TravelWorks
Advanced Travel Analysis Tools

RapidPolicy
ASSESSMENT TOOL

USER'S GUIDE

RAPID POLICY ASSESSMENT TOOL DOCUMENTATION

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Advanced Travel Analysis Tools

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1.0 INTRODUCTION TO SHRP 2 C16 PROJECT AND RPAT

This document is the user's guide for the Rapid Policy Assessment Tool (RPAT) software, which is a tool for evaluating the impact of various smart growth policies and other transportation investment such as highway and transit investments and demand management policies.

The tool was developed as part of the SHRP 2 C16 project, which provided tools, methods, and resources for transportation planning agencies in the United States to evaluate the effects of smart growth policies on travel demand. The project built upon existing work in this field, while recognizing that this is a relatively new area of study in transportation planning. The SHRP 2 C16 research team's development of tools and online resources relied on research, performance metrics, and application tools already in use. The tools and resources were reviewed by the project's Technical Expert Task Group and by select Metropolitan Planning Organizations (MPOs) and state departments of transportation (DOTs) who engaged in pilot studies of RPAT.

RPAT is one of the SHRP 2 research products now being maintained at AASHTO's TravelWorks site (http://planningtools.transportation.org/10/travelworks.html), which hosts a collection of tools to improve modeling and transportation analysis. New releases of the RPAT software will be available for download from TravelWorks.

1.1 SHRP 2 C16 PROJECT OBJECTIVES

The overall goal of project SHRP 2 C16 was to provide transportation planning agencies with improved tools and methods for more accurately and comprehensively integrating transportation investment decision-making with land development and growth management. To achieve this objective, there were several steps:

- Understanding the critical decision points in the transportation planning process for highway capacity and assessing whether, how, and to what extent smart growth approaches to land-use policies and planning may affect demand for such capacity.
- Reporting on existing research to understand the dynamics and interrelationships of smart-growth strategies with the performance of a transportation investment.
- Building on existing applications to identify the range of features and capabilities these tools and methods need to represent, including the performance metrics needed to assess smart growth alternatives.

- Facilitating improved communication, interaction, and partnerships between decision-makers and planners in both the transportation and land-use arenas.

A PDF document of the final report from the SHRP 2 C16 project can be downloaded from http://www.trb.org/Main/Blurbs/168761.aspx. It should be noted that during the SHRP 2 C16 project, the RPAT software was known as SmartGAP but has since been rebranded as RPAT.

1.2 ORGANIZATION OF THIS USER'S GUIDE

This user's guide is organized into the following sections:

- RPAT introduction and model design (more detail on the technical aspects of the model such as discussion of model specifications can be found in the SHRP 2 C16 final report).
- Installation instructions: installing R, about R, and installing RPAT.
- Running RPAT: about the user interface, creating projects and scenarios, running the model, viewing and export output, and creating charts to compare results across scenarios
- Developing input data.
- Evaluating outputs: performance metrics.
- RPAT implementation examples: examples from the pilot testing of RPAT to provide guidance on how an agency could use RPAT.

2.0 DESIGN OF RPAT

2.1 OBJECTIVES OF THE SOFTWARE TOOL

RPAT is a tool for evaluating the impact of various smart growth policies. RPAT is designed to be a high-level evaluation at a regional scale that can bridge the distance between evaluating smart growth policies during a regional visioning process and evaluating smart growth policies at a project or alternative level in a regional transportation plan. RPAT evaluates policy scenarios to identify the most promising policies that could be further tested using a more detailed project-level tool. Currently, RPAT can provide information on the following changes in the regional system:

- Built Environment – changes to the urban form (proportion of population and employment living in mixed-use areas, transit-oriented developments, or rural/greenfield areas)
- Travel Demand – changes in population demographics (age structure), changes in personal income, changes in firms by size or industry, relative amounts of development occurring in urban core, close-in communities, suburban or rural areas, urban core, auto and light truck proportions by year, and induced demand
- Transportation Supply – amounts of regional transit service, amounts of freeway and arterial capacity
- Policies – pricing (vehicle miles traveled charges or parking pricing programs), intelligent transportation system (ITS) strategies for freeways and arterials, demand management (vanpool, telecommuting, ridesharing, and transit pass programs)

RPAT is designed to evaluate regions, which can be a multi-county metropolitan region. It distinguishes between population and employment living/working in the urban core, close-in communities, suburban and rural/greenfield areas based on densities, diversity in land uses, street design or intersection densities, job accessibility by auto, distances to transit stops, and connectivity of the street system.

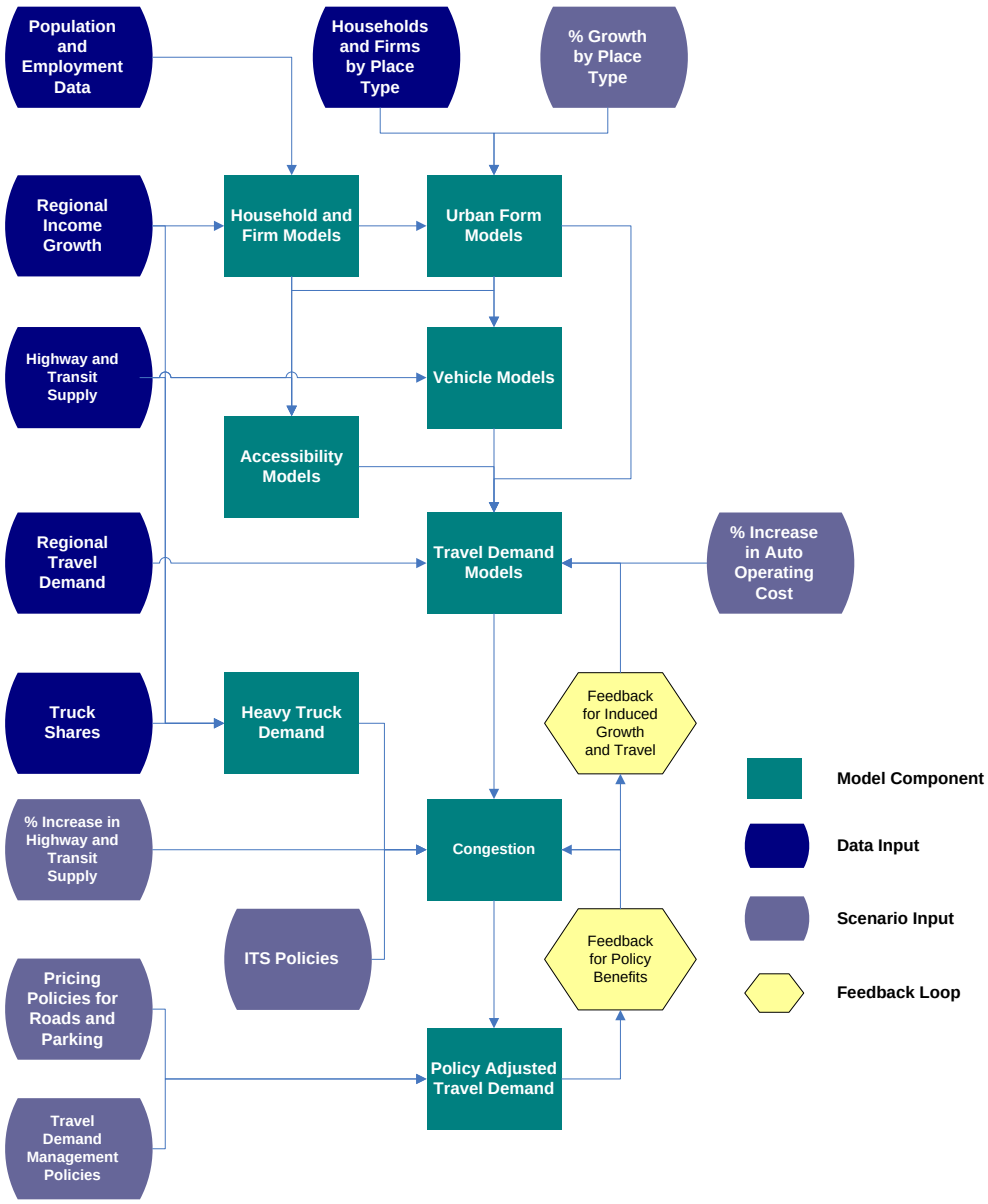
The intended audience for RPAT is regional decision-makers and land use and transportation planners involved in the development and evaluation of transportation and land use policies and who need to conduct scenario planning to evaluate smart growth policies and determine their impact on travel demand. RPAT was designed to address as many of the limitations identified in the research as possible and to provide a tool that filled a gap in the set of available tools. The relationships in the RPAT tool were based upon the background research conducted for the SHRP 2 C16 project. RPAT is designed to allow the evaluation of a wide range of policies and combination of policies in a consistent framework quickly and easily so that promising smart growth strategies can be

identified and pursued in the land use and transportation planning processes. RPAT is intended to precede and supplement more sophisticated modeling efforts, which can be used to evaluate specific smart growth projects. It is designed to be accessible to land use and transportation planners with no modeling experience.

2.2 MODEL STRUCTURE

RPAT is a disaggregate policy model that predicts travel demand impacts at an individual household level. Figure 1 presents the modeling system with inputs, model components, and feedback loops.

FIGURE 1: OVERVIEW OF MODELING PROCESS



RPAT does not provide specific spatial results beyond the built environment categories at the regional level, but does capture individual household and firm characteristics and the interactions between policies. The disaggregate nature of the model captures impacts that may be occurring for small portions of the population (say 0-vehicle households) where aggregate models have a more difficult time capturing these impacts.

The following is an explanation of major steps in the model execution in Figure 1.

HOUSEHOLD AND FIRM MODEL

- Create Synthetic Households - A set of households is created for each forecast year that represents the likely household composition for the region, given the county-level forecast of persons by age. Each household is described in terms of the number of persons in each of six age categories residing in the household. A total household income is assigned to each household, given the ages of persons in the household and the average per capita income of the region where the household resides.
- Create Synthetic Firms - A set of firms is created for each forecast year that represents the likely firm composition for the region, given the County Business Pattern data of firms by size and industry. Each firm is described in terms of the number of employees and its industry.

URBAN FORM MODEL

- Calculate Place Types for Households and Firms - Population and employment location characteristics are important variables in the vehicle ownership, travel demand, and accessibility models. There are four place types (urban core, Close-in Community, suburban, and rural and five location categories (residential, commercial, mixed-use, transit-oriented development, and Greenfield). Models for households were developed to estimate location characteristics using National Household Travel Survey data. Firms are currently allocated randomly to fit the employment allocation inputs since there are no national datasets from which to draw these relationships.

ACCESSIBILITY MODEL

- Calculate Freeway, Arterial, and Public Transit Supply Levels - The number of lane miles of freeways and arterials is computed for each region based on the change in inventories for a particular scenario. For public transit, the inputs specify the change in transit revenue miles relative to the base. Inputs for each area also specify the revenue mile split between electrified rail and buses.

VEHICLE MODEL

- Calculate Vehicle Ownership - Each household is assigned the number of vehicles it is likely to own based on the number of persons of driving age in the household, whether only elderly persons live in the household, the income of the household, the population density where the household lives, the freeway supply, the transit supply, and whether the household is located in an urban mixed-use area.

TRAVEL DEMAND MODEL

- Calculate Travel Demand - The average daily vehicle miles traveled, auto and transit trips for each household is modeled based on household information determined in previous steps for the base conditions. The model is sensitive to household income, population density of the neighborhood where the household resides, number of household vehicles, whether the household owns no vehicles, the levels of public transportation and freeway supplies in the region, the driving age population in the household, the presence of persons over age 65, and whether the neighborhood is characterized by mixed-use development.
- Calculate Truck and Bus Vehicle Miles Traveled (VMT) - Regional truck VMT is calculated based on changes in the regional household income. As a default, a one-to-one relationship between regional income growth and truck VMT growth is assumed. In other words, a doubling of total regional income would result in a doubling of truck VMT. Bus VMT is calculated from bus revenue miles that are factored up to total vehicle miles to account for miles driven in non-revenue service.

CONGESTION MODEL

- Calculate the amount of congestion – Auto, and light truck VMT, truck VMT and bus VMT in are allocated to freeways, arterials, and other roadways. Truck and bus VMT are allocated based on mode-specific data, and auto and light truck VMT are allocated based on a combination of factors and a model that is sensitive to the relative supplies of freeway and arterial lane miles. System-wide ratios of VMT to lane miles for freeways and arterials are used to allocate VMT to congestion levels using congestion levels defined by the Texas Transportation Institute for the Urban Mobility Report. Each freeway and arterial congestion level is associated with an average trip speed for conditions that do and do not include ITS treatment for incident management on the roadway. Overall average speeds by congestion level are calculated based on input assumptions about the degree of incident management. Speed vs. fuel efficiency relationships for light vehicles, trucks, and buses are used to adjust the fleet fuel efficiency averages computed for the region.

FEEDBACK LOOPS

Following initial calculations for baseline conditions, the model has feedback loops, which allow for changes in travel demand and other impacts based on induced travel demand and for changes in policies for a given scenario. Congestion is recalculated following these adjustments to demand.

Induced Demand Model

- Calculate Induced Travel Demand – Induced demand is calculated for changes in roadway supply in the near term as a function of speed, based on potential mode and route shifts to produce changes in VMT and in the longer term to include changes in vehicle ownership, still as a function of speed. This model does not include induced demand as a result of changes in growth that may occur as part of a smart growth scenario because the evidence is limited empirical evidence.

Policy Adjusted Travel Demand

- Calculate Scenario Travel Demand – The average daily VMT for each household can be adjusted based on changes in growth patterns by place type, changes in auto operating cost, changes in road lane miles or transit revenue miles for any scenario. There are also a series of policy assumptions that can contribute to changes in VMT: pricing such as VMT charges or parking pricing, ITS strategies for freeways and arterials, and vanpool, telecommuting, ridesharing, and transit pass programs. All of these will contribute to shifts in travel demand for a given scenario.

Performance Metrics

- Calculate Performance Metrics – The other impacts that are produced for a given scenario include environment and energy impacts greenhouse gas (GHG) emissions and fuel consumption), financial and economic impacts (highway and transit infrastructure costs, transit operating costs, and traveler costs), regional accessibility, and community impacts (livability and public health indicators).

3.0 INSTALLATION INSTRUCTIONS

RPAT is implemented in R, the freely available language and environment for statistical computing and graphics, which provides a wide variety of statistical and graphical techniques: linear and nonlinear modeling, statistical tests, time series analysis, classification, clustering, etc. Thus, the installation of RPAT is a two-step process.

1. Install R
2. Install RPAT

The RPAT installer combines the installation of R and the installation of RPAT into a single installer executable file. The controlled installation of a stable version of R and RPAT's required R packages mitigates the versioning challenges that can arise when working with open source software.

Previous experience with R is not required to run RPAT. Users who are interested in exploring R are encouraged to do so by starting at the R Project website (www.r-project.org/). There are many resources for helping newer R users become more familiar with using R for data analysis and modeling. Here are some places to get started:

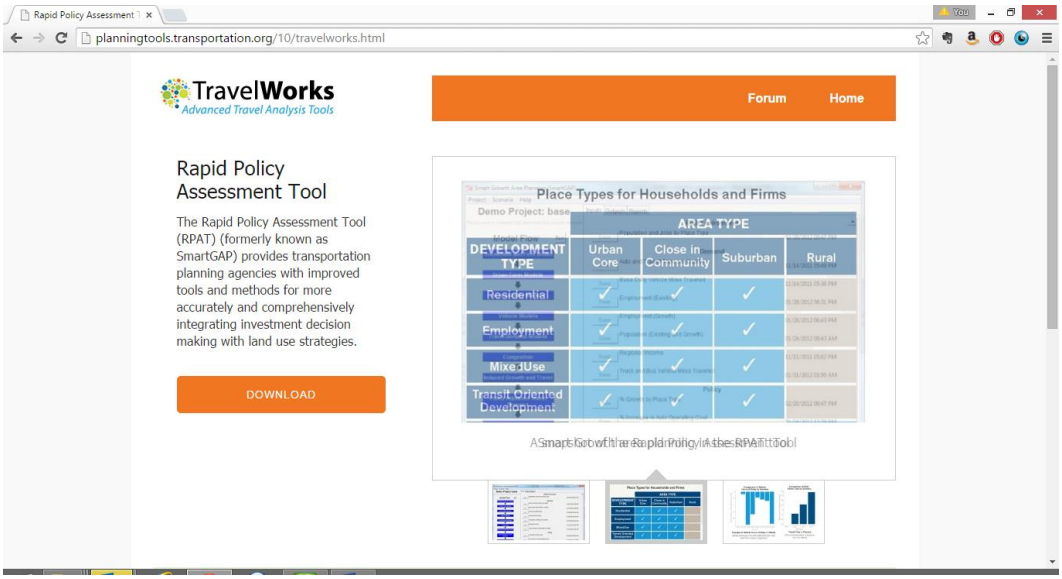
- Manual and introduction to R: http://cran.r-project.org/manuals.html
- Journal: The R Journal (http://journal.r-project.org/) is the refereed journal of the R project for statistical computing. It features short to medium length articles covering topics that might be of interest to users or developers of R.
- Books: http://www.r-project.org/doc/bib/R-books.html
- R function reference card: http://cran.r-project.org/doc/contrib/Short-refcard.pdf
- R search engine: http://www.rseek.org/

3.2 INSTALLING RPAT

DOWNLOADING RPAT

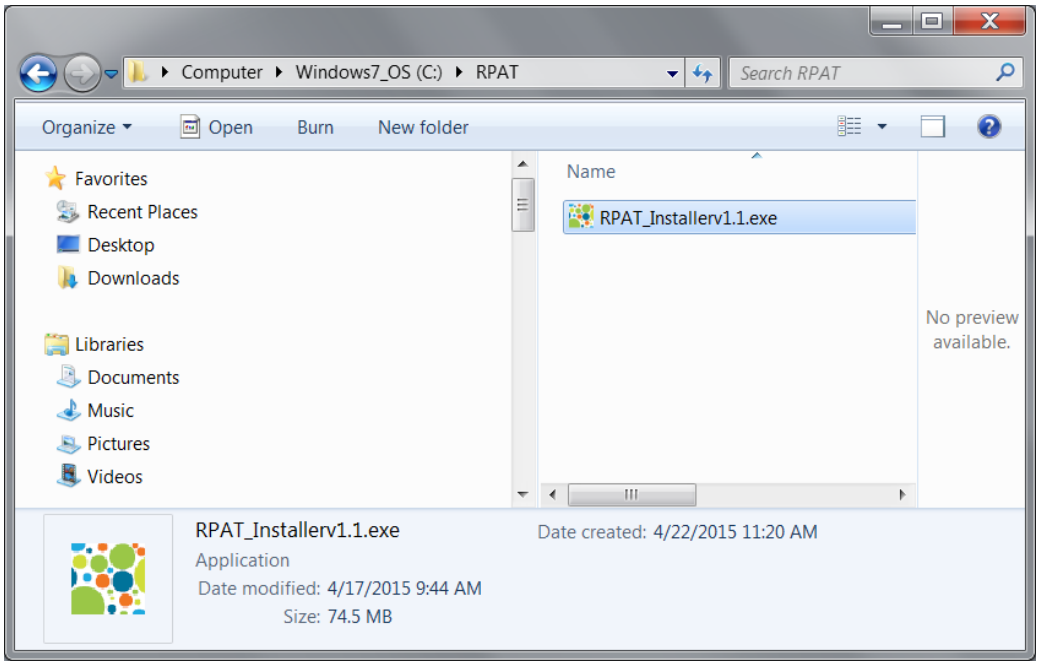
RPAT is available for download from AASHTO's TravelWorks site, at http://planningtools.transportation.org/10/travelworks.html (Figure 2).

FIGURE 2: RPAT PAGE ON TRAVELWORKS



RPAT is provided as an executable (.exe) installer. The installer is called "RPAT_Installerv#.#.exe" where the hashtags indicate the version (Figure 3).

FIGURE 3: RPAT EXECUTABLE INSTALLER

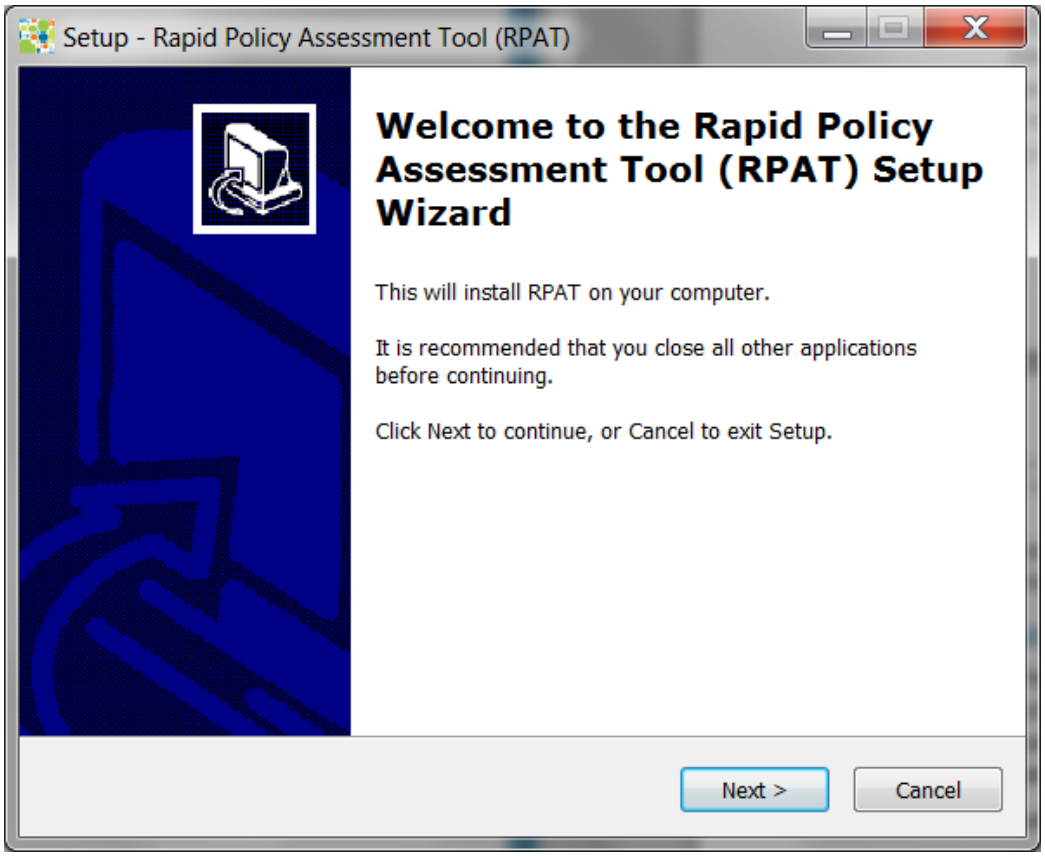


EXECUTING THE INSTALLER

Once downloaded to your computer RPAT is installed through the following steps:

1. Double-click the executable in order to start the RPAT Setup Wizard as shown in Figure 4. The Wizard will guide you through the setup process.

