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Model Construction and Calibration Technical Documentation Draft

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1.0 Introduction

This paper describes in detail the process and methodology used within Bismarck/Mandan's TP+ transportation planning model. This is a technical reference that documents the methodology and assumptions underling each major step within the model.

All of the data provided as input to the model has been either provided by Bismarck/Mandan city planners or produced by ATAC. This data is compatible with the existing GIS data system used by both cities.

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. This software provides a method for organizing the script and is used to view and edit the input and output files.

The modeling is performed in the following six steps:

Data Preparation inputs two way links from GIS and properly assigns parameters to one-way links. Description of data preparation can be found in Chapter 2.

Trip Generation uses static equations based upon person or vehicle trip rates, employment, and household size to generate appropriate number of trips produced or attracted to each Traffic Analysis Zone (TAZ). Further description of the Trip Generation process can be viewed in Chapter 3.

Trip Distribution assigns the productions and attractions generated during the previous step to their proper origin-destination location. The Trip distribution process can be viewed in Chapter 4.

Mode Split distributes the trips based on the percentage of trips using different modes that include vehicles, transit bus, or trains. A further discussion of mode split may be found in Chapter 5.

Assignment distributes the trips to the network links while trying to minimize time or distance of the trips. This process description can be found in Chapter 6.

Calibration adjusts the model to resemble actual volumes occurring in the base year. The description of calibration can be seen in Chapter 7.

2.0 Data Preparation

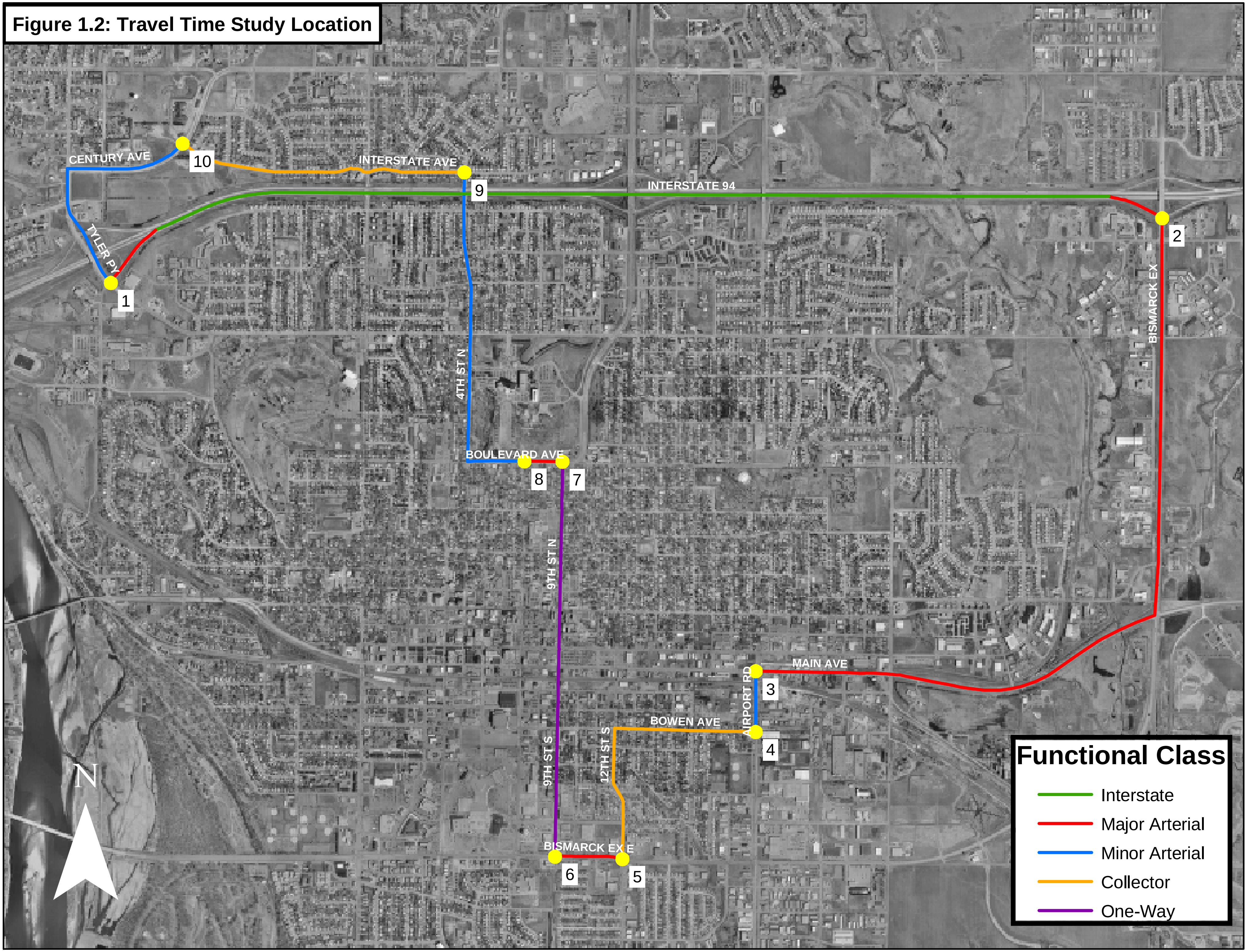
This step is used to convert the input files and model field data to a form that allows the rest of the model to remain unchanged for each scenario that is run. The network attributes are input from the two-way links in the GIS network and are properly assigned to the one-way links in the TP+ network. All the network variables receive their generic names that are used throughout the rest of the modeling process.

