430 IACC Building – Fargo, ND 58105
Tel 701-231-8058 – Fax 701-231-1945
www.ugpti.org – www.atacenter.org

F-M COG 2005 Model Construction & Calibration Technical Document

Final Report

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Prepared for:
Fargo-Moorhead Council of Governments

Prepared by:
Advanced Traffic Analysis Center
Upper Great Plains Transportation Institute
North Dakota State University
Fargo, North Dakota

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1.0 Introduction

The calibration of travel demand models is important for accurately modeling current and future travel patterns in a metropolitan area. This technical document provides a detailed description of the process and methodology used in developing the Fargo-Moorhead Council of Governments' (FM-COG) transportation planning model. In addition, it documents the methodology and assumptions underlying each major step within the model.

In order to make sound decisions on future investments for transportation improvements, it is important to quantify the impacts of these improvements on the system and its users. Such estimates are usually derived from the process of travel demand analysis. Traditional travel demand modeling utilizes the Urban Transportation Modeling Systems (UTMS) procedures. The inputs for UTMS involve specifying the characteristics of the activities generating vehicle traffic on the transportation system, while the output represent the estimated vehicle traffic flows on the system generated by those activities.

The UTMS consists of four major stages that are related to the user's trip decision-making process: 1) Trip Generation, 2) Trip Distribution, 3) Modal Split, and 4) Trip Assignment. Therefore, this approach is also referred to as the four-step model. As we progress in the model steps, the influence of activity characteristics decreases, while that of trip characteristics increases. The first two steps are related to the nature of the land-use patterns, while the last two steps are dependent on the attributes of the modeled transportation network.

Several initial steps must be carried out to model the study area and build the transportation network before a four-step model is implemented. These involve representing the transportation network as a set of links and nodes. These links and nodes are then assigned different properties such as speeds, control and capacity which are used to model traffic attributes on the network. The study area included in the model is divided into traffic analysis zones (TAZ). These zones are used to organize trip related data, where the area included within a zone has similar social and economic attributes.

The process of constructing and calibrating the F-M COG's travel demand model consists of six steps. Each step will have a dedicated chapter in this report, which includes the following:

- Data preparation is required to build the transportation network from geographic information systems (GIS) format and properly assign the different parameters to the links. A description of data preparation can be found in Chapter 2.

- Trip generation uses socio-economic data to predict the number of trips produced by and attracted to each zone within the study area. There is an assumption that these trips are made by individuals participating in different activities. Trip generation uses static equations based upon persons per household, jobs, and occupancy rates to generate appropriate number of trips produced by or attracted to each TAZ. Further description of trip generation process is provided in Chapter 3.

- Trip distribution is used to connect trip ends and establish the trips flow from production zones to attraction zones. The output from this step is a matrix representing the production and attractions between TAZs, called the origin-destination (O-D) matrix. The trip distribution process description is provided in Chapter 4.

- Mode split divides trips between the various transportation modes available for users. Mode split distributes the trips based on the percentage of trips using different modes, vehicles, transit bus, or trains. Discussion of mode split is provided in chapter 5.

- Traffic assignment is usually the last step in UTMS. In this step, the predicted traffic flows are assigned to the modeled network links. Further discussion is provided in chapter 6.

- Calibration is performed to adjust model parameters to reproduce base year volumes reported in the field. Description of the calibration process is discussed in Chapter 7.

2.0 Data Preparation

The regional travel model for the Fargo-Moorhead (F-M) area consists of 543 TAZs and a network of 1,710 nodes which are connected by 2,412 links (Figure 2.1). The modeled area includes four jurisdictions: the cities of Fargo and West Fargo (North Dakota), as well as Moorhead and Dilworth (Minnesota).

The data used in the model have been either provided by F-M COG or produced by ATAC as a result of literature reviews or primary data collection. The data are compatible with the existing GIS data system used by the F-M COG. The model has been developed to run in the TP+ modeling system produced by Citilabs and has been completely developed within Citilabs' CUBE software product. CUBE provides an effective method for organizing the script and is used to view and edit the input and output files.

The data preparation step is required to convert the input data into a form that is compatible with TP+, thus preserving the basic structure of the model while evaluating different scenarios. All of the network variables are assigned generic names that are used for the remaining modeling process steps.

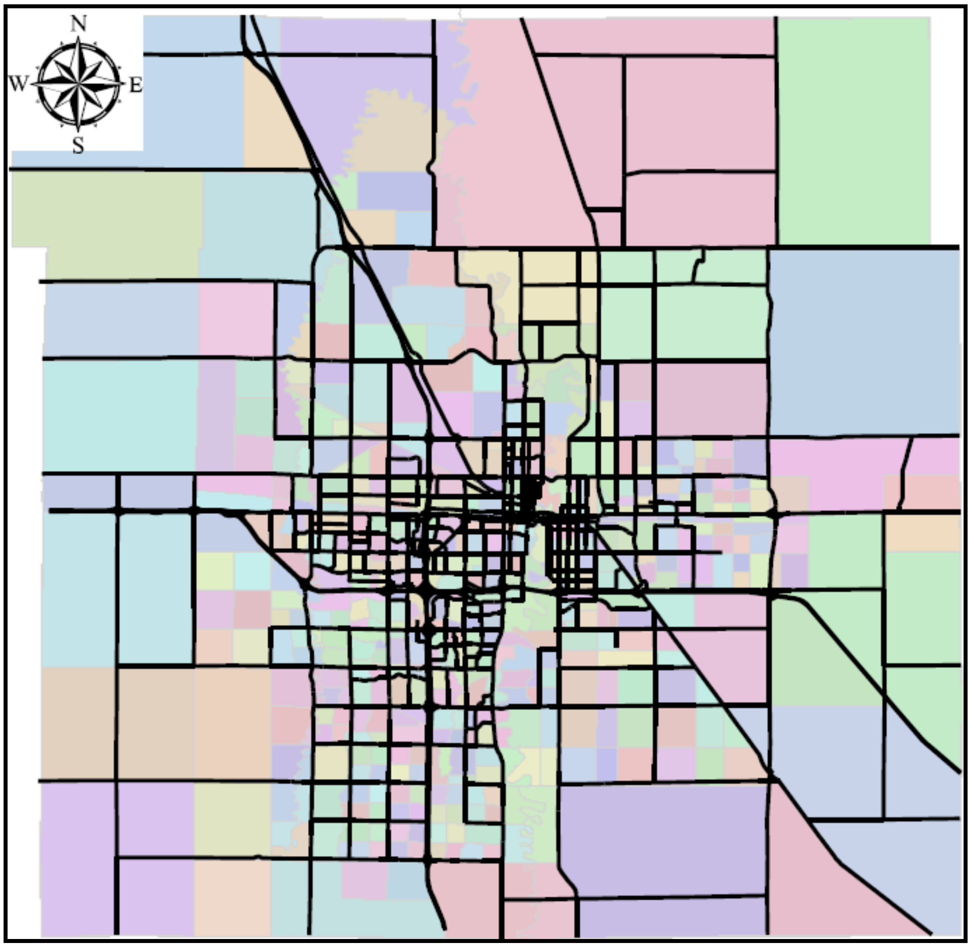

Figure 2.1. The modeled Fargo-Moorhead Transportation Network and TAZs

2.1 Capacity Calculation

The Highway Capacity Manual (HCM) procedures are usually used in travel demand modeling to analyze signalized intersections, determine capacity, and measure delay. Using the HCM procedures should produce more accurate results; however, this method has several drawbacks when used for travel demand modeling applications. The HCM procedures depend on the traffic volume and turning percentages for intersection analysis, which are dynamic, making it difficult for the model to converge on a solution.

