Appendix K Data Analysis and Forecasting at the PSRC, New Tools Within an Integrated Modeling Framework

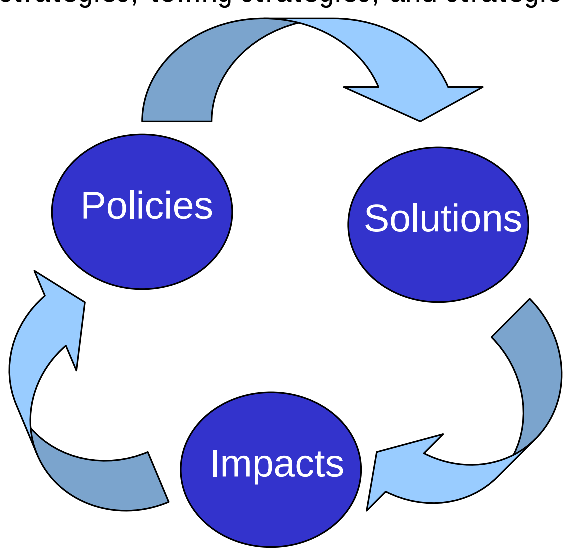
APPENDIX K. Analysis Tool Documentation

Data Analysis and Forecasting at the PSRC - New Tools within an Integrated Modeling Framework

The Puget Sound Regional Council (PSRC) has been developing new tools to improve the analysis and forecasting capabilities for use in the Transportation 2040 plan update process. These new tools are part of an overall integrated modeling framework that will eventually simulate all persons and vehicles at the parcel level in the region. This ultimate vision will not be complete for several more years, but the interim set of tools in the framework has advanced the process significantly and will address a number of specific limitations in previous analysis tools.

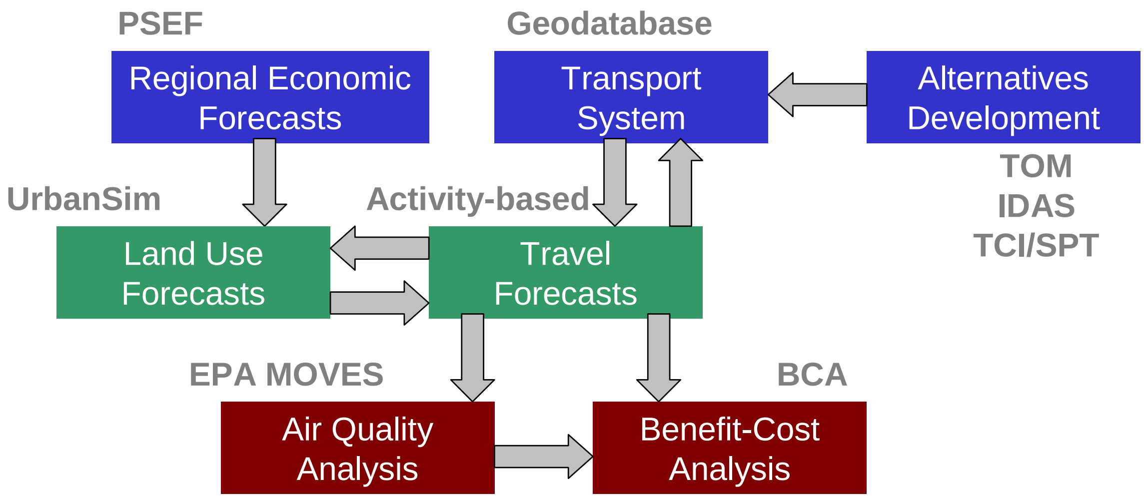
Two themes are represented in these new tools. They are *integrated* rather than sequential or not linked at all, and they simulate *individuals* rather than groups. The integration provides consistency across modeling components, additional sensitivity in the modeling components, and improved accuracy. Simulation of individuals allows us to represent a distribution of the population rather than reporting results of averages of groups of the population. This is inherently a more realistic way of modeling choices and a more powerful way of modeling what-if scenarios. Both of these features are significant advancements in the analytical process.

The primary reasons to upgrade the analytical tools are to support new policies in VISION 2040, provide the means to evaluate new solutions being proposed in Transportation 2040, and provide new measures for evaluating these new solutions. The new policies are in the areas of the environment, economy, development patterns, public services, and transportation. The new solutions being proposed include demand and system management strategies, tolling strategies, and strategic capacity enhancement. The new impacts to be measured include climate change, freight, land use, reliability, health, security, and equity. This is a tall order. While we believe that the new tools in place will address these new demands in some way, we also reiterate that the longer term integrated modeling framework will address these demands in a more rigorous manner, most especially when these tools are completed in about 3 years.



