Transportation Modeling Process

All models are wrong, but some are useful.

- George Box

Introduction

Regional transportation planning shapes the transportation policies, strategies, and programs for the region resulting in an integrated multi-modal system that moves people and goods efficiently. As part of the planning process, transportation demand modeling facilitates the evaluation of alternatives for current and future problems, helping to guide long-range transportation infrastructure investment decisions. Modeling also provides information to jurisdictional engineers and planners for localized analysis of short-range transportation issues.

What is a transportation model and how is it used in the planning process?

Simply put, the transportation demand model is a set of mathematical procedures and equations that represent the choices that people in this region make to travel. Traffic on the roads results from individual decisions like where to travel, when to travel, and how to travel. Land use decisions such as where to live, where to work, and where to shop also greatly impact our travel behavior. To account for all these decisions and to asses the impact of such individual choices on our community and transportation system, engineers formulate mathematical procedures and equations that are applicable to our region.

The amount and detail of available data constrains the formulation of such procedures and equations. This leads to making reasonable assumptions on unavailable data regarding the travel behavior in the region. The modeler tests these assumptions, procedures and equations for their capability to replicate the current state of the travel behavior by comparison with actual traffic counts. The model is adjusted until it reasonably estimates the present state of traffic movement.

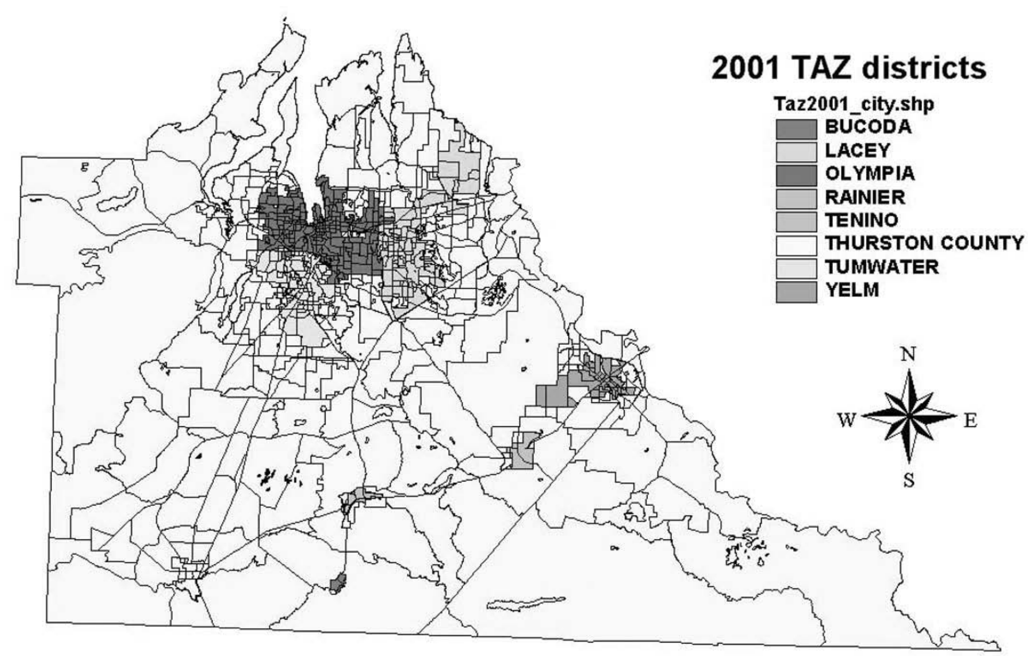
After testing the viability of these equations and assumptions, forecasts are made. Typically, models estimate the trips made in a future year – 10 to 20 years from now – for a forecasted future land use and the current transportation infrastructure. This tests the capability of the current system to hold the future traffic. Such a process reveals the road sections that are most likely to become congested in a future year. Alternative solutions are proposed to solve the congestion, and the model evaluates their performance.

Why is transportation modeling needed?

In addition to the federal requirement for model use in regional plans, transportation modeling is highly applicable for allocating scarce resources in a way that benefits the region's transportation network. Transportation models support informed and judicious transportation investment decisions. Models provide a platform to identify future problems, potential solutions, and the outcome of employing such solutions. Policy makers can compare these alternatives and either select the most promising option or propose measures and policies to alleviate the problem.

Transportation models help to build high quality transportation systems, reducing environmental impact, minimizing traffic congestion, and avoiding dangerous travel patterns and undesirable land use patterns.