The most common practice for capacity calculations by planning organizations, including North Dakota metropolitan planning organizations (MPOs), is to develop capacity tables. These tables report the capacity per lane based on the facility type and area where the facility is located. The drawback from this approach is that the capacities are static and not affected by lane configuration changes in the network. Many models use average values that do not represent the traffic in the area or account for traffic signal management strategies.

ATAC utilizes an approach that represents a mix of the two methods. HCM capacity equations were used for rural and interstate highways (*1*). The capacity for interstate highways was based on the number of lanes and speeds along each section. The capacity for rural roads was determined based only on the number of lanes in each section of the highway. For urban streets a different technique was used based on information from National Cooperative Highway Research Program (NCHRP) report 365 (*2*). Based on the functional class, number of lanes, and intersection configuration in urban areas, each street by functional class was applied a default capacity. If the roadway had more than one lane, left turn lanes, or right turn lanes, the capacity was increased by an appropriate amount as shown in Table 2.1.

Table 2.1. Modeled Capacities for Urban and Rural Roads

	Capacities (Vehicle/Hour/lane)					
	Functional Class	**One Lane**	**Multi Lane (Per Lane)**	**Each Additional lane**	**Each Right Turn Lane**	**Each left Turn Lane**
Rural	Interstate	-	1,800	-	-	-
	Non-Interstate	1,500	1,700	-	-	-
Urban	Interstate	-	1,700	-	-	-
	Major Arterial/ Oneway	1,000	-	800	300	75
	Minor Arterial	675	-	600	200	75
	Collectors/ locals	450	-	400	100	75

2.2 Node Delay Calculation

Delay at controlled intersections influences route selection for motorists. ATAC developed an estimate of control delay based on controlled intersection analyses. An average control delay was assigned to signalized and stop sign controlled intersections based on the roadway functional classification.

The delays were minimal for traffic signals along major arterials or one-way streets when compared to signal delays on minor arterials and side streets. This is to be expected because signals are typically coordinated along a street with high functional classification. The initial intersection control delays according to corresponding roadway functional classification are shown in Table 2.2. These delays were adjusted during calibration to replicate the trip making behavior in the modeled regions.

Table 2.2. Initial Modeled Node Delays

	Node Delay (sec/veh)	
Functional Classification	**Traffic Signal**	**Stop Sign**
Interstate	-	-
Major Arterial	8	10
Minor Arterial	8	10
One-Way	8	10
Collector	30	10
Local	30	10

3.0 Trip Generation

After the data preparation step is performed, the next step within the transportation model is trip generation. Trip generation utilizes socio-economic data to predict the number of trips produced by and attracted to each traffic analysis zone (TAZ) within the modeled area. There is an assumption that these trips are made by individuals to participate in different activities. Trip production is associated with residential areas and different attributes of households, whereas trip attraction is related to non-residential area characteristics. Production is estimated using factors, such as the number of households in that area, household sizes, income and automobile ownership rates, along with other variables that might affect the general trend of trip productions. Attraction is estimated using variables, such as employment levels and floor space.

To establish the relationship between trip generation rates and socio-economic data of each zone, trip generation models use historical data to estimate the number of trips generated. The Institute of Transportation Engineers (ITE) Trip Generation Manual, provides the type of data used, trip rates, and other related statistical data. This step takes the zonal and external trip data as input and produces an array of production and attraction values. The values within the array are the number of person trips produced within and attracted to each internal TAZ or to TAZs located outside the planning model (external).

3.1 Production for Internal Zones

The number of trips produced in the modeled area is based on the number of dwelling units in the metro area. The dwelling units were categorized into single family and multifamily residences based on the 2000 census data in addition to building permit data for the years 2000 to 2005. These categories were used to determine the number of home based work (HBW), home based other (HBO), and non-home based (NHB) production trips.

The number of trip productions was estimated by multiplying the total number of single family or multifamily dwelling units by the appropriate daily vehicle trip rate (Table 3.1). The trips were separated into HBW, HBO, and NHB production trips by multiplying the total vehicle-trips with the percentage of trips by purpose to replicate the trip making behavior in the metro area, the vehicle trip rates were adjusted during the calibration process.

Table 3.1. Vehicle Trip Generation Rates (Based on NCHRP, Report 365, Table3)

		Percentage of Trips by Purpose		
Dwelling Category	**Daily Vehicle Trip Rate**	**HBW**	**HBO**	**NHB**
Single Family	9.55	0.20	0.57	0.23
Multifamily	6.47	0.20	0.57	0.23

3.2 Attractions for Internal Zones

For trip attractions purposes, all the TAZs within the metro area were classified as being within a central business district Area (CBD) or a non central business district area (NCBD). Table 3.2 summarizes the rates and equations used to determine HBW, HBO, and NHB trip attractions for CBD and NCBD zones.

Table 3.2. Trip Attraction Rates (Based on NCHRP, Report 365, Table 8)

Trip Purpose	CBD Zones	NCBD Zones
HBW	1.45 x TE	1.45 x TE
HBO	2.0 RE + 1.7 SE + 0.5 OE + 0.9 HH	9.0 RE + 1.7 SE + 0.5 OE + 0.9 HH
NHB	1.4 RE + 1.2 SE + 0.5 OE + 0.5 HH	4.1 RE + 1.2 SE + 0.5 OE + 0.5 HH

Where:
TE = Total Employment
RE = Retail Employment
SE = Service Employment
OE = Other Employment
HH =Households

3.3 University Trip Productions and Attractions

To account for the different trip making behavior of university trips, North Dakota State University (NDSU), Concordia College, and Minnesota State University Moorhead (MSUM) were treated as special trip generators. In addition to the daily HBW, HBO, and NHB trips, a category of home-based university trips was implemented. To estimate the number of trips produced by and attracted to college campuses, the trip generation component used equations that were developed by ATAC. Using NDSU as a model, primary data were gathered to determine the number of trips made to and from campus and areas directly affected by the trips generated at NDSU. Based on the results from that analysis, it was concluded that the number of college trips could be predicted based on variables that can be forecasted by the F-M COG. Each educational institution was then evaluated on individual bases to determine trip productions for each of the zones affected by that school (Table 3.3).

Table 3.3. University Trip Estimation Variables

			Predicted 2005 Enrollment		
Purpose	**Rate**	**Population Category**	**Concordia College**	**MSUM**	**NDSU**
HBW Productions	0.16	On-Campus Students	1,794	1,559	2,876
HBO Productions	0.37	On-Campus Students	1,794	1,559	2,876
NHB Productions	0.17	Total Students	2,608	7,491	11,723
HBS Productions	0.12	On-Campus Students	1,794	1,559	2,876
HBW Attractions	0.30	Total Students	2,608	7,491	11,723
HBO Attractions	0.44	Total Students	2,608	7,491	11,723
NHB Attractions	0.17	Total Students	2,608	7,491	11,723
HBS Attractions	0.72	Off-Campus Students	814	5,932	8,847

To estimate the college trips productions and attractions, the appropriate rate was multiplied by the predicted 2005 school enrollment data. Based on data obtained previously through interviews and parking data that was provided by the administration at each institution, a summary of college trips by purpose is provided in Table 3.4.

