# Hampton Roads Transportation Planning Organization, Regional Travel Demand Model V2 User Guide

FINAL REPORT

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# 1 INTRODUCTION

The Hampton Roads Travel Demand Model (Model) is in its second generation as V2. The Model has been updated to include additional localities (the City of Franklin and Southampton County) and includes an option for testing Connected and Autonomous Vehicle (CAV) scenarios. The latest model is an advanced practice four step model that includes trip generation, trip distribution, mode choice, and assignment steps. A full feedback loop is provided in the model to better represent the effects of highway congestion on the trip distribution process. This version of the model has enhancements to reflect the current best practices of modeling. The model enhancements include:

- The highway network has been expanded to include the City of Franklin and Southampton County.
- The transit networks and their processes were updated to be consistent with the routes as they were defined for 2017.
- The coding of attributes in the highway network follows the Virginia Transportation Modeling (VTM) Policies and Procedures Manual, Version 1.3, May 2009.
- The model has been refined to conduct full time-of-day modeling. The first three steps in the model (trip generation, trip distribution and mode choice) are stratified for the peak period and the off-peak period separately. The highway assignments are further stratified into four time periods – AM peak, Midday, PM peak and Night.
- The refined trip generation and distribution models make extensive use of the 2009 National Household Travel Survey (NHTS) Virginia Add-On. Key relationships such as trip rates by purpose, average trip lengths, and trip frequency distributions are based on that survey.
- An FTA compatible mode choice model was updated using a variety of data sources. These include the Comprehensive Operations Analysis (COA) survey, NHTS data (automobile occupancy) and model parameters from FTA "national experience". The mode choice model is executed using the CUBE XCHOICE module.
- The highway assignment procedures include a variety of enhancements. These include the use of Conical Volume-Delay functions built up on the VDF optimization research done by Virginia Modeling, Analysis and Research Center (VMASC) at Old Dominion University (Source: Evaluation of Volume-Delay Functions and Their Implementation in VDOT Travel Demand Models, May 2011). The enhancements also include refinements to the speed-capacity tables and the use of enhanced toll procedures.
- The model has been generally calibrated and validated to the standards defined in the VTM Policies and Procedures Manual.
- The reporting application has been maintained to display the model statistics and validation results in a user-friendly format.

The model has been validated to year 2017 conditions. The remainder of this document covers model installation and an overview of each model step. The document has 5 main sections:

- Section 1 covers model application installation.
- Section 2 explains the model interface and the catalog structure.
- Section 3 explains the steps to run the Base Year Scenario. This includes explanation about the input and output files.
- Section 4 covers the steps involved in creating a new scenario. This section includes explanation about the keys, calibration files and files associated with the new scenario.

- Section 5 explains the coding rule for the highway network attributes.

For additional details about the methodology adopted in each step, please refer to the Hampton Roads Model Methodology Report Version.

## 1.1 Model Software Installation

The model is written in the Voyager script language and executed through Cube software, a widely-used proprietary modeling platform developed by Citilabs (www.citilabs.com). The model runs on Version 6.4.4. The user needs administrator privileges on the machine where the model is run.

Before the model can be run, the Citilabs Cube software must be installed. At a minimum, the user should install the Cube Base package and the Cube Voyager script environment. Citilabs can provide information on obtaining the software and a suitable license, as well as instructions on installing the package.

Citilabs (Source: Cube Voyager Help Menu) gives the following information on the system requirements to install and run Cube Voyager:

Cube Voyager requires a Windows environment in which to function. The system utilizes RAM as needed; most applications will not require any special RAM considerations. The exact amount of RAM required cannot be determined until an application runs and the combination of user options is diagnosed. It is safe to state that if a computer can run Windows, it has enough RAM to run Cube Voyager. Cube Voyager is designed to run in a multitasking environment. In such an environment, there is a possibility that several simultaneous applications could try to access the same data files simultaneously. This could possibly cause problems if one application is trying to update a file while other applications are accessing it.

The specifications of the model development machine are as follows and represent a minimum specification:

Intel(R) Core(TM) i7-6820HQ CPU @ 2.70GHz, 8.00 GB RAM

Certain agencies are eligible to obtain a licensed copy of the Cube platform under the Virginia Department of Transportation statewide license. Contact VDOT's travel demand modeling group for more information:

http://www.virginiadot.org/projects/vtm/vtm.asp.

## 1.2 Model Support

The support for the Hampton Roads Travel Demand Model is provided by VDOT and the staff of the Hampton Roads Transportation Planning Organization (HRTPO). Contact information is available through the VDOT travel demand modeling website:

http://www.virginiadot.org/projects/vtm/hampton_roads.asp.

Before seeking support, please familiarize yourself with this User Manual, and the model's Technical Documentation.

## 1.3 Model Package Installation

The model is distributed as a single ZIP archive (or as an uncompressed set of file folders). To install the model, the user extracts (or copies) the model files into an empty folder, preserving the folder hierarchy.

In a standard Cube/Voyager installation, the model setup screen may be opened by double-clicking the catalog file (**HR_Model.cat**), located in the root folder of the model hierarchy. Alternatively, the user may start Cube and then use the "Open Catalog" function to open the catalog file. The first time the catalog file is opened, Cube will offer to adjust paths for all the scripts and files in the model to match the installed location. The user should permit this operation by choosing "Yes" in the initial dialog. The section on ***Cube Catalog Overview*** of this report explains this in detail. The model will open in "Applier" mode by default. At a minimum, the user should be familiar with the model's Technical Documentation.

# 2 MODEL INTERFACE

This section describes the model folder structure and introduces Cube Catalog and Application environment.

The model installation creates the necessary folder structure assumed in the model setup. The folder structure is illustrated in Figure 2-1.


Figure 2-1: HRTPO – Folder Structure

The main model folder contains the Cube Catalog file (HR_Model.cat) that has the model setup. Sub-folders contain various elements of the model, its input files, and its output files. These folders are typically manipulated through the Cube interface, but certain input files must be created manually for new scenarios, as described in detail below. Explanations of each sub-folder follow:

- HR_Model_V2_0 – The folder in which the model is installed. Note that this folder name is used as an example here and can be chosen by the user. The folder name will be recorded in the Cube Catalog when it is first opened.
    - Applications – Contains script files and application groups for the model.
    - Images – Contains bitmap used in displaying the model interface.

The names of the sub-folders inside HR_Model_V2_0 are fixed and cannot be changed without re-architecting the Cube Catalog setup.

- Base– Contains input files for the 2017 base validation run.
    - <Y***XXXX***> - As an example, the child scenario is shown as Future_Scenario in the above figure. In general, the name of this folder depends on the scenario name. Note that Future_Scenario is shown only for the purposes of showing the model structure and does not exist in the model catalog as of this writing.

  Base contains the input files for Base 2017 scenario. The child scenario (eg: Y2045) contains input files for that scenario. The input files can be manually edited by the user. It is intended that the folders directly under the Base folder will act as templates for the year designated. The user can then create a child scenario from the year in which the model run is needed.
- Calibration Constants – Contains model parameters and files that do not vary from one scenario to another.
- Cluster – This folder is required by Cube for performing cluster operations.
- Documents – Contains model documentation files, including this user guide.
- Geodatabase – contains the empty geodatabase for storing the model network and TAZ shapefile.
- Inputs – This folder contains files that are developed for the scenarios that are run. Some of these will be used for any model run, while others are year, or scenario, specific.
- Maps – contains the ArcGIS maps used to display model statistics.
- Reports – Contains the cube report files used for displaying the model statistics.
- Shp – Contains the shape file used for True Shape.
- TAZboundary – This folder contains the TAZ shape file for the HTRPO region.

The Base folder may not be delivered with all model transmittals as the model output is voluminous. If the Base folder and the necessary sub-folders do not exist when a model scenario is run, they will be created automatically during first few minutes of the model run.

## 2.1 Cube Catalog Overview

The model can be started by opening the Cube interface and using the Open Catalog option on the File menu, or simply by double clicking the **HR_Model.cat** file. It is important, after a new installation, that the user permit Cube to update the model paths to the folder location in which the model has been installed. If the model path is not up to date, a dialog will appear like the one shown in Figure 2-2, and the user should select “Yes”.

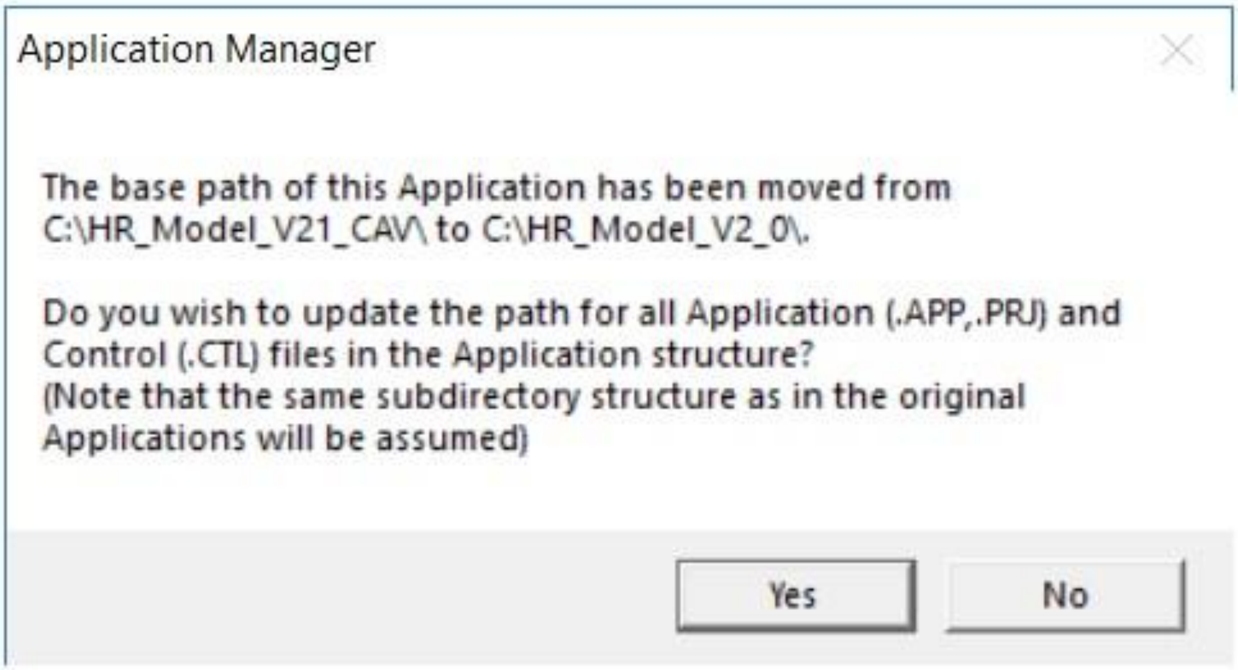


Figure 2-2: File Path Update Following New Installation

The Cube Catalog interface is documented in detail by Citilabs. The interface is somewhat intuitive, and a brief overview is provided here to enable model users to start working with minimal training.
The elements of the Cube Catalog interface are as follows and shown in Figure 2-3. The full flowchart is shown in Figure 2-4 to cover the entire Application Flowchart from top to bottom.

- Scenario Window – The scenario window contains the information about the current scenarios of the model and allows the user to create new scenarios. For example, the Base scenario for Hampton Roads model is defined as Base and uses the year 2017 parameters and files. Under the Base scenario, are folders for years 2015, 2017 and 2045. These year folders represent parent folders and child scenarios would be added under the year scenario.
- Application Window – The application window displays in a tree structure the logical modules ("application groups") that make up the overall model. For example, the application group "HNET00.app" named as "Highway Net" includes all the programs and procedures for preparing highway network to run a scenario.
- Data Window – The data flowchart provides quick access to all important input and output files.
- Catalog Keys – The keys contain parameterized inputs and file paths for the input files in the model.
- Application Flowchart – The application flowchart displays the detailed relationships between the scripts that comprise each application group. This window will be empty until the user selects an application group from the Application Window. This is done by double clicking on the Application name in the Application Window. The number on each application module box represents the execution order of the application when the entire model is run. For example, the "SETUP" application is run prior to "HIGHWAY NET" application. The outputs from one application could be added as inputs to any application with higher execution order. For example, the output files from Trip Generation application are linked to the input files for peak and off-peak Trip Distribution applications.

The Hampton Roads model also employs loops within the model stream. Loops are designed to link together steps in the modeling process that are run iteratively. As shown in Figure 2-3 the Hampton Roads model has peak and off-peak Feedback loops to feed the congested travel times from highway assignment back to trip distribution and mode choice until the convergence criteria are met. The maximum number of iterations for the peak and off-peak feedback loop are set to 3. The highway network with free-flow speeds is defined as initial network for both peak and off-peak loop controls. The AM and MD highway assignment networks are defined as feedback networks for peak and off-peak loop controls. The User can edit the loop by right-clicking the circle box and selecting the properties to update.

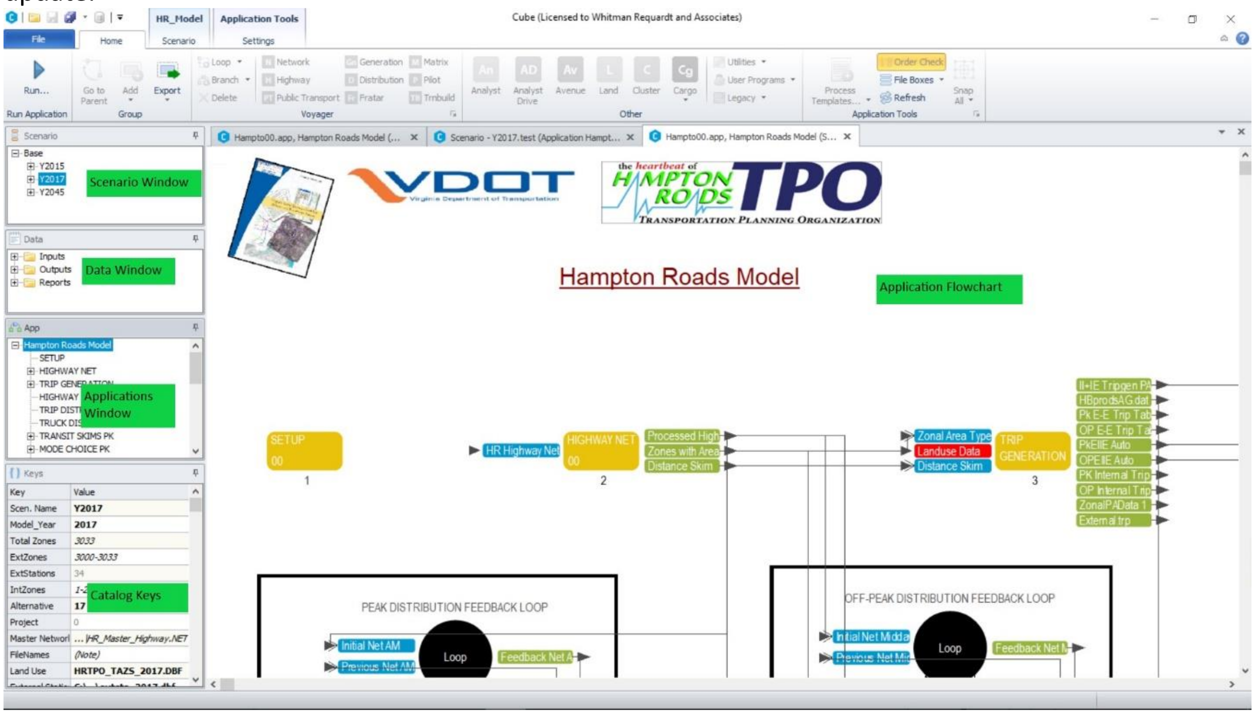


Figure 2-3: Cube Catalog Window, Displaying Application Flowchart

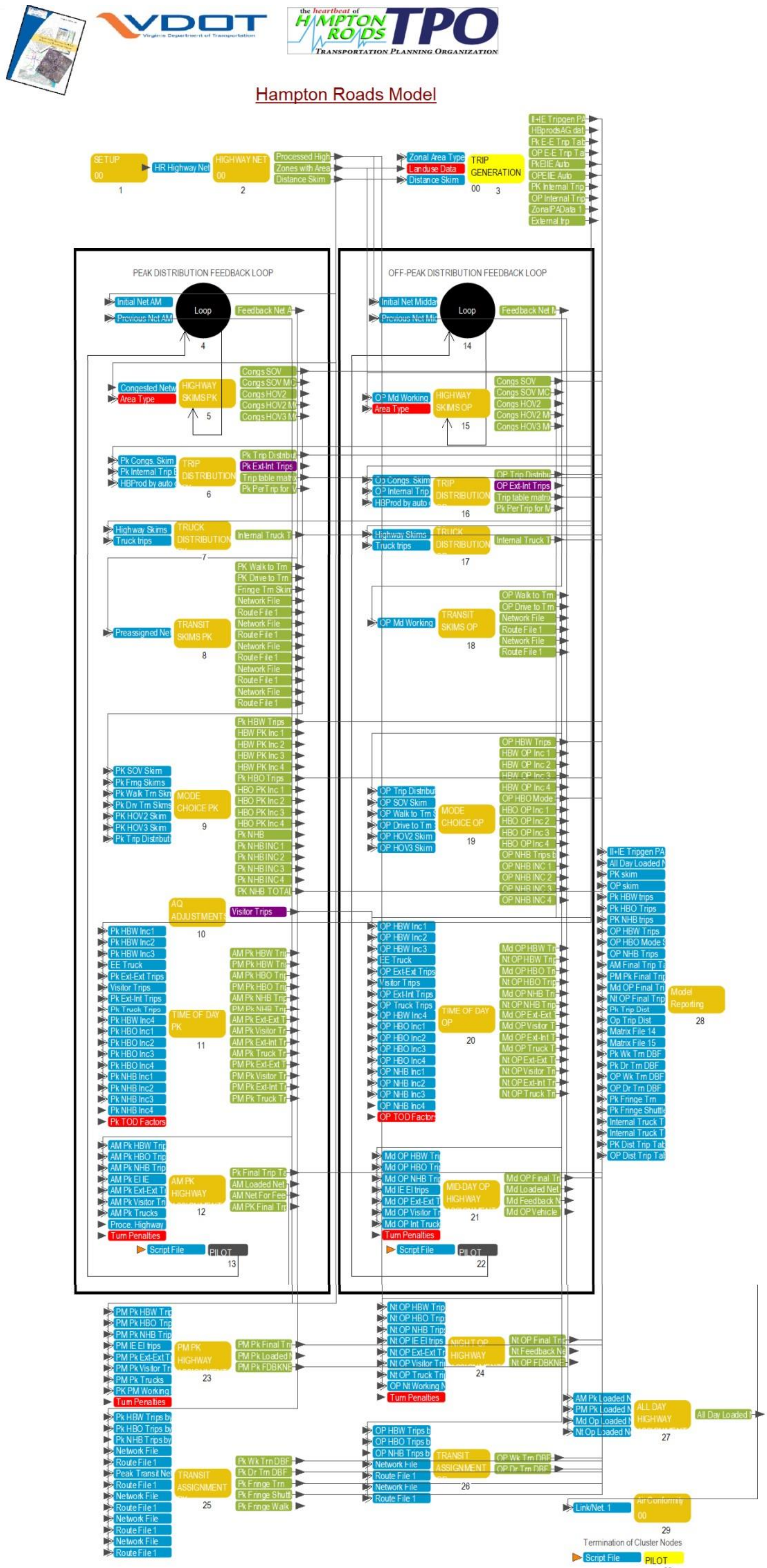


**Figure 2-4: HRTPO – Flow Chart**

When the user opens a scenario by double-clicking in the Scenario Window, Cube will open the "Scenario Edit/Run Dialog" as shown in Figure 2-5, Figure 2-6, Figure 2-7, Figure 2-8, Figure 2-9 and Figure 2-10. The user may use this dialog to adjust values in the Catalog Keys that identify the model input files and other operating parameters for the scenario. The input files and model operating parameters are discussed in detail later in this document. To save changes without running the scenario, choose the Save button. To start a model run for this scenario, choose the Run button.

