JEMnR MODEL USER'S GUIDE

Oregon Department of Transportation
Transportation Planning Analysis Unit

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JEMnR Model User's Guide

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1. INTRODUCTION

1.1 Report Purpose

The purpose of the *JEMnR Model User's Guide* is to provide users with instructions on how to apply the JEMnR (Joint Estimation Model in R) travel demand forecasting model. JEMnR was originally estimated and calibrated for the Portland area by Portland Metro staff using data from the 1994-95 Oregon/SW Washington (Vancouver) Household Activity and Travel Behavior Survey. Subsequently, it was used as the basis for the development of the Transportation Planning Analysis Unit's (TPAU) models for the Corvallis Area Metropolitan Planning Organization (CAMPO), Bend MPO (BMPO), and Rogue Valley Area MPO (RVMPO). The model was updated in 2014 to include a special market model for students of major universities, a commercial vehicle model, and with revised transit skimming, assignment, and mode choice parameters. It was then used to update the Bend-Redmond Model (BRM), Corvallis-Albany-Lebanon Model (CALM) and Rogue Valley Area MPO v.4 (RVMPO) models. [1] The core modules of JEMnR are implemented entirely through a series of script files written in the R statistical programming language.[2] The modules follow the same basic process used for the Portland Metro model; however, there are specific differences between TPAU's models and the Metro model.

The *User's Guide* serves an important role in clearly and comprehensively describing the proper model application procedures so that the models are used in a manner consistent with the way they were developed. It can be used as an everyday resource for answers to questions about a wide range of model applications. The *User's Guide* is intended for use by modeling practitioners who may or may not have previous experience with JEMnR. This includes TPAU staff, MPO and other local agency staff, and consultants. It is assumed that the reader has a basic understanding of travel demand modeling theory and at least some level of experience with general model application and model application software.

For those with no previous JEMnR application experience, it is strongly recommended that they read entire *User's Guide* prior to applying the MPO models. The user must also be familiar with related information that can be found in the *JEMnR Model Base Report*[3] and the *CALM, BRM, and RVMPO Model Development Reports*[4, 5, 6]. The *JEMnR Model Base Report* contains information on all topics that are common to the three models, such as the original JEMnR model development process, model structure, components, input data, and common zone system and network features. The *CALM, BRM, and RVMPO*

[1] The Salem Kaiser Area Transportation Study's (SKATS) model is also a version of JEMnR.
[2] R is supported by The R Project for Statistical Computing at: http://www.r-project.org/.
[3] Oregon Department of Transportation, JEMnR Model Base Report, (2011).
[4] Oregon Department of Transportation, CALM Model Development Report, (2018).
[5] Oregon Department of Transportation, BRM Model Development Report, (2018).
[6] Oregon Department of Transportation, RVMPO v4 Model Development Report, (2017).

Model Development Reports contain descriptions of how JEMnR was implemented within each MPO area, including the calibration of individual model components to better reflect local travel characteristics and model validation results. Together with the *User's Guide*, these documents provide a complete background on the development, calibration/validation, and application of the models.

Other reports that may be helpful are the *Modeling Procedures Manual for Land Use Changes*[7] and *An Introduction to R*.[8] The *Modeling Procedures Manual for Land Use Changes* report provides guidance on the application of travel models and model output data for the analysis of the transportation impacts of proposed land use changes. The *An Introduction to R* report provides an introduction to the R language and how to use R for performing statistical analysis and graphics.

1.2 Overview of JEMnR Application Process

An important decision to be made prior to applying one of the MPO models, or any other model, is whether it is the appropriate tool to use. Making the correct decision depends in large part on whether the question to be answered has been clearly identified and the information required to answer the question has been adequately defined. Generally, the model should be regarded as the first option, but other available tools should also be considered. For example, ODOT's *Analysis Procedures Manual (APM)*[9] contains guidelines for applying two other forecasting methods referred to as the "Historical Trends" method and "Cumulative Analysis" method.

If optional tools are available, then several factors should be considered in determining which one to use:

- How well the tool will satisfy the data requirements of the analysis, both in terms of the type and quality of the data produced. Information on the capabilities and limitations of JEMnR is provided in Section 2 (Overview of JEMnR).
- The level of effort and amount of time required to produce the data. In the case of JEMnR, this may include the need to modify the model input data and the availability of qualified staff to apply the model.
- Beyond the immediate data needs of the analysis, the likelihood of additional data being required for other analyses. One advantage of models, in general, is that once they have been set up they are relatively easy to apply for different scenarios and different types of output compared to manual methods.

If it has been decided that JEMnR is the best tool to use to help answer the question, the next step is to identify the appropriate method for applying the model to produce the

[7] Oregon Department of Transportation, Modeling Procedures Manual for Land Use Changes, (2011).
[8] R Core Development Team, An Introduction to R, (2011).
[9] Oregon Department of Transportation, Analysis Procedures Manual, (2007)

information needed. Applying the model in a way that is consistent with its development is essential to avoid incorrect or misleading results. Information on application procedures for two of the most common model uses, the identification of the effects of proposed network changes and land use changes, is provided in Section 7 (Typical Applications).

Once the model application approach has been determined, it is likely that the input data will need to be modified. This may include socioeconomic data, level-of-service (network data), zonal data, or external travel data. Instructions for the preparation of model input data are contained in Section E. Model application may also involve changing specific model parameters, such as auto operating cost, to perform "what if"-type scenario testing. Information on the model parameters is presented in Section 3 (JEMnR Setup and Application).

Following the modification of the input data, the core submodules of JEMnR are processed using a set of model run files. Unlike many other models, the JEMnR submodules are not implemented within a proprietary software package such as Emme or VISUM. Rather, they are written in the open source R statistical programming language, requiring the user to have the R software package installed and the JEMnR submodule code available on their computer. The R software package is available for free download at the The R Project for Statistical Computing website at: http://www.r-project.org/, while the JEMnR run files and submodules can be obtained from TPAU. Although a detailed knowledge of R is not necessary to apply JEMnR, an understanding of some of basic commands is helpful for the user to perform reasonableness checking of the submodule outputs.

Although the JEMnR submodules are implemented in R, the trip assignment step of the process is performed using the Emme software package. The vehicle trip matrices generated by JEMnR for assignment are reformatted and written directly to the Emme database or as Emme batchout files by one of the JEMnR submodules. JEMnR then opens Emme, and Emme runs the assignment with no user control required.

The University special market model is implemented in the Java programming language. All source code is also open-source, and is available under the terms of the Apache public license. Running this model component requires the installation of the Java Runtime Environment (JRE) version 7 or later.

The trip assignment results from the final iteration of JEMnR processing should be checked by the user for reasonableness. A recommended set of reasonableness checks to be applied are presented in Section 6 (Trip Assignment). Once the model output has been verified, it can be used for analysis purposes. Methods for displaying various outputs in R and Emme, as well as producing output not directly retrievable in Emme, are described in Section 8 (Viewing Model Output).

1.3 Report Organization and Contents

The *User's Guide* is organized in the order of setting up, applying, and viewing output in JEMnR. It is divided into the following sections:

A. Introduction
B. Overview of JEMnR – summarizes the general features and individual submodules of JEMnR and describes JEMnR's capabilities and limitations.
C. JEMnR Setup and Processing – contains information on model installation, the directory structure for JEMnR implementation, model processing (including run files, inputs, and outputs), and execution diagnostics.
D. Network Coding – describes the general Emme network structure, Emme network editing procedures, network coding conventions for the MPO models, and network validation checks.
E. Input Data Preparation - provides instructions for the preparation of socioeconomic, level-of-service, zonal, and external travel data, including data sources and tools and reasonableness checks to verify the accuracy of the data.
F. Trip Assignment – describes the linkage between JEMnR and Emme for trip assignment, how to set up and run auto and transit assignments, and a set of checks that can be used to validate the reasonableness of the assignments.
G. Typical Applications – provides step-by-step instructions for the two most common model applications - developing travel forecasts for proposed land use changes and network changes.
H. Viewing Model Output - describes the methods used to view model output in both Emme and R.

2. OVERVIEW OF JEMNR

2.1 JEMnR Structure

JEMnR is a trip-based travel demand model. It was developed by Metro in a way to fully utilize the data contained in the 1994-95 Oregon/SW Washington Household Activity and Travel Behavior Survey in order to meet the following requirements:

- The MPOs' responsibility to develop a 20-year transportation plan that includes both long-range and short-range strategies/actions that lead to the development of integrated, intermodal transportation system.
- The Transportation Planning Rule (TPR) requirement for the preparation of local transportation system plans (TSPs) that "establish a system of transportation facilities and services adequate to meet identified local transportation needs".[10]
- Other model uses such as: 1) Preparation of subarea transportation studies in which models are focused for a subarea of a city or county to examine detailed land use or transportation system alternatives; 2) Analysis of the transportation system impacts of large-scale development proposals; and 3) Evaluation of the effects of large-scale transportation projects.

JEMnR represents a significant improvement in the modeling capabilities available to MPOs in Oregon prior to its development. Some of the distinguishing features of JEMnR are:

- **Market segmentation** of households by 64 household/income/age-of-head-of-household categories to better reflect the different travel behavior characteristics of different household types.
- Incorporation of zonal **accessibility** variables to represent the effects of the environment in which travel decisions are made.
- Inclusion of eight **trip purposes** compared to the typical three or four trip purposes to more accurately represent differences in trip types.
- Trip distribution using the **destination choice** model form rather than the conventional gravity model.
- For all trip purposes other than home-based school, generation of **trip matrices** by income category (high, medium, and low) and time period (peak and off-peak) within the trip distribution and mode choice models.
- An expanded set of **modes** for the mode choice model, including drive alone, drive-with-passenger, auto-passenger, walk-access transit, bike, and walk, as well as park-and-ride for all of the home-based trip purposes.

[10] Oregon Land Conservation and Development Department, OAR 660-012-0005, (2006).

- Use of peak and off-peak **transit** coverage factors for households and employment to define the transit-eligible portion of the travel market for each zone pair.

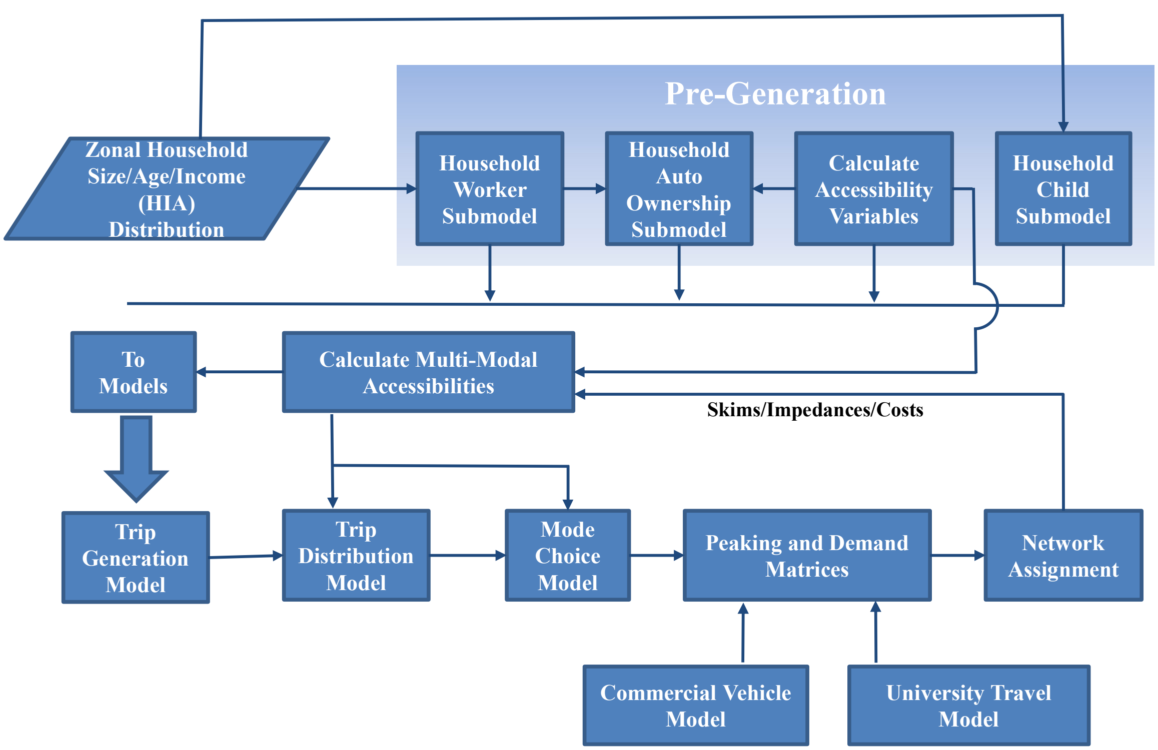
2.2 JEMnR Modules

JEMnR comprises the eight general modules shown in the MPO model flow diagram in Figure 1:

- Pre-generation, including the development of accessibility variables
- Trip generation
- Multimodal accessibility
- Trip distribution (destination choice)
- Mode choice
- Commercial vehicle model
- University travel model (only applicable to CALM)
- Peaking and demand matrices

Trip assignment is performed outside of JEMnR following the peaking and demand matrices module using the Emme software package.

Figure 1: MPO Model Flow



Each of the modules is briefly described below. Appendix A – JEMnR Submodules, provides the reader with a detailed understanding of JEMnR and the how the individual submodules function.

The **pre-generation** module comprises submodules to calculate three accessibility measures, as well as three household submodels that stratify households by the number of workers, number of autos owned, and number of children.

The accessibility measures are developed to account for both the relative magnitudes of and interactions between household density, employment density, and intersection density. These measures are used as input to the auto ownership submodel, multi-modal accessibility module, and mode choice model.

The three household submodels are of the multinomial logit form, in which utilities are calculated for the number of workers, number of autos owned, and number of children. The household distributions produced by the submodels are used as input to the trip generation model.

The **trip generation** model estimates daily trip productions using a set of cross-classification models for eight trip purposes – home-based work (HBW), home-based shop (HBshop), home-based recreation (HBrec), home-based other (HBoth), non-home-based work (NHBW), non-home-based non-work (NHBNW), home-based college (HBcoll), and home-based school (HBsch). For each zone, the number of productions is calculated by multiplying the number of households in each household category by a production rate. The trip productions are input to the trip distribution model. Trip attractions are also calculated for the HBW and HBcoll trip purposes for use in the trip distribution model.

The **multi-modal accessibility** module calculates the utilities used in the trip distribution module. This is done in two steps. In the first step, weighted average modal utilities are calculated by trip purpose, mode, and income level. The weights represent the percentages of trips by trip purpose occurring in the peak and off-peak time periods. In the second step, purpose/income-specific logsums are calculated from the individual modal utilities.

The **trip distribution** model distributes the daily trips to destinations for all trip purposes using a destination choice model, with the exception of HBsch trips, which are distributed using a separate simpler exogenously defined enrollment area allocation method. The destination choice model is a multinomial logit model in which utilities are calculated as a function of the logsum variables from the multimodal accessibility module and attraction zone variables. For the HBW trip purpose, trips are distributed separately by income group. For the other trip purposes, there is no distinction between income groups, but separate trip matrices are created at the end based on the number of trip productions within each income group. The trip matrices produced by the trip distribution model are input to the mode choice model.

Trip distribution for internal-external (I-E), external-internal (E-I), and external-external (E-E) trips are handled with separate procedures.

The **mode choice** model estimates average weekday person trips by mode for the same trip purposes included in the trip generation and trip distribution models. Except for the HBsch trip purpose, trips are estimated by time period and income group. The drive alone, drive-with-passenger, auto passenger, walk-access transit, bike, and walk modes are available for all trip purposes except HBsch. The park-and-ride mode is also available for HBW, HBshop, HBrec, and HBoth trips. The mode choice step for HBsch trips is handled with a separate non-modeling procedure where mode percentages are exogenously provided. The mode choice utility functions contain the same variables and coefficients used in the multi-modal accessibility functions, in addition to market segment variables.

The modal trip matrices are input to the peaking demand matrices module.

The **peaking and demand matrices** module creates trip matrices for trip assignment. The daily internal-internal (I-I) trip matrices output in production-attraction format by the mode choice model are converted to time period-specific origin-destination matrices based on input time-of-day/directional factors by trip purpose.

The **commercial vehicle** model is a three-step model that can be run prior to assignment in order to account for commercial vehicle movements. This model is based on an establishment survey of work-related travel by employees of businesses in Ohio. The models are trip-based, with models of trip generation, trip distribution, and time-of-day choice, developed analogously to common practice for trip-based models of person travel. The model generates truck trips for two trip purposes: workplace-based trips and non-workplace based trips, and for three modes: car (including small vans and trucks under 8,500 lbs. gross vehicle weight), single-unit truck (trucks over 8,500 lbs. with a single chassis), and multi-unit truck (which articulate between a tractor and trailer). The trip generation models are cross-classification models which are based upon zonal employment and input trip rates for each of the six combinations of purpose and mode. A gravity formulation is used for the trip distribution models, and time-of-day factors are applied to estimate total trucks in each time period prior to assignment.

The CALM **university travel** model estimates the average weekday trips made by university students, staff and faculty. The university travel model was designed as simple tour-based models, which are characterized by the following considerations:

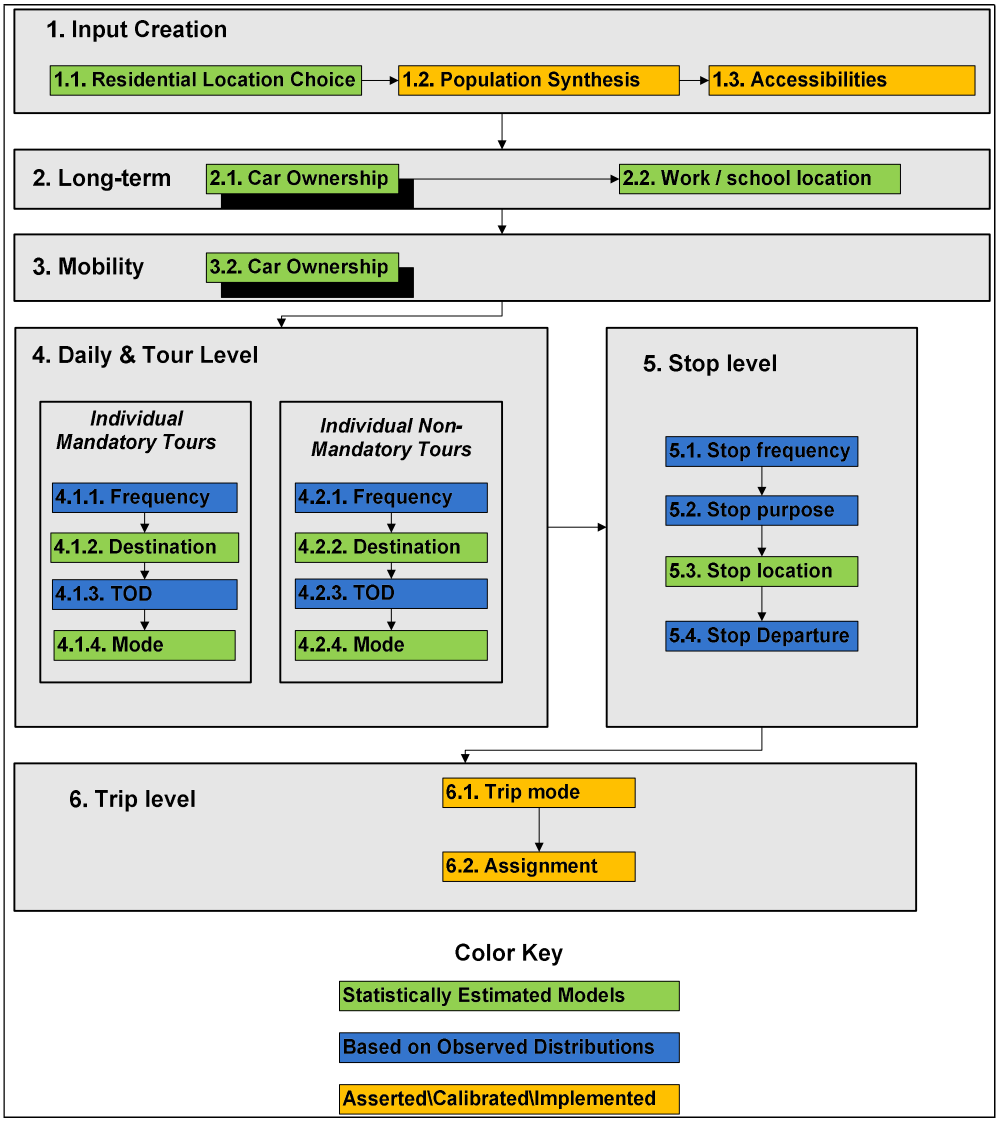
1. A micro-simulation of travel using a fully-disaggregate student population and a Monte Carlo discrete choice application paradigm wherein a database of students and faculty\staff are explicitly represented, and travel choices are modeled explicitly for each person.

2. Tours are used as fundamental unit of travel. A tour is a series of trips starting and ending at home. Tours have an anchor location (home), a primary destination (work, school, or some other dominant out-of-home activity) and zero or more intermediate stop locations. The use of a tour as the unit of travel allows the model system to predict activity locations, modes, and times of trips on tours consistently.

3. The tour-based modeling approach is simple, in that tours are modeled independently of each other. They are not scheduled into a daily activity pattern at a person level, nor are there interactions among household members. This is a key differentiating characteristics between a tour-based model and an activity-based model. In an activity-based model, tours or activities are scheduled such that no person can be in more than one place at the same time, and typically the number and schedule of higher-priority activities influence the number and schedule of lower-priority activities. Activity-based models also seek to coordinate travel across household members.

The university travel model system is shown in the Figure 2, and briefly described.

Figure 2: University Travel Model System



The general description of each model component follows the flow chart in Figure 1.

1. Input creation: A synthetic population is created for the region containing all persons except for those living in group quarters. The population contains a field indicating whether persons are students of the major university.

    1.1. Residential location choice: As discussed above, a residential location choice model predicts the number of students by segment and MAZ. This model is implemented in a spreadsheet.

    1.2. Population synthesis: A synthetic population is generated prior to running the university model (as an input to the model) and is subject to household constraints specified at the TAZ, TRACT, and regional levels, as well as the major university student marginals predicted by model 1.1. A special group quarters population is synthesized in the university model Java software.

1.3. Accessibilities: A set of origin-based accessibilities are calculated for each MAZ and segment (TBD) to be used in tour generation models. These accessibilities take the form of destination-choice logsums, but can be segmented by specific modes (walk or transit-only for example) as well as market segment (0 auto versus auto insufficient versus auto sufficient) and tour purpose (maintenance versus discretionary). This and all subsequent steps except for highway and transit skimming and assignment are implemented in the university model Java software.

2. Long Term Models

2.1. Auto ownership: The number of autos is determined for each household containing a university student.

2.2. Work/School location choice: The work TAZ for each student worker is predicted. Proximity to major university is likely to be a strong variable. General school location is already known for major university students, though exact MAZ for each tour must be predicted.

3. Mobility Models

3.1. Auto ownership: The number of autos model is re-run with exact accessibilities for each workplace and school location.

4. Daily and Tour Level Models: These models predict tour frequency, primary destination, outbound/return time period, and general or preferred tour mode. They are segmented into mandatory and non-mandatory models.

4.1. Mandatory tour models: Mandatory purposes are tours made for work or school.

4.1.1. Tour frequency: The exact number of university or work tours is predicted for each major university student, based on the coefficients estimated through a multinomial logit model. Likely alternatives are 0 tours, 1 work\0 school, 2 work\0 school, 0 work\1 school, 0 work\2 school, 1 work\1 school. Exact alternatives TBD after investigation of data.

4.1.2. Tour Destination choice: Each tour is assigned a primary destination, based on the coefficients estimated through a multinomial logit model. The university tours will select a specific university MAZ, while work tours can select from any available work MAZ.

4.1.3. Tour Time of Day: Each tour is assigned a departure and arrival half-hour period, based on probability distribution that varies by tour purpose.

4.1.4. Tour Mode Choice: Each tour selects a preferred primary tour mode, based on the coefficients estimated in a multinomial or nested logit model.

4.2. Non-Mandatory tour models: Non-mandatory purposes are tours made for purposes other than work or school, such as escort, shopping, recreational, or eating-out. The exact purposes will be determined after investigation of data.

4.2.1. Tour frequency: The exact number non-mandatory tours is predicted for each major university student, based on the coefficients estimated through a multinomial logit model. Exact alternatives TBD after investigation of data.

4.2.2. Tour Destination choice: Each tour is assigned a primary destination MAZ, based on the coefficients estimated through a multinomial logit model.

4.2.3. Tour Time of Day: Each tour is assigned a departure and arrival half-hour period, based on probability distribution that varies by tour purpose.

4.2.4. Tour Time of Day: Each tour is assigned a departure and arrival half-hour period, based on probability distribution that varies by tour purpose.

4.2.5. Tour Mode Choice: Each tour selects a preferred primary tour mode, based on the coefficients estimated in a multinomial or nested logit model.

5. Stop Models

5.1. Stop Frequency Choice: Each tour is attributed with a number of stops in the outbound direction and in the inbound direction, based upon sampling from a distribution.

5.2. Stop Purpose: Each stop is attributed with a purpose, based upon sampling from a distribution.

5.3. Stop Location Choice: Each stop is assigned a location based upon a multinomial logit model

5.4. Stop Departure Choice: Each stop is assigned a departure time-period (half-hourly) based upon sampling from a distribution.

6. Trip Level Models

6.1. Trip Mode Choice: Each trip within the tours selects a preferred trip mode, based on an asserted nested logit model.

6.2. Trip Assignment: Each trip is assigned to the appropriate time-of-day specific network.

Following the peaking and demand matrices module, auto assignment is performed.[11] This done using an equilibrium, capacity constrained assignment method. The travel times from the assignment are fed back into JEMnR for the next iteration of model processing. This process is repeated until there are no significant differences between the travel times from the current iteration and the travel times from the previous iteration.

2.3 JEMnR Capabilities and Limitations

To fully realize the benefits of JEMnR, it is important to identify appropriate and inappropriate uses of the model.

Historically, travel demand forecasting models have been developed primarily for analyzing future area-wide or system-level travel behavior. Thus, JEMnR serves as an excellent tool for supporting the development and update of regional transportation plans. This includes testing of alternative transportation system and land use scenarios as well as policy analysis. There are also many other uses of JEMnR that can support a wide range of transportation planning and analysis activities. Some examples of these are:

- **Preparation of subarea transportation studies.** For this application, the model's zone system and network are refined within a subarea to increase the accuracy of the forecasts for the subarea.
- **Analysis of the transportation impacts of land use changes.** Forecasts can be produced for land use changes ranging from regional alternative land use scenarios to smaller-scale development proposals.[12]
- **Evaluation of the effects of larger-scale transportation projects.** The model can be used to estimate how future travel patterns may be affected by transportation improvement projects. The model can also be used in the assessment of the benefits and environmental justice impacts of these projects. Example improvements include additional travel lanes or extensions of existing roadways or new roadways. Smaller-scale improvements such as intersection turn lanes cannot be reflected in the model, however.
- **User fee-based funding analysis.** An example of this would be applying the model in a select link analysis to identify the number of future trips using a particular roadway improvement or set of improvements. This information could

[11] Transit assignment is only done pre-model run to develop the transit skim used in the model choice model. The resulting transit trip table is not assigned to the network during the JEMnR run.
[12] For more information on model application procedures for land use changes, see the ODOT *Modeling Procedures Manual for Land Use Changes*, (2011).

be used together with the total cost of the improvement(s) to establish an estimated cost per trip.

- **Performance-based planning.** Traffic forecasts can be used as the basis for computing many performance measures to assess the relative effectiveness of transportation system and facility alternatives. Example measures include the number of congested lane miles and vehicle hours of delay.

- **Identification of traffic distribution patterns.** Information about the distribution of traffic for proposed development projects can be used for the preparation of traffic impact analyses. Model volumes developed through select link analysis can be used to develop distribution percentages for the proposed project. Alternatively, the percentage of total trips from a proposed project using a particular facility improvement can be determined using select link analysis for such purposes as fair-share cost assessment.

- **Support for regional emissions and air quality analysis.** VMT and speed data from the model can be used as inputs to air quality software packages such as MOVES.

There are also specific applications for which JEMnR is not well-suited. Generally, these are transportation planning and analysis tasks requiring data that the model has not been calibrated or validated for or that is too detailed to be reliably estimated by the model. For instance, the model also does not model visitor travel and school bus trips with as much detail, limiting their use in policy analysis. Additionally, employment forecasts do not receive as much scrutiny by MPO and regional jurisdictions as the population forecasts, which must match state long term forecasts by the Office of Economic Development (OED). Several other examples of areas to use the model cautiously, if at all follow:

- **Bicycle and pedestrian facility planning.** Most travel forecasting models, including the CALM, BRM, and RVMPO models, are not developed to estimate bicycle and pedestrian demand at the network or facility level. The models do, however, produce estimates of zone-to-zone bicycle and pedestrian person trips, which can be used to estimate the relative shifts in bicycle and pedestrian mode shares between alternatives.

- **Travel Demand Management (TDM) planning.** There is frequently the need to know how much trip making could be reduced, particularly SOV trips, through workplace TDM strategies such as preferential parking for rideshares, subsidies for transit riders, transportation allowances, and parking management programs. JEMnR cannot provide this information because it is structured at the TAZ level and does not include the variables that would allow these strategies to be reflected. JEMnR output can, however, be used with stand-alone packages such as Comsis Corporation’s TDM Evaluation Tool.

- **Use of model v/c estimates for facility planning/design.** A standard model output used for the comparison of transportation system alternatives is link volume/capacity (v/c) ratios. The volumes are taken directly from the model (without post-processing) and the capacities are those used within the traffic assignment. Therefore, the link v/c ratios are only rough approximations of congestion levels. These are suitable for system-level analysis, but are too coarse for detailed facility design. The model volumes can be used to develop post-processed volumes, however, which can be input to traffic operations software to produce more accurate estimates of v/c ratios and other operating characteristics used in the design process.

- **Use of "raw" model volumes.** Model volumes can be used to develop post-processed volumes, but they should never be used directly for facility planning/design analyses. An example of an inappropriate model use would be to input forecast turning movement volumes from the model directly into an intersection LOS analysis package. The proper process for applying model volumes can be found in the *APM*[13] at: http://www.oregon.gov/ODOT/Planning/Pages/APM.aspx.

- **Use of "raw" speed data.** Link speeds can be derived from model travel times and distances. The CALM, BRM, and RVMPO models were not calibrated/validated to produce accurate speed data, however. Therefore, the speed estimates must be adjusted prior to use in other applications. This includes regional air quality and emissions analysis.

3. JEMNR SETUP AND APPLICATION

3.1 Model Installation

JEMnR is installed in the following sequence of steps.

1. The first step in installing JEMnR is to obtain a copy of the all of the files required to run the model by emailing TPAU at ModelingRequestsTPAU@odot.state.or.us. The files are contained in a .zip file and include:

    - Three folders:
        - emme
        - inputs
        - rcode

[13] Oregon Department of Transportation, Analysis Procedures Manual, (2007)

- JEMnR 'runModel' script (R script, others in 'rcode' folder)
- functiontable.csv (maps R script functions to be used)
- Shortcut to open R software program

These files should be stored in a new project folder set up to store all of the files associated with the JEMnR project application. Note: Additional folders/files are created when the model is run.

2. The R software package must be downloaded and installed in order to run the JEMnR code. The software is available free-of-charge from the R Project for Statistical Computing website at: http://www.r-project.org/. The appropriate release of the software to be downloaded can be identified in model development report for the specific model to be used.

3. Special R software packages called "emme2", "doParallel", and "igraph" must also be downloaded from the R website. The "emme2" package is used to read and write Emme matrices into/out of JEMnR directly from/to the Emme database. The "doParallel" package acts as an interface between for each and the parallel package. The "igraph" package provides versatile options for descriptive network analysis and visualization in R. The packages are downloaded in the following steps:

   - Open R
   - In the R console, click the "Packages" tab and select "Install package".
   - A drop-down menu of locations to download from appears; pick a location.
   - Another drop-down menu of packages to download appears; pick the necessary package.
   - The package is automatically downloaded and installed. The installation is permanent; i.e., it must be performed only once.

4. The CALM university model requires additional components if it is to be run. Since the implementation is in Java, a 64-bit version of Java 7 JRE or later is required. Furthermore, the EMX to ZMX matrix converter that uses Python (comes with EMME) is required.

3.2 Directory Structure

A JEMnR project directory contains the following folders:

- rcode
- inputs
- emme
- unimodel (optional, for CALM university model)

Additional folders used to store JEMnR outputs are generated when the model is run.

Figure 3: JEMnR Project Directory Structure

The **rcode** folder contains all of the program files required to run the model. Within this folder, there is a separate subfolder for each of the JEMnR modules. For example, the “tripgen” subfolder contains all of the program files required to run the trip generation model. These program files are actually R script files in text format containing the functions that implement each of the JEMnR submodules. During model execution, the required program files are read from the rcode subfolders as needed. The rcode folder also includes a script file for controlling the order of execution the submodules and several files used at various points for input data processing, matrix balancing, and writing matrices to the Emme database.

The **inputs** folder contains all of the input files used by the model, with the exception of the travel time matrices from Emme. Unlike the **rcode** folder, there are not separate subfolders for each JEMnR module. All of the files are in CSV (comma-separated values) format. They contain a variety of input data ranging from utility equation coefficients to model parameters. These files are discussed in more detail in the Inputs/Outputs section below. They are read-in for input to the JEMnR submodules, with most of the data reformatted as R data (.RData) files and stored in the RData subfolder of the **inputs** folder, which is created by JEMnR when the model is run.

The **emme** folder must contain the Emme database (Database sub-folder), which contains the model networks and initial matrices, as well as associated Emme files and macros (macros sub-folder). The input travel time matrices are read-in directly from the database or from batchout files produced by Emme. The vehicle trip matrices are also written directly into the database or as Emme batchout files for use in the trip assignment.

The output from the JEMnR submodules is written into a separate folder for each submodule. The folder names are abbreviations of the submodule names; thus, the name of the output folder for the trip distribution submodule is “tripdist”. Depending on the structure of the output data, some of the folders have subfolders. For example, the trip matrices produced by the mode choice submodule are by trip purpose and income group. Therefore, the “modec” folder contains a subfolder for each trip purpose, and within these, a subfolder for each income group.

3.3 Model Application

Performing a JEMnR model run involves the following basic steps:

1. Preparation of input files
2. Review of model parameter settings
3. Model processing
4. Reasonableness checking of model outputs
5. Technical Memo Documentation of model run

3.3.1 Preparation of Input Files

For typical model applications, most of the inputs do not need to be modified. Some of the data items may need to be changed, however, to reflect the specific characteristics of the scenario being analyzed. The files containing the inputs most likely to be changed are shown in Appendix B. These include the TAZ.csv file (inputs folder), which would be modified to reflect assumptions about future land uses,[14] and the various inputs associated with roadway network changes, such as the peak and off-peak auto time matrices and the auto distance matrix (emme folder). All monetary units are expressed in 1995 dollars.

To simplify, many of the inputs have been put into sub-folders. The primary inputs are found in the base inputs folder. Only infrequently will the user need to update the inputs in the externalModel folder, such as revised AADT or growth rates at external stations. The user does not need to bother with any the inputs in the utilities or RData folder. These include utility functions that are read-in by JEMnR as comma separated values (CSV) files and data items generated internally based on other inputs, such as walk and bike times, auto trip costs, and the distribution of households by household characteristics and TAZ.

To better understand the JEMnR inputs and the effects of the inputs on model outputs, the inputs that would be modified for several example planning scenarios are described below. These are:

1. Estimating the effects on roadway volumes of an increase in development densities, combined with improved transit service or roadway capacity improvements.
2. Identifying the transportation system impacts of a major proposed development in an undeveloped portion of a local area.

[14] A general note about CSV files is that it is safer to edit these files using a text editor rather than Excel. A number of issues have been identified with the use of Excel, including the unintended removal of significant digits and the addition of empty columns and rows.

3. Determining the effects on VMT of locating households closer to employment.

The changes described are for the inputs that would most commonly be modified for these scenarios. Depending on the specific characteristics of the scenario, however, other inputs may also need to be changed.

In the first example, both the increased development densities and increase in transit service would be expected to have a positive effect on transit ridership. To reflect this scenario, the following inputs may need to be modified:

- *Socioeconomic data (TAZ.csv file).* The number of households and/or employment by type within the applicable TAZ(s) would be increased by an assumed amount. This would increase the attractiveness of the TAZ(s), which would increase the number of trips destined to the TAZ(s).
- *Number of intersections within ½-mile of TAZ centroid ("intersections" column of TAZ.csv file).* With an increase in development density, an increase in the density of the street network within the local area could be assumed. This would increase accessibility, which would increase the number of trips destined to the TAZ(s).
- *Peak and off-peak household and employment transit coverage factors ("peakHhCov, offPeakHhCov, peakEmpCov, and offPeakCov"columns in TAZ.csv file).* The percentage of households and/or employment within ¼-mile of transit service would likely increase. This would increase the number of transit trips to the area.
- *Transit impedance matrices (regeneration of matrices in Emme to reflect transit service changes).* With an increase in transit service, impedances to transit travel would decrease. The increase in service would be reflected in the transit in-vehicle time, total wait time, initial wait time, and walk time matrices. This would increase the number of transit trips to the area.
- *Auto travel time and distance matrices (regeneration of matrices in Emme to reflect roadway network changes)*. The existing roadway network would need to be augmented to reflect any proposed changes to facilities, such as capacity improvements, signalization. The changes to the roadway network would result in changes to auto travel times and distances.

In the second example, a major proposed development in an undeveloped portion of the area would affect the trip distribution, network travel times, and possibly modal shares if transit service was instituted as a part of the development. To estimate these changes with the model, the following inputs would be modified:

- *Socioeconomic data (TAZ.csv file)*. The proposed development would be represented by adding the equivalent number of households and/or employment by type for the applicable TAZ(s). This would increase the attractiveness of the TAZ(s), which would increase the number of trips destined to the TAZ(s).

- *Auto travel time and distance matrices (regeneration of matrices in Emme to reflect roadway network changes)*. Because the proposed development is located in an undeveloped portion of the area, the existing roadway network would need to be augmented to reflect the proposed facilities. The changes to the roadway network would result in changes to auto travel times and distances.
- *Number of intersections within ½-mile of TAZ centroid ("intersections" column of the TAZ.csv file)*. In addition to the new roadway network, some type of local street system would need to be assumed. The new roadway network and local street system would need to be reflected in the number of intersections within ½-mile of the TAZ centroids in the area of the proposed development.
- *Peak and off-peak household and employment transit coverage factors ("peakHhCov, offPeakHhCov, peakEmpCov, and offPeakCov"columns in TAZ.csv file)., regeneration of matrices to reflect transit improvements)*. Similar to the example above, these input data would need to be modified if new transit service was assumed for the proposed development. This would increase the number of transit trips to/from the area, generated by residents or attracted by employment.
- *Shopping center square footage (sqft.csv file)*. If the proposed development is a regionally significant shopping center (attracts more average weekday traffic than indicated by its employment alone), the amount of shopping center floorspace is used within the model to develop an estimate of retail employment for the shopping center TAZ; this estimate would be used if it was higher than the retail employment in the TAZ file (first bullet above). This would increase the attractiveness of the TAZ compared to using just the lower retail employment in the TAZ file (overrides the employment-only calculation of attractions noted above). A rough guide to which shopping areas to include, is if the center has over 350 employees or 50,000 sqft of retail space. All retail space in the zone should be included.
- *Long- and short-term parking costs ("shortTermParkingCost" and "longTermParkingCost" columns in the TAZ.csv file)*. Long-term and/or short-term parking cost estimates may need to be modified in the TAZ containing the proposed development. The number of trips destined for the proposed development TAZ would decrease if the parking costs were increased.

In the third example, the location of households closer to employment areas would be expected to decrease the total VMT in the region. This scenario would involve making changes to the following model inputs:

- *Socioeconomic data (TAZ.csv file).* Households and employment would be redistributed among TAZs to increase their proximity, while maintaining the same regional household and employment control totals. This would increase the number of shorter trips and decrease the number of longer Home-based work trips. (Changes to the trip length of other trip purposes would typically be less significant)

- *Peak and off-peak household and employment transit coverage factors ("peakHhCov, offPeakHhCov, peakEmpCov, and offPeakCov"columns in TAZ.csv file).* These inputs would be changed to reflect the different spatial distribution of development within the TAZs and changes in their proximity to transit services, with the redistribution of households and employment.
- *Auto travel time and distance matrices (regeneration of Emme matrices to reflect roadway network changes)*. These inputs would need to be changed if the centroids and/or centroid connectors for the TAZs with the redistributed households and employment were modified (e.g., to reflect improved accessibility to the transit network). This would also be done if any roadway network changes were made in association with the redistribution. Associated local street system changes would also need to be reflected in the input: "number of intersections within ½ mile of TAZ centroid,"
- *Transit impedance matrices (regeneration of Emme matrices to reflect transit accessibility changes)*. These inputs would need to be changed if the centroids and/or transit walk connectors for the TAZs with the redistributed households and employment were modified (e.g., to reflect improved accessibility to the transit network). This would also be done if any changes in transit service were made in association with the redistribution.

Additional information on model application procedures will be included in the next version of ODOT's *Travel Demand Model Development and Application Guidelines*.

3.3.2 Review of Model Parameter Settings

The preparation for a model run also includes reviewing and modifying as needed the values of the model parameters contained in the **settings.csv** file, which is stored in the inputs folder. This is a model setup file containing model constants (i.e., inputs that are not a table or matrix).

Most of the parameter values in the **settings.csv** file shown in Table 1 do not need to be changed. Values would typically only need to be changed under the following circumstances:

- Parameters defining the scenario to be analyzed - for example, if the effects of higher or lower fuel prices were being tested, the auto operating cost parameter value would be changed.
- Parameters defining characteristics that are specific to the model run, such as the user's initials or the number of the Emme scenario containing the transit network;
- Parameters defining characteristics that are specific to the model being run, such as calibration factors and use of non-standard Emme matrices; for these values (shown as "Varies by model" in Table 1), the user must refer to the applicable model development report.

Default values are provided for most parameters. Parameters that typically would not be changed are shown at the bottom of Table 1 and are shaded in gray.

