Chapter 6
TRAVEL DEMAND MODEL

The urban area travel demand modeling process for Kalamazoo was a cooperative effort between the Kalamazoo Area Transportation Study (KATS) and the Michigan Department of Transportation, Statewide and Urban Travel Analysis Section (MDOT). MDOT provided the lead role in the process and assumed responsibility for modeling activities with both entities reaching consensus on selective process decisions.

Travel demand modeling and capacity deficiency identification and analysis were undertaken as part of the continuing phase of the transportation planning process required by the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). The travel demand modeling of the transportation system is utilized for aiding in the policy determinations that result in both long range plans and short range studies (corridor studies and sub-area studies). Emphasis in this current effort was on the development of the 2035 Transportation Plan. For the 2035 Transportation Plan, a countywide model was developed, calibrated and validated for base year 2008 and was used to evaluate the transportation system for the future year of 2035. The results of the modeling effort provide an important decision making tool for plan development.

The travel demand modeling for Kalamazoo has been completed through the use of TransCAD software utilized by MDOT. The model is a computer simulation of current and future traffic conditions and is a system-level transportation planning model. The deficiencies identified are generalized 24-hour (daily) deficiencies, based on generalized 24-hour capacities and traffic assignment volumes.

There are two basic systems of data organization in the travel demand forecasting process. The first system of data is organized based on the street system. Roads with a National Functional Class (NFC) of Minor Collector and higher are included in the network. The unit of analysis is called a "link." Usually, a link is a segment of roadway which is terminated at each end by an intersection. In a traffic assignment network, intersections are called "nodes." Therefore, a link has a node at each end.

The second data organization mechanism is the traffic analysis zones. Zones are determined based upon several criteria, including similarity of land use, compatibility with jurisdictional boundaries, the presence of physical boundaries, compatibility with the street system, U.S. Census geography, and compatibility with the zone system used within the Statewide Model. Streets are generally utilized as zone boundary edges. All socio-economic and trip generation information for both the base year and future year are summarized by zone.

The two data systems, the street system (network) and the zone system (socio-economic data), are interrelated through the use of "centroids." Each zone is portrayed on the network by a point (centroid) which represents the weighted center of activity for that zone. A centroid is connected by a set of links to the adjacent street system. That is, the network is provided with a special set of links for each zone which connects the zone to the street system. Since every zone is connected to the street system by these "centroid connectors," it is possible for trips from each zone to reach every other zone by a number of paths through the street system.

NETWORK

A computerized "network" (traffic assignment network) is built to represent the existing street system. It includes most streets within the study area classified as a Minor Collector or higher by the National Functional Classification system. Other roads are added to provide continuity and/or allow interchange between these facilities. The network was built based on Michigan Geographic Framework Version 8 road data.

The Kalamazoo 2008 calibrated/validated network includes 812 miles of roadway (excluding centroid connectors) with the following classifications:

- 98 miles of freeways (trunklines)
- 22 miles of ramps (trunklines)
- 80 miles of other trunklines
- 50 miles of local major arterials
- 204 miles of minor arterials
- 358 miles of collectors

There are 153 miles of one-way links and 659 miles of two-way links. Transportation system information required for each link includes, at a minimum:

- distance
- posted speed
- link type
- National Functional Classification
- Traffic counts (where available)
- 24-hour volumes for a specified level of service (frequently described as its capacity)

If the information is not the same for the entire length of a link, the predominant value is used. The KATS and local agency staffs reviewed and approved the network and link attributes. The network for the KATS urban area is shown in the following figures.

Network link types follow MDOT's standard format:

1 - freeways
2 - ramps
3 - other state trunkline
4 - major arterials
5 - minor arterials
6 - collectors
7 - centroid connectors

The urban travel demand forecasting process used has six phases:

1. Data Collection: Socio-economic and facility inventory data are collected and distributed to traffic analysis zones (TAZ).

2. Trip Generation: Calculates the number of trips produced in or attracted to a TAZ.

3. Trip Distribution: Takes the trips produced in a TAZ and distributes them to all other TAZs, based on attractiveness of the zone.