Table 3.4. University Trips Generated by Purpose

	Concordia College	**MSUM**	**NDSU**
HBW Productions	287	249	460
HBO Productions	664	577	1,064
NHB Productions	443	1,273	1,993
HBS-University Productions	215	187	345
HBW Attractions	782	2,247	3,517
HBO Attractions	1,148	3,296	5,158
NHB Attractions	443	1,273	1,993
HBS-University Attractions	586	4,271	6,370

3.4 High School and Grade School Productions and Attractions

Using information provided previously by the school district and a survey of parents throughout the area, ATAC developed trip generation rates that were used to independently calculate the home based-school (HBS) attraction trips. To determine the relative attractiveness of area schools, the initial value of attractions per zone was set to the number of students enrolled in the school zone. The population was divided into two different age groups to distinguish between high school and grade school aged students. This was done because of the different trip characteristics of the students who may possess a driver license. The trip productions were initially calculated as one production for each person in the population age bracket. During subsequent runs the productions were adjusted using equations that ATAC developed. Table 3.5 shows the total value of home based school attractions and production trips for grade and high schools in the model.

Table 3.5. Total Attractions and Productions for Grade and High Schools

Trip Purpose	High School	Grade School
HBS Productions	9,025	20,185
HBS Attractions	7,782	16,815

3.5 Airport Trip Generation

The Fargo Hector International Airport is located within TAZ number 42 in the travel demand model. Special consideration was given to this TAZ to accurately capture the trip productions and attractions to that zone in the transportation model. In 2005, there were 549,209 enplanements for Hector International Airport. Initially basic trip generation were used to develop the preliminary HBO and NHB attractions for the airport zone. To estimate the daily attracted trips to the airport, the total enplanements were divided by 365 to obtain the average daily trips.

ATAC utilized the 2000 ITE's Trip Generation reference book to obtain the average person trip ends and then multiplied those values by the average daily trips. The attractions produced by the airport were added together with the trips produced from the household data in this TAZ. This method produced results that accounted for both households living in TAZ number 42 and airport trip generation.

3.6 External Trips

External-external trips are defined as trips with both ends outside the modeled area; those trips are assumed to account for 10% of the interstate traffic. In the travel demand model, the trips made from an external zone to an external zone without stopping within the model are subtracted from the external productions and attractions.

Trips with only one trip end outside the modeled area are defined as either external-internal or internal-external trips. Attractions for external nodes were found by multiplying the average daily traffic with the percentage of trips by purpose at each external node. To calculate the number of productions for the interstate highways, ATAC subtracted the total number of through trips from the ADT and then multiplied it by percentage of trips by purpose.

3.7 Adjustment

Applying the methodology and equations described in the previous sections to the TAZ socio-economic data yields unbalanced production and attraction totals. In the travel demand mode each production must be matched to an attraction to form a trip, the total productions must equal the total attractions for each trip type. In general, the total trip productions are considered a more accurate estimate than the total trip attractions. Hence, it is necessary to adjust the attraction values to match the total number of productions. The total unadjusted numbers of trips produced by TAZs and attracted to those TAZs are reported in Table 3.6.

Table 3.6. Total Unadjusted Productions and Attractions Generated by Purpose

Trip Purpose	Total Trip Productions	Total Trip Attractions
HBW	159,347	124,846
HBO	452,513	266,435
NHB	99,546	99,546
HBS-University	9,824	9,942
HBS-High School	9,027	7,782
HBS- Grade School	20,185	16,815

To perform trip generation adjustment the total number of attractions was divided by the total number of productions for each trip purpose. The factor resulting from this process for each trip purpose was applied to each TAZ's attraction total to find the new adjusted attraction values. As for HBS-University trips, trips were adjusted to match the number of attractions because it is easier to quantify the number of trips arriving at the universities than it is to predict the location from which the students are generating their trips. Table 3.7 summarizes the total adjusted numbers of trips produced by TAZs and attracted to those TAZs.

Table 3.7: Total Adjusted Productions and Attractions Generated by Purpose

Trip Purpose	Total Trip Productions	Total Trip Attractions
HBW	159,347	159,347
HBO	452,513	452,513
NHB	99,546	99,546
HBS-University	9,942	9,942
HBS-High School	9,027	9,027
HBS- Grade School	20,185	20,185

4.0 Trip Distribution

After the trip production and attraction for each zone had been determined in the trip generation step, trip distribution models are used to connect trip ends, that is, to establish the flow of trips from production zones to attraction zones. The output from this step is a matrix representing the production and attractions between TAZs, called the origin-destination (O-D) matrix.

The most commonly used type of trip distribution model is the gravity model. This model is a modified version of Newton’s law of gravitation between physical bodies in space (Equation 4.1). In it, the number of trips between zones is assumed to be based on the relative attractiveness of zones, which is measured by travel time or cost. The gravity model assigns trips based on the number of productions, attractions, a friction factor (F), and a scaling factor (K). The friction factor is a value that is inversely proportional to distance, time, or cost which measure the impedance between the zonal pairs. The k factor is a scaling factor that is used during calibration and it limits or increases the volume of traffic that crosses sections of the network. Equation 4.1 below provides the mathematical function of the Gravity Model.

$$T_{IJ} = P_I \frac{K_{IJ} A_J F_{IJ}}{\sum (K_J A_J F_J)} \qquad \text{Equation 4.1}$$

Where:

T_{IJ} = Number of trips assigned between Zones i and j
PI = Number of Productions in Zone I
AJ = Number of Attractions in Zone J
FIJ = Friction Factor
KIJ = Scaling factor used in calibration to influence specific IJ pairs

4.1 Friction Factor Computation

Friction factors are used in the travel demand model to account for the impedance (or resistance to flow), which represents the travel time for all trip purposes except home based school trips. The impendence for HBS was the travel distance, allowing school trips to be assigned to the nearest zone that has a school in it which is similar to how school-districts are divided in the area.

The initial iteration used free flow travel for calculating the impedance. For the second iteration, congested speeds from the first iteration are used for the model run. A standard friction factor lookup table was used. This table makes shorter trips more desirable than longer ones.

5.0 Mode Split

Mode split predicts the mode of travel that is used for TDM trips, and as such divides trips between the various transportation modes available for users. Since the area has a low percentage of public transit use, automobiles are the only mode choice represented in this transportation model.

5.1 Hourly Origin-Destination Calculation

Currently, the number of trips generated by the travel demand model is represented by vehicle trips per day. However, the model needs to assign trips in hourly increments so that the assigned trips will have the same units for the roadway (i.e., vehicles per hour). The daily matrix of trips needs to be converted to an hourly matrix that can be assigned to the roadways. Based on a previous analysis of several hourly counts throughout the city, daily traffic was divided as follows: AM Peak (7:45AM-8:45AM, 7.53%), PM Peak (5:00PM-6:00PM, 8.52%), and all other as Off Peak (6.0%/hr*14hrs. = 84% ADT).

The production attraction matrix is added to the transposed production attraction matrix and then the trips are divided by two. Using this method, it is assumed that half of the trips go from production to attraction and half of the trips are returning from the attraction back to the production. The matrix was then multiplied by the appropriate time of day percentage to obtain three origin destination matrices. Figure 5.1 shows the percentages associated with time of day for the off peak and each peak hour.