Table 1: JEMnR settings.csv File

Setting	Description	Default Value
Initials	User initials	Varies by model
Project	JEMnR project name	Varies by model
Year	Model base year	Varies by model
peak_scen_num	Emme scenario number for peak hour	Varies by model
Dailyoffpeak_scen_num	Emme scenario number for daily	Varies by model
runReCalib		True/False
calibMC	Calibrate Mode Choice	True/False
addPopSyn		True/False
externalModelFromSWIM	Flag indicating whether SWIM data will be used in external model	True/False
runCommercialVehicleModel	Boolean flag to determine if the CVM is to be run	True/False
runSledge		True/False
runPeakOffPeakTransitAssignment	Run peak and off-peak period transit assignments (“T”); alternative is daily-only assignment	True/False
runUniversityModel	Flag indicating whether the university model should be run. True=run the model.	True/False
inputLoc	inputs/externalModel/	
SWIM_SL_Filename_Pattern	Pattern for filename on SWIM Select Link files input to external model	_outputs
storeLoc	inputs/externalModel/	
pumaFileName	File name for regional cross-tabulation of households by size, income, and age-of-head of-household	Varies by model
bankFolder	Subdirectory for Emme database and associated files within project directory	emme/database
macrosFolder	Directory for storing Emme macros	emme/macros
referenceRun	Location of a reference run to compare the current run scenario to. modelReport.R contains the code that produces the scenario comparison HTML report.	Varies by model
EMME_File	The EMME scenario file from which the peak mf* matrices are extracted from for use in the university model.	Varies by model
Emme_Python	Python needed to convert	Python26

Setting	Description	Default Value
	EMME outputs to ZMX format	
GNU_Tools	University model utilizes a tool provided by the GNU free software foundation to redirect, or "pipe", output from a DOS process (specifically Java) to a text file.	tee.exe
Java	64 bit Java 7 (JRE or JDK) used by the university model	"C:/Program Files/Java/jdk1.7.0_25"
maxIter_Commercial	Maximum number of balancing iterations performed during the commercial vehicle model run.	5
externalDisaggregateMethodNumber	External Disaggregate Method Number	4
bikeSpeed	Assumed bike speed (mph)	10
drivePass_pass_extra_auto_walk_time	Additional out-of-vehicle time for drive-with-passenger and passenger modes (mins.)	1
externalStationAutoWalkTime	Auto out-of-vehicle time for external stations	1
maxBikeDistance	Maximum bike distance for bike mode (miles)	10
maxWalkDistance	Maximum walk distance for walk mode (miles)	5
opwaitTimeACap	Maximum initial wait time for bus mode - off-peak period (mins.)	30
opwaitTimeBCap	Maximum transfer time for bus mode - off-peak period (mins.)	30
opwalkTimeCap	Maximum walk time for bus mode - off-peak period (mins.)	30
percentDriveForParkAndRideCost	Factor to calculate P&R travel time cost as share of Auto Operating Cost	0.25
pkwaitTimeACap	Maximum initial wait time for bus mode - peak period (mins.)	30
pkwaitTimeBCap	Maximum transfer time for bus mode - peak period (mins.)	30
pkwalkTimeCap	Maximum walk time for bus mode - peak period (mins.)	30
walkSpeed	Assumed walk speed (mph)	3
walkTimepeakparkAndRideBusCap	Maximum walk time park-and-ride mode (mins.)	30
absTTChange	Convergence criteria for travel time feedback loop – absolute change in travel time between	0.01

Setting	Description	Default Value
	successive iterations (mins)	
maxIter	Convergence criteria for travel time feedback loop – Maximum iterations	10
maxRMSE	Convergence criteria for travel time feedback loop –% Root Mean Square Error in travel time between successive feedback iterations	1
pkTimeOldPercent	Factor to calculate first iteration travel as share of Drive Alone IVTT	0.9
Universityiterations		1
universitySampleRate	Sample rate to be used in the university model.	1
UnivJEMNREmpFact	Used to factor employment above or below the ratio of houses in the NonUniversity population to all houses	1
vacancyRate	Vacancy rate for visitor lodgings	Varies by model
IZFactA	Intra-zonal factor for auto	0.75
IZFactB	Intra-zonal factor for bike	0.60
IZFactW	Intra-zonal factor for walk	0.50
hbcollPeakFactor	Input peak factor for hbcoll used to weight peak versus off peak variables in utilities and to split trips by period in mode choice model.	0.407
hboPeakFactor	Input peak factor for hbo used to weight peak versus off peak variables in utilities and to split trips by period in mode choice model.	0.377
hbrPeakFactor	Factors used to boost trips or employment in hbr generation	0.309
hbsPeakFactor	Factors used to boost trips or employment in hbs generation.	0.3
hbwPeakFactor	Factors used to boost trips or employment in hbw generation.	0.606
nhbwPeakFactor	Input peak factor for nhbw used to weight peak versus off peak variables in utilities and to split trips by period in mode choice model.	0.382
nhbnwPeakFactor	Input peak factor for nhbnw used to weight peak versus off peak variables in utilities and to split trips by period in mode choice	0.331

Setting	Description	Default Value
	model.	
hbwTotalEmploymentCalibrationFactor	HBW trip production model calibration factor	Varies by model
nhbwTotalEmploymentCalibrationFactor	NHBW trip production model calibration factor	Varies by model
hbcollTripProdCalibrationFactor	HBcoll trip production model calibration factor	Varies by model
hbsroTripProdCalibrationFactor	Home-based (shop, recreation, other) trip production model calibration factor	Varies by model
nhbnwTripProdCalibrationFactor	NHBNW trip production model calibration factor	Varies by model
hbsroVisitorCalibrationFactor	Home-based (shop, recreation, other) Visitor trip production rate calibration factor	Varies by model
nhbnwVisitorCalibrationFactor	NHBNW Visitor trip production rate calibration factor	Varies by model
scalingFactors_hbo	HBoth trip distribution model scaling factor	Varies by model
scalingFactors_hbr	HBrec trip distribution model scaling factor	Varies by model
scalingFactors_hbs	HBshop trip distribution model scaling factor	Varies by model
scalingFactors_hbwhighInc	HBW trip distribution model scaling factor – high income	Varies by model
scalingFactors_hbwmidInc	HBW trip distribution model scaling factor- middle income	Varies by model
scalingFactors_hbwlowInc	HBW trip distribution model scaling factor – low income	Varies by model
scalingFactors_nhbw	NHBW trip distribution model scaling factor	Varies by model
scalingFactors_nhbnw	NHBNW trip distribution model scaling factor	Varies by model
autoOperCost	Auto operating cost (1995 dollars)[15]	0.091
Deflat	Deflates income from 2010 to 1995	0.7043
shopEmpFactor	Shopping center employee density factor	3
CVMFactor	Factor for total CVM trips	
transit_modes	Modes related to transit	bw,b,w
autoTimeoffPeak_matNum	Emme off-peak auto travel time matrix number	19
autoTimepeak_matNum	Emme peak auto travel time matrix number	20

[15] All cost variables within JEMnR are expressed in 1995 dollars, corresponding to the year of model estimation.

Setting	Description	Default Value
boardingsoffPeakbusWalk_matNum	Emme off-peak number of boarding matrix number	85
boardingspeakbusWalk_matNum	Emme peak number of boarding matrix number	85
dailybus_matNum	Emme daily bus person trip matrix number	2
dailyvehicle_matNum	Emme daily vehicle trip matrix number	3
ivTimeoffPeakbusWalk_matNum	Emme off-peak bus in-vehicle time matrix number	80
ivTimepeakbusWalk_matNum	Emme peak bus in-vehicle time matrix number	80
opadbus_matNum	Emme off-peak period bus person trip matrix number	6
pkadbus_matNum	Emme peak period (AM+PM) bus person trip matrix number	5
pm1vehicle_matNum	Emme PM peak hour vehicle trip matrix number	4
waitTimeAoffPeakbusWalk_matNum	Emme off-peak bus initial wait time matrix number	82
waitTimeApeakbusWalk_matNum	Emme peak bus initial wait time matrix number	82
waitTimeBoffPeakbusWalk_matNum	Emme off-peak bus transfer time matrix number	83
waitTimeBpeakbusWalk_matNum	Emme peak bus transfer time matrix number	83
walkTimeoffPeakbusWalk_matNum	Emme off-peak bus walk time matrix number	81
walkTimepeakbusWalk_matNum	Emme peak bus walk time matrix number	81
autoDistance_matNum	Emme auto distance matrix number	9
walkDistance_matNum	Emme walk distance matrix number	10
bikeDistance_matNum	Emme bike distance matrix number	11
tranDistance_matNum	Emme transit distance matrix number	12

3.4 Model Processing

Once the input files and settings.csv file have been prepared, model processing involves the application of the JEMnR modules within the R environment and performing trip assignments using the Emme software.

To apply the model, the user double-clicks on the R shortcut located in the project directory. This starts the R GUI, which opens up an R console where the user type commands and results can be reviewed and analyzed. The model is run in the R workspace that is opened with the R console from the shortcut. The Emme assignment routine is called by the R-script. An Emme key (and associated license) is required to be in place before the assignment step occurs.

3.4.1 Processing Flow

The following files control the processing of the model:

- runModel.R
- rcode/ModelModules.R
- functiontable.csv

The model application is initiated by clicking and dragging the **runModel.R** script file into the workspace that has been opened from the R shortcut. **runModel.R** executes the model within a feedback loop in which the travel times from the previous iteration are compared to those from the current iteration. If the times differ by greater than a specified amount, the model is run for another iteration, up to a default limit of 10 iterations or as specified by the user. Prior to the first iteration, **runModel.R** also reads-in and stores the parameter values in the **settings.csv** file.

To start the first/next iteration of JEMnR, **runModel.R** automatically loads the **ModelModules.R** script into the workspace. **ModelModules.R** controls the model run in the following steps:

- Sets the location of the rcode folder containing the R scripts for the individual JEMnR modules.
- Reads the **functiontable.csv** file (see below).
- Loads the function files referenced in the **functiontable.csv** file.
- Attaches a set of JEMnR-specific functions to the workspace (referenced in functiontable.csv).
- Runs inputCheck_V4.R for the 1st iteration to check for errors in the TAZ.csv inputs.
- Loads the model inputs and produces R file versions of the inputs that are stored in the “rdata” subfolder (created within the inputs folder).
- Runs the JEMnR submodules.

The **functiontable.csv** file comprises a list of paths and file names for the files containing the functions for all of the JEMnR submodules. This includes a number of common utility functions used in the submodules for purposes such as reading in coefficient values and summarizing arrays by a specified dimension. It also includes the functions used to implement the models within the submodules. The utility functions read in via the

functiontable.csv file are attached to the R workspace. This allows the functions to be called directly by the submodules.

Following completion of a model run iteration, **runModel.R** writes the transit and auto trip matrices produced in the run to the Emme database.[16] JEMnR calls a set of Emme macros which adjust the PM peak hour auto trip matrix and performs auto and transit assignments (daily and others as specified in settings.csv, per note in Table 1) to generate the travel time matrices used as input for the next iteration. A description of the auto trip matrix adjustment procedure is provided in Section 6 (Trip Assignment).

runModel.R then compares the travel times from the current iteration to the times from the previous iteration. If the convergence criteria (AbsTTChange, maxRMSE or maxIter as specified in settings.csv) are not met, the processing returns to the top of the loop and another iteration is initiated. If any one of the criteria is met, the processing terminates.

3.4.2 JEMnR Objects

All of the inputs, variables, and outputs used in JEMnR processing are referred to as objects. During model processing, all of the required objects reside within the R workspace. Because of RAM limitations, all of the JEMnR objects cannot exist in the R work space at the same time. Therefore, at each step, the objects are written out as Rdata files to the project folder and then read back into the work space when needed.

Specific conventions are followed within JEMnR for object naming. Having an understanding of these conventions is important in recognizing the contents of the various JEMnR objects by the object name.

Object names generally start with a lower case letter. Abbreviations are avoided unless the word or phrase used within the name is too long. For example, "mc" is used for "mode choice" and "hbw" is used for "home-based work". Some object names comprise multiple words. If this true, the words are concatenated and intercapping is used to distinguish the words, rather than dots or underscore marks. For example, the name "hbwTripProdAry" stands for "home-based work trip production array".

Common terms are used within the object names. Some of examples of these keywords are listed below.

[16] Optionally, the matrices can be output as Emme batchout files in ASCII text format, which JEMnR then reads into the Emme database. This option is controlled using the "binaryMatrices" parameter in the **settings.csv** file.

Table 2: JEMnR Object Name Keywords

Keyword	Description
• hbw • hbs • hbr • hbo • nhbw • nhbnw • hbcoll • hbsch	• Home-based work trip purpose • Home-based shop trip purpose • Home-based recreational trip purpose • Home-based other trip purpose • Non-home-based work trip purpose • Non-home-based non-work trip purpose • Home-based college trip purpose • Home-based school trip purpose
• lowInc • midInc • highInc	• Low-income • Middle-income • High-income
util	Utility
logSum	Log sum
<purpose>Dist	Person trip distribution by trip purpose
<purpose>TripProdAry	Trip production array by trip purpose
pandr	Park-and-ride
<purpose>PeakFactor	Peak factors by trip purpose for percent of trips occurring within peak period
<employment category>Emp	Employment by category
remainingEmp	Remaining employment
collAttr	College vehicle trip attractions

3.4.3 Processing Errors

Processing errors are generally not a significant issue when running JEMnR because the R script files have been extensively debugged. Errors may occur, however, particularly with initial model runs for new installations of JEMnR.

To identify where the problem is occurring, it is helpful to run the model incrementally by copying sections of the runModel.R and ModelModules.R run files into the R workspace one-by-one rather than attempting to run the model in a single pass. If this is done and the problem still can't be identified, then portions of the R code for individual JEMnR submodules (rcode directory) can be copied into the workspace and run in smaller and smaller increments until the problem is isolated.

Once the problem has been located, the cause of the problem is not always obvious from the error message generated by R. For help in interpreting common error messages when running JEMnR, a list of frequently encountered errors is contained in Appendix C. Other useful resources on R error messages and the R language in general can be found at:

- http://www.r-project.org/
- http://www.burns-stat.com/

If the problem still cannot be resolved using these sources of information, the TPAU staff person responsible for the model should be contacted.

3.4.4 Reasonableness Checking of Model Outputs

It is important to perform reasonableness checks of the model output at several key points in the model application process prior to trip assignment so that potential errors can be detected as soon as possible.

3.5 Structure of Outputs

Nearly all of the outputs produced by the JEMnR modules are in the form of an array. An array in R can have one, two, or more dimensions. A one-dimensional array is a vector. Socioeconomic data such as the number of households and employment by type are stored as vectors in JEMnR, in which the single dimension is the TAZ. A two-dimensional array is a matrix. TAZ-to-TAZ data such as travel times and trips are stored as matrices in JEMnR, in which the first dimension is the "from" TAZ and the second dimension is the "to" TAZ. Larger-dimensioned arrays in JEMnR include the trip production arrays output by the trip generation submodule, which are dimensioned by TAZ and the following household characteristics:

- Number of workers
- Household size
- Household income
- Age-of-head-of-household
- Number of autos owned

A listing of the output files by submodule is given in Table 3. Additional information on the outputs is presented in Appendix A – JEMnR Submodules.

Table 3: JEMnR Submodule Output Files

Submodule	Output File Name
Pre-Generation (/pregen/)	
Access	mixrhm.RData, mixthm.RData, tot30t.RData
Whia (workers)	whiazAry.RData
Chwi (Cars)	whiazcAry.RData, cvalIndexAry.RData, cvalAry.RData
Khia (Kids)	khiazAry.RData
Visitor	visitorWhiazcAry.RData

Table 3 (cont.): JEMnR Submodule Output Files

Submodule	Output File Name
Trip Generation (/trigen/)	
hbwGen, hbsroGen[17], nhbGen, hbcollGen, hbschGen	<purpose>TripProdAry.RData, where:<purpose> is one of the trip purposes – hbw, hbs, hbr, hbo, nhbw, nhbnw, hbcoll, or hbsch and <purpose>Attractions, where: <purpose> is either the hbw or hbcoll trip purpose
hbschGen	SchTripsByZone.RData
Multi-Modal Accessibility (/access/)	
accessUtilities	util<mode><income><purpose>.RData, where: • <mode> is one of the modes in the modes object – driveAlone, drivePass, pass, busWalk, parkAndRideBus, bike, or walk; (not hbcoll, nhbw, nhbnw) • <income> is one of the income categories – lowInc, midInc, or highInc; and (hbo, hbr, hbs, hbw only) <purpose> is one of the trip purposes – hbw, hbs, hbr, hbo, nhbw, nhbnw, or hbcoll (not hbsch)
accessLogSum	logSum<purpose>.RData, where: <purpose> is one of the trip purposes – hbw, hbs, hbr, hbo, nhbw, nhbnw, or hbcoll (not hbsch)
Trip Distribution (/tripdist/)	
tripDistribution	<purpose><income>Dist.RData, where: • <purpose> is one of the trip purposes – hbw, hbs, hbr, hbo, nhbw, nhbnw, or hbcoll; (not hbsch) and <income> is one of the income categories – lowInc, midInc, or highInc
balanceDist	<purpose><income>Dist.RData, where: • <purpose> is either the hbw or hbcoll trip purpose; and <income> is one of the income categories – lowInc, midInc, or highInc
hbschDistByType	hbschDist.Rdata
tripDistribution	<purpose>dist.rpt (no hbsch) (includes breakout by income in file)

[17] 'hbsro' refers to the combined home-based purposes of shopping, recreation, and other.

Table 3 (cont.): JEMnR Submodule Output Files

Submodule	Output File Name
Mode Choice (/modec/common + modec/<purpose>/<income>)	
modeChoiceCommon	util<mode><income><purpose><period>.RData, where: • <mode> is one of the modes in the modes object – driveAlone, drivePass, pass, busWalk, parkAndRideBus (no hbcoll, nhbw, nhbnw), bike, or walk(no income breakout); • <income> is one of the income categories – lowInc, midInc, or highInc • <purpose> is one of the trip purposes – hbw, hbs, hbr, hbo, nhbw, nhbnw, or hbcoll (no hbsch); and • <period> is either hMc.rptpeak or offPeak
hbschMcByType	trips.RData and hbschMc.rpt
processSegmentUtils	marketUtil.RData for each trip purpose
calcTripsByMode	<period>Trips.RData for each trip purpose (except hbsch) and income category, where: • <period> is either peak or offPeak
Peaking and Demand (/peaking/<purpose>))	
Peaking	<demand period><class>.RData, where: • <demand period> is one of the periods for either the vehicle or bus class period factors • <class> is either the vehicle or bus class
pandrPeaking	<demand period>pandrBusVehicle.RData and <demand period>pandrBusTransit.RData, where: • <demand period> is one of the periods for the pandrBus class period factors
collapseTables	<class>.RData for each trip purpose, where: • <class> is one of the classes in the modes object – vehicle, bus, pandrBus, or other
allocateParkAndRide	pandrBusVehicle.RData and pandrBusTransit.RData
externalModel	SCEN_ExtModelRef_BRMPO_2009_outputs.RData, externalOD_ZnZnTdMd.RData
addExternals	<demand period>vehicle.RData, where: • <demand period> is one of the periods for the vehicle class period factors

3.6 Reasonableness Checks

Depending on the type of application, checks of the JEMnR output should be performed following the execution of the trip generation, trip distribution, mode choice, and peaking and demand matrices modules. All of the checks involve the comparison of the model output from a scenario to the output for a reference scenario, to determine if the differences are consistent with the expected levels of change. Because in most instances the models are applied for future year scenarios, the reference scenario is often the future "No-Build" alternative.

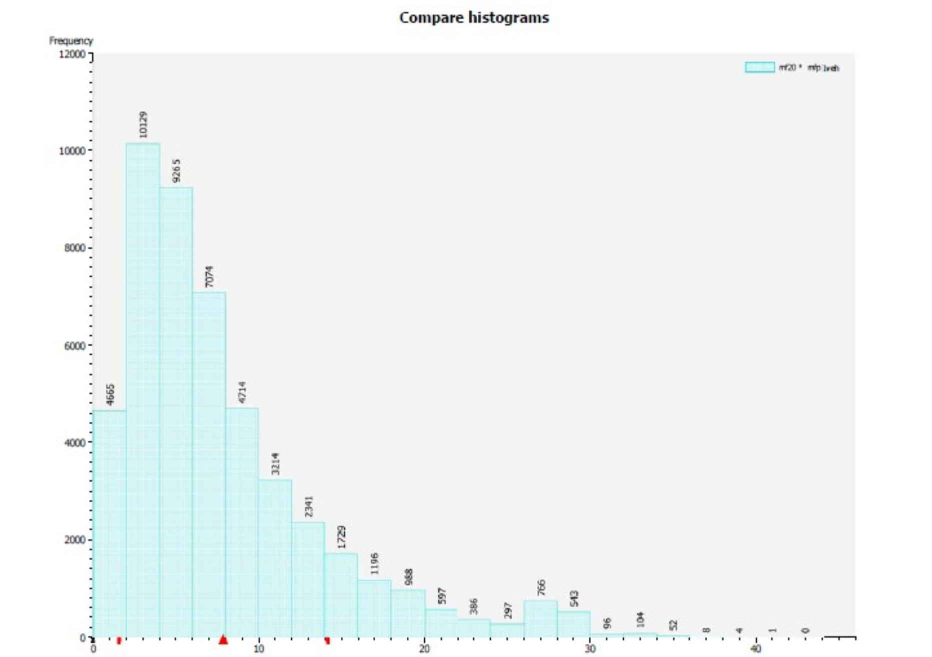
3.6.1 Trip Generation Checks

For the trip generation module, **trip productions per household** should be checked if a change has been made to the total households for a zone or subset of zones. This value should be similar to the trip productions per household for the same zones prior to the change or similar zones if there were no households previously. Significant differences could indicate that the number of households was miscoded or the household distribution data items (cross-tabulation shares by income, size, and age-of-head of household) were omitted or incorrect for the zones in the TAZ.csv file.

3.6.2 Trip Distribution Checks

Several checks can be performed to verify the reasonableness of the model's trip distribution estimates in response to changes in land use or network assumptions. The first check is to produce **trip length frequency distributions** by trip purpose using both travel time (minutes) and distance (miles) as the unit of impedance. These distributions show the percentage of trips within each travel time or distance interval for all zones or a subset of zones. Differences in the distributions between the test scenario and reference scenario can indicate whether land use or network changes have been properly reflected by the model. For example, a land use scenario that shifts trip productions closer to trip attractions would be expected to shift the distribution of the hbw trips into the shorter travel time and distance intervals, resulting in a lower average travel time and distance.

Figure 3: JEMnR Travel Time Trip Length Frequency Distribution



A second trip distribution check is for **origin-destination patterns**, in which the volume and/or share of trips between districts is examined. Generally, this is applied for larger scale land use or network scenarios that may affect the regional distribution of travel. To apply this check, the modeling area is divided into districts and the number and share of trips between the districts is summarized in a table. An example of differences between origin-destination patterns would be the distribution of trips for a roadway capacity enhancement scenario compared to that for a transit-oriented scenario. The number of trips between widely separated districts would expected to be lower for the transit-oriented scenario compared to the capacity enhancement scenario because of longer transit travel times between these districts.

Another check on origin destination patterns is the **orientation ratio**. This measures the propensity of trips from a production area (or zone) to an attraction area and is defined as follows:

- The numerator is the trips to the attraction area from the production area divided by the sum of all trips to the attraction area; and
- The denominator is all trips from the production area divided by all trips in the region.

If, for example, there are 300 trips from District A to District B, and 800 total trips produced in District A, 100,000 total trips attracted to District B, and 750,000 total regional trips, the orientation ratio for District A to District B would be computed as:

$$(300/100{,}000) / (800/750{,}000) = 2.81$$

An orientation ratio with a value of less than 1.0 indicates that the production area is less oriented to the attraction district than the region as a whole. An example of this might be a low-income residential area located adjacent to a “tech center” area. Conversely, an orientation ratio with a value of greater than 1.0 indicates that the zone is more oriented to the attraction area than other zones in the region. The orientation ratio can be calculated at the zonal level or a mixed zonal and district level, as desired.[18]

A third type of check on the trip distribution results is the **number of destinations by trip purpose** for a zone or subset of zones. This check would be used to determine if the model has estimated a reasonable change in the attractiveness of an area based on different development assumptions or changes in accessibility to the area.

3.6.3 Mode Choice Checks

Shifts in **modal shares** may occur as a result of land use or network changes. A densification of development or increase in the mix of land uses may cause more trips to be made via the walk, bicycle, or transit modes. Increased transit service in the form of higher service frequencies or expanded service coverage would be expected to produce an increase in the transit mode share. Comparison of the mode shares for the areas affected by these changes to the modes shares in the reference scenario would indicate whether the expected mode shifts have been reasonably estimated by the model.

3.6.4 Demand Matrix Checks

The trip matrices output by the last JEMnR module, the **peaking and demand matrices** module, should be checked if adjustments have been made to the number of I-E/E-I trip ends or the E-E trip matrix. The relative change in these trips should be compared to that for the internal-internal trips. If significant differences are found, these should be explainable based on the adjustments that were made.

[18] Travel Model Improvement Program, Travel Model Validation and Reasonableness Checking Manual, Second Edition, (2010).

3.7 Documentation of Model Run

The final step in model application is to document the application process, including such information as input data preparation, network changes, if any, and a summary of the application results.

4. NETWORK CODING

JEMnR uses Emme4 for the assignment of trips to networks, and for user analysis of model result. Since network coding, a critical model input, is performed in Emme, this overview summarizes Emme attributes and terms. Further detail can be found in the *Emme Prompt Manual*:[19]

4.1 Overview

An Emme network corresponds to a scenario in an Emme database. A network comprises network elements, an attribute list for each element type, and auxiliary data, such as titles. The network structure includes the *mode, node, link, transit vehicle, transit line, transit segment,* and *turn* elements. Matrix-related data are also considered part of the network in Emme. These include the *zone, origin, destination*, and *O-D pair* network element types.

Modes define which types of vehicles are allowed on a link. There are four types of modes: auto, transit, auxiliary auto, and auxiliary transit. The auto mode represents private vehicles. The transit mode represents transit vehicles such as buses, light-rail, and subways. User-defined classes such as trucks and high-occupancy vehicles are reflected by the auxiliary auto mode. The auxiliary transit mode is used to model access to and from transit lines and transfers between lines that do not stop at the same node.

Nodes are divided into centroids and regular nodes. Regular nodes may correspond to an intersection or transit stop. A centroid represents the activity center of a TAZ.

All *links* in Emme are directional and are used by one or more modes.

Transit vehicles are vehicles or combinations of vehicles used by a transit line. Examples of vehicles are regular or articulated buses and trains consisting of several cars. A vehicle type is associated with only one mode.

A *transit line* corresponds to a regular transit service (fixed frequency and fixed travel times) on a fixed itinerary. The itinerary is defined as a sequence of *transit segments*, with each segment corresponding to a link in the base network.

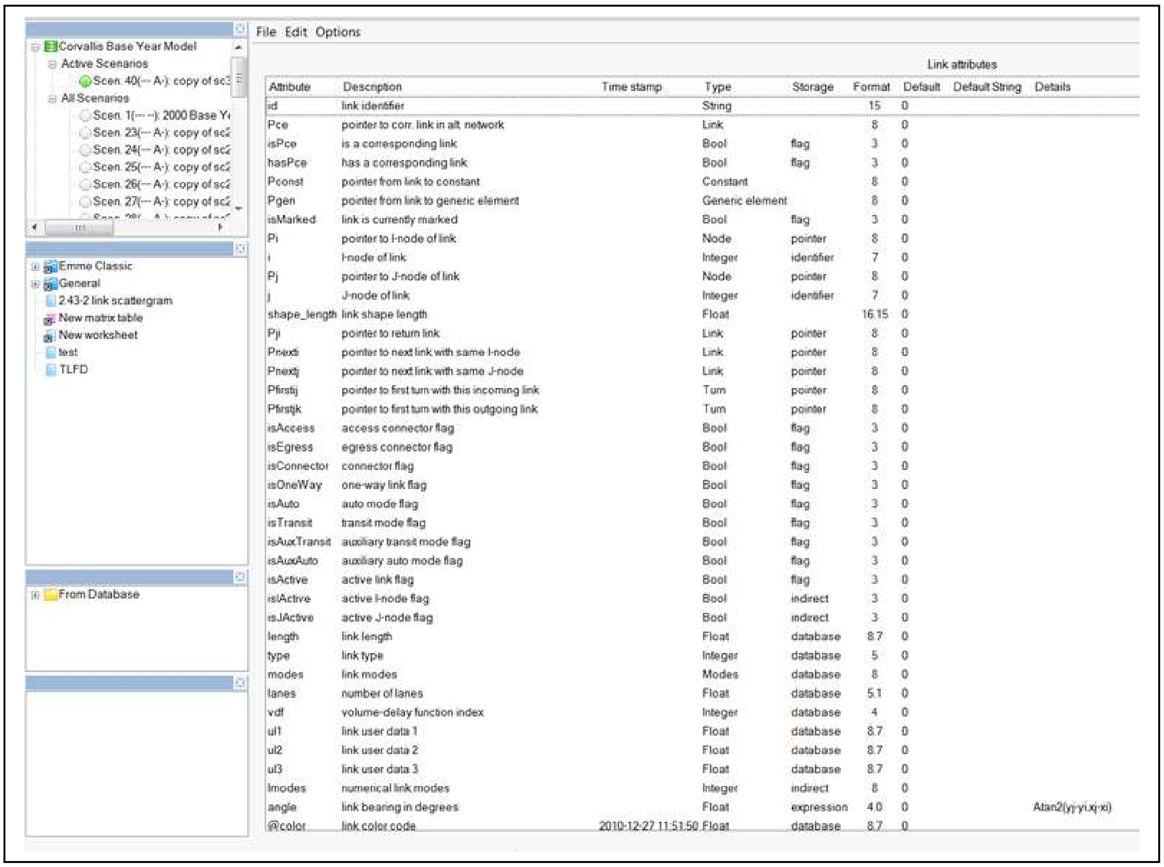
Turns are considered at intersection nodes. A turn is a node triplet, *JIK,* that defines a turning movement at an intersection, where *J* is the intersection node, *IJ* is the first (incoming) link of the turn and *JK* is the second (outgoing) link of the turn.

[19] Inro, Emme Prompt Manual, (2011).

The *zones, origins, destinations*, and *O-D pairs* elements are associated with the matrix data in the model. *Zones* form the basis of the origin and destination vectors and full matrices that are used to store the input and output data for the demand models. The *origin* element consists of attributes related to the origin end of the trip, while the *destination* element contains destination attributes. *O-D pairs* include attributes related to travel between the zones.

An attribute list is stored within the database for each element. An example attribute list for network *links* is shown below.

Figure 4: Emme Link Attribute Listing



4.2 Network Coding in Emme

Network coding in Emme can be performed using the *Network Editor* or the Emme Prompt. The *Network Editor* is a special worksheet allowing the interactive modification of all network elements in the primary scenario. The Emme Prompt is a command-line interface that provides access to the core Emme modules. Because the *Network Editor* is generally more efficient to use for most network coding tasks, the procedures for the

Network Editor are described within this section. Additional information on the Emme Prompt can be found in the *Emme Prompt Manual* and *Emme^3 Desktop Manual*.[20]

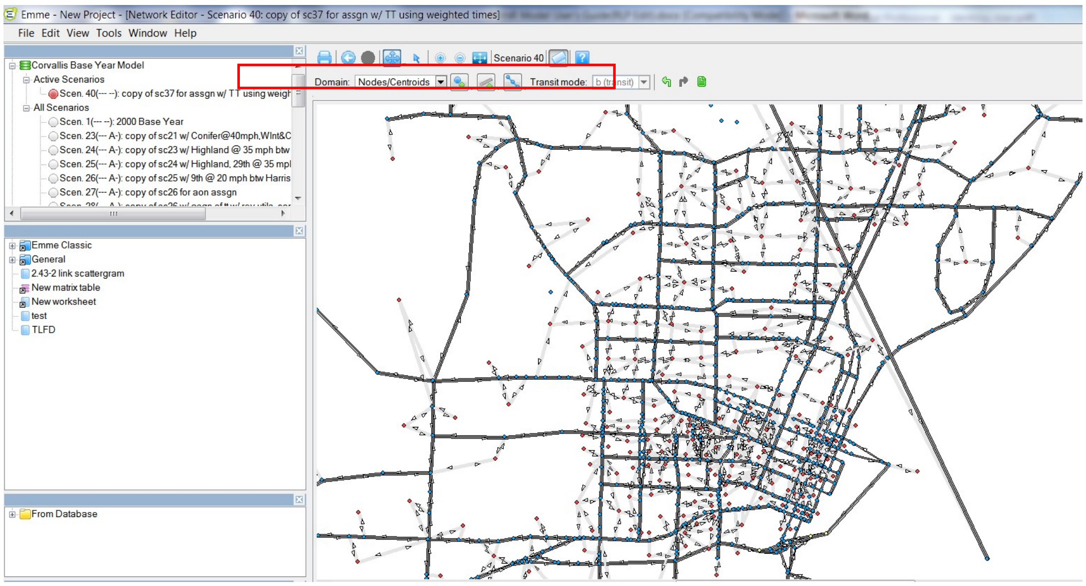
When opening the Emme desktop, the center view shows the model network. To the right hand side of the screen is a "layers" control panel which controls the "view" panel along with symbol graphics and filters. The table at the bottom lists the attributes of the active domain, used in selecting and editing.

The *Network Editor* is opened from the Emme desktop by selecting *Tools → Network Editor* on the Menu bar or right-clicking on the primary scenario within the scenario listing and selecting *Network Editor* from the context menu. It contains the following tools:

- Domain selection – a drop-down menu for the selection of the network element to be edited. Alternatively, the domain can be selected by clicking on the appropriate tab below the domain table at the bottom of the worksheet.
- Node edit tools – a drop-down menu for selection of node editing tasks (add or delete nodes or centroids).
- Link edit tools - a drop-down menu for selection of link editing tasks (add or delete links).
- Line edit tools - a drop-down menu for adding transit lines.
- Transit mode selection – a drop-down menu for adding, deleting, or modifying transit modes.
- Undo last edit button
- Redo last undo button
- Toggle on/off button for a window showing the history of all edit commands

[20] Inro, Emme Prompt Manual, (2011); Inro, Emme^3 Desktop Manual, (2011).

Figure 5: Emme Network Editor



Prior to editing, default values of the standard network attributes for nodes and centroids, links, and transit lines can be specified for use in adding these elements to the base network.[21] This is done using the element-specific *Default Attribute Values* window. To open the *Default Attribute Values* window:

- Open the *Edit → Default Attributes → Domain* menu and select a network domain (nodes/centroids, links, or transit lines); or
- From the editor worksheet toolbar, click the element button for the element that default attribute values are to be entered for and select *Element Defaults*

To enter a new default value, click on the attribute value and enter the new value. To have the *Network Editor* prompt for attribute values while adding network elements, toggle the *Prompt?* checkbox on.

The following sections summarize information contained in the *Emme[3] Desktop Manual*[22] for step-by-step editing of the network elements. For additional details, the manual can be accessed via the help button in the Emme Desktop.

> *Note to reader: With the upgrade to Emme 4.3, it is now required to save the scenario, separately, before exiting Network Editor.*

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[21] In Emme, the term "base network" is defined as a set of nodes connected to each other by directional links of one or more modes.
[22] Inro, Emme[3] Desktop Manual, (2011).

4.3 Base (Roadway) Network Editing

As defined above, a base network includes the modes element. Modes would typically not be edited by the model user; however, mode editing is included here for the reader's information. Also, although turns are technically not a part of the base network, turn editing is also discussed in this section.

4.3.1 Nodes/Centroids

1. Select *Nodes/Centroids* in the **Domain** drop-down list of the worksheet toolbar or click the *nodes* tab at the bottom of the worksheet to make the node table active.
2. To add a new node, press the **Add Nodes** tool; to add a new centroid, press the **Add Centroids** tool. Position the cursor at the desired position and click. Either provide the requested attributes for the point, or if prompted specify if default attribute values are to be set. If specified, the *Default attribute values* window is opened. For each attribute, specify the default value and whether attribute values are to be prompted for when nodes are added.
3. To delete a node/centroid, press the **Delete Nodes** tool and select the nodes to be deleted.
4. To modify node attributes, select the node in the table or press the pointer tool and select the node on the map; double-click a cell in the table and enter the new value.
5. To change the properties of the node display, expand the *Nodes* layer in the layer controls panel (on the right):
    - **Filter:** restrict the nodes shown. The node table filter is synchronized automatically (at the bottom of the central Network Editor window).
    - **Symbol:** choose the symbol used to show nodes.
    - **Nodes:** change the properties of the style used for coloring nodes; the default is the first color for regular nodes, the second color for centroids, and the third color for intersections. Also allows you to display conditions specified in the index field.
    - **Index:** specify an expression for the nodes style index (immediately above). The 'which (A,B,C,…)' command is useful where A,B, and C represent true-false element conditions where the style 1, 2, or 3 will be displayed.
    - **Select:** change the properties of the style used for the selected nodes.
    - **Select width:** change the size of the symbol for the selected nodes.
    - **Node numbers:** toggle the display of node numbers.
    - **Node labels:** toggle the display of node labels.
    - **Text size:** specify the text size of the node numbers.

4.3.2 Links

1. Select *Links* in the **Domain** drop-down list of the worksheet toolbar or click the *links* tab at the bottom of the worksheet to make the link table active.
2. To add a new link, press the **Add Links** tool; select the start node, move the cursor to the end node and click. To chain another link, click on the next end node (the previous end node is now the start node); click anywhere in the background to stop link chaining.
3. To specify default link attribute values or user prompting for attribute values when links are added, use **Link Defaults**.
4. To delete a link, press the **Delete Links** tool and select the links to be deleted.
5. To modify link attributes, select the link in the table or press the pointer tool and select the link on the map; double-click a cell in the table and enter the new value.
6. To change the properties of the link display, expand the *Links* layer in the layer controls pane:
    - **Filter:** restrict the links shown. The link table filter (bottom of page) is synchronized automatically.
    - **Offset:** specify the link offset (in pixels).
    - **Links:** change the properties of the style used to display links (display conditions are specified in the index field).
    - **Index:** specify the expression for the link style index.
    - **Select:** change the properties of the style used for the selected links.
    - **Select width:** change the size of the bars used to show the selected links.
    - **Link value:** specify up to 12 link values to be displayed as text on links, separated by commas (for stacked display).
    - **Text size:** change the text size of the link value(s) displayed on links.
    - **Decimals:** change the number of decimals for the link value(s) displayed on links.
    - **Link arrows:** draw an arrow showing the direction of the link. The size of the arrow is proportional to the link offset.
    - **Link shape vertices:** draw a diamond at each link shape vertex.

4.3.3 Modes

Note to reader: While there is no need for editing the modes in the MPO models, general information on mode editing is presented here for completeness.

1. Select *Modes* in the **Domain** drop-down list of the worksheet toolbar or click the *modes* tab at the bottom of the worksheet to make the mode table active.

2. To create a new mode, press the **Add** button in the mode table. The *Create mode* window is opened. Specify the mode identifier (one letter), mode description (maximum of 10 characters) and mode type.
3. To delete a mode, select the mode in the table and press **Delete**.
4. To modify mode attributes, select the mode in the table, double-click a cell and enter the new value.

4.3.4 Turns

1. Select *Turns* in the **Domain** drop-down list of the worksheet toolbar or click the *turns* tab at the bottom of the worksheet to make the turn table active.
2. To create an intersection, press the pointer tool, move the cursor on the desired regular node, right-click and select **Create intersection** from the context menu.
3. To delete an intersection, move the pointer on the desired intersection node, right-click and select **Delete intersection** from the context menu.
4. To modify turn attributes, move the pointer to the desired intersection node and click to select. The table will show the turns for the selected intersection node only
(j = =*node number*):
    - To zoom to the intersection node, select **Zoom to intersection** from the context menu. The default is for non-penalized turns to be shown in green, prohibited turns are shown with a dotted line, and penalized turns are shown in blue.
    - Select a turn in the table: the turn is highlighted in red.
    - Double-click a cell in the table and enter the new value. The attribute *tpf* refers to the *turn penalty* function index.
5. To change the properties of the intersection node display, expand the *Intersections* layer in the layer controls pane:
    - **Filter:** restrict the number of intersections displayed. The default is all intersections.
    - **Turns:** change the style used to display turns.
    - **Highlight:** change the style used for highlighting intersection nodes.
    - **Diameter:** specify the maximum intersection diameter (in pixels).
    - **Linear part:** specify the portion of the diameter used for the linear part of spline turns.
    - **Turn offset:** specify the turn offset (in pixels). This is useful for identifying U-turns.
    - **Arrow width:** width of the turn arrows (in pixels).
    - **Arrow height:** height of the turn arrows (in pixels).

- **Turn arrows:** draw an arrow at the beginning and end of each turn.
- **Automatic sizing:** for reducing the size of an intersection to avoid overlap with neighboring nodes.

4.4 Transit Network Editing

The transit network includes transit lines, vehicles, and transit modes. Although transit modes would typically not be edited by the user, the procedures are the same as those for general mode editing listed above.

4.4.1 Transit Lines

1. Select *Transit lines* in the **Domain** drop-down list of the worksheet toolbar or click the *transit lines* tab at the bottom of the worksheet to make the transit domain active.
2. Select the transit mode of interest from the *Transit mode* widget of the worksheet toolbar (currently for the MPO models, the only transit mode is “b” for bus):
   - Links that do not allow for this mode are displayed using index 1 of the *Links* style.
   - Transit lines of the specified mode are colored according to the Index expression in the *Transit lines* layer controls.
3. To add a transit line, set the line attribute default values if needed and then press the **Add Transit Line** tool - the *New transit line attribute* window is opened. Enter the line name and description and any transit line attribute for which user prompting was requested. Finally, specify the itinerary:
   - Click on a node indicating the beginning of the line.
   - Move the cursor over another node - the shortest path between the last selected node and the current node is displayed; click to select the new node.
   - Double-click to define the end of the line.
4. To select a line, click the row in the table or press the pointer tool; click a link and select the line from the context menu - the line itinerary is displayed when the mouse hovers on the line name. When a line is selected, right-click on the map plane to choose the action from the context menu:
   - Modify (itinerary)
   - Duplicate Itinerary
   - Add Reverse Itinerary
   - Remove
5. To change the display properties of the transit lines, expand the *Transit lines* layer in the layer controls pane:

- **Line filter:** restrict the number of lines displayed – the default is all lines of the selected transit mode. The line table filter (bottom of page) is synchronized automatically.
- **Link filter:** define the part of the network that is of interest.
- **Line offset:** specify the distance between transit lines on the same link.
- **Lines:** change the properties of the style used to display the transit lines.
- **Index:** specify the line expression that applies to the Lines style tool.
- **Selected line:** change the style used to display the line that is selected.
- **Line ends:** mark the line ends and layovers of the selected line graphically.
- **Line stops:** show transit stops along the selected transit line as small circles.
- **Stop size:** specify the size of transit stops and layovers for the selected line.
- **Segment offset:** specify the distance between segments on the same link for the selected line.
- **New line:** change the properties of the style used to display the proposed itinerary while adding a transit line.
- **Width:** specify the width of the line used to display the proposed itinerary.

4.4.2 Transit Vehicles

Transit vehicles would not be modified for most model applications. This would only be done if a new vehicle type was being modeled, such as articulated buses or rail vehicles.

1. Select *Vehicles* in the **Domain** drop-down list of the worksheet toolbar or click the *transit vehicles* tab at the bottom of the worksheet to make the table active.
2. To create a new vehicle, press the **Add** button in the table. The *Create vehicle* window is opened. Specify the vehicle type, the vehicle description (maximum of 10 characters) and the mode to which the vehicle belongs.
3. To delete a vehicle, select the vehicle in the table and press **Delete**.
4. To modify the vehicle attributes, select the vehicle in the table, double-click a cell and enter the new value.

4.5 Network Coding Standards for MPO Models

4.5.1 Roadway Network Coding

The coded highway networks in the MPO models include all roads with a functional classification of minor collector or higher, as well as local roads that connect higher level facilities, subareas, or TAZs to the remainder of the network. ODOT's functional classification maps for local jurisdictions[23] are typically used as a guide for identifying these facilities.

Network coding modifications would be made to represent a future network change, such as a new roadway or a change in the features of an existing roadway. Depending on the type of change, this may require modifications to the network structure or the attributes of the network elements (nodes and links).

Network changes must always be considered within the context of the network that is being edited (the reference network) in order to maintain consistency and confidence in the model results. Therefore, it is essential that the user be familiar with the reference network and model development documentation in order to understand the network coding approach used.

4.5.2 Nodes/Centroids

Node modifications include adding a new node or deleting or changing the location of an existing node in the network. Before adding new nodes, the user should refer to the applicable model development report for information on the node numbering conventions used in the network.

When adding a regular node, an unused node number from the next unused node number range should be selected. For example, if the highest existing node number is 10947, then the node number for the new node should be 11000. If a new centroid is added, such as for zone disaggregation, it should be located at the estimated center of trip activity for the zone.

Depending on the model, the node user fields may have specific uses. The applicable model development report should be referred to for information on these uses.

4.5.3 Links

New links may need to be added or existing links modified or deleted from the network for an application.

The following attributes must be coded when adding links in an MPO model networks:

- Mode
- Type
- Length
- Lanes

[23] Or federal functional class http://www.oregon.gov/odot/td/tdata/pages/rics/functionalclassification.aspx

- Volume-delay function (VDF) code
- User data item 1 – free flow speed
- User data item 2 – lane capacity

To do this, it is generally a good practice to copy and paste the attributes from a similar, nearby link to the new link as a starting point. The specific characteristics of the new link can then be reflected by modifying the copied attributes.

A related method for copying network changes from one scenario to another is the generation of a **transcript file** when making the changes in the first scenario. This can be done by saving the network editing scripts into a file and then use the file in another scenario for repeating the network edits.

In the MPO model networks, the *mode* link attribute can be coded with the values “a” (auto), “b” (bus), or “w” (walk). The auto and bus modes are permitted on all regular (non-centroid connector) links. Centroid connectors are coded with the auto mode only or, for connectors that are used for both auto access and walk access to transit, the auto and walk modes.

Link *type* is used to reflect the functional classification of a link or whether a link is a centroid connector. Functional classification is used as one of the determinants of link capacity, as well as for network reporting purposes. The applicable model development report should be referred to for information on the link type codes for the functional classifications.

The *length* of all links, except centroid connectors, is coded as the actual distance. The length of centroid connectors is coded as the Euclidean distance.

The *lanes* value is the number of <u>through</u> lanes in the direction of the link. It does not include two-way center turn lanes, if present. Within the VDFs, the number of lanes value is multiplied by the capacity per lane to derive total directional link capacity.

The *vdf* attribute is used as a look-up code for the VDF to be used in calculating link travel time. The applicable model development report should be referred to for a description of the functions associated with the codes.

Free flow speeds are stored in the link *user data item 1*. Posted speed limits are used as an approximation of the free-flow speed.[24]

Link *user data item 2* is used to store the lane capacity (vphpl). The capacities are obtained from a look-up table in which capacity values are defined by facility type/area type or facility type/speed. The capacity values for each model are defined in the model development reports.

[24] Free-flow speed is defined as the speed that a single vehicle would typically travel if it was unencumbered by surrounding traffic and obeyed all traffic control devices.

Adjustments to the speeds and capacities are not needed for most model applications. If, however, it is believed that adjustments are necessary due to special characteristics of the roadway or atypical traffic operating conditions, these should be discussed with the TPAU staff person responsible for the model prior to making the changes.

Other link data such as traffic counts can be stored in *user data item 3* or a predefined extra link attribute.

When adding or modifying links, the link geometry should be traced over background GIS maps of the roadway network. Shapefiles and ArcGIS maps such as Bing Maps and OpenStreetMap can be added to a worksheet in the Emme Desktop using the ArcGIS plug-in. Shapefiles must have the Oregon Geographic Information Council's (OGIC) Lambert projection.

Centroid connectors should be coded according to the following conventions:

- The connection points to the network should reflect realistic traffic loading points for as much of the zone as possible based on the distribution of development and configuration of the local street system within the TAZ.
- The use of network intersections as connection points should be avoided.
- The minimum number of connectors should be used, while maintaining a realistic representation of traffic loading.
- Centroid connectors should not cross zone boundaries (referred to as "tunneling").

Also, the location of centroid connectors must be revisited when changes to the local development pattern or local street network are assumed.

Mode code editing is not discussed here because this is not necessary for application of the MPO models.

Turns are coded in the MPO models to define prohibited intersection turning movements. **Turns penalty functions currently are not used for estimating intersection delay.** Intersections with turn prohibitions are listed in the applicable model development reports.

