Appendix B

Travel Demand Modeling Task

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Travel demand models are used to project future traffic and are the basis for the determination of the need for new road capacity, transit service changes and changes in land use policies and patterns. Travel demand modeling involves a series of mathematical models that attempt to simulate human behavior while traveling. The models are done in a sequence of steps that answer a series of questions about traveler decisions. Attempts are made to simulate all choices that travelers make in response to a given system of highways, transit and policies. Many assumptions need to be made about how people make decisions, the factors they consider and how they react to a particular transportation alternative.

Travel simulations require that an urban area be represented as a series of small geographic areas called travel analysis zones (TAZs). TAZs are characterized by their population, employment and other factors and are the places where trips begin (trip producers) or end (trip attractors). Trip making is first estimated at the household level and then aggregated to the zone level. Trip making is assumed to begin at the center of activity in a zone (zone centroid). Trips that are very short, that begin and end in a single zone (intrazonal trips) are usually not directly included in the forecasts. This limits the analysis of pedestrian and bicycle trips in the typical travel demand modeling process since they tend to be short trips.

The Twin Cities Regional Travel Demand model was developed by the Metropolitan Council and the Minnesota Department of Transportation. This model, divided up into 1,200 TAZs, was developed in the early 1990s based on Census data, and a Travel Behavior Inventory.

Network Development

The highway system and transit systems are represented as networks for computer analysis. Networks consist of links to represent highways segments or transit lines and nodes to represent intersections and other points on the network. Data for links includes travel times on the link, average speeds, capacity, and direction. Node data includes information about intersections and the location of the node (coordinates).

Highway Network

The highway networks will be updated to include all major facility changes that have occurred since the model has last been updated. This includes improvements to I-394, I-35W, and other major roadway capacity changes and connectivity changes that may affect the operation of the HOV lanes.

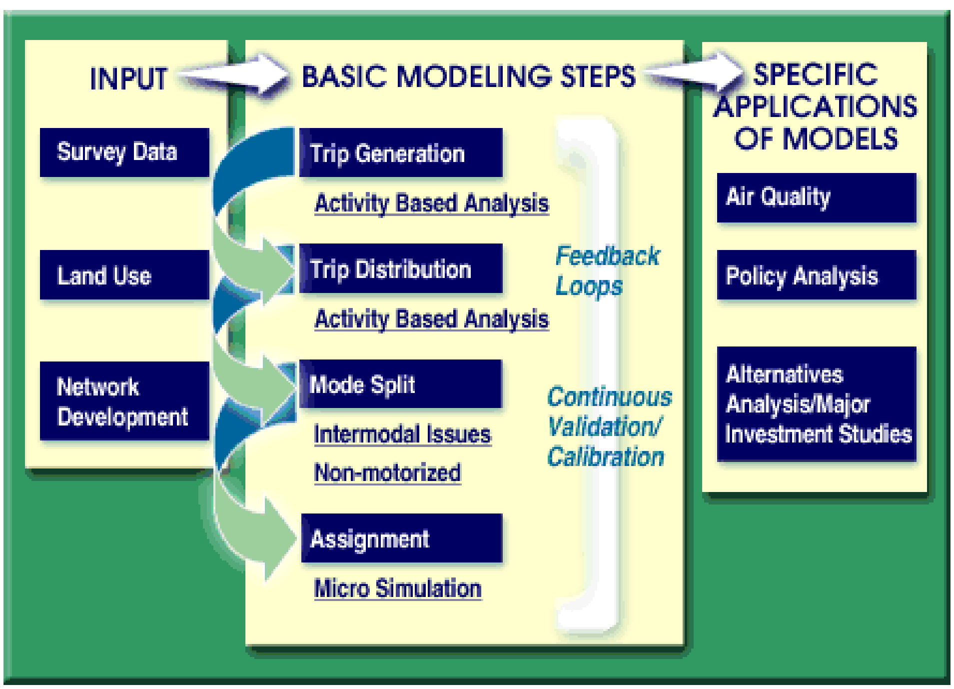
Transit Network

The transit network will be refined to reflect transit facilities currently in operation that may have a primary impact on the study corridors. This is necessary in order to forecast the usage of transit and/or HOV lanes. To forecast usage, it is first necessary to calibrate existing usage. One method of determining calibration is to compare the computer simulated trips to actual trips. This is important for determining or projecting the potential of multi-person vehicles using the HOV lanes that may choose transit if HOV benefits are reduced.

Four-Step Travel Demand Model Process

The travel simulation process follows trips as they begin at a trip generation zone, move through a network of links and nodes and end at a trip-attracting zone. The simulation process is known as the four-step process for the four basic models used. These are trip generation, trip distribution, mode split and traffic assignments. The process used to represent urban areas and the use of model results will also be described. The basic modeling process is illustrated in the diagram below.

Figure B.1 Basic Travel Demand Forecasting Four-Step Process



Source: U.S. DOT Travel Model Improvement Program.

Trip Generation

The first step in travel forecasting is trip generation. In this step, information from land use, population, and economic forecasts are used to estimate how many person trips will be made to and from each zone. This is done separately by trip purpose. Trip purposes that can be used include home-based work trips, home-based shopping trips, home-based other trips, school trips, non-home-based trips, and truck trips. Trip generation uses trip rates that are averages for large segment of the study area. Trip productions are based on household characteristics, such as the number of people in the household and the number of vehicles available. Trip generation is used to calculate person trips. These are later adjusted in the mode split/auto occupancy step to determine vehicle trips.

