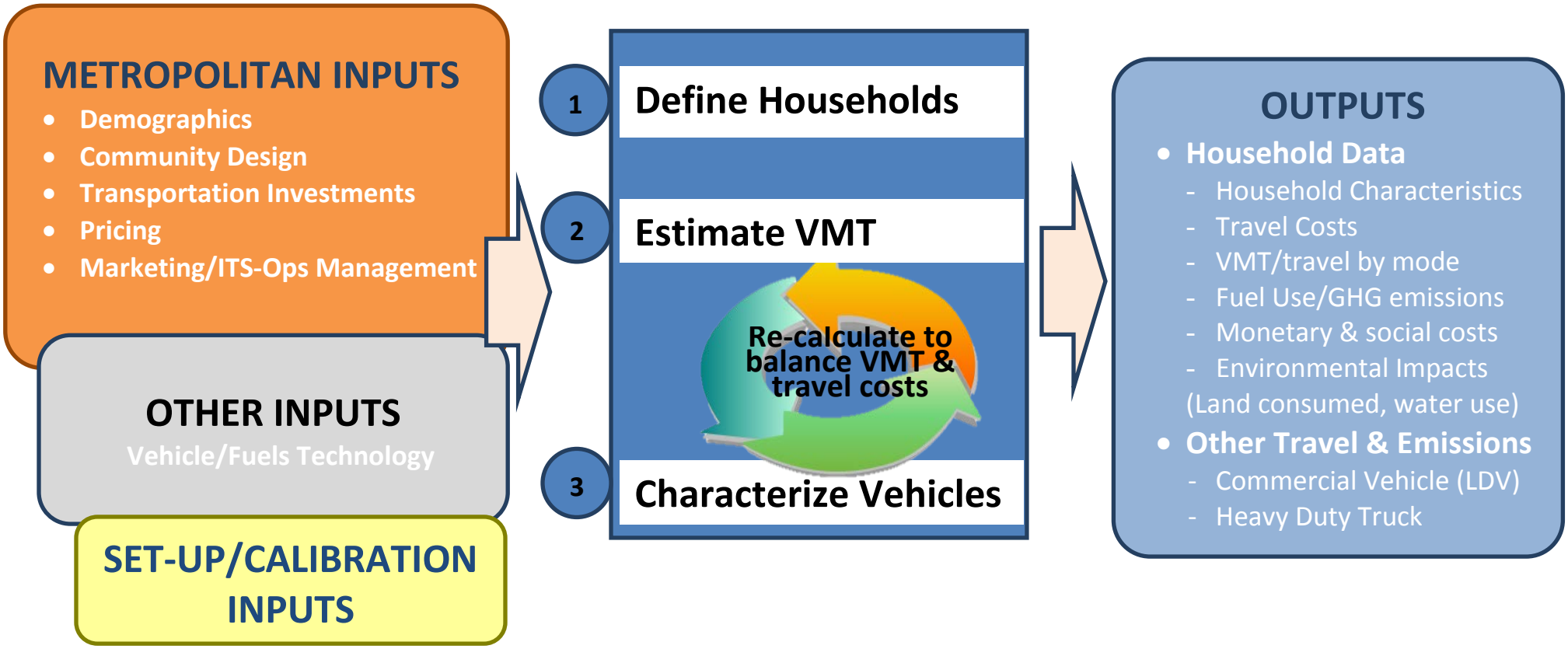
DRAFT Oregon Strategic Assessment – RSPM User's Guide

RSPM (**R**egional **S**trategic **P**lanning **M**odel)

January 2014



Purpose of User's Guide

The purpose of this guide is to inform metropolitan planning organizations (MPO) staff, local planners, and decision makers about the resources required to conduct a Strategic Assessment. More specifically, this guide:

1. Provides some background on the planning processes, State support available to metropolitan areas, and the Regional Strategic Planning Model (RSPM);
2. Identifies the key inputs, including datasets and key decisions needed to run the RSMP;
3. Explains the RSPM outputs and how to interpret these results; and
4. Includes more detailed technical information about the RSPM in the appendices.

By clarifying terminology, roles and responsibilities, resource requirements, and data needs, this guide provides the information needed for metropolitan areas to determine if they wish to conduct a Strategic Assessment.

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Background

The Regional Strategic Planning Model (RSPM) is a tool developed by ODOT to assist metropolitan areas and local governments in developing long range transportation and land use plans for their regions and communities. The RSPM helps Metropolitan areas and local governments who wish to:

- Evaluate the outcomes of their existing plans and various sensitivity testing through a **Strategic Assessment**, or
- Engage in **scenario planning** to evaluate a set of different future scenarios.

This User's Guide provides an outline for collecting the data and making key assumptions for the Strategic Assessment process. It also supports development of base and reference case scenarios for Scenario Planning.

Strategic Assessment

A Strategic Assessment provides metropolitan areas an opportunity to evaluate how their region's transportation system will perform in the future assuming that current plans are carried out and current trends continue. Although GHG emissions reduction is an important component of Strategic Assessments, it is not the only component and Strategic Assessments help to inform long-range planning. In addition, through sensitivity testing, a Strategic Assessment helps metropolitan areas understand how different aspects of the transportation system, land use, and other factors affect future performance. The future time horizon that is assessed includes 2035, in parallel to the greenhouse gas (GHG) reduction targets, but also extends beyond to 2050 to enable metropolitan areas to consider the potential consequences of longer range trends that have significant planning implications.

Sensitivity testing is done as part of a Strategic Assessment to evaluate how changes in policies and trends at the metropolitan and state levels could influence GHG emissions from light-duty vehicle travel in metropolitan areas, as well as other indicators. Sensitivity tests are 'what if' analyses to help planners understand what the relative effect of changes to policy, investments, and programs could be. Depending on the variables used, sensitivity testing allows metropolitan areas to determine how large an effect potential actions are likely to have on the results of the Strategic Assessment and scenario planning. Sensitivity testing can be used to evaluate a wide range of variables such as the impact of increasing downtown density, doubling transit service, or promoting eco-driving. To streamline the sensitivity testing process, ODOT staff identified seven key policy measures to test as part of the Strategic Assessment process. Please refer to the *Outputs: Interpreting Results* section of this User's Guide for a list of these measures.

A Strategic Assessment uses models and other analysis tools to allow metropolitan areas to ascertain the extent to which current policies and trends at the metropolitan and state levels will reduce GHG emissions and other regional goals and community visions. Information on travel and environmental trends that result from the assessment will include indicators such as GHG emissions, household transportation expenditures, and community health indicators, such as air quality.

Metropolitan areas can use the results of a Strategic Assessment to inform development of transportation plans and investment priorities. In addition, a Strategic Assessment can help the metropolitan area governments to develop a long-range vision for their region which addresses community goals and prepares the community for the future. It will also help the region to identify state-level actions that are important for enabling necessary reductions in GHG emissions from metropolitan area light-duty vehicle travel.

Strategic Assessments also help to implement the Oregon Statewide Transportation Strategy: A 2050 Vision for Greenhouse Gas Emissions Reduction (STS). The STS is a state-level scenario planning effort that examines all aspects of the transportation system, including the movement of people and goods, and identifies a combination of strategies to reduce GHG emissions. Through acceptance in March 2013, the Oregon

Transportation Commission agreed with the general course of action presented in the STS for reducing transportation related GHG emissions. For more information on the STS, please visit the STS Web site .

Scenario Planning

Scenario planning allows communities to explore the potential benefits of a variety of different land use and transportation related scenarios. Scenario planning encourages local policy makers, planners and stakeholders to consider a wider range of opportunities, challenges and possible futures than are typically considered in most traditional planning processes. Through the process of conceiving, developing and evaluating a series of future scenarios and the outcomes they produce, communities can obtain information for decision-making that combines real community values with choices and options for on the ground solutions.

Required per HB 2001 (2009), the Portland Metro and Central Lane MPOs are currently engaged in scenario planning. For other metropolitan areas, this process is voluntary. After the conclusion of a Strategic Assessment, some areas may decide to move forward with scenario planning.

State Support

To assist in these efforts, the Oregon Departments of Transportation (ODOT) and Land Conservation and Development (DLCD) provide support to metropolitan areas interested in engaging in Strategic Assessments and scenario planning. More specifically, through contracts negotiated by ODOT, metropolitan areas can request financial and technical assistance. The funding available can be used to cover MPO staff time associated with data collection, model assembly and calibration, as well as other costs associated with the Strategic Assessment or scenario planning process. Furthermore, DLCD staff provides assistance with data collection and reporting of results and ODOT staff provides modeling assistance and runs analyses, in addition to providing overall project management support.

RSPM Modeling Approach

The Regional Strategic Planning Model (RSPM), was developed by the Oregon Department of Transportation (ODOT) for the purpose of estimating and forecasting the effects of various policies and other influences on the amount of vehicle travel, the types of vehicles and fuels used, and the resulting greenhouse gas (GHG) emissions among other things. As the name indicates, the RSPM is a model which supports strategic planning processes, such as Strategic Assessments and scenario planning, at a regional level.

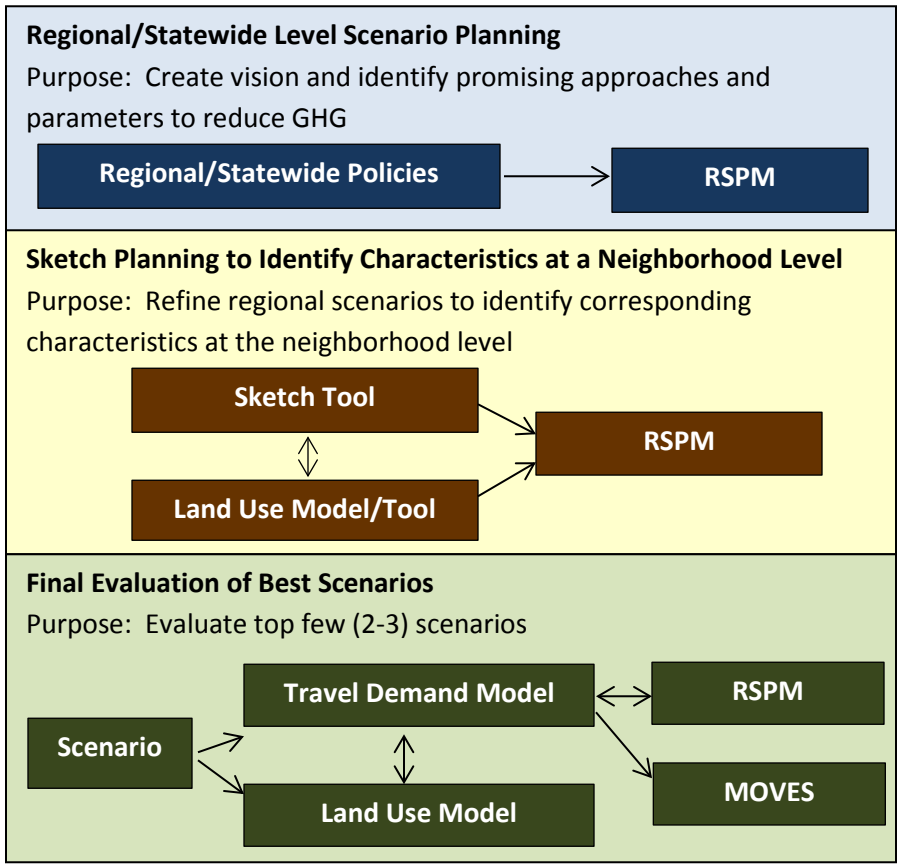
The RSPM[1] is a tool to help regions better assess the effects of fundamental shifts underway that will affect future travel (e.g., demographics and vehicle technology), as well as the impact of policy options (e.g., TDM programs, car sharing) not yet fully addressed in traditional travel models. The development of RSPM was reviewed extensively by state, national and international travel and emissions modeling experts in multiple venues.[2]

RSPM differs from the travel demand models that support planning in most urban areas. The RSPM operates at a strategic level and is less detailed but considers a wider range of potential policies and outcomes. Urban travel demand models, in constrast, are designed to model the effects of specific transportation projects or groups of projects on specific parts of the transportation system. They are also important in meeting air quality conformity regulations and detailed project studies. Figure 1 shows the interactions of Oregon's various modeling tools in GHG analysis and planning.

Figure 1. Examples of Interactions of Oregon Tools for GHG Analysis

[1] RSPM was formerly known as GreenSTEP. The name change reflects expanded capabilities for metropolitan area application while addressing a more general set of transportation and land use considerations in addition to greenhouse gas emissions.

[2] In 2010, the American Association of State Highway and Transportation Officials (AASHTO) awarded ODOT its 'Presidents Award for Planning' for the development of the GreenSTEP model. Evaluation at the national level lead to the Federal Highway Administration adopting GreenSTEP as the basis for their EERPAT[2] model



Since RSPM was developed to assess GHG emissions, its initial focus was on a household's total annual *vehicle* miles; Indicators for the use of other modes was secondary. This contrasts with the multi-modal trip-based focus of traditional travel demand models. Because of this, RSPM accounts for vehicle miles traveled (VMT) and emissions in a different manner. Whereas urban travel demand models forecast weekday average and peak period VMT on study area roadways based on trips, the RSPM forecasts total VMT (weekend as well as weekday) generated by study area households. Urban models thus capture congested peak periods which highly influence air quality pollutants. In contrast, GHG emissions are widely dispersed and have a cumulative effect more suited to the strategic level of detail in RSPM.

A final distinction between models is how the RSPM considers a more complete cost of travel. The total cost of travel to each household from gas prices, gas taxes, parking charges, etc. is calculated with an evaluation of whether the total cost exceeds an estimate of a household's total budget. If so, then the household's forecasted travel is reduced so that their budget is not exceeded. This is an important capability of the RSPM given future fuel prices increase and the effectiveness of pricing in managing transportation system demand. The interactions between vehicle fuel economy and prices are also modeled. For example, increasing fuel economy can result in more VMT (the rebound effect) because the same budget can buy more travel. These aspects are not currently accounted for in most urban travel models.

The models are complementary, with the RSPM supporting a discussion of a region's future, helping to identify a mix of policies that might meet the region's vision. An urban travel demand model can then be used to evaluate specific elements of this vision.

How the RSPM Works

The RSPM estimates vehicle ownership, vehicle travel, fuel consumption, and GHG emissions at the individual household level. This structure accounts for the synergistic and antagonistic effects of multiple policies and factors (e.g., gas prices) on vehicle travel and emissions. For example, the battery range of electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs) is less of an issue for households residing in compact mixed-use neighborhoods because those households tend to drive fewer miles each day. Modeling at the household level makes it possible to evaluate the relationships between travel, emissions and the characteristics of households, land use, transportation systems, vehicles, and other factors. In addition, household level analysis makes it possible to evaluate the equitability of the costs and benefits of different strategies.

Figure 2 shows a schematic of model calculation steps.[3] Each step is composed of a number of calculations that operate on the results of the previous step and on input data that reflect scenario assumptions. The nature of each calculation was determined through the statistical analysis of several data sources such as the National Household Travel Survey.

The process to balance the VMT with travel costs allows congestion and other costs introduced at this step to influence the amount of travel. This step recalculates household VMT, fuel and GHG in the balancing process.

The primary outputs of the RSPM are household travel, fuel and power consumption, and GHG emissions calculations. Similar information is produced for commercial (light duty) and freight (heavy duty) travel.

The RSPM operates at the household level using Census data and local inputs and decisions related to land use and transportation systems. It does not examine the interactions between different districts within the study area. This limits some of the analytical capabilities of the model, as discussed in more detail in Appendix 3.

Components of the RSPM were tested throughout the development process to check the reasonability of results and whether the model could replicate observed behavior and conditions. Sensitivity tests were also performed to check whether the sensitivity of the model is consistent with results reported by other studies.[4]

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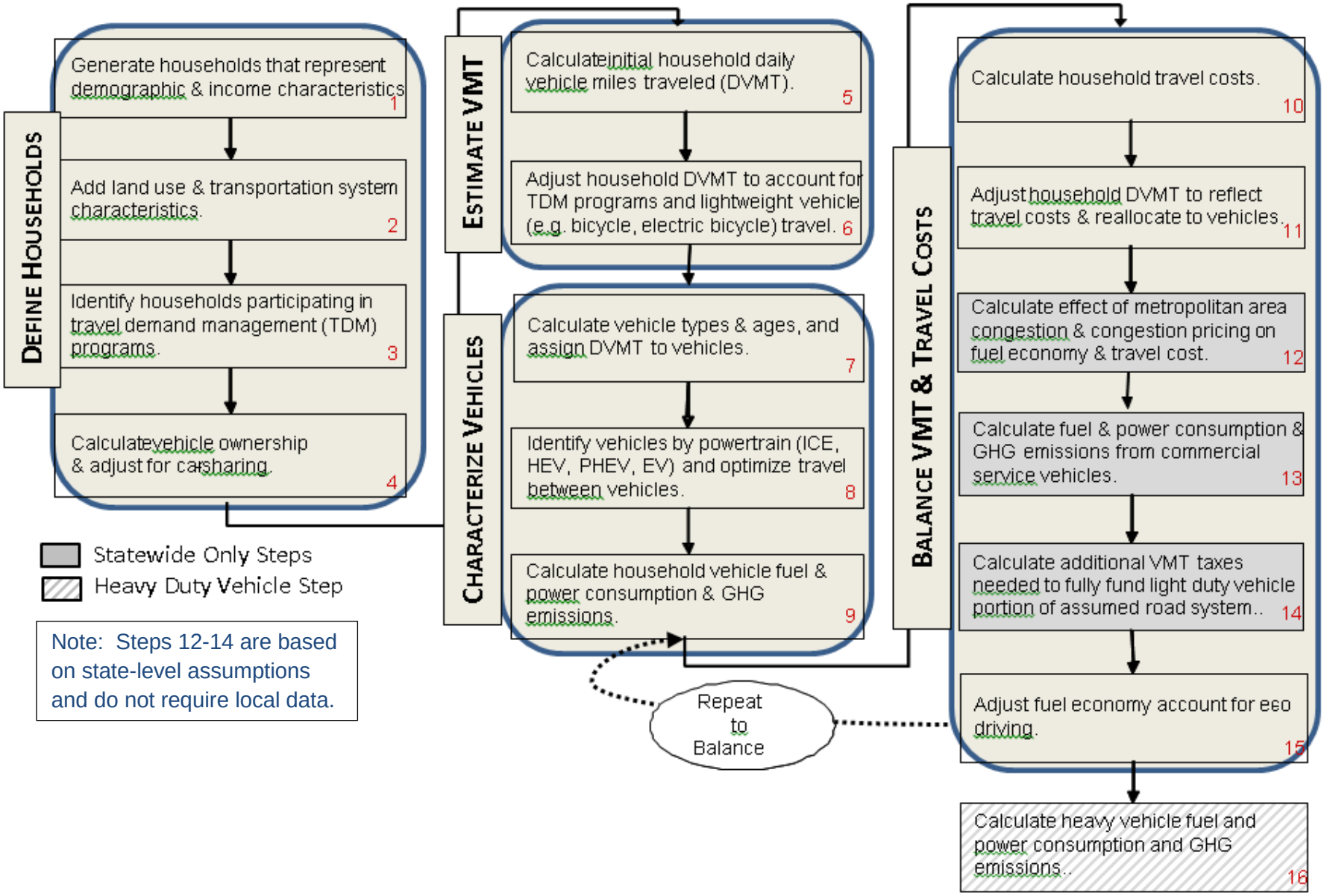
[3] The diagram shows the current structure of the RSPM model, reflecting changes over the course of the STS as well as Metro and CLMPO scenario planning.

[4] For example, the sensitivity of RSPM to changes in urban area population density and land use mix was compared to findings published in the Transportation Research Board TRB Special Report 298, *Driving and the Built Environment: Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions*. September 2009.

