VE NHTS

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2022-09-21

Contents

Welcome

This guide contains documentation for users and developers of the VisionEval modeling system. This guide contains a diversity of information intended for different audiences interacting with VisionEval. The table below contains a list of chapters contained in this guide along with their descriptions and can be referenced identify the sections that will serve the best starting points.

Chapter	Description
Getting Started	Instructions on getting started with VisionEval on your computer
Concept Primer	A high-level introduction to the concepts and definitions underlying the VisionEval modeling system
VisionEval Tutorial 101	Introductory tutorial on how to start applying a VisionEval model
VERSPM Tutorial	Comprehensive and in-depth tutorial materials on the VERSPM model
VE-State Tutorial	Comprehensive and in-depth tutorial materials on the VE-State model
VERPAT Tutorial	Comprehensive and in-depth tutorial materials on the VERPAT model
Developer Documentation	Information for developers or researchers interested in making contributions to the VisionEval system
API Documentation	Module documentation from the model source code
Estimation in VisionEval	Overview of model estimation in VisionEval and instructions to customize model applications
Module Build Process	Overview of building a VisionEval package module using custom data
Population Synthesis	Customizable household data and third-party population synthesis
Software Framework	Technical overview of the VisionEval software framework

About VisionEval

VisionEval is a collaborative project to build a family of strategic tools for performance-based transportation planning into a single open-source programming framework. Strategic tools are designed to evaluate many alternative futures and policies to help state and metropolitan area governments address pressing issues, despite uncertainty.

Why Use VisionEval?

Strategic planning is becoming increasingly important as a means to help state and metropolitan area governments select policies and actions to address pressing issues that are fraught with uncertainty. More specifically, Federal direction has challenged state, regional, and local transportation agencies with measuring the outcomes of decisions through performance-based planning, including considering how transportation solutions may impact future goals such as sustainability, health, and mobility. Further complicating matters, plans need to be resilient to changing transportation and land use trends and the implications of emerging technologies and constraints. VisionEval is an open source common framework building on the successful GreenSTEP family of strategic planning tools that is intended to address these needs.

VisionEval merges this family of tools into an open-source project with a supporting community forum of partner agencies and others sharing in its use and enhancement. The goal is to support a broad array of potential tool uses and enable pooled enhancements expanding the types of outcomes measured or refine the specificity of transportation and land use solutions considered. The work to date draws from successful past and interested future users nationally, who will both define the policy needs and uses of these tools, and set their direction moving forward.

How to Use this Guide

This guide contains a diversity of information intended for different audiences interacting with the VisionEval system. Use the list below to try to identify what kind of user you are and the sections of this guide that will serve the best starting points.

Decision-maker & semi-technical planner: You are interested in applying the VisionEval system but want a high-level overview and not the technical details.

- Concept Primer: An introduction to the concepts underlying the VisionEval modeling system and how it can be used to support transportation planning efforts, without technical model details.

Model applier: You are wanting to learn about the VisionEval system and implement a model application.

- Getting Started: Instructions on how to get VisionEval installed and running
- Concept Primer: An introduction to the concepts underlying the VisionEval modeling system and how it can be used to support transportation planning efforts, without technical model details
- Tutorials: Start with VisionEval Tutorial 101 for an introduction to start applying a VisionEval model, followed by referencing more in-depth tutorial materials on the VERSPM, VERPAT, and VE-State models.

Developer: You are a developer or researcher and interested in making contributions to the VisionEval system.

- Developer Documentation

Chapter 1

Getting Started

1.1 Overview

This page explains how to obtain the VisionEval software and install it, and provides a brief tour of how the system can used to support scenario planning, and to develop strategies to manage transportation system performance.

The remainder of this page explains how to install VisionEval, and provides a brief overview of what to do with it after it is installed. Content in the VisionEval Tutorial found later in this book contains more complete details on setting up VisionEval models with local data, running scenarios, and extracting and analyzing results.

- Installation and Setup
- Workflow
- Editing and Running Models
- Getting Results
- Using Walkthrough

1.2 Installation and Setup

VisionEval runs within the R Statistical Environment on any system for which R is available. There are two paths to installing VisionEval:

1. **Install from the stand-alone Windows installer**:

   - **Download a zipped folder** from the VisionEval website for a specific version of R.
     This is the simplest way to quickly get VisionEval on your computer.

2. **Copy, clone or 'fork' the system code repository**:

- If you area a Mac/Linux user, or if you are interested in contributing to the development of VisionEval modules, models, framework, or visualizer, choose this path.
- The most recent stable release is hosted at VisionEval on **GitHub**. Development releases are available at VisionEval-dev. Once you have downloaded or cloned one of the VisionEval repositories, instructions for building a runtime are found in `build/Building.md` (or you can locate that file in the repository to preview it).
- Detailed instructions on obtaining the system code can be found later in this manual.

1.2.1 Install for Windows

1.2.1.1 Pre-requisites

You will need:

- R, at least version 4.1.3
- RStudio

Once you have R and RStudio installed, you can retrieve the VisionEval installer itself:

1.2.1.2 Installer

Get VisionEval Here

Note: 580 Mb download! Packaged for R 4.1.3

The link above will download a .zip file containing the following:

- The VisionEval framework code and sample models
- All necessary R packages
- Documentation (both this book as well as API documentation)

Unzip that file into an empty folder of your choice (e.g. `C:\VisionEval`).

1.2.1.3 Completing the Installation

After installing R 4.1.3 (or the version of R corresponding to the installer you are retrieving) and RStudio, unzip the VisionEval installer into an empty destination folder of your choice.

To complete the installation and start VisionEval, do this:

1. Navigate to the folder into which you unzipped the installer:
2. Double-click **`VisionEval.Rproj`**

RStudio will start, and the VisionEval will load. You should see a message similar to the following in the RStudio Console:

```
Loading VisionEval for R4.1.3
Loading required package: VEModel
Welcome to the new VisionEval!
Running in C:/VisionEval
```

If the `VisionEval.Rproj` file does not open RStudio when you double-click it, you can start RStudio directly, then choose `File / Open Project...` and get to the same place. By default, RStudio remembers the project you last loaded, so having done that once you should get back to VisionEval each time you start RStudio (unless you work on a different project).

1.2.1.4 Starting VisionEval Manually

If you need to start VisionEval manually for some reason, just start RStudio (or even plain R), change into your installation folder using

- RStudio's `Session / Set Working Directory...` menu option, or
- In plain R, the `File / Change dir...` menu option, or the `setwd` command on the R command line.

Then run this instruction to start VisionEval:

```
source("VisionEval.R")
```

1.3 Workflow of VisionEval

VisionEval models and the underlying software framework are written in the R programming language for statistical computing and graphics. The purpose of the model system and framework is to enable models be created in a plug-and-play fashion from modules that are distributed as R packages. A simple R script is used to implement a model by initializing the model environment and then calling modules successively. Scenarios are then constructed through a set of files that provide variant model inputs for evaluation and comparison.

To use VisionEval to evaluate scenarios, there are several elements that users need to set up:

1. Select and install one of the VisionEval models, customizing it as needed:

   - **VERSPM** – Regional Strategic Planning Model
   - **VERPAT** – Rapid Policy Analysis Tool
   - **VE-State** – VisionEval State-Level Model

   Instructions and tutorials for configuring these models are presented in the model-specific tutorials elsewhere in this book, which is your entry point to a wealth of documentation on the VisionEval models.

2. Develop a *Base Model* for the region under analysis. The Base Model specifies:

  - **Model Geography** (zone structure), reported as Marea (metropolitan area), AZones (county-sized), and BZones (often census-tract-sized or could be related to Traffic Analysis Zones in other travel demand models) and related configuration files
  - **Base and Future Years** to be evaluated for each scenario (e.g., 2019 and 2050)
  - **Local Data Files** describing Base Scenario conditions in the region (including both observed base year data, and estimates of future year conditions with no scenario policies applied)

3. Develop variant *Future Actions* and *Scenarios*, by adjusting specific input elements for the Future Years. VisionEval models support having many different scenarios. See the scenario development chapter later in this book for details.

4. Run the model to process each of its scenarios.

5. Extract or query the results for summarization and further analysis in R or export tabular data files to other data analysis systems.

1.4 Editing and Running Models

As described in the model tutorials, a VisionEval Model contains the following components:

- Model configuration: `visioneval.cnf`
- The model script file, typically called `run_model.R` (sometimes in a `/scripts` sub-folder), which describes the steps that will be performed when the model runs
- Global parameters describing the model geography, preferred data units, and currency conversion deflators in the `/defs` sub-folder
- Base Model Input data in the `/inputs` sub-folder
- Pre-defined query scripts (in the `/queries` sub-folder) that can extract useful metrics from the model scenarios once they have run
- Additional optional folders for the model scenarios (either as top-level directories or within the `/scenarios` sub-folder, which describe how that scenario various from the Base Model. Scenarios may have some different inputs or a different model script.

Once any of the model scenarios have been run, the model will also have a `/results` sub-folder. After queries have been run or raw results extracted into a tabular data format like `.csv`, there will be a sub-folder within `/results` called `/output`.

See the tutorial chapters later in this book for instructions on how to set up VisionEval for your local area. Typically, you will start by installing one of the standard models and then adjusting `visioneval.cnf`, `/defs` and `/inputs` to complete your local Base Model. Once you have completed the Base Model, you can add scenarios to your model (as described later) by varying a few inputs to describe alternate future conditions.

1.5 End User Interface

VisionEval includes a simple R command-line interface for running models and extracting their results.

The tutorials later in this book will explain how to select and customize one of the VisionEval models, as well as how to develop inputs and create scenarios for your area.

Once you have received the `Welcome to the new VisionEval!` message, you can try things out by copying or entering the following instructions into the R Console window. They will install the sample VisionEval RSPM (Regional Strategic Planning Model) with inputs for the small Rogue Valley MPO in Oregon, run the models, dump the model results into a text table (.csv format), and run a set of basic queries to report model performance metrics.

```
rspm <- installModel("VERSPM")
rspm$run()
results <- rspm$results()
results$export()
query <- rspm$query("Full-Query")
query$run()
query$export()
```

Exporting the results creates a series of `.csv` files in the `outputs` subfolder of `results`. Exporting the query will create a table of metrics for each model year and scenario that is defined in the model, placing that in another subfolder of `outputs`.

1.6 Using the Walkthrough

Many additional features of VisionEval are systematically explored in commented R scripts located in the VisionEval runtime `/walkthrough` folder. The walkthrough files are best explored using RStudio.

Here is an overview of the walkthrough files and what you will learn from each of them:

00-setup.R Sets up the walkthrough runtime directory

00-walkthrough.R Master list of walkthrough scripts (nothing specific to run here)

01-install.R How to install a VisionEval model sample from the packaged examples

02-running.R How to run a VisionEval model

03-structure.R The components of a VisionEval model

04-extract.R How to get raw results (or a subset) from a VisionEval model

05-mini-model.R How to build a small model programatically (extended view of structure.R)

06-model-stages.R The concept of model stages and how to manipulate them

07-queries.R How to run queries (summarizing results) on model results (including scenarios)

08-scenarios.R How to set model stages up as scenarios, run such a model, and examine results

09-run-parameters.R Understanding run parameters (model configuration settings)

10-debugging.R Using partial models to debug VisionEval

Once you have seen the message "Welcome to the new VisionEval", you can set up the walkthrough by running this instruction:

```
walkthrough()
```

The walkthrough will create a special runtime directory (within your main runtime folder), so nothing you do while trying it out will affect any of your "real" models, which will remain untouched in your "models" directory.

To explore any of the walkthrough scripts, open them in RStudio by navigating in the RStudio "Files" pane to the walkthrough directory, then double-clicking one of the scripts to open it in the RStudio script editor. You then select individual lines in script editor and press "Enter" to run that line in the console. You should run the lines in order ("walk through them") and not skip any!

If things get messed up because you didn't run the walkthrough lines in order, it's usually enough to back up and run the lines you skipped. If you need to, you can reset the walkthrough by starting it like this:

```
walkthrough(reset=TRUE)
```

Be careful: the "reset=TRUE" instruction will clear the walkthrough runtime. Anything you saved there (including outputs from running and exporting the test models) will be lost. Your regular runtime models directory will remain untouched.

Chapter 2

Concept Primer

VisionEval differs from traditional travel demand models both in how it works and what kind of planning concerns it helps to address. This chapter provides a quick introduction approach to the unique features and applications of VisionEval. It reviews the main model components and key concepts at a high level, to assist new users in understanding concepts they will apply as they set up scenarios, develop inputs and evaluate outputs. Links to more detailed documentation will allow the reader to delve further into each topic, as they choose.

2.1 What can I do with VisionEval?

Structurally, VisionEval may be described as a “disaggregate demand/aggregate supply” model. That is, it combines rich demographic and socioeconomic detail from a synthetic population with aggregate treatments of travel (multi-modal VMT and congestion without explicit trips, or transport networks). The implication of the “aggregate supply” model is that VisionEval cannot be used to evaluate performance of specific projects or corridors.

What VisionEval can do, and even makes especially simple, is to evaluate large numbers of scenarios and explore how combinations of alternative future conditions might affect performance measures. Travel demand models, whether built using traditional trip-based or more contemporary activity-based techniques, sacrifice flexibility for network detail. It is difficult in such models to capture novel behaviors such as an increased propensity to use inexpensive ride-hailing services, or to express shifts in vehicle ownership and occupancy that may be influenced by multiple factors some of which have not yet been observed. Yet these potential shifts are often very important for assessing the potential of pricing, investment strategies or other policy priorities. VisionEval also makes it relatively simple to explore risks and opportunities that may eventually be realized as new transportation options mature.

VisionEval won't help us determine if a particular highway segment should be built or upgraded, or what kind of transit service improvements should be extended into new areas. But it can help us look at the market for new technologies, and explore future scenarios that are based both on changed circumstances (altered demographics, increased congestion, or alternate road pricing strategies) as well as on changed behaviors (including behaviors that *might* happen, but that we have not yet observed because the key enabling technologies are too early in their deployment). VisionEval results can be explored in detail by market segment, asking questions about how benefits might be distributed regionally, and what overall system performance might look like.

Ultimately, VisionEval is a system for asking a very broad range of "what if" questions about how the transportation system might perform, and how its benefits and costs might be distributed over the community. It can efficiently process hundreds of scenarios looking at many different types of interventions, alternative policies, and hypothetical future conditions and travel behaviors. The results can inform strategic questions, helping decision makers answer questions such as "What are our options for achieving this performance result?" or "What are our risks if new transportation technologies develop in these different ways?"

Using VisionEval to answer such questions does not make other types of modeling obsolete (such as travel demand models or corridor microsimulations). Instead, it helps to determine what is worth the effort to code into these more detailed models, and also to explore and document novel assumptions about the future that may require extra effort to implement, and that would be prohibitively expensive to explore through traditional planning models.

2.2 Strengths and limitations

VisionEval operates at broad geographic levels and without explicit network representations to enable very fast analyses across scores of different assumptions and inputs. It is especially well suited for quickly evaluating several different combinations of policies or assessing the range of impacts when uncertainty exists in several key inputs. Because much of the travel behavior is asserted based on observed travel patterns the latter can be changed to reflect expected changes due to new technologies, services, and expected changes in behavior over time. Thus, VisionEval is better suited than traditional travel modeling approaches for certain pursuits:

- Screening a wide range of policy actions, especially in the face of uncertainties where ranges of expected responses or effects must be considered
- Resilience testing under uncertainties (e.g., population growth, household size, fuel prices)
- Directly "comparing and contrasting" broad ranges or combinations of policies (e.g., ITS, transit service, active transport, demand management)

- Analysis of broad policy or technology changes (e.g., carbon taxes, low-carbon fuels)
- Evaluating fuel consumption, particulate emissions, and greenhouse gas emissions impacts of proposed policies

However, VisionEval is not well suited for detailed geographic analyses, to include the effects of congestion on individual trips or tours. Thus, examining the effects of localized land use (e.g. parcel or block) or network assumptions cannot be carried out using VisionEval. Improvements in network capacity, efficiency, or safety can only be indirectly incorporated in VisionEval.

2.3 VisionEval geographies

Traditional travel forecasting models divide a study area into thousands of traffic analysis zones in order to facilitate highly granular spatial analyses. This allows trip (tour segment) origins and destinations to enter and exit a detailed representation of the multimodal transportation network in order to study network flows, congestion, and efficiency outcomes. VisionEval operates at a much broader spatial scale, using several levels of geography:

- A region defines the entire area covered by the VisionEval analyses
- Azones are large areas such as cities, counties, or Census Public Use Microdata Areas (PUMAs)
- Bzones are subdivisions of Azones that represent neighborhoods, Census tracts or block groups, or other relatively homogenous areas
- Metropolitan areas (Marea) are defined as groups of Azones that define them

The location type of each household is also coded as urban, town, or rural areas. A place type is also defined in terms of urban density and its mix of jobs and housing. Both are usually defined for each Bzone used in the model.

> Watch a video presentation with more information about VisionEval geographies

2.3.1 Performance metrics

The following table summarizes many of the possible performance metrics that can be summarized at the region level. The ability to easily export the data enables the analyst to construct new or different performance measures easily.

- Mobility
  - Daily VMT per capita
  - Annual walk trips per capita
  - Daily Bike trips per capita
- Economy
  - Annual all vehicle delay per capita (hours)
  - Daily household parking costs

  - Annual household vehicle operating cost (fuel, taxes, parking)
  - Annual household vehicle ownership costs (depreciation, vehicle maintenance, tires, finance charge, insurance, registration)
- Land Use
  - Number or percent of residents living in mixed use areas
  - Number of dwelling units by housing type (e.g., single family [SF], multi-family [MF])
- Environmental
  - Annual greenhouse gas emissions per capita
  - Household vehicle greenhouse gas/mile
  - Commercial vehicle greenhouse gas/mile
  - Transit vehicle greenhouse gas/mile
- Energy
  - Annual per capita fuel consumption for all vehicles (gallons)
  - Average fuel efficiency (net miles per gallon) for all vehicles
  - Annual external social costs per households (total/percent paid)

2.4 Typical applications

VisionEval can be used to inform planning in several different realms, as described in the following sections.

2.4.1 Strategic modeling

VisionEval is a strategic modeling system. It differs from traditional travel demand and microsimulation models principally in that it is applied earlier in the planning process, and it is used for different purposes. Rather than examining the detailed performance of specific facilities (assessing individual projects), VisionEval estimates regional and small area performance metrics that reflect overarching policy goals such as emission reduction, regional VMT, or mode share.

Traditional travel models used for planning purposes are applied to estimate outcomes under a small number of alternate input scenarios that vary land use characteristics (e.g. type and density of land uses), socioeconomic characteristics (e.g. population, ages, incomes), and/or transportation characteristics (e.g. road alignments, lane configurations, tolls, etc.). In these models, the response to the changed inputs is estimated based on parameters typically derived from household surveys and other related data sources: that is, the behavior in the model is presumed to be what we see today. Even though such models are often behaviorally complex (e.g., activity-based models), the effort required to assess many alternative scenarios is often prohibitive, and because such models are built using complex estimation procedures rooted in detailed data about existing behavior, it can be technically difficult or impossible to reliably encode possible future shifts in behavior, or to explore alternative possible future behaviors.

VisionEval is typically set up to run many scenarios that explore a broad set of alternative policies and investment priorities that may result from a variety of possible categories of policy and project interventions, or from a range of possible future conditions (strong or weak economic growth, demographics that shift at different rates), or from uncertain deployment of new technologies such as app-based ridesharing (Transportation Network Companies or TNCs).

A full application of VisionEval may examine hundreds or even thousands of permutations of inputs representing many possible future outcomes. The outputs allow planners and decision-makers to explore the outcomes of each scenario compared to the others, so they can visualize and discuss the relative impact and cross-influences, as well as the unintended consequences, of factors represented across the scenarios. VisionEval allows planners to assess alternative assumptions about uncertain phenomena such as autonomous vehicle (AV) deployment, it is a very effective tool for identifying risks and opportunities, as well as for formulating effective strategic responses to new challenges for which little current data exists or for which many outcomes are possible yet none are certain. The most interesting of the resulting strategic plans can be refined with more detailed models. Based on the strategic modeling findings, uncertainties can be confidently simplified into a smaller number of scenarios to explore in detail.

Notwithstanding its typical application as a strategic model, VisionEval does allow detailed investigation of certain phenomena such as fleet composition and vehicle ownership in relation to Greenhouse Gas Analysis. It also is unique in its ability to explore budget constraints on travel. Its simulation of individual households enables it to assess policies that would be difficult or impossible to model successfully with traditional models.

2.4.2 Local policy actions

VisionEval is well suited for evaluating a wide range of local policies at varying levels of geography:

- Demographics (Azone)
  - Population by age (households & non-institutional group quarters)
  - Average household size and percent of single-person households
  - Driver licensing rates (optional)
  - Average per capita Income
- LandUse (Bzone)
  - Employment by type (Total, Retail, Service)
  - Dwelling units by type (SF, MF)
  - Income quartiles (for allocating households to neighborhoods and Dwelling units)
  - Share of households in urban mixed-use areas (optional)
  - 5D built form measures (Design & Transit)
  - Developable area

  - Parking pricing policies
- Transportation Operations Actions
  - Road lane-miles (freeways, arterials) (Marea)
  - Transit service (service miles by transit mode) (Marea)
  - Short SOV trip diversion (to bikes, personal electrics, etc.) (Azone)
  - ITS Operations (Ramp metering, Incident response, (Marea)
  - ITS speed smoothing (Freeway ATM, Art Signal optimization) (Marea)
  - VMT covered by Drivers in Eco-Drive programs (Marea)
  - EV Charging infrastructure (residential) (Azone)
- Pricing
  - Fuel and electricity costs (Azone)
  - Road cost recovery – registration fee, gas taxes, VMT fee (Azone)
  - Carbon pricing and otherand other environmental impact and social costs (Region)
  - Congestion fees (Marea)
  - PAYD insurance participation (Azone)
- Vehicle, Fuels, & Emissions
  - Electricity carbon intensity (Azone)
  - Fuel carbon intensity (composites by vehicle group) (Region)
  - LDV-HH percent light trucks (stock) (Azone)
  - LDV-HH vehicle age average (Azone)
  - LDV car service, vehicle mix (stock) (Region)
  - Transit vehicles & fuels mix (Marea)
  - LDV commercial service vehicle mix, %Light Trucks (stock) (Region)
  - Heavy truck vehicle mix (stock) (Region)

2.5 Scenario analyses

A key value of VisionEval is how it facilitates running many scenarios or possible futures. In practice, the user typically starts by setting up the model with a reference scenario (i.e. a scenario that represents current policies and extrapolation of current trends). The model can be validated for current and past years at this point. This Reference scenario then serves as a pivot point for the development of alternative scenarios that modify one or more policy assumptions or other assumptions about the future (e.g. assumptions about urban area expansion, assumptions about future light-duty vehicle fleet composition). Because VisionEval models address a large number of factors that are specified by dozens of input files, and because each set of inputs could have many different values, the potential number of alternate scenarios that could be defined is probably uncountable. For this reason, the scenario generation process is simplified by defining *categories* of inputs that are related in how they affect behavior or are related in how policies are likely to be deployed. An example of the former would be the definition of a pricing category that groups all inputs affecting the price/cost of operating light-duty vehicles (e.g. fuel price, congestion price, carbon price). An example of the latter would be the definition of a land use category which in addition to including land use inputs such as development density, also includes transportation inputs that are associated with land use such as transit service frequency. For each category of inputs, several *levels* of change from the reference scenario assumptions are defined. Alternate scenarios can then be developed by swapping out reference scenario inputs in each category with different level inputs for the category. This is typically done in two ways:

- Sensitivity tests that change a single category of inputs for each run. Such tests are useful for exploring the relative effects of each category.
- Combinatorial tests which compose scenarios from combinations of all categories and all levels.

Note that the number of combinatorial scenarios is a function of the number of categories and the number of levels in each category. For example, if inputs are grouped into 5 categories and each category has 3 levels, at total of 243 scenarios (3x3x3x3x3) would be generated by all combinations. For this reason, automated processes are typically developed to aid in the set-up and running of these scenarios, and analysis of the results.

2.6 Building blocks

2.6.1 Household synthesis and land use

One of the strengths of VisionEval is the rich detail on individual households. This allows for household specific policies, travel behavior can respond to specific household costs and attributes, and outputs can be mined for differences by population groups. The approach of building on a synthesized population borrows from the state of the practice in activity-based travel demand models.

> Watch a short video on household synthesis

VisionEval creates simulated households in each Azone from user-supplied projections of persons by age group and average per capita income. Each simulated household has the characteristics of the number of persons in each of 6 age groups, number of workers in each of 5 age groups, lifecycle category, and household income. The simulated households are assigned a dwelling unit type (single family or multi-family) using a model that is sensitive to the household characteristics and the number of units of each type assigned to the Azone (based on user inputs). Each simulated household is assigned to a Bzone based on the number of dwelling units of their assigned type in each Bzone and the household's income compared to the relative income distribution by BZone. Separately, Bzones are attributed with employment and land use attributes (location type, built form 'D' values, urban mixed use, and employment by type). Household members who are workers are assigned a Bzone work location as a function of the distribution of jobs in the model area. Each home and work location is tied to a specific Bzone with its associated attributes.

Policies are added to each household as a function of their home and work Bzones:

- Parking restrictions (work and non-work)
- Travel demand management (TDM) programs (home and work-based)
- Car service availability

The following sections describe each module that contributes to this concept.

2.6.1.1 Synthesize households

Household synthesis is carried out in several steps:

1. *Create customized PUMS dataset*: This is done prior to setting up a model in VisionEval. A household dataset is prepared from Census PUMS data for the modeled region. The default data included with VisionEval is for Oregon. PUMS data for other regions may be used instead, rebuilding the package to reflect Census households for the region of interest.
2. *Create Households*: The identified types of PUMS households are expanded to meet user control totals and other demographic inputs. Census PUMS data are used define probabilities that a person by age group would be found in each of hundreds of household types. A matrix balancing process is used to allocate persons by age to each of the PUMS household types in a way that matches input control totals and optional constraints. The sampled households are expanded to meet user control totals and other demographic inputs.
3. *Predict Workers*: The number of workers by age group within each simulated household is predicted using Census PUMS probabilities. The user may optionally specify changes in employment rates by age group and Azone to simulate changes in labor force participation over time and/or differences in employment rates by location.
4. *Assign LifeCyle*: Categorizes households are categorized by six lifecycle categories given the household age mix and employment status.
5. *Predict Income*: The annual income for each simulated household is predicted as a function of the household's worker count by age group, the average per capita income where the household resides (AZone), and interactions between neighborhood income and age (all and seniors). The models are estimated with Census PUMS data.

2.6.1.2 Household drivers and autos

The number of drivers and autos in each household are calculated in two steps:

1. *Assign Drivers*: Drivers by age group are assigned to each household as a function of the numbers of persons and workers by age group, the household income, land use characteristics, and transit availability. Metropolitan areas are also sensitive to transit service level and urban mixed use

indicators at the home location. Optional restriction on drivers by age group can be used in calibration or to address trends such as lower millennial licensure rates.
2. *Assign Vehicle Ownership*: The number of vehicles owned or leased by each household are determined as a function of household characteristics, land use characteristics, and transportation system characteristics. Households in metropolitan areas are also sensitive to transit service level and urban mixed use indicators at the home location. The model first predicts zero-auto households and then the number of vehicles owned (up to 6), if any.

2.6.1.3 Land use attributes

Two steps are required to add land use attributes to the synthetic population:

1. *Calculate 4D Measures*: Several land use 5D built form measures are calculated for each Bzone. The `density`, `diversity`, and `destination` accessibilities are based on Bzone population, employment, dwelling units, and `developable land area` inputs. The `design` variable is a user input.
2. *Calculate Urban Mixed Use Measure*: An urban mixed measure for the household is calculated based on population density of the home Bzone and dwelling unit type. The model is based on 2001 NHTS data. The model iterates to match an optional input target on the share of households to locate in urban mixed-use areas.

2.6.1.4 Land use-household linkages

Several land use attributes are added to each household:

1. *Assign Location Types*: Households are assigned to land use location types – urban, town, or rural – by random allocation based on the household's dwelling unit type and input proportions on the mix of dwelling types in its enclosing Bzone.
2. *Predict Housing*: Dwelling unit types are assigned to regular and group quarter households based on the input Bzone supply of dwelling units by type. Residential households also consider the relative costliness of housing within the Azone (logged ratio of the household's income relative to mean income in their Azone), household size, oldest age person, and the interaction of size and income ratio.
3. *Locate Employment*: The number of input jobs by Bzone and employment type (retail, service, total) are scaled so that total jobs equals total household workers within the Marea. A worker table is developed and each worker is assigned to a work Bzone. The assignment essentially uses a gravity-type model with tabulations of workers and jobs by Bzone (marginal controls) and distance between residence and employment Bzones (IPF seed, inverse of straight-line distances between home and all work Bzone centroids).

2.6.1.5 Policy levers

Several assumptions about parking, demand management, and mobility services can also be coded:

1. *Assign Parking Restrictions*: Households are assigned specific parking restrictions and fees for their residence, workplace(s), and other places they are likely to visit based on parking inputs by BZone (within Bzones coded as within metropolitan areas [Marea] only).

   - *Residential Parking Restrictions & Fees*: The number of free parking spaces available at the household's residence is set based on input value that identify the average residential parking spaces by dwelling type in each Bzone. For household vehicles that cannot be parked in a free space a residential parking cost (part of auto ownership costs) is identified as a function of input parking rates for the home Bzone (if any).
   - *Employer Parking and Fees*: Which workers pay for parking is set by inputs that define the proportion of workers facing parking fees in each Bzone. Whether their payment is part of a cash out/buy back program is similarly set by input proportions by Bzone and associated fees set by input parking rates for the work Bzone.
   - *Non-work Parking Fees:* The cost of parking for other activities such as shopping is estimated as the likelihood that a household would visit each Bzone and the parking fee in that Bzone. The likelihood is calculated with a gravity-type model, given the relative amount of activity in the Bzone (numbers of households by Bzone and the scaled retail and service job attractions by Bzone as marginals) and the proximity to each destination (inverse distance matrix from home Bzone seed matrix). The average daily parking cost is a weighted average of the fee faced in each destination bzone and the likelihood of visiting that Bzone.

