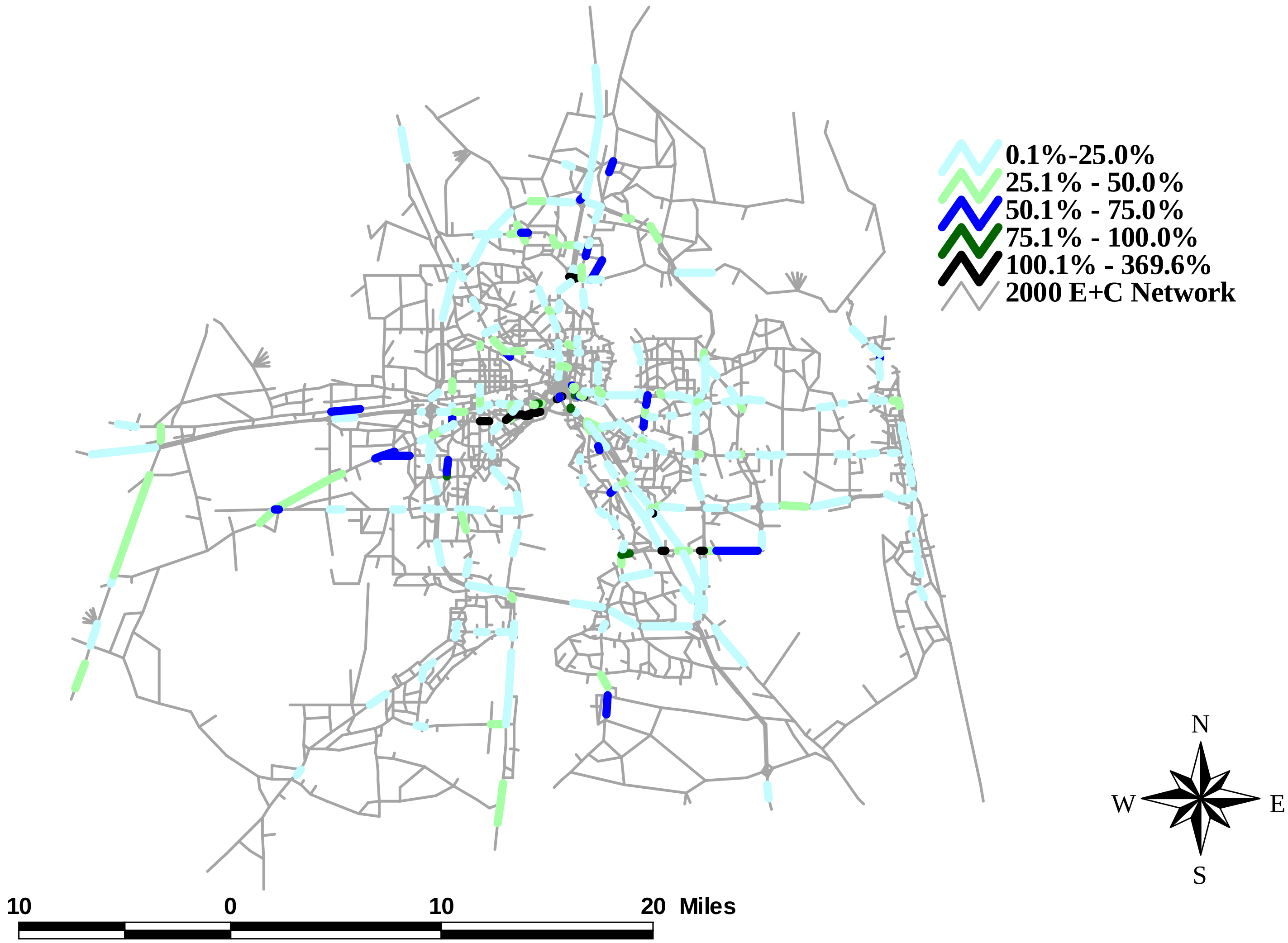

Figure 9.2 Volume Difference over PSWADT in Percentage for the 2000 E+C Model with Combined Effect (One-Digit Coding)

Table 9.4 Volume Discrepancies by AT for Model with Combined Effect (One-Digit Coding)

Difference	Area Type				
	1x	2x	3x	4x	5x
0~5,000	8	30	141	24	37
5,001~10,000	1	15	42	5	5
10,001~15,000	-	6	5	-	-
15,001~20,687	-	-	2	-	-

Table 9.5 Volume Discrepancies by FT for Model with Combined Effect (One-Digit Coding)

Difference	Facility Type				
	1x	2x	3x	4x	6x
0~5,000	59	136	30	5	10
5,001~10,000	22	35	11	-	-
10,001~15,000	5	5	1	-	-
15,001~20,687	-	2	-	-	-

9.2 Combined Effect of ZDATA, Highway Network, and Two-Digit Coding

In this section, the combined effect introduced by the updated ZDATA files, highway network, and two-digit coding schemes was examined. The two-digit coding schemes are described in Chapter 8.