Note: The Catalog keys highlighted with a red color border were added/updated in the V2.0 version of the HR model.

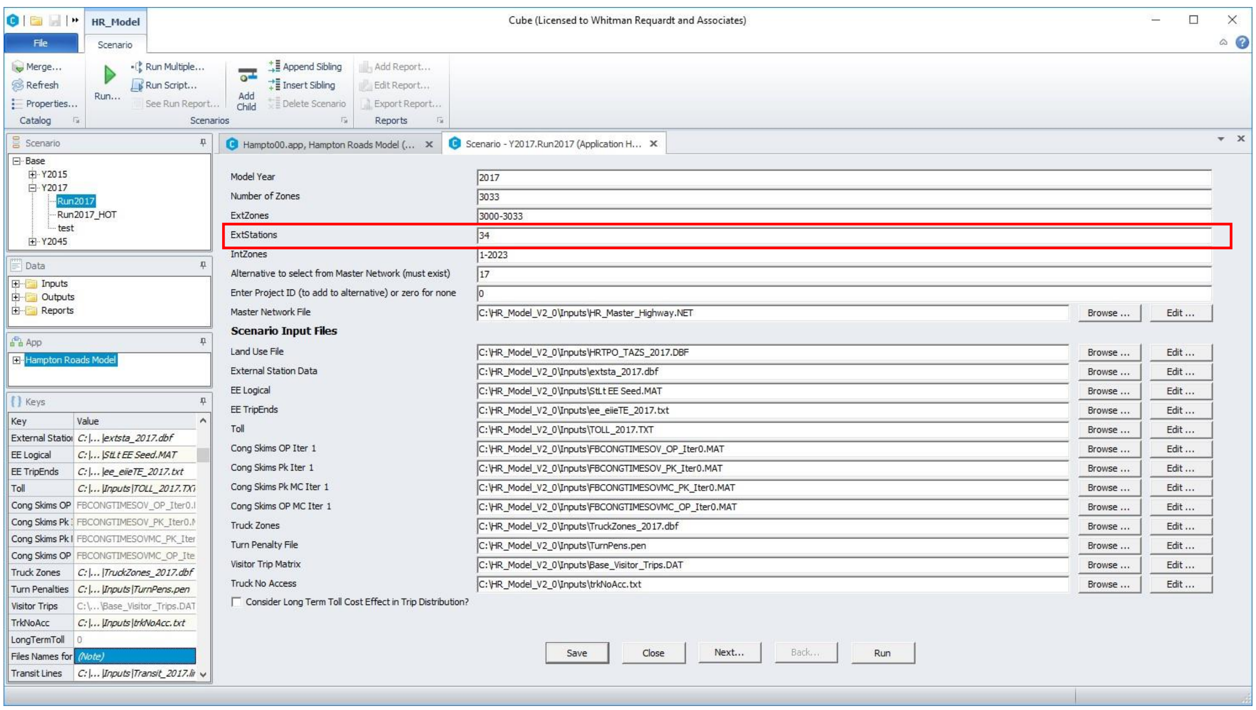


Figure 2-5: EDIT / Run Scenario Tab 1

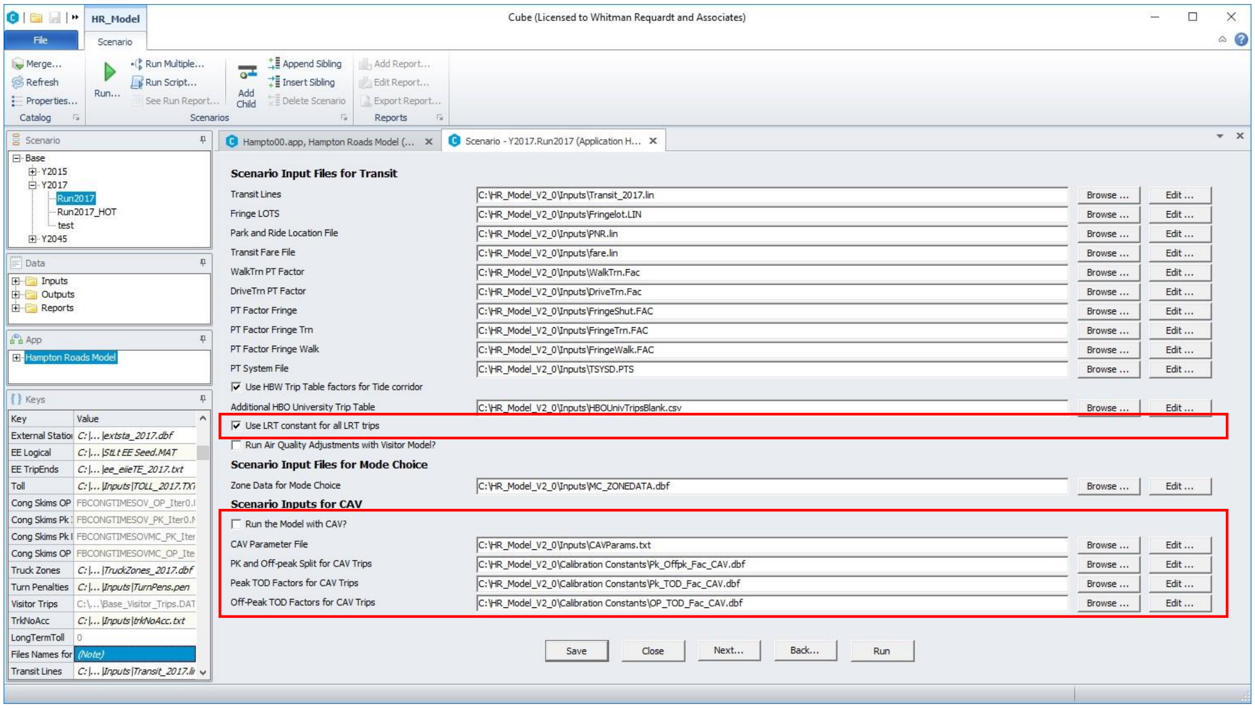


Figure 2-6: EDIT / Run Scenario Tab 2

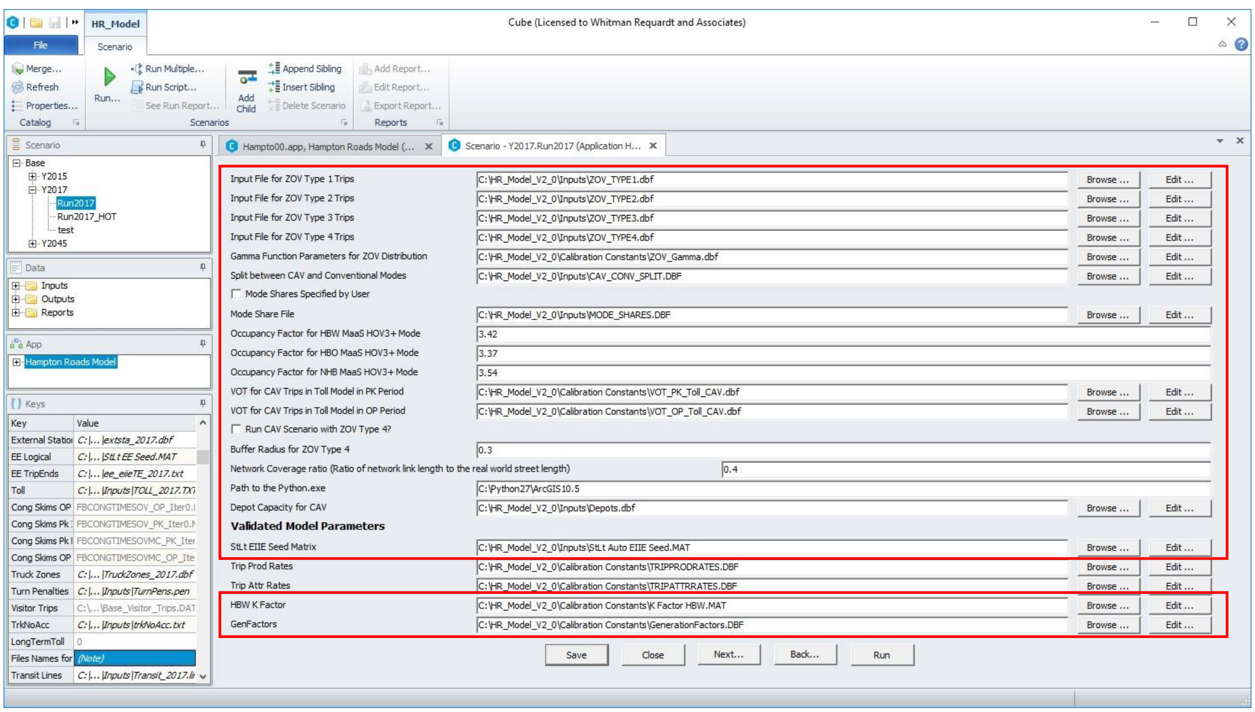


Figure 2-7: EDIT / Run Scenario Tab 3

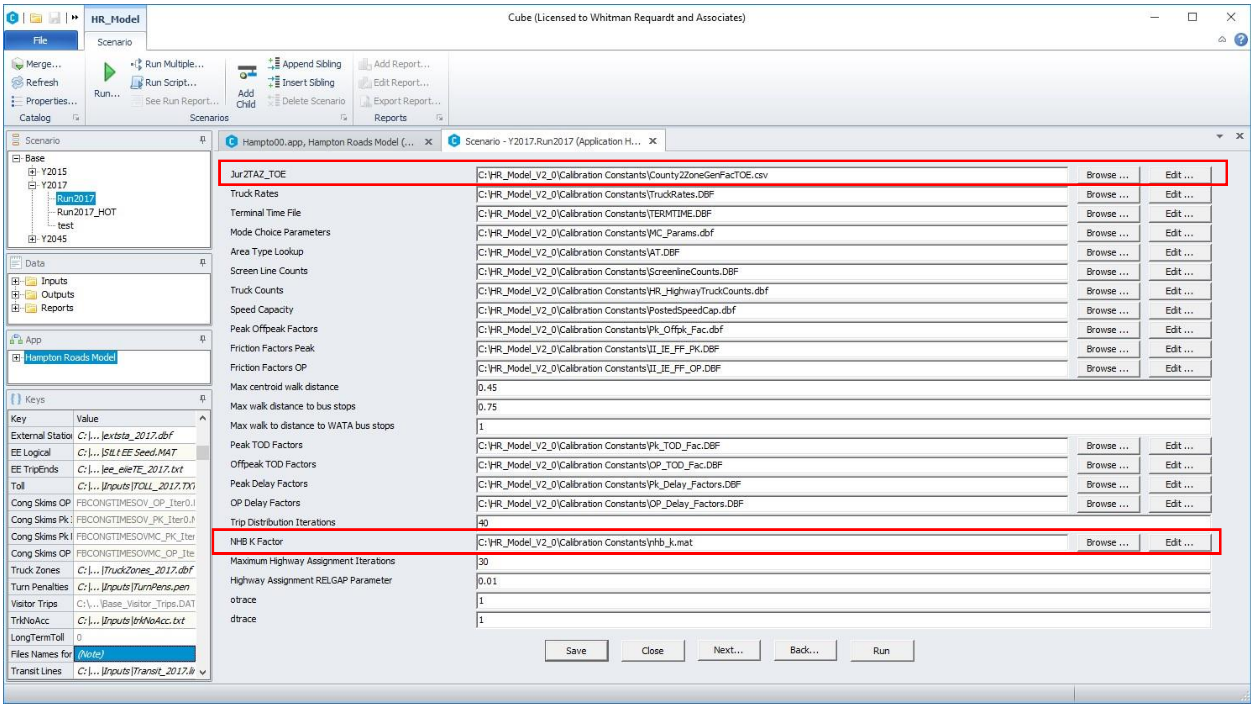


Figure 2-8: EDIT / Run Scenario Tab 4

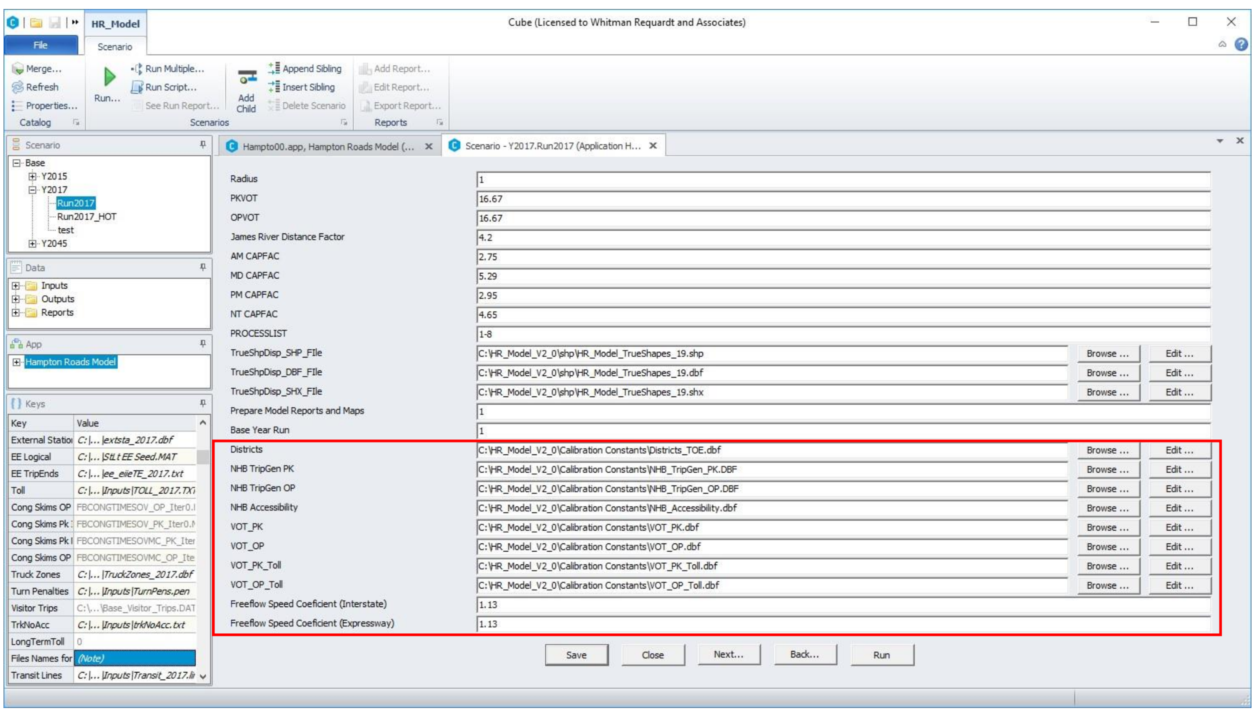


Figure 2-9: EDIT / Run Scenario Tab 5

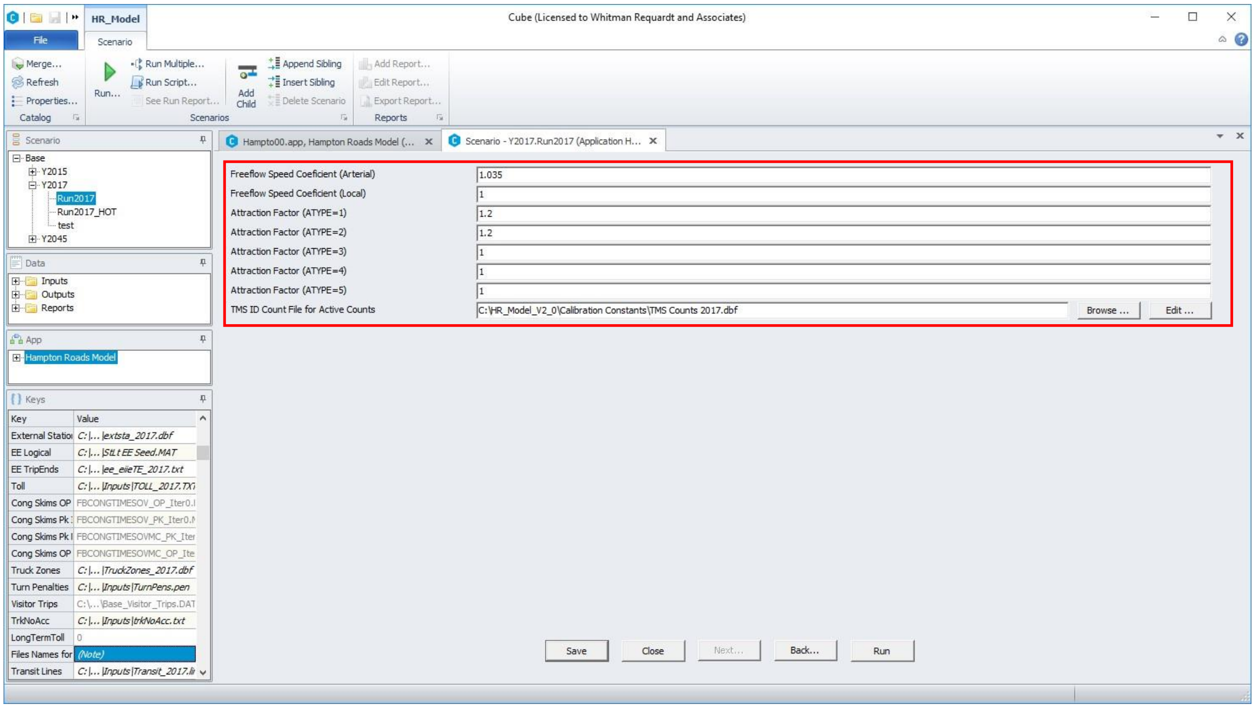


Figure 2-10: EDIT / Run Scenario Tab 6

## 2.2 Scenario Keys

The Scenario Edit/Run Dialog is used to specify input files and parameters for the model (Figure 2-5, Figure 2-6, Figure 2-7, Figure 2-8, Figure 2-9 and Figure 2-10). Table 2-1 lists the elements ("keys") of the Scenario Edit/Run Dialog. When a new scenario is created, the new scenario keys are copied from the parent scenario. The input scenario files are thus copied to the new scenario folder. The user may edit those copied files or create new files and set the key to the new file name. It is recommended that the files be kept in the corresponding Input or Calibration Constants folder, as correct model performance in subsequent scenarios cannot otherwise be ensured.

Table 2-1: Scenario Edit/Run Dialog Parameters

| **Scenario Settings** | |
|---|---|
| Total Zones | Maximum Number of TAZs |
| IntZones,ExtZones | List of Internal and External zones |
| Master Network File | Highway Network File |
| **Scenario Input Files** | |
| Land Use File | Land Use File |
| External Station Data | Auto and Truck Counts |
| EE Seed Matrix Generation Files | Input files to generate EE Seed matrix for scenario year |
| Toll | Input Toll Data |
| Cong Skims Pk Iter 1 | Peak Congested Time for Iter 1 Feedback Loop |
| Cong Skims OP Iter 1 | OP Congested Time for Iter 1 Feedback Loop |
| Cong Skims Pk MC Iter 1 | Peak Congested Time for Iter 1 Feedback Loop for Mode Choice |
| Cong Skims OP MC Iter 1 | OP Congested Time for Iter 1 Feedback Loop for Mode Choice |
| Truck Zones | Truck Zones |
| Turn Penalty File | Turn Penalties |
| Visitor Trip Matrix | Base Year Visitor Trips – Not updated during Base Year Validation |
| Truck No Access | List of Zones with no accessibility for Trucks |
| Long Term Toll in Trip Distribution | Flag (0/1) to include Toll Cost for HBW Trip Distribution impedance |

| | |
|---|---|
| **Scenario Settings** | |
| StreetLight EIIE Seed Matrix | Matrix to Fratar EIIE trips |
| **Transit Related Input Files** | |
| Transit Line File | Transit Files |
| Fringe LOTS | Transit Files |
| Park and Ride Location File | Transit Files |
| Transit Fare File | Transit Files |
| PT Factor File Walk Trn | Transit Files |
| PT Factor File Drive Trn | Transit Files |
| PT Factor File Fringe Transit | Transit Files |
| PT Factor File Fringe Shuttle | Transit Files |
| PT Factor File Fringe Walk | Transit Files |
| PT System File | Transit Files |
| Run Air Quality Adjustments with Visitor Model? | Option for running visitor model |
| **Mode Choice Related Input Files** | |
| Zone Data for Mode Choice | Mode Choice File |
| **Scenario Inputs for CAV** | |
| Run the Model with CAV | Check for "Yes", uncheck for "No" |
| CAV Parameter File | Parameter settings file for CAV running (Path to the file) |
| PK and Off-peak Split for CAV Trips | Split percentages for CAV trips (Path to the file) |
| Peak TOD Factors for CAV Trips | Peak Time of Day factors for CAV (Path to the file) |
| Off-Peak TOD Factors for CAV Trips | Off-Peak Time of Day factors for CAV (Path to the file) |
| ZOV Type 1 | Percentage of private CAV trips contributing to ZOV type 1 (Path to the file) |
| ZOV Type 2 | Percentage of private CAV trips contributing to ZOV type 2 (Path to the file) |
| ZOV Type 3 | Percentage of private CAV trips contributing to ZOV type 3 (Path to the file) |
| ZOV Type 4 | Percentage of private CAV trips contributing to ZOV type 4 (Path to the file) |
| Gamma Function Parameters | Gamma function parameters used to distribute ZOV trips (Path to the file) |
| Split between CAV and Conventional Modes | Split factors between CAV and Conventional modes (Path to the file) |
| Mode Shares Specified by User | Check for "Yes", uncheck for "No" |
| Mode Share File | User specified mode share file (Path to the file) |
| Occupancy Factor for HBW MaaS HOV3+ Mode | The occupancy factor for HBW HOV3+ trips in MAAS |
| Occupancy Factor for HBO MaaS HOV3+ Mode | The occupancy factor for HBO HOV3+ trips in MAAS |
| Occupancy Factor for NHB MaaS HOV3+ Mode | The occupancy factor for NHB HOV3+ trips in MAAS |
| VOT for CAV Trips in Toll Model in PK Period | Peak VOT for CAV scenarios (Path to the file) |
| VOT for CAV Trips in Toll Model in OP Period | Off-peak VOT for CAV scenarios (Path to the file) |
| Run CAV Scenario with ZOV Type 4 | Check for "Yes", uncheck for "No" |
| Buffer Radius for ZOV Type 4 | The radius of the buffer area around zone centroids to identify specific links used for ZOV circulation |
| Network Coverage Ratio | Percentage of all roads in the region covered in the model network |
| Path to the Python.exe | Path to Python.exe to run t python code used in ZOV Type 4 |
| Depot Capacity for CAV | Capacity of CAV depots in each zone (Path to the file) |
| **Validated Model Parameters** | |
| StreetLight EIIE Seed Matrix | EIIE Seed Matrix for Fratar |
| Trip Production Rates | Production Rates |
| Trip Attraction Rates | Attraction Rates |
| HBW K Factor | Kactor Matrix for HBW Trips |
| GenFactors | Generation Factors for district movements |
| Jur2TAZ_TOE | Lookup Table |
| Truck Rates | Trip Generation Truck Rates |

| **Scenario Settings** | |
|---|---|
| Terminal Time File | Terminal Times |
| Mode Choice Parameters | Coefficients/Constants for Mode Choice (Updated for HRT Version Catalog) |
| Area Type Lookup | Area Type Lookup Based on Population/Employment Densities |
| Screen Line Counts | Screen Line Counts for Base Year |
| Truck Counts | Truck Counts file |
| Speed Capacity | Speed-Capacity Lookup Table |
| Peak Offpeak Factors | Peak and Offpeak Factors to split trips after Trip Generation |
| Friction Factors Peak | Friction Factors for Trip Distribution in Peak Period |
| Friction Factors Offpeak | Friction Factors for Trip Distribution in Offpeak Period |
| Peak TOD Factors | Time Of Day Factors to split Peak into AM and PM |
| Offpeak TOD Factors | Time Of Day Factors to split Offpeak into Midday and Night |
| Peak Delay Factors | Delay in minutes/mile to be applied to Transit Times in Peak Period |
| OP Delay Factors | Delay in minutes/mile to be applied to Transit Times in Offpeak Period |
| Trip Distribution Iterations | # Iterations in Distribution Process |
| NHB K Factor | NHB K Factor Matrix |