2. *Assign Demand Management*: Households are assigned to individualized marketing programs based on input participation levels within their home Bzone. Each worker in the household can also be assigned to an employee commute options program based on input participation levels for workers within their assigned work Bzone. A simple percentage reduction in household VMT is applied based on the household's participation in one or more of these program (maximum of multiple program participation, to avoid double-counting). Worker reductions are only applied to that worker's work travel portion of overall household VMT, and summed if multiple workers in the household participate in such programs.

   > Caution: The model assumes high-caliber TDM programs are in place that produce significant VMT savings. Inputs should reflect this.

3. *Assign CarSvc Availability*: A car service level is assigned to each household based on the input car service coverage for where the household resides (Bzone). High Car Service availability can have an impact on auto ownership (households may own fewer vehicles where high level car service is available) and auto operating cost (see the discussion in the next section on household costs and budgets).

2.6.2 Household multimodal travel

Watch a video overview of the Household Multimodal Travel module

Travel of various modes by households (vehicle, transit, bike, and walk modes) is estimated as a simple function of the rich demographic and land use attributes of the household. In metropolitan areas travel is also influenced by inputs on transport supply on a per capita basis, such as available roadway capacity and bus-equivalent transit service levels. Transit, bike, and walk trips are also influenced by household VMT (i.e. if household VMT decreases, trips by these modes increase, and vise verse). Traditional travel models incorporate behavioral dynamics in choice models to build tours and trips for each synthetic person. VisionEval, by contrast, uses simple regression equations that directly estimate average per capita trips and miles by mode, linked by average trip lengths.

After adjusting VMT for household budget limitations it is further adjusted for household participation in TDM programs (home & work-based) and short-trip SOV diversion before calculating household trips for all modes. The household's bike miles are also adjusted to reflect SOV diversion input.

The following sections describe each module, which are implemented in sequence:

1. The household's daily VMT is calculated without household budget adjustments
2. The household's vehicle operating costs are calculated
3. The household's vehicle operating cost budget is calculated and daily VMT is adjusted to fit within the budget if necessary
4. Daily VMT reductions due to TDM measures and short-trip SOV diversions are calculated and applied
5. Vehicle and non-vehicular (AltMode) trips are calculated for each household

2.6.2.1 Transport supply

Transport supply variables are defined in two steps. Note that these calculations are only carried out within metropolitan areas (Mareas) only:

1. *Assign Transit Service*: Transit service levels are input for each metropolitan areas and neighborhood (Bzone). Annual revenue-miles (i.e. transit miles in revenue service) by eight transit modes are read from inputs for each metropolitan area. A Bzone-level Transit D attribute defines access

to transit (not yet work access) for each household based on inputs on relative transit accessibility. Using factors derived from the National Transit Database (NTD), input annual transit revenue miles for each of the eight transit modes are converted to bus-equivalent miles by three transit vehicle types (van, bus, and rail). Per capita relative transit supply and bus-equivalent service-miles are calculated.
2. *Assign Road Miles*: Stores input on the numbers of freeway lane-miles and arterial lane-miles by metropolitan area and year. Computes the relative roadway supply, arterial and freeway lane-miles per capita.

2.6.2.2 Household travel calculations

Household travel by vehicles are calculated in three steps:

1. *Calculate Household Daily VMT (Dvmt)*: Household average daily vehicle miles traveled (VMT) is estimated as a function of household characteristics(income, workers, children, drivers), vehicle ownership, and attributes of the neighborhood (population density) and metropolitan area (urban mixed-use, transit service level, freeway lane-miles) where the household resides. It also calculates household VMT percentiles which are used by other modules to calculate whether a household is likely to own an electric vehicle (EV) and to calculate the proportions of plug-in hybrid electric vehicles (PHEV) VMT powered by electricity. These values are derived from the 2001 NHTS data.
2. *CalculateVehicleTrips*: This module calculates average daily vehicle trips for households consistent with the household VMT. Average length of household vehicle trips is estimated as a function of household characteristics (drivers/non-driers, income), vehicle ownership (auto sufficiency), and attributes of the neighborhood (population density) and metropolitan area (urban mixed-use, freeway lane-miles) where the household resides, and interactions among these variables. The average trip length is divided into the average household VMT to get an estimate of average number of daily vehicle trips.
3. *Calculate AltMode Trips*: This module calculates household transit trips, walk trips, and bike trips. The models are sensitive to household VMT so they are run after all household VMT adjustments (e.g., to account for cost on household VMT) are made. Twelve models estimate trips for the three modes in metropolitan and non-metropolitan areas, in two steps each. The first step determines whether a household has any AltMode trips and the second part determines the number of trips. All of the models include terms for household characteristics (size, income, age mix) and the household's overall VMT. Neighborhood factors (population density) factors into all but the bike trip models. For households in metropolitan areas transit service level has an impact as well, with transit ridership also sensitive to when residents live in urban mixed-use neighborhoods.

2.6.2.3 SOV diversion

Household single-occupant vehicle (SOV) travel is reduced to achieve bike and micro-transportation input policy goals, i.e., for diverting a portion of SOV travel within a 20-mile tour distance (round trip distance). This allows evaluating the potential for light-weight vehicles (e.g. bicycles, electric bikes, electric scooters) and infrastructure to support their use, in reducing SOV travel. First, the amount of the household's VMT that occurs in SOV tours having round trip distances of 20 miles or less is estimated. Then the average trip length within those tours is estimated. Both models are sensitive to household characteristics(drivers, income, kids), vehicle ownership (auto sufficiency), and attributes of the neighborhood (population density, dwelling type) and metropolitan area (urban mixed-use, freeway lane-miles) where the household resides, and the household's overall VMT.

The diversion of these short trips is assumed to only apply in urban and town location types. The VMT reductions are allocated to households as a function of the household's SOV VMT and (the inverse of) SOV trip length. In other words, it is assumed that households having more qualifying SOV travel and households having shorter SOV trips will be more likely to divert SOV travel to bicycle-like modes. The estimates of the household's share of diverted VMT, average trip length of diverted VMT are applied elsewhere to reduce DMVT and increase bike trips. Zero vehicle households are not allowed to divert SOV travel. Census PUMS data is used to estimate the models.

2.6.2.4 DVMT reductions

Each household's VMT is adjusted for their TDM program(s) participation, if any, as well as input from metropolitan area short-trips SOV diversion goals. The SOV diversion also increases bike trips (diverted SOV VMT divided by SOV average trip length).

2.6.3 Vehicles, fuels and emissions

The powertrains, fuels, and associated emissions datasets for all modeled vehicle groups are among the most complex inputs used in VisionEval. Default datasets are included in the VisionEval installer to simplify this for the user. The user can use these defaults or develop their own data that matches the VisionEval input requirements. It is anticipated that different datasets will be developed by users that can be shared with the VisionEval community. For example, one package may represent a base scenario of federal vehicle, fuel, and emission standards, while another package represents the California zero-emissions vehicle (ZEV) rules and low carbon fuel for the home location's car service.

The model looks in household vehicle sales tables indexed by vehicle type and age to determine the probability of each powertrain in that sales year, along with its associated fuel efficiency and other attributes. Each household vehicle is assigned attributes consistent with these probabilities. In some cases electric vehicles (EVs) are replaced by plug-in hybrid electric vehicles (PHEVs) if household VMT and residential charging limitations exist.

The powertrain mix of non-household vehicle groups – car service, commercial service, transit, and heavy trucks – is applied to VMT (rather than individual vehicles) in the scenario year (rather than sales year). There is some input adjustment for average vehicle age and commercial vehicle type share.

Fuels for each vehicle groups can rely on the package defaults, or use one of two input options. The user can either provide a composite carbon intensity representing all gallons of fuel used for that vehicle group, or provide fuel mix shares (base fuel mix, biofuel blend proportions), combined with package default lifecycle (well-to-wheels) carbon intensity for the individual fuels. The resulting carbon intensity per gallon are applied to gallons generated from VMT and vehicle fuel efficiency assumptions. Adjustments to fuel efficiency due to reduced speeds due to congestion as well as ITS operational programs (e.g., speed smoothing) and EcoDrive programs.

The table below summarizes the vehicle and fuel options available within VisionEval.

Vehicle Group	Vehicle Types	Powertrain Options	Veh Input Adjustments	Fuel Options
Household Vehicles	automobile, light truck	ICE, HEV, EV, PHEV	(default veh mix), age, %LtTrk	gas/ethanol, diesel/biodiesel, CNG/RNG
Car Service VMT	automobile, light truck	ICE, HEV, EV	veh mix, age (HH %LtTrk)	gas/ethanol, diesel/biodiesel, CNG/RNG
Commercial Service VMT	automobile, light truck	ICE, HEV, EV	veh mix, age, %LtTrk	gas/ethanol, diesel/biodiesel, CNG/RNG
Heavy Truck VMT	heavy truck	ICE, HEV, EV	veh mix	gas/ethanol, diesel/biodiesel, CNG/LNG
Public Transit VMT	van, bus, rail	ICE, HEV, EV	veh mix	gas/ethanol, diesel/biodiesel, CNG/RNG

Note that individual vehicles are modeled for households, based on sales year default datasets and age of the owned vehicle. Other groups' vehicle and fuel attributes apply to VMT in the scenario modeled year. As a result, PHEVs do not exist other than household vehicles, instead PHEVs are represented as miles driven in HEVs and miles in EVs.

Watch a video overview of vehicles, fuels, and emissions

2.6.3.1 Household vehicle table

The household vehicle table is generated in two steps:

1. *Create Vehicle Table:* A vehicle table is created with a record for every vehicle owned by the household, and additional vehicle records are added to reach the household's number of driving age persons. Each vehicle record is populated with household ID and geography fields (Azone, Marea) and access time attributes. Each vehicle record is either "own" or (driving-age person without a vehicle) assigned access to a car service level, depending upon coverage in the household's home Bzone.
2. *Assign Vehicle Type:*. Identifies how many household vehicles are light trucks and how many are automobiles as a function of number of vehicles, person-to-vehicle and vehicle-to-driver ratios, number of children, dwelling unit type, income, density, and urban mixed use data (in metropolitan areas only).

2.6.3.2 Powertrains and fuels defaults

These values are defined in two steps:

1. *Load Default Values:*. This script, run before the rest of VisionEval is started, reads and processes the default powertrains and fuels files in the package and creates datasets used by other modules to compute fuel and electricity consumption, and well as associated fuel and electricity carbon intensity emissions from vehicle travel.
2. An *Initialize* step is run by VisionEval as part of its initialization on each run. Optional user-supplied vehicle and fuel input files, if any, are processed (including input data checks). When available, modules that compute carbon intensities of vehicle travel will use the user-supplied data instead of the package default datasets.

2.6.3.3 Assign household powertrains and fuels

The powertrain and fuel type is assigned to each vehicle in each household in three steps:

1. *Assign Vehicle Age:* Assigns vehicle ages to each household vehicle and car service vehicle used by the household as a function of the vehicle group (household vehicles only), household income, and assumed mean vehicle age by vehicle type and Azone. The age model starts with an observed vehicle age distribution and relationship between vehicle age and income. These data are currently based on summaries of the 2001 NHTS.

Adjustments are made based on user average vehicle age inputs (household by vehicle type, car service overall).

2. *Assign Household Vehicle Powertrain:* This module assigns a powertrain type to each household vehicle. The age of each vehicle is used with default tables by vehicle type that identify the powertrain mix of vehicles sold in each sales year. Other default tables identify vehicle characteristics tied to powertrain that include battery range, fuel efficiency, and emissions rate. Assignments of EVs may be changed to PHEVs if the battery range is not compatible with estimated day-to-day trip lengths, or the home dwelling lacks vehicle charging availability.
3. *Calculate Carbon Intensity:* This module calculates the average carbon intensity of fuels (grams CO2e per megajoule) by vehicle group and, if applicable, vehicle type. Average fuel carbon intensities for transit vehicle modes are calculated by metropolitan area, other vehicles are calculated for the entire model region. The module also reads the input average carbon intensity of electricity at the Azone level.

2.6.3.4 Assign non-household powertrains and fuels

The assignment of powertrain and fuel characteristics is carried out in two steps:

1. *Calculate Transit Energy And Emissions:* This module calculates the energy consumption and carbon emissions from transit vehicles in urbanized areas. Assumptions (package default or user input) on powertrain mix and fuels for three transit vehicle types by metropolitan area are applied to associated Marea transit service miles for these types. Assumptions (package default or user input) on average carbon intensity of fuel and electricity by transit vehicle types are then applied to Marea fuel and electricity usage across types to calculate carbon emissions.
2. *Calculate Commercial Energy And Emissions:* The energy consumption and carbon emissions of heavy trucks and commercial service VMT (no vehicles) are calculated by on-road (not sales) year. VMT shares of Commercial Service powertrains by vehicle type and heavy truck powertrains are calculated (per package default or user input). Any fuel efficiency (MPG and MPKWH) adjustments are then applied, due to policies (Eco-Driving, speed smoothing and/or congestion (including effects of any ITS operational and congestion fee policies). Ecodriving applies only to internal combustion engine (ICE) vehicles and ITS operational policies and congestion apply only in metropolitan areas. Both vary by powertrain and for commercial vehicles, vehicle type. Combining fuel efficiency and VMT (from the Household Multimodal Travel Model) results in estimates of energy usage (fuel and electricity). Fuel carbon intensity for these modes is calculated by metropolitan area and/or region and applied to fuel and electricity usage to estimate CO2e emissions.

2.7 Adjustments

2.7.1 Congestion adjustments

Congestion, only calculated on urbanized roads (a subset of metropolitan area roads, requires estimating and combining together the VMT of all vehicle groups. For non-household vehicles, base year VMT is calculated directly from inputs and model parameters, while future year is a function of the input growth basis. Initial allocations of DMVT across road class] is based on input values.

Light duty vehicle (LDV) VMT is allowed to re-allocate between freeways and arterials to balance demand (VMT) and roadway supply (lane-miles) through a generalized cost framework (including roadway speed and congestion fees, if any). Roadway supply (i.e., capacity) is adjusted by delay-reducing ITS operations policies based on fuel-speed curves by powertrain, the resulting congested speeds impact vehicle fuel efficiency. Further adjustments are applied to reflect any speed smoothing and EcoDrive programs that may not affect delay but reduce acceleration and deceleration with associated impacts on fuel efficiency.

No fuel efficiency adjustments for congestion or policies are made to non-urban roadway VMT. The delays faced by each household and associated fuel economy impacts are applied to each individual household's VMT and vehicles. Resulting overall average speeds, delays, and DMVT proportions, by road class at each congestion level on urbanized and other roads are also tabulated along with the resulting average per mile congestion fees paid, if any, and overall vehicle hours of delay (VHD) by vehicle group.

Watch a video summary of VisionEval's congestion adjustment

2.7.1.1 Initialize roadway conditions

The roadway conditions in the model are calculated in three steps:

1. *Load Default Road VMT Values:* These calculations are completed before the model run starts. The base year roadway VMT is processed, including light duty vehicle and heavy truck VMT by state and urbanized area as well as VMT proportions by urbanized area, vehicle group (light duty vehicle, heavy truck, bus), and road class. The user can either provide direct inputs for these values or specify a state and/or urbanized area and the model will use default data from the 20xx USDOT Highway Statistics, where available.
2. *Initialize:.* This step is run when the model run is initialized. User inputs used by several modules are read and checked (many with several valid options, proportions sum to 1, consistency, congestion fees increase with congestion level). Some of these values are optional, using default data where not specified. This includes various assumptions on base year VMT within both urbanized area(s) and the full model region, by vehicle group, allocation among road class, growth basis, and assumptions for freight

vehicle groups. It also checks inputs on ITS operational policies and Eco-Driving programs, including any user-specified “other ops” programs and congestion fees (by road class and congestion level).

3. *Calculate Road VMT:* Adds together metropolitan area VMT of all vehicle groups (Households, CarService, Commercial Service, Heavy Truck, Transit) and allocates it across road classes (freeway, arterial, other), limiting it to urbanized area roadways for use in congestion calculations. To do so, several factors are established in the base year. One uses the input growth basis (population, income, household VMT) to estimate future year freight vehicle group (commercial service and heavy truck) VMT (using input base year VMT values by region and Marea, if provided, model-estimates otherwise). A second base year factor identifies the urban and non-urban allocation of VMT from metropolitan area households and related commercial service vehicles. For Heavy Trucks VMT an input specifies the proportion of VMT on urbanized roads while transit VMT (of all transit service modes) is assumed to only occur on urbanized roads. Base year allocations of urban VMT by vehicle group among road classes are based on input shares, subject to adjustment during subsequent congestion calculations. Finally, to assess delay faced by each household and associated fuel efficiency impacts, each individual household’s VMT is split between miles on urbanized and other road miles.

2.7.1.2 Congestion model and adjustments

Three adjustments are made based on congestion levels:

1. *Calculate Road Performance:* Congestion level by road class and the associated amounts of VMT are iteratively estimated. Light duty vehicle (LDV) VMT is allowed to re-allocate between freeways and arterials to balance demand and roadway supply (lane-miles) through a generalized cost framework (including roadway speed and congestion fees, if any and an estimated base year urbanized area lambda parameter based on the area’s population and freeway-arterial lane-mile ratio). DMVT allocation at different aggregate demand-supply ratios relies on data from the 2009 Urban Mobility Study (UMS) for 90 urbanized areas, where the model chooses the 5-10 cities with most similar congestion ratios.

   The supply calculation considers the delay-reduction effects of deploying urban area ITS operations programs (freeway ramp metering, freeway incident management, arterial signal coordination, arterial access control or user-defined “other ops” programs. The standard ITS-operations program impacts are based on research (Bigazzi & Clifton 2011). Non-urban speeds are also calculated, using a simple ratio of rural-to-urban travel volumes.

   The resulting average speeds, delay and DMVT proportions, by road class at each congestion level on urbanized and other metropolitan area roads are calculated, as is the resulting average per mile congestion fees paid, if any, and overall VHD by vehicle group.

2. *Calculate Mpg Mpkwh Adjustments:* Adjustments to fuel efficiency (MPG and MPKwhr) for all vehicle groups resulting from traffic congestion, congestion fees, ITS speed smoothing (i.e. active traffic management which reduces speed variation), and EcoDriving are calculated. The fuel-speed curves vary by road class, congestion powertrains (LdIce, LdHev, LdEv, HdIce) and, where applicable, vehicle type relative to reference speeds by road class. The adjustments are based on drive-cycle level simulation research (Bigazzi & Clifton 2011). Note that no adjustments are made for ITS policies (standard and speed smoothing policies) or EcoDrive programs on 'other' road classes (non-freeway or arterials) and non-urbanized roads, which are assumed to be uncongested.

3. *Adjust Household Vehicle MPg Mpkwh:* Implements the fuel efficiency (MPG and MPKwh) adjustments of household vehicles (including Car Service VMT), reflecting the effects of congestion, congestion fees, ITS speed smoothing, and eco-driving that were calculated elsewhere. These adjustments vary by vehicle powertrain, vehicle type, and the proportion of the household's travel that is driven on urban and non-urban roads within the metropolitan area. Joint effects are calculated as the product of congestion speed effects and the maximum of implemented speed-smoothing policies (eco-driving & ITS-speed smoothing).

2.7.2 Household costs and budgets

Two adjustments are made in response to household budgets. Vehicle ownership costs are calculated and an adjustment is made to the number of household owned autos if the costs are greater than switching to a 'High' level car service, where available (subject to input limits on car service substitutability). Vehicle ownership costs include financing, depreciation, insurance (unless in PAYD program), annual registration fees, and residential parking fees.

Additionally, in order to respond to pricing policies and energy costs, VisionEval imposes an operating cost budget limitation. Household VMT is constrained such that annual vehicle operating costs must stay below a maximum share of annual household income, or budget limit. A household-specific average annual vehicle operating costs is first calculated, including out-of-pocket per mile costs for each household owned and car service vehicles used by the household, as well as time-equivalent cost (input access times, estimates of VMT at congested speeds, and value of time input). Vehicle operating costs determine the proportional split of VMT across household vehicles. Out-of-pocket costs include the energy, maintenance, repair, & tires, road use taxes (including EV surcharge and optional calculation of fee to fully recover road costs), work/non-work parking, PAYD insurance, input share of carbon and other social costs, as well as car service fees by the household. Note that time-equivalent costs are only used to allocate travel between household vehicles (including car services used by the household). Time-equivalent cost is not used in the balancing of household vehicle operating cost and budget.

The following sections describe each module that contributes to this concept.

Watch a video overview of costs and budgets

2.7.2.1 Auto Ownership Cost & Adjustment

Two steps are required to calculate and adjust auto ownership costs:

1. *Calculate Vehicle Own Cost:* Average Vehicle ownership costs are calculated for each vehicle based on the vehicle type, age, and annual VMT (financing, depreciation, and insurance), annual registration fees (flat and ad valorum), combined with any residential parking costs (if household exceeds free parking limits). To do so, PAYD insurance participation is assigned based on household characteristics (drivers by age, annual mileage, income, location type, vehicle type and age) and input PAYD insurance program participation. The ownership cost is converted into an average vehicle-specific ownership cost per mile by dividing by estimated household VMT per vehicle.

Note that PAYD insurance does not affect the cost of vehicle ownership when determining whether a household will substitute car services for one or more of their vehicles. It does affect the out-of-pocket operating cost used in budget limitations on household VMT.

2. *Adjust Vehicle Ownership:* Household vehicle ownership is adjusted based on a comparison of the cost of owning versus ‘high’ car service per mile rates, where available. The module identifies all household vehicles in a ‘High’ car service area, where the car service mileage rate exceeds the household’s estimated vehicle ownership cost per annual household VMT. The household’s vehicle table entry changes from ‘Own’ to ‘HighCarSvc’ for these vehicles, limited by input assumptions regarding the average likelihood that an owner would substitute car services for a household vehicle (separate values are specified by vehicle type). Other auto ownership values are also updated (e.g., insurance, total vehicles).

2.7.2.2 Auto Operating Cost & Adjustment

Three primary adjustments adjustments to auto operating cost are carried out in VisionEval:

1. *Calculate Vehicle Operating Cost:* A composite per mile cost is calculated as an out-of-pocket cost for various household and car service vehicle VMT (see below), combined with cost equivalent of travel time (access time and travel time at congested speeds times value of time (VOT)). Total costs result from applying this vehicle-specific cost rate to each vehicle’s VMT, where VMT is split among household vehicles (including car services used

by household members) as a (reciprocal) function of this vehicle-specific composite cost rate:

- **Vehicle maintenance, repair, and tire cost (MRT)** costs are calculated as a function of the vehicle type, powertrain and vehicle age based on data from the American Automobile Association (AAA) and the Bureau of Labor Statistics (BLS).
- **Fuel and energy costs** are calculated as energy rates time average fuel efficiency (miles per gallon or Kwhr electricity).
- **Gas taxes** are federal, state and local per gallon taxes to cover road costs. For Electric vehicles, an equivalent per mile cost is calculated and can be applied to some or all electric vehicles ($/gallon or EV vehicle surcharge tax).
- **Other Road Cost Recovery taxes** (i.e. VMT tax) is a user input. If the (optional) `BalanceRoadCostsAndRevenues` module is run, an extra VMT tax is calculated that recovers household share of road costs, consistent across all model households.
- **Congestion fees** are calculated average congestion price ($/mile) for travel on urbanized roads in the Marea multiplied by the proportion of household travel occurring on those roads.
- **Carbon fee** and **other social cost fees** are carbon cost per mile is calculated as the input carbon price times the average household emissions rate (grams/mile), a VMT-weighting of all vehicles in the household. Of the other social costs, some are per gallon (non-EV vehicle miles) others per mile (regardless of powertrain). The full per mile costs are discounted to only reflect the input proportion of social cost paid by user.
- Daily **parking costs** from work parking costs (workers who pay for parking) and other parking cost (cost of parking for shopping, etc.) are summed and divided by the household DMVT. Note that residential parking costs are included in the vehicle ownership not per mile cost calculations.
- **Pay-as-you-drive (PAYD) insurance** is defined for participating households as the sum of the annual insurance cost for all the household vehicles is divided by the annual household VMT.
- **Car-service costs** are the cost of using a car service (dollars/mile) is a user input by car service level (Low, High).

2. *Balance Road Costs And Revenues:* Optionally, an extra mileage tax ($/mile) for household vehicles needed to make up any difference in the cost of constructing, maintaining, and operating roadways and the revenues from total road cost fees including fuel, VMT, and congestion charges. Optionally, an additional mileage fee ($/mile) on household travel is calculated that would fully pay for roadway costs attributable to household vehicle travel. The cost of existing and new freeway and arterial lane-miles by Marea is calculated from the difference in input lane-miles relative to the base year and input unit road costs (constructing, maintaining, and operating). Reductions in lane-miles are ignored. The proportion of road

costs attributable to households is set as the ratio of household VMT divided by the sum of household (including CarService), commercial service, and car-equivalent heavy truck VMT (multiply by PCE). Average road taxes collected per household vehicle mile are calculated as a weighted average of the average road tax per mile of each household (calculated by the `CalculateVehicleOperatingCost` module) using the household VMT (calculated by the `BudgetHouseholdDvmt` module) as the weight. Currently no annual fees contribute to road cost recovery.

3. *Budget Household Dvmt:* Household VMT is adjusted to keep within the household's vehicle operating cost budget, based on the historic maximum proportion of income the household is willing to pay for vehicle operations. This proportions varies with income. The household's DMVT is then reduced as needed to keep annual out-of-pocket vehicle operating cost within that share of the household's annual income. Annual vehicle operating costs include the household's VMT times their out-of-pocket per mile vehicle costs, adding credits for selected annual payments (annual work parking fee if in a work parking cash-out-buy-back program, annual vehicle insurance if in a PAYD insurance program, and annual auto ownership costs if car service program reduced auto ownership). The module relies on aggregate survey data from the U.S. Bureau of Labor Statistics (BLS) Consumer Expenditure Survey (CES) for years 2003-2015.

2.8 Processing

VisionEval is designed to be easy to install, run, and summarize, even when comparing scores of different scenarios. It produces consistent and detailed performance metrics. The user can modify the metrics produced by the model or define their own from data exported from the model. There are also several ways to think about validation of the model within the VisionEval mindset. These topics are explored in this chapter.

2.8.1 Running VisionEval

VisionEval is implemented entirely in the R statistical language and operates on recent versions of Microsoft Windows. All development work is done there, although macOS and Linux versions are usually distributed. A fully self-contained installer for the more recent production release of VisionEval can be found on the download page. It permits installation of the full VisionEval platform, to include example data, even behind firewalls that prevent access to R Project and GitHub repositories.

Once installed the user assembles data into a standard directory structure. Once the model run script is customized by the user it is typically run from a command prompt. Running it in this manner allows several different scenarios to be run at the same time with minimal user interaction. The results can then be mined or visualized using a variety of VisionEval and third-party products. Some users use R Shiny or similar interactive environments for summarizing and visualizing the output from VisionEval. Such an environment is especially useful when comparing key metrics from a large number of scenarios.

2.8.2 Typical outputs

VisionEval generates a large set of performance metrics at varying summary levels. Several pre-defined metrics are compiled for mobility, economic, land use, environmental, and energy categories in each model run. They can be tabulated for individual scenarios or compared to other scenarios, as well as visualized using a variety of tools.

The intermediate data generated during the various VisionEval module steps can be compiled as performance metrics, both in absolute and per-capita terms and at various geographies. Traditional transportation network metrics such as VMT, vehicle and person hours of travel, and total delay are easily compiled by overall or focused areas within the model. Likewise, emission estimates and fuel consumption are tabulated. These can be viewed in standard reports or in `VEScenarioManager` files, especially when comparing such values between scenarios.

One example of a set of region-wide performance metrics used by Oregon DOT includes:

- Mobility
  - Daily per capita VMT
  - Annual walk trips per capita
  - Daily Bike trips per capita
- Economy
  - Annual all vehicle delay per capita (hours)
  - Daily household parking costs
  - Annual HH vehicle operating cost (fuel, taxes, parking)
  - Annual HH ownership costs (depreciation, vehicle maintenance, tires, finance charge, insurance, registration)
- Land Use
  - Residents living in mixed use areas
  - Housing type (SF: MF)
- Environmental
  - Annual GHG emissions per capita
  - HH vehicle GHG/mile
  - Commercial vehicle GHG/mile
  - Transit Vehicle GHG/mile
- Energy
  - Annual all vehicle fuel consumption per capita (gallons)
  - Average all vehicle fuel efficiency (net miles per gallon)
  - Annual external social costs per households (total/% paid)

2.8.3 Exporting data

Most of the data generated during a VisionEval model run can be exported (using exporter.R) if desired for further analyses. The user can then mine and visualize the data using a variety of open source and proprietary tools. This provides the user with considerable flexibility for creating more detailed statistics than those provided by the program. These VisionEval outputs might further serve as inputs to other models (e.g., emissions models, economic impact models) and visualization tools, and compilation of additional performance metrics.

2.8.4 Validation

Setting up the model includes the steps required to apply the model for a given study. It is somewhat related to validation, both for informing what types of studies that VisionEval are appropriately sensitive to and interpreting the results. See the Getting Started page on the wiki for an overview of getting started initially.

Validation is the assessment of a model's suitability for its intended purpose, often informed by comparisons against information not used in its original development. In traditional transportation planning models the comparison of observed versus modeled link flows is often a key component of validation. VisionEval is a data-driven model in that most of its inputs values are exogenously defined rather than emergent behavior from complex mathematical equations. Its aggregate representation of travel demand dictates that it be validated at the same level, with an emphasis on a wider number of comparisons than many traditional models.