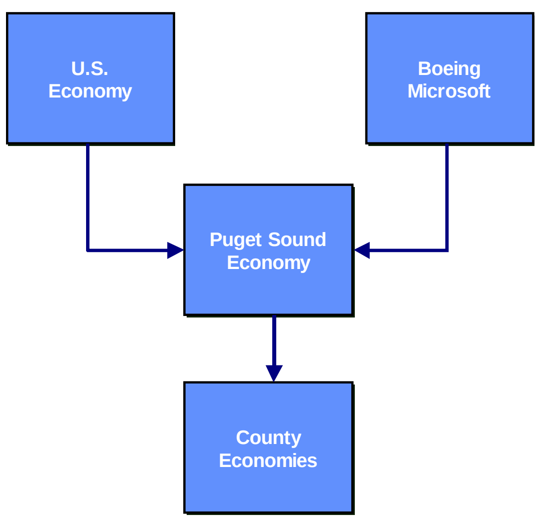
Overview of Tools

PSRC is developing new tools for an integrated modeling system to conduct analyses of alternatives in the region. These tools expand the capabilities to develop and analyze various alternatives, improve accuracy in the forecasts, and provide efficiencies in the analytical process. The advancements and capabilities are described for each of the new tools below.



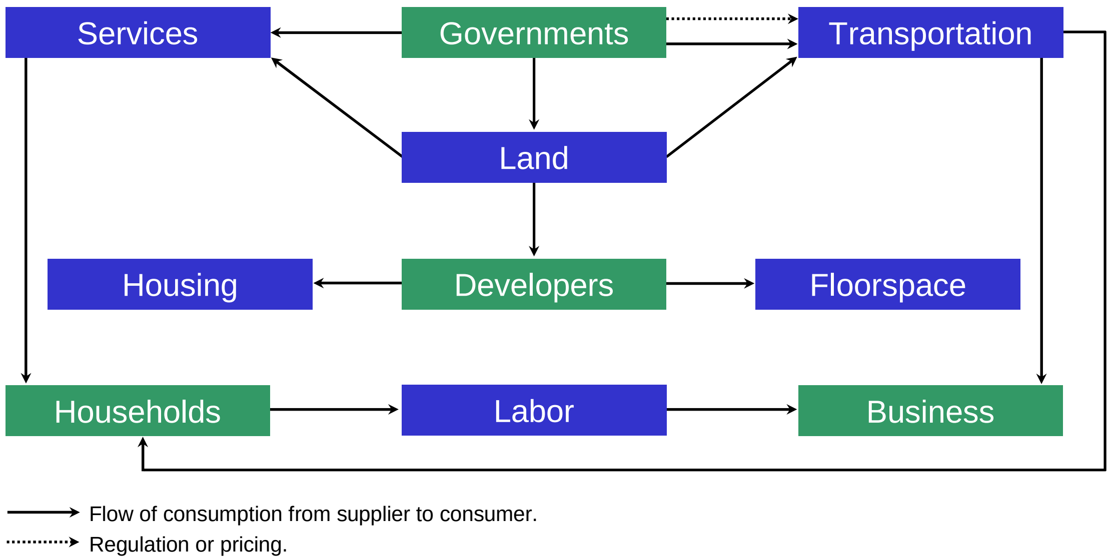
Regional Economic Forecasts

The Puget Sound Economic Forecasting (PSEF) model produces regional and county economies as input to the land use forecasting model. This is a new model for implementation in the Transportation 2040 process. It consists of two submodels: one projecting the regional economy, and one forecasting the individual county economies. Although the model produces county-level forecasts, much of the employment and population forecast detail is available only at the regional level, due to database limitations. PSRC uses only the regional forecasts from PSEF as inputs to the land use forecasting models, given both the data limitations, and the consensus that local land use trends, patterns, and plans need to be considered in developing a final county-level forecast.