Table 9.6 presents the statistics from trip distribution. As described in Chapter 6, more trips were produced after the ZDATA files were updated for all trip purposes other than IE trips. As indicated in Table 9.6, the model yielded significantly higher average trip lengths for every trip purpose compared with the original E+C model and the model with only the ZDATA files updated (see Table 6.9). The trip lengths were also longer than those given in Chapter 8 (see Table 8.1), which were obtained with updated highway network and two-digit coding but without considering the effect of ZDATA files.

Table 9.6 Trip Distribution Statistics for Model with Combined Effect (Two-Digit Coding)

Trip Purpose	Total Trips	Intrazonal Trips	Average Trip Length
HBW[1]	701,954	16,544	21.629
HBW[2]	701,954	23,364	25.566
HBS	452,975	34,833	15.347
HBSR	447,983	14,675	15.689
HBO	697,366	33,727	18.127
NHB	737,512	45,460	16.960
T/T	336,175	26,201	15.676
E-I	176,904	-	45.068

1 First pass for pre-loaded highway network
2 Congested highway network.

Table 9.7 provides the number of person trips by purpose using auto modes for travel estimated by the E+C model that incorporated all the effects of ZDATA, highway network, and two-digit coding. Table 9.8 summarizes the transit usage statistics for the daily work trips and non-work trips for the local and express bus modes.

Table 9.7 Highway Person Trips for Model with Combined Effect (Two-Digit Coding)

Highway Mode	Trip Purpose			Total
	HBW	HBNW	NHB	
Drive Alone	567,947	643,963	448,794	1,660,704
Drive w/ 1 Passenger	79,919	356,016	145,177	581,112
Drive w/ 2 Passenger	22,273	500,035	84,433	606,741
Total	678,466	1,515,038	691,843	2,885,346

Table 9.8 Daily Transit Usage Statistics for Model with Combined Effect (Two-Digit Coding)

Trip Purposes	Transit Mode	Passengers		
		Trips	Miles	Hours
Work Trips	Local Bus	8,613	31,741	1,718
	Express Bus	820	6,218	345
	ASE	1,644	1,260	86
	Subtotal	11,077	39,219	2,149
Non-Work Trips	Local Bus	31,792	92,386	4,008
	ASE	15,855	14,664	995
	Subtotal	47,647	107,050	5,003
Total		58,724	146,269	7,152

Figure 9.3 illustrates the average differences between the modeled and observed traffic volumes for the 2000 JUATS network. Figure 9.4 shows the differences as a percentage of the PSWADTs for both directions. As shown in Figure 9.3, the largest discrepancy was 16,435 vehicles per day, which is smaller than that from the model without the two-digit coding, as shown in Figure 9.1. Improvement may also be observed when comparing Figure 9.4 with Figure 9.2. In Figure 9.4, fewer links had large traffic volume discrepancies compared with the results from the model presented in Section 9.1. Therefore, the performance of the E+C model has been improved with the two-digit coding scheme.

Tables 9.9 and 9.10 give the number of links by area and facility types, respectively, in different ranges of volume discrepancies. Compared to the same model but without the two-digit coding (see Tables 9.4 and 9.5), there are noticeable improvements in model accuracy for network links of area types 1x, 2x, and 3x or of facility types 1x and 3x. For links of these area and facility types, the numbers of links in the larger error ranges decreased, while those in the smaller error ranges increased. In the next section, statistics that describe the performance of the all the models tested in this project are presented.

