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Bismarck Mandan Travel Demand Model Construction and Calibration (2007 Base Case)

Final Report

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1. Introduction

This memorandum describes the process and methodology used in updating and validating the Bismarck-Mandan (Bis-Man) transportation planning model. The model was updated to support Bismarck-Mandan's long range transportation plan. This reference documents the underlying methodology and assumptions used in each major step within the model.

Travel demand models (TDM) are an important tool used in the transportation planning process to analyze alternative transportation policies and decisions. These models assume that travel demand in an urban area is related to its socioeconomic/land use intensity and characteristics, as well as its transportation supply. These relationships are the basis for developing the TDM.

The process typically involves the development and validation of a base year model that replicates existing traffic levels reasonably using available socioeconomic and land use data. Developing a reasonable base year model is crucial in projecting future transportation demand in the Bis-Man metropolitan area. Model parameters developed in the base year are used to predict future travel patterns based on forecasted future socioeconomic and land use characteristics of the Bis-Man urban area.

The TDM was validated to ensure that its output reflected the metropolitan area's existing traffic level data. All input data used in the model was either provided by the Bis-Man Metropolitan Planning Organization (MPO) or generated by the Advanced Traffic Analysis Center (ATAC). The model was developed to run in the Citilabs TP+ modeling platform using its CUBE software product.

The process of constructing, calibrating, and validating the Bis-Man TDM consists of sevens steps. An overview of these steps is provided below:

- Data preparation builds the transportation network, traffic analysis zones (TAZ) and socioeconomic data in a Geographic Information Systems (GIS) using ArcGIS. The GIS outputs are then transformed into formats compatible with CUBE and used as inputs to the TDM. Chapter 2 provides a detail description of data preparation.
- Trip generation uses static equations based on vehicle trip rates, employment and household size to compute trips generated for each TAZ. The output is a trip generation table containing the number of trips attracted to and produced by each TAZ. Chapter 3 discusses the trip generation step used in this model.
- Trip distribution pairs trips developed in the previous step to their proper origin-destination (O-D) locations. The output is an O-D matrix containing trip production and attractions between the different TAZs. A description of the trip distribution process is found in Chapter 4.
- Traffic Assignment is the last step in TDM and assigns the trips to the network links by minimizing travel costs. A further discussion of traffic assignment is found in Chapter six.

- Model Calibration and Validation adjusts the model parameters to replicate reported base year traffic levels and patterns within a reasonable deviation.
- User Guide provides a detailed explanation of the processes involved in executing the Bis-Man travel demand model with the CUBE software. A description of this process is found in Chapter 8.

2. Data Preparation

The data preparation step gathers all input data required to develop the model. Several different data including, network data, TAZ data, and socioeconomic data are developed in this step.

The Bis-Man TDM modeled network consists of a link-node system. Nodes represent intersections while links represent actual roadways on the network. The network was updated from the Bis-Man 2000 TDB network to reflect changes made since that time and reflects the 2007 base year (*1*). The network is first developed as two-way links in GIS and then converted to a format compatible with TP+ as one-way links. All the network variables are assigned generic names that are used throughout the rest of the modeling process. A total of 239 internal and 16 external zones were developed for the 2007 Bis-Man TDM compared to 187 internal used in the 2000 model.