| Maximum Highway Assignment Iterations | # Iterations in Highway Assignment Process (This is not same as Feedback parameter) |
| Highway Assignment Relative Gap | Relative Gap (RELGAP) parameter for highway assignment convergence. |
| Radius | Radial Distance in miles used in Area Type Calculations |
| PKVOT | Peak Value of Time in cents/minute |
| OPVOT | Off-Peak Value of Time in cents/minute |
| James River Distance Factor | Psychological barrier factor applied in non-work trip distribution. |
| AM CAPFAC | Capacity Factor in AM |
| PM CAPFAC | Capacity Factor in PM |
| MD CAPFAC | Capacity Factor in MD |
| NT CAPFAC | Capacity Factor in NT |
| PROCESSLIST | Parameter specified for Cube Cluster. Default set to 1-7 |
| TrueShpDisp_SHP_File, DBF_File, SHX_File | Highway Network Shape File to display true shape display |
| Prepare Reports and Maps | To prepare model reports or maps |
| Base Year Run | Identify calibration (base year) run |
| Districts | Districts Table of Equals file |
| NHB TripGen PK | NHB Generation Rates for PK |
| NHB TripGen OP | NHB Generation Rates for OP |
| NHB Accessibility | Alpha and Gamma parameters for Accessibility |
| VOT_PK | Value of Time parameters |
| VOT_OP | Value of Time parameters |
| VOT_PK_Toll | Value of Time parameters for toll |
| VOT_OP_Toll | Value of Time parameters for toll |
| Freeflow Speed Coeficient (Interstate) | Coefficient for speed adjustment |
| Freeflow Speed Coeficient (Expressway) | Coefficient for speed adjustment |
| Freeflow Speed Coeficient (Arterial) | Coefficient for speed adjustment |
| Freeflow Speed Coeficient (Local) | Coefficient for speed adjustment |
| Attraction Factor (ATYPE=1) | Adjustment Factor by Area Type |
| Attraction Factor (ATYPE=2) | Adjustment Factor by Area Type |
| Attraction Factor (ATYPE=3) | Adjustment Factor by Area Type |
| Attraction Factor (ATYPE=4) | Adjustment Factor by Area Type |
| Attraction Factor (ATYPE=5) | Adjustment Factor by Area Type |
| TMS ID Count File for Active Counts | Count file (2015 and 2017 provided) for validation purposes |

# 3 RUNNING THE BASE YEAR MODEL

This section explains the steps involved in running the Base Year Scenario from the Catalog, accessing files associated with it, and information on the contents of the input and output files.

When the model is first installed on a computer, it is a good test to run the base year scenario to ensure that the Cube software and the model application files have been successfully installed. As shown in Figure 2-3, the base year scenario is identified as Run2017 in the Scenario Window.
The Base Year Scenario can be run using the following steps:

1. Start Cube and use either the File Center or the File/Open Catalog menu option to select the file **HR_Model.cat** (Catalog File Type) file from the folder where you installed the model. Alternatively, you can open the installation folder and double-click the **HR_Model.cat** file in Windows Explorer. Please see the instructions associated with Figure 2-2 if you are opening the catalog for the first time.
2. The user will see four panes: Scenarios, Applications, Data, and Keys as shown in Figure 2-3. In order to see the Application Flowchart as shown in Figure 2-3, the user should double-click the application name "Hampton Roads Model" in the Applications Window.
3. Select **Run2017** in the Scenario Window by double-clicking on it. The Scenario Edit/Run Dialog will open, and the Cube window should resemble Figure 2-5.
4. To run the Base Year Scenario, simply click the "Run" button at the bottom of the dialog. Alternatively, the user can single-click the Scenario Run2017, click on Application in the File menu, followed by a click on Run Application. The Run Application window appears as shown in Figure 3-1. In order to run the entire model, select the option of "Run Application now from Task Monitor" as shown in Figure 3-1.

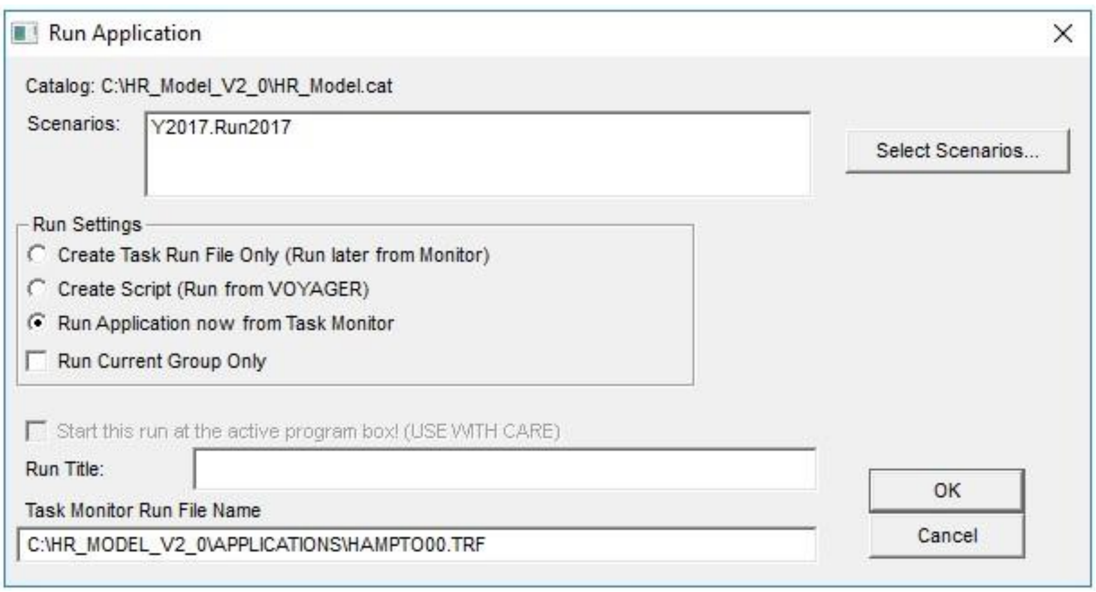

Figure 3-1: Run Application Window

In general, the Catalog Keys for the Run2017 scenario should not be changed. Doing so may invalidate the model for the base year. If the user is interested in testing a scenario by editing a few inputs for the base year scenario, it is recommended that they do it by creating a Child Scenario, explained in the section "Scenario Example".

## 3.1 Model Run Time

The running time for the Hampton Roads Model RUN2017 scenario can be anywhere between 8 hours to 10 hours, depending on the speed of the computer and whether Cube Cluster is utilized. The run times on the model development machine utilizing eight additional Cube Cluster nodes averaged around 8 hours. The specifications of the model development machine are: Intel(R) Core(TM) i7-6820HQ CPU @ 2.70GHz, 8.00 GB RAM. The model is designed to utilize the Cube Cluster by default and the "PROCESSLIST" is set to 1-8. The model runs on both 32-bit and 64-bit versions of Windows. Note that there could be variations in the results during clustering depending on the number of cluster nodes and the number of cores available on the modeling machine.

## 3.2 Accessing Files

The model results can be accessed in several ways – using Cube's Data Window, or from the Application Flowchart, or directly from the disk from the relevant scenario folder. All of these methods are discussed below.

### 3.2.1 Accessing Files through the Data Window

Cube's Data Window contains direct links to "important" input and output files.

**Important:** The files selected in the Data Window correspond to the currently selected scenario(s). In order to open the correct file, the user must first select the desired scenario in the Scenario Window (or through the context menu that appears when right-clicking a file in the Data Window). If the scenario has not previously been run, output files will not exist, and an error message will appear stating that the file does not exist. If a missing file message appears after the scenario was run, it indicates that some error condition (typically a missing or incorrect input file) prevented the model from running to completion. The user may inspect the output files and log files to determine where the error occurred. A missing file message can also occur if the file path indicated in the Keys is not consistent with the file path in the Data Window.

The model's Data Window contains three sections: Inputs, Outputs and Reports. Input files and their formats are discussed in detail in the next section, "Constructing New Scenarios". The files listed in the Data Window are discussed in the following sections. The files can be opened with a double-click on the file entry in the Data Window. The file will open in Cube and may be exported to other formats through the Cube interface for analysis in outside programs. The column "Execution order in catalog" in Table 3-1: Data Window Files shows the corresponding order in the application flowchart.