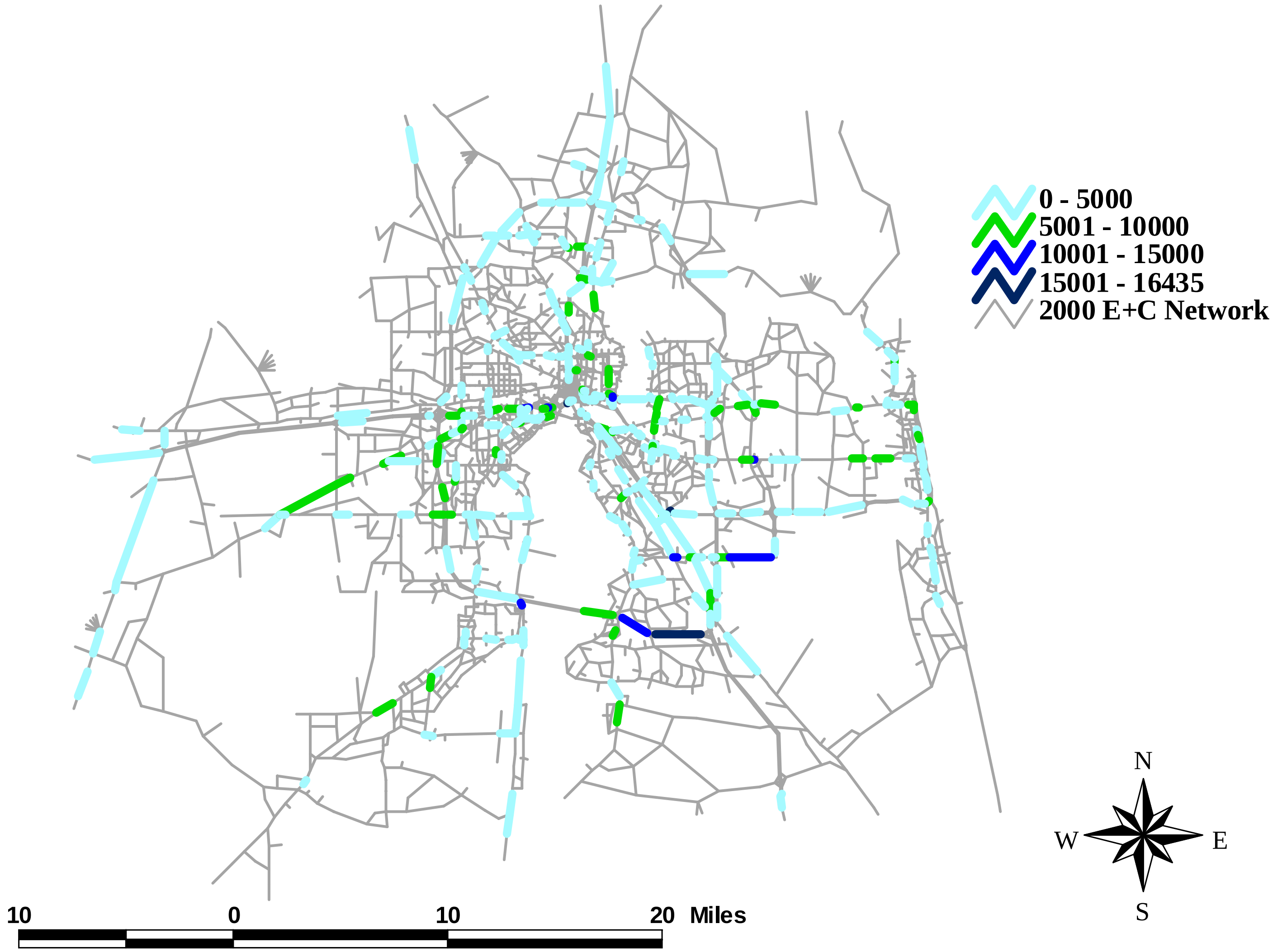

Figure 9.3 Volume Differences for the 2000 E+C Model with Combined Effect (Two-Digit Coding)

