Section 2

TRAVEL DEMAND MODELING

2.0 Introduction to the Modeling Process

The predictability of future traffic flow is complex and is best determined by a technique known as "travel demand modeling" or transportation modeling. Transportation models attempt to develop reliable mathematical relationships between socioeconomic data - i.e., number of households, household size and income, number of automobiles owned or available, school enrollment, number of people employed and the type of their employment - and trip-making. By manipulating these relationships and comparing predicted trips with known (or estimated) trip patterns, an accurate method for predicting future travel demand can be developed.

The modeling process consists of four steps; (1) trip generation, (2) trip distribution, (3) mode split and (4) trip assignment. Each of these segments will be explained in detail later except for mode-split, which is not taken into consideration. The overall accuracy of this model depends on the accuracy of trip generation (how well does the model estimate the number and kinds of trips actually made in the area, both regionally and locally). Also, model results can be affected by the accuracy of trip distribution (how well do the actual trip lengths compare to the model estimates and are actual trip patterns well duplicated).

The level of accuracy, in turn, is dependent on the quality of the input of data and the relationships developed from that data, and the way the model actually assigns the estimated trips to the road system. So while good data is required to develop a good model, it does not insure one; the model must also replicate "traffic" the way the area's street network does.

2.1 Network Development

A model network is made up of "zones" representing trip-ends, “nodes" representing intersections, and "links" representing roadways. The trips to and from zones enter the road system through nodes, which are connected by links. A set of links connecting any two zones is called a path, and a trip will always be assigned to the path with the lowest "cost" (measured as time or distance). However, depending on how much "traffic" is already on a street (path), the individual link costs - reflected by speed - are altered; therefore, paths can change. The relationship of speed and traffic volume is a function of capacity.