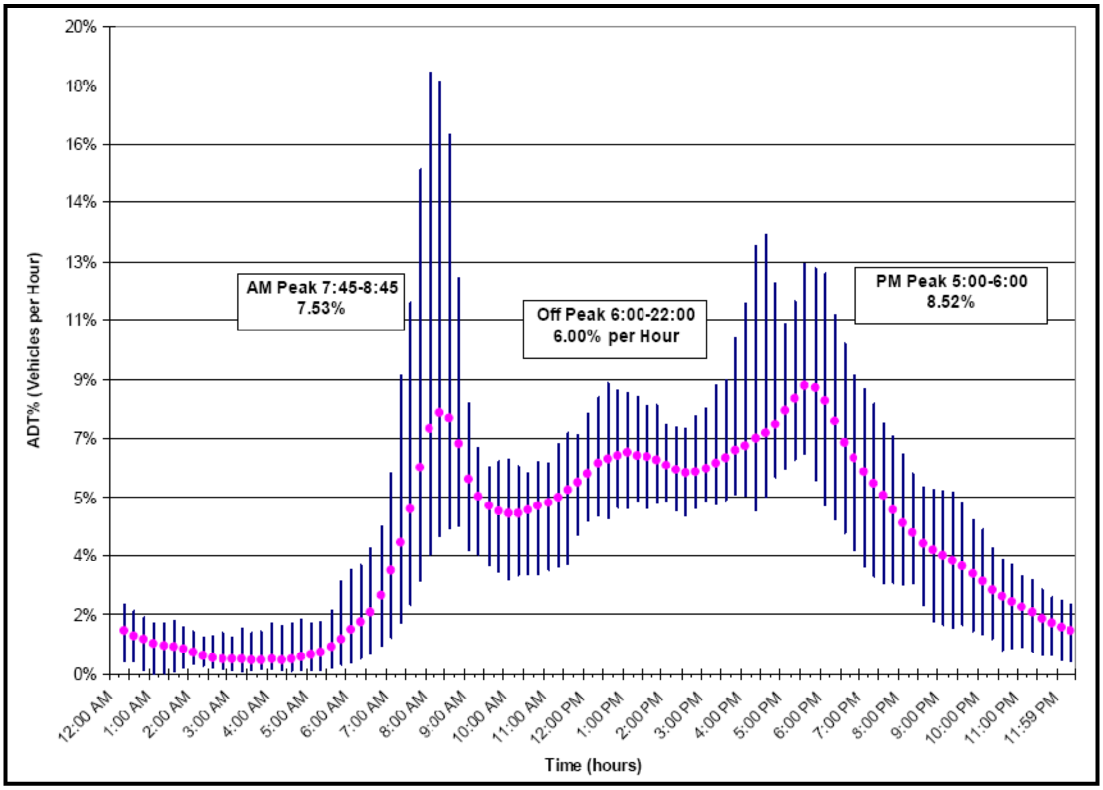

Figure 5.1. Results from the Fargo-Moorhead Traffic Survey

6.0 Traffic Assignment

This is the last step performed in the travel demand model. In this step, the predicted traffic flows are assigned to the modeled network links. Traffic assignment follows the main principles of equilibrium stated by Wardrop in the 1950s: 1) user-equilibrium, and 2) system-equilibrium. In user-equilibrium, users of the system choose the route that would minimize their cost (or travel time) without consideration to the overall average travel time on the system. In system-equilibrium, system users would behave cooperatively in choosing their own route to ensure the most efficient use of the system, thus optimizing the overall average cost of travel on the system. User-equilibrium traffic assignment method is more realistic; hence, it was used for this model. It was implemented using a cost function to evaluate the most desirable path. This method was chosen for the convenience of conducting different studies.

Assignment begins with three separate origin-destination (O-D) matrixes; AM peak, PM peak, and off peak, which contain the volumes that are to be assigned to each O-D pair. User equilibrium in TP+ uses built in functions in order to assign trips to paths from each origin zone. ATAC used a vehicle cost variable which assigned trips to minimize the cost. Travel time was set to the free flow travel time for the first iteration and then changed with iterations depending on congestion. This iterative process continued until there was no available path at which the cost could be reduced.

6.1 Level of Service (LOS) Determination

The level of service criteria is used as a measure of the roadway serviceability on a scale of A to F, with A being a roadway with the most desirable driving conditions and F being a roadway with undesirable conditions. ATAC used the procedures developed within the Highway Capacity Manuel (HCM). This procedure compares free flow speeds (FFS) to modeled travel speeds or densities given the standard speed or density parameters from the HCM. HCM standard speeds or densities are disaggregated according to area type, rural or urban, number of lanes, and functional class, which allows for a more accurate LOS determination.

With the exception of freeways and multilane highways, the LOS for roadways is determined by comparing the FFS with the modeled travel speed. A lower LOS reflects a greater difference between the modeled travel speed and the FFS. Interstate systems and multilane highways used a different methodology for determining the LOS. Modeled densities were compared to the standard density given in the HCM.

It is important to note the analyst cannot assume that a low LOS indicates the roadway is close to or exceeding capacity. A low LOS may be because travel speeds incorporate delay at intersections. Therefore, a short link with a signal or stop sign control may have a lower average travel speed because of the delay imposed by the intersection control.

7.0 Travel Demand Model Calibration

The final stage in the development of the transportation model is the calibration of the travel demand model. The main goal of the calibration process is to make as many of the modeled roadway links as possible meet the designated criteria range. The process of calibration is a tedious process that needs to be conducted in a thorough and exact manner. Figure 7.1 provides an illustration of the calibration procedure followed by ATAC.