2.1 Speed and Capacity Calculations

Speed data was input into the network using a table of values based upon the number of lanes, functional class, and area in which the facility resides. Since individual speeds fluctuate, the speed table was comprised of average values determined through a speed study in Bismarck. The layout of the study area can be viewed in Figure 1.1 on the following page. As can be scene in the figure, the study area contained links of different lanes, functional classes, and area types. 20 runs were performed through the 15 mile loop beginning at node one and working chronological till node ten. These average speeds from the study were adjusted during calibration to match the trip making behavior in the area. Further discussion of global speed adjustment can be viewed in Chapter 7.0 of this document.

Since the input network does not identify traffic control locations, Bismarck-Mandan's transportation model uses the method of developing a table of capacities per lane. The capacities are dependent on facility type, number of lanes, and the area in which the facility resides. With this method it is difficult to determine specific intersection capacities and the values used in the table are an average value that is dependant on the parameters discussed above.

Figure 1.2: Travel Time Study Location



3.0 Trip Generation

Trip Generation is the second step within the transportation model. 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 vehicle trips produced within and attracted to each Traffic Analysis Zone (TAZ).

3.1 Production Computation for Internal Zones

The number of trips produced in an area is estimated by applying a person trip rate to the number of households in the area. The household data consists of 2000 census data compiled by the Bismarck/Mandan Planning Organization. The household counts were compiled to create the following five categories:

1. Households consisting of 1 person
2. Households consisting of 2 persons
3. Households consisting of 3 persons
4. Households consisting of 4 persons
5. Households consisting of 5 or more persons

These five household groups were used in determining the home based work (HBW), home based other (HBO), and non-home based (NHB) production trips. The number of productions was found by multiplying the total number of households in each category by the appropriate rate, shown in Table 3.1, of daily person trips per household. Then, the appropriate percentage, shown in Table 3.1, was applied to determine the proportion of the trips that would be made for each purpose. These trips produced by each household group were summed together and divided by the appropriate occupancy rate to acquire the HBW, HBO, and NHB vehicle trip productions for each zone. The average daily vehicle trip rates were adjusted during the calibration process to simulate the trip making behavior in the network area.

Table 3.1: Trip estimation variable by urban size population of 50,000-199,999

Household Size	Average Daily Person Trips per Household	% Average Daily Person Trips by Purpose		
		HBW	HBO	NHB
1	3.7	20	54	26
2	7.6	22	54	24
3	10.6	19	56	25
4	13.6	19	58	23
5+	16.6	17	62	21

Source: National Research Board, Report 365, Table 9.

3.2 Attraction Computation for Internal Zones

For the purpose of attraction computation, each TAZ within the planning area is classified as being within a Central Business District Area (CBD) or a Non-Central-Business-District (NCBD) Area. The equations used to determine HBW, HBO, and NHB attractions for the NCBD and CBD zones, are listed below in Table 3.2. Again, the equations were applied to all the 187 TAZ zones using TP+.