4. Traffic Assignment: Determines what routes are utilized for trips.

5. Model Calibration/Validation: Involves verifying that the volumes (trips) simulated in traffic assignment replicate observed traffic counts.

6. System Analysis: Tests alternatives and analyzes changes in order to improve the transportation system.

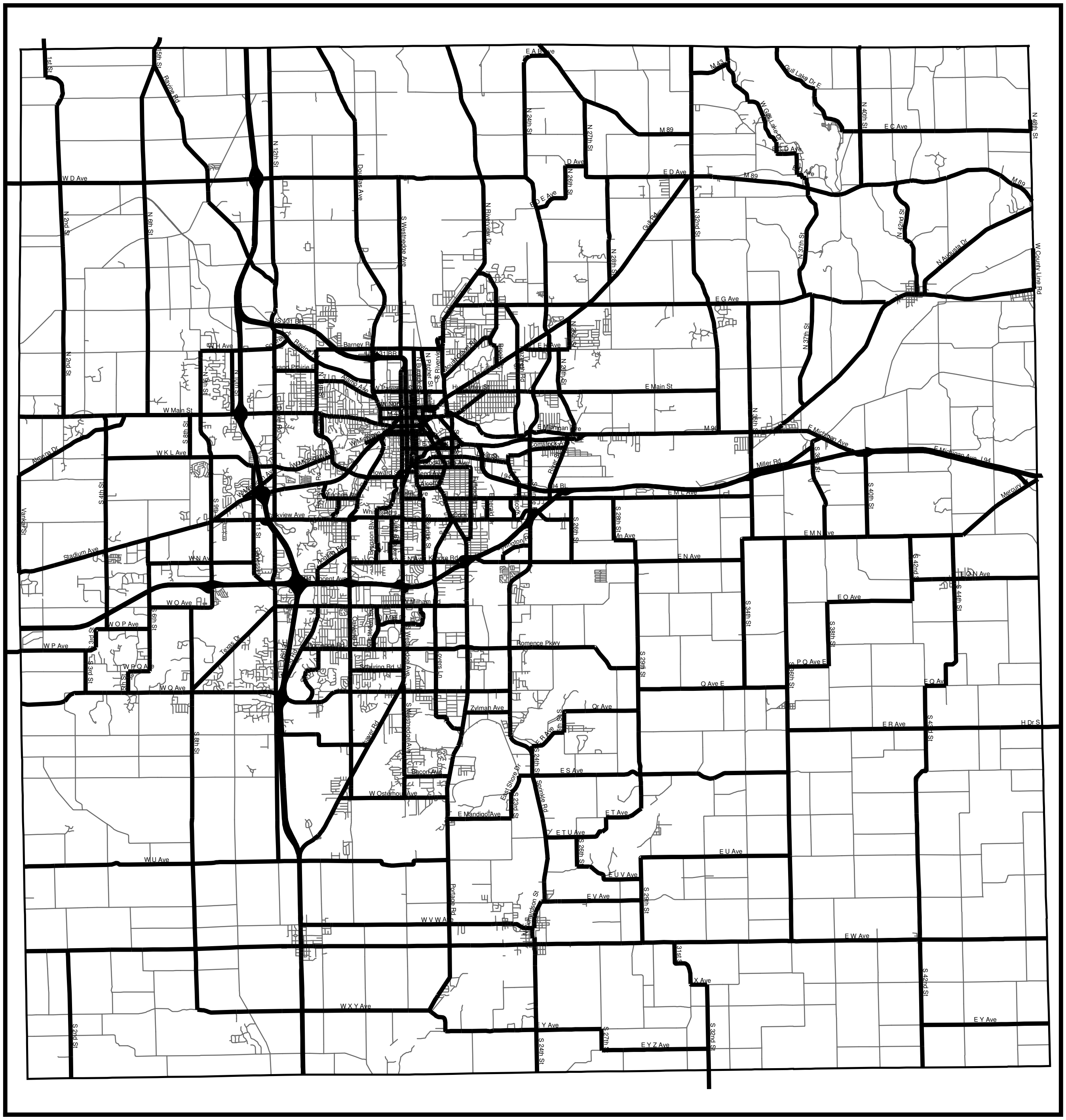
The street network is used in the traffic assignment process. The traffic assignment process takes the trip interactions between zones from the trip distribution and loads them onto the network. The travel paths for each zone-to-zone interchange are based on the minimum travel time between zones. They are calculated by a computer program which examines all possible paths from each origin zone to all destination zones. The shortest path is determined by the distance of each link and the speed at which it operates. The program then calculates travel times (distance divided by speed) for all of the possible paths and records the links which comprise the shortest travel time path. Time penalties were added for right and left intersection movement.