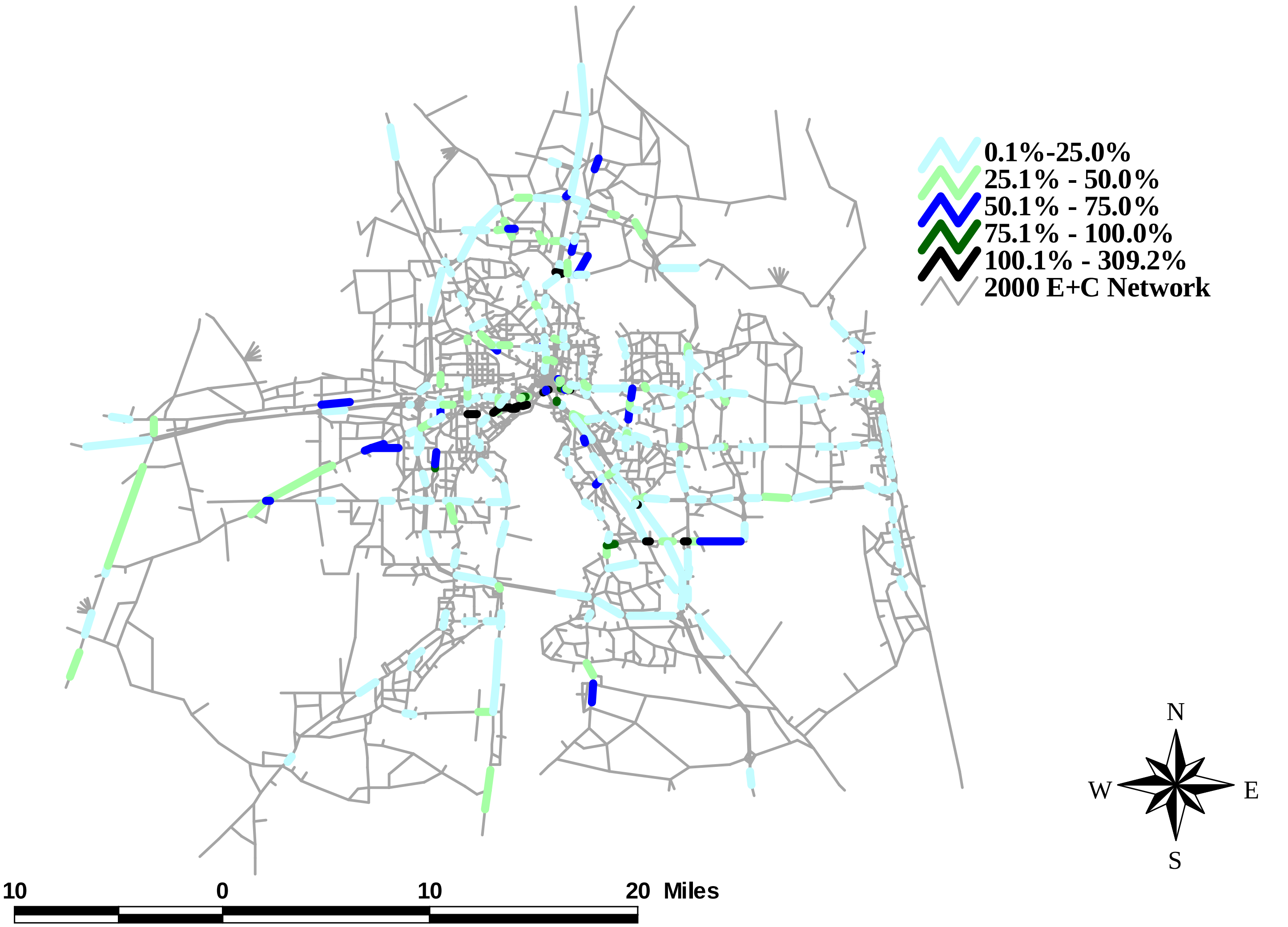

Figure 9.4 Volume Difference in Percentage for the 2000 E+C Model with Combined Effect (Two-Digit Coding)

Table 9.9 Volume Discrepancies by Area Type for Model with Combined Effect (Two-Digit Coding)

Difference	Area Type				
	1x	2x	3x	4x	5x
0~5,000	9	36	146	22	36
5,001~10,000	-	11	38	7	5
10,001~15,000	-	3	5	-	-
15,001~16,435	-	1	1	-	1

Table 9.10 Volume Discrepancies by Facility Type for Model with Combined Effect (Two-Digit Coding)

Difference	Facility Type				
	1x	2x	3x	4x	6x
0~5,000	66	136	33	4	10
5,001~10,000	15	36	9	1	-
10,001~15,000	4	4	-	-	-
15,001~16,435	1	2	-	-	-

9.3 Evaluation of Overall Effect

A number of statistical tests were performed to determine the overall effect of network coding and the ZDATA/EETRIPS files on the model to perform short-term traffic volume projection. These test statistics include:

- Chi-square statistic
- Neyman's modified Chi-square statistic
- Simplified Freeman-Tukey statistic
- Scaled deviance statistic
- Sum of Errors Squared
- Mean Errors Squared.

These test statistics are defined as follows.

Chi-Square Statistics

$$\sum_{i=1}^{n} \frac{\left(x_i^c - x_i^v\right)^2}{x_i^v} \qquad (4)$$

Neyman's Modified Chi-Square Statistics

$$\sum_{i=1}^{n} \frac{\left(x_i^c - x_i^v\right)^2}{x_i^c} \qquad (5)$$

Simplified Freeman-Tukey Statistics

$$\sum_{i=1}^{n} 4 \times \left(\sqrt{x_i^c} - \sqrt{x_i^v} \right)^2 \tag{6}$$

Scale Deviance Statistics

$$\sum_{i=1}^{n} 2 \times \left[x_i^c \times \log\left(\frac{x_i^c}{x_i^v} \right) \right]^2 \tag{7}$$

Sum of Errors Squared

$$\sum_{i=1}^{n} \left(x_i^c - x_i^v \right)^2 \tag{8}$$

Mean Error Squared

$$\frac{\sum_{i=1}^{n} \left(x_i^c - x_i^v \right)^2}{n} \tag{9}$$

where

n	=	the number of links with ground count information;
x_i^c	=	traffic count of link *i*; and
x_i^v	=	assigned volume to link *i*.

A model with a better spatial accuracy should have a smaller value of the above statistics. It is possible that these statistics may give different indications of whether a model is an improvement over another, making it more important to use multiple criteria. Table 9.11 shows the statistics for the six test criteria previously described. In the table, Model 1 refers to the E+C model with its original model structure and input data. The output from this model run with FSUTMS Version 5.5 was presented in Chapter 5. Model 2 was the E+C model with the ZDATA files updated to reflect the demographic and socioeconomic characteristics as well as the E-I and E-E trip patterns in Year 2000. The highway network for Model 2, however, was not updated to agree with the traffic system in the forecast year. The results from FSUTMS for Model 2 were presented in Chapter 6. Models 3 and 4 refer to the E+C models with one- and two-digit coding schemes, respectively, after the highway network was updated to represent the traffic system in year 2000. The models' outputs were described in Chapters 7 and 8. Model 5 refers to the E+C model with updated ZDATA files and highway network but the original one-digit coding. The FSUTMS results for Model 5 were shown in Section 9.1. Finally, Model 6 was created to investigate the joint effect of ZDATA files, highway network, and two-digit coding on the projection of traffic volume by the 2000 E+C model and is described in Section 9.2.