Table 3.2: Person-trip attraction rates

Purpose	CBD	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

Source: National Research Board, Report 365, Table 8.

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

3.3 External Trip Computation

Trips that begin and end outside the planning area and do not stop within the planning area are considered external-external trips and assumed to be 10% percent of the interstate and Highway 83 traffic. The model takes into consideration these trips when computing external productions and attractions made from an external zone to an external zone without stopping within the model.

Trips with only one trip end outside the planning model used a special methodology to calculate the productions and attractions. These trips are considered internal-external (IE) trips. For the computation of IE trips, the IE volume was set to the average daily traffic (ADT) of the link connecting to each of the 16 external zones. Next, it was assumed that 80% of these trips were produced by and 20% of these trips were attracted to the external zones. This percentage was applied to the ADT to determine the appropriate number of productions and attractions generated by each external zone.

For the 187 interior zones the IE 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 IE productions and attractions.

3.4 Bismarck State College Computation

Bismarck State College used a special methodology to compute HBW, HBO, and NHB productions and attractions for zones within and affected by the college. Affected zones were based upon the number of parking locations and the percentage of spots available for student use. The trip generation model used these percentages along with equations that were produced by ATAC to determine the appropriate number of trips generated by college students. Table 3.3 shows the trip estimation variables used to determine the trips generated for each campus.

Table 3.3: Bismarck State College trip estimation variables

			Predictive 2000 Enrollment
Purpose	**Rate**		**Bismarck State College**
HBW Productions	0.32	On-Campus Students	208
HBO Productions	0.98	On-Campus Students	208
NHB Productions	0.34	Total Students	3,168
HBW Attractions	0.60	Total Students	3,168
HBO Attractions	0.88	Total Students	3,168
NHB Attractions	0.34 1.44	Total Students + Off Campus Students	3,168 2,960

The productions and attractions were calculated by multiplying the appropriate rate with the 2000 enrollment of the school and the ratio of activity that was associated with each affected zone. The ratio of activity in each affected zone was determined through phone interviews provided by the administration at the institution.

3.5 Airport Trip Generation

Special consideration was taken for TAZ number 160 that houses Bismarck Municipal Airport. ATAC wanted to make sure the productions and attractions for the airport were accurately accounted for in the transportation model. It was found that Bismarck Municipal Airport had approximately 134,483 enplanements for the year 2000. The HBO and NHB attraction trips attributed to the airport were found by dividing the enplanements by 365, to obtain the trip generation in trips per day, and then multiplying it with a preliminary trip rate found from ITE’s Trip Generation reference book. This trip rate was adjusted until the trip making behavior closely matched the airport’s average daily traffic counts.

3.6 Adjustment

Applying the equations described in prior sections to the TAZ data, yields the following production and attraction totals. It is important to note that since each production must be matched to an attraction to form a trip, the total productions must equal the total attractions for each trip type. Generally, the production totals are more accurate than attractions and as a result it is necessary to adjust the attraction values to match the total number of productions. Table 3.4 shows the unadjusted number of productions and attractions generated by purpose.

Table 3.4: Total number of productions and attractions generated by purpose

Purpose	Number of Productions	Number of Attractions
HBW	80,618	70,741
HBO	153,237	159,694
NHB	65,888	87,773
Internal-External	233,856	235,490

To adjust the attractions for HBW, HBO, and internal-external trips, the total number of attractions was divided by the total number of productions for each trip purpose. This produced a factor for each trip purpose, which was applied to each TAZ's attraction total to find the new adjusted attraction values, as shown in Table 3.5.

NHB and Internal-External (IE) 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 IE 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: Adjusted production and attraction values by purpose

Purpose	Number of Production	Number of Attractions
HBW	80,618	80,618
HBO	153,237	153,237
NHB	76,831	76,831
Internal-External	28,814	28,814

4.0 Trip Distribution

Trip distribution allocates trips between traffic analysis zones within the study area and distribution of trips is performed using the gravity model. The purpose is to match the productions and attractions for each zonal pair in order to define a trip. The gravity model is used to determine the number of trips assigned to each zonal pair. This model assigns trips based on the number of productions, attractions, a friction factor, and a k factor. The friction factor is a value that is inversely proportional to distance, time, or cost, to 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 cross sections of the model. Chapter 7.0 describes k factors in more detail. Equation 4.1 shows the gravity model equation.