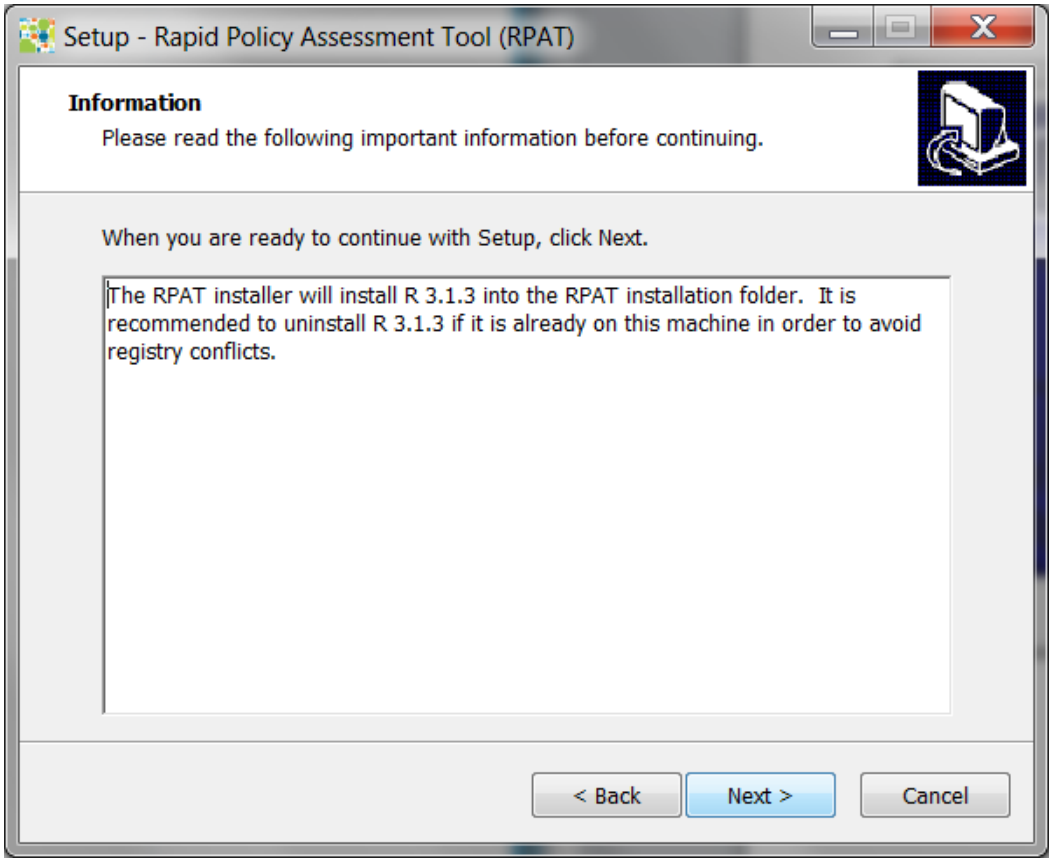
FIGURE 4: RPAT SETUP WIZARD



2. Once you have reviewed the welcome screen, please press "Next >" in order to continue setup.

3. The next window, as seen in Figure 5, will inform you that RPAT will need to install R 3.1.3 to your computer and suggest that you remove any prior installations of R 3.1.3 from your computer. Note that alternative versions of R will not cause conflicts.

FIGURE 5: RPAT SETUP R INSTALLATION WARNING



4. You can check whether you have R 3.1.3 installed on your computer by navigating to the following locations:
    - Your Local Hard Drive (typically your "C:" drive) → "Program Files" → "R"
    - Your Local Hard Drive (typically your "C:" drive) → "Program Files (x86)" → "R"

    Please uninstall pre-installed R 3.1.3 versions if necessary and then click "Next >"

5. The next window, as seen in Figure 6, will allow you to choose the location of your RPAT installation. By default, the Setup Wizard will create a folder called "RPAT" at the root of your Hard Drive for the installation.
   Click "Next >" once you are satisfied with location to which RPAT will be installed. If the directory already exists, the Setup wizard will inform you as such, see Figure 7, and you will need to confirm your choice by clicking "Yes" or revise your choice by clicking "No" instead.

FIGURE 6: RPAT SETUP DIRECTORY WINDOW

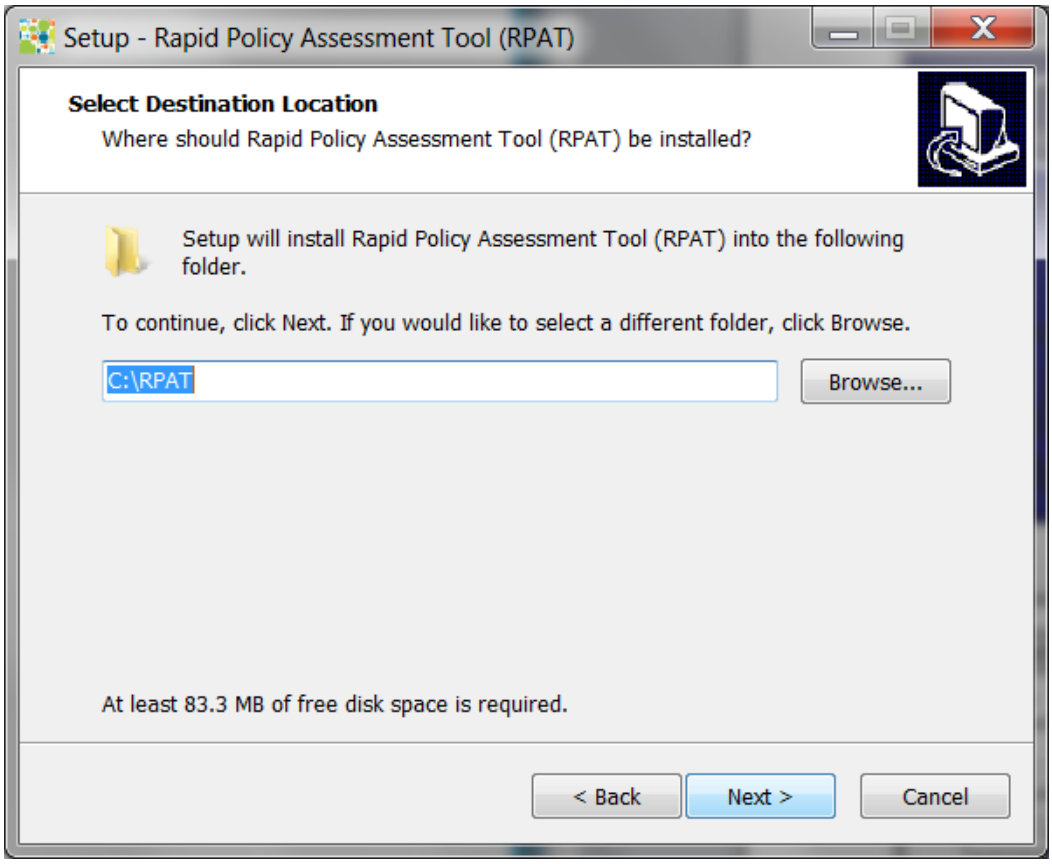
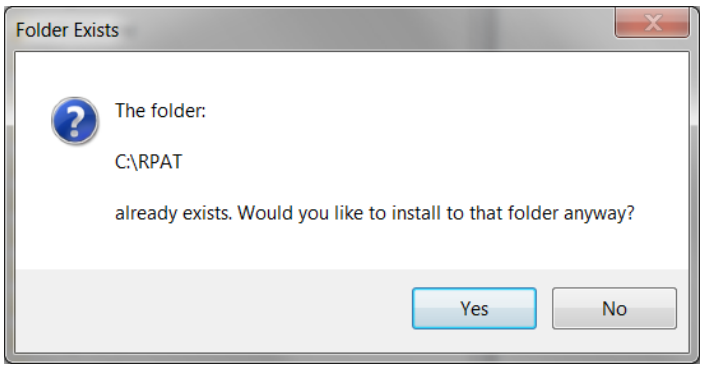
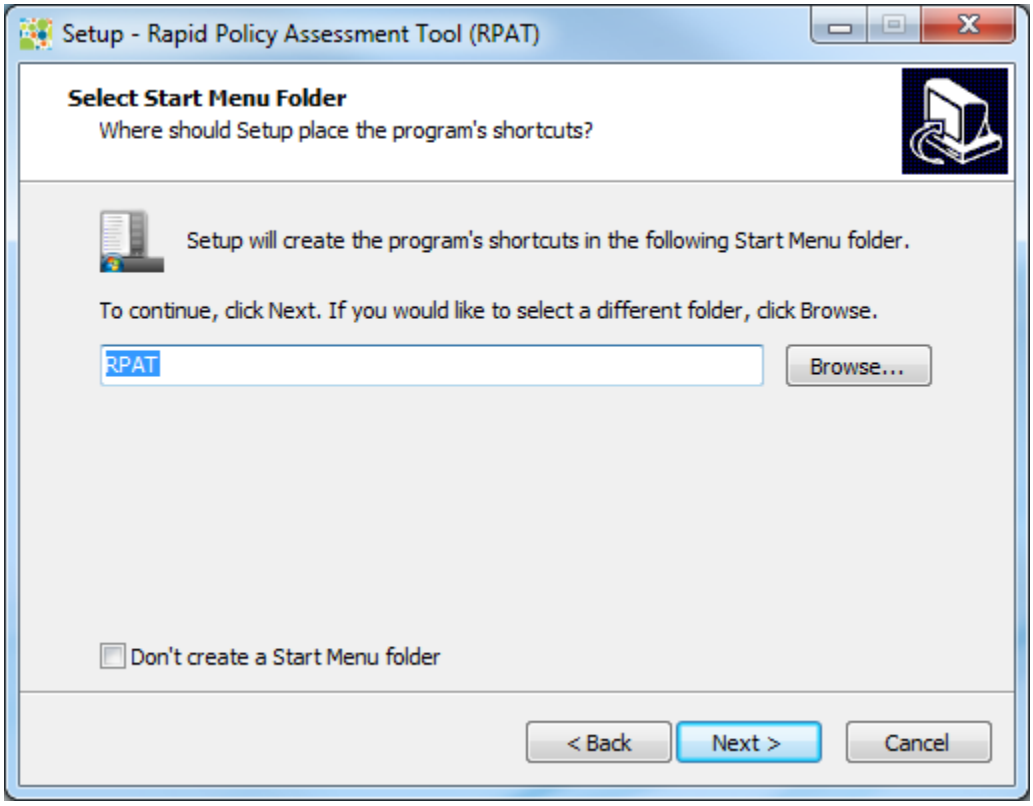


FIGURE 7: RPAT WARNING INSTALLATION DIRECTORY EXISTS



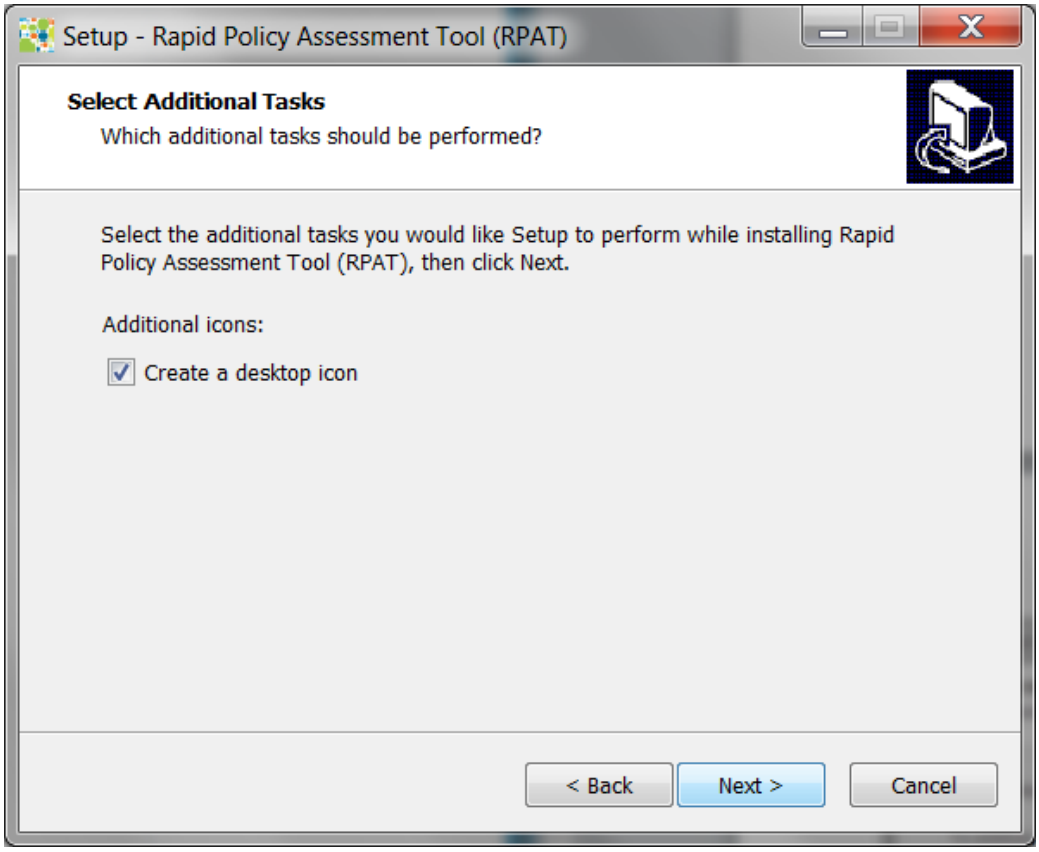
6. The next window will allow you to choose the location to which the program's shortcuts will be created, see Figure 8. The default location is the RPAT installation directory. Note that you can also click the option "Don't create a Start Menu folder" if you choose to forego this step. Click "Next >" when you are satisfied with your choices.

FIGURE 8: RPAT SETUP PROGRAM SHORTCUTS



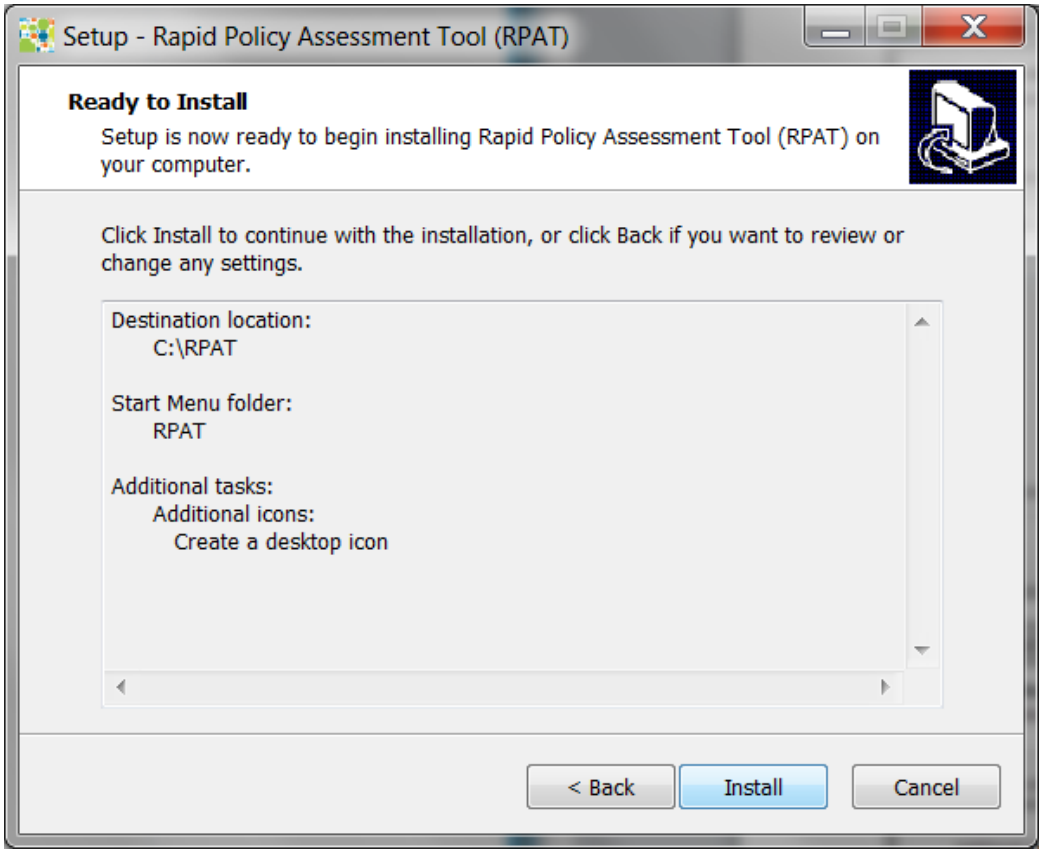
7. The next window will allow you to choose whether the Setup Wizard will create a desktop icon, see Figure 9. Click "Next >" when you are satisfied with your choices.

FIGURE 9: RPAT SETUP DESKTOP ICON



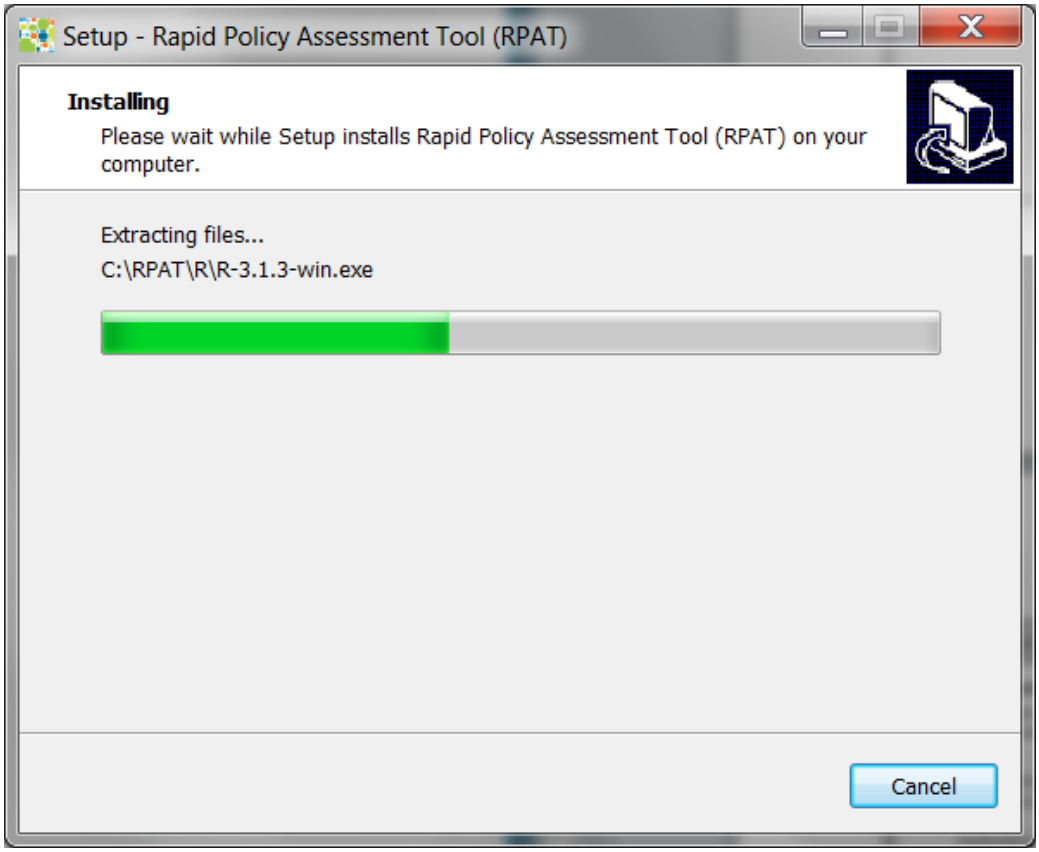
8. The next window, as shown in Figure 10, will summarize the installation choices that you have made. This window provides you with a final chance to make revisions to your installation settings. Click "< Back" if you would like to make adjustments to your installation settings. Click "Next > " if you are ready to install RPAT!