The metric used in validation can range from relatively few, such as per-capita mobility estimates (e.g., VMT and VHT by mode), to a large number of more detailed targets. Examples of the latter include comparisons to external sources (e.g., HPMS data, DMV data), sensitivity tests of key variables, and comparison to comparable communities. An example of detailed validation criteria used by the Oregon DOT provides examples of these targets.

There are several options for making adjustments in order to calibrate and validate the models. These adjustments vary in difficulty, and the most appropriate approach varies by module. From easiest to most difficult the options for making adjustments are:

- *Self-calibration:* Several of the modules are self-calibrating in that they automatically adjust calculations to match input values without intervention by the user.[Selected value should be validated to confirm the calculations are done correctly]
- *Adjustment of model inputs:* Some modules allow the user to optionally enter data that can be used to adjust the models to improve their match to observed conditions.
- *Model estimation data*: Several modules use data specific to the region

where the model is deployed, such as household synthesis. Functions within each module generate cross-tabulations required from these data. Census PUMS data from Oregon were used to develop the original models, and should be replaced with PUMS data for the modeled area.

- *Model estimation scripts:* An advanced user or developer can make adjustments to the model code itself in order to facilitate better matching observed local behavior or patterns. This, of course, is the most difficult option and opens up potential for significant errors, but it is possible for users that know what they are doing.

The main validation targets have historically included household income, vehicle ownership, vehicle miles of travel, and fuel consumption. The number of workers and drivers within each geography have recently become more widely used. These statistical comparisons can be made for the modeled area as a whole or for large geographies nested within them (e.g., Azones, Mareas). Sensitivity tests should be performed to evaluate the reasonableness (eg. correct direction and magnitude) of the VisionEval output estimates. Comparable community applications of VisionEval may also provide a reasonableness check that the model is functioning appropriately.

Note that HPMS definition of VMT differs from that used in VisionEval. VisionEval reports on all household travel regardless of where it occurs, and adds Commercial vehicle and Heavy Duty Truck and Bus travel on MPO roads. HPMS reports vehicular travel of all modes on roads within the MPO boundary.

2.9 Lexicon

2.9.1 5D built form measures

The five dimensions considered in designing efficient and sustainable cities include density, design, destination access, distance to transit, and diversity of the built environment. The five dimensions build upon the original 3Ds (density, diversity, and design) advanced by Cervero & Kockelman (1997). These measures are calculated in the `Calculate4DMeasures` module during household synthesis.

2.9.2 access time

The time required to get from the origin to the vehicle (or in the case of car service, the time for the vehicle to get to the traveler) and the time to get from the vehicle to the destination (including time to park the vehicle). These values are defined for vehicles owned by the household and for two levels of car service (low and high availability levels) in each Bzone. These factors are defined in `azone_vehicle_access_times.csv` and used by the `CalculateVehicleOperatingCost` module in the `VETravelPerformance` package. Additional details

2.9.3 age group

VisionEval uses the same age groups used in the U.S. Census: 0-14, 15-19, 20-29, 30-54, 55-64, and 65+ years old. The number of persons in each age group are defined for each synthetic household.

2.9.4 auto sufficiency

Auto sufficiency is achieved when the number of vehicles available to a household is equal to or greater than the number of licensed drivers in a household. A household in "auto insufficient" when that is not true. Zero-auto households are cases where the household has access to a vehicle. In the age of ubiquitous mobility services this definition may become less important in describing mobility options open to the household.

2.9.5 azones

Aggregations of Bzones, often corresponding to county, city, Census named place, or comparable political divisions. Additional details on VisionEval model geography levels.

2.9.6 bus-equivalent-miles

The total bus revenue miles for a transit system are divided by the assumed transit vehicle type capacities to arrive at bus-equivalent miles of service. The total bus revenue miles for a transit system are divided by the population of the enclosing Marea(s) to compute per capita bus-equivalent miles. Additional details

2.9.7 bzones

The smallest levels of geography coded in VisionEval, and often correspond to Census tracts or block groups. In most instances the Bzones are larger than traffic analysis zones used in traditional travel demand forecasting models. Additional details on VisionEval model geography levels.

2.9.8 carbon intensity

A emissions measure in grams of carbon dioxide equivalents per megajoule of energy. VisionEval uses a "well-to-wheels" estimate that takes into account not only the emissions resulting from the use of the fuel ("tank-to-wheels" measures) but also the carbon emissions required to produce and transport the fuel it where it is purchased by consumers. Default values are estimated from various sources in VisionEval. The user can specify different values. These values are used in several places in the `VEPowertrainsAndFuels` package. Additional details

2.9.9 carbon price

A carbon price in dollars per ton is used to estimate part of the social cost of emissions in the `CalculateVehicleOperatingCost` module of the `VETravelPerformance` package. Additional details

2.9.10 car service

Car services are a specific mode used in VisionEval models treated as vehicles available to the household. Car services can be considered a synonym for popular ride-sharing services provided by mobility-as-a-service (MaaS) companies. VisionEval distinguishes between two levels of car service, categorized as “high” or “low” level service. Users can define different attributes for each level of car service. Notably, households in areas with a “high” level of car service, car service will be competitive with vehicle ownership. Users can define the car service substitution probability.

2.9.11 car service level

Car services include taxis, car sharing services (e.g. Car-To-Go, Zipcar), and future automated taxi services. A high car service level is one that has vehicle access times (time to walk between car and origin or final destination) that are competitive with private car use. High level of car service is considered to increase household car availability similar to owning a car. Low level car service, approximates current taxi service does not have competitive access time and is not considered as increasing household car availability.

2.9.12 car service substitution probability

Average likelihood that an owner would substitute car services for a household vehicle (separate values by vehicle type. For example, if the user assumes that only a quarter of light truck owners would substitute car services for owning a light truck (e.g. because car services wouldn’t enable them to use their light truck as they intend, such as towing a trailer), then the light truck substitution probability would be 0.25.

2.9.13 cash-out/buy-back program

Parking cash-out schemes are an employee benefit that enables them to accept taxable cash income in lieu of paid or subsidized parking at the workplace. The cash-out is sometimes combined with discounted transit passes in some places. It is used as an inducement to reduce commuting by auto, especially in single-occupant vehicles. FHWA has an excellent primer on the topic, while many consider Donald Shoup’s online book a definitive resource on the topic.

2.9.14 Census PUMS

The Public Use Microsample (PUMS) data are anonymized long form responses from the American Community Survey (ACS) that enable custom tabulations, summaries, and visualizations. The PUMS were formerly associated with each dicennial Census of Households and Population. The samples are anonymized by assigning each to a Public Use Microdata Area (PUMA) of 100,000 or more households. Several multi-dimensional summaries used in model estimation are gleaned from the PUMS that cannot be obtained from other Census data. Data indexed along these multiple dimensions permit the PUMS data to be fused with travel survey data and to create synthetic populations. ACS PUMS data from 2005-19 in annual increments can be accessed from the PUMS website. Data from 1996-2004 can be accessed separately.

2.9.15 commercial service

The use of vehicles by firms and government agencies for non-personal travel other than the delivery of freight. (e.g., parcel delivery, business meetings, sales calls). Both automobiles and light trucks can be used for commercial services, and are defined both in terms of powertrain and fuel type (gasoline, diesel, or compressed natural gas). Additional details

2.9.16 congestion fee

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. The input is the average amount paid per mile in congestion pricing fee. This is an input to the `CalculateRoadPerformance` module in the `VETravelPerformance` package. Additional details

2.9.17 congestion level

Five levels of congestion – none, moderate, heavy, severe, and extreme – are estimated within each Marea by comparing relative roadway supply with the aggregate level of daily VMT (demand). Lookup tables are then used to estimate average speeds and delay for freeways and arterials. The effects of four standard operations programs (freeway ramp metering and incident management, arterial signal progression and access control) and optional user-defined programs are included in the calculations. The calculations are carried out in the `CalculateRoadPerformance` module of the `VETravelPerformance` package. Additional details

2.9.18 development type

NEED MORE INFO The mixing of jobs and housing

2.9.19 dwelling unit type

Each household inhabits a dwelling unit that is either a single-family dwelling, a multi-family dwelling, or group quarters. Additional details

2.9.20 EcoDrive

A term used to describe energy efficient use of vehicles in order to reduce fuel consumption and emissions. Primarily a European pursuit, EcoDriving involves changes to vehicular technology, vehicle navigation and automation systems, and driving techniques. Factors expressing the degree of EcoDriving adoption are applied in the `CalculateMpgMpkwhAdjustments` module of the `VETravelPerformance` package. Additional details

2.9.21 employee commute options program

A voluntary employer-based program aimed at reducing solo commutes by automobile using strategies and incentive tailored towards each specific organization. Strategies range from providing information and management encouragement to use alternative modes of transportation to cash incentives. Cash-out/buy-in programs are one example of the latter. A massDOT guidebook provides extensive information about such programs. In some states such programs are mandatory for large employers. Information on Oregon's Employee Commute Options program includes information about conducting employee surveys to demonstrate progress towards commuting trip reduction targets.

2.9.22 employment rate

The employment rate is the number potential workers aged 17 and over divided by the total number of persons in the Bzone. Note that it is a calculated rate based on zonal attributes, and is a proxy for the labor force participation rate.

2.9.23 employment type

Zonal employment estimates in VisionEval are made for retail, service, and total employment categories. The delineation of retail and service employment is typically by the two-digit sectors in the North American Industrial Classification System (NAICS). The NAICS system is widely used in most governmental reporting systems.

2.9.24 EV surcharge

Some states impose a tax on electric vehicles beyond sales tax and vehicle registration fees to make up for the shortfall in gasoline sales tax revenue they might otherwise contribute towards the costs of roadway infrastructure. The methods and rates vary considerably, with some EV owners paying more in sales tax and EV surcharges than most owners of conventional autos. The EV surcharge can be accounted for in the `CalculateVehicleOperatingCosts` module in the `VETravelPerformance` package. Additional details

2.9.25 freeway lane-miles

The sum of the number of lanes multiplied by the length of each freeway segment within a metropolitan area (Marea). The lane-miles of arterials are calculated separated (see roadway lane-miles. Both are created in the `AssignRoadMiles` module of the `VETransportSupply` package. Additional details

2.9.26 freight vehicle groups

see vehicle groups

2.9.27 fuel efficiency

VisionEval does not simulate driving cycles so uses measures of relative fuel efficiency derived from the USEPA's Physical Emission Rate Estimator (PERE) for different vehicle powertrains during congested conditions. The user-supplied values in `congestion_efficiency.csv` define the congestion performance of each powertrain relative to best (1.0) and worst (0.0) values. The data are used in the `LoadDefaultValues` module in the `VEPowertrainsAndFuels` package. Additional details

2.9.28 fuel-speed curves

A set of exogenously calculated adjustments to the average fuel economy of vehicles as a function of the vehicle type (light-duty or heavy-duty), powertrain, and roadway type. The curves and their derivation are described by Bigazzi & Clifton (2011).

2.9.29 growth basis

The growth in commercial and heavy truck travel over time increase at the same rate as the population does, as firms and establishments are not explicitly modeled in VisionEval. Future year daily VMT is calculated as a function of population or income from heavy trucks or population, income, or household daily VMT for commercial service. Additional details

2.9.30 heavy truck

A single class of heavy trucks are used to represent all commercial vehicles larger than the light duty trucks included in the commercial service vehicles. The same vehicle operating and emissions parameters specified for other vehicle groups are defined for heavy trucks, and their impacts are calculated in several VisionEval packages.

2.9.31 individualized marketing programs

Education and public outreach efforts designed to encourage voluntary travel behavior changes. Rather than using broad messages for the entire population this approaches targets specific groups of travelers with information more relevant to them. A concise fact sheet describes its implementation in Oregon. Dill & Mohr (2010) investigate the long-term effectiveness of such programs.

2.9.32 intelligent transportation systems (ITS)

Systems that integrate information, communications, and advanced vehicular technologies into transportation infrastructure, maintenance, and operations programs to improve mobility and safety. ITS programs are typically centrally controlled by transportation agencies rather than individually autonomous solutions like personal navigation systems. Examples of ITS systems include traveler information systems (e.g., 511 systems, variable message signs), adaptive traffic signal systems, ramp metering, and electronic toll collection.

2.9.33 ITS

see [intelligent transportation systems](#intelligent-transportation-systems}

2.9.34 lambda parameter

The assumed split of light-duty household and commercial service vehicles between freeways and arterials is calculated dynamically as the ratio of the respective average travel speeds and an urbanized area specific factor (lambda). The latter adjusts the raw ratio of speeds to match observed percentages using data from 90 urbanized areas. The calculation is carried out in the `CalculateRoadPerformance` module. Additional details

2.9.35 licensure rate

The percent of adults aged 17 and over that possess a drivers license, summarized from the PUMS data for the modeled region.

2.9.36 lifecycle

A label used to describe the stage of life that a household's members are at. This is guessed at in VisionEval as a function of the number of adults, children, and workers in the household. This is assigned in the `AssignLifeCycle` module. It assumes one of 10 values defined in the 2009 NHTS LIF_CYC variable Additional details

2.9.37 location type

Each household is classified by whether its enclosing Bzone is located in an urban, town, or rural area. The `location_type` variable is defined for each Bzone. Additional details

2.9.38 metropolitan area (Marea)

In VisionEval a metropolitan area (Marea) is a collection of Azones that define a unique urbanized area with shared characteristics such as freeway lane-miles and transit revenue-miles. In some cases a transit service area might define a metropolitan area rather than political boundaries. Additional details on VisionEval model geography levels.

2.9.39 mixed use

see urban mixed-use

2.9.40 National Household Travel Survey (NHTS)

The NHTS collects household and traveler information and travel diaries from a random sample of U.S. households. The 2017 survey collected data from 26,000 households selected nationwide and an additional 103,112 additional "add-on" samples purchased by nine states and four regional and metropolitan planning agencies. The information collected is comparable to the data collected in bespoke household travel surveys. The latest year for which NHTS data are available is 2017, with seven prior surveys dating to 1969 conducted before it. Publicly available data are available with reduced geographic detail (i.e., households only coded to state and place size ranges) for 2017 and prior years. VisionEval was developed using the public use NHTS data from 2001, while the Multimodal Travel package was developed using confidential 2009 NHTS data.

2.9.41 NHTS

see National Household Travel Survey

2.9.42 Non-institutional group quarters

Persons living in non-institutional group dwellings (e.g., college dormitories, halfway houses). Persons living in institutional group dwellings are not included in VisionEval, and include hospital patients, prison inmates, and military barracks.

2.9.43 out-of-pocket cost

The variable costs of automobile usage are considered out-of-pocket costs. They are often considered the perceived cost of using automobiles. In VisionEval they include the cost of fuel and parking or the cost of using CarService. The out-of-pockets are a subset of the auto operating costs.

2.9.44 parking costs

Parking costs in VisionEval are trip-based costs, 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. 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. This includes fees for parking at workplace (including cash-out policies) and for non-work trips. Parking fees are a subset of parking restrictions. Parking fees can be paid for residential, workplace, or other destinations.

2.9.45 parking restrictions

Parking restrictions and fees affect households at their places of residence and work, as well as other places they travel to within the modeled area. This information is coded at the Bzone level and typically includes the average number of free parking spaces by dwelling unit type (single family, multi-family, and group quarters), the average daily parking cost, and proportion of workers who pay for parking or participate in a cash out-buy back program. Parking restrictions are used for Azones that are members of a defined metropolitan area (Marea) within the model. Additional details

2.9.46 pay-as-you-drive (PAYD)

An insurance program, also known as usage-based insurance, whose premiums are based on actual usage of the insured vehicle as well as how well you drive. It is viewed by some as the emerging standard in insurance. Using a PAYD assumption in VisionEval enables the analyst to more precisely calculate auto ownership cost based on household daily VMT estimates. The proportion of households using PAYD are included in the calculations carried out by the `CalculateVehicleOwnCost` module. Additional details

2.9.47 passenger car equivalents (PCE)

A factor that indicates the number of light-duty vehicles that a heavy truck is equivalent to in terms of vehicle length and lane usage when calculating roadway capacity. It is used in the `BalanceRoadCostsAndRevenues` module of the `VETravelPerformance` package. Additional details

2.9.48 place type

NEED DEFINITION

2.9.49 powertrain

VisionEval uses detailed operating and emissions characteristics from several different types of vehicular powertrains, enabling scenarios to be quickly assembled with different assumptions about their mix in future years. Four powertrain types are presently defined in VisionEval: internal combustion engines (ICE), hybrid electric vehicles (HEV), plug-in hybrid electric vehicles (PHEV), and battery electric vehicles (BEV). The powertrain is assigned to each household vehicle in the `AssignHhVehiclePowertrain` module.

2.9.50 regular households

Related and unrelated persons living in the same dwelling unit, but not including persons living in non-institutional group quarters

2.9.51 region

The region defines the entire modeled area represented in the model. There is no limit to the size of the modeled region, although sub-state areas, states, andmegaregions are often simulated using VisionEval. Additional details on VisionEval model geography levels.

2.9.52 relative roadway supply

A synthetic measure that divides the total arterial and freeway lane-miles (i.e., the sum of the length in miles times the number of lanes for each distinct roadway segment) by the sum of the estimated trip lengths for all households. This calculation is carried out for each Marea and year. Thus, it is a measure that only applies in metropolitan areas defined in the model. This value is calculated in the `AssignRoadMiles` module and is used in several other modules. Additional details

2.9.53 relative transit supply

NEED DEFINITION

2.9.54 road class

The proportion of lane miles that are classified as freeway, arterial, and other roadways. The vehicle miles of travel (VMT) calculated for households, commercial service, and heavy trucks is split between these three classes of roadways in the `LoadDefaultRoadDvmtValues` module of the `VETravelPerformance` package. Additional details

2.9.55 road costs

This includes costs for roadway expansion, other modernization projects, preservation, operations, maintenance and administration. VisionEval calculates an average mileage tax for household vehicles needed to make up any differences in the cost of constructing, maintaining, and operating roadways from the revenues from fuel taxes and pricing schemes (e.g., VMT taxes, congestion taxes). The latter are calculated based on assumptions about fuel consumption (a function of total daily VMT) and fuel efficiency. While VisionEval adds this to the auto operating costs of households it is important to note that such costs might not be passed on by governments in future years as assumed by VisionEval. The road costs and revenues are reconciled in the `BalanceRoadCostsAndRevenue` module in the `VETravelPerformance` package. Additional details

2.9.56 road lane-miles

The sum of the number of lanes multiplied by the length of each arterial roadway segment within a metropolitan area (Marea). The lane-miles of freeways are calculated separated (see freeway lane-miles. Both are created in the `AssignRoadMiles` module of the `VETransportSupply` package. Additional details

2.9.57 road use taxes

see road costs

2.9.58 short-trip SOV diversion

The `DivertSovTravel` module reduces travel in single-occupant vehicles (SOVs) to account for assumed availability of solo travel alternatives such as bicycles (traditional and electric) and scooters. The user inputs a goal for diverting a proportion of SOV travel within a 20-mile round-trip distance (i.e., for trips longer than 10 miles in one direction). Additional details

2.9.59 social costs

Present and future generations bear costs due to the impact of transportation that are not fully recouped through auto operating costs or auto ownership costs, such as the costs of abating pollution, security and safety costs, and noise. VisionEval includes these costs in their full-cost accounting approach to calculating costs and benefits. The social cost parameters are defined as inputs to the `CalculateVehicleOperatingCost` module in the `VETravelPerformance` package. Additional details

2.9.60 speed smoothing

A traffic management action or design that reduces the speed variation on freeways and arterials. Note that the introduction of autonomous vehicles will likely achieve this effect even when they only constitute a quarter or more of all vehicles on the roadway (Levin & Boyles 2015, Mahmassani 2016). Thus, speed smoothing might become an important property of future traffic systems that analysts should include in future years even in spite of current local interest in such programs. Additional details

2.9.61 transit d

NEED DEFINITION

2.9.62 transit modes

VisionEval includes eight transit modes, which are also called transit service modes in some places in the documentation. The eight modes include demand-responsive (DR), vanpool and similar (VP), standard motor bus (MB), bus rapid transit and commuter bus (RB), monorail or other automated guideway (MG), streetcar or trolley bus (SR), light or heavy rail (HR), and commuter rail (CR) services. The latter includes specialized CR services such as hybrid rail, cable cars, and aerial tramways. Additional details

2.9.63 transit service level

User-supplied annual revenue miles of service for each of the eight transit modes are translated into bus-equivalents, revenue miles, and ultimately, vehicle miles. The transit service levels are set in the `AssignTransitService` module in the `VETransportSupply` package. Additional details

2.9.64 transit service miles

Bus-equivalent-miles used to compute transit service levels are summed to calculate transit miles by each transit mode. The calculations are carried out in the `AssignTransitService` module in the `VETransportSupply` package. Additional details

2.9.65 transit vehicle type

Different energy consumption and emissions characteristics are defined for vans, buses, and rail transit modes. Additional details

2.9.66 travel demand management (TDM)

Policies and programs used to discourage travel in single-occupant vehicles in order to achieve safer and more efficient multimodal transportation systems.

TDM encompasses a wide variety of initiatives, to include promotion of active transport, public transportation modes, car and bike sharing, and telecommuting. Adjustments in household VMT due to TDM actions are coded in the `BudgetHouseholdDvmt` module in the `VETravelPerformance` package. Additional details

2.9.67 urban mixed-use

A mixed use development or neighborhood is one that includes residential and non-residential land uses in close proximity to one another, allowing for pedestrian access to many desired goods and services. Such places are walkable,"bikeable," and encourage a local economy and strong social connections. From a transportation perspective such places are distinguished by their high degree of accessibility using non-motorized modes (active transport). In VisionEval the proportion of each Bzone that falls into this category can either be specified by the user or calculated by the program. If the latter a random sampling from an asserted distribution is used to define whether a household is in a mixed-use area. The density of the enclosing Bzone weights the probability of a household being so classified (i.e., the higher the density the higher probability of being assigned to a mixed-use neighborhood). These calculations are carried on in the `CalculateUrbanMixMeasure` module of the `VEHouseholds` package. Additional details

2.9.68 urbanized area {urbanized-area}

Collectively the urban, or "metro", location type portion of the metropolitan area (Marea) set of zones. The road, transit and urban mixed use variables only cover this portion of the Marea, which is typically equivalent to a Census urbanized area.

2.9.69 value of time (VOT)

The opportunity cost of the time that a person spends traveling rather than engaged in other activities. In theory it represents what the traveler would be willing to pay in order to reduce their time traveling. It is a surrogate for the value of travel times savings, which attempts to place a monetary value on the benefits of more efficient travel. While often an important parameter along with the equally influential value of reliability in pricing studies (Kockelman et al. 2013, Parsons Brinckerhoff et al. 2013) VOT is an average value in VisionEval. It is used in `TimeCost` calculations in the `CalculateVehicleOperatingCost` module. Additional details

2.9.70 vehicle age

The age of each household vehicle is estimated as a function of vehicle type (auto or light truck), household income, and the assumed average vehicle age coded for each vehicle type and Azone. The vehicle age is assigned in the `AssignVehicleAge` module in the `VEHouseholdVehicles` package. Additional details

vehicle group {#vehicle-group} Different types of vehicles are used in VisionEval by different types of users. Automobiles and light trucks are used by households, car service, and commercial service, and are assigned in the `VEHouseholdVehicles` package. Heavy trucks are treated separately, and three types of vehicles – vans, buses, and rail – are used for transit. Additional details

2.9.71 vehicle hours of delay (VHD)

An aggregate performance measure usually calculated by subtracting vehicle hours of travel under uncontested conditions from total vehicle hours of travel (VHT). Both measures are approximated for each metropolitan area in VisionEval in the `CalculateRoadPerformance` module of the `VETravelPerformance` package. Additional details

2.9.72 vehicle operating costs

A combination of out-of-pocket and travel time costs used to estimate the cost per mile of owning and operating an automobile. These costs include fuel (energy), maintenance, tires, and repairs for all households. In addition, pollution or carbon taxes, parking charges, and pay-as-you-drive (PAYD) insurance costs are included where coded for the household's enclosed Bzone. The costs are calculated in the `CalculateHhVehicleOperatingCosts` module of the `VETravelPerformance` package. Additional details

2.9.73 vehicle ownership costs

The average cost of auto ownership is calculated based upon vehicle type (automobile, light truck) and age using typical cost figures from AAA data. The cost per mile is estimated by dividing the average cost by the household daily VMT estimates produced by the model. A depreciation model is used to adjust this cost based upon the vehicle type, age, and annual miles driven (daily VMT converted into annual miles). The ownership costs represent the full costs of ownership, to include maintenance, tires, depreciation, fuel, insurance, etc.Auto ownership is adjusted when the per-mile cost of owning a car is higher than car service (mobility services) when the latter has high availability. This adjustment is made in the `AdjustVehicleOwnership` module. Additional details on auto ownership and auto ownership adjustments

2.9.74 vehicle table

A vehicle table is a list of every vehicle owned by a household in VisionEval. It includes the vehicle characteristics, household ID, and the Azone and Marea the household is allocated to. It is created in the `CreateVehicleTable` module in the `VEHouseholdVehicles` package. Additional details

vehicle type {#vehicle-type} In VisionEval vehicle type refers to the distinction between automobiles and light trucks that are used by all light duty vehicle groups: households, car service, and commercial service vehicles.

Chapter 3

VisionEval Tutorial

The VisionEval Tutorial provides an introductory walkthrough on how to set up a VisionEval model specific to your area of interest. This chapter does not cover how to install and run VisionEval, those instructions are covered in the Getting Started chapter. For users completely new to VisionEval, reviewing the Concept Primer chapter for an overview of VisionEval modeling system is highly recommended before starting into the tutorial materials.

This VisionEval tutorial breaks down the process of setting up a model into several steps. Each step is described in it's own chapter, referenced below, and can also be accessed from the main navigation menu.

- The **Picking a Model** chapter is where to start for an overview of the three VisionEval models, VERSPM, VE-State, and VERPAT, and information on how to make a selection based on model differences and user needs.
- The **Model Geography and Years** chapter is the first step in applying the selected VisionEval model by making key decision on spatial scale and years.
- The **Developing Inputs** chapter has detailed information on the the specific inputs for each VisionEval model as well as generalized best practices on data sources and methods.
- The **Validating and Troubleshooting** chapter is relevant once users have a complete set of inputs need to debug or validate their base model.
- The **Developing Scenarios** chapter contains details on how to use VisionEval to set up multi-scenario runs for exploratory scenario planning.
- The **Estimation in VisionEval** chapter reviews advanced customization techniques for users, including how model estimation is integrated into the VisionEval modeling system and how to replace a model's default estimation with local data.

Chapter 4

Picking a Model

The VisionEval system is comprised of three models:

- **VERSPM** (VisionEval Regional Strategic Planning Model) was developed by Oregon Department of Transportation (ODOT) as an offshoot of the GreenSTEP model to support the preparation of metropolitan area scenario plans. The name reflects a broadening of the policies, beyond state statutory requirements. This model operates largely at the zonal level (i.e. inputs and outputs are zone-based).
- **VE-State** is a state level version of VERSPM. Like VERSPM, this model operates at the zonal level, but the zones are larger than their VERSPM counterparts.
- **VERPAT** (VisionEval Rapid Policy Analysis Tool) was developed under the federal Strategic Highway Research Program (SHRP2). The model was developed to help planners evaluate the potential effect of growth policies on regional travel. Portions of the GreenSTEP model were used in VERPAT, but substantial revisions were made to the code, including use of land use place type categories. This model operates largely at the region or place type level for the entire region.

4.1 Spatial Detail

One key distinction between the all VisionEval models is the level of spatial detail. In general, the VisionEval models with a greater level of spatial detail also require more effort for developing the model inputs. In picking a model, users should consider their needs in the context of this trade-off between spatial detail and development effort.

VERSPM was developed as a regional model for regional planning areas and MPOs. VERSPM models the region in zones (in a manner similar to traditional travel model zones), which results in improved spatial resolution of outputs, but which also increases the data development burden. The selection of the right tool therefore depends on a number of factors – available of data, project resources, desired spatial output detail, etc. Take a look at the model inputs, which has many inputs by Bzones.

VE-State was developed as an extension of the VERSPM model to enables users to apply the model for statewide applications. The main difference between the VERSPM and VE-State models is that a number of VERSPM inputs are specified at the Bzone level. Examples include numbers of dwelling units by type and numbers of jobs by sector. VE-State models run at a higher level of abstraction than VERSPM models and don't have Bzone level inputs. Instead, the VE-State uses a process to synthesis Bzones.

VERPAT, like VERSPM, operates primarily at the region level. However, VERPAT has less spatial detail than VERSPM and requires inputs at place type level. As shown below, place types are defined as a combination of area type and development type. Area type (or regional role) describes the interdependencies of each neighborhood compared to the rest of the region, e.g. how centered is it to jobs in the region. Development type (or neighborhood character) is used to describe the physical characteristics of each neighborhood in isolation. Operating at the place type level simplifies the input data requirements and the spatial precision of outputs while still capturing the effects of the different place types in the region. Take a look at the model inputs, which has only one input by Bzone (i.e., population and employment) which represents population and employment for each place type.

		REGIONAL ROLE *(Area Type)*			
		Regional Center	**Close In Community**	**Suburban/ Town**	**Low Density/ Rural**
NEIGHBORHOOD CHARACTER *(Development Type)*	**Transit Supported Development**	√	√	√	
	Mixed Use - High	√	√	√	
	Mixed Use	√	√	√	
	Employment	√	√	√	
	Residential	√	√	√	
	Low Density/ Rural				√

Chapter 5

Model Geography and Years

Once a VisionEval model has been selected, the next step is deciding on the model geography and years. Both the model geography and years will inform the input data needed.