Equation 4.1: Gravity Model Equation

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

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
K_{IJ} = A scaling factor used in calibration to influence specific IJ pairs

4.1 Friction Factor Computation

Friction factors are an inverse measure of the impedance. The impedance used was travel time for all trip purposes. Travel time included 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. The model is run a second iteration, using output congested speeds 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 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. Table 4.1 shows the calibrated friction factors used in the model.

Table 4.1: Calibrated Friction Factors

Time (Min)	HBW	HBO	NHB
3	1	37972	41713
4	1	18233	19640
5	1	11493	14436
6	1	7197	8865
7	1	4885	6375
8	1	3741	4901
9	1	2759	3771
10	1	2363	3348
11	1	2298	3027
12	1	2124	2809
13	1	1573	2091
14	1	1472	1844
15	1	1279	1624
16	1	1060	1422
17	1	822	1145
18	1	799	1046
19	1	606	787
20	1	499	659
21	1	398	565
22	1	353	456
23	1	281	366
24	1	229	338
25	1	193	280
26	1	153	244
27	1	126	168
28	1	0	7
29	1	0	0
30	1	0	0
31	1	0	0
32	1	0	0
33	1	0	0
34	1	0	0
35	1	0	0
36	1	0	0
37	1	0	0
38	1	0	0
39	1	0	0
40	1	0	0

5.0 Mode Split

Mode choice and mode split models are traditionally used to determine the number of trips using each different mode. Since the area has an extremely low percentage of public transit use, vehicles 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 added together half of the production attraction matrix and half 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.

6.0 Assignment

Traffic assignment is the last step in the model and it is the basis for determining if the model has produced applicable results. The results will be used during calibration (described in Chapter 7.0) to adjust the model match the actual ADTs. The model uses the user equilibrium traffic assignment method. This iterative convergent process uses the belief in which no traveler can improve their path by changing links.

Up to this point, capacity has been given as vehicles per hour and volumes are given as vehicles per day. However, the model needs both capacities and volumes to be given in vehicles per day. Each roadway capacity was changed into vehicle per day by applying an adjustment factor of 7.5 to help reflect actual daily capacities on each modeled roadway.

Assignment begins with origin-destination (OD) matrixes which contain the volumes that are to be assigned to each OD pair. User equilibrium, in TP+, uses built in functions in order to assign trips to paths from each origin zone. Travel time was set to the free flow travel time for the first iteration and the travel time changed with iterations depending on congestion. The iterative process continued until there was no available path at which the time could be lessened. If the system has much congestion, it may be impossible to reach a state of equilibrium.

7.0 Calibration

Calibration is the final stage in the development of a transportation model. Calibration is a tedious process that needs to be conducted in a thorough and exacting manner. A flow chart is shown in Figure 7.2 describing ATAC's methodology for calibration.

7.1 Trip Length Distribution

The first stage of calibration is to check if the model vehicles trips are similar in length to the trips made in the area. Information regarding trip lengths for trip times ranging from 0-45 minutes were found from the 2000 Census. Shorter trips tend to occur more frequently than do longer trips. 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. As can be seen from Figure 7.1 HBO and NHB trips were modeled as 84.3% and 83.5% of the HBW data, respectively.