FIGURE 10: RPAT SETUP SETTING REVIEW



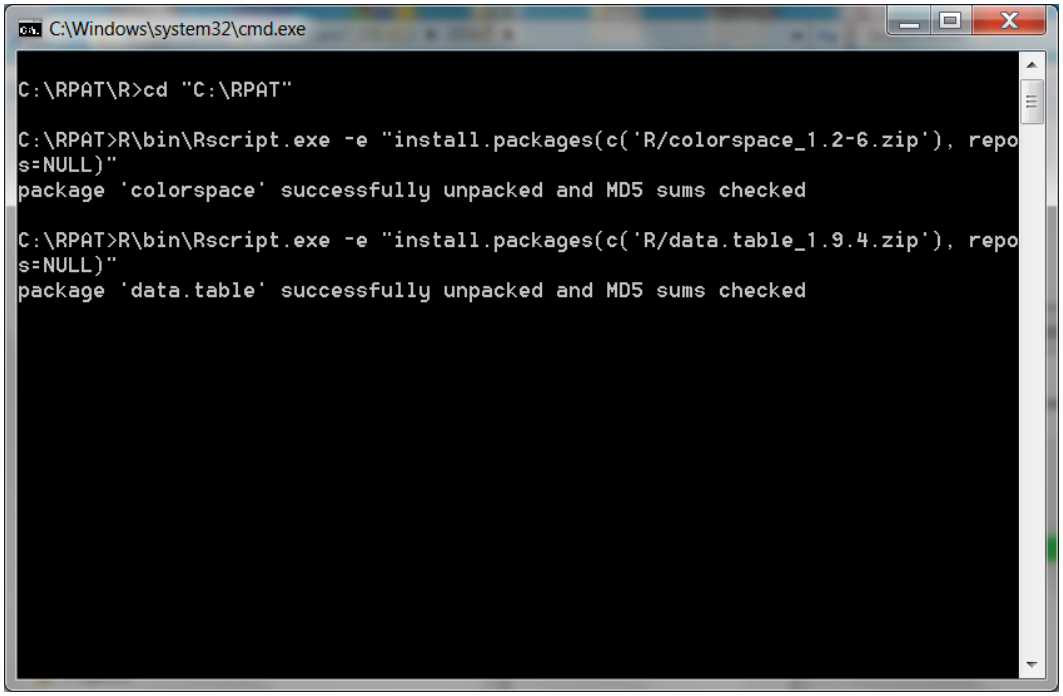
9. RPAT installation has begun! The installation progress window, as shown in Figure 11 will open to keep you informed about the status of your installation. You can click "Cancel" at any time to halt or abort the installation.

FIGURE 11: RPAT SETUP INSTALLATION PROGRESS WINDOW



10. As the RPAT Installation continues, an additional command shell dialog box will open to report the installation of specialized R packages. The command shell dialog box will look similar to the image in Figure 12. Do not attempt to close this window.

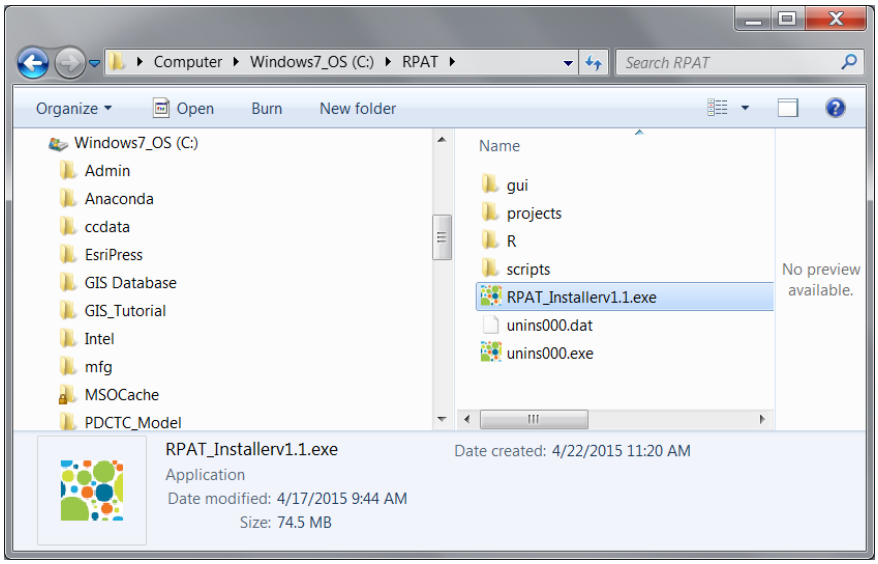
FIGURE 12: RPAT SETUP R PACKAGE INSTALLATION



11. When the RPAT installation completes the RPAT Setup Wizard will show the window in Figure 13. Click "Finish" to close out of the Setup Wizard. You will notice that the directory that you chose to house the RPAT installation will now look very similar to Figure 14.

FIGURE 13: RPAT SETUP COMPLETION

FIGURE 14: RPAT INSTALLATION DIRECTORY POST INSTALL



GRAPHICAL USER INTERFACE (GUI) DIRECTORY

The RPAT model is implemented within a user-friendly environment that facilitates the development, management, and processing of scenarios for comparison. While R is the back end software that provides a platform for modeling and graphics development, the requisite software for RPAT's graphical user interface (gui) is stored within this directory.

PROJECT DIRECTORY

In this directory, there is one folder for your project and an additional folder for a demo project. The "Demo Project" folder contains an example project demonstrating the model. Your project directory contains a "base" scenario and other policy scenario folders as they are created. There are no caveats for naming the future scenario directories except that they should not be called "parameters" or "reports" as that would create a conflict with the parameters and reports folder respectively. The scenario directory includes two subdirectories: inputs and outputs. The inputs directory includes all of the input files needed to specify a scenario. The outputs directory contains all of the output files that are produced by the model. Your project directory includes a parameters folder that holds model parameters that can be edited; model parameters are common across all scenarios for a specific project.

R DIRECTORY

This directory contains the installation of R 3.1.3 that was performed as part of the RPAT installation. This directory contains all of the files required by R including the library of packages required by RPAT.

SCRIPTS DIRECTORY

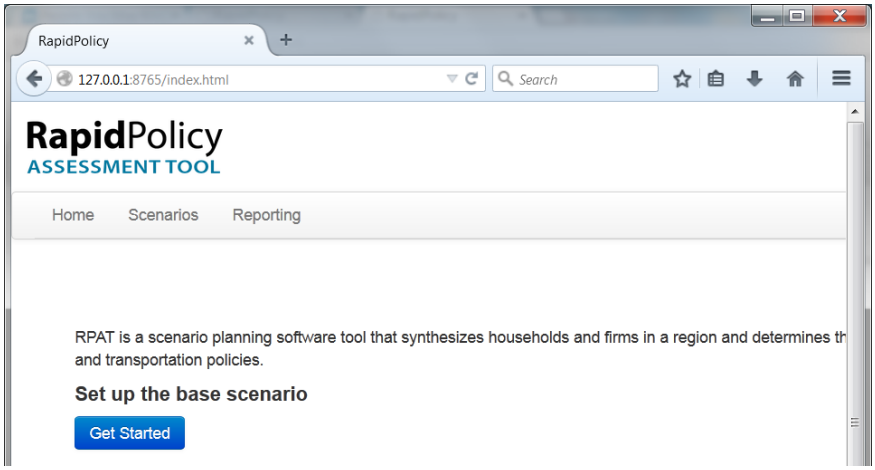
This directory contains all of the R scripts that run portions of RPAT. It also contains an .RData file (an R binary file) that contains functions, model specifications, and data tabulations used by the various model components. These files should not be modified.

OPENING RPAT

Open RPAT by double clicking on the RPAT shortcut

The RPAT GUI will then open in a separate web browser (based on your computer's preferred browers settings) as shown in the Firefox example in Figure 15.

FIGURE 15: SMARTGAP GUI ON OPENING



Congratulations! You have successfully installed RPAT to your computer. Now you are ready to run the software.

4.0 RUNNING RPAT

4.1 GETTING STARTED

The first time that RPAT opens the interface will look like Figure 16. In order to prepare RPAT for modeling you must create scenarios, but, at this point, RPAT contains no scenario input data. The first scenario that model users should create is the base scenario. To aid that process, an example project is supplied with the software. This example project is used as a template for the base scenario inputs. You can locate this example project within the “projects” folder of the RPAT directry, it is labeled “Demo Project”.

Click the blue “Get Started” button, as seen in Figure 15, in order to start the process of creating the base scenario. Once the button is clicked you will be prompted with a screen similar to the one in Figure 17 requesting you to name the “Base” scenario. The default name is “Base” and RPAT will not allow you to make changes to the name (subsequent alternative scenarios can be named by the user).

FIGURE 16: RPAT USER INTERFACE OPEN FIRST OPENING

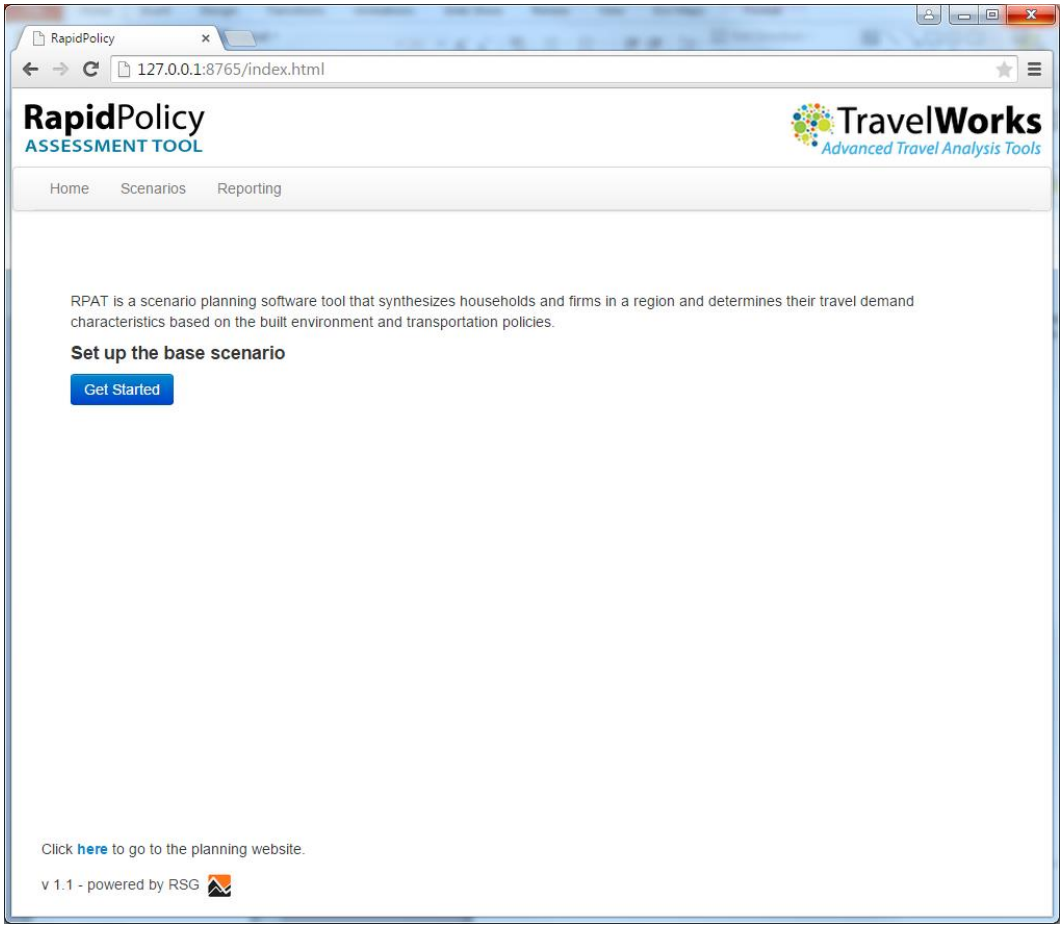
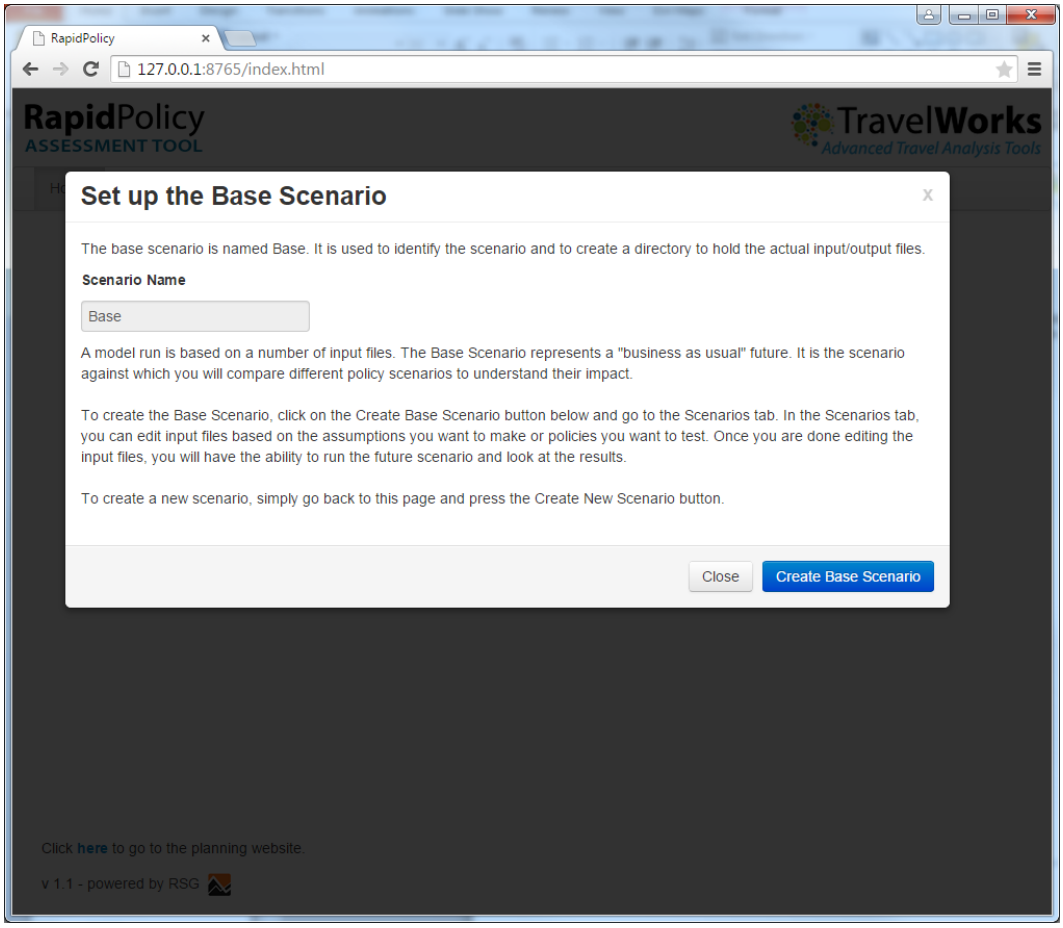


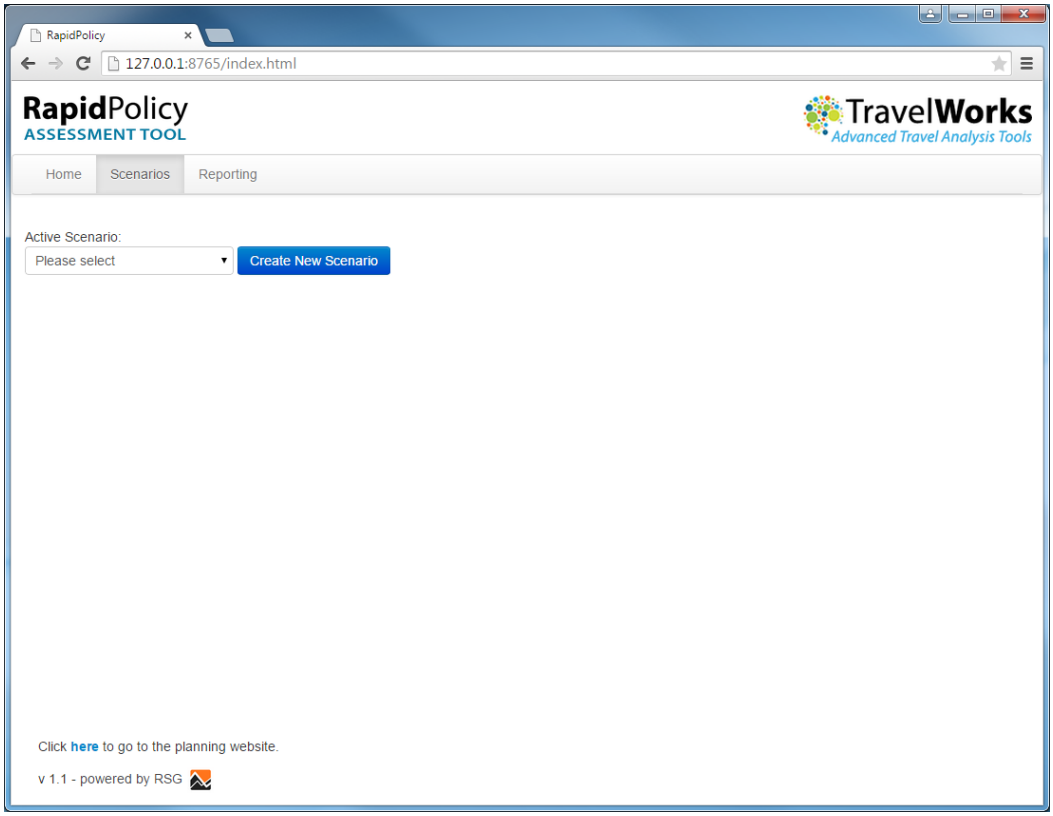
FIGURE 17: STARTING THE FIRST PROJECT



4.2 OPENING THE BASE SCENARIO

Now that a “Base” scenario has been created you will need to populate the scenario with region specific data. Click the “Scenarios” menu in the heading to switch to the scenarios menu. Once clicked, RPAT will bring you to the “Scenarios” page that will appear similar to the one in Figure 18. This page will allow you to select a scenario to update.

FIGURE 18: SCENARIOS MENU



Click the "Active Scenario" dropdown menu like in Figure 19 and choose the "Base" scenario. A table with four (4) options will appear like in Figure 20. These options will be enumerated in the following documentation sections.

FIGURE 19: SELECTING A SCENARIO

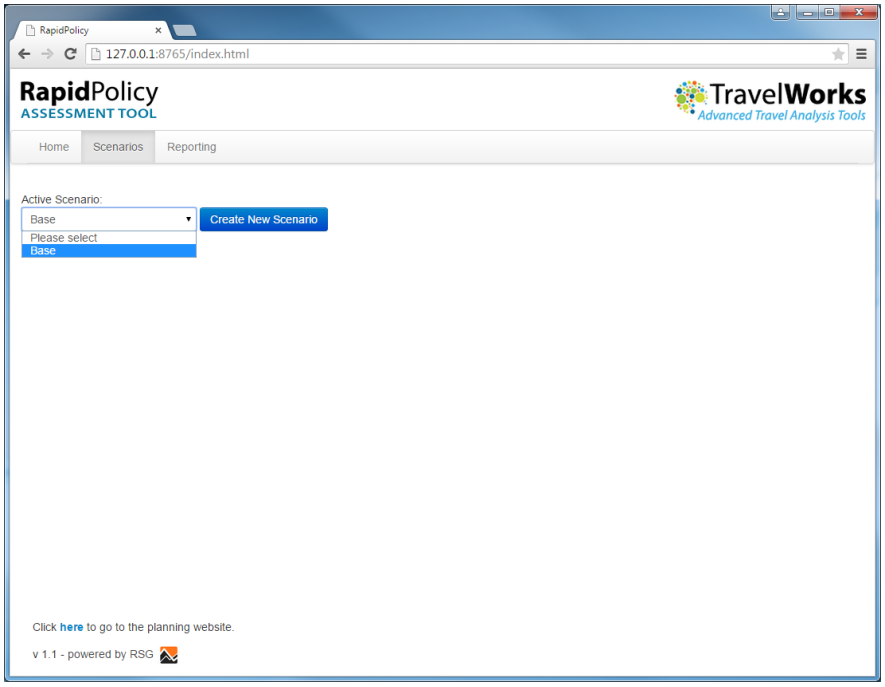
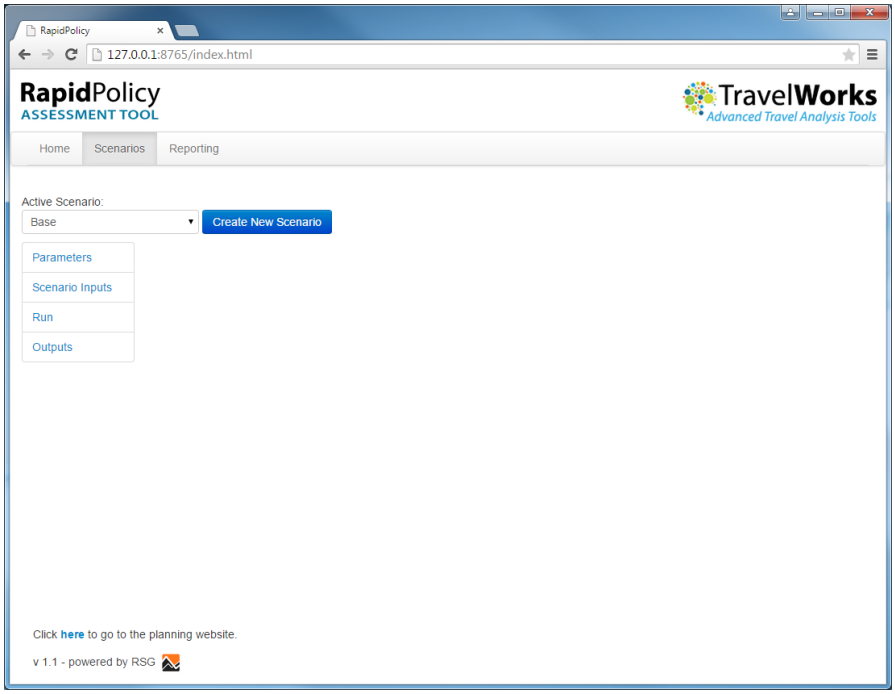


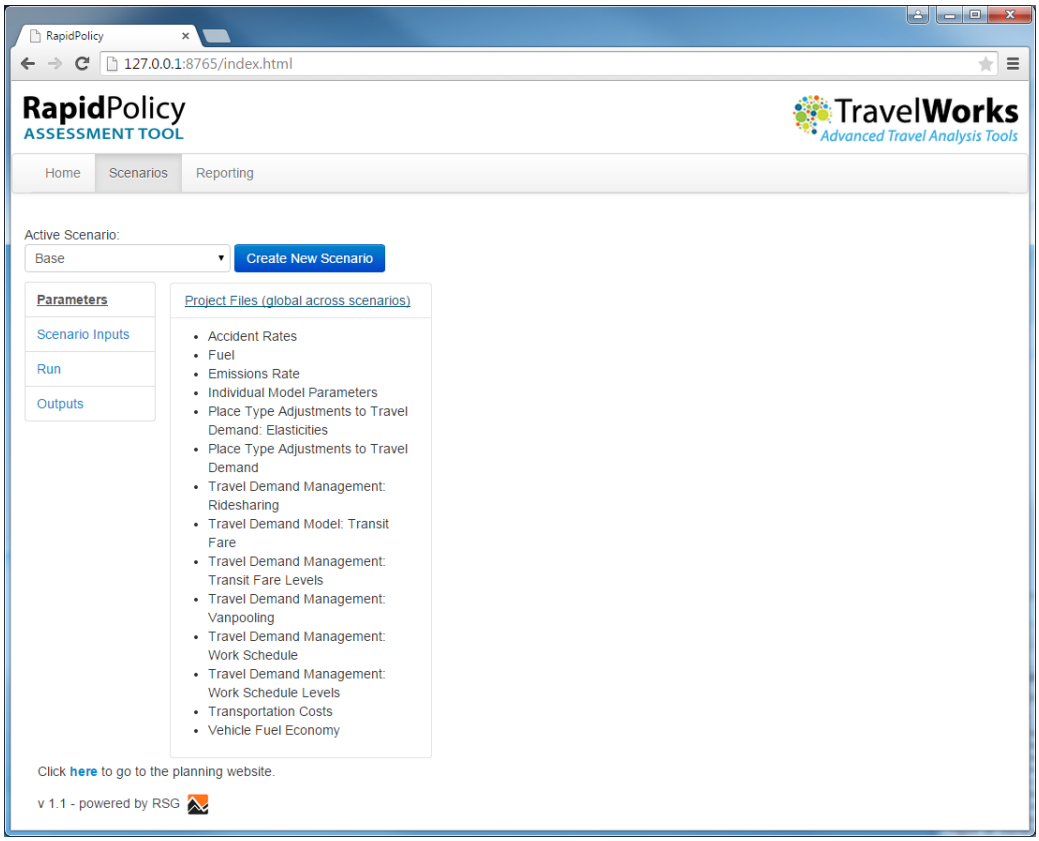
FIGURE 20: SCENARIO OPTIONS



4.3 UPDATING THE SCENARIO PARAMETERS

The parameters menu allows you to view and edit various model inputs. Click “Parameters” to open the parameters menu. Once opened, the parameters menu will look like Figure 21.

