Appendix I
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 multimodal 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?
The transportation demand model is a mathematical representation of supply and demand for travel in the region and represents the choices that people here make to travel. Traffic on the roads results from individual decisions like where, when, and how to travel. The transportation supply is generally represented by roadway, transit, and trail networks. The roadway network represents major roads in the region, the transit network represents public transportation service in the region, and the trails network represents major trails. In addition to the transportation networks, the other major input to the model is the land use data for the region. The demand for travel is developed using a series of equations and mathematical models applicable to the region. Land use decisions such as where to live, work, and shop also greatly impact our travel behavior. To account for all these decisions and to assess the impact of such individual choices on our community and transportation system, analysts formulate behavioral equations within the transportation model that are driven by regional surveys applicable to the greater Thurston area.

Availability of detailed data constrains the formulation of such procedures and equations.
Therefore, the modelers use reasonable assumptions for unavailable data regarding travel behavior in the region. The modeler tests these assumptions, procedures, and equations for their ability to replicate the current (base year) state of travel behavior by comparison with actual traffic counts and survey responses. The model is adjusted until it reasonably estimates the present state of travel behavior.

Policy makers can compare these alternatives and either select the most promising option, or propose measures and policies to alleviate the problem. To provide data to inform decision making, the model generates a variety of outputs: vehicle volume to capacity ratios, travel delay, vehicle miles traveled, and mode split.

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

How is the transportation model used in the Regional Transportation Plan (RTP)?

Forecasting occurs after testing the viability of the model’s base year equations and assumptions. Typically, models estimate the trips made in a future year – 20 to 25 years from now – for a forecasted future land use and the current transportation infrastructure. This tests the ability of the current system to “hold” future traffic. Such a process reveals the road sections most likely to reach congestion in a future year. Alternative projects or policies are proposed to address the congestion, and the model helps us evaluate their performance.

Why is transportation modeling needed?

In addition to the federal requirement for using transportation models to develop regional plans, such modeling provides a platform to assess future problems, potential solutions, and the outcome of employing such solutions.

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Figure I-1: Forecast Modeling Phases

Land Use Forecast

Land use forecasts provide information for the transportation demand model:

- Population Forecasts: How many households and of what size?
- Employment Forecasts: Where will people work, shop, or go to school?
- Land Use Development Patterns: Where will people live and what activities will take place?

Land use forecasts can articulate a single trend based on a set of assumptions and adopted plans, or a series of alternative futures. Alternative future visions, policies, and investment strategies will lead to alternative land use development patterns. In the Thurston region, there are two land use forecasts:

- Baseline Forecast: The region’s adopted population and employment forecast based on actual trends and adopted policy.
- Preferred Alternative: The Sustainable Thurston Plan preferred alternative based on a more compact development style of growth.
Regional Transportation Issues that Influence Thurston Regional Planning Council’s (TRPC’s) Model Development

The population of Thurston County was 267,400 in 2015. The County had approximately 134,000 jobs in 2014 and is one of the fastest-growing counties in Washington State. The largest city, Olympia, is the state capital (Map I-1). Seattle and Tacoma, the two largest cities of the Puget Sound Regional Council (PSRC) MPO planning area, lie respectively 30 and 60 miles to the north, while Portland, Oregon lies 100 miles to the south. Interstate 5 (I-5) carries local, regional, state, and interstate traffic through the area. US 101 is another major highway which carries significant amounts of traffic to and from Washington’s Olympic Peninsula on Thurston County’s west and northwest. Pierce County to the northeast contains the main part of Joint Base Lewis-McChord (JBLM), a portion of which lies within Thurston County. JBLM and Pierce County generate large amounts of travel to and from the Thurston region.

I-5 crosses the Thurston/Pierce County border at the Nisqually River, an environmentally sensitive area. This section of highway is heavily congested during much of each weekday and also on the weekends during the summer and holidays. Widening is constrained here due to environmental and cost considerations. In 2015, the Washington State Legislature included funding for corridor improvements to the north of the Nisqually River in Pierce County, from Mounts Road to the Thorne Lane interchange. However, they did not fund a solution for congestion at the Nisqually bridge. Commuters’ ability to travel between Pierce and Thurston Counties has tremendous influence on Thurston County’s travel patterns.

Numerous geographic barriers complicate the region’s goal of creating a multimodal, interconnected transportation network. Glacial patterns created a series of north-south oriented inlets and lakes allowing only a few, heavily used east-west roads. A large amount of public forest and military land constrained the routing of freeways and highways. The region’s rapid growth, much of it prior to Washington’s Growth Management Act, saw the creation of cul-de-sac subdivisions connected by auto-oriented arterials. Overcoming these barriers will require creative solutions.