Figure 7.1: Final trip length distribution graph

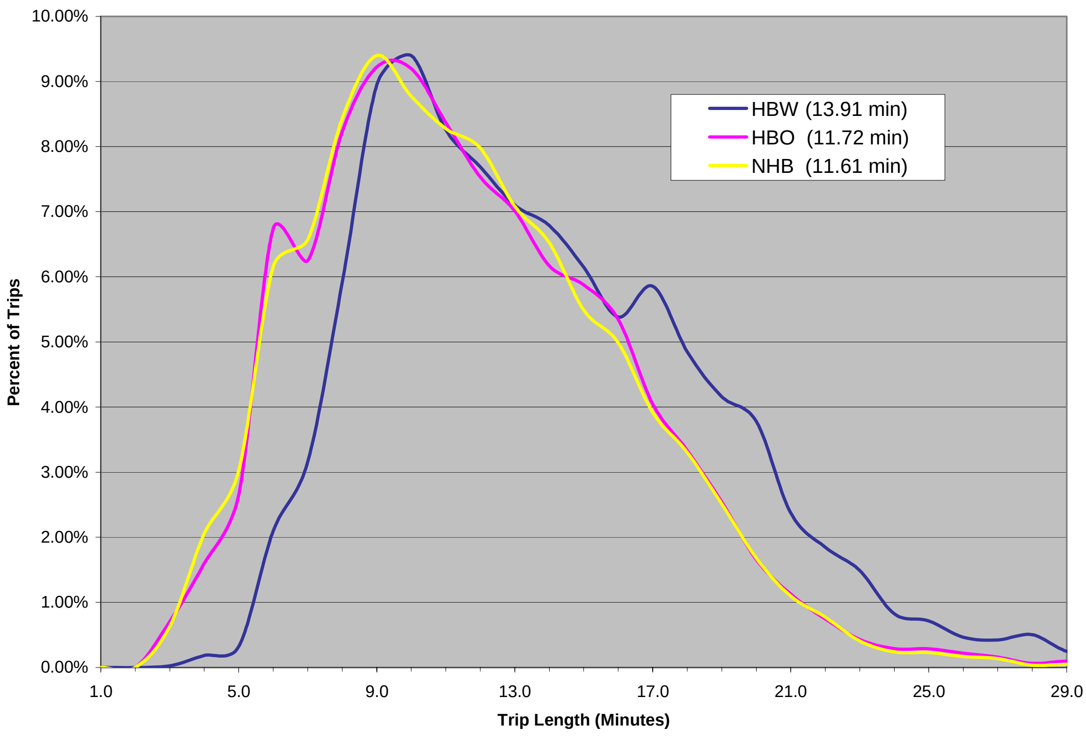
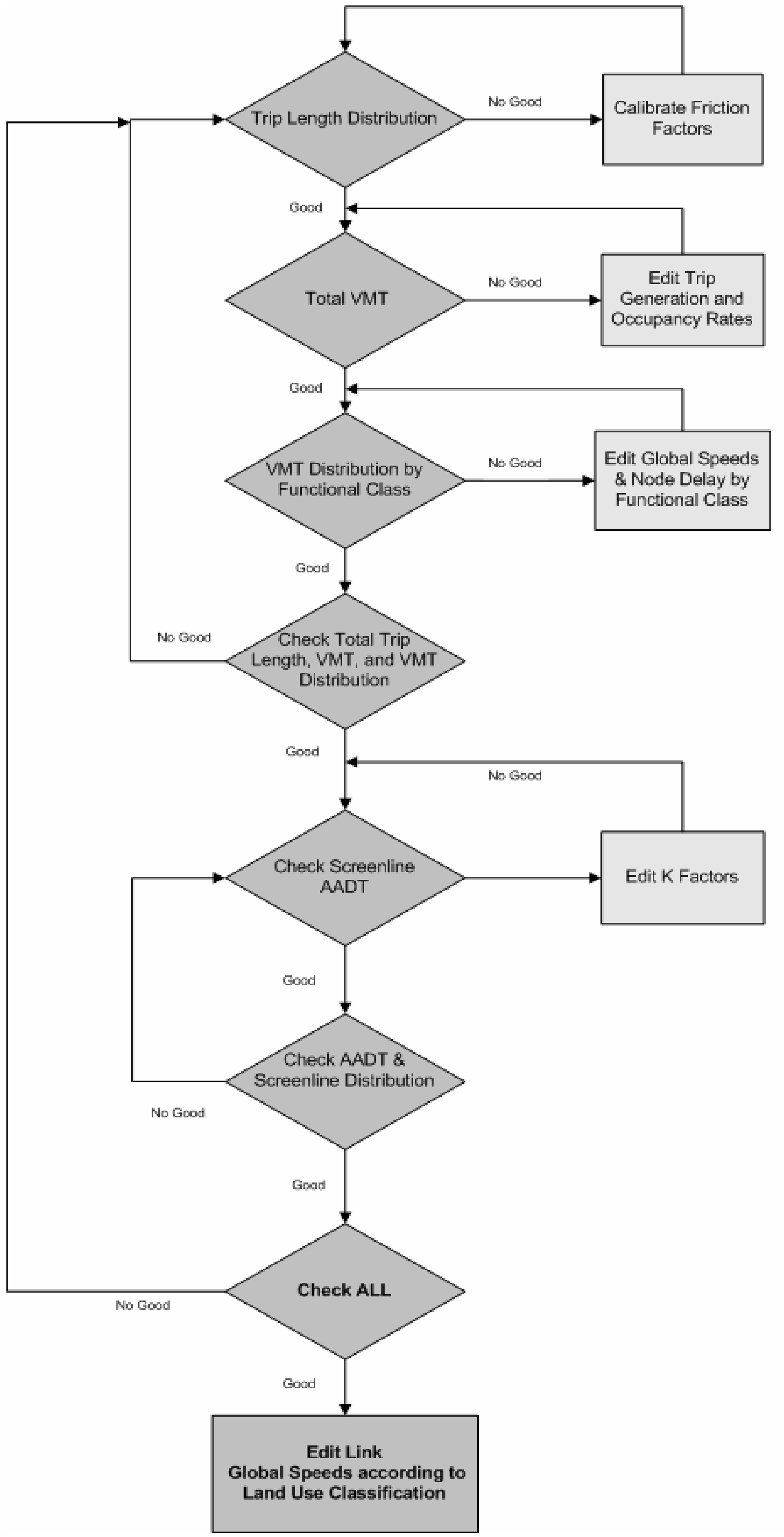