TIME PENALTY TABLE

MOVEMENT	PENALTY (MINIMUM)
Right Turn	0.15
Straight Through	None
Left Turn	0.33
U-Turn	Prohibited

Free flow speeds used to calculate minimum travel times are based on each link’s posted speed limit. Speeds represent a relative impedance to travel and posted speed limit is a major factor in overall average travel speed on a link. Various speeds for each roadway type and area type were tried in an attempt to get reasonable travel paths. The final free flow speed for freeways and one-way links are same as posted speed limit, all other two-way links with signalization are set to be 90% of posted speed to account for delays at intersections.

The shortest travel time paths were reviewed to ensure that they represent actual travel patterns around, through, and within the Kalamazoo urban area.



KATS Model Network

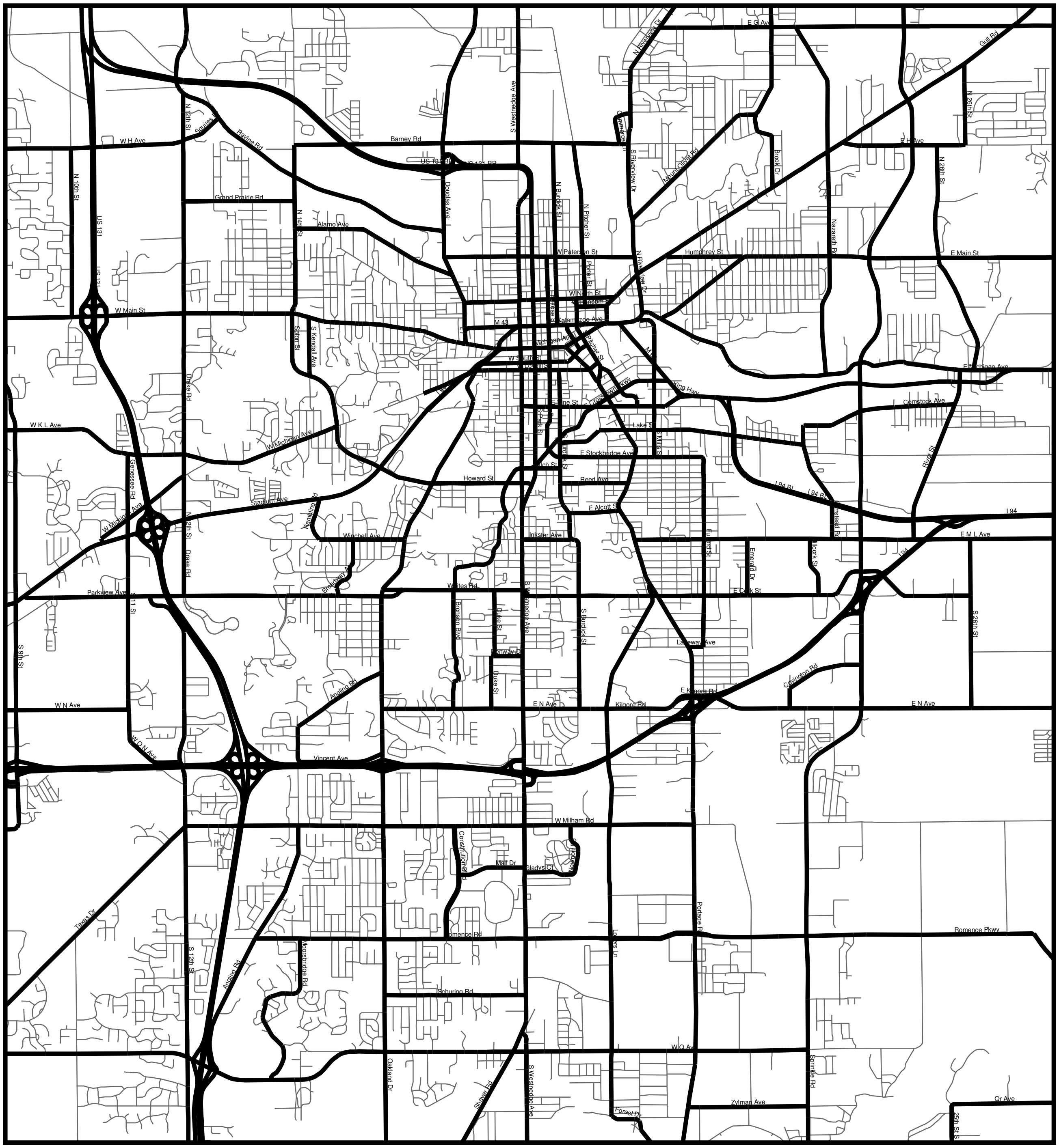
N

Legend

Federal Aid Roads

Local Roads

Data Source: MCGI, KATS



KATS Urban Area Model Network

N

Legend

Federal Aid Roads

Local Roads

Data Source: MCGI, KATS

SOCIO-ECONOMIC DATA

The socio-economic data was provided by KATS. KATS provided to MDOT both 2008 base year and 2035 projected population, dwelling units, vehicles and employment summaries by traffic analysis zone (TAZ). There are 515 internal TAZs and 30 external stations (entry and exit from the county). Detail of the TAZs in the KATS study area and the socio-economic data is included in Projected Transportation Demand chapter.

TRIP GENERATION

The trip generation process calculates the number of person-trips produced from or attracted to a zone based on the socio-economic characteristics of that zone. The urban transportation forecasting models do not consider travel characteristics such as direction, length, or time of occurrence as part of trip generation. The relationship between person-trip making and land activity are expressed in equations for use in the modeling process. The Kalamazoo model uses the trip generation formulas specified in the Travel Estimation Techniques for Urban Planning to generate productions and attractions.

The formulas were derived from transportation study data and other research throughout the United States. Productions were generated with a cross-classification look-up process based on autos and dwellings. Attractions were generated with a regression approach. Detailed discussion on the development of the formulas is provided in the Travel Estimation Techniques for Urban Planning by National Cooperative Highway Research Program (NCHRP Report 365), 1998. Productions and attractions were generated for trip purposes:

- Home-Based Work Productions (HBW-P)
- Home-Based Work Attractions (HBW-A)
- Home-Based Non-Work Productions (HBNW-P)
- Home-Based Non-Work Attractions (HBNW-A)
- Non-Home-Based Productions (NHB-P)
- Non-Home-Based Attractions (NHB-A)

The total number of productions and attractions estimated using NCHRP Report 365 are person trips for all modes. Those person trips are then converted to private auto trips for trip distribution by removing nonmotorized and transit trips.

Trips that begin or end beyond the study area boundary are called “cordon trips.” These trips are made up of three components: external to internal (EI) or internal to external (IE) trips and through-trips. EI trips are those trips which start outside the study area and end in the study area. IE trips start inside the study area and end outside the study area. Through-trips are those trips that pass through the study area without stopping. A summary of the cordon volumes and distribution of those volumes is listed in the Kalamazoo Cordon Information table.