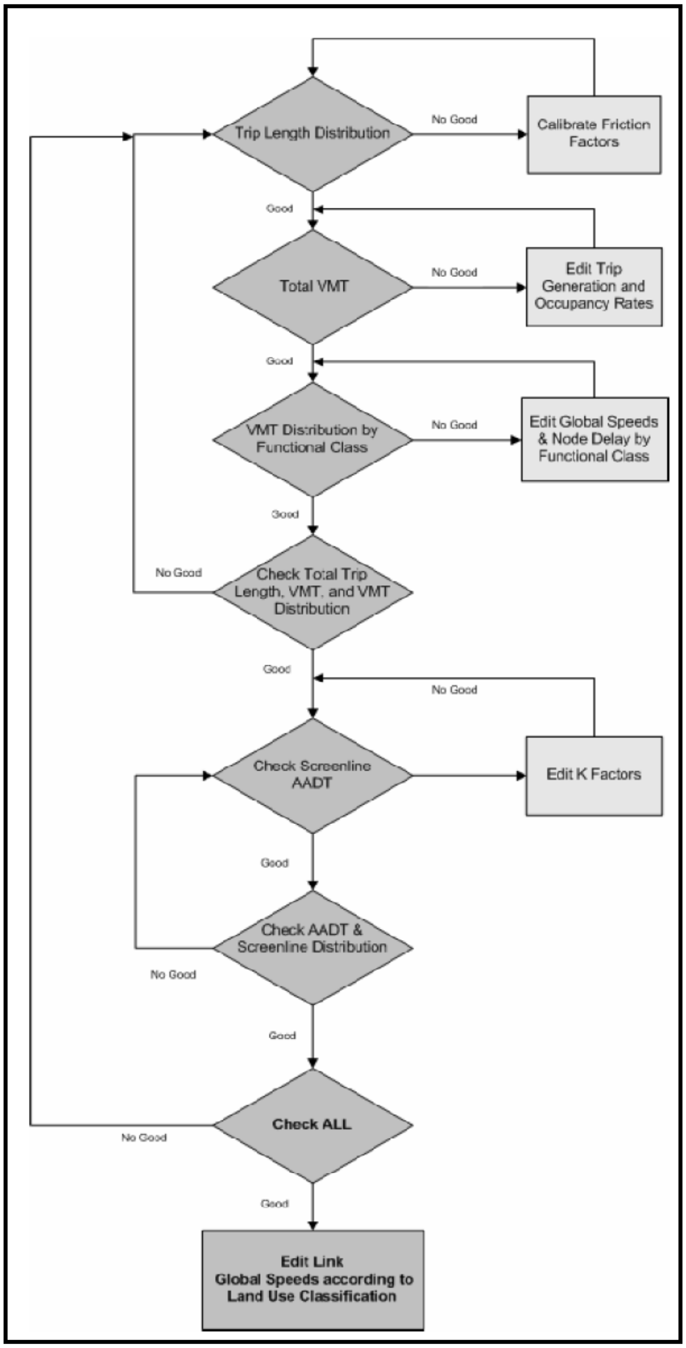

Figure 7.1. Calibration Flow Chart

7.1 Trip Length Distribution

The first task of the calibration process is to check if the modeled vehicles trips are similar in length (minutes) to the length of those trips provided by the 2000 Census for Transportation Planning Package (CTPP) data. It is expected that shorter trips tend to occur more frequently than longer trips do and the transportation model needs to reflect this trend. ATAC compared the modeled HBW, HBO, and NHB trip lengths to the 2000 CTPP data. If the modeled trend did not follow the 2000 CTPP data trend, ATAC adjusted friction factor coefficients until the model resembled, as closely as possible, the 2000 CTPP data. The HBO and NHB trips were modeled as 75.2% and 88.4% of the HBW data, respectively (Figure 7.2). Figure 7.3 illustrates the trip length distribution based on the 2000 census data.

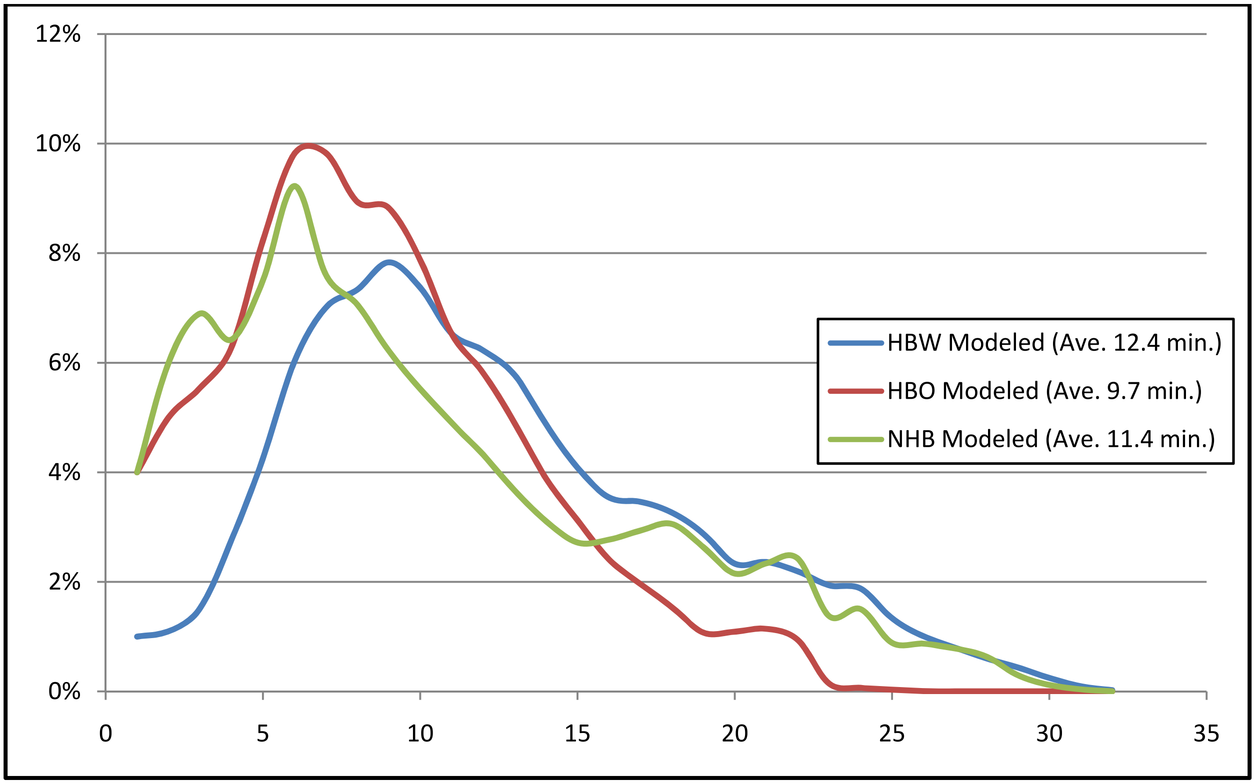

Figure 7.2. Trip Length Distribution by Trip Purpose (Modeled)

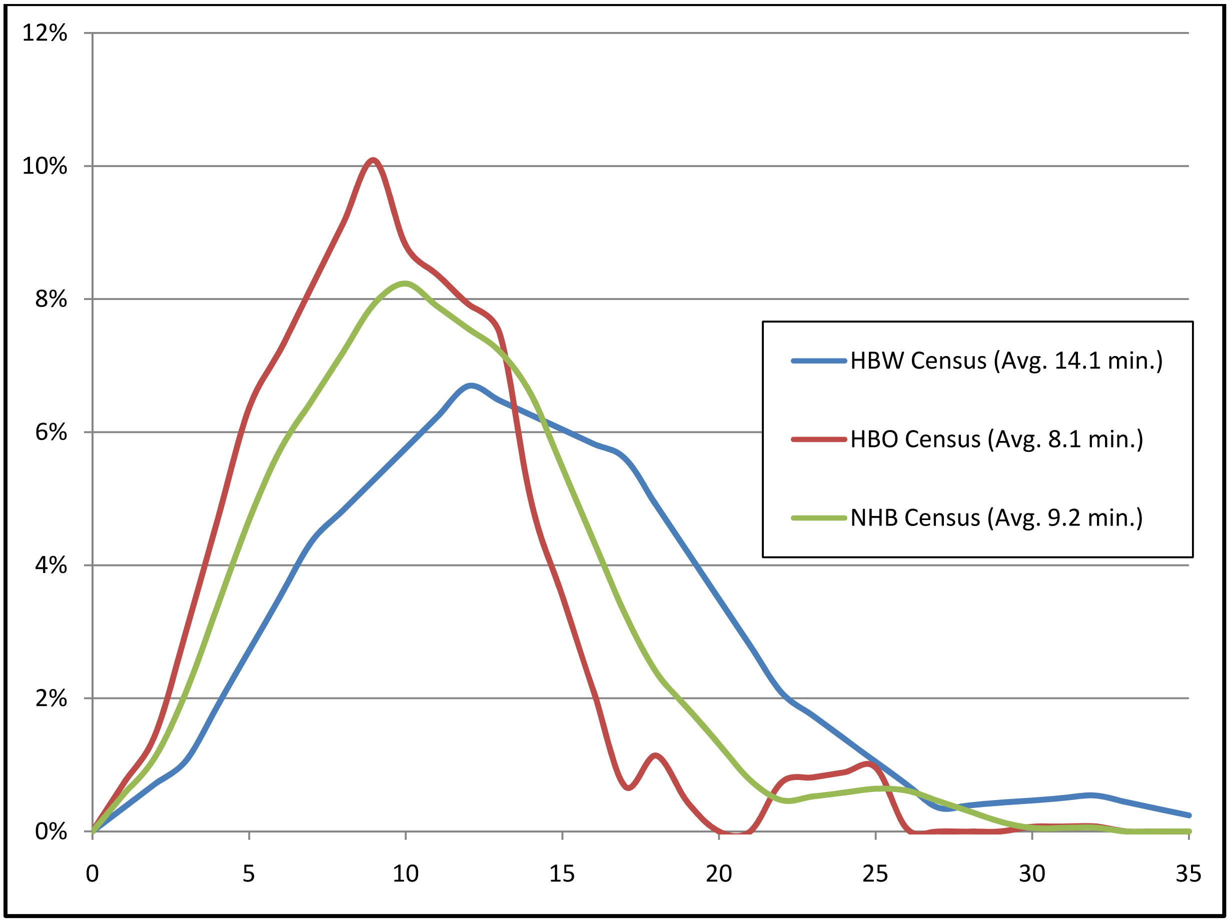

Figure 7.3. Trip Length Distribution by Trip Purpose (Census)