5.1 Years

Inputs in VisionEval are developed for every model year. Most applications consist of a base year and a future year. If the model area has a travel demand model available, it is good practice to align the VisionEval model years with those in the travel demand model, allowing the user to use the travel demand model to develop VisionEval inputs and validate the VisionEval Model. VisionEval may be used to model interim years, however each year modeled requires additional input data.

5.2 Geography

All VisionEval models share a standard geography framework. Although models are applied at different scales, sharing a common geographic definitions enables modules to be more readily shared between models. The standard geogrpahy framework specifies levels of geographical units, their names, their relative sizes, and the hierarchical relationships between them. It is flexible in that it allows geographical boundaries to be determined by the user and it allows the units in some geographical levels to be simulated rather than being tied to actual physical locations. Allowing simulation of one or more geographic levels enables modules to be shared between models that operate at different scales. For example a statewide model and a metropolitan area model could use the same module for assigning households to land development types even though the statewide model lacks the fine scale of geography of the metropolitan model.

Following is the definition of the geographic structure of the VisionEval model system:

- **Region** level is the entire model area. Large-scale characteristics that do not vary across the region are specified at the region level. For example, the carbon intensities of vehicle fuels are defined at the region level since they tend not to vary widely across a large geographic area. Typically, in a VERSPM model the region level is the metropolitan planning region being modeled, for VE-State it's the entire state.
- **Azones** are large subdivisions of the region level. Azones are used to represent demographic and economic characteristics that vary across the region such as population forecasts of persons by age group and average per capita income. County boundaries are commonly used to represent Azones in both VE-State. In VERSPM, county or municipal boundaries are commonly used. The Azone level of geography must represent actual geographic areas and may not be simulated.
- **Bzones** are subdivisions of Azones. Bzones are nested within Azones and provide more granularity on the intensity and nature of development. Bzones may correspond to actual geographic areas or may be simulated. Bzone simulation greatly reduces model input data requirements while still enabling the modeling of land-use-related policies and the effects of land use on various aspects of travel behavior. In VERSPM, Bzones must be represented by actual geographic areas; examples of VERSPM Bzone inputs include housing and population density. Common Bzone boundaries for VERSPM are TAZs, Census Tracts, or Census Block Groups. In VE-State and VERPAT, Bzones are simulated and do not represent physical geographic boundaries. Bzones in VE-State are synthesized to represent characteristics likely to be found in an actual set of Bzones within each Azone, such as neighborhood density. In VERPAT, Bzones are simulated as *place types* which characterize the intensity and nature of development.
- **Mareas** represent metropolitan urbanized areas. Mareas are represented in VisionEval as collections of Azones associated with an urbanized area either because a portion of the urbanized area is located in the Azone or because a substantial proportion of the workers residing in the Azone work at jobs located in the urbanized area. Metropolitan models (VERSPM and VERPAT) typically only have one assigned Marea whereas state models may have several. The model system requires that each Azone may be associated with only one Marea. It is also required that all Azones be associated with an Marea. A special Marea named **'None'** is used to apply to Azones that are not associated with any urbanized area. Mareas are used to specify and model urbanized area transportation characteristics such as overall transportation supply (transit, highways) and congestion. They are also used to specify large scale land-use-related characteristics and policies in models that use Bzone synthesis.

- **Location Type** is not a geography level but a categorical level that identifies whether households are urban/town/rural.
- **Place Type** is not a geography level but defines the level of urbanization (area type) and mixing of jobs and housing (development type).

5.2.1 Setting Up the Model Geography

Users should note that their selected model geography will determine the geography levels for input data development. Geographical relationships for a model are described in the "geo.csv" file contained in the "defs" directory. This file tabulates the names of each geographic unit (except for region) and the relationships between them. Each row shows a unique relationship. Where a unit of geography is not explicitly defined (i.e. it will be simulated), "NA" values are placed in the table.

The examples below show versions of the "geo.csv" file where only Azones are specified and where Azones and Bzones are specified. It should be noted that there are no naming conventions for individual zones. The user is free to choose what conventions they will use.

Example of a geo.csv file that only specifies Azones

Azone	Bzone	Czone	Marea
A	NA	NA	M1
B	NA	NA	M1
C	NA	NA	None
D	NA	NA	None

Example of geo.csv file that specifies Azones and Bzones

Azone	Bzone	Czone	Marea
A	A1	NA	M1
A	A2	NA	M1
A	A3	NA	M1
B	B1	NA	M1
B	B2	NA	M1
C	C1	NA	None
C	C2	NA	None
C	C3	NA	None
C	C4	NA	None
D	D1	NA	None
D	D2	NA	None
D	D3	NA	None

5.2.1.1 Model Geography Example

This section details the model geography for ODOT's VE-State model as an example. The geography levels are defined as follows:

- **Azones** must be physical boundaries and are represented by counties.
- **Mareas** are represented by the boundaries of Metropolitan Planning Organizations (MPOs), which can be multi-county. Azones, or counties, without an MPO have the Marea `None`.
- **Location Type** (Urbanized, Town, Rural) are defined as MPOs being urbanized (defined in the model as `Metro`), urban growth boundaries (UGBs) smaller than MPOs are `Town`, and the rest is `Rural`.
- **Marea Area Types** (Center, Inner, Outer, Fringe) (VE-State only) are based on VE-State EPA-SLD-based definition. ODOT builds TAZ-level place type maps for all MPOs to generate.

ODOT VE-State geo.csv

Azone	Bzone	Czone	Marea
Baker	NA	NA	None
Benton	NA	NA	Corvallis
Clackamas	NA	NA	Metro
Clatsop	NA	NA	None
Columbia	NA	NA	None
Coos	NA	NA	None
Crook	NA	NA	None
Curry	NA	NA	None
Deschutes	NA	NA	Bend
Douglas	NA	NA	None
Gilliam	NA	NA	None
Grant	NA	NA	None
Harney	NA	NA	None
Hood River	NA	NA	None
Jackson	NA	NA	RogueValley
Jefferson	NA	NA	None
Josephine	NA	NA	GrantsPass
Klamath	NA	NA	None
Lake	NA	NA	None
Lane	NA	NA	EugeneSpringfield
Lincoln	NA	NA	None
Linn	NA	NA	Albany
Malheur	NA	NA	None
Marion	NA	NA	SalemKeizer
Morrow	NA	NA	None
Multnomah	NA	NA	Metro
Polk	NA	NA	SalemKeizer

Azone	Bzone	Czone	Marea
Sherman	NA	NA	None
Tillamook	NA	NA	None
Umatilla	NA	NA	None
Union	NA	NA	None
Wallowa	NA	NA	None
Wasco	NA	NA	None
Washington	NA	NA	Metro
Wheeler	NA	NA	None
Yamhill	NA	NA	None

Users can also have Mareas be equivalent to a Census urbanized area definition. Mareas do not include `Town` location types within the Marea counties. As such, "towns" in the Marea counties typically fall outside of the continuous urbanized area (i.e. Census urbanized area). A county with only `Town` and `Rural` location types will have the Marea `None`. Some exceptions may be made if the outside areas are contiguous enough with the official urbanized area or will be in the horizon of the modeled scenarios, such that they will use common (high frequency) transit systems, and share the same road/congestion. Some examples of this are Eugene VERSPM model including the city of Coburg as "urbanized" rather than a "town" and Portland including Ridgefield in the urbanized area. The recommendation can be summarized as designating an Marea city outside the census "Urbanized area" definition as "towns" unless: (1) they are contiguous to the larger urbanized area, or will be in the planning horizon, or (2) if they have significant transit service, road congestion that the "town" formulas will not account for.

Chapter 6

Model Inputs

Once VisionEval model has been installed, a directory with sample data will be available within the model directory (e.g., `../models/VERSPM/` where `..` refers to the parent directory of the unzipped installer file).

The model directory serves the dual purposes of providing sample data and a template for local modification to other locations.

The default VERSPM and VERPAT directories contains sample input files for the Rogue Valley region in Oregon, while the default VE-State directory contains sample input files for the State of Oregon. These inputs can be modified or replaced to investigate the impacts of policy changes or to model a different region.

The `defs` directory contains five model definition files which are introduced in Set-Up Inputs section.

The `inputs` directory contains a number of `CSV` and `JSON` files that provide inputs for the modules. Each module specifies what input files it needs. The majority of input files are `CSV` formatted text files. The names of the file identify the geography level for the input data. For example, `azone_hh_pop_by_age.csv` is the input for household population by age, and should have data at the Azone level. Each input file has:

- **Field names** identifying dataset names
- **Year** field when inputs vary by model year
- **Geo** field when inputs vary by geography

Field names can also have modifiers, such as the year that money values are denominated in (e.g. 2010) or magnitude multiplier for large numbers (e.g. 1e3). Input specifications, which can be located in the source code for each module as well as the module documentation, can be referenced when users are unsure of the input data type, units, and any prohibited values. In formatting input files, users should pay attention to the following:

- Need values for every combination of year and geography
- Field names must exactly match specifications
- Values must match specification data type and not contain any prohibited values
- No data for years other than model run years
- No data for areas other than those defined in geo.csv file

The rest of this section will contain generalized best practices for input development applicable to all VisionEval models and go into the details of inputs for each model.

6.1 Set-up Inputs

The set-up inputs are those in the `defs` directory. Most of these files shouldn't change much from the download, unless users want their own deflators, etc. The exception is the geo.csv file which will need to be developed to inform the model geography.

- run_parameters.json
- model_parameters.json
- deflators.csv
- geo.csv
- units.csv

6.1.1 run_parameters.json

This file contains parameters that define key attributes of the model run and relationships to other model runs. This file is a needs to be modified by the user to specify the model base year and run years. A more detailed description of the file can be found here. The results of model run are stored in a directory with the name specified by `"DatastoreName"`. This name should be changed when running different scenarios. For e.g. when running base scenario the output directory name can be set to *BaseScenario* by using `"DatastoreName": "BaseScenario"` in the file. The format of this file is as follows:

```
{
    "Model": "VERSPM",
    "Scenario": "Test",
    "Description": "Test of VERSPM",
    "Region": "RVMPO",
    "BaseYear": "2010",
    "Years": ["2010", "2038"],
    "DatastoreName": "Datastore",
    "DatastoreType": "RD",
```

```
    "Seed": 1
}
```

6.1.2 model_parameters.json

This file contains global parameters for a particular model configuration that may be used by multiple modules. A more detailed description of the file and its structure can be found here. The source of the default $16/hr is per a Nov 2016 ODOT Report: “The Value of Travel-Time: Estimates of the Hourly Value of Time for Vehicles in Oregon”.

The format of this file is as follows:

```
[
  {"NAME": "ValueOfTime",
   "VALUE": "16",
   "TYPE": "double",
   "UNITS": "base cost year dollars per hour"
  }
]
```

6.1.3 deflators.csv

This file defines the annual deflator values, such as the consumer price index, that are used to convert currency values between different years for currency denomination. This file does not need to be modified unless the years for which the dollar values used in the input dataset is not contained in this file. The format of the file is as follows:

Year	Value
1999	172.6
2000	178.0
2001	182.4
…	…
2010	218.344
…	…
2016	249.426

6.1.4 geo.csv

This file describes all of the geographic relationships for the model and the names of geographic entities in a CSV formatted text file. The Azone, Bzone, and Marea names should remain consistent with the input data. More information on developing this file and VisionEval model geographic relationships can be found here. The format of the file is as follows:

Azone	Bzone	Czone	Marea
RVMPO	D410290001001	NA	RVMPO
RVMPO	D410290001002	NA	RVMPO
RVMPO	D410290002011	NA	RVMPO
RVMPO	D410290002012	NA	RVMPO
RVMPO	D410290002013	NA	RVMPO
RVMPO	D410290002021	NA	RVMPO
RVMPO	D410290002022	NA	RVMPO
RVMPO	D410290002023	NA	RVMPO
RVMPO	D410290002031	NA	RVMPO
RVMPO	D410290002032	NA	RVMPO
RVMPO	D410290002033	NA	RVMPO
RVMPO	D410290003001	NA	RVMPO
RVMPO	...	NA	RVMPO

6.1.5 units.csv

This file describes the default units to be used for storing complex data types in the model. This file should NOT be modified by the user. The VisionEval model system keeps track of the types and units of measure of all data that is processed. More details about the file and structure can be found here. The format of the file is as follows:

Type	Units
currency	USD
distance	MI
area	SQMI
mass	KG
volume	GAL
time	DAY
energy	GGE
people	PRSN
trips	VEH
area	TRIP
households	HH
employment	JOB
activity	HHJOB

6.2 Inputs by Concept

This section covers over generalized inputs by concepts shared by all VisionEval models. Best practices for inputs by concepts are also discussed. To learn about the specific inputs used by each model skip ahead to the following sections:

- VERSPM inputs
- Ve-State inputs
- VERPAT inputs

6.2.1 Household Synthesis Inputs

The demographic and land use inputs are those related to population, employment, and income that result in the household synthesis. VisionEval takes user input statewide population by age group, assembles them into households with demographic attributes (lifecycle category, per capita income).

- **Pool of available households.** Modelwide, Census PUMS data represents actual households and representative mix of household composition and demographics for your area it is built into the code. Note that users must rebuild the VESimHousehold package to use local PUMS data as Oregon data is the default, see the chapter on Estimation in VisionEval for instructions on how to rebuild packages.

- **Population by age control totals.** For population inputs, VisionEval models distinguish between the regular household population and group quarter population due to distinct differences in travel behaviors. Zone-level inputs for (1) regular households and (2) group quarters households (can be 0) include population by age group and average per capita income. Base year totals for the household population can be obtained from Census. Future year forecasts should be consistent with but may need to be extrapolated beyond adopted regional plans (e.g., RTP, County and City TSPs). 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. Group quarters population data is best obtained from the university administration, by age if possible. Group quarters can be approximated from enrollment data by class year. All other group quarters data (e.g., income) are difficult to obtain but not of paramount importance to the model, simplifying assumptions are often required. Per capita income can be obtained from either the Census or Bureau of Economic Analysis. Since the model accounts for inflation, future income can remain the same in future years, or adjusted based on local plans.

- **Optional household adjustments.** (Optional) constraints on regular households include average household size and proportion of single-person households, adjustments to licensure rate for driving age persons. Household size values can be obtained from the Census and licensure data can be obtained from the state DMV.

- **Employment.** VERSPM employment inputs require employment by type in each model year by Bzone. VE-State requires workers by location type (Optional) constraints on aggregated employment rate for working age persons by Azone.

6.2.2 Land Use Inputs

Once households are synthesised, VisionEval allocates them to Bzone-level dwelling units inputs. Separately Bzones are attributed with employment and land use attributes (location type, built form 'D' values, mixed use, employment by type). Household members are identified as workers and/or drivers and number of household vehicles are estimated. Each home and work location is tied to a specific Bzone with its associated attributes. Additionally, some local policies are land use based.

- **Dwelling units.** Numbers of dwelling units by type in each model year and proportions of each in each development type. Income quartiles tied to households in dwelling units help VisionEval assign households to a compatible Bzone location. The base year dwelling unit data can sourced from either the Census or an available travel demand model. Future year dwelling units can be obtained from local Comprehensive Plans. Adjustments may be needed to count only occupied units, and 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.

- **Land use.** Inputs set the total developable land area, by development type. VERSPM also requires its location (centroid latitude-longitude) for spatially linking to source data, and input assumptions on the built form measures. These inputs can change by model run year. Some land use data use EPA Smart Location Datasbase (SLD) data. Geospatial SLD data can be downloaded at the block group level and extrapolated to other geographies if needed using just used the EPA block group data.

- **Land use-household linkages.** VisionEval assigns a Bzone to each household's home and to each household worker's work location, with the associated Bzone attributes. The VisionEval-calculated urban mixed use designation of the Bzone can optionally be modified by input targets on the proportion of households assigned that designation in each Bzone in this process.

  - **Note:** Input files must be consistent. This includes: (1) land area must be specified for each azone location type that has households or employment assigned to it; (2) dwelling units must be a reasonable match with population (divided by household size); (3) shares of jobs within each Azone must sum to 1 for all Azones in the Marea.

6.2.2.1 Defining "Location Type" (metro, town, rural)

One method is to define land in MPO boundaries to be **metro**, for urban areas smaller than MPOs, land inside their UGB is a **town**. Everything else is **rural**. Note that if you want to further refine within the MPO, place types can identify low density areas that you might consider "rural" and areas that less accessible/more isolated (don't have access to broader transit service) as "town". Some states have official population forecasts done for each urban area that helps with the population inputs. Users can also use LEHD where we used the boundaries identified above to designate location types, and then used LEHD to calculate worker flows between county home location-to-work LocType (any county).

An alternative method is to use the Census Urban and Rural Classification. The Census Urban and Rural Classification distinguishes between two types of urban areas:

- Urbanized Areas (UAs) of 50,000 or more people are defined as **metro**
- Urban Clusters (UCs) of at least 2,500 and less than 50,000 people are definied as **town**
- Everything else is **rural**

6.2.2.2 Defining "Area Type" (center, inner, outer, fringe)

"Area Type" is based on a mix of activity density levels and destination accessibility levels, as discussed in the documentation discussing the VE-State EAP-SLD-based Bzone synthesis.

ODOT develops place types using data from local travel demand models, specifically TAZs within MPOs (Mareas). Area type VisionEval inputs are generated using population and employment data by TAZ using the below calculations. By using local travel model TAZ data which has base and future population and employment, users can create a future version of these variables and thus the VE-State area type inputs we calculate cover different areas over time:

- **Activity Density** = TAZ-level (population [households and qroup quarter units] + employment / 2.5) / unprotected acres [with parks and water removed). SLD variable D1B is roughly the same.
- **Destination Accessibility** = TAZ-level as shown below. There's not an equivalent SLD attribute, but some of the D5 attributes are similar.
  - (D5) Harmonic mean of employment within 2 miles and population within 5 miles (2 * TotEmp_InDist2mi * Pop_InDist5mi) / (TotEmp_InDist2mi + Pop_InDist5mi).
  - Levels: VL = 0 - 2e3, L = 2e3 - 1e4, M = 1e4 - 5e4, H = 5e4+.
- **Design** = SLD variable D3bpo4

6.2.3 Household Travel Behavior Inputs

Many of the inputs relating to household multi-modal travel are those that also can serve as policy levers to be tested in multi-run scenario exercises. Users should work with stakeholders to refine these values and finalize reference scenario inputs that reflect financially constrained adopted plans in their area. These discussions with local staff also start to define more/less ambitious scenarios to include in the multi-run scenario modeling.

- **Transport supply (Mareas only)** Unlike traditional travel demand models, VisionEval does not have a roadway network. The inputs for transportation supply define roadway capacity in terms of lane miles of arterials and freeways and transit service miles (annual revenue service miles) for each transit service mode) for the urbanized area portion of each Marea by model run year. A separate Bzone-level input sets neighborhood transit accessibility or Transit D. For lane-miles in the model area, HPMS is the standard source. Users can use use the lane-length values as lane-mile inputs, aggregating as follows:
  - Fwys = "Interstate"& "Other Freeways & Expressways"
  - Arterials = "Other Principal Arterial" & "Minor Arterial"
  - Major/Minor collectors and local streets are not included
- **Personal short trips/alternative modes.** VisionEval inputs define policies for transit, bike and walk modes. These include transit service levels and transit accessibility (Transit D) per transit supply above. Biking trips are defined by the proportion of short-trip SOV diversion (20 miles or less round-trip). Walk while walk trips are dependent upon mixed-use development and built form design and measures.
- **Travel demand management (TDM).** 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) 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.
  - **Workplace TDM Programs.** 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. 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%. Users can modify this value but it requires rebuilding the VELandUse package for VERSPM or VESimLandUse for VE-State. 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. The proportion of employees participating in ECO programs is a policy input at the Bzone-level in VERSPM and either the Azone or Marea level in VE-State. The input assumes workers participate in a strong employee commute options programs (e.g., free transit pass, emergency ride home, bike rider facilities, etc.).

  - **Individualized Marketing TDM Programs.** 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. VisionEval assumes that households participating in an IM program reduce their DVMT by 9% based on studies done in the Portland area. Users can modify this value but it requires rebuilding the VELandUse package or VESimLandUse for VE-State. 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. The VisionEval input for IM programs include an overall assumption for the percentage of households participating in an IM program. 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 Bzone. 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.

- **Parking.** Parking in VisionEval is defined by parking supply and parking restrictions, including parking costs.

6.2.4 Vehicle, Fuels and Emissions Inputs

Vehicle and fuel technology are expected to change significantly during the next several decades 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. As a consequence, the VisionEval inputs on vehicle and fuel technology are largely specified modelwide at the region level. These inputs can be used to assess the impacts of changing vehicle powertrains and fuels on energy use and GHG emissions in the model area. The key local contribution to these inputs is the bus powertrain and fuels inputs, which are defined by metropolitan area (Marea) although defaults can be used if no additional local data is available. These variables are briefly summarized below.

- **Powertrains.** Several input files specify vehicle attributes and fuel economy for autos, light trucks, heavy truck, and transit vehicles. User inputs modify vehicle powetrains for commercial service vehicles, car service vehicles, transit vehicles, and heavy trucks. Changing the powertrain mix of household vehicles involves rebuilding the VEPowertrainsAndFuels package. Four vehicle powertrain types are modeled:
  - 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.
- **Household owned vehicles.** Household vehicle characteristics are defined by Azone and model run year to account for regional trends. Characteristics include the passanger fleet share by vehicle type (light truck or auto) and average vehicle age. The purpose of these inputs is to allow scenarios to be developed which test faster or slower turn-over of the vehicle fleet or test fleets mixes in terms of passenger autos and light trucks or SUVs, both of which impact fuel economy. Users also define the availability of residential electric vehicle charging stations at the Azone level by dwelling unit type and model run year. Vehicle type and age characteristics combine with powertrain sales by year defined in the VEPowertrainsAndFuels package. Each powertrain in each year has an associated fuel efficiency and power efficiency assumptions for PHEVs (MPG for PHEVs in charge-sustaining mode). For EVs and PHEVs, battery range is specified. Note that the actual EV-HEV split depends on whether enough households have their 95Th percentile daily travel within the EV battery range
- **Car service vehicles.** Car services are a specific mode used in VisionEval models treated as vehicles available to the household. Car services can be considered a synonym for popular ride-sharing services provided by mobility-as-a-service (MaaS) companies. VisionEval distinguishes between two levels of car service, categorized as "high" or "low" level service. A high car service level is one that has vehicle access

times (time to walk between car and origin or final destination) that are competitive with private car use. High level of car service is considered to increase household car availability similar to owning a car. Users can define the car service substitution probability by vehicle type. Low level car service, approximates current taxi service does not have competitive access time and is not considered as increasing household car availability. Users can define different attributes for each level of car service. Users can define several characteristcs of car service by level, including cost per mile by car service level, average age of car service vehicles, and limits on household car service substitution probability for owned vehicles. Region-level inputs on powertrain mix by model (not sales) year and (optional) region-wide composite fuel carbon intensity.

See the section on Pricing, Household Costs & Budgets inputs for more information on car service levels, geographic coverage, and fees. See the Vehicles, Fuels & Emissions inputs section for more information on defining the car service fleet powertrain characteristics.

- **Transit.** Transit vehicles characteristics are defined by Marea and model run year for transit vehicle type(van, bus, rail), including powertrain mix by model (not sales) year and optional detail on fuel-biofuel shares. Users can also optionally define region-wide composite fuel carbon intensity by transit vehicle types.
- **Freight vehicles (heavy trucks and commercial service).** Commercial service vehicle vehicle characteristics are defined by Azone and model run year, including vehicle type shares and average vehicle age. (optional) Region-wide composite fuel carbon intensity by vehicle type. Heavy truck vehicle characteristics are region-level, including powertrain mix and composite fuel carbon intensity by model (not sales) year.
- **Electric carbon intensity.** Since electricity generation varies by locality, users can define the electricity carbon intensity at the Azone-level. This impacts GHG emission rates (in average pounds of CO2 equivalents generated per kilowatt hour of electricity consumed by the end user) by local area.
- **Fuel input options**. Three options are available for fuel assumptions. The choices are outlined in the table and options described below. User choice of option can vary by vehicle group and where applicable, vehicle type:

1. Default package datasets. These may represent federal or statewide fuel policies that apply to all metropolitan areas and all vehicle groups in the model (e.g., state ethanol regulations, low carbon fuel policies). NAs would be placed in all user input files.
2. Detailed fuel and biofuel inputs. Values for the proportions of fuels types (gasoline, diesel, compressed natural gas), as well as fuel blend proportions (gasoline blended with ethanol, biodiesel blended with diesel, renewable

natural gas is blended with natural gas). A third assumption specifies the carbon_intenaity of the fuels (input or default). For example, heavy trucks can be set to 95% diesel, 5% natural gas, with diesel having a 5% biodiesel blend.

3. Composite carbon intensity. This option simplifies the process of modeling emissions policies, particularly low carbon fuels policies by bypasses the need to specify fuel types and biofuel blends. Average carbon intensity by vehicle group and if applicable, vehicle type is specified directly. These inputs, if present and not 'NA', supercede other transit inputs.

- Note: Given that transit agencies in different metropolitan areas may have substantially different approaches to using biofuels, transit vehicles have the option of region or metropolitan area specifications for Options (1) and (2).

- Note: The proportions in option (2) do not represent volumetric proportions (e.g. gallons), they represent energy proportions (e.g. gasoline gallon equivalents) or DVMT proportions.
- Note: Individual vehicles are modeled for households. Other groups vehicle and fuel attributes apply to VMT. As a result, PHEVs in all but household vehicles should be split into miles driven in HEVs and miles in EVs.

Vehicle Group	Vehicle Types	Powertrain Options	Veh Inputs	Fuel Options	Fuel input options
Household	automobile, light truck	ICE, HEV, PHEV, EV	(default veh mix), age, %LtTrk	gas/ethanol, diesel/biodiesel, CNG/RNG	default, region composite
Car Service	automobile, light truck	ICE, HEV, EV	veh mix, age (HH veh mix)	gas/ethanol, diesel/biodiesel, CNG/RNG	default, region composite
Commercial Service	automobile, light truck	ICE, HEV, EV	veh mix, age, %LtTrk	gas/ethanol, diesel/biodiesel, CNG/RNG	default, region composite
Heavy Truck	heavy truck	ICE, HEV, EV	veh mix	gas/ethanol, diesel/biodiesel, CNG/LNG	default, region composite
Public Transit	van, bus, rail	ICE, HEV, EV	veh mix	gas/ethanol, diesel/biodiesel, CNG/RNG	default, fuel/biofuel mix, marea or region composite

6.2.5 Pricing, Household Costs & Budget Inputs

Most of these will be state-led actions and thus reflect the state policies of the modeled area.

- **Per mile vehicle out-of-pocket costs.** Several inputs define the per mile costs used in calculating household vehicle operating costs that may be limited by the household's income-based maximum annual travel budget. These inputs include those defining energy costs, car service fees, and fees to recover road and social costs, as noted below.

- **Energy costs.** Unit cost of energy to power household vehicles, both fuel (cost per gallon) and electricity (cost per kilowatt-hour).

- **Car service fees.** If car service is used by a household, the per mile fees paid for that service, outside of energy costs. Car service characteristics cost per mile by [car service level by Azone and model run year.

- **Road cost recovery VMT fee.** Inputs include a fuel tax or levying a fuel-equivalent tax on travel by some/all electric vehicles (PevSurchgTaxProp), for their use of roads in lieu of gas purchases. User can also directly specify a VMT (mileage) fee, to further recover road costs, or optionally flag VisionEval to iteratively estimate the VMT fee to fully recover user-defined road costs incurred by household VMT.

- **Social cost recovery/carbon fees.** (Optional) Inputs allow per mile fee to cover social costs or externalities, not recovered in this way today, but instead incur costs elsewhere in the economy (e.g., safety, health). This is the cost imposed on society and future generations, not the cost to the vehicle user. This requires assumptions on the cost incurred from these externalities (per mile, per gallon) and the proportion to be paid by drivers as a per mile fee (varies by vehicle powertrain). The proportion of carbon costs (e.g., impact on fuel price from cap & trade policy) imposed on drivers is specified separately from other social costs, so it can be assessed on its own if desired; including (optionally) specifying the cost of carbon to over-ride the default value of carbon.

- **Per mile time-equivalent costs.** Users can define the value of time, which is included in vehicle operating costs calculations. The model calculates travel time (model-calculated), which includes time to access vehicle on both ends of trip (between vehicle parking location and origin or end destination), multiplied by value of time.

- **Annual vehicle ownership costs.** Vehicle ownership cost inputs are defined at the Azone-level by year. These inputs include annual vehicle fees (flat fee and/or tax on vehicle value), pay-as-you-drive (PAYD) insurance participation rates, residential parking limitations and fees, that are combined with model-estimated ownership costs (financing, depreciation, insurance).

- **Congestion Fees.** Congestion fees are defined by Marea. The input is the average amount paid per mile in congestion pricing fee.

6.2.6 Congestion Inputs

- **Base year VMT.** Users provide can provide base year VMT (for both light-duty vehicles and heavy trucks) or use the model default by using a state/UzaLookup. Users also select a growth basis for heavy trucks of either population or income and for commercial service VMT (population, income, or household VMT). Users also provide the DVMT split of light-duty vehicles, heavy trucks, and buses on urban roads by road class. Values for UzaNameLookup must be present in the list provided in the module documentation, otherwise user inputs must specify the data directly.

- **ITS-Operational Policies.** Users define the proportion of VMT by road class affected by standard ITS-Operation policies on freeways and arterials. Another optional input can define additional operations effects, providing flexibility for future user-defined freeway and arterial operations program coverage and effectiveness. These programs reduce delay. The specific ITS programs available in the model are the following:

  - **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. 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 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 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.
  - **Arterial signal coordination** – Traffic signal coordination, particularly for adaptive traffic signals, can reduce arterial delay by in-

creasing 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%.

  - **Other ops programs** – A seperate input that gives users the ability to accommodate future enhancements. Further research and significant program investment would be needed to justify benefits in these enhanced ITS programs.