FIGURE 21: PARAMETERS MENU



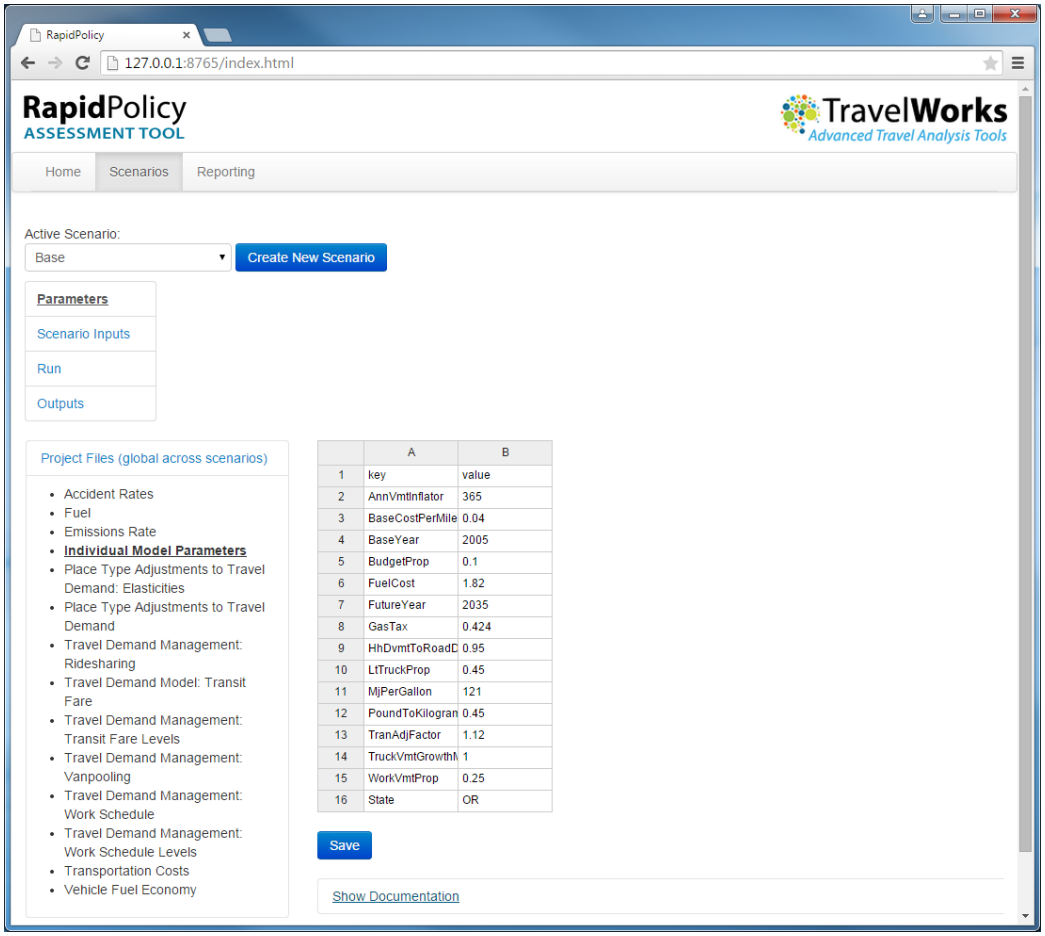
While you are provided access to the model parameters, you are encouraged to use the default parameter values unless directed to use alternatives. The model user is warned that the default parameters have been derived from documented research sources. Editing modeling parameters should be based only on research pertaining to local data sources and may result in unpredictable results. There are three exceptions, all of which are located in the “Individual Model Parameters” file as shown in Figure 22. These exceptions include:

- BaseYear;
- FutureYear; and
- State.

The “BaseYear” variable should reflect the base year for which the rest of your model inputs have been developed while the “FutureYear” should reflect the horizon year for which you wish to do scenario comparisons. The base and future year values must be on increments of 5 years between 1990 and 2050 (e.g.,

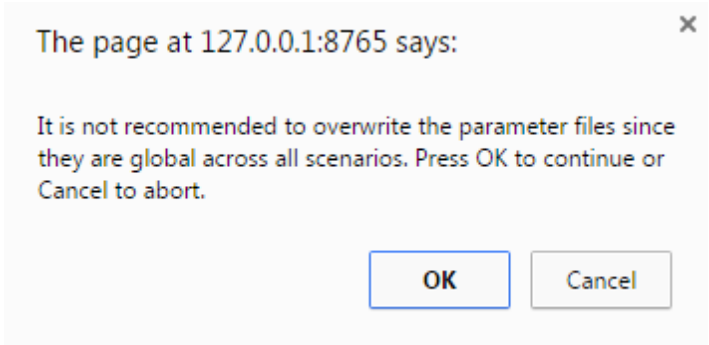
1990, 1995, etc., 2050). The "State" variable should correspond to the two (2) letter abbreviation of the state within which the majority of the model area falls.

FIGURE 22: INDIVIDUAL MODEL PARAMETERS



To update the "BaseYear", "FutureYear", and "State" inputs, click the corresponding value located in the "B" column. When you are finished, click the "Save" button. A pop-up similar to the one in Figure 23 will warn you not to overwrite the parameters files. Click "OK" to make the changes.

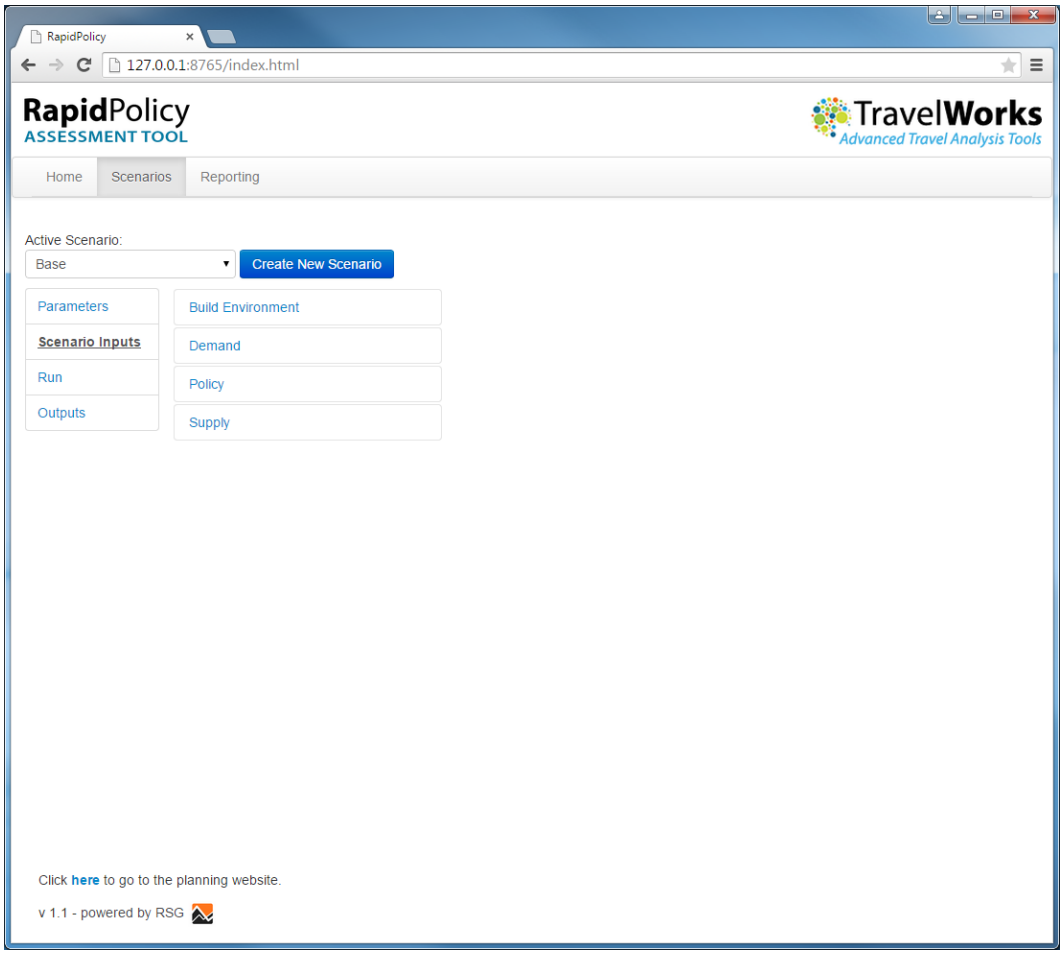
FIGURE 23: PARAMETERS OVERWRITE WARNING



4.4 UPDATING THE BASE SCENARIO INPUTS

Click “Scenario Inputs” to move to the Scenario Inputs page, as shown in Figure 24, to adjust the “Base” scenario inputs for your RPAT implementation.

FIGURE 24: SCENARIO INPUTS MAIN PAGE

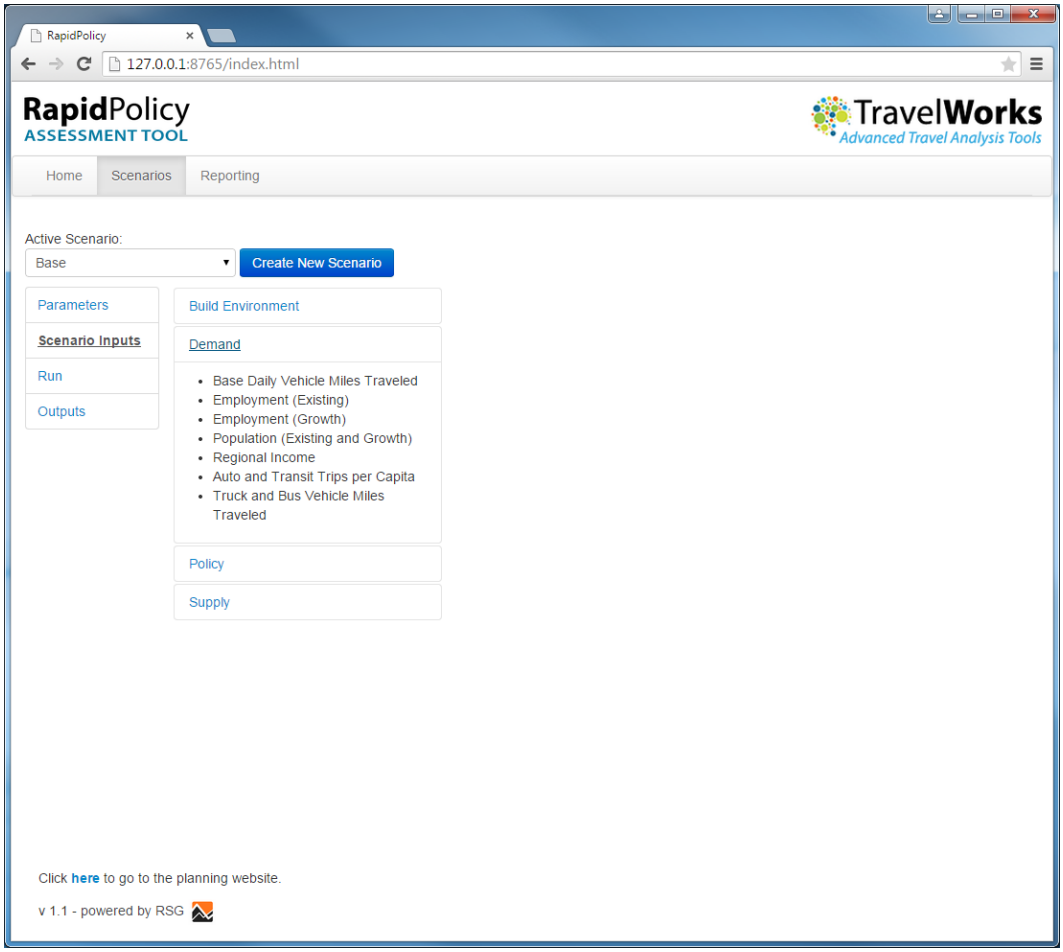


Note that the scenario Inputs are split into four (4) categories:

- Build Environment
- Demand
- Policy
- Supply

Each category is subdivided into individual input files. For instance, when you click the “Demand” category, you will see the menu expand to reveal the individual “Demand” category inputs like in Figure 25.

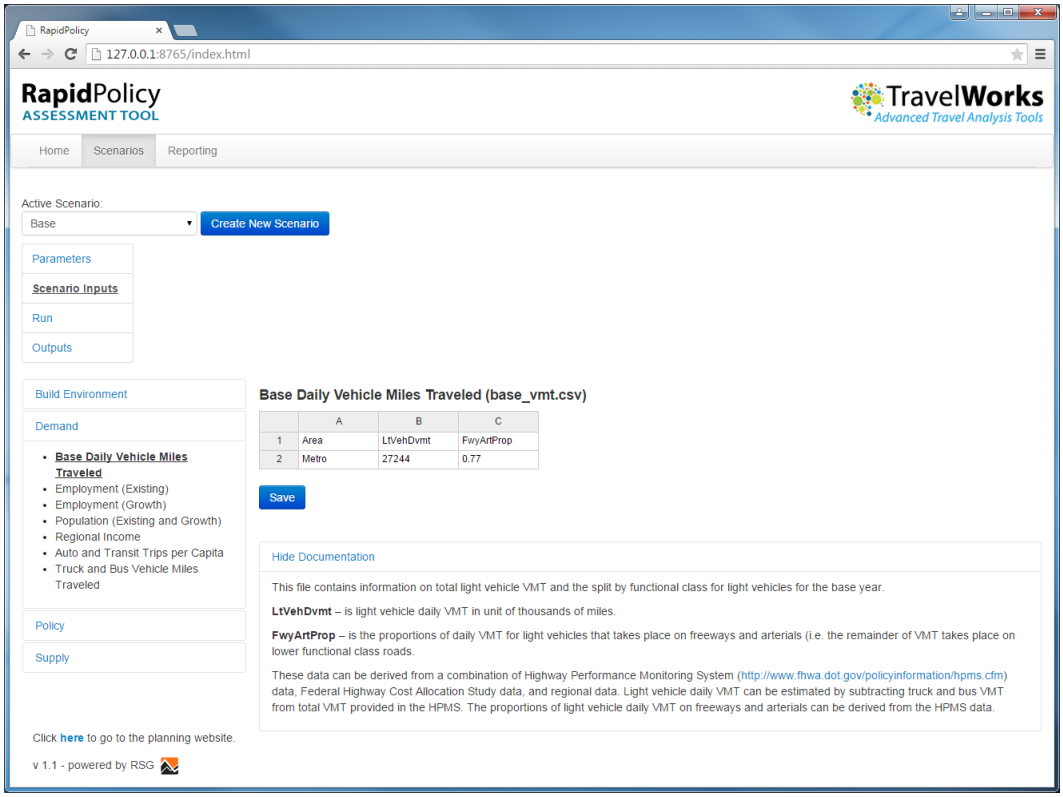
FIGURE 25: SCENARIO INPUTS DIRECTORY



You will need to go through and populate each of the input files for each of the categories based on the data for you application. To do this you will need to select each individual file and update its contents similar to what was done to update the parameters in section 4.3

Figure 26 shows the “Base Daily Vehicle Miles Traveled” input file. Note that the page contains documentation to help guide the adjustment of the input data table. When you are satisfied with each data input table click the “Save” button and RPAT will return you to the previous page. Documentation describing each scenario input is also included in Chapter 5 of this user’s guide.

FIGURE 26: EXAMPLE SCENARIO INPUT DATA ADJUSTMENT

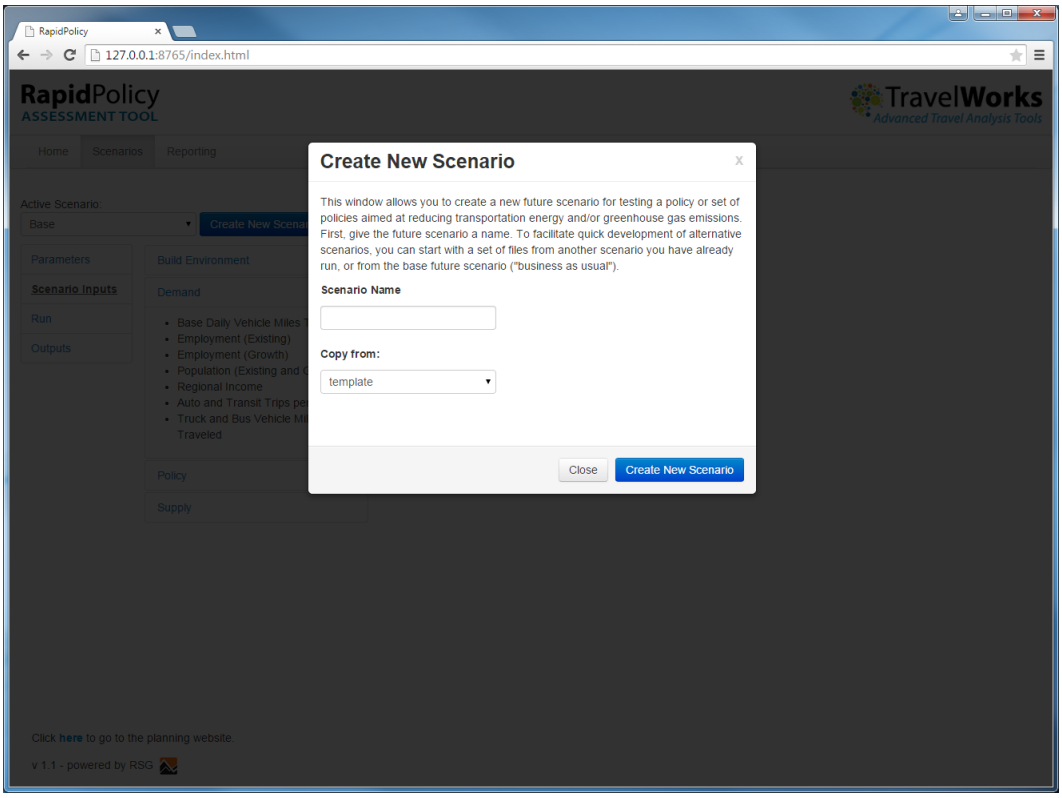


4.5 CREATING SCENARIOS

The "Scenarios" menu also facilitates the creation of new scenarios, the navigation between scenarios, and the running of scenarios. Click the "Create New Scenario" button on the "Scenarios" page as seen in Figure 26 in the previous section. This will open a window similar to Figure 27 to guide the creation of a new scenario. Follow the instructions on the page and enter an informative name in the "Scenario Name" section (the name cannot be "Base", "parameters", or "reports"). Then choose from what source the scenario will be copied in the "Copy from" dropdown menu. Click "Create New Scenario" when you are satisfied with your choices. You will note that the new scenario is now available for selection in the "Active Selection" dropdown menu.

The suggested option is to copy from the base, unless your new scenario is intended to be a minor modification of another alterative scenario, in which case it is most straightforward to copy from that alternative scenario.