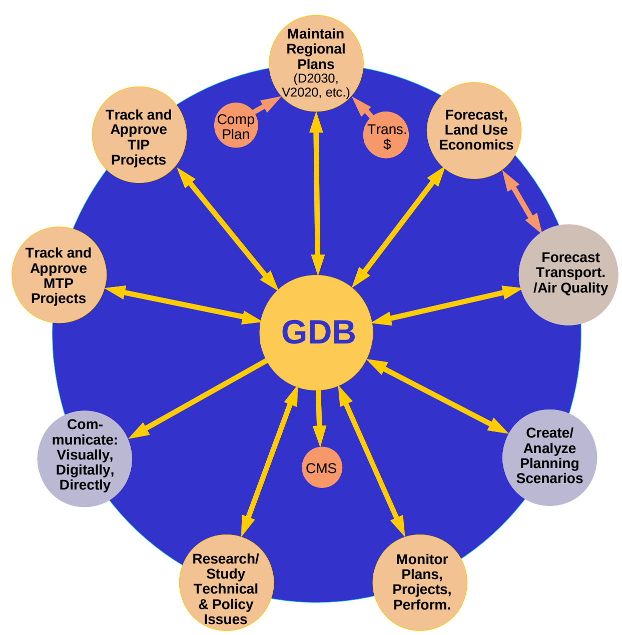
Land Use Forecasts

The new land use forecasting model, UrbanSim, is a parcel-based, market-driven model. In addition to the new capabilities in this model, we will be applying the model iteratively for each alternative to evaluate how land use is affected by each transportation investment. This is a big shift in our analysis process, where land use was assumed to be fixed for each forecast year. In addition, these new land use models are sensitive to land use and public policies so we can test the impacts of changes to policy on growth and transportation. This will be used to test the policies required to achieve VISION 2040.



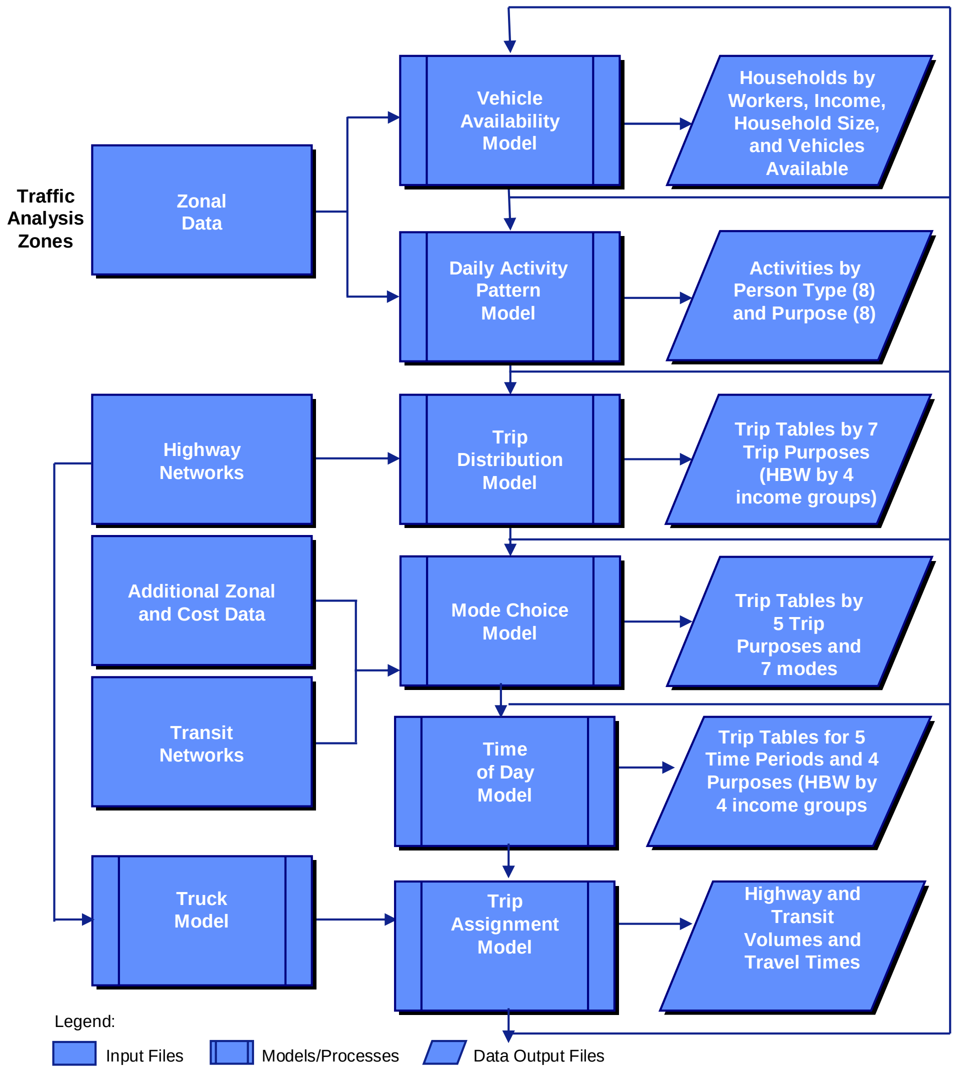
Transport Systems

Another new tool at PSRC is the geodatabase. This is a central repository for many planning functions at the agency to reduce duplication of efforts and to improve consistency and accuracy among transportation data. The previous version of this chart at PSRC was a veritable spider web without the central repository of the geodatabase. This tool was developed in a geographic environment so that all transportation data can be provided spatially and automatically updated for each planning function that uses it. The geodatabase stores information on transportation facilities by mode and maintains attributes of these facilities. In addition, the geodatabase stores all relevant information on transportation improvement projects and projects proposed for the metropolitan transportation plan.