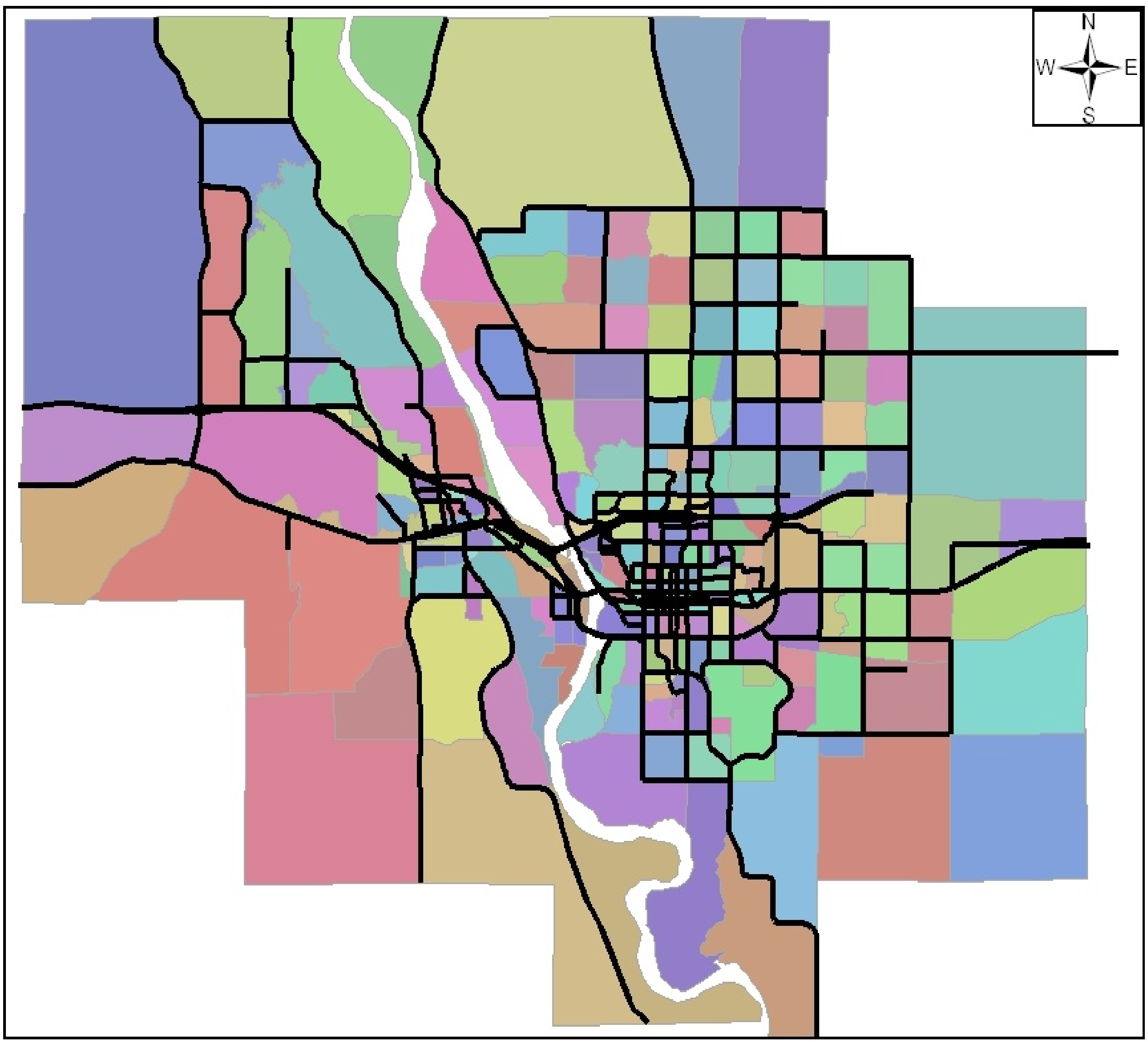

Figure 2.1. Bismarck-Mandan Transportation Network and TAZs.

2.1 Speed and Capacity Calculations

Representing link capacities accurately is important in the modeling process since link volumes are assigned based on link travel costs (volume to capacity ratios). Link capacities were calculated based on either Highway Capacity Manual (HCM) procedures or the National Cooperative Highway Research Program 365 (NCHRP 365) procedures. The HCM procedure calculates link capacities based on the links functional class, its intersection geometry, and the area in which the facility resides.

For interstate highways, HCM capacities based on the number of lanes and area type (rural or urban) where the facility resides (*2*). For all other link functional groups, NCHRP 365 capacities based on the number of through lanes, number of turn lanes and the facility type were used, as shown in Table 2.1. (*3*).

Table 2.1. Modeled Capacities for Bismarck-Mandan Travel Demand Model.

	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

Speed data was incorporated into the network using a table of values based on the number of lanes, functional class, and area in which the facility resides. The table comprised of average speed values determined through a speed study that was conducted in Bismarck in 2000. The speed study area consisted of links of different number of lanes, functional classes and area types (Figure 2.1.). The study included 20 runs through a 15 mile loop beginning at node one, and ending at node 10. The average speeds from this study were later used to adjust posted speeds in the calibration step of the model to reflect trip making behavior in the area. Further discussion of global speed adjustment is contained in Chapter 7.0 of this document.

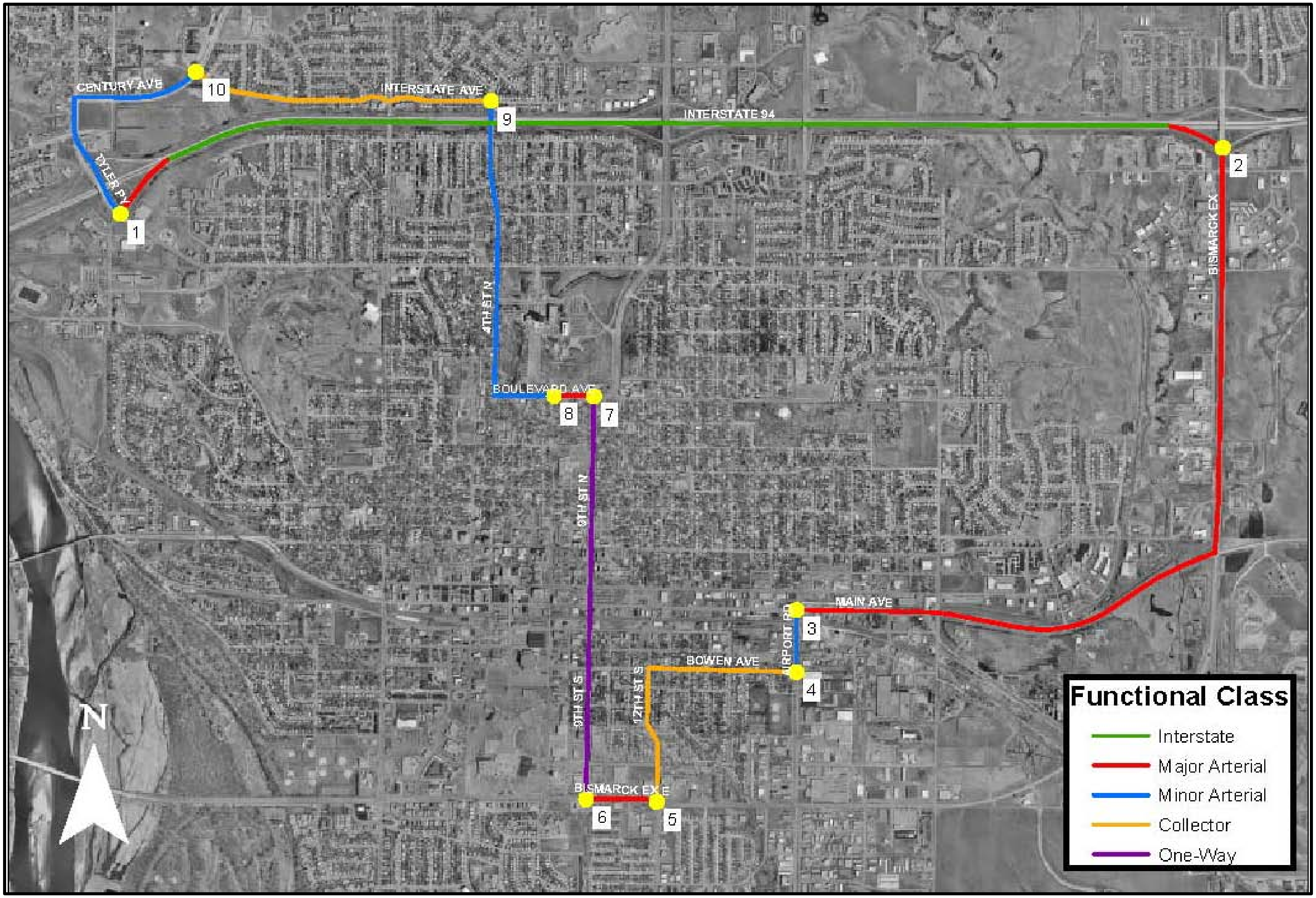

Figure 2.2. Travel Time Study Location.