Total trips generated in the region will not differ due to changes in the transportation system. This is because the amounts of trips are determined primarily by the socioeconomic characteristics of the region, and is independent of the available transportation networks. Therefore, the socioeconomic data will be updated in simulated existing conditions and for projecting 2020 transportation alternatives.

Trip Distribution

Trip generation finds the number of trips that begin or end at a particular zone. These trip ends are linked together to form an origin-destination pattern of trips through the process of trip distribution. Trip distribution is used to represent the process of destination choice. Trip distribution leads to a large increase in the amount of data, which needs to be dealt with. Origin-destination tables are very large. For the Twin Cities Model, which consists of 1,200 TAZs, there are 1,440,000 possible trip combinations in its O-D table. Separate tables are also done for each trip purpose.

The Twin Cities Model uses the 'gravity model' for trip distribution. The gravity model takes the trips produced at one zone and distributes to other zones based on the size of the other zones (as measured by their trip attractions) and on the basis of the distance to other zones. A zone with a large number of trip attractions will receive a greater number of distributed trips than one with a small number of trip attractions. Distance to possible destinations is the other factor used in the gravity model. The number of trips to a given destination decreases with the distance to the destination (it is inversely proportional). The distance effect is found through a calibration process, which tries to lead to a distribution of trips from the model similar to that found from field data.

'Distance' can be measured several ways. The simplest way this is done is to use auto travel times between zones as the measurement of distance. Other ways might be to use a combination of auto travel time and cost as the measurement of distance. Still another way is to use a combination of transit and auto times and costs (composite cost). This method involves multiplying auto travel times and costs by a percentage and transit time/cost another percentage to get a composite time and cost of both modes. Because of calculation procedures, the model must be iterated a number of times in order to balance the trip numbers to match the trip productions and attractions found in trip generation.

Mode Choice

Mode choice is one of the most critical parts of the travel demand modeling process. It is the step where trips between a given origin and destination are split into trips using transit, trips by car pool or as automobile passengers and trips by automobile drivers. Calculations are conducted that compare the attractiveness of travel by different modes to determine their relative usage. All proposals to improve public transit or to change the ease of using the automobile are passed through the mode split/auto occupancy process as part of their assessment and evaluation. It is important to understand what factors are used and how the process is conducted in order to plan, design and implement new systems of transportation.

The Twin Cities Model uses the 'Logit' model to determine mode split. This involves a comparison of the "disutility" of travel between two points for the different modes that are available. Disutility is a term used to represent a combination of the travel time, cost and convenience of a mode between an origin and a destination. It is found by placing multipliers (weights) on these factors and adding them together. Travel time is divided into two components: 1) in-vehicle time to represent the time when a traveler is actually in a vehicle; and 2) out-of-vehicle time which includes time spent traveling, which occurs outside of the vehicle (time to walk to and from transit stops or parking places, waiting time, transfer time).

Travel cost is multiplied by a factor to represent the value that travelers place on time savings for a particular trip purpose. For transit trips, the cost of the trip is given as the average transit fare and in/out of vehicle time for that trip while for auto trips cost is found by adding the parking cost to the length of the trip as multiplied by a cost per mile. HOV trip cost is a combination of the two. For instance, many HOVs currently receive reduced parking rates at the Third Avenue Distributor parking garages in Downtown Minneapolis.

Once disutilities are known for the various mode choices between an origin and a destination, the trips are split among various modes based on the relative differences between disutilities. The logit equation is used in this step. A large advantage in disutility will mean a high percentage for that mode. Mode splits are calculated to match splits found from actual traveler data.

Automobile, transit, and HOV trips are converted from person trips to vehicle trips with an auto occupancy model. Mode split and auto occupancy analysis can be two separate steps or can be combined into a single step, depending on how a forecasting process is set up. In the simplest application a highway/transit split is made first which is followed by a split of automobile trips into auto driver and auto passenger trips. The Twin Cities Model divides trips into multiple categories (single occupant auto, two or more person car pool, local bus and express bus, etc.).

Assignment

Upon determining the split of trips into highway and transit modes, the specific path that they use to travel from their origin to their destination is found. These trips are then assigned to that path. Traffic assignment is the most time consuming and data intensive step in the process. The process first involves the calculation of the shortest time path from each origin to all destinations.

Trips for each O-D pair are then assigned to the links in the minimum path and the trips are added up for each link. The assigned trip volume is then compared to the capacity of the link to see if it is congested. If a link is congested the speed on the link needs to be reduced to result in a longer travel time on that link. The whole process is undergoes several iterations until there is equilibrium between travel demand and travel supply.

Transit trip assignment is done in a similar way to auto trip assignment except that transit headways are adjusted rather than travel times.

Model Calibration and Validation

This model was originally calibrated for the Year 1990. Model calibration and validation will be updated to the current year for certain variables, depending on available information. The calibration and validation for this study will focus on Average Weekday Traffic Volumes (AWDT) in the study corridors for both HOV lanes, and general-purpose lanes.