7.2 Total Vehicle Miles Traveled (VMT)

The modeled vehicle miles traveled are a function of trips generated by the model and the length of those trips in miles. To calibrate the VMT values, ATAC first calibrated the total VMT for the entire network. If the modeled VMT value was different from the value reported in the field ATAC adjusted the trip generation and occupancy rates until the model and reported VMT values were similar. Adjusting the trip generation and occupancy rates changes the total number of trips that are generated within the transportation model. This in turn increases or decreases the total number of vehicle miles traveled. Once the total VMT was on target, ATAC checked the VMT distribution according to the functional class. If the functional class distribution was off target, global speeds, according to land use characteristics, and node delays were adjusted. Table 7.1 provides a summary of the final modeled and reported VMT values by jurisdiction within the metro area. The overall adjusted VMT was within 2% of the actual overall reported VMT. This is well within the standard 5% given in the Travel Model Improvement Program's Model Validation and Reasonable Checking Manual (*3*).

Table 7.1. Vehicle Miles Traveled by Jurisdiction

Jurisdiction	VMT Reported	VMT Modeled	Difference in VMT	% Difference in VMT
Fargo	1,845,042	1,823,416	-21,626	-1.17%
Moorhead	482,413	430,514	-51,899	-10.76%
West Fargo	169,523	172,657	3,134	1.85%
Dilworth	41,029	71,825	30,796	75.06%
ND	2,014,565	1,996,073	-18,492	-0.92%
MN	523,442	502,339	-21,203	-4.03%
Metropolitan Area	2,538,007	2,498,412	-39,595	-1.56%

7.3 Screenlines

To check the screenline component of the calibration, ATAC examined the total AADT of the links crossing the screenline. The screelines used for this model include I-29, I-94, the Red River, and the main railroads tracks. If the total modeled traffic volume screenline was above the specified criteria, a lower k factor was assigned to inhibit traffic from crossing the screenline. Similarly, if the screenline had a volume total modeled traffic volume below the designated criteria, a higher k factor would be applied to affected zones. This would make zonal pairs that cross the screenline more attractive. After achieving an accurate screenline distribution, the calibration process was repeated starting with checking the trip length distribution, until all the successive calibration components were completed. Table 7.2 shows the k factors used in the transportation model and how the modeled volumes compared to the AADTs crossing these screenlines.

Table 7.2. Screenline K Factors

Screenline	K Factor	AADT	Modeled ADT	Traffic Volume Difference	Percent Difference (%)
Interstate 29	0.80	96200	91500	-4700	-4.89%
Interstate 94	0.33	135075	136400	1325	0.98%
Red River	0.30	109950	110600	650	0.59%
Railroad	0.40	122875	122800	-75	-0.06%

7.4 Network Wide Adjustments

The final phase of the model calibration process is to check the network's link AADT distribution. ATAC checked how the modeled traffic volume over the network links compared to the AADT obtained from traffic counts in the field. If links in a region were found to have a highly differing volume, global speeds were adjusted based on land use characteristics. Using an appropriate speed adjustment would help links to fit into the specified criteria range. Table 7.3 shows the percentage of links that meet each criterion provided by the Model Validation and Reasonable Checking Manual based on volume range (*3*).

Table 7.3. Model Assignment by Modeled Traffic Volume Range

Volume Range	**Above Criteria**	**Meets Criteria**	**Below Criteria**	**Within Criteria**	**ND Criteria Deviation**
AADT>25,000	0	18	1	95%	22%
25,000 to 10,000	6	131	23	82%	25%
10,000 to 5,000	35	134	22	71%	29%
5,000 to 2,500	33	129	15	72%	36%
2,500 to 1,000	46	72	13	56%	47%
AADT<1000	34	27	2	43%	60%
Total	154	511	76	69%	

To determine the overall difference between the modeled and reported traffic volume, ATAC used the Root Mean Square Error (RMSE). The RMSE value is found by averaging the square error for each link and then taking the square root for the averages. Table 7.4 provides the RMSE values classified by the traffic volume ranges.

Table 7.4. RMSE Values by Volume Range

Volume Range	**RMSE (%)**	**Typical Limits (%)**
AADT>25,000	14 %	15-20 %
25,000 to 10,000	24 %	25-30 %
10,000 to 5,000	37 %	35-45 %
5,000 to 2,500	55 %	45-100 %
2,500 to 1,000	93 %	45-100 %
AADT<1000	>100 %	>100 %

An important measure of how well the travel demand model is assigning traffic to the transportation links is the correlation between the modeled and reported traffic volumes over the links. The correlation could be quantified by the coefficient of determination R^2. The guidance provided by the Travel Demand Improvement Program as part of the US Department of Transportation (USDOT) suggests that the R^2 value be at least 0.88 for the overall region. For the calibrated F-M COG travel demand model the value of R^2 was 0.89 which satisfies the limits. Figure 7.3 shows the traffic volume correlation for the base model, while Figure 7.4 provides visual representation of how those volumes fit within the criteria.