Figure 7.2: Calibration Flow Chart



7.2 Total Vehicle Miles Traveled (VMT)

VMT is dependent on the number of trips generated and the length of those trips. ATAC first calibrated the total VMT for the entire network. If the model values were different than the values produced in the field, ATAC adjusted the trip generation and occupancy rates until the model VMT was similar. Adjusting the trip generation and occupancy rates adjusts 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. The overall adjusted VMT was within 6.0% of the actual reported VMT. Table 7.1 shows the vehicle miles traveled by jurisdiction.

Table 7.2: Vehicle miles by jurisdiction

Jurisdiction	Vehicle Miles Reported	Vehicle Miles Modeled	Difference in Vehicle Miles	Percent Difference
Bismarck	780,823	716,574	-64,249	-8.23%
Mandan	313,440	311,931	-1,509	-0.48%
Metropolitan Area	1,094,263	1,028,505	-65,758	-6.01%

7.3 Vehicle Miles Traveled (VMT) Distribution by Functional Class

Once the total VMT was on target, ATAC checked the VMT distribution by functional class. If the functional class distribution was off, ATAC adjusted global speeds according to facility class. Table 7.3 shows the percent VMT by functional class.

Table 7.3: Vehicle miles by functional class

Facility	Percent Reported	Percent Modeled	Percent Difference
Interstate	22.89%	25.50%	2.61%
Principle Arterial	29.27%	30.99%	1.73%
Minor Arterial	29.71%	29.49%	-0.22%
Collector	18.14%	14.02%	-4.12%
Total	100%	100%	0.0%

7.4 Screenlines

Screenlines are an important component during calibration. First, ATAC checked the total AADT of the links crossing a screenline. If the total volume of vehicles crossing a screenline was above the specified criteria, a lower k factor was assigned. This would inhibit traffic from crossing the screenline. Similarly, if the screenline had a volume below the designated criteria, a higher k factor would be applied to the 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 7.4 shows the k factors used in the transportation model.

Table 7.4: Screenline k factors

Screenline	k factor	AADT	Modeled ADT	Volume Difference	Percent Difference
Missouri River	0.42	53,800	54,142	342	0.64%
Interstate 94	1.00	105,700	110,498	4,798	4.54%
Railroad	1.00	138,575	137,991	-584	-0.42%
Downtown	1.00	207,700	207,548	-152	-0.07%

7.5 Network Wide Adjustment

The final phase of calibration looks into the whole network link AADT distribution. ATAC examined how the modeled link's volume compared to the AADT for that link. If link 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 7.5 shows the percentage of links that meet each criterion based on volume range