The region is primarily rural outside the MPO boundary, where state highways serve as main street through many cities and communities. Downtown Olympia is home to the Port of Olympia’s marine terminal, primarily a hub for log exports. Distribution centers locating along I-5 in Lacey, Tumwater, and to the south in Lewis County serve retailers in the greater Puget Sound region.

Within this context, TRPC and its members developed and sustained a strong transportation policy framework focused on preserving the region’s environmental quality and livability. The region is committed to a vision of a fully multimodal transportation system, integrating land use policy with transportation planning, using system and demand management as a means of creating efficiencies that forestall the need for traditional roadway capacity expansion, and ultimately creating good accessibility for all the region’s residents and businesses.

amended 11/2017
Travel Forecast
The transportation 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 geographic locations called Transportation Analysis Zones or TAZs (Map I-2). Four transportation decisions are used to simulate travel choices:

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

These decisions are aggregated for everyone in a TAZ. The relationship between individual decisions and their aggregated form is shown in Figure I-2. “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 homes are present in a TAZ, trip production will include home-based trips, with characteristics such as household size and income influencing the number of trips. If the TAZ contains commercial/office locations, then the total number of
In developing the RTP, TRPC uses what is referred to as a “four-step” model, reflecting the four main steps: trip generation, trip distribution, mode choice, and trip assignment.

The majority of Metropolitan Planning Organizations (MPOs) that perform regional transportation demand modeling use some form of a trip-based four-step model. Modelers use the first three steps to estimate the demand for travel. In the fourth step – trip assignment – the modelers balance the travel demand with the travel supply, as trips are loaded onto one or more transportation networks.

Trip Distribution: Where to travel?

The previous step provides the total number of trips 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 pairs of TAZs.

TRPC uses the most popular method used for trip distribution, the gravity model. In this method, a destination TAZ with more activity (measured in terms of trips attracted and trips produced) attracts more trips from any given origin TAZ than a destination TAZ with less activity, and a destination TAZ that is closer to the origin TAZ attracts more trips than a destination TAZ that is farther away. The “farther” measure reflects not just the geographical distance, but also the travel time and cost 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 repeated until a 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: drive alone, carpool, vanpool, transit, bike, or walk.

The analysis of the choice of mode considers many factors, including:

- The characteristics of the household, such as income and number of vehicles.
- The characteristics of the mode that influence mode choice, such as bus frequency, bike lanes, in-vehicle travel time, and parking costs.

Analysts most commonly employ logit models for this step. These highly mathematical models predict the probability that a given traveler chooses a particular mode. For the current model we calibrated mode choice to the 2013 Household Travel Survey.

Traffic Assignment: What route to take?

Next, the model estimates the specific roads or transit routes taken by travelers. 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, estimating 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 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.

Transportation Impacts

TRPC’s vision is to create a model that both addresses its fundamental planning mandates (long range plan update analysis, air quality conformity determination, etc.) and helps to answer the following major planning questions:

- What is the future travel demand between the Thurston region and the central Puget Sound region to the north, and what are the resultant impacts both on the Thurston region as a whole and on key facilities such as I-5? A corollary question: How will the presence and growth of JBLM affect these travel patterns?
- How can the Thurston region absorb its projected future growth and provide good transportation services while achieving its environmental and land use goals?
- What specific strategies for managing demand and maximizing system efficiency (e.g. congestion pricing, managed lanes, increased vanpooling, etc.) would be effective for the Thurston region given our goals and values?
• What are likely daily congestion patterns across all modes as the region grows?
• How can the region’s transit services best respond to future growth in light of regional goals and values?
• Where and how will freight move within, into, and out of the Thurston region?

History of TRPC’s Transportation Models

TRPC’s Greater Thurston Region Travel Demand Model was completed in 2015. The 2015 model development effort is a significant milestone for TRPC and is based on guidelines received from a FHWA-sponsored national review by experts in the field called the Travel Model Improvement Program modeling peer review. The new model:

• Contains an enhanced network of trails and bicycle lanes.
• Models new or enhanced travel modes such as carpool, vanpool, and trips involving park-and-ride lots.
• Improves travel demand estimates at key border crossings by expanding into Pierce, Grays Harbor, Lewis, and Mason counties.
• Models travel patterns in greater detail within Thurston County.
• Is better coordinated with the Puget Sound Regional Council’s travel demand model.
• Contains the ability to model household travel behavior based on income groups.
• Contains a truck module.
• Will allow modeling of more transportation demand management factors, including parking prices, or anticipated effects of new telework policies.

