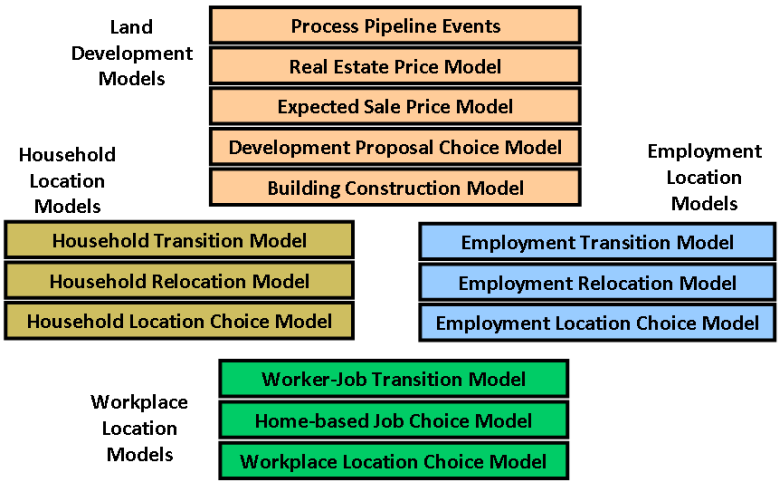
Testing The Puget Sound's Land Use Model Response to Transportation Strategies

Background and History

In the past ten years, land use forecasting at the Puget Sound Regional Council (PSRC) has been undergoing a significant change. Previous land use forecasting was completed using an in-house version of the DRAM/EMPAL software framework, first deployed in 1981 to support the agency's travel demand models. While the DRAM/EMPAL models provided a stable and transparent process to develop land use forecasts, their aggregate structure limited the PSRC's ability to use models to answer policy questions, a shortcoming noted during the preparation of the region's transportation plan in the late 1990s.

In 2000, a series of recommendations to improve the PSRC's forecasting capabilities were developed and the UrbanSim software was selected as a replacement for DRAM/EMPAL. UrbanSim is an urban simulation system developed to better inform deliberation on public policy choices by simulating long-term, significant effects on growth patterns[1]. UrbanSim is designed to reflect the interdependencies in dynamic urban systems, focusing on the real estate market and the transportation system, and on the effects of individual interventions, and combinations of them, on patterns of development, travel demand, and household and firm location. The PSRC has been working to develop, calibrate and apply land use forecasting models using UrbanSim as the framework since 2003, in partnership with the model's lead developer, Dr. Paul Waddell of the University of California, Berkeley (formerly the University of Washington).

Figure 1 – UrbanSim Model Components



The new PSRC UrbanSim land use forecasting models represent a significant improvement over DRAM/EMPAL in terms of facilitating 'what-if' scenarios. Perhaps the key enhancement is the ability to input parcel-level development constraints derived directly from each city and county's comprehensive plans. Furthermore, its disaggregate model structure (forecasting development events on individual parcels, and the subsequent location choices made by households, jobs, and workers) offers expanded and more robust abilities to test policies - such as the impacts tolling and parking pricing have on household location, given a household's income level. Figure 1 summarizes the current suite of models comprising the PSRC UrbanSim package[2].

[1] More information on UrbanSim can be found at http://www.urbansim.org/Main/WebHome. For additional material on PSRC's land use forecasting model, please refer to http://www.psrc.org/data/models/urbansim/.

[2] For more information on the model components, please refer to http://www.psrc.org/assets/2936/UrbanSim_White_Paper_2009_Final.pdf.

Accessibility Measures in the Land Use Models

The initial specifications of the PSRC land use model included a number of variables as inputs that are derived directly from travel model output. These can be grouped into four broad categories as shown in Table 1. Four models specifically used inputs from the travel model in their forecasts – the Real Estate Price Model (REPM), Household Location Choice Model (HLCM), Employment Location Choice Model (ELCM), and Workplace Location Choice Model (WLCM). In addition, the REPM and ELCM contain multiple sub-models for either different land uses or employment sectors, and each was specified with its own 'best fit' accessibility measures.