KALAMAZOO CORDON INFORMATION

		2008			2035		
External Station	Station Location	IE & EI Trips	Total Cordon	Through Trips	IE & EI Trips	Total Cordon	Through Trips
600	Ravine	5307	5686	379	6739	7221	482
601	US-131 (N)	27854	41600	13746	33470	47216	13746
602	N. 12th St	3467	3710	243	4403	4712	308
603	Douglas Ave	3987	4270	283	5064	5423	359
604	Riverview Dr	2464	2637	173	3129	3349	220
605	N. 22nd St	933	997	64	1184	1266	82
606	M-89	4949	6530	1580	5618	7411	1793
607	Gullway	1088	1183	95	1382	1503	121
608	M-43 / 3rd	2669	3023	354	3029	3431	402
609	Gull Lake Dr	1347	1442	95	1711	1831	120
610	40th St	1756	1890	134	2230	2400	171
611	E. C Ave	872	929	57	1107	1180	73
612	W. M-89	3748	4782	1034	4254	5428	1173
613	Augusta Dr	2767	2944	177	3514	3739	225
614	M-96	8015	8580	565	9097	9738	642
615	I-94 (E)	15450	45932	30482	21651	52133	30482
616	Mercury Dr	5874	6019	144	7460	7644	183
617	S. 42nd St	775	824	49	984	1046	63
618	S. 32nd St	525	558	33	666	709	43
619	S. 24th St	3705	3947	242	4706	5013	307
620	US 131 (S)	8801	15616	6815	9989	17724	7735
621	W. W Ave	1319	1388	69	1675	1763	88
622	W. U Ave	1783	1880	97	2264	2388	123
623	W. S Ave	606	638	32	770	810	41
624	Q Ave	1096	1156	60	1392	1468	76
625	I-94 (W)	13275	29500	16225	15067	33483	18415
626	Stadium Ave	9580	10091	511	12166	12816	649
627	Almena Dr	4742	5002	260	6023	6353	330
628	M-43/ W. Main	11970	14104	2134	13585	16008	2423
629	D Ave	2835	2990	155	3601	3797	196

In order to develop a trip table, productions (P's) and attractions (A's) must be balanced. To accomplish this, the study area's total attractions are factored to equal the study area's total productions for the HBW, HBNW and NHB trip purposes. This is called normalization. The Kalamazoo Area Trip Generation tables identify productions, attractions, and normalization factors for the study area for 2008 and 2035.

2008 KALAMAZOO AREA TRIP GENERATION SUMMARY

	Production	Attraction	Normalization Factor
HBW	197846	203650	0.97
HBNW	572907	392919	1.46
NHB	253433	233754	1.08

2035 KALAMAZOO AREA TRIP GENERATION SUMMARY

	Production	Attraction	Normalization Factor
HBW	218855	249778	0.88
HBNW	632267	443050	1.43
NHB	279803	271341	1.03

TRIP DISTRIBUTION

Trip distribution involves the use of mathematical formula which determines how many of the trips produced in a zone will be attracted to each of the other zones. It connects the ends of trips produced in one zone to the ends of trips attracted to (in) other zones. The equations are based on travel time between zones and the relative level of activity in each zone. Trip purpose is an important factor in development of these relationships. The trip relationship formula developed in this process is based on principals and algorithms commonly referred to as the Gravity Model, which was originally derived from Newton's Law of Gravity. Newton's Law states that the attractive force between any two bodies is directly related to the masses of the bodies and inversely related to the distance between them. Analogously, in the trip distribution model, the number of trips between two areas is directly related to the level of activity in an area (represented by its trip generation) and inversely related to the distance between the areas (represented as a function of travel time).

Research has determined that the pure gravity model equation does not adequately predict the distribution of trips between zones. In most models the value of time for each purpose is modified by an exponentially determined "travel time factor" or "F factor" --also known as a "Friction Factor." F factors represent the average areawide effect that various levels of travel time have on travel between zones. The F factors used were developed from the process described in the Travel Estimation Techniques for Urban Planning, NCHRP 365. The matrix is generated in TransCAD during the gravity model process.

The primary inputs to the gravity model are the normalized Productions & Attractions by trip purpose developed in the trip generation phase. The second data input is a measure of the temporal separation between zones. This measure is an estimate of travel time over the transportation network. Zone-to-zone travel times are referred to as "skims."