- **Speed smoothing programs.** Proportion of VMT by road class covered by ITS speed smoothing, and Eco-drive programs. These programs reduce vehicle accelerations and decelerations, but do not affect delay.

  - **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; advanced signal optimization techniques that reduce stops and starts on arterials; and truck/bus-only lanes that can move high-emitting vehicles through congested areas at improved efficiency. Literature review of fuel efficiency improvements found that speed smoothing policies could only reasonably achieve a portion of the theoretical maximum of 50%, which is the ratio applied to the user input of full deployment (input of 1=100%).
  - **Eco-drive programs** 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. Vehicle operations and maintenance programs (e.g. eco-driving) based on policy assumptions about the degree of deployment of those programs and the household characteristics. Vehicle operating programs (eco-driving) reduces emissions per VMT at a max of 33% for freeways and 21% for arterials for full deployment (input of 1=100%).

6.3 VERSPM Input Files

This section details the specific VERSPM input files.

- **azone_carsvc_characteristics.csv**: This file specifies the different characteristics for high and low car service level and is used in the

CreateVehicleTable and AssignVehicleAge modules.

- **azone_charging_availability.csv** This file has data on proportion of different household types who has EV charging available and is used in the AssignHHVehiclePowertrain module.

- **azone_electricity_carbon_intensity.csv** (optional) This file is used to specify the carbon intensity of electricity and is only needed if user wants to modify the values). The file is used in Initialize (VEPowertrainsAndFuels) and CalculateCarbonIntensity modules.

- **azone_fuel_power_cost.csv** This file supplies data for retail cost of fuel and electricity and is used in the CalculateVehicleOperatingCost module.

- **azone_gq_pop_by_age.csv**: This file contains group quarters population estimates/forecasts by age and is used in the CreateHouseholds module.

- **azone_hh_pop_by_age.csv** This file contains population estimates/forecasts by age and is used in the CreateHouseholds module.

- **azone_hh_veh_mean_age.csv** This file provides inputs for mean auto age and mean light truck age and is used in the AssignVehicleAge module.

- **azone_hh_veh_own_taxes.csv** This file provides inputs for flat fees/taxes (i.e. annual cost per vehicle) and ad valorem taxes (i.e. percentage of vehicle value paid in taxes). The file is used in CalculateVehicleOwnCost module.

- **azone_hhsize_targets.csv**: This file contains the household specific targets and is used in CreateHouseholds module.

- **azone_lttrk_prop.csv** This file specifies the light truck proportion of the vehicle fleet and is used in AssignVehicleType module.

- **azone_payd_insurance_prop.csv** This file provides inputs on the proportion of households having PAYD (pay-as-you-drive) insurance and is used in the CalculateVehicleOwnCost module.

- **azone_per_cap_inc.csv** This file contains information on regional average per capita household and group quarters income in year 2010 dollars and is used in the PredictIncome module.

- **azone_prop_sov_dvmt_diverted.csv** This file provides inputs for a goal for diverting a portion of SOV travel within a 20-mile tour distance and is used in the DivertSovTravel module.

- **azone_relative_employment.csv**: This file contains ratio of workers to persons by age and is used in the PredictWorkers module.
- **azone_veh_use_taxes.csv** This file supplies data for vehicle related taxes and is used in the CalculateVehicleOperatingCost module.
- **azone_vehicle_access_times.csv** This file supplies data for vehicle access and egress time and is used in the CalculateVehicleOperatingCost module.
- **bzone_transit_service.csv** This file supplies the data on relative public transit accessibility and is used in the AssignTransitService module.
- **bzone_carsvc_availability.csv** This file contains the information about level of car service availability and is used in the AssignCarSvcAvailability module.
- **bzone_dwelling_units.csv**: This file contains the number single-family, multi-family and group-quarter dwelling units and is used in the PredictHousing module.
- **bzone_employment.csv**: This file contains the total, retail and service employment by zone and is used in the LocateEmployment module.
- **bzone_hh_inc_qrtl_prop.csv** This file contains the proportion of households in 1st, 2nd, 3rd, and 4th quartile of household income and is used in the PredictHousing module.
- **bzone_lat_lon.csv** This file contains the latitude and longitude of the centroid of the zone and is used in the LocateEmployment module.

- **bzone_network_design.csv** This file contains the intersection density in terms of pedestrian-oriented intersections having four or more legs per square mile and is used in the Calculate4DMeasures module.
- **bzone_parking.csv** This file contains the parking information and is used in the AssignParkingRestrictions module.
- **bzone_travel_demand_mgt.csv** This file contains the information about workers and households participating in demand management programs and is used in the AssignDemandManagement module.
- **bzone_unprotected_area.csv** This file contains the information about unprotected (i.e., developable) area within the zone and is used in the Calculate4DMeasures module.
- **bzone_urban-mixed-use_prop.csv** This file contains the target proportion of households located in mixed-used neighborhoods in zone and is used in the CalculateUrbanMixMeasure module.
- **bzone_urban-town_du_proportions.csv** This file contains proportion of Single-Family, Multi-Family and Group Quarter dwelling units

within the urban portion of the zone and is used in the AssignLocTypes module.

- **marea_base_year_dvmt.csv** (optional) This file is used to specify to adjust the DVMT growth factors and is only needed if user wants to modify the values. The file is used in the Initialize (VETravelPerformance), CalculateBaseRoadDvmt and CalculateFutureRoadDvmt modules.
- **marea_congestion_charges.csv** (optional) This file is used to specify the charges of vehicle travel for different congestion levels. The file is used in the Initialize (VETravelPerformance) and CalculateRoadPerformance modules.
- **marea_dvmt_split_by_road_class.csv** (optional) This file is used to specify the DVMT split for different road classes. The file is used in the Initialize (VETravelPerformance) and CalculateBaseRoadDvmt modules.
- **marea_lane_miles.csv** This file contains inputs on the numbers of freeway lane-miles and arterial lane-miles and is used in the AssignRoadMiles module.
- **marea_operations_deployment.csv** (optional) This file is used to specify the proportion of DVMT affected by operations for different road classes. The file is used in the Initialize (VETravelPerformance) and CalculateRoadPerformance modules.
- **marea_speed_smooth_ecodrive.csv** This input file supplies information of deployment of speed smoothing and ecodriving by road class and vehicle type and is used in the CalculateMpgMpkwhAdjustments module.
- **marea_transit_ave_fuel_carbon_intensity.csv** (optional) This file is used to specify the average carbon intensity of fuel used by transit. The file is used in the Initialize (VETravelPerformance) module.
- **marea_transit_biofuel_mix.csv** (optional) This file is used to specify the biofuel used by transit. The file is used in the Initialize (VETravelPerformance) and CalculateCarbonIntensity modules.
- **marea_transit_fuel.csv** (optional) This file is used to specify the transit fuel proportions. The file is used in the Initialize (VETravelPerformance) and CalculateCarbonIntensity modules.
- **marea_transit_powertrain_prop.csv** (optional) This file is used to specify the mixes of transit vehicle powertrains. The file is used in the Initialize (VETravelPerformance) and CalculatePtranEnergyAndEmissions modules.
- **marea_transit_service.csv** This file contains annual revenue-miles for different transit modes for metropolitan area and is used in the AssignTransitService module.

- **other_ops_effectiveness.csv** (optional) This file is used to specify the delay effects of operations in different road classes and is only needed if user wants to modify the values. The file is used in the Initialize (VETravelPerformance) and CalculateRoadPerformance modules.
- **region_ave_fuel_carbon_intensity.csv** (optional) This file is used to specify the average carbon density for different vehicle types and is optional (only needed if user wants to modify the values). The file is used in the Initialize (VETravelPerformance) and CalculateCarbonIntensity modules.
- **region_base_year_hvytrk_dvmt.csv** (optional) This file is used to specify the heavy truck dvmt for base year. The file is used in the Initialize (VETravelPerformance), CalculateBaseRoadDvmt and CalculateFutureRoadDvmt modules.
- **region_carsvc_powertrain_prop.csv** (optional) This file is used to specify the powertrain proportion of car services. The file is used in the Initialize (VETravelPerformance), AssignHhVehiclePowertrain and AdjustHhVehicleMpgMpkwh modules.
- **region_comsvc_lttrk_prop.csv** This file supplies data for the light truck proportion of commercial vehicles and is used in the CalculateComEnergyAndEmissions module.
- **region_comsvc_powertrain_prop.csv** (optional) This file is used to specify the powertrain proportion of commercial vehicles. The file is used in the Initialize (VEPowertrainsAndFuels)) and CalculateComEnergyAndEmissions modules.
- **region_hh_driver_adjust_prop.csv** (optional) This file specifies the relative driver licensing rate relative to the model estimation data year and is used in the AssignDrivers module.
- **region_hvytrk_powertrain_prop.csv** (optional) This file is used to specify the powertrain proportion of heavy duty trucks. The file is used in the Initialize (VEPowertrainsAndFuels)) and CalculateComEnergyAndEmissions modules.
- **region_prop_externalities_paid.csv** This file supplies data for climate change and other social costs and is used in the CalculateVehicleOperatingCost module.

6.3.1 azone_carsvc_characteristics.csv

This file specifies the different characteristics for high and low car service levels by `Azone`. More information on car service can be found here(placeholder). Changing this input is *optional* and using the default input values is standard practice.

- **HighCarSvcCost**: Average cost in dollars per mile for travel by high service level car service exclusive of the cost of fuel, road use taxes, and carbon taxes (and any other social costs charged to vehicle use)
- **LowCarSvcCost**: Average cost in dollars per mile for travel by low service level car service exclusive of the cost of fuel, road use taxes, and carbon taxes (and any other social costs charged to vehicle use)
- **AveCarSvcVehicleAge**: Average age of car service vehicles in years
- **LtTrkCarSvcSubProp**: The proportion of light-truck owners who would substitute a less-costly car service option for owning their light truck
- **AutoCarSvcSubProp**: The proportion of automobile owners who would substitute a less-costly car service option for owning their automobile

Here is a snapshot of the file:

Geo	Year	HighCarSvcCost.2010	LowCarSvcCost.2010	AveCarSvcVehicleAge	LtTrkCarSvcSubProp	AutoCarSvcSubProp
RVMPO	2010	1	3	3	0.75	1
RVMPO	2038	1	3	3	0.75	1

6.3.2 azone_charging_availability.csv

This input file supplies data on proportion of different household types with plug-in electric vehicle (PEV) charging available by `Azone`.

- **PropSFChargingAvail**: Proportion of single-family dwellings in Azone that have PEV charging facilities installed or able to be installed
- **PropMFChargingAvail**: Proportion of multifamily dwelling units in Azone that have PEV charging facilities available
- **PropGQChargingAvail**: Proportion of group quarters dwelling units in Azone that have PEV charging facilities available

Here is a snapshot of the file:

Geo	Year	PropSFChargingAvail	PropMFChargingAvail	PropGQChargingAvail
RVMPO	2010	1	0.0	0
RVMPO	2038	1	0.2	0

6.3.3 azone_electricity_carbon_intensity.csv

This input file specifies the carbon intensity of electricity by `Azone`. This input file is OPTIONAL and is only needed if the user wants to modify the carbon intensity of electricity.

- **ElectricityCI**: Carbon intensity of electricity at point of consumption (grams CO2e per megajoule)

Here is a snapshot of the file:

Geo	Year	ElectricityCI
RVMPO	2010	153
RVMPO	2038	23

6.3.4 azone_fuel_power_cost.csv

This file supplies data for retail cost of fuel and electricity by `Azone`. This input can be developed using local history or querying the Energy Information Administration (EIA) for historical gasoline and diesel and power prices.

- **FuelCost**:Retail cost of fuel per gas gallon equivalent in dollars (before taxes are added)
- **PowerCost**: Retail cost of electric power per kilowatt-hour in dollars (before taxes are added)

Here is a snapshot of the file:

Geo	Year	FuelCost.2005	PowerCost.2005
RVMPO	2010	2.43	0.08
RVMPO	2038	5.75	0.208

6.3.5 azone_gq_pop_by_age.csv

This file contains group quarters population estimates/forecasts by age for each of the base and future years. The file format includes number of persons within the following six age categories:

- 0-14
- 15-19
- 20-29
- 30-54
- 55-64
- 65 Plus

Group quarters are distinguished between two types: institutional and non-institutional. Institutional group quarter populations are those in correctional facilities or nursing homes. Non-institutional group quarters include college dormitories, military barracks, group homes, missions, or shelters. Only non-institutional group quarters are included in the modeled population, given the assumption that institutional group quarters populations do not account for much, if any, travel. Base year data for group quarter populations can be sourced from the Census.

Here is a snapshot of the file:

Geo	Year	GrpAge0to14	GrpAge15to19	GrpAge20to29	GrpAge30to54	GrpAge55to64
RVMPO	2010	0	666	382	66	7
RVMPO	2038	0	666	382	66	7

6.3.6 azone_hh_pop_by_age.csv

This file contains population estimates/forecasts by age for each of the base and future years. The file format includes number of persons within six age groups:

- 0-14
- 15-19
- 20-29
- 30-54
- 55-64
- 65 Plus

Base year data for population by age category can be sourced from the Census. Future year data must be developed by the user; in many regions population forecasts are available from regional or state agencies such as population data centers, universities, metropolitan planning organizations, or similar agencies.

Here is a snapshot of the file:

Geo	Year	Age0to14	Age15to19	Age20to29	Age30to54	Age55to64	Age65Plus
RVMPO	2010	30193	10970	20557	52327	24840	29240
RVMPO	2038	39759	12781	24972	75984	27563	66139

6.3.7 azone_hh_veh_mean_age.csv

This file provides inputs for mean auto age and mean light truck age by `Azone`. The user can develop this file using State DMV data.

- **AutoMeanAge**: Mean age of automobiles owned or leased by households.
- **LtTrkMeanAge**: Mean age of light trucks owned or leased by households.

Here is a snapshot of the file:

Geo	Year	AutoMeanAge	LtTrkMeanAge
RVMPO	2010	10.8	10.5
RVMPO	2038	12.0	12.0

6.3.8 azone_hh_veh_own_taxes.csv

This file provides inputs for flat fees/taxes (i.e. annual cost per vehicle) and ad valorem taxes (i.e. percentage of vehicle value paid in taxes).

- **VehOwnFlatRateFee**: Annual flat rate tax per vehicle in dollars

- **VehOwnAdValoremTax**: Annual proportion of vehicle value paid in taxes

Here is a snapshot of the file:

Geo	Year	VehOwnFlatRateFee.2015	VehOwnAdValoremTax
RVMPO	2010	50	0.00
RVMPO	2038	0	0.01

6.3.9 azone_hhsize_targets.csv

This file contains the household-specific targets for the population synthesizer. This file contains two attributes:

- **AveHhSize**: Average household size for non-group quarters households
- **Prop1PerHh**: Proportion of non-group quarters households having only one person

Household size data for the base year can be sourced from the Census.

Here is a snapshot of the file:

Geo	Year	AveHhSize	Prop1PerHh
RVMPO	2010	NA	0.3
RVMPO	2038	NA	NA

6.3.10 azone_lttrk_prop.csv

This file specifies the light truck proportion of the vehicle fleet. The user can be developed from local registration data. Alternatively, if MOVES is available for the model region, this input can be calculated from the MOVES vehicle population data (SourceTypeYear). The vehicle types used in MOVES (SourceType) correspond with the two categories of passenger vehicles used in EERPAT: MOVES SourceType 21, Passenger Car, is equivalent to autos in EERPAT and MOVES Source Type 31, Passenger Truck, is equivalent to light trucks.

- **LtTrkProp**: Proportion of household vehicles that are light trucks (pickup, SUV, van).

Here is a snapshot of the file:

Geo	Year	LtTrkProp
RVMPO	2010	0.45
RVMPO	2038	0.34

6.3.11 azone_payd_insurance_prop.csv

This file provides inputs on the proportion of households having PAYD insurance.

- **PaydHhProp**: Proportion of households in the Azone who have pay-as-you-drive insurance for their vehicles

Here is a snapshot of the file:

Geo	Year	PaydHhProp
RVMPO	2010	0.01
RVMPO	2038	0.50

6.3.12 azone_per_cap_inc.csv

This file contains information on regional average per capita household (`HHIncomePC`) and group quarters (`GQIncomePC`) income by forecast year in year 2010 dollars. The data can be obtained from the U.S. Department of Commerce Bureau of Economic Analysis for the current year or from regional or state sources for forecast years. In order to use current year dollars just replace 2010 in column labels with current year. For example, if the data is obtained in year 2015 dollars then the column labels in the file shown below will become `HHIncomePC.2015` and `GQIncomePC.2015`.

Here is a snapshot of the file:

Geo	Year	HHIncomePC.2010	GQIncomePC.2010
RVMPO	2010	32164	7500
RVMPO	2038	43334	10000

6.3.13 azone_prop_sov_dvmt_diverted.csv

This file provides inputs for a goal for diverting a portion of SOV travel within a 20-mile tour distance (round trip distance). The user can use local household travel survey data (if available) to develop this input.

- **PropSovDvmtDiverted**: Goals for the proportion of household DVMT in single occupant vehicle tours with round-trip distances of 20 miles or less be diverted to bicycling or other slow speed modes of travel

Here is a snapshot of the file:

Geo	Year	PropSovDvmtDiverted
RVMPO	2010	0.04
RVMPO	2038	0.80

6.3.14 azone_relative_employment.csv

This file contains the ratio of workers to persons by age cohort in the model year relative to the model estimation data year. This file contains five age cohorts:

- **RelEmp15to19**: Ratio of workers to persons age 15 to 19 in model year versus in estimation data year

Geo	Year	RelEmp15to19	RelEmp20to29	RelEmp30to54	RelEmp55to64	RelEmp65Plus
RVMPO	2010	1	1	1	1	1
RVMPO	2038	1	1	1	1	1

- **RelEmp20to29**: Ratio of workers to persons age 20 to 29 in model year versus in estimation data year
- **RelEmp30to54**: Ratio of workers to persons age 30 to 54 in model year versus in estimation data year
- **RelEmp55to64**: Ratio of workers to persons age 55 to 64 in model year versus in estimation data year
- **RelEmp65Plus**: Ratio of workers to persons age 65 or older in model year versus in estimation data year

Setting a value of 1 assumes that the ratio of workers to persons is consistent with estimation data for that specific age cohort.

Here is a snapshot of the file:

6.3.15 azone_veh_use_taxes.csv

This file supplies data for vehicle taxes related to auto operating costs

- **FuelTax**:Tax per gas gallon equivalent of fuel in dollars
- **VmtTax**: Tax per gas gallon equivalent of fuel in dollars
- **PevSurchgTaxProp**: Proportion of equivalent gas tax per mile paid by hydrocarbon fuel consuming vehicles to be charged to plug-in electric vehicles per mile of travel powered by electricity

Here is a snapshot of the file:

Geo	Year	FuelTax.2005	VmtTax.2005	PevSurchgTaxProp
RVMPO	2010	0.424	0	0
RVMPO	2038	0.484	0	0

6.3.16 azone_vehicle_access_times.csv

This file supplies data for vehicle access and eagress time.

- **OwnedVehAccessTime**:Average amount of time in minutes required for access to and egress from a household-owned vehicle for a trip
- **HighCarSvcAccessTime**: Average amount of time in minutes required for access to and egress from a high service level car service for a trip
- **LowCarSvcAccessTime**: Average amount of time in minutes required for access to and egress from a low service level car service for a trip

Here is a snapshot of the file:

Geo	Year	OwnedVehAccessTime	HighCarSvcAccessTime	LowCarSvcAccessTime
RVMPO	2010	5	10	45
RVMPO	2038	5	10	45

6.3.17 bzone_transit_service.csv

This file supplies the data on relative public transit accessibility at the `Bzone` level. The data to inform this input can be sourced from the EPA's Smart Location Database.

- **D4c**: Aggregate frequency of transit service within 0.25 miles of block group boundary per hour during evening peak period (Ref: EPA 2010 Smart Location Database)

Here is a snapshot of the file:

Geo	Year	D4c
D410290014002	2010	0
D410290013012	2010	0
D410290014001	2010	0
D410290014003	2010	0
D410290013021	2010	0

6.3.18 bzone_carsvc_availability.csv

This file contains the information about level of car service availability and contains a value of either `Low` or `High` for `Bzones`. `High` means car service access is competitive with household owned car and will impact household vehicle ownership; `Low` is not competitive and will not impact household vehicle ownership.

Here is a snapshot of the file:

Geo	Year	CarSvcLevel
D410290014002	2010	Low
D410290013012	2010	Low
D410290014001	2010	Low
D410290014003	2010	Low
D410290013021	2010	Low

6.3.19 bzone_dwelling_units.csv

This file contains the number single-family dwelling units (`SFDU`), multifamily dwelling units (`MFDU`) and group-quarter dwelling units (`GQDU`) by `Bzone` for each of the base and future years. Data for the base year for single-family and multifamily dwelling units can be sourced from Census housing data with information on units in structure, with multifamily dwelling units defined as any structures with 2-or-more units. For group quarters, unless more detailed local data is available, Census data for non-institutionalized group quarter population can serve as a proxy for dwelling units assuming a `1:1` ratio of dwelling unit per GQ population.

Here is a snapshot of the file:

Geo	Year	SFDU	MFDU	GQDU
D410290014002	2010	559	0	0
D410290013012	2010	79	8	523
D410290014001	2010	1398	180	0
D410290014003	2010	1385	172	0
D410290013021	2010	271	0	0

6.3.20 bzone_employment.csv

This file contains the total, retail and service employment by zone for each of the base and future years. Employment categorizations are from the Environmental Protection Agency's (EPA) Smart Location Database 5-tier employment classification.

- **TotEmp**: Total number of jobs in zone
- **RetEmp**: Number of jobs in retail sector in zone (Census LEHD: CNS07)
- **SvcEmp**: Number of jobs in service sector in zone (Census LEHD: CNS12 + CNS14 + CNS15 + CNS16 + CNS19)

Here is a snapshot of the file:

Geo	Year	TotEmp	RetEmp	SvcEmp
D410290014002	2010	403	262	96
D410290013012	2010	1382	73	880
D410290014001	2010	271	12	172
D410290014003	2010	609	66	413
D410290013021	2010	49	1	41

6.3.21 bzone_hh_inc_qrtl_prop.csv

This file contains the proportion of `Bzone` non-group quarters households by quartile of `Azone` household income category for each of the base and future years. The total for each `Bzone` should sum to `1`.

Here is a snapshot of the file:

Geo	Year	HhPropIncQ1	HhPropIncQ2	HhPropIncQ3	HhPropIncQ4
D410290014002	2010	0.12	0.54	0.26	0.54
D410290013012	2010	0.00	0.32	0.36	0.32
D410290014001	2010	0.24	0.16	0.26	0.16
D410290014003	2010	0.16	0.19	0.36	0.19
D410290013021	2010	0.29	0.29	0.15	0.29

6.3.22 bzone_lat_lon.csv

This file contains the latitude and longitude of the centroid of each Bzone.

Here is a snapshot of the file:

Geo	Year	Latitude	Longitude
D410290014002	2010	42.48657	-122.8014
D410290013012	2010	42.44259	-122.8461
D410290014001	2010	42.46010	-122.7925
D410290014003	2010	42.47673	-122.8008
D410290013021	2010	42.37304	-122.7793

6.3.23 bzone_network_design.csv

This file contains values for `D3bpo4`, a measure for intersection density determined by the number of pedestrian-oriented intersections having four or more legs per square mile. The data to inform this input can be sourced from the EPA's Smart Location Database.

Here is a snapshot of the file:

Geo	Year	D3bpo4
D410290014002	2010	0.2618757
D410290013012	2010	0.4830901
D410290014001	2010	1.8038130
D410290014003	2010	18.9766301
D410290013021	2010	0.1013039

6.3.24 bzone_parking.csv

This file contains the parking information by `Bzone` for each of the base and future years. Users should use available local data on parking availability, costs, and program participation to develop this input.

- **PkgSpacesPerSFDU**: Average number of free parking spaces available to residents of single-family dwelling units
- **PkgSpacesPerMFDU**: Average number of free parking spaces available to residents of multifamily dwelling units
- **PkgSpacesPerGQ**: Average number of free parking spaces available to group quarters residents
- **PropWkrPay**: Proportion of workers who pay for parking
- **PropCashOut**: Proportions of workers paying for parking in a cash-out-buy-back program
- **PkgCost**: Average daily cost for long-term parking (e.g. paid on monthly basis)

Here is a snapshot of the file:

Geo	Year	PkgSpacesPerSFDU	PkgSpacesPerMFDU	PkgSpacesPerGQ	PropWkrPay	PropC
D410290014002	2010	3	1.5	0	0	
D410290013012	2010	4	4.0	0	0	
D410290014001	2010	4	4.0	0	0	
D410290014003	2010	4	4.0	0	0	
D410290013021	2010	4	4.0	0	0	

6.3.25 bzone_travel_demand_mgt.csv

This file contains the information about workers and households participating in demand management programs. Users should use available local data on travel demand management programs to develop this input.

- **EcoProp**: Proportion of workers working in `Bzone` who participate in strong employee commute options program (can also be used to approximate the impacts of teleworking)
- **ImpProp**: Proportion of households residing in `Bzone` who participate in strong individualized marketing program

Here is a snapshot of the file:

Geo	Year	EcoProp	ImpProp
D410290014002	2010	0.0	0.0
D410290013012	2010	0.2	0.4
D410290014001	2010	0.2	0.4
D410290014003	2010	0.0	0.0
D410290013021	2010	0.0	0.0

6.3.26 bzone_unprotected_area.csv

This file contains the information about unprotected (i.e., developable) area within the zone.

- **UrbanArea**: Area that is `Urban` and unprotected (i.e. developable) within the zone (Acres)
- **TownArea**: Area that is `Town` and unprotected within the zone (Acres)
- **RuralArea**: Area that is `Rural` and unprotected within the zone (Acres)

Here is a snapshot of the file:

Geo	Year	UrbanArea	TownArea	RuralArea
D410290014002	2010	298.6487137	0	4996.11876
D410290013012	2010	830.6009450	0	384.80922
D410290014001	2010	983.1506646	0	3699.94017
D410290014003	2010	439.2145619	0	90.86259
D410290013021	2010	0.3548548	0	6212.57640

6.3.27 bzone_urban-town_du_proportions.csv

This file contains proportion of SF, MF and GQ dwelling units within the urban portion of the zone.

- **PropUrbanSFDU**: Proportion of single family dwelling units located within the urban portion of the zone
- **PropUrbanMFDU**: Proportion of multi-family dwelling units located within the urban portion of the zone
- **PropUrbanGQDU**: Proportion of group quarters accommodations located within the urban portion of the zone
- **PropTownSFDU**: Proportion of single family dwelling units located within the town portion of the zone
- **PropTownMFDU**: Proportion of multi-family dwelling units located within the town portion of the zone
- **PropTownGQDU**: Proportion of group quarters accommodations located within the town portion of the zone

Here is a snapshot of the file:

Geo	Year	PropUrbanSFDU	PropUrbanMFDU	PropUrbanGQDU	PropTownSFD
D410290014002	2010	0.4686941	1	1	0
D410290013012	2010	0.8860759	1	1	0
D410290014001	2010	0.8626609	1	1	0
D410290014003	2010	0.9906137	1	1	0
D410290013021	2010	0.0147601	1	1	0

6.3.28 marea_base_year_dvmt.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the adjust dvmt growth factors from base year in by Marea

- **UrbanLdvDvmt**: Average daily vehicle miles of travel on roadways in the urbanized portion of the Marea by light-duty vehicles during the base year
- **UrbanHvyTrkDvmt**: Average daily vehicle miles of travel on roadways in the urbanized portion of the Marea by heavy trucks during he base year

Here is a snapshot of the file:

Geo	UzaNameLookup	UrbanLdvDvmt	UrbanHvyTrkDvmt
RVMPO	Medford/OR	NA	NA

6.3.29 marea_congestion_charges.csv

This input file is OPTIONAL. It is only needed if the user wants to add a congestion charge policy for vehicle travel using different congestion levels and roadway classes.

- **FwyNoneCongChg**: Charge per mile (U.S. dollars) of vehicle travel on freeways during periods of no congestion
- **FwyModCongChg**: Charge per mile (U.S. dollars) of vehicle travel on freeways during periods of moderate congestion
- **FwyHvyCongChg**: Charge per mile (U.S. dollars) of vehicle travel on freeways during periods of heavy congestion
- **FwySevCongChg**: Charge per mile (U.S. dollars) of vehicle travel on freeways during periods of severe congestion
- **FwyExtCongChg**: Charge per mile (U.S. dollars) of vehicle travel on freeways during periods of extreme congestion
- **ArtNoneCongChg**: Charge per mile (U.S. dollars) of vehicle travel on arterials during periods of no congestion
- **ArtModCongChg**: Charge per mile (U.S. dollars) of vehicle travel on arterials during periods of moderate congestion
- **ArtHvyCongChg**: Charge per mile (U.S. dollars) of vehicle travel on arterials during periods of heavy congestion
- **ArtSevCongChg**: Charge per mile (U.S. dollars) of vehicle travel on arterials during periods of severe congestion
- **ArtExtCongChg**: Charge per mile (U.S. dollars) of vehicle travel on arterials during periods of extreme congestion

Here is a snapshot of the file:

Geo	Year	FwyNoneCongChg.2010	FwyModCongChg.2010	FwyHvyCongChg.2010	FwySevCongChg.
RVMPO	2010	0	0	0	0.0
RVMPO	2038	0	0	0	0.1

6.3.30 marea_dvmt_split_by_road_class.csv

DVMT Split by Road Class This input file is OPTIONAL. It is only needed if the user wants to modify the dvmt split for different road classes. This data can be derived from the FHWA Highway Statistics data.