3. Trip Generation

Trip generation is the next step within the TDM and estimates the intensity and type of trip making activity for each traffic analysis zone (TAZ). Travel demand is assumed to be derived demand, i.e., the demand for travel arises due to the demand for other goods and services. Transportation demand being derived demand forms the basis of developing trip generation equations. Using zonal socioeconomic and land use data/intensity, we can reasonably estimate the average number of trips being attracted or being produced within each TAZ. Trip productions are associated with residential household characteristics such as number of households, average household sizes, income levels and automobile ownership rates. Trip attractions are related to commercial activity within each TAZ and use variables such as number and type of jobs, to estimate the number of trips attracted to that TAZ. The output from this step is a table listing the number of zonal productions and attractions for each trip purpose. The next sections describe the methods and procedures used in the trip generation step for the Bis-Man TDM.

3.1 Production Computation for Internal Zones

The number of trips produced within each TAZ was estimated by applying a person trip rate to the number of households in the TAZ. The household data consisted of 2007 total number of household/TAZ data compiled by the Bis-Man MPO.

The number of individuals per household influences the number of trips being made by each household. For example, a five person household is expected to make more trips than a one person household. The total number of households/TAZ data were disaggregated to generate persons/household/TAZ data based on NCHRP 365 rates. The following five categories were created from the disaggregation:

- Households consisting of 1 person,
- households consisting of 2 persons,
- households consisting of 3 persons,
- households consisting of 4 persons, and
- households consisting of 5 or more persons.

These five household categories were used to determine the number of trips for three different purposes; home base work (HBW), home based other (HBO), and non home based (NHB) trip productions. The number of trips produced for each purpose per TAZ was found by multiplying the total number of households in each TAZ by the appropriate rates from NCHRP 365 as shown in Table 3.1. These trips produced by each household group were summed together and divided by the appropriate occupancy rates to acquire the HBW, HBO, and NHB vehicle trip productions for each zone.

Table 3.1. Trip Estimation Variables by Urban Size Population of 50,000-199,999

Household (HH) Size	HH in Each HH Category	Average Daily Person Trips Per HH	Average Daily Person Trips By Purpose		
			HBW	**HBO**	**NHB**
1	28.0%	3.7	20%	54%	26%
2	34.5%	7.6	22%	54%	24%
3	15.6%	10.6	19%	56%	25%
4	14.0%	13.1	19%	58%	23%
5+	7.9%	16.6	17%	62%	21%

Source: NCHRP 365, Report 365, Table 5 (3).

3.2 Attraction Computation for Internal Zones

To calculate internal trip attractions, each TAZ within the planning area is classified as being within a Central Business District (CBD) or a Non-Central Business District (NCBD) area. Trip attraction equations developed in NCHRP 365 were used to determine attractions for each of the three purposes for CBD and NCBD areas.

Table 3.2. Person Trip Attraction Rates

Trip Purpose	CBD Zones	NCBD
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

Soruce: NCHRP 365, Report 365, Table 8 (*3*).

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

3.3 University Trip Productions and Attractions

To account for different trip making behaviors for colleges, special trip rates were developed for Bismarck State College and the University of Mary. These rates were based on the available number of parking spots, the percentage of these parking spots available to students and the number of on and off-campus students enrolled in each university. Equations for college trip generation rates were developed by ATAC (Table 3.3.). Trip productions and attractions for the TAZs containing the universities were calculated by multiplying the appropriate rate with the 2007 enrollment for each university.

Table 3.3. University Trip Production and Attraction Rates

Trip Purpose	Rate	Student Residence
HBW Productions	0.32	On Campus
HBO Productions	0.98	On Campus
HNB Productions	0.34	Total Students
HBW Attractions	0.6	Total Students
HBO Attractions	0.88	Total Students
NHB Attractions	0.34	Total Students
NHB Attractions	1.44	Off Campus Students

3.4 Airport Trip Generation

To account for trips using the Bismarck Municipal airport, special trip rates were developed to accurately model these trips. For year 2007, the Bismarck Municipal airport had 181,762 enplanements. Daily HBO and NHB trips attracted to the TAZ (160) which contains the Bismarck Municipal Airport were found by dividing the yearly enplanement by 365, and then multiplying by a trip rate obtained from ITE's Trip Generation Manual (*4*). This trip rate was adjusted until the trip making behavior closely matched the airport's average daily traffic counts.

3.5 External Trip Generation

Trip generations for trips with at least one trip end out of the Bismarck-Mandan metropolitan area were calculated differently for internal-internal trips. Trips that pass through the Bis-Man area without stopping are considered as external-external (E-E) trips. These trips are assumed to make up 10% of Interstate and Highway 83 traffic. This percentage is applied to average daily traffic (ADT) volume counts on the links at the external zones for I-94 and Highway 83 to generate E-E trip productions and attractions.

Trip generations for trips that have only one trip end in the study area are calculated using a special methodology. These trips are defined based on whether they originate (productions) or terminate (attractions) in the study area e.g., internal-external (I-E) or external-internal (E-I) trips. To compute these trips, I-E and E-I volumes were set to the traffic volume counts of the link connecting to each of the 16 external TAZs. It was assumed that I-E trips made up 20%, while E-I trips made up 80% of ADT volume counts for each TAZ.