Figure 2 RSPM - Model Schematic



Inputs: Decisions & Data

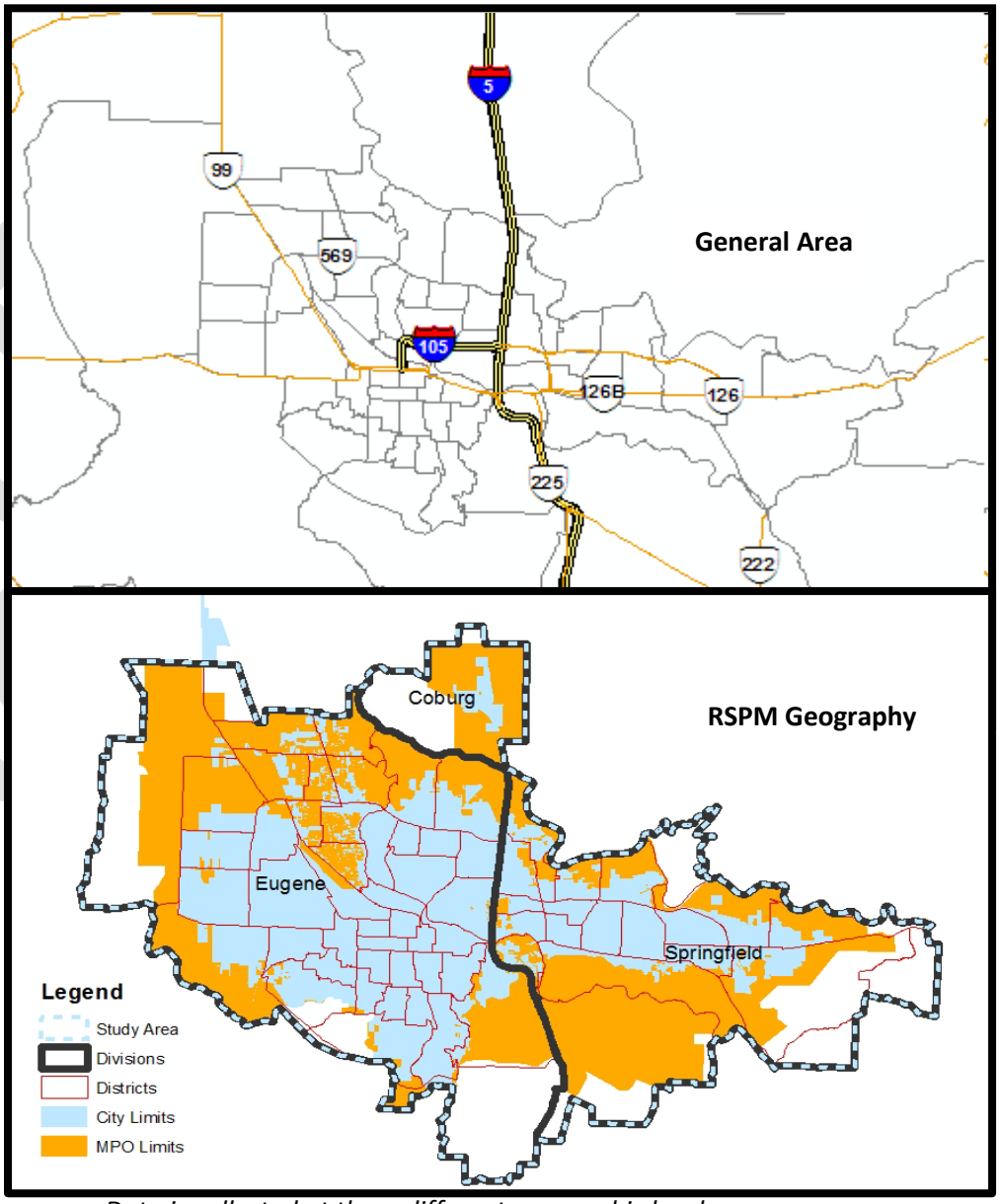
Each RSPM run requires a number of decisions and inputs from the local metropolitan area. The initial decision is to determine the model geography. Given this geography, inputs need to be developed to first calibrate the base year RSPM and identify future year assumptions. The geography and data needed for calibration are the most time critical and will allow the ODOT staff to begin setting up and calibrating the model. The remaining inputs and decisions are not required immediately, and can continue to be worked on while the model is being calibrated. The geography and inputs are described below with more detail in Appendix 2.

Step 1: Establish RSPM Geography

RSPM has three different geographic units at which different critical information must be collected to operate RSPM. The geographies are nested largely to align with US Census tracts for key data inputs and with existing MPO boundaries to allow for data outputs that address the GHG target rule. Figure 3 identifies the RSPM geography in Central Lane MPO.

- **Study Area -** Defines the extent of the area included in the model. It can be as small as the MPO boundary (used in the GHG target rule), or may add additional areas where the region might expand to accommodate growth by 2050. The area should break along Census boundaries. The inclusion of multiple, dispersed, urban areas is discouraged due to RSPM limitations in capturing intercity travel (see Appendix 5).
- **Divisions** - The study area may be partitioned into "divisions" which define large portions of the metropolitan area which have different land use and transportation policies or where differing policies may be applied in the future. Divisions should be relatively large (e.g. population greater than 50,000) and/or identify unique parts of the study area. Divisions were created to address the significantly different policy decisions in the Central Lane MPO (CLMPO) for Eugene, Springfield, and Coburg, beyond the

Figure 3. RSPM Nested Geography (CLMPO)



Data is collected at three different geographic levels.

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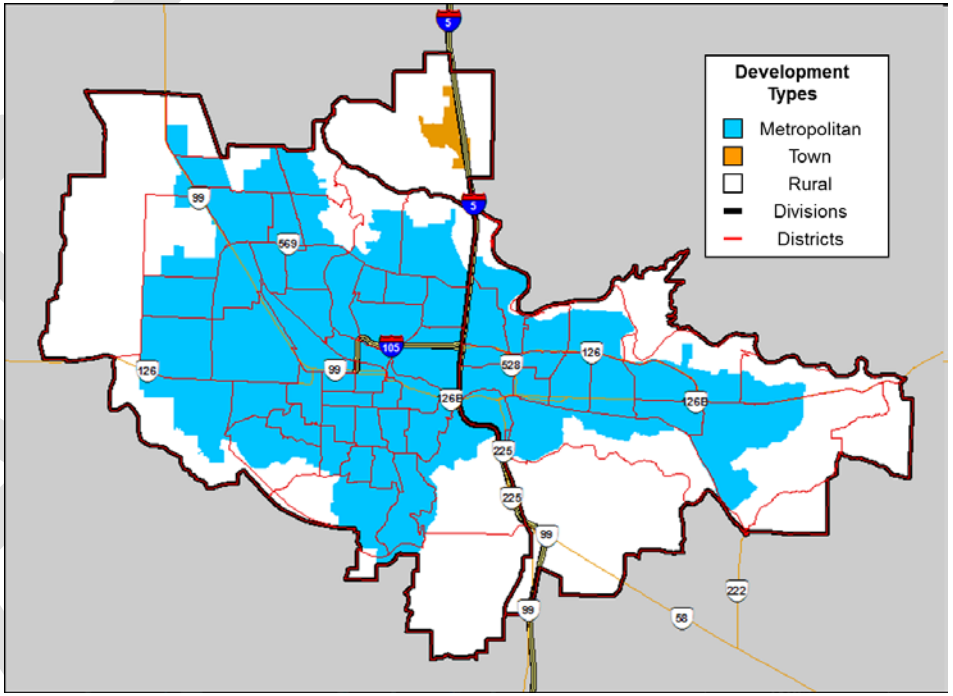
need to report results differently.

- **Districts** - The geographic unit used for assigning the projected households to a place. To align with the GHG target rule, districts should fall entirely inside or outside the MPO boundary. Additionally, some policies (e.g. bicycling goals and transportation demand management goals) are specified at the district level. Districts are ordinarily defined according to Census Tract boundaries (approximately 1,200 – 8,000 persons) to simplify input data collection and to match the geographic units used in model estimation. Deviations from census tracts may be allowed based on more detailed census data (block or block group). If splitting Census Tracts to conform to the MPO boundaries (or potential UGB expansion study areas) results in small acreages, it is desirable to combine them with adjacent districts for ease in analysis/reporting.

Within RSPM, land area is characterized by **development type**. A district generally contains a mix of types (see Figure 4 for CLMPO example). For modeling purposes, land area and dwelling units are defined by a combination of the district boundaries and the assigned development type. These determine the density important to many variables in the model including those that define how urban mixed use areas perform. Thus, a critical determination is to distinguish between currently urbanized and potentially urbanizable land. The development types include:

- **Metropolitan** –The most urban areas of the region, typically defined as all urbanized land within the urban growth boundary (UGB) of the MPO's primary city or contiguous cities. If large areas within the UGB are not urbanized, they should be classified as rural, to better reflect the actual density of the urbanized area.
- **Town** – Typically less dense but still urbanized areas within the study area that fall outside of the UGB of MPO's primary city or contiguous cities (e.g. small towns within the MPO).
- **Rural** – All non-urbanized, less dense lands within the study area. This development type can include lands inside and outside the UGB (and outside the MPO boundary if the study are is larger than the MPO). Rural lands can be assumed to convert to the urbanized development types in future years, reflecting anticipated development densities.

Figure 4. RSPM Development Types (CLMPO)



Geography is important in the RSPM and treated differently than in traditional urban travel models:

- RSPM predicts household travel based on the characteristics of the geographic area where a household resides including population density and housing type(s).
- Inputs can vary by geographic area and therefore can be tailored to represent the differing characteristics of an urban pattern. For example, the proportion of mixed-use development is likely to be higher in districts near the city core than in those in the urban fringe.

- By measuring land use details at the district level, RSPM captures the relationship of each household to the land use characteristics in the whole neighborhood around it (i.e., the influence area appropriate to inform travel behavier). Isolated density is not as effective as a full Census tract of higher activity concentrations and mixed uses.
- By altering the mix of development types within a district, the effects of different allocations of population around the metropolitan area can be assessed in RSPM. For example, modeling a scenario which allocates a larger proportion of households to lower density districts will produce higher VMT forecasts than modeling a scenario which allocates more households to higher density urban districts.

Step 2: Collect Input Data for Base Year and Reference Case Future Year

The following years will be modeled in the RSPM for Strategic Assessments.

- **2005** – back-cast to match the MPO GHG reduction target base year.
- **2010** Base Year – basis for data collection, calibration, and other runs.
- **2035** – the date associated with MPO GHG reduction targets and is near the RTP forecast date.
- **2050** – the date associated with statutory GHG reduction goals in the STS. The longer time frame enables consideration of more visionary changes that will take longer than the RTP time frame to occur.

The RSPM inputs can be grouped into two sequential parts, reflecting the timeline when the data is required:

- **Set-up/calibration inputs** - These include data based on the geography and the base and future year demographics and community design data used to establish the basic households, their location and attributes. This is needed early in the process to set-up the model framework, and
- **Other assumptions and inputs for the base and future year** reflecting existing conditions and adopted local plans respectively.

These inputs require a mix of data and decisions by the metropolitan area. Local inputs are combined with statewide assumptions provided by others.

Figure 5 provides a one-page summary of RSPM inputs, expanding the cover graphic. It summarizes the metropolitan inputs as well as those provided by others, with a quick guide on the geographic level at which data must be provided. Inputs specified as "DEFAULT" can be customized for local conditions, or can use statewide default estimates (e.g., STS values).

Appendix 1 is a detailed checklist table that outlines all of the inputs and decisions by the local metropolitan area required to operate the model. The checklist includes a line for each discrete data input or decision that is needed at the local level. The table also notes DEFAULT inputs where local data could override default values. The checklist provides MPO and local government staff and decision makers with information to estimate the local/regional level of effort required for a Strategic Assessment.

Appendix 2 provides more detail including sources and approaches for collecting input data. A **template set of input files** for the CLMPO RSPM is provided as a companion to the User's Guide (Attachment 1).

Step 3: Decide on Sensitivity Test Inputs

A key value of the Strategic Assessment is the ability of the metropolitan area to determine the relative effect of potential changes to the reference case on GHG emissions and the other evaluation measures. These include changes in local investments, programs, and/or policy direction. In order to streamline this process, the ODOT staff identified the following set of sensitivity tests. A recommended set will be customized for the local area, and reviewed with the MPO:

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The following sensitivity tests are planned for Strategic Assessments:

1. More compact and mixed **land use** patterns;
2. Increased **transit** service levels;
3. Increased shift of short-distance single-occupant vehicle (SOV); travel to bicycle, electric bicycle, and similar **light-weight vehicles**;
4. Expanding **parking pricing** programs (e.g. proportion of workers who pay for parking and/or employers implementing cash-out-buy-back programs);
5. Improving **driving efficiency** through eco-driving, ITS deployment, etc.;
6. Expanding **travel demand management** programs such as employee commute options and individualized marketing;
7. Further improvements of **vehicle technology, fleet and fuel** characteristics identified in the STS (e.g. higher levels of adoption of PHEV and EV); and,
8. Other **state-level changes** in pricing and other factors that influence vehicle travel and GHG emissions such as pay-as-you-drive (PAYD) insurance and user fees.

Each sensitivity test is represented by a small number of changes to reference case input files. Once the changes are made (e.g. changing the input regarding the proportion of households having pay-as-you-drive insurance) an automated procedure is used to create scenarios which combine the inputs into a variety of tests (e.g. increasing transit service and improving TDM). The results of all the combinations are then evaluated to show be potential changes that can occur by combining various programs.

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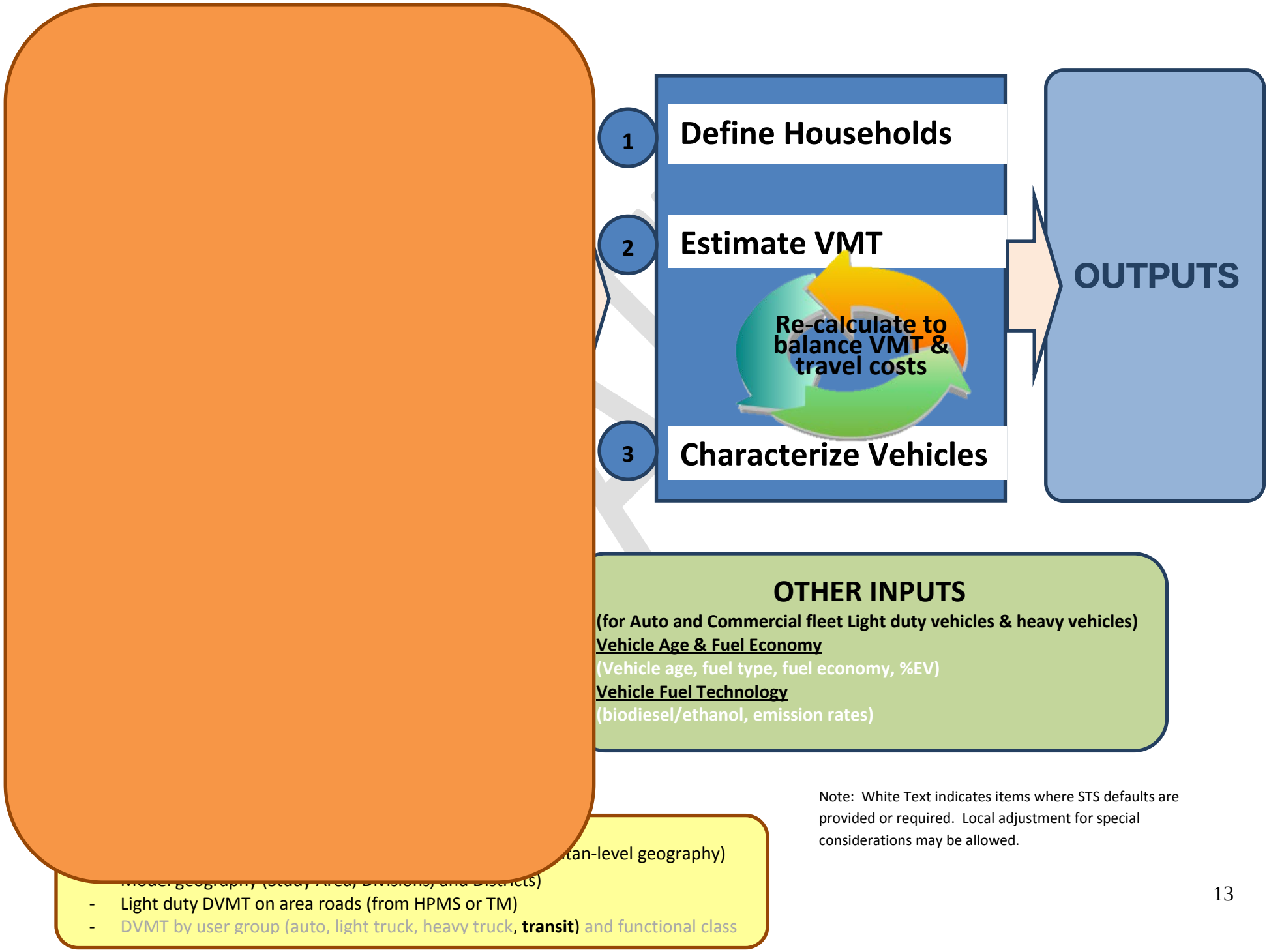
Figure 5. RSPM – Inputs Summary



Note: White Text indicates items where STS defaults are provided or required. Local adjustment for special considerations may be allowed.

Outputs: Interpreting Results

The RSPM has the capacity to calculate a number of evaluation measures and supplemental information that metropolitan areas and local jurisdictions can utilize to help inform future planning processes. This section provides information on the output measures available from the Strategic Assessment, sensitivity testing, and scenario planning processes:

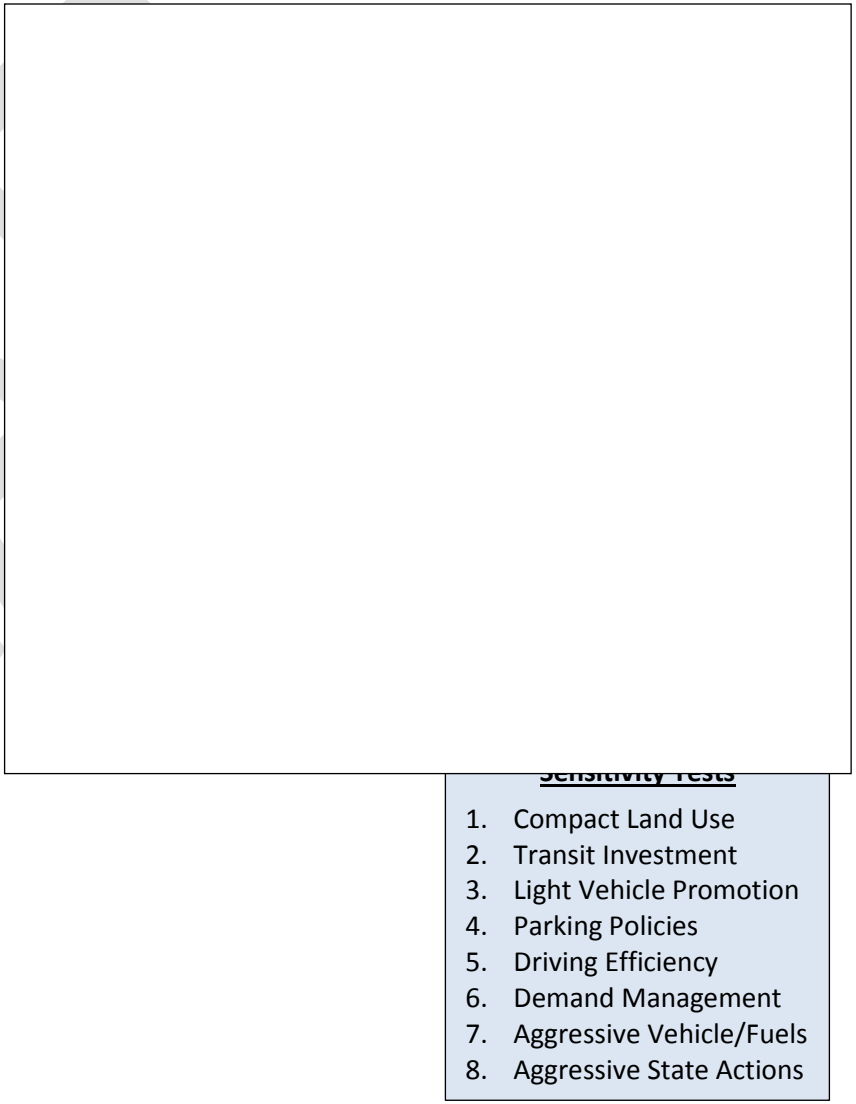
Strategic Assessment

A Strategic Assessment includes output measures for a base year (e.g., 2005 and 2010), a future reference case (e.g., 2035 and/or 2050) and sensitivity tests. The Strategic Assessment provides a relatively quick regional estimate of baseline travel and its environmental implications. In addition, the reference case shows what the future will look like if the status quo continues and what various changes to the status quo could accomplish.