FIGURE 27: CREATE NEW SCENARIO



4.6 DEFINING A SCENARIO

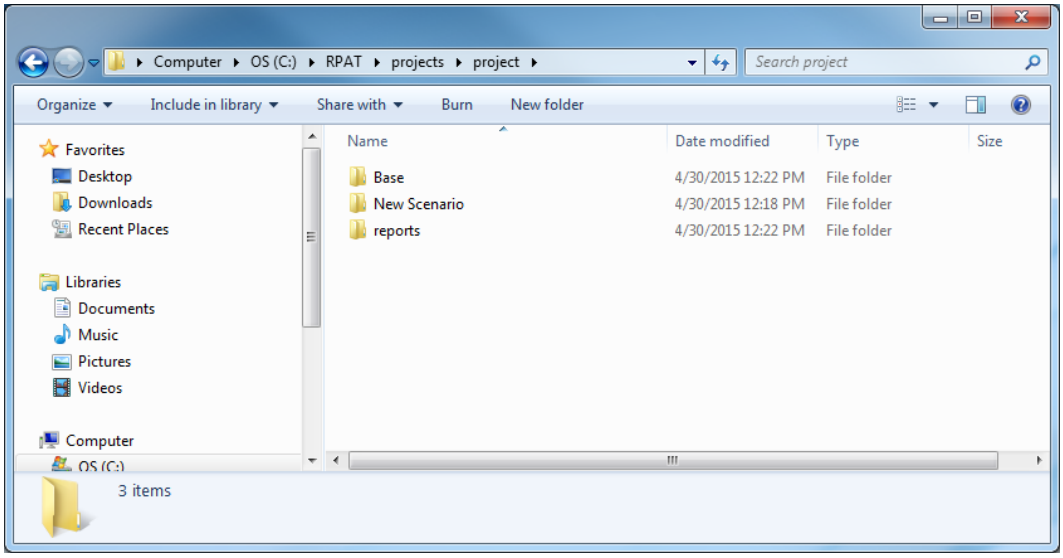
A scenario is defined and distinguished from the base by editing and altering input files. A new scenario starts with references back to the base inputs. These inputs should be adjusted and edited to reflect the scenario that you wish to model. As in section 4.4 you will need to adjust all of the necessary inputs for

your scenario. Always check to make sure that you have the appropriate “Active Scenario” selected.

4.7 SCENARIO MANAGEMENT

The software builds a file structure in the RPAT file directory that manages the scenarios of your project. Your project directory structure will look similar to Figure 28. Within each scenario folder is one directory for inputs, one directory for outputs, and one directory for parameters. The inputs and parameters are stored as .csv files, while the outputs are stored as .rdata files that can be exported to .csv format using the software or opened in R.

FIGURE 28: PROJECT DIRECTORY STRUCTURE



4.8 RUNNING THE MODEL

Once a scenario is loaded with inputs, the model can be run for that scenario. The model can be run in its entirety by clicking the “Run” command in the Scenarios menu and then clicking the blue “Start Run” button, see Figure 29. Note that a command dialog box may open temporarily while the model is running.

As soon as the run button is clicked, the main window will indicate that the model is running. Note that a command box window will open. This window activates the appropriate R scripts and they should be left open while RPAT is processing. Each gray box indicates a model that has yet to be run while a green box indicates a model that has run through to completion (see Figure 30).

Run times vary considerably depending on the computer system used for running the model and, more importantly, the size of the region’s population and its number of businesses. Tests were performed on a computer with an Intel Core 2 Quad CPU Q9400 @ 2.66 GHz, 8 GB RAM, and a 64 Bit Windows 7 Ultimate

operating system. The following run times were observed for a single scenario, which increased close to linearly as the population of the region increased:

- Cecil County, Maryland, 2035 population of 170,000: 2-3 minutes
- Thurston County, Washington, 2040 population of 425,000: 4-5 minutes
- Montgomery County, Maryland, 2035 population of 1.1 million: 15 minutes
- Portland Metropolitan region, 2035 population of 2.3 million: 25 minutes
- Atlanta Region, 2040 population of 8.3 million: 1 hour 45 minutes

FIGURE 29: SCENARIO MODEL RUN

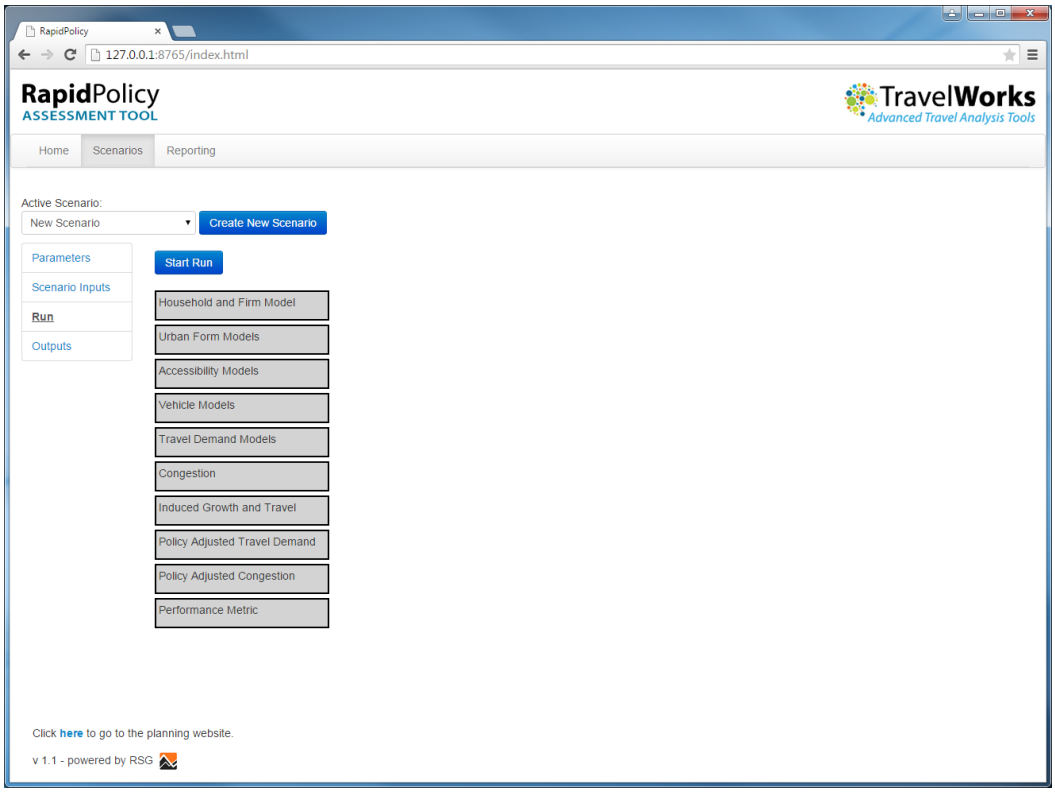
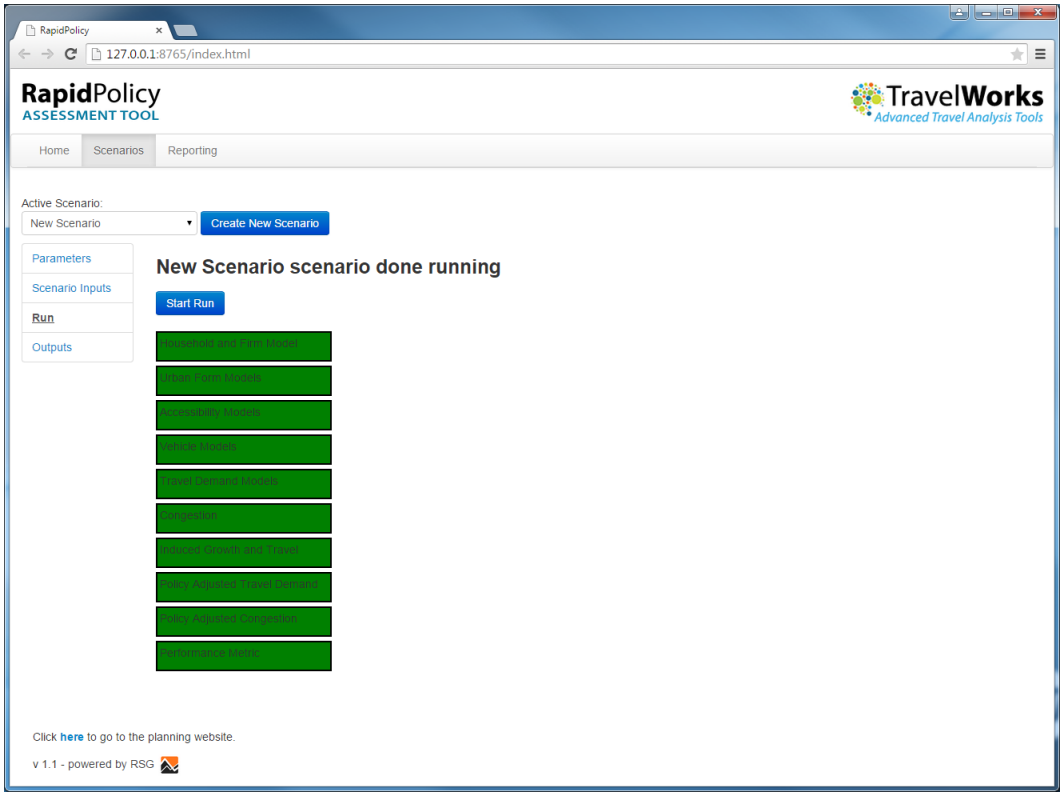


FIGURE 30: COMPLETED SCENARIO MODEL RUN



4.9 OUTPUTS

The model outputs are accessed through the "Scenarios" tab as can be seen in Figure 31. The model writes out a set of ".Rdata" R binary files that contain tables of results for the various performance metrics that the model produces. As a model run progresses and these outputs are produced, they immediately become available to the model user. Click through the categories to reveal the individual output files as in Figure 32. At the completion of a model run, the outputs are also exported to .csv files located in the scenario's outputs folder that can accessed via the computers file system.

FIGURE 31: MODEL OUTPUTS HOME

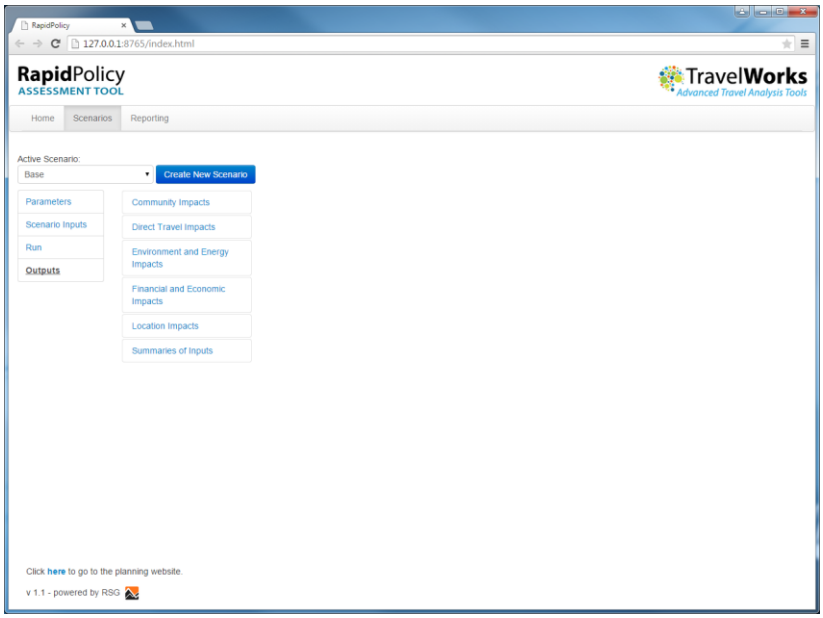
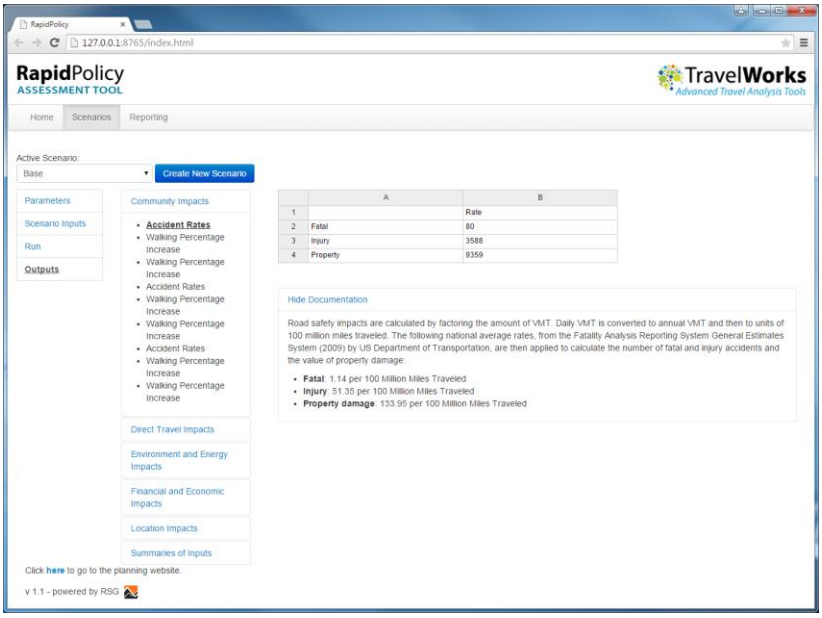


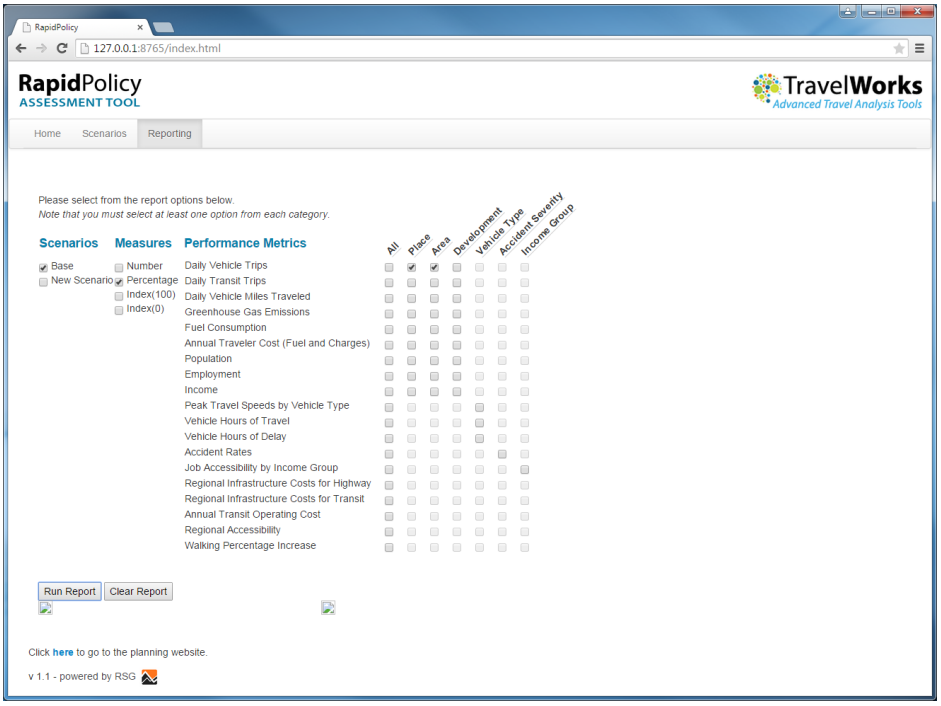
FIGURE 32: ACCIDENT RATES OUTPUT FILE



4.10 REPORTING

The reporting tab allows results for individual or multiple scenarios to be charted and compared. The charts can be viewed using the user interface and as they are created in the user inferface are also written to image files for incorporating in reports documenting scenario testing. Figure 33 shows the appearance of the Reporting tab with the Base scenario and one (1) additional scenario.

FIGURE 33: REPORTING TAB



There are several sets of check boxes that allow the user to build a chart as follows:

- Scenarios – checking the scenarios check boxes includes the selected scenarios in the chart
- Measures – allows you to choose to display the results as one of the following:
  - Number – absolute values
  - Percentage – percentages within the aggregation categories for each scenario
  - Index (100) – index comparison across scenarios for each aggregation category with the first scenario displayed indexed to 100 and other scenarios relative to that
  - Index (0) – index comparison across scenarios for each aggregation category with the first scenario displayed indexed to 100 and other scenarios relative to that, but then all of the values shifted to be relative to a base of zero
- Performance Metrics – the model produces a set of performance metrics such as as number of accidents and daily vehicle mile traveled as described in Chapter 6 of this user's guide. One metric can be displayed on each chart.
- Aggregation – the performance metrics are reported by the model at various levels of detail and the aggregation selection indicates the level of summary that the user wishes to see. Only the aggregation levels applicable to that metric are selectable in the matrix of check boxes. For example, Dvmt (daily VMT) is reported for the 13 place types. Selecting "Place Types" will show all 13 place types. Selecting "Area Types" will aggregate the results to the four area types. Selecting "Development Types" will aggregate the results to the five development types. The aggregation level is "All" displays the total value for the region for that metric.

Select the options you wish to have displayed in your report and click the "Run Report" button. Selecting multiple checkboxes from the measures list and from the performance metrics matrix will create charts displaying all of the combinations of measures and performance metrics for the set of scenarios selected from the scenarios list.

Similar to running the models, command windows will open to activate the reporting R scripts. Please allow these window to remain open will RPAT generates reports. Once the appropriate reports are generated RPAT will add them to the Reporting window as in Figure 34.

FIGURE 34: EXAMPLE REPORTS IN REPORTING TAB

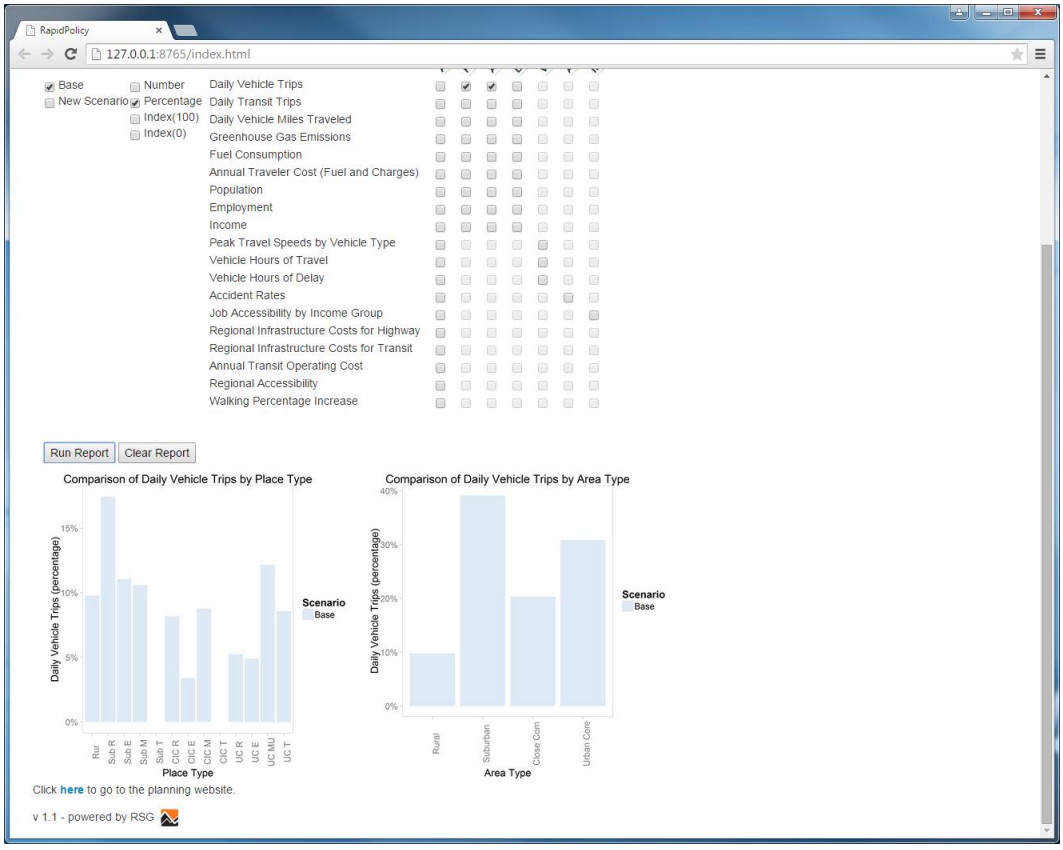
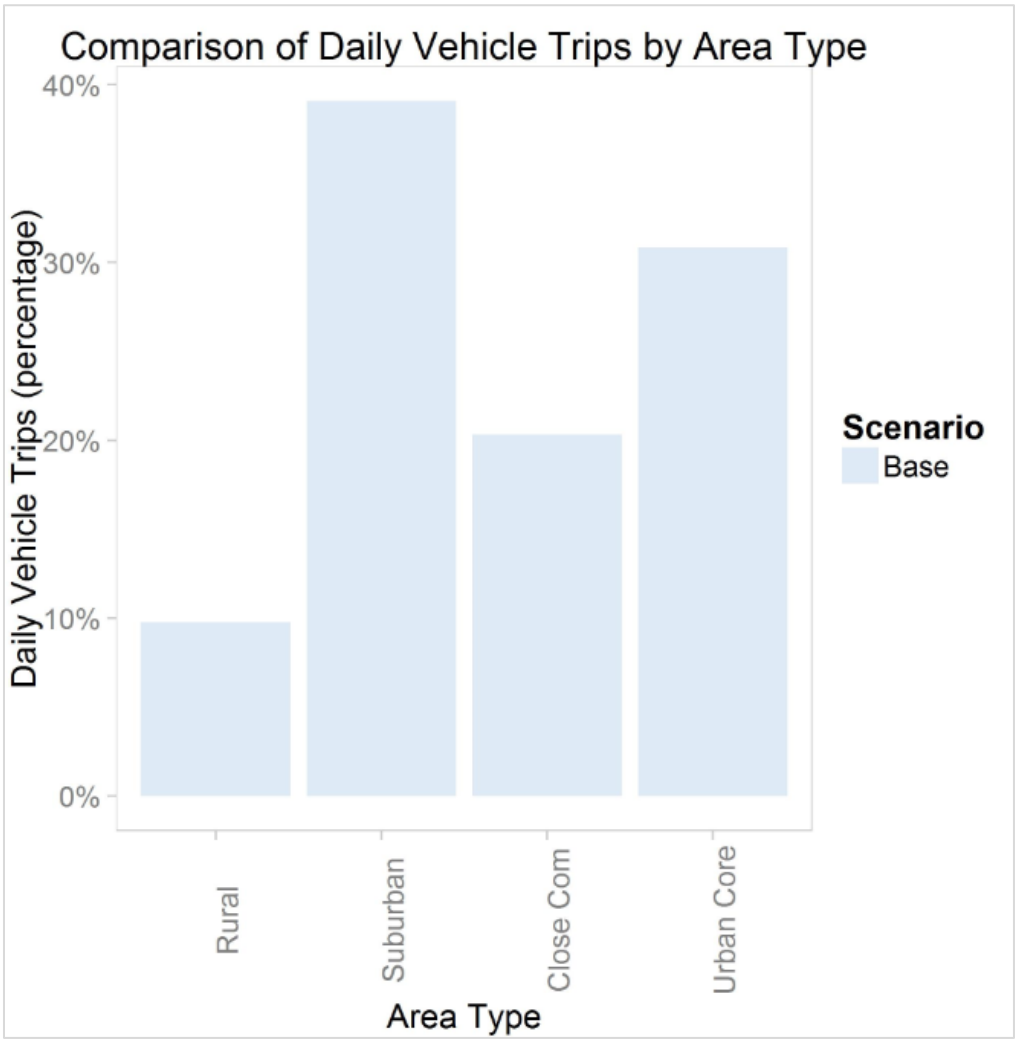


Figure 35 shows an example chart created by selecting the “Base” scenario, the “Percentage” measure, and the “Area Types” aggregation.