Table 3-1: Data Window Files

| Sub-Section | Execution Order in Catalog | Name in Data Window | Description |
|---|---|---|---|
| Inputs | | | |
| Highway Network | 2 | | |
| | | Master_Network | Master Network used in the model |
| | | Turn Penalties | Turn Penalties associated with the highway network |

| Sub-Section | Execution Order in Catalog | Name in Data Window | Description |
|---|---|---|---|
| | | Terminal Times | Auto terminal times by area type |
| Trip Generation | 3 | | |
| | | Land Use Data | Population, Employment etc. by zone |
| | | External Station Counts | Counts at the external stations |
| | | Trip Production Rates | Trip rates for productions from National Household Travel Survey (NHTS) |
| | | Trip Attraction Rates | Trip rates for attractions from NHTS |
| | | Truck Zones | List of zones with significant truck trips |
| | | Truck Rates | Trip rates for trucks |
| Trip Distribution | 6 (Pk), 16 (OP) | | |
| | | Peak Friction Factors | Peak curves by purpose |
| | | Offpeak Friction Factors | Offpeak curves by purpose |
| | | Peak HBW 0 car HH Attr Splits | Home Based Work 0 car attraction splits by district for peak |
| | | Peak HBO 0 car HH Attr Splits | Home Based Other 0 car attraction splits by district for peak |
| | | Peak HBS 0 car HH Attr Splits | Home Based Shopping 0 car attraction splits by district for peak |
| | | Offpeak HBW 0 car HH Attr Splits | Home Based Work 0 car attraction splits by district for offpeak |
| | | Offpeak HBO 0 car HH Attr Splits | Home Based Other 0 car attraction splits by district for offpeak |
| | | Offpeak HBS 0 car HH Attr Splits | Home Based Shopping 0 car attraction splits by district for offpeak |
| | | Truck Peak Friction Factors | Peak curves by purpose for truck trips |
| | | Truck Offpeak Friction Factors | Offpeak curves by purpose for truck trips |
| Transit | 8 (Pk), 18 (OP) | | |
| | | Transit Network | Local, Express, Premium Bus PT transit lines |
| | | Transit Fares | Transit fare file |
| | | Park and Ride | File with list of park & ride lots in the model region |
| | | Factor File – Walk Transit | Path parameters for walk to transit |
| | | Factor File – Drive Transit | Path parameters for drive to transit |
| | | Factor File – Fringe Shuttle | Path parameters for Fringe Shuttle |

| Sub-Section | Execution Order in Catalog | Name in Data Window | Description |
|---|---|---|---|
| | | Factor File – Fringe Walk | Path parameters for Fringe Walk |
| | | Factor File – Fringe Transit | Path parameters for Fringe Transit |
| Mode Choice | 9 (Pk), 19 (OP) | | |
| | | Mode Choice Zone Data | Terminal times and parking costs data |
| | | Mode Choice Parameters | Coefficients and constants by purpose |
| Outputs | | | |
| Highway Network | 2 | | |
| | | Area Type by Zones | Zonal Area Type calculated using land use data |
| Trip Generation | 3 | | |
| | | Peak Internal Trip Ends | Internal trip productions and attractions by zone for peak period |
| | | Offpeak Internal Trip Ends | Internal trip productions and attractions by zone for off-peak period |
| | | Peak E-E Matrix | External-External trip matrix for peak period |
| | | Offpeak E-E Matrix | External-External trip matrix for off-peak period |
| | | EE Trucks | External-External auto and truck trip tables |
| | | II and IE Trucks | Truck trip ends |
| Highway Network Skims | 5 (Pk), 15 (OP) | | |
| | | Peak Feedback Congested Skims – SOV | Zone-to-zone shortest level of service data for single occupancy and high occupancy vehicles for peak and off-peak periods |
| | | Peak Feedback Congested Skims – HOV | |
| | | Offpeak Feedback Congested Skims – SOV | |
| | | Offpeak Feedback Congested Skims – HOV | |
| | | Peak Highway skims for Mode Choice | Highway skims without terminal times for peak |
| | | Offpeak Highway skims for Mode Choice | Highway skims without terminal times for offpeak |
| Trip Distribution | 6 (Pk), 16 (OP) | | |
| | | Peak Internal Person Trips | |

| Sub-Section | Execution Order in Catalog | Name in Data Window | Description |
|---|---|---|---|
| | | Offpeak Internal Person Trips | Internal-Internal trips matrices for peak and off-peak periods |
| | | Peak External-Internal Trips | External-Internal trips matrices for peak and off-peak periods |
| | | Offpeak External-Internal Trips | |
| Truck Distribution | 7 (Pk), 17 (OP) | | |
| | | Peak Truck Trips | Internal-Internal and External-Internal truck trips matrices for peak and off-peak periods |
| | | Offpeak Truck Trips | |
| Transit Skims | 8 (Pk), 18 (OP | | |
| | | Peak Walk to Transit Matrix | Peak and offpeak zone-to-zone shortest path level of service data for walk-to-transit, drive-to-transit and fringe transit (only peak) |
| | | Peak Drive to Transit Matrix | |
| | | Peak Fringe to Transit Matrix | |
| | | OP Walk to Transit Matrix | |
| | | OP Drive to Transit Matrix | |
| Mode Choice | 9 (Pk), 19 (OP) | | |
| | | Peak HBW Trips by Mode | Zone-to-zone person trips by mode for peak period |
| | | Peak HBO Trips by Mode | |
| | | Peak NHB Trips by Mode | |
| | | Offpeak HBW Trips by Mode | Zone-to-zone person trips by mode for off-peak period |
| | | Offpeak HBO Trips by Mode | |
| | | Offpeak NHB Trips by Mode | |
| Highway Assignment | 12 (AM), 23 (PM), 21 (Md), 24 (Nt) | | |
| | | Peak AM Loaded Network | Loaded highway networks from highway assignments for AM peak, Midday, PM peak and Overnight periods |
| | | Peak PM Loaded Network | |
| | | Off Peak MD Loaded Network | |
| | | Off Peak NT Loaded Network | |
| | | Peak Feedback Network | |

| Sub-Section | Execution Order in Catalog | Name in Data Window | Description |
|---|---|---|---|
| | | Off-Peak Feedback Network | Highway networks used in the next feedback iteration for peak and off-peak periods |
| | | All Day Loaded Network | Loaded highway network for 24 hours |
| Transit Assignment | 25 (Pk), 26 (OP) | | |
| | | Peak Walk to Transit Line Volumes | Transit assignment results for peak and off-peak walk/drive to transit. |
| | | Offpeak Walk to Transit Line Volumes | |
| | | Peak Drive to Transit Line Volumes | |
| | | Offpeak Drive to Transit Line Volumes | |
| | | Peak Fringe Walk | Transit assignment results for peak fringe paths |
| | | Peak Fringe Transit | |
| | | Peak Fringe Shuttle | |
| Summaries | 12 (AM), 23 (PM), 21 (MD), 24 (NT) | | |
| | | Peak AM Screen Line summary | Observed vs. Modeled volumes summary for Screenlines for four time periods |
| | | Peak PM Screen Line summary | |
| | | Offpeak MD Screen Line summary | |
| | | Offpeak NT Screen Line summary | |
| Air Quality | | | |
| | | Visitor OD Trips | Visitor trips matrix used for air quality analysis |

**INPUT FILES**

The file names listed in this section refer to the Run2017 validation scenario. Some of the file names are likely to be different for other years or scenarios depending on how they are named. A list of input files in the base year scenario and which are required to define a new scenario are listed in Section 4.2, Table 4-1.

**Trip Generation**

- Landuse Data (HRTPO_TAZS_2017.dbf) – Population, employment and other socio-economic data by Traffic Analysis Zones (TAZs) as provided by HRTPO.
- External Station Counts (extsta_2017.dbf) – Observed counts data at the external stations for the validation year (2017) from VDOT.
- Seed EE trip table (StLt EE Seed.MAT) – External-External trips matrix for base year, also used as a seed to estimate future year trips. Derived using StreetLight data.
- Trip Production Rates (TripProdRates.dbf) – Factors from NHTS by purpose, household size and auto ownership to estimate trip productions at each zone.
- Trip Attraction Rates (TripAttrRates.dbf) – Factors from NHTS by purpose to estimate trip attractions to each zone.
- Truck Zones (TruckZones_2017.dbf) – List of zones where truck facilities exist, or truck trips have significant share as identified by VDOT and HRTPO.
- Truck Rates (TruckRates.dbf) – Trip rates to estimate truck trips at each zone. Truck rates were derived during base year validation (details in Hampton Roads Methodology Report).

**Highway Network**

- Base Network (HR_ProcNet.net) – The base highway network. This has standard link attributes as defined in Policies and Procedures Manual and is extracted from the Master Network.
- Turn Penalties (TurnPens.pen) – Scenario specific turn penalties in Voyager format. These penalties should be compatible with the highway network that will be used for the model run. Penalties were derived by HRTPO and VDOT.
- Terminal Times (TermTime.dbf) – Auto origin-to-parking and parking-to-destination times by area type. These times are used to update the land use file for mode choice after the area type procedure calculates the zonal area type.

**Trip Distribution**

The factors in the following files were developed as part of calibration and validation of the base year model.

- Peak Friction Factors (II_IE_FF_PK.dbf) - Friction factor curves used in the gravity model for peak purposes.
- Offpeak Friction Factors (II_IE_FF_OP.dbf) - Friction factor curves used in the gravity model for offpeak purposes.
- Peak HBW 0 Car HH Attr Splits (hbwpk_attrsplt.dat) – Attraction splits for estimating 0 car home-based work trips for peak.
- Peak HBS 0 Car HH Attr Splits (hbspk_attrsplt.dat) – Attraction splits for estimating 0 car home-based shopping trips for peak.
- Peak HBO 0 Car HH Attr Splits (hbopk_attrsplt.dat) – Attraction splits for estimating 0 car home based other trips for peak.
- Offpeak HBW 0 Car HH Attr Splits (hbwop_attrsplt.dat) – Attraction splits for estimating 0 car home-based work trips for offpeak.
- Offpeak HBS 0 Car HH Attr Splits (hbsop_attrsplt.dat) – Attraction splits for estimating 0 car home-based shopping trips for offpeak.
- Offpeak HBO 0 Car HH Attr Splits (hboop_attrsplt.dat) – Attraction splits for estimating 0 car home based other trips for offpeak.

**Transit**

- Transit Network – (Transit_2017.lin) – Transit line file in Public Transport format with local, express, premium buses. The service plans are from Hampton Roads Transit (HRT), Williamsburg Area Transit Authority (WATA) and HRTPO.
- Fringe LOTS (Fringelot.LIN) – Line for for Fringe lot access.
- Transit Fares (Fare.lin) – Transit fare definition file. Fares are taken from the transit agency websites.
- Park and Ride (PNR.lin) – List of park & ride lots in the model region from the transit agency websites.
- Factor File – Walk Transit (WalkTrn.fac) – Path parameters such as runtime factors, initial wait time, transfer penalties, available modes etc., for peak and offpeak walk to transit paths.
- Factor File – Drive Transit (DriveTrn.fac) – Path parameters such as runtime factors, initial wait time, transfer penalties, available modes etc., for peak and offpeak drive to transit paths.
- System File – Walk and Drive to Transit (TSYSD.pts) – System wide transit parameters such as mode definitions, wait time curves, fares for peak and offpeak walk and drive to transit paths.
- Factor File – Fringe Transit (FringeTrn.fac) – Path parameters such as runtime factors, initial wait time, transfer penalties, available modes etc., for peak fringe transit paths.
- Factor File – Fringe Shuttle (FringeShut.fac) – Path parameters such as runtime factors, initial wait time, transfer penalties, available modes etc., for peak fringe shuttle paths.
- Factor File – Fringe Walk (FringeWalk.fac) – Path parameters such as runtime factors, initial wait time, transfer penalties, available modes etc., for peak fringe walk path.

**Mode Choice**

- Mode Choice Land Use (MC_ZoneData.dbf) – Terminal times and parking costs for auto trips by TAZ. The data is taken from the old (prior) Hampton Roads model.
- Mode Choice Parameters (MC_Params.dbf) – Coefficients and constants used for all purposes for all time periods. The constants are the result of model calibration and should not be changed for any model run based on the base year model.

**CAV Option**

- CAV components described in Connected and Autonomous Vehicle section.

**<u>OUTPUT FILES</u>**

**Trip Generation**

- Peak Internal Trip Ends (PK_II.dbf) – Productions and Attractions by TAZ that are estimated by the trip generation step. This file has data for productions and attractions of internal-internal trips in the peak period, productions of internal-external trips in the peak period and attractions of external-internal trips in the peak period.
- Offpeak Internal Trip Ends (OP_II.dbf) – Productions and Attractions by TAZ that are estimated by the trip generation step. This file has data for productions and attractions of internal-internal trips in the offpeak period, productions of internal-external trips in the offpeak period and attractions of external-internal trips in the offpeak period.
- Peak E-E Matrix (PK_EE_Trips.mat) –Matrix with zone-to-zone estimate of external-external trips for peak period.
- Offpeak E-E Matrix (OP_EE_Trips.mat) –Matrix with zone-to-zone estimate of external-external trips for off-peak period.

- E-E Trucks (EEYear.trp) – Estimated auto and truck external-external trips for average weekday for the model year.
- I-I and E-E Trucks (Truck_PA_ALL.dbf) – Truck trip ends for both internal and external destinations.
- E-E Matrix (ee.trp) – Auto and Truck external to external trips.

**Highway Network Skims**

- Peak Feedback Congested Skims – SOV (FBCONGTIMESOV.mat) – Binary Voyager matrix containing peak congested level of service data for single occupancy vehicles and trucks - Time, Distance and Generalized cost (time including toll value of time).
- Peak Feedback Congested Skims – HOV (PKSkimHOV2.mat) – Binary Voyager matrix containing peak congested level of service data for high occupancy vehicles - Time, Distance and Generalized cost (time including toll value of time).
- Offpeak Feedback Congested Skims – SOV (FBCONGTIMESOV_OP.mat) – Binary Voyager matrix containing off-peak congested level of service data for single occupancy vehicles and trucks - Time, Distance and Generalized cost (time including toll value of time).
- Offpeak Feedback Congested Skims – HOV (OpskimHOV2.mat) – Binary Voyager matrix containing peak congested level of service data for high occupancy vehicles - Time, Distance and Generalized cost (time including toll value of time).
- Peak Highway Skims for Mode Choice - SOV (FBCONGTIMESOVMC.mat) – Highway times without terminal times for use in peak mode choice.
- Offpeak Highway Skims for Mode Choice - SOV (FBCONGTIMESOVMC_OP.mat) – Highway times without terminal times for use in offpeak mode choice.
- Peak Highway Skims for Mode Choice – HOV2 (FBCONGTIMEHOV2MC.mat) – Highway times without terminal times for use in peak mode choice.
- Offpeak Highway Skims for Mode Choice – HOV2 (FBCONGTIMEHOV2MC_OP.mat) – Highway times without terminal times for use in offpeak mode choice.
- Peak Highway Skims for Mode Choice – HOV3 (FBCONGTIMEHOV3MC.mat) – Highway times without terminal times for use in peak mode choice.
- Offpeak Highway Skims for Mode Choice – HOV3 (FBCONGTIMEHOV3MC_OP.mat) – Highway times without terminal times for use in offpeak mode choice.

**Trip Distribution**

- Peak Internal Person Trips (Pk_Person_TripTable.mat) – Trip-table matrix, containing seven tables: home-based work trips by persons in zero-car households, home-based-work trips by persons where a car is available in the household, home-based shop trips by persons in zero-car households, home-based-shop trips by persons where a car is available in the household, home-based other by persons in zero-car households, home-based other trips by persons where a car is available in the household, and non-home based trips. These trips represent travel in the peak period.
- Peak External-Internal Trips (EITdist_pk.mat) – Trip-table matrix, with all External-Internal trips for the peak period from the trip distribution gravity model.
- Offpeak Internal Person Trips (Op_Person_TripTable.mat) – Trip-table matrix, containing five tables: home-based work trips by persons in zero-car households, home-based-work trips by persons where a car is available in the household, home-based shop trips by persons in zero-car households, home-based-shop trips by persons where a car is available in the household, home-

based other by persons in zero-car households, home-based other trips by persons where a car is available in the household, and non-home based trips. These trips represent travel in the off-peak period.
- Offpeak External-Internal Trips (EITdist_op.mat) –Trip-table matrix, with all External-Internal trips for the off-peak period from the trip distribution gravity model.

**Truck Distribution**

- Peak Truck Trips (Truck_Trips_Pk.mat) – Trip-table matrix, with all truck trips for the peak period from the truck trip distribution gravity model.
- Offpeak Truck Trips (Truck_Trips_Op.mat) – Trip-table matrix, with all truck trips for the off-peak period from the truck trip distribution gravity model.

**Transit Skims**

- Peak Walk to Transit Matrix (WTRNPK.MC) – Transit skim matrix for peak period walk to transit.
- Peak Drive to Transit Matrix (DTRNPK.MC) – Transit skim matrix for peak period drive (park & ride) to transit.
- Peak Fringe to Transit Matrix (FringeSkimPK.MC) – Skim matrix for peak period fringe paths.
- Offpeak Walk to Transit Matrix (WTRNOP.MC) – Transit skim matrix for off-peak walk to bus.
- Offpeak Drive to Transit Matrix (DTRNOP.MC) – Transit skim matrix for off-peak drive to bus (park-and-ride).
- Transit skim files contain in-vehicle travel time (IVTT), out-of-vehicle travel time (OVTT), walk time (WALK), fare (in cents), time spent riding various types of vehicles (Bus, Trolley, Express Buses etc), total trip distance, and number of transfers.