4.6 Roadway Network Validation

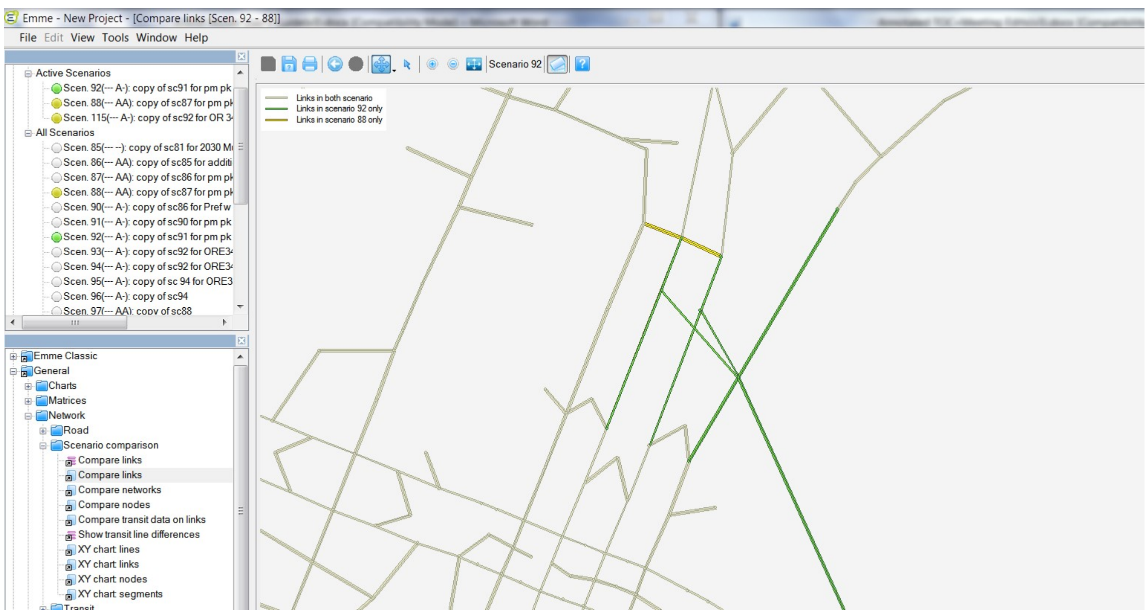
Checks should be performed to determine if the roadway network changes were properly coded. An initial check is to verify that the intended network changes were actually made by comparing the network topology and link attributes of the new scenario to those of the reference scenario.

1) Link expressions to compare scenarios

A useful mapping tool for doing validation in Emme is the *General->Network->Scenario comparison->Compare links* worksheet (worksheet/Table Explorer window). The scenarios compared are the first two scenarios in the *Active Scenarios* list. The topology of the links are compared by opening the *Link comparison* layer control in the worksheet:

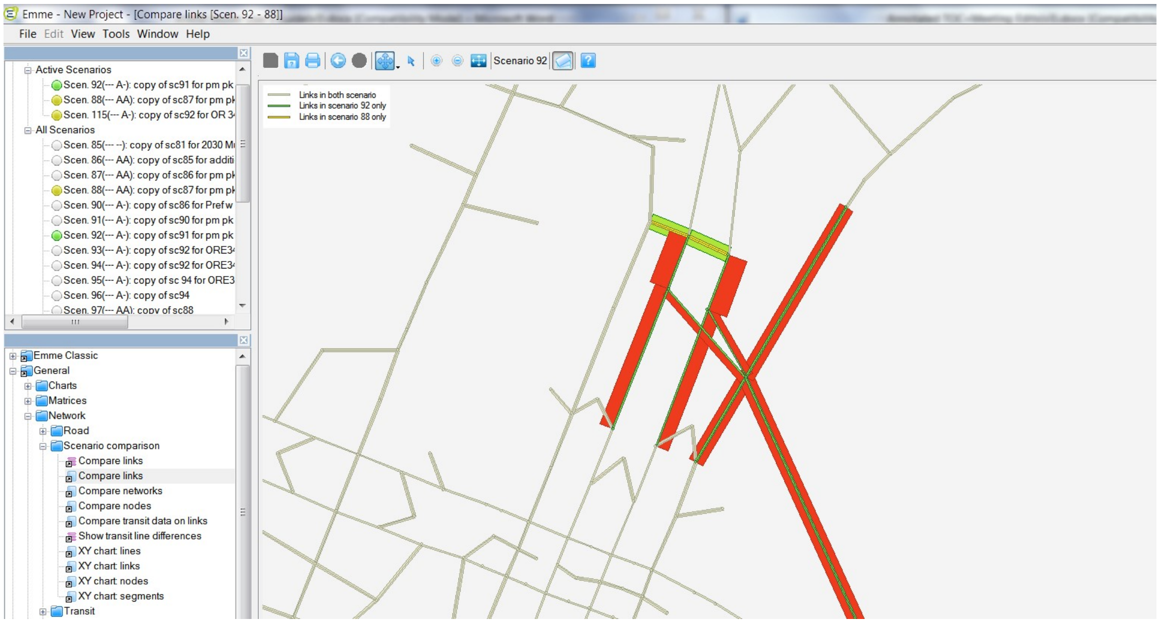
- Links defined in both scenarios are colored in yellow.
- Links defined in the first scenario but not in the second one are colored in orange.
- Links defined in the second scenario but not in the first one are colored in green.
- The default color scheme can be changed using the *Links* style.
- The comparison can be restricted to a subnetwork using the *Filter*.

Figure 6: Emme Comparison of Link Topology



In the example below, differences in the number of lanes are mapped. The *Link value* field is used to specify the link attribute to be compared. The desired expression can be entered in the field or the drop-down menu can be used to choose the link attribute.

Figure 7: Emme Comparison of Link Attributes



Nodes can be compared between scenarios using the *General->Network->Scenario comparison->Compare nodes* worksheet, which is very similar to the *Compare links* worksheet.

2) Network Checks using Validnet

The Emme "Validnet" macro is used for identifying the following coding inconsistencies:

- Dead-end links and unused nodes. Nodes with no links or only incoming or outgoing links and nodes connected to the network by a single two-way link are marked.
- Asymmetric link length on two-way links.
- Asymmetric link type on two-way links.
- Asymmetric number of lanes on two-way links.
- Asymmetric VDFs on two-way links.
- Links with a defined VDF but no lanes or auto mode.
- Links allowing the auto mode but without lanes or a defined VDF.
- Links with zero volume after the assignment of a full demand matrix. This could indicate links with incorrect attribute values, network connectivity problems, or links forming redundant loops.

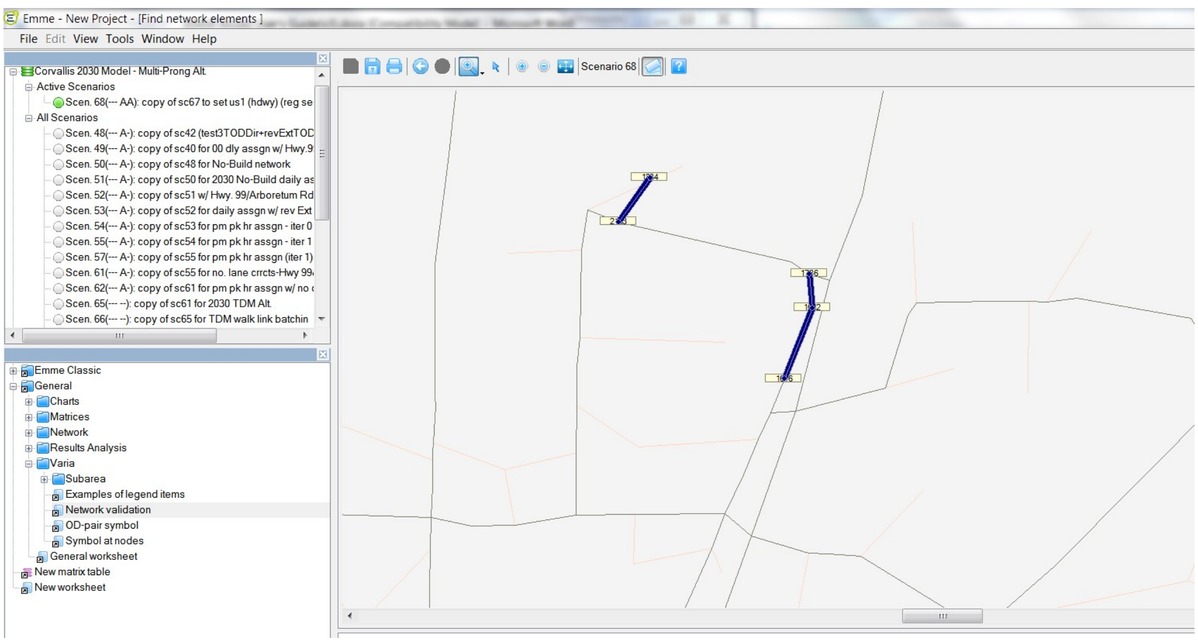
"Validnet" does not perform exhaustive testing, but constitutes a very fast and efficient tool for first level evaluations. It is applied within the Emme Prompt by issuing the command "~< Validnet.mac" from the command line at the main menu.

A worksheet version of "Validnet" is also available from the *General → Varius* folder of the *Worksheet/Table Explorer*. Within the *Network Validation* worksheet, elements with the same potential problems identified above can be listed, marked, and viewed from the links, nodes, and transit line tables that are docked within the worksheet. These elements are identified and displayed using predefined filters within each of the tables.

3) Network Checks through Filters

Alternately, user-defined filters may be entered to identify elements that may require validation. The example below shows two links identified with the *Network Validation* worksheet having inconsistent link lengths.

Figure 8: Emme Network Validation Worksheet



Application of the *Network Validation* worksheet consists of:

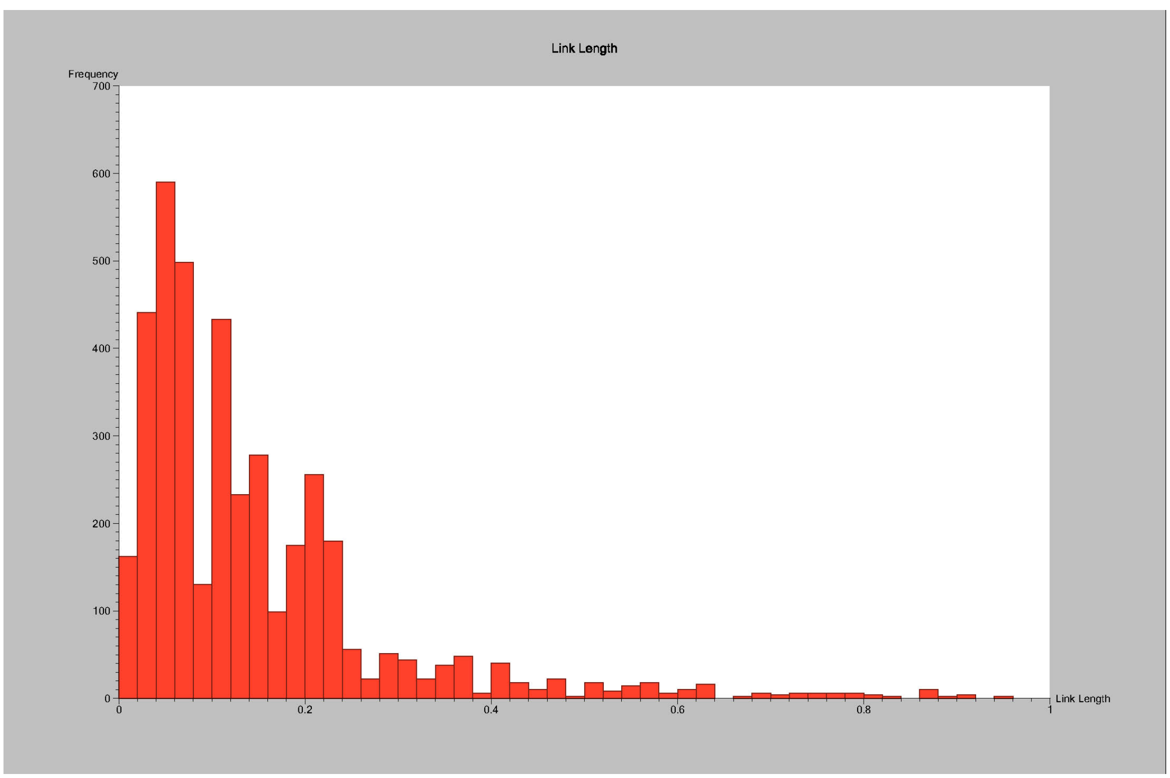
1. Selecting a table of elements at the bottom of the screen (links, nodes, or transit lines)
2. Selecting or defining a filter to be applied.[25]
3. Selecting the specific links or nodes to be filtered or transit lines to be displayed. All items can be selected by right-clicking in the table and choosing *Select All* from the context menu.
4. Marking the selected items, which will allow them to be displayed in the network window. Marked items will also be available in other worksheets, such as the

[25] No filters are available for transit lines.

Network Editor by using the "isMarked" flag in the filter expressions. Marked items can be unmarked using the *Reset marked elements* layer in the worksheet.

5. Displaying the selected items in the network window by right-clicking in the table and choosing *Change View to Selected Items* in the context menu. The style of the marked nodes, links, and transit lines can be modified in their corresponding layers.
6. Shortest Path Checks: An additional check that should be performed is to examine the shortest time and distance paths between nodes in the area of the network change to determine if there are erroneous link lengths or speeds or missing connections in the network. This can be done using Module 6.15 within the Emme Prompt or the *Emme Classic* worksheets found in the *Worksheets > Emme Classic > 6. Results > 6.15 Shortest path on auto network folder* of the *Worksheet/Table Explorer* window.
7. Link Attribute Checks: Link attribute values should be checked. This can be done visually for the specific links that have been changed or globally using the *General > Charts > Histograms > Histogram (matrix)* worksheet of the *Worksheet/Table Explorer* window. In the histogram, the attribute value is displayed on the horizontal axis, while the number of links of each type is shown on the vertical axis. Erroneous coding can be identified immediately by examining the range of attribute values on the horizontal axis.

Figure 9: Emme Link Attribute Histogram



4.7 Transit Network Coding

4.7.1 Transit Lines/Segments

A standard set of transit line attributes is used to describe the characteristics that apply to the entire line. Segment attributes are used to define the characteristics of transit lines that vary by line segment. As described in Table 4 below, specific conventions must be followed in coding several of the transit line/segment attributes.

Table 4: Emme Transit Line/Segment Attributes

Attribute	Description	Value	Notes
mode	Mode of line	b	Used for all lines.
veh	Vehicle type	1	Used for all lines.
headway	Vehicle headway	Actual headway	Used for information purposes only. "us1" attribute is used for effective headways (see below).
speed	Vehicle default speed	15	Used in place of transit time function.
dwt	Dwell time per line Segment	.01 if ttf =0,1 1.3 if ttf = 2	Dwell time is included in default speed.
ttfl	Transit time function number on links	1	Used for "dummy" line segments only (see below).
ttft	Transit time function number on turns	0	Used for "dummy" line segments only.
ttf	Transit time function number on links and turns	0 – Use default speed 1 – 1.11*Auto time 2 – 1.33*Auto time	Specify the transit travel time function to reflect the level of roadway congestion on transit travel times. Usually it is set to 1 – for Interstate and State Highways 2 – for all other facility types Set to zero if default speed is to be used.
us1	Segment user data 1	.01 or actual headway	.01 used for "dummy" line segments only.
lay	Layover time	0	Layover time is included in default speed.

As shown in Table 4, the *us1* segment user data item is used for coding the vehicle headways for each line segment, rather than the *headway* attribute, which applies to all segments of a line. This is done to allow special dummy segments to be coded at the end of each line with headway values set to the minimum value of .01. This is done to avoid the problem of passengers having to alight and reboard at the last (layover) node of circular lines, which would result in undue waiting time. Different transit time function attributes are also used for these segments, so that travel time can be set to zero. Normal headways and transit time functions are used for all other line segments.

As can be seen from Table 4, the user can either set the transit travel time functions to zero or use the function codes 1, 2 depending on the facility type. The former assumes that a default average vehicle speed of 15-mph is used for all segments, rather than a transit time function that computes travel time based on auto times. This can be done if average transit travel speeds are fairly uniform for all lines because of the similarity of operating conditions along the routes (traffic speeds, dwell times, and layover times).

A speed of 15-mph is used because this is a commonly-used value for average transit speeds in similar areas. Because the dwell time at stops and layover times are reflected in the average speed, the *dwt* and *lay* attributes are set to the minimum values of .01 and 0, respectively.

However, it is recommended that travel time functions be used whenever possible as it captures the effect of roadway congestion on the transit travel times. The travel time function code of 1 (1.11 * Auto time) should be used when the service is running on an access restricted facility (such as Interstates and Highways) whereas, the function code 2 (1.33 * Auto time) should be used for the other facility types. Also note that when using the transit travel time function the *dwt* attribute should be set to the minimum value of 0.01 with function code 1 (as buses typically do not stop on access restricted facilities) and 1.33 times auto minutes for function code 2. These values are general guidelines for a medium sized urban area (for example RVMPO) – the functions should be adjusted for different regions to reflect the local conditions.

4.7.2 Transit and Access Links

Roadway network links in the MPO models are also designated for use by the transit mode if the link is part of a transit line itinerary. In addition to these links, special transit-only links can be coded. Transit-only links are useful for exclusive right-of-way links, as well as situations where a portion of the transit line follows local streets not included in the roadway network. For transit-only links, length and mode are the only relevant attributes for coding, because these links are not used by autos. Speed is not coded, because it is included as a transit line attribute.

Walk access to transit is achieved primarily using the street network and centroid connectors. All the links in the roadway network except for freeways is coded with walk mode – EMME transit path builder finds the most attractive strategy between zone pairs using the walk and transit network. Within JEMnR, the zone pairs that have no transit component in its path ("walk all the way" ie; 0 transit IVT) do not see transit as a feasible alternative.

4.7.3 Park-and-Ride Lots

Although park-and-ride lots are an element of a transit network, they are not reflected in the MPO models in the typical manner as individual nodes, with park-and-ride connectors to/from the production TAZs. Rather, the interzonal travel times to/from the TAZ in which the park-and-ride lot is located are used as a surrogate for the travel times that would be developed through the traditional skim-building process for the park-and-ride mode.

The park-and-ride skims are generated within the model based on a park-and-ride lot index (specified in the "LOTZONE" field of the TAZ.csv input file) that identifies, for each production TAZ, the park-and-ride lot TAZ that would most likely be used by transit riders from that TAZ. To add a new park-and-ride lot to the network or change the location of an existing lot, the index would be modified in a two-step process: (1) selection of the most appropriate TAZ to represent the location of the park-and-ride lot, followed by (2) determination of which TAZs would most likely use this park-and-ride lot for transit access, modifying the TAZ.csv "LOTZONE" field, accordingly..

The first step is generally straightforward, unless the park-and-ride lot is located on boundary of two or more TAZs. In this case, the TAZ with the centroid located closest to the actual park-and-ride lot location is selected.

The second step is somewhat more complicated. Because only one park-and-ride lot can be defined for each TAZ, the question of which lot would most likely be used must be considered within the context of where most people within the TAZ will be traveling via transit. Based on the locations of major trip attractors and the orientation of the transit systems in the MPO areas, this is the central portion of the modeling area.

Several factors are considered in the assignment of park-and-ride lots to the TAZs:

- Generally, the park-and-ride lot should be located closer to the trip destination than the TAZ, since people do not want to travel out-of-direction to access the lot.
- Distance of the park-and-ride lot from the TAZ relative to the distances for alternative lots.
- Connectivity of the road network from the TAZ to the park-and-ride lot. For example, one lot may be a shorter distance from a TAZ, but if the connection is circuitous, then another lot may be more attractive.

- Attractiveness of the available transit service at the park-and-ride lot, i.e., areas served and frequency of service.

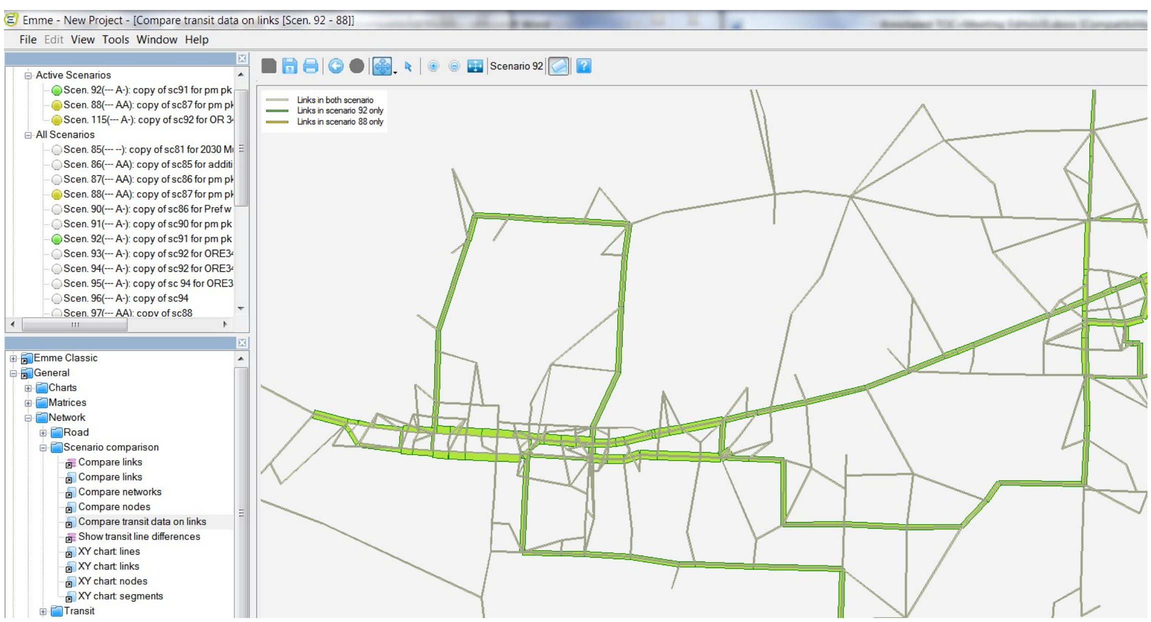
Park-and-ride lots are assigned to the internal TAZs only, since, by definition, all of the trips at the external stations are auto vehicle trips.

Details about the modification of the park-and-ride lot index are provided in the following Section 5 (Input Data Preparation).

4.7.4 Transit Network Validation

Any changes to the transit line and transit walk connector coding should be checked. The transit line itineraries should be compared to the transit operator's system map to ensure that any differences reflect the intended changes. The Emme *General->Network->Scenario comparison->Compare transit data on links* worksheet can also be used to verify that the intended changes have been made by comparing the transit lines in the new scenario to those in the reference scenario.

Figure 11: Emme Transit Line Comparison



The *Transit comparison* layer control is used to define the content and format of the plot in a similar manner to the *General->Network->Scenario comparison->Compare links* worksheet.

Network maps color-coded by mode can be used to help verify that walk access links have been coded for the appropriate TAZs and that the correct connection points to the transit network have been selected.

Similar to roadway links, transit line and walk link attributes can be checked by generating histograms of the attributes and verifying that the values are within acceptable ranges. This is done using the *General > Charts > Histograms > Histogram (matrix)* worksheet of the *Worksheet/Table Explorer*.

5. INPUT DATA PREPARATION

Most of the JEMnR input data files do not and should not be changed for model application. Depending on the type of application, however, specific files may need to be modified to reflect the scenario being tested.

There are four broad categories of input data:

- Zonal socioeconomic data
- Level-of-service (network) data
- Other zonal data
- External travel data

In the following sections, information is provided on the input files within these categories that the user can edit and how to prepare the data. All of the files are stored in the inputs folder of the JEMnR project directory. Additional information on the input files is presented in Appendix B.

5.1 Socioeconomic Data

Socioeconomic data consists of information related to the households and employment by type for each TAZ. It is stored within the **TAZ.csv** input file. The “HHBASE” field can to be changed to reflect a different total number of households within a TAZ. Although the data name implies that the household totals are for the base year, the same name is used in any JEMnR scenario, including future year scenario TAZ files. While the “POPBASE” field is not used directly in JEMnR, it should be updated if the total number of households is changed for documentation purposes. This is done by multiplying the total number of households by the average household size (“AHHSBASE”) and adding the “GQPOPBASE”. The “GQPOPBASE” field represents group quarters housing residents who are limited in their travel. This field should, but does not have to be changed with changes to the HHBASE or POPBASE fields.

If any households exist in a TAZ, it is essential that household distribution data is provided for the TAZ. This data describes the distribution of households by household size (“HHS1BASE – HHS4BASE”), income (“HHI1BASE – HHI4BASE”), and age-of-head-of-household (AGE1BASE – AGE4BASE”) within the TAZ, and should sum to 1.0 (100%). Without this data, the model will zero-out the number of households in this zone in the household cross-classification (hiazAry.RData) file created within the JEMnR pregen module. If the household distribution data is not already included for a TAZ (e.g., new household are added to a previously zero-household TAZ), then it should be copied from a similar, neighboring TAZ and pasted into the appropriate columns. The household distribution should also be reviewed if households are being added to or subtracted from a TAZ to determine if the distribution will continue to accurately represent the new household total. If there is a question about this procedure, the TPAU staff person responsible for the model should be contacted.

The TAZ.csv file contains 10 categories of employment data that may be modified to reflect an employment change in a zone. These are listed in Table 5, together with the associated industry classification (NAICS) codes.

Table 5: JEMnR TAZ Employment Data

Data Item	Employment Category	NAICS Codes
AFREMP	Agriculture and Forestry	000000 - 119999
MINEMP	Mining	210000 - 219999
CONEMP	Construction	230000 - 239999
MFGEMP	Manufacturing	310000 - 339999, 511000 - 512999
TCPEMP	Transportation, Communication and Public Utilities	220000 - 229999, 480000 - 499999
WSTEMP	Wholesale	420000 - 430000
RETEMP	Retail	440000 - 459999
FINEMP	Financial, Insurance and Real Estate	520000 - 531999, 550000 - 559999
SVCEMP	Service	515000 - 519999, 532000 - 549999, 560000 - 819999
GVTEMP	Government	920000 - 929999

To identify the category that a specific type of employment falls into, descriptions of the NAICS codes can be found at: http://www.census.gov/eos/www/naics/.

JEMnR automatically checks for errors in the TAZ.csv inputs in the **InputCheck_V4.R** script, which is executed by **ModelModules.R** before the first iteration of model processing. Checks are made for the following errors:

- Block group number is not provided.
- Block group numbers for all TAZs are the same.
- Average household size is less than one.
- Total employment does not match the sum of employment by category.
- Household distribution percentages do not sum to 100%.
- All households in one household category (size, income, or age-of-head-of-household).
- Illogical household distribution.
- TAZ contains school, but has no school trips.
- University model flag is set to true in the settings, but the model is missing the JAR or inputs.

- EMME matrices listed in the settings file are missing from the emmebank or are empty.
- Time periods listed in TOD_periods.csv are inconsistent with those used in SWIM external models.

5.2 Level-of-Service Data

Changes to the highway or transit networks must be reflected in the appropriate level-of-service data files that are input to the model. Level-of-service refers to the characteristics of travel by mode between zone pairs.

5.2.1 Auto Level-of-Service Data

If the highway network is modified, zone-to-zone uncongested auto time and distance matrices and a congested auto time matrix must be created by running traffic assignments. These matrices and associated network attributes are stored within the Emme database. This initial assignment, specifically the travel time matrices built from this assignment, is required before starting a JEMnR model run. It serves as a starting point for the iterative travel time feedback process.

Traffic assignments are run using Emme's standard traffic assignment procedure. The Emme Prompt Module 5.11 is used to set up the assignment and Module 5.21 is used to run the assignment. Further detail on running assignments are provided in Section 6 (Trip Assignment) of this document.
To produce the uncongested time (mf19 peak and mf20 op) and distance (mf21) matrices, an additional options assignment is run using a zero-valued scalar demand matrix. This is done by providing the following information within the Module 5.11 dialog:

- Link length is selected as the source for additional attributes in order to create the distance matrix.
- "+" is specified as the operator to compute additional path attributes.
- The matrix to hold the distances is identified in response to the "Matrix to hold additional O-D attributes" query.
- The "active additional demand" option is selected in response to the "Type of additional O-D attribute" query.
- Zero is entered for the maximum number of iterations.
- The default stopping criteria values are used, since the assignment will terminate at the end of iteration zero.

For the initial model run iteration, the uncongested auto times are used for both the peak and off-peak time periods, since congested times are not available until a demand-based assignment is run. For subsequent iterations, a peak period auto time matrix is created automatically within **runModel.R** by performing a PM peak hour auto assignment and then transposing the output auto time matrix to reflect the congested times in the proper P-A direction.

Intrazonal times and distances do not have to be added to the time and distance matrices because this is done within JEMnR.[26] The matrix numbers assigned within Emme and those in the **settings.csv** file must match. Therefore, the default matrix numbers in the settings.csv file should be checked to verify this; if not, then the matrix numbers in the settings.csv file must be changed to match those in the Emme database.

The auto operating cost matrices for the drive alone, drive-with-passenger, and auto-passenger modes are generated within JEMnR based on the auto distance matrix and the value of the average auto operating cost per mile parameter (autoOperCost) in the settings.csv file.

5.2.2 Transit Level-of-Service Data

Changes in transit service must be reflected in the transit level-of-service (impedance) matrices, which are stored within the Emme database. These include transit travel times, transfers, and cost (fare, in 1995 dollars).

The transit travel time and transfer matrices are created by performing a standard transit assignment. The Emme Prompt Module 5.11 is used to set up the assignment and Module 5.31 is used to run the assignment. Details on performing a transit assignment are provided in Section 6 (Trip Assignment).

If there are no differences in peak and off-peak transit service, the same transit impedance matrices can be used for both the peak and off-peak time periods. In this case, the peak period transit *_matNum" model parameters in the **settings.csv** file are set equal to the matrix numbers for the daily/off-peak transit impedance matrices, as shown in the default values of Table 1. The "runPeakOffPeakTransitAssignment" parameter is also set to "F" (the default value) and the parameter "dailyoffpeak_scen_num" is set equal to the number of the scenario containing the daily/off-peak transit network.

If there are differences in transit service, then separate peak and off-peak impedance matrices should be prepared. Within the **settings.csv** file, the model parameters for the peak and off-peak transit impedance matrices would be set equal to the matrix numbers selected in Emme for these matrices. In addition, the parameter "runPeakOffPeakTransit Assignment" would be set to "T" and the parameters "dailyoffpeak_scen_num" and "peak_scen_num" would be set equal to the numbers of the scenarios containing the off-peak and peak transit networks, respectively.

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[26] Intrazonal travel times and distances are calculated as one-half the average time/distance to the four nearest zones.

The settings for the “pkadbus_matNum”, “opadbus_matNum”, and “dailybus_matNum” parameters, which are specified by the user to indicate the matrix numbers of the peak period, off-peak period, and daily transit demand matrices, would be the same regardless of which option is selected for the creation of the peak and off-peak transit impedance matrices.

Transfer times are computed within JEMnR based on total wait time and initial wait time.

Changes to the transit fare level or fare structure are reflected through a combination of two files, the districts.csv file and the transitFares.csv file. In the districts.csv file, the column labeled “transitDistricts” is used to define transit fare districts. For each TAZ listed in the first column, there is an associated district in the “transitDistricts” column, which defines the fare district that includes that TAZ. The transitFares.csv file defines the fare levels to travel between each pair of “transitdistricts”.

In the following example of a transitFares.csv file, District 2 is a fareless square. Travel between TAZs within the fareless square is free. All other TAZs belong to District 1. Travel between TAZs within District 1 and between District 1 and District 2 costs $0.81. Note that all monetary units should be represented in 1995 dollars, using Oregon CPI if necessary. [27]

Table 6: JEMnR Sample transitFares.csv File

From District	To District	Fare
1	1	0.81
1	2	0.81
2	1	0.81
2	2	0

5.2.3 Other Modes Level-of-Service Data

The level-of-service data for the other modes are generated automatically within JEMnR based on the auto and transit level-of-service matrices. The auto distance matrix is used to compute a walk mode walk time matrix based on an assumed average walk speed of 3 mph and maximum distance of 5 miles. A bike time matrix is developed using an average speed of 10 mph and maximum distance of 10 miles. These are defaults for parameters included in the **Settings.csv** file.

As described in the previous section, the impedance matrices for the park-and-ride mode are created within JEMnR using a combination of the drive-auto impedance from the trip

[27] Oregon Employment Department (OED) Workforce & Economic Research, Consumer Price Index, Portland-Salem, OR-WA. (10/16/2012).

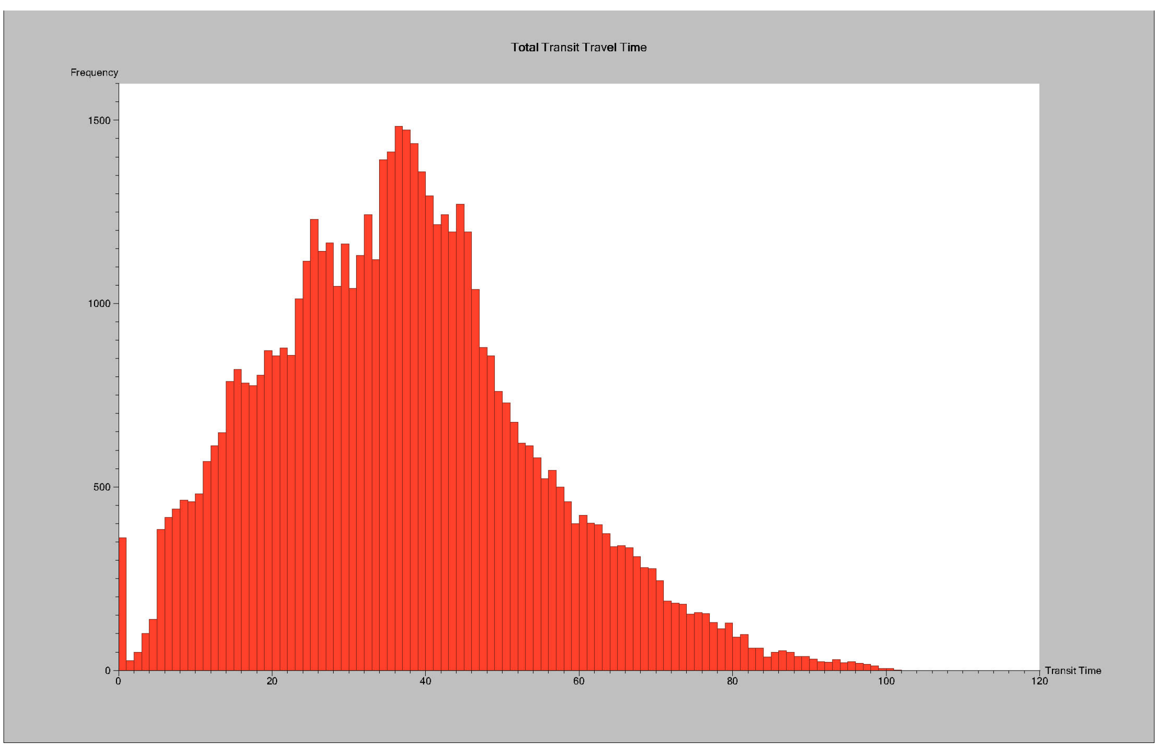
production TAZ to the park-and-ride lot TAZ and the transit impedance from the park-and-ride lot TAZ to the destination TAZ.

Changes in park-and-ride lot locations must be reflected in the park-and-ride lot index field (LOTZONE) of the **TAZ.csv** file. This field specifies the park-and-ride lot TAZ used by trips from the "home" TAZ ("0" if no lot is available). If a new park-and-ride lot is added, the index value in the "LOTZONE" field would be adjusted for the appropriate "home" TAZs to represent the new lot. If an existing park-and-ride lot is moved to another location, the index value would be modified for the "home" TAZs previously served by the lot (and replaced with another lot or a "0" if no other lot is available) and the "home" TAZs that would be served by the lot at the new location.

5.2.4 Reasonableness Checks for Level-of-Service Data

Reasonableness checks for any of the level-of-service data can be performed by developing a matrix histogram of zone-to-zone impedances. Potential problems may be reflected in unexpectedly large impedance values or concentrations of zone pairs within lower or higher impedance intervals. This is done using the *General* > *Matrices* > *Matrix Histogram* worksheet of the *Worksheet/Table Explorer*. An example histogram for a total transit time matrix is shown in Figure 12.

Figure 12: Emme Total Transit Time Histogram

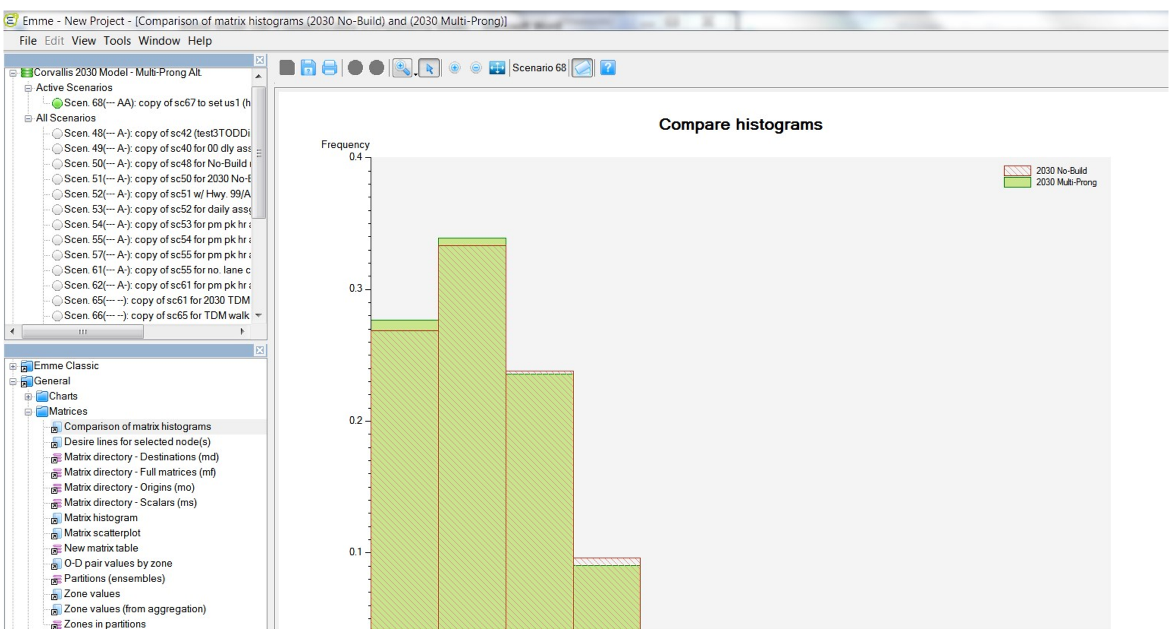


Another histogram tool for checking level-of-service data is the *General->Matrices->Comparison of matrix histograms* chart. It can be used to compare the level-of-service data between the new scenario and the reference scenario to determine if the differences are reasonable based on the differences in the scenarios. In the example shown in Figure 13, the auto travel times for a future year “Build” scenario are compared to the times for a “No-Build” scenario. For the “Build” scenario, it would be expected that a higher percentage of interzonal travel times would be in the lower time intervals and a lower percentage would be in the higher time intervals. If this is not the case, then errors could have been made in either the network coding or in the preparation of the travel time matrix for the “Build” scenario.

The *Compare matrices* layer control is used to specify the two travel time distributions. For Distribution 1 and Distribution 2, the travel time matrix is specified as the *Data* matrix. By default, the height of each bar gives the number of O-D pairs within a given travel time interval. The distributions can be weighted by the number of trips in each interval by specifying a demand matrix as the *Weight* matrix.

The range and interval size of the histograms are adjusted using the *Diagram setting* layer control or the *Auto Axes* buttons. Submatrices can be defined by entering an expression in the *Filter* input fields.

Figure 13: Emme Comparison of Auto Travel Times



5.2.5 Other Zonal Data

Other, non-socioeconomic zonal data describe the environment in which travel decisions are made at the production and attraction ends of the trip. These data are used within each of the JEMnR components.

Several zonal data items may need to be modified depending on the model application. The household and employment transit coverage factors (**peakHhCov, offPeakHhCov, peakEmpCov and offPeakEmpcov input columns in TAZ.csv file**) respectively describe the percentage of households and employment within ¼-mile of transit service in each TAZ. The coverage factors should be reviewed if households or employment are changed within a TAZ and must be specifically modified if there is a change in transit routing that results in a different percentage of households or employment within the ¼-mile transit buffer around the transit route (not station specific). Different factors can be provided for the peak and off-peak periods if there is a difference in service coverage between the two time periods.

The "**intersections**" data field in the **TAZ.csv** file defines the number of intersections within ½-mile of a TAZ centroid. It should be modified if there is a change to the auto network that results in a different intersection density in a local area. An example of this would be the addition of a new roadway that increases the number of intersections, or new development that brings additional local access roads. Local street intersections are included in this measure.

If there is change in the amount of regionally-significant shopping center square footage assumed within a TAZ, then the **sqft.csv** file should be modified to reflect the revised total square footage. A shopping center is defined as a retail center consisting of one or more stores with a combined square footage of greater than 50,000 sqft. Similarly, **lodgings.csv** houses the number of hotel rooms by TAZ. If this changes appreciably, this file should be updated.

Although not necessary for most model applications, another field in the **TAZ.csv** file that may need to be updated is the college vehicle trip ("COLEBASE") field. This should be modified if there is a change in university or college enrollment. It is calculated as:

University College Vehicle Trips = 2.5 * Total Enrollment; or
Community College Vehicle Trips = 1.5 * Total Enrollment

5.2.6 External Travel Data

The external travel data includes the total number of vehicles entering and exiting at external stations for both autos and trucks,, future annual growth rates, and peak share of daily travel at these locations. The O-D trip patterns for these trips, including E-E trips draws from the Oregon Statewide Integrated Model (SWIM2), which has a larger understanding of long distance travel. Changes to this data would be required only in special circumstances. An example of this would be to test a large-scale land use proposal within a portion of the modeling area that may alter the number and/or composition of trips at an external station. Another example might be to address a large-scale rural development outside the model area that would alter the direction of external trips. In the latter case, an update could benefit from an alternate SWIM model run to identify new long distance travel patterns outside the local model area.

Information on future volumes at external stations on state highways can be obtained from ODOT's Future Volumes Table at:

https://www.oregon.gov/ODOT/Planning/Documents/FutureVolumeTables.xls

Future volumes for external stations on local facilities, not covered in the Future Value Tables above are typically estimated from a base year traffic count using a linear traffic growth rate based on historical traffic volumes or a growth rate from a nearby state highway external station. Growth rates can also be obtained from SWIM2 runs for the area and can be compared to the future volume table growth rates and or historic growth rates obtained from counts.

TPAU staff should be contacted prior to making any modifications to the external travel input data[28].

[28] Methods for allocating the external station ADT among E-I, I-E and E-E shares are originated from SWIM.

6. TRIP ASSIGNMENT

6.1 Overview

JEMnR trip assignment is a key step in the model application process in which the zone-to-zone travel flows (trip tables by purpose) produced by the R-scripts are converted into network flows (link volumes), with the resulting travel times used as an input to the next iteration of model feedback process.

JEMnR auto and transit assignments are both performed in Emme. The vehicle trip and transit person trip matrices produced by the **addExternals** submodule of the **peaking and demand matrices** module are reformatted and written from JEMnR to the Emme database in preparation for use in the assignments.

Auto and transit assignments are run automatically by the JEMnR **runModel.R** script as a part of the full model application process. Prior to the first iteration of model processing, however, assignments must be manually run to produce the auto travel time and distance matrices and transit travel time matrices needed as inputs to the model. In addition, there is frequently a need to perform assignments for specific purposes outside of automated JEMnR process, such as identifying the effects of minor network changes. Therefore, information is presented below on how to prepare an Emme scenario for auto and transit assignments and execute the assignments.

6.2 Auto Assignment

6.2.1 Assignment Matrix Pre-Processing

Once the JEMnR trip matrices have been input to Emme databank, the **runModel.R** script calls for “sledhammer.mac”. Basically, the peak period count differential is developed through an external process, but the factors developed for each external station are then applied to the origins and destinations.

6.2.2 Auto Assignment Procedure

Following the adjustment of the PM peak hour trip matrix, the **runModel.R** script calls a second macro (**emme/macros/quickassign.mac**) to run a user-optimal equilibrium assignment. The underlying principle of equilibrium assignments is described as follows in the *Emme Prompt Manual*:[29]

> "Each traveler chooses the path (or route) perceived as being the best; if there is a shorter path than the one being used, the traveler will choose it. At the equilibrium, no one can improve their travel time by changing paths. The volumes resulting from an equilibrium assignment are thus such that all paths used between an origin-destination pair are of **equal time**."

The Emme Prompt Modules 5.11 and 5.21 are used to set up and run the assignment. Within Module 5.11, the user is queried for responses to the following prompts to identify the parameter values and options to be applied for the assignment:

1. Select: Type of assignment
   1= fixed demand traffic assignment
   2= fixed demand transit assignment
   3= variable demand traffic assignment
   4= end

   Option 1 is selected, indicating that the assignment is to be performed using a fixed demand matrix.

2. Select: 1= single class assignment on auto mode
   2= single class assignment with generalized cost
   3= multiclass assignment
   4= multiclass assignment with generalized cost
   5= generalized cost multiclass assignment with class specific volumes
   6= generalized cost multiclass assignment with path analysis

   Option 1 is selected, indicating that the assignment will include only one class of user (e.g., cars vs. trucks) for the portion of the network defined by the auto mode.

3. Select: Source for additional volumes
   1= no additional volumes
   2= auto equivalent of transit vehicles
   3= user data on links and turns
   4= transit vehicles and user data
   5= assign additional demand (additional options assignment)

   Option 1 is selected, indicating that only the volumes from the demand matrix will be used in the assignment.