Map I-1
2001 Thurston County Traffic Analysis Zones



Modeling Steps

The modeling process involves a step-by-step evaluation of travelers' choices. Since it is impractical to obtain information regarding every traveler in the region, a certain level of aggregation and generalization is required. Modelers perform such tasks in a way that makes them statistically significant. To facilitate the aggregation, the whole region is divided into small, manageable geographical locations. In technical terms, these locations are called Traffic Analysis Zones or TAZs (Map I-1).

Evaluation of travelers' choices primarily distinguishes among four transportation decisions:

- How often to travel - **Trip Generation**
- Where to travel - **Trip Distribution**
- Which mode of transportation to use - **Mode Choice**
- What route to take - **Traffic Assignment**

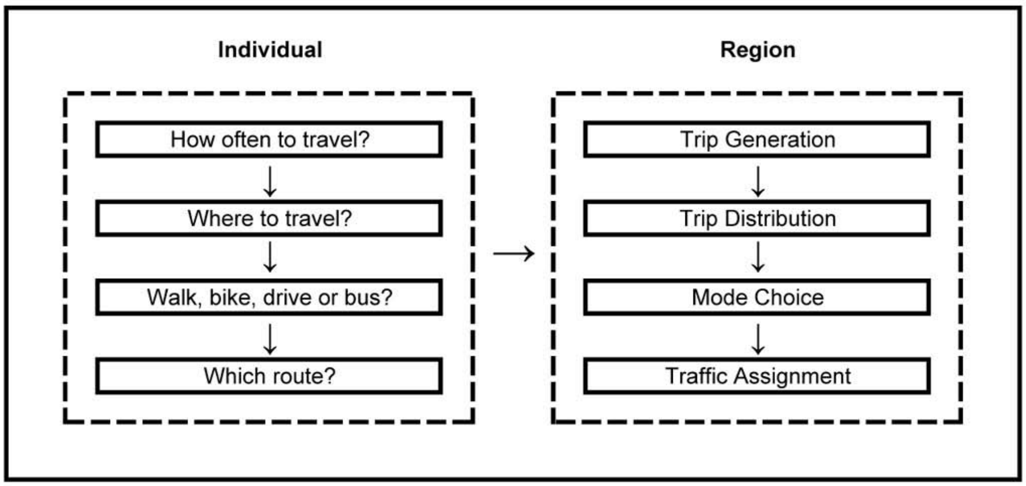
These decisions are aggregated for everyone in a TAZ. The relationship between individual decisions and their aggregated form is shown in Figure I-1. "When to travel?" is not considered here, but the entire travel demand model process can be performed after deciding the time of the day of the analysis.

Trip Generation: How often to travel?

This step estimates the total number of person trips from each TAZ by aggregating all travelers' decisions of how often to travel. If the TAZ contains commercial/office locations, then the total number of person trips also includes how often people travel to these locations. This step of the model employs land use, population and economic forecasts. It also uses the estimated values of how frequently people travel to different types of land uses like school, college, office, or shopping. The 1998 Household Travel Survey for Thurston County forms the basis for calculating trip frequency by land use.

For each TAZ, since each trip has two ends, the model distinguishes trips produced and trips attracted. Trips produced are the trips that originate in the TAZ, and trips attracted are those that end at the TAZ. Person trips are categorized according to their purpose – home-based work trips, home-based shopping trips, or non-home-based trips depending on the requirement of the analysis.

Figure I-1
Relationship between Individual and Aggregated Travel Decisions



Trip Distribution: Where to travel?

The previous step gives the analyst the total number of trips that are produced (originating) and attracted (ending) for a given TAZ. However, it does not answer the question of where the originating trips end or where the ending trips begin. This step of travel demand modeling – trip distribution – answers the question: How many trips from a given TAZ, downtown Olympia for example, are going to other TAZs, such as Capital Mall or Yelm. From a different perspective, this step can also be viewed as an aggregated form of individual travelers' decisions of where to travel because it calculates the number of trips between two TAZs.

The most popular method used for trip distribution is the gravity model. The rationale for this method is that a destination TAZ with more activity (measured in terms of trips attracted and trips produced) attracts more trips from any given origin TAZ and fewer trips if farther from the origin TAZ. The "farther" measure reflects not just the geographical distance, but also the travel time between the TAZs.