Travel Forecasts

The regional travel forecasting model at PSRC has undergone changes to represent activities rather than travel. This is significant because travel decisions are all linked together around activities. For example, if I go to work, then stop for gas, food, and to pick up my child on the way home, my choice of mode, destination, timing, and even how many trips I make are all linked to this chain of events. These new models, called activity-based models, track individuals rather than groups of people, making them more behaviorally correct than trip-based models. PSRC has completed Phase I of the activity-based model and incorporated the trip-making component into our current regional forecasting process. This will allow us to determine changes in the number of trips and stops by trip purpose for different transportation alternatives. We have also implemented some other short-term model improvements that can address the strategies we need to test for Transportation 2040:

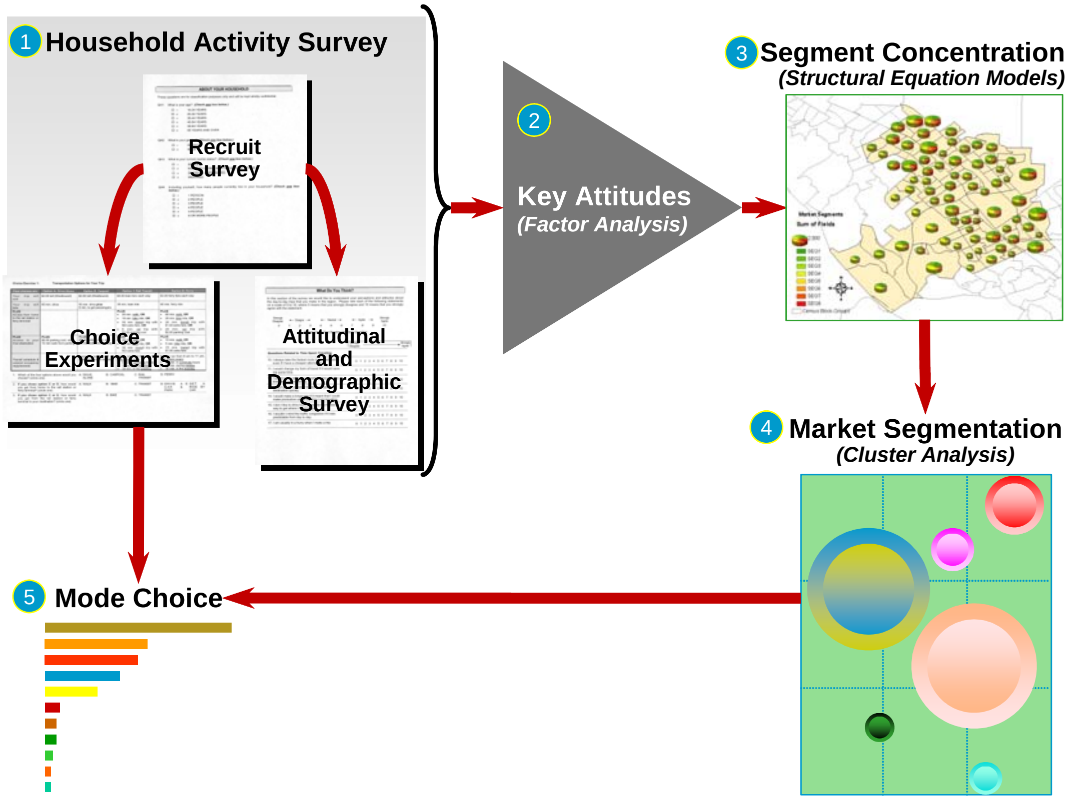


- Pricing/Tolling – improved sensitivity in the models to costs
- Freight Analysis – refined speeds and costs for trucks
- Modal Choice Analysis – stratified transit modes into local bus, premium bus, light rail, commuter rail, and ferry
- Nonmotorized Analysis – added pedestrian and bicycle factors
- Speed and Reliability Impacts – added reliability and improved speed validation
- Greenhouse Gas Emissions – used EPA MOVES model to generate emission rates by type for different speed ranges