**Mode Choice**

The output trip tables from the mode choice include internal-internal person trips by mode for three purposes (HBW, HBO and NHB) for two time periods (peak/off-peak). Each matrix has the following 14 tables – Drive Alone (DA), Shared Ride 2 persons (SR2), Shared Ride 3+ persons (SR3), Walk to Transit (WKTRN), Drive to Transit (DRTRN), Fringe Walk (FPWLK), Fringe Transit (FPTRN), Fringe Shuttle (FPSHT), Walk to Light Rail (WKLRT), Drive to Light Rail (DRLRT), Mobility As A Service Drive Alone (MAASDA) ), Mobility As A Service Shared Ride 2 persons (MAASSR2) , Mobility As A Service Shared Ride 3+ persons (MAASSR3) and Total trips (Total). Note that some tables will be empty in some matrices as not all purposes have the same mode choice nesting structure. For example, the three fringe tables have data only for HBW peak period. For all other purposes and time period those tables are empty. Additionally, these tables are also provided broken out by Income Groups 1 through 4 as separate matrices.

- Peak HBW Trips by Mode (HBWOUT_Pk.dat) – Person trips by mode for peak period for home-based work person trips.
- Peak HBO Trips by Mode (HBOOUT_Pk.dat) – Person trips by mode for peak period for home-based other person trips.
- Peak NHB Trips by Mode (NHBOUT_Pk.dat) – Person trips by mode for peak period for non-home-based person trips.
- Offpeak HBW Trips by Mode (HBWOUT_Op.dat) – Person trips by mode for off-peak period for home-based work person trips.

- Offpeak HBO Trips by Mode (HBOOUT_Pk.dat) – Person trips by mode for off-peak period for home-based other person trips.
- Offpeak NHB Trips by Mode (NHBOUT_Pk.dat) – Person trips by mode for off-peak period for non-home-based person trips.

**Highway Assignment**

- AM Pk Final Trip Table (AM_pk_Final_TripTable_VOT_TMP.dat) – The vehicle trip table assigned to the highway network. This trip table includes all personal vehicle and truck trips, including adjustments for occupancy rates, and truck PCEs by five value of time buckets.
- Peak AM Loaded Network (AM_Pk_FDBKNET.net) – This network contains the model results from the AM highway assignment and is used for creation of the All Day Loaded Net.
- Peak AM Loaded Network (AM_PK_Feedback.net) – This network contains the model results from the AM highway assignment and is feedback to distribution.
- MD Op Final Trip Table (MD_op_Final_TripTable_VOT_TMP.dat) – The vehicle trip table assigned to the highway network.
- Off Peak MD Loaded Network (MD_Op_FDBKNET.net) – This network contains the model results from the Midday highway assignment and is used for creation of the All Day Loaded Net.
- Peak MD Loaded Network (Md_OP_Feedback.net) – This network contains the model results from the MD highway assignment and is feedback to distribution.
- PM Pk Final Trip Table (PM_pk_Final_TripTable_VOT_TMP.dat) – The vehicle trip table assigned to the highway network.
- Peak PM Loaded Network (PM_Pk_FDBKNET.net) – This network contains the model results from the PM highway assignment and is used for creation of the All Day Loaded Net.
- NT Op Final Trip Table (NT_op_Final_TripTable_VOT_TMP.dat) – The vehicle trip table assigned to the highway network.
- Off Peak NT Loaded Network (NT_Op_FDBKNET.net) – This network contains the model results from the Overnight highway assignment and is used for creation of the All Day Loaded Net.

**Transit Assignment**

- Peak Walk to Transit Line Volumes (LINKWPK.dbf) – Ridership volumes for each line for given period and access mode.
- Offpeak Walk to Transit Line Volumes (LINKWOP.dbf) – Ridership volumes for each line for given period and access mode.
- Peak Drive to Transit Line Volumes (LINKDPK.dbf) – Ridership volumes for each line for given period and access mode.
- Offpeak Drive to Transit Line Volumes (LINKDOP.dbf) – Ridership volumes for each line for given period and access mode.
- Peak Fringe Walk Line Volumes (LINKFWLKPK.dbf) – Ridership volumes for each line for given period and access mode.
- Peak Fringe Transit Line Volumes (LINKFTRNPK.dbf) – Ridership volumes for each line for given period and access mode.
- Peak Fringe Shuttle Line Volumes (LINKFSHTPK.dbf) – Ridership volumes for each line for given period and access mode.

**Summaries**

- Peak AM Screen Line Volume Summary (Am_Pk_Screenlines.prn) – Volume/Count ratio for each of the screenlines, for use in model validation.
- Peak PM Screen Line Volume Summary (Pm_Pk_Screenlines.prn) – Volume/Count ratio for each of the screen lines, for use in model validation.
- Peak MD Screen Line Volume Summary (Md_Op_Screenlines.prn) – Volume/Count ratio for each of the screen lines, for use in model validation.
- Peak AM Screen Line Volume Summary (Nt_Op_Screenlines.prn) – Volume/Count ratio for each of the screen lines, for use in model validation.

The above four files are in the REPORTS folder within the scenario output. **At this time, no period data is available for population and proper use of these screenlines. These are left in the model for future when more count data becomes available.**

- **Air Quality Analysis**
- Visitor OD Trips (ODVisitorTrips.MAT) – This trip table contains additional vehicle trips occurring during the typical summer weekday travel period. Assigning these trips is required for air-quality conformity analysis, but they are typically not assigned for general traffic analysis.

- **Note: The visitor trip model is not updated during the Run2017 validation process. The visitor trip matrices from the old (prior) model are kept in the model setup.**

<u>**CALIBRATION CONSTANT FILES**</u>

- The calibration constant files were developed during the calibration of the base year model. These files should not change between scenarios. Changing these files may violate the calibration of the model. The contents of this folder are shown in Table 3-2.

**Table 3-2: Contents of the Calibration Constants Folder**

| **Filename** | **Content** |
|---|---|
| Base_visitor_trips.dat | Seed matrix for summer visitor trips |
| AT.dbf | Area Type - Density look up table |
| County2ZoneGenFacTOE.csv | Zone to Jurisdiction number |
| Districts_TOE | Districts Table of Equals for various aggregations |
| GenerationFactors.DBF | Generation Factors by Jurisdiction by Trip Purpose by Prod/Attr |
| HBO_OP_SHADOW.DBF | Shadow pricing |
| HBO_PK_SHADOW.DBF | Shadow pricing |
| HBW_OP_SHADOW.DBF | Shadow pricing |
| HBW_PK_SHADOW.DBF | Shadow pricing |
| Hbwpk_attrsplt.dat | Peak HBW 0 Car Attraction Splits |
| Hbspk_attrsplt.dat | Peak HBS 0 Car Attraction Splits |
| Hbopk_attrsplt.dat | Peak HBO 0 Car Attraction Splits |
| Hbwop_attrsplt.dat | Offpeak HBW 0 Car Attraction Splits |
| Hbsop_attrsplt.dat | Offpeak HBS 0 Car Attraction Splits |
| Hboop_attrsplt.dat | Offpeak HBO 0 Car Attraction Splits |
| HR_HighwayTruckCounts.dbf | Truck Counts |
| II_IE_FF_Pk.dbf | Peak Friction Factors |

| Filename | Content |
|---|---|
| II_IE_FF_Op.dbf | Offpeak Friction Factors |
| II_IE_FF_Pk_CAV.dbf | Peak Friction Factors used during CAV run |
| II_IE_FF_Op_CAV.dbf | Offpeak Friction Factors used during CAV run |
| Juris2Zone.dat | Equivalency table |
| K Factor HBW.MAT | K Factor Matrix for Home Base Work |
| MC_Params.dbf | Mode Choice parameters by purpose |
| NHB_Accessibility.dbf | Alpha and Gamma values for accessibility routine |
| nhb_k.mat | Non-Home-Based K Factor matrix |
| NHB_TripGen_OP.DBF | OP Non-Home-Based Trip Generation values |
| NHB_TripGen_PK.DBF | PK Non-Home-Based Trip Generation values |
| OP_Delay_Factors.dbf | OP Delay values |
| OP_TOD_Fac.dbf | Offpeak Time-of-day factors from NHTS |
| OP_TOD_Fac_CAV.dbf | Offpeak Time-of-day factors from NHTS used during CAV run |
| PK_Delay_Factors.dbf | PK Delay values |
| Pk_Offpk_Fac.dbf | Peak and Offpeak splits from NHTS |
| Pk_Offpk_Fac_CAV.dbf | Peak and Offpeak splits from NHTS used during CAV run |
| PK_TOD_Fac.dbf | Peak Time-of-day factors from NHTS |
| PK_TOD_Fac_CAV.dbf | Peak Time-of-day factors from NHTS used during CAV run |
| PostedSpeedCap.dbf | Speed Capacity Table |
| ScreenlineCounts.dbf | Base Year counts for screen lines |
| Termtime.dbf | Terminal Time Table |
| TMS Counts 2015.dbf | Counts table for 2015 |
| TMS Counts 2017.dbf | Counts table for 2017 |
| TRIPATTRRATES.DBF | Trip Attraction Rates |
| TRIPPRODRATES.DBF | Trip Production Rates |
| TruckRates.dbf | Generation Truck Rates |
| VOT_OP | Value of Time parameters |
| VOT_OP_Toll.dbf | Value of Time parameters for toll |
| VOT_OP_Toll_CAV.dbf | Value of Time parameters for toll used during CAV run |
| VOT_PK | Value of Time parameters |
| VOT_PK_Toll.dbf | Value of Time parameters for toll |
| VOT_PK_Toll_CAV.dbf | Value of Time parameters for toll used during CAV run |
| ZOV_Gamma.dbf | Zero Occupant Vehicle coefficient values |

### 3.2.2 Accessing Output Files from the Application Flowchart

The files seen in the Application Flowchart, both input as well as output, can be opened by double-clicking the file box. This is the most common way of accessing files from the model catalog. The files will be opened in Cube, unless the format is not supported. Table 3-1 shows the execution order of the modules in the catalog and Section 3.2.1 (OUTPUT FILES) shows the file names.

Certain well-known file formats (DBF, text) can also be opened through Windows by right-clicking on the program input or output box and choosing “Open (Windows)” from the context menu. Opening the file in Windows will use the standard Windows viewer for the file type, typically the same viewer that opens if a file of that type is double-clicked in Windows Explorer.

**Important:** When opening files from the Application Flowchart or the Data Window, the user must make sure that the correct scenario is currently selected in the Scenario Window.

### 3.2.3 Accessing Output Files Directly from the Output Folder

Output files can also be accessed directly from the Output subfolder in the Catalog folder. *In general, it will be easier and less error-prone to open output files from the Application Flowchart or the Data Window.*

If the Output folder does not exist when the model is first installed, it is created automatically when the first scenario is run within Cube. The Output folder contains a sub-folder with the outputs of each scenario that has been run. For the Run2017 scenario, an output folder called "Run2017" will be created inside the Base folder. Since the Run2017 is a child scenario of Y2017 the output directory called "Y2017.Run2017" will be created inside the Base folder. Each scenario sub-folder in the Base contains three additional sub-folders. The first is called "Logs", which contains log files for each program step. The log files can be useful when attempting to report or diagnose errors. The files in the Logs folder have the same base name as the corresponding program step (for example, the HNMAT00.PRN log file corresponds to the HNMAT00.S script file). The second sub-folder is called "OUTPUT" and contains the majority of the files created during the model run. The third sub-folder is called "Reports", which contains summaries of model performance and results in text format.

**Helpful Tip:** If the model does not run correctly (for example, a loaded network is not generated), the Logs folder can indicate where the failure occurred – each Log file is named after the corresponding program file and if these files are displayed in date order, the most recent Log file usually contains an error message. The user can then refer to the Application Flowchart to locate the program script (with the same name as the log file, but with a.S extension) and inspect its input files. Table 6-3 in the Appendix shows a list of common errors.

## 3.3 Interpreting the Loaded Networks and Other Model Results

The Loaded Networks by AM, PM, Midday and Night periods are the most frequently used output network files. The fields in these networks are detailed in Table 6-1 in the APPENDIX (Refer to Table 6-2 for rules on coding the network attributes). Following the table, suggestions for interpreting the model results are presented.

The "Source" column in the table has the following possible entries:

- Scenario – indicates that the attribute is supplied with the Master Network.
- Output – indicates that the attribute is generated by the model.

## 3.4 All Day Loaded Network

The loaded networks from AM, PM, Midday and Night highway assignment are combined to generate All Day Loaded network which is used to compute daily statistics and generate summary reports. The attributes of this network are summarized in the following table

## 3.5 Interpreting Model Results

A reporting application automatically produces reports and maps for Hampton Roads model. Before running the model, users have an option to either create the automatic reports and maps or not by populating a catalog key. The key accepts two numbers either 1 or 0 where:

- Key value =1: Users **wants** to produce the reports and maps
- Key value =0: User **does not want** to produce the reports and maps.

Another key – *Base Year Run* is used to determine whether to produce the validation statistic block of the application or not. Like before this key accepts two values 1 and 0 where:

- Key value =1: Users **wants** produce validation statistics
- Key value =0: User **does not want** produce validation statistics.

**Please note that users cannot run the validation reports for future years so the key value for future scenario should always be equal to zero, else the application will fail.**

**Application Inputs**

Major inputs to the reporting application are either referenced to the files produced earlier in the model run or provided by the users. Each input file is explained in Table 3-3 below.

Table 3-3: Summary and Reporting Application Inputs

| File Name | Description | Source Application |
|---|---|---|
| Referenced from Model Outputs (User input not required) | | |
| AUTO_PA_inc_IE.DBF | Productions and Attractions for all zones | Trip Generation |
| AllDay_LoadedNetwork.NET | Loaded Highway Network | All Day Highway Assignment |
| HBWOUT_PK.DAT | Peak HBW trips Matrix | Time of Day PK |
| HBOOUT_PK.DAT | Peak HBO trips Matrix | Time of Day PK |
| NHBOUT_PK.DAT | Peak NHB trips Matrix | Time of Day PK |
| HBWOUT_OP.DAT | Off Peak HBW trips Matrix | Time of Day OP |
| HBOOUT_OP.DAT | Off Peak HBO trips Matrix | Time of Day OP |
| NHBOUT_OP.DAT | Off Peak NHB trips Matrix | Time of Day OP |
| AM_Pk_Final_TripTable.DAT | AM peak final trip table | AM PK Highway Assignment |
| PM_Pk_Final_TripTable.DAT | PM peak final trip table | PM PK Highway Assignment |
| Md_OP_Final_TripTable.DAT | MB off peak final trip table | Mid-Day OP Highway Assignment |
| Nt_OP_Final_TripTable.DAT | NT off peak final trip table | Night OP Highway Assignment |
| DistMatrix_PK.MAT | Summary of trips by district | Trip Distribution PK |
| DistMatrix_OP.MAT | Summary of trips by district | Trip Distribution OP |
| LINKWPK.DBF | Peak Walk to Transit Trips | Transit Assignment PK |
| LINKDPK.DBF | Peak Drive to Transit Trips | Transit Assignment PK |
| LINKWOP.DBF | Off Peak Walk to Transit Trips | Transit Assignment OP |
| LINKDOP.DBF | Off Peak Drive to Transit Trips | Transit Assignment OP |
| LINKFTRNPK.DBF | Peak Fringe walk trips | Transit Assignment PK |
| LINKFSHTPK.DBF | Peak Fringe shuttle trips | Transit Assignment PK |
| PkHwySkims.MAT | Peak Highway Skims | Highway Skims PK |

| File Name | Description | Source Application |
|---|---|---|
| Referenced from Model Outputs (User input not required) | | |
| OPHwySkims.MAT | Off Peak Highway Skims | Highway Skims OP |
| Dist_Number.dbf | List of districts and corresponding numbers | Reports |
| CONGESTION_PARAMETERS.dbf | Parameters to define congestion parameters | Reports |

Dist_Number.dbf: stores the district numbers and corresponding district names. Users should modify this file if the district numbering for the model area changes.

CONGESTION_PARAMETERS.dbf: stores the congestion parameters used to determine the congested links in the model. The volume to count ratio value is stored separately for freeway and other roads. Users can modify the value if needed.