Creating additional reports by making new check box selections and clicking the “Run Reports” button will add the new charts below those that have already been created. The reports screen can be cleared by clicking the “Clear Report” button. All of the charts that are created are saved as image files in the scenario’s reports folder.

FIGURE 35: EXAMPLE REPORT



5.0 DEVELOPING INPUT DATA

The scenario inputs required by RPAT to completely define a scenario, are introduced in this section of the user's guide. The scenario inputs are tabular text files with a comma separated value (CSV) format. The CSV files include a header record on the first line, describing the variables in the files. A quick reference of the units for the output data please see Table 1; the subsequent sections of this chapter introduce each file in turn and describe its contents and how to develop the file from source data.

TABLE 1: SCENARIO INPUTS

INPUT GROUP	INPUT NAME	FILENAME	DESCRIPTION
Built Enivronment	Population and jobs by place type	Place_type_existing.csv	Base year distribution of population and jobs across the 13 place types
Demand	Auto and Transit Trips per Capita	trips_per_cap.csv	Average number of auto and transit trips per person per day in the region
	Base Daily VMT	base_vmt.csv	Base year VMT by autos in the region and split between functional classes
	Employment (Existing)	employment.csv	Existing employment and number of firms in the region
	Employment (Growth)	employment_growth.csv	Expect growth in overall employment by the future year
	Population (Existing and Growth)	pop_by_age.csv	Base and future population in the region by age group
	Regional Income	regional_income.csv	Average per capita income for the base and future year
	Truck and Bus VMT	truck_bus_vmt.csv	Truck and bus VMT in the region and split between functional classes
Transport Supply	Road Lane Miles and Transit Revenue Miles	transportation_supply.csv	Supply of freeways and aterials in lane miles and transit service in revenue miles by bus and rail

INPUT GROUP	INPUT NAME	FILENAME	DESCRIPTION
Policy	% Growth by Place Type	place_type_growth.csv	Allocation of added population and jobs by the 13 place types
	% Increase in Auto Operating Cost	auto_op_cost_growth.csv	Expected increase in auto operating costs by the future year
	% Increase in Road Lane Miles, Transit Revenue Miles per Cap	transportation_supply_growth.csv	Expect increase in road lanes and transit revenue miles per capita by the future year
	% of Employees Offered Commute Options	commute_options.csv	Participation levels and other parameters describing various workplace commuting programs
	% Road Miles with ITS Treatment	its.csv	Proportion of the freeway and arterial networks with ITS for incident reduction
	Auto Operating Surcharge per VMT	vmt_charge.csv	Vehicle miles traveled charges levied on drivers
	Bicycling/Light Vehicle Targets	light_vehicles.csv	Bike ownership targets and parameters to describe effects of policies to encourgage bicycling
	Increase in Parking Cost and Supply	parking_growth.csv	Pricing and participation in various parking charging policies

5.1 BUILT ENVIRONMENT

POPULATION AND JOBS BY PLACE TYPE (PLACE_TYPE_EXISTING.CSV)

FIGURE 36: FILE FORMAT FOR PLACE_TYPE_EXISTING.CSV

PlaceType	PopGrowth	EmpGrowth
Rur	0.05	0.1
Sub R	0.05	0
Sub E	0.05	0.1
Sub M	0.05	0.1
Sub T	0.1	0.1
CIC R	0.1	0
CIC E	0.1	0.1
CIC M	0.1	0.1
CIC T	0.1	0.1
UC R	0.05	0
UC E	0.05	0.1
UC MU	0.1	0.1
UC T	0.1	0.1

This file contains the distribution of existing (i.e., for the base year) population and employment among the 13 place types. Each column must sum to one (1). It is acceptable to have no land use (i.e., a value of 0) in certain categories.

TABLE 2: PLACE TYPES

	URBAN CORE	CLOSE-IN COMMUNITY	SUBURBAN	RURAL
Residential	✓	✓	✓	
Commercial	✓	✓	✓	
Mixed-Use	✓	✓	✓	
Transit-Oriented Development	✓	✓	✓	
Rural/Greenfield				✓

The built environment is described by 13 place types as shown below. One emerging school of thought in land use planning is to consider land uses in terms of place types instead of simply residential or commercial or high density compared to low density. A place type refers to all of the characteristics of a developed area including the types of uses included, the mix of uses, the density and intensity of uses.

An initial typology or system to organize place types can be traced to the Smart Growth Transect, which contained six zones in its original configuration including:

- Rural Preserve
- Rural Reserve
- Edge
- General
- Center
- Core

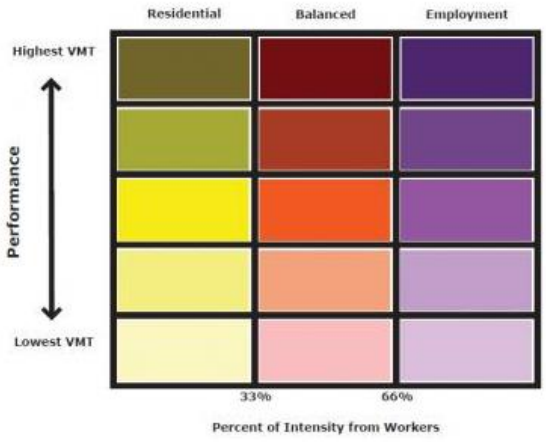
This approach to classifying place types was further refined in the Caltrans Smart Mobility which defined the following seven place types including:

- Urban Centers
- Close-In Compact Communities
- Compact Communities
- Suburban Communities
- Rural and Agricultural Lands
- Protected Lands
- Special Use Areas

Several of these place type categories provided additional options such as the Close-In Compact Communities which had three subdefinitions including Close-In-Centers, Close-In Corridors, and Close-In Neighborhoods.

An alternative view of place types was provided by Reconnecting America, which developed a performance based place type approach for describing areas proximate to transit stations. Station areas would vary in terms of their relative focus between residential units, employees or a mix of the two. Station areas are also characterized on their relative intensity as well as shown below.

FIGURE 37: PERFORMANCE BASED TYPOLOGY FOR TRANSIT STATION AREAS



Source: Center for Transit-Oriented Development, 2010

The approach employed for the place types in RPAT is therefore an amalgam of these approaches, in that the terminology is borrowed from the Smart Growth Transect and Caltrans Smart Mobility Study, while the relative performance of each place type is taken from the Reconnecting America approach but applied to a region instead of transit station sites.

Four general area types are defined in RPAT including:

- The **Urban Core** is the high-density mixed-use places with high jobs-housing ratios, well connected streets and high levels of pedestrian activities. It is anticipated that for many regions, the Urban Core will be the traditional downtown area of which there likely would be only one.
- The **Close-in Community** would be those areas located near to the Urban Cores and would consist primarily of housing with scattered mixed-use centers and arterial corridors. Housing would be varied in terms of density and type. Transit would be available with a primary focus on commute trips. These areas may be classified by their residents as suburban would be considered to be close-in communities given their adjacency to the Downtown and therefore the higher levels of regional accessibility.
- The **Suburban** place type is anticipated to represent the majority of development within regions. These communities are characterized by low level of integration of housing with jobs, retail, and services, poorly connected street networks, low levels of transit service, large amounts of surface parking, and limited walk ability.
- The **Rural** place type is defined as settlements of widely spaced towns separated by firms, vineyards, orchards, or grazing lands. These areas would be characterized by widely dispersed residential uses, little or no transit service, and very limited pedestrian facilities.

Further definition of the place types is allowed through the use of development types within the Urban Core, Close-in Community, and Suburban area types including:

- **Residential** includes all place types that are predominantly residential in character with limited employment and retail opportunities. Examples of this development type might include typical Suburban Residential or areas of the Downtown which are primarily residential as well. It is anticipated that this development type may be found in all of the area types except for rural.
- **Employment** includes those areas which are focused on employment with limited retail and residential. An example of this might include a Suburban Office Complex or a large cluster of office buildings within a Close-in Community or Urban Core. As with the residential development type, it is

anticipated that this type of use would be found in all place types except for rural.

- **Mixed-Use** are those areas within a region which have a mix of residential, employment, and retail uses. While this development type can be found in the Suburban place type, it is most commonly found in the close-in community and urban core place type. Downtown areas that have retained their residential population to complement the employment are examples of this development type.
- **Transit-Oriented Development (TOD)** which is similar to the other development types in that it is applied to all area types except for Rural areas since it is thought to be highly unlikely that a rural TOD would be developed. The TOD development type is characterized by greater access to transit in all area types. Examples of this development type might include a Suburban TOD focused on a commuter rail station.

The process of allocating existing land use to the 13 place types is somewhat dependent on the types of data available in a region that describe existing land use, and the process can be either very detailed or somewhat simplified. The following description relays the process developed by Atlanta Regional Commission (ARC) as part of the pilot testing of RPAT and provides an example of how, mechanically, an agency can approach this allocation. It should be noted that this is merely one approach and not a specific recommendation for a method that should be followed.

In general, ARC followed a somewhat detailed process to derive input data from land use data as presented in their "Unified Growth Policy Map", and from their regional travel demand model. They developed heuristics to align their land use with the 13 place types that RPAT uses.

The conversion of land use data to the place type scheme used in RPAT involved taking ARC's Unified Growth Policy Map (UGPM) Areas and converting them to the 13 RPAT place types.

1. The first step was to allocate the UGPM areas to the four area types used in RPAT. The Urban Core area type includes Region Core, Region Employment Centers and Aerotropolis UGPM areas; Close-in Community includes Maturing Neighborhoods; Suburban includes Developing Suburbs and Established Suburbs; and Rural includes Rural Areas and Developing Rural.

2. The ARC traffic analysis zone (TAZ) system was overlaid with the area types and the centroid of the TAZ was used to determine its area type.

3. The RPAT development type, the other dimension of the place type matrix, which included residential, mixed-use, employment, and TOD development types was determined for each TAZ not in the rural area

type using the base year percentage of the TAZ's employment in relation to the total of the population and employment in the TAZ. The mix between the employment and employment was used to determine the TAZs development type using the following cut points:

- Residential: < 33.33%
- Mixed Use: 33.33 to 66.67%
- Employment: > 66.67%

4. Identify any TAZs that are TOD based on transit service and specific development plas: only one TAZ was determined to be TOD as a development type, Lindbergh Center, in the Urban Core area type.

5. The combination of the area type and the development type was then used to allocate all TAZs to one of the 13 place types.

6. The 2010 TAZ employment and population totals were summed by the 13 place type and then scaled to total one for both employment and population as called for by the file format for place_type_existing.csv.

The population and employment growth amounts between 2010 and 2040 were determined for the 13 place types and were scaled to total 1 for both employment and population as called for by the file format for place_type_growth.csv.

The following is an enumeration of each place type abbreviation as it appears in the input file as well as a brief description of that value:

- Rur - Rural
- Sub R - Suburban Residential
- Sub E - Suburban Employment(i.e. Commercial)
- Sub M - Suburban Mixed Use
- Sub T - Suburban Transit Oriented Development
- CIC R - Close in Community Residential
- CIC E - Close in Community Employment (i.e. Commercial)
- CIC M - Close in Community Mixed Use
- CIC T - Close in Community Transit Oriented Development
- UC R - Urban Core Residential
- UC E - Urban Core Employment (i.e. Commercial)
- UC MU - Urban Core Mixed Use
- UC T - Urban Core Transit Oriented Development

5.2 DEMAND

AUTO AND TRANSIT TRIPS PER CAPITA (TRIPS_PER_CAP.CSV)

FIGURE 38: FILE FORMAT FOR TRIPS_PER_CAP.CSV

Mode	Trips
Auto	3.2
Transit	0.4

This file contains regional averages for auto and transit trips 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 (http://nhts.ornl.gov/index.shtml) 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. http://www.ntdprogram.gov/ntdprogram/data.htm), 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.

BASE DAILY VMT (BASE_VMT.CSV)

FIGURE 39: FILE FORMAT FOR BASE_VMT.CSV

Area	LtVehDvmt	FwyArtProp
Metro	27244	0.77

This file contains information on total light vehicle VMT and the split by functional class for light vehicles for the base year.

LtVehDvmt – is light vehicle daily VMT in unit of thousands of miles
FwyArtProp – is 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.

These data can be derived from a combination of Highway Performance Monitoring System (http://www.fhwa.dot.gov/policyinformation/hpms.cfm) 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). 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.

EMPLOYMENT (EXISTING) (EMPLOYMENT.CSV)

FIGURE 40: FILE FORMAT FOR EMPLOYMENT.CSV (PARTIAL FILE SHOWN)

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
Chemung	2015	9999	6	3	3	0	0	0	0	0	0	0	0	0	0	0	0
Chemung	2015	9999	168	8	4	0	1	2	1	0	0	0	0	0	0	0	0
Chemung	2015	9999	184	3	1	1	0	0	0	1	0	0	0	0	0	0	0
Chemung	2015	9999	1567	165	108	23	20	9	3	2	0	0	0	0	0	0	0
Chemung	2015	9999	6085	84	20	15	12	16	6	8	6	0	1	0	0	0	0
Chemung	2015	9999	1472	98	38	23	23	9	3	2	0	0	0	0	0	0	0
Chemung	2015	9999	6083	370	127	122	60	40	12	8	1	0	0	0	0	0	0
Chemung	2015	9999	1003	57	20	9	14	9	5	0	0	0	0	0	0	0	0
Chemung	2015	9999	583	29	12	7	1	7	1	1	0	0	0	0	0	0	0
Chemung	2015	9999	952	87	41	30	11	2	1	2	0	0	0	0	0	0	0
Chemung	2015	9999	434	80	54	18	6	1	1	0	0	0	0	0	0	0	0
Chemung	2015	9999	830	114	64	26	20	2	2	0	0	0	0	0	0	0	0
Chemung	2015	9999	165	11	4	1	3	3	0	0	0	0	0	0	0	0	0
Chemung	2015	9999	2226	73	33	15	9	7	3	4	2	0	0	0	0	0	0
Chemung	2015	9999	943	14	6	3	1	2	1	0	0	1	0	0	0	0	0
Chemung	2015	9999	6435	214	75	50	50	21	8	5	3	1	1	0	0	0	0
Chemung	2015	9999	575	37	16	9	6	4	1	1	0	0	0	0	0	0	0
Chemung	2015	9999	3495	200	77	33	46	27	15	2	0	0	0	0	0	0	0
Chemung	2015	9999	1384	207	121	51	24	10	1	0	0	0	0	0	0	0	0
Chemung	2015	9999	4	2	2	0	0	0	0	0	0	0	0	0	0	0	0

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 (see http://www.census.gov/econ/cbp/ for more information on this dataset). 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”. 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.

EMPLOYMENT (GROWTH) (EMPLOYMENT_GROWTH.CSV)

FIGURE 41: FILE FORMAT FOR EMPLOYMENT_GROWTH.CSV

key	value
EmploymentGrowth	1.5

This file contains 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.

POPULATION (EXISTING AND GROWTH) (POP_BY_AGE.CSV)

FIGURE 42: FILE FORMAT FOR POP_BY_AGE.CSV

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

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.

REGIONAL INCOME (REGIONAL_INCOME.CSV)

FIGURE 43: FILE FORMAT FOR REGIONAL_INCOME.CSV

Year	Income
2005	32515
2035	40000

This file contains information on regional average per capita income by forecast year in year 2000 dollars. The data can be obtained from the U.S. Department of Commerce Bureau of Economic Analysis

(http://www.bea.gov/regional/index.htm) for the current year or from regional or state sources for forecast years.

We recommend using Consumer Price Index (CPI) to adjust current year dollars to 2000 dollars (http://www.usinflationcalculator.com/inflation/consumer-price-index-and-annual-percent-changes-from-1913-to-2008/, http://www.bls.gov/cpi/cpid1401.pdf). The following table enumerates adjustments to 2000 dollars.

TABLE 3: CPI ADJUSTMENTS TABLE

YEAR	CPI, 1980=100	ADJUST TO 2000
1980	100.000	0.581
1985	107.600	0.625
1990	130.700	0.759
1995	152.400	0.885
2000	172.200	1.000
2005	195.300	1.134
2010	218.056	1.266
2014	236.736	1.375

TRUCK AND BUS VMT (TRUCK_BUS_VMT.CSV)

FIGURE 44: FILE FORMAT FOR TRUCK_BUS_VMT.CSV

Value	PropVmt	Fwy	Art	Other
BusVmt	0	0.15	0.591853844	0.258146156
TruckVmt	0.08	0.452028197	0.398645294	0.149326508

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 input file.

The truck VMT proportion (PropVMT column, TruckVMT row) can be obtained from Highway Performance Monitoring System (http://www.fhwa.dot.gov/policyinformation/hpms.cfm) 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, http://www.fhwa.dot.gov/policy/hcas/final/two.htm) 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.

5.3 TRANSPORT SUPPLY

ROAD LANE MILES AND TRANSIT REVENUE MILES (TRANSPORTATION_SUPPLY.CSV)

FIGURE 45: FILE FORMAT FOR TRANSPORTATION_SUPPLY.CSV

SupplyClass	Miles
Freeway	250
Arterial	900
Bus	19
Rail	4

This file contains the amount of transportation supply in the base year in terms of lane miles of freeways and arterial roadways and the revenue miles operating by the transit system in the region.

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. (http://www.fhwa.dot.gov/policy/ohim/hs05/roadway_extent.htm)
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. http://www.ntdprogram.gov/ntdprogram/data.htm), where the annual database contains a "service" table that has annual revenue mile data by mode for each transit operator.

5.4 POLICY

% GROWTH BY PLACE TYPE (PLACE_TYPE_GROWTH.CSV)

FIGURE 46: FILE FORMAT FOR PLACE_TYPE_GROWTH.CSV

PlaceType	PopGrowth	EmpGrowth
Rur	0.05	0
Sub R	0.05	0
Sub E	0.05	0
Sub M	0.05	0
Sub T	0.1	0
CIC R	0.1	0
CIC E	0.1	0
CIC M	0.1	0
CIC T	0.1	0
UC R	0.05	0.25
UC E	0.05	0.25
UC MU	0.1	0.25
UC T	0.1	0.25

This file is a table of the allocated growth between the base and the future years in population and employment to each of the 13 place types. Each column must sum to one (1). It is acceptable to have no land use growth (i.e., a value of 0) in certain categories. 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.

% INCREASE IN AUTO OPERATING COST (AUTO_OP_COST_GROWTH.CSV)

FIGURE 47: FILE FORMAT FOR AUTO_OP_COST_GROWTH.CS

key	value
OpCostGrowth	1.5

This file is a single value reflecting 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 multplies base year operating costs by 1.5 and thus reflects a 50% increase.

% INCREASE IN ROAD LANE MILES, TRANSIT REVENUE MILES PER CAP. (TRANSPORTATION_SUPPLY_GROWTH.CSV)

FIGURE 48: FILE FORMAT FOR TRANSPORTATION_SUPPLY_GROWTH.CSV

SupplyClass	Growth
Freeway	1.1
Arterial	1
Bus	1.2
Rail	1.1

This file contains four values that allow the user to change the transportation supply in the region in the future year.

- **Freeway** – is the percent increase in road lane miles including freeways, arterials and other facilities. 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.
- **Arterial** – is a similar value to freeway except that it measures arterial lane mile growth. It is also proportional to population growth.
- **Bus** – 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.
- **Rail** - is the percent increase in transit revenue miles per capita for rail. This encompasses all rail modes, from light rail through to commuter rail.

% OF EMPLOYEES OFFERED COMMUTE OPTIONS (COMMUTE_OPTIONS.CSV)

FIGURE 49: FILE FORMAT FOR COMMUTE_OPTIONS.CSV

TDMProgram	DataItem	DataValue
Ridesharing	RidesharingParticipation	0.05
TransitSubsidy	TransitSubsidyParticipation	0.1
TransitSubsidy	TransitSubsidyLevel	1.25
WorkSchedule	Schedule980Participation	0.01
WorkSchedule	Schedule440Participation	0.04
WorkSchedule	Telecommute1.5DaysParticipation	0.13
Vanpooling	LowLevelParticipation	0.04
Vanpooling	MediumLevelParticipation	0.01
Vanpooling	HighLevelParticipation	0.01

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.

% ROAD MILES WITH ITS TREATMENT (ITS.CSV)

FIGURE 50: FILE FORMAT FOR ITS.CSV

Year	ITS
2005	0
2035	0

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.

AUTO OPERATING SURCHARGE PER VMT (VMT_CHARGE.CSV)

FIGURE 51: FILE FORMAT FOR VMT_CHARGE.CSV

key	value
VmtCost	0.05

This file contains is a cost in cents per mile that would be levied on auto users through the form of a VMT charge.

BICYCLING/LIGHT VEHICLE TARGETS (LIGHT_VEHICLES.CSV)

FIGURE 52: FILE FORMAT FOR LIGHT_VEHICLES.CSV

DataItem	DataValue
TargetProp	0.2
Threshold	2
PropSuitable	0.1

This file contains input data for the non-motorized vehicle model. In RPAT, 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 http://www.academia.edu/1839374/Bicycle_Ownership_in_the_United_States_Empirical_Analysis_of_Regional_Differences for an analysis of regional differences.