- **LdvFwyArtDvmtProp**: Proportion of light-duty daily vehicle miles of travel in the urbanized portion of the Marea occurring on freeway or aerial roadways
- **LdvOthDvmtProp**: Proportion of light-duty daily vehicle miles of travel in the urbanized portion of the Marea occurring on other roadways
- **HvyTrkFwyDvmtProp**: Proportion of heavy truck daily vehicle miles of travel in the urbanized portion of the Marea occurring on freeways
- **HvyTrkArtDvmtProp**: Proportion of heavy truck daily vehicle miles of travel in the urbanized portion of the Marea occurring on arterial rdways
- **HvyTrkOthDvmtProp**: Proportion of heavy truck daily vehicle miles of travel in the urbanized portion of the Marea occurring on other roadways
- **BusFwyDvmtProp**: Proportion of bus daily vehicle miles of travel in the urbanized portion of the Marea occurring on freeways
- **BusArtDvmtProp**: Proportion of bus daily vehicle miles of travel in the

urbanized portion of the Marea occurring on arterial roadways

- **BusOthDvmtProp**: Proportion of bus daily vehicle miles of travel in the urbanized portion of the Marea occuring on other roadways

Here is a snapshot of the file:

Geo	LdvFwyDvmtProp	LdvArtDvmtProp	LdvOthDvmtProp	HvyTrkFwyDvmtProp	Hv
RVMPO	0.2632296	0.47739	0.2593804		

6.3.31 marea_lane_miles.csv

This file contains inputs on the numbers of freeway lane-miles and arterial lane-miles by `Marea` and year. The data to develop this input can be sourced from the FHWA Highway Performance Monitoring System (HPMS), using either the HPMS geospatial data or Highway Statistics, or the State DOT.

- **FwyLaneMi**: Lane-miles of roadways functionally classified as freeways or expressways in the urbanized portion of the metropolitan area
- **ArtLaneMi**: Lane-miles of roadways functionally classified as arterials (but not freeways or expressways) in the urbanized portion of the metropolitan area

Here is a snapshot of the file:

Geo	Year	FwyLaneMi	ArtLaneMi
RVMPO	2010	91	356
RVMPO	2038	97	371

6.3.32 marea_operations_deployment.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the proportion of DVMT affected by operations for different road classes.

- **RampMeterDeployProp**: Proportion of freeway DVMT affected by ramp metering deployment
- **IncidentMgtDeployProp**: Proportion of freeway DVMT affected by incident management deployment
- **SignalCoordDeployProp**: Proportion of arterial DVMT affected by signal coordination deployment
- **AccessMgtDeployProp**: Proportion of arterial DVMT affected by access management deployment
- **OtherFwyOpsDeployProp**: Proportion of freeway DVMT affected by deployment of other user-defined freeway operations measures
- **OtherArtOpsDeployProp**: Proportion of arterial DVMT affected by deployment of other user-defined arterial operations measures

Here is a snapshot of the file:

Geo	Year	RampMeterDeployProp	IncidentMgtDeployProp	SignalCoordDeployProp	AccessMgtDepl
RVMPO	2010	0.00	0.50	0.50	0.00
RVMPO	2038	0.95	0.95	0.95	0.24

6.3.33 marea_speed_smooth_ecodrive.csv

This input file supplies information of deployment of speed smoothing and eco-driving by road class and vehicle type.

- **FwySmooth**:Fractional deployment of speed smoothing traffic management on freeways, where 0 is no deployment and 1 is the full potential fuel savings
- **ArtSmooth**: Fractional deployment of speed smoothing traffic management on arterials, where 0 is no deployment and 1 is the full potential fuel savings
- **LdvEcoDrive**: Eco-driving penetration for light-duty vehicles; the fraction of vehicles from 0 to 1
- **HvyTrkEcoDrive**: Eco-driving penetration for heavy-duty vehicles; the fraction of vehicles from 0 to 1

Here is a snapshot of the file:

Geo	Year	FwySmooth	ArtSmooth	LdvEcoDrive	HvyTrkEcoDrive
RVMPO	2010	0.2	0.1	0.2	0.05
RVMPO	2038	0.4	0.2	0.4	0.2

6.3.34 marea_transit_ave_fuel_carbon_intensity.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the average carbon intensity of fuel used by transit.

- **TransitVanFuelCI**: Average carbon intensity of fuel used by transit vans (grams CO2e per megajoule)
- **TransitBusFuelCI**: Average carbon intensity of fuel used by transit buses (grams CO2e per megajoule)
- **TransitRailFuelCI**: Average carbon intensity of fuel used by transit rail vehicles (grams CO2e per megajoule)

Here is a snapshot of the file:

Geo	Year	TransitVanFuelCI	TransitBusFuelCI	TransitRailFuelCI
RVMPO	2010	90.38	NA	NA
RVMPO	2038	72.30	NA	NA

6.3.35 marea_transit_biofuel_mix.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the biofuel used by transit services.

- **TransitEthanolPropGasoline**: Ethanol proportion of gasoline used by transit vehicles
- **TransitBiodieselPropDiesel**: Biodiesel proportion of diesel used by transit vehicles
- **TransitRngPropCng**: Renewable natural gas proportion of compressed natural gas used by transit vehicles

Here is a snapshot of the file:

Geo	Year	TransitEthanolPropGasoline	TransitBiodieselPropDiesel	TransitRngPropCng
RVMPO	2010	0.1	0.05	0
RVMPO	2038	0.1	0.05	0

6.3.36 marea_transit_fuel.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the transit fuels proportions.

- **VanPropDiesel**: Proportion of non-electric transit van travel powered by diesel
- **VanPropGasoline**: Proportion of non-electric transit van travel powered by gasoline
- **VanPropCng**: Proportion of non-electric transit van travel powered by compressed natural gas
- **BusPropDiesel**: Proportion of non-electric transit bus travel powered by diesel
- **BusPropGasoline**: Proportion of non-electric transit bus travel powered by gasoline
- **BusPropCng**: Proportion of non-electric transit bus travel powered by compressed natural gas
- **RailPropDiesel**: Proportion of non-electric transit rail travel powered by diesel
- **RailPropGasoline**: Proportion of non-electric transit rail travel powered by gasoline

Here is a snapshot of the file:

Geo	Year	VanPropDiesel	VanPropGasoline	VanPropCng	BusPropDiesel	BusPropGas
RVMPO	2010	0	1	0	0.2	0
RVMPO	2038	0	1	0	0.2	0

6.3.37 marea_transit_powertrain_prop.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the mixes of transit vehicle powertrains.

- **VanPropIcev**: Proportion of transit van travel using internal combustion engine powertrains

- **VanPropHev**: Proportion of transit van travel using hybrid electric powertrains
- **VanPropBev**: Proportion of transit van travel using battery electric powertrains
- **BusPropIcev**: Proportion of transit bus travel using internal combustion engine powertrains
- **BusPropHev**: Proportion of transit bus travel using hybrid electric powertrains
- **BusPropBev**: Proportion of transit bus travel using battery electric powertrains
- **RailPropIcev**: Proportion of transit rail travel using internal combustion engine powertrains
- **RailPropHev**: Proportion of transit rail travel using hybrid electric powertrains
- **RailPropEv**: Proportion of transit rail travel using electric powertrains

Here is a snapshot of the file:

Geo	Year	VanPropIcev	VanPropHev	VanPropBev	BusPropIcev	BusPropHev	BusPropBev	Ra
RVMPO	2010	1	0	0	1	0	0	
RVMPO	2038	1	0	0	1	0	0	

6.3.38 marea_transit_service.csv

This file contains annual revenue-miles for different transit modes for metropolitan area. Data to develop this input can be sourced from the Federal Transit Administration NTD.

- **DRRevMi**: Annual revenue-miles of demand-responsive public transit service
- **VPRevMi**: Annual revenue-miles of van-pool and similar public transit service
- **MBRevMi**: Annual revenue-miles of standard bus public transit service
- **RBRevMi**: Annual revenue-miles of rapid-bus and commuter bus public transit service
- **MGRevMi**: Annual revenue-miles of monorail and automated guideway public transit service
- **SRRevMi**: Annual revenue-miles of streetcar and trolleybus public transit service
- **HRRevMi**: Annual revenue-miles of light rail and heavy rail public transit service
- **CRRevMi**: Annual revenue-miles of commuter rail, hybrid rail, cable car, and aerial tramway public transit service

Here is a snapshot of the file:

Geo	Year	DRRevMi	VPRevMi	MBRevMi	RBRevMi	MGRevMi	SRRevMi	HRRe
RVMPO	2010	382639	0	607922	0	0	0	0
RVMPO	2038	2381995	0	3580237	0	0	0	0

6.3.39 other_ops_effectiveness.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the other delay effects of operations in different road classes

- **Level**: Congestion levels: None = none, Mod = moderate, Hvy = heavy, Sev = severe, Ext = extreme
- **Art_Rcr**: Percentage reduction of recurring arterial delay that would occur with full deployment of other user-defined arterial operations measures
- **Art_NonRcr**: Percentage reduction of non-recurring arterial delay that would occur with full deployment of other user-defined arterial operations measures
- **Fwy_Rcr**: Percentage reduction of recurring freeway delay that would occur with full deployment of other user-defined freeway operations measures
- **Fwy_NonRcr**: Percentage reduction of non-recurring freeway delay that would occur with full deployment of other user-defined freeway operations measures

Here is a snapshot of the file:

Level	Art_Rcr	Art_NonRcr	Fwy_Rcr	Fwy_NonRcr	AccessMgtDeployProp	OtherFwyOp
None	0	0	0	0	0	0
Mod	0	0	0	0	0	0
Hvy	0	0	0	0	0	0
sev	0	0	0	0	0	0
Ext	0	0	0	0	0	0

6.3.40 region_ave_fuel_carbon_intensity.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the average carbon density for different vehicle types for the model region.

- **HhFuelCI**: Average carbon intensity of fuels used by household vehicles (grams CO2e per megajoule)
- **CarSvcFuelCI**: Average carbon intensity of fuels used by car service vehicles (grams CO2e per megajoule)
- **ComSvcFuelCI**: Average carbon intensity of fuels used by commercial service vehicles (grams CO2e per megajoule)
- **HvyTrkFuelCI**: Average carbon intensity of fuels used by heavy trucks (grams CO2e per megajoule)
- **TransitVanFuelCI**: Average carbon intensity of fuels used by transit vans (grams CO2e per megajoule)

- **TransitBusFuelCI**: Average carbon intensity of fuels used by transit buses (grams CO2e per megajoule)
- **TransitRailFuelCI**: Average carbon intensity of fuels used by transit rail vehicles (grams CO2e per megajoule)

Here is a snapshot of the file:

Geo	Year	HhFuelCI	CarSvcFuelCI	ComSvcFuelCI	HvyTrkFuelCI	TransitVanFuelC	TransitBusF
RVMPO	2010	90.23	90.23	90.23	NA	NA	NA
RVMPO	2038	72.30	72.30	72.30	NA	NA	NA

6.3.41 region__base__year__dvmt.csv

This input file is OPTIONAL. It is only needed if the user wants to adjust heavy truck DVMT for base year

- **HvyTrkDvmtGrowthBasis**: Factor used to grow heavy truck DVMT from base year value
- **HvyTrkDvmt**: Average daily vehicle miles of travel on roadways in the region by heavy trucks during he base year
- **HvyTrkDvmtUrbanProp**: Proportion of Region heavy truck daily vehicle miles of travel occurring on urbanized area roadways

Here is a snapshot of the file:

StateAbbrLookup	HvyTrkDvmtGrowthBasis	HvyTrkDvmt	ComSvcDvmtGrowthBasis
	Income	NA	Population

6.3.42 region__carsvc__powertrain__prop.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the powertrain proportion of car services.

- **CarSvcAutoPropIcev**: Proportion of car service automobile travel powered by internal combustion engine powertrains
- **CarSvcAutoPropHev**: Proportion of car service automobile travel powered by hybrid electric powertrains
- **CarSvcAutoPropBev**: Proportion of car service automobile travel powered by battery electric powertrains
- **CarSvcLtTrkPropIcev**: Proportion of car service light truck travel powered by internal combustion engine powertrains
- **CarSvcLtTrkPropHev**: Proportion of car service light truck travel powered by hybrid electric powertrains
- **CarSvcLtTrkPropBev**: Proportion of car service light truck travel powered by battery electric powertrains

Here is a snapshot of the file:

Geo	Year	CarSvcAutoPropIcev	CarSvcAutoPropHev	CarSvcAutoPropBev	CarSvcLtTrk
RVMPO	2010	0.990	0.010	0.000	1.000
RVMPO	2038	0.441	0.528	0.031	0.533

6.3.43 region_comsvc_lttrk_prop.csv

This file supplies data for the light truck proportion of commercial vehicles for the region.

- **ComSvcLtTrkProp**: Regional proportion of commercial service vehicles that are light trucks

Here is a snapshot of the file:

Year	ComSvcLtTrkProp
2010	0.51
2038	0.51

6.3.44 region_comsvc_powertrain_prop.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the powertrain proportion of commercial vehicles.

- **ComSvcAutoPropIcev**: Proportion of commercial service automobile travel powered by internal combustion engine powertrains
- **ComSvcAutoPropHev**: Proportion of commercial service automobile travel powered by hybrid electric powertrains
- **ComSvcAutoPropBev**: Proportion of commercial service automobile travel powered by battery electric powertrains
- **ComSvcLtTrkPropIcev**: Proportion of commercial service light truck travel powered by internal combustion engine powertrains
- **ComSvcLtTrkPropHev**: Proportion of commercial service light truck travel powered by hybrid electric powertrains
- **ComSvcLtTrkPropBev**: Proportion of commercial service light truck travel powered by battery electric powertrainss

Here is a snapshot of the file:

Geo	Year	ComSvcAutoPropIcev	ComSvcAutoPropHev	ComSvcAutoPropBev	ComSvcL
RVMPO	2010	0.990	0.010	0.000	1
RVMPO	2038	0.441	0.528	0.031	0

6.3.45 region_hh_driver_adjust_prop.csv

This file is optional and can be used to adjust the estimate of household drivers by age cohort. The file specifies the relative driver licensing rate relative to the model estimation data year in order to account for observed or projected changes in licensing rates.

- **Drv15to19AdjProp**: Target proportion of unadjusted model number of drivers 15 to 19 years old (1 = no adjustment)
- **Drv20to29AdjProp**: Target proportion of unadjusted model number of drivers 20 to 29 years old (1 = no adjustment)
- **Drv30to54AdjProp**: Target proportion of unadjusted model number of drivers 30 to 54 years old (1 = no adjustment)
- **Drv55to64AdjProp**: Target proportion of unadjusted model number of drivers 55 to 64 years old (1 = no adjustment)
- **Drv65PlusAdjProp**: Target proportion of unadjusted model number of drivers 65 or older (1 = no adjustment)

Here is a snapshot of the file:

Year	DrvPerPrsn15to19	Drv20to29AdjProp	Drv30to54AdjProp	Drv55to64AdjProp	Drv65PlusAdjProp
2010	0.8174609	0.9466447	0.9466447	0.9900000	0.9349951
2038	0.9091840	0.9091840	0.9091840	0.9508236	0.8979954

6.3.46 region_hvytrk_powertrain_prop.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the powertrain proportion of heavy duty trucks.

- **HvyTrkPropIcev**: Proportion of heavy truck travel powered by internal combustion engine powertrains
- **HvyTrkPropHev**: Proportion of heavy truck travel powered by hybrid electric powertrains
- **HvyTrkPropBev**: Proportion of heavy truck travel powered by battery electric powertrains

Here is a snapshot of the file:

Geo	Year	HvyTrkPropIcev	HvyTrkPropHev	HvyTrkPropBev
RVMPO	2010	1.0	0.0	0.0
RVMPO	2038	0.4	0.4	0.2

6.3.47 region_prop_externalities_paid.csv

Proportional external costs for the ragion (This file supplies data for climate change and other social costs.

- **PropClimateCostPaid**: Proportion of climate change costs paid by users (i.e. ratio of carbon taxes to climate change costs
- **PropOtherExtCostPaid**: Proportion of other social costs paid by users

Here is a snapshot of the file:

Year	PropClimateCostPaid	PropOtherExtCostPaid
2038	1	0.5

Year	PropClimateCostPaid	PropOtherExtCostPaid
2010	0	0

6.3.48 region_road_cost.csv (TO DO)

Year	RoadBaseModCost.2005	RoadPresOpMaintCost.2005	RoadOtherOpMaintCost.2005	FwyLnMiCost.2005	ArtLnMiCost.2005	HvyTrkPCE
2010	0.004	0.01	0.015	4900	1800	3
2038	0.004	0.01	0.015	4900	1800	3

6.4 VE-State Input Files

- **azone_carsvc_characteristics.csv** This file specifies the different characteristics for high and low car service level and is used in the CreateVehicleTable and AssignVehicleAge modules.
- **azone_charging_availability.csv** This file has data on proportion of different household types who has EV charging available and is used in the AssignHHVehiclePowertrain module.
- **azone_electricity_carbon_intensity.csv** This file is used to specify the carbon intensity of electricity and is optional (only needed if user wants to modify the values). The file is used in Initialize (VEPowertrainsAndFuels) and CalculateCarbonIntensity modules.
- **azone_fuel_power_cost.csv** This file supplies data for retail cost of fuel and electricity and is used in the CalculateVehicleOperatingCost module.
- **azone_gq_pop_by_age.csv** This file contains group quarters population estimates/forecasts by age and is used in the CreateHouseholds module.
- **azone_gq_pop-prop_by_area-type.csv** This file provides the proportions for groupquarters in different area types and is used in the Initialize module.
- **azone_hh_loc_type_prop.csv** This file provides the proportions for households residing in the metropolitan, towns and rural part of the Azone and is used in the Initialize module.
- **azone_hh_pop_by_age.csv** This file contains population estimates/forecasts by age and is used in the CreateHouseholds module.
- **azone_hh_veh_mean_age.csv** This file provides inputs for mean auto age and mean light truck age and is used in the AssignVehicleAge module.

- **azone_hh_veh_own_taxes.csv** This file provides inputs for flat fees/taxes (i.e. annual cost per vehicle) and ad valorem taxes (i.e. percentage of vehicle value paid in taxes). The file is used in CalculateVehicleOwnCost module.
- **azone_hhsize_targets.csv** This file contains the household specific targets and is used in CreateHouseholds module.
- **azone_loc_type_land_area.csv** This file provides land area data for different area types and is used in Initialize module.
- **azone_lttrk_prop.csv** This file specifies the light truck proportion of the vehicle fleet and is used in AssignVehicleType module.
- **azone_payd_insurance_prop.csv** This file provides inputs on the proportion of households having PAYD (pay-as-you-drive) insurance and is used in the CalculateVehicleOwnCost module.
- **azone_per_cap_inc.csv** This file contains information on regional average per capita household and group quarters income in year 2010 dollars and is used in the PredictIncome module.
- **azone_prop_sov_dvmt_diverted.csv** This file provides inputs for a goal for diverting a portion of SOV travel within a 20-mile tour distance and is used in the DivertSovTravel module.
- **azone_relative_employment.csv** This file contains ratio of workers to persons by age and is used in the PredictWorkers module.
- **azone_veh_use_taxes.csv** This file supplies data for vehicle related taxes and is used in the CalculateVehicleOperatingCost module.
- **azone_vehicle_access_times.csv** This file supplies data for vehicle access and egress time and is used in the CalculateVehicleOperatingCost module.
- **azone_wkr_loc_type_prop** This file provides the proportions for workers residing in Azone who works in the metropolitan, towns and rural part of the Azone and is used in Initialize module.
- **marea_base_year_dvmt.csv** This file is used to specify to adjust the DVMT growth factors and is optional (only needed if user wants to modify the values). The file is used in the Initialize (VETravelPerformance), CalculateBaseRoadDvmt and CalculateFutureRoadDvmt modules.
- **marea_carsvc_availability.csv** This file has the data for activity proportions which are served by car services and is used in the Initialize (AssignCarSvcAvailability)
- **marea_congestion_charges.csv** This file is used to specify the charges of vehicle travel for different congestion levels and is optional. The file is

used in the Initialize (VETravelPerformance) and CalculateRoadPerformance modules.

- **marea_dvmt_split_by_road_class.csv** This file is used to specify the dvmt split for different road classes and is optional. The file is used in the Initialize (VETravelPerformance) and CalculateBaseRoadDvmt modules.
- **marea_d3bpo4_adj.csv** This file provides the D3bpo4 value for urban, town and rural areas from the EPA 2010 Smart Location Database and is used in the Simulate4DMeasures
- **marea_lane_miles.csv** This file contains inputs on the numbers of freeway lane-miles and arterial lane-miles and is used in the AssignRoadMiles module.
- **marea_mix_targets.csv** This file represents Marea target for proportion of households located in mixed-use neighborhoods (or NA if no target) and is used in the SimulateUrbanMixMeasure module.
- **marea_operations_deployment.csv** This file is used to specify the proportion of dvmt affected by operations for different road classes and is optional. The file is used in the Initialize (VETravelPerformance) and CalculateRoadPerformance modules.
- **marea_parking-avail_by_area-type.csv** This file has the data for average number of parking spots available to households and is used in the AssignParkingRestrictions
- **marea_parking-cost_by_area-type.csv** This file has the data related to parking costs and population proportions paying the parking costs and is used in the AssignParkingRestrictions
- **marea_speed_smooth_ecodrive.csv** This input file supplies information of deployment of speed smoothing and ecodriving by road class and vehicle type and is used in the CalculateMpgMpkwhAdjustments module.
- **marea_transit_ave_fuel_carbon_intensity.csv** This file is used to specify the average carbon intensity of fuel used by transit and is optional. The file is used in the Initialize (VETravelPerformance) module.
- **marea_transit_biofuel_mix.csv** This file is used to specify the biofuel used by transit and is optional. The file is used in the Initialize (VETravelPerformance) and CalculateCarbonIntensity modules.
- **marea_transit_fuel.csv** This file is used to specify the transit fuel proportions and is optional. The file is used in the Initialize (VETravelPerformance) and CalculateCarbonIntensity modules.
- **marea_transit_powertrain_prop.csv** This file is used to specify the mixes of transit vehicle powertrains and is optional. The file is used

in the Initialize (VETravelPerformance) and CalculatePtranEnergyAndEmissions modules.

- **marea_transit_service.csv** This file contains annual revenue-miles for different transit modes for metropolitan area and is used in the AssignTransitService module.
- **marea_travel-demand-mgt_by_area-type.csv** This file has the data for proportions participating in demand management programs and is used in the AssignDemandManagement module.
- **marea_uza_profile_names.csv** This file provides the name of a specific urbanized area for the urbanized area profile to use in SimBzone creation and is used in the Initialize module.
- **other_ops_effectiveness.csv** This file is used to specify the delay effects of operations in different road classes and is optional (only needed if user wants to modify the values). The file is used in the Initialize (VETravelPerformance) and CalculateRoadPerformance modules.
- **region_ave_fuel_carbon_intensity.csv** This file is used to specify the average carbon density for different vehicle types and is optional (only needed if user wants to modify the values). The file is used in the Initialize (VETravelPerformance) and CalculateCarbonIntensity modules.
- **region_base_year_hvytrk_dvmt.csv** This file is used to specify the heavy truck dvmt for base year and is optional. The file is used in the Initialize (VETravelPerformance), CalculateBaseRoadDvmt and CalculateFutureRoadDvmt modules.
- **region_carsvc_powertrain_prop.csv** This file is used to specify the powertrain proportion of car services and is optional. The file is used in the Initialize (VETravelPerformance), AssignHhVehiclePowertrain and AdjustHhVehicleMpgMpkwh modules.
- **region_comsvc_lttrk_prop.csv** This file supplies data for the light truck proportion of commercial vehicles and is used in the CalculateComEnergyAndEmissions module.
- **region_comsvc_powertrain_prop.csv** This file is used to specify the powertrain proportion of commercial vehicles and is optional. The file is used in the Initialize (VEPowertrainsAndFuels) and CalculateComEnergyAndEmissions modules.
- **region_comsvc_veh_mean_age.csv** This input file contains average age of commercial service vehicles and is used in the CalculateComEnergyAndEmissions module.
- **region_hh_driver_adjust_prop.csv** This file specifies the relative driver licensing rate relative to the model estimation data year and is used in the AssignDrivers module.

- **region_hvytrk_powertrain_prop.csv** This file is used to specify the powertrain proportion of heavy duty trucks and is optional. The file is used in the Initialize (VEPowertrainsAndFuels) and CalculateComEnergyAndEmissions modules.

- **region_prop_externalities_paid.csv** This file supplies data for climate change and other social costs and is used in the CalculateVehicleOperatingCost module.

- **region_road_cost.csv** This file supplies data for different types of road costs and is used in the BalanceRoadCostsAndRevenues module.

6.4.1 azone_carsvc_characteristics.csv

This file specifies the different characteristics for high and low car service levels

- **HighCarSvcCost**: Average cost in dollars per mile for travel by high service level car service
- **LowCarSvcCost**: Average cost in dollars per mile for travel by low service level car service
- **AveCarSvcVehicleAge**: Average age of car service vehicles in years
- **LtTrkCarSvcSubProp**: The proportion of light-truck owners who would substitute a less-costly car service option for owning their light truck
- **AutoCarSvcSubProp**: The proportion of automobile owners who would substitute a less-costly car service option for owning their automobile

Here is a snapshot of the file:

6.4.2 azone_charging_availability.csv

This input file supplies data on proportion of different household types who has available charging

- **PropSFChargingAvail**: Proportion of single-family dwellings in Azone that have PEV charging facilties installed or able to be installed
- **PropMFChargingAvail**: Proportion of multi-family dwelling units in Azone that have PEV charging facilities available
- **PropGQChargingAvail**: Proportion of group quarters dwelling units in Azone that have PEV charging facilities available

Here is a snapshot of the file:

6.4.3 azone_electricity_carbon_intensity.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the carbon intensity of electricity.

- **ElectricityCI**: Carbon intensity of electricity at point of consumption (grams CO2e per megajoule)

Here is a snapshot of the file:

6.4.4 azone_fuel_power_cost.csv

This file supplies data for retail cost of fuel and electricity

- **FuelCost**:Retail cost of fuel per gas gallon equivalent in dollars
- **PowerCost**: Retail cost of electric power per kilowatt-hour in dollars

Here is a snapshot of the file:

6.4.5 azone_gq_pop_by_age.csv

This file contains group quarters population estimates/forecasts by age for each of the base and future years. The file format includes number of persons within the following six age categories:

- 0-14
- 15-19
- 20-29
- 30-54
- 55-64
- 65 Plus

Here is a snapshot of the file:

6.4.6 azone_gq_pop-prop_by_area-type.csv

This file provides the proportions for groupquarters in different area types.

- **MetroLandArea**: Land area (excluding large water bodies and large tracts of undevelopable land) in the metropolitan (i.e. urbanized) portion of the Azone
- **TownLandArea**: Land area (excluding large water bodies and large tracts of undevelopable land) in towns (i.e. urban-like but not urbanized) in the Azone
- **RuralAveDensity**: Proportion of workers residing in the Azone who work at jobs in the metropolitan (i.e. urbanized) area associated with the Azone

Here is a snapshot of the file:

6.4.7 azone_hh_loc_type_prop.csv

This file provides the proportions for households residing in the metropolitan, towns and rural part of the Azone

- **PropMetroHh**: Proportion of households residing in the metropolitan (i.e. urbanized) part of the Azone

- **PropTownHh**: Proportion of households residing in towns (i.e. urban-like but not urbanized) in the Azone
- **PropRuralHh**: Proportion of households residing in rural (i.e. not urbanized or town) parts of the Azone

Here is a snapshot of the file:

6.4.8 azone_hh_pop_by_age.csv

This file contains population estimates/forecasts by age for each of the base and future years. The file format includes number of persons within six age groups:

- 0-14
- 15-19
- 20-29
- 30-54
- 55-64
- 65 Plus

Here is a snapshot of the file:

6.4.9 azone_hh_veh_mean_age.csv

This file provides inputs for mean auto age and mean light truck age by Azone.

- **AutoMeanAge**: Mean age of automobiles owned or leased by households.
- **LtTrkMeanAge**: Mean age of light trucks owned or leased by households.

Here is a snapshot of the file:

6.4.10 azone_hh_veh_own_taxes.csv

This file provides inputs for flat fees/taxes (i.e. annual cost per vehicle) and ad valorem taxes (i.e. percentage of vehicle value paid in taxes).

- **VehOwnFlatRateFee**: Annual flat rate tax per vehicle in dollars
- **VehOwnAdValoremTax**: Annual proportion of vehicle value paid in taxes

Here is a snapshot of the file:

6.4.11 azone_hhsize_targets.csv

Rhis file contains the household-specific targets for the population synthesizer. This file contains two attributes:

- **AveHhSize**: Average household size for non-group quarters households
- **Prop1PerHh**: Proportion of non-group quarters households having only one person

Here is a snapshot of the file:

6.4.12 azone_loc_type_land_area.csv

This file provides land area data for different area types

- **MetroLandArea**: Land area (excluding large water bodies and large tracts of undevelopable land) in the metropolitan (i.e. urbanized) portion of the Azone
- **TownLandArea**: Land area (excluding large water bodies and large tracts of undevelopable land) in towns (i.e. urban-like but not urbanized) in the Azone
- **RuralAveDensity**: Average activity density (households and jobs per acre) of rural (i.e. not metropolitan or town) portions of the Azone not including large waterbodies or large tracts of agricultural lands, forest lands, or otherwise protected lands

Here is a snapshot of the file:

6.4.13 azone_lttrk_prop.csv

This file specifies the light truck proportion of the vehicle fleet.

- **LtTrkProp**: Proportion of household vehicles that are light trucks (pickup, SUV, van).

Here is a snapshot of the file:

6.4.14 azone_payd_insurance_prop.csv

This file provides inputs on the proportion of households having PAYD insurance.