**Application Outputs**

The application generates multiple output files, which are then referenced to create cube reports and ArcGIS maps. Users can access these scenario specific reports and maps via the data section in Cube catalog. Reports are stored under the "Reports" folder. ArcGIS maps are stored under the "GDB_MAPS" folder. To open the files, first highlight the scenario and then double-click on the report or map to open it. The outputs generated a summarized below:

1. Maps
    - Volume.mxd – Traffic Volume bandwidth map
    - AM Volume.mxd – AM traffic volume bandwidth map
    - PM Volume.mxd – PM traffic volume bandwidth map
    - MD Volume.mxd – MD traffic volume bandwidth map
    - NT Volume.mxd – NT traffic volume bandwidth map
    - AM Screenline VC.mxd – map showing the AM screenline volume to count
    - PM Screenline VC.mxd – map showing the PM screenline volume to count
    - MD Screenline VC.mxd – map showing the MD screenline volume to count
    - NT Screenline VC.mxd – map showing the NT screenline volume to count
    - Congestion.mxd – map showing the congestion level on each road
    - HBW Trip Productions.mxd –Home Based Work trip productions for each TAZ
    - HBO Trip Productions.mxd –Home Based Other trip productions for each TAZ
    - NHB Trip Productions.mxd –Non-Home-Based trip productions for each TAZ
    - HBS Trip Productions.mxd – Home Based Shop trip productions for each TAZ
    - Transit OP.mxd – OP transit volume bandwidth
    - Transit PK.mxd – PK transit volume bandwidth
2. Reports
    - Landuse.rep
        - Table - Land Use summary
        - Table - Trip Production by Jurisdiction
        - Table - Trip Attraction by Jurisdiction
    - Trip P and A.rep

- Pie Chart - Trip Production by purpose
- Table – Trip Production by purpose and jurisdiction
- Pie Chart - Trip Attraction by purpose
- Table – Trip Attraction by purpose and jurisdiction

- Daily Trip Generation Summary.rep – All pie charts
  - Daily Trip Production by Purpose – Model Area, all jurisdictions and external stn
  - Daily Trip Attraction by Purpose – Model Area, all jurisdictions and external stn
- Trip Length Frequency.rep
  - Bar Graph - Trip Length Frequency for Home Based Work (peak and off peak)
  - Bar Graph - Trip Length Frequency for Home Based Other (peak and off peak)
  - Bar Graph - Trip Length Frequency for Non-Home Based (peak and off peak)
  - Table- Trip Length Frequency by purpose (peak and off peak)
- Trip Summary.rep
  - Table – Trip summary (Travel Time and Trip Distance) for Model Region
- VMT.rep
  - Cross classification Table – free VMT by Jurisdiction, Facility Type and Area Type
- VMT Congested.rep
  - Cross classification Table – Congested VMT by Jurisdiction, Facility Type and Congestion level
- VHT.rep
  - Cross classification Table – free VHT by Jurisdiction, Facility Type and Area Type
- VHT Congested.rep
  - Cross classification Table – Congested VHT by Jurisdiction, Facility Type and Congestion level
- Speed.rep
  - Cross classification Table – Average free flow speed by Jurisdiction, Facility Type and Area Type
- Congested Speed.rep
  - Cross classification Table – Congested Speed by Jurisdiction, Facility Type and Area Type
- Trips.rep
  - Table – Person and Vehicle Trips per capita
- RMSE.rep
  - Table – RMSE
  - Table – Volume to Count Ratio by Facility Type
  - Table – Volume to Count Ratio by Area Type
- AQ.rep
  - Pie Chat – VMT distribution by jurisdiction
  - Table – VMT distribution by jurisdiction
  - Bar chart – average congested speed by jurisdiction
  - Table – average congested speed by jurisdiction
  - Bar chart – change in average free flow speed by jurisdiction
  - Table – change in average free flow speed by jurisdiction
- Corridor.rep
  - Table – total volume for all corridors by TOD
  - Table - average contested speed for all corridors by TOD

- District to District trips.rep
    - Cross classification table – HBW district to district trips (peak and off peak)
    - Cross classification table – HBO district to district trips (peak and off peak)
    - Cross classification table – NHB district to district trips (peak and off peak)
    - Cross classification table – HBS district to district trips (peak and off peak)
    - Cross classification table – All purposes district to district trips (peak and off peak)
- District to District Truck Trips.rep
    - Cross classification table – district to district truck trips (peak and off peak)
- HOV.rep
    - Table – total volume for all HOV facilities by TOD
    - Table – average contested speed for all HOV facilities by TOD
    - Table – volume to capacity ratio for all HOV facilities by TOD
- Mode Choice.rep
    - Table – Peak Mode distribution and statistics by purpose
    - Table – Off Peak Mode distribution and statistics by purpose
    - Pie chart - HBW mode split (peak and off peak)
    - Pie chart - HBO mode split (peak and off peak)
    - Pie chart - NHB mode split (peak and off peak)
- Transit.rep
    - Table- Peak period transit route summary
    - Table- Off Peak period transit route summary

# 4 Constructing New Scenarios

Preparing a new scenario is a straightforward procedure in Cube. To specify a new scenario, the user must supply suitable land use files, a master highway network, suitable transit files, and other relevant input files. The input files distributed with the model will typically support some portion of the future network. As of this writing, this model has not yet been applied to air quality analysis.

## 4.1 Creating a Cube Scenario

To create a new scenario, select an existing scenario in the Scenario Window (Y2015, Y2017 and Y2045 are the provided scenarios), right click, and choose “Create Child”. A child scenario also initially shares all its parameters with its parent. When the new scenario is created, Cube will make a new sub-folder below the parent folder under the “Base” hierarchy – this folder will contain the input files for the scenario, and all changes to the input files that are required for the scenario will be stored in these folders. In addition to making an input folder, Cube will copy key files from the parent scenario into the new child scenario input folder. Due to this behavior, each new scenario will start out with the same files and setup as its parent. By changing file names and file contents in the child’s input folder, the scenario can be fully specified. The Base scenario has input files that are saved in “Y2017” and in “Calibration Constants” directories. The child scenario will have all these input files from the Y2017 scenario. The input files in Calibration Constants are the validation files and it is recommended that they be kept the same for the future year scenarios. However, the input files from Y2017 directory may be changed for the future year scenarios (example: transit schedules, turning penalties etc).

The remainder of this section describes how to set up input files for a new scenario using the Scenario Edit/Run dialog in Cube, and how to inspect those files.

## 4.2 Description of Input Files

The input files in the model are already described in Section 3.2.1. The files included in the “Input” folder and necessary to define a new scenario are listed in Table 4-1.

Table 4-1: Contents of the Base Scenario Folder

| Filename | Description |
|---|---|
| Base_Visitor_Trips.DAT | Seed Matrix for Summer Visitor Trips |
| CAV_CONV_SPLIT.DBF | see CAV section |
| CAVParams.txt | CAV parameters file |
| Depots.dbf | File for Capacity definition of zones with Depots |
| DriveTrn.fac | Drive to Transit PT Factor File |
| ee_eiieTE_***YYYY***.txt | Target Values for Auto and Truck Externals EE and EIIE Splits |
| extsta_***YYYY***.dbf | Target Values for Auto and Truck Externals |
| Fare.lin | Transit: Base Year Transit Fare File |
| FringeLot.lin | Fringe Parking Locations |
| FringeShut.fac | Fringe-Shuttle PT Factor File |
| FringeTrn.fac | Fringe-Transit PT Factor File |
| FringeWalk.fac | Fringe-Walk PT Factor File |
| HBOUnivTripsBlank.csv | Template file for HBO trips |
| HR_Master_Highway | Master Network used in the model |

| Filename | Description |
|---|---|
| HR_Master_Highway_2017_HOT_Only | Master Network used in the model for HOT lane scenario |
| HRTPO_TAZS_***YYYY*** | Land Use: Landuse Data |
| MC_ZoneData.dbf | Land Use: Zonal Data for Mode Choice Program |
| MODE_SHARES.DBF | Mode Share splits |
| PNR.lin | Transit: Base Year Park and Ride Locations |
| StLt Auto EIIE Seed.MAT | Auto EIIE Seed Matrix developed from StreetLight data |
| StLt EE Seed.MAT | EE Seed Matrix for Auto and Truck developed from StreetLight data |
| TOLL_***YYYY***.txt | toll file |
| Transit_***YYYY***.lin | Transit Lines |
| trkNoAcc.txt | Truck No Access Zones |
| TruckZones_***YYYY***.dbf | Truck Zones |
| TSYSD.PTS | Transit System File |
| TurnPens.pen | Other Files: Turn Penalty File |
| WalkTrn.fac | Walk to Transit PT Factor File |
| ZOV_TYPE***X***.dbf | Zero Occupant Vehicle Parameter File |
| Following 4 files are base year congested skims used for the $1^{st}$ iteration in base year run. If the user has congested skims for the future year, then they can use them with these file names. If not, continue using these base year skims files. | |
| FBCongTimeSOV_Pk_Iter0.mat | Peak Congested Time for Iter 1 Feedback Loop. |
| FBCongTimeSOV_OP_Iter0.mat | OP Congested Time for Iter 1 Feedback Loop |
| FBCongTimeSOVMC_Pk_Iter0.mat | Peak Congested Time for Iter 1 Feedback Loop for Mode Choice |
| FBCongTimeSOVMC_OP_Iter0.mat | OP Congested Time for Iter 1 Feedback Loop for Mode Choice |

***YYYY*** - Year designation (2015, 2017 or 2045)

***XX*** - Values range 1-4

### 4.2.1 Land Use File and Zone Data File for Mode Choice

Land use file for this model has been developed by the Hampton Roads Transportation Planning Organization (HRTPO). Typically, land use forecasts are prepared for a horizon year with attributes for each zone in the model (for a description of the zone structure, see the Hampton Roads Methodology Report). Intermediate year values are computed by linear interpolation of each zone between base year and horizon year. The land use file is in dBase IV format with the fields shown in Table 4-2. All fields are numeric and of a width sufficient to accommodate the actual data.

**Table 4-2: Primary Land Use File Attributes**

| Name | Description |
|---|---|
| ZONE | Zone Number |
| POP | Total Population in Households |
| HH | Households |
| AUTOS | Automobiles registered in this zone |
| WORKER | Number of Workers |
| TOTEMP | Total employment in this zone |
| RETEMP | Retail employment in this zone |
| NRETEMP | Non-Retail employment in this zone |
| BA_OFF | Office employment in the zone |
| BA_IND | Industrial employment in the zone |

| Name | Description |
|---|---|
| BA_OTH | Other employment in the zone |
| AVGAUTO | Average Autos per Household |
| AREA | Zone area in acres |
| COUNTY | County of each zone |
| GQ | Group Quarters in zone "Y" or "N" |
| GQ_TOT | Total Group Quarters population in the zone |
| MHI | 2015 Median Household Income in the zone |

The field TOTEMP (total employment) is redundant and should always be the sum of RETEMP (Retail Employment) and NRETEMP (Non-Retail Employment). The redundancy is maintained to facilitate zonal data reports. For the purposes of the truck model, non-retail employment is further split into three categories: Industrial, Office and Other employment using North American Industrial Classification System (NAICS) data provided by VDOT.

**Zone Data File for Mode Choice**

In addition to the land use file in dBase IV format, a secondary DBF file with the zonal data is maintained for use in the mode choice program. The secondary file contains the fields shown in Table 4-3. All fields are numeric and of a width sufficient to accommodate the actual data. This file was created to keep the input additional information required by the mode choice program separate from all other land use data. The terminal time values are updated with information from the calibration file "TerminalTimes.dbf" after area type procedure calculates zonal area type using land use data. The terminal time attributes for each zone (TTO and TTD) reflect modal access times for trips originating in and destined to the zone, respectively.

Table 4-3: Attributes in Mode Choice Input File

| Name | Description |
|---|---|
| ZONE | Zone Number |
| ZONE_2009 | 2009 zone numbering |
| TTO | Terminal Time for trips originating in the zone |
| TTD | Terminal Time for trips destined to the zone |
| PCOST | Destination Parking Cost |

### 4.2.2 Master Highway Network

The Master network is a highway network for the base year as well as future planned projects. The base year network was developed by VDOT and planned projects for future years were added by HRTPO and VDOT. The model extracts the alternative specific base highway network and user specified changes required for a scenario from the Master network during the model run. The Master network is available in the input folder and is the same for all scenarios.

The HRTPO, in conjunction with VDOT coded planned projects from the 2040 LRTP for incorporation into the master network. As per VDOT Policy and Procedure Manual, standard attributes (listed in Methodology Report) are maintained in the Master network. In addition to the standard attributes, HRTPO has also defined alternative or project specific attributes (eg: standard attribute LANES and scenario specific LANES34). These additional attributes are useful for running specific alternatives defined through the Master network. The scenario specific highway network is extracted using the "Alternative" and "Project" names defined in the catalog keys. A flag variable (NETxx) is included in the Master network to identify the Alternative. For example, Y2017 scenario is defined by attribute NET17=1. The user should note that the scripts developed for running the model are compatible with the standard attribute names. Hence, the attributes extracted for a specific alternative base network will have standard names for the link attributes during model process. Table 6-2 in Appendix provides detailed listing and coding rules for attributes in master network.

The user has an option to manually enter the values for area type, free flow speed and link capacity on the links through R_AREATYPExx, R_FFLOWSPEEDxx and R_LINK_CAPxx attributes in the master network.

**Important:** Note that the user is responsible for manually coding the area type = 1 for CBD in the master network through "R_AREATYPE" attribute.

The Master network also includes the transit only links and nodes to facilitate the transit line coding and incorporate fixed guideway transit system (e.g. LRT) as explained in the following section. As explained in Table 6-2, the properties for these links are defined using the attributes LINKFLAG and R_FFLOWSPEED and the highway movements are restricted using the attribute HOVTYPE.

### 4.2.3 Transit Files

Transit routes and other transit information as operated and/or provided by Hampton Roads Transit (HRT), Williamsburg Area Transit Authority (WATA) and HRTPO are encoded in transit line files designated by model year, and in supplemental files describing transit fare policy, walk links from centroids to bus stops, and park-and-ride links from centroids to park-and-ride facilities.

The transit routes operated by HRT and WATA are coded in the Cube network. HRT transit includes the local buses and the MAX (express) buses in Hampton, Chesapeake, Newport News, Norfolk, Portsmouth, Suffolk, and Virginia Beach. The transit network also includes ferry, Virginia Beach Wave, and the NET. Transit networks are coded with headways for peak period and off-peak period. The networks are compatible with the Public Transport (PT) program in Cube Voyager. Access, egress and transfer links are built using PT procedures. Park-N-Ride information is also defined on the highway nodes to model drive to transit trips. The base year transit files are shown in Table 4-4. Default versions of these files coded for the base year scenario are located in the Base scenario input folder.

If the highway network is updated for a new scenario with addition or removal of nodes and/or links, the user should remember to make necessary changes in the transit line coding file. If the series of nodes and links in the transit coding is not consistent with the highway network, the model run will give an error during the transit skimming process. The log file will show where the error occurred. If the transit lines demand the use of transit-only links which may not be the part of the highway network, for example fixed-guideway transit stations on LRT, the user can define the nodes and links for such links in Master network. As explained in Table 6-2, the attributes LINKFLAG and HOVTYPE are used to define the properties and restrict any highway movements on these links. The travel time on the transit-only links is computed through manual override speed R_FFLOWSPEED coded in the master network.

**Important:** If the transit-only links are coded for future year (xx) alternative, the alternative specific attributes NETxx, R_FFLOWSPEEDxx, LANESxx noted in the previous section have to be coded for the model to extract these links from Master network and define them for specific alternative.

Each transit line in the Transit line file is coded with a unique identifying name, one-way flag, color, mode, peak headway, and off-peak headway. Since the Hampton Roads highway network is micro-coded for most arterials and freeways, the bus lines are coded separately for the individual directions. PT does not allow the bus line to be coded as a two-way (oneway=F) on a one-way link. The user can refer to Cube's PT documentation for more details on transit line coding.

The Factor file and the System file, both created during the base year calibration/validation process, provide information about in-vehicle time, out-of-vehicle time weights, wait time functions, modes available etc in the transit skimming process. The user can refer to the Factor files and the System file used in the Base year scenarios to define new scenarios. Transit fares are coded as mode specific. A fare system number is defined for each mode. The boarding fares and transfer fares are coded in a separate transit fare file for each fare system. The information about coding these files is available in Cube's PT documentation.

**Table 4-4: Transit Input Files**

| File Name | Description |
|---|---|
| Transit_***YYYY***.lin | Local, Express and Premium Bus Routes |
| Fringelot.lin | Fringe Park and Ride Locations |
| PNR.lin | Park and Ride Locations |
| Fare.lin | Transit Fare File |
| Walktrn.fac | Walk to Transit path parameters |
| Drivetrn.fac | Drive to Transit path parameters |
| Fringe.fac | Fringe Transit and Shuttle path parameters |
| Fringewalk.fac | Fringe walk path parameters |
| Tsysd.pts | System wide walk and drive to transit parameters |

***YYYY*** – Year Designation (2015, 2017 or 2045)

### 4.2.4 Other Input Files and Parameters

The Turn Penalty File has a format documented with the Cube Voyager HIGHWAY program. This file was updated for the base year scenario and may need to be updated for new scenarios. The turn penalties were derived by VDOT and HRTPO for the base year scenario. The turn penalties can be applied by time of day. Table 4-5 shows the turn penalty flags and their application in the base year scenario.

**Table 4-5: Turn Penalty Flags**

| Turn Penalty Flag | Description |
|---|---|
| 1 | Turn prohibitions applied as part of base year validation |
| 2 | Turn prohibition all day |
| 3 | Turn prohibition in AM (6:00 am to 9:00 am) |
| 4 | Turn prohibition in Midday (9:00 am to 3:00 pm) |
| 5 | Turn prohibition in PM (3:00 pm – 6:00 pm) |
| 6 | Turn prohibition in Night (6:00 pm to 6:00 am) |

The Visitor Model is not updated as part of the base year validation effort and placeholder matrices for the module are used from the old (prior) Hampton Roads model. The checkbox labeled “Run Air Quality Conformity Analysis with Visitor Model”, adds a correction factor to the trip assignment that converts the model output to Average Summer Weekday Traffic. The setup and the correction factors are the same as they were in the old (prior) Hampton Roads model. This checkbox is left unchecked for project and scenario analysis as well as for the base year scenario.

## 4.3 Scenario Example

This section presents a step-by-step overview of the process of running a scenario, and of creating a new model scenario.