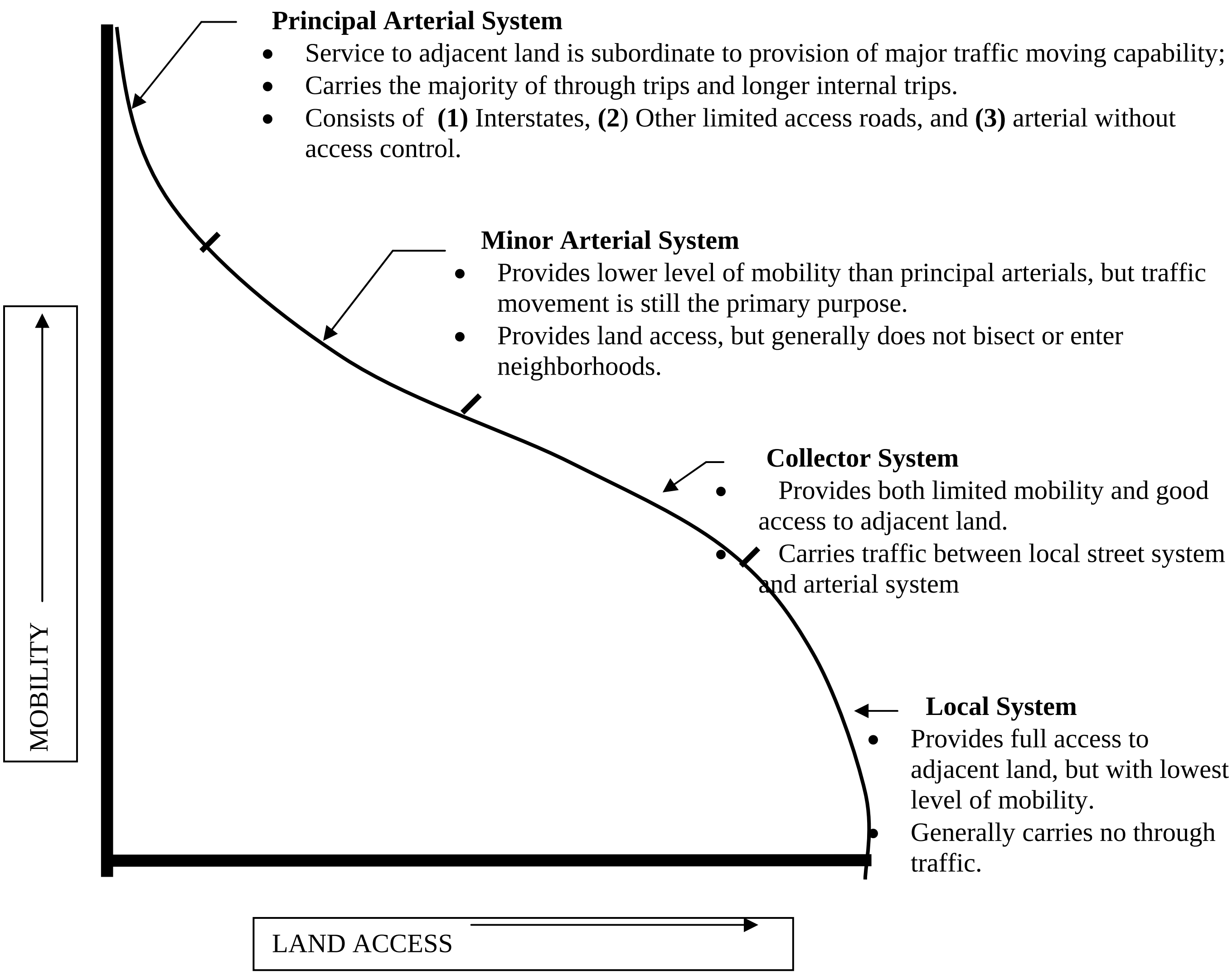
2.1.1 Roadway Capacity

In the real world, the capacity of a road is usually determined by the capacity of its intersections and can be expressed as the capacity of each of the intersection approaches - or - links. This capacity depends on numerous factors - among them are number of through lanes, number of turn lanes, lane width, peaking characteristics, and signalization. Of these factors, several are categorized as physical characteristics and several as operating characteristics. Models normally group links by both their physical and operating characteristics.

2.1.2 Roadway Classification

Different types of streets provide different types of service. The hierarchy of streets and roads ordered by the type of service each provides is called "functional classification". Generally, roads within each functional class will exhibit similar operating characteristics which will, in turn, vary between classifications. Since operating characteristics will to a large degree determine roadway capacity, it is extremely important that links are correctly classified in any travel model. The functional classification system used in urban areas is summarized in the following figure.

Figure 2.1
Functional Classification and Mobility vs. Access



The principal use of functional classification in modeling is to stratify roads throughout a system by primary purpose, thus allowing the development of a single set of general values to describe the operating characteristics of all roads of a given type. Two of the most important of these characteristics are speed and capacity - and the relationship between the two. Since most traffic assignment models operate on the premise that as traffic volumes approach capacity, speed decreases, the model will adjust link speed in some predetermined manner based on the relationship between a given load and coded capacity. This speed adjustment will affect the paths taken between zones.

2.1.3 Network Speed

To successfully replicate real-world trip patterns, the speeds coded in the model network must have some relationship to reality. When testing future networks, however, speeds will need to be coded for roads that are not yet constructed, so the coding criteria must also be defined by some tangible characteristic that can be applied in a uniform manner. Therefore, link speeds are determined by either the physical features of the road and its surroundings (such as number of lanes, its physical design characteristics, or the type of adjacent development), the road's functional classification (operational characteristics), or a combination of the two. The number of lanes is the dominant factor in determining free speeds for arterials and collectors, but all else being equal, principal arterials are usually coded faster than lower level arterials.

2.1.4 Level of Service

The "level of service" (LOS) concept is used to define the operational characteristics of roads at various traffic volumes. LOS can be used to establish the most severe conditions acceptable to the public. This is not to say or imply that the limits of acceptability are desirable - but simply they are tolerable. Levels-of-service range from A through F, with A being the best (least amount of traffic) and F being the worst (capacity, unstable flow). Abbreviated definitions of the levels-of-service as stated in the **2000 Highway Capacity Manual** follow:

LOS A is free flow. Drivers are virtually unaffected by others; freedom to select desired speed and maneuverability is high. Level of comfort/convenience is excellent.