- **PaydHhProp**: Proportion of households in the Azone who have pay-as-you-drive insurance for their vehicles

Here is a snapshot of the file:

6.4.15 azone_per_cap_inc.csv

This file contains information on regional average per capita household (`HHIncomePC`) and group quarters (`GQIncomePC`) income by forecast year in year 2010 dollars. The data can be obtained from the U.S. Department of Commerce Bureau of Economic Analysis for the current year or from regional or state sources for forecast years. In order to use current year dollars just replace 2010 in column labels with current year. For example, if the data is obtained in year 2015 dollars then the column labels in the file shown below will become `HHIncomePC.2015` and `GQIncomePC.2015`.

Here is a snapshot of the file:

6.4.16 azone_prop_sov_dvmt_diverted.csv

This file provides inputs for a goal for diverting a portion of SOV travel within a 20-mile tour distance (round trip distance).

- **PropSovDvmtDiverted**: Goals for the proportion of household DVMT in single occupant vehicle tours with round-trip distances of 20 miles or less be diverted to bicycling or other slow speed modes of travel

Here is a snapshot of the file:

6.4.17 azone_relative_employment.csv

This file contains the ratio of workers to persons by age cohort in the model year relative to the model estimation data year. This file contains five age cohorts:

- **RelEmp15to19**: Ratio of workers to persons age 15 to 19 in model year versus in estimation data year
- **RelEmp20to29**: Ratio of workers to persons age 20 to 29 in model year versus in estimation data year
- **RelEmp30to54**: Ratio of workers to persons age 30 to 54 in model year versus in estimation data year
- **RelEmp55to64**: Ratio of workers to persons age 55 to 64 in model year versus in estimation data year
- **RelEmp65Plus**: Ratio of workers to persons age 65 or older in model year versus in estimation data year

Here is a snapshot of the file:

6.4.18 azone_veh_use_taxes.csv

This file supplies data for vehicle related taxes

- **FuelTax**:Tax per gas gallon equivalent of fuel in dollars
- **VmtTax**: Tax per gas gallon equivalent of fuel in dollars
- **PevSurchgTaxProp**: Proportion of equivalent gas tax per mile paid by hydrocarbon fuel consuming vehicles to be charged to plug-in electric vehicles per mile of travel powered by electricity

Here is a snapshot of the file:

6.4.19 azone_vehicle_access_times.csv

This file supplies data for vehicle access and eagress time.

- **OwnedVehAccessTime**:Average amount of time in minutes required for access to and egress from a household-owned vehicle for a trip
- **HighCarSvcAccessTime**: Average amount of time in minutes required for access to and egress from a high service level car service for a trip

- **LowCarSvcAccessTime**: Average amount of time in minutes required for access to and egress from a low service level car service for a trip

Here is a snapshot of the file:

6.4.20 azone_wkr_loc_type_prop.csv

This file provides the proportions for workers residing in Azone who works in the metropolitan, towns and rural part of the Azone

- **PropWkrInMetroJobs**: Proportion of workers residing in the Azone who work at jobs in the metropolitan (i.e. urbanized) area associated with the Azone
- **PropWkrInTownJobs**: Proportion of workers residing in the Azone who work at jobs in towns (i.e. urban-like but not urbanized) in the Azone
- **PropWkrInRuralJobs**: Proportion of workers residing in the Azone who work at jobs in rural (i.e. not urbanized or town) parts of the Azone
- **PropMetroJobs**: Proportion of the jobs of the metropolitan area that the Azone is associated with that are located in the metropolitan portion of the Azone

Here is a snapshot of the file:

6.4.21 marea_base_year_dvmt.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the adjust dvmt growth factors from base year in by Marea

- **ComSvcDvmtGrowthBasis**: Factor used to grow commercial service vehicle DVMT in Marea from base year value
- **HvyTrkDvmtGrowthBasis**: Factor used to grow heavy truck DVMT from base year value
- **UrbanLdvDvmt**: Average daily vehicle miles of travel on roadways in the urbanized portion of the Marea by light-duty vehicles during the base year
- **UrbanHvyTrkDvmt**: Average daily vehicle miles of travel on roadways in the urbanized portion of the Marea by heavy trucks during he base year

Here is a snapshot of the file:

6.4.22 marea_carsvc_availability.csv

This file has the data for acitivity proportions which are served by car services

- **CenterPropHighCarSvc**: Proportion of activity in center area type that is served by high level car service (i.e. service competitive with household owned car)

- **InnerPropHighCarSvc**: Proportion of activity in inner area type that is served by high level car service (i.e. service competitive with household owned car)
- **OuterPropHighCarSvc**: Proportion of activity in outer area type that is served by high level car service (i.e. service competitive with household owned car)
- **FringePropHighCarSvc**: Proportion of activity in fringe area type that is served by high level car service (i.e. service competitive with household owned car)

Here is a snapshot of the file:

6.4.23 marea_congestion_charges.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the charges of vehicle travel for different congestion levels

- **FwyNoneCongChg**: Charge per mile (U.S. dollars) of vehicle travel on freeways during periods of no congestion
- **FwyModCongChg**: Charge per mile (U.S. dollars) of vehicle travel on freeways during periods of moderate congestion
- **FwyHvyCongChg**: Charge per mile (U.S. dollars) of vehicle travel on freeways during periods of heavy congestion
- **FwySevCongChg**: Charge per mile (U.S. dollars) of vehicle travel on freeways during periods of severe congestion
- **FwyExtCongChg**: Charge per mile (U.S. dollars) of vehicle travel on freeways during periods of extreme congestion
- **ArtNoneCongChg**: Charge per mile (U.S. dollars) of vehicle travel on arterials during periods of no congestion
- **ArtModCongChg**: Charge per mile (U.S. dollars) of vehicle travel on arterials during periods of moderate congestion
- **ArtHvyCongChg**: Charge per mile (U.S. dollars) of vehicle travel on arterials during periods of heavy congestion
- **ArtSevCongChg**: Charge per mile (U.S. dollars) of vehicle travel on arterials during periods of severe congestion
- **ArtExtCongChg**: Charge per mile (U.S. dollars) of vehicle travel on arterials during periods of extreme congestion

Here is a snapshot of the file:

6.4.24 marea_dvmt_split_by_road_class.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the dvmt split for different road classes.

- **LdvFwyArtDvmtProp**: Proportion of light-duty daily vehicle miles of travel in the urbanized portion of the Marea occurring on freeway or arterial roadways

- **LdvOthDvmtProp**: Proportion of light-duty daily vehicle miles of travel in the urbanized portion of the Marea occurring on other roadways
- **HvyTrkFwyDvmtProp**: Proportion of heavy truck daily vehicle miles of travel in the urbanized portion of the Marea occurring on freeways
- **HvyTrkArtDvmtProp**: Proportion of heavy truck daily vehicle miles of travel in the urbanized portion of the Marea occurring on arterial roadways
- **HvyTrkOthDvmtProp**: Proportion of heavy truck daily vehicle miles of travel in the urbanized portion of the Marea occurring on other roadways
- **BusFwyDvmtProp**: Proportion of bus daily vehicle miles of travel in the urbanized portion of the Marea occurring on freeways
- **BusArtDvmtProp**: Proportion of bus daily vehicle miles of travel in the urbanized portion of the Marea occurring on arterial roadways
- **BusOthDvmtProp**: Proportion of bus daily vehicle miles of travel in the urbanized portion of the Marea occuring on other roadways

Here is a snapshot of the file:

6.4.25 marea_d3bpo4_adj.csv

This file provides the D3bpo4 value for urban, town and rural areas from the EPA 2010 Smart Location Database

- **UrbanD3bpo4Adj**: Proportion of base urban D3bpo4 value as tabulated from the EPA 2010 Smart Location Database for the urbanized portion of the marea
- **TownD3bpo4Adj**: Proportion of base town D3bpo4 value as tabulated from the EPA 2010 Smart Location Database for towns
- **RuralD3bpo4Adj**: Proportion of base town D3bpo4 value as tabulated from the EPA 2010 Smart Location Database for rural areas

Here is a snapshot of the file:

6.4.26 marea_lane_miles.csv

This file contains inputs on the numbers of freeway lane-miles and arterial lane-miles by `Marea` and year.

- **FwyLaneMi**: Lane-miles of roadways functionally classified as freeways or expressways in the urbanized portion of the metropolitan area
- **ArtLaneMi**: Lane-miles of roadways functionally classified as arterials (but not freeways or expressways) in the urbanized portion of the metropolitan area

Here is a snapshot of the file:

6.4.27 marea_mix_targets.csv

This file represents Marea target for proportion of households located in mixed-use neighborhoods (or NA if no target)

- **UrbanMixProp**: Marea target for proportion of households located in mixed-use neighborhoods (or NA if no target)

Here is a snapshot of the file:

6.4.28 marea_operations_deployment.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the proportion of dvmt affected by operations for different road classes.

- **RampMeterDeployProp**: Proportion of freeway DVMT affected by ramp metering deployment
- **IncidentMgtDeployProp**: Proportion of freeway DVMT affected by incident management deployment
- **SignalCoordDeployProp**: Proportion of arterial DVMT affected by signal coordination deployment
- **AccessMgtDeployProp**: Proportion of arterial DVMT affected by access management deployment
- **OtherFwyOpsDeployProp**: Proportion of freeway DVMT affected by deployment of other user-defined freeway operations measures
- **OtherArtOpsDeployProp**: Proportion of arterial DVMT affected by deployment of other user-defined arterial operations measures

Here is a snapshot of the file:

6.4.29 marea_parking-avail_by_area-type.csv

This file has the data for avereage number of parkings available to households

- **CenterPkgSpacesPerSFDU**: Average number of free parking spaces available to residents of single-family dwelling units in center area type
- **InnerPkgSpacesPerSFDU**: Average number of free parking spaces available to residents of single-family dwelling units in inner area type
- **OuterPkgSpacesPerSFDU**: Average number of free parking spaces available to residents of single-family dwelling units in outer area type
- **CenterPkgSpacesPerMFDU**: Average number of free parking spaces available to residents of multifamily dwelling units in center area type
- **InnerPkgSpacesPerMFDU**: Average number of free parking spaces available to residents of multifamily dwelling units in inner area type
- **OuterPkgSpacesPerMFDU**: Average number of free parking spaces available to residents of multifamily dwelling units in outer area type
- **CenterPkgSpacesPerGQ**: Average number of free parking spaces available to group quarters residents in center area type
- **InnerPkgSpacesPerGQ**: Average number of free parking spaces available to group quarters residents in inner area type
- **OuterPkgSpacesPerGQ**: Average number of free parking spaces available to group quarters residents in outer area type

Here is a snapshot of the file:

6.4.30 marea_parking-cost_by_area-type.csv

This file has the data related to parking costs and population proportions paying the parking costs

- **CenterPropWkrPay**: Proportion of workers who pay for parking in center area type
- **InnerPropWkrPay**: Proportion of workers who pay for parking in inner area type
- **OuterPropWkrPay**: Proportion of workers who pay for parking in outer area type
- **CenterPropCashOut**: Proportions of workers paying for parking in a cash-out-buy-back program in center area type
- **InnerPropCashOut**: Proportions of workers paying for parking in a cash-out-buy-back program in inner area type
- **OuterPropCashOut**: Proportions of workers paying for parking in a cash-out-buy-back program in outer area type
- **CenterPkgCost**: Average daily cost for long-term parking (e.g. paid on monthly basis) in center area type
- **InnerPkgCost**: Average daily cost for long-term parking (e.g. paid on monthly basis) in inner area type
- **OuterPkgCost**: Average daily cost for long-term parking (e.g. paid on monthly basis) in outer area type

Here is a snapshot of the file:

6.4.31 marea_speed_smooth_ecodrive.csv

This input file supplies information of deployment of speed smoothing and eco-driving by road class and vehicle type

- **FwySmooth**:Fractional deployment of speed smoothing traffic management on freeways, where 0 is no deployment and 1 is the full potential fuel savings
- **ArtSmooth**: Fractional deployment of speed smoothing traffic management on arterials, where 0 is no deployment and 1 is the full potential fuel savings
- **LdvEcoDrive**: Eco-driving penetration for light-duty vehicles; the fraction of vehicles from 0 to 1
- **HvyTrkEcoDrive**: Eco-driving penetration for heavy-duty vehicles; the fraction of vehicles from 0 to 1

Here is a snapshot of the file:

6.4.32 marea__transit__ave__fuel__carbon__intensity.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the average carbon intensity of fuel used by transit.

- **TransitVanFuelCI**: Average carbon intensity of fuel used by transit vans (grams CO2e per megajoule)
- **TransitBusFuelCI**: Average carbon intensity of fuel used by transit buses (grams CO2e per megajoule)
- **TransitRailFuelCI**: Average carbon intensity of fuel used by transit rail vehicles (grams CO2e per megajoule)

Here is a snapshot of the file:

6.4.33 marea__transit__biofuel__mix.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the biofuel used by transit services.

- **TransitEthanolPropGasoline**: Ethanol proportion of gasoline used by transit vehicles
- **TransitBiodieselPropDiesel**: Biodiesel proportion of diesel used by transit vehicles
- **TransitRngPropCng**: Renewable natural gas proportion of compressed natural gas used by transit vehicles

Here is a snapshot of the file:

6.4.34 marea__transit__fuel.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the transit fuels proportions.

- **VanPropDiesel**: Proportion of non-electric transit van travel powered by diesel
- **VanPropGasoline**: Proportion of non-electric transit van travel powered by gasoline
- **VanPropCng**: Proportion of non-electric transit van travel powered by compressed natural gas
- **BusPropDiesel**: Proportion of non-electric transit bus travel powered by diesel
- **BusPropGasoline**: Proportion of non-electric transit bus travel powered by gasoline
- **BusPropCng**: Proportion of non-electric transit bus travel powered by compressed natural gas
- **RailPropDiesel**: Proportion of non-electric transit rail travel powered by diesel
- **RailPropGasoline**: Proportion of non-electric transit rail travel powered by gasoline

Here is a snapshot of the file:

6.4.35 marea_transit_powertrain_prop.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the mixes of transit vehicle powertrains.

- **VanPropIcev**: Proportion of transit van travel using internal combustion engine powertrains
- **VanPropHev**: Proportion of transit van travel using hybrid electric powertrains
- **VanPropBev**: Proportion of transit van travel using battery electric powertrains
- **BusPropIcev**: Proportion of transit bus travel using internal combustion engine powertrains
- **BusPropHev**: Proportion of transit bus travel using hybrid electric powertrains
- **BusPropBev**: Proportion of transit bus travel using battery electric powertrains
- **RailPropIcev**: Proportion of transit rail travel using internal combustion engine powertrains
- **RailPropHev**: Proportion of transit rail travel using hybrid electric powertrains
- **RailPropEv**: Proportion of transit rail travel using electric powertrains

Here is a snapshot of the file:

6.4.36 marea_transit_service.csv

This file contains annual revenue-miles for different transit modes for metropolitan area.

DRRevMi: Annual revenue-miles of demand-responsive public transit service **VPRevMi**: Annual revenue-miles of van-pool and similar public transit service **MBRevMi**: Annual revenue-miles of standard bus public transit service **RBRevMi**: Annual revenue-miles of rapid-bus and commuter bus public transit service **MGRevMi**: Annual revenue-miles of monorail and automated guideway public transit service **SRRevMi**: Annual revenue-miles of streetcar and trolleybus public transit service **HRRevMi**: Annual revenue-miles of light rail and heavy rail public transit service **CRRevMi**: Annual revenue-miles of commuter rail, hybrid rail, cable car, and aerial tramway public transit service

Here is a snapshot of the file:

6.4.37 marea_travel-demand-mgt_by_area-type.csv

This file has the data for proportions participating in demand management programs

- **CenterEcoProp**: Proportion of workers working in center area type in Marea who participate in strong employee commute options program
- **InnerEcoProp**: Proportion of workers working in inner area type in Marea who participate in strong employee commute options program
- **OuterEcoProp**: Proportion of workers working in outer area type in Marea who participate in strong employee commute options program
- **FringeEcoProp**: Proportion of workers working in fringe area type in Marea who participate in strong employee commute options program
- **CenterImpProp**: Proportion of households residing in center area type in Marea who participate in strong individualized marketing program
- **InnerImpProp**: Proportion of households residing in inner area type in Marea who participate in strong individualized marketing program
- **OuterImpProp**: Proportion of households residing in outer area type in Marea who participate in strong individualized marketing program
- **FringeImpProp**: Proportion of households residing in fringe area type in Marea who participate in strong individualized marketing program

Here is a snapshot of the file:

6.4.38 marea_uza_profile_names.csv

This file provides the name of a specific urbanized area for the urbanized area profile to use in SimBzone creation.

- **UzaProfileName**: Name of a specific urbanized area for the urbanized area profile to use in SimBzone creation or one of the following: small, medium-small, medium, medium-large, large, very-large

Here is a snapshot of the file:

6.4.39 other_ops_effectiveness.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the other delay effects of operations in different road classes

- **Level**: Congestion levels: None = none, Mod = moderate, Hvy = heavy, Sev = severe, Ext = extreme
- **Art_Rcr**: Percentage reduction of recurring arterial delay that would occur with full deployment of other user-defined arterial operations measures
- **Art_NonRcr**: Percentage reduction of non-recurring arterial delay that would occur with full deployment of other user-defined arterial operations measures
- **Fwy_Rcr**: Percentage reduction of recurring freeway delay that would occur with full deployment of other user-defined freeway operations measures
- **Fwy_NonRcr**: Percentage reduction of non-recurring freeway delay that would occur with full deployment of other user-defined freeway operations

measures

Here is a snapshot of the file:

6.4.40 region_ave_fuel_carbon_intensity.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the average carbon density for different vehicle types.

- **HhFuelCI**: Average carbon intensity of fuels used by household vehicles (grams CO2e per megajoule)
- **CarSvcFuelCI**: Average carbon intensity of fuels used by car service vehicles (grams CO2e per megajoule)
- **ComSvcFuelCI**: Average carbon intensity of fuels used by commercial service vehicles (grams CO2e per megajoule)
- **HvyTrkFuelCI**: Average carbon intensity of fuels used by heavy trucks (grams CO2e per megajoule)
- **TransitVanFuelCI**: Average carbon intensity of fuels used by transit vans (grams CO2e per megajoule)
- **TransitBusFuelCI**: Average carbon intensity of fuels used by transit buses (grams CO2e per megajoule)
- **TransitRailFuelCI**: Average carbon intensity of fuels used by transit rail vehicles (grams CO2e per megajoule)

Here is a snapshot of the file:

6.4.41 region_base_year_hvytrk_dvmt.csv

This input file is OPTIONAL. It is only needed if the user wants to adjust heavy truck dvmt for base year

- **HvyTrkDvmtGrowthBasis**: Factor used to grow heavy truck DVMT from base year value
- **HvyTrkDvmt**: Average daily vehicle miles of travel on roadways in the region by heavy trucks during he base year
- **HvyTrkDvmtUrbanProp**: Proportion of Region heavy truck daily vehicle miles of travel occurring on urbanized area roadways

Here is a snapshot of the file:

6.4.42 region_carsvc_powertrain_prop.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the powertrain proportion of car services.

- **CarSvcAutoPropIcev**: Proportion of car service automobile travel powered by internal combustion engine powertrains
- **CarSvcAutoPropHev**: Proportion of car service automobile travel powered by hybrid electric powertrains

- **CarSvcAutoPropBev**: Proportion of car service automobile travel powered by battery electric powertrains
- **CarSvcLtTrkPropIcev**: Proportion of car service light truck travel powered by internal combustion engine powertrains
- **CarSvcLtTrkPropHev**: Proportion of car service light truck travel powered by hybrid electric powertrains
- **CarSvcLtTrkPropBev**: Proportion of car service light truck travel powered by battery electric powertrains

Here is a snapshot of the file:

6.4.43 region_comsvc_lttrk_prop.csv

This input file defines the proportion of commerical vehicles that are light trucks.

- **ComSvcLtTrkProp**: Regional proportion of commercial service vehicles that are light trucks

Here is a snapshot of the file:

Year	ComSvcLtTrkProp
2010	0.51
2040	0.51

6.4.44 region_comsvc_powertrain_prop.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the powertrain proportion of commercial vehicles.

- **ComSvcAutoPropIcev**: Proportion of commercial service automobile travel powered by internal combustion engine powertrains
- **ComSvcAutoPropHev**: Proportion of commercial service automobile travel powered by hybrid electric powertrains
- **ComSvcAutoPropBev**: Proportion of commercial service automobile travel powered by battery electric powertrains
- **ComSvcLtTrkPropIcev**: Proportion of commercial service light truck travel powered by internal combustion engine powertrains
- **ComSvcLtTrkPropHev**: Proportion of commercial service light truck travel powered by hybrid electric powertrains
- **ComSvcLtTrkPropBev**: Proportion of commercial service light truck travel powered by battery electric powertrains

Here is a snapshot of the file:

6.4.45 region_comsvc_veh_mean_age.csv

This input file contains average age of commercial service vehicles

- **AveComSvcVehicleAge**: average age of commercial service vehicles

Here is a snapshot of the file:

6.4.46 region_hh_driver_adjust_prop.csv

This file specifies the relative driver licensing rate relative to the model estimation data year in order to account for observed or projected changes in licensing rates.

- **Drv15to19AdjProp**: Target proportion of unadjusted model number of drivers 15 to 19 years old (`1` = no adjustment)
- **Drv20to29AdjProp**: Target proportion of unadjusted model number of drivers 20 to 29 years old (`1` = no adjustment)
- **Drv30to54AdjProp**: Target proportion of unadjusted model number of drivers 30 to 54 years old (`1` = no adjustment)
- **Drv55to64AdjProp**: Target proportion of unadjusted model number of drivers 55 to 64 years old (`1` = no adjustment)
- **Drv65PlusAdjProp**: Target proportion of unadjusted model number of drivers 65 or older (`1` = no adjustment)

Here is a snapshot of the file:

6.4.47 region_hvytrk_powertrain_prop.csv

This input file is OPTIONAL. It is only needed if the user wants to modify the powertrain proportion of heavy duty trucks.

- **HvyTrkPropIcev**: Proportion of heavy truck travel powered by internal combustion engine powertrains
- **HvyTrkPropHev**: Proportion of heavy truck travel powered by hybrid electric powertrains
- **HvyTrkPropBev**: Proportion of heavy truck travel powered by battery electric powertrains

Here is a snapshot of the file:

6.4.48 region_prop_externalities_paid.csv

This file supplies data for climate change and other social costs.

- **PropClimateCostPaid**: Proportion of climate change costs paid by users (i.e. ratio of carbon taxes to climate change costs
- **PropOtherExtCostPaid**: Proportion of other social costs paid by users

Here is a snapshot of the file:

6.4.49 region_road_cost.csv

This file supplies data for different types of road costs

- **RoadBaseModCost**: Average base modernization cost per light-duty vehicle mile traveled (dollars per vehicle mile). Base modernization includes roadway improvements exclusive of addition of lanes.
- **RoadPresOpMaintCost**: Average road preservation, operations, and maintenance cost per light-duty vehicle mile traveled (dollars per vehicle mile).
- **RoadOtherCost**: Average other road cost (e.g. administration, planning, project development, safety) per light-duty vehicle mile traveled (dollars per vehicle mile).
- **FwyLnMiCost**: Average cost to build one freeway lane-mile (dollars per lane-mile)
- **ArtLnMiCost**: Average cost to build one arterial lane-mile (dollars per lane-mile)
- **HvyTrkPCE**: Passenger car equivalent (PCE) for heavy trucks. PCE indicates the number of light-duty vehicles a heavy truck is equivalent to in calculating road capacity.

Here is a snapshot of the file:

Year	RoadBaseModCost.2005	RoadPresOpMaintCost.2005	RoadOtherCost.2005	FwyLnMiCost.2005	ArtLnMiCost.2005	HvyTrkPCE
2010	0.004	0.01	0.015	4900	1800	3
2040	0.004	0.01	0.015	4900	1800	3

6.5 VERPAT Input Files

The scenario inputs are split into four (4) categories: *Built Environment*, *Demand*, *Policy*, and *Supply*. There are two ways to specify these inputs. **CSV Inputs** are specified in a `*.csv` file and **JSON Inputs** are specified in `model_parameters.json` file. The users are encouraged to change these inputs to build different scenarios. The RPAT to VERPAT the connection between RPAT inputs to VERPAT inputs.

Built Environment - CSV Inputs - bzone_pop_emp_prop.csv

Demand - CSV Inputs - region_trips_per_cap.csv - azone_employment_by_naics.csv - azone_hh_pop_by_age.csv - azone_gq_pop_by_age.csv - azone_hhsize_targets.csv - azone_per_cap_inc.csv - azone_relative_employment.csv - region_truck_bus_vmt.csv - JSON Inputs - BaseLtVehDvmt - BaseFwyArtProp - EmploymentGrowth

Transport Supply

- CSV Inputs
  - marea_lane_miles.csv
  - marea_rev_miles_pc.csv

Policy - CSV Inputs - region_commute_options.csv - azone_its_prop.csv - region_light_vehicles.csv - marea_parking_growth.csv - JSON Inputs - Auto-

CostGrowth - FwyLaneMiGrowth - ArtLaneMiGrowth - BusRevMiPCGrowth - RailRevMiPCGrowth - VmtCharge

6.5.0.1 Model Parameters

There are two ways to specify model parameters. **CSV Parameters** are specified in a `*.csv` file and **JSON Parameters** in a `model_parameters.json` file. While you are provided access to the model parameters, you are encouraged to use the default parameter values unless directed to use alternatives. Editing modeling parameters should be based only on research pertaining to local data sources and may result in unpredictable results.

Model Parameters

- CSV Parameters
  - model_accident_rates.csv
  - model_fuel_prop_by_veh.csv
  - model_fuel_composition_prop.csv
  - model_fuel_co2.csv
  - model_place_type_elasticities.csv
  - model_place_type_relative_values.csv
  - model_tdm_ridesharing.csv
  - model_tdm_transit.csv
  - model_tdm_transitlevels.csv
  - model_tdm_vanpooling.csv
  - model_tdm_workschedule.csv
  - model_tdm_workschedulelevels.csv
  - model_transportation_costs.csv
  - model_veh_mpg_by_year.csv
  - model_phev_range_prop_mpg_mpkwh.csv
  - model_hev_prop_mpg.csv
  - model_ev_range_prop_mpkwh.csv
- JSON Parameters
  - AnnVmtInflator
  - BaseCostPerMile
  - DvmtBudgetProp
  - FuelCost
  - KwhCost
  - GasTax
  - LtTruckProp
  - TranRevMiAdjFactor
  - TruckVmtGrowthMultiplier
  - WorkVmtProp

6.5.1 Input Files to Change

The user should change the input files described here.

6.5.2 Built Environment

6.5.2.1 CSV Inputs

6.5.2.2 bzone_pop_emp_prop.csv

Population and Jobs by Place Type: This file contains the distribution of population and employment among the 13 place types for base and future year. See this explanation for more infomation regarding place types. Each column, for each year, must sum to one (1). It is acceptable to have no land use (i.e. a value of 0) in certain categories.

The yearly TAZ employment and population totals were summed by the 13 place type and then scaled to total one for both employment and population. The allocation of growth between the base and the future years in population and employment to each of the 13 place types is captured by the rows containing future years. The discussion of the population and jobs by place type input above describes how to allocate existing land use to the 13 place types. A similar approach can be used to allocate expected growth from spatial planning resources such as TAZ or Census Block Group level forecasts to the place types. Here is a snapshot of the file:

Geo	Year	Pop	Emp
Rur	2005	0.05	0.1
Sub_R	2005	0.3	0
Sub_E	2005	0	0.2
Sub_M	2005	0.1	0.1
Sub_T	2005	0	0
CIC_R	2005	0.15	0
CIC_E	2005	0	0.2
CIC_M	2005	0.1	0.1
CIC_T	2005	0	0
UC_R	2005	0.1	0
UC_E	2005	0	0.1
UC_M	2005	0.1	0.1
UC_T	2005	0.1	0.1
Rur	2035	0.05	0.1
Sub_R	2035	0.3	0
Sub_E	2035	0	0.2
Sub_M	2035	0.1	0.1
Sub_T	2035	0	0
CIC_R	2035	0.15	0
CIC_E	2035	0	0.2
CIC_M	2035	0.1	0.1
CIC_T	2035	0	0

Geo	Year	Pop	Emp
UC_R	2035	0.1	0
UC_E	2035	0	0.1
UC_M	2035	0.1	0.1
UC_T	2035	0.1	0.1

6.5.3 Demand

6.5.3.1 CSV Inputs

6.5.3.2 region_trips_per_cap.csv

Auto and transit trips per capita: This file contains regional averages for auto and transit trips per capita per day for the base year.

- **Auto** is the regional average of auto trips per capita, including drive alone and shared ride travel. This data can be derived from the National Household Travel Survey by region or from a local household travel survey or regional travel demand forecasting model.
- **Transit** is the regional average of transit trips per capita, including walk and drive access to transit. This data can be derived from the National Transit Database where the annual database contains a "service" table that has annual transit trip data for each transit operator or from a local household travel survey or regional travel demand forecasting model.