Table 9.11 Test Statistics for Model Performance

Model	Test Statistic					
	1	2	3	4	5	6
1	2,567,278	1,505,819	1,521,824	3,875,294	38,641,826,126	120,379,521
2	1,951,776	1,414,985	1,394,254	2,991,100	36,973,408,797	115,181,959
3	1,712,380	1,593,237	1,403,585	2,686,244	31,367,493,664	97,718,049
4	1,643,840	1,424,805	1,269,527	3,029,858	29,246,062,697	91,109,230
5	1,465,029	1,365,138	1,193,834	2,045,930	28,147,538,340	87,687,035
6	1,843,605	1,119,273	1,062,367	1,768,257	22,825,305,672	71,106,871

Statistic 1: Chi-square statistic
Statistic 2: Neyman's modified Chi-square statistic
Statistic 3: Simplified Freeman-Tukey statistic
Statistic 4: Scaled deviance statistic
Statistic 5: Sum of Errors Squared
Statistic 6: Mean Errors Squared
Model 1: Original network with one-digit coding and original ZDATA (Section 5)
Model 2: Original network with one-digit coding and updated ZDATA (Section 6)
Model 3: Updated network with one-digit coding and original ZDATA (Section 7)
Model 4: Updated network with two-digit coding and original ZDATA (Section 8)
Model 5: Updated network with one-digit coding and updated ZDATA (Section 9.1)
Model 6: Updated network with two-digit coding and updated ZDATA (Section 9.2)

As may be seen from Table 9.11, Model 6 outperformed the other models according to every evaluation criterion except the Chi-square statistic. In other words, the 2000 E+C model performed better for short-term traffic estimation when the ZDATA and highway network were both updated and two-digit area and facility coding was employed. The two-digit coding schemes were implemented in Models 4, which performed better than Model 3, which utilized one-digit coding. The same is true for Model 6 compared to Model 5. There is also a general trend with a few exceptions that the models increasingly improved.

To further evaluate the models, the percent root-mean-square error (%RMSE) for each of the six models was calculated. The %RMSE is a statistic to compare the model generated volumes and the actual ground counts on links and is adopted by the FDOT as a criterion in calibrating models. The equations for calculating the root-mean-square error (RMSE) and then the %RMSE are given as follows:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}\left(x_i^c - x_i^v\right)^2}{n-1}} \qquad (10)$$

$$\%RMSE = \frac{RMSE}{\sum_{i=1}^{n} x_i^c \Big/ n} \qquad (11)$$

Table 9.12 lists the %RMSE for the six models. Again, Model 6 performed better than the other five models, followed by Model 5 and then Model 4. Table 9.13 shows the improvement in the model performance, as measured by %RSME, each time a new improvement was introduced into the model. In the table, the first column specifies the model number. The second column indicates the number of updates implemented in a model. There are three possible updates: ZDATA, network, and two-digit coding. Columns 4, 5, and 6 describe which updates were incorporated in the model. “O” means the input was the same as the original model, and “U” indicates that the specific update was implemented in the model. The sixth column shows the model to which the model specified in the first column is compared. The last column gives the difference of the %RSME values of the two models compared.

It may be seen that the update of the ZDATA files alone introduced a much smaller improvement on the accuracy of the projected traffic volumes (0.0063) than the highway network update (0.0286). Compared to Model 3, which has an updated network but not the ZDATA files or the two-digit coding, Model 4 (with two-digit coding added) and Model 5 (with ZDATA files updated) both have reduced %RSME. The effect of ZDATA file update is slightly greater than the two-digit coding (0.0128 versus 0.01.10). Finally, Model 6, which incorporates all the updates of ZDATA, network, and two-digit coding, brought noticeable improvements of 2.94% and 2.46%, respectively, when compared with Models 4 and 5.

Table 9.12 %RMSE for the Six Models

Model	1	2	3	4	5	6
%RMSE	0.2896	0.2833	0.2610	0.2520	0.2472	0.2226

Table 9.13 %RMSE Improvements for Each Introduced Update

Model	Number of Model Updates	Model			Compared to	Improvement in %RMSE
		ZDATA	Network	Two-Digit Coding		
1	0	O	O	O	–	–
2	1	U	O	O	Model 1	0.0063
3	1	O	U	O	Model 1	0.0286
4	2	O	U	U	Model 3	0.0110
5	2	U	U	O	Model 2	0.0361
6	3	U	U	U	Model 4	0.0294
					Model 5	0.0246
6	3	U	U	U	Model 1	0.0670

Table 9.14 describes the model performance for each of the six models for links of different facility types. The first column indicates the facility type of the links. The second column gives the number of links of a given facility type based on which the statistics are computed. The third column shows the percentage of difference in lane-miles for a given type of facility between the E+C model and the 2000 base year model. The last two columns provide the MSE and %RMSE statistics for the links of a given facility type.

It may be seen from the table that no new facilities of types 1x (freeways and expressways) and 2x (divided arterials) were constructed between 1995 and 2000. However, significantly more facilities of types 3x (undivided arterials) and 4x (collectors) were constructed between 1995 and 2000 but were not projected in the E+C model. These shortfalls in network projection resulted in much larger errors for these two types of facilities. The magnitudes of the errors are also positively related to the errors in the projected network. However, since these facilities are more local in nature than facilities of types 1x and 2x, the errors did not propagate directly to the latter.

With the exception of facility type 4x, Model 6 with complete updates performed either the best or comparable to the best model.