4. Demand in persons
   Enter: Matrix=

[29] Inro, Emme Prompt Manual, (2011).

The user specifies the demand matrix to be used in the assignment. This can be done using either the matrix type and matrix number (e.g., mf01) or matrix name (e.g., pmtrip).

5. Vehicle occupancy in persons/veh (optional)
   Enter: Matrix=

   Not specified.

6. Additional demand in auto equivalents (optional)
   Enter: Matrix=

   Not specified.

7. Matrix to hold travel times (optional)
   Enter: Matrix=

   May or may not be specified.

8. Enter: Max. number of iterations (100)=

   Refer to the applicable model development report for the value to be entered for the stopping criterion, which should be consistent with the value in **Settings.csv**.

9. Enter: Stopping criterion for best relative gap (0.01 %)
   [, relative gap (0)]=

   Refer to the applicable model development report for the value to be entered for the stopping criterion, which should be consistent with the value in **Settings.csv**. The default value of 0 is used for the relative gap.

10. Enter: Stopping criterion for normalized gap (excess avg time)
    (0.01 min)=

    Refer to the applicable model development report for the value to be entered for the stopping criterion, which should be consistent with the value in **Settings.csv**.

The last three queries (#8-10) are used to specify the stopping criteria for the assignment.

- The **maximum number of iterations** specified is used only if the preferred second and third criteria are not satisfied.
- The **best relative gap** criterion specified is an estimate of the difference between the current assignment and a perfect equilibrium assignment, in which all paths used for a given O-D pair would have exactly the same time. The relative gap is the difference between the total travel time on the network and the total travel time on the shortest paths for the current iteration, divided by the total travel time on the network of the prior iteration.

- The **normalized gap** criterion is the difference between the mean trip time of the current assignment and the mean minimal trip time. The mean trip time is the average trip time on the paths used in the previous iteration. The mean minimal trip time is the average time computed using the shortest paths of the current iteration.

Variations of this Emme assignment procedure are used to set up special purpose assignments, such as the additional options assignment (selecting option 5 in step #3 above) described in Section 5 (Input Data Preparation) for producing the initial auto travel distance matrix and assignments, as well as the select link assignment described in Section 8 (Viewing Model Output) to identify the origins and destinations of trips using specific links in the network. For more information on these assignment procedures, the reader is referred to Section 4.5.1 of the *Emme Prompt Manual*.[30]

Following the preparation of the scenario for assignment in Module 5.11, the assignment is executed in the Emme Prompt Module 5.21. This is a simple one-query dialog asking the user to specify the destination of the assignment report (screen or file).

6.2.2.1 Volume-Delay Functions

The link travel times produced within the auto assignment are calculated by one or more volume-delay functions (VDFs). The times are calculated as a function of link attributes, including volume, lanes, lane capacity, and link type, which are identified by keywords within the VDFs. In the network, a VDF index is specified for each link. When a traffic assignment is performed, this index is used to retrieve the corresponding VDF. The same function may thus be used for several links. An auto VDF must be a positive, non-decreasing function of auto volume (keyword = volau).

There are many types of VDFs that can be used within travel forecasting models. Usually, these functions are expressed as the product of the free flow time multiplied by a congestion function *f(x)*:

$$t(v) = t_0 * f(\frac{v}{c})$$

where:

$t(v)$ = total link travel time

t_0 = zero-volume travel time (free-flow time)

v/c = volume/capacity ratio

[30] Inro, Emme Prompt Manual, (2011).

A typical type VDF used in the RVMPO/BRM/CALM models is shown below as it is coded within the Emme database:

For volume/delay functions for daily assignment:
fd1 =(length * 60 / ul1) * (1 +.05 *(volau / (ul2 * 16 * lanes))^10)
fd2 =(length * 60 / ul1) * (1 +.2 *(volau / (ul2 * 16 * lanes))^10)

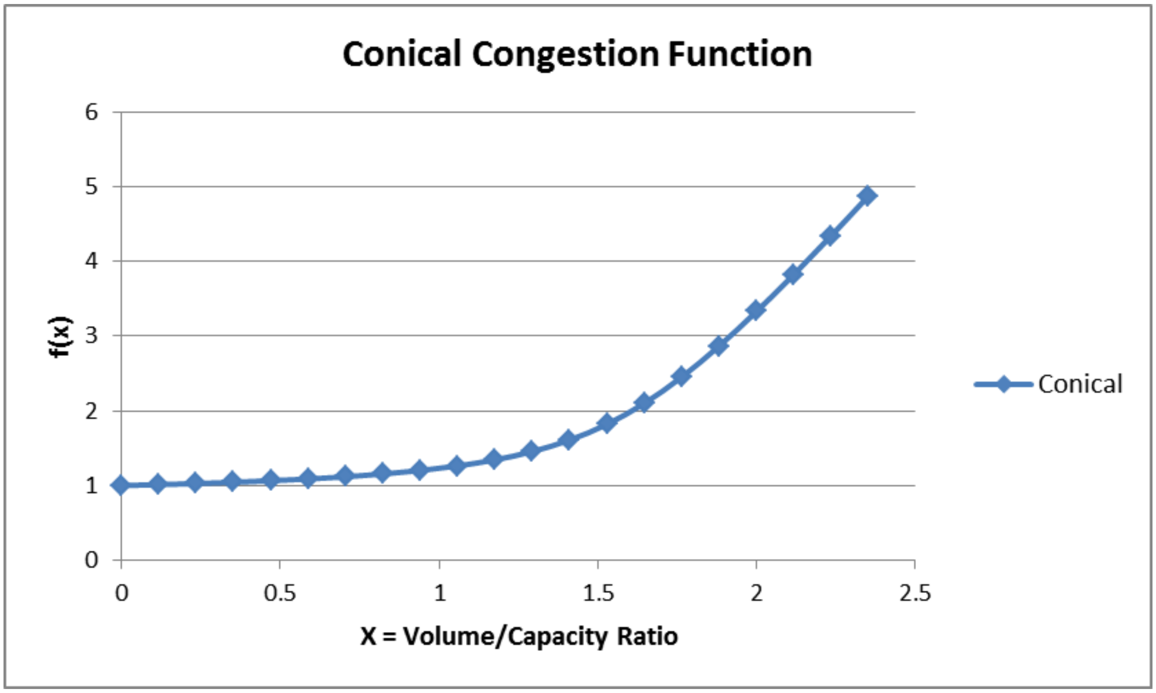
For volume/delay functions for peak assignment:
fd5 =(length * 60 / ul1) * (1 + .05 * (volau / (ul2 * lanes))^10)
fd6 =(length * 60 / ul1) * (1 + .2 * (volau / (ul2 * lanes))^10)

where:

fd1 = total link travel time (minutes)
length = link length (miles)
ul1 = link user data item 1 containing free-flow speed (mph)
volau = link volume (vehicles)
lanes = number of lanes
ul2 = capacity/lane (vph)

The effects of the congestion function within this equation are shown below:

Figure 14: Conical Congestion Function



As can be seen, over the range of v/c ratios between 0 and 1 congestion builds gradually, with a degradation of travel speed of about 20% at a v/c value of 1. Beyond capacity, congestion increases more rapidly so that at a v/c value of 2, travel time is roughly 3.5 times greater than for free flow conditions. This means that in relatively uncongested conditions (v/c < 0.85), traffic will tend to follow the more direct paths between origin and destination zones, with little diversion to alternate routes. As the v/c ratio increases, however, particularly for values over 1, there can be much more "spreading" of traffic if viable alternate routes exist.

This effect is accentuated with VDFs that become very steep beyond capacity which can cause a significant amount of path-switching between assignment iterations.

Within the MPO models, one set of VDFs is used to perform hourly traffic assignments and another set is used to perform daily traffic assignments. The daily functions are identical to the hourly functions, except that the hourly capacities are multiplied by a daily time period factor. The VDFs for each MPO model are presented in the individual model development reports.

In addition to the VDFs for general traffic assignment, there are special-purpose functions available that are used to estimate the congestion effects for network links with different flow characteristics, such as freeway on-ramps with ramp meters, or roundabouts. Ramp meter functions are currently not used within the MPO models, but could be introduced if ramp meters are considered as a possible traffic control measure in the future.

The VDF-based travel time acts as a good signal that the iterative assignment method has converged. The VDF approach breaks down however if alternate routes are not available or the all-or-nothing equilibrium assignment oscillates between routes. In the former case, volume-to-capacity ratios in the range of 2.0 or more can produce unrealistic breakdown conditions. Caution should be used to avoid these cases.

6.2.2.2 Multiclass Assignment

Another assignment technique that is available but has not yet been implemented in the existing JEMnR MPO models is multiclass assignment. With this technique, several classes of users can be assigned to the network simultaneously. This allows a class of users to be assigned to a restricted network and/or face different network attributes (e.g., costs, speeds), or the user's desire to keep track of the assignment of a specific demand class (e.g., by purpose, externals). It can be applied to a wide variety of situations, including:

- Route restrictions for heavy vehicles
- HOV lanes
- First order assessment of toll roads with stratified fare schemes in which different classes of users pay different tolls. JEMnR is not set up to model tolls. In assignment this would require a shift to generalized travel costs in the VDF function and consider monetary cost of travel, user's value of time, along with the time cost from congestion.

Each class has access to a sub-network of the road network and can face link-level conditions (e.g., link tolls or restrictions). A sub-network is defined by network coding that allows either the auto mode or an auxiliary auto mode on the link. The demand for each class is assigned to paths that are restricted to the relevant sub-network. All classes are considered equivalent; that is, no class has a priority over other classes. Also, all classes that are allowed to use a given link perceive the same time, which is based on the total volume on the link.

The resulting volumes for each class can be saved in extra attributes. The sum of these volumes, for all classes, is referred to as the auto volume.

To implement this technique, the network is modified to create sub-networks defined by the modes allowed to use each link. For example, HOV lanes on an existing freeway would be defined by coding special HOV links parallel to the freeway which could only be used by the HOV class. A multiclass assignment is set up using the Emme Prompt Module 5.11 in a similar manner to a single-class assignment, with the multiclass assignment option specified in response to the assignment type query.

6.2.2.3 Auto Assignment in Travel Time Feedback

Within the overall JEMnR application process, an iterative auto assignment is run in the last step of the **runModel.R** script for the purpose of generating an auto travel time matrix that is used in the next iteration of processing. As described in Section 3 (JEMnR Setup and Application), prior to the next iteration, the travel times from the previous iteration are compared to those from the current iteration. If the times differ by greater than a specified amount, the model is run for another iteration, up to a maximum number of iterations or as specified by the user. The default stopping criteria are summarized below:

- The percent root mean square error (% RMSE) for the sum of the travel times for each pair of zones for the current iteration compared to the previous iteration is less than or equal to 1% (maxRMSE in Settings.csv); or
- The maximum relative difference in the sum of the travel times for each pair of zones for the current iteration compared to the previous iteration is less than or equal to 1% (absTTchange in Settings.csv); or
- The number of iterations that the model has run is less than 10 (maxIter in Settings.csv).

These stopping criteria may vary by modeling area and can be modified by the user in the **settings.csv** file.

6.3 Transit Assignment

Transit assignments are carried out using the Emme standard transit assignment procedure. All transit assignments in Emme are multipath assignments based on the concept of strategy, which is a generalization of the concept of path. A strategy is described as follows in the *Emme Prompt Manual*:[31]

> "Due to the waiting time at stops in a transit network, a traveler may select from a more complex choice set than just a simple path toward a destination; in a strategy, the traveler chooses a set of paths before embarking on the trip, and then decides at the stop which of these paths to take.
>
> The type of strategy considered in Emme can be expressed as follows: at each node where there is waiting (transit stop), the traveler has chosen a set of attractive lines, boards a vehicle from one of these lines, and alights at a predetermined node, based on the expected travel time from that node to the destination; this process is repeated until the traveler reaches his destination. The optimal strategy is the one that minimizes the total expected travel time (including waiting, riding, walking, etc.)."

[31] Inro, Emme Prompt Manual, (2011).

As with auto assignments, the Emme Prompt Module 5.11 is used to set up the transit assignment. To do this, the following prompts and responses are provided within the Module 5.11 dialog:

1. Select: Type of assignment
   1= fixed demand traffic assignment
   2= fixed demand transit assignment
   3= variable demand traffic assignment
   4= end

   Option 2 is selected, indicating that a transit assignment is to be performed using a fixed demand transit matrix.

2. Transit demand matrix
   Enter: Matrix=

   The user specifies the demand matrix to be used in the assignment. The matrix can be specified using either the matrix type and matrix number or matrix name. A zero-valued scalar matrix is used because it is assumed that transit times are not a function of transit demand.

3. Matrix to hold transit times (optional)
   Enter: Matrix=

   May or may not be specified.

4. Matrix to hold in-vehicle times (optional)
   Enter: Matrix=

   May or may not be specified.

5. Matrix to hold auxiliary transit times (optional)
   Enter: Matrix=

   May or may not be specified.

6. Matrix to hold total waiting times (optional)
   Enter: Matrix=

   May or may not be specified.

7. Matrix to hold first waiting transit times (optional)
   Enter: Matrix=

   May or may not be specified.

8. Matrix to boarding times (optional)
   Enter: Matrix=

May or may not be specified.

9. Matrix to hold average number of boardings (optional)
   Enter: Matrix=

   May or may not be specified.

10. Active transit and aux. transit modes for assignment

    Enter: Mode(s)

    The character string “bw” is entered (b = bus, w = walk). This is the set of modes defining the sub-network links for which the assignment is to be performed.

11. Select: Source for effective headways
    1= actual line headways
    2= actual line headways with maximum
    3= user defined line attribute
    4= user defined segment attribute

    Option 4 is selected, indicating that the effective headways are to be obtained from a user defined segment attribute. As described in Section 4 (Network Coding), this is the *us1* segment attribute. The effective headway is the headway actually perceived by the users of a transit line.

12. Select: Source for boarding times
    1= same value for entire network
    2= node specific boarding times
    3= line specific boarding times
    4= node and line specific boarding times

    Option 1 is selected, indicating that the same boarding time value will be used for all transit lines. Boarding time is the penalty associated with every boarding, whether it is an initial boarding or transfer boarding.

13. Enter: Boarding time (mins)=

    A value of “0” is entered.

14. Select: Source for wait time factors
    1= same value for entire network
    2= node specific wait time factors

    Option 1 is selected, indicating that the same wait time factor value will be used for all transit lines. The wait time factor is a parameter used in the computation of transit waiting times. Wait time is the time spent waiting for the initial boarding or a transfer boarding. It is defined in JEMnR as a factor multiplied by the headway.

15. Enter: Wait time factor=

A value of "0.5" is entered. This value corresponds to a regularly spaced service which results in a wait time of half the combined headway.

16. Enter: Wait time weight [, spread factor]=

A value of "2" is entered. Weights, or perception factors, are associated with the travel time components. They are used to quantify the various perceptions of waiting, boarding, and auxiliary transit time, with respect to the in-vehicle time.

17. Enter: Auxiliary transit time weight=

A value of "1.5" is entered. Auxiliary transit time is the time spent walking to or from a transit stop.

18. Enter: Boarding time weight=1

A value of "1" is entered.

19. Perform additional options assignment?

Typically, an "n" would be entered. An additional options assignment could be run for special purposes, such as computing a transit district matrix or performing a select link or select line analysis.

6.3.1 Trip Assignment Validation

Once an auto or transit assignment has been completed, checks must be performed to determine if the assignment results are consistent with the changes that have been made to the network, transit system, and/or land use data. The general approach for the checks is to compare the current assignment results to those for similar scenarios that have been determined to be reasonable. Depending on the scale of the change, different checks can be performed at the regional, sub-regional, or corridor/subarea level.

6.4 Auto Assignment Checks

For auto assignments, checks that can be performed at the regional and sub-regional level include:

- VMT per capita
- Total VMT by functional classification
- Average congested speeds by functional classification
- Changes in volumes across screenlines, cutlines, and cordon lines

As an example, the comparison of an assignment for a "No-Build" or financially constrained scenario having limited capacity improvements to the assignment for a

"Build" scenario with significantly increased network capacity might be expected to show:

- Higher VMT per capita due to the diversion of traffic to more circuitous routes as drivers try to avoid congestion.
- Higher VMT and higher average congested speeds on lower-classified roads due to traffic diversion.

These effects would be stronger in the more congested areas.

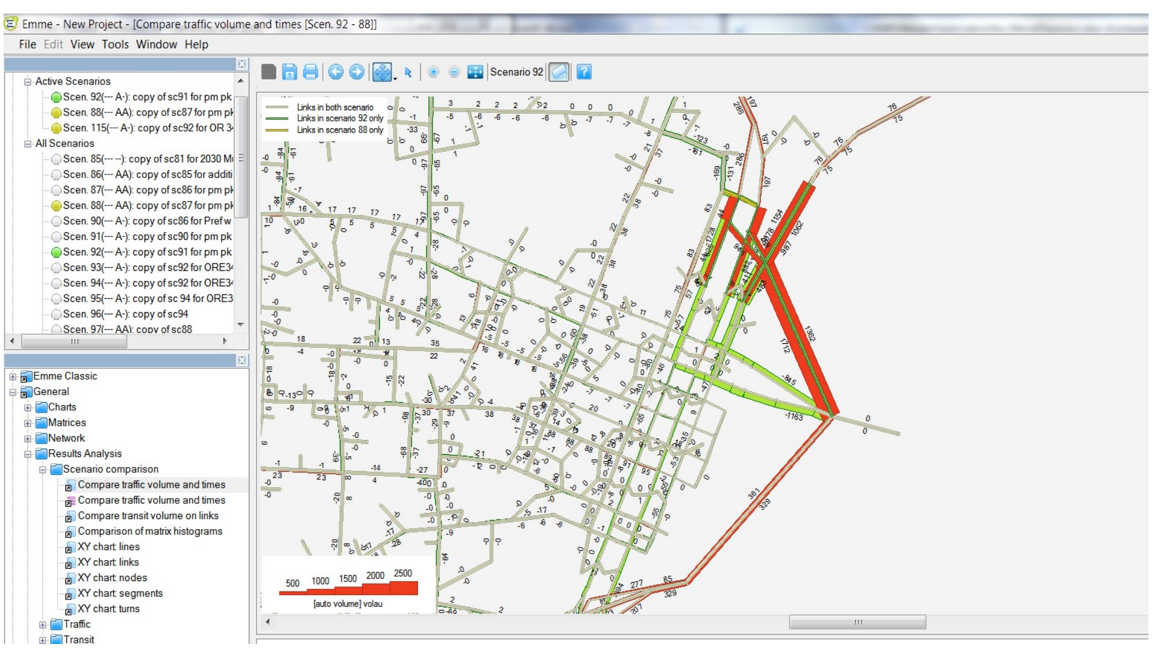
Examples of corridor/subarea-level checks for assignments reflecting network changes are:

- Volume comparison maps showing actual volumes, volume differences, and the percentage change in volumes.
- Comparison of facility speeds.

Volume comparison maps can be generated from the assignment in the Emme bank using the following sequence of steps from the Emme Desktop:

1. Open the *General->Results Analysis->Scenario comparison->Compare auto volumes and times* worksheet in the *Worksheet/Table Explorer*.
2. Open the *Link comparison* layer control.
3. To change the type of result compared, change the *Value* field as desired. For example, a speed difference map would be generated by selecting the *speedau* attribute.

Figure 16: Emme Auto Volume Comparison Map



4. To restrict the comparison to a sub-network of the auto network, use the *Filter*. This filter applies to the links in both scenarios.
5. By default, the absolute difference is computed. To obtain a relative difference, set the *Difference* field as desired.
6. To limit the display to difference values inside a certain range, use the *Threshold*. To retain the difference values outside that range, reverse the order of the values. For example:

    - To display the differences larger than 100, use 100, 999999
    - To display the differences outside the range -100,100, use 100,-100
    - To display all the differences, use 0, 0.

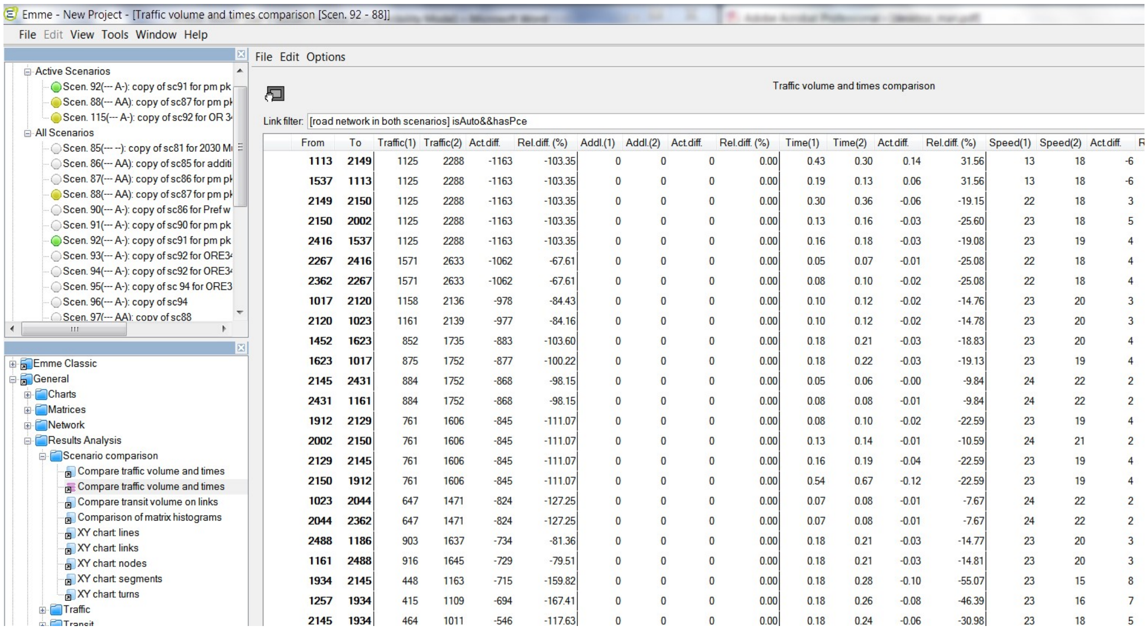
7. By default, negative differences are displayed in green and positive differences in red. To change this color scheme, use the *Bars* style.

The scenarios compared are the first two in the *Active Scenarios* list. To compare other scenarios or other link attributes (e.g., speeds) or similar maps, modify the predefined choices offered in this worksheet, by using the *General->Network->Scenario comparison->Compare links* worksheet in the *Worksheet/Table Explorer*.

Auto volume and time differences can also be displayed in tables by opening the *General->Results Analysis->Scenario comparison->Compare auto volumes and times* table in the *Worksheet/Table Explorer*, which displays the values in both scenarios, as well as the absolute and relative difference for:

- Auto volume
- Additional volume
- Auto time
- Auto speed

Figure 17: Emme Auto Volume and Time Comparison Table



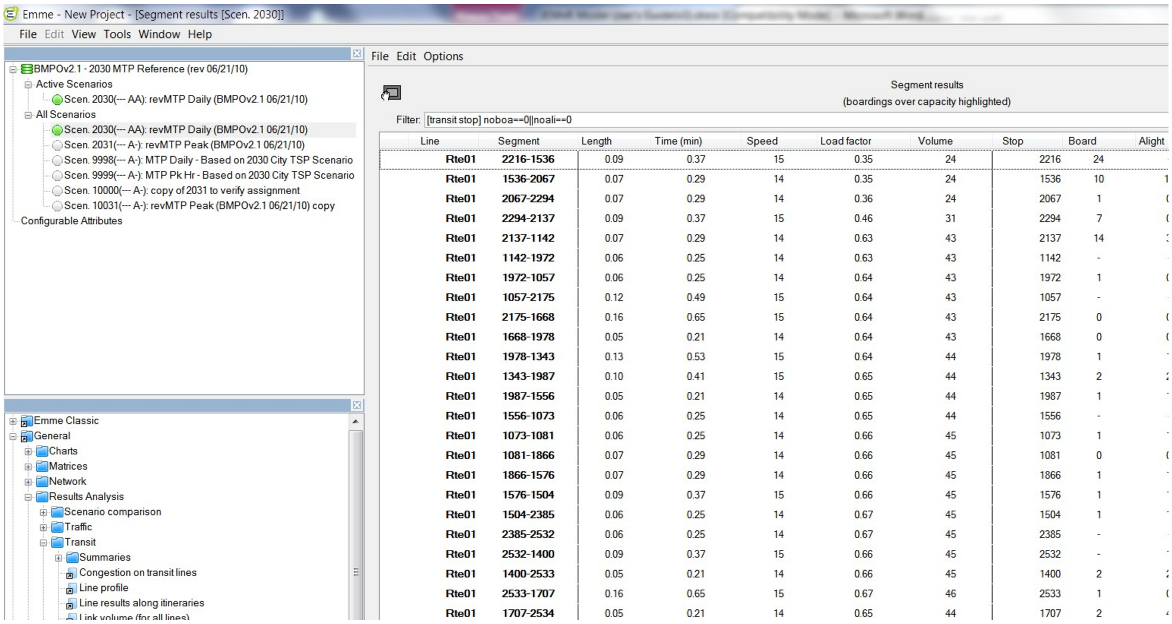
From	To	Traffic(1)	Traffic(2)	Act.diff.	Rel.diff. (%)	Addl.(1)	Addl.(2)	Act.diff.	Rel.diff. (%)	Time(1)	Time(2)	Act.diff.	Rel.diff. (%)	Speed(1)	Speed(2)	Act.diff.
1113	**2149**	1125	2288	-1163	-103.35	0	0	0	0.00	0.43	0.30	0.14	31.56	13	18	-6
1537	**1113**	1125	2288	-1163	-103.35	0	0	0	0.00	0.19	0.13	0.06	31.56	13	18	-6
2149	**2150**	1125	2288	-1163	-103.35	0	0	0	0.00	0.30	0.36	-0.06	-19.15	22	18	3
2150	**2002**	1125	2288	-1163	-103.35	0	0	0	0.00	0.13	0.16	-0.03	-25.60	23	18	5
2416	**1537**	1125	2288	-1163	-103.35	0	0	0	0.00	0.16	0.18	-0.03	-19.08	23	19	4
2267	**2416**	1571	2633	-1062	-67.61	0	0	0	0.00	0.05	0.07	-0.01	-25.08	22	18	4
2362	**2267**	1571	2633	-1062	-67.61	0	0	0	0.00	0.08	0.10	-0.02	-25.08	22	18	4
1017	**2120**	1158	2136	-978	-84.43	0	0	0	0.00	0.10	0.12	-0.02	-14.76	23	20	3
2120	**1023**	1161	2139	-977	-84.16	0	0	0	0.00	0.10	0.12	-0.02	-14.78	23	20	3
1452	**1623**	852	1735	-883	-103.60	0	0	0	0.00	0.18	0.21	-0.03	-18.83	23	20	4
1623	**1017**	875	1752	-877	-100.22	0	0	0	0.00	0.18	0.22	-0.03	-19.13	23	19	4
2145	**2431**	884	1752	-868	-98.15	0	0	0	0.00	0.05	0.06	-0.00	-9.84	24	22	2
2431	**1161**	884	1752	-868	-98.15	0	0	0	0.00	0.08	0.08	-0.01	-9.84	24	22	2
1912	**2129**	761	1606	-845	-111.07	0	0	0	0.00	0.08	0.10	-0.02	-22.59	23	19	4
2002	**2150**	761	1606	-845	-111.07	0	0	0	0.00	0.13	0.14	-0.01	-10.59	24	21	2
2129	**2145**	761	1606	-845	-111.07	0	0	0	0.00	0.16	0.19	-0.04	-22.59	23	19	4
2150	**1912**	761	1606	-845	-111.07	0	0	0	0.00	0.54	0.67	-0.12	-22.59	23	19	4
1023	**2044**	647	1471	-824	-127.25	0	0	0	0.00	0.07	0.08	-0.01	-7.67	24	22	2
2044	**2362**	647	1471	-824	-127.25	0	0	0	0.00	0.07	0.08	-0.01	-7.67	24	22	2
2488	**1186**	903	1637	-734	-81.36	0	0	0	0.00	0.18	0.21	-0.03	-14.77	23	20	3
1161	**2488**	916	1645	-729	-79.51	0	0	0	0.00	0.18	0.21	-0.03	-14.81	23	20	3
1934	**2145**	448	1163	-715	-159.82	0	0	0	0.00	0.18	0.28	-0.10	-55.07	23	15	8
1257	**1934**	415	1109	-694	-167.41	0	0	0	0.00	0.18	0.26	-0.08	-46.39	23	16	7
2145	**1934**	464	1011	-546	-117.63	0	0	0	0.00	0.18	0.24	-0.06	-30.98	23	18	5

An auto assignment check that should be performed for land use changes is select zone volume maps for the TAZs containing the land use changes. This is a select link on the centroid connectors in/out of a zone; See Appendix H). This check is done to verify both the volume and orientation of traffic associated with the changes. The same type of volume difference maps used for network changes can also be used for land use changes to determine if the volumes for the "with land use change" scenario are reasonable compared to those for the "without land use change" scenario.

Transit assignment checks are typically performed to determine if a change in transit service has had the anticipated effects on transit ridership. An example of this would be an increase in service frequency for a transit line. A reasonableness check in this case would be to compare the ridership level associated with improved service frequency with the previous ridership. Transit assignment results can be mapped in the same manner as traffic volume differences by opening the *General->Results Analysis->Scenario comparison->Compare transit volume on links* worksheet in the *Worksheet/Table Explorer* and using the *Transit comparison* layer control to adjust the content and format of the map.

Emme also has several tools for displaying transit assignment results along line itineraries. Ridership volumes can be displayed in tabular format by line by opening the *General->Results Analysis->Transit->Segment results by lines* table in the *Worksheet/Table Explorer*. For each line segment, the segment volume is shown, together with boardings and alighting at the segment stop node. Additional information shown is the segment length, time, and speed.

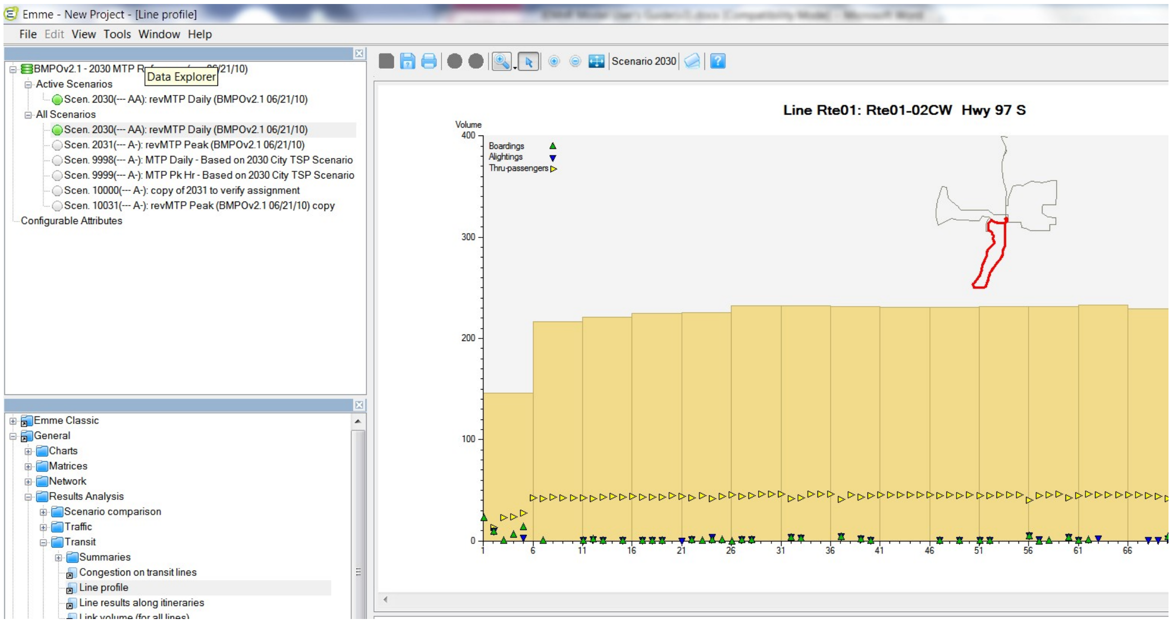
Figure 18: Emme Transit Segment Results by Line



Line	Segment	Length	Time (min)	Speed	Load factor	Volume	Stop	Board
Rte01	2216-1536	0.09	0.37	15	0.35	24	2216	24
Rte01	1536-2067	0.07	0.29	14	0.35	24	1536	10
Rte01	2067-2294	0.07	0.29	14	0.36	24	2067	1
Rte01	2294-2137	0.09	0.37	15	0.46	31	2294	7
Rte01	2137-1142	0.07	0.29	14	0.63	43	2137	14
Rte01	1142-1972	0.06	0.25	14	0.63	43	1142	-
Rte01	1972-1057	0.06	0.25	14	0.64	43	1972	1
Rte01	1057-2175	0.12	0.49	15	0.64	43	1057	-
Rte01	2175-1668	0.16	0.65	15	0.64	43	2175	0
Rte01	1668-1978	0.05	0.21	14	0.64	43	1668	0
Rte01	1978-1343	0.13	0.53	15	0.64	44	1978	1
Rte01	1343-1987	0.10	0.41	15	0.65	44	1343	2
Rte01	1987-1556	0.05	0.21	14	0.65	44	1987	1
Rte01	1556-1073	0.06	0.25	14	0.65	44	1556	-
Rte01	1073-1081	0.06	0.25	14	0.66	45	1073	1
Rte01	1081-1866	0.07	0.29	14	0.66	45	1081	0
Rte01	1866-1576	0.07	0.29	14	0.66	45	1866	1
Rte01	1576-1504	0.09	0.37	15	0.66	45	1576	1
Rte01	1504-2385	0.06	0.25	14	0.67	45	1504	1
Rte01	2385-2532	0.06	0.25	14	0.67	45	2385	-
Rte01	2532-1400	0.09	0.37	15	0.66	45	2532	-
Rte01	1400-2533	0.05	0.21	14	0.66	45	1400	2
Rte01	2533-1707	0.16	0.65	15	0.67	46	2533	1
Rte01	1707-2534	0.05	0.21	14	0.65	44	1707	2

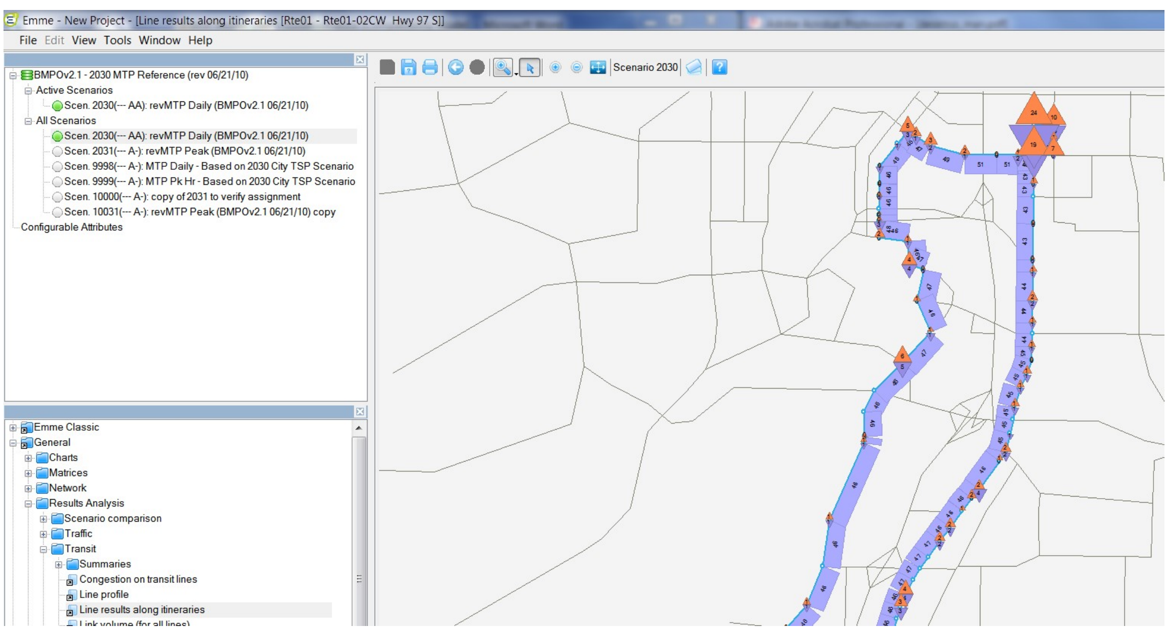
The *General->Results Analysis->Transit->Line profile* worksheet in the *Worksheet/ Table Explorer* shows line ridership information graphically, including on-board volumes, boardings, and alightings, as well as a small network map showing the line itinerary.

Figure 19: Emme Transit Line Profile



Line ridership can also be mapped by opening the *General->Results Analysis->Transit->Line results along itineraries* worksheet in the *Worksheet/Table Explorer*, which displays on-board volume, boardings, and alightings for one or more line(s).

Figure 20: Transit Line Results along Itineraries



7. TYPICAL APPLICATIONS

The most common model applications are for the development of travel forecasts for proposed changes to the network, land use, and significant changes in transit service. This section provides guidelines for these types of applications, together with several specific example applications.

Prior to starting the application process, it must be decided if the proposed change can be modeledi.e., can the change be reflected by the transportation supply and land use characteristics included in the model. An example of a roadway network change that cannot be represented in the model is the addition of intersection turning lanes. This is because a turn lane is below the level of detail of the network coding. The user must also avoid using a coded network attribute as a surrogate for the actual change. For example, increasing the directional capacity of a link to account for the presence of intersection turn lanes would not be appropriate, because the model has not been developed or validated in this way. TPAU staff should be contacted if there is a question about whether or how a change can be represented in the model. Other cautions are noted in Section 2 (Overview of JEMnR) under 'JEMnR Capabilities and Limitations.'

If it decided that the proposed change can be represented in the model, the next step is to review the applicable model development report to determine if there are any special application procedures that should be followed, beyond the standard practices described in this document. This is necessary to ensure consistency between the model application results for the proposed change and those for the reference scenario. In many cases both the baseyear and future year(s) scenarios must be updated to reflect more current conditions and data (e.g., land use and networks).

7.1 Proposed Network Changes

The basic procedures for applying the model for the addition of a new roadway and a change in an existing roadway characteristic are described below. The addition of a new roadway may include an entirely new facility or the extension of an existing facility. A change in an existing characteristic refers to a coded node or link attribute, such as speed or capacity. All of the coding operations included in the steps below can be performed in the Emme *Network Editor* worksheet. Previously Section 4 (Network Coding) provided further guidance for roadway and transit network changes in the section "Network coding standards for MPO models."

7.1.1 Addition of New Roadway

1. *Review the existing network coding in the vicinity of the change.*

   The review of attributes such as link speed, capacity, mode, VDF, number of lanes, functional class node type, roadway geometry, and centroid connectors in the vicinity of the change will provide an understanding of how the new roadway should be coded to maintain consistency with the reference scenario.

2. *Import a base map.*

   As described in Section 4 (Network Coding), when adding or modifying links, the link geometry should be traced over a background GIS map of the proposed roadway network.

3. *Code any additional nodes needed to represent the new roadway.*

   In some cases, such as the extension of an existing road between two other roads, there may be existing nodes that can be used. If new nodes are needed, however, the node attributes must be coded as described in the applicable model development report.

4. *Code the links for the new roadway.*

   Links are added between nodes to define the new roadway. If the change is a roadway extension, then the *Copy Attributes* and *Paste Attributes* feature can be selected from the context menu in the *Network Editor* to copy the attributes from an existing link along the roadway to the new link. If an entirely new roadway is being added, this feature can also be used to copy the attributes of a similar, nearby link as a starting point, with modifications made to the copied attributes to reflect the specific characteristics of the new roadway, if necessary.

   Another convenient link coding option within the *Network Editor* are the *Split One-Way Link* and *Split Two-Way Link* features. These features are used for representing new intersections created by the roadway. A new node is added in the middle of the selected link, with the length of each split link equal to one-half the length of the original link. Once the link has been split, the location of the added node can be adjusted using the *Network Editor*.

5. *Review nearby centroid connectors.*

   Centroid connectors may need to be added that link the new roadway to the adjacent TAZs. If so the guidelines presented in Section 4 (Network Coding) should be followed, as well as any other conventions described in the applicable model development report. The attributes values of an existing connector can be copied and pasted directly for new connectors.

   As a part of this step, the existing centroid connectors for the zones adjacent to the roadway should be examined to determine if adjustments are necessary. An adjustment would be needed, for example, if a new connector changed the traffic loading pattern of a TAZ such that an existing connector is no longer needed.

6. *Perform coding checks.*

   Depending on the extent of the change, network validation checks should be performed as discussed in Section 4 (Network Coding). For minor changes, such as adding a single link for a roadway extension, these checks are probably not necessary. For larger-scale changes, such as adding a subarea network in an undeveloped portion of the modeling area, these checks must be performed.

7. *Run the model; perform reasonableness checks.*

   The extent of the network change will also determine whether a full model run or only the traffic assignment step should be performed. The key factor in this decision is whether the change is large enough to affect the trip distribution pattern. An example of such a change would be the addition of a major new highway corridor or significant improvement of an interchange that might affect level of service across the region. This type of change could significantly reduce travel times between large portions of the modeling area, thus increasing the likelihood of trips between these areas. For small-scale changes, such as the example above of adding a short roadway extension, the travel time changes would be too small to affect trip distribution. In this case, only a new traffic assignment step would be needed using the same vehicle trip matrix as for the reference scenario, along with the revised network. TPAU staff should be contacted if there is a question about the need for a full model run or just a new traffic assignment.

7.1.2 Change in Existing Roadway Attributes

1. *Review the current coding of the attribute to be changed.*

   As with the new roadway scenario, the review of the link and node attributes and geometry of the coded network in the focus area will provide an understanding of how the change should be coded to maintain consistency with the existing network.
2. *Identify the link and/or node revised attribute value to reflect the change.*
3. *Code the revised value for the identified links and/or node attributes.*
4. *Perform coding checks.*

   These may or may not be necessary depending on the extent of the change.
5. *Run the model; perform reasonableness checks.*

   The need for a complete model run or only a new traffic assignment will also be determined by the extent of the change. A large capacity increase along a major corridor would likely necessitate a complete model run. A minor change to a lower-level facility would require only a new traffic assignment.

7.2 Proposed Transit Service Changes

Transit service changes may include the addition of a new transit line, a line extension, or a change to the attribute of an existing line. An attribute change refers to the coded attributes of a line, such as headway or speed or itinerary. All of the coding operations included in the steps below can be performed in the *Network Editor* worksheet.

7.2.1 Addition of New Transit Line/Line Extension

1. *Review the existing transit coding in the vicinity of change.*

   The review will provide an understanding of how the new line should be coded to maintain consistency with the reference scenario. Both transit line and walk access coding should be reviewed.
2. *Determine if the entire line can be coded based on the existing network.*

The network should be reviewed to determine if all of the links needed to code the line are available and the links are coded to allow transit mode use.

3. *If needed, code special transit-only links.*

   Special transit-only links must be coded where existing network links are not available. If the difference between the actual route and the existing coded network is minor (1 – 2 blocks), then the existing network can be used and the special transit-only links are not needed. If special transit-only links are to be coded, a base map should be imported to do this. Length and mode are the only relevant attributes for these links, because they are not used by autos. Speed is not coded, because this is included as one of the transit line attributes in the settings.csv file (except when transit travel time functions are provided). The mode attribute should be coded with a value of “b” only, with autos not allowed.

4. *Identify line attribute values*

   Values for all of the line attributes to be coded should be identified, following the conventions described in Section 4 (Network Coding) and any special practices defined in the model development report.

5. *Code the new line/line extension*

   The line is added by specifying the line attributes and itinerary in the *Network Editor* worksheet.

6. *Add walk connectors.*

   Walk connectors are added to link the new line to the adjacent TAZs. If a line segment follows the route of an existing line, then the walk links for the existing line can also be used for the new line if they adequately reflect how the new line would be accessed. If not, then additional walk links need to be coded.

7. *Perform network validation checks.*

   Validation checks should be performed for all new transit lines and line extensions per Section 4 (Network Coding).

8. *Adjust the transit coverage factors.*

   If the new line increases the transit coverage within a TAZ for either households or employment, then the household and/or employment transit coverage factors must be modified. To maintain consistency with the existing factors, TPAU staff should be contacted to identify the methodology that was used to estimate the factors for the particular JEMnR model that is being applied.

9. *Adjust the park-and-ride lot index file.*

   If the new line or line extension serves a park-and-ride lot, and the new service would add or change the selection of the park-and ride lot used by travelers from a TAZ, then the park-and-ride lot index should be modified to reflect this change.

10. *Run the model; perform reasonable checks.*

    Full model runs must be performed for all transit line additions or extensions, followed by the reasonableness checks described in Section 6 (Trip Assignment).

7.2.2 Change in Existing Transit Service Attribute

1. *Review the current coding of the existing service attribute to be changed.*

   The review will provide an understanding of how the change should be coded to maintain consistency with the existing network.

2. *Identify the revised attribute value to reflect the change.*

   This can include line attributes, walk connections, transit coverage factors, park and ride lot index, etc.

3. *Code the revised attribute value.*

4. *Perform coding checks.*

   These may or may not be necessary depending on the extent of the change.

5. *Run the model; perform reasonableness checks.*

   Full model runs must be performed for service attribute changes, followed by the reasonableness checks described in Section 6 (Trip Assignment).

7.3 Proposed Land Use Changes

Unlike network and transit service changes, for which the model application process is fairly clear-cut, the approach taken for land use changes can vary depending on the details of the proposed change. Therefore, a fair amount of judgment is usually required in identifying the appropriate application method.