Alternatives Development

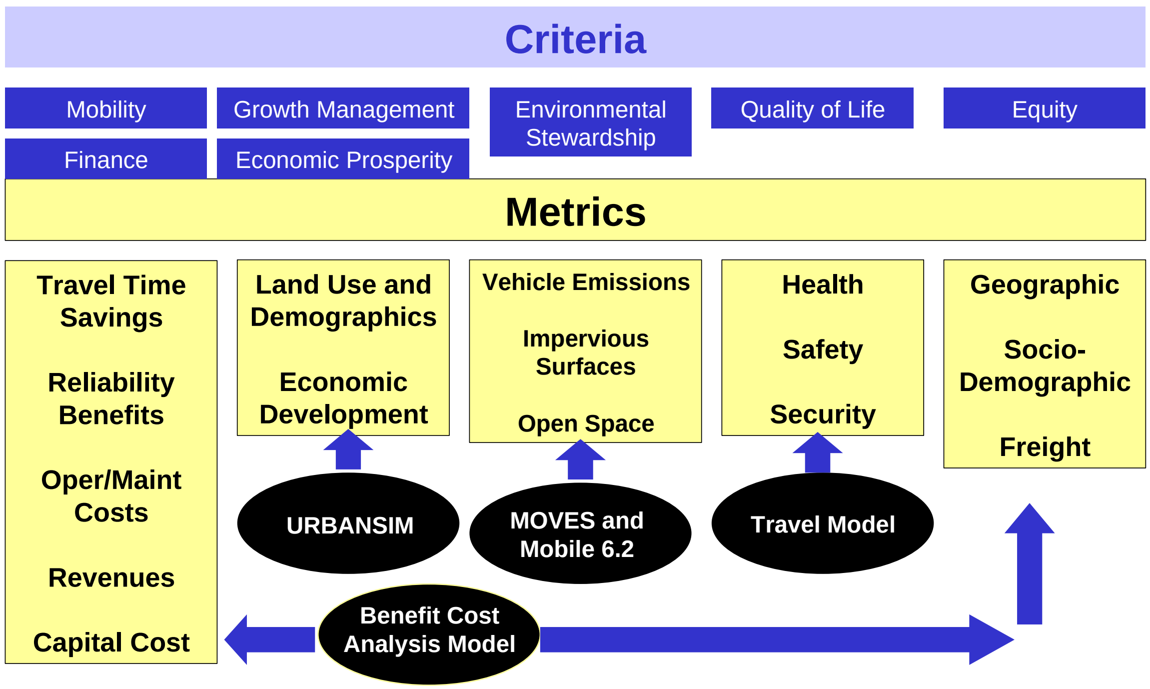
Several tools were used to develop transportation alternatives for the Transportation 2040 plan as follows:

- Toll optimization methods for setting toll rates based on the objective of maximizing user benefits. This objective amounts to minimizing the total cost of travel (time, money, allowances for unreliability, etc.) for all users for any given time period. The approach began by setting a benefit-maximizing toll for full system tolling, in which case the toll per road segment per time of day is equivalent to the marginal cost imposed by each new vehicle added to the system. The freeway system tolls were then derived from the optimal full system tolls using mathematical techniques known as Ramsey pricing, which seek to toll the priced portion of the system with per-segment rates that achieve maximum benefit while minimizing diversion to the untolled portions of the network. To set high occupancy toll (HOT) lane toll rates, consultants applied a Toll Optimization Model (TOM) to individual roadway segments. TOM was created by EcoNorthwest for use in setting toll rates to achieve different tolling policies, such as maximizing toll revenues or maximizing user benefit. TOM takes as its input results from a first-pass model run where the HOT lanes are represented as untolled high occupancy vehicle (HOV) lanes to estimate total demand. It then optimizes per-segment tolls to sort the estimated vehicle demand on each segment into users willing to pay to use the HOT lane and those who choose to remain in the general-purpose lanes by maximizing use of the HOT lanes without degrading its speed and throughput.
- System management tools for evaluating Intelligent Transportation System (ITS) strategies called the ITS Deployment Analysis System (IDAS). The IDAS software was developed by the Federal Highway Administration (FHWA) for use in planning for ITS deployments. We have used IDAS to estimate the benefits and costs of ITS investment, which are either alternatives to or enhancements of traditional highway and transit infrastructure. IDAS can currently predict relative costs and benefits for more than 60 types of ITS investments.
- Transit sketch planning tools called the Transit Competitiveness Index (TCI) and the Service Planning Tool (SPT). These tools identify corridors where transit is a highly competitive mode and then interactively allow users to test the level of service that would produce the highest ridership in that corridor.


1 Household Activity Survey
Recruit Survey
Choice Experiments
Attitudinal and Demographic Survey
2
Key Attitudes
(Factor Analysis)
3 Segment Concentration
(Structural Equation Models)
4 Market Segmentation
(Cluster Analysis)
5 Mode Choice

Evaluation Criteria

We have developed seven evaluation criteria and a series of metrics for each criterion that are drawn from the various analysis tools. Many of the metrics come directly from the travel demand forecasting model or the land use forecasting model (UrbanSim). The remaining measures are generated from two additional tools developed to support air quality and benefit-cost analysis.



Air Quality Analysis

Environmental analysis is changing across the country and at PSRC. We are proceeding with travel modeling improvements from an FHWA grant that will enhance our ability to measure the impacts of transportation investments on climate change.