INCREASE IN PARKING COST AND SUPPLY (PARKING_GROWTH.CSV)

FIGURE 53: FILE FORMAT FOR PARKING_GROWTH.CSV

Year	PropWrkPkg	PropWrkChrgd	PropCashOut	PropOthChrgd	PkgCost
2005	1	0.1	0	0.05	5
2035	1	0.1	0	0.05	5

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:

- **PropWrkPkg** – proportion of employees that park at work
- **PropWrkChrgd** – 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
- **PrkOthChrgd** – proportion of other parking that is not free
- **PkgCost** – average daily parking cost. 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 in the Center City, then the average will be heavily weighted toward the price in the Center City.

6.0 PERFORMANCE METRICS

The performance metrics, reported in RPAT's output data files, are designed to address a variety of impacts that are helpful for decision-making. The output data are saved as .RData files and can be exported as tabular text files with a comma separated value (CSV) format. The CSV files include a header record on the first line, describing the variables in the files. The performance metrics can all be charted using the reporting tab in RPAT, which includes the ability to compare the results across scenarios. For a quick reference of the units for the output data please seeTable 4.

TABLE 4: OUTPUT DATA UNITS

OUTPUT GROUP	OUTPUT MEASURE	UNITS	TEMPORAL RESOLUTION
Direct Travel Impacts	Daily Vehicle Miles Traveled	Miles	Day
	Daily Vehicle Trips	Trips	Day
	Daily Transit Trips	Trips	Day
	Average Travel Speeds by Vehicle Type	MPH	Day
	Vehicle Hours of Travel Delay	Hours	Day
Environment and Energy Impacts	Fuel Consumption	Gallons	Day
	Greenhouse Gas Emissions	Metric Tons	Day
Financial and Economic Impacts	Regional Highway Infrastructure Costs	Dollars	Year
	Regional Transit Infrastructure Costs	Dollars	Year
	Regional Transit Operating Costs	Dollars	Year
	Annual Traveler Cost (Fuel + Charges)	Dollars	Year
Location Impacts	Regional Accessibility	Percent Change From Base	-
Community Impacts	Accident Rates	Count	Year
	Walking Percentage Increase	Percent Change From Base	-
	Job Accessibility by Income Group	Percent Change From Base	-

6.1 DIRECT TRAVEL IMPACTS

DAILY VMT

Daily VMT is calculated by the travel demand models with scenario changes that reflect the effects of changes in land use, transportation supply, and policies. The model reports light vehicle VMT for each place type. (Additional output files not

reported in RPAT's user interface contain VMT for light vehicles, trucks and buses and are used in the estimation of congestion effects).

DAILY VEHICLE TRIPS

The model's calculations generally work with VMT and not individual trips. The change in the number of vehicle trips is calculated using a set of elasticities from Index 4D Values (2001) (shown below) 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.

TABLE 5: VEHICLE TRIP ELASTICITIES

D	DESCRIPTION	VEHICLE TRIP DECREASE
Density	**Household/Population Density**	**-0.043**
Diversity	**Land Use Mix (entropy)**	**-0.051**
Design	**Intersection/Street Density**	**-0.031**
Regional Accessibility	**Job Accessibility By Auto**	**-0.036**
Distance to Transit	**Distance to Nearest Transit Stop**	**0**

DAILY TRANSIT TRIPS

The change in the number of transit trips is calculated using a set of elasticities from Index 4D Values (2001) (shown below) 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.

TABLE 6: TRANSIT TRIP ELASTICITIES

D	DESCRIPTION	TRANSIT TRIP INCREASE
Density	**Household/Population Density**	**0.07**
Diversity	**Land Use Mix (entropy)**	**0.12**
Design	**Intersection/Street Density**	**0.23**
Regional Accessibility	**Job Accessiblity By Auto**	**0**
Distance to Transit	**Distance to Nearest Transit Stop**	**0.29**

AVERAGE TRAVEL SPEEDS BY VEHICLE TYPE

The congestion component of the model is used to produce both travel speeds by vehicle type and the vehicle hours of travel and delay. VMT for each of light vehicles, heavy trucks, and buses, is assigned to speeds bins for the three facility types that the model considers – freeways, arterials and other roads. Speed distributions, in terms of the amount of VMT that occurs within each speed bin, are used to derive average speeds

VEHICLE HOURS OF TRAVEL, DELAY

The congestion model calculates vehicles hours of travel using the VMT by speed distributions discussed above. The amount of delay is calculated by comparing the vehicle hours of travel with the amount of daily vehicle hours of travel that would have taken place if travel was at free flow speeds.

6.2 ENVIRONMENT AND ENERGY IMPACTS

FUEL CONSUMPTION

Fuel consumption (in gasoline equivalent gallons per day) by vehicle type is calculated from the respective estimates of VMT and fuel economy. These estimates are then split into fuel types. The model addresses five fuel types: gasoline, ultra-low-sulfur diesel (ULSD), ethanol, biodiesel, and compressed natural gas (CNG). For each vehicle type, input data specify the fuel proportions by year. These data can be changed for future year scenarios via the parameters menu) to represent various fuels policies and assumptions.

For light vehicles (automobiles and light trucks), the first step is to allocate fuel consumed between gasoline, CNG, and diesel types. Different proportions are provided for automobiles and light trucks. Fuel for gasoline engines is then split between gasoline, ethanol, and CNG based on input proportions. Similarly, diesel

fuel use is split between ULSD and biodiesel. A similar process is used to split heavy truck and bus fuel consumption into fuel types. The report of fuel consumption by place type in RPAT reports just light vehicle fuel consumption.

GREENHOUSE GAS EMISSIONS

Once fuel consumption is split into the five types (measured in gasoline equivalent gallons per day), CO_2 equivalents of emissions can be calculated in a straightforward manner. The energy value of the fuel consumed by type is calculated by multiplying by the energy value of a gallon of gasoline. Then the CO_2 equivalent (CO_2e) daily emissions are calculated by applying the appropriate carbon intensities (grams CO_2e per mega joule) of each fuel type. Values reflect "pump-to-wheels" emission rates, representing just the tailpipe emissions and do not include the "well-to-pump" emissions resulting from the production and transportation of fuels. The values included as parameters in the model are shown below. The values are derived from the MOVES 2010a database (the fuel sub type table provides carbon contents and oxidation factors) and from Emission Facts: Greenhouse Gas Emissions from a Typical Passenger Vehicle (U.S. EPA, 2011) to convert to CO_2 equivalents (which includes the global warming potential of other gases emitted by vehicles such as CH4, N2O, and hydrofluorocarbons (HFCs).

TABLE 7: CARBON INTENSITY BY FUEL TYPE (GRAMS CO_2E PER MEGA JOULE)

FUEL TYPE	CARBON INTENSITY (GM PER MEGA JOULE)
ULSD	77.19
Biodiesel	76.81
Reformulated gasoline (RFG)	75.65
CARBOB (gasoline formulated to be blended with ethanol)	75.65
Ethanol	74.88
CNG	62.14

All of the light vehicle calculations of fuels and emissions are done at the disaggregate level of households. This allows emissions to be aggregated to place type and along other dimensions. The report of greenhouse gas emissions by place type in RPAT reports just light vehicle fuel consumption. Heavy truck and transit emissions are calculated at the regional level.

6.3 FINANCIAL AND ECONOMIC IMPACTS

REGIONAL HIGHWAY INFRASTRUCTURE COSTS

The source for highway infrastructure costs is FHWA's Highway Economic Requirements System model, or Highway Economic Requirements System (HERS). Information was obtained from Chapter 6 of the 2005 Technical Report for all US states (FHWA, 2005). Table 8-1 in HERS provides unit costs (per lane mile) for both Rural and Urban highway systems, and distinguishes among three functional classes: interstates, freeways and expressways; other principal arterials; and minor arterials and collectors. Costs estimates are provided for the following improvements:

- Reconstruction and widening
- Reconstruct pavement
- Resurface and widen lanes
- Resurface pavement
- Improve shoulders

Additional choices are offered to distinguish between adding a lane at "normal" vs. "high cost", and also for pavement realignment, also under normal vs. high cost conditions.

For practical reasons, it was decided to use only "new construction" (which also includes adding lanes) costs as the basis for the cost estimates, and to ignore for now the categories of reconstruction, resurfacing, and realignment, although the normal vs. high estimates are used to provide a range for users. These construction costs include right of way, construction, and a "small" allowance for bridges and support facilities.

The infrastructure costs focus only on the "urban" system, not rural, which also makes it possible to differentiate by three size classes: Small Urban, Small Urbanized, and Large Urbanized. The numbers shown below are in 2002 dollars; FHWA advises escalation to current dollars using its National Highway Construction Cost Index (NHCCI, which is available online at http://www.fhwa.dot.gov/policyinformation/nhcci.cfm); the report in RPAT escalates uses this Index to escalate to 2010 values.

TABLE 8: CONSTRUCTION COST PER LANE MILE IN 2002 DOLLARS

FUNCTIONAL CLASSIFICATION	SMALL URBAN	SMALL URBANIZED	LARGE URBANIZED
Freeways	$3.1 - $11.1	$3.4 - $12.1	$5.7 - $60.0
Principal Arterial	$2.6 - $9.4	$2.9 - $10.2	$4.2 -$15.0
Minor Arterial/ Collector	$2.0 - $7.0	$2.1 - $7.4	$2.9 - $10.2

HERS includes a table of state cost indices if desired, although a spokesperson for HERS says that the general sentiment has been toward not using them for reliability reasons.

REGIONAL TRANSIT INFRASTRUCTURE AND OPERATING COSTS

The source for transit capital and operating costs is the National Transit Database (NTD), which is available online at http://www.ntdprogram.gov/ntdprogram/), and in particular the National Transit Profile which is available on the NTD website. The most recent statistics published are for 2009, so CPI adjustments may be necessary if more current data are not available to the user at the time. Costs are available in a variety of index formats, e.g.,, cost per revenue mile or hour, though cost per passenger trip appears to be the most relevant association with estimation of future transit service needs. These costs are presented in

Table 9.

TABLE 9: NET COST TO SUPPLY AN UNLINKED PASSENGER TRIP BY TRANSIT MODE (2009)

MODE	CAPITAL COST	OPERATING COST	TOTAL COST	FARE REVENUE	NET COST
Bus	$0.71	$3.40	$4.11	$0.91	$3.20
Heavy Rail	$1.78	$1.80	$3.58	$1.09	$2.49
Commuter Rail	$5.74	$9.80	$15.54	$4.69	$10.85
Light Rail	$7.82	$3.00	$10.82	$0.78	$10.04

Costs are presented for each mode, since the capital, operating and revenue profiles are quite different for each. It is interesting to note that the comparative cost per trip of bus and heavy rail, while commuter rail and light rail are both considerably -- almost four times -- higher.

ANNUAL TRAVELER COST (FUEL + CHARGES)

The traveler costs values reported by RPAT are the total of the following components:

1. Gas cost: the fuel consumption multiplied by the gas cost parameter
2. Fuel tax: the fuel consumption multiplied by the fuel tax parameter
3. Parking costs: the parking costs paid under the travel demand management policies in effect for the scenario
4. VMT charge: VMT multiplied by the VMT charge in effect for the scenario

The values reported are annual costs by place type and account for light vehicle travelers only.

6.4 LOCATION IMPACTS

REGIONAL ACCESSIBILITY

The performance measure for land market and location impacts is related to the regional accessibility calculations, embodied in the analysis of place types. The estimation of VMT by place types includes one variable related to regional accessibility which is jobs accessibility by auto. Job accessibility by auto would be highest in the urban core area and relatively lower in the other place types. The lowest job accessibility by auto would occur in the rural place types.

It is anticipated that the job accessibility by auto would vary based on the amount of new growth allocated to the various place types. If a majority of the new growth is allocated to the rural and suburban place types, it is anticipated that there would be limited growth in jobs accessibility by auto. Otherwise, if a majority of the new growth is allocated to the close-in community and urban core place types, then there will be more growth in this measure.

RPAT reports the relative increase in jobs accessibility in auto based on the existing scenario. This relative increase is a function of the distribution of growth between the four place types, weighted by the population and employment growth in each of the place types.

6.5 COMMUNITY IMPACTS

ACCIDENT RATES

Road safety impacts are calculated by factoring the amount of VMT. Daily VMT is converted to annual VMT and then to units of 100 million miles traveled. The following national average rates, from the Fatality Analysis Reporting System General Estimates System (2009) by US Department of Transportation, are then 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

WALKING PERCENTAGE INCREASE

The percentage change in the amount of walking is calculated by applying a set of elasticities developed in their 4D Meta Analysis by Cervero and Ewing (shown below). 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.

TABLE 10: WALKING ELASTICITIES

D	DESCRIPTION	WALKING INCREASE
Density	Household/Population Density	0.07
Diversity	Land Use Mix (entropy)	0.15
Design	Intersection/Street Density	0.39
Regional Accessibility	Job Accessibility By Auto	0
Distance to Transit	Distance to Nearest Transit Stop	0.15

JOB ACCESSIBILITY BY INCOME GROUP

This is an income stratification of the regional accessibility measure.

7.0 MODEL PARAMETERS

This section of the user's guide documents the model's parameter files.

INDIVIDUAL MODEL PARAMETERS (KEYVALUE.CSV)

FIGURE 54: FILE FORMAT FOR KEYVALUE.CSV

key	value
AnnVmtInflator	365
BaseCostPerMile	0.04
BaseYear	2005
BudgetProp	0.1
FuelCost	1.82
FutureYear	2035
GasTax	0.424
HhDvmtToRoadDvmt	0.95
LtTruckProp	0.45
MjPerGallon	121
PoundToKilogram	0.45
TranAdjFactor	1.12
TruckVmtGrowthMultiplier	1
WorkVmtProp	0.25
State	OR

- AnnVmtInflator: factor to convert VMT between annual and average daily amounts.
- BaseCostPerMile: base cost per mile in dollars for transportation costs used in the travel demand model to initially represent travel as close to unconstrained by transportation costs. The transportation costs are then fully constrained later in the model as travel reductions caused by budget constraints are estimated.
- BaseYear: Base year for the model. This should be set by the model user to be consistent with the base year for their input data.
- BudgetProp: the proportion of household budget that can be allocated to transportation spending. The travel demand models includes a constraint that reduces household travel if too high a proportion of household spending is spent on transportation. See "Travel Demand Models" section of Appendix B, SHRP 2 C16 report).
- FuelCost: Average cost per gallon of fuel (before taxes are added).
- FutureYear: Future year for the model. This should be set by the model user to be consistent with the future year for their input data.
- GasTax: Average cost per gallon of fuel of gas taxes.

- HhDvmtToRoadDvmt: factor to account for some proportion of a household's VMT taking place outside of the metro area.
- LtTruckProp: proportion of household vehicles that are light trucks (SUVs, pickup trucks) as opposed to autos.
- MjPerGallon: Energy content of a gallon of fuel in mega Joules per gallon.
- PoundToKilogram: Conversion rate between pounds and kilograms.
- TranAdjFactor: Factor to convert transit revenue miles (i.e.,, miles run in service on routes) to total transit vehicle miles operated to account for vehicle miles run while deadheading from depots to route endpoints.
- TruckVmtGrowthMultiplier: Rate at which heavy truck VMT growth in relation to total regional household income growth in the region. A value of 1 indicates that heavy truck VMT grows at the same rate as total regional household income. A value less than 1 means slower growth in truck VMT, and greater than 1 means faster growth in truck VMT than total regional household income.
- WorkVmtProp: the proportion of household VMT that takes place for commute to work purposes; used to differentiate between travel purposes for use in estimating overall VMT reductions that are targeted at the commute to work.
- State: the model state.

ACCIDENT RATES (ACCIDENT_RATES.CSV)

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

FIGURE 55: FILE FORMAT FOR ACCIDENT_RATES.CSV

Accident	Rate
Fatal	1.14
Injury	51.35
Property	133.95

FUEL (FUEL.CSV)

The fuel parameters allocate VMT for each of the four road vehicle types that RPAT represents – auto, light truck, bus, and heavy truck (truck) – to different

fuel types. The remaining proportion of fuel not accounted for in these categories is assumed to be gasoline:

- PropDiesel – The proportion of the fleet that uses diesel
- PropCng – The proportion of the fleet that uses CNG
- GasPropEth – The average ethanol proportion in gasoline sold
- DieselPropBio – The average biodiesel proportion in diesel sold.

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.

FIGURE 56: FILE FORMAT FOR FUEL.CSV

Type	PropDiesel	PropCng	GasPropEth	DieselPropBio
Auto	0.007	0	0.1	0.05
LtTruck	0.04	0	0.1	0.05
Bus	0.995	0.005	0.1	0.05
Truck	0.945	0.005	0.1	0.01

EMISSIONS RATE (FUEL_CO2.CSV)

The emissions rate parameters file contains information on "pump-to-wheels" CO_2 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 CO_2 equivalent emissions.

FIGURE 57: FILE FORMAT FOR FUEL_C02.CSV

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

PLACE TYPE ADJUSTMENTS TO TRAVEL DEMAND (PLACE_TYPE_ELASTICITES.CSV, PLACE_TYPE_RELATIVE_VALUES.CSV)

The place_type_elasticites.csv and place_type_relative_values.csv parameter files are used to calculate the effect of land use on various performance metrics relative to a regionally average location.

The place_type_elasticites.csv 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.

FIGURE 58: FILE FORMAT FOR PLACE_TYPE_ELASTICITIES.CSV

D	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

The place_type_relative_values.csv contains the D values, which are proportional values for each of the 13 place types that are relative to a regional average, for each of the five Ds used in RPAT - design (intersection street density), accessibility (job accessibility by auto), distance to transit (nearest transit stop), density (population density) and diversity (land use mix).

FIGURE 59: FILE FORMAT FOR PLACE_TYPE_RELATIVE_VALUES.CSV

PlaceType	Density	Diversity	Design	Regional_Accessibility	Distance_to_Transit
Rural Greenfield	0.5	0.5	0.5	0.5	0.5
Sub Residential	0.75	0.75	0.75	0.75	0.75
Sub Employment	0.75	0.75	0.75	0.75	0.75
Sub Mixed-Use	1	1	1	0.75	0.75
Sub TOD	1	1	1	1	1
CIC Residential	1.2	1.2	1.2	1.2	1
CIC Employment	1.2	1.2	1.2	1.2	1
CIC Mixed-Use	1.2	1.2	1.2	1.2	1
CIC TOD	1.2	1.2	1.2	1.2	1.2
UC Residential	1.5	1.2	1.5	1.5	1.2
UC Employment	1.5	1.2	1.5	1.5	1.2
UC Mixed-Use	1.5	1.5	1.5	1.5	1.2
UC TOD	1.5	1.5	1.5	1.5	1.5

TRAVEL DEMAND MANAGEMENT: RIDESHARING (TDM_RIDESHARING.CSV)

The ridesharing Travel Demand Management file contains parameters describing the effectiveness of ridersharing 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 submodel 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.

FIGURE 60: FILE FORMAT FOR TDM_RIDESHARING.CSV

PlaceType	Effectiveness
Rural	0
Suburban	0.05
Close In Community	0.1
Urban Core	0.15

TRAVEL DEMAND MANAGEMENT: TRANSIT FARES (TDM_TRANSIT.CSV, TDM_TRANSITLEVELS.CSV)

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 (from tdm_transit.csv) 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.

FIGURE 61: FILE FORMAT FOR TDM_TRANSIT.CSV

PlaceType	Subsidy0	Subsidy1	Subsidy2	Subsidy3	Subsidy4
Rural	0	0	0	0	0
Suburban	0	0.02	0.033	0.079	0.2
Close In Community	0	0.034	0.073	0.164	0.2
Urban Core	0	0.062	0.129	0.2	0.2

The subsidy levels are matched to the dollar values in tdm_transitlevels.csv.

FIGURE 62: FILE FORMAT FOR TDM_TRANSITLEVELS.CSV

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

TRAVEL DEMAND MANAGEMENT: VANPOOLING (TDM_VANPOOLING.CSV)

tdm_vanpooling.csv contains parameters describing the effectiveness in terms of VMT reductions for vanpooling programs across three levels of employee involvement.

The vanpool program submodel 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 tdm_vanpooling.csv.

FIGURE 63: FILE FORMAT FOR TDM_VANPOOLING.CSV

VanpoolingParticipation	VMTReduction
Low	0.003
Medium	0.0685
High	0.134

TRAVEL DEMAND MANAGEMENT: WORK SCHEDULE (TDM_WORKSCHEDULE.CSV, TDM_WORKSCHEDULELEVELS.CSV)

tdm_workschedule.csv and tdm_workschedulelevels.csv are 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; and
- 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 tdm_workschedule.csv.

FIGURE 64: FILE FORMAT FOR TDM_WORKSCHEDULE.CSV

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
Telecommute1.5Days	0	0.0022	0.0066	0.011	0.022	0.055

The participation levels in tdm_workschedule.csv correspond to the values in tdm_workschedulelevels.csv, which describe the proportion of employees participating in the program.

FIGURE 65: FILE FORMAT FOR TDM_WORKSCHEDULELEVELS.CSV

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

TRANSPORTATION COSTS (TRANSPORTATION_COSTS.CSV)

transportation_costs.csv 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,[1] 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 RPAT.

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 unit costs (per lane mile) for both Rural and Urban highway systems, and distinguishes among three functional classes: interstates, freeways and expressways; other principal arterials; and minor arterials and collectors. Costs estimates are provided for the following improvements:

- Reconstruction and widening
- Reconstruct pavement
- Resurface and widen lanes
- Resurface pavement
- Improve shoulders

Additional choices are offered to distinguish between adding a lane at "normal" vs. "high cost", and also for pavement realignment, also under normal vs. high cost conditions. For practical reasons, it was decided to use only "new construction" (which also includes adding lanes) costs as the basis for the cost estimates, and to ignore the categories of reconstruction, resurfacing, and

[1] Available online at http://www.ntdprogram.gov/ntdprogram/

realignment. These construction costs include right of way, construction, and a "small" allowance for bridges and support facilities.

The infrastructure costs focus only on the "urban" system, not rural, which also makes it possible to differentiate by three size classes: Small Urban, Small Urbanized, and Large Urbanized. The numbers from HERS are in 2002 dollars; FHWA advises escalation to current dollars using its NHCCI, which is available online at http://www.fhwa.dot.gov/policyinformation/nhcci.cfm); the report in RPAT escalates uses this Index to escalate to 2010 values.