Table 7.6: Model assignment by volume range

Volume Range	Above Criteria	Meets Criteria	Below Criteria	Percent Within Criteria	RMSE	ND Criteria Percent Deviation
30,000 to 20,000	0	10	0	1.000	0.090	± 22%
20,000 to 15,000	0	15	1	0.938	0.124	± 25%
15,000 to10,000	2	59	5	0.894	0.153	± 29%
10,000 to 5,000	14	130	20	0.793	0.247	± 36%
5,000 to 2,500	9	83	30	0.675	0.468	± 47%
AADT < 2,500	13	89	31	0.670	0.851	± 60%
Total	38	386	87	0.755		

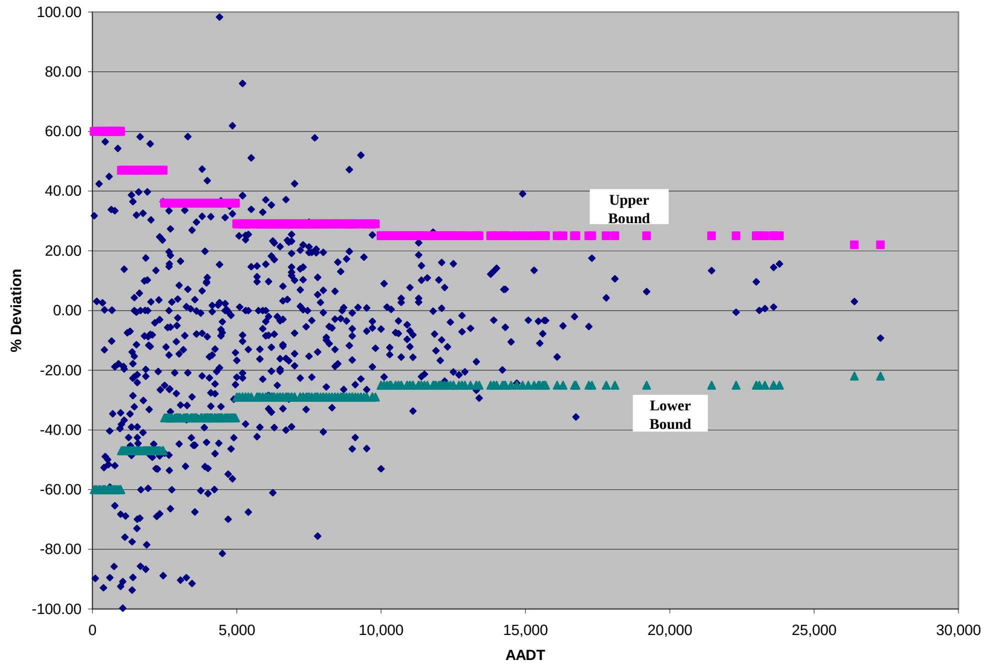
Root mean square error (RMSE) is a method for determining the overall error for each link. It is found by squaring all of the errors for each link. Then these values are averaged and by taking the square root of the averages determines the RMSE. The RMSE by link volume class and typical percentages are shown in the Table 7.7.

Table 7.7: RMSE Comparison

Volume Range	RMSE	Typical Limits
AADT > 25,000	9%	15- 20%
25,000 to 10,000	12%	25-30%
10,000 to 5,000	15%	35-45%
5,000 to 2,500	25%	45-100%
2,500 to 1,000	47%	45-100%
AADT < 1,000	85%	>100%

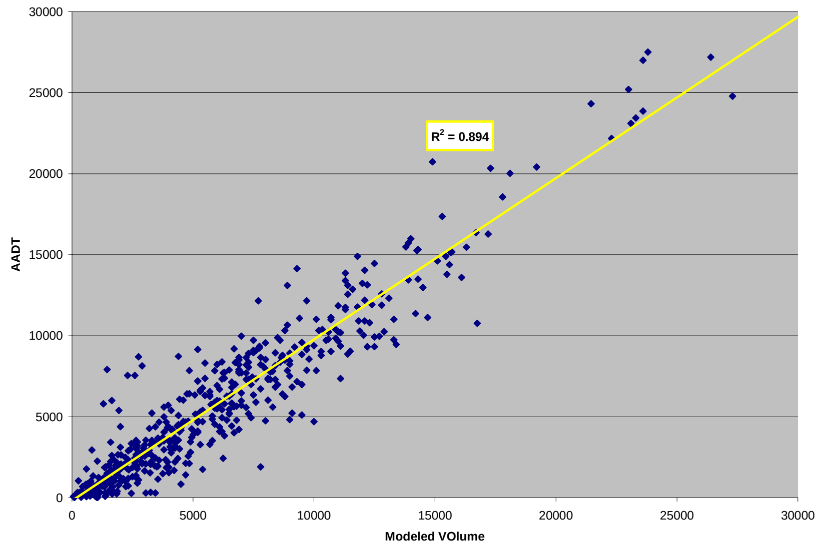
Figure 7.3 shows the distribution of the model links by volume range. This graph may be helpful to visual examine that the majority of the model links are meeting criteria and it is important to note that outliers are expected.