For the 286 interior zones, the I-E productions was simply set to the addition of HBW and HBO production trips that were generated by each zone. Internal-external attractions were set to the sum of HBW and HBO attraction trips generated from the equations described in Table 3.2. A special methodology was used for TAZ 160, which contains Bismarck Municipal Airport, to make this zone more attractive for external zones. An airport survey was conducted to determine the areas that have the most concentration of airport trip generation. This percentage of traffic originating or designating outside the planning region was applied to the airport's I-E productions and attractions.

3.6 Balancing Productions and Attractions

The total number of trips produced by households is expected to equal the total number of trips attracted at activity centers. In the TDM process, each production must be matched to an attraction; however, most TDM attractions and productions do not match. This is due primarily to errors arising when estimating total households and jobs and their various characteristics. Trip generation equations also contribute to this imbalance to a lesser extent. To correct for this imbalance, trip attraction and production totals for each purpose are adjusted so they equal each other (Table 3.4.).

Table 3.4. Total Number of Unbalanced Productions and Attractions by Purpose

Trip Purpose	Total Productions	Total Attractions
HBW	62,503	77,639
HBO	178,937	173,164
NHB	73,488	104,614
Internal-External	241,440	259,981

For HBW, HBO, and Internal-External trips, total attractions are scaled to equal total productions. This is because household data is generally assumed to be more accurate than employment data. This is done by dividing the total number of attractions by the total number of productions to generate a control factor. Zonal attractions for each purpose are then multiplied by the control factor to obtain balanced trip productions and attractions (Table 3.5).

NHB and Internal-External (I-E) trips used a different methodology to adjust the productions and attractions. NHB trips were adjusted by averaging the production and attraction trips. It was assumed that for I-E trips, 80% were produced to the external zone while 20% were attracted and IE trips were calibrated to the average daily traffic on each link.

Table 3.5. Total Number of Balanced Productions and Attractions by Purpose

Trip Purpose	Total Productions	Total Attractions
HBW	62,503	62,503
HBO	178,937	178,937
NHB	90,551	90,551
Internal-External	33,180	33,180

4. Trip Distribution

Trip distribution is the second computational step in the travel demand modeling process. This step pairs trip productions to the trip attractions between each zonal pair in order to define a trip. The gravity model was used in the Bis-Man TDM for trip distribution. The gravity model distributes trips between zonal pairs based on the attractiveness (intensity of land use) of each zone and the spatial separation between the zones. Zonal number of trip productions and attractions, friction factors and a socioeconomic (K) factors are the main variables used in the gravity model. The gravity model equation used to distribute trips for this model (equation 4.1)

$$T_{ij} = P_i \left[\frac{A_j F_{ij} K_{ij}}{\sum A_n F_{in} K_{in}} \right] \qquad \text{equation 4.1}$$

Where,
T_{ij} = The number of trips assigned between Zones *i* and *j* ,
P_i = Number of Productions in Zone *i* ,
A_j = Number of Attractions in Zone *j*,
F_{ij} = The Friction Factor, and
K_{ij} = A scaling socioeconomic factor used in calibration to influence specific *ij* pairs.

Socioeconomic factors (K factors) are trip distribution factors that adjust total trip distributions between defined regions in the model. K factors are discussed in more detail in chapter 7.

Friction factors used in the Bis-Man TDM are the main independent variable in the gravity model and measure the impedance to travel. The impedance used for all trip purposes was travel time and includes not only the drive time but also the origin, destination, and terminal times. For the initial iteration, free flow travel times are used for calculating impedance. A second iteration of the model is run using congested speeds outputted from the first iteration. This allows a continuous function for the friction factor without any irregularities. Friction factors make short trips more desirable and the benefit decreases as the trips get longer.

The 2000 Census data (the year with the most recent census information) was used to determine a trip length distribution based on the travel time for work trips. The friction factors were then calibrated until the model was replicating this curve. The NHB trips and HBO trips are estimated at 80% of the length of the average work trip length. Friction factors were calibrated to replicate these shorter trips.

5. Mode Split

Mode choice and mode split models are traditionally used to determine the number of trips using each different mode. Adequate data to correctly model modal choice is not available for the Bis-Man MPO, hence, automobiles are the only mode choice in this transportation model.

5.1 Origin-Destination Calculations

Before traffic assignment step can be performed, the daily trips need to have a starting and ending or origin-destination location. This is achieved by adding together half of the production attraction matrix and half of the transposed production attraction matrix. 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 zone.

6. Traffic Assignment

Traffic assignment is the last computational step of Bis-Man TDM provides the final output of the modeling process. This output is used to validate the models ability to replicate observed travel in the base year. The user equilibrium traffic assignment method built into TP+ was used for this model. The main assumption of this method is that travelers are rational and will act in a way that minimizes their transportation cost (travel time). This method is an iterative process which converges when no traveler can improve their travel time by changing their path.

The traffic assignment step begins with origin-destination (O-D) matrixes which contain the volumes that are to be assigned to the network. Travel time for the first iteration was set to the free flow travel time for the first iteration while the hourly capacity was multiplied by 7.5 to reflect actual daily capacities in each modeled link.

A capacity constrained function, which approximates the equilibrium of congested travel paths in the network, was used to correctly model the impacts of congestion on travel times. The Bureau of Public Roads (BPR) function was used to account for the reduction in travel speeds caused by congestion (equation 6.1). The BPR function is set up such that as traffic volumes increase, travel speeds decrease, and travel time increases due to increased congestion. The travel time is adjusted between O-D pairs between iterations until there was no available path that could reduce the travel cost between the pairs. If the system has significant congestion, it may be impossible to reach a state of equilibrium.

$$T_t = T_f \times \left(1 + \alpha \times \left[\frac{v}{c}\right]^{\beta}\right) \qquad \text{equation 6 .1}$$

Where,
T_t = congested travel time,
T_f = link free-flow travel time,
v = assigned link traffic volumes,
c = link capacities, and
α,β = volume/delay coefficients

The output from the trip assignment is modeled traffic volume on each link. To ensure that the model replicates counted ADT reasonably, the model's parameters are adjusted as described in the next chapter.