The parameter values in transportation_costs.csv are average values per lane mile, simplifying the calculations of highway costs to just differentiate investments in freeway vs. arterial functional class roads.

FIGURE 66: FILE FORMAT FOR TRANSPORTATION_COSTS.CSV

SupplyClass	CapCosts	OpCosts	Fare
Freeway	17	0	0
Arterial	7	0	0
Bus	0.71	3.4	0.91
Rail	5.11	4.87	2.19

VEHICLE FUEL ECONOMY (VEHICLE_MPG.CSV)

Vehicle_mpg.csv contains estimates and forecasts of average fuel economy and power economy in miles per gallon for autos, light trucks, heavy trucks (trucks) and miles per kilowatt for trains by vehicle model year. Note that this is not the fleet average for that year. It is the average for new vehicles sold in that year. The fuel economy is the same for all fuel types and is measured in gasoline equivalent gallons (i.e., energy content of a gallon of gasoline). This file is used in the calculations of fuel consumption. This file can be used to test alternative vehicle development scenarios, such as improved technology and/or fuel economy standards that lead to higher vehicle fuel economies.

FIGURE 67: FILE FORMAT FOR VEHICLE_MPG.CSV

Year	Auto	LtTruck	Truck	Bus	Train
1975	15.1	12.7	5.1	4.2	0.098266
1976	16.6	13.2	5.1	4.1	0.098266
1977	17.4	14.1	5.1	4.1	0.098266
1978	19.2	13.7	5.1	4	0.098266
1979	19.3	13.1	5.1	3.9	0.098266
1980	22.6	17.1	5.3	3.9	0.098266
1981	24.2	18.6	5.1	3.8	0.098266
1982	25.6	19	5.2	3.8	0.098266
1983	25.4	19.6	5.3	3.7	0.098266
1984	26	19.3	5.5	3.7	0.098266
1985	26.7	19.4	5.6	3.6	0.098266
1986	27.7	20.2	5.6	3.6	0.098266
1987	27.8	20.5	5.7	3.7	0.096335
1988	28.3	20.2	5.8	3.7	0.085597
1989	27.9	19.8	5.8	3.7	0.088017
1990	27.5	19.8	5.8	3.8	0.101255
1991	27.6	20.3	5.7	3.8	0.10073
1992	27.5	19.9	5.8	3.7	0.096296
1993	27.8	20.1	5.8	3.8	0.098577
1994	27.7	19.7	5.8	3.8	0.120567
1995	28.1	19.5	5.8	3.9	0.120139
1996	28	19.9	5.9	3.8	0.117134
1997	28	19.5	6.1	3.8	0.114127
1998	28	19.8	6.1	3.6	0.114961
1999	27.5	19.2	6	3.7	0.117067
2000	27.3	19.4	6	3.6	0.114039
2001	27.5	19.1	6	4	0.111499
2002	27.4	19.1	5.9	4.3	0.119608
2003	27.5	19.3	5.9	4.5	0.126824
2004	27.6	19.2	5.7	4.5	0.121881
2005	27.9	19.8	5.6	4.7	0.121191
2006	27.7	20.2	5.6	4.7	0.121191
2007	27.7	20.4	5.6	4.7	0.121191
2008	30.9	23.3	5.6	4.7	0.121191
2009	27.9	20	5.6	4.8	0.121191
2010	29.2	20.9	5.6	4.8	0.121191
2011	32.9	22.5	5.6	4.8	0.121191
2012	37.6	24.3	5.6	4.8	0.121191
2013	38.1	24.5	5.6	4.8	0.121191
2014	39	24.9	5.6	4.8	0.121191
2015	40.6	25.5	5.6	4.8	0.121191
2016	42.1	26.2	5.6	4.8	0.121191
2017	44.2	28	5.6	4.8	0.121191
2018	46.5	30.4	5.6	4.8	0.121191
2019	47.8	32.1	5.6	4.8	0.121191
2020	49.1	32.7	5.6	4.8	0.121191
2021	53	34.2	5.6	4.8	0.121191
2022	55.5	35.8	5.6	4.8	0.121191
2023	58.1	37.5	5.6	4.8	0.121191
2024	60.9	39.3	5.6	4.8	0.121191
2025	63.7	41.1	5.6	4.8	0.121191
2026	63.7	41.1	5.6	4.8	0.121191
2027	63.7	41.1	5.6	4.8	0.121191
2028	63.7	41.1	5.6	4.8	0.121191
2029	63.7	41.1	5.6	4.8	0.121191
2030	63.7	41.1	5.6	4.8	0.121191
2031	63.7	41.1	5.6	4.8	0.121191
2032	63.7	41.1	5.6	4.8	0.121191
2033	63.7	41.1	5.6	4.8	0.121191
2034	63.7	41.1	5.6	4.8	0.121191
2035	63.7	41.1	5.6	4.8	0.121191
2036	63.7	41.1	5.6	4.8	0.121191
2037	63.7	41.1	5.6	4.8	0.121191
2038	63.7	41.1	5.6	4.8	0.121191
2039	63.7	41.1	5.6	4.8	0.121191
2040	63.7	41.1	5.6	4.8	0.121191
2041	63.7	41.1	5.6	4.8	0.121191
2042	63.7	41.1	5.6	4.8	0.121191
2043	63.7	41.1	5.6	4.8	0.121191
2044	63.7	41.1	5.6	4.8	0.121191
2045	63.7	41.1	5.6	4.8	0.121191
2046	63.7	41.1	5.6	4.8	0.121191
2047	63.7	41.1	5.6	4.8	0.121191
2048	63.7	41.1	5.6	4.8	0.121191
2049	63.7	41.1	5.6	4.8	0.121191
2050	63.7	41.1	5.6	4.8	0.121191

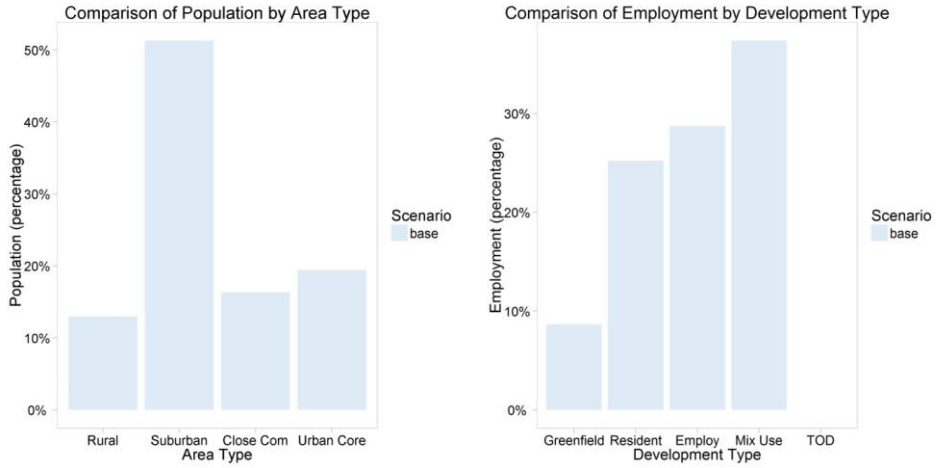
8.0 RPAT APPLICATION EXAMPLES

This section of the user's guide provides some examples from the pilot testing of RPAT on how a set of scenarios might be developed, tested, and analyzed by an agency. Chapter 4 of the SHRP 2 C16 Final Report provides a more complete discussion of the pilot testing process.

8.1 DEVELOPING THE BASE SCENARIO

Chapter 5 discusses the development of the input files, many of which are involved in describing the base scenario. The most complex input to develop is likely to be the land use allocation to place types. The section on built environment inputs in Chapter 5 includes the approach used by ARC during their pilot test of RPAT and provides a good example of how to achieve the allocation to place types. Thurston Regional Planning Council (TRPC) followed a similar GIS based procedure to that followed by ARC, while MDOT followed a simpler, qualitative process. The reporting tab can be used to produce charts of several of the land use and demographic inputs for the base scenario to review how the results of the allocation process (Figure 68).

FIGURE 68: EXAMPLES OF POPULATION ALLOCATION BY AREA TYPE (ARC PILOT TEST) AND EMPLOYMENT ALLOCATION BY DEVELOPMENT TYPE (TRPC PILOT TEST)



8.2 DESIGNING SCENARIOS

RPAT is designed to provide a flexible platform for efficient testing a variety of policies individually and in combination in a consistent framework. Once the base scenario is created, which is generally the expected future, scenarios can be added using the process in described in Chapter 4. In those new scenarios, any of the inputs can be varied from the values used in the base scenario in order to evaluate the effect of that policy change or alternative investment. Each of the pilot studies tested a relatively consistent set of eight scenarios, and an

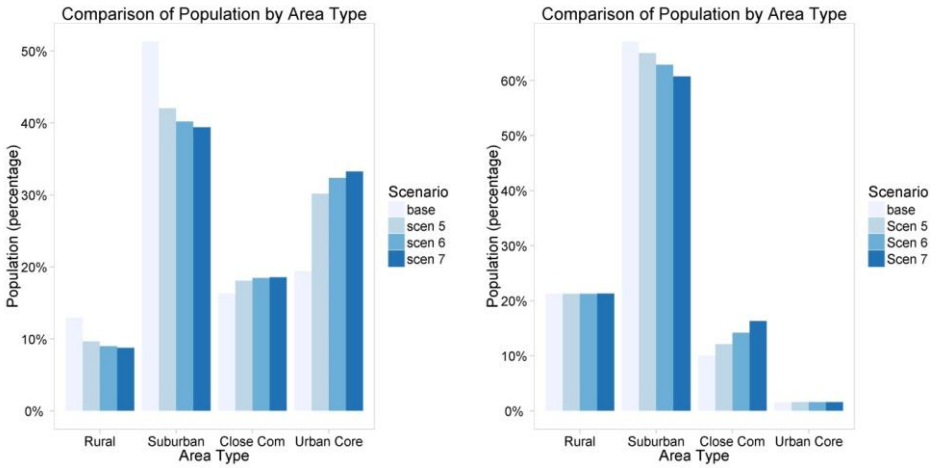
additional two scenarios are reported in the SHRP 2 C16 Final Report that were tested in Portland by the research team. The scenarios, shown in Table 11, focus initially on testing changes individually to understand the impacts of those policies separately. For example, scenario #2 is the same as the baseline except for just the addition of extra transit supply. Scenarios #5-7 test the effect of increasing the magnitude of a policy: each deals only with focusing development in dense areas, with each successive scenario representing a more aggressive implementation of that policy. Scenario #8 is an example of combining several strategies across the land use, transportation and policy areas, as might be done in reality. This allows the evaluation of the combinatorial effect of those policies: in some cases, the effects from different changes might counteract each other, and in others they might have reinforcing effects.

TABLE 11: PILOT TEST SCENARIO DEFINITIONS

SCENARIO	LAND USE	TRANSPORTATION	POLICY
#1. Baseline	Baseline	Baseline	Baseline
#2. Increase Transit Supply	Baseline	+ 20% in Transit Supply	Baseline
#3. Increase Roadway Supply	Baseline	+ 20% in Roadway Supply	Baseline
#4. Add ITS	Baseline	Baseline	+20% in Lane Miles with ITS
#5. Shift 10% Growth to More Dense Areas	Shift 10% Pop, Emp to Close-in Community, 10% to Urban Core, from Suburban Area	Baseline	Baseline
#6. Shift 20% Growth to More Dense Areas	Shift 20% Pop, Emp to Close-in Community, 20% to Urban Core, from Suburban Area	Baseline	Baseline
#7. Shift 30% Growth to More Dense Areas	Shift 30% Pop, Emp to Close-in Community, 30% to Urban Core, from Suburban Area	Baseline	Baseline
#8. Shift 30% Growth to More Dense Areas and Add ITS and Transit Supply	Shift 30% Pop, Emp to Close-in Community, 30% to Urban Core, from Suburban Area	+20% in Transit Supply	+20% in Lane Miles with ITS
#9. Increase Operating Costs	Baseline	Baseline	+ 25% auto operating cost growth
#10. Add VMT Charge	Baseline	Baseline	10 c/mile VMT charge

During the pilot testing, the agencies implemented the scenarios based on their knowledge of their own regions. This meant applying caps in some cases to the amount of land use reallocated in scenarios #5-7, for example. The built environment inputs can be compared across scenarios in the reporting tab of RPAT to understand and review how the scenario definitions affect the future distribution of population and employment. Figure 69 compares the approaches used by ARC and TRPC for the land use change scenarios. The charts show the focus in ARC of moving suburban to urban core development and in TRPC of more reallocation to close-in communities with little growth allocated to their urban core.

FIGURE 69: EXAMPLES OF POPULATION ALLOCATION BY AREA TYPE (ARC PILOT TEST TO THE LEFT, TRCP PILOT TEST TO THE RIGHT) FOR BASE AND SCENARIOS #5-7



RPAT has no constraint on the number of scenarios that can be tested or on the number of inputs that can be changed in a given scenario. The only constraints are the time available to develop, run and analyze the results available to the user and their ability to understand and interpret the results when multiple inputs are changed in a scenario. A recommended approach is to test individual policies at first, the move to testing combinations once the individual effects are understood. For policies where the aggressiveness of the implementation of the policy could vary significantly, multiple scenarios can be evaluated, as with scenarios #5-7 discussed above. Chapter 5 discusses the various inputs files and how they can be varied, and the SHRP 2 C16 Final Report provides additional context and references discussing the different policies. An important aspect of scenario testing to keep in mind is that testing a wide range of inputs, even beyond what might be expected to be achievable, is part of the task in order to understand what outcomes might results from a range of inputs.

8.3 ANALYZING SCENARIO RESULTS

RPAT produces results in the form of performance metrics, which are described in Chapter 6. The results are available in tabular form via the outputs tab in RPAT, or can be displayed and exported in form of charts in the report tabs. Both the outputs tab and the reports tab are described in Chapter 4.

The reports tab allows two general type of comparison: within scenario and across scenarios. The two can be combined on a single chart (although this can be become harder to interpret if many scenarios are compared). This section of the user's guide provides some examples of different visualizations produced during the pilot tests that show the range of charts that can be produced. The settings for the report tabs are included for each chart.

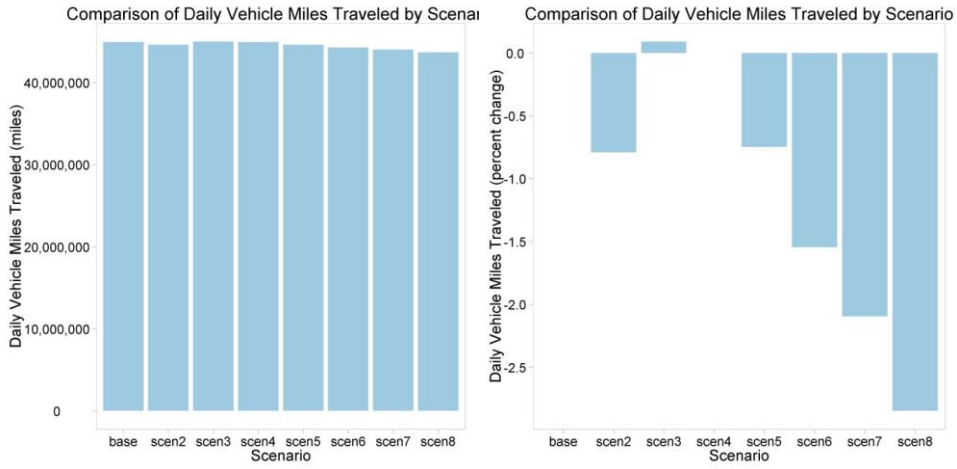
8.4 AGGREGATE COMPARISONS ACROSS SCENARIOS

Figure 70 show two charts from the Portland test of RPAT. The chart on the left shows total daily VMT by scenario. In this case, eight scenarios were compared. While displaying the totals using the number measure provides an indication for each scenario of the total magnitude of VMT, the differences between the scenarios are difficult to interpret as they are relatively small in percentage terms leading to very similar bar heights in the chart. The chart on the right shows the output for the same scenarios and performance metric, but the measure is changed to the Index (0) type, which first scales the values to an index, with the base scenario set to 100, and then translates all of the index values to be relative to a base scenario value of 0. In effect, the values displayed are percent changes relative to the base scenario, with positive bars (just scenario #3 in this case) indicating an increase in VMT relative to the base scenario, zero bars (scenario #4 as well as the base) indicating the same VMT as the base scenario, and negative bars indicating a decrease in VMT relative to the base scenario.

The reports tab settings to produce the left and right charts respectively are as follows:

- Scenarios: Select base and scenarios #2-8 Select base and scenarios #2-8
- Metric: Daily VMT Daily VMT
- Aggregation: All All
- Measure: Number Index (0)

FIGURE 70: PORTLAND DAILY VMT BY SCENARIO (TOTAL AND PERCENT CHANGE FROM BASE)



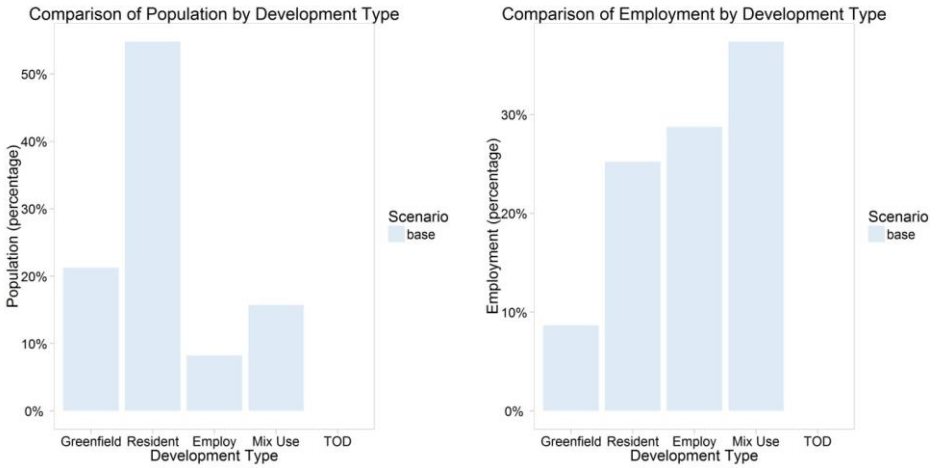
8.5 SEGMENTATION WITHIN SCENARIOS

Many of the performance metrics available on the reports tab can be segmented using the different aggregations other than all. RPAT only makes those available to the user that the data supports; once the user selects a performance measure, the aggregation levels that can be used will be selectable, with the remaining aggregations inactive and grayed out. A typical analysis using segmentation is to understand how the metric is distributed across the segments. Figure 71 shows an example from the TRPC pilot, where the charts show the distribution of population and employment by the development type aggregation. In this case, the measure is percentage and so the bars indicate the percentage of the population and jobs that are allocation to each development type. The bars sum to 100% across all of the development types.

The reports tab settings to produce the left and right charts respectively are as follows:

• Scenarios:	Select base scenarios	Select base scenarios
• Metric:	Population	Employment
• Aggregation:	Development type	Development type
• Measure:	Percentage	Percentage

FIGURE 71: TRPC PERCENT OF 2040 POPULATION AND EMPLOYMENT BY DEVELOPMENT TYPE



8.6 SEGMENTED COMPARISONS ACROSS SCENARIOS

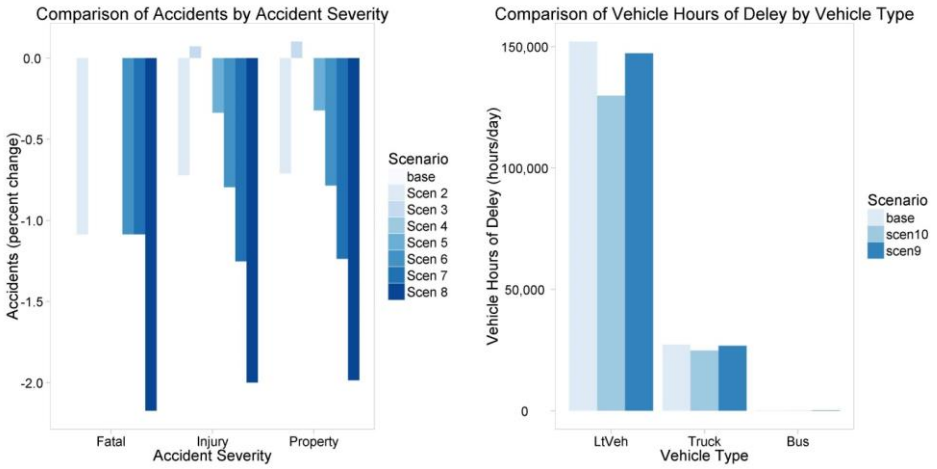
The final type of comparison that can be achieved using the reporting tab is displaying a segmented performance metric across a series of scenarios. This allows comparison of say how the distribution of a performance metric is affected by different scenarios.

Figure 72 shows two examples of this type of chart. On the left, the accidents metric from eight scenarios is displayed segmented by accident severity, a three category segmentation with levels of fatal, injury and property. On the right, the vehicle hours of delay metric from three scenarios is displayed segmented by vehicle, another three category segmentation, this time with levels of light vehicle, truck, and bus. In this type of chart, the segmentation variable is the x-axis and the various scenario values are shown clustered for each segment. The difference between the two charts is the measure used. On the left, the measure is Index (0) and so the bars indicate relative percent change in comparison to the base scenario value for that segment (which has a value of zero and so no bar is shown). On the right, the measure is number and so the bars indicate the actual number of hours of delay experienced by each vehicle type in each scenario.

The reports tab settings to produce the left and right charts respectively are as follows:

• Scenarios:	Select base and scenarios #2-7 Select base and scenarios #9-10	
• Metric:	Accidents	Vehicle Hours of Delay
• Aggregation:	Accident severity	Vehicle Type
• Measure:	Index (0)	Number

FIGURE 72: ACCIDENTS BY ACCIDENT SEVERITY (MDOT) AND VEHICLE HOURS OF DELAY BY VEHICLE TYPE (PORTLAND)



9.0 REFERENCES

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