This model replaces an earlier version of the EMME model, developed in the early 2000s and used for the 2025 RTP. The previous model represented a large step forward for the region’s technical capabilities, allowing for multimodal transportation demand modeling for the first time. The previous model was also the first TRPC model to be developed using local household travel data, obtained from the 1998/9 TRPC Household Travel Survey and the 1997 I-5/US 101 origin-destination survey.

TRPC’s first transportation demand model was T-Model2, a model that estimated only vehicle trips based on national average travel data rather than a region-specific survey.

Limitations of Transportation Models

We can use transportation demand modeling for a variety of applications — within certain limitations. A modeler and model users 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 that behavior, such as transit ridership by elders, might not be captured. Alternative methods, such as surveys, are often recommended for analysis of such aspects.
Since transportation models are used for regional forecasts, they typically focus on weekday peak travel times during the morning and evening rush hours, when the system is busiest. Traditionally, the model does not include travel behavior on weekends.

Other limitations are inherent in the model:

- Unable to directly model some policies and programs. For example, the model does not predict telework or flex work days, and is not sensitive to employer transportation demand programs and incentives. We can adjust for those behaviors, but would require external data support (such as the Commute Trip Reduction Survey).

- 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. People often consider this example to be one trip, while the model requires information on each segment as if it is a separate trip. Surveys seldom provide the level of detail that modelers would ideally want.

- Unable to consider the inter-relationship between transportation investment and land use, because land use is a constant. However, we can use scenario analysis to examine how transportation patterns change under alternative land use futures.

Travel demand modeling is a generalized way of looking at travel behavior with application more in planning than in operations and maintenance. Detailed and location-specific traffic simulation models are more appropriate for evaluating localized operations. 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, we cannot use the transportation demand model to estimate the increase in pedestrian and bike traffic if the community provides better pedestrian facilities.

When looking at regional traffic flows, the travel demand model is a valuable resource for transportation planners in the Thurston Region.
What Is a Transportation Model?

- A set of mathematical relationships to represent (model) the choices people make when traveling. These choices include how many trips to make, where to, and what modes. Travel demand is the combined effect of thousands of individuals making these choices.
- A tool to help planners study the impacts of alternate transportation scenarios, such as new highways, bus route changes, or parking restrictions on future travel demand, in order to make informed policy decisions.

Why Are Models Important?

- Federal law requires Metropolitan Planning Organizations (MPOs), including Thurston Regional Planning Council, to address at least a 20 year planning horizon, including short- and long-range strategies, to develop an integrated intermodal transportation system. Models provide a multimodal evaluation of the transportation, socioeconomic, environmental, and financial impacts of a transportation project.
- Model estimations help policy makers prioritize how millions of transportation dollars will be spent to ensure taxpayer dollars are used wisely.
- Utilizing the best tools available helps ensure high-quality transportation services at a reasonable cost with minimal environmental impact.

What Can Our Transportation Model Do?

- Forecast the number of trips on the region’s road, transit, and trail networks.
- Project long-range traffic growth patterns by area and roadway network.
- Highlight the traffic impacts of new land use developments.
- Estimate air quality based on Vehicle Miles Traveled (VMT).
- Evaluate the effectiveness of various transportation project scenarios.
- Test policy implications of travel mode choice (Transportation Demand Management).
- Help local jurisdiction find ways to mitigate current and future traffic capacity constraints.

How Do We Know the Model Works?

- The model is adjusted to match the results of several regional travel behavior surveys as closely as possible. Surveys and data sources include:
  - 2013 Household Travel Survey.
  - Puget Sound Regional Council’s transportation model for Pierce County.
  - Regional traffic count data for vehicles.
  - Automated passenger count (APC) data for transit trips.

Model Limitations

- The model is a statistical estimation of regional travel behavior. As such, it should only be used for general planning purposes.
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What’s New in the Model

The updated Greater Thurston Region four-step travel demand model was released in 2016. The updated model:

• Contains an enhanced network of trails and bicycle lanes.
• Models new or enhanced travel modes, such as carpool and vanpool, and trips involving park-and-ride lots.
• Improves travel demand estimates at key border crossings by adding 177 transportation analysis zones (TAZs) in Pierce, Grays Harbor, Lewis, and Mason Counties.
• Models travel patterns in greater detail within Thurston County, expanding to 778 transportation analysis zones from 588 (in 1995).
• Better coordinates with the Puget Sound Regional Council’s transportation demand model.
• Contains the ability to model household travel behavior based on income.
• Contains a truck module.
• Will allow modeling of more transportation demand management factors, including parking prices, or anticipated effects of new telework policies.