7. Model Calibration and Validation

Calibration is the final step in the development of travel demand models. Figure 7.1. shows the conceptual framework ATAC used in calibrating the Bis-Man TDM. Several criteria discussed in the next sections are used to calibrate and validate TDM.

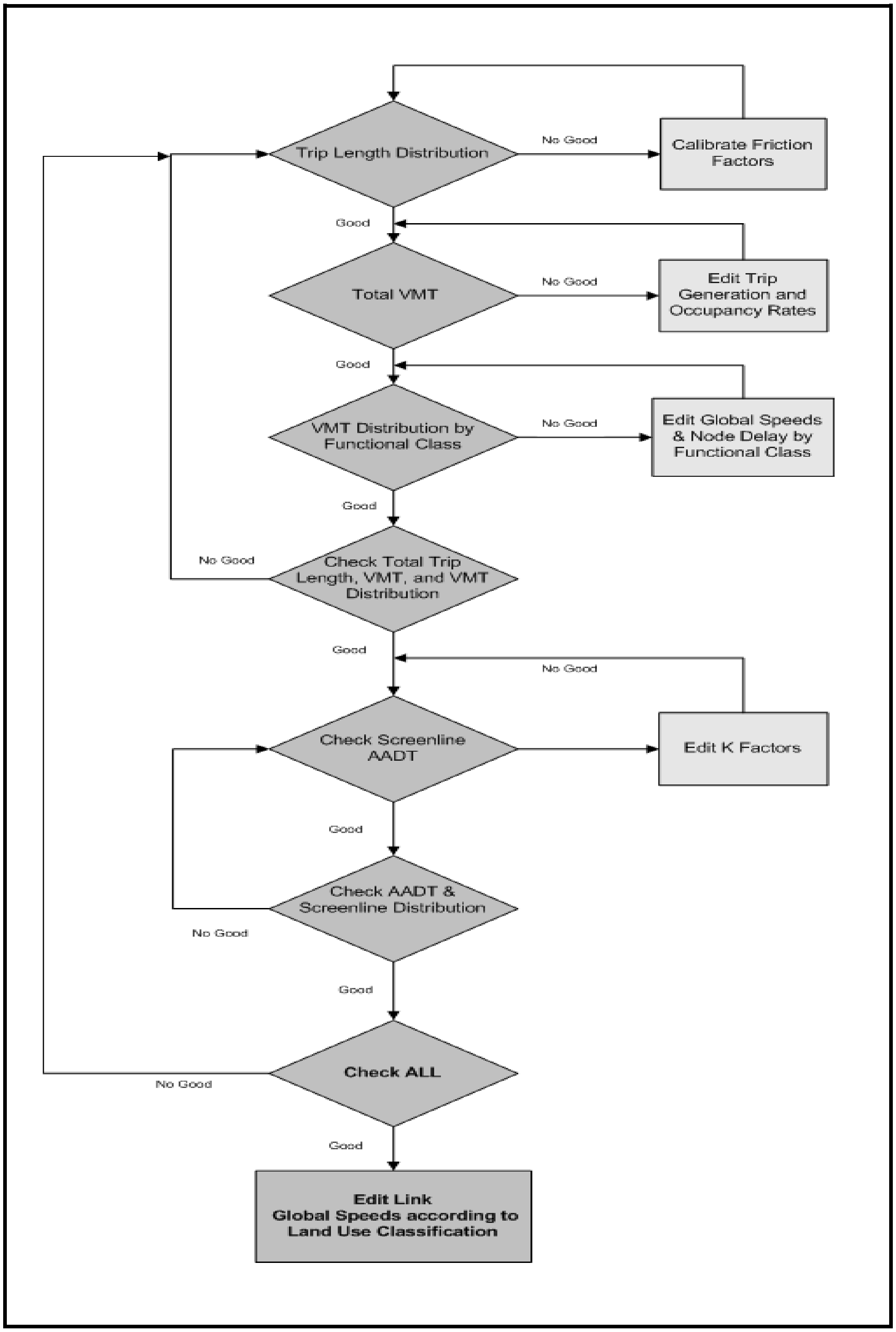

Figure 7.1.Bis-Man TDM Calibration Flow Chart

7.1 Trip Length Distribution

The first stage of calibration verifies whether the modeled vehicles trips are similar in length to observed trip lengths made in the area. Information regarding trip lengths for trip times ranging from 0-45 minutes were found using 2000 Census Transportation Planning Package (5). Shorter trips tend to occur more frequently than longer trips; therefore the transportation model needed to represent this trend. ATAC compared the modeled HBW, HBO, and NHB trip lengths to the 2000 Census data. If the modeled trend did not follow the 2000 Census data trend, ATAC adjusted friction factor coefficients until the model resembled, as closely as possible, the 2000 Census data. The targets for the trips were as follows: HBW-100%, HBO-80.0% of the 2000 Census data, and NHB-80.0% of the 2000 Census data. HBO and NHB trips were modeled as 84.3% and 83.5% of the HBW data, respectively (Figure 7.2.).