Figure 7.3: Link distribution by volume range



The correlation of modeled traffic volumes to the counted AADT on the links is an important measure of how well the model is replicating existing traffic conditions. This can be quantified by the coefficient of determination, R^2. Guidance published by the Travel Model Improvement Program as part of the USDOT suggests that the R^2 value should be equal to at least 0.88 region wide, the calibrated model has a correlation factor of 0.89. Figure 7.4 shows the volume correlation for the base model.

Figure 7.4: Volume correlation



8.0 User Guide

This chapter is to serve 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 a first time user of the model to efficiently understand each process involved.

8.4 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 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
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

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 come up 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 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.

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	203

Once the fields are updated, click “build” and the new network file will be generated.

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 ran, any output files may be retrieved in the “output” folder.

There are 5 main input files 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.

8.3.1 Road Network

The base network called **2000basenet.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, *2000penalty.pen*, will be created that will allow a more accurate distribution of traffic through the network.

8.3.2 Socioeconomic Data

The Bismarck/Mandan model area was subdivided into 187 interior Traffic Analysis Zones (TAZ). Socioeconomic data for these zones includes number of households, population, and the number of retail, service, and other jobs located within each in zone. **2000TAZData.dbf** and **2000Projections.dbf** are the two input files that contain the necessary information for the trip generation step. TAZ data, located in **2000TAZData.dbf**, is used to establish relative variables for each zone. This data will most likely never be changed by the user. The input file **2000Projections.dbf** contains the data that must be changed for each forecast year.

8.3.3 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 dependant upon the average daily traffic count (ADT) for each roadway. A dbf formatted file named **2000externalADT.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.

8.3.4 Terminal Times

A terminal time file, **2000TerminalTimes.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 (OD) 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 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 a Description of Each

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

8.6 Final Assignment

ATAC has established 7 different model options. Each option runs the final assignment module but different output text files or network files are created with each. The following section will describe each of the seven 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 Trip Distance Distribution

Trip distance option outputs a file titled *trip distance.txt*. This text file shows the trip distance distribution for each purpose with one mile increments for 45 miles. The user can also view the average trip distance occurring for each purpose in the model.

8.6.4 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.

8.6.5 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.

8.6.6 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.

8.6.7 Select Region Analysis

This option generates an output file called *SubArea.mat*. The user may highlight a region in the input file and create a new sub area. The output file will contain the volume of traffic entering the new sub-area. Sub-area analysis acts the same way as a cordon line check. Volumes of traffic entering and exiting the region will only be output to the matrix file.

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.

Table 8.4: Output Network Variables

Network Name	Description
Name	Specifies the roadway name
Model_ADT	Future Modeled Link Volume
Lanes	Specifies the number of lanes contained on each link
Mod_2000	2000 Calibrated Network Volume
Diff_2000/Diff	2000 ADT volume subtracted from Calibrated 2000 modeled volume
Growth	2000 Modeled Volume subtracted from Total Future Volume and this divided by the 2000 Calibrated Model Volume
TT	Total Travel Time for each Link
Assigngrou	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
City	Region where the link resides according to the following code: 0-Rural 1-Bismarck 2-Mandan
SPD	Calibrated Link Speed
FFS	Link Free Flow Speed
Total_VOL	Modeled Link Volume
Total_Cap	Daily Link Capacity
Total_VC	Link Volume to Capacity Ratio (VC)
Oneway_Two	Indicates if the link is a one-way or bi-directional link
AADT	Specifies the ADT count value

References

Institute of Transportation Engineers*.* *Trip Generation.* Washington, D.C., 1997.

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