Here is a snapshot of the files:

Mode	Trips
Auto	3.2
Transit	0.4

6.5.3.3 azone_employment_by_naics.csv

Employment: This file contains employment data for each of the counties that make up the region. The file is derived from County Business Pattern (CBP) data by county. Industries are categorized by the North American Industrial Classification System (NAICS) 6 digit codes. Firm size categories are:

- **n1_4**: 1- 4 employees
- **n5_9**: 5-9 employees
- **n10_19**: 10-19 employees
- **n20_99**: 20-99 employees
- **n100_249**: 100-249 employees
- **n250_499**: 250-499 employees

- **n500_999**: 500-999 employees
- **n1000**: 1,000 or More Employee Size Class
- **n1000_1**: 1,000-1,499 employees
- **n1000_2**: 1,500-2,499 employees
- **n1000_3**: 2,500 to 4, 999 Employees
- **n1000_4**: Over 5,000 employees

While the county field is required to be present, the business synthesis process does not require a meaningful value and therefore users may simply enter 'region'. The consistency in the naming of the "region" should be maintained across all the files that contains the label *"county"* or *"Geo"*. It is also not necessary to use such detailed NAICS categories if those are not available; the current business synthesis model and subsequent models do not use this level of detail (although future versions of the model may) – at minimum, the number of establishments for all employment types can be provided by size category. Regions with significant employment in industries such as government and public administration that are not covered by the CBP may need to add records to the file that cover this type of employment to more accurately match employment totals in their region. The two additional fields contained in the file are:

- **emp**: Total number of employees
- **est**: Total number of establishments

Here is the snapshot of the file:

county	year	naics	emp	est	n1_4	n5_9	n10_19	n20_49	n50_99	n100_249	n250_499	n500_999	n1000	n1000_1	n1000_2	n1000_3	n1000_4
Multnomah	2005	113110	0	5	2	1	0	2	0	0	0	0	0	0	0	0	0
Multnomah	2005	113310	0	3	2	0	0	1	0	0	0	0	0	0	0	0	0
Multnomah	2005	114111	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
Multnomah	2005	114112	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Multnomah	2005	115114	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
Multnomah	2005	115210	0	4	3	1	0	0	0	0	0	0	0	0	0	0	0
Multnomah	2005	115310	0	5	2	0	1	1	1	0	0	0	0	0	0	0	0
Multnomah	2005	212319	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Multnomah	2005	212321	0	4	1	1	1	1	0	0	0	0	0	0	0	0	0

6.5.3.4 azone_hh_pop_by_age.csv

Household population: This file contains population estimates/forecasts by county and age cohort for each of the base and future years. The file format includes six age categories used by the population synthesis model:

- **0-14**
- **15-19**
- **20-29**
- **30-54**
- **55-64**

- **65 Plus**

Future year data must be developed by the user; in many regions population forecasts are available from regional or state agencies and/or local academic sources. As with the employment data inputs the future data need not be county specific. Rather, regional totals by age group can be entered into the file with a value such as "region" entered in the county field.

Here is a snapshot of the file:

Geo	Year	Age0to14	Age15to19	Age20to29	Age30to54	Age55to64	Age65Plus
Multnomah	2005	129869	41133	99664	277854	71658	72648
Multnomah	2035	169200	48800	144050	327750	116100	162800

6.5.3.5 azone_gq_pop_by_age.csv :construction:

Group quarter population: This file contains group quarters population estimates/forecasts by county and age cohort for each of the base and future years. The file format includes six age categories used by the population synthesis model:

- **0-14**
- **15-19**
- **20-29**
- **30-54**
- **55-64**
- **65 Plus**

Here is a snapshot of the file:

Geo	Year	GrpAge0to14	GrpAge15to19	GrpAge20to29	GrpAge30to54	GrpAge55to64	GrpAge65Plus
Multnomah	2005	0	0	0	1	0	0
Multnomah	2035	0	0	0	1	0	0

6.5.3.6 azone_hhsize_targets.csv :construction:

Household size (*azone_hhsize_targets.csv*): This file contains the household specific targets. This contain two household specific attributes:

- **AveHhSize**: Average household size of households (non-group quarters)
- **Prop1PerHh**: Proportion of households (non-group quarters) having only one person

Here is a snapshot of the file:

Geo	Year	AveHhSize	Prop1PerHh
Multnomah	2005	NA	NA
Multnomah	2035	NA	NA

6.5.3.7 azone_per_cap_inc.csv

Regional income: This file contains information on regional average per capita household (**HHIncomePC**) and group quarters (**GQIncomePC**) income by forecast year in year 2000 dollars. The data can be obtained from the U.S. Department of Commerce Bureau of Economic Analysis for the current year or from regional or state sources for forecast years. In order to use current year dollars just replace ***2000*** in column labels with current year. For example, if the data is obtained in year 2005 dollars then the column labels in the file shown below will become **HHIncomePC.2005** and **GQIncomePC.2005**. Here is a snapshot of the file:

Geo	Year	HHIncomePC.2000	GQIncomePC.2000
Multnomah	2005	32515	0
Multnomah	2035	40000	0

6.5.3.8 azone_relative_employment.csv

Relative employment: This file contains ratio of workers to persons by age cohort in model year vs. estimation data year. The relative employment value for each age group, which is the employment rate for the age group relative to the employment rate for the model estimation year data is used to adjust the relative employment to reflect changes in relative employment for other years. This file contains five age cohorts:

- **RelEmp15to19**: Ratio of workers to persons age 15 to 19 in model year vs. in estimation data year
- **RelEmp20to29**: Ratio of workers to persons age 20 to 29 in model year vs. in estimation data year
- **RelEmp30to54**: Ratio of workers to persons age 30 to 54 in model year vs. in estimation data year
- **RelEmp55to64**: Ratio of workers to persons age 55 to 64 in model year vs. in estimation data year
- **RelEmp65Plus**: Ratio of workers to persons age 65 or older in model year vs. in estimation data year

Here is a snapshot of the file:

Geo	Year	RelEmp15to19	RelEmp20to29	RelEmp30to54	RelEmp55to64	RelEmp65Plus
Multnomah	2005	1	1	1	1	1
Multnomah	2035	1	1	1	1	1

6.5.3.9 region_truck_bus_vmt.csv

Truck and bus vmt: This file contains the region's proportion of VMT by truck and bus as well as the distribution of that VMT across functional classes (*freeway*, *arterial*, *other*). The file includes one row for bus VMT data and one row for Truck VMT data. It should be noted that it is not necessary to enter values in the **PropVmt** column for **BusVmt** as this is calculated using the values in the ***transportation_supply.csv*** #EDIT (marea_rev_miles_pc.csv?) user input file. The truck VMT proportion (PropVMT column, TruckVMT row) can be obtained from Highway Performance Monitoring System data and local sources or the regional travel demand model if one exists. The proportions of VMT by functional class can be derived from the Federal Highway Cost Allocation Study and data from transit operators. The Federal Highway Cost Allocation Study (Table II-6, 1997 Federal Highway Cost Allocation Study Final Report, Chapter II is used to calculate the average proportion of truck VMT by functional class. Data from transit authorities are used to calculate the proportions of bus VMT by urban area functional class. Here is a snapshot of the file:

Type	PropVmt	Fwy	Art	Other
BusVmt	0	0.15	0.591854	0.258146
TruckVmt	0.08	0.452028	0.398645	0.149327

6.5.3.10 JSON Inputs

6.5.3.11 BaseLtVehDvmt

Light vehicle dvmt (*BaseLtVehDvmt*): Total light vehicle daily VMT for the base year in thousands of miles. This data can be derived from a combination of Highway Performance Monitoring System data, Federal Highway Cost Allocation Study data, and regional data. Light vehicle daily VMT can be estimated by subtracting truck and bus VMT from total VMT provided in the Highway Performance Monitoring System (HPMS). Regional travel demand model outputs can also be used to derive these data. It should be defined in model_parameters.json as follows:

```
{
    "NAME" : "BaseLtVehDvmt",
    "VALUE": "27244",
    "TYPE" : "compound",
    "UNITS" : "MI/DAY",
```

```
    "PROHIBIT" : "c('NA', '< 0')",
    "ISELEMENTOF" : ""
}
```

6.5.3.12 BaseFwyArtProp

Dvmt proportion by functional class (*BaseFwyArtProp*): The proportions of daily VMT for light vehicles that takes place on freeways and arterials (i.e., the remainder of VMT takes place on lower functional class roads for the base year. This data can be derived from a combination of Highway Performance Monitoring System data, Federal Highway Cost Allocation Study data, and regional data. The proportions of light vehicle daily VMT on freeways and arterials can be derived from the HPMS data. Regional travel demand model outputs can also be used to derive these data. It should be defined in model_parameters.json as follows:

```
{
    "NAME" : "BaseFwyArtProp",
    "VALUE": "0.77",
    "TYPE" : "double",
    "UNITS" : "proportion",
    "PROHIBIT" : "c('NA', '< 0', '> 1')",
    "ISELEMENTOF" : ""
}
```

6.5.3.13 EmploymentGrowth

Employment Growth (*EmploymentGrowth*): This variable represents a growth rate for employment in the region between the base year and the future year. A rate of 1 indicates no changes in overall employment, a value of more than 1 indicates some growth (e.g., 1.5 = 50% growth) and a value of less than 1 indicates decline in employment. It should be defined in model_parameters.json as follows:

```
{
    "NAME": "EmploymentGrowth",
    "VALUE": "1.5",
    "TYPE": "double",
    "UNITS": "multiplier",
    "PROHIBIT": "",
    "ISELEMENTOF": ""
}
```

6.5.4 Transport Supply

6.5.4.1 CSV Inputs

6.5.4.2 marea_lane_miles.csv

Road lane miles: This file contains the amount of transportation supply by base year in terms of lane miles of freeways and arterial roadways in the region. The base year data is duplicated for future year. **Freeway** and **Arterial** are total lane miles for those functional classes in the region. These data can be derived from the Federal Highway Administration's (FHWA) Highway Statistics data. Here is a snapshot of the file:

Geo	Year	FwyLaneMi	ArtLaneMi
Multnomah	2005	250	900
Multnomah	2035	250	900

6.5.4.3 marea_rev_miles_pc.csv

Transit revenue miles: This file contains the amount of transportation supply by base year in terms of the revenue miles operating by the transit system in the region. The base year data is duplicated for future year. **Bus** and **Rail** are annual bus and rail revenue miles per capita for the region. These data can be derived from the National Transit Database, where the annual database contains a "service" table that has annual revenue mile data by mode for each transit operator. Here is a snapshot of the file:

Geo	Year	BusRevMiPC	RailRevMiPC
Multnomah	2005	19	4
Multnomah	2035	19	4

6.5.5 Policy

6.5.5.1 CSV Inputs

6.5.5.2 region_commute_options.csv

Percentage of employees offered commute options: This file contains assumptions about the availability and participation in work based travel demand management programs. The policies are ridesharing programs, transit pass programs, telecommuting or alternative work schedule programs, and vanpool programs. For each, the user enters the proportion of workers who participate (the data items with the "Participation" suffix). For one program, the transit subsidy, the user must also enter the subsidy level in dollars for the TransitSubsidyLevel data item. Here is a snapshot of the file:

TDMProgram	DataItem	DataValue
Ridesharing	RidesharingParticipation	0.05
TransitSubsidy	TransitSubsidyParticipation	0.1
TransitSubsidy	TransitSubsidyLevel	1.25
WorkSchedule	Schedule980Participation	0.01
WorkSchedule	Schedule440Participation	0.01
WorkSchedule	Telecommute1.5DaysParticipation	0.01
Vanpooling	LowLevelParticipation	0.04
Vanpooling	MediumLevelParticipation	0.01
Vanpooling	HighLevelParticipation	0.01

6.5.5.3 azone_its_prop.csv

Percent road miles with ITS treatment: This file is an estimate of the proportion of road miles that have improvements which reduce incidents through ITS treatments in both the base and future years. Values entered should be between 0 and 1, with 1 indicating that 100% of road miles are treated. The ITS policy measures the effects of incident management supported by ITS. The ITS table is used to inform the congestion model and the travel demand model. The model uses the mean speeds with and without incidents to compute an overall average speed by road type and congestion level providing a simple level of sensitivity to the potential effects of incident management programs on delay and emissions. The ITS treatments are evaluated only on freeways and arterials. The ITS treatments that can be evaluated are those that the analyst considers will reduce non-recurring congestion due to incidents. This policy does not deal with other operational improvements such as signal coordination, or temporary capacity increases such as allowing shoulder use in the peak. Here is a snapshot of the file:

Geo	Year	ITS
Multnomah	2005	0
Multnomah	2035	0

6.5.5.4 region_light_vehicles.csv

Bicycling/light vehicles targets: This file contains input data for the non-motorized vehicle model. In VERPAT, non-motorized vehicles are bicycles, and also electric bicycles, segways, and similar vehicles that are small, light-weight and can travel at bicycle speeds or slightly higher. The parameters are as follows:

- **TargetProp**: non-motorized vehicle ownership rate (average ratio of non-motorized vehicles to driver age population)
- **Threshold**: single-occupant vehicle (SOV) tour mileage threshold used in the SOV travel proportion model. This is the upper limit for tour lengths that are suitable for reallocation to non-motorized modes.

- **PropSuitable**: proportion of SOV travel suitable for non-motorized vehicle travel. This variable describes the proportion of SOV tours within the mileage threshold for which non-motorized vehicles might be substituted. This variable takes into account such factors as weather and trip purpose.

The non-motorized vehicle model predicts the ownership and use of non-motorized vehicles (where non-motorized vehicles are bicycles, and also electric bicycles, segways and similar vehicles that are small, light-weight and can travel at bicycle speeds or slightly higher than bicycle speeds). The core concept of the model is that non-motorized vehicle usage will primarily be a substitute for short-distance SOV travel. Therefore, the model estimates the proportion of the household vehicle travel that occurs in short-distance SOV tours. The model determines the maximum potential for household VMT to be diverted to non-motorized vehicles, which is also dependent on the availability of non-motorized vehicles. Note that bike share programs (BSP) serve to increase the availability of non-motorized vehicles and can be taken into account by increasing the **TargetProp** variable. Use national estimates of non-motorized ownership if regional estimates of non-motorized ownership are not available (unless the region has notably atypical levels of bicycle usage). See Bicycle Ownership in the United States for an analysis of regional differences. Here is a snapshot of the file:

DataItem	DataValue
TargetProp	0.2
Threshold	2
PropSuitable	0.1

6.5.5.5 marea_parking_growth.csv

Increase in parking cost and supply: This file contains information that allows the effects of policies such as workplace parking charges and "*cash-out buy-back*" programs to be tested. The input parameters are as follows and should be entered for both the base and future year:

- **PropWorkParking**: proportion of employees that park at work
- **PropWorkCharged**: proportion of employers that charge for parking
- **PropCashOut**: proportion of employment parking that is converted from being free to pay under a "*cash-out buy-back*" type of program
- **PropOtherCharged**: proportion of other parking that is not free
- **ParkingCost.2000**: average daily parking cost in 2000 year USD. In order to use base year dollars just replace ***2000*** in column labels with base year. This variable is the average daily parking cost for those who incur a fee to park. If the paid parking varies across the region, then the "*PkgCost*" value should reflect the average of those parking fees, but weighted by the supply – so if most parking is in the Center City, then the average will be heavily weighted toward the price in the Center City.

Here is a snapshot of the file:

Geo	Year	PropWorkParking	PropWorkCharged	PropCashOut	PropOtherCharged	ParkingCost.2000
Multnomah	2005	1	0.1	0	0.05	5
Multnomah	2035	1	0.1	0	0.05	5

6.5.5.6 JSON Inputs

6.5.5.7 AutoCostGrowth

% Increase in Auto Operating Cost (*AutoCostGrowth*): This parameter reflects the proportional increase in auto operating cost. This can be used to test different assumptions for future gas prices or the effects of increased gas taxes. A value of 1.5 multiplies base year operating costs by 1.5 and thus reflects a 50% increase. It should be defined in model_parameters.json as follows:

```
{
    "NAME" : "AutoCostGrowth",
    "VALUE": "1.5",
    "TYPE" : "double",
    "UNITS" : "multiplier",
    "PROHIBIT" : "c('NA', '< 0')",
    "ISELEMENTOF" : ""
}
```

6.5.5.8 FwyLaneMiGrowth

FwyLaneMiGrowth: The variable indicates the percent increase in supply of freeways lane miles in the future year compared to base year. By default, the transportation supply is assumed to grow in line with population increase; therefore a value of 1 indicates growth in proportion with population growth. A value less than 1 indicates that there will be less freeway lane mile supply, per person, in the future. A value of 1 indicates faster freeway expansion than population growth. It should be defined in model_parameters.json as follows:

```
{
    "NAME": "FwyLaneMiGrowth",
    "VALUE": "1",
    "TYPE" : "double",
    "UNITS" : "multiplier",
    "PROHIBIT" : "c('NA', '< 0')",
    "ISELEMENTOF" : ""
}
```

6.5.5.9 ArtLaneMiGrowth

ArtLaneMiGrowth: The variable indicates the percent increase in supply of arterial lane miles in the future year compared to base year. It is a similar value to freeway except that it measures arterial lane mile growth. It is also proportional to population growth. It should be defined in model_parameters.json as follows:

```
{
    "NAME" : "ArtLaneMiGrowth",
    "VALUE": "1",
    "TYPE" : "double",
    "UNITS" : "multiplier",
    "PROHIBIT" : "c('NA', '< 0')",
    "ISELEMENTOF" : ""
}
```

6.5.5.10 BusRevMiPCGrowth

BusRevMiPCGrowth: It is the percent increase in transit revenue miles per capita for bus. It behaves in a similar way to the freeway and rail values in that a value of 1 indicates per capita revenue miles stays constant. It should be defined in model_parameters.json as follows:

```
{
    "NAME" : "BusRevMiPCGrowth",
    "VALUE": "1",
    "TYPE" : "double",
    "UNITS" : "multiplier",
    "PROHIBIT" : "c('NA', '< 0')",
    "ISELEMENTOF" : ""
}
```

6.5.5.11 RailRevMiPCGrowth

RailRevMiPCGrowth: It is the percent increase in transit revenue miles per capita for rail. This encompasses all rail modes, from light rail through to commuter rail. It should be defined in model_parameters.json as follows:

```
{
    "NAME" : "RailRevMiPCGrowth",
    "VALUE": "1",
    "TYPE" : "double",
    "UNITS" : "multiplier",
    "PROHIBIT" : "c('NA', '< 0')",
    "ISELEMENTOF" : ""
}
```

6.5.5.12 VmtCharge

Auto Operating Surcharge Per VMT (*VmtCharge*): It is a cost in cents per mile that would be levied on auto users through the form of a VMT charge. It should be defined in model_parameters.json as follows:

```
{
    "NAME" : "VmtCharge",
    "VALUE": "0.05",
    "TYPE" : "compound",
    "UNITS" : "USD/MI",
    "PROHIBIT" : "c('NA', '< 0')",
    "ISELEMENTOF" : ""
}
```

6.5.6 Model Parameters

Users can modify these parameters to test alternative scenarios. For e.g. users can use model_veh_mpg_by_year.csv to test alternative vehicle development scenarios, such as improved technology and/or fuel economy standards that lead to higher fuel economies.

6.5.6.1 CSV Inputs

6.5.6.2 model_accident_rates.csv

Accident Rates: Road safety impacts are calculated by factoring the amount of VMT. The following national average rates, from the Fatality Analysis Reporting System General Estimates System (2009) by US Department of Transportation, are applied to calculate the number of fatal and injury accidents and the value of property damage:

- Fatal: 1.14 per 100 Million Miles Traveled
- Injury: 51.35 per 100 Million Miles Traveled
- Property damage: 133.95 per 100 Million Miles Traveled

Here is a snapshot of the file:

Accident	Rate
Fatal	1.14
Injury	51.35
Property	133.95

6.5.6.3 model_fuel_prop_by_veh.csv

Vehicle VMT proportion by fuel (*model_fuel_prop_by_veh.csv*): The file contains allocation of VMT for each of the four road vehicle types that VERPAT represents (*auto*, *light truck*, *bus*, and *heavy truck*) to different fuel types (*Diesel*, *CNG*, *Gasoline*). This file is used in the calculations of fuel consumption. This file can be used to test alternative fuel scenarios by varying the shares of non-gasoline fuels.

- **PropDiesel**: The proportion of the fleet that uses diesel
- **PropCng**: The proportion of the fleet that uses CNG
- **PropGas**: The proportion of the fleet that uses gasoline

Here is a snapshot of the file:

VehType	PropDiesel	PropCng	PropGas
Auto	0.007	0	0.993
LtTruck	0.04	0	0.96
Bus	0.995	0.005	0
Truck	0.945	0.005	0.05

6.5.6.4 model_fuel_composition_prop.csv

Fuel composition: This file contains the composition of fuel used for each of the four road vehicle types that VERPAT represents (*auto*, *light truck*, *bus*, and *heavy truck*). This file is also used in the calculations of fuel consumption along with the aforementioned file. The column labels in the file are:

- **GasPropEth**: The average ethanol proportion in gasoline sold
- **DieselPropBio**: The average biodiesel proportion in diesel sold

Here is a snapshot of the file:

VehType	GasPropEth	DieselPropBio
Auto	0.1	0.05
LtTruck	0.1	0.05
Bus	0.1	0.05
Truck	0.1	0.01

6.5.6.5 model_fuel_co2.csv

Emission Rate: The emissions rate file contains information on "pump-to-wheels" CO2 equivalent emissions by fuel type in grams per mega Joule of fuel energy content. There is one row for each fuel type: ULSD, biodiesel, RFG (reformulated gasoline), CARBOB (gasoline formulated to be blended with ethanol), ethanol, and CNG. This file is used to convert fuel use to CO2 equivalent emissions. Here is a snapshot of the file:

Fuel	Intensity
ULSD	77.19
Biodiesel	76.81
RFG	75.65
CARBOB	75.65
Ethanol	74.88
Cng	62.14

6.5.6.6 model_place_type_elasticities.csv

This file contains elasticities for four performance metrics:

- **VMT** – Following the estimate of travel demand that incorporates induced demand, an adjustment is made to travel demand that accounts for changes in growth by the place types that are used in the model to describe urban form. These changes are interpreted as changes in design (intersection street density), accessibility (job accessibility by auto), distance to transit (nearest transit stop), density (population density) and diversity (land use mix). The effect on travel demand is determined as changes in VMT by these urban form categories, as shown in the table below. The elasticities that are shown in the table are multiplied by the D values for each place type. The D values are proportion values for each place type that are relative to the regional average, which is set to 1.0.
- **VehicleTrips** – The change in the number of vehicle trips is calculated using a set of elasticities from Index 4D Values (2001) that pivots from the current number of vehicle trips per capita based on the scenario's allocation of growth by place type. The elasticities shown in the table are applied to D values, which are proportional values for each place type that are relative to a regional average for that D value that is set to 1.0. The model reports the additional number of trips caused by the growth assumed in the scenario and not the regional total.
- **TransitTrips** – The change in the number of transit trips is calculated using a set of elasticities from Index 4D Values (2001) that pivots from the current number of transit trips per capita based on the scenario's allocation of growth by place type. The elasticities shown in the table are applied to D values, which are proportional values for each place type that are relative to a regional average for that D value that is set to 1.0. The model reports the additional number of trips caused by the growth assumed in the scenario and not the regional total.
- **Walking** – The elasticities shown in the table are applied to D values, which are proportional values for each place type that are relative to a regional average for that D value that is set to 1.0. The product of the

elasticity and D value is applied to the place type growth quantities for the scenario to calculated the percentage increase or decrease in walking for new residents in the region relative to a the current place type distribution.

Here is a snapshot of the file:

Parameters	VMT	VehicleTrips	TransitTrips	Walking
Density	-0.04	-0.043	0.07	0.07
Diversity	-0.09	-0.051	0.12	0.15
Design	-0.12	-0.031	0.23	0.39
Regional_Accessibility	-0.2	-0.036	0	0
Distance_to_Transit	-0.05	0	0.29	0.15

6.5.6.7 model_place_type_relative_values.csv

This file contains the *D* values, which are proportional values for each of the 13 place types (*Bzones*) that are relative to a regional average, for each of the five Ds used in VERPAT - design (intersection street density), accessibility (job accessibility by auto), distance to transit (nearest transit stop), density (population density) and diversity (land use mix). Here is a snapshot of the file:

Geo	Density	Diversity	Design	Regional_Accessibility	Distance_to_Transit
Rur	0.5	0.5	0.5	0.5	0.5
Sub_R	0.75	0.75	0.75	0.75	0.75
Sub_E	0.75	0.75	0.75	0.75	0.75
Sub_M	1	1	1	0.75	0.75
Sub_T	1	1	1	1	1
CIC_R	1.2	1.2	1.2	1.2	1
CIC_E	1.2	1.2	1.2	1.2	1
CIC_M	1.2	1.2	1.2	1.2	1
CIC_T	1.2	1.2	1.2	1.2	1.2
UC_R	1.5	1.2	1.5	1.5	1.2
UC_E	1.5	1.2	1.5	1.5	1.2
UC_M	1.5	1.5	1.5	1.5	1.2
UC_T	1.5	1.5	1.5	1.5	1.5

6.5.6.8 model_tdm_ridesharing.csv

Travel Demand Management: Ridesharing: The ridesharing Travel Demand Management file contains parameters describing the effectiveness of ridesharing programs by place type. The proportion of employees participating in the ridesharing program is a policy input. This is converted into a proportion of working-age persons by using an assumed labor force participation rate (0.65) to sample working-age persons in households. The ridesharing sub-model then computes the anticipated level of VMT reduction resulting from the implementation of ridesharing, based on the place type the household lives in, using the effectiveness values shown in this parameter file. Previous studies have determined that the level of ridesharing participation will be less in the rural and suburban areas, as compared to the more-urban areas. Typically, more people will carpool in the more urbanized areas due to the presence of parking charges, potential difficulties in finding parking, and other disincentives that are typically present in more urbanized areas. Here is a snapshot of the file:

ModelGeo	Effectiveness
Rur	0
Sub	0.05
CIC	0.1
UC	0.15

6.5.6.9 model_tdm_transit.csv

Travel Demand Management: Transit Fares: The transit fare Travel Demand Management files are parameters for the effectiveness (level of VMT reduction) and fare subsidy values for employer. The subsidized/discounted transit model begins by evaluating the level of participation within the region. Monte Carlo processes are used to identify which households participate in transit pass programs. The proportion of employees participating in this program is a policy input. This is converted into a proportion of working-age persons by using an assumed labor force participation rate (0.65) to sample working-age persons in households. The model then allows the selection of one of four potential subsidy levels (also a policy inputs), which influence the level of VMT reduction based on the level of subsidy applied to the place type. The anticipated level of VMT reduction is then further reduced to account for the proportion of work travel in overall daily travel. Here is a snapshot of the file:

ModelGeo	Subsidy0	Subsidy1	Subsidy2	Subsidy3	Subsidy4
Rur	0	0	0	0	0
Sub	0	0.02	0.033	0.079	0.2
CIC	0	0.034	0.073	0.164	0.2
UC	0	0.062	0.129	0.2	0.2

6.5.6.10 model_tdm_transitlevels.csv

Travel Demand Management: Transit Subsidy Levels: This file contains the dollar value match to the subsidy levels used in model_tdm_transit.csv file. Here is a snapshot of the file:

SubsidyLevel	SubsidyValue.2000
Subsidy0	0
Subsidy1	0.75
Subsidy2	1.49
Subsidy3	2.98
Subsidy4	5.96

6.5.6.11 model_tdm_vanpooling.csv

Travel Demand Management: Vanpooling: This file contains parameters describing the effectiveness in terms of VMT reductions for vanpooling programs across three levels of employee involvement. The vanpool program sub-model operates by evaluating the likely level of participation. Monte Carlo processes are used to identify which households participate in vanpool programs. The proportion of employees participating in this program is a policy input. This is converted into a proportion of working-age persons by using an assumed labor force participation rate (0.65) to sample working-age persons in households. Those employers that would participate in the program are then categorized into three levels of involvement from low to medium to high. The level of involvement reflects the extent to which an employer would actively facilitate and promote vanpooling. For example, a low level of involvement might represent an employer who organizes only a minimal number of vanpools. The high level of involvement could represent an employer who has an extensive vanpooling program to cover a large number of employees. Based on the level of involvement, the reduction in VMT is estimated on the basis of the values in this file. Here is a snapshot of the file:

VanpoolingParticipation	VMTReduction
Low	0.003
Medium	0.0685
High	0.134

6.5.6.12 model_tdm_workschedule.csv

Travel Demand Management: Work Schedule: This file contains parameters that describe the effectiveness for different participation levels for three different telecommuting or alternative work schedules. The telecommuting or alternative work schedule model first evaluates the likely level of participation throughout the region in terms of telecommuting or alternatively-works schedules. Monte Carlo processes are used to identify which households participate in telecommuting programs. The proportion of employees participating in this program is a policy input. This is converted into a proportion of working-age persons by using an assumed labor force participation rate (0.65) to sample working-age persons in households. The model then determines the type of programs that might be implemented. Three potential alternatives are offered including:

- **4/40 Schedule**: 4 days per week with 40 hours per week
- **9/80 Schedule**: working 4 days every other week with an average of 80 hours over 2 weeks
- **Telecommuting**: Workers may work 1 to 2 days a week remotely

Once the option has been identified and the level of participation, the estimated VMT is determined on the basis of the parameters in this file. Here is a snapshot of the file:

WorkSchedulePolicy	Participation0	Participation1	Participation2	Participation3	Participation4	Participation5
Schedule980	0	0.0007	0.0021	0.0035	0.007	0.0175
Schedule440	0	0.0015	0.0045	0.007	0.015	0.0375
TelecommuteoneandhalfDays	0	0.0022	0.0066	0.011	0.022	0.055

6.5.6.13 model_tdm_workschedulelevels.csv

Travel Demand Management: Work Schedule Participation Levels: This file describes the proportion of employees participating in the program corresponding to the participation levels used in *model_tdm_workschedule.csv* file. Here is a snapshot of the file:

ParticipationLevel	ParticipationValue
Participation0	0
Participation1	0.01
Participation2	0.03
Participation3	0.05
Participation4	0.1
Participation5	0.25

6.5.6.14 model_transportation_costs.csv

Transportation Costs: This file contains unit cost rates for transportation infrastructure investments and operating costs and transit fare revenue. The parameters are used in the calculations of the transportation costs performance metrics. The source for transit capital, operating costs, and fare revenue is the NTD, and in particular the National Transit Profile which is available on the NTDB website. Costs are available in a variety of index formats, e.g. cost per revenue mile or hour; cost per passenger trip is used in VERPAT. The source for highway infrastructure costs is FHWA's Highway Economic Requirements System model, or HERS. Information was obtained from Chapter 6 of the 2005 Technical Report for all US states (FHWA, 2005). Table 8-1 in HERS provides