LOS B marks the point at which freedom to maneuver begins to decline. Ability to select speed is still good, but presence of others begins to affect driver behavior. Comfort and convenience are good.

LOS C indicates that individual drivers are significantly affected by interaction with other vehicles. Selection of speed and maneuverability are both affected by the traffic stream. Noticeable decline in comfort and convenience levels.

LOS D is high-density, but stable, flow. Speed and maneuverability are severely restricted. Small traffic increases will cause operational problems. Comfort and convenience levels are poor.

LOS E is operation at or just below capacity. Speeds are reduced to low levels. Virtually no room exists for maneuverability without forcing another vehicle to yield. Operation is usually unstable, as any traffic increase causes breakdown. Comfort and convenience levels are extremely poor and driver frustration is high.

LOS F is forced, or breakdown, flow. Operation is characterized by stop-and-go waves that are very unstable. The amount of traffic approaching a point is greater than the amount that can pass the point.

2.2 Trip Generation

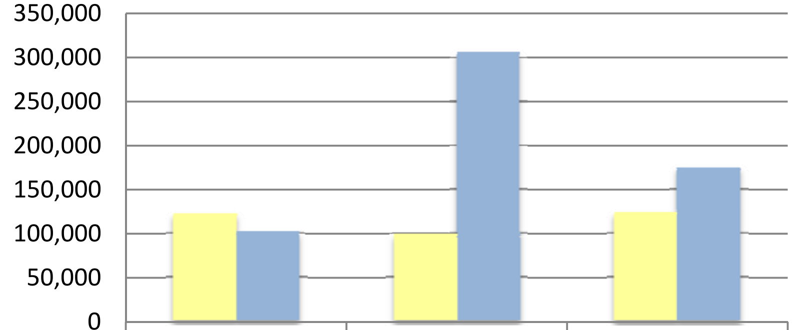
Trip generation is the initial step in the travel demand modeling process. Trip generation models translate estimates of land use activity into trips by a procedure which converts socioeconomic data and study area traffic counts to trip-ends. The median household income of a traffic zone is then used to determine an approximate vehicle-trip rate for each household in that zone; the trip rate times the number of households yields the estimated trips "produced" by the zone. College dormitories are also treated as households, but the trip rate used is the areawide rate for one-auto households as opposed to an income-dependent rate.

2.2.1 Land Use and Socioeconomic Characteristics

The number, type and length of trips made in any area, whether urban or rural, large or small, depends primarily on the land use found in that area and the socioeconomic characteristics of the population. Factors such as the number of households, median household income, school enrollment, and retail and non-retail employment are the basic determinants of trip making. Socioeconomic data is vitally important to trip generation and land use patterns are strongly linked to trip distribution, thus their respective importance to the transportation plan development. **Figure 2.2** shows the projected increase in several of these categories for the Huntsville study area. More detailed socioeconomic data is available at **Section 3**.

Total retail employment is projected to decrease from 122,644 jobs in 2005 to 101,493 total jobs in future year 2035. Total non-retail employment also increased from 98,882 jobs to 306,400. There is also an increase in the number of households projected. In 2005 there were 123,692 households in the study area. By the year 2035 the projected number of households increase by 42% or 175,266 households.

Figure 2.2
Socioeconomic Projections
Year 2005 vs. 2035



	Total Retail Employment	Total Non-Retail Employment	Total Households
Base Year 2005	122,644	98,882	123,692
Future Year 2035	101,493	306,400	175266