We are working with EPA to be a beta test site for their new emissions model, MOVES. The new MOVES model will estimate emissions separately for each vehicle in the region rather than estimating emissions at a regional level. This new system will estimate emissions for on-road and non-road sources, cover a broad range of pollutants, and allow multiple-scale analysis, from fine-grain analysis to statewide or national inventory estimation. This model will increase the accuracy of air quality analysis significantly by modeling each vehicle rather than groups of vehicles. The draft MOVES model is being used to analyze greenhouse gas emissions for Transportation 2040, and the existing model, MOBILE6.2, is being used to analyze all other air pollutants.

Benefit-Cost Analysis

We have a new tool, called the Benefit-Cost Analysis (BCA) tool, which compiles the benefits and costs for the transportation measures. The BCA tool reports travel time and reliability benefits, and compares these to operating, maintenance, and capital costs to determine the benefit-cost ratio of a program or project. The BCA tool also reports accident costs and vehicle emission costs so these can be directly accounted for in the benefit-cost ratio. BCA is also used to evaluate geographic, socio-demographic, and freight equity issues by allocating benefits and costs to these market segments.

Overview of Assumptions

There are a series of assumptions in any analytical tool or model that provides a framework for understanding and interpreting the results.

Land Use

The land use forecasting model (UrbanSim) produces forecasts of land use and buildings by type. There are 1.18 million parcels in the region and 30 land use types in six general categories. Each parcel in the Puget Sound region has a unique land use type. There are 23 building types and 1 million buildings as represented in the 2000 forecast for the region. There are a few land use types that do not have any buildings (these are *italicized*) and one building type (outbuildings) that does not have a corresponding land use type.

Land Use and Building Types

Food, Forest, Mining
- Agriculture
- *Fisheries*
- *Forest, harvestable*
- *Forest, protected*
- *Mining*

Public
- Civic and Quasi-Public
- Government
- Military
- Park and Open Space
- Recreation
- School

Retail and Service
- Commercial
- Office
- Hospital, Convalescent Center

Residential
- Group Quarters
- Mobile Home Park
- Multi-Family Residential
- Condo Residential
- Single-Family Residential

Industrial
- Industrial
- Transportation, Communication, Utilities
- Warehousing
- *Water*
- *Right-of-Way*
- Parking

Other
- Mixed Use
- No Code
- *Vacant Developable*
- *Vacant Undevelopable*
- *Other*/Outbuilding

Note: Land use types without buildings

Demographics and Economics

PSEF produces forecasts of population by age group (1-4 years, 5-19 years, 20-64 years, and 65 years and older), population by type (household or group quarters), number of households, personal income, and employment by sector (19). These forecasts are used as regional control totals in the land use forecasting process; they do not vary by transportation alternative.

The land use forecasting model produces a synthetic population database consistent with existing and future regional demographics, with the following characteristics for each household: age of head of household, number of children, number of workers, income, and number of persons. There are 1.28 million households and 3.2 million people in 2000 and forecasts of 2.19 million households and 5.0 million people in 2040. There are 19 employment sectors represented in the economic and land use forecasting models, 10 employment sectors in the truck forecasting model, and 6 sectors in the passenger travel demand forecasting model. There were 1.85 million jobs in the Puget Sound region in 2000 and 3.07 million jobs forecasted for 2040. The land use forecasts are sensitive to changes in transportation investments and will demonstrate how growth patterns vary by investment package.

Household and Person Characteristics

Person Type
- Full-time worker
- Part-time worker
- Retired
- Non-worker
- University student
- Student age 16+
- Student age 5-15
- Child under 5

Household size
- One person
- Two persons
- Three persons
- Four or more persons

Number of workers
- Zero worker
- One worker
- Two workers
- Three or more workers

Income group (2006$)
- Under $30,000
- $30,000 to $55,000
- $55,000 to $90,000
- Over $90,000

Note: Household income is assumed to increase with inflation.

