CHAPTER XI

TRAVEL DEMAND FORECAST MODEL (TDFM)

Future roadway capacity deficiency identification and analysis has traditionally been a key ingredient in an area's long-range transportation plan. Both the identification of deficiencies and the plan itself are dynamic; initiated under ISTEA and continuing under TEA-21, SAFETEA-LU, MAP-21, & FAST, they are to be updated every four to five years to reflect changing transportation and land use conditions. In essence, the roadway capacity deficiency analysis, and the plan (prepared by the MPO with input from the MDOT) are "snapshots in time," reflecting the conditions and trends at the time of development.

The purpose of roadway capacity deficiency identification and analysis is to determine where future congestion is projected to occur and where safety deficiencies related to a roadway's capacity might develop. Deficiency identification and analysis is done with a computerized network model of the street and highway system. The identification and analysis of capacity deficient corridors and links is intended to serve as the basis for system improvement/expansion funding decisions. Technical terms utilized in this discussion are defined in the glossary at the front of this document.

MODEL PROCESS DESCRIPTION

Travel demand forecasting within the Battle Creek urban area has been completed through application of a travel demand forecast model (TDFM) developed and maintained by staff of MDOT's Statewide & Urban Travel Analysis (SUTA) section in Lansing, in cooperation with the BCATS staff. The model is a computer simulation of current and future traffic conditions, and is based in *TransCAD,* a transportation modeling software and geographic information system (GIS). This is the same GIS program used in-house by BCATS. Since the model is a "systems-level" transportation planning model, the deficiencies identified are generalized, 24-hour (daily) deficiencies, based on generalized 24-hour capacities and traffic assignment volumes.

The urban travel demand forecasting model development process generally consists of six phases:

1. Data Collection, in which socio-economic and facility inventory data are collected.
2. Trip Generation, which calculates the number of trips produced in or attracted to a traffic analysis zone (TAZ).
3. Trip Distribution, which determines how much travel will occur between TAZs, based on the "attractiveness" of the other zones.
4. Traffic Assignment, which determines what routes trips will take between zones.
5. Model Calibration/Validation, which involves adjusting the model and verifying that the volumes (trips) simulated in traffic assignment replicate (as closely as possible) actual, observed traffic counts.
6. System Analysis, to test alternatives and to analyze changes in order to improve the transportation system.

There are two basic systems of data in the travel demand forecasting process. The first system is the street and highway network (links). The network generally includes only links of the "collector" functional classification and higher. The second data organization mechanism involves the traffic analysis zones (TAZ's). These geographic areas are determined based on similarity of land use and human activity, compatibility with jurisdictional boundaries, presence of physical boundaries, and the links that make up the road network.

DATA COLLECTION

The BCATS staff produced population (in households), households (occupied housing units), and employment summaries by TAZ for input into the model. As described in Chapter X, each data item by TAZ was estimated first for 2010, then forecast at five-year intervals to the horizon year 2040, and then 2017 values were interpolated between 2015 & 2020. Additional discussion of the socio-economic data is presented in Chapter X. A summary of the data for the BCATS metropolitan area, as used within the TDFM, is shown in Table XI-1.

TABLE XI-1
SOCIO-ECONOMIC DATA SUMMARY

Data Type	2017	2040	Change
POPULATION	94,289	95,238	1.0%
HOUSEHOLDS	38,340	39,956	4.2%
RETAIL EMPLOYMENT	5,303	4,853	-8.5%
SERVICES EMPLOYMENT	25,699	32,101	24.9%
OTHER EMPLOYMENT	27,403	27,264	-0.5%
TOTAL EMPLOYMENT	58,405	64,218	10.0%

TRIP GENERATION

Trip generation is the process by which the TDFM translates the socio-economic data into numbers of person trips. Generally the households produce trips and the employment places attract trips. For each TAZ the number of trips produced and attracted to a zone are determined based on the socio-economic data for each zone. The three trip purposes used in the model are home-based work (HBW), home-based other (HBO), and non-home-based (NHB). Trips that originate or end outside the model area are called external trips. External trips that originate inside the model area and travel outside the model area are identified as "internal to external" (I-E) trips, and vice-versa, trips from outside the model area (external) into the model area are referred to as "external to internal" (E-I) trips. Trips that pass through the model area without stopping are "external to external" (E-E) trips. Details of travel characteristics generated from the model can be provided upon request.

TRIP DISTRIBUTION

Trip distribution involves the use of a mathematical formula (a "gravity model") which determines how many trips produced in a zone will be attracted to each of the other zones. The gravity model assumes that a destination zone attracts trips based on the activity in that zone (number of employees and/or households) and the proximity to the zone of origin. Using this gravity model, trips produced in one zone are "distributed" to all other zones. At the end of distribution, formulas are applied by each purpose to convert person trips to vehicle trips.

TRAFFIC ASSIGNMENT

Traffic assignment is the process of route selection between zones. Traffic assignment takes the trips distributed in the previous phase and assigns them a path on the roadway network using the "capacity restraint" process. The capacity restraint method assigns the trips based on the shortest time path, but when the assigned volume of trips on a link nears the road capacity, trips begin to be diverted to the next quickest route. This continues until the system reaches equilibrium. (The capacity for each link is the maximum number of vehicles that can travel on that segment of road in an "average" 24 hour day. A capacity calculator program developed for MDOT computes the daily capacity for each link). When the assignment process is completed, each link (road) will have a volume that represents the number of vehicles that travel on that link (road) over a typical twenty-four hour day.