Table 1 – Accessibility Measures Used by UrbanSim Model Blocks

		UrbanSim Models			
	Accessibility Measure	Real Estate Price(1)	Household Location Choice	Employment Location Choice(1)	Workplace Location Choice
Zone-Based , Origin Zone to Location					
	Generalized Cost HBW AM SOV to Seattle CBD	16	--	7	--
	Generalized Cost HBW AM SOV to Bellevue CBD	--	--	9	--
Zone-Based, Origin Zone to All Other Zones					
	Average trip-weighted Travel Time, HBW AM SOV,	15	--	7	--
	Jobs within 30 minutes time, AM SOV	12	--	17	--
Person-Based, Home to Work Zones					
	Network Distance from Home to Work	--	X	--	X
	Logsum of HBW AM Trip	--	X	--	X
Grid Cell-based, Proximity to Roadways					
	Distance to Highway	4	--	13	--
	Distance to Arterial	1	--	14	--

(1) – Number of submodels that contain the measure in current specifications, there are 18 sub-models in the Real Estate Price Model, and 17 in the Employment Location Choice Model

- *Zone-based, Origin Zone to Specific Location* – The current specification of UrbanSim found that accessibility to two of the region's employment centers – the Seattle CBD and the Bellevue CBD – to be significant for both real estate price and employment location choice modeling. The generalized cost measure combines travel time, operating costs, and user fees (tolls and parking) into a single measure (minutes of travel time) assigned to each zone.
- *Zone-based, Origin Zone to All Other Zones* – Real estate price and employment location choice also included two other measures of a zone's overall accessibility – the trip-weighted Average Travel Time from the origin zone to all other zones, and the number of jobs within a 30 minute travel time, both using the results of AM peak, Home-based work travel by single-occupant (SOV) vehicles.
- *Person-based, Home to Work Zones* – Both the Household and Workplace Location Choice models utilize a Distance from Home to Work and a Logsum measure in determining the utilities of specific choices. These variables limit the measure of accessibility to a single pair of zones for each option in the choice set - from the home or workplace zone to the zone where the potential housing unit or job choice is located.

- *Grid cell-based, proximity to roadway* – Whether a parcel is within a predetermined distance of a highway or arterial is currently included in both Real Estate Price and Employment Location Choice sub-models. Note that parcels are first assigned to a 150 meter grid cell structure, where each grid cell is already identified as being within the prescribed distance to highways or arterials using GIS analysis of the travel model networks.

PSRC staff is in the process of implementing a series of improvements for the land use forecasting model. As part of this effort, the accessibility measures used by all UrbanSim models and sub-models will be tested. Revisions that improve the response of land use to transportation system changes and provide better consistency among models will be considered.

Initial Application of UrbanSim

Entering 2009, the PSRC was focused on utilizing the integrated UrbanSim and travel demand model in the analysis work for the region's updated transportation plan, Transportation 2040. This coupling of the models was considered an essential part of the analysis, given the desire to estimate the degree to which each of the transportation system alternatives under consideration would contribute to the policy goals and objectives established by the adoption of VISION 2040, the regional growth plan adopted in 2008.[3] The Regional Growth Strategy (RGS), a key element of VISION 2040, provides specific numeric guidance for the distribution of growth to *Regional Geographies*, which are defined by the distinct roles they will play in the region's future. The Regional Growth Strategy focuses the majority of the region's employment and housing growth into designated growth centers in *Metropolitan Cities*, *Core Cities*, and *Larger Cities*, - regional geographies collectively referred to as the *Urban Core* geography - in areas characterized by proximity to services and jobs, a variety of housing types, access to regional amenities, high quality transit service, and other advantages.

Due to schedule deadlines for the Transportation 2040 analysis, PSRC staff elected to use the land use forecasting model as a comparative tool when evaluating different transportation system alternatives. Rather than focusing on the actual forecast totals for a zone, city, county or other geographical unit, the evaluation metrics compared the change in land use model output for each alternative scenario to the Transportation 2040 Baseline scenario. Complicating the process were early results from UrbanSim that showed the region by 2040 nearly exhausting its supply of zoned residential dwelling unit capacity. To ensure the land use models had the freedom to vary the future locations of households and jobs under the different transportation systems being modeled, the development constraints derived from existing comprehensive plans were inflated (in many instances doubled) to allow for ample potential sensitivity.

Working with stakeholder groups, twenty-six measures were agreed on for evaluating Transportation 2040 alternatives, covering seven broad policy areas: Mobility, Finance, Growth Management, Economic Prosperity, Environmental Stewardship, Quality of Life, and Equity. The following measures were derived directly or indirectly from comparative analysis of UrbanSim output:

Growth Management
GM1. Population
GM2. Employment
GM3. Jobs to Housing Balance

[3] More on VISION 2040 and Transportation 2040 can be found on the PSRC web page at http://www.psrc.org/growth/vision2040 and http://www.psrc.org/transportation/t2040.