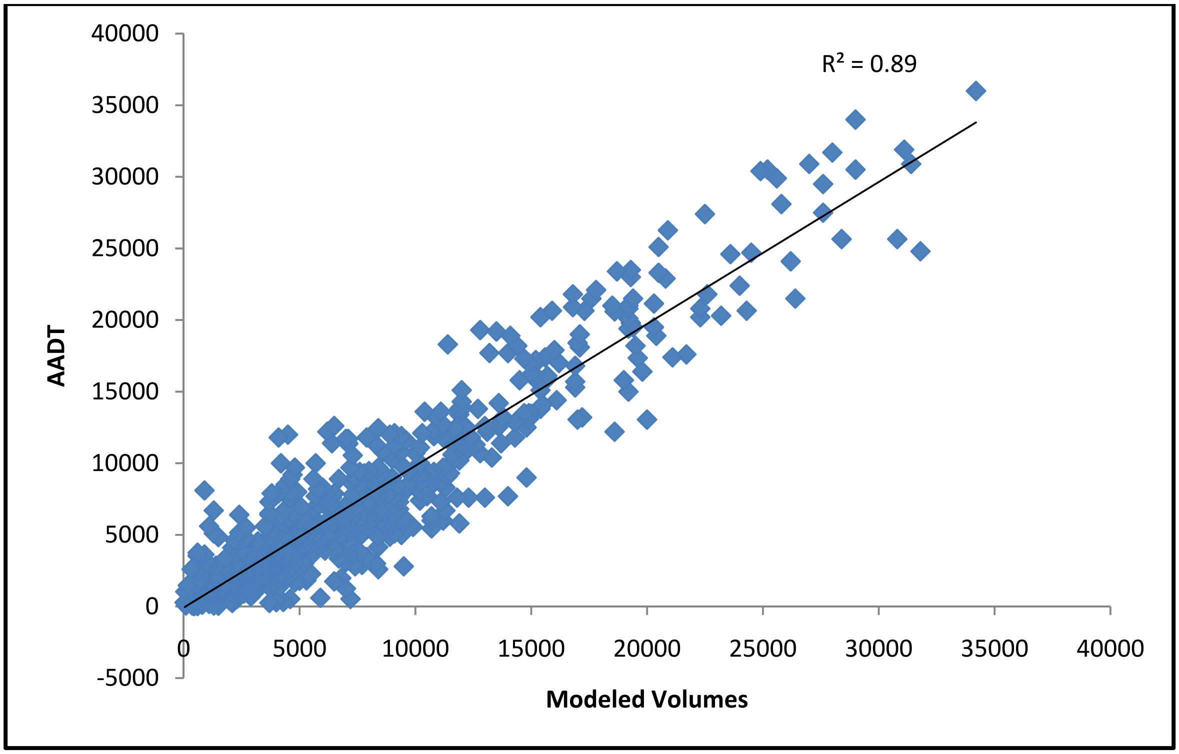

Figure 7.3. Traffic Volume Correlation

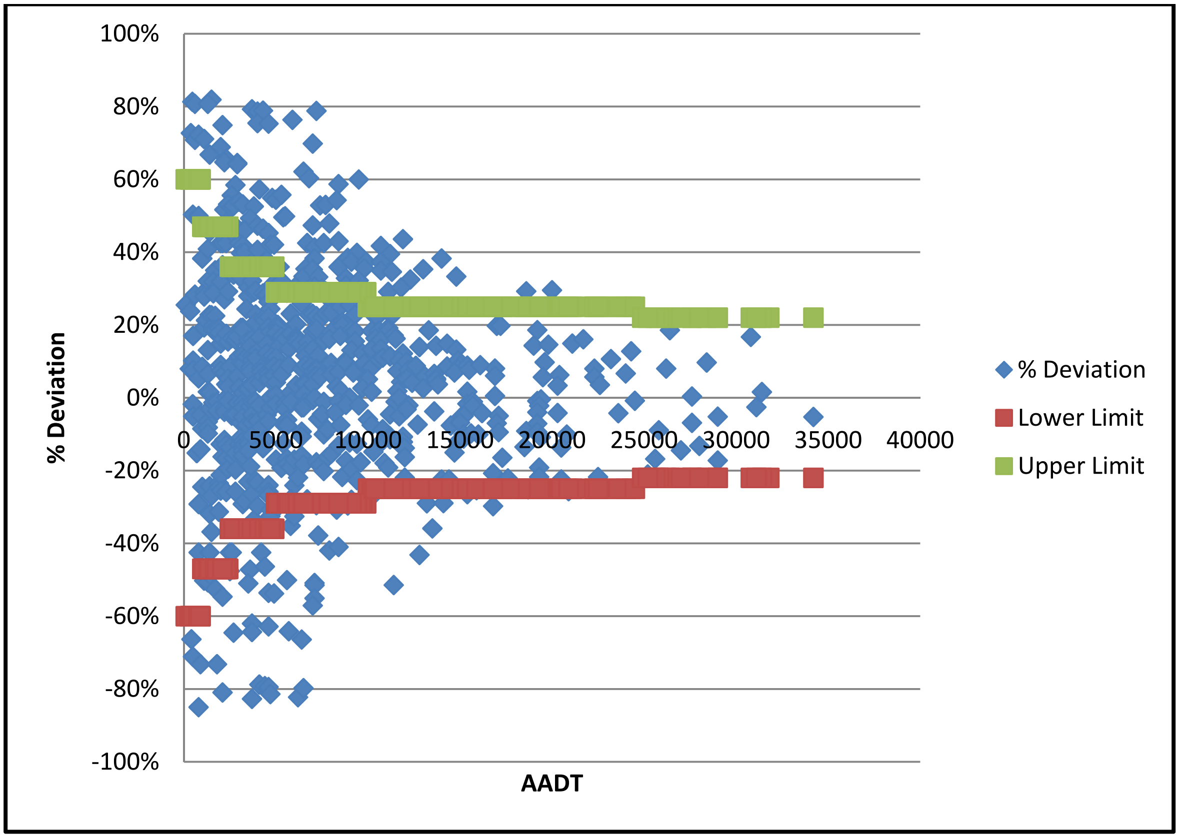

Figure 7.4. Link Distribution by Link Volume

8.0 User Guide

This chapter serves as a guide to users that explains the execution process involved in FM-COGs travel demand model. The following font style will be used for identification of various model files:

- Model input files: **Bold Characters**
- Model output files: *Italicized and Underlined Characters*

8.1 Introduction

F-M COGs travel demand model is completely developed within Citilabs' Cube software and is run using Citilabs' TP+ software. CUBE enables the user to view and edit input and output files. Unlike using only TP+, CUBE also allows users the option to organize the model script. ATAC has organized and labeled each major step within Fargo/Moorhead's travel demand model. This will help a first time user of the model to efficiently understand each process involved.

8.2 Model Description

F-M COGs travel demand model is broken down into three main subgroups, first iteration, final iteration, and final assignment. First iteration uses the input network, TAZ data, job data, and travel time data to direct the following processes:

- Data Preparation
- Trip Generation
- Gravity Model
- Change Production/Attractions to an Origin-Destination Matrix
- First Assignment

During the final iteration, a second gravity model is performed and the final production attraction file is changed to an origin destination matrix. Final assignment portion is described in Section 8.6.

8.3 Network Construction

The base network has been completely constructed using ESRI's ArcGIS software. Each network file has corresponding point shape files that show the interior traffic analysis zones (TAZ), model nodes, and exterior zones. The network and the point shape files are connected to each other based on the A and B fields described in the Table 8.1, which gives the name of a few fields in the network file with a corresponding description.

Table 8.1. ArcGIS Network Field Variables and Description

Field Name	Description
Name	Specifies the roadway name
Oneway_twoway	Specifies if the roadway has one directional traffic or two directional traffic
A	Specifies the link starting node number
B	Specifies the link ending node number
Numlanes/R_Lanes	Specifies the number of lanes contained on each link
A_	Identical to the A node field It. is used to determine the forward direction in CUBE
Enabled	This should be left as the default value “True”
Modeled	Separates the roadway links from the pseudo links according to the following code: 1-Modeled Roadway Link 2-Pseudo Link
Direction/R_Direction	Specifies the direction of vehicle travel according to the following code: 4-Northbound Link 8-Southbound Link 2-Eastbound Link 6-Westbound Link
Control/R_Control	Specifies the intersection control according to the following code: 0-No Control 1-Yield Sign 2-Stop Sign 3-Signal
Func_Class	Link Functional Class according to the following code: 1-Interstate 2-Major Arterial 3-Minor Arterial 4-One-Way 5-Collector 6-Local 7-Pseudo Link
AreaType	Area Classification the facility resides according to the following code: 1-Rural 2- Urban 3- Central Business District (CBD)
City	Region where the link resides according to the following code: 9-West Fargo 12-Moorhead 16-Cass County 17-Fargo 19-Dilworth 27-Clay County
District	State where the link resides according to the following code: 1-North Dakota 2-Minnesota

A network file for the model can easily be generated from an exported base network shape file using TP+ software. The first step in generating the network file is to open the exported shape file in TP+. Next, select “Build Network from Shape” under the “GIS tools” menu. A window will appear asking where the new network file should be placed and the file’s name. Name the file and place it into the input folder and click open. After specifying the name and input location, another window will open and it will ask to specify values for each field. Table 8.2 serves as a guide for providing the important field values. Once the fields are updated, click “build” and the new network file will be generated.