Certain users will not need to construct a new scenario and may find that their needs are met by running and inspecting the results of scenarios distributed with the model.
To run a scenario that already exists:

1. Open the model catalog.
2. Open the scenario in the catalog’s Scenario Window (Figure 2-3) by double-clicking the scenario, or by right-clicking and choosing “Edit/Run Scenario” from the context menu.
   Press the “Run” button in the Edit/Run Scenario Dialog (Figure 2-3).
3. Inspect model output through the Data Window or Application Flowchart (see Figure 2-3).

To create a new scenario:

1. Within the Scenario Window pane, right click the *Y2017* scenario (Figure 2-3). This scenario will be referred to as the “Parent Scenario”, and the folder that contains its input files is the “Parent Folder”.
2. Select the “Add Child” option. You may add a name for the scenario. Once the name has been entered, a box will appear allowing you to type in a description of the scenario.
3. The Edit/Run Scenario dialog (Figure 2-3) will appear, with the file keys already filled in. The file names will refer to copies of the parent input files that have been placed in the new child scenario input folder, a sub-folder of the parent folder. See the Cube Catalog documentation for more information.
4. You may provide alternate file names for certain inputs to the child scenario or leave them unchanged.
5. Once you have set up the input files appropriately, you may “Save” the scenario, or you may “Run” it. Saving the scenario records your changes into the catalog, and running the scenario will record the changes, and will also start a model run.
6. If the model run does not complete successfully, see the discussion of the Logs folder (“Section 3.2.3 Accessing Output Files Directly from the Output Folder”) for guidance.
7. Inspect model output through the Application Flowchart window or the Data Window (Figure 2-3).

# 5 Connected and Autonomous Vehicle

The Hampton Roads Travel Demand Model was enhanced to include a framework for addressing connected and autonomous vehicles (CAVs). A framework similar to what RSG developed for the Michigan statewide travel demand model and Charlottesville Travel Demand Model can be implemented in trip-based models such as the Hampton Roads model. The framework should initially support exploratory model analysis (EMA) and scenario planning, and later support forecasting as data on CAV use becomes available. Scenario planning is a structured way to think about future using a limited number of scenarios such as best case, worst case, most likely, etc., and EMA considers varied input assumptions across a wide range of future scenarios along key dimensions of uncertainty to explore potential outcomes, find critical input assumptions, and identify robust future policy directions in the face of deep uncertainty.

The are several uncertainties in both transportation demand and supply in modeling CAVs. The main demand uncertainties are market penetration, level of carsharing and ridesharing as a substitute for private vehicle use, zero occupant vehicle (ZOV) trips, parking location and behavior changes, decrease in disutility of travel time, and induced trip-making. On the supply side, several assumptions can be made for CAV capacity and speed, which makes their modeling more challenging. Moreover, this new mobility needs specific infrastructure such as smart signals and dedicated lanes to fully realize some of this potential, and some of this infrastructure is costly. The last but not the least, CAV fleet size and depot locations of transportation network companies that offer mobility as a service are not clear in advance, which adds further complexity to the model.

Although little data currently exists for estimating CAV impacts, it is already generally agreed that CAVs could drastically alter travel patterns in ways that can either alleviate or exacerbate congestion. The Hampton Roads model should allow users to design a wide range of CAV scenarios. Creating these scenarios will involve asserting assumptions about the fundamental parameters of behavioral change. The assumptions will be speculative until higher levels of autonomous vehicle functionality become real and data begins to become available on how travelers respond. Even without CAV data, however, incorporating fundamental parameters into the model framework is not premature for two reasons. First, an understanding of the range of possible futures and importance of different factors or robustness of policies from EMA can be valuable in itself. Second, real data on the travel behavior of at least early adopters of CAV technology will become available during the lifespan of the model.

A framework for modeling CAVs can largely be thought of as an overlay on conventional mode travel models with the ability to adjust existing components and the addition of a few new components specifically related to the new phenomenon of zero occupant vehicle (ZOV) trips. The framework should address both privately owned CAVs (pCAVs) and shared CAVs (sCAVs). The user should be able to specify assumptions about how each dimension of travel may change for various market segments (e.g., induced trip-making and decreased sensitivity to travel time for households with their own pCAV).

## CAV Modeling framework

The general framework to model CAV in HRTPO model is shown in Figure 5-1. Different parts of the model such as auto and truck trips were shown separately to make the process clear. New features to each step of the model are briefly explained in the following sections.

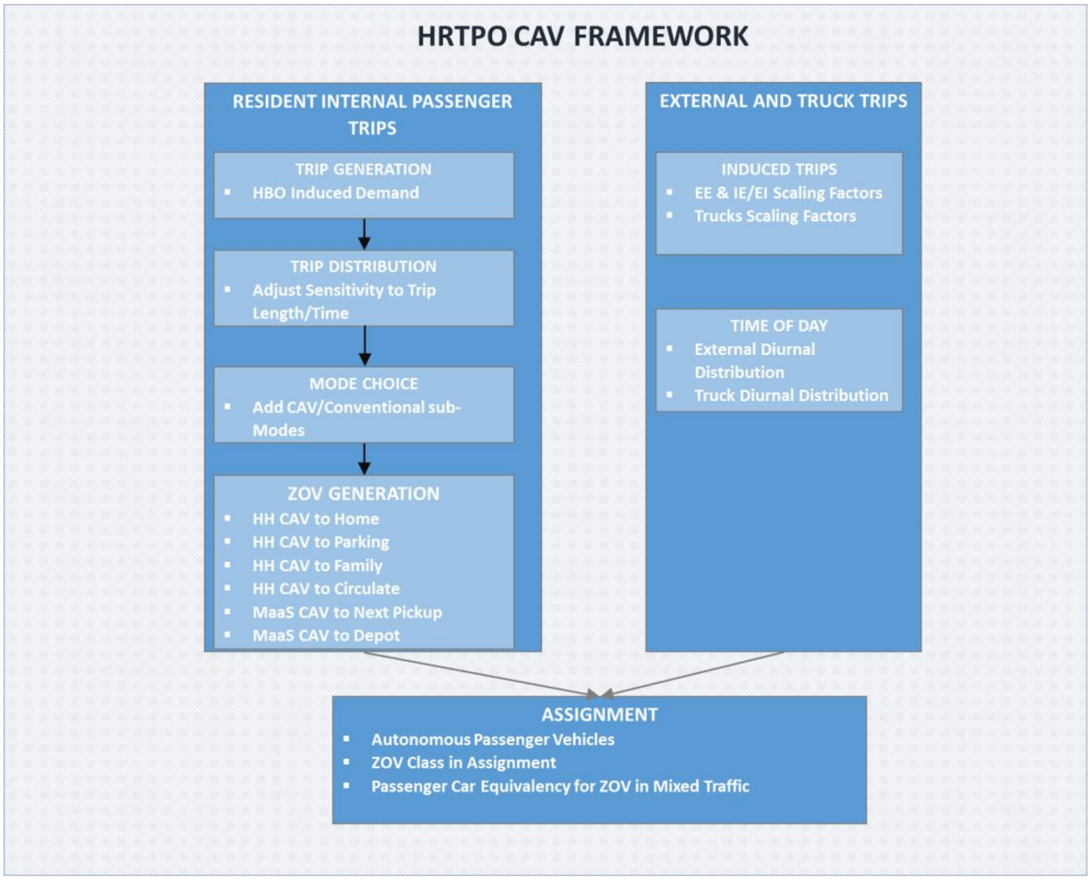


Figure 5-1: HRTPO Model CAV Framework

A CAV framework such as this should allow the MPO to rapidly adjust travel assumptions as soon as substantial data on CAV use becomes available or explore the range of possible futures and the commonalities and differences between them. It should be noted that this framework is an option for the user in the HRTPO model. In fact, this option is not active by default and the model produces the trip tables without CAV as described in previous sections of this report; however, there is a key in the user interface called “Run the Model with CAV?” which turns on this option if it is checked. This key is unchecked by default. There is another parameter file associated with CAV scenarios called “CAVParams.txt” in the “Inputs” folder. This file includes most of the keys and parameters used to run a scenario with CAV mode and the keys can be changed/modified by the user.

## 5.1 Trip Generation

Given expected induced demand because of CAVs, trip generation rates can be scaled-up with special emphasis on households for whom CAVs will reduce barriers to mobility—households with disabled person(s), households with seniors, and households with children—but also on the population in general. Increasing evidence suggests that MaaS with conventional vehicles is already inducing trip-making even among drivers. Moreover, a recent study emulating CAV ownership by providing study participants with a chauffeur for two weeks found travelers increased trip-making by over 80%. While the study sample was small and novelty may have inflated this finding, even so, studies such as these begin to present evidence of potential for significant increases in trip-making at least among households that own their own CAVs.

As explained above, adding CAV to the model increases daily non-work trips in different ways. For instance, it makes travel easier and sometime possible for seniors, children, and disabled people who may not otherwise be able travel alone. It may also allow households with no or few vehicles to make trips they otherwise would not through the use of shared CAV services. Others may be willing to make more trips since they can use their travel time for other activities and need not be sober. Although forecasting these trips is very complicated, scaling up the trip rates to represent these induced demands is a simple, effective and helpful approach assuming if different scaling factors are considered as separate scenarios. The following parameters found in “CAVParams.txt” can be used for the induced demand due to CAV. Although it is expected to have increase in the trips because of CAV, any reduce in trips due to CAV can be also tested with negative values for these parameters.

**Table 5-1: Keys used to Define CAV Shares and Induced Demand due to CAV**

| Key | Description | Existing Value |
|---|---|---|
| **CAVPen** | Share of CAV in household vehicles | 0.5 |
| **HBSH_TFAC** | Change in HBSR and HBSH trips due to CAV | 0.2 |
| **HBO_TFAC** | Change in HBO trips due to CAV | 0.3 |

## 5.2 Trip Distribution

CAVs can also be expected to impact on trip distribution but not as much mode choice or trip generation. The most likely effect is that passengers may be willing to travel farther because in-vehicle travel time can be easily used for working, relaxing, sleeping, and other activities. The traveler’s sensitivity to travel time, therefore, can be factored down as people can perform many of their personal or business activities while they are on their way to their destination. This effect is presumed to be primarily relevant for only CAV trips and the market segments who own their own CAVs since it is assumed that shared CAV services will still be priced by time/distance and this can be assumed to generally maintain traveler’s sensitivity to travel time/distance. Table 5-2 reports the travel time disutility factors that are used in the trip distribution. These keys exist in “CAVParams.txt” file.

**Table 5-2: Keys Used to Define Travel Time Disutility Factor Due to CAV**

| Key | Description | Existing Value |
|---|---|---|
| **PkHBW_TimeFac** | Travel Time Disutility Factor for HBW in Peak Period | 0.8 |
| **OpHBW_TimeFac** | Travel Time Disutility Factor for HBW in Off-Peak Period | 0.8 |
| **PkHBO_TimeFac** | Travel Time Disutility Factor for HBO in Peak Period | 0.8 |
| **OpHBO_TimeFac** | Travel Time Disutility Factor for HBO in Off-Peak Period | 0.8 |

## Mode choice

Because CAV and MaaS are substantially different from and will be a substitute for other transportation modes, traditional mode choice models must be expanded to reflect the increased choice set for travelers. Within CAV modes, the distribution of trips taken in pCAVs and sCAVs is critical to the operational characteristics of CAVs. To include these additional choices in our models, these new modes were added to the model through two adaptations of the existing nesting structure. First, MAAS was added as an upper level mode, in competition with private auto, transit, and fringe to walk. Second, all auto modes (including MaaS) were subdivided into conventional auto and CAV sub-modes. The one exception to this is that drive-access to transit and fringe to walk are not subdivided as they are too small to support more detailed modeling (although this may be important in large metro areas with rail transit). The resulting nesting structure is shown in Figure 5-2.

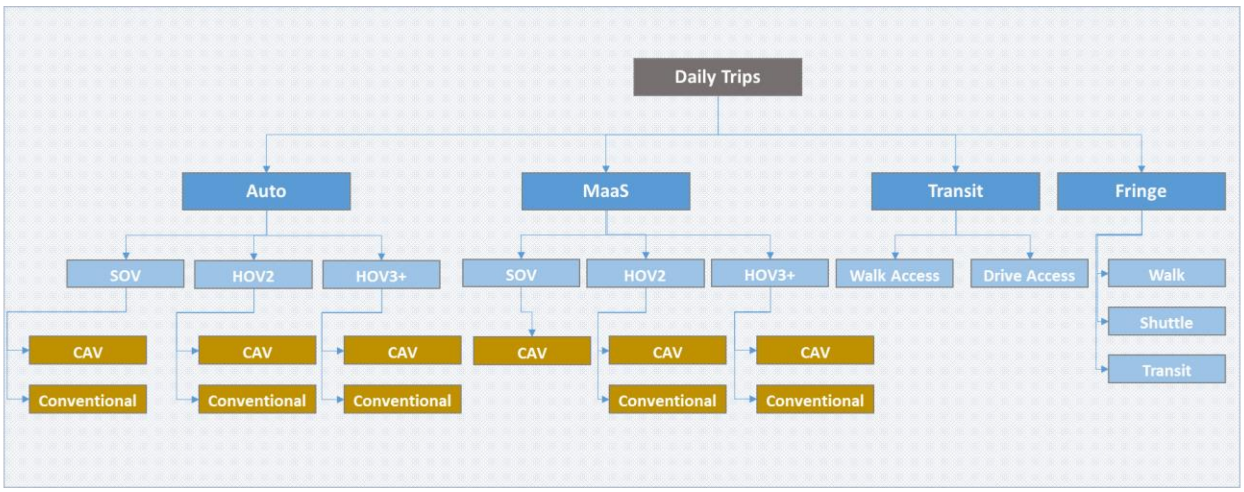


Figure 5-2: HRTPO Model Mode Choice with CAV

The user will assert the shares of these new modes (or all modes) to create different scenarios. These shares can be asserted separately by the trip purpose and time period (peak vs off-peak).

Another key uncertainty is the occupancy of MAAS HOV3+ vehicles (both sCAV and conventional). Rather than represent this with a formal, pseudo-behavioral nested choice, a simple occupancy factor is used to convert HOV3+ person trips to vehicle trips. Given the importance of this factor different scenarios should be created and analyzed to provide a better sense how these factors affect mode shares, VMT and other possible future outcomes.

"Mode_Shares.DBF" and "CAV_CONV_SPLIT.DBF" in "Inputs" folder can be used to determine the shares for any combination of modes and also to split trips between CAV and Conventional for each trip purpose and time period. The split between CAV and conventional modes must be specified by the user for any CAV scenario but the cells in the mode share file can be blank. If the model finds a predetermined share for any mode, it adds a shadow price to the utility function for those modes and updates them accordingly in an iteration process to generate desired mode shares. The final shadow prices by trip purpose and time period are separately stored in the "Calibration Constants" folder. Shadow prices are updated for 10 iterations unless the maximum difference between the model and predetermined mode shares is less than 5 percent. Since, there is no data for MAAS to calibrate the utility function for this mode, the model will have MAAS trips if MAAS share(s) are specified in "Mode_Shares.DBF" file. In fact, if the target mode share file has null value or blank cell for any mode, the model will not have any trip for that mode in the final trip table. As a result, the summation of shares over all modes for each combination of purpose and time period in the "Mode_Shares.DBF" file must be equal to one if this option is selected by the user.

## 5.3 Non-HOME-BASED trips

Since the new methodology to estimate NHB trips conditional on HB trips has been implemented for HRTPO travel demand model, the impacted home-based (HB) trips by CAV will also affect NHB trips. In fact, it is assumed that the relationships between HB and NHB trips will remain the same. HB CAV and conventional trips for any upper level mode (SOV, HOV2, and HOV3+) are added to each other to be used in NHB trip generation. Then, the resulted trips are split between CAV and conventional based on user defined shares which exist in "CAV_CONV_SPLIT.DBF" file. This procedure is repeated over all house income groups to generate NHB trips by household income group with all CAV and conventional modes.

The vehicle occupancy factor was defined to convert HB and NHB HOV3+ person trips to vehicle trips by purpose and mode (MaaS, CAV, and Conventional). The vehicle occupancy factors can be found in "CAVParams.TXT" in "Inputs" folder as shown in Table 5-3. The vehicle occupancy factor for conventional vehicles are read from the model configuration file.

Table 5-3: HOV3+ Vehicle Occupancy Factor by Mode and Purpose for CAV Scenario

| Key | Description | Existing Value |
|---|---|---|
| **HBW_CAV_PK_Occ** | HBW CAV HOV3 Occupancy Factor for PK Period | 3.42 |
| **HBO_CAV_PK_Occ** | HBO CAV HOV3 Occupancy Factor for PK Period | 3.42 |
| **NHB_CAV_PK_Occ** | NHB CAV HOV3 Occupancy Factor for PK Period | 3.42 |
| **HBW_CAV_OP_Occ** | HBW CAV HOV3 Occupancy Factor for OP Period | 3.42 |
| **HBO_CAV_OP_Occ** | HBO CAV HOV3 Occupancy Factor for OP Period | 3.42 |
| **NHB_CAV_OP_Occ** | NHB CAV HOV3 Occupancy Factor for OP Period | 3.42 |
| **HBW_MS_CAV_PK_Occ** | HBW CAV MaaS HOV3 Occupancy Factor for PK Period | 3.42 |
| **HBO_MS_CAV_PK_Occ** | HBO CAV MaaS HOV3 Occupancy Factor for PK Period | 3.42 |
| **NHB_MS_CAV_PK_Occ** | NHB CAV MaaS HOV3 Occupancy Factor for PK Period | 3.42 |
| **HBW_MS_CAV_OP_Occ** | HBW CAV MaaS HOV3 Occupancy Factor for OP Period | 3.42 |
| **HBO_MS_CAV_OP_Occ** | HBO CAV MaaS HOV3 Occupancy Factor for OP Period | 3.42 |
| **NHB_MS_CAV_OP_Occ** | NHB CAV MaaS HOV3 Occupancy Factor for OP Period | 3.42 |

## 5.4 Auto External Trips

Long-distance travelers may choose to use traveling hours for sleeping and, as a result, shift long-distance trips to nighttime hours. This temporal shift in long distance travel may help offset induced trip-making which may be significant for this market segment since CAVs would substantially decrease the cost of long-distance travel, for instance, by obviating the need to pay for a hotel on route to a destination. Parameters "AUTO_EE" and "AUTO_EXT " are representing the induced demand of E-E and I-E/E-I trips because of CAV technology. Parameters "EE_CAV" and "EX_CAV" represent share of CAV in E-E and I-E/E-I trips, respectively. All parameters which are shown in Table 5-4 can be found in "CAVParams.txt" file in "Inputs" folder. Although the same values for the induced demand and CAV share can be used for EI\IE and E-E trips, the model is capable of treating them differently because E-E trips and their diurnal distributions seem to be affected by this technology more than EI/IE trips.