MODEL CALIBRATION/VALIDATION

The purpose of model calibration is to adjust the model to achieve statistically valid model outputs which are reflected in model validation. Model validation verifies that the base year assigned volumes simulate actual base year traffic counts. When validation is complete, the base model is considered statistically acceptable. This means that the process can proceed to future socio-economic data being substituted for existing (base) data. Then the trip generation, trip distribution and traffic assignment can be repeated and future trips can be simulated for system analysis, as part of the plan process. For this *2040 Metropolitan Transportation Plan*, the calibrated "base year" is 2010.

SYSTEM ANALYSIS

Once the base and future trips are simulated, a number of system analysis procedures can be conducted:

- Potential improvements to relieve congestion can be tested for the plan. Future traffic can be assigned to the existing network to show what would happen in the future if no improvements were made to the present transportation system. From this, improvements can be planned that would alleviate demonstrated capacity problems. This analysis was performed for the BCATS Plan, and is discussed in further detail in the next chapter of this document.
- The impact of planned roadway improvements or network improvements can be assessed.
- Links can be analyzed to determine what zones are contributing to the travel on that link (i.e., the link's service area). This can be shown as a percentage breakdown of total link volume (e.g., 50% of the trips in a given TAZ utilize the selected link).
- The network can be tested to simulate conditions with or without a proposed bridge. The assigned future volumes on adjacent links would then be compared to determine traffic flow impacts. This, in turn, would assist in assessing whether a bridge should be replaced and/or where it should be relocated.
- The impacts of land use changes on the network can be evaluated (e.g., what are the impacts of a new major retail store being built).
- Road closure/detour evaluation studies can be conducted to determine the effects of closing a roadway. This type of study is very useful for construction management.
- Model runs are also done as part of air quality conformity analysis, if required.

Generally three different alternative scenarios are developed for a long-range transportation plan:

- Existing trips on the existing network; this scenario created 2010 volumes, generated by 2010 socio-economic (SE) data, onto the highway network as it was in 2010. This is referred to as the "calibrated", existing network scenario, or **"base-year"** alternative, and is a prerequisite for the other two scenarios.
- Future trips on the "existing plus committed" (E+C) network; this scenario creates 2040 volumes, generated by 2040 SE data and the highway network as it exists in 2017, with any improvements listed in BCATS' current *Transportation Improvement Program (TIP)* for which funds have been "committed" to complete the project. This alternative displays future capacity and congestion problems if no further improvements beyond those committed thru 2020 are made. This "deficiency analysis" on the 2017 E+C network is also called the "do

nothing", or **"no-build"** alternative, and includes the 2017 E+C network, with current capacities and those "committed" capacity improvements.

– Future trips on the future network; this scenario creates 2040 volumes, generated by 2040 SE data and the highway network as it is proposed to be in 2040. This scenario is the long-range transportation plan **"build"** alternative. It includes the 2040 E+C highway network, plus alternative capacity improvement projects selected to alleviate congested areas or corridors. Projects that successfully resolve or mitigate forecasted congestion in the TDFM continue on in the plan process to be evaluated against expected financial resources and then to possibly be recommended for programming in the *TIP* and implementation at some time over the course of the plan.

Much of the preceding narrative in this chapter was provided by MDOT SUTA staff, initially for BCATS' *2030 Transportation Plan* (November 2007), as technical explanation of the TDFM process. For the application of the TDFM within development of this *Plan*, note the following:

– Passenger car equivalents (PCEs) were used to take account of the differential traffic impacts of larger vehicles, by treating them as having the same volume impact as some number of added cars. For example, larger, heavier vehicles occupy more physical roadway space than passenger cars and have poorer acceleration and deceleration. A PCE factor can be applied to different types of vehicles estimated in the traffic stream; in the Battle Creek model a PCE value of 1.5 was applied to "commercial vehicles" (3+ axles) during traffic assignment. The use of PCEs supports more accurate identification of likely congested segments & corridors, particularly where there is high percentage of "commercial vehicles", like the 40-50% commercial on I-94 across the BCATS metropolitan area.
– Given improvements within the TDFM process, including better verification & validity of roadway attributes (especially calculated capacities) and socio-economic data, fewer forecast capacity deficiencies have been identifed with each update of BCATS' long-range plan. The TDFM for this *2040 MTP* shows no segments where 2040 traffic exceeds the 2017 capacity [volume to capacity (V/C) >100%]. Accordingly, and with emphasis on operations & maintenance improvements to existing roadways, no capacity increasing projects were necessary to be tested as part of the "build" alternative. A limited number of segments with a forecast V/C of 70-83% are discussed in the next chapter.
– It is hoped that over the next two years the BCATS TDFM can be updated to a peak-hour model, and to offer several other enhanced analytical processes. The new TDFM is expected to provide a more accurate measure of perceived congestion during peak-hours, and, coupled with the use of PCEs, an improved calculation of the impact that high volumes of commercial traffic i.e. "semi-tractor trailers" has on highway capacity, and subsequently on the forecast V/C ratios, especially on I-94.
– As noted in the previous chapter, uncertainty about a site at the Fort Custer Training Center being considered by the US Dept of Defense Missile Defense Agency for a ground-based Continental Interceptor Site (CIS) prompted the CIS impacts to not be evaluated as part of the TDFM for this *Plan*. However, if and when the CIS becomes imminent and/or more details released, its construction & operation could be incorporated into the TDFM to identify impacts on the transportation system and develop projects to address potential deficiencies. A "scenario planning" process, including appropriate adjustments to both the socio-economic data and the roadway system & attributes, would be followed before re-running the TDFM under the new conditions. Different scenarios can be prepared anytime for any significant developments of housing or employment, or for changes to the transportation network.