After the completion of the model runs, the ODOT staff provides the metropolitan area with tables and graphs which show regional outputs for the base year, reference case, and sensitivity tests. Some outputs can also be shown at the geographic division and district levels. For a list of potential outputs see Figure 6.

Working in partnership with the metropolitan area, the ODOT and DLCD staff will interpret the results of the model outputs and determining how best to display results. Sample graphics produced for the STS Technical Appendices are included in Figure 7.

Figure 6. Output Data available with each RSPM Run



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From the output data (Figure 6), the Strategic Assessment allows ODOT staff to quantify the following trends and complete other analyses:

Travel Trends

- **VMT and VMT per capita**. Contributors to changes in VMT may include changes in income, demographics, fuel prices and other factors as well as land use and transportation factors.
- **Travel Delay**. Contributors to travel delay may include changes in auto VMT, light vehicles (including bikes) and walking, transit, and ITS.
- **Transit service** trends per capita.
- **Walk and bike trip miles.**
- First order **Infrastructure costs** attributable to passenger vehicle traffic.

Environmental Trends

- **Energy, Fuel, and GHG emissions**, and the contributors including VMT, forecast changes in vehicle technology, and in fuel type (including increased electric vehicle use). This can be discussed in the context of current local region vehicle mix and the impact of future federal CAFE standards and further state plans.
- **Land consumed** due to residential development.
- First order **Air quality** (criteria air pollutants, kg/day).

Other First Order Assessments:[5]

- **Household costs** – Travel costs can be compared by income group.
- **Intercity Travel** – Non- RSPM analysis will identify existing trends in the region regarding intercity commuting and shopping patterns, making use of the Census and state and local OHAS survey data (see Appendix 5 for more on Intercity travel).
- **Social Costs** per household (safety, pollution, energy security, etc.)

[5] These measures are of interest but either not fully captured in the urban version of the model (household budgets, social costs), or are outside of the model and represent only base year conditions (intercity travel).

Scenario Planning

Many other measures are possible by customizing scripts using the raw RSPM outputs. Due to the effort required to customize these measures, they are not intended for use in Strategic Assessments, but provide opportunities for additional performance measures in the larger scenario planning process. Therefore, building off of a Strategic Assessment, metropolitan areas may choose to engage in a scenario planning process.

Whereas the Strategic Assessment provides metropolitan areas with a glimpse of its future under status quo conditions, a scenario planning process will help local jurisdictions and MPOs arrive at a vision of what mix of investments and programs are required to best meet regional goals. Future RTP and TSP efforts can incorporate policies and objectives that complement this vision.

For more information please refer to **Appendix 4** and the Scenario Planning Guidelines.

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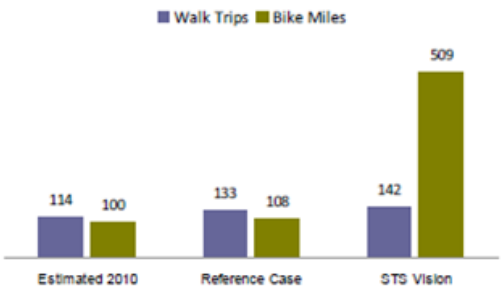
Figure 7. Example Measures from the Statewide Transportation Strategy Model Results
(http://www.oregon.gov/ODOT/TD/OSTI/docs/STS/STS_TechAppendices.pdf, Technical Appendix 1, p.65+)

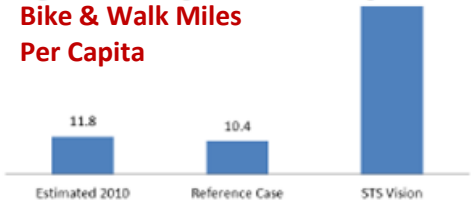
TRAVEL

Bike & Walk Miles



Average Annual Walk Trips and Bike Miles Per Capita

Bike & Walk Miles Per Capita



Average Metropolitan Per Capita Transit Service (annual revenue miles per

VMT

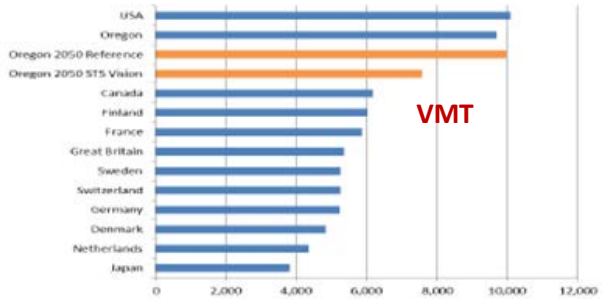
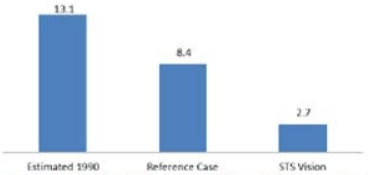


Figure 24. Comparison of 2050 Scenarios with 2005 for Oregon, U.S. And Selected Countries (Annual Total VMT Per Capita)

ENVIRONMENTAL

GHG Emissions



Annual Statewide Light Vehicle GHG Emissions (million metric tons)

Fuel Gallons

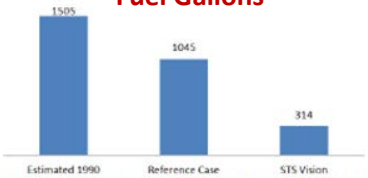
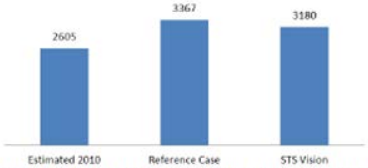


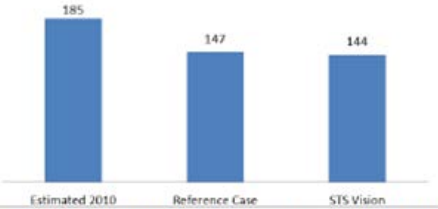
Figure 28. Annual Light Vehicle Fuel Consumption (million gasoline equivalent gallons)[20]

Land Consumed



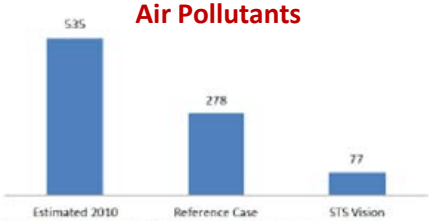
Urban and Rural Land Area Consumed By Development (square miles)

Water Consumed



Metropolitan Per Capita Residential Water Consumption (gallons)

Air Pollutants



Metropolitan Criteria Air Pollutants (kilograms per day)

OTHER

HH Travel Costs

Figure 30. Average Annual Household Out-Of-Pocket Costs for Owning and Operating Vehicles as a Percentage of Household Income

Travel Share of HH Budget

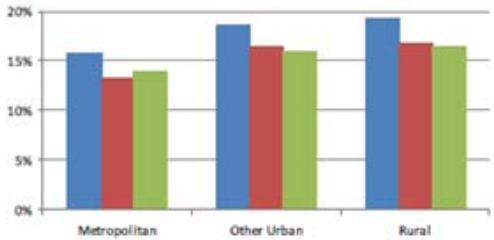


Figure 31. Average Annual Household Out-Of-Pocket Costs for Owning and Operating Vehicles by Type of Area as a Percentage of Household Income

Transportation Costs & Revenues

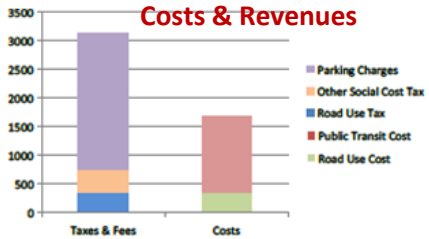
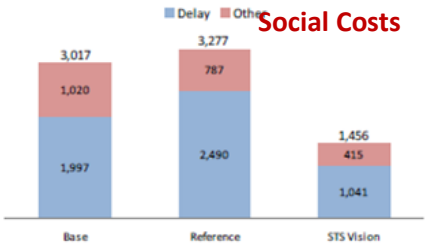


Figure 33. Partial Estimate of Transportation Revenues and Costs of STS Vision Calculated as an Annual Average Per Household (2005 dollars)

Social Costs



KEY:
***Responsibility:** 1 = Data Collection, 2 = Review, 3 = Decision, 4 = Compile for model

Italicized text denotes inputs with default values. Default values will be used unless MPO suggests alternative source.

For strategic assessments with no Divisions, input data requested at the Division dimension should be collected at the Study Area dimension.

Appendix 1. Metropolitan Data/Decision Checklist

Input Data	Units	Dimensions	2010 Source	2035 Source	Responsibility*			Considerations
Step 1/2A: Establish Geography					MPO	DLCD	ODOT	
Study Area	Acres	MPO Boundary (Typically)	MPO Maps	N/A	3	1,4	2	Limit intercity travel
Divisions	Acres	City UGB (Typically)	MPO and City Maps	N/A	3	1,4	2	Not required. Limit application to situations where substantially different policy approaches are expected
Districts	Acres	Census Tracts (Typically)	Census Maps; City Maps; Local Knowledge	N/A	3	1,4	2	Build from Census blocks to match MPO boundary with population of 1-8K each
Step 2A: Calibration Data					MPO	DLCD	ODOT	
2010 Light duty DVMT on study area roads	DVMT	Study Area	HPMS or Travel model input files	N/A-calibration only	--		1-3	Use travel model input files or remain consistent w/ RTP
DVMT by user class: - Transit	% DVMT by FC	Study Area	Transit Agency	N/A-calibration only	--	1,4	2	Important for congestion diversion to alternate routes
- Auto *- Light truck* *- Heavy truck*	*% DVMT by FC*	*Study Area*	*(MPO/County)*	N/A-calibration only				
Step 2A: Demographics					MPO	DLCD	ODOT	
Population in Households by Age	Persons	Division	Census	OR Office of Economic Analysis (County by age), County TSP (by jurisdiction)	1,2	1,4	2	Consistent w/ RTP; In future years assume base year age distributions by district
Group Quarters Pop by Age	Persons	Division	University Data by class	University Forecast	1,2	1,4	2	In future years assume base year age distributions
Group Quarters Autos Owned	Autos/person	Division	University Data/ survey (if available)	University guidance	2,3	1,4	2	In future years assume base year ownership
Households	Households	District	Census	N/A-calibration only	2	1,4	2	Consistent w/ RTP
Per Capita Household Income	Annual, 2005$	District	Census	N/A-calibration only	2	1,4	2	Not including group quarters population
Average Household Size	*Persons/Household*	Division	Census	*Default value only for 2035 input*	2	1,4	2	Not including group quarters population

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Input Data	Units	Dimensions	2010 Source	2035 Source	Responsibility*			Considerations
% 1-person Households	*% of Households*	Division	Census	*Default value only for 2035 input*	2	1,4	2	
Step 2A: Community Design					MPO	DLCD	ODOT	
Land Area by Development Type	Acres by dev type	District	Comp Plan, Census, Aerial photos	Comp Plan	1,2	1,4	2	
Dwelling Units by Development Type and Housing Type	# Units by dev and hsg type	District	Census/Comp Plan	Comp Plan	1,2	1,4	2	
% HHs living in Urban Mixed Use Areas	*% of HHs*	*District*	*(calculated by RSPM)*	*(Comp Plan)*				Estimate housing in mixed use districts for 2035
Step 2B: Transportation Investments					MPO	DLCD	ODOT	
Freeway + Arterial Lane Miles	Lane Miles	Study Area	RTP	RTP	1,2	1,4	2	
Transit Revenue Miles, excluding dial-a-ride, deadheading	Bus-equivalent Revenue Miles	Study Area	Transit Agency/RTP	Transit Agency/RTP	1,2	1,4	2	
Bike/Light Vehicle -Distance threshold	*miles*	*District*	*OHAS, local data*	*MPO (planned goal)*				Metro/CLMPO used 20 miles per OHAS
- % auto trips diverted to Bike	% of SOV trips diverted below distance threshold	District	OHAS, local data	MPO (planned goal)	3	1,4	2	Metro/CLMPO/STS range
Step 2B: Pricing					MPO	DLCD	ODOT	
Parking Inputs - Who pays?	% of workers % of non-worker trips	Division	MPO travel model input files	MPO travel model input files	3	1,4	2	Consistent w/ RTP
Parking rate	Study Area Ave $/day (long term daily rate)	Division	MPO travel model input files	MPO travel model input files	3	1,4	2	Consistent w/ RTP
% in cash-out-buy-back program	*% of workers*	*Division*	*MPO*	*MPO (planned goal)*				Metro/LCOG used 0%
PAYD Insurance	*% HHs using*	*Study Area*	*(MPO or STS default)*	*(MPO or STS default)*				Metro/CLMPO used 0% in base year
Local Gas tax	*$/gallon, 2005$*	*Study Area*	*(MPO or STS default)*	*(MPO or STS default)*				
Step 2B: Marketing/ITS-Ops Management					MPO	DLCD	ODOT	
Workplace TDM Programs	% of HHs engaged in program	District	(MPO or STS default)	MPO (planned goal)	3	1,4	2	Metro/CLMPO/STS range
Individualized Mktg Program	% of HHs engaged in program	District	(MPO or STS default)	MPO (planned goal)	3	1,4	2	Metro/CLMPO/STS range
Car Sharing Deployment	High & Med density pop per vehicle	Division	(MPO or STS default)	MPO (planned goal)	3	1,4	2	Metro/CLMPO/STS range
ITS Degree of Deployment - Freeways-Ramp & Incident - Arterial -Signal & Access	% Deployment level (100% max)	Study Area	(MPO or STS default)	MPO (planned goal)	1-3	1,4	2	Metro/CLMPO/STS range
Eco-Driving Practices	*% of HHs in pgm*	*Study Area*	*(MPO or STS default)*	*(MPO or STS default)*				Metro/CLMPO used STS
Low Rolling Resistance Tires	*% of HHs use*	*Study Area*	*(MPO or STS default)*	*(MPO or STS default)*				Metro/CLMPO used STS
Vehicle Use Optimization	*% optimizer HHs*	*Study Area*	*(MPO or STS default)*	*(MPO or STS default)*				Metro/CLMPO used STS
Step 2B: Vehicle / Fuels Technology					MPO	DLCD	ODOT	
Transit fuel mix	*% of fuel used by type*	*Study Area*	*(Transit Agency or STS default)*	*(Transit Agency or STS default)*				

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Input Data	Units	Dimensions	2010 Source	2035 Source	Responsibility*			Considerations
Transit % electric	*% Bus-equivalent Revenue Miles*	*Study Area*	*(Transit Agency or STS default)*	*(Transit Agency or STS default)*				
Truck share of personal autos	*% of personal autos*	*Division*	*(MPO/DMV data)*	*(MPO/DMV data)*				
Electricity emissions rate	*Co2e lbs /kwhr*	*District*	*(Utility or STS default)*	*(Utility or STS default)*				

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Appendix 2. RSPM Input Details

This appendix provides more detail on the inputs used in the RSPM grouped by major topic area. The focus is on those inputs that must be provided and customized for the local area. In some cases inputs are noted as "default", indicating that default values are available from the STS work, although local adjustment in special cases is an option. In introducing each group of inputs, a table is provided listing the specific RSPM filenames with a short description of their contents, as well as the "geography" or spatial level of detail.

All of the model data, program code, input data and output data for a RSPM model run (i.e. running a scenario for multiple years) is stored in one folder that the user can name whatever they like (e.g. "Reference_Case"). This folder must contain the following folders and files in the structure noted below. Attachment 1 provides an example set of input files in this format from the CLMPO RSPM model set-up.

Figure 8. RSPM Folder Structure

```
Reference_Case (user named)
      model
        du_forecasts
        land_forecasts
        pop_forecasts
      scenarios
        base
            inputs
            outputs (created when run)
        scen1(user named)
            inputs
            outputs (created when run)
      scripts
```

The ***model* folder** contains all of the model files that make up the calibrated RSPM. Set-up/calibration input files are in the root of this folder, which are used to establish the base and future year reference files used to run all scenarios. These include information about assumed land use including mixed use (***land forecasts*** subfolder); dwelling units by type (***du_forecast*** subfolder); and household and group quarters population and income assumptions (***pop_forecasts*** subfolder). There is typically one file for each year of each data type, with data specified by district and other relevant classification types. The contents of this ***model*** folder will not change under most transport-based scenarios.

The ***Scenario* folder** contains the inputs and outputs of all the policy scenarios that are modeled, with a sub-folder for each scenario. Before starting a RSPM model run, the file in the scenario's ***inputs*** folder must be complete, along with the base files in the three ***model*** sub-folders. During the model run, a scenario ***outputs*** folder is created with a subfolder for each model year (e.g. "YearXXXX" where "XXXX" is a 4-digit year).

Inputs Step 1: Establish Geography

In setup, the user must specify the following 3-levels of nested geography (see Figure 3 above), following census as well as MPO and/or city boundaries:

- **Study Area** – Typically the group of census blocks that make up the metropolitan urban growth boundary. If including more than the MPO, intercity travel should be limited (see Appendix 5 FAQ).
- **Divisions** – Not required. Limit application to situations where substantially different policy approaches are expected. If used, the study area may be partitioned into "divisions" with relatively large (e.g. population greater than 50,000).
- **Districts** - Assemble study area census blocks with approximately 1,200-8,000 person each (consistent with census tracts used in model estimation).[6,7] Retain Census Tract boundaries, if possible to simplify input data collection

[6] "Geographic Terms and Concepts – Census Tract", http://www.census.gov/geo/reference/gtc/gtc_ct.html

[7] In RSPM input files, districts should be named as follows XXXSSCCBBBBx, where XXX=3-letter district code, followed by the Census FIPS code where SS=state, CC=county, BBBB=Block group codes. An 'x' can be added to the strict name to indicate that the census tract has been modified significantly (e.g., is not fully within the study area).

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Land in each district is inventoried (in acres) as one the following **development types** (see Figure 4 above). The key consideration is to separate developed from undeveloped land to avoid diluting resulting population density calculations:

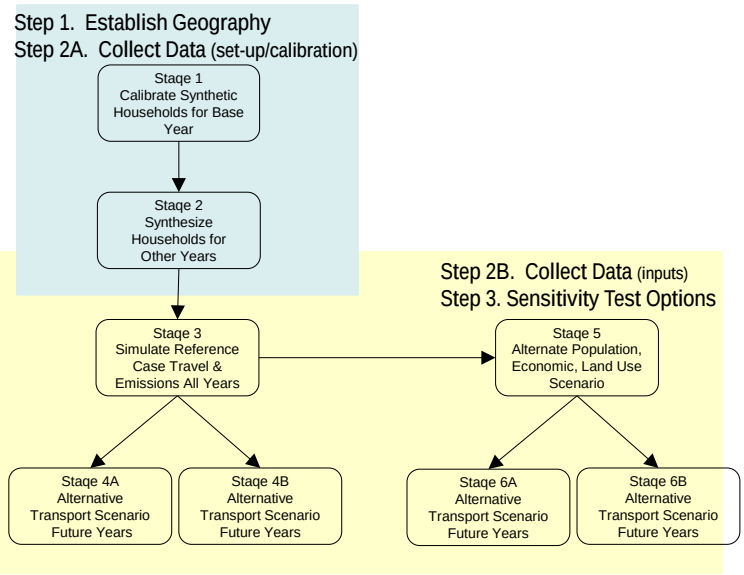
- The "**metropolitan**" development type includes built-up, urbanized areas located within the primary city in the MPO. This is often best approximated by the city limits.
- The "**town**" development type, is similar to the Metropolitan type, but outside the primary city (e.g. satellite communities).
- The "**rural**" development type includes all remaining lands. These less developed lands located outside, often located outside of urban growth boundaries, ranging from resource lands to undeveloped urban land.