In order to more closely approximate actual times between zones and also to account for the travel time for intra-zonal trips, the skims were updated to include terminal and intra-zonal times. Terminal times account for the non-driving portion of each end of the trip and were generated from a look-up table based on area type. They represent that portion of the total travel time used for parking and walking to the actual destination. Intra-zonal travel time is the time of trips that begin and end within the same zone. Intra-zonal travel times were calculated utilizing a nearest neighbor routine.

The Gravity Model utilizes the by-purpose Productions & Attractions, the by-purpose F factors, and the travel times, including terminal and intra-zonal. The by-purpose P's & A's (trip table) is combined with the through-trip table and then balanced so that the zonal P & A's are equal. The resulting trip exchange table between TAZs is used for subsequent analysis.

TRAFFIC ASSIGNMENT

Before performing traffic assignment, the trip exchange table (in Production and Attraction format) from the Trip Distribution Process went through transformations to obtain the origin and destination matrix and then converted to vehicle trips by using average vehicle occupancy rate by purpose. This final OD vehicle trip matrix can then be applied in traffic assignment process.

The traffic assignment process takes the trips produced in a zone (trip generation) and distributed to other zones (trip distribution) and loads them onto the network via the centroid connectors. A program examines all of the possible paths from each zone to all other zones and calculates all reasonable time paths from each zone (centroid) to all other zones. Trips are assigned to paths that are the shortest time path between each combination of zones. As the volumes assigned to links approach capacity, travel times on all paths are recalculated to reflect the congestion and the remaining trips are assigned to the next shortest path. This process continues through several iterations until no trip can reach its destination by taking the next shortest path. This is a user equilibrium assignment method and reflects the alternative routes that motorists use as the shortest path become congested. The assignment produces an assigned volume for each link.

MODEL CALIBRATION/VALIDATION

Model calibration/validation verifies that the assigned volumes simulate actual traffic counts on the street system. When significant differences occur, additional analysis is conducted to determine the reason.

When this step is completed, the systems model is considered statistically acceptable. It is assumed that the quantifiable relationships modeled in the base year will remain reasonably stable over time.

CALIBRATION RESULTS

The initial accuracy check involves making comparisons of the modeled vehicle miles of travel (VMT) to traffic count/VMT. VMT's are calculated by taking the link distance and multiplying it by the modeled link volumes and the link traffic counts, respectively. These calculations were made for links on the network that have traffic count data available. The value of the calibration analysis is that it provides a good measure of how well the model predicts the total number of trips and how well it assigns those trips to the street network. The Kalamazoo 2008 model meets the MDOT targets by areawide vehicle miles traveled and VMT by link classifications.

VEHICLE MILES OF TRAVEL (VMT) COMPARISONS VS. TARGETS BY LINK CLASSIFICATION

	Assignment	Count	Variation	Target
Areawide	1762173	1764370	1.00	0.95 - 1.05
Freeway	501233	477457	1.05	0.94 - 1.06
Ramps	44924	44257	1.02	No Standard
Trunkline	19659	19785	0.99	0.94 - 1.06
Major Arterial	264211	285160	0.93	0.93 - 1.07
Minor Arterial	517095	542498	0.95	0.90 - 1.10
Collector	415051	395214	1.05	0.80 - 1.20

Based on the validation results, the Kalamazoo model will serve as a valid tool for estimating the transportation impact that future proposed development might have on the street and highway system. It will also serve as a useful tool for testing future transportation system changes and major development proposals for the KATS area.

APPLICATIONS OF THE CALIBRATED/VALIDATED MODEL

Forecasted travel is produced by substituting forecasted socio-economic and transportation system data for the base year data. This forecasted data is provided by the MPO. The same mathematical formulae are used for the base and future year data. The assumption is made that the relationships expressed by the formulae in the base year will remain constant over time (to the target date).

After either base year or future trips are simulated, other types of modeling studies can be conducted.

- The impact of planned roadway improvements or network changes can be assessed.
- The impacts of land use changes on the network can be evaluated.

Two issues are critical in using the modeling tools and processes:

- The modeling process is most effective for system level analysis.
- The accuracy of the model is heavily dependent on the accuracy of the socio-economic data and network data provided by the local participating agencies.