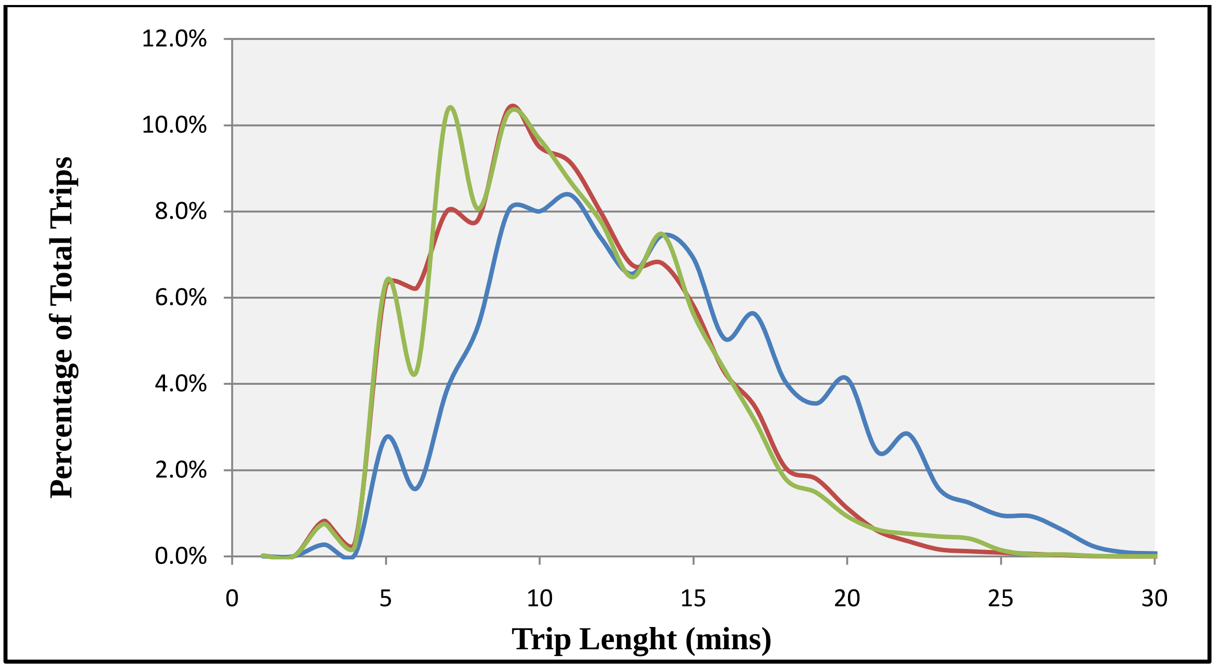

Figure 7.2. Final Trip Length Distribution Graph

7.2 Total Vehicle Miles Traveled (VMT)

Vehicle miles traveled (VMT) is the total number of miles traveled by road users. It is a function of the number of trips generated and the length those trips travel between their various O-D pairs. If the values differed between the modeled VMTs and actual values estimated in the field by the North Dakota Department of Transportation (NDDOT), trip generation and occupancy rates were adjusted until the modeled VMT were similar to the NDDOT VMTs. The modeled VMT closely replicate the field VMT data (Table 7.1.).

Table 7.1. VMT Comparison by Jurisdiction

	Reported VMT	Modeled VMT	Difference in VMT	Percent Difference
Bismarck	865,404	831,116	-34,288	-4.1
Mandan	339,784	330,633	-9,151	-2.8

7.3 Screenlines

Screenlines are natural and artificial barriers to travel such as rivers and interstates which restrict movements between two regions in the urban area. This restriction causes movement between these two regions to be restricted on certain routes and form an important part in calibrating and validating TDMs. Four screenlines, Interstate 94, Missouri River, the railroad and the downtown cordon area, were used as screenlines for this model. K factors were adjusted accordingly to either increase or decrease modeled volumes on the screenlines to match as closely as possible counted ADT volumes. The goal of this process was to minimize the deviation between modeled screenlines and counts along the screenline.

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 documents the K factors used in the transportation model and the screenline comparisons between the counted and modeled volumes.

Table 7.2. K Factors and Screenline Comparisons

Screenline	K Factors	Modeled ADT	Counted ADT	ADT Difference	Percent Difference
Railroad	1	151,800	150,175	-1,625	-1.08
Missouri River	0.24	55,600	58,100	2,500	4.30
Interstate 94	1.2	89,200	89,700	500	0.56
Cordon	1.5	202,800	201,325	-1,475	-0.73

7.4 Network-wide Adjustment and Validation

The final phase of calibration and validation was to compare the modeled traffic volumes to network links with traffic counts from the field. The goal was to maximize the number of modeled links that replicate observed travel behavior. If modeled network link volumes in a region were found to deviate significantly from field traffic counts, global speeds were adjusted accordingly (increased or decreased) based on the facility types to correct for this deviation. The percentage of links that meet link volume criterion based on functional class are shown in Table 7.3. (*6*).

Table 7.3. Model Assignment by Facility Type

Functional Class	Above Criteria	Meets Criteria	Below Criteria	Percent Within Criteria	RMSE
Freeway	0	17	0	1	0.148
Major Arterials	10	97	3	88.2	0.286
Minor Arterials	28	140	22	73.7	0.752
Collector	19	112	32	68.7	0.940
Total	57	373	65	75.4	

A comparison of modeled and counted ADTs by volume range was also performed as part of the validation process. North Dakota preset criteria were used to evaluate traffic assignment by volume range. The overall objective is to maximize the number of links that meet the ND preset criteria. The preset criteria were met on 75% of all links in the study area as shown in Table 7.4.

Table 7.4. Model Assignment by Volume Range

Volume Range	Above Criteria	Meets Criteria	Below Criteria	Percent Within Criteria	ND Criteria Percent Deviation
ADT>25,000	0	6	0	100	±22
20,000 to 15,000	3	13	1	76.5	±25
25,000 to 10,000	2	53	16	74.7	±29
10,000 to 5,000	12	122	24	77.2	±36
5,000 to 2,500	16	91	10	75.2	±47
AADT<2500	24	88	14	69.8	±60
Total	57	373	65	75.4	

Deviations between modeled and counted ADTs on each link are another technique used to validate TDMs. Root mean square error (RMSE) is a goodness of fit statistical measure that estimates the difference between predicted and observed values (*7*). RMSE was the method used to estimate the average variations between ADT counts and modeled volumes for this model. RMSE were calculated by volume class and shown in Table 7.5. RMSE by volume class shows that the model performs within generally accepted limits for all volume ranges.