Source: Because these decisions vary by Metropolitan region, ODOT/DLCD staff will develop a proposed geography for local review and approval. Key sources are Aerial maps with Census (Tract, Block Group, Block) boundaries, MPO, City and Urban Growth Boundaries.

Inputs Step 2A: Collect Input Data - Setup/Calibration

As shown in Figure 9, RSPM involves an initial setup and calibration of the base year households (Stage 1) followed by setup of future year households (Stage 2). These steps establish and locate the households in the region's various districts. This household synthesis process, which essentially fabricates a complete set of the region's households with a rich set of attributes, is commonly used in modeling to represent the aggregate characteristics of a population as well as the diversity of individual mix of household characteristics that are present in a population. After this, the model is run to estimate travel in base and future reference years (Stage 3). These setup steps form the basis for alternative scenarios (Stage 4).). The alternative scenarios can be developed through an automated sensitivity testing approach (described above) or through a more participatory approach where group consensus is pursued on all aspects of a scenario. Occasionally a new set up is required if the alternative scenarios anticipates changes in the base population (Stages 6-7). Strategic Assessments are intended to only exercise Stages 1-3 and Stage 4 sensitivity testing. Sensitivity testing and Scenario Planning will exercise Stage 4 with more deliberative scenario building and possibly Stages 5-6.

Figure 9. RSPM Setup Process



Introduction for Setup/Calibration Inputs

The initial stages of the RSPM (Stages 1- 2 in Figure 9) populate the study area's districts with synthetic households, essentially constructing a full set of the region's households with a rich set of attributes. Once this set of households is built and located for the base and future years, it will not be altered in most alternative future scenarios.[8] Thus typically, only the following demographic and community design input files are needed for a model run after the setup/calibration stage.

[8] In select cases, it is possible for the user to create an alternate set of households (Stages 5-6 in Figure 9) such as a sensitivity test that wants to test the effect of more compact allocation of the forecast regional population.

- age-specific population data by year (pop_forecasts/***pop_by_age_yyyy.csv***, ***group_pop_by_age_yyyy.csv***)
- calibrated income files (**calibrated_income_proportions.csv, calibrated_income_weights.csv)** are created during setup and used to modify the following model inputs: ***regional_inc_prop.csv***, ***income_weights.csv***).

The following Demographic & Community Design inputs have default values, which can be changed if conditions have changed significantly from the levels generated by RSPM during calibration (e.g., future greenfield development):

- future ratio to state income by division (***regional_inc_prop.csv***),
- future mixed use areas (*metropolitan_urban_type_proportions.csv*)
- alternative dwelling unit forecast, representing an alternate land use pattern (***du_yyyy.csv***)
- significant development alters average income by district (***income_weights.csv***)

Using RSPM as a Land Use Tool

The RSPM can be used to help a region develop zonal household allocations for use in RSPM or urban travel models. After base year calibration, the user can simply specify metro-level population forecasts and district-level dwelling units, along with aggregate regional attributes (i.e., average income, household size). The RSPM will create a set of synthetic households, assign a dwelling unit type to each, and locate each household in the various districts based on the supply of housing by type in each district and calibrated income attractiveness factor.

Table 1. Set-up/Calibration Inputs

Input File	Geography	Description
district_groups.csv	model	Correspondence table between districts, divisions, and full metropolitan study area
global_values.txt	model	Various model parameters
calibrated_income_proportions.csv	Division	Calibrated average income relative to state average income (used to develop /regional_inc_prop.csv)
calibrated_income_weights.csv	district	Calibrated income weights by district and development type (used to develop /land forecasts/income_weights.csv)
land_forecasts/income_weights.csv	district	Weights identifying the relative desirability of districts by development type (from calibration, revisit in future year scenarios ; requires Household Dataset Update)
hh_dvmt_to_road_dvmt.csv	metropolitan	Base year ratio of DVMT of households residing in metropolitan area (from RSPM) to light-duty vehicle DVMT on roads located within metropolitan area (from HPMS or Travel Model DVMT)
mpo_base_dvmt_parm.csv	metropolitan	Base year values for light duty vehicle road DVMT - proportion of DVMT that is trucks, and proportion of light duty vehicle DVMT on freeways and arterials
truck_bus_fc_dvmt_split.csv	metropolitan	Proportional split of truck DVMT and bus DVMT by functional class

Note: All Monetary units are reported in 2005 dollars; Light Gray entries are optional, dark Gray are typically default values provided by others.

Calibration inputs are used in the base year setup (Stage 1 of Figure 9) not in actual model runs. They are primarily needed for two purposes both a check against observed travel in the base year. The first is to bridge the gap between the measures output by RSPM and the legislative GHG targets, as discussed in Appendix 4. Additionally other local inputs are required to understand the mix of vehicle types using each type of functional class, useful in understanding possible shifting to other functional classes if congestion fees are imposed. All these values are metropolitan-wide. In some cases, STS default values may be used if local data is not available. Two files specify geography (***district_groups.csv***) and global assumptions used in the model (***global_values.txt***).

Calibration Data - Light duty DVMT on area roads

RSPM generates estimates for household travel, while the state GHG targets cover light-duty travel on area roadways. A factor is developed in the base year to convert from one to the other (***hh_dvmt_to_road_dvmt.csv***). The factor does not change household VMT outputs in RSPM, but is used in the congestion sub-model and most importantly the RSPM post-processing scripts that calculate emissions from light duty vehicle travel on metropolitan area roads that is consistent with the target VMT. (see Appendix 5 for more information on this factor)

> *Source: The numerator "target" consistent DVMT (**hh_dvmt_to_road_dvmt.csv**) can be found from HPMS submittals or an urban travel demand model, trying to match as close as possible the geographic coverage to the RSPM metropolitan study area. State defaults are available to remove Heavy Duty Vehicle share, as needed.*

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Calibration Data - Proportions of VMT by type by Functional Class

To adequately model congestion in the model as well as shifts in routing caused by congestion pricing, RPMS requires input on the proportion of VMT by functional class for various user types (heavy truck, auto, light truck, and transit). These inputs provide the base year allocation of each user type by roadway functional class (***mpo_base_dvmt_parm.csv, truck_bus_fc_dvmt_split.csv***). The three functional classes are freeway, arterial, and other. Most of these inputs borrow the statewide averages from the STS. However, it is useful to get local information on transit mileage in particular.

> *Source: The transit DVMT by roadway functional class (part of **truck_bus_fc_dvmt_split.csv**) can be estimated by looking at the transit routes graphically, assigning a functional class to each road segment traversed, and estimating from the frequency the number of revenue-miles on each link type. The road usage inputs for the other user types can use STS default, if no local data is available.*

Calibration Data – Global Values.txt

This file defines various global values for the model that are not defined elsewhere.

- Specifies the base year for analysis (typically 2010)
- Specifies base year annual VMT for the full metropolitan area (light truck and heavy truck)
- Truck VMT growth multiplier
- VMT Conversion factors (daily to annual VMT, commercial service VMT from household VMT)
- Budget parameters (budget proportion, base travel cost per mile, Value of Time, multiplier for cost difference to determine effect on household income, multiplier to adjust for non-discretionary/tax share of gross HH income)
- Other parameters and conversions (US to metric conversion, energy content Mega joules per gallon, Lambda values for metropolitan areas, transit revenue miles to vehicle miles that accounts for deadheading)

> *Source: These are model parameters that should not change after calibration.*

Inputs Step 2B: Collect Input Data - Scenario Inputs

Demographics

Table 2. Demographic Inputs

Input File	Geography	Description
Set-up/Calibration		
base_hh_pop_inc.csv	District	Base year population (in households and group quarters), number of households, and per capita income (income does not include group quarters population)
group_hh_income.csv	Division	Average income of persons in group quarters by age category and year (2005 dollars)
group_auto_ownership.csv	Division,	Group quarters auto ownership rate by person age
pop_targets.csv	Division	Targets for average household size and proportion of 1-person households and year
per_cap_inc.csv	statewide	Statewide average per capita income in constant (2005) dollars by analysis year
Scenario Inputs (post-Set-up/Calibration)		
pop_forecasts/pop_by_age_yyyy.csv	Division	Population by age group for each year
pop_forecasts/group_pop_by_age_yyyy.csv	Division	Group quarters population by age group for each year
pop_targets.csv	Division	Targets for average household size and proportion of 1-person households and year
regional_inc_prop.csv	Division	Ratio of average per capita income in metropolitan division to statewide average per capita income (from calibration, revisit in future year scenarios)

Group Quarters: defined here as persons in university supplied housing
Age Groups: Age0to14, Age15to19, Age20to29, Age30to54, Age55to64, Age65Plus
Note: All Monetary units are reported in 2005 dollars; Light Gray entries are optional, dark Gray are typically default values provided by others.

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Population in Households

Forecasts of population in households by age are primary inputs to RSPM. The forecasts are transformed into a set of household records where each household is defined by the number of persons in each of six age categories in the household (0 – 14, 15 – 19, 20 – 29, 30 – 54, 55 – 64, 65+). In model setup for the base year, population by age control totals by district is needed (***base_hh_pop_inc.csv***), exclusive of persons living in group quarters. In future years only division-level numbers of households by age are needed (***pop_by_age_yyyy.csv***)

*Source: Base year totals of households and associated population (**base_hh_pop_inc.csv**) can be obtained from Census (block or block group data). Future year forecasts (**pop_by_age_yyyy.csv**) should be consistent with but may need to be extrapolated beyond adopted regional plans (e.g., RTP, County and City TSPs). County-level age distributions from the Oregon Office of Economic Analysis (OEA) long range county population forecasts can be applied to base year district level population totals, if sub-county age information is not available. Some local governments may have detailed age information generated as part of a Housing Needs Analysis completed for the Periodic Review of the local Comprehensive Plan. If not, future population by age can apply ratios from the base year model set-up.*

Assumptions: Decide and document your rational and source for selecting a future year population and age forecast.

Group Quarters Data (Population by age, Autos Owned)

Group quarters population is included alongside the population of those in households (***base_hh_pop_inc.csv***). Base and future year group quarters population are strictly defined in RSPM as university provided housing. Additionally, average income (***group_hh_income.csv,*** in 2005$) and auto ownership (***group_auto_ownership.csv***) both by age group is required for the group quarters population by division.

*Source: Group quarters population data is best obtained from the university administration, by age if possible (**group_pop_by_age_yyyy.csv**). Group quarters can be approximated from enrollment data by class year. All other group quarters data (autos owned and income) are difficult to obtain but not of paramount importance to the model, simplifying assumptions are often required (e.g., In CLMPO, income is assumed constant at $10,000 per capita and auto ownership at XX)* CLMPO Source

Assumptions: Decide and document your rational and source for determining group quarter population, group quarter income, and group quarter auto ownership.

Household Size

Average household size and share of households that have a household size of 1 is needed by division for model setup and calibration (***pop_targets.csv***). The 1-person household is typically found near college campuses. It is also helpful to have the base year household size at the more detailed district level.

*Source: These household size values (**pop_targets.csv**) can be obtained from the 2010 Census block group data and aggregated into divisions (or districts). HH size should be consistent with the values used in the regional urban travel demand model and assumptions in the local Comprehensive Plan. These two data inputs can be assumed constant in the future, if no other local data is available.*

Assumptions: Decide and document your rational and source for changing the average HH size for 2035.

Per Capita Household Income

For RSPM calibration of the base year, household per capita average income is needed by district (***base_hh_pop_inc.csv***). At the more aggregate division level income RSPM uses the relationship between local income and average statewide income. In base year calibration, the ratio of per capita household income in each Division to the state average income is

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automatically calculated. This can be adjusted by the user for future years if relative incomes are expected to change (***regional_inc_proportions.csv, per_cap_inc.csv)***. This is an optional adjustment to calibrated defaults.

*Source: District-level per capita income can be obtained from Census Block Group Data. If a district includes multiple block groups, the income should be a weighted average based on the number of households in each. Since the model accounts for inflation, future income can remain the same in future years, or adjusted based on local plans. Consumer Price Index (CPI) values (file??.pdf) provide indices to convert data from other years into 2005$. Regional income relative to the state (**regional_inc_proportions.csv**) can assumed STS defaults, unless a change is expected in the future.*

Assumptions: Decide and document your rational and source for making an optional adjustment for future per capita income.

Process for Developing Geography & Demographic Data used in Model Set-up/Calibration:
To ensure consistency during set-up/calibration of the base and future year inputs, a process has been developed to build a single file of census block and block-group data that is rolled up to develop RSPM district-level input files. This census file contains the following fields, as well as calculations and notes used in deriving these required RSPM input fields.
Fields: TotHh, TotPop by age group, HhSize, 1personHH, PerCapInc, GroupPop by age group, A24, A5P, MH, SFA, SFD, GQ [repeat land use types for each division].
Other helpful fields: HHinc, HHpop, OccRate[by land use type], OccDU [by land use type]
Used in these RSPM input files: base_hh_pop_inc.csv, pop_targets.csv, du_yyyy.csv, land_supply.csv

Community Design

Table 3. Community Design Inputs

Input File	Geography	Description
Set-up/Calibration		
du_forecasts/du_yyyy.csv	district	Number of housing units by district, development type and housing type
land_forecasts/land_supply.csv	district	Land area (square miles) by district and development type
Scenario Inputs (post-Set-up/Calibration)		
land_forecasts/ metropolitan_urban_type_proportions.csv	district	proportion of households in urban mixed-use neighborhoods by analysis year (NA means allow model to calculate)

Development Type: Metropolitan, Town, Rural
Housing Type: A24 - Includes apartments 2-4 units, mostly duplexes, triplexes and quadplexes. A5P - Apartments with 5 plus units. MH - Mobile Homes and Manufactured Homes. SFA - Single family Attached includes condos. SFD- Single family detached homes. GQ - Group Quarters includes student dorms and fraternities/sororities

Land Area (acres)

In RSPM several land use characteristics must be predicted for households in order to estimate household vehicle ownership and vehicle travel. These include the **development type** of area where the household resides (metropolitan, town, rural), the population density (persons per square mile), and the **urban form** characteristics (urban mixed-use vs. other) for the district where the household resides. (see Step 1 Establishing Geography above)

*Source: Land supply is input for each year (**land_forecasts/land_supply.csv**) for each combination of district and development type. When developing the study area that matches MPO boundary from census block data, each block can be assigned a development type. These blocks can be rolled-up to establish a base year inventory for each district in acres. In future years, the total acres within the district are held constant, but the portion of each development type can change, shifting from lower density rural and town to higher density urban types.*

Assumptions: Decide and document your rational and source for any adjustments made for the future development type assigned to a division.

*Dwelling Units*Error! Bookmark not defined.

The inventory of dwelling units by district is used to calculate the overall supply of dwelling units for the study area. A submodel of the RSPM allocates households to dwelling unit types based on the characteristics of each household and the supply of available housing. After households are assigned a dwelling type, they are then assigned to a district based on the supply of housing by type in that district, and a calibrated district weight, which is a surrogate for relative attractiveness of the district for higher income households (i.e. the relative price of housing in the district). This process enables simultaneous balancing on dimensions of income, age, household size, and location producing household density assignments that are reflective of housing type preferences. Thus, higher-income smaller households will tend to predominate in single family homes in low density neighborhoods, while smaller, lower-income households will tend to predominate in multi-family housing in higher density neighborhoods.

The key user input to this process is the overall mix of housing types for each district. For base and future years during model setup, the user must provide counts of dwelling units by type in each district, split among land development types (***du_forecasts/du_yyyy.csv***). This is used with income and calibrated district weights to allocate households to housing types in each district and then calculate likely neighborhood densities that reflect the housing type mix and the overall population density. RSPM requires that the sum of dwelling units across all districts, sum to at least the number of households across all districts (calculated by RSPM from population inputs, in file **XXX.csv**). If there is a surplus of housing, the model will tend to use the more desirable single family homes first. Thus, it may be necessary to apply occupancy factors to the dwelling unit totals so lower income areas are allocated sufficient population in the model.

> *Source: The base year district level dwelling unit data (**du_forecasts/du_yyyy.csv**) can be assumed to match the base year household counts from 2010 Census data (stratified by RSPM housing types) developed with RSPM demographic inputs. Future year dwelling units can be obtained from local Comprehensive Plans. Adjustments may be needed to count only occupied units. District occupancy rates can be obtained from Census block group data, as a starting point. Base and future year dwelling unit counts should be consistent with household assumptions in the region's travel demand model.*
>
> *Assumptions: Decide and document your rational and source for any adjustments that you make related to dwelling unit type or occupancy rates.*

Mixed Use Areas

The urban mixed use classification is useful for capturing land use effects in the RSPM vehicle ownership and vehicle travel models that are not captured by population density alone. The urban classification used here is closely related to the older, more central portions of metropolitan areas[9]. These areas typically have more neighborhood-level mixing of different land uses, a grid-based street system with greater connectivity, greater pedestrian accessibility and sidewalk orientation of land uses, and greater transit accessibility. The variable measures the relationship of the district/census tract to the density of the nearest population center. It also has a relationship to the destination accessibility of the area. As such, this urban classification represent several land use characteristics on the so called '5Ds'list for successful compact multi-modal mixed use areas, which have been shown to reduce vehicular travel.[10]

Households in metropolitan areas are designated as being in an urban mixed-use community/neighborhood or not, based on district/census tract density (recommended in the base year) or metropolitan decision for urban mixed-use

[9] Brian to provide documentation on Claritas/NHTS community type variable definitions and/or put in GreenSTEP Technical documentation, including assessment of how well definition fit with Portland Metro Mixed Use areas.

[10] *Density, Diversity, Design, Destination accessibility, Distance to transit* per Transportation Research Board (TRB) Special Report 298.

development (in future years, if adjustments to the base year are desired). See Appendix 5 for comparison of RSPM-generated base year urban mixed-use areas relative to CLMPO's 20-minute neighborhood map.

NOTE: Realistic constraints imposed in the model mean that not all possible 'urban mixed use' share targets are achievable. For example, it is unrealistic to expect a high percentage of urban mixed-use development in a metropolitan area having a low overall population density. In most cases, the model can be adjusted to achieve the target proportion, but high proportions are not achievable at lower densities and a minimum proportion can be expected at all densities.

> *Source: During the base and future model setup and calibration, the share of households located in mixed use areas by district is initially calculated by the model ('NA' is put place of values in the input file:* ***/land_forecasts/ metropolitan_urban_type_proportions.csv****). RSPM calculations are based on the density of population. In future years, RSPM values can be retained, or adjusted if local conditions are expected to change significantly.*
>
> *Assumptions: Decide and document your rational and source for the 2035 percentage of households located in mixed use areas.*

Transport Investments

Metropolitan area freeway, arterial and public transit supply levels are important inputs to the household vehicle ownership and travel models and to fuel efficiency models. The metropolitan area freeway supply (lane-miles per capita) and transit supply (annual revenue miles per capita) are significant predictors of metropolitan household vehicle ownership and travel. Arterial supply (lane-miles per capita) is not a significant predictor of vehicle ownership or travel, but along with freeway supply, is important for estimating the traffic congestion levels. Traffic congestion affects average trip speeds, vehicle fuel economy, and emissions.

Table 4. Transport Investment Inputs

Input File	Geography	Description
freeway_lane_miles.csv	metropolitan	Base year freeway lane-miles
arterial_lane_miles.csv	metropolitan	Base year arterial lane-miles
transit_revenue_miles.csv	metropolitan	Base year bus equivalent transit revenue miles (for all transit modes)
scen/fwy_art_growth.csv	metropolitan	rates of freeway and arterial growth relative to population growth (constant all years)
scen/transit_growth.csv	metropolitan	transit revenue mile growth and percent electric by analysis year
scen/light_vehicles.csv	district	light vehicle (e.g. bicycle) target proportions, tour mile threshold, and suitability proportions by analysis year (OwnRatio, Threshold, PropSuitable)

Freeway and Arterial Lane Miles

The calculations of base and future year freeway, arterial and transit supplies are straight forward. The base year model inputs include inventories of freeway lane-miles (***freeway_lane_miles.csv***) and arterial lane-miles (***arterial_lane_miles.csv***) by metropolitan area (e.g., a one mile stretch of a roadway with 2 through lanes would count as 2 lane-miles). Future year growth rates of freeway and arterial lane miles are specified relative to metropolitan area population growth rates, defined during setup (***pop_forecasts/pop_by_age_yyyy.csv***). For example, a value of one for freeway supply growth means that freeway lane miles grow in direct proportion to population growth. If metropolitan area population doubles, then freeway lane miles will double as well and per capita freeway lane miles will remain unchanged.