If a sufficiently long time period is selected – a day – the total number of trips produced in this time-period in the whole region is exactly equal to the total number of trips attracted to the region. However, the results from the gravity model might not represent this balance. Therefore, the whole step is performed repeatedly until this balance between trips produced and attracted is achieved.

Mode Choice: Which mode of transportation to use?

Once the "how often and where to travel" questions are answered, the next step is to choose a transportation mode. This step primarily categorizes the trips between a given origin TAZ and destination TAZ according to the transportation modes, such as drive alone, carpool, vanpool, transit, bike or walk. This step categorizes the trips between TAZs according to the individual traveler's choice of transportation mode.

The analysis of the choice of mode considers many factors:

- The characteristics of the traveler – such as income or age;
- The characteristics of the mode – bus frequency, bike lanes, waiting time for the mode, or in-vehicle travel time.

Analysts most commonly employ Logit models for this step. These models are highly mathematical and predict the probability that a given traveler chooses a particular mode. For this region, this step uses data from the 1998 Household Travel Survey and 1999 Onboard Transit Ridership Survey conducted by TRPC and Intercity Transit.

Traffic Assignment: What route to take?

Next, the modeler estimates the specific roads or transit routes taken by these travelers. Using that route information, this step computes the traffic on the roads and transit ridership.

Known as traffic assignment, this step assigns trips between a given origin and destination TAZ pair to a calculated route. When trips between all origin and destination pairs are assigned to their respective routes, the traffic builds on the transportation system resulting in the traffic volumes on each road. Usually auto assignment (assigning cars to their route) is done separately from transit assignment (assigning ridership to fixed bus routes).

The simple way of estimating a route between TAZs is to compute the shortest path that takes the least travel time. In the case of auto assignment, if congestion and its effects are also included in calculating the travel time of the routes, this process needs to be performed repeatedly until a solution is obtained.

Since the actual routes taken are different from the shortest path, highly mathematical techniques like Deterministic User Equilibrium and Stochastic User Equilibrium that use non-linear programming and optimization techniques are often employed. The rationale for these methods is that a traveler cannot improve his travel time by changing his current route while other travelers are still following their routes.

That means every traveler between a given origin and destination TAZ pair experiences the same travel time irrespective of the route they take.

Limitations of Transportation Models

Transportation demand modeling can be used for a variety of applications, but has certain limitations. A modeler must carefully decide how the capability of the model matches a specific analysis purpose.

Generally the data used for formulation of transportation models is large enough to produce a statistically significant model. However, due to the inherent complexity of travel behavior, specific aspects of travel behavior such as transit ridership by elders might not be captured. Alternative methods or surveys are often recommended for analysis of such aspects.

Since transportation models are used for regional forecasts, it is acceptable to ignore certain details regarding travel behavior at specific areas or specific times. Traditionally, for example, the travel behavior on weekends is not included in the model.

Other limitations are inherent in the model. It is:

- Insensitive to some policies. For example, the model may not reflect impacts of an increase or decrease in parking cost or gasoline price on travel behavior.
- Unable to model certain behaviors. Trip-chaining, a travel behavior that involves traveling to different activities before returning to the starting point (Home – Coffee – Work – Shop – Home), is treated differently. Surveys often do not record instances of such behavior, making that analysis statistically infeasible.
- Incapable of modeling the effects of CTR or other TDM measures.
- Unable to consider the inter-relationship between transportation investment and land use, because land use is a constant.
- Unable to connect time-of-day variations. The effects of flexible work schedules, telework and related policies are hard to capture without external data support.

Demand modeling is a macroscopic way of looking at travel behavior with application more in planning than in operations and maintenance. Traffic simulation models are more appropriate for those functions. Demand modeling deals with navigational issues and traffic simulation deals with maneuvering issues. Due to this basic distinction, travel demand models cannot resolve all issues and are inappropriate for certain purposes. For example, queue lengths and waiting time at an intersection need alternative models, not transportation demand models. Similarly, the model cannot be used to estimate the increase in pedestrian and bike traffic if better pedestrian facilities are provided.

References

Beimborn, Edward and Kennedy, Rod. *Inside the Black Box: Making Transportation Models Work for Livable Communities*, Citizens for a Better Environment, Milwaukee, WI, 1996.

Rutherford, Scott. *An Introduction to Urban Travel Demand Forecasting*, University of Washington, Seattle, WA, 1992.