Table 9.14 %RMSE by Facility Type for the Six Models

FT	No. of Links	Lane-Mile Change (E+C – 2000)	Model			Performance	
			ZDATA	Network	2-Digit	MSE	%RMSE
1x	86	0 (0%)	O	O	O	159,549,159	0.2050
			U	O	O	199,926,191	0.2295
			O	U	O	95,311,107	0.1585
			U	U	O	96,376,927	0.1593
			O	U	U	114,083,460	0.1734
			U	**U**	**U**	**89,046,766**	**0.1532**
2x	177	0 (0%)	O	O	O	124,073,245	0.3366
			U	O	O	97,482,283	0.2991
			O	U	O	110,520,936	0.3185
			U	U	O	91,130,935	0.2892
			O	U	U	94,652,965	0.2947
			U	**U**	**U**	**70,574,780**	**0.2545**
3x	42	-24.57 (-5.69%)	O	O	O	68,449,860	0.4103
			U	O	O	54,544,647	0.3662
			O	U	O	81,110,914	0.4466
			U	U	O	82,879,206	0.4514
			O	**U**	**U**	**51,762,480**	**0.3568**
			U	U	U	53,295,721	0.3620
4x	5	-405.82 (-94.01%)	**O**	**O**	**O**	**15,755,573**	**0.6616**
			U	O	O	17,196,204	0.6912
			O	U	O	15,832,307	0.6632
			U	U	O	16,260,144	0.6721
			O	U	U	59,683,829	1.2876
			U	U	U	63,510,048	1.3283
6x	10	-0.62 (-0.14%)	**O**	**O**	**O**	**11,914,889**	**0.2807**
			U	O	O	14,851,473	0.3134
			O	U	O	12,099,410	0.28.29
			U	U	O	16,148,935	0.32.68
			O	U	U	20,714,833	0.3702
			U	U	U	11,955,587	0.2812
Total	322	-431.01	O	O	O	120,349,987	0.2896
			U	O	O	115,181,959	0.2833
			O	U	O	97,718,049	0.2610
			U	U	O	87,687,035	0.2472
			O	U	U	91,109,230	0.2520
			U	**U**	**U**	**71,106,871**	**0.2226**

Table 9.15 presents similar information as in Table 9.14 but by TAD instead of facility type. Some of the TADs are not included in the table because there are not enough observations of traffic volumes in those TADs. For each TAD compared, the differences in population (POP), households (HH), and employment (EMP) between the forecast and actual data are given in columns 2, 3, and 4. However, it is more difficult to attribute the model inaccuracy to either the errors in the ZDATA or those in the network. There is not apparent relationship between the magnitude of the %MSE and that of the input inaccuracies based on the statistics for TADs.

Table 9.15 %RMSE by TAD for the Six Models

TAD	Difference (E+C – 2000)			Lane-Mile Change (E+C-2000)	Model			Performance	
	Pop	HH	EMP		ZDATA	Network	Coding	MSE	%RMSE
5	-141 (-0.3%)	-1,914 (-12.4%)	-2,607 (-11.5%)	-62.61 (-14.50%)	O	O	O	61,853,055	0.3123
					U	O	O	79,335,075	0.3537
					O	U	O	48,371,901	0.2762
					U	**U**	**O**	**42,602,363**	**0.2592**
					O	U	U	51,969,735	0.2863
					U	U	U	46,624,120	0.2712
6	-8,999 (-5.5%)	-14,754 (-26.7%)	-12,379 (-26.4%)	-52.44 (-12.15%)	O	O	O	167,005,662	0.3431
					U	O	O	134,721,312	0.3081
					O	U	O	106,754,809	0.2743
					U	U	O	68,818,410	0.2202
					O	U	U	67,256,717	0.2177
					U	**U**	**U**	**52,463,707**	**0.1923**
9	-281 (-1.4%)	-1,451 (-17.6%)	-2,826 (-39.4%)	-15.75 (-3.65%)	O	O	O	140,879,451	0.2822
					U	O	O	61,278,998	0.1861
					O	U	O	103,140,812	0.2415
					U	U	O	48,230,321	0.1651
					O	U	U	118,244,189	0.2586
					U	**U**	**U**	**21,443,533**	**0.1101**
10	-25,883 (-5.4%)	-17,848 (-27.5%)	-45,104 (-46.6%)	-51.09 (-11.83%)	O	O	O	210,783,328	0.2877
					U	O	O	205,460,371	0.2841
					O	U	O	125,845,623	0.2223
					U	U	O	137,359,228	0.2323
					O	U	U	144,897,438	0.2385
					U	**U**	**U**	**104,318,612**	**0.2024**
11	10165 (21.7%)	1626 (9.4%)	17637 (18.6%)	-36.52 (-8.46%)	O	O	O	80,913,026	0.3037
					U	**O**	**O**	**73,019,115**	**0.2885**
					O	U	O	97,732,937	0.3337
					U	U	O	77,387,771	0.2970
					O	U	U	84,391,219	0.3101
					U	U	U	81,542,943	0.3049
12	8905 (6.5%)	-3,416 (-7.4%)	-3,989 (-6.5%)	-111.49 (-25.83%)	O	O	O	90,731,178	0.2466
					U	O	O	110,074,277	0.2716
					O	U	O	142,088,374	0.3086
					U	U	O	145,870,115	0.3127
					O	U	U	90,656,398	0.2465
					U	**U**	**U**	**79,255,308**	**0.2305**
14	2468 (1.8%)	-5,825 (-12.8%)	2895 (8.2%)	-101.78 (-23.58%)	O	O	O	50,305,911	0.2084
					U	O	O	31,531,346	0.1650
					O	U	O	61,759,314	0.2310
					U	U	O	**31,260,161**	**0.1643**
					O	U	U	88,602,768	0.2766
					U	**U**	**U**	63,881,558	0.2349
Total	-13,766	-43,582	-46,373	-431.69	O	O	O	122,886,379	0.2940
					U	O	O	115,161,498	0.2846
					O	U	O	101,645,294	0.2674
					U	U	O	89,543,153	0.2510
					O	U	U	95,358,684	0.2590
					U	**U**	**U**	**73,137,046**	**0.2268**