Default assumed costs for building these roadway investments are included in (***costs.csv***). This is incorporated to assist with summary results of the costs of various scenarios. It includes base cost plus O&M and administrative/other costs per lane-mile. These are default inputs that should not change.

The future growth ratio (***fwy_art_growth.csv***) is calculated by computing base and future freeway and arterial road miles from RTP, STIP or other local and regional plans (and the network models used for analysis); calculating the growth in lane

miles and population over the same period; and identifying the ratio of the lane-miles growth rate divided by the population growth rate.

*Source: Freeway and arterial lane miles (**fwy_art_growth.csv**) should come from the RTP, STIP, or other local and regional plans;* financially constrained?

Assumptions: Decide and document your rational and source for the 2035 lane miles.

Transit Service (Bus-equivalent Revenue-Miles)

For the base year, transit service is provided in units of bus-equivalent fixed route transit revenue miles (not counting miles for transit vehicles when not in service) (***transit_revenue_miles.csv***). These are in units of annual service miles per capita. Future transit service inputs are provided in units of growth of the region's bus-equivalent revenue miles per capita (***transit_growth.csv***). It is also important to note that revenue miles are reported in bus-equivalent units. Light Rail and other modes are assumed to have the following bus-equivalency: ????

*Source: The base (**transit_revenue_miles.csv**) and future (**transit_growth.csv**) transit revenue miles can typically be obtained directly or calculated from miles on various routes combined with hours of operation and headways from the local Transit Agency. This should only include fixed route service.*

Assumptions: Decide and document your rational and source for the 2035 revenue miles.

Bike/Light Vehicle Usage

Light-weight vehicles include bicycles, electric bicycles, Segways and similar vehicles that are small, light-weight and can travel at bicycle speeds or slightly higher than bicycle speeds. This class of vehicles, though currently a minor mode of urban transportation has the potential for having a large impact on transportation emissions in the future. Standard bicycles are the dominant form of light-weight vehicle in use in the United States. This may well change as electric bicycles and other light-weight electric vehicles grow in market share. Light-weight electric vehicles have the potential for substantially increasing light-weight vehicle travel because they reduce the difficulty and increase the convenience of this mode of travel. Technological improvements – lighter batteries and more efficient and powerful electric motors – are increasing the performance and reducing the costs of light-weight electric vehicles. Transportation system changes to accommodate light-weight vehicles (e.g. adding bike lanes) are increasing the convenience and safety of light-weight vehicle travel. These changes, along with increasing costs of gasoline, auto congestion, and concerns about the impacts of vehicle travel could promote substantial increases in light weight vehicle travel in the future. An indication of the potential can be seen in the

use of electric bicycles in China where it is estimated that up to 120 million are in use and where more than 1,000 companies manufacture electric bicycles.[11]

RSPM models the potential for diverting household DVMT to light vehicles rather than modeling the use of light vehicles directly. The core idea is that light-weight vehicle usage will primarily be a substitute for short-distance single occupant vehicle (SOV) travel. As such, RSPM first models of the proportion of each household's vehicle travel that occurs in short-distance SOV tours that are competitive with these light vehicles (based on an input of the maximum expected light vehicle round trip tour length). RSPM then predicts the number of light vehicles owned by each household, based on NHTS bicycle ownership data and a user input of the overall light vehicle ownership rate by district (e.g., bicycles per driving age person). For those households with availability, a final input estimates the proportion of SOV tours that light vehicles are assumed to be substituted. This input proportion should reflect the effect of weather and trip purpose on limiting trips by light vehicles. This factor is multiplied by the potential DVMT that might be diverted by the household for households having light vehicles to calculate the DVMT that is diverted.

For each district in each year, the following input goals are specified for shifting single occupant vehicle (SOV) travel to bicycling or other light-weight vehicle travel (e.g. electric bikes, electric scooters, etc.) (***light_vehicles.csv***). It is suggested that the low barrier to entry of bike/light vehicles implies a 100% ownership rate, and OHAS has identified a distance threshold of 20 miles round-trip for Metro and LCOG bicycle trips. This simplifies local adjustments to the PropSuitable share of VMT that is anticipated to shift to these light vehicles in the 0-20 mile round trip range. Future years might consider modified inputs reflecting the range and SOV diversion potential of e-bikes and other motorized light vehicles:

- **OwnRatio** – Average availability of bicycles and other light-weight vehicles (e.g. bicycles per driving age person)
- **Threshold** – Maximum tour (i.e. round trip) distance in miles considered reasonable for diverting SOV travel to light-weight vehicle travel. Metro and CLMPO have assumed 20 mile round trip threshold based on OHAS analysis.
- **PropSuitable** – Proportion of SOV tours having distances less than or equal to the distance threshold that may be diverted to light-weight vehicle travel

> *Source: These bike inputs are a local policy inputs. Base year data can be obtained from Oregon Household Activity Survey (OHAS) data, if available, or comparison with inputs assumed in Oregon peer cities. OHAS can identify the distance threshold, and assess tours by single occupancy vehicle within that tour length. Census journey to work data can also provide bike mode share for commuting trips.*
>
> *Assumptions: Decide and document your rational and source.*

Pricing Inputs

Pricing is one of the most effective and market-based policy in reducing vehicle miles travelled, promoting healthy active modes, and reducing energy use and emissions. In RSPM the following four pricing types combine to make up the travel costs faced by households. They all are applied consistently across the study area and input in 2005$, adjusted for inflation in future years. (All costs are contained in the ***costs.csv*** input file unless noted otherwise):

- **Costs for fuel and or electricity** to run vehicles and **variable use taxes**; This includes fuel costs, electricity costs, gas taxes, mileage (i.e. VMT) taxes, congestion taxes (typically only implemented in the statewide version), carbon taxes,

[11] Joelle Garrus, Electric Bikes on a Roll in China, Agence France-Presse, 2/21/2010. http://www.google.com/hostednews/afp/article/ALeqM5iZWhbppjy_KtEwNap4PVgYg0bdDA

pay-as-you-drive (PAYD) insurance, and parking pricing. The sum of these costs influences the amount of household travel in the household budget model.

- **Other costs of vehicle ownership** and use that the household pays directly; This includes vehicle depreciation, vehicle maintenance, tires, finance charges, insurance, and registration. These costs primarily affect vehicle ownership and not vehicle use and therefore are not used in the household budget model to affect the household DVMT.
- **External costs** that are paid for by society as a result of the household's vehicle travel; This includes social and environmental costs that accrue to society but are not typically paid for by vehicle users. These costs include air pollution, climate change, energy security, safety, noise, and other resource impacts. Social costs are calculated on a per VMT, per gallon, or per metric ton of CO2 basis so that they can be added to other taxes for scenarios in which it is assumed that full costs will be paid.
- **Road system costs**; This includes costs for roadway expansion, other modernization projects, preservation, operations, maintenance and administration. These costs were developed for the STS to compare with total vehicle use taxes (e.g. gas, mileage, congestion) to determine whether sufficient revenues were generated to cover costs.

Outside of the parking costs, which need to be input for local conditions and adjusted as a future year policy input, these costs are typically default values applied to all areas of the state, but can be modified by local Metropolitan area, if desired.

Table 5. Pricing Inputs

Input File	Geography	Description
scen/parking.csv	division	parking pricing rates and share subject to parking costs for work/non-work trips and parking cash-out-buy-back targets by year (PropWrkPkg, PropWrkChrgd, PropCashOut, PropOthChrgd, PkgCost)
scen/congestion_charges.csv	metropolitan	freeway and arterial congestion charges for VMT in congestion (severe, extreme) by metropolitan area
scen/costs.csv	metropolitan	fuel, energy, social, auto ownership, and facility unit costs by analysis year (ownership & facility for V3 and CLMPO only)
scen/payd.csv	metropolitan	pay as you drive insurance inputs by analysis year (Proportion RatePerMile)

Note: All Monetary units are reported in 2005 dollars; Light Gray entries are optional, dark Gray are typically default values provided by others.

Parking

Parking pricing is a trip-based cost, commonly paid for at one or both ends of a trip, and sometimes paid for on a monthly basis. The standard practice for handling parking pricing in urban travel demand models is to include it in the trip costs for auto travel. GreenSTEP handles parking pricing in a more general way within a household budget framework, where overall travel costs impact a household's daily VMT. Two types of parking costs are addressed in the model - parking costs at places of employment and parking costs at other places. Daily parking costs are calculated for each household and added in with other variable costs.

For employer-based parking, the proportion of employees that pay for parking is a policy input for each metropolitan area. Employer-based parking includes parking provided at the employment site as well as parking in other parking facilities near the employment site. A related policy variable is the availability of free parking in the vicinity of employment sites. This is specified as the ratio of employment parking to available parking in the vicinity of employment sites. It is assumed that the proportion of employees who pay for parking is a function of the proportion of employers who charge for parking and the employment parking proportion of total parking available in the vicinity of employment sites. After the proportion of workers paying for parking has been calculated, the proportion of working age adults paying for parking is calculated.

Another policy input is the proportion of employment parking that is converted from being free to being charged under a "cash-out buy-back" type of program. Under these programs all employees are charged for employer-provided parking but they are also provided with a stipend equal to the parking cost which works out to a net benefit unless parking is purchased. This provides an incentive for employees to carpool or use other modes of transportation to get to work.

The rate per working age adult and the proportion of "cash-out buy-back" parking are used to determine the number of adults in the household that have to pay for parking at their place of work and the number that pay through a "cash-out

buy-back" program. Households are charged the daily parking rate (dollars per day in 2005$) for the number of working age persons identified as paying for parking. Their income is increased for the number of working age persons identified as participating in "cash-out buy-back" programs with the amount equal to the daily parking rate times the number of working days in a year (260).

Parking charges associated with non-work travel are specified in terms of the proportion of non-work vehicle trips that incur parking costs. The daily household parking cost for non-work travel is calculated as the proportion of non-work trips that incur a parking cost times the average proportion of DVMT that is for non-work travel (0.78) times the average daily parking cost.

RSPM requires the following parking program parameters by metropolitan division and year (***scen/parking.csv***). :

- **PropWrkPkg** - The employer parking proportion of parking available to workers. For example a value of 1 means workers can only park in their employer's parking lot or some other paid parking lot. No free on-street parking is permitted.
- **PropWrkChrgd** – The proportion of workplace parking that workers are charged to park in.
- **PropCashOut** – The proportion of workplace paid parking that is administrated through a "cash-out-buy-back" program where parking is charged, but employee wages are increased by the cost of parking
- **PropOthChrgd** – The proportion of non-work vehicle trips that have to pay for parking at the non-home end of the trip
- **PkgCost** – The average daily rate for long-term parking (i.e. parking paid by workers renting a parking spot on a monthly basis) ($/day in 2005$)

Source: Parking policies and rates can typically be collected from local business district parking contracts or travel demand models, and should be adjusted to reflect future plans for coverage and pricing (in 2005$). Costs should be consistent with assumptions in the regional urban travel demand model and represent a weighted average rate across the division.

Assumptions: Decide and document your rational and source for parking data and assumptions for any changes to 2035.

Calculating Parking Costs:
*The proportion charged for parking and the division-wide parking rates can be calculated using the **regional travel demand model**. The proportion calculation uses the percentage of home based (or non-home based) work trips that originate in the respective division and end in a TAZ with paid parking. The parking rate can be calculated as the weighted average parking price in the MPO area (i.e., sum over all i zones: Daily price(i) x # spaces at price (i)/all paid spaces in MPO inventory).*

PAYD Insurance (DEFAULT)

Pay-as-you-drive (PAYD) insurance is automobile insurance that is paid strictly on a mileage traveled basis, rather than on a lump-sum periodic basis. On average, PAYD insurance does not change the amount that households pay for insurance. However, since the cost of PAYD to the motorist varies with the number of miles driven, there is an incentive to reduce travel to save money. It has been estimated that a PAYD insurance rate of 4 to 6 cents per mile, could reduce VMT from light vehicles by about 3.8%.[12] In RSPM the estimated effect of PAYD insurance will depend on what other travel costs are being paid as well, influencing the VMT estimated based on travel costs relative to the household budget. RSPM requires input on the proportion of households in the full Metropolitan area buying car insurance using PAYD (***payd.csv***). A cost of 5 cents per mile (2005$) of PAYD insurance is used, a default value estimated through literature review and testing (**payd.csv**), which should not be changed.

[12] U.S. Department of Transportation, Report to Congress, Transportation's Role in Reducing U.S. Greenhouse Gas Emissions, Volume 2: Technical Report, April 2010, pp. 5-22.

Source: PAYD input is typically a default value; zero in the base year, applied to all areas of the state. STS defaults are available for the base and future year enrollment levels. These values can be modified by local Metropolitan area, if desired.

Assumptions: Decide and document your rational and source for any modifications to the state's default values.

Per Mile Fees (Gas, VMT, Carbon in 2005$)(DEFAULT)

Several per mile fees combine to make up the roadway travel costs faced by households in RSPM. As discussed above they are typically default values used consistently across the state for each modeled year. They reside in the ***costs.csv*** file, as shown in Table 4 and 5.

- **Fuel & Electricity Costs** – Cost for fuel and or electricity to run vehicles. This is defined as the average cost of gasoline and diesel fuels excluding taxes in dollars per gasoline equivalent gallon.
- **Operating Costs** - Other costs of vehicle ownership and use that the household pays directly (including vehicle maintenance , tires, vehicle financing, insurance, and registration costs)
- **Gas Tax** – Taxes on gasoline (in dollars per gallon)
- **VMT Fee**– Road user fee collected from all vehicles per mile travelled (in 2005 dollars per vehicle mile)
- **Carbon Fee** – The fees collected based on the carbon content of the fuel/electricity usage (in 2005 dollars per metric ton carbon dioxide equivalent)
- **Congestion Charges** – The fee collected to manage congestion, by charging a higher price during congested periods, and thereby reducing demand and freeing capacity for higher value users such a freight movement. Separate price schemes can be set by year to be imposed only during severe or extreme congestion (in 2005 dollars per vehicle mile, where imposed (***congestion_charges.csv***)
- **Proportion of Social Costs Paid** – Proportion of social costs assumed to be paid by drivers. Social costs include externalities include air pollution, safety, noise, damage to other resources (e.g., water pollution), and the costs of maintaining secure energy. (NOTE since social costs include climate change cost it is double counting to set the CarbonTax to a non-zero value and to set PropExtPd to a non-zero value as well.)

Source: Under most circumstances, these values should not be changed for a Strategic Assessment. These are default values applied to all areas of the state. The exception is inclusion of any local gas taxes.

Assumptions: No local assumptions.

Table 6. Default Costs that vary by year (*costs.csv*) (2005$)

	Fuel Cost* ($/gallon)	KwhCost** ($/Kwh)	Share of Social Costs Paid by Drivers (%)	
Year	STS-Ref	STS-Ref	STS-Ref	STS-Vision
1990	1.63	0.073	0	0
1995	1.17	0.07	0	0
2000	1.47	0.065	0	0
2005	2.12	0.073	0	0
2010	2.43	0.08	0	0.1
2015	3.42	0.123	0	0.6
2020	4.25	0.222	0	2.6
2025	4.78	0.257	0	10.5
2030	5.15	0.286	0	34.1
2035	5.53	0.303	0	69.4
2040	5.95	0.314	0	90.9
2045	6.27	0.325	0	97.8
2050	6.57	0.335	0	99.5

* STS Appendix p.29 of 190, Historic US EIA prices, forecast-REF???, extended to 2050 based on 2030-2035 price increase, converted into 2005$ using CPI.; Fuel prices-explain increase+future mpg impact; ** For Electric Vehicles

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Table 7. Default Vehicle Costs that are constant across all years (*costs.csv*) (2005$) - STS Ref vs. Vision?

Cost	Value	Units
User Fees		
VMT Tax	0	$/mile
CarbonTax	0	$/mile
GasTax	0.424	$/mile
Operating Costs		
VehMaint	0.041	$/mile, keep default
VehTire	0.007	$/mile, keep default
VehFin	725	$/mile, keep default
VehIns	740	$/mile, keep default
VehReg	39	$/mile, keep default
Social Costs		
AirPollution	0.014	$/mile, keep default
OtherResource	0.003	$/mile, keep default
ClimateChange	30	$/mile, keep default
EnergySecurity	0.45	$/mile, keep default
Safety	0.005	$/mile, keep default
Noise	0.001	$/mile, keep default
Roadway Costs		
FwyLnMi	4900	$/lane-mile, keep default
ArtLnMi	1800	$/lane mile, keep default
BaseMod	0.004	$/mile, keep default
PresOpMaint	0.01	$/mile, keep default
OtherRoad	0.015	$/mile, keep default

Marketing/ITS-Operations Management

In RSPM, each household is assigned as a participant or not in a number of travel demand management programs (e.g. employee commute options program, individualized marketing) and/or to vehicle operations and maintenance programs (e.g. eco-driving, low rolling resistance tires) based on policy assumptions about the degree of deployment of those programs and the household characteristics. Individual households are also identified as candidate participants for car sharing programs based on their household characteristics and input assumptions on the market penetration of car sharing vehicles. Households are also characterized as to their behavior in optimizing their vehicle use usage to maximize fuel economy given a mix of vehicles owned.

Inputs specifying the level of deployment of several roadway Intelligent Transportation System (ITS) programs, determine the area roadway speeds which influence fuel efficiency. Level of deployment assumptions for TDM (at work and home locations) lead to reduced VMT, diverting travel to other modes. Car Sharing reduces VMT through changes in auto ownership and per mile costs. Vehicle operating programs (eco-driving, low roll resistance tires, vehicle optimizers) reduce emissions per VMT.

Table 8. Marketing/ITS Management Inputs (DEFAULT)

Input File	Geography	Description
scen /prop_wrk_eco.csv.csv	metropolitan	values for work and household VMT reduction for households in employee commute options
scen /Imp_prop_goal.csv	metropolitan	values for work and household VMT reduction for households in individualized marketing programs
scen/carshare.csv	metropolitan	****
scen/eco_tire.csv	metropolitan	proportions of households that are eco-drivers, proportions that have low rolling resistance tires, and MPG improvements due to tires by analysis year (EcoDrvProp, LowRollProp, TireMpgImp, TireMpkwhImp)
scen/ops_deployment.csv	metropolitan	****
scen/other_ops.csv	metropolitan	proportional reductions in delay due to deployment of other operations programs by analysis year (Mod/Hvy/Sev/Extr by Fwy-Art and LDV-Truck types)
scen/speed_smooth_ecodrive.csv	metropolitan	freeway and arterial speed smoothing percentages, eco-driving proportion of light duty vehicle drivers and heavy duty vehicle drivers by analysis year
scen/optimize.csv	metropolitan	proportion of households who are vehicle use optimizers by analysis year

Note: All Monetary units are reported in 2005 dollars; Light Gray entries are optional, dark Gray are typically default values provided by others.

Workplace TDM Programs

Employee commute options (ECO) programs are work-based travel demand management programs. They may include transportation coordinators, employer-subsidized transit passes, bicycle parking, showers for bicycle commuters, education and promotion, carpool and vanpool programs, etc. The default assumption is that that ECO programs reduce the average commute DVMT of participating households by 5.4%.[13] It is assumed that all work travel of the household will be reduced by this percentage if any working age persons are identified as ECO participants

[13] Cambridge Systematics, "Moving Cooler", Urban Land Institute, Washington, D.C., 2009, Technical Appendix, Table 5.13, p. B-54.

The proportion of employees participating in ECO programs is a policy input at the district level (***prop_wrk_eco.csv***). The input assumes workers participate in a strong employee commute options programs (e.g., free transit pass, emergency ride home, bike rider facilities, etc.).