Table 5-4: External Trip Parameters Used in CAV Scenarios

| Key | Description | Existing Value |
|---|---|---|
| **AUTO_EE** | Relative change in E-E auto trips | 0.25 |
| **AUTO_EXT** | Relative change in I-E/E-I auto trips | 0.5 |
| **EE_CAV** | CAV share in E-E auto trips | 0.4 |
| **EX_CAV** | CAV share in I-E/E-I auto trips | 0.3 |

## 5.5 Truck trips

While time-of-day shifts may be the primary impact on truck travel patterns, there is considerable uncertainty in how truck traffic will be impacted more generally. Therefore, in addition to varying the truck diurnal distributions, the user will simply have the ability to scale truck trips up (or down, perhaps to represent the use of aerial drones for delivery) to reflect this uncertainty and explore possible future scenarios. Table 5-5 shows the parameters that truck model needs to run a CAV scenario including internal and external scaling factors for trucks, time of day split factors, and share of truck CAVs.

Table 5-5: Truck Trip Parameters Used in CAV Scenarios

| Key | Description | Existing Value |
|---|---|---|
| **TRK_II** | Relative change in internal truck trips by CAV | 0.5 |
| **TRK_EXT** | Relative change in I-E/E-I truck trips by CAV | 0.5 |
| **TRK_EE** | Relative change in E-E truck trips by CAV | 0.5 |
| **PK_TRK** | Share of peak period in truck trips due to CAV | 0.25 |
| **OP_TRK** | Share of off-peak period in truck trips due to CAV | 0.75 |
| **TRK_CAV** | Share of CAV in truck trips | 0.3 |

## 5.6 Time-of-day

Time-of-Day (TOD) or diurnal distributions of travel for residents may also be impacted by vehicle automation, but significant shifts in long distance passenger and truck traffic should be anticipated. Trucks may shift their trips to overnight to avoid daytime congestion. In this model, it is assumed diurnal distribution for short trips remains the same, but passengers may take advantage of the ability to sleep overnight on longer distance trips. Therefore, the user will be able to specify new diurnal distributions separately for autos and trucks for internal-internal, internal-external trips, external-internal trips, and through trips. There are three files in the model which include TOD factors for CAV scenario as follows:

1- Pk_offpk_FAC_CAV.DBF: This file includes split factors between peak and off-peak for auto external trips (I-E/E-I and E-E). This file is in “Calibration Constants” directory.

2- PK_TOD_FAC_CAV.DBF: This file includes split factors between AM and PM periods out of peak period trips for the following segments: HBW, HBO, NHB, Auto I-E/E-I, Auto E-E, Truck I-E/E-I, and Truck E-E. This file is in “Calibration Constants” directory. These factors are only applied to CAV trip tables.

3- OP_TOD_FAC_CAV.DBF: This file includes split factors between MD and NT periods out of off-peak period trips for the following segments: HBW, HBO, NHB, Auto I-E/E-I, Auto E-E, Truck I-E/E-I, and Truck E-E. This file is in “Calibration Constants” directory. These factors are only applied to CAV trip tables.

It should be mentioned that the TOD factors for conventional trips are defined in the original TOD files (PK_TOD_FAC.DBF and OP_TOD_FAC.DBF). Moreover, the overall split between peak and off-peak truck trips is determined by the factors explained in the Section 2.2.

## 5.7 Zero-Occupant Vehicle Trips

The introduction of CAVs into the vehicle fleet will result in a new type of trip: zero-occupant vehicle trips (ZOVs). CAVs could generate a significant number of ZOV trips as vehicles travel to pick up and drop off passengers or simply avoid parking costs. The resulting increase in VMT could be the largest impact of CAVs and substantially exacerbate congestion if unregulated. Further, ZOV deadheading would occur most frequently during peak periods and in areas where parking is at a premium — precisely when and where urban systems are already stressed. For these reasons, the handling of ZOV trips is a critical facet of any CAV modeling framework.

The characteristics of ZOVs will depend on whether a CAV is privately owned (pZOV) or operated as a MAAS (sZOV), since sCAVs can simply pick up the nearest passenger, whereas pCAVs must travel to pick up very specific people, such as family members who may be far away. ZOV trips also differ based on their purpose, with sCAVs presumably focused on passenger pick-up/drop-off while pCAVs may also be used significantly for parking cost avoidance.

For pCAVs, car-sharing among members of the same household may result in ZOV trips (Type 1) if a pCAV drops one household member off at some destination and subsequently travels to some other location to pick up another member of the same household. To incorporate within-household pCAV car-sharing ZOV trips into our trip-based framework, the zonal origins and destinations of an assumed percentage of household person trips were inverted and fed into a gravity model. The HBW and HBO are the trip purposes considered as a source for this type of ZOV trips. The percentage of household person trips for this type of ZOV trips varies by purpose, time period, and zone and can be changed by the user. “ZOV_TYPE1.DBF” which is in “Inputs” folder is the file containing the percentage of household contributing in this type of ZOV trips in each zone by the purpose and time period (peak and off-peak). The user, therefore, can choose different shares by purpose and time period.

The gravity model applied to distribute ZOV type 1 trips between origins and destinations uses a gamma function as impedance function and the gamma function takes trip length from the skim into account which is shown in the equation below:

$f(d_{ij}) = a d_{ij}^{-b} \text{Exp}(-c \times d_{ij})$

Where:

$f(d_{ij})$: is the friction factor generated by the gamma function,

$d_{ij}$: is the trip length from TAZ *i* to TAZ *j* based on the congested network, and

a, b, and c: are the parameters

The parameters used in the gamma function are stored in “ZOV_Gamma.DBF” in the “Calibration Constants” folder and can be modified by the user.

**Table 5-6: Gamma Function Parameters used for ZOV Type 1 Trip Distribution**

| Parameter | Time Period | Existing Value |
|---|---|---|
| **a** | Peak | 1 |
| **b** | Peak | 0.05 |
| **c** | Peak | 0.5 |
| **a** | Off-Peak | 1 |
| **b** | Off-Peak | 0.05 |
| **c** | Off-Peak | 0.5 |

The output of gravity model is in production-attraction (PA) format and needs to be converted to origin-destination (OD) format. This PA to OD conversion is conducted based on conventional conversion factors.

Additionally, pCAVs may return to their home location after dropping an occupant off to avoid paid parking (Type 2). These ZOV trips were included in our framework by inverting the trip origins and destinations of an assumed percentage of HBW and HBO trips to TAZs with paid parking. The percentage of household person trips contributed to this type of ZOV trips may vary by zone, purpose, and time period and is stored in “ZOV_TYPE2.DBF” in “Inputs” folder. The output of this procedure is in OD format but needs to be divided to time-of-day periods.

Alternately, pCAVs may travel to some other remote (non-home) location to avoid paid parking (Type 3). These trips were incorporated into our framework by creating HBW, HBO, and NHB trips between TAZs with paid parking and nearby TAZ with non-paid parking as a function of long duration activities at zones with paid parking. Similar to ZOV Type 2, the percentage of household person trips contributed to ZOV Type 3 trips may vary by zone, purpose, and time period and is stored in “ZOV_TYPE3.DBF” in “Inputs” folder. The gravity model is also applied to distribute ZOV Type 3 trips between origins and destinations with the parameters shown in Table 5-7.

Table 5-7: Gamma Function Parameters used for ZOV Type 3 Trip Distribution

| Parameter | Time Period | Existing Value |
|---|---|---|
| **a** | Peak | 1 |
| **b** | Peak | 0.05 |
| **c** | Peak | 0.5 |
| **a** | Off-Peak | 1 |
| **b** | Off-Peak | 0.5 |
| **c** | Off-Peak | 0.5 |

The resulted trip table is in OD format but needs to be divided to time-of-day (TOD) periods. The TOD factors by purpose are in “PK_TOD_Fac_CAV.DBF” and “OP_TOD_Fac_CAV.DBF” in “Calibration Constants” directory, that are used for CAV trips TOD split in general. This TOD split for ZOV trips in OD format is only conducted for ZOV Type 2 and 3 trips.

Finally, pCAVs may circulate after dropping off an occupant for a short-duration activity in lieu of parking (Type 4). Circulating trips were modelled by assuming some percentage of only HBO trips resulted in the generation of additional VMT. This VMT was then apportioned to the network within a buffer of the zone dividing by the length of each segment to convert the VMT into vehicle volumes which were preloaded on the network prior to assignment. There are some details for this type of ZOV trips which should be mentioned as follows:

1- Similar to ZOV Type 2 and 3, the percentage of household person trips resulted in generation of ZOV Type 4 trips is a parameter that can be modified by the user and is stored in “ZOV_Type4.DBF” in “Inputs” folder.

2- The percentage of household trips contributed to ZOV Type 4 trips varies by TAZ and time period.

3- With the assumption of 12 minutes circulation with 20 mph speed, each vehicle is traveling about 4 miles in average. This travel distance is considered when VMT is converted to vehicle volume. This average drive distance is a parameter called “ZOV_T4_Dist” in “CAVParams.txt” file and can be updated by the user.

4- All non-freeway and non-connector links within the buffer area with the radius of 0.3 mile around each zone centroid are considered for the circulation. Since the model network does not cover all roads and streets in the reality, another factor which represents the share of network roads to real roads is also taken into account. This factor which is currently equal to 0.4 and the buffer radius exist in the model user interface and can be modified by the user.

5- Since the calculation of ZOV Type 4 trips is in peak and off-peak periods, the resulted trips in each of them should be divided to the corresponding time periods (AM and PM for peak and MD and NT for off-peak). The factors used to split ZOV Type 4 trips to time periods are the same as the ones used for HBO CAV trips and can be found in “PK_TOD_Fac_CAV.DBF” and “OP_TOD_Fac_CAV.DBF” files in “Calibration Constants” folder

6- The final output of this process is stored in separate fields in the loaded network and will be considered as preloads in the assignment. The fields are as follows:

   a. Z4VHBO_AM1

b. Z4VHBO_AM2

c. Z4VHBO_AM3

d. Z4VHBO_AM4

e. Z4VHBO_PM1

f. Z4VHBO_PM2

g. Z4VHBO_PM3

h. Z4VHBO_PM4

i. Z4VHBO_MD1

j. Z4VHBO_MD2

k. Z4VHBO_MD3

l. Z4VHBO_MD4

m. Z4VHBO_NT1

n. Z4VHBO_NT2

o. Z4VHBO_NT3

p. Z4VHBO_NT4

To get ZOV Type 4 volumes, Cube must run a Python code which generates a buffer around each zone centroid and find the non-freeway and non-connector links in the buffer and their length for each zone. The output of the Python code is read by the model for the rest of the procedure as explained above. The user has this option to skip this type of ZOV trips in case his/her machine does not have required Python libraries. There is a key in the user interface which that controls running this specific type of ZOV trips.

Zero-occupant vehicle trips will also occur for sCAVs. After dropping off a passenger, sCAVs will often need to dead-head to a different location to pick up the next passenger (Type 5). Dead-heading was incorporated into our modeling framework by inverting all passenger origins and destinations of MAAS CAV trips and feeding into a gravity model. The sCAV passenger (SOV & HOV) destinations become the corresponding ZOV origins, and the passenger (SOV & HOV) origins are the corresponding ZOV destinations.  Table 5-8 reports the gamma function parameters used to distribute ZOV Type 5 trips. The resulted trip table is in PA format and similar to ZOV Type 1, the PA to OD conversion is conducted by using conventional conversion factors.

**Table 5-8: Gamma Function Parameters used for ZOV Type 5 Trip Distribution**

| Parameter | Time Period | Existing Value |
|---|---|---|
| **a** | Peak | 1 |
| **b** | Peak | 0.05 |
| **c** | Peak | 0.5 |
| **a** | Off-Peak | 1 |
| **b** | Off-Peak | 0.05 |
| **c** | Off-Peak | 0.5 |

Additionally, sCAVs will need to return to centralized depots intermittently, either to re-charge or when demand is low (Type 6). These trips can be modeled in our framework by first asserting that some TAZs contain depots with set capacities, generating trips based on assumptions regarding vehicle charging requirements and/or variation in demand between periods and employing a gravity model between sCAV origins and destinations and TAZs containing sCAV depots. In fact, it is assumed that improvements in battery technology will make variations in passenger demand throughout the day the primary driver of these trips. Hence, the number of these trips from depots will be estimated as a function of the passenger demand in the current period minus the passenger demand in the previous period, and the number of these trips to depots will be estimated as a function of the passenger demand in the current period minus the passenger demand in the subsequent period. A gravity model will be used to connect the depots to sCAV passenger (SOV & HOV) origins/destinations. “Depots.DBF” in “Inputs” folder includes the depot capacity for each TAZ and Table 5-9 reports the gamma function parameters used to distribute ZOV Type 6 trips. Since the trips from/to depots are estimated and distributed separately, the resulted trip table is in OD format. Moreover, the analysis is conducted by time period. The time-of-day split, therefore, is not needed for this type of ZOV trips.

**Table 5-9: Gamma Function Parameters used for ZOV Type 6 Trip Distribution**

| Parameter | Time Period | Existing Value |
|---|---|---|
| **A** | Peak | 1 |
| **b** | Peak | 0.05 |
| **c** | Peak | 0.5 |
| **A** | Off-Peak | 1 |
| **b** | Off-Peak | 0.05 |
| **c** | Off-Peak | 0.5 |

There are also two more parameters used for this type of ZOV trips which can be modified by the user. These parameters which exist in the “CAVParams.txt” file, are reported in Table 5-10.

**Table 5-10: Other Parameters used for ZOV Type 6**

| Parameter | Description | Existing Value |
|---|---|---|
| **PkMSWait** | Vehicle-Wait Time for MAAS Mode in PK Period | 10 |
| **OPMSWait** | Vehicle-Wait Time for MAAS Mode in OP Period | 10 |

As mentioned above, the user will assert the percentages of pCAV on different trip purposes to areas with paid parking in which the passenger will use different strategies. Since each trip purpose contributes to different types of ZOV, the user must notice that the summation of shares over ZOV Types 2, 3, and 4 does not exceed one. Table 5-11 presents the shares in each ZOV type, selected by the user for each trip purpose. The share of trips which pay for the parking, therefore, must be equal or greater than zero with respect to the percentages asserted by the user for all ZOV types. In addition to the exclusivity of the parking strategies, the user should consider that some HB trips will not opt to send the car away because they have additional subsequent stops on the tour for which they desire it.

Table 5-11: Parameters for Private CAV Parking Avoidance

| Trip Purpose | Pay for Parking | Send Car Home to Park (Type 2) | Send Car to Park Somewhere Else (Type 3) | Circulate to Avoid Parking (Type 4) |
|---|---|---|---|---|
| **HBW** | 1-a-b | a% | b% | |
| **HBO** | 1-c-d-e | c% | d% | e% |
| **NHB** | 1-f | | f% | |

## 5.8 Assignment

Vehicles are assigned by period using multi-class equilibrium with generalized costs. The new HRTPO model has several classes in the assignment varying by trip purpose, mode, household income group, and toll/non-toll path. More vehicle classes are in the assignment of a CAV scenario because ZOV trips by purpose and household income are assigned as separate classes. CAV and conventional trips for each combination of trip purpose, mode, and household income are combined to save assignment runtime; otherwise, the model will crash due to too many assignment vehicle classes.

One of the most widely touted benefits of CAVs is their ability to reduce crash rates and provide improved safety to travelers. However, this benefit would likely come at the cost of increased consumption of capacity by CAVs in mixed traffic. CAVs would reduce crash rates by driving more conservatively than humans, leaving more space between vehicles, and thereby reducing throughput. This effect can easily be incorporated in static user equilibrium assignment models through the use of passenger car equivalency (PCE) factors. While the traditional use of PCEs was to reflect trucks' consumption of more roadway space / capacity, the same technique can be applied for CAVs. "ZOV_PCE" which can be found in "CAVParams.txt" file is the factor that can be modified by the user. CAV values of time exist in "VOT_PK_Toll_CAV.DBF" and "VOT_PK_Toll_CAV.DBF" in the "Calibration Constants" folder and can be updated by the user. The same scaling factors as conventional modes are used for CAV trips in the toll choice model.

Several runs were conducted to test the model with CAV scenario and analyze the model responses. The tests were different in terms of private CAV shares in ZOV types or impact of CAV on trip generation. It was expected to see significant increase in the person trips and VMT and the model confirmed it with the increase in person trip between 6 and 21 percent and increase in VMT between 29 and 64 percent.

## 5