Employment Sectors in Economic, Land Use, and Travel Models

<table>
<tr><th></th><th>Economic and Land Use Forecasting</th><th>Truck Model</th><th>Passenger Model</th></tr>
<tr><td colspan="4">Goods producing</td></tr>
<tr><td></td><td rowspan="2">Natural resources and mining</td><td>Natural Resources</td><td rowspan="6">Manufacturing</td></tr>
<tr><td></td><td>Mining</td></tr>
<tr><td></td><td>Aerospace</td><td>Manufacturing - Equipment</td></tr>
<tr><td></td><td>Other durable goods</td><td rowspan="2">Manufacturing - Products</td></tr>
<tr><td></td><td>Nondurable goods</td></tr>
<tr><td></td><td>Construction</td><td>Construction</td></tr>
<tr><td colspan="3">Service producing</td><td rowspan="7">WTCU</td></tr>
<tr><td></td><td>Wholesale trade</td><td>Wholesale trade</td></tr>
<tr><td></td><td>Transportation and warehousing</td><td rowspan="4">TCU</td></tr>
<tr><td></td><td>Utilities</td></tr>
<tr><td></td><td>Telecommunications</td></tr>
<tr><td></td><td>Other information</td></tr>
<tr><td></td><td>Retail trade</td><td>Retail trade</td><td>Retail trade</td></tr>
<tr><td></td><td>Financial activities</td><td rowspan="6">FIRES</td><td rowspan="6">FIRES</td></tr>
<tr><td></td><td>Professional and business services</td></tr>
<tr><td></td><td>Food services and drinking places</td></tr>
<tr><td></td><td>Educational services</td></tr>
<tr><td></td><td>Health services</td></tr>
<tr><td></td><td>Other services</td></tr>
<tr><td colspan="4">Government</td></tr>
<tr><td></td><td>Government</td><td rowspan="2">Education/Government</td><td>Government</td></tr>
<tr><td></td><td>Education</td><td>Education</td></tr>
<tr><td>Notes</td><td colspan="3">FIRES = Finance, Insurance, Real Estate, Services
WCTU = Warehouse, Communications, Transportation, Utilities
TCU = Transportation, Communications, Utilities</td></tr>
</table>

Travel Characteristics

Travel is classified by purpose, mode, and time period in the travel demand forecasting models. Travel purpose is defined in two ways: first, by identifying the purpose of the primary destination of a tour (defined as the series of trips linked together that start and end at home), and second, by identifying the individual purpose of a single trip.

Travel Purposes

Tour Purpose (Destination)

- Work
- School
- Escort
- Personal Business
- Shop
- Meal
- Social/Recreational
- Home

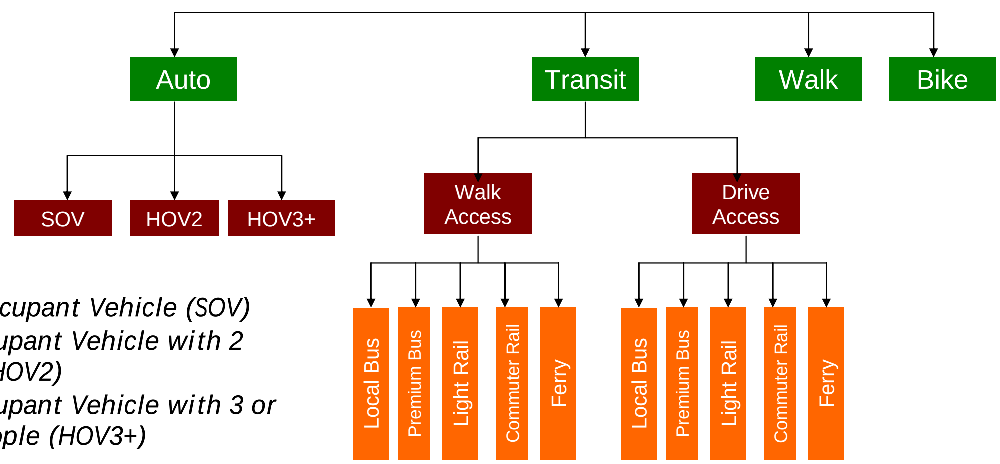
Trip Purpose (Origin and Destination)

- Home-based work
- Home-based school
- Home-based college
- Home-based shop
- Home-based other
- Non-home-based work
- Non-home-based other

The daily activity patterns generated for the tour purposes are sensitive to changes in transportation investments, toll policies, congestion, and growth patterns. The linking of trips into tours also reflects that travel choices are made based on the whole tour rather than just an individual trip. The current PSRC model represents tours for the trip generation component of the process, but combines this with destination, mode, time of day, and route choice behavior at the individual trip level. These individual trips are not linked together as tours and are therefore less effective in capturing travel decisions that are linked together. PSRC is currently developing the remaining tour models (also called activity-based models) to improve this process. We can report on tours and trips at the household level, but cannot yet track tours for destination, mode, time of day, or route choice level.

Travel Modes

There are 16 travel modes represented in the passenger travel demand forecasting model in three categories: auto, transit, and nonmotorized. These are evaluated in a nested logit structure that groups modes that are more likely to provide tradeoffs with one another.



Notes

- *Single Occupant Vehicle (SOV)*
- *High Occupant Vehicle with 2 people (HOV2)*
- *High Occupant Vehicle with 3 or more people (HOV3+)*

Time Periods

There are 32 time periods in the detailed time-of-day choice component of the passenger travel demand models, and these are aggregated to five time periods for use in other modeling components. The more detailed time periods are used to determine the actual time of an individual trip; these are aggregated to determine an average travel time, cost, and volume for the aggregated time periods. The more detailed time periods in the time-of-day models can be used in trip assignment, but this is best used for corridor-level analysis and not for regional planning purposes.