> *Source: Base and future year deployment levels are specified based on the existing and anticipated metropolitan area programs. STS defaults are available for the base and future year enrollment levels. These values can be modified by local Metropolitan area, if desired.*

Assumptions: Decide and document your rational and source future years.

Individualized Marketing Program

Individualized marketing (IM) programs are travel demand management programs focused on individual households in select neighborhoods. IM programs involve individualized outreach to households that identify residents' travel needs and ways to meet those needs with less vehicle travel. Customized to the neighborhood, IM programs work best in locations where a number of travel options are available. RSM assumes that households participating in an IM program reduce their DVMT by 9% based on studies done in the Portland area.[14]IM programs target work as well as non-work travel and produce larger reductions than ECO work-based programs. Only the IM reduction is used for households that are identified as participating in both ECO and IM programs.

RSPM district-level inputs for IM programs (***imp_prop_goal.csv***) include an overall assumption for the percentage of households participating in an IM program. RSPM assumes a minimum population density of 4,000 persons per square mile necessary to implement a successful IM program and the requirement that the household reside an urban mixed-use district. The number of households identified as participating is the minimum of the number needed to meet the program goal or the number of qualifying households.

> *Source: This is a policy input and is most likely zero in the base year. STS defaults are available for the base and future year enrollment levels. These values can be modified by local Metropolitan area, if desired.*
>
> *Assumptions: Decide and document your rational and source future years.*

Eco-Driving Practices (autos and trucks) (DEFAULT)

Eco-driving involves educating motorists on how to drive in order to reduce fuel consumption and cut emissions. Examples of eco-driving practices include avoiding rapid starts and stops, matching driving speeds to synchronized traffic signals, and avoiding idling. Practicing eco-driving also involves keeping vehicles maintained in a way that reduces fuel consumption such as keeping tires properly inflated and reducing aerodynamic drag. In RSPM, fuel economy benefits of improved vehicle maintenance are included in the eco-driving benefit. A default 19% improvement in vehicle fuel economy is assumed (***eco_tire.csv***).[15] The fuel economy of all household vehicles of participating households is increased by a factor representing the average fuel economy gains of persons who are trained in eco-driving techniques.

An RSPM input (***speed_smooth_ecodrive.csv***) specifies the proportion of light duty vehicle drivers who exhibit eco-driving habits. This is applied consistently across the study area in each modeled year. The same file has default statewide assumptions for a similar assumption on the proportion of heavy truck drivers who are eco-drivers, which should not be changed.

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[14] Insert reference. Portland IM studies

[15] Cambridge Systematics, "Moving Cooler", Urban Land Institute, Washington, D.C., 2009, Technical Appendix, Table 7.1, page B-63.

* AND/OR *

An RSPM input specifies the proportion of households that are eco-drivers (***eco_tire.csv***). This is applied consistently across the study area in each modeled year. This file also contains the improvements in vehicle fuel economy (or electric vehicle fuel efficiency) from eco-driving, which should not be changed.

> *Source: This is a policy input and is most likely zero in the base year. STS defaults are available for the base and future year enrollment levels. These values can be modified by local Metropolitan area, if desired.*
>
> *Assumptions: No local assumption.*

Low Rolling Resistance Tires (DEFAULT)

Low rolling resistance tires reduce fuel consumption by reducing energy losses due to tire deformation as the tire rolls down the road. The effect of low rolling resistance tires is modeled by specifying the proportion of households that use low rolling resistance tires. The fuel economy of vehicles in these households is assumed to increase by 1.5%.[16]

An RSPM input specifies the proportion of households that have low rolling-resistance tires (***eco_tire.csv***). This is applied consistently across the study area in each modeled year. This file also contains the improvements in vehicle fuel economy (or electric vehicle fuel efficiency) from low rolling-resistance tires, which should not be changed.

> *Source: This is a policy input and is most likely zero in the base year. STS defaults are available for the base and future year enrollment levels. These values can be modified by local Metropolitan area, if desired. Adjust for studded tires?*
>
> *Assumptions: No local assumption.*

Car Sharing (population per vehicle)

Car-sharing is a relatively new phenomenon in the United States, but programs currently operate in Portland and Eugene. According to an analysis of a survey of almost 10,000 car sharing persons in North America,[18] car sharing households have the following characteristics:

- Low car ownership prior to joining: About 60% owned no cars. About 30% owned one car. Almost all of the rest owned two cars.
- Small households: The average is 1.9 persons compared to a U.S. average of 2.6 persons.
- Younger adults: The average age is about 37 years. About 10% are 55 or older. About 2% are 65 or older.
- Incomes are distributed across the spectrum, but the average income is higher than the population average. (not addressed in RSPM)
- Above average education: Over 80% have a bachelor's degree or advanced degree. (not addressed in RSPM)

In RSPM, households participating in a car sharing program are chosen based on a weighting process. The weight assigned to each household is the product of the individual attribute weights of the first three bullets above. The effects of car-sharing on vehicle travel are addressed through vehicle ownership and the variable costs of vehicle travel paid by participants. The number of vehicles owned by car sharing households is adjusted to reflect reductions in ownership. After this reduction, the household vehicle ownership of all car-sharing households is increased by 1/20th of a vehicle to account for the availability of a car-share vehicle. Additionally, the average household cost per mile for car share households is

[16] Transportation Research Board, "Tires and Passenger Vehicle Fuel Economy", Special Report 286, Transportation Research Board, Washington, D.C., 2006.

adjusted to reflect that car-share users pay the full cost of using a car-share vehicle per mile of travel. Based on the values reported in the TDM Encyclopedia, the variable (per mile) cost of using a car share vehicle is about 5 times more than the variable cost of using a privately owned vehicle. [17,18,19,20]

In RSPM, the scope of car-sharing programs is specified as a model input (***carshare.csv***). The number of car-share vehicles per 2,000 inhabitants of medium density Census tracts (4,000 – 10,000 persons per square mile) and the number per 1,000 inhabitants of high density Census tracts (> 10,000 persons per square mile) are specified for each metropolitan division. The target number of households that participate in car-sharing is calculated based on the assumption that there are 20 participating households per car-share vehicle, on average. For example a value of 1,000 in high density areas would mean that there is one car share vehicle for every 1,000 people living in high density areas. Values are specified by metropolitan division and year.

> *Source: This is a policy input and is most likely zero in the base year. STS defaults are available for the base and future year enrollment levels. These values can be modified by local Metropolitan area, if desired.*
>
> *Assumptions: Decide and document your rational and source future years.*

ITS-Ops Degree of Deployment

ITS impact is modeled within RSPM, through speed reductions from basic and enhanced traffic operations, and active management of speed smoothing operational programs. Average speed on roadways in RSPM, is calculated as a function of congestion level and the type and amount of deployment of traffic operations programs. An average speed is associated with each roadway functional class (freeway or arterial) and congestion level. Those speeds are modified depending on the cumulative effect of user-specified deployment of the following traffic operations programs:

- **Freeway ramp metering** - Metering freeways can reduce delay by keeping mainline vehicle density below unstable levels. It creates delay for vehicles entering the freeway, but this is typically more than offset by the higher speeds and postponed congestion on the freeway facility. The Urban Mobility Report cites a delay reduction of 0 to 12%, with an average of 3%, for 25 U.S. urban areas with ramp metering.[21] Only urban areas with Heavy, Severe, and Extreme freeway congestion can benefit from ramp metering in RSPM
- **Freeway incident management** - Incident Response programs are designed to quickly detect and remove incidents which impede traffic flow. The UMR study[22] reports incident-related freeway delay reductions of 0 to 40%, with an average of 8%, for the 79 U.S. urban areas with incident response programs. This reflects the combined effects of both service patrols to address the incidents and surveillance cameras to detect the incidents. Effects were seen in all sizes of urban area, though the impacts were greater in larger cities.
- **Arterial signal optimization** – Traffic signal coordination, particularly for adaptive traffic signals, can reduce arterial delay by increasing throughput in peak flow directions. UMR and other analysis estimates delay reductions of up to 6-9% due to signal coordination, with more potential savings from more sophisticated control systems. An average arterial delay savings was found to be about 1%.

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[17] Cambridge Systematics, "Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions", Urban Land Institute, Washington, D.C., October 2009, pp. B-51 to B-52.

[18] Martin, Elliot, Susan Shaheen "Greenhouse Gas Emissions Impacts of Carsharing in North America", Mineta Transportation Institute, College of Business, San Jose State University, June 2010.

[19] Millard-Ball, Adam, et.al., "Car-Sharing: Where and How It Succeeds. TCRP Report 108, Transit Cooperative Research Program, Transportation Research Board, Washington, D.C., 2005.

[20] Victoria Transportation Policy Institute, "TDM Encyclopedia", Carsharing, http://www.vtpi.org/tdm/tdm7.htm

[21] (Schrank & Lomax, 2009b) per Alex Bigazzi Technical Report

[22] TTI Urban Mobility Report (UMR) (Schrank & Lomax, 2009). per Alex Bigazzi Technical Report

- **Arterial access management**– Access management on arterials can increase speeds by reducing the number of enter/exit points on the arterial and reduce crashes by reducing conflict points. Although improvements such as raised medians can reduce throughput by causing turning queue spillback during heavy congestion, other types of access management, such as reduced business ingress/egress points, show consistent benefits system-wide.
- **Enhanced ITS/Speed Smoothing programs**– Insufficient aggregate performance data is available for a number of other current and future ITS/operations strategies. These include: speed limit reductions, speed enforcement, and variable speed limits that reduce the amount of high-speed freeway travel; , variable speed limits, and signal coordination effects that reduce fuel consumption at a given travel speed; and truck/bus-only lanes that can move high-emitting vehicles through congested areas at improved efficiency.

RSPM inputs specify the deployment of the first four of these roadway operations programs relative to maximum deployment by year, applied consistently across the study area (***ops_deployment.csv***). Ramp metering and incident management largely apply to freeways, while signal optimization and access management operations apply to arterials. A value of 1 indicates that the program is fully deployed. Any increase would not yield any additional benefits. A value of 0.5 is the typical deployment for urban areas of similar size, 0 means no deployment. There are no benefits for communities less than 0.5 million due to too little freeway delay? Speed and delay improvements are also minimal in regional with limited congestion. These are policy inputs applied consistently across the study area, as specified for each year modeled. These programs are operating to various degrees across the state. An assessment of existing and future deployment potential would need to be made for these metropolitan-wide inputs in each modeled year.

The latter program allows flexibility within the model to accommodate future enhancements (***other_ops.csv, speed_smoothing_ecodrive.csv***). Further research and significant program investment would be needed to justify benefits in these enhanced ITS/speed smoothing programs.[23]

> *Source: Basic ITS programs including ramp metering, incident management, signal optimization, and access management, may be implemented to various extents in different regions (**ops_deployment.csv**). The deployment level in the base year and information to provide a policy input in the forecast year can be obtained from the City's engineering department. The enhanced programs should not be used without further research.*
>
> *Assumptions: Decide and document your rational and source future years.*

Household Vehicle Use Optimization (DEFAULT)

The split of household DVMT among household vehicles is optimized for households identified as vehicle use optimizers. These are households which split their travel among their vehicles to minimize fuel consumption, rather than just assign vehicles to people, regardless of vehicle use. The proportion of households that are optimizers is a model input. The optimizing process does not change the proportional split of mileage among vehicles, it only changes which vehicles are assigned which proportions. For optimizing households, VMT proportions are ordered in the order of vehicle fuel economy. For example, if a household owns 3 vehicles with fuel economy ratings of 15 MPG, 21 MPG and 32 MPG, and if the household is an optimizer, the household will put 50% of their DVMT on the 32 MPG vehicle, 30% of their DVMT on the 21 MPG vehicle and the remaining 20% of their DVMT on the 15 MPG vehicle. If the household is not an optimizer, the vehicle use proportions are randomly assigned to the household vehicles.

[23] For the enhanced ITS operation programs, an additional RSPM input specifies the proportional delay reduction anticipated at different freeway and arterial congestion levels resulting from these more aggressive operations programs (***other_ops.csv, speed_smoothing_ecodrive.csv***). Lastly, the speed smoothing program benefits result from an RSPM inputs that specifies the proportion of DVMT that is subject to speed smoothing (i.e. speed harmonization). The parameter is set for Freeway and Arterials separately.

An RSPM input specifies the proportion of households who optimize the use of their vehicles (i.e. putting the most mileage on the vehicles having the best fuel economy) (***optimize.csv***). This is applied consistently across the study area in each modeled year.

Source: This is a policy input and is most likely zero in the base year. STS defaults are available for the base and future year enrollment levels. These values can be modified by local Metropolitan area, if desired.

Assumptions: No local assumption.

Vehicle/Fuels Technology Inputs (typically Statewide defaults)

Vehicle and Fuel Technology are expected to change significantly during the next 20-50 years as vehicles turn-over and the newer fleets are purchased. The characteristics of the fleet of new cars and trucks are influenced by federal CAFÉ standards as well as state energy policies and promotions. Local areas can contribute through decisions about the light-duty fleet used by local transit agencies and by assisting in deployment of electric vehicle charging stations and their costs in work and home locations, but otherwise have less influence on the characteristics of the future vehicle fleet, including auto, light truck, and heavy truck vehicles.[24] As a consequence, the RSPM inputs on vehicle and fuel technology are largely specified at the state level. These include inputs that reflect the default assumptions included in the Metropolitan GHG target rules and a more aggressive future as specified in the Oregon Statewide Transportation Strategy. These will both be available to provide sensitivity test to assess their impact on energy use and GHG emissions in the metropolitan area.

The key local contribution to these inputs is the bus electric/fuels inputs; although defaults can be used if no additional local data is available. These variables are briefly summarized below.

Table 9. Vehicle/Fuels Technology Inputs (DEFAULT)

Input File	Geography	Description
scen/phev_characteristics.csv	metropolitan	auto and light truck PHEV fuel economy, battery range, electricity economy, and market proportion by analysis year
scen/ev_characteristics	metropolitan	auto and light truck EV characteristics (battery range, market proportion, efficiency) by model year
scen/hev_characteristics.csv	metropolitan	auto and light truck HEV fuel economy and proportions of ICE & HEV vehicles that are HEV by model year
scen/age_adj.csv	metropolitan	adjustment factors for vehicle fleet age by analysis year(change to 95th percentile age from 2005 vehicle age cumulative distribution)
scen/lttruck_prop.csv	division	light truck proportion of household auto & light truck fleet by analysis year
scen/comm_service_lttruck_prop.csv	metropolitan	light truck proportion of commercial service fleet by analysis year
scen/comm_service_ev_prop.csv	NA	EV proportion of commercial service autos and light trucks by model year
scen/comm_service_pt_prop.csv	metropolitan	powertrain proportions for commercial service autos and light trucks by model year
scen/auto_lighttruck_mpg.csv	metropolitan	MPG for autos and light trucks with ICE engines by model year
scen/hvy_veh_mpg_mpk.csv	metropolitan	heavy truck and bus MPG and train MPkWh by model year
scen/cong_efficiency.csv	metropolitan	relative fuel efficiency of light duty vehicles and heavy trucks in congestion by powertrain and analysis year
scen/auto_lighttruck_fuel.csv	metropolitan	auto and light truck fuel type proportions by analysis year
scen/bus_fuels.csv	metropolitan	bus vehicle miles vehicle type (PropGas, PropCng) and fuel type (DieselPropBio, GasPropEth) proportions by analysis year
scen/comm_service_fuel.csv	metropolitan	commercial service auto and light truck fuel type proportions by analysis year
scen/heavy_truck_fuel.csv	metropolitan	fuel type proportions for heavy trucks by analysis year
scen/fuel_co2.csv	metropolitan	carbon intensity of fuel types by analysis year
scen/power_co2.csv	district	pounds of CO2e per kilowatt hour of electricity consumed by analysis year

Note: All Monetary units are reported in 2005 dollars; Light Gray entries are optional, dark Gray are typically default values provided by others.

[24] Commercial service vehicles are treated separately in RSPM. They include light-duty vehicles used for commercial purposes such as deliveries, service and repair calls, and other business travel, and thus contribute to the GHG emissions in the GHG target rule. Commercial service vehicle VMT is calculated as a fixed proportion of household VMT. RSPM allows a variety of inputs about their fleet (typically autos and light trucks), as these are typically businesses or distribution operators that own their fleet, and can thus be provided incentives to make them more environmentally friendly. The inputs are similar but separate to that for other vehicle types, and will use STS defaults.

Vehicle-Powertrain types: LdIce = light duty internal combustion engine, LdHev=light duty internal combustion engine, LdEv=light duty electric vehicle, LdFcv=light duty fuel cell vehicle, HdIce = heavy duty internal combustion engine.

Vehicle age, fuel economy, and congestion

Several RSPM input files specify vehicle attributes relative to fuel source (diesel, compressed natural gas), fuel economy, and vehicle age for autos, light trucks, and heavy trucks. Four vehicle powertrain types are modeled by GreenSTEP:

- **ICE** - Internal Combustion Engines having no electrical assist;
- **HEV** - Hybrid-Electric Vehicles where all motive power is generated on-board;
- **PHEV** - Plug-in Hybrid Electric Vehicles where some motive power comes from charging an on-board battery from external power supplies;
- **EV** - Electric Vehicles where all motive power comes from charging an on-board battery from external power supplies.

The proportions of vehicles of each powertrain are specified by 3 files in several sequential steps (***ev_characteristics.csv, hev_characteristics.csv, pev_characteristics.csv***). Their associated efficiency (miles per gallon on kilowatt, mpg or mpk) is either contained in these files or two additional files (***auto_lighttruck_mpg.csv, hvy_veh_mpg_mpk.csv***). Commercial service light duty vehicles are specified separately in another file (***comm_service_pt_prop.csv***). More detail on the content of these files is provided in the following paragraph.

First vehicles are split between the combined categories of ICE/HEV and PHEV/EV using proportions for the PHEV/EV component stored in the ***phev_characteristics.csv*** file. This file also specifies the battery range and power efficiency assumptions for PHEVs and the average MPG for PHEVs in charge-sustaining mode. The ICE/HEV category is split into ICE and HEV vehicles using proportions stored in the ***hev_characteristics.csv*** file. This file also specifies the MPG for HEVs. The PHEV/EV category is split into PHEV and EV vehicles using proportions stored in the ***ev_characteristics.csv*** file. This file specifies the maximum proportion of EVs; the actual split depends on whether enough households have their 95Th percentile daily travel within the EV battery range which is also specified in the file. This file also specifies the power efficiency of EVs. The MPG of ICE vehicles is specified in the ***auto_lighttruck_mpg.csv*** file. Likewise the MPG of heavy vehicles (trucks and buses) and power efficiency of streetcars and light rail trains is specified in the ***hvy_veh_mpg_mpk.csv*** file. All of these inputs are specified by vehicle model year. The powertrain attributes of light-duty commercial service vehicles are specified in the ***comm._service_pt_prop.csv*** file.

A separate file contains a table of vehicle age adjustment factors by vehicle type and year. The purpose of this input is to allow scenarios to be developed which test faster or slower turn-over of the vehicle fleet (***age_adj.csv***). This is supplemented by inputs specifying the share of trucks in the light duty fleet of personal and commercial vehicles (***lttruck_prop.csv, comm_service_lttruck_prop.csv***).

An additional input looks at the performance of vehicles under congested conditions, as fuel economy varies by speed and varies by class of vehicles (***cong_efficiency.csv).*** This file gives the relative congestion-efficiency of vehicles by year. Congestion efficiency is a measure of how efficiently the vehicle performs in congestion relative to the best-performing vehicle. These are fleet averages for the model run year. A value of 1 means that the fleet operates like the best possible vehicle. The values are organized by year and by the vehicle and powertrain types.

> *Source: These inputs are defaults used statewide and should not be modified. If more detailed data is available, the default truck share of light duty vehicles (**lttruck_prop.csv**) can be modified.*
>
> *Assumptions: No local assumption.*

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Vehicle Fuel Technology

A second set of inputs specifies the attributes of the fuels and their contributions to GHG emissions (***fuel_co2.csv***). This file contains information on lifecycle CO2 equivalent emissions by fuel type in grams per mega joule of fuel energy content. Fuel types are ultra-low sulfur diesel (ULSD), Biodiesel, reformulated gasoline (RFG), CARBOB (California Reformulated Gasoline Blendstock for Oxygenate Blending), Ethanol, compressed natural gas (CNG), LtVehComposite. The latter category is a blend of the carbon values of all of the fuel types relative to the proportions in which they were used in 1990. This allows the model to be more easily run to simulate lower carbon content of fuels without having to specify the relative proportions of each specific fuel type. The additives in fuel sold that contribute to GHG emissions. These include the average ethanol proportion in gasoline and biodiesel proportion in diesel (***auto_lighttruck_fuel.csv, comm_service_fuel.csv, heavy_truck_fuel.csv***).