2.2.2 Traffic Analysis Zones

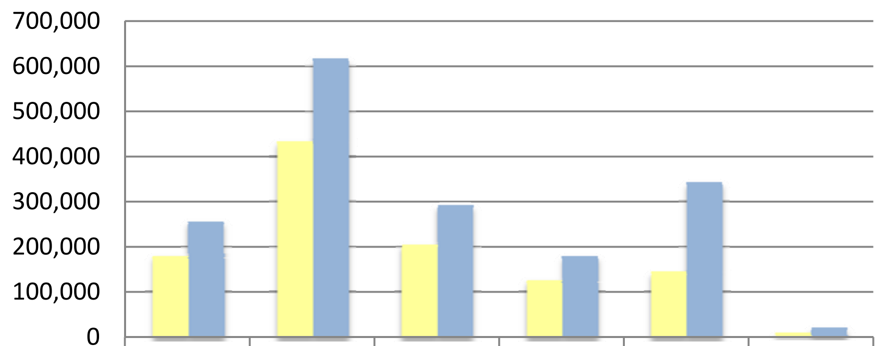
The socioeconomic conditions have changed somewhat since the last census in 2000. Changes in both terms of the scope and the distribution of growth by sub-area have occurred. This redistribution of projected growth resulted in changes in projected travel patterns and traffic volumes on certain roadways. Demands on the future transportation facilities must be reevaluated. The study area is broken into numerous small areas for detailed analysis. These areas are called Traffic Analysis Zones (TAZ). Refer to **Section 3, Map 3.1** for the map depicting the TAZs and **Section 3, Table 3.1** for the supporting socioeconomic data at the TAZ level.

TAZs are usually smaller than census tracts, but are larger than individual neighborhoods or blocks; for ease of data collection and manipulation, several TAZs normally aggregate to census tracts. The Huntsville study area is divided into 525 traffic analysis zones, 508 internal and 17 external. Automobile trips are divided into six purposes based on the location of each end of trip: (1)Home-Based (HBW), trips with the "production" end at home, the "attraction" end at work; (2) Home-Based Other (HBO), trips with the production at home, the attraction anywhere except work; (3)Non-Home Based (NHB), trips with neither end at home; (4) Internal-External (IE), trips that have one end inside the study area and one end outside the study area; (5) External-External (EE), trips that pass through the study area but do not have destination inside the study area; and (6) Truck and Taxi (TT), trips that have no set origin or destination.

2.2.3 Trip Generation Results

Two types of calculations are made independently during trip generation: trip productions by purpose by zone and trip attractions by purpose by zone. **Figure 2.3** shows the number of trips that existed in the base year of 2005 and the number of projected trips by purpose for the year 2035. According to **Figure 2.4**, total purpose trips will increase from 1,028,294 to 1,811,998 by the year 2035.

Figure 2.3
Projected Trips by Trip Purpose
Base Year 2005 vs. Future Year 2035



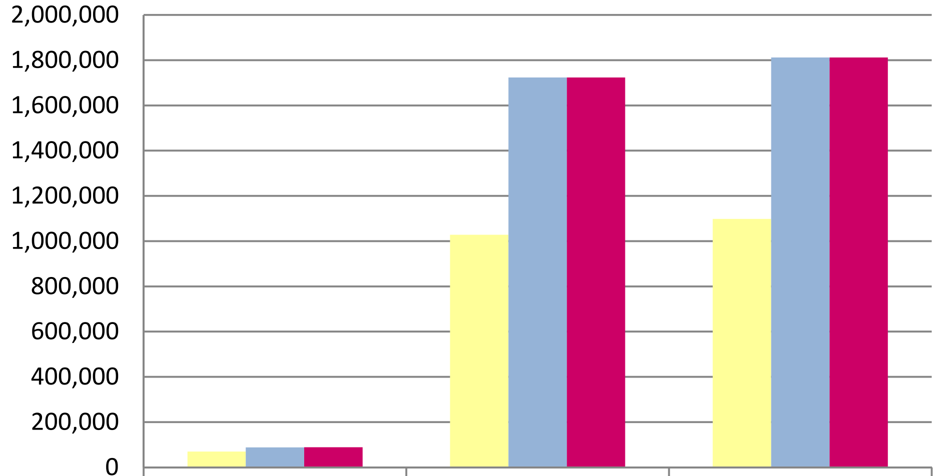
	Home-Based Work	Home-Based Other	Non-Home Based	Truck and Taxi	External-Internal	Local External
Base Year 2005	180,446	434,700	204,723	126,309	143,736	8,319
Future Year 2035	256,786	618,551	292,341	179,736	343,410	20,634

2.3 Trip Distribution

Trip distribution is the second step in the travel demand modeling process. It consists of matching the production end of each trip with an attraction end, i.e., connecting trip-ends together. The "gravity model" is the mathematical expression used to construct these trips. The number of trips between two zones increases as the activity (trip ends) in the zones increases and decreases as the separation of the zones increases. Three basic data elements are needed as input to the gravity model: (1) productions and attractions for each trip purpose for each zone, (2) the impedance values for trips between each pair of zones, and (3) a set of friction factors for each trip purpose covering the range of impedance values found in the network.