10. CONCLUSIONS

This study compared the Jacksonville urban area traffic volumes projected by the 2000 E+C FSUTMS model with the PSWADTs based on the estimated AADTs from the 2000 FTI CD. The individual and combined effects of the ZDATA/EETRIPS files, highway network, and two-digit coding scheme on the accuracy of the traffic volumes projected by the E+C model for a short time horizon were investigated. The findings from this study may be summarized as follows.

First, the results show that the accuracy of the E+C model in projecting traffic volumes may be improved when the ZDATA/EETRIPS files were updated to accurately reflect the changes in the study area boundary, population and employment. The study area originally defined in the 1990 base year model and the 2000 E+C model was significantly smaller than the one in the latest 2000 base year model. As a result, the EE and IE trips projected in the original E+C model may not be accurate. The socioeconomic and demographic statistics of the study area such as number of residents/employment for a given TAZ were also underestimated. ZDATA1, ZDATA2, ZDATA3, ZDATA4, and EETRIPS files were subsequently updated based on the input and output data from the 2000 base year model. The results from FSUTMS Version 5.5 indicate that the updated ZDATA and EETRIPS files improved the %RMSE statistic for the E+C model from 0.2896 to 0.2833.

Second, not all committed highway improvements projected in the 2000 E+C network were constructed as scheduled. Most of them are undivided arterials and collectors. As a result, the original 2000 E+C network does not realistically reflect the actual highway infrastructure in year 2000. After the highway network was updated, the %RMSE statistic calculated from the observed and counted traffic volumes was reduced to 0.2610 without any modification to the original ZDATA/EETRIP files. This means that the updated highway network had a more significant effect on the model accuracy than the ZDATA/EETRIPS files.

Third, the performance of the E+C model was improved by applying the two-digit coding scheme specified in the SPDCAP file for the 2000 base year model. While the model produced the lowest %RMSE values, there is an increases in the average trip lengths from the trip distribution step, suggesting that the E+C model yielded different trip patterns after the two-digit coding was implemented.

The three factors of ZDATA, network, and two-digit coding are not independent. In other words, they do not have a fixed effect on the model accuracy. Their effects on the model depend on their combinations and the presence of one factor enhances the effect of another. The results from this particular study suggest that correct network is most important. The benefit of updated ZDATA cannot be realized until network is updated. Therefore, special attention is needed to ensure the quality of network coding.

As may be expected, errors in projected improvements for facilities of non-freeways affected freeways less than non-freeways. This means that it is more important to make the projection for major facilities right than the relatively less important facilities.

The E+C model significantly underestimated the traffic volumes on freeway links. One major enhancement to the later versions of FSUTMS has been to allow the UROAD factor and the parameters for the BRP formula to be varied by facility type, which may have a significant effect on the assignment results. Other enhancements to FSUTMS may also help improve model performance in predicting future traffic flows. However, the effect of these enhancements in FSUTMS on the projected traffic flows is not investigated in this study. While progress has been made in our understanding of the effect of ZDATA and highway network on the accuracy of short term traffic projection, the findings from this study call for future studies to investigate other effects of parameters specified in a given travel demand models.

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APPENDIX A. AREA TYPE AND FACILITY TYPE DEFINTION

Table A.1 One-Digit Area Type Codes

Area Type	Description
1	Central Business District (CBD)
2	Fringe
3	Residential
4	Outlying Business District (OBD)
5	Rural

* FDOT FSUTMS Technical Reports (1997-1998)

Table A.2 One-Digit Facility Type Codes

Facility Type	Description
1(10)	Freeway
2(20)	Divided Arterial
3(30)	Undivided Arterial
4(40)	Collector
5(50)	Centroid Collector
6(60)	One-Way Streets
7(70)	Ramp
8(80)	HOV lane
9(90)	Tolls

* FDOT FSUTMS Technical Reports (1997-1998)