Source: These inputs are defaults used statewide and should not be modified.

Assumptions: No local assumption.

Truck share of personal + fleet autos (DEFAULT)

Household own a mix of passenger autos and light trucks or SUVs. This mix has an impact on fuel economy. In RSPM a file contains base year and target values for the proportion of the passenger vehicle fleet that is light trucks for each Metropolitan division (***lttruck_prop.csv***). This is typically set as a policy target value but if no input is provided, the RSPM will calculate a value reflecting continuation of current conditions. If a number (between 0 and 1) is input, the model will make adjustments to match the target value instead.

Source: The default base and future year value used in the STS should be retained, reflecting realistic reductions in the share of SUV/light trucks over time (decrease to 1980 levels by 2035? or is this the STS vision sensitivity test?). Alternatively decoded DMV data can be used for more specific level detail by division.

Assumptions: No local assumption.

Electric Emissions Rate (Co2e lbs/ kwhr) of electricity consumed (DEFAULT)

Since electricity generation varies across the state, a local input to the model is the average cost and GHG emission rates of the local area. The average cost of electricity per kilowatt hour (kWh) in dollars across the metropolitan study area is included in the file ***costs.csv***, while the emissions rate (in average pounds of CO2 equivalents generated per kilowatt hour of electricity consumed by the end user) by district and forecast year is found in a separate input file (***power_co2.csv***). Statewide default values for these inputs are available, if no local source is obtained.

Source: In most cases, the default county value for electricity cost and emissions rates from the DOE used in the STS should be retained. CLMPO used a cleaner utility rate, reflecting special efforts of their municipal city utility in recent years, rather than the STS value which reflects the county average.

Assumptions: No local assumption.

Transit Vehicles/Fuels (DEFAULT)

Other inputs about the transit system vehicles important in calculating energy use and GHG emissions are also required. These include the local transit agency assumed portion of public transit service that is/will be electric rail (e.g. light rail or trolley) (***transit_growth.csv***). This is used to compute the amounts of fuels vs. electric power used to provide future public transit service. Additionally, the fuel mix used by the non-electric transit system is required (***bus_fuels.csv***). For each metropolitan area and each forecast year, the following proportions are specified:

Fuel Mix Shares (the remaining share is assumed to be diesel fuel):

- **PropGas** – The proportion of bus miles using gasoline
- **PropCng** – The proportion of bus miles using compressed natural gas

Biofuel Additives:

- **DieselPropBio** – The biodiesel proportion of diesel fuel used
- **GasPropEth** – The ethanol proportion of gasoline used

Source: These inputs should be obtained from the local Transit Agency, and reflect only revenue service miles. State-level default values can be assumed, reflecting nominal trends in vehicle technology improvements.

Assumptions: Decide and document your rational and source for the 2035 future transit powered by electricity and by alternative fuels.

Note: Units for PctElectric in transit_growth.csv should be values from 0-100 (rather than 0-1 used in other input files.

Attachment 1: LCOG Template set of RSPM input files

A template set of input files to run the LCOG model is provided to facilitate understanding of the inputs. The detailed description of the inputs with filenames can be found in Appendix 2.

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Appendix 3. RSPM Model Overview

The Regional Strategic Planning Model (RSPM)[25], was developed by the Oregon Department of Transportation (ODOT) for the purpose of estimating and forecasting the effects of various policies and other influences on the amount of vehicle travel, the types of vehicles and fuels used, and the resulting greenhouse gas (GHG) emissions among other things. As the name indicates, the RSPM is a model which supports strategic planning processes, such as strategic assessments and scenario planning, at a regional level. In this case, the region to be modeled is an individual metropolitan area; however the RSPM can also be used to model a larger area such as an entire state.

In Scenario Planning, the RSPM serves as a strategic tool to help regions better understand fundamental shifts underway that will affect future travel (e.g., demographics and vehicle technology), as well the impact of policy options (e.g., TDM programs, car sharing) not yet fully addressed in traditional travel models. As RSPM (GreenSTEP) was developed, it was reviewed extensively by state, national and international travel and emissions modeling experts in multiple venues.[26]

How the RSPM Works

The RSPM model estimates vehicle ownership, vehicle travel, fuel consumption, and GHG emissions at the individual household level. This structure accounts for the synergistic and antagonistic effects of multiple policies and factors (e.g. gas prices) on vehicle travel and emissions. For example, the battery range of electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs) is less of an issue for households residing in compact mixed-use neighborhoods because those households tend to drive fewer miles each day. Modeling at the household level makes it possible to evaluate the relationships between travel, emissions and the characteristics of households, land use, transportation systems, vehicles, and other factors. In addition, household level analysis makes it possible to evaluate the equitability of the costs and benefits of different strategies. Figure 2 (above) shows a schematic of model calculation steps.[27]

Each calculation step is composed of a number of calculations that operate on the results of the previous calculation step and on input data that reflect scenario assumptions. The nature of each calculation was determined through the statistical analysis of several data sources such as the National Household Travel Survey. A key method employed in many steps is to sample from observed or target distributions. For example, choosing which households are enrolled in a car sharing program is done by first isolating the correct conditions (e.g., applicable densities) and then randomly assigning enrollment to every X^{th} household that meets the criteria. Each component calculation was estimated and checked using source data.

The steps are grouped as follows:

1. Define households;
2. Calculate VMT;
3. Characterize vehicles; and,
4. Balance VMT with travel costs.

The iterative process to balance the VMT with travel costs allows congestion and other costs introduced at this step influence the amount of travel. This

[25] RSPM was formerly known as GreenSTEP. The name was changed to reflect expanded capabilities for applying it at a metropolitan area level and to address a more general set of transportation and land use considerations in addition to greenhouse gas emissions.

[26] In 2010, the American Association of State Highway and Transportation Officials (AASHTO) awarded ODOT staff its Presidents Award for Planning for the development of the GreenSTEP model. Evaluation at the national level lead to the Federal Highway Administration adopting GreenSTEP as the basis for their EERPAT model

[27] The diagram shows the current structure of the RSPM model. Changes to the model have been made, reflecting changes over the course of the STS study as well as Metro and CLMPO scenario planning.

step balances the amount of household travel with the cost of travel and recalculates household VMT, Fuel & GHG in the process.

The primary outputs of the RSPM are household travel, fuel and power consumption, and GHG emissions calculations, but other information is produced for households and commercial vehicles as well. The amount of commercial (light-duty) and freight (heavy duty) travel is calculated as well as associated fuel, power consumption and GHG emissions for those vehicles (steps 13 and 16 in figure 2, above). In addition, heavy vehicle travel, fuel and power consumption, and emissions are calculated (step 15).

The lack of an explicit representation of interactions between different districts within the study area limits some of the analytical capabilities of the RSPM, as discussed in Appendix 5.

Components of RSPM were tested throughout the development process to check the reasonability of results and whether the model could replicate observed behavior and conditions. Sensitivity tests were also performed to check whether the sensitivity of the model is consistent with results reported by other studies.[28]

The following summary descriptions of each step identify the scenario inputs that affect the results of the calculations. User inputs and policy input indicates a potential opportunity for user input to represent base and future conditions.

DEFINE HOUSEHOLDS

1. ***Generate households:*** A set of households is created for each forecast year that represents the likely household composition for each county given the county-level forecast of persons by age. Each household is described in terms of the number of persons in each of six age categories residing in the household. A total household income is assigned to each household given the ages of persons in the household and the average per capita income of the region where the household resides.
2. ***Add land use & transportation system characteristics:*** Households are assigned a housing type (e.g. single-family, multi-family, etc.) and a development type (metropolitan, town, rural) based on scenario assumptions regarding the projected dwelling units of each type in each portion of the metropolitan area. Households are assigned a location in the metropolitan area based on the projected supply of housing and neighborhood affordability. Neighborhood population density and mixed-use character are assigned based on the number of households assigned to each district and scenario assumptions regarding mixed use development targets. In metropolitan areas, transit and road service levels are assigned based on scenario assumptions regarding expansion of these services and facilities.
3. ***Identify households participating in TDM programs:*** Each household is assigned as a participant or not in a number of travel demand management programs (e.g. employee commute options program, individualized marketing) and/or to vehicle operations and maintenance programs (e.g. eco-driving, low rolling resistance tires) based on policy assumptions about the degree of deployment of those programs and the household characteristics.
4. ***Calculate vehicle ownership and adjust for car-sharing:*** Each household is assigned the number of vehicles it is likely to own based on the characteristics of the household and the land use and transportation characteristics of its location. Households are identified as participating in a car-sharing program based on the characteristics of the household and scenario assumptions regarding the future extent of car-sharing. The vehicle ownership of car-sharing households is adjusted.

[28] For example, the sensitivity of RSPM to changes in urban area population density and land use mix was compared to findings published in the TRB Special Report 298, *Driving and the Built Environment: Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions*. September 2009.

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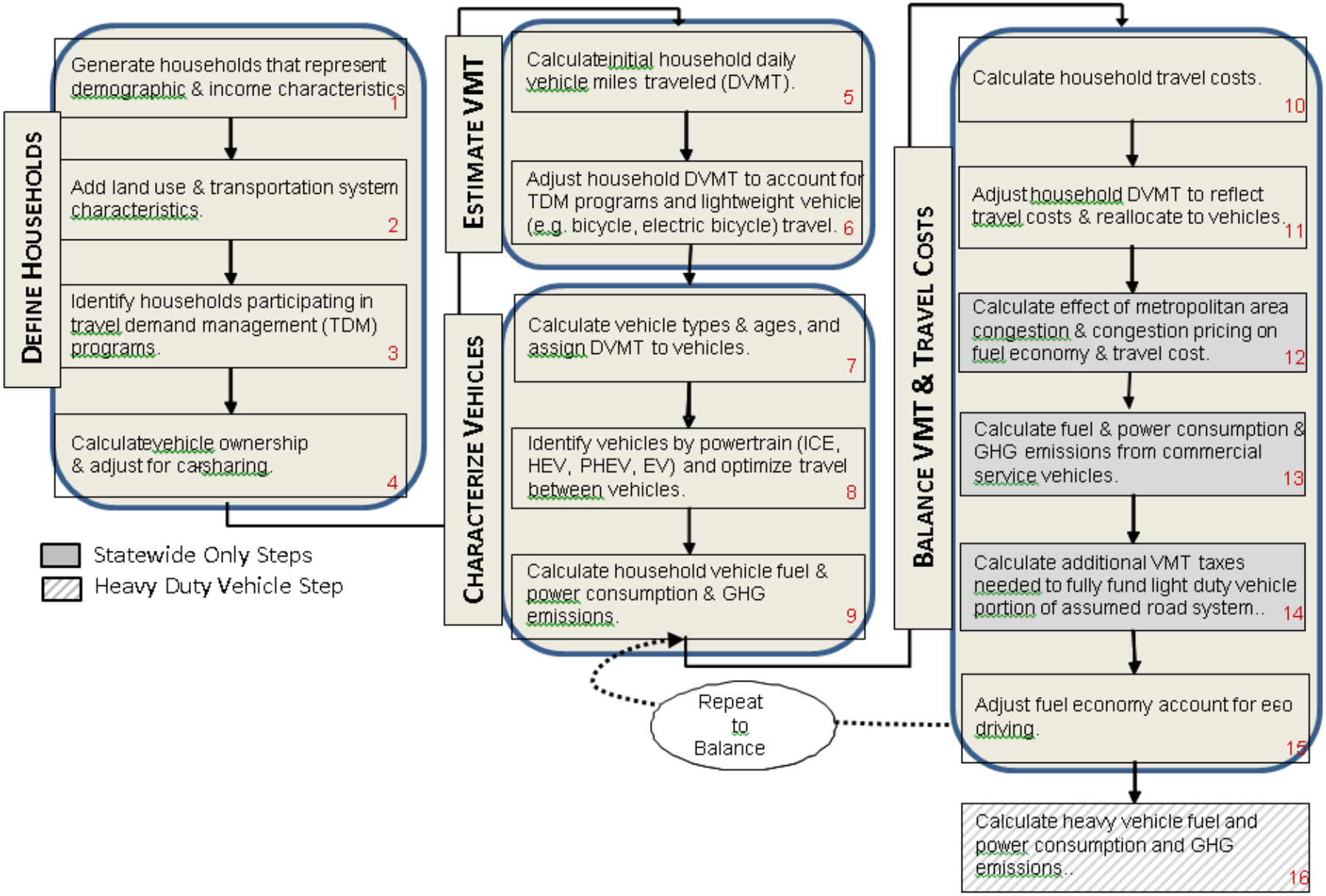
Figure 2. RSPM - Model Schematic



ESTIMATE VMT

5. ***Calculate initial household DVMT:*** An initial estimate of average daily vehicle miles traveled (DVMT) is calculated for each household based on the household characteristics determined in previous steps. Household demographics, income, access to transportation options, and land use are all important to the calculation.
6. ***Adjust household DVMT to reflect TDM and bicycle travel:*** Household DVMT is reduced for households identified as participating in TDM programs. Calculations are also done to estimate the amount of single-occupant vehicle travel that might shift to bicycles or other light-weight vehicles like electric bicycles based on scenario input targets for shifting a portion of short distance single occupant vehicle (SOV) trips.

CHARACTERIZE VEHICLES

7. ***Calculate vehicle characteristics and assign household DVMT to vehicles:*** Household vehicles are assigned to be either autos or light trucks (e.g. SUV, pickup truck, van) based on the household and land use characteristics and light truck percentage targets established for the scenario. The age of each vehicle is determined based on current age profiles by vehicle type and household income and any objectives for adjusting the vehicle age distribution that might be established for the scenario. Average household DVMT is assigned to vehicles without regard to optimizing use to minimize fuel consumption; which is done in the next step.
8. ***Identify vehicles by powertrain and optimize travel between vehicles:*** The powertrain of each household vehicle is identified as being either an internal combustion engine (ICE), hybrid-electric vehicle (HEV), plug-in hybrid electric vehicle (PHEV), or electric vehicle (EV). The identification of vehicle powertrain type is based on scenario input assumptions regarding future market shares by model year. Vehicle fuel economy and power efficiency (for PHEV and EV) is assigned to each vehicle based on the vehicle type, age and powertrain and corresponding scenario assumptions for each model year. Households are identified as fuel economy optimizers based on scenario input assumptions regarding the proportion of households that will optimize their use of vehicles to minimize fuel use. Vehicle DVMT shares of optimizing households are switched between vehicles so that the most miles are assigned to the vehicle with the highest fuel economy. The proportion of household DVMT powered by fuel vs. electricity is also calculated.

BALANCE TRAVEL COSTS

Steps #9-14 balance the amount of household travel with the cost of travel and recalculate household VMT, Fuel & GHG in the process. This is necessary because: 1) congestion calculations affect fuel economy and thus the amount and cost of fuel consumed; 2) congestion pricing affects the amount of travel and household travel costs; 3) fuel, vehicle travel, and other taxes and fees affect the amount and cost of travel; and 4) eco-driving improves fuel economy and reduces fuel cost. The effect of these adjustments to household travel costs need to be included in the total household travel costs and the adjustment to household DVMT. Steps #9-14 are repeated several times until DVMT changes very little between iterations.

9. ***Calculate household fuel and power consumption and GHG emissions:*** Total household fuel consumption is calculated based on the DVMT assigned to each vehicle, the proportion of the DVMT that is powered by fuel, and the average fuel economy of the vehicle. Likewise electrical power consumption is calculated for the miles of household vehicle travel powered by electricity. GHG emissions are calculated based on the future lifecycle carbon intensity of fuels and electricity production assumed for a scenario.
10. ***Calculate household travel costs:*** Household travel costs are calculated from the amounts of miles driven, fuel consumed, electricity consumed, and GHG emitted. In addition, a parking model is applied to calculate how much each household would pay for parking based on scenario input assumptions about what proportions of employees pay for parking, what proportions of non-work trips also involve paid parking, and what the long-term daily parking rates would be. Scenario input assumptions establish the rates for fuel costs, power costs, fuel taxes, VMT taxes, PAYD insurance, and several external costs (i.e. costs imposed on society by driving that drivers do not pay for such as pollution). Scenario input assumptions also establish what portion of external costs will be paid by drivers.

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11. ***Adjust household DVMT to reflect travel costs:*** A household budget model is used to adjust household DVMT to reflect the effect of household travel costs on the amount of household travel. The adjusted household DVMT is allocated to vehicles in proportion to the previous allocation.
12. ***Calculate the effects of metropolitan area congestion and pricing:*** Total light duty vehicle (household and commercial service vehicle), truck and bus DVMT is calculated for the metropolitan area and assigned to portions of the road system (freeway, arterial, other). Congestion levels are calculated and the effects of congestion on speeds are estimated considering the traffic loads, scenario input assumptions regarding the deployment of traffic operations programs (e.g. ramp metering, traffic signal coordination), and scenario assumptions regarding congestion pricing. Fuel economy adjustments are calculated for each vehicle powertrain type based on the calculated speeds and scenario input assumptions regarding the congestion efficiency of powertrains in the future. The average added travel cost per mile due to congestion pricing is also calculated.
13. ***Calculate fuel & power consumption & GHG emissions from commercial service vehicles:*** Commercial service vehicle DVMT is split between different vehicle types, powertrains, and fuels based on input assumptions for the scenario being analyzed. The vehicle age distributions and fuel economy and power efficiency by vehicle type, powertrain and model year are the same at those used for household light duty vehicles.
14. ***Calculate additional VMT taxes needed to fully fund road system:*** In the future, as vehicle fuel economy improves and PHEVs and EVs become more prevalent, fuel taxes will be insufficient to pay the cost to maintain, operate and improve the road system. The user may run the model with the option of calculating the amount of VMT tax necessary to pay for the planned road system improvements. This is accomplished by calculating total costs imposed by light duty vehicles and total revenues collected from light duty vehicles. The revenue gap is divided by the total light duty vehicle VMT to calculate a VMT surcharge fee to make the system whole.
15. ***Adjust fuel economy to account for eco-driving:*** The average fuel economy of households identified as eco-driving is adjusted to reflect the effect that eco-driving has on improving fuel economy. Although this step is included in the loop of steps that is repeated several times, it is only executed once in the loop.

HEAVY VEHICLES

16. ***Calculate heavy vehicle fuel and power consumption and GHG emissions:*** Public transportation VMT is calculated from scenario input assumptions about future revenue miles per capita, future population, and the average ratio of vehicle miles of travel to revenue miles of travel. VMT is split between vehicles powered by on-board fuels vs. electricity based on scenario input assumptions. The amount of fuel consumed is calculated from the VMT powered by fuel and input assumptions regarding the age distribution of vehicles and the fuel economy of vehicles by age of vehicle. GHG emissions from fuel powered vehicles are calculated based on input assumptions regarding the mix of fuels used in the future (e.g. diesel, biodiesel, CNG). Electric power consumption is calculated from the VMT powered by electricity and input assumptions regarding the age distribution of vehicles and the power efficiency of vehicles by age of vehicle. GHG emissions from electrically powered vehicles are calculated based on the amount of power consumed and scenario input assumptions regarding the carbon intensity of electrical power generation.

Components of RSPM were tested throughout the development process to check the reasonability of results and whether the model could replicate observed behavior and conditions. Sensitivity tests were also performed to check whether the sensitivity of the model is consistent with results reported by other studies.[29]

[29] For example, the sensitivity of RSPM to changes in urban area population density and land use mixing was compared to findings published in the Transportation Research Board Special Report 298, *Driving and the Built Environment: Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions*. September 2009.