Table 7.4. Root Mean Square Error Comparison by Volume Range

	Root Mean Square Error	Typical Deviation Limits
AADT>25,000	4.2%	15-20%
10,000 to 25,000	24.4%	25-30%
5,000 to 10,000	32.7%	35-45%
2500 to 5,000	46.6%	45-100%
1,000 to 2,500	88.8%	45-100%
AADT<1000	130.3%	> 100%

Figure 7.3. shows the distribution of the model links by volume range. This graph may be helpful to visually examine that the majority of the modeled links are meeting criteria and it is important to note that outliers are expected.

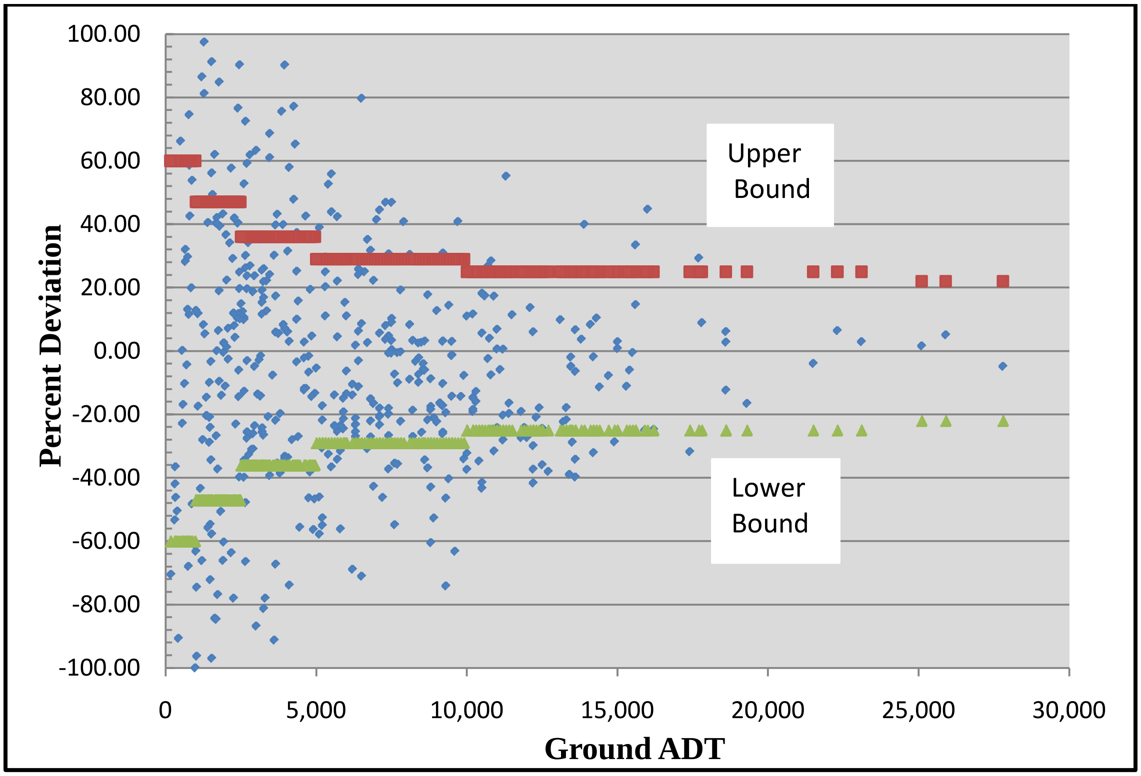

Figure 7.3. Link Distributions by Volume Range

The correlation coefficient between counted and modeled volumes for each link is an important measure of how well the model is replicating existing traffic conditions. The coefficient of determination (r^2) is the measure used to quantify this relationship. Guidance published by USDOTs Travel Model Improvement Program suggests r^2values of at least 0.88 (*6*). The r^2 value between observed and modeled volumes exceeds this threshold value at 0.92 as shown on the scatter plot in Figure 7.4.

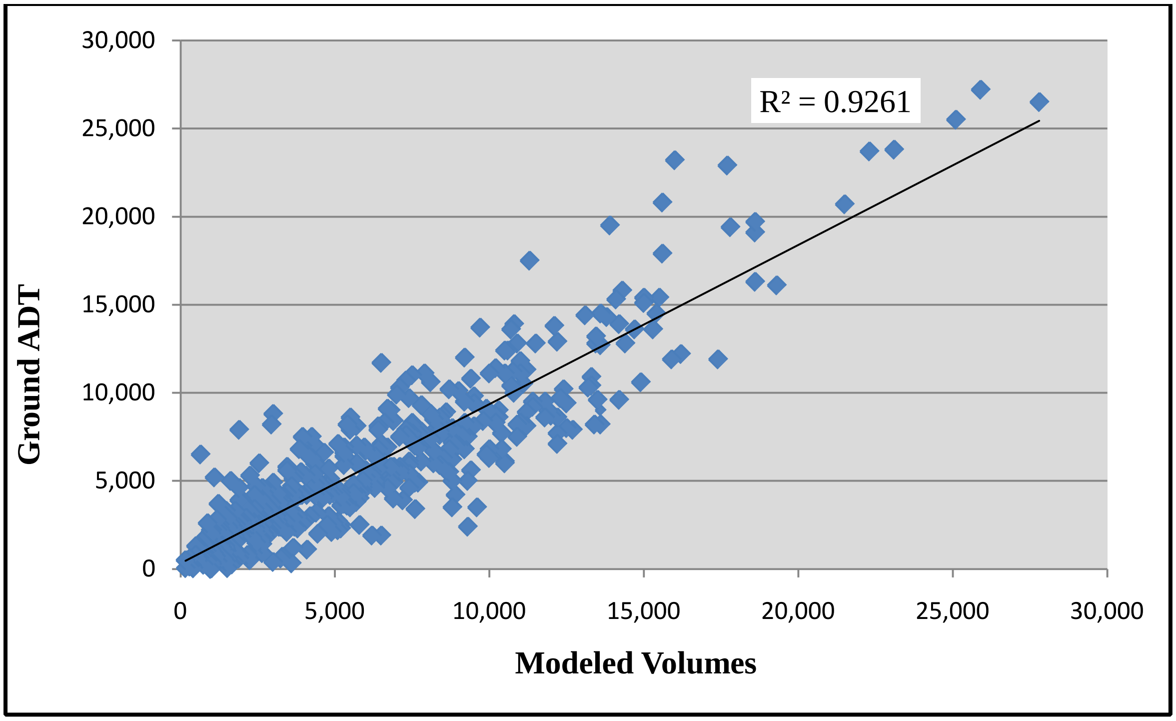

Figure 7.4. Scatter Plot of Observed ADTs and Modeled Volumes

8. User Guide

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

- Model input files: **Bold Characters**
- Model output files: *<u>Italicized & Underlined Characters</u>*