Table 8.2. Build Network from Shape File Option Values

Field Name	Specified Input Value
A-Node Field Name	A
B-Node Field Name	B
Clear All values in the A-Node and B-Node field first	Box should remain unchecked
1-Way/2-Way Options	Check “Use Indicator Field” Use OneWay_Two.
Add Distance Field	Leave Unchecked
Scale	Leave as default value of 1.0
Do Not Add Distance Field	Leave Checked
Node Grouping Limit	Leave as default value of 1.0
Starting New Node Number	Leave as default number
Highest Zone Number	624

8.4 Folder Structure

A folder system has been established to efficiently organize the input, program, and output files. Each application uses input files found only in the “input” folder and any application, program, or script files used are located in the folder titled “programs”. Once the application has been run, any output files may be retrieved in the “output” folder. There are five main input files found in the “input” folder and these files are the only ones that will need to be updated to run future travel demand models. The following section will describe how each file was generated and the names for each of the necessary input files.

Road Network: The base network, called **2005basenet.net,** allows the user to make changes to the network by changing the links and nodes within CUBE. Link attributes such as area type (areatype), number of lanes (numlanes), or functional class (func_class) may be changed for future networks at anytime, if needed. By running the model the speed and capacities will be updated. Also, a turning movement penalty file, *offpeak.pen*, will be created that will allow a more accurate distribution of traffic through the network.

Socio-economic Data: The F-M COGs model area was subdivided into 543 interior traffic analysis zones (TAZ). Socio-economic data for these zones includes number of single family dwellings, multifamily dwellings, retail jobs, service jobs, and other jobs located within each in zone. **Data_2005.dbf** is the input file that contains the necessary information for the trip generation step.

External Traffic Analysis Zone (TAZ) Data: External traffic analysis zones (TAZ) ranging from TAZ 600 to TAZ 624 was established on the exterior of the model. Each of these exterior zones connects to an internal zone and external traffic is input into the network through these links. The amount of traffic generated by each zone is dependent upon the average daily traffic count (ADT) for each roadway. A dbf formatted file named **ExternalPercents.dbf** was created and contains each external TAZ number with a corresponding ADT count. This data is used during the trip generation process to set the correct internal-external (IE) trips and external to external trips.

Program files are the backbone to the model and the “Program” folder files should never be deleted unless the user is certain the files are unnecessary. Output files are described in more detail in Section 8.6.

8.5 Key Fields

The CUBE software enables the user to establish key parameters. These key parameters are unique to each scenario and are used to establish locations for file paths or make it convenient to adjust dynamic parameter values. These parameters may be changed or updated on the main CUBE screen and there is no need to change their value in the model code.

Table 8.3. Key Fields and their Description

Key Field Name	Description
Scen.Name	Current selected scenario name
Network	Path to input network
IOPath	The Path to the Working Directory which contain scenarios, input, and output folders
Socio Data	Path to TAZ data DBF File
External Trips	Path to External Trips DBF File
Percent Through	The Percent of Thru Trips
Forcast Year	Forecast Year
FF Lookup	Path to Friction Factor DBF File
Enplanements	List known enplanements
Time Cost	The vehicle cost variable
NDSU On Campus Enrollment	List known enrollments
NDSU Off Campus Enrollment	List known enrollments
MSUM On Campus Enrollment	List known enrollments
MSUM Off Campus Enrollment	List known enrollments
Concordia On Campus Enrollment	List known enrollments
Concordia Off Campus Enrollment	List known enrollments
Select Link	Enter the TP+ code specifying links, nodes, or zones for the select link analysis see the “HwyLoad Module” in TP+ User Manual

8.6 Final Assignment

ATAC has established five different model options. Each option runs the final assignment module but different output text files or network files are created with each. Having a breakdown of different options allows the user to only run one or more assignments at a time. This CUBE layout will help save valuable time because unnecessary script will not be run. The following section will describe each of the seven options and the output files that are produced in each.

Network File: This option outputs a network file named *Loaded.net*. This network file was created using TP+. Table 8.4 shows output field names along with a short description.

Trip Length Distribution: The trip length distribution option allows the user to view a text file that contains the average trip length dependent upon purpose, HBW, HBO, NHB, or internal-external trips. It also contains a trip length distribution breakdown for each purpose over a 45-minute time frame. The *triplength.txt* file can be found in the output folder.

Screen Line Volumes Screen line distributions are important for the accurate calibration of the travel demand model. F-M COGs model used four screen lines during the calibration process and these include the following:
Red River (*SCR_River.txt*)
Interstate 94 (*SCR_I-94.txt*)
Interstate 29 (*SCR_I-29.txt*)
Railroad (*SCR_Railroad.txt*)

The corresponding output files in parenthesis can be found in the output folder. These five files give the name of the link, modeled volume, and a growth percentage. These files will be helpful to quickly view modeled volumes crossing each screen line.

Vehicle Miles Traveled (VMT): The vehicle miles traveled option outputs a text file named *VMT.txt* to the “output” folder. This file contains information regarding VMT based upon functional class and city. It also contains information on the number of trips per household.

Select Link Analysis: This option allows the user to specify zones, links, or node numbers using the key field entitled “Select Link”. The output network *SelectLink.net* will contain only modeled volumes who utilized the specified link, zone, or node. Select Link Analysis allows the user to visually determine which path vehicles are using to reach the specified destination.

Table 8.4. Output Network Variables

Network Name	Description
Model_ADT	Modeled Link Volume
TT	Total Travel Time for each Link
Func_Class	Link functional class according to the following code: 1-Interstate 2-Major Arterial 3-Minor Arterial 4-One-Way 5-Collector 6-Local 7-Pseudo Link
AreaType	Area Classification where the facility resides according to the following code: 1-Rural 2- Urban 3- Central Business District (CBD)
City	Region where the link resides according to the following code: 9-West Fargo 12-Moorhead 16-Cass County 17-Fargo 19-Dilworth
SPD Peak SPD_OffPeak	Calibrated link speed for peak and off peak hours
TT_Peak TT_OffPeak	Calibrated link travel time for peak and off peak hours
LOS Peak LOS OffPeaK	Link level of service (LOS) for peak and off peak hours
VC_Peak VC_OffPeak	Link volume to capacity ratio (VC) for peak and off peak hours
Den Peak Den Offpeak	Link density for each peak and off peak hours

8.7 Conducting a Model Run

Once the code has been established, the user is ready to run the model. The following is to serve as a guide for developing a new model run:

1. Create a new Folder for the analysis scenario within the “forecast folder”
2. Create input and output folders within the scenario window
3. Update any necessary input files and save them in the input folder
4. Create a new scenario in CUBE
5. Double click the new scenario and edit any new key field values
6. Select the scenario and double click the “forecast” application
7. Set the appropriate execution order for the final assignment
8. Double click the scenario to run the model and click “run”

The model will now run and any output files will be available to view once the run has been completed.

References

1. Transportation Research Board, Highway Capacity Manual 2000, Washington D.C., 2000.

2. National Cooperative Highway Research Program, Report 365, Transportation Research Board, *Travel Estimation Techniques for Urban Planning*, Washington, D.C. 1998.

3. Federal Highway Administration, *Model Validation and Reasonable Checking Manual*, Washington D.C., February 1997.