Appendix 4. RSPM Outputs (available for Scenario Planning)

Additionally, many other measures are possible by customizing scripts using the raw RSPM outputs (household and non-household datasets). All of the household level data is retained from a model run so that any sort of cross tabulation, summation or correlation of household attributes may be done. Both raw data and pre-calculated intermediate cross tabulations of these datasets are noted below. Due to effort required to customize these measures, they are not intending for use in Strategic Assessments, but provide opportunities for additional performance measures in the larger scenario planning process. The following attributes are available, intermediate cross tabulations are shown as well:

Household Attributes

- ❖ **Households, population and population density by district, income group, development type, and density**
- Age## (less than or equal to 14, 15 to 19, 20 to 29, 30 to 54, 55 to 64, above or equal to 65)
- Hhsize – number of persons in household
- Hhincttl, IncGrp – annual household income/income group (0to20K, 20Kto40K, 40Kto60K, 60Kto80K, 80Kto100K, 100KPlus)
- DrvAgePop – number of household members whose age are above or equal to 15.

Community

- DevType – general development type (Metropolitan, Town, and Rural).
- Htppopdn – development density of district where household resides (persons per square mile)
- Urban – whether or not the district where the household resides is urban mixed-use character
- Fwylnmicap – average freeway lane miles per person in the metropolitan area
- Tranmilescap – average transit revenue miles per person in the metropolitan area

Program Participation

- Payd – whether the household has pay-as-you-drive insurance
- IsEcoDriver – does the household practice eco-driving techniques
- IsLowRollTire – does the household have low rolling-resistance tires on their vehicles

Transport

- ❖ **VehPerDrvAgePop – number of vehicles divided by the number of driving age persons in the household Number of vehicles by powertrain by district, income group, development type, and density**
- Hhvehcnt – number of vehicles owned by the household
- VehType – types of each vehicle in household (light truck or auto)
- VehAge – the age of each vehicle in a household
- VehMpg – the fuel economy (miles per gallon) of each vehicle in a household
- Carshare – whether the household subscribes to a car sharing service

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Calculated Transport Costs

- ❖ **Household vehicle travel costs by district, income group, development type, and density**
- ❖ **Household vehicle ownership costs by district, income group, development type, and density**
- ❖ **Parking costs by district, income group, development type, and density**
- ❖ **Gas and other vehicle taxes by district, income group, development type, and density**

- BaseCostPerMi, FutrCostPerMi - base/future driving cost per mile
- DailyPkgCost – average daily cost of parking
- VehOwnExp – total vehicle ownership expenses
- HhTotCost – total cost of vehicle use by household (not including cost of owning vehicles)
- TotExtCost – the total social costs/externalities of vehicle travel (i.e. costs like pollution that are not paid for by households)
- DepExp – vehicle depreciation expenses

Calculated Travel

- ❖ **Auto and light truck DVMT by district, income group, development type, and density**
- ❖ **Auto and light truck DVMT powered by electricity by district, income group, development type, and density**
- ❖ **Walk trips by district, income group, development type, and density**
- ❖ **Bicycle and other light-weight vehicle travel by district, income group, development type, and density**

- Dvmt – average daily vehicle miles traveled by light duty vehicle (i.e. car, SUV, pickup truck, van)
- MaxDvmt – maximum daily vehicle miles traveled
- Dvmt95 – 95th percentile daily vehicle miles traveled
- DvmtProp – the proportion of household DVMT traveled on each vehicle
- VehDvmt – DVMT traveled on each vehicle
- LtVehDvmt – average daily vehicle miles by bicycle, electric bicycle or other similar light weight vehicle
- AveWalkTrips – Average daily walk trips of household

Calculated Fuel & GHG

- ❖ **Auto and light truck fuel consumed by district, income group, development type, and density**
- ❖ **Auto and light truck DVMT powered by gasoline or other hydrocarbon fuels by district, income group, development type, and density**
- ❖ **Electrical power consumed for auto and light truck travel by district, income group, development type, and density**
- ❖ **Auto and light truck greenhouse gas emissions by district, income group, development type, and density**
- ❖ **Commercial vehicle greenhouse gas emissions by district, income group, development type, and density**
- ❖ **Heavy vehicle DVMT and emissions by district, income group, development type, and density**

- FuelGallons – average daily gallons of fuel consumed for household travel
- ElecKwh – average electric power consumed for household travel
- FuelCo2e – greenhouse gas emissions from fuel consumed
- ElecCo2e – greenhouse gas emissions from electric power consumed
- EvVehDvmt – the DVMT of each vehicle powered by electricity
- HcVehDvmt – the DVMT of each vehicle powered by hydrocarbon fuels
- VehMpkwh – the power efficiency (miles per kilowatt-hour)
- Powertrain – the powertrain of each vehicle (ICE, HEV, PHEV, EV)

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Appendix 5. FAQs

1. How does RSPM deal with Intercity Travel? with through travel included in the GHG target rule?

The lack of a explicit representation of interactions between different districts within the study area limits some of the analytical capabilities of the RSPM. The RSPM may underestimate or overestimate VMT because it does not calculate the effects of jobs/housing balance on work trips. In small to medium size metropolitan areas, this deficiency is unlikely to have a substantial effect on VMT projections for metropolitan area residents because work trips represent a minor share of all VMT and becausetypically all jobs and housing are relatively close to one another within small and medium sized metropolitan areas.[30] Howeer, significant underestimation of VMT due to jobs/housing imbalances is possible when modeling large metropolitan areas having regional jobs/housing imbalances or if the metropolitan study area includes more distant satellite cities or rural areas. Preliminary research (OHAS) indicates that these conditions lead to larger than average trip lengths, which are not reflected in the typical travel assumed in RSPM.

The lack of an explicit representation of interactions between districts also poses some challenges for projecting changes in GHG emissions in the terms used by state rules that establish planning targets for reducing GHG emissions from light-duty vehicles (i.e. autos and light trucks) in metropolitan areas.[31] Those rules, and the statutes they implement, treat GHG emissions like localized criteria air pollutants by focusing on emissions from light-duty VMT occurring on metropolitan area roadways. Excluded from consideration are the GHG emissions of metropolitan area residents that occur outside of the metropolitan area. On the other hand, the emissions of people who live outside of the metropolitan area, but travel on metropolitan area roadways are included.

[30] Insert some information about average work trip percentage of total VMT either from the NHTS or OHAS. What is criteria for small/med metro areas?

[31] Oregon Administrative Rule 660-044.

Intercity Effects

Figure 10 compares what the GHG reduction targets address with the quantities that the RSPM calculates. This comparison is illustrated with two hypothetical households, one that lives within the metropolitan urban growth boundary (household "A") and one that lives in a small city some distance away from the urban growth boundary (household "B"). The travel of household "A" is illustrated with blue arrows while the travel of household "B" illustrated with orange arrows. The RSPM estimates and forecasts the travel by the blue and orange arrows. If the study area only includes the metropolitan area, then only the travel and related GHG emissions of household A and other households residing in the metropolitan area would be estimated.

The solid portions of the lines illustrate the travel of these households that the GHG reduction target rules address while the dashed portions show the emissions that that the rules don't address. The targets do not address GHG emissions of metropolitan household travel that occurs outside of the metropolitan area. They address emissions from the travel of households of non-metropolitan households occurring within the metropolitan urban boundary but do not consider the majority of the emissions from travel to the boundary.

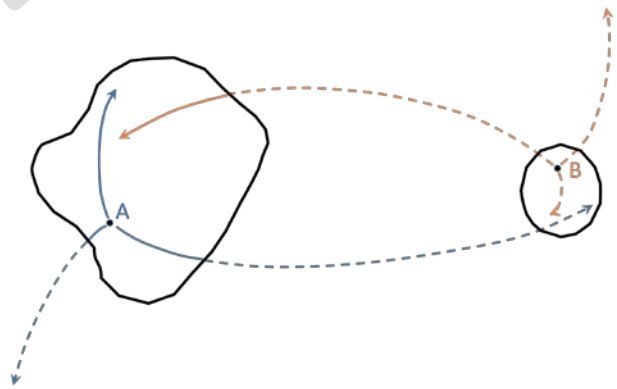

Figure 10. Accounting for Inter-city travel

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Relative Target Effects

Although the RSPM does not model light duty vehicle travel in the same way that the target rules define them, the RSPM can still be used to evaluate achievement of the targets for the following reasons. This can be done because the targets do not specify an absolute amount of GHG emissions to be achieved. Instead, they specify a percentage reduction in GHG emissions from a 2005 year base value. Therefore the RSPM does not need to calculate the emissions in the same way, it only needs to calculate the change of emissions in a comparable way. If the emissions from travel illustrated by the solid portions of the arrows is a fixed proportion of the emissions represented by the blue arrows, and if the proportion does not change over time, then the change in emissions calculated by modeling the emissions metropolitan area households would be the same as the change in emissions on metropolitan area roads. Therefore the RSPM can be used to analyze whether the targets are met if it is assumed that this relationship is constant over the time period being analyzed.

Through Travel Effects

The assumption of a constant relationship between GHG emissions from internal and external travel is a necessary assumption to make for other practical reasons as well. MPO planning authorities do not include all of the areas producing trips that travel on metropolitan area roads. In the case of some metropolitan areas, traffic on metropolitan area roads from non-residents is a substantial portion of the total and can have a large effect on computes changes in GHG emissions.

Target Calculations in RSPM

Therefore the approach to modeling the GHG reduction targets is to assume a constant relationship between the light-duty vehicle travel of metropolitan area residents and the light-duty vehicle travel occurring on metropolitan area roads. This relationship is calibrated for the base year by dividing an estimate of the former, taken from the urban travel demand model or imputed from traffic counts, and divided by the latter, modeled using the RSPM. Future RSPM forecasts are then multiplied by the ratio to estimate the travel and GHG emissions on metropolitan area roadways.

Two other considerations resulting from the GHG target definition:

- Commercial vehicle fleets travelling in light duty vehicles are included in the local region travel. Their travel and emissions are calculated by RSPM, but are treated the same across the state (Step 13 of Figure 2). Heavy vehilces are also forecast by RSPM but not considered in the targets.
- The targest assume local impacts relative to 2005 on GHG emissions beyond reductions "from the use of improved vehicle technologies and fuels and changes to the vehicle fleet". As such, to compare to the targets, the 2005 baseyear is run with future STS fleet assumptions, to remove them from changes forecast by RSPM. To do so, a 2005 baseyear is created and run with future fleets in this 2005-hybrid scenario as the baseyear for comparison when calculating GHG emissions for target comparisons.

2. How the RSPM compare to my regional travel demand model?

As a strategic model, RSPM differs from the urban travel demand models that support planning in most urban areas. The RSPM is higher level and less detailed but considers a wider range of potential policies, outcomes, as well as considering uncertainty regarding whether assumptions in the forecast will occur. Urban travel demand models, in constrast, are designed to model the effects of specific transportation projects or groups of projects on specific parts of the transportation system. They are also important in meeting air quality conformity regulations, and detailed project studies. In regards to differences in detail, the RSPM predicts the effects of roadway expansions on travel and congestion, but does so by evaluating the effects of changes in overall system capacity rather than by evaluating the effects of changes to specific roads. In contrast, the "link-based" approach common to all urban travel demand models, allows them reto be used to analyze the prospective effects of widening particular streets on the amounts of travel and congestion occurring on those streets and other streets that are connected to them. This "link-based" approach is common to all urban travel demand models.

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The RSPM is not designed to match the level of detail of urban travel demand models. Policies are modeled in a more general manner. For example, although the model predicts the effects of roadway expansions on travel and congestion, it does so by evaluating the effects of changes in overall system capacity rather than by evaluating the effects of changes to specific roads. But what the RSPM lacks in detail is made up for in its ability to evaluate a broader array of policies and programs such as travel demand management, car sharing, eco-driving, pay-as-you-drive insurance, and carbon pricing among others.

In regards to uncertainty, RSPM considers demographics of age and income more fully than current regional travel demand models. Additionally it adds consideration of the changes in travel costs on overall household budgets. For instance, RSPM accounts for the observed response when increasing fuel economy results in more VMT (the rebound effect) because it reduces a budget constraint on travel. Aspects such ase these are not accounted for in travel demand models.

The RSPM also accounts for VMT and emissions in a different manner. Whereas urban travel demand models forecast weekday average and peak period VMT on study area roadways, the RSPM forecasts total VMT (weekend as well as weekday) generated by study area households. The link-based approach of urban travel demand models for predicting VMT serves the purpose of helping planners to determine where specific improvements to the transportation system should be made. It provides useful information about how prospective changes to the transportation system or land uses could affect various parts of the transportation system and what portions of the urban area and urban area populations would most benefit or be harmed by those changes. Since amounts of travel and congestion are greatest during weekdays, and especially during weekday peak periods, it makes sense for these models to predict travel during those times.

These local air quality impacts differ from GHG emissions, which are widely dispersed and have a cumulative effect more suited to the RSPM level of detail. Indeed, the direct effects of rising global temperatures caused by increasing GHG concentrations (e.g. higher temperatures, rising sea levels, more powerful storms, droughts) and the indirect effects (e.g. water scarcity, reduced food production, infrastructure damage, lost lives) do not depend on where the emissions occur. Therefore a household's travel has the same effect in this regard whether the travel occurs within or outside of a metropolitan area. Mitigation programs can help reduce all such emissions, not just those emissions occurring on metropolitan area roads.[32]

A final distinction between models is how the RSPM model considers a more complete cost of travel. The total cost of travel to each household from gas prices, gas taxes, parking charges, etc. is calculated with an evaluation of whether the total cost exceeds the household's total budget. If so, then the household's forecasted travel is reduced so that their budget is not exceeded. This is an important capability for a strategic transportation planning model given prospects that fuel prices may increase substantially in the future and the effectiveness of pricing to help manage the transportation system. This capability is also important in estimating the interactions between vehicle fuel economy, prices, and household budget constraints.

The models are complementary, with the RSPM supporting a discussion of a region's future, identifying a mix of policies that might meet the region's vision. This can be supported by an urban travel demand model to evaluate specific elements of this vision. For example, a strategic plan for a metropolitan area might include a vision and goals for focusing development in areas around a number of activity nodes that are connected by rapid transit and are served by safe and convenient walking and bicycling networks. A general plan, such as a regional transportation system plan, will determine what roads should be widened and what transit lines should be constructed and/or improved given assumptions about future revenue availability and about how much development will occur in each part of the metropolitan area.

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[32] Strictly speaking, the conditions under which travel occurs do affect GHG emissions rates (GHG per mile of travel) to some degree because emissions rates are higher in congestion. This effect will be limited in the future, however, because people travel shorter distances when congestion is higher and because the emissions rates of cleaner vehicles and fuels are affected much less by congestion.

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3. How can the RSPM evaluate effects with such large zones and no link-level travel network?

The RSPM uses a less detailed representation of metropolitan area. With respect to geographic areas, the RSPM for a metropolitan area will have many fewer districts (i.e. zones) than there are transportation analysis zones in the corresponding travel demand model for the area. The larger zones are necessary because the RSPM does not explicitly represent spatial relationships and interactions between portions of the metropolitan area. By measuring population density and urban mixed use attributes over a larger area, the RSPM captures to a significant extent the relationship of each household to the land use characteristics of the area around it

Tests of the RSPM have shown that the sensitivity of the model , using the district or census-tract level of geography is sufficient for strategic planning, as changes in density and mixed use in the RSPM are consistent with the consensus of other research findings published in the literature.[33].

[33] When tested of a range of density levels with and without assumptions of mixed urban development, the RSPM household VMT model produced elasticity estimates of from -7% to -8% on average for places that are not characterized as mixed use urban areas and from -20% to -23% for places that are characterized as mixed use urban areas. The sensitivity was found to be higher at higher densities: -12% to -14% at densities from 5,000 to 10,000 persons per square mile vs. -4% to -5% at densities from 1,000 to 5,000 persons per square mile. These results are consistent with the findings of Special Report 298 of the Transportation Research Board ("Driving and the Built Environment: Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions", September 1, 2009) From page 4 of the report: "Studies aimed at isolating the effect of residential density while controlling for socio-demographic and other land use variables consistently find that doubling density is associated with about 5 percent less VMT on average; one rigorous California study finds that VMT is lower by 12 percent. The same body of literature, mainly U.S.-based studies, reports that VMT is lower by an average of 3 to 20 percent when other land use factors that often accompany density, such as mixed uses, good design, and improved accessibility are accounted for, and suggests further that in some cases these reductions are additive."

4. Can the RSPM Results be used to estimate VMT for TPR purposes?

TBD

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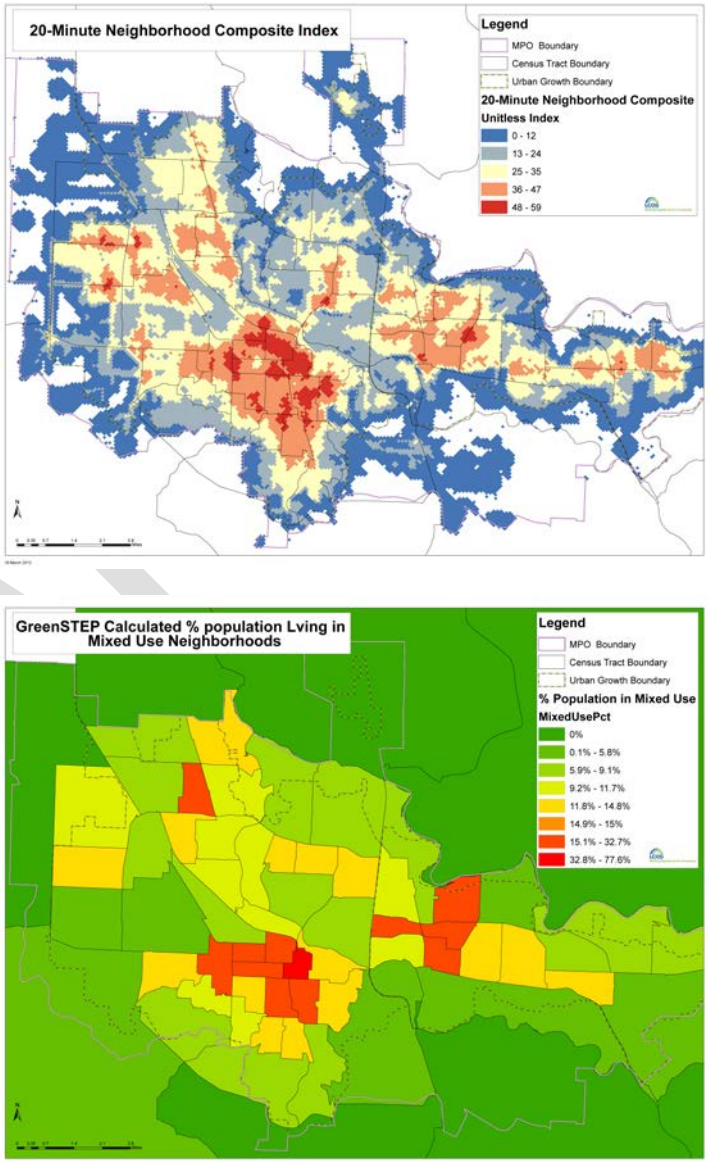
5. How does the RSPM-calculated urban mixed use areas compare to other data?

In CLMPO Scenario Planning work, the calibrated baseyear 2010 urban mixed use areas were compared to the locally developed map of 20-minute neighborhoods.[34] The full composite heat map sums the values for density of sidewalks, density of bike facilities, intersection density, distance to elementary schools, distance to bus stops, distance to parks, distance to full service grocery, distance to convenience stores and density of other commercial services, as well as the measures for residential population and employees. The resulting map is intended to portray an index of walkability, where higher scores (illustrated in red and orange) are those places where many of the factors occur and are considered more walkable, and lower scores (shown in blue and green) have fewer of the factors and are considered generally less walkable. The two maps, developed by the Lane Council of Governments' GIS staff, are compared in Figure 11.

Figure 11. Comparison of RSMP Urban Mixed Use in Central Lane



[34] City of Eugene 20-minute neighborhood Assessment, heat map. http://www.eugene-or.gov/index.aspx?NID=506

6. What are RSPM income weights, and how are they set in calibration?

TBD – checks against buildable lands/travel model?

7. What are Social/external costs and how are they calculated in the RSPM?

TBD – see p4?

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