To assist in the decision about how to apply the model for a proposed land use change, information is provided below for four common categories of proposed land use changes:

- Site development proposals
- Proposed zoning changes
- Comprehensive plan updates
- Proposed land use changes within Interchange Management Areas

The discussion covers the areas of:

- Preparation of land use-related data
- Associated network changes
- Partial vs. full model run
- Model focusing

There are a number of other model application issues that may also need to be considered. Information on these topics can be found in the *Modeling Procedures Manual for Land Use Changes*.[32]

Site development refers to the development of individual sites or parcels of land. Generally, more detailed information is known about the characteristics of proposed site developments than other types of land use changes, such as the particular type of retail or industrial use or even the future occupant of the site. The time frame for development is also usually shorter. Depending on the size of the development, this may be only 1 – 2 years. The keys for effectively applying models for site developments are:

- Having an adequate understanding of the trip characteristics of the proposed development.
- Providing input data to the model that accurately describes the development within the parameters of the model.
- Applying the model in a manner that is consistent with the character of the development and at the proper level of resolution.
- Producing the type of output needed for the analysis and in the required format.

Zoning changes, for purposes of this discussion, do not include changes with site development proposals attached to them. The area of a proposed zoning change may be quite small, but is usually larger than that of a site development proposal, and may be substantial. Fewer details may be known about the ultimate uses of the rezone area, and the proposal may result in a greater mix of future uses. The time frame for development with a zoning change can range from short-term to long-term.

Comprehensive plan updates are generally the largest type of land use change considered by local jurisdictions, with potentially the largest impacts to the transportation system. The time frame for development is usually mid- to long-term. Information about the development that will occur with a comprehensive plan change is usually very general, corresponding to the broad land use categories contained in the comprehensive plan. For model application, more and broader assumptions about the proposed change may need to be made, such as:

- Supporting transportation network (auto and transit)
- Need for modification of the TAZ system (and/or centroid connectors)
- Regional jobs-housing balance impact to trip distribution (and trip lengths)
- Need for adjustments to the regional population and employment totals and household size
- External trip making and impacts in the allocation of internal trip ends
- Need for special generators

The development of these assumptions may require significant coordination with multiple local agencies, as well as consultation with TPAU about model changes and assumptions.

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[32] Oregon Department of Transportation, Modeling Procedures Manual for Land Use Changes, (2011).

Land use changes within Interchange Management Areas are different from the other types of changes not because of their character or size, but due to their location. Because traffic operations within interchange areas tend to be more complex, different analysis methods may need to be used. This, in turn, may require different model outputs. Such studies may want to consider adding greater TAZ system detail within the interchange area to allow the identification and tracking of trips to/from specific areas of development and more refinement to the roadway network to support the more detailed traffic analysis that is typically performed for interchange areas.

7.3.1 Preparation of Land Use-Related Data

For general planning purposes, land use quantities for proposed land use changes are specified in different units than what is needed for the model. For site developments, land uses are usually defined in terms of the number of dwelling units for residential uses and building square footage for non-residential uses. For zoning changes and comprehensive plan amendments, fewer details may be known about the ultimate uses of the development area. The land uses may be identified in more general terms, such as gross acres of land by zoning or comprehensive plan category.

In either case, the land use quantities need to be converted for model use into the number of households by socioeconomic category for residential uses and employment by type for non-residential uses. Similar conversion processes are used for both types of changes, but are slightly different due to the different level of detail of the base data.

For site developments, the future forecast of land use translates into demand for travel. The general process for residential uses is to apply a vacancy rate to the dwelling units to obtain an estimate of the number of occupied units, which is assumed to be roughly equal to the number of households. Non-residential land uses are converted to employment by type by applying employee densities to the square footages and then allocating the employment to the appropriate category.

The conversion process for zoning changes and comprehensive plan amendments involves additional front-end steps to estimate the number of future dwelling units and building square footages from general land use quantities, such as gross acres of land by zoning category or comprehensive plan category. Assumptions about the percentage of land to be set aside for public uses, such as streets, must be applied first to obtain estimates of net developable acres. Following this, density assumptions can be applied to the estimates of net developable acres (i.e., dwelling units per acre for residential uses and floor-area ratios for non-residential uses) to derive estimates of the number of dwelling units and building square footages. In some cases where development takes place in isolated parts of an existing zone with significantly different roadway access points, there may be a need to split the zone and update centroid connections appropriately, or provide multiple centroid connectors. The remaining steps of the process are identical to those for proposed site developments.

Following the conversion of land use data into households and employment by type, the corresponding fields in the **TAZ.csv** file for the “changed” TAZ(s) need to be modified:

- Total households – “HHBASE”

- Employment by type – "AFREMP", "MINEMP", "CONEMP", etc.

Other data in the TAZ.csv file that may need to be changed are the household distribution fields ("HHS1BASE – HHS4BASE, "HHI1BASE – HHI4BASE", and "AGE1BASE – AGE4BASE"). If the values for these are blank or they do not represent the expected household distribution for the "changed" TAZ(s), then the values for a similar TAZ needs to be copied.[33]

Other land-use related data that may need to be modified are:

- Shopping center square footage – **sqft.csv** file
- Transit coverage factors – **TAZ.csv** file

The shopping center square footage data item is modified if the proposed change would result in an increase or decrease in the total shopping center square footage for the "changed" TAZ(s). The transit coverage factors are modified if the percentage of households and/or employment within ¼-mile of transit would be affected by the change.

7.3.2 Associated Network Changes

In addition to the land use quantities that will determine the future travel demand generated by the proposed change, the network that will support the proposed land uses must also be represented in the model. For smaller land use changes, the network reflected in the reference scenario may be adequate. For larger land use changes, however, particularly those located near the periphery of an urban area where the existing network may be sparse, there may be a need to define additional transportation facilities.

If the proposed change is for a site development, the project proponent will sometimes provide information on the planned facilities. In many cases, however, there will be no information about the network changes that need to be coded in the model. Therefore, an important issue is how to identify these changes.

It is not possible to define a step-by-step process for the identification of network changes because many of the decisions will depend on location-specific conditions. However, there are several general factors that should be considered. These are:

- Structure of the existing network near the area of the proposed change.
- Planned improvements included in the local transportation system plan.
- Level of refinement of the surrounding TAZs.
- Level of detail required for the model outputs.
- Network coding conventions for the model.

For defining the future reference network that will be used as the starting point for identifying the network changes, it is important to check with ODOT and local transportation system

[33] "Similar" means a TAZ with household demographics comparable to those of the household types that would be expected with the proposed land use change.

providers about the improvements that will likely be implemented by the end of the planning period. In addition, ODOT, the local jurisdiction, and the project proponent (if applicable) should all participate in the identification of the network changes.

Another network element that should be considered in connection with proposed land use changes are centroid connectors. If the proposed change would result in a shift in the distribution of development within a TAZ, then the loading points for traffic from the TAZ onto the network may change. If the current coding does not accurately reflect this loading, then the existing connectors may need to be modified or new connectors may need to be added. Transit service changes may also precipitate updates to the transit coverage factors (**TAZ.csv**).

7.3.3 Partial vs. Full Model Run

Full model run involves processing all of the model components shown in Figure 1 and further detailed in Appendix A using inputs that reflect the proposed land use and network changes. Once all of the input data have been prepared (provided the TPAU model calibration to the baseyear is still valid given the changes), the time requirement for a single model run is not significant (e.g., 90 minutes for RVMPOv3 JEMnR model),. If multiple runs are needed, however, the total time requirement could be large, along with time to review the results must be added. An example of when multiple model runs may be needed is if the ultimate size and/or composition of the proposed development has not been decided, and testing of various sizes or development types is needed to make this determination. For example, if 20 model runs are required to define the final development scenario, the time and cost to do this might be prohibitive.

For exploratory scenario testing such as this, it may be possible to use alternative methods for the development of model-based outputs that do not require application of the complete model. Two of these methods are:

- Interpolation of model output
- Partial model application using modified trip matrices

With the first method, the model output for several representative development scenarios is interpolated to derive data for alternative scenarios. For example, if there was a question about how large a proposed development should be, model runs could be performed for small, medium, and large-size scenarios. For a small/medium-size alternative, link volumes could be derived by interpolating between the link volumes for the small and medium-size projects. This would provide rough volume estimates for the analysis of the test scenario. Often 2 scenarios can bound the problem sufficiently. It gets more challenging if multiple changes are occurring and/or roadways are meeting the threshold for needing additional lanes or other key upgrades.

The second method involves modification of the vehicle trip matrix used for traffic assignment to reflect the proposed land use change. Normally, this matrix is created by running the model through the entire process shown in Figure A-1. With the alternative method, these steps are skipped. Instead, the trip matrix for the "without change" scenario is modified to reflect the trips for the proposed change. This is done by:

- Adding a new TAZ (or splitting an existing TAZ) for the proposed development to the trip matrix and network.
- Copying the portion of the matrix for a neighboring TAZ having similar trip distribution characteristics.
- Rebalancing the modified matrix using the estimated origins and destinations for the development TAZ.
- Running an assignment using the rebalanced trip matrix and the modified network.

This procedure should only be used if certain conditions are met:

- The proposed development is not large enough to cause a widespread shift in travel patterns compared to the distribution of trips for the "without change" scenario. If this is not true, the entire model should be run to adequately reflect the new distribution.
- There must be a neighboring TAZ whose trip distribution can be copied and used as an estimate of the distribution for the development TAZ (e.g., similar trip lengths, trip destinations by purpose). If this is not true, then the entire model should be run to create the actual trip distribution for the proposed development.
- If a higher level of accuracy of the model output is required for the vicinity of the proposed development (e.g., intersection volumes), the entire model should be run to better estimate the actual distribution of trips.

These alternative methods are most appropriate for use with smaller proposed changes, such as site developments and small zoning changes. Large land use changes or those changing previously isolated or open land would likely not meet the first condition listed above, so that a full model run would be required.

Once the scenario testing is finished, a full model run must be performed for the final development scenario to produce the output to be used in the impact analysis.

7.3.4 Model Focusing

Model focusing is a special procedure used when greater detail is needed within the model network and TAZ system to adequately represent a portion of the modeling area. It involves disaggregation of the TAZs within the "focus" area, as well as refining the network to be consistent with the smaller TAZs. Focusing is different than the concept of "windowing", in which the regional model is cut off at a cordon line surrounding the subarea and trips to and from the subarea are represented at external stations along the cordon line.

Focusing is used for general subarea modeling, but it is also an excellent tool for producing more detailed and accurate model output for the analysis of impacts in the vicinity of a proposed land use change. The need for model focusing may be higher in the fringe of the modeling area, where TAZs tend to be larger and the network may be less detailed.

The focusing technique is applied after a full model run has been performed. Once this has been done, the following procedure is used:

1. The model's TAZ system and network are refined in the vicinity of the proposed change.
2. The origins and destinations for the original or "parent" TAZs from the "with change" model run are allocated to the disaggregated TAZs using one of several possible weighting schemes typically with outside data sets or land use coverage maps. Examples of weights that may be used are:

   - The sum of population (or households) and employment estimated for the disaggregated TAZs.
   - Total trip generation (trip ends) estimated for the disaggregated TAZs representing trip productions and attractions.

3. The vehicle trip matrix from the "with change" model run is expanded to reflect the revised TAZ system.
4. The expanded matrix from Step 3 is balanced using the disaggregated origins and destinations from Step 2.
5. A new trip assignment (using the assignment procedures of Section 6 (Trip Assignment)) is run with the vehicle trip matrix from Step 4 and the refined "with change" network.

This focusing procedure should be applied first for the model base year ("without change"), without the proposed land use change. The results of the application should be compared to the output from the full model run and observed data to ensure that the focus model is functioning properly. Link volumes should be compared to traffic counts near the area of the change using measures such as the relative and absolute error, % RMSE, and scatterplots of observed vs. estimated volumes, including R^2 values as noted in Section 6.3.1 (Trip Assignment Validation). Additional checks are select zone and select link assignments to assess the reasonableness of route choice, and travel time isochrones for selected TAZs in the change area. Once the focus model has been validated in the "without change" scenario, it should be applied in the same manner for the "with change" scenario.

In addition to the greater level of detail of the model output and potential for increased accuracy if good weighting data is used, another advantage of model focusing is that trips from the change area can be tracked through the network by running select zone assignments. This information can be used for purposes such as fair share cost assessment (e.g. system development charges).

The key factor to be considered in deciding whether the focus modeling procedure should be used is whether the standard TAZ system and network will produce model outputs that are accurate and detailed enough for the analyses to be performed. If so, then this approach is usually not necessary.

Focus models can be applied for land use changes of any size, from site developments to large-scale comprehensive plan amendments. A comparison of the TAZ systems and networks for a standard model vs. a focus model is shown in Figures 21 and 22. The significant increase in centroid loading points by a smaller set of trips should provide more accuracy on roadway links and intersection turn movements.

Figure 21: TAZ System and Network for Standard Model

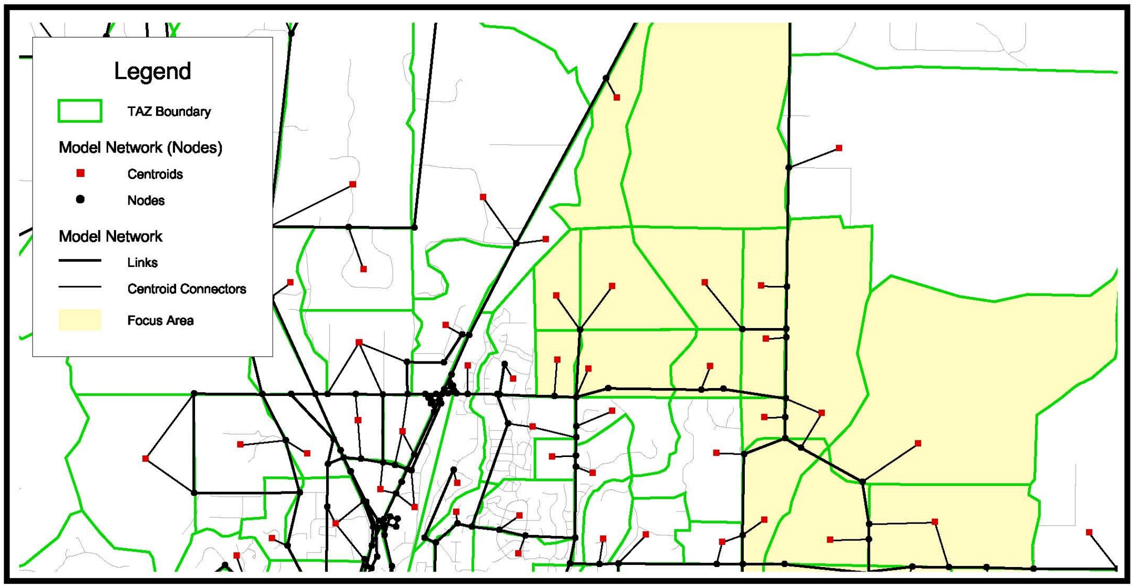
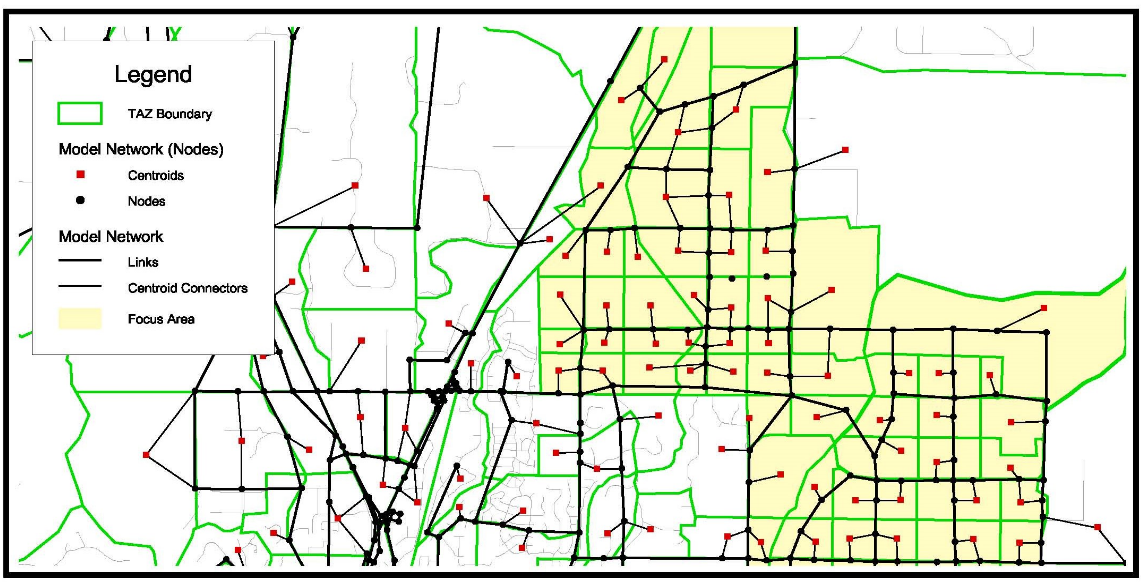


Figure 22: TAZ System and Network for Focus Model



8. VIEWING MODEL OUTPUT

Once a model run has been completed, there is a variety of ways to view the model output. Traffic and transit assignment results can be viewed using the worksheets and tables in the *Worksheet/Table Explorer*. Output from the JEMnR modules can be viewed using R commands. In the sections below, examples of how to display commonly-viewed outputs in Emme and R are presented.

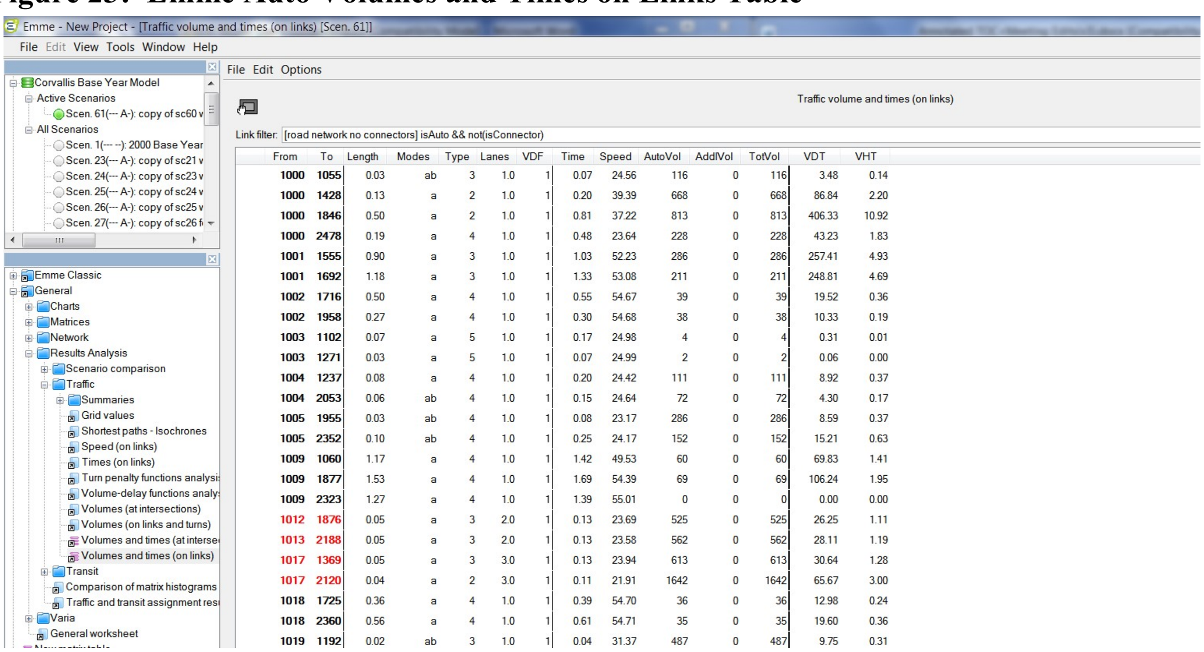
8.1 Viewing Model Output in Emme

8.1.1 Tabular link Data

Auto assignment results can be listed in tables containing detailed and summary information or on maps with bars and numeric values on links and turns. To list results by link, open the *General->Results Analysis->Traffic->Volumes and Times (on links)* table, which displays:

- Basic link information, including length, number of lanes, and VDF code
- Auto time and speed
- Assigned auto volume (number of vehicles for all classes)
- Additional volume (background traffic)
- Total volume (sum of assigned and additional volumes)
- Vehicle distance and vehicle hours traveled (VDT and VHT)

Figure 23: Emme Auto Volumes and Times on Links Table



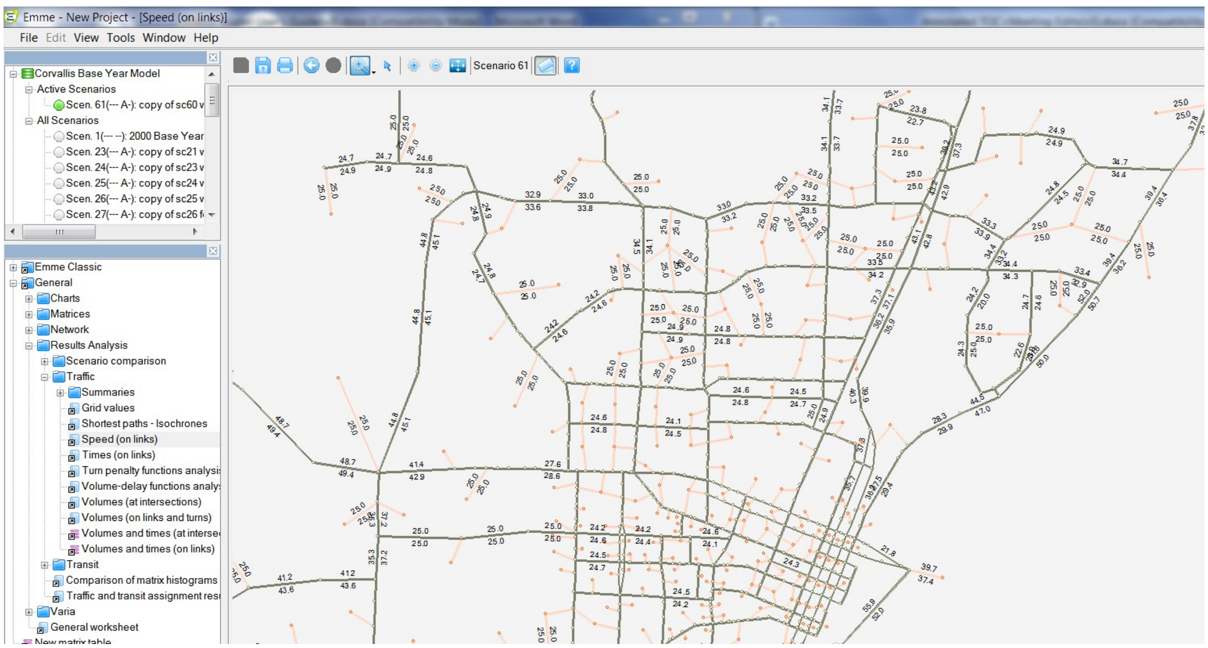
From	To	Length	Modes	Type	Lanes	VDF	Time	Speed	AutoVol	AddlVol	TotVol	VDT	VHT
1000	1055	0.03	ab	3	1.0	1	0.07	24.56	116	0	116	3.48	0.14
1000	1428	0.13	a	2	1.0	1	0.20	39.39	668	0	668	86.84	2.20
1000	1846	0.50	a	2	1.0	1	0.81	37.22	813	0	813	406.33	10.92
1000	2478	0.19	a	4	1.0	1	0.48	23.64	228	0	228	43.23	1.83
1001	1555	0.90	a	3	1.0	1	1.03	52.23	286	0	286	257.41	4.93
1001	1692	1.18	a	3	1.0	1	1.33	53.08	211	0	211	248.81	4.69
1002	1716	0.50	a	4	1.0	1	0.55	54.67	39	0	39	19.52	0.36
1002	1958	0.27	a	4	1.0	1	0.30	54.68	38	0	38	10.33	0.19
1003	1102	0.07	a	5	1.0	1	0.17	24.98	4	0	4	0.31	0.01
1003	1271	0.03	a	5	1.0	1	0.07	24.99	2	0	2	0.06	0.00
1004	1237	0.08	a	4	1.0	1	0.20	24.42	111	0	111	8.92	0.37
1004	2053	0.06	ab	4	1.0	1	0.15	24.64	72	0	72	4.30	0.17
1005	1955	0.03	ab	4	1.0	1	0.08	23.17	286	0	286	8.59	0.37
1005	2352	0.10	ab	4	1.0	1	0.25	24.17	152	0	152	15.21	0.63
1009	1060	1.17	a	4	1.0	1	1.42	49.53	60	0	60	69.83	1.41
1009	1877	1.53	a	4	1.0	1	1.69	54.39	69	0	69	106.24	1.95
1009	2323	1.27	a	4	1.0	1	1.39	55.01	0	0	0	0.00	0.00
1012	1876	0.05	a	3	2.0	1	0.13	23.69	525	0	525	26.25	1.11
1013	2188	0.05	a	3	2.0	1	0.13	23.58	562	0	562	28.11	1.19
1017	1369	0.05	a	3	3.0	1	0.13	23.94	613	0	613	30.64	1.28
1017	2120	0.04	a	2	3.0	1	0.11	21.91	1642	0	1642	65.67	3.00
1018	1725	0.36	a	4	1.0	1	0.39	54.70	36	0	36	12.98	0.24
1018	2360	0.56	a	4	1.0	1	0.61	54.71	35	0	35	19.60	0.36
1019	1192	0.02	ab	3	1.0	1	0.04	31.37	487	0	487	9.75	0.31

The number of links can be restricted using the *Filter* and the table can be sorted by clicking on the header of the appropriate column.

8.1.2 Mapped Link attributes

Link speeds and times can be mapped by opening the *General->Results Analysis->Traffic->Speed (on links)* worksheet or the *General->Results Analysis->Traffic->Times (on links)* worksheet. In the *Links* layer control, the number of links displayed can be controlled using the *Link filter*. The number of *Decimals* and *Text size* can also be adjusted. Different data items can be selected using the *Text value* drop-down menu.

Figure 24: Emme Auto Speeds on Links



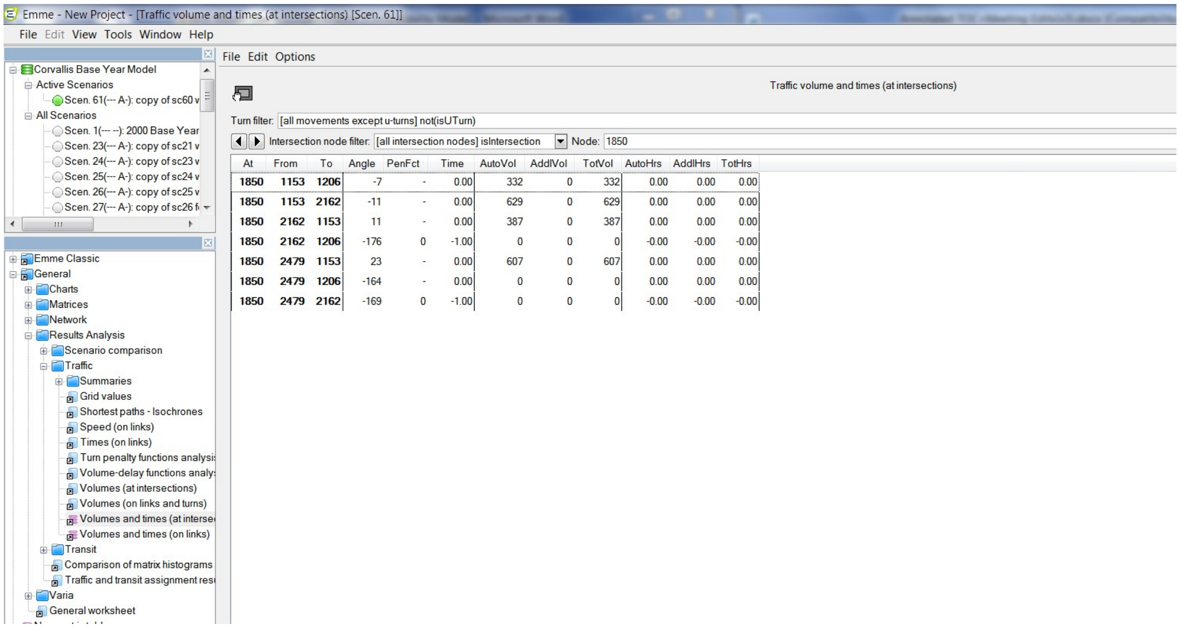
8.1.3 Intersection attributes

Assignment results at intersections are listed and mapped in a similar manner. The following data items can be listed by opening the *General->Results Analysis->Traffic->Volumes and times (at intersections)* table:

- Turn angle, penalty function, and time
- Assigned auto volume
- Additional volume (background traffic)
- Total volume (sum of assigned and additional volumes)
- Vehicle hours traveled (VHT) for the assigned, additional, and total volumes

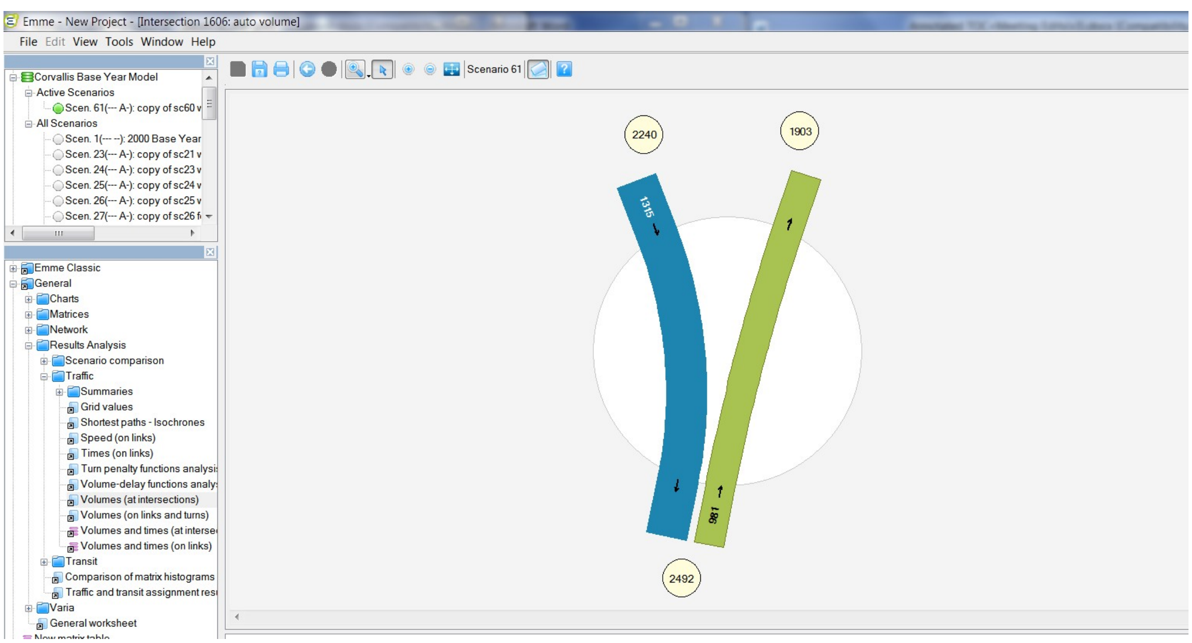
The drop-down *Node* menu is used to specify the intersection to be displayed.

Figure 25: Emme Auto Volumes and Times at Intersections Table



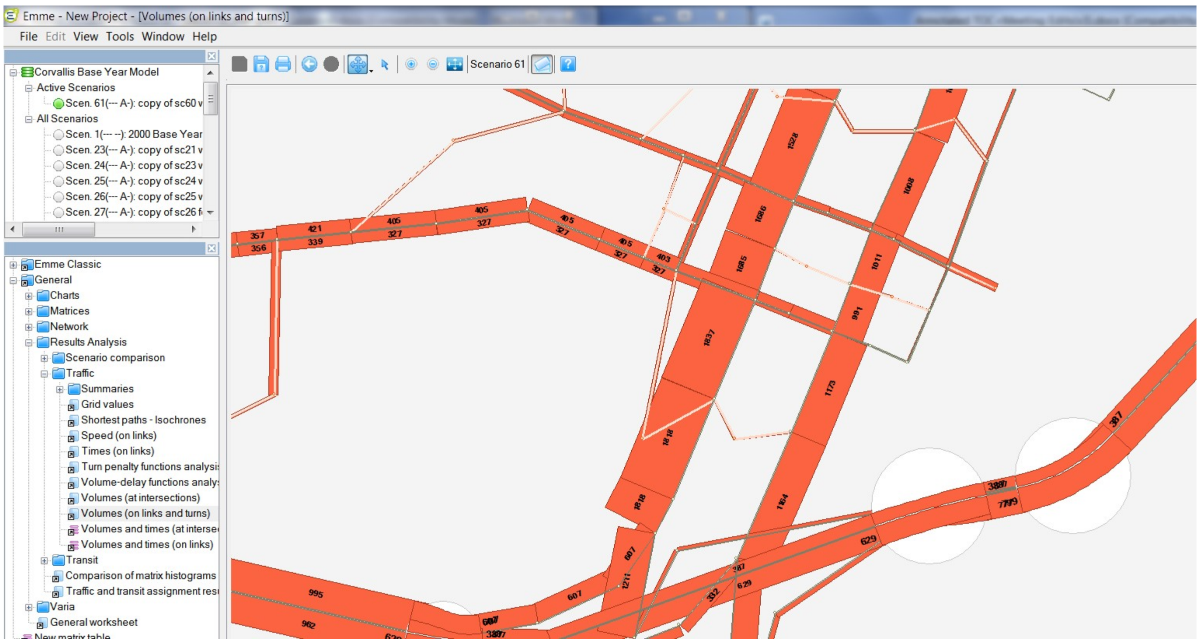
Auto volumes at intersections are mapped by opening the *General->Results Analysis->Traffic->Volumes (at intersections)* worksheet, which displays turn volumes as bars for one intersection node. The intersection to be displayed is specified by double-clicking the desired row in the *nodes* table associated with the worksheet or via the drop-down menu by choosing the desired intersection in the *Intersection filter*, then using the up/down arrows to display one intersection after another.

Figure 26: Emme Auto Volumes at Intersections Map



The *General->Results Analysis->Traffic->Volumes (on links and turns)* worksheet maps various combinations of auto volume and additional volume for links and turns. The *Bar value* field within the *Links* layer control is used to change the type of volume displayed; the value for turns is determined accordingly. The *Turns at intersections* layer control is used to modify the way turn volumes are displayed.

Figure 27: Emme Auto Volumes and Times on Links Map



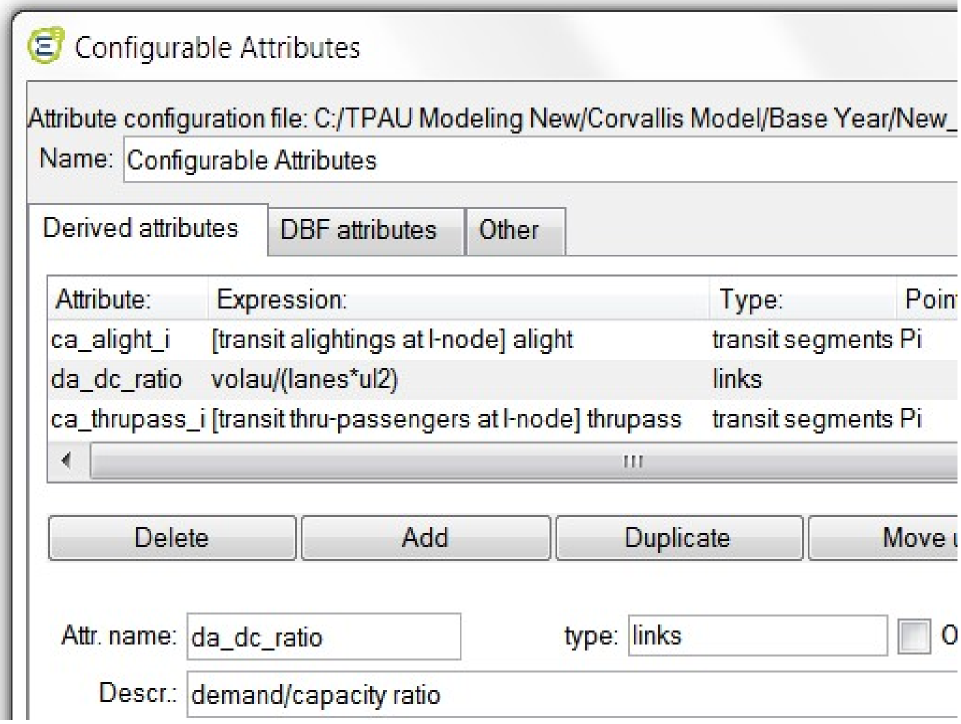
8.1.4 Configurable link attributes

In some cases, the user may need to display data that is not a standard assignment result. An example of this is the demand/capacity (d/c) ratio, which would be used to analyze congestion levels in the network. This data can be obtained by creating a configurable attribute, which is a user-defined attribute derived from an expression. These attributes are saved in an attribute configuration (.ema) file, which can be associated with a project in the *General* pane of the *Project Settings* window.

As an example, a configurable attribute for the d/c ratio is created within the following steps:

1. Open *Tools → Configurable Attribute Calculator*.
2. Click the *Add* button. The fields in the lower portion of the window become blank.
3. Enter the attribute name in the *Attr. name* field. In this case, the name "da_dc_ratio" is used.
4. Enter a description in the *Descr.* field.
5. Select the expression type. For the new derived attribute "da_dc_ratio", the expression will be calculated for links. Therefore, *links* is selected from the *Expr. type* drop-down list.
6. Enter the expression. In this case, the expression is:

- volau/(lanes*ul2)
- Press **Enter** for the expression to appear in the attribute list above the fields.

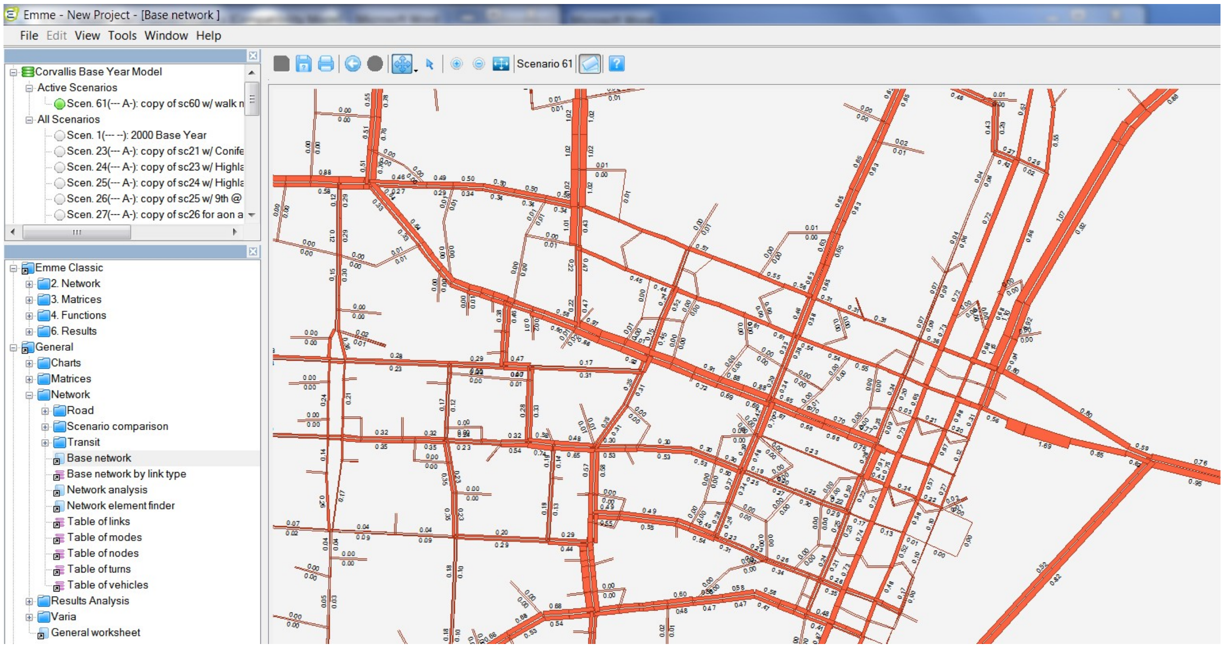


7. The *isAuto* filter is selected from the *Filter* field to limit the calculation to the auto network only.
8. The default value in the *Def. value* field is left as zero.
9. The number of decimal places used to store/display the attribute is specified as "2" in the *Decimals* field.
10. Click *OK* to close the *Configurable Attribute Calculator*. The changes are applied but <u>not</u> saved in the attribute configuration file.

- To save the changes, use *Save as*.
- To cancel the changes, use *Load* to reload the original file.

Once a configurable attribute has been created, it can be mapped or listed in the same manner as standard attributes and extra attributes:

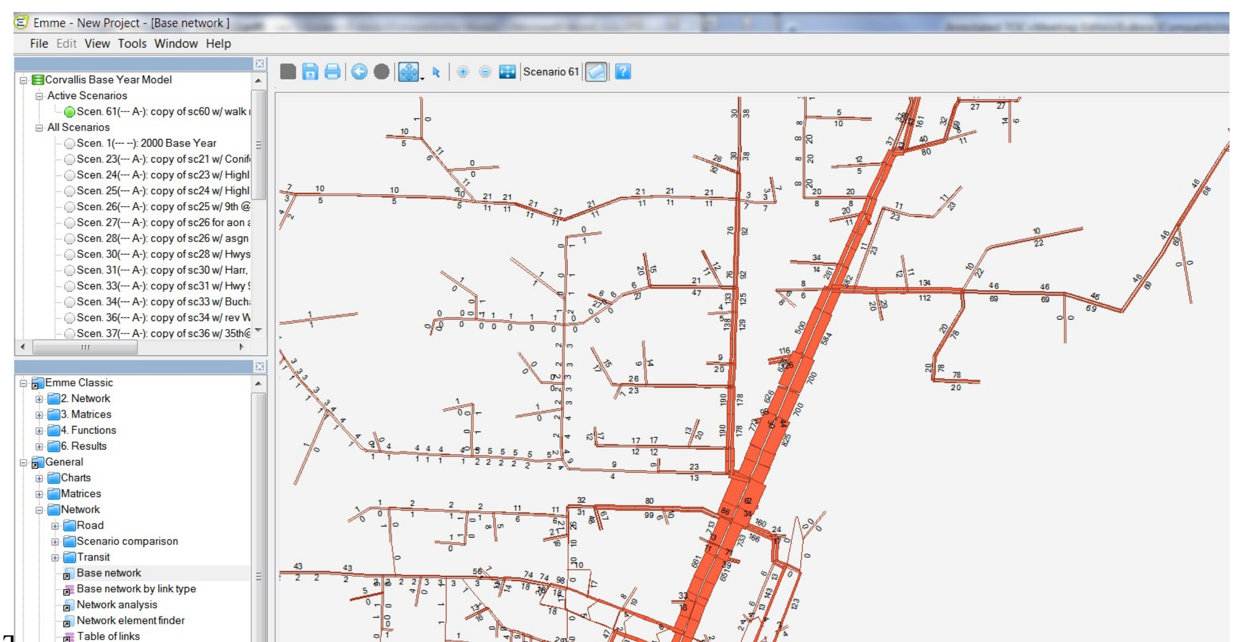
Figure 28: Emme Demand/Capacity Ratio Configurable Attribute



8.1.5 Mapped Select link results

Volumes from the select link/select zone assignment procedures (refer to EMME manual for procedures) can be mapped as any other extra link attribute would be by opening the *General->Network->Base Network* worksheet and using the *Link value* layer control to select the extra attribute containing the select link volume.

Figure 29: Emme Select Link Volumes



8.2 Viewing Model Output in R

Upon a successful run of the JEMnR model, the runModel.R script will seek the modelReport.R script (either on the network or locally), which produces an HTML report containing a comparison between the current run and a reference run specified in the settings file, via the "referenceRun" parameter. Presently, only the generated trips by income and purpose are plotted and tabulated, but additional components will be added for a more extensive analysis.

APPENDIX A JEMNR SUBMODULES

A.1 JEMnR Flowchart

As described in Section 2 (Overview of JEMnR), the general structure of the MPO models follows the basic four-step process consisting of trip generation, trip distribution, mode choice, and trip assignment. The first three steps are carried out within the following six main JEMnR modules:

1. Pre-Generation
2. Trip Generation
3. Multi-Modal Accessibility
4. Trip Distribution
5. Mode Choice
6. Commercial vehicle model (see Appendix E Commercial Vehicle Model)
7. University travel model (see Appendix F University Travel Model)
8. Peaking and Demand Matrices

The trip assignment step is performed separately within Emme. The overall processing flow within JEMnR is illustrated in Figure A-1. Each module is discussed below with a flow chart and list of inputs and outputs. Further information on the model theory and model development can be found in the *JEMnR Model Base Report*,[34]

A.2 Pre-Generation

The **Pre-Generation** module consists of four submodules:

- Calculate accessibility variables (**access**)
- Household worker submodel (**whia**)
- Household auto ownership submodel (**chwi**)
- Household child submodel (**khia**)

The **access** submodule calculates several accessibility variables that are used in the auto ownership submodel, multi-modal accessibility (**accessUtilities**) submodule, and mode choice model (**modeChoiceCommon**).