Time of Day Models

- A.M. peak (5:00 a.m. to 9:59 a.m.) in 30-minute increments
- Midday (10:00 a.m. to 2:59 p.m.) in 30-minute increments
- P.M. peak (3:00 p.m. to 7:59 p.m.) in 30-minute increments
- Evening (8:00 p.m. to 10:59 p.m.)
- Night (11:00 p.m. to 4:59 a.m.)

Other Models

- A.M. peak (6:00 a.m. to 8:59 a.m.)
- Midday (9:00 a.m. to 2:59 p.m.)
- P.M. peak (3:00 p.m. to 5:59 p.m.)
- Evening (6:00 p.m. to 9:59 p.m.)
- Night (10:00 p.m. to 5:59 a.m.)

Travel Costs

There are four types of direct costs in the travel demand forecasting models: auto operating cost, parking costs, tolls, and transit fares. Auto operating costs are applied at 14.4 cents per mile (in 2006 year dollars) to all auto modes and to the auto-access to transit modes. Daily standard and carpool parking costs are used in the work model. Non-work models use hourly parking costs. Ferry fares paid when crossing the Sound with a vehicle also are considered as auto operating costs. In 2006, there was only one toll bridge, the Tacoma Narrows Bridge, which charges $3.00 in one direction. All occupants of shared-ride modes share the auto operating costs and parking costs equally. A zone-to-zone transit fare matrix representing the fares for each transit mode also is used as input to the model. A bi-directional averaging procedure is used for cost. All travel costs are assumed to increase with inflation, except parking cost, which assumes a 1.5 percent increase above inflation based on historical trends. A separate analysis of the impacts of increasing gas prices on travel behavior is being conducted to demonstrate the sensitivity of vehicle miles traveled to changes in cost.

Special Generators

There are four types of special generators added to the trip tables for passenger and truck models:

- Sports complex (the SoDo Sports Complex and the Tacoma Dome)
- Regional center (the Seattle Center)
- Ports (Sea-Tac Airport, Port of Seattle, and Port of Tacoma)
- Warehouse and distribution centers (located in the SR 167 corridor)

Trips to and from the ports of Seattle and Tacoma and the warehouse and distribution centers are input to the truck model, while trips to the other special generators are input to the passenger model. For the Port of Seattle, the trips between the Port and the intermodal yards are specified separately from remaining regional or external trips to and from the Port.

External Travel

There are three types of external travel added to the trip tables for passenger and truck models:

- Trips from outside the region destined to somewhere in the region
- Trips from inside the region destined to somewhere outside the region
- Trips from outside the region destined to somewhere outside the region, but that pass through the region on the way

There are 18 external stations in the Puget Sound region. Passenger and truck external trips are developed separately from observed data sources and forecasts are based on relevant growth patterns.

Commercial Vehicles

Commercial vehicles are defined as any vehicle used for commercial purposes and can include autos, vans, sport utility vehicles, small trucks, as well as medium and heavy trucks. These are inclusive of all commercial vehicles, such as taxis, rental cars, school buses, ambulances, etc., but these special-purpose vehicles are not directly represented in the current model, rather they are indirectly represented. These commercial vehicles are forecast using a truck model, which includes all commercial vehicles based on relative weight classes and separates light, medium, and heavy trucks for analysis purposes:

Truck Type	Configuration	Gross Vehicle Weight
Light Truck	Four or more tires Two axles	Less than 16,000 lbs.
Medium Truck	Single unit Six or more tires Two to four axles	16,000 to 52,000 lbs.
Heavy Truck	Double or triple unit Combinations Five or more axles	Greater than 52,000 lbs.

Note: Light trucks also include non-personal use of cars and vans.

This truck model was developed using a conversion of truck volumes to passenger car equivalents (PCE) for assignment purposes. This factor provides a means to account for the fact that larger trucks take up more capacity on the roads than passenger cars. This model is important to determine the effects on capacity and congestion for assignment of both trucks and passenger cars. The following assumptions were used:

- Light trucks are 1.0 PCE
- Medium trucks are 1.5 PCEs
- Heavy trucks are 2.0 PCEs

Vehicle Classes

There are six classes of vehicles assigned in the multi-class assignment:

- Single-Occupant Vehicle (SOV)
- 2-person carpools (HOV2)
- 3+ person carpools (HOV3)
- Vanpools
- Light trucks
- Medium trucks
- Heavy trucks

In order to combine vehicle costs and times, we have assigned a value of time for each vehicle class and have further stratified SOV by purpose and income class to capture differences in values of time for each market segment. HOV and vanpool vehicles are further subdivided by time period because vehicle occupancies vary by trip purpose and time period and these affect the overall value of time for each vehicle.