GM4. Population and Jobs in Centers
Environmental Stewardship
ES2. Impervious Surfaces
ES3. Agriculture and Natural Resource Lands
ES4. Energy Usage from Vehicle and Building Use

In terms of examining the land use model's response to transportation system changes, the results of the first two metrics, Population and Employment, serve as the focus for this paper.[4] The forecast results for these measures were tabulated by classifying each of the Regional Geographies into Urban Core, Outlying Urban, or Rural areas, as displayed in Table 2 below. Total population and employment results for year 2040 are presented for the Baseline alternative, and the aggregate change observed for each of the five DEIS alternatives and two variations of the Preliminary Preferred Alternative (PPA) – a financially Constrained version, and an expanded Unprogrammed version.

Table 2: Aggregate Changes in Population & Employment by Transportation Alternative

		Change from the Baseline						
POPULATION	**Baseline**	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**	**PPA_Unp**	**PPA_Con**
Urban Core	2,853,800	200	-3,100	6,900	2,100	6,400	7,600	5,100
Outlying Urban	1,500,600	5,700	3,700	-5,800	-2,400	-6,000	-8,500	-5,500
Rural	532,700	-600	-700	-1,000	-200	-300	-900	-300
TOTAL	4,887,100	100	-100	100	-100	100	0	-100

		Change from the Baseline						
EMPLOYMENT	**Baseline**	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**	**PPA_Unp**	**PPA_Con**
Urban Core	2,541,200	-700	-2,700	-900	-17,000	-1,700	13,900	5,100
Outlying Urban	420,700	8,200	2,700	400	16,300	-100	-11,900	-3,700
Rural	93,600	1,000	200	1,000	1,000	-500	-1,200	-600
TOTAL	3,055,500	200	-200	-500	-300	-1,300	800	800

Note: Totals may not sum to zero due to rounding and variation in the number of unplaced jobs

The VISION 2040 regional growth strategy seeks to encourage more growth in Urban Core areas and less growth in Outlying Urban and Rural areas. The population increased in the Urban Core areas for all alternatives except 2, which focused on highway expansion and would be expected to spread growth to outlying areas. The employment decreased in all early alternatives for Urban Core areas, but increased for the preferred alternative options due to improvements in how tolls were assessed in the PPA. Both

[4] The complete alternatives analysis can be found in Appendix D of the Transportaton 2040 DEIS at http://www.psrc.org/assets/1941/appd.pdf.

the population and employment changes for the preferred alternative at a regional level support the VISION 2040 growth strategy.

The initial application of UrbanSim in Transportation 2040 helped identify further refinements PSRC staff needed to pursue, including a number of potential changes to the accessibility measures. While the model estimations used in the Transportation 2040 analysis were derived from analytically-sound estimation results, it was recognized that additional variables should be added to better facilitate policy analysis in the future. A notable example was the use of logsum measures only in the HLCM and WLCM – since the logsums were the only travel model measure that incorporated transit accessibility, changes in transit service would not be captured in accessibility measures used in the ELCM and REPM models.

Sensitivity Testing

To further test the land use and travel model integration, and help validate the modeling results, an initial set of sensitivity model assignments were conducted using various Transportation 2040 alternatives. For Alternative 1, two variations of the transportation pricing assumptions were tested – higher vehicle operating costs, and lower parking costs. These shifts in household and employment locations were generally in the direction expected; further review of these data at the local level is underway. Table 3 shows the UrbanSim model output for those zones that had parking costs reduced in the sensitivity analysis – combined, an additional 3,700 households and 4,600 jobs located in those zones as a result of lower parking costs.