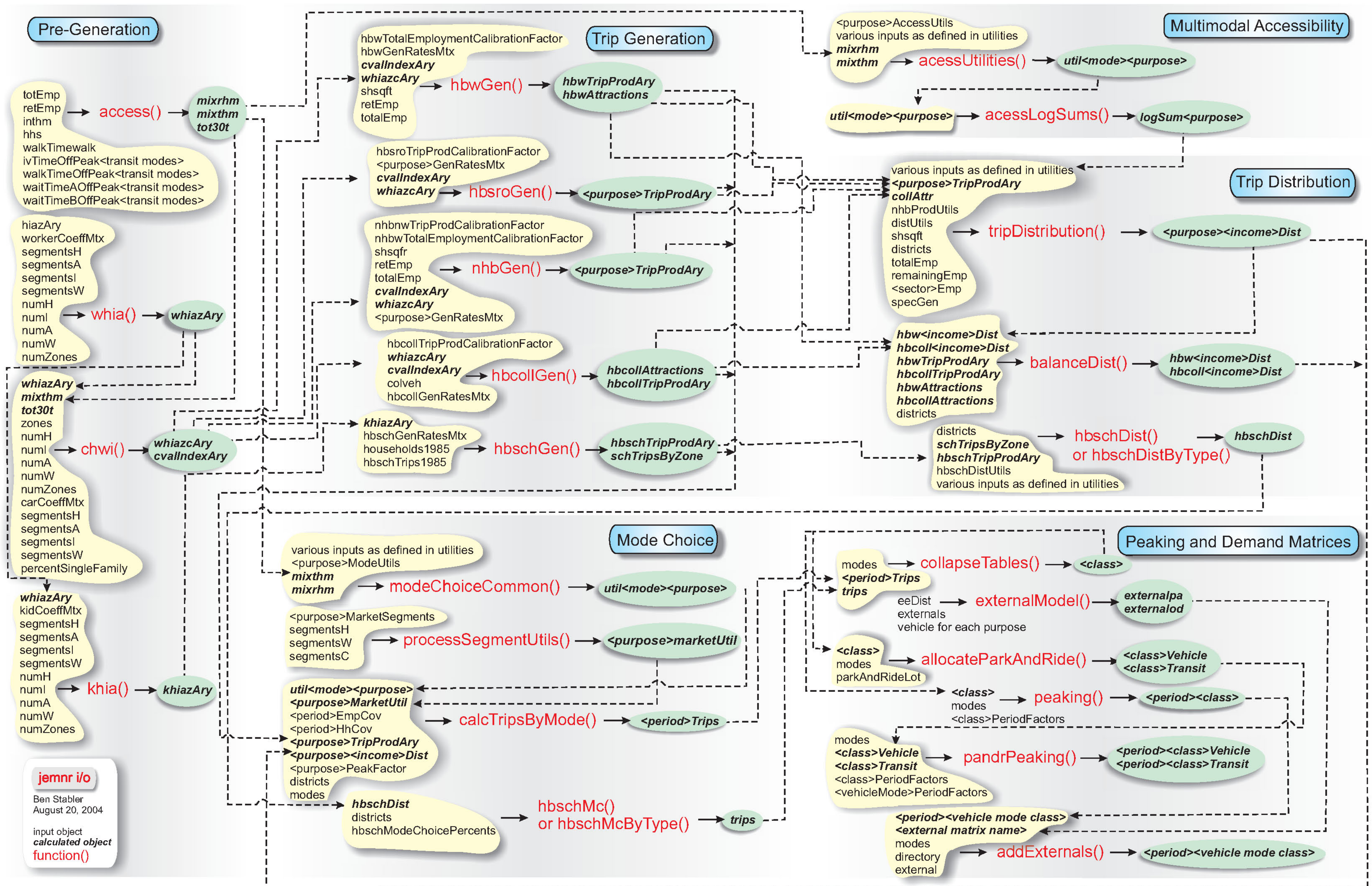
The household submodels further disaggregate the distribution of households by size, income, age-of-head-of-household, and TAZ (hiazAry object) created internally within JEMnR, resulting in the following distributions, or arrays:

[34] Oregon Department of Transportation, JEMnR Model Base Report, (2011).

- Households by HIAZ by number of workers (0, 1, 2, 3+) – whiazAry
- Households by WHIAZ by number of autos owned (0, 1, 2, 3+) – whiazcAry; and
- Households by KHIAZ by number of children (0, 1, 2, 3+) – khiazAry.

The household distributions are required inputs to the trip generation models.

Figure A-1
JEMnR Model Flowchart



A.3 Calculate Accessibility Variables (access)

Prior to the application of the household submodels, the **access** submodule calculates several accessibility variables:

- A composite accessibility or “mix” variable reflecting retail employment density and intersection density near each zone.
- A second composite accessibility or “mix” variable reflecting total employment density and intersection density near each zone.
- Total employment within 30 minutes of transit travel time (includes walk and wait time) of zone.

The composite accessibility variables are developed to account for both the relative magnitudes of and interactions between household density, employment density, and intersection density (a measure of street connectivity) – the three urban design variables known to affect travel behavior. The household and employment values are normalized to intersection units using geometric means. The natural log is used to transform the variables’ units for compatibility with other variables in the auto ownership, multimodal accessibility, and mode choice models, as shown in the following equation:

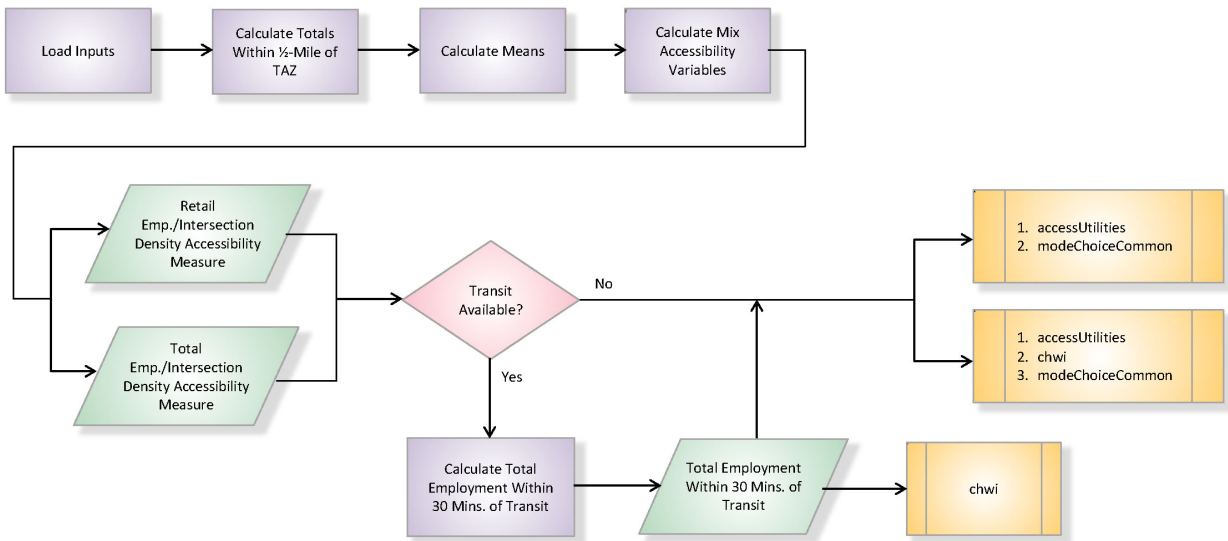
Mix = Ln ((int*(emp*(int.mean/emp.mean))*(hh*(int.mean/hh.mean)))/
(int+(emp*(int.mean/emp.mean))+(hh*(int.mean/hh.mean))))

where:

int	= number of local intersections within ½ mile of each zone
emp	= retail or total employment within ½ mile of each zone
hh	= households within ½ mile of each zone
int.mean	= mean int value across all zones
emp.mean	= mean emp value across all zones
hh.mean	= mean hh value across all zones

These variables are used in the auto ownership submodel (**chwi**), multi-modal accessibility submodule (**accessUtilities**), and mode choice model (**modeChoice Common**).

Submodule Flowchart



Input Objects

Name	Description	Output From
totEmp	Total employment by TAZ	inputsSave.R
retEmp	Retail employment by TAZ	inputsSave.R
inthm	Number of intersections within ½ mi. of TAZ centroid	inputsSave.R
hhs	Total households by TAZ	inputsSave.R
walkTimewalk	Walk mode walk time	inputsSave.R
ivTimeoffPeakbusWalk	Off-peak bus in-vehicle time	inputsSave.R
walkTimeoffPeakbusWalk	Off-peak bus walk time	inputsSave.R
waitTimeAoffPeakbusWalk	Off-peak bus initial wait time	inputsSave.R
waitTimeBoffPeakbusWalk	Off-peak bus transfer time	inputsSave.R

Output Objects

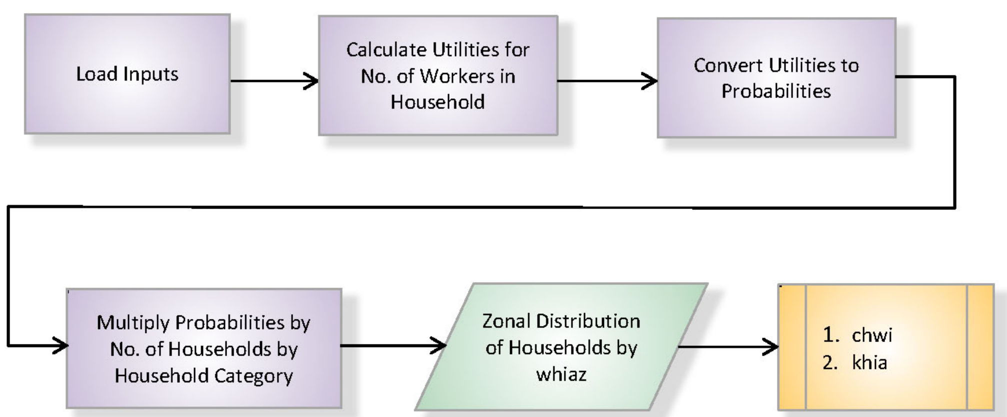
Name	Description	Input To
mixrhm	Retail employment density/intersection density composite accessibility measure	1. accessUtilities 2. modeChoiceCommon
mixthm	Total employment density/intersection density composite accessibility measure	1. accessUtilities 2. chwi 3. modeChoiceCommon
tot30t	Total employment within 30 minutes total transit travel time of TAZ	1. chwi

A.4 Household Worker Submodel (whia)

The **whia** submodule implements the household worker submodel, a multinomial logit model in which utilities are calculated for the number of workers in the household based on household size, income, and age-of-head-of-household (HIA) characteristics. The utilities are converted to probabilities, which are multiplied by the number of households within each HIA category to produce a distribution of the number of households in each TAZ by the number of workers, household size, household income, and age-of-head-of-household. This distribution is input to the household auto ownership (**chwi**) and household child (**khia**) submodels.

Information on the development of the household worker submodel can be found in the *JEMnR Model Base Report*,[35] Section E. – Model Development, starting on page 35.

Submodule Flowchart



[35] Oregon Department of Transportation, JEMnR Model Base Report, (2011).

Input Objects

Name	Description	Output From
hiazAry	Distribution of TAZ households by size, income, and age of head of household	inputsSave.R
workerCoeffMtx	Coefficients for household worker submodel utility functions	inputs.R
segmentsH	Household size classes	inputs.R
segmentsI	Household income classes	inputs.R
segmentsA	Age of head of household classes	inputs.R
segmentsW	Number of workers in household classes	inputs.R
numH	Number of household size classes	inputs.R
numI	Number of household income classes	inputs.R
numA	Number of age of head of household classes	inputs.R
numW	Number of workers in household classes	inputs.R
numZones	Number of zones	inputsSave.R

Output Objects

Name	Description	Input To
whiazAry	Distribution of TAZ households by number of workers, size, income, and age of head of household	1. chwi 2. khia

A.5 Household Auto Ownership Submodel (chwi)

The **chwi** submodule implements the household auto ownership submodel, a multinomial logit model in which utilities are calculated for the number of auto owned by the household based on:

- Household number of workers, size, and income characteristics
- Zonal accessibility (total employment density/intersection density “mix” and total employment within 30 minutes of total transit travel time)
- Dwelling unit type (single-family or other)

The utilities are converted to probabilities, which are multiplied by the number of households within each worker/size/income/dwelling unit type category to produce a distribution of the number of households in each TAZ by the number of workers, household size, household income, age-of-head-of-household, and number of autos owned. This distribution is input to all of the non-school trip generation models.

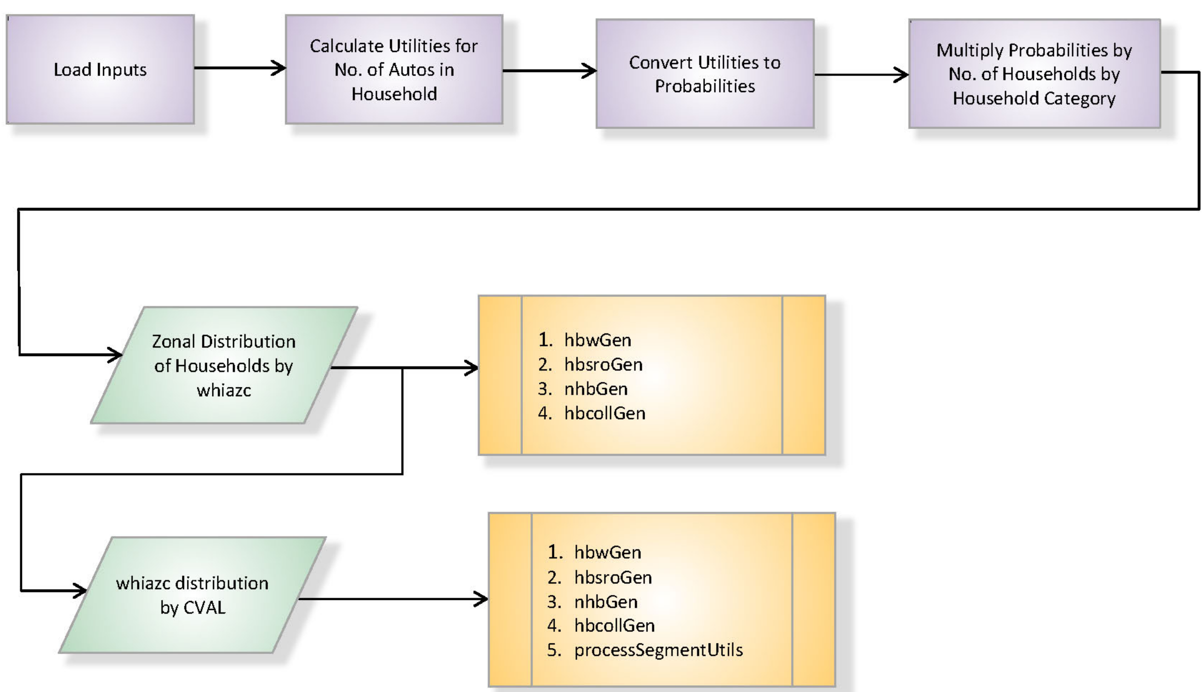
An additional household distribution is generated from the WHIAZC array, reflecting auto sufficiency, i.e., the relationship between the number of autos owned and the number of workers, based on the following categories:

- CVAL 0: Number of autos owned = 0
- CVAL 1: Number of autos owned < number of workers
- CVAL 2: Number of autos owned = number of workers
- CVAL 3: Number of autos owned > number of workers

This distribution is created by storing the WHIAZC array by each of the "CVAL" household categories. It is used within the mode choice model (**processSegmentUtils**).

Information on the development of the household auto ownership submodel can be found in the *JEMnR Model Base Report*,[36] Section E. – Model Development, starting on page 35.

Submodule Flowchart



[36] Oregon Department of Transportation, JEMnR Model Base Report, (2011).

Input Objects

Name	Description	Output From
whiazAry	Distribution of TAZ households by number of workers, size, income, and age of head of household	whia
Mixthm	Total employment density/intersection density composite accessibility measure	access
tot30t	Total employment within 30 minutes total transit travel time of TAZ	access
Zones	Vector from 1: number of zones	inputsSave.R
segmentsH	Household size classes	inputs.R
segmentsI	Household income classes	inputs.R
segmentsA	Age of head of household classes	inputs.R
segmentsW	Number of workers in household classes	inputs.R
segmentsC	Household auto ownership classes	inputs.R
numH	Number of household size classes	inputs.R
numI	Number of household income classes	inputs.R
numA	Number of age of head of household classes	inputs.R
numW	Number of number of workers in household classes	inputs.R
numC	Number of household auto ownership classes	inputs.R
numZones	Number of zones	inputsSave.R
carCoeffMtx	Coefficients for household auto ownership submodel utility functions	inputs.R
percentSingleFamily	Percent single-family dwelling units by TAZ	inputsSave.R

Output Objects

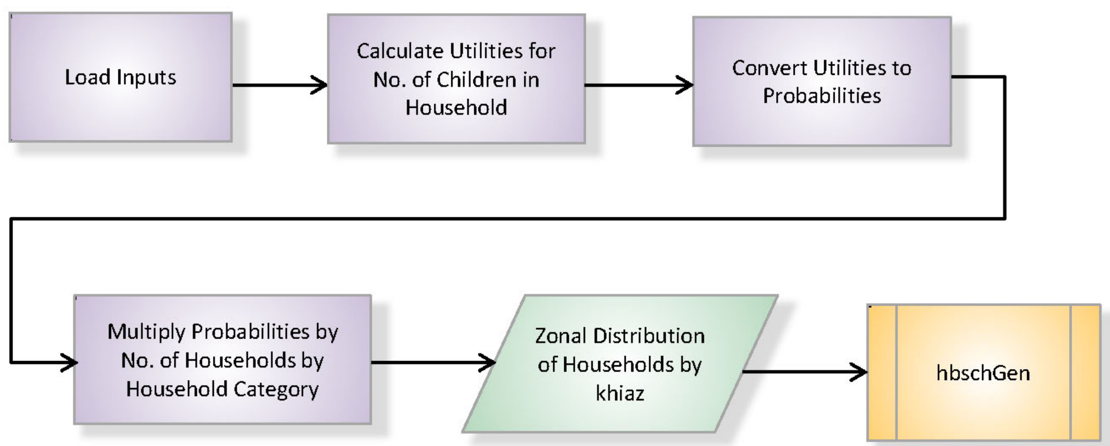
Name	Description	Input To
whiazcAry	Distribution of TAZ households by number of workers, size, income, age of head of household, and number of autos (WHIAZC)	1. hbwGen 2. hbsroGen 3. nhbGen 4. hbcollGen
cvalIndexAry	WHIAZC distribution stored by auto ownership/number of workers index value (CVAL)	1. hbwGen 2. hbsroGen 3. nhbGen 4. hbcollGen 5. processSegmentUtils

A.6 Household Child Submodel (khia)

The **khia** submodule implements the household child submodel, a multinomial logit model in which utilities are calculated for the number of children in the household based on household size and age-of-head-of-household characteristics. The utilities are converted to probabilities, which are multiplied by the number of households within each household size/age-of-head-of-household class to produce a distribution of the number of households in each TAZ by the number of children, household size, household income, and age-of-head-of-household. This distribution is input to the home-based school trip generation model.

Information on the development of the household child submodel can be found in the *JEMnR Model Base Report*,[37] Section E. – Model Development, starting on page 35.

Submodule Flowchart



Input Objects

Name	Description	Output From
whiazAry	Distribution of TAZ households by number of workers, size, income, and age of head of household	whia
kidCoeffMtx	Coefficients for household child submodel utility functions	inputs.R
segmentsH	Household size classes	inputs.R
segmentsI	Household income classes	inputs.R
segmentsA	Age of head of household classes	inputs.R
segmentsW	Number of workers in household classes	inputs.R
numH	Number of household size classes	inputs.R

[37] Oregon Department of Transportation, JEMnR Model Base Report, (2011).

Name	Description	Output From
numI	Number of household income classes	inputs.R
numA	Number of age of head of household classes	inputs.R
numW	Number of number of workers in household classes	inputs.R
numZones	Number of zones	inputsSave.R

Output Objects

Name	Description	Input To
khiazAry	Distribution of TAZ households by number of children, size, income, and age of head of household	hbschGen

A.7 Trip Generation

The **Trip Generation** module estimates average weekday person trip productions for eight trip purposes within the following submodules:

- **hbwGen** – Home-Based Work (HBW)
- **hbsroGen** - Home-Based Shopping (HBshop), Home-Based Recreation (HBrec), Home-Based Other (HBoth)
- **nhbGen** - Non-Home-Based Work (NHBW), Non-Home-Based Non-Work (NHBNW)
- **hbcollGen** – Home-Based College (HBcoll)
- **hbschGen** - Home-Based School (HBsch)

All of the trip generation models are of the cross-classification form in which, for each zone, the number of households in each household category is multiplied by a production rate. The number of trip productions is then factored by applying a calibration factor which varies by purpose. Trip attractions are also calculated for the HBW and HBcoll trip purposes for use in the trip distribution model.

Information on the development of the trip generation models can be found in the *JEMnR Model Base Report*,[38] Section E. – Model Development, starting on page 42.

[38] Oregon Department of Transportation, JEMnR Model Base Report, (2011).

A.7.1 Home-Based Work Trip Generation Model (hbwGen)

The **hbwGen** submodule implements the home-based work trip generation model. Trip productions are estimated based on the number of workers in the household. Trip attractions are also estimated for use in the trip distribution model. Attractions are calculated according to the following procedure:

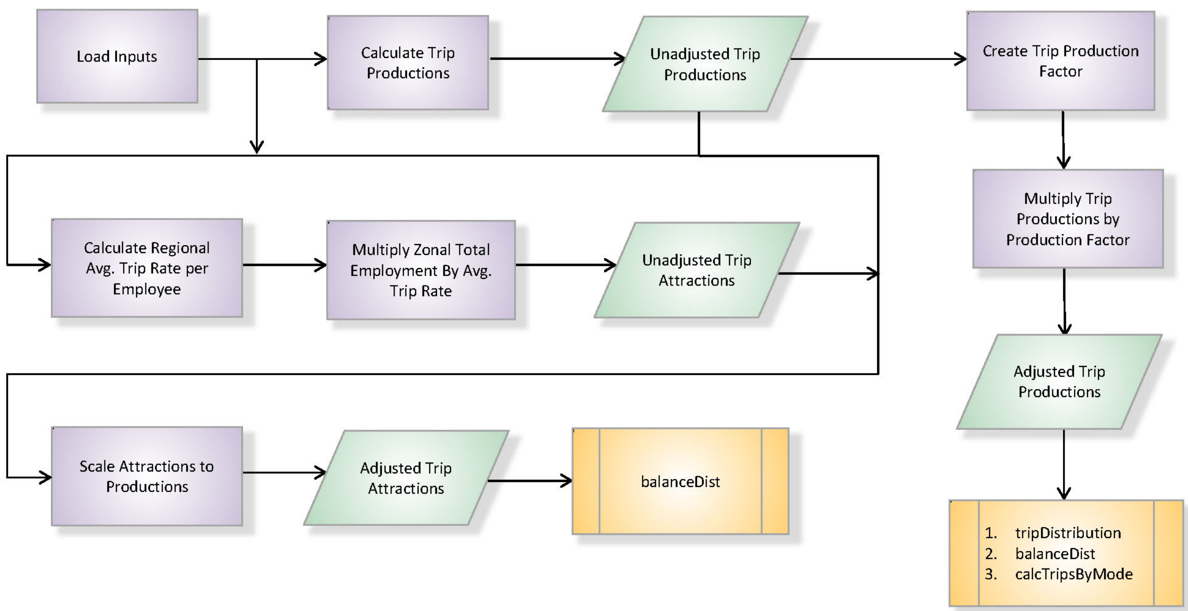
- An estimate of retail employment for each TAZ is developed based on shopping center floor space in square feet; if greater than the input value of retail employment, this estimate is used to adjust total employment upward.
- A regional average trip rate per employee is calculated by dividing the sum of HBW productions by total employees.
- Trip attractions for each TAZ are calculated by multiplying the average trip rate by the total employment for the TAZ.
- Attractions are scaled to productions by multiplying the attractions for each TAZ by the ratio of total productions to total attractions.

Final trip production estimates are developed in the following steps:

- Total employment is multiplied by a calibration factor, then divided by total productions to create a production factor.
- Final HBW productions are calculated by multiplying the productions for each TAZ by the production factor.

The trip productions are input to the trip distribution and mode choice models, while the trip attractions are input to the trip distribution model.

Submodule Flowchart



Input Objects

Name	Description	Output From
whiazcAry	Distribution of TAZ households by number of workers, size, income, age of head of household, and number of autos	chwi
hbwGenRatesMtx	HBW trip generation rates	inputs.R
hbwTotalEmployment CalibrationFactor	Total employment calibration factor for HBW trip generation	runModel.R
shsqft	Shopping center square footage by TAZ	inputsSave.R
retEmp	Retail employment by TAZ	inputsSave.R
totalEmp	Total employment by TAZ	inputsSave.R
cvalIndexAry	WHIAZC distribution stored by auto sufficiency index value (CVAL)	chwi

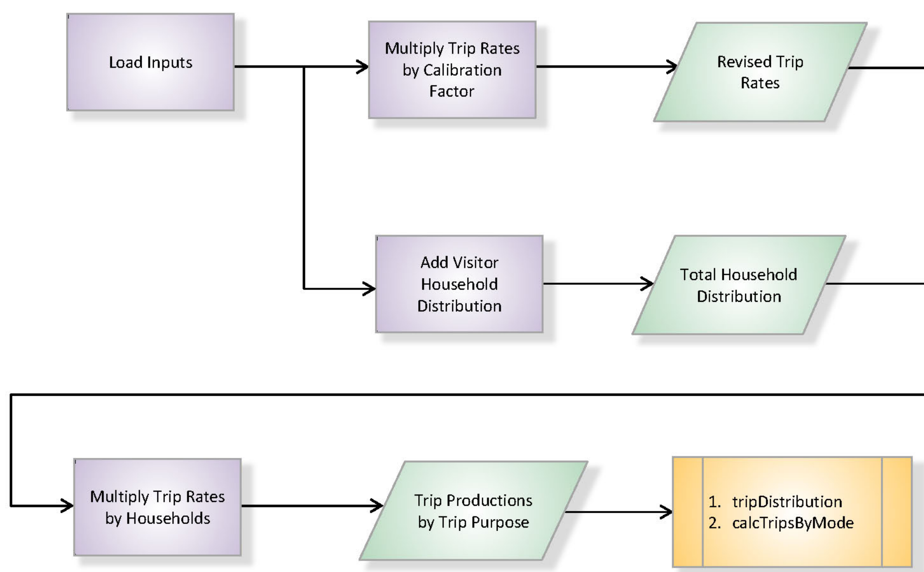
Output Objects

Name	Description	Input To
hbwTripProdAry	Daily HBW trip productions by WHIAZC	1. tripDistribution 2. balanceDist 3. calcTripsByMode
hbwAttractions	Daily HBW trip attractions by TAZ	balanceDist

A.7.2 Home-Based Shopping/Recreation/Other Trip Generation Models (hbsroGen)

The **hbsroGen** submodule implements the home-based shopping, home-based recreation, and home-based other trip generation models. HBshop trip productions are estimated based on household size and the number of workers, while HBrec and HBoth trip productions are estimated based on household size and the employment status of household members. The resulting trip productions for all three trip purposes are multiplied by a calibration factor. They are input to the trip distribution and mode choice models.

Submodule Flowchart



Input Objects

Name	Description	Output From
whiazcAry	Distribution of TAZ households by number of workers, size, income, age of head of household, and number of autos	chwi
<purpose>GenRatesMtx	Trip generation rates by trip purpose	inputs.R
hbsroTripProdCalibration Factor	Trip production calibration factor for HBshop, HBrec, and HBoth trip generation	runModel.R
cvalIndexAry	WHIAZC distribution stored by auto sufficiency index value (CVAL)	chwi

Output Objects

Name	Description	Input To
<purpose>TripProdAry	Daily trip productions by trip purpose by WHIAZC	1. tripDistribution 2. calcTripsByMode

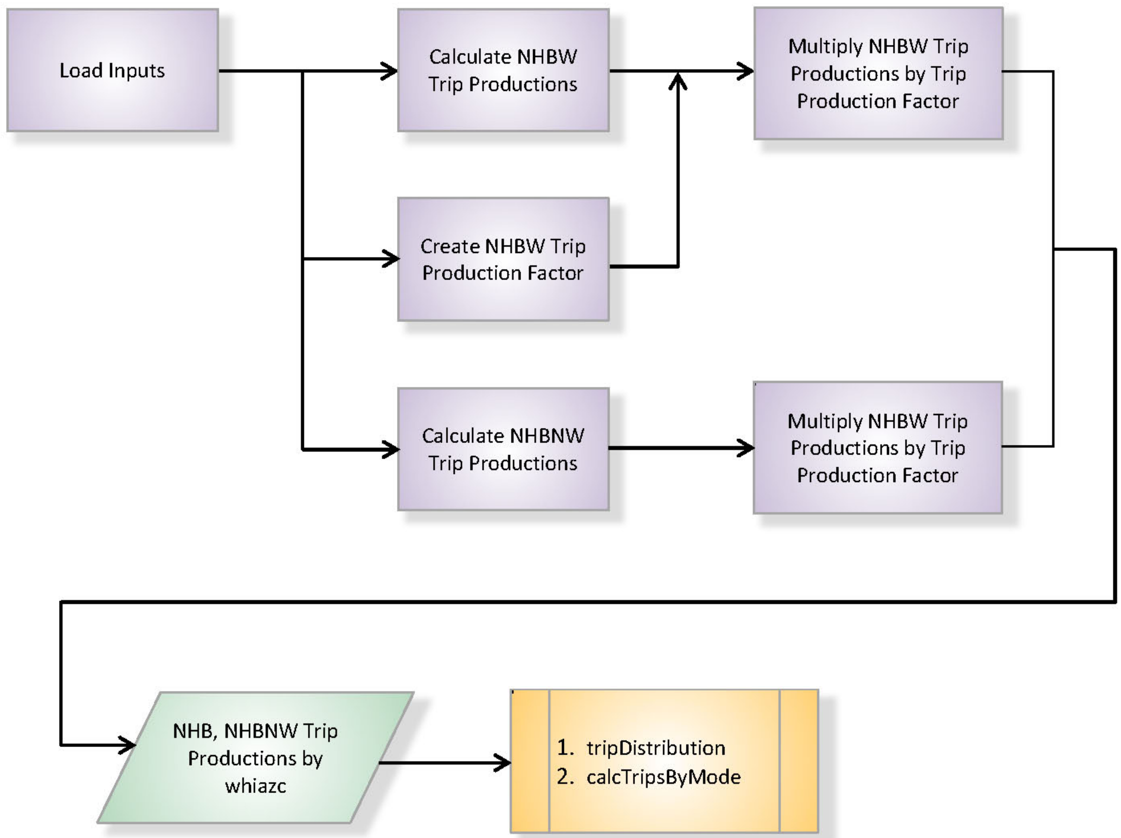
A.7.3 Non-Home-Based Work/Non-Work Trip Generation Models (nhbGen)

The **nhbGen** submodule implements the non-home-based work and non-home-based non-work trip generation models. NHBW trip productions are estimated based on the number of workers, while NHBNW trip productions are estimated based on household size and the employment status of household members. The NHBW productions are scaled to total employment according to the following procedure:

- An estimate of retail employment for each TAZ is developed based on shopping center square footage; if greater than the input value of retail employment, this estimate is used to adjust total employment upward.
- Total employment is multiplied by a calibration factor, then divided by total productions to create a production factor.
- Final NHBW productions are calculated by multiplying the productions for each TAZ by the production factor.

The NHBNW productions are multiplied by a calibration factor, in part to cover commercial vehicle and other non-home-based travel not directly accounted for elsewhere. The non-home-based trip productions are input to the trip distribution and mode choice models.

Submodule Flowchart



Input Objects

Name	Description	Output From
whiazcAry	Distribution of TAZ households by number of workers, size, income, age of head of household, and number of autos	chwi
nhbwGenRatesMtx	NHBW trip generation rates	inputs.R
nhbnwGenRatesMtx	NHBNW trip generation rates	inputs.R
nhbwTotalEmployment CalibrationFactor	Trip production calibration factor NHBW trip generation	runModel.R
nhbnwTripProdCalibrat-ionFactor	Trip production calibration factor for NHBNW trip generation	runModel.R
cvalIndexAry	WHIAZC distribution stored by auto sufficiency index value (CVAL)	chwi
shsqft	Shopping center square footage by TAZ	inputsSave.R
retEmp	Retail employment by TAZ	inputsSave.R
totalEmp	Total employment by TAZ	inputsSave.R

Output Objects

Name	Description	Input To
<purpose>TripProdAry	Daily trip productions by trip purpose by WHIAZC	1. tripDistribution 2. calcTripsByMode

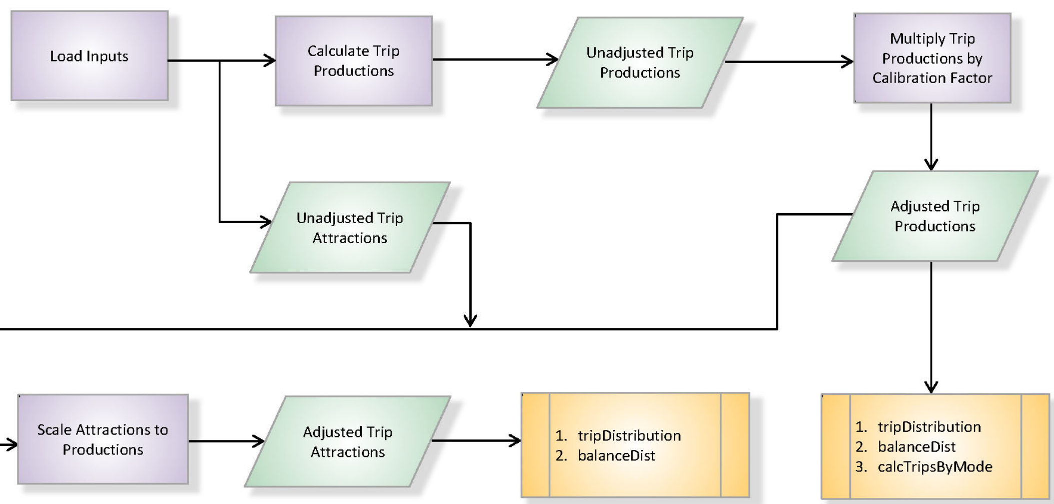
A.7.4 Home-Based College Trip Generation Model (hbcollGen)

The **hbcollGen** submodule implements the home-based college trip generation model. Trip productions are estimated based on household size and the age-of-head-of-household. The resulting trip productions are multiplied by a calibration factor.

The college vehicle trip attractions by TAZ that are input are also balanced to productions for use in the trip distribution model by multiplying the college attractions in each TAZ by the ratio of total productions to total attractions.

The trip productions are input to the trip distribution and mode choice models, while the trip attractions are input to the trip distribution model.

Submodule Flowchart



Input Objects

Name	Description	Output From
whiazcAry	Distribution of TAZ households by number of workers, size, income, age of head of household, and number of autos	chwi
hbcollGenRatesMtx	HBcoll trip generation rates	inputs.R
hbcollTripProdCalibrationFactor	Trip production calibration factor for HBcoll trip generation	runModel.R

Name	Description	Output From
colveh	College vehicle trips by TAZ	inputsSave.R
cvalIndexAry	WHIAZC distribution stored by auto sufficiency index value (CVAL)	chwi

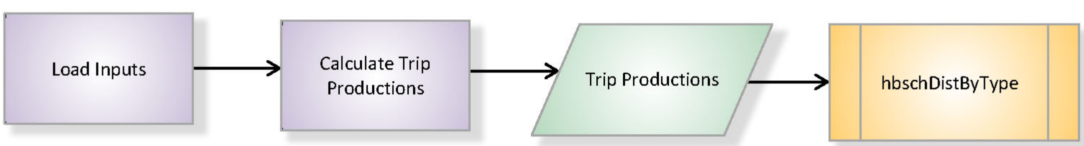
Output Objects

Name	Description	Input To
hbcollTripProdAry	Daily HBcoll trip productions by WHIAZC	1. tripDistribution 2. balanceDist 3. calcTripsByMode
hbcollAttractions	Daily HBcoll trip attractions by TAZ	1. tripDistribution 2. balanceDist

A.7.5 Home-Based School Trip Generation Model (hbschGen)

The **hbschGen** submodule implements the home-based school trip generation model. Trip productions are estimated based on household size and the number of children. These are input to the trip distribution and mode choice models.

Submodule Flowchart



Input Objects

Name	Description	Output From
khiazAry	Distribution of TAZ households by number of children, size, income, and age of head of household	khia
hbschGenRatesMtx	HBsch trip generation rates	inputs.R

Output Objects

Name	Description	Input To
hbschTripProdAry	Daily HBsch trip productions by KHIAZ	hbschDistByType

A.8 Multi-Modal Accessibility

The **Multi-Modal Accessibility** module calculates the accessibility utilities that are used within the trip distribution and mode choice models. It consists of two submodules. The **accessUtilities** submodule calculates utilities for each trip purpose except HBsch. The **accessLogSums** submodule aggregates the modal utilities produced by **accessUtilities** to calculate logsums for each trip purpose.

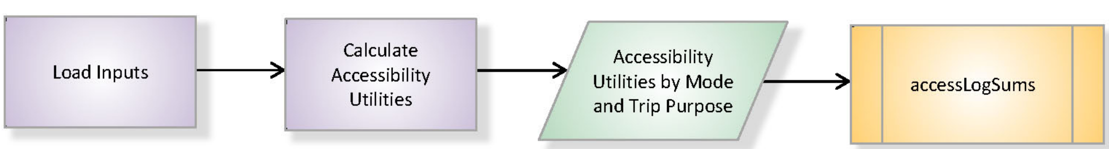
A.8.1 Calculate Accessibility Utilities (accessUtilities)

The **accessUtilities** submodule calculates utilities for each trip purpose except HBsch for the following modes:

- Drive alone – only available to households with at least one car
- Drive with passenger – only available to households with at least one car
- Auto passenger
- Bus by walk access – only available if both trip ends are within ¼ mile of bus stop
- Bus by park-and-ride access – only available if destination trip end is within ¼ mile of bus stop
- Bike – only available for trips less than ten miles
- Walk – only available for trips less than five miles

For the HBW, HBshop, HBrec, and HBoth trip purposes, these utilities are calculated by income group. Factors by trip purpose are used to calculate weighted averages of the peak and off-peak utilities within the utility functions. The utilities are input to the **accessLogSums** submodule.

Submodule Flowchart



Input Objects

Name	Description	Output From
(Variables for utility equations)	See Table B-1	inputsSave.R
mixthm	Total employment density/intersection density composite accessibility	access

Name	Description	Output From
	measure	
mixrhm	Retail employment density/intersection density composite accessibility measure	access

Output Objects

Name	Description	Input To
util<mode><purpose>	Accessibility utilities by mode, and trip purpose (including income for some combinations)	accessLogSums

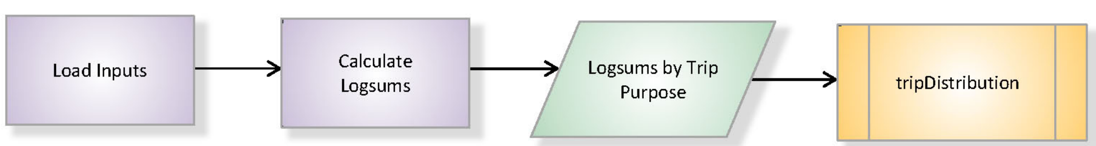
A.8.2 Calculate LogSums (accessLogSums)

The **accessLogSums** submodule uses the modal utilities produced by the **accessUtilities** submodule to calculate logsums for each trip purpose according to the following general equation for trip purpose p:

$$\text{Logsum}_p = \ln\left(U_{\text{Drive alone, p}} + U_{\text{Drive with Passenger, p}} + U_{\text{Auto Passenger, p}} + U_{\text{Walk to Bus, p}} + U_{\text{Park–and –Ride, p}} + U_{\text{Bike, p}} + U_{\text{Walk, p}} \right)$$

The logsums are a key input to the trip distribution and mode choice model.

Submodule Flowchart



Input Objects

Name	Description	Output From
util<mode><purpose>	Accessibility utilities by mode and trip purpose(including income for some combinations)	accessUtilities

Output Objects

Name	Description	Input To
logSum<purpose>	Logsums by trip purpose (including income for some combinations)	1. tripDistribution 2.

A.9 Trip Distribution

The **Trip Distribution** module estimates average weekday person trip tables by trip purpose within the following submodules:

- **tripDistribution** - Trip distribution (non-HBsch)
- **balanceDist** - Balance HBW and HBcoll trip distribution matrices
- **hbschDistByType** - HBsch trip distribution

Except for the HBsch trip purposes, all of the trip distribution models are of the destination choice form. They were developed using a multinomial logit estimation procedure, other than the HBcoll model, which is based simply on multimodal accessibility and college attractions. For the HBsch trip purpose, a separate procedure is used in which trips are distributed directly to school zones based on school enrollment boundaries (exogenously defined in the *districts.csv* input file).

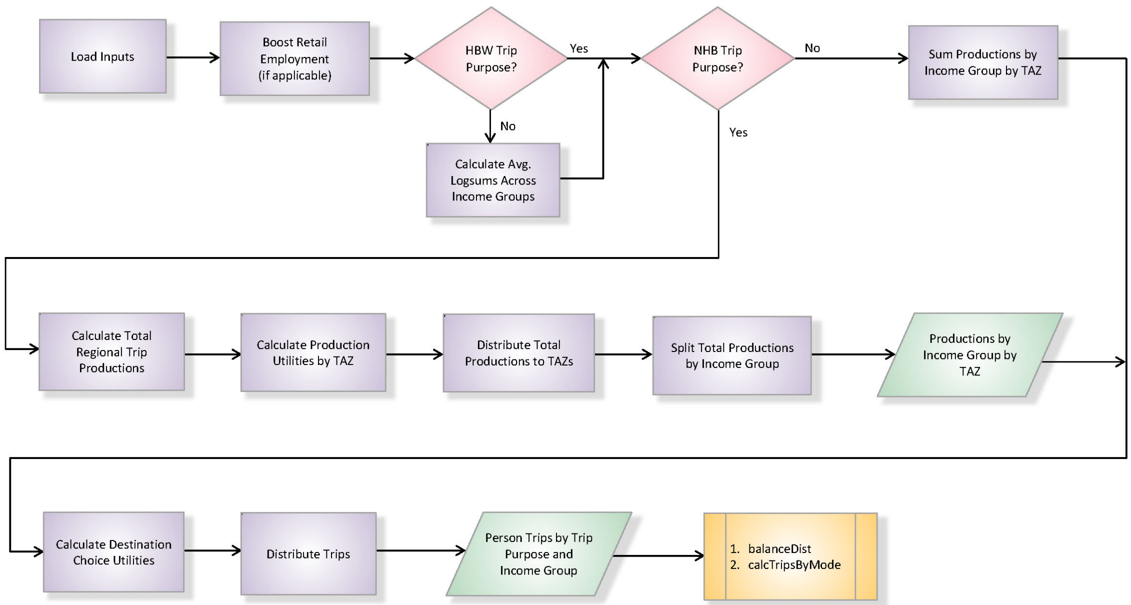
Information on the development of the trip distribution models can be found in the *JEMnR Model Base Report*,[39] Section E. – Model Development, starting on page 54.

A.9.1 Trip Distribution Model (tripDistribution)

The **tripDistribution** submodule implements the trip distribution models for all purposes except HBshop and HBsch. Within this submodule, trips are distributed separately by income group. For the HBW trip purpose, different logsums are used for each income group. The same logsum is applied for all income groups for the other trip purposes using an average logsum value computed across the individual income groups. For the NHBW and NHBNW purposes, an additional step is required prior to distribution in which the total regional trip productions are distributed to the non-home zones where the trips actually occur. This is done using a multinomial logit model. The zonal productions are then split by income group based on the proportion of regional productions within each group. The resulting trip tables are input to the mode choice model (CalcTripsbyMode.R)

[39] Oregon Department of Transportation, JEMnR Model Base Report, (2011).