8.1 Introduction

Bismarck-Mandan's 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 occurring throughout Bismarck-Mandan's travel demand model. This will help the user of the model to efficiently understand each process involved.

8.2 Model Description

Bismarck-Mandan's 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 which give the names of the important fields in the network file with a corresponding description (Table 8.1.).

Table 8.1. ARCGIS Network Field Variables and Descriptions

Field Name	Description
Name	Specifies the roadway name
Speed	The link posted speed
A	Specifies the link starting node number
B	Specifies the link ending node number
Lanes/R_Lanes	Specifies the number of lanes contained on each link
A_	Identical to the "A" node field. It is used to determine the primary 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: 0-Modeled Roadway Link 1-Pseudo Link
Direction/R_Direction	Specifies the direction of vehicle travel according to the following code: 2-Eastbound Link 4-Northbound Link 6-Westbound Link 8-Southbound Link
Assigngroup	Link Functional Class according to the following code: 1-Interstate 2-Major Arterial 3-Minor Arterial 4-Collector 5-Pseudo Link 6-One-Way
AreaType	Area Classification where the facility resides according to the following code: 1-Downtown 2- Industrial or Commercial 3- Residential 4-Industrial or Commercial 5-Rural
Oneway_Two	Indicates if the link is a one-way or bi-directional link.
City	Region where the link resides according to the following code: 0-Rural 1-Bismarck 2-Mandan
R_TUR_L /R_TUR_L	Indicates the number of turn lanes at intersection

A network file for the model is 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 pop-up window will ask 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 pop 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	300

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.

Five main input files are found in the "input" folder and these files are the only ones that may need to be updated to run future travel demand models. The following section will describe how each file was generated and names for each of the necessary input files.

8.4.1 Road Network

The base network called **2007basenet.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 (lanes), or functional class (assigngrou) 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, *penalty.pen*, will be created that will allow a more accurate distribution of traffic through the network.

8.4.2 Socioeconomic Data

The Bismarck-Mandan model area was subdivided into 286 interior Traffic Analysis Zones (TAZ). Currently, 47 of those zones are pseudo zones so that in case there is a need to change the zonal node structure, it could be done without disrupting the node numbers. Socioeconomic data for these zones includes number of households, population, and the number of retail, service, and other jobs located within each in zone. **2007 TAZ DATA.dbf** and **2007PROJECTIONS.dbf** are the two input files that contain the necessary information for the trip generation step. TAZ data, located in **2007 TAZ DATA.dbf**, is used to establish relative variables for each zone. This data will most likely never be changed by the user. The input file **2007PROJECTIONS.dbf** contains the data that must be changed for each forecast year.

8.4.3 External Traffic Analysis Zone (TAZ) Data

External Traffic Analysis Zones (TAZ) ranging from TAZ 188 to TAZ 203 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 **2007 externalADT.dbf** was created containing 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.

8.4.4 Terminal Times

A terminal time file, **TerminalTimes.dbf**, was established to add in origin, destination, and terminal times to the vehicle travel time file. The total travel time file will be used during the Trip Distribution step to distribute the trips to their proper origin destination (O-D) location.

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 also enables the user to establish key parameters used in the model. 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.).

Table 8.3. Key Fields and their Descriptions

Key Field Name	Description
Scen.Name	Current selected scenario name
Network	Path to input network
TermTimes	Path to Terminal Times DBF
IOPath	The Path to the Working Directory which contain scenarios, input, and output folders
TAZ Data	Path to TAZ data DBF File
TAZ Projection	Path to TAZ Projections DBF File
ExTrips	Path to External Trips DBF File
Thru Trips	The Percent of Thru Trips
Year	Forecast Year
BSC On-Campus Enrollment	List known enrollments
BSC Off-Campus Enrollment	List known enrollments
Enplanements	List known enplanements
Select Link	Enter the TP+ code specifying links, nodes, or zones for the select link analysis see the "HwyLoad Module" in TP+ User Manual
Sub Area	Path to the Sub-Area Network
Total Zones	Enter the Total Number of Zones
Begin_External	Enter the lowest external zone number
Internal_Zones	Enter Highest internal zone number
U of Mary Off-Campus Enrollment	List known enrollments
U of Mary On-Campus Enrollment	List known enrollments

8.6 Final Assignment

ATAC has established 4 different model options to simplify the verification of the model results. The model options include: network file, trip length distribution, screenline volumes and vehicle miles traveled. Each option runs the final assignment module but outputs a different text or network files. The following section will describe each of the four options and the output files that are produced in each.

8.6.1 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.

8.6.2 Trip Length Distribution

This trip length distribution option allows the user to view a text file that contains the average trip length dependant 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.

8.6.3 Screenlines Volumes

Screenline distributions are important for the accurate calibration of the travel demand model. Bismarck-Mandan's model used 3 screenlines and one cordon check during the calibration process and these included:

- Missouri River (*SCR_Missouri.txt*)
- Interstate 94 (*SCR_I-94.txt*)
- Railroad (*SCR_Railroad.txt*)
- Downtown Cordon (*SCR_Cordon.txt*)

The corresponding output files in parenthesis can be found in the output folder. These four 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 screenline.

8.6.4 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.

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.

9. References

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