The development of zonal productions and attractions has already been discussed. Determination of zone-to-zone impedance values involves some assumptions that should be documented for later reference. Impedance has at least three components, and some models use more. At a minimum, impedance includes the costs "skimmed" from the paths through the network between each zone pair, the costs incurred by trips with both ends inside a single traffic zone ("intrazonal" trips), and terminal costs, also called "excess" costs, which are incurred at the beginning and end of any trip (finding parking, walking to a final destination, etc.). **Figure 2.4** shows the number of assigned interzonal and intrazonal trips for the Base Year, the E+C Network, and for the 2035 Future Year Network.

Figure 2.4
Comparison of Interzonal-Intrazonal Trips
Among Established Networks



	Intrazonal Trips	Assigned Interzonal Trips	Total Trips
Base Year	69,951	1,028,294	1,098,245
2035 E+C	88,211	1,723,800	1,812,011
Year 2035	88,673	1,723,325	1,811,998

Terminal time (cost) varies considerably as a function of land use at the trip-end, or more generally by geographic location of the traffic zone. Intrazonal times are determined by the size and development characteristics of a given zone, as are the terminal times and friction factors. The output of the gravity model is a matrix for each trip purpose which records the trips from each zone to each other zone. These five matrices are combined into one matrix - showing all trips from each zone to each other zone - and later assigned to the network.

2.4 Traffic Assignment

Traffic assignment is the fourth and final step in the modeling process. It is basically the product of the entire modeling procedure; all prior steps in developing the model are brought together at this point. Traffic assignment refers to placing the trip matrix (the trips from each zone to each other zone) on the individual facilities that make up the highway network. The models use one of three types of assignment: all-or-nothing, capacity restraint, or equilibrium. The traffic assignment model used in this update was equilibrium user-specified weightings and parameters.

2.4.1 Equilibrium Assignment Techniques

Equilibrium assignment techniques are based on similar concepts used in the previous two methods mentioned above. In an equilibrium assignment, there are usually several equally good paths through the network for each origin-destination pair. These extra paths help produce a more accurate assignment, and they also have an important benefit during calibration. The extra paths buffer the effect of link speeds on link volumes, that is, a small change in speed will cause a small change in volume. Many of the adjustments and refinements mentioned in previous portions of this Section cannot actually be made until after at least one assignment is completed, allowing a rough estimate of the trip movements and traffic patterns produced by the model and its empirical assumptions.

2.5 Model Validation

The process of comparing a model's estimate of traffic to the traffic counts actually taken in the field is called "validation". Validation allows the error of the model to be minimized and its confidence limits to be established. Validation includes verification of network and facility assumptions, checks on area wide trip movement, and ultimately, the accuracy of assignments on individual links.

Validation is thus an iterative process of model development whereby the entire model chain is repeated numerous times as individual model parameters are modified and the assignment results compared - to each other as well as to actual conditions. This process will produce a simulated computer version of the projected base year (2005) network with traffic volumes. These volumes are then compared to actual counts of traffic and adjustments are made until the model produces an assignment reasonably close to actual volumes.

The models are calibrated with the base year (2005) data to duplicate travel for the base year and then used for the year 2035 trips. The models subsequently test demands on alternative transportation systems.

2.6 Statewide Conformity

The travel demand model used by the Huntsville Area MPO in the development of this plan is derived through "TranPlan" software. This modeling software, endorsed by the Alabama Department of Transportation, is uniformly utilized and managed by all MPOs in the State of Alabama. This conformity system wide provides the State of Alabama with complementary transportation plans and Statewide plans.