Submodule Flowchart



Input Objects

Name	Description	Output From
(Variables for utility equations)	See Table B-1.	inputsSave.R
logSum<purpose>	Logsums by trip purpose (and income for HBW only)	accessLogSums
<purpose>TripProdAry	Daily trip productions by trip purpose by WHIAZC	<purpose>Gen
colveh	College vehicle trips by TAZ	inputsSave.R
nhbProdUtils	Utility functions to allocate NHBW and NHBNW trip productions to TAZs	inputs.R
distUtils	Trip distribution utility functions	inputs.R
shsqft	Shopping center square footage by TAZ	inputsSave.R
totalEmp	Total employment by TAZ	inputsSave.R
<sector>Emp	Employment by type by TAZ	inputsSave.R

Output Objects

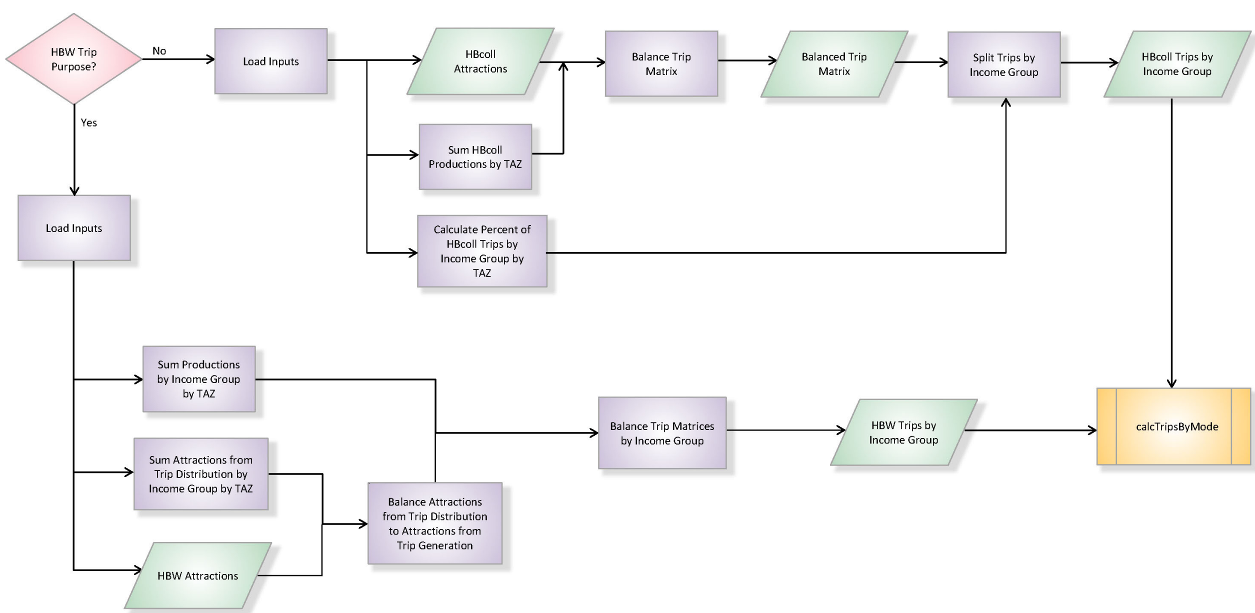
Name	Description	Input To

Name	Description	Input To
<purpose><income>Dist	Daily person trips by trip purpose and income group	1. balanceDist 2. calcTripsByMode

A.9.2 Balance Trip Matrices (balanceDist)

The **balanceDist** submodule doubly constrains, i.e., balances the HBW and HBcoll trip matrices output from the **tripDistribution** submodule. For other trip purposes, the matrices are balanced to the trip productions and trip attractions from the trip generation model using iterative proportional fitting (IPF). This is necessary because the destination choice model does not conserve the original zonal trip attractions estimated by the trip generation model. It should also be noted that only the zones that contain trips are balanced – zero rows and columns are removed from the matrix prior to balancing and added in immediately after. The balanced matrices are input to the mode choice model (**calcTripsByMode**).

Submodule Flowchart



Input Objects

Name	Description	Output From
hbw<income>Dist	Daily HBW person trip matrices by income group	tripDistribution
hbcoll<income>Dist	Daily HBcoll person trip matrices by income group	tripDistribution
hbwTripProdAry	Daily HBW person trip productions by WHIAZ	hbwGen

Name	Description	Output From
hbcollTripProdAry	Daily HBcoll person trip productions by WHIAZ	hbcollGen
hbwAttractions	Daily HBW trip attractions by TAZ	hbwGen
hbcollAttractions	Daily HBcoll trip attractions by TAZ	hbcollGen

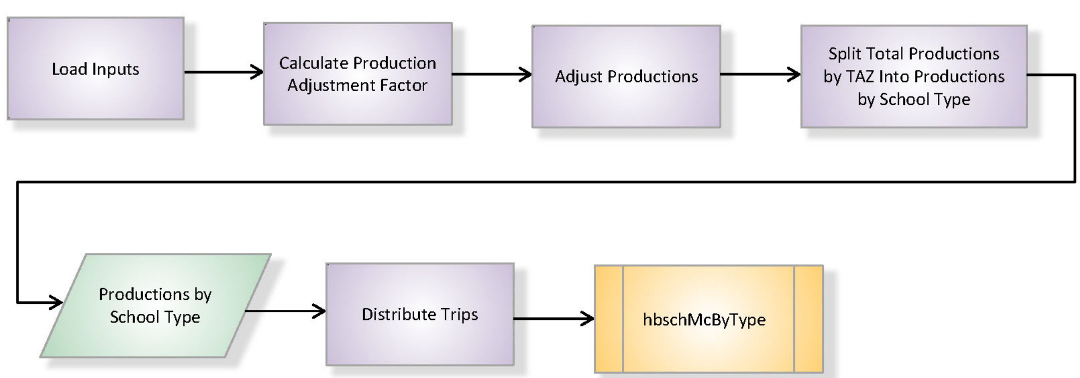
Output Objects

Name	Description	Input To
hbw<income>Dist	Daily HBW person trips by income group (balanced)	calcTripsByMode
hbcoll<income>Dist	Daily HBcoll person trips by income group (balanced)	calcTripsByMode

A.9.3 Home-Based School Trip Distribution (hbschDistByType)

A non-modeling procedure is used in the **hbschDistByType** submodule to distribute HBsch trips directly to school zones according to the home zone – school zone equivalences input in the districts object. The equivalences are based on enrollment boundaries for each elementary, middle, and high school in the modeling area. Prior to the distribution, total trip productions are adjusted to match total model-wide K12 enrollments. The adjusted productions are then split by school type according to the percentages of elementary, middle, and high school enrollment. The resuting HBsch trip matrix is input to the HBsch mode choice module (**hbschMcByType**).

Submodule Flowchart



Input Objects

Name	Description	Output From
hbschTripProdAry	Daily HBsch trip productions by KHIAZ	hbschGen

Name	Description	Output From
districts	School enrollment areas by school district and school type	inputsSave.R
elemPct	Percent of total regional school enrollment that elementary school enrollment	runModel.R
middlePct	Percent of total regional school enrollment that middle school enrollment	runModel.R
highPct	Percent of total regional school enrollment that high school enrollment	runModel.R
totalEnroll	Total regional school enrollment	runModel.R

Output Objects

Name	Description	Input To
hbschDist	Daily HBsch person trips	hbschMcByType

A.10 Mode Choice

The **Mode Choice** module calculates peak and off-peak trips by mode, trip purpose, and income group. This is done within the following submodules:

- **modeChoiceCommon** – Calculate common modal utilities
- **processSegmentUtils** – Calculate market segment-specific modal utilities (household attributes combined with auto sufficiency)
- **calcTripsByMode** – Mode choice model (non-school)
- **hbschMcByType** – HBsch mode choice

The **modeChoiceCommon** submodule calculates once for efficiency the portion of the modal utilities that are common to each market segment for a particular trip purpose. The modal utilities related to specific market segments are calculated within the **processSegmentUtils** submodule. These are input to the full mode choice models, which are implemented within the **calcTripsByMode** submodule.

The mode choice models were developed using a multinomial logit estimation procedure. The mode choice step for the HBsch trip purpose is addressed separately within the **hbschMcByType** submodule using a non-modeling procedure, in which modal trips are calculated directly based on actual modal share data.

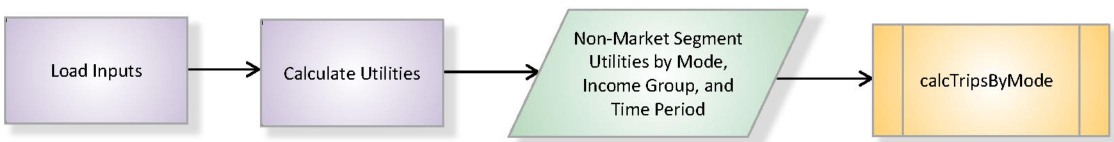
Information on the development of the mode choice models can be found in the *JEMnR Model Base Report*,[40] Section E. – Model Development, starting on page 61.

[40] Oregon Department of Transportation, JEMnR Model Base Report, (2011).

A.10.1 Calculate Non-Market Segment Utilities (modeChoiceCommon)

The **modeChoiceCommon** submodule calculates the modal utilities not related to specific market segments, such as in-vehicle time, operating cost, and trip distance. These include all of the variables used within the multimodal accessibility functions, as well as a trip distance variable, the composite accessibility or "mix" variables, and constants. The utilities are calculated by mode, trip purpose, and time period (peak, off-peak) and, for certain modes, by income group. They are input to the **calcTripsbyMode** submodule where they are combined with the market segment-specific utilities calculated in the **processSegmentUtils** submodule. The complete mode choice utility functions are shown in the **calcTripsByMode** section.

Submodule Flowchart



Input Objects

Name	Description	Output From
(Variables for utility equations)	See Table B-1.	inputsSave.R
mixthm	Total employment density/intersection density composite accessibility measure	access
mixrhm	Retail employment density/intersection density composite accessibility measure	access

Output Objects

Name	Description	Input To
util<mode><purpose><period>	Non-market segment utilities by mode, income group, and time period	calcTripsByMode

A.10.2 Calculate Market Segment Utilities (processSegmentUtils)

The **processSegmentUtils** submodule creates a table of coefficients (utilities) for the mode choice model variables related to specific market segments. This is done for each trip purpose having market segment-specific variables within the modal utility equations. The table contains variable coefficients for unique combinations of market segments (household size, number of workers, and auto ownership - HWC) having the same coefficient values.

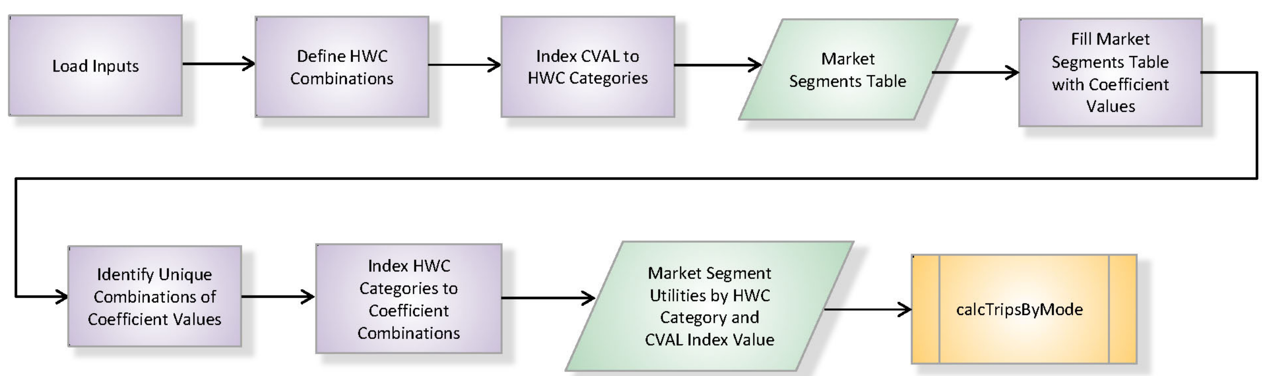
The purpose of the table is to reduce the processing time required to calculate the modal utilities in the mode choice model. It is indexed by household size, number of workers, and the "CVAL" variable, which reflects the relationship between the number of autos owned and the number of workers, based on the following categories:

Market Segment Definition:

- H – Household size
- W – Number of Household Workers
- CVAL – Auto Sufficiency
  - CVAL 0: Number of autos owned = 0
  - CVAL 1: Number of autos owned < number of workers
  - CVAL 2: Number of autos owned = number of workers
  - CVAL 3: Number of autos owned > number of workers

The table is input to the **calcTripsbyMode** submodule, where it is used to calculate market-segment utilities which are combined with the non-market segment utilities produced by the **modeChoiceCommon** submodule. The complete mode choice utility functions can be found in the *JEMnR Model Base Report*,[41] Section E. – Model Development, starting on page 67.

Submodule Flowchart



[41] Oregon Department of Transportation, JEMnR Model Base Report, (2011).

Input Objects

Name	Description	Output From
<purpose>MarketSegments	Mode choice utility function coefficients for market segment variables (number of workers, auto sufficiency, household size) by trip purpose	inputsSave.R
segmentsH	Household size classes	inputs.R
segmentsW	Number of workers in household classes	inputs.R
segmentsC	Household auto ownership classes	inputs.R

Output Objects

Name	Description	Input To
<purpose>marketUtil	Market segment utilities by HWC category and auto sufficiency (CVAL) index value	calcTripsByMode

A.10.3 Mode Choice Model (calcTripsByMode)

The full mode choice model estimates person trips by mode, income group, and time period (peak, off-peak) for each trip purpose except HBsch for the following modes:

- Drive alone – only available to households with at least one car
- Drive with passenger – only available to households with at least one car
- Auto passenger
- Bus by walk access – only available if both trip ends are within ¼ mile of bus stop
- Bus by park-and-ride access – only available if destination trip end is within ¼ mile of bus stop
- Bike – only available for trips less than 10 miles (default in settings.csv)
- Walk – only available for trips less than 5 mile s(default in settings.csv)

This is done within several steps in the **calcTripsByMode** submodule for each trip purpose, time period and income group:

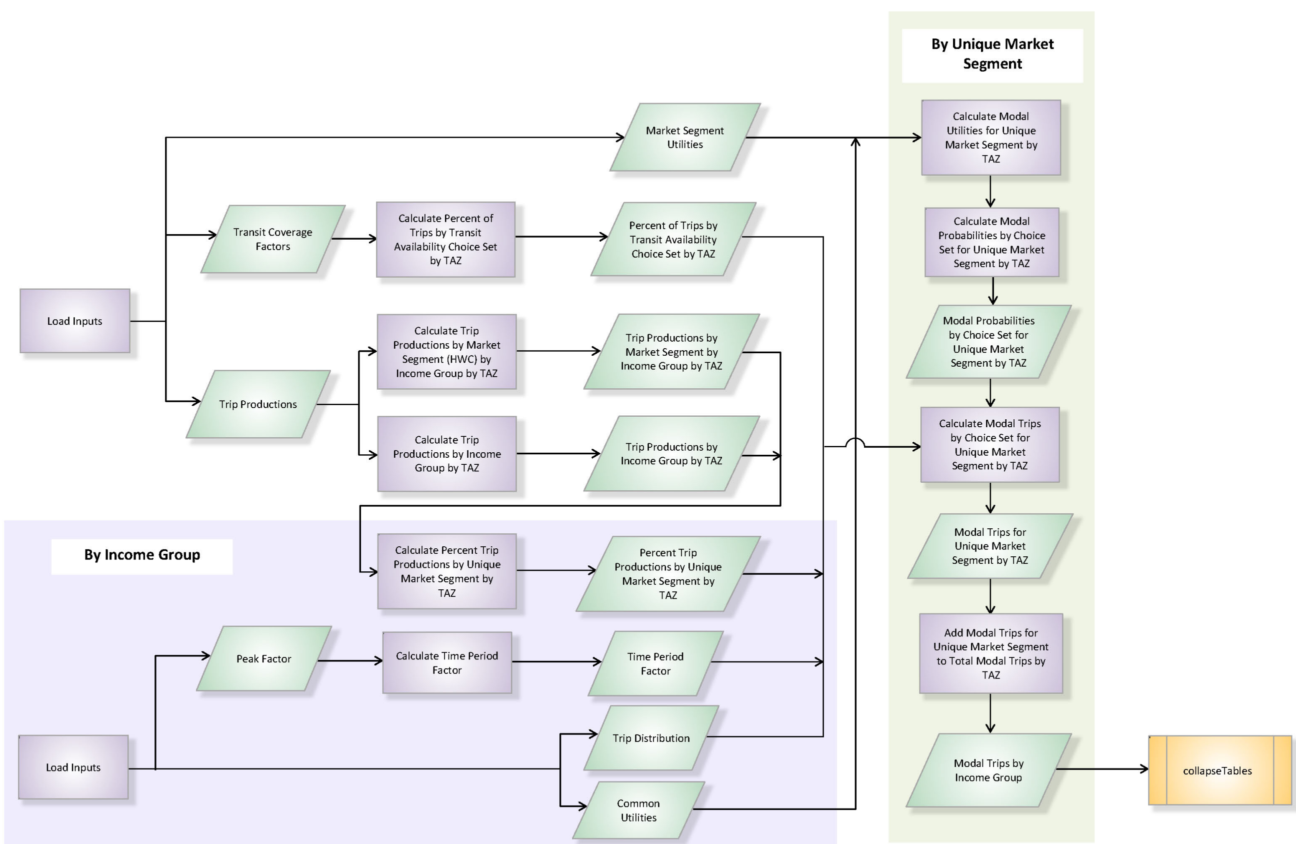
- Calculate percent trips by transit availability choice set by TAZ. The choice set comprises:
    - trips with transit access at both ends,
    - trips with park-and-ride access at the destination end, and
    - trips with no transit access at the destination end.

- Calculate trip productions by market segment by income group and total trip productions by income group by TAZ.
- Calculate percent trip productions by unique market segment by TAZ.
- For each unique market segment, calculate modal utilities as product of non-market segment (common) utility (from **modeChoiceCommon** submodule) and market segment utility (from **processSegmentUtils** submodule).
- Sum modal utilities across all modes for each choice set.
- Calculate modal probabilities by choice set.
- Multiply modal probabilities by time period factor, percent trip productions for unique market segment, percent of trips for choice set, and trips from trip distribution matrix to obtain modal trips by choice set for unique market segment.
- Sum trips across choice sets to obtain modal trips for unique market segment.
- Sum trips across all unique market segments to obtain total trips by purpose, income group, time period, and mode.

An example of the modal probability calculation for the drive alone mode is shown in the following equation:

$$Prob_{\text{Drive alone}} = U_{\text{Drive alone}} / \left(U_{\text{Drive alone}} + U_{\text{Drive with Passenger}} + U_{\text{Auto Passenger}} + U_{\text{Walk to Bus}} + U_{\text{Park\&Ride}} + U_{\text{Bike}} + U_{\text{Walk}} \right)$$

The modal trip matrices produced by **calcTripsByMode** are input to the **collapseTables** submodule within the **Peaking and Demand Matrices** module.
Submodule Flowchart



Input Objects

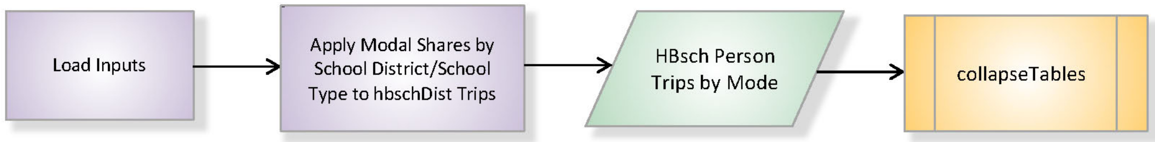
Name	Description	Output From
util<mode><purpose><period>	Non-market segment utilities by mode, income group, and time period	modeChoiceCommon
<purpose>MarketUtil	Market segment utilities by HWC category and CVAL index value	processSegmentUtils
<period>EmpCov	Employment transit coverage factors by time period	inputsSave.R
<period>HhCov	Household transit coverage factors by time period	inputsSave.R
<purpose>TripProdAry	Daily trip productions by trip purpose WHIAZC	1. hbwGen 2. hbsroGen 3. nhbGen 4. hbcollGen
<purpose><income>Dist	Daily person trips by trip purpose and income group	1. tripDistribution 2. balanceDist
<purpose>PeakFactor	Percent of trips occurring within peak period by trip purpose	runModel.R
modes	Mode definitions	inputs.R

Output Objects

Name	Description	Input To
<period>trips	Daily person trips by trip purpose, income group, time period, and mode	collapseTables

A.10.4 Home-Based School Mode Choice (hbschMcByType)

A non-modeling procedure is used in the **hbschMcByType** submodule to split HBsch trips by mode directly based on actual school trip mode share data that is input by school district and school type. The mode shares are applied to the HBsch person trip tables produced by the **hbschDistByType** submodule to create school trip matrices for each mode specified (drive alone, drive with passenger, transit, walk/bike, and school bus).
Submodule Flowchart



Input Objects

Name	Description	Output From
hbschDist	Daily HBsch person trips	hbschDistByType
districts	School enrollment areas by school district and school type	inputsSave.R
hbschModeChoicePercents	HBsch mode choice percents by school district and school type	inputsSave.R

Output Objects

Name	Description	Input To
trips	Daily HBsch person trips by mode	collapseTables

A.10.5 Peaking and Demand Matrices

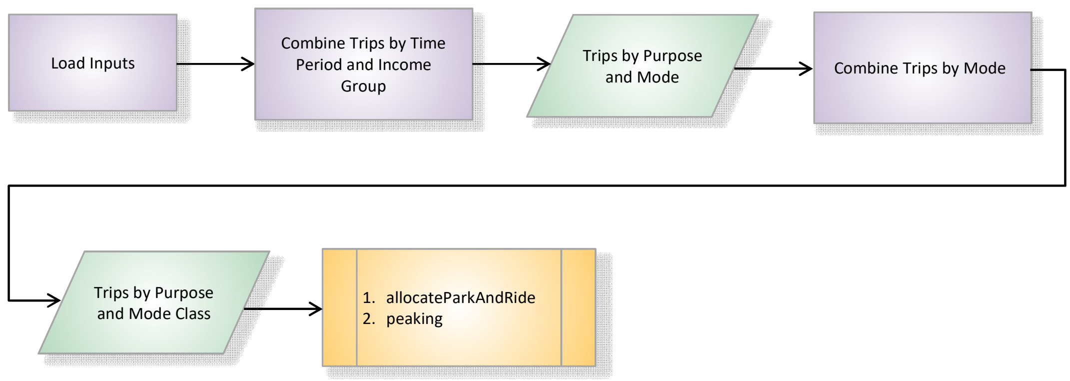
The **Peaking and Demand Matrices** module creates the demand matrices used in the assignment model. This is done within the following submodules:

- **collapseTables** – Combine person trip matrices
- **externalModel** – Distribute I-E, E-I trips, add E-E trips
- **allocateParkandRide** – Split park-and-ride trips into vehicle and transit trips
- **peaking** – Create trip matrices by time period
- **pandrPeaking** – Create park-and-ride vehicle and transit trips by time period
- **addExternals** – Create total vehicle trip matrices by time period

A.10.6 Collapse Trip Tables (collapseTables)

The **collapseTables** submodule combines the person trip matrices by income group, time period, and mode produced by the **calcTripsByMode** submodule into daily person trips by trip purpose and mode class. Because the matrices produced by the **hbschMcByType** submodule are not by income group or time period, these are simply read-in. It then combines the person trips by mode into mode classes based on the class definitions contained in the modes object (vehicle, other, bus, and park-and-ride bus). Note that these tables omit person modes not assigned to the network (auto passenger, bike, walk, and school bus). The output trip matrices are input to the **peaking** and **allocateParkAndRide** submodules.

Submodule Flowchart



Input Objects

Name	Description	Output From
Modes	Mode definitions	inputs.R
<period>trips	Daily person trips by trip purpose (non-school), income group, time period, and mode	calcTripsByMode
Trips	Daily HBsch person trips by mode	hbschMcByType

Output Objects

Name	Description	Input To
<class>	Daily person trips by trip purpose and mode class	1. allocateParkAndRide 2. peaking

A.11 External Model (externalModel_SWIM)

The external model estimates the distributions of daily trips with one or both ends outside the model area (E-E, I-E and E-I trips) by pulling patterns and flows from the Oregon Statewide Integrated Model (SWIM), combined with regional activity and traffic counts.

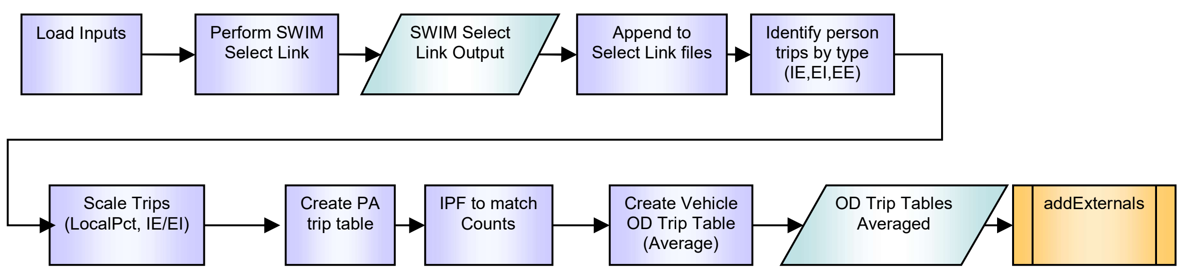
Prior to a JEMnR model run, the SWIM links corresponding to the JEMnR external stations are identified (*selectLinks.csv*) and the SWIM model is run with a select link process, generating files of possible trips in, out, and through the JEMnR model area by type, short and long distance auto, and trucks (*select_link_output#.zip*). The JEMnR external module processes these SWIM files along with the following exogenous inputs:

- a zonal crosswalk file with the SWIM zones that overlap the JEMnR region (*InternalZones.txt*) and identified overlap share *SWIM_JEMnR_TAZ_CW.csv*);
- External Station traffic counts and growth rates (*selectlink.csv*);

The SWIM select link process first appends information to the selected trip set (zone equivalency, trip type/purpose), then creates a sub-set of those trips in, out and through the JEMnR region. This subarea person trip matrix is generated by purpose in PA form, using the home location known in SWIM. Trips with one end in the JEMnR model region are scaled to ensure consistency with local zonal activity using local population for I-E trips, employment for E-I trips. These person trips are converted to vehicular trips using vehicle occupancy, and averaged over multiple SWIM dataset years (e.g. to span the JEMnR modelwide population). The resulting external trip tables are combined and adjusted to better match traffic counts (IPF to growth-rate adjusted baseyear AADT).

The output I-E, E-I, and E-E daily and peak trip matrices developed by the Externals Model is added to other trip tables in the **addExternals** submodel, which creates time of day trip matrices.

Submodel Flow Chart



Input Objects

Names	Description	Output From
selectLinks	External Station data including corresponding SWIM links by direction, baseyear AADT (auto and truck), time of day factors, and growth rates	InputsSave.R
select_link<year>_output>.zip	SWIM Select Link output (trips within JEMnR region), filename segment specified in Settings,csv follows the SWIM year that was run.	SWIM select link
InternalZones	List of SWIM zones in JEMnR region	InputsSave.R
SWIM_JEMnR_TAZ_CW	SWIM to JEMnR zone cross walk	InputsSave.R
TODperiods	Time of Day definition	InputsSave.R
TAZ	JEMnR TAZ data including HHBASE, POPBASE, EMPBASE (standard JEMnRv3 format)	InputsSave.R
settings	(standard JEMnRv4 format)	InputsSave.R

Output Objects

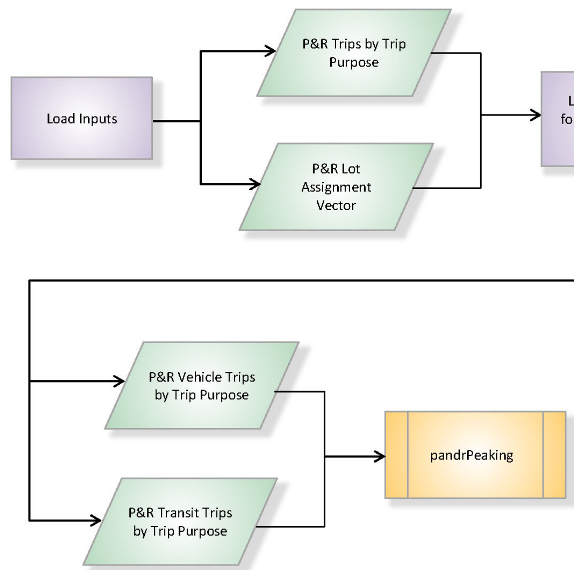
Names	Description	Input To
externalod_auto.RData	Averaged All auto trips daily OD matrix	addExternals.R
externalod_truck.RData	Averaged All truck trips daily OD matrix	addExternals.R
SWIM_TAZ_CW_Report.csv	Computed zonal shares	Diagnostic

A.12 Allocate Park-and-Ride Trips (allocateParkAndRide)

The **allocateParkandRide** submodule splits the park-and-ride trips into the separate vehicle trip and transit trip components. This is done based on the park-and-ride lot assignment vector, which assigns a park-and-ride lot TAZ to each TAZ lying within a park-and-ride catchment area. For each trip in the park-and-ride trip matrix, the production zone number is looked up in the park-and-ride lot assignment vector to identify the associated park-and-ride lot TAZ. The park-and-ride trip is then split into a vehicle trip from the production zone to the park-and-ride lot zone and a transit trip from the park-and-ride lot zone to the attraction zone. This process is repeated for each trip purpose, with the resulting vehicle and transit trips stored in separate matrices that are input to the **pandrpeaking** submodule.

Submodule Flowchart

Input



Objects

Name	Description	Output From
pandrBus	Daily park-and-ride person trips by trip purpose	collapseTables
modes	Mode definitions	inputs.R
parkAndRideLot	Park-and-ride lot assignment vector	inputsSave.R

Output Objects

Name	Description	Input To
pandrBusVehicle	Daily park-and-ride vehicle trips by trip purpose	pandrPeaking
pandrBusTransit	Daily park-and-ride transit trips by trip purpose	pandrPeaking

A.13 Create Trip Tables by Time Period (peaking)

The **peaking** submodule applies directional/time-of-day factors by trip purpose to the daily person trip matrices by mode class produced by the **collapseTables** submodule to create modal trip matrices by mode class and time period in O-D format. These matrices are input to the **addExternals** submodule. The “other” mode class includes trips that are not assigned to the network (auto passenger, bike, walk, and school bus trips) and thus are omitted from this process. Also, park-and-ride trips are processed separately in the **pandrPeaking** submodule.

Submodule Flowchart
Input Objects

Name	Description	Output From
<modeclass>	Daily person trips by trip purpose and mode class	collapseTables
modes	Mode definitions	inputs.R
<modeclass>PeriodFactors	Directional/time-of-day factors by mode class and trip purpose	inputs.R

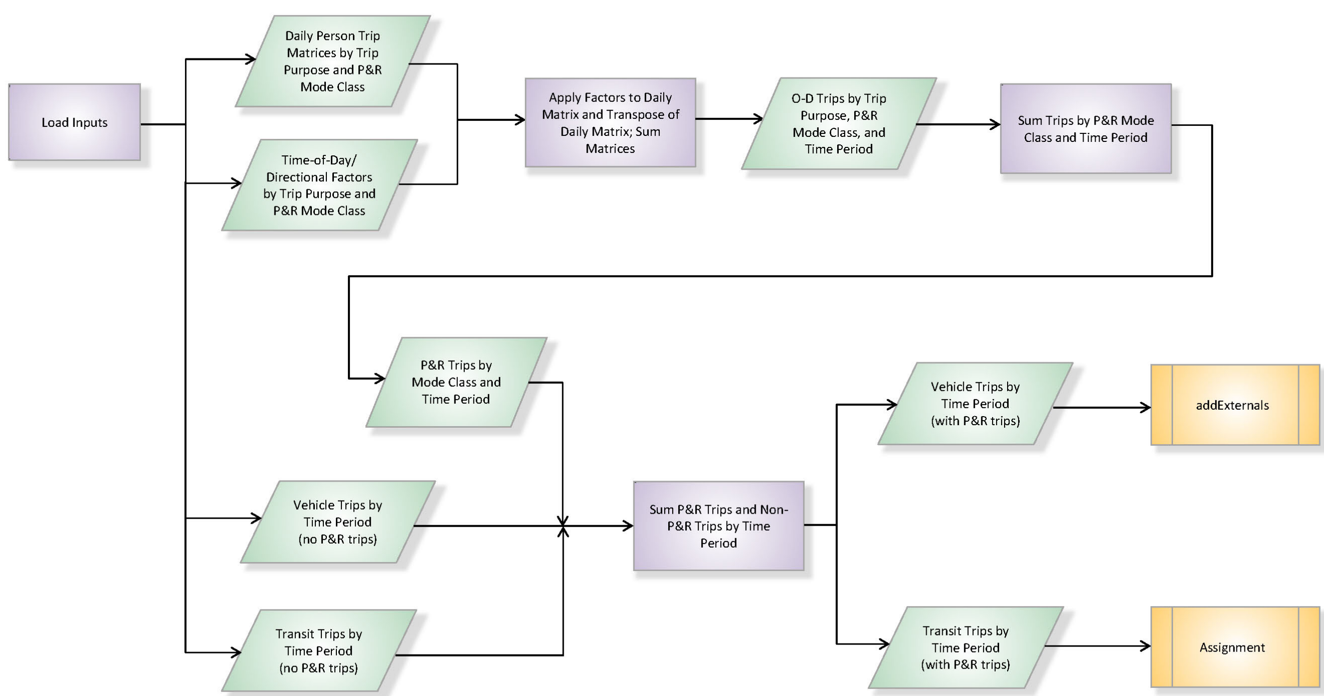
Output Objects

Name	Description	Input To
<period><modeclass>	Modal trips by time period in O-D format	pandrPeaking

A.14 Create Park-and-Ride Trip Tables by Time Period (pandrPeaking)

The **pandrPeaking** submodule applies directional/time-of-day factors by trip purpose to the daily park-and-ride vehicle and transit trip matrices produced by the **allocateParkAndRide** submodule to create park-and-ride vehicle and transit trip matrices by time period in O-D format. These matrices are added to the non-park-and-ride vehicle and transit trip matrices. The non-park-and-ride vehicle and transit factors are used for the park-and-ride trips.

Submodule Flowchart



Input Objects

Name	Description	Output From
pandrBusVehicle	Daily park-and-ride vehicle trips by trip purpose	allocateParkAndRide
pandrBusTransit	Daily park-and-ride transit trips by trip purpose	allocateParkAndRide
modes	Mode definitions	inputs.R
pandrvehiclePeriodFactors	Directional/time-of-day factors for park-and-ride vehicle mode class by trip purpose	inputs.R
pandrBusPeriodFactors	Directional/time-of-day factors for park-and-ride transit mode class by trip purpose	inputs.R
<period>vehicle	Internal drive alone vehicle trips by time period (without park-and-ride trips)	peaking
<period>bus	Transit trips by time period (without park-and-ride trips)	peaking

Output Objects

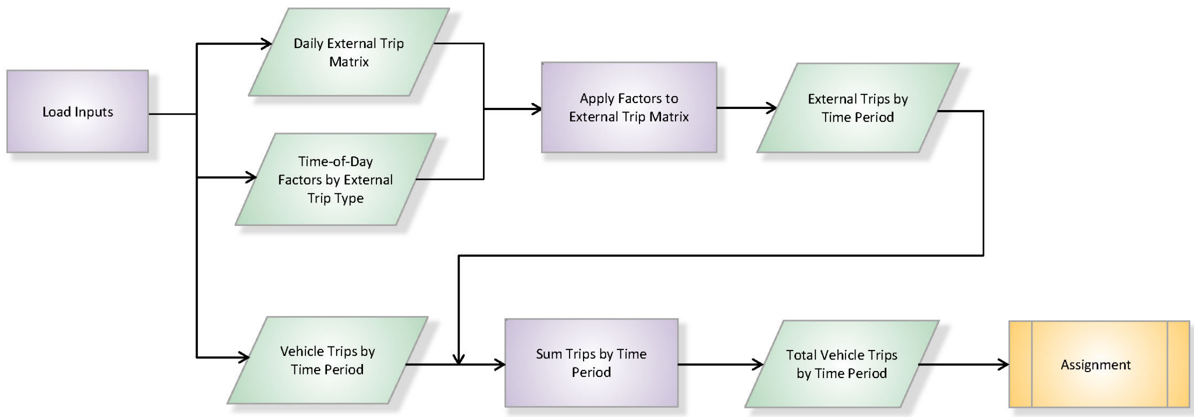
Name	Description	Input To
<period>pandrBusVehicle	Park-and-ride vehicle trips by time period in O-D format	N/A
<period>pandrBusTransit	Park-and-ride transit trips by time period in O-D format	N/A
<period>vehicle	Vehicle trips by time period (with park-and-ride trips)	addExternals
<period>bus	Transit trips by time period (with park-and-ride trips)	Assignment model

A.15 Add External Trips (addExternals)

The factors and a description of the development process can be found in the individual model development reports.

The resulting external trips by time period are then added to the drive alone vehicle trip matrices to create total vehicle trip matrices by time period. These matrices are input to the Emme **assignment model**.

Submodule Flowchart



Input Objects

Name	Description	Output From
<period>vehicle	Vehicle trips by time period	pandrPeaking
externalod	Daily external vehicle trips	externalModel
TOD_PeriodFactors	External time-of-day factors	inputs.R

Output Objects

Name	Description	Input To
<period>vehicle	Total vehicle trips by time period	Assignment model

APPENDIX B INPUT DATA

Table B-1 lists by file name the more commonly modified JEMnR inputs for reflecting the specific characteristics of analysis scenarios.

Table B-1: JEMnR User-Modified Input Data

Data Name	Description	Use	Data Source
TAZ.csv			
HHBASE	Total households	Pre-generation module	Census data
POPBASE	Total household population	Not used directly in JEMnR, but should be updated if number of households is changed.	Census data
GQPOPBASE[42]	Total Group Quarters population	Not used directly in JEMnR, but helps convert to population if households change.	
AHHSBASE	Average household size	Not used directly in JEMnR, but helps convert to population if households change.	N/A
HHS1BASE	Proportion of households in household size class 1.	Pre-generation module	Census data
HHS2BASE	Proportion of households in household size class 2.	Pre-generation module	Census data
HHS3BASE	Proportion of households in household size class 3.	Pre-generation module	Census data
HHS4BASE	Proportion of households in household size class 4.	Pre-generation module	Census data
HHI1BASE	Proportion of households in household income class 1.	Pre-generation module	Census data
HHI2BASE	Proportion of households in household income class 2.	Pre-generation module	Census data

[42] Group Quarters population is assumed to do limited travel, with travel to GQ land uses based on associated employment attractions. They are however included in the conversion between households and populations: HHBASE = (POPBASE-GQPOPBASE)/AHHSBASE

Data Name	Description	Use	Data Source
HHI3BASE	Proportion of households in household income class 3.	Pre-generation module	Census data
HHI4BASE	Proportion of households in household income class 4.	Pre-generation module	Census data

Table B-1 (cont.)
JEMnR User-Modified Input Data

Data Name	Description	Use	Data Source
AGE1BASE	Proportion of households in age-of-head-of-household class 1.	Pre-generation module	Census data
AGE2BASE	Proportion of households in age-of-head-of-household class 2.	Pre-generation module	Census data
AGE3BASE	Proportion of households in age-of-head-of-household class 3.	Pre-generation module	Census data
AGE4BASE	Proportion of households in age-of-head-of-household class 4.	Pre-generation module	Census data
EMPBASE	Total employment	Pre-generation module	Calculated based on employment by type.
AFREMP	Agricultural and forestry employment	Pre-generation module	ES-202 data
MINEMP	Mining employment	Pre-generation module	ES-202 data
CONEMP	Construction employment	Pre-generation module	ES-202 data
MFGEMP	Manufacturing employment	Pre-generation module	ES-202 data
TCPEMP	Transportation, communication, and utilities employment	Pre-generation module	ES-202 data
WSTEMP	Wholesale trade employment	Pre-generation module	ES-202 data
RETEMP	Retail employment	Pre-generation module	ES-202 data
FINEMP	Financial, insurance, and real estate employment	Pre-generation module	ES-202 data
SVCEMP	Services employment	Pre-generation module	ES-202 data
GVTEMP	Government employment	Pre-generation module	ES-202 data
SCHEBASE	Total school enrollment	HBsch trip distribution submodule	Local data
COLEBASE	College vehicle trips; 2.5 trips per 2-year/commuter college; 1.5 trips per 4-year college	1. HBcoll trip generation submodule 2. HBcoll trip distribution submodule	Calculated based on total enrollment and college vehicle trip rate.

Data Name	Description	Use	Data Source
intersections	Number of intersections within ½-mi. of TAZ centroid.	Pre-generation module	Local data
LOTZONE	TAZ number for zone containing park-and-ride lot used by travelers from this TAZ.	Peaking and demand matrices module	Local data
shortTermParkingCost	Short-term parking cost	Calculation of HBW and HBcoll auto operating cost matrices.	Local data
longTermParkingCost	Long-term parking cost	Calculation of HBrec, HBshop, HBoth, NHBW, and NHBNW auto operating cost matrices.	Local data
peakHhCov	Peak household transit coverage factor by TAZ	Mode choice module	Local data
offPeakHhCov	Off-peak household transit coverage factor by TAZ	Mode choice module	Local data
peakEmpCov	Peak employment transit coverage factor by TAZ	Mode choice module	Local data
offPeakEmpCov	Off-peak employment transit coverage factor by TAZ	Mode choice module	Local data

Table B-1 (cont.)
JEMnR User-Modified Input Data

Data Name	Description	Use	Data Source
mfXX*			
autoTimepeak	Peak auto time	1. Multi-modal accessibility module 2. Mode choice module	Auto assignment
autoTimeoffPeak	Off-peak auto time	1. Multi-modal accessibility module 2. Mode choice module	Auto assignment
tripDist	Auto trip distance	1. Multi-modal accessibility module 2. Mode choice module	Auto assignment
ivTimePeakbusWalk	Peak bus in-vehicle time	1. Multi-modal accessibility module 2. Mode choice module	Transit assignment
walkTimePeakbusWalk	Peak bus walk time	1. Multi-modal accessibility module 2. Mode choice module	Transit assignment

Data Name	Description	Use	Data Source
waitTimeAPeakbusWalk	Peak bus initial wait time	1. Multi-modal accessibility module 2. Mode choice module	Transit assignment
boardingspeakbusWalk	Peak bus transfers	1. Multi-modal accessibility module 2. Mode choice module	Transit assignment
ivTimeoffPeakbusWalk	Off-peak bus in-vehicle time	1. Multi-modal accessibility module 2. Mode choice module	Transit assignment
walkTimeoffPeakbusWalk	Off-peak bus walk time	1. Multi-modal accessibility module 2. Mode choice module	Transit assignment
waitTimeAoffPeakbusWalk	Off-peak bus initial wait time	1. Multi-modal accessibility module 2. Mode choice module	Transit assignment
boardingsoffPeakbusWalk	Off-peak bus transfers	1. Multi-modal accessibility module 2. Mode choice module	Transit assignment
sqft.csv			
SQFT_BLDG	Shopping Center square footage	1. HBW trip generation submodule 2. NHBW/NHBNW trip generation submodule 3. Trip distribution module	Local data for larger shopping centers only.

Table B-1 (cont.)
JEMnR User-Modified Input Data

Data Name	Description	Use	Data Source
transitFares.csv			
Fare	Transit fare	Calculation of transit fare matrix	Local data
districts.csv			
transitDistricts	Transit fare district in which TAZ is located	Calculation of transit fare matrix	Local data

* Emme matrix numbers can be assigned by the user. Default matrix numbers are listed in the settings.csv table in Section 3 (JEMnR Setup and Application).

APPENDIX C FREQUENTLY ENCOUNTERED ERRORS

Error: *"Cannot access software protection device"*
Resolution: Indicates a problem with Emme license. Establish license and re-run. May also indicate that **Emme** bank file is write protected.

Error: *""*
Resolution: Emme bank file (/emm4/databank/Emme bank) is write protected. Right click file to remove the read-only protection, given you have sufficient access rights to this file. Re-run.

Error: *"Databank already in use"*
Resolution: Emme bank is being used by another process. Close the other process and re-run.

Warning: *"IPF did not converge"*
Resolution: IPF processes in the trip generation and externalModel_SWIM modules did not converge correctly, most likely due to incorrect user inputs (e.g., external model selectlinks.csv). This does not stop the model run, but may compromise the integrity of the model results and should be investigated.

(To be populated based on future model user experiences)

APPENDIX D JEMNR MODEL CATEGORIES

The following tables summarize the categories used in the JEMnR Model and Emme bank.

Table D-1: Household Categories

Household Category	Values
Income (1995$)	< $15K, $15-30K, $30-60K,$60K+
Household Size	1,2,3,4+
Workers Per Household	0,1,2,3+
Autos Per Household	0,1,2,3+
Children in Household	0,1,2,3+
Age of Head-of-Household	15-24, 25-54, 55-64,65+
Auto Sufficiency Index (CVAL)	0:0 autos 1: autos < workers 2:autos = workers 3: autos > workers

Table D-2: Employment Categories

Code	Emp Description	SIC codes (2000 census)	NAICS codes (2010 census)
afr	Agriculture, Forestry	01-09	11
min	Mining	10-14	21
con	Construction	15-17	23
mfg	Manufacturing	20-39	31-33, 511-512
tcp	Transportation, Communications, Pulic Utilities	40-49	22, 48-49
wst	Wholesale	50-51	42
ret	Retail	52-59	44-45
fin	Financial	60-67	52-531,55
svc	Service	70-89	515-519, 532-54. 56-81
gvt	Government	90-99	92

Table D-3: Trip Purposes

Trip Purposes	Description
HBW	Home Based Work
HBShop	Home Based Shop
HBrec	Home Based Recreation
HBoth	Home Base Other
HBcoll	Home Based College
HBSch	Home Base K12 School
NHBW	Non-Home Based Work
NHBNW	Non-Home Based non-Work

Table D-4: Travel Modes

Person Trip Mode	Vehicle Trip Mode
Drive Alone Drive Passenger Passenger	Auto
busWalk parkAndRideBus	Bus (not assigned)
Bike Walk	Bike (not assigned)
SchoolBus	(not assigned)

Table D-5: Time of Day Period Definitions (default)

Time Period	Hours
am1	6am to 9am
am2	7am to 8am
md	9am to 3pm
pm1	3pm to 7pm
pm2	5pm to 6pm
daily	Midnight-midnight

Input file: TOD_periods.csv

GIS projection: OGIC Lambert projection

Area type: (HH+2*Emp)/Area
1 = CBD, 2=CBD Fringe, 3=Urban, 4=Rural

Table D-6: Emme Basic Node Attributes

Network Link Attribute		Typical Values
TYPE	Node Type	R Regular Nodes C Centroid Connectors and Externals Stations
NODE_ID	Node Number	1-99 External Stations 100-999 Centroid Connectors (may vary by model) 1000+ Regular Network nodes
UD1	Signal Flag	1 Signalized Intersection

Table D-7: Emme Basic Link Attributes

Network Link Attribute		Typical Values
Fnode Tnode	From & To Zone (sets unique link ID)	
Type	Functional Class	1 Interstate 2 Principal Arterial 3 Minor Arterial 4 Collectors 5 Local Street 30 Freeway Ramps 99 Centroid Connectors/Ext Sta 8 Transit line 200 Walk
Lanes	# of directional lanes	
Modes	Allowed modes on link	a auto b bus w walk
VDF	Volume-Delay Function Index	1 Within 250' of signal – approach direction only
UL1	Speed	25mph on centroid connectors Otherwise speed limit or prevailing speed if different.
UL2	Capacity per lane (based on Link Type and Area type)	TYPE1 1900 TYPE2 700-950 CBD-Rural area type TYPE3 575-760 CBD-Rural area type TYPE4 450-650 CBD-Rural area type TYPE5 400-625 CBD-Rural area type TYPE99 9999
LENGTH	link travel distance	(miles)
@od24 @odpp	Link volume	Daily (od24) PM peak (odpp)

Matrix	Definition
mf43, mf44, mf45	Bus –Peak, offpeak, daily
mf46, mf47	Auto – Daily, peak
mf21	Distance
mf19, mf20	Travel Time – Offpeak, peak
mf8-mf13	Transit Time components (generalized cost, in vehicle time, walk-time, wait time A, boarding time)
mf14	Average number of transit boardings

APPENDIX E COMMERCIAL VEHICLE MODEL

The commercial vehicle model is a three-step model that can be run prior to assignment in order to account for NHBW trips in JEMnR that are occurring due to commercial vehicle movements. The model can be enabled using the "runCommercialVehicleModel" flag in the settings file. Furthermore, the total number of balancing iterations for trip balancing can be specified by the "maxIter_Commercial" parameter in the settings. The model runs as part of JEMnR, as a separate module defined by the rcode/peaking/cvm.R script. The model uses a separate set of inputs defined in the inputs/cvm folder. The model estimates single-unit truck, multi-unit truck and car commercial vehicle trips by time periods defined in TOD_periods.csv. The resulting demand is saved into the "commercialdailyvehicle" and defined period matrices. These are then added to the corresponding "daliyvehicle" and period vehicle demand matrices generated by the overall JEMnR run.