TAZs and Model Network

How our roads, trails, and bus routes are represented in the model:

Transportation Analysis Zone (TAZ): Geographic area ranging in size from a few blocks to several square miles. TAZs are the primary unit of analysis in the travel demand model. TAZs are characterized by their land use, including number of households, employment, environmental constraints, and parking costs.

TAZ Centroid: Node at the center of each TAZ, and the start and end point of all trips to and from that zone.

Centroid Connectors: Connect TAZs with the transportation network.

Nodes: Points where links meet. Some nodes represent intersections and may have defined turning restrictions.

Network Link: Connected links that represent the region’s streets, transit lines, bike lanes, and multiuse trails. Each link contains data on length, travel speed, lanes, and allowable modes of transportation.
Four-Step Modeling Process

The Greater Thurston Region Transportation Demand Model is built using the EMME modeling platform. The four-step modeling process is explained below:

1 **Trip Generation: How many trips will be made?**

   Trip generation is the first step in travel forecasting. There are two components to trip generation: trip production and trip attraction.

   Trip production calculates how many trips start at each TAZ. Trip production is based on household characteristics, including the household size, income, and the number of school-aged children.

   Trip attraction calculates how many trips end at each TAZ. Trip attraction is based primarily on the number and type of jobs, student enrollment, and households. Jobs are broken into the following categories:
   - Construction and resources.
   - Manufacturing, warehousing, transportation, communications, and utilities.
   - Retail trade, accommodations, and food services.
   - Finance, insurance, real estate, and services.
   - Government (excluding K12 education).
   - Education.

**Key Household Characteristics that Affect Trip Generation**

2 **Trip Distribution: Where do people go?**

   Trips have a beginning (origin) and an end (destination). Trip distribution is used to represent the process of where people choose to go (Destination Choice).

   Two major factors affect trip distributions:
   - Trip purpose (home to work, shopping, school (K-12 and college/university), or other, and non-home based).
   - Proximity of potential destinations (including travel time and cost).

**“Destination Choice” Means “Trip Distribution”**

Trips are statistically distributed to various locations (TAZs) based on purpose, land use, and distance/time factors.

Distribution of home-based trips in Thurston County.
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3 Mode Choice: What method is used for travel?

Mode choice is the process by which the model estimates how individuals will get to their destination. The model includes seven possible modes: Drive Alone, Carpool, Vanpool, Transit, Park-and-Ride, School Bus, Bicycle, and Walk. The model evaluates the attractiveness of each mode to determine its relative usage. Three factors affect mode choice:

- Household characteristics, including income, and vehicle ownership.
- The accessibility and cost of travel between points, including:
  - Transit availability, travel time, and cost.
  - Vehicle travel time and cost, including traffic delays, and operating and parking costs.
  - Walk and bike travel time.
- Land use characteristics or development patterns at the destination:
  - Employment density within a certain transit travel time.
  - Employment density within a certain walk distance.

4 Trip assignment: What routes will be used?

After trips have been generated, trip distribution determined, and mode choice selected, the trip must be assigned to a specific road, transit route, or trail. This process is called Trip Assignment and it is the most data intensive, time consuming step. The model calculates the quickest route between each origin and destination, then performs several iterations of complex calculations to account for the trip start time and network capacity, until an optimal equilibrium is reached. The modeler or planner can then observe the number of trips on a stretch of road for a given time of day.

Mode Choice Modeling: 100 Trips

The probability that a person making a trip will drive alone, drive with someone else in the vehicle, share a ride as a passenger, ride transit, walk, or ride a bicycle.
Map I-1: Greater Thurston Region Transportation Model Extent

- Greater Thurston County
- County Border
- City Limits
- Urban Growth Area
- Reservation
- Joint Base Lewis-McChord
- State or National Forest

DISCLAIMER: This map is for general planning purposes only. Thurston Regional Planning Council makes no representations as to the accuracy or fitness of the information for a particular purpose.
Map I-2: Greater Thurston Region
Transportation Analysis Zones

- Transportation Analysis Zone (TAZ)
- County Border
- City Limits
- Reservation
- Joint Base Lewis-McChord
- State or National Forest
- Urban Growth Area

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