Table 3: Sensitivity Results for the lower parking cost test

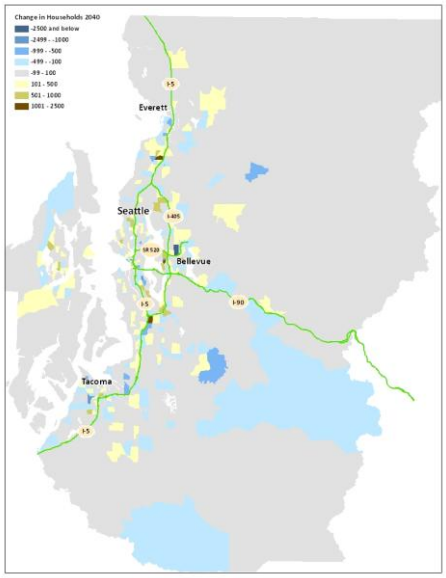
	Year 2040 Model Output	
Alternative 1 Scenario	Households	Jobs
Baseline	359,100	1,339,100
Lowered Parking Costs	362,800	1,343,700
Change	3,700	4,600

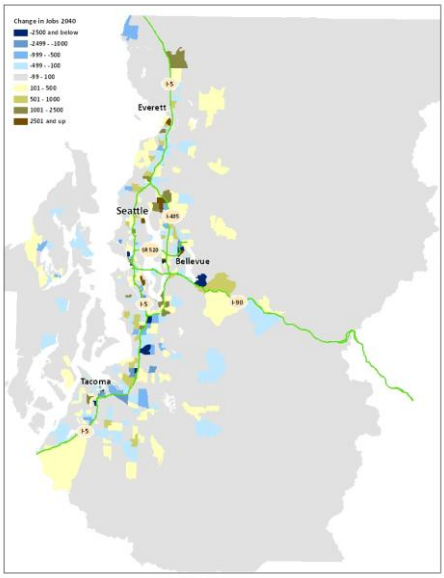
Maps presenting the resulting change in Households and Employment when vehicle operating costs are increased are displayed in Figure 2. Higher costs resulted in more households locating in areas better served by the major freeways, and more employment in centers closer to existing housing stocks, leading to denser overall patterns. A total of 4,100 additional households and 3,300 jobs were forecast in the area served by the region's primary interstates, I-5 and I-405, between the cities of Everett, Tacoma, Bellevue and Seattle.

Figure 2 –Sensitivity Results for the Higher Fuel Cost Test – Change from Year 2040 Alternative 1 Model Run

Change in Households – Higher Vehicle Operating Costs

Change in Jobs – Higher Vehicle Operating Costs





Following the Transportation 2040 analysis effort, PSRC will be focusing on further UrbanSim refinements prior to using the model for updated land use forecasts in 2010. As part of this refinement effort, PSRC staff are planning additional sensitivity tests to examine the land use forecast response to a series of limit-stretching transportation system changes to the Preferred Alternative arrived at in the Transportation 2040 plan. Sensitivity tests under consideration include the following options, subject to revision:

- Double transit service frequency – evaluate land use impacts in corridors and urban centers served by transit.
- Double LRT transit service – evaluate impacts around light rail stations.
- Expand highway capacity– evaluate whether development becomes less compact overall.
- Increase or Decrease user costs – evaluate density and mix of land use activity as costs of travel rise or fall substantially.

Completion of this paper would include the results of these additional sensitivity tests.

Conclusion

The initial application of UrbanSim provided the analysis support expected during the preparation of the Puget Sound region's long-range transportation plan, Transportation 2040. By fully integrating the UrbanSim land use model with the PSRC travel demand model, a major shortcoming noted in the agency's modeling approach has been addressed- providing a more robust method of assessing the change in land use as transportation systems change, and the feedback loop of how land use activity distribution then impacts the performance of the transportation system.

However, given the complexity and relative newness of these new models, it is important to recognize the limitations of the output and the degree to which it can inform the policy and plan decisions. PSRC's approach was to restrict this initial use of UrbanSim to a comparison model, focusing the metrics on the change observed from the baseline scenario, as different transportation system plans were modeled. This approach also had to be considered when finalizing the land use modeling inputs, as UrbanSim

needed enough flexibility in where future year development and activity could be forecast, given varying transportation conditions. And subsequently, care was taken to present results at a summary level appropriate to the methodology and limitations – i.e. in the aggregate, reasonable shifts in population and employment were observed among the major VISION 2040 regional geography aggregations.

Next steps in the refinement of UrbanSim will include additional research on the accessibility measures used in the integrated modeling process, focusing on both the desire to improve the overall model's forecasting ability and using a more consistent representation of accessibility among models, while ensuring the specifications optimize the ability of PSRC staff to test policy scenarios. Sensitivity tests of these improvements will be a key step in continuing to build the credibility of the UrbanSim model.