E.1 Running the Model

The entire model script is contained within the "cvm.R" file. Prior to running it, ensure that the appropriate inputs and outputs folders are present and populated. The standard JEMnR settings.csv file in the /inputs directory also now has additional parameters, listed in Table E-1. These are the only additional user parameters. The *runCommercialVehicleModel* is a True/False flag that enables or disables the model. The *maxIter_Commercial* parameter is used to set the number of iterations that the gravity model makes. Additional iterations reduce the error (difference between estimated attractions and generated attractions by TAZ), but the improvement is very small after five iterations, thus the default values has been set at five. The result of a successful model run should be (#modes x #periods – presently 3 x 6 = 18) CSV files created in the " JEMnR/peaking/cvm" folder (listed as part of the output file name tokens, in Table E-3). Furthermore, the daily trip matrix will be saved as the "dailycommercialvehicle.Rdata" file in the "JEMnR/peaking" folder.

Table E-1: Additional parameters in settings.csv file

Parameter	Description	Sample Value
runCommercialVehicleModel	Boolean flag to determine if the CVM is to be run	TRUE
maxIter_Commercial	Max iterations for balancing CVM trips	5

Table E-2 lists all of the input parameters that are user-modifiable. The primary parameters are the production, attraction rates and friction factors that were based on an establishment survey of work-related travel by employees of businesses in Ohio, since a similar survey was not available in Oregon. These are read in as CSV files, with work and non-work rates located in separate files. Time-of-day factors are also necessary; these are also input in CSV format and should be separated into different files by mode (car, single unit truck, multi-unit truck).

The TAZ range used in the commercial vehicle model is obtained from the input file TAZ range - the model is run for only the common TAZ interval (min overall TAZ to max overall TAZ available from skim and TAZ data files).

Table E-2: Input parameters

Parameter	Description	Sample Value
tazFileName	TAZ data w/ employment data	"inputs/TAZ.csv "
nonWorkProductionFileName	Production rates for non-work trips	"inputs/cvm/nonWorkProd_IntraTrips.csv"
workProductionFileName	Production rates for work trips	"inputs/cvm/workProd_IntraTrips.csv "
nonWorkAttractionFileName	Attraction rates for non-work trips	"inputs/cvm/nonWorkAttr.csv "
workAttractionFileName	Attraction rates for work trips	"inputs/cvm/workAttr.csv "
nonWorkFrictionFileName	Non-work friction factor params	"inputs/cvm/nonWorkFriction.csv "
workFrictionFileName	Work friction factor parameters	"inputs/cvm/workFriction.csv "
skimFileName	R file with the distance/time skim	"inputs/RData/ivTimepeakdriveAlone.Rdata”
carTODFileName	TOD distribution of car trips	"inputs/cvm/TOD_Car.csv "
suTODFileName	TOD distribution of single-unit trips	"inputs/cvm/TOD_SUTruck.csv "
muTODFileName	TOD distribution of multi-unit trips	"inputs/cvm/TOD_MUTruck.csv "

The output filename prefixes are specified in Table E-3 – these will be used to create the filenames of the output matrices which will be placed into the outputDir folder. Each prefix will be combined with a time period suffix to create the trip table filename – for example “CAR_pm.csv” will be the car mode trip table for the “pm” time period. Time periods for the final trip table production are specified in the JEMnR model environment, using the “SWIM_TOD_Periods.csv” file.

Table E-3: Output parameters

Parameter	Description	Sample Value
carOut	Prefix of car trip table files to be created	“CAR”
suOut	Prefix of single-unit trip table files	“SU”
muOut	Prefix of multi-unit trip table files	“MU”

Using the production and attraction rates provided in the inputs, and the TAZ employment data, the number of trips produced in each TAZ and attracted to each TAZ is computed, as outlined in the following section.

E.2 Trip Generation

Trip generation is achieved by cross-multiplying the production and attraction factors obtained from CSV files by the corresponding employment values for each TAZ. The TAZ employment categories and their corresponding categories within the production and attraction files are listed in Table E-4.

Table E-4: TAZ employment categories corresponding to model inputs

TAZ Employment Data Category	Label in Model Input Files
AFREMP	“Agriculture, Forestry”
MINEMP	“Mining”
CONEMP	“Construction”
MFGEMP	“Manufacturing”
TCPEMP	“Transportation, Communications, Public Utilities”
WSTEMP	“Wholesale”
RETEMP	“Retail”
FINEMP	“Financial”
SVCEMP	“Service”
GVTEMP	“Government”

The productions and attractions for each TAZ are calculated for both work and non-work trip purposes separately. Once these are prepared, they are used along with the travel impedance values provided by the friction factors to create trip tables, as outlined in the Trip Distribution section.

E.3 Trip Distribution

The distribution of trips between zone pairs is achieved through iterative application of the Gravity model:

$$T_{ij} = P_i \frac{A_j F_{ij}}{\sum_{k=0}^{n} \mathrm{A}_k F_{ik}}$$

where:

T_{ij} = Number of trips between zone i and j,

P_i = Trips produced in zone i,

A_j = Trips attracted to zone i,

N = Total number of zones,

$$F_{ij} = \exp\left(bt_{ij} + \frac{r+st_{ij}}{1+qt_{ij}^{2}}\right)$$

and *b*,*r*,*s* and *q* are coefficients coming from the friction factors inputs. The impedance *t* is the auto travel time between zones i and j, obtained from the skim (such as "ivTimepeakdriveAlone.Rdata").

The above expression is solved *balance_iter* times, with a reallocation of TAZ attractions done during each iteration. The column (attractions) sums of the trips (*T)* matrix are compared to the attractions by TAZ obtained during the Trip Generation stage and the attractions (*A*) vector is correspondingly adjusted at each iteration. After the maximum number of iterations is reached (or the root mean square error between the trips matrix attractions and the generated attractions is sufficiently low (1e-5)) the trip tables by mode (car, single-unit truck, multi-unit truck) and purpose (work, non-work) are prepared to be allocated by time-of-day.

E.4 Time-of-Day Choice

In the final step of this model, trips are allocated based on the time-of-day distributions given in the input files (such as "TOD_car.csv"). The shares given for each trip type (Work to Visit (P->A), Visit to Work (A->P) and Visit to Visit (P->P)) in the input files are aggregated by time period (as defined in the TOD_periods JEMnR variable (via "TOD_Periods.csv")) and are then used to scale the trip tables accordingly. The scaled matrices are then combined to create a single trip table for each mode, for each time period. (Thus, the total number of tables produced as output is #modes x #periods). The total trips for each mode are computed as follows:

$$TotalTrips = WorkOD + NonWorkOD$$

where:

$$WorkOD = Work.Visit[period] * Trips + Visit.Work[period] * transpose(Trips)$$

$$NonWorkOD = Visit.Visit[period] * Trips + Visit.Visit[period] * transpose(Trips)$$

$$Work.Visit = time\ of\ day\ share\ matrix\ P \rightarrow A\ (for\ each\ mode)$$

$$Visit.Work = time\ of\ day\ share\ matrix\ A \rightarrow P\ (for\ each\ mode)$$

$$Visit.Visit = time\ of\ day\ share\ matrix\ A \rightarrow A\ (for\ each\ mode)$$

$$Trips = \text{the trip matrix in P} \rightarrow \text{A form}$$

$$period = \text{the analysis time of day period}$$

APPENDIX F UNIVERSITY TRAVEL MODEL

Please refer to the CALM Model Report in the following link for full details:

\\s6000e\6420only\County\Benton\CALMModel_V3\Draft_Document\Corvallis_Albany_Lebanon Model Development Report_041718_.pdf

General Description:

The university travel model estimates the average weekday trips made by university students, staff and faculty. This is a disaggregate tour-based model that is run as a separate process, provided it is turned on in the settings file, based upon synthetic population files for the region. When the model is turned on, the uni.R script (peaking/uni.R) runs the runUniversityModel.cmd batch file (unimodel/ runUniversityModel.cmd) that launches the Java processes and runs the entire model, producing output in the form of CSV trip tables (in unimodel/outputs). In order to prevent double-counting university travel in JEMnR, the inputs to JEMnR are summed from the synthetic population files without including university students. The following steps occur to combine the results of the university model with the overarching JEMnR run:

1. Synthetic population data is collapsed to a zonal level for running the non-university JEMnR models. This is done in inputs.r.
2. Employment in University TAZs is multiplied by universityHBWFactor and universityNHBWFactor during the trip generation step of JEMnR (nhbgen.r). These factors are defined in the settings file.
3. The university model is run as a separate Java process.
4. The resultant university model trips.csv file is converted into an OD matrix and added to "dailyvehicle" as follows: each SOV trip = 1 trip, each HOV2 trip = 1/2 trip and each HOV3 trip = 1/3.5 trips. Each transit trip = 1 trip and is added to "dailybus" (writeToBank.r).
5. The JEMnR model run continues as before.

The university model is implemented in Java software, using the PB Common Modeling Framework library of tools. The university model reads emme mf*.emx matrices (converted to ZMX using EMZtoZMX.py) and its own set of inputs as described below. These matrices, and land-use data inputs, are specified in a set of excel spreadsheets referred to as Utility Expression Calculator (UEC) spreadsheets. All inputs are specified on the data page of the UECs or in the university model properties file (tpau_tbm.properties). The spreadsheets also specify the variables and coefficients used in each University travel model.

When running from JEMnR, the entire model is run from the peaking/uni.R script, which sets up the environment variables, calls the batch file which executes the Java code (runUniversityModel.cmd) and then translates the output .csv trip matrices into R objects (which are then added to the emmebank for assignment).

F.1 Software Requirements

The following software is required to execute the university model, in addition to what is needed for JEMnR:

F.1.1 Java

The University model is implemented in Java and utilizes the open- source Common Modeling Framework (CMF) library developed by Parsons Brinckerhoff. The 64-bit Java Runtime Environment (version 1.7 or later) must be installed on the computer. The 64-bit version of the software allows the software to take advantage of larger memory addresses.

F.1.2 Python

The university model reads in level-of-service matrices in ZMX file format. To convert the existing level-of-service matrices from EMME into a ZMX format, the EMXtoZMX.py Python script is used. This script uses the Python version included with EMME. The folder name of the version used should be specified in the "settings.csv" file ("EMME_Python" property). For example if EMME came with Python 2.6, specify the setting as "Python26" (so that python.exe can be located at "EMMEPATH"\Python26\python.exe). This assumes the EMMEPATH system variable has been set to the EMME location.

F.1.3 GNU tools

The university model utilizes a tool provided by the GNU free software foundation to redirect, or “pipe”, output from a DOS process (specifically Java) to a text file. This is useful in case the java process terminates in an error, as the text file can be opened to determine what the error might have been. The GNU Win32 tools is installed automatically as part of the university model setup. However, they can also be downloaded from sourceforge.net (http://gnuwin32.sourceforge.net/). The specific tool used is tee.exe, which is part of the CoreUtils package.

F.1.4 Microsoft Excel (not required but helpful)

The discrete choice models are specified via spreadsheets, referred to as Utility Expression Calculators or UECs. These files are Excel-based. See http://analytics.mtc.ca.gov/foswiki/Main/UtilityExpressionCalculator for a more detailed explanation on these Excel files. It is helpful to have Excel installed so that the spreadsheets can be opened, though it is not essential for running the model system.

F.2 Input Files

There are a number of input files required for running the model. They are organized into the following categories: Data Inputs, Model Specifications, Programs, and Properties Files.

F.2.1 Data Inputs

The following data inputs are required to run the university model:

- Synthetic household and person files: The university student residential location choice model is implemented in a stand-alone spreadsheet, and provides constraints to the population synthesizer which is implemented separately. It is assumed that these processes have been run prior to running the university model.
- Public Use Microdata files: Both household and person files from Census PUMS data are read in by the university model, and are used to create the group quarters and the university faculty\staff synthetic population.
- TAZ data file: The TAZ data file contains households by type, employment by type, and a number of other fields that are necessary to run the university model.
- Travel time and cost skims: a set of time and cost skims are used for calculation of accessibilities, mode, and destination choice models.
- Parking data: Available parking lots/spaces are specified in a file and used to constrain the parking locations for students and faculty\staff who drive to campus.
- Baseline parking demand: Parking demand at each lot by market segment and time period affects tour mode choice; baseline estimates of parking demand should be used as an input to the university model. Testing changes in parking supply require iterating the model, as described below. The actual file is described under model outputs since the file is produced by the parking location choice component of the university model.

The full list of data inputs is given in Table F-1. Detailed descriptions of the TAZ level data can be found in The university model relies upon a TAZ data file that is different from the JEMnR TAZ file. The university model TAZ file (tazData.csv, described in Table F-4) must be manually created based upon the JEMnR TAZ file by mapping the JEMnR employment categories to the University model employment categories, and applying shares of non-Single Family homes by TAZ to the household totals in the taz.csv file to calculate SF versus MF fields. It is sufficient to leave the other housing type fields empty. The university square footage fields are used in the university destination choice models and must be updated based upon current or future space estimates for major universities. The group quarters fields (GQ and GQTYPE) are used by the university model software to generate the group quarters population, and should include on-campus housing estimates as well as number of rooms in off-campus fraternities and sororities.

Table F-4. Skims descriptions are listed in Table F-6.

Table F-1: Data Inputs

File Name	Description
ss11pRVMPOWithZeros.csv	2011 ACS PUMS Person File, with zeros for missing integer fields and N.A. for missing text fields. This file is not year-specific or scenario-specific.
ss11hRVMPOWithZeros.csv	2011 ACS PUMS Household File, with zeros for missing integer fields and N.A. for missing text fields. This file is not year-specific or scenario-specific.
persons.csv	Synthetic population person file; year-specific or land-use scenario specific.
households.csv	Synthetic population household file; year-specific or land-use scenario specific.
tazData.csv	Input TAZ data file; year-specific or land-use scenario specific. Fields and description are given in The university model relies upon a TAZ data file that is different from the JEMnR TAZ file. The university model TAZ file (tazData.csv, described in Table F-4) must be manually created based upon the JEMnR TAZ file by mapping the JEMnR employment categories to the University model employment categories, and applying shares of non-Single Family homes by TAZ to the household totals in the taz.csv file to calculate SF versus MF fields. It is sufficient to leave the other housing type fields empty. The university square footage fields are used in the university destination choice models and must be updated based upon current or future space estimates for major universities. The group quarters fields (GQ and GQTYPE) are used by the university model software to generate the group quarters population, and should include on-campus housing estimates as well as number of rooms in off-campus fraternities and sororities. Table F-4.
Parking_Capacity.csv	Parking Capacity data file. Fields and description are given in The SpaceType field restricts use of the spaces to relevant travel markets; if spaceType is set to 0, only faculty\staff can utilize the lot. If spaceType is set to 1, the space is reserved for either faculty\staff or students (faculty\staff can park in student-designated spaces at Oregon State University in the base year). If the space is designated 2, it is also available for parking by students and faculty\staff; however each space type is utilized according to the properties set in the tpau_tbm.properties file. See below for a more detailed description of how to use the parking_capacity.csv file and the properties file to model different parking scenarios. Table F-5.
Emmebank	An EMME databank containing matrices as shown in Table F-6.

The University model is a disaggregate micro-simulation model and hence requires a disaggregate list of households and persons as input to the model. This list of household is generated using population synthesis procedure (PopSynIII) as described in Memorandum 2.1: Population Synthesis Design and Memorandum 2.2: PopSyn User's Guide. Table F-2 and Table F-3 describes the fields for households and persons files produced by the population synthesizer. Please note that PopSynIII uses a geographic naming convention that is different from what is used in JEMnR. It operates at three levels of geographies ; MAZ, TAZ and DISTRICT (or META). These correspond to JEMnR TAZ system, Census Tracts, and the entire region. Furthermore, PopSyn requires a sequential zone numbering system while the JEMnR TAZ number is non-sequential. Hence, a sequential numbering system must be developed and used for the JEMnR region and in the synthesis procedure. The MAZ field in the synthetic population files refer to the sequential JEMnR TAZ number. A script is run on the output PopSyn files which renames the TAZ field (which contains Census tract) to TRACT and adds a new TAZ field which contains the non-sequential JEMnR TAZ.

Table F-2: Synthetic Population Household Table in Expanded Form from PopSynIII (households.csv)

FIELD	**Description**
HHID	Unique household ID
TEMPID	Unexpanded household ID
REGION	District code (MPO Region) in which HH is located
PUMA	PUMA code for HH record
TAZ	TAZ code in which HH is located (Non-sequential JEMnR TAZ)
MAZ	MAZ code in which HH is located (Sequential JEMnR TAZ)
WGTP	Initial PUMS Housing Weight (not used)
FINALPUMSID	HH ID generated during population synthesis
FINALWEIGHT	Final HH weight generated during population synthesis (not used)
SERIALNO	Unique housing PUMS record identifier
N	Used to expand households after synthesis to create final synthetic population (not used)
NWRKRS_ESR	Number of workers in the household
HHINCADJ	Household income in 2010 inflation adjusted dollars
*	Other PUMS HH fields specified in PopSyn SQL scripts.

Table F-3: Synthetic Population Person Table in Expanded Form from PopSynIII (persons.csv)

FIELD	**Description**
HHID	Unique household ID
PERID	Unique person ID
TEMPID	Unexpanded household ID
REGION	District code (MPO Region) in which HH is located
PUMA	PUMA code for HH record
TAZ	TAZ code in which HH is located (Non-Sequential JEMnR TAZ)
MAZ	MAZ code in which HH is located (Sequential JEMnR TAZ)

WGTP	Housing Weight
FINALPUMSID	Person ID generated during population synthesis
FINALWEIGHT	Identical to FINALWEIGHT in household file (not used)
N	Identical to N in household file (not used)
SPORDER	Person number in HH
EMPLOYED	Is person employed 0 = not employed, 1 = employed
OCCP	Occupation code for this person (see Table F-16)
UofOTag	University student record identifier
*	Other PUMS Person fields specified in PopSyn SQL scripts

The university model relies upon a TAZ data file that is different from the JEMnR TAZ file. The university model TAZ file (tazData.csv, described in Table F-4) must be manually created based upon the JEMnR TAZ file by mapping the JEMnR employment categories to the University model employment categories, and applying shares of non-Single Family homes by TAZ to the household totals in the taz.csv file to calculate SF versus MF fields. It is sufficient to leave the other housing type fields empty. The university square footage fields are used in the university destination choice models and must be updated based upon current or future space estimates for major universities. The group quarters fields (GQ and GQTYPE) are used by the university model software to generate the group quarters population, and should include on-campus housing estimates as well as number of rooms in off-campus fraternities and sororities.

Table F-4: tazData.csv File Fields

Field Name	Description	Source[43]
TAZ	TAZ ID for the zone (non-sequential JEMnR TAZ)	JEMnR TAZ
TD	Not Used	0
SF	Number of Single Family households in the zone	HHBASE*PSFD
Duplex	Number of Duplexes in the zone	0
MF	Number of Multi-Family households in the zone	HHBASE - SF
MH	Number of Mobile Homes in the zone	0
TotalHH	Total number of households in the zone	HHBASE
Food_Emp	Number of employees in the food manufacturing industry	0
OthDur_Emp	Number of employees working in non-food durable goods manufacturing	MFGEMP
OthNonDur_Emp	Number of employees working in non-durable goods manufacturing	0
Constr_Emp	Number of employees in the	CONEMP

[43] The relevant field from taz.csv is given if used to populate the tazData.csv field. A zero indicates that the field could not be populated from JEMnR inputs or other available data and was therefore set to zero.

	construction industry	
TCU_Emp	Number of employees working in transportation, communications, and utilities	TCPEMP
Wholesale_Emp	Number of employees working in wholesale	WSTEMP
FIRE_Emp	Number of employees working in finance, insurance, or real estate	FINEMP
GenRetail_Emp	Number of employees working at retail establishments that are local attractors	RETEMP
GenServ_Emp	Number of employees working at service establishments that are local attractors	SVCEMP
MajRet_Emp	Number of employees working at retail establishments that are regional attractors	0
MajSvc_Emp	Number of employees working at service establishments that are regional attractors	0
TempGrp_Emp	Number of employees working in temporary housing (i.e. hotels, motels, etc.)	0
Lumber_Emp	Number of employees working in the lumber industry	0
Mining_Emp	Number of employees working in the mining industry	MINEMP
Federal_Emp	Number of federal government employees	GVTEMP
StateLocGov_Emp	Number of state and local government employees	0
StateLocEduc_Emp	Number of state and local education employees	0
Agric_Emp	Number of employees working in agriculture	AFREMP
Other_Emp	All other employees	0
TotalEmp	Total employment	Sum of employment
GQ	Number of group quarters housing units	Census block group data and university land-use inventory
GQType	Type of group quarters housing (1=Major University GQ, 2=Non-major university GQ, 3 = Military GQ, 4 = Other GQ)	University land-use inventory, assumed other for non-university GQ
universitySqFt	Number of square feet of OSU useable space	University land-use inventory
universitySqFtClass	Number of square feet of OSU	University land-use inventory

	classroom space	
universitySqFtOffice	Number of square feet of OSU office space	University land-use inventory
universitySqFtRec	Number of square feet of OSU recreational space	University land-use inventory

University model parking data inputs are specified in parking_capacity.csv, described in Table F-5. There is one record per lot and space type (in other words, if there is a lot with a mixture of space types, each space type should be summarized in a separate record). This file should be modified if there are specific parking policies to test, such as a new parking lot or increasing capacity in an existing lot. The SpaceType field restricts use of the spaces to relevant travel markets; if spaceType is set to 0, only faculty\staff can utilize the lot. If spaceType is set to 1, the space is reserved for either faculty\staff or students (faculty\staff can park in student-designated spaces at Oregon State University in the base year). If the space is designated 2, it is also available for parking by students and faculty\staff; however each space type is utilized according to the properties set in the tpau_tbm.properties file. See below for a more detailed description of how to use the parking_capacity.csv file and the properties file to model different parking scenarios.

Table F-5: Parking_Capacity.csv File Fields

Field Name	Description
TAZ	The TAZ where the lot is located (non-sequential JEMnR TAZ)
informalLot	1 if parking is informal, else 0
spaceType	0 = faculty/staff permit, 1 = student permit, 2 = free
Spaces	Number of spaces available for that space type in that TAZ
terminalTime	Approximate time to access the network from the parking lot (in minutes)

As discussed above, EMME matrices are converted to zmx files using a Python script and then read by the university model software. The matrices are listed in Table F-6.

Table F-6: Level-of-Service Skims

Field Name	Description
mf21	Auto Distance (peak and off-peak)
mf19	Auto Travel Time – Off-Peak
mf20	Auto Travel Time – AM Peak
mf9	Bus – Daily In-vehicle Travel Time
mf10	Bus – Daily Walk to Transit Time
mf11	Bus – Daily Transfer Wait Time
mf12	Bus – Daily First Wait Time
mf14	Bus – Daily Boardings

F.2.2 Model Specifications

The university model is specified in a set of Excel workbooks referred to as Utility Expression Calculators (UECs), and observed probability distributions. The model specifications are listed in Table F-7 in order of use by model component.

Table F-7: UECs and Observed Probability Distributions

UEC File	Description (UEC file for)
UniversityAccessibilities.xls	Origin-based accessibility specification.
UniversityAutoOwnership.xls	Auto ownership model.
UniversityTourFrequencyGQ.csv	University tour frequency distribution for students living in group quarters.
UniversityTourFrequencyNonFamily.csv	University tour frequency distribution for students living in non-family households.
UniversityTourFrequencyFamily.csv	University tour frequency distribution for students living in family households.
UniversityTourDestinationChoiceSOAAlternatives.csv	A list of the tour destination choice alternatives for the initial sampling of alternatives model (should equal the number of TAZs in the model area)
UniversityTourDestinationChoiceAlternatives.csv	A list of the number of tour destination choice alternatives to sample (currently set to 30, for 30 sampled TAZs from the full set)
UniversityTourDestinationChoiceSOA.xls	University Tour Destination Choice Sample of Alternatives UEC. Note that this UEC includes size terms for tour and stop destination choice models, as well as those used in the accessibility calculations.
UniversityTourDestinationChoice.xls	University Tour Destination Choice Full Model UEC
UniversityTourTimeOfDayDistributions.csv	Observed probability distributions for university tour time-of-day choice.
UniversityTourModeChoice.xls	University Tour Mode Choice UEC.
UniversityStopFrequencyDistributions.csv	University Stop Frequency Distributions by tour purpose, duration, and number of inbound/outbound stops
UniversityStopPurposeDistributions.csv	University Stop Purpose Distributions by tour purpose, inbound stop, stop number, multiple stops on tour

	indicator.
UniversityStopLocationChoiceSOA.xls	University Stop Location Choice Sample of Alternatives UEC
UniversityStopLocationChoice.xls	University Stop Location Choice Full Model UEC
UniversityStopLocationChoiceAlternatives.csv	List of University Stop Location Choice Alternatives for Full Model (15)
UniversityOutboundStopDurationDistributions.csv	University stop duration distributions for stops on outbound journeys
UniversityInboundStopDurationDistributions.csv	University stop duration distributions for stops on inbound journeys
UniversityTripModeChoice.xls	University Trip Mode Choice UEC

F.2.3 Model Programs & Running the Model

There are a few programs and batch files required in order to run the university model, as listed in Table F-8. The batch file that runs the university model is 'runUniversityModel.cmd'. The batch file takes eight arguments, as follows:

Argument 1: PROJECT_DIRECTORY

The path to the /unimodel folder, where the university model files are. This parameter is obtained automatically when running the model from R via the uni.R script.

Argument 2: SAMPLERATE

The sample rate used by the university model. This parameter is set in the "settings.csv" input file, when run from JEMnR.

Argument 3: ITERATION

The overall JEMnR iteration number, set by the uni.R script based in current "iter" variable value.

Argument 4: EMME_FILE

The EMME project file that contains the scenario to be used for analysis, from the JEMnR/emme folder (e.g. "CALM_edits.emp"). Set in "settings.csv" when run from JEMnR.

Argument 5: EMME_Scenario

The scenario number in the file above to use (e.g. 3010 - peak). This property is used in the matrix conversion process. The implementation uses the "peak_scen_num" setting in "settings.csv" when run from JEMnR.

Argument 6: EMME_Python

The folder name of the Python distributed with EMME (e.g. "Python26"). Set in "settings.csv" when run from JEMnR.

Argument 7: JAVA_64_PATH

Path to the 64-bit Java Runtime Environment install directory (1.7 or later). Set in "settings.csv" when run from JEMnR.

Argument 8: EMME_MATS

List of EMME matrices that are needed to be converted to ZMX format. When running from JEMnR, the code will convert **all matrices** listed in the "settings.csv" file that have a "matNum" property in "settings.csv". The list is enclosed in parentheses, like so: " mf21 mf9 mf19 mf14 mf11..."

An example of running the batch file would be as follows:

```
runUniversityModel.cmd  "C:/CALM/unimodel" 1 1 CALM-Edits.emp 3010 Python26
"C:/Program Files/Java/jdk1.7.0_25" "mf21 mf9 mf19 mf14 mf11..."
```

This tells the program that the scenario directory is on the c: drive in the directory CALM/unimodel. Note the use of forward slashes in the path instead of backward slashes; java uses forward slashes by convention. The sample rate of 1.0 indicates that a 100% sample is to be run. The sample rate can be any floating point number between 0 and 1.0; each output record (see Outputs, below) has an expansion factor that can be used to scale the record up to the full population. The iteration number is just used for logging

Table F-8: Program Files

Program	**Description**
tpau.jar	Compiled java code needed to run the university model
runUniversityModel.cmd	List of MS-DOS instructions that control model flow. This is the batch file that is called to run the university model.

F.2.4 Property Files

There are two property files read by the university model:

1. tpau_tbm.properties: This is the main property file which lists general settings such as the number of time periods in the model, as well as properties specific to each particular model component, such as the location of input UECs or observed distributions, the page number for the data specification in that Excel file, and for

each model component. The model is highly-configurable by changing properties specified in this file, but it is not recommended to change most properties without familiarity with the underlying code. The properties file is fairly well-commented. For example, in order to change the person\household traced through the model, change the HouseholdManager.debug.HouseholdIds setting to list the households to trace.

2. log4j.xml: This property file controls logging for each model component. The university model uses log4j, a third-party logging tool in Java, for reporting during model runs. By modifying this file, the user can send different logging to different report files, and also control whether those files are appended to or overwritten each time the model is run. Currently the file is configured to send logging to either the event.log file or the universityModel.log file (most logging is sent to this latter file, including all debugging/tracing of specific agents in the model system). It is not recommended to change this file.

F.3 Output Files

There are five key output files from the model system, listed below.

1. Accessbilities.csv: A zone-based file with origin-based accessibilities by purpose and mode or segment, as described above.

2. HouseholdsOut.csv: A household output file with variables coded from the input synthetic population file.

3. PersonsOut.csv: A person output file with variables coded from the input synthetic population file, as well as chosen work TAZ and school TAZ for workers and students, the auto availability choice for the person, and the total number of tours generated by that person.

4. Tours.csv: A tour output file listing the tours generated by each person in each household. This includes the purpose of the tour, the time the person departed on the tour (in 15 minute increments starting at 3:00AM), the time the person arrived at the primary destination of the tour, the origin and primary destination TAZ of the tour, the primary mode of the tour, and the number of outbound and inbound stops on the tour. Also for all stops on the tour, the information about each stop is generated, i.e. stop is inbound (inbound = 1) or outbound (inbound = 0), mode used for that stop (see Trip Mode below), the time period, TAZ of the stop, and purpose of the stop (same code as tour purpose).

5. Trips.csv: A trip output file listing all trips made on each the tour by each person in each household. This includes the origin and destination TAZ of the trip, trip mode(see code below), origin and destination purpose, period of the trip (30 minute increments starting at 3:00AM), whether the trip was inbound (inbound = 1), or outbound (inbound = 0),

whether the trip is the first of the tour (firsttrip = 1), or the last of the tour (lasttrip = 1), and whether origin or destination is the primary destination of the tour.

6. ParkingDemand.csv: A parking demand output file listing the number of people by market segment (faculty/staff, student, visitor) parking in each space type in each TAZ for each time period. This demand includes new vehicles parking in that time period as well as vehicles that were already there from a previous time period. Note that this file is both a model output as well as a model input.

Additional details about outputs can be found in the tables below (**Table F-9** to

Table F-22).

Table F-9: Accessibilities.csv file fields

Field Name	**Description**
Maintenance_SOV	Accessibility to Maintenance activities by SOV
Maintenance_HOV	Accessibility to Maintenance activities by HOV
Maintenance_WALKTRAN	Accessibility to Maintenance activities by Walk-Transit
Maintenance_WALK	Accessibility to Maintenance activities by Walk
Maintenance_AUSUF0	Accessibility to Maintenance activities for 0 auto travelers
Maintenance_AUSUF1	Accessibility to Maintenance activities for 1+ auto travelers
Maintenance_ALL	Accessibility to Maintenance activities for all travelers
Discretionary_SOV	Accessibility to Discretionary activities by SOV
Discretionary_HOV	Accessibility to Discretionary activities by HOV
Discretionary_WALKTRAN	Accessibility to Discretionary activities by Walk-Transit
Discretionary_WALK	Accessibility to Discretionary activities by Walk
Discretionary_AUSUF0	Accessibility to Discretionary activities for 0 auto travelers
Discretionary_AUSUF1	Accessibility to Discretionary activities for 1+ auto travelers
Discretionary_ALL	Accessibility to Discretionary activities for all travelers
AllEmp_SOV	Accessibility to all employment by SOV
AllEmp_HOV	Accessibility to all employment by HOV
AllEmp_WALKTRAN	Accessibility to all employment by Walk-Transit
AllEmp_WALK	Accessibility to all employment by Walk
AllEmp_AUSUF0	Accessibility to all employment for 0 auto travelers
AllEmp_AUSUF1	Accessibility to all employment for 1+ auto travelers
AllEmp_ALL	Accessibility to all employment for all travelers
AllHH_SOV	Accessibility to all households by SOV
AllHH_HOV	Accessibility to all households by HOV
AllHH_WALKTRAN	Accessibility to all households by Walk-Transit
AllHH_WALK	Accessibility to all households by Walk
AllHH_AUSUF0	Accessibility to all households for 0 auto travelers
AllHH_AUSUF1	Accessibility to all households for 1+ auto travelers
AllHH_ALL	Accessibility to all households for all travelers

Table F-10: HouseholdsOut.csv file fields

Field Name	**Description**
hh_id	Household ID
autos	Number of autos (in the case of the university model, this is the number of autos from the synthetic population, not the output from the auto ownership model)

workers	Number of workers in the household (from popsyn)
income	Household income (in $2011, from popsyn)
adults	Adults in household (from popsyn)
family	1 if family household, else 0 (from popsyn)
taz	Household residence TAZ (from popsyn)
buildingType	Household building type (from popsyn); See Table F-11
debugChoiceModels	1 if household was selected for debugging, else 0
seed	Random number seed for household choice models
expansionFactor	Household expansion factor

Table F-11: Household building type

Code	Description
0	Single Family
1	Townhouse
2	Apartment
3	Mobile home
4	Group quarters

Table F-12: PersonsOut.csv file fields

Field Name	Description
hh_id	Household ID
person_id	Person ID
female	1 if female, else 0
age	Age in years
occupation	Occupation of worker, see Table F-16
workStatus	Work status, see Table F-17
studentStatus	Student status, see Table F-18
majorUniversityStudent	1 if major university student, else 0
majorUniversityWorker	1 if major university worker, else 0
personType	Person type, see Table F-19
workTaz	Work TAZ if worker
schoolTaz	School TAZ if student
autoAvailable	Chosen auto availability; 1 if auto available, else 0
parksFreeAtWork	Chosen free parking at work; 1 if parks free, else 0
numberOfTours	Number of tours generated by person
seed	Random number seed for person choice models
expansionFactor	Expansion factor

Table F-13: Tours.csv file fields

Field Name	Description
hh_id	Household ID

person_id	Person ID
tour_id	Tour ID
purpose	Tour purpose, see Table F-20
departTime	Departure time period, see Table F-21
arriveTime	Arrival time period, see Table F-21
originTaz	Origin TAZ
destinationTaz	Primary destination TAZ
parkingTaz	Primary parking TAZ
parkingSpaceType	0 = faculty/staff permit, 1 = student permit, 2 = free
tourMode	Tour mode, see Table F-22
seed	Random number seed for tour and stop choice models
expansionFactor	Expansion factor
numberOutboundStops	Number of stops on outbound tour direction
numberInboundStops	Number of stops on inbound tour direction
numberTrips	Number of trips on tour
outstop_*n*_inbound	Outbound stop *n* inbound code (always 0)
outstop_*n*_mode	Mode of trip to outbound stop *n*, see Table F-22
outstop_*n*_period	Departure time period of outbound stop *n,* see Table F-21
outstop_*n*_taz	Outbound stop *n* TAZ
outstop_*n*_purpose	Outbound stop *n* purpose, see Table F-20
outstop_*n*_seed	Outbound stop *n* random number seed
instop_*n*_inbound	Inbound stop *n* inbound code (always 1)
instop_*n*_mode	Mode of trip to inbound stop *n*, see Table F-22
instop_*n*_period	Departure time period of inbound stop *n,* see Table F-21
instop_*n*_taz	Inbound stop *n* TAZ
instop_*n*_purpose	Inbound stop *n* purpose, see Table F-20
instop_*n*_seed	Inbound stop *n* random number seed

Table F-14: Trips.csv file fields

Field Name	**Description**
hh_id	Household ID
person_id	Person ID
tour_id	Tour ID
trip_id	Trip ID
expansionFactor	Expansion factor
originTaz	Departure time period, see Table F-21
destinationTaz	Arrival time period, see Table F-21
tripMode	Trip mode, see Table F-22
originPurpose	Purpose at origin end of trip, see Table F-20
destinationPurpose	Purpose at destination end of trip, see Table F-20
period	Departure period for trip, see Table F-21
inbound	1 if trip occurs on inbound tour direction, else 0
firstTrip	1 if first trip on tour, else 0

lastTrip	1 if last trip on tour, else 0
originIsTourDestination	1 if trip origin is tour primary destination, else 0
destinationIsTourDestination	1 if trip destination is tour primary destination, else 0
parkingLotTrip	1 if trip is access/egress trip to/from a parking lot, else 0

Table F-15: parkingDemand.csv file fields

Field Name	Description
TAZ	Parking Zone
spaceType	0 = faculty/staff permit, 1 = student permit, 2 = free
facultyStaffDemand_*n*	Faculty/Staff parking demand for the given space type in that TAZ in time period *n*; see Table F-21
studentDemand_*n*	Student parking demand for the given space type in that TAZ in time period *n*; see Table F-21
visitorDemand_*n*	Visitor parking demand for the given space type in that TAZ in time period *n*; see Table F-21 (not currently modeled)

Table F-16: Occupation codes

Code	Description
0	Management of business, science, and the arts
1	White collar
2	Blue collar
3	Sales and office
4	Natural resource extraction, construction, and maintenance
5	Production, transportation, material moving
6	Military

Table F-17: Work status codes

Code	Description
0	Non-worker
1	Full-time worker
2	Part-time worker

Table F-18: Student status codes

Code	Description
0	Non-student
1	Pre-kindergarten student
2	K-12 student
3	College student

Table F-19: Person type codes

Code	Description
0	Full-time worker
1	Part-time worker
2	University student
3	Non-working adult
4	Retired adult
5	Driving age student
6	Pre-driving age student
7	Pre-school child

Table F-20: Purposes

Code	Description
-1	Home
0	Work
1	University
2	Maintenance
3	Discretionary
21	Parking Access/Egress

Table F-21: Time periods

Code	Start of Period	End of Period
0	3:00 AM	3:30 AM
1	3:30 AM	4:00 AM
2	4:00 AM	4:30 AM
3	4:30 AM	5:00 AM
4	5:00 AM	5:30 AM
5	5:30 AM	6:00 AM
6	6:00 AM	6:30 AM
7	6:30 AM	7:00 AM
8	7:00 AM	7:30 AM
9	7:30 AM	8:00 AM
10	8:00 AM	8:30 AM
11	8:30 AM	9:00 AM
12	9:00 AM	9:30 AM
13	9:30 AM	10:00 AM
14	10:00 AM	10:30 AM
15	10:30 AM	11:00 AM
16	11:00 AM	11:30 AM
17	11:30 AM	12:00 PM

18	12:00 PM	12:30 PM
19	12:30 PM	1:00 PM
20	1:00 PM	1:30 PM
21	1:30 PM	2:00 PM
22	2:00 PM	2:30 PM
23	2:30 PM	3:00 PM
24	3:00 PM	3:30 PM
25	3:30 PM	4:00 PM
26	4:00 PM	4:30 PM
27	4:30 PM	5:00 PM
28	5:00 PM	5:30 PM
29	5:30 PM	6:00 PM
30	6:00 PM	6:30 PM
31	6:30 PM	7:00 PM
32	7:00 PM	7:30 PM
33	7:30 PM	8:00 PM
34	8:00 PM	8:30 PM
35	8:30 PM	9:00 PM
36	9:00 PM	9:30 PM
37	9:30 PM	10:00 PM
38	10:00 PM	10:30 PM
39	10:30 PM	11:00 PM
40	11:00 PM	11:30 PM
41	11:30 PM	12:00 AM
42	12:00 AM	12:30 AM
43	12:30 AM	1:00 AM
44	1:00 AM	1:30 AM
45	1:30 AM	2:00 AM
46	2:00 AM	2:30 AM
47	2:30 AM	3:00 AM

Table F-22: Modes

Code	Description
1	Drive-alone, general purpose
2	Drive-alone, toll-eligible (not currently available)
3	Shared ride 2, general purpose
4	Shared ride 2, toll-eligible (not currently available)
5	Shared ride 3+, general purpose
6	Shared ride 3+, toll-eligible (not currently available)
7	Walk
8	Bike
9	Walk-local transit
10	Walk-premium transit (not currently available)
11	Park-and-ride transit
12	Kiss-and-ride transit

F.4 University Model Use Cases

The university model can be used to analyze a number of different policies; the effects of increased enrollment or a change in the location of student group quarters on transportation demand, ridership on transit routes serving the university, and parking demand. To test increased enrollment, the analyst would need to modify the university student residential location choice model spreadsheet and re-build the synthetic population before running the JEMnR model with the university model enabled. To test a change in the location and quantity of group quarters, the analyst would need to change the GQ and GQType fields in the input tazData.csv file. To test a new transit route, the input JEMnR transit network must be modified as described above.

To test a change in parking supply and/or location, the input parking_Capacity.csv file must be modified. Typically new parking lots would be coded as formal lots. The analyst must determine how many spaces are designated specifically for faculty\staff use, how many spaces are for student permit-holders, and how many spaces are for visitors. Each space quantity must be a separate record in the input file. The analyst must also estimate the average walking time required to access the network from the lot. For very large lots, the time can be significant; the analyst is encouraged to use the input base-year values as a guideline for how to code this time for a new lot. There may additionally be transit services introduced to provide access to the university for a new remote parking lot. Such transit services would be coded in the transit network according to the guidance provided in relevant sections of the documentation above.

The current version of the parking lot choice model component of the university model utilizes a simulation algorithm. After the university model is run, all tours that access university zones using the auto mode select a space in a lot according to their departure time from home; once this space is selected, it is unavailable for the duration of their university tour for any other university student or faculty\staff. As described in the university model documentation, the selection of parking lot is based upon the utility of auto travel between home and each alternative lot, the utility of walking and transit between each available lot and the university destination zone, and the lot-space constants. The coefficients controlling this choice are all provided in the tpau_tbm.properties file, the tokens begin with the string "UniversityParkingLotChoiceModel". They should not be changed by the analyst.

The tour mode choice model also responds to the supply and accessibility of parking spaces according to the tour departure time. As parking supply becomes more constrained, tour mode choice should react by decreasing the utility (and probability) of driving to campus. This feedback mechanism between parking location choice and tour mode choice requires that tour mode choice read the parkingDemand.csv file output from the parking location choice simulation model. If a new lot is introduced, the model system must therefore be run twice. The first time it is run, the parking lot will have zero demand input to mode choice and the model will see additional unconstrained capacity in the lot which will make the auto mode more attractive. If, after the parking location choice simulation model is run, there are few or no spaces in certain time periods, then the next time tour mode choice is run the auto utility will decrease compared to the first time.

In previous testing, only two runs of the model are necessary to reach a relatively stable result. The analyst should examine the model output (especially the tour mode choice results and the parkingDemand.csv file) to determine if the changes made to parking supply result in reasonable results.

F.5 Updating Zonal Data

For future year model runs, three inputs must be updated. These inputs are described below:

- tazData.csv: The input TAZ data file must be updated with future-year land use data. This file was initially created by transferring certain data items from the taz.csv input JEMnR land-use file, and coding certain fields based upon university land-use inventories, as shown in Table F-4.
- Synthetic population inputs: Input synthetic household and person files must be updated by running the population synthesizer with future year controls. This includes updating the university student residential location choice model.
- University total workers: The total workers at the major university in the tpau_tbm.properties file must be updated. The property is 'University.totalWorkers'.

The zonal data tazData.csv and the synthetic population must also be modified if the zone system changes (if the analyst adds or splits zones in the model region). In addition, the following files must be modified:

- Parking_capacity.csv: The parking capacity must be transferred to the new zone system.
- parkingDemand.csv: Baseline parking demand must be transferred to the new zone system.

- UniversityTourDestinationChoiceSOAAlternatives.csv: The file that specifies what alternatives are available for university tour destination choice must be updated to match the updated zone system. Note that this file is for non-university tours. University tour destination choice is controlled by the university square footage values specified in tazData.csv.
- University model reference TAZ: A reference TAZ is used by the university model when selecting university workers from the synthetic population. It must be updated if the university TAZs change. It should reference a zone in the middle of campus. The TAZ is set in the tpau_tbm.properties file, the token is ‘University.referenceTaz’.