Table A.3 Two-Digit Area Type Codes

Area Type	Description
1x	**Central Business District (CBD) Areas (AT 10 is the default)**
11	Urbanized Area (over 500,000) Primary City CBD
12	Urbanized Area (under 500,000) Primary City CBD
13	Other Urbanized Area CBD and Small City Downtown
14	Non-Urbanized Area Small City Downtown
2x	**Central Business District (CBD) Fringe Areas (AT 20 is the default)**
21	All CBD Fringe Areas
3x	**Residential Areas (AT 30 is the default)**
31	Residential Area of Urbanized Areas
32	Undeveloped Portions of Urbanized Areas
33	Transitioning Areas/ Urban Areas over 5,000 Population
34	Beach Residential (per Southeast Regional Planning Model - SERPM)
4x	**Outlying Business District (OBD) Areas (AT 40 is the default)**
41	High Density OBD
42	Other OBD
43	Beach OBD (per Southeast Regional Planning Model - SEPRM)
5x	**Rural Area (AT 50 is the default)**
51	Developed Rural Areas/ Small Cities Under 5,000 Population
52	Undeveloped Rural Areas

* FDOT FSUTMS Highway Network (HNET) Procedural Enhancements Study: Final User's Manual (March 1998).

Table A.4 Two-Digit Facility Type Codes

Facility Type	Description
1x	**Freeways and Expressways (FT 10 is the default)**
11	Urban Freeway Group 1 (cities of 500,000 or more)
12	Urban Freeway Group 2 (within urbanized area and not in Group 1)
15	Collector/Distributor Lane
16	Controlled Access Expressway
17	Controlled Access Parkway
2x	**Divided Arterials (FT 20 is the default)**
21	Divided Arterial Unsignalized (55 mph)
22	Divided Arterial Unsignalized (45 mph)
23	Divided Arterial Class 1a (> 0.00 to 2.49 signalized intersections per mile)
24	Divided Arterial Class 1b (2.50 to 4.50 signalized intersections per mile)
25	Divided Arterial Class II/III (> 4.50 signalized intersections per mile)
3x	**Undivided Arterials (FT 30 is the default)**
31	Undivided Arterial Unsignalized with Turn Bays
32	Undivided Arterial Class 1a (> 0.00 to 2.49 signalized intersections per mile) with Turn Bays
33	Undivided Arterial Class 1b (2.50 to 4.50 signalized intersections per mile) with Turn Bays
34	Undivided Arterial Class II/III (> 4.50 signalized intersections per mile) with Turn Bays
35	Undivided Arterial Unsignalized without Turn Bays
36	Undivided Arterial Class 1a (> 0.00 to 2.49 signalized intersections per mile) without Turn Bays
37	Undivided Arterial Class 1b (2.50 to 4.50 signalized intersections per mile) without Turn Bays
38	Undivided Arterial Class II/III (> 4.50 signalized intersections per mile) without Turn Bays
4x	**Collectors (FT 40 is the default)**
41	Major Local Divided Roadway
42	Major Local Undivided Roadway with Turn Bays
43	Major Local Undivided Roadway without Turn Bays
44	Other Local Divided Roadway
45	Other Local Undivided Roadway with Turn Bays
46	Other Local Undivided Roadway without Turn Bays
47	Low Speed Local Collector
48	Very Low Speed Local Collector
5x	**Centroid Connectors (FT 50 is the default)**
51	Basic Centroid Connector
52	External Station Centroid Connector
6x	**One-Way Facilities (FT 60 is the default)**
61	One-Way Facility Unsignalized
62	One-Way Facility Class Ia (> 0.00 to 2.49 signalized intersections per mile)
63	One-Way Facility Class Ib (2.50 to 4.50 signalized intersections per mile)
64	One-Way Facility Class II/III (> 4.50 signalized intersections per mile)

65	Frontage Road Unsignalized
66	Frontage Road Class Ia (> 0.00 to 2.49 signalized intersections per mile)
67	Frontage Road Class Ib (2.50 to 4.50 signalized intersections per mile)
68	Frontage Road Class II/III (> 4.50 signalized intersections per mile)
7x	**Ramps**
71	Freeway On-Ramp
72	Freeway Loop On-Ramp
73	Other On-Ramp
74	Other Loop On-Ramp
75	Freeway Off-Ramp
76	Freeway Loop Off-Ramp
77	Other Off-Ramp
78	Other Loop Off-Ramp
79	Freeway-Freeway High-Speed Ramp
8x	**HOV Facilities (FT 80 is the default)**
81	Urban Freeway Group 1 (cities of 500,000 or more) 1 HOV Lane (Barrier Separated)
82	Urban Freeway Group 2 (within urbanized area and not in Group 1) HOV Lane (Barrier Separated)
83	Freeway Group 1 HOV Lane (Non-Barrier Separated)
84	Other Freeway HOV Lane (Non-Barrier Separated)
85	Non Freeway HOV Lane
86	AM&PM Peak HOV Ramp
87	AM Peak Only HOV Ramp
88	PM Peak Only HOV Ramp
89	All Day HOV Ramp
9x	**Toll Facilities**
91	Urban Freeway Group 1 (cities of 500,000 or more) Toll Facility
92	Urban Freeway Group 2 (within urbanized area and not in Group 1) Toll Facility
93	Expressway/Parkway Toll Facility
94	Divided Arterial Toll Facility
95	Undivided Arterial Toll Facility
97	Toll On-Ramp
98	Toll Off-Ramp
99	Toll Plaza

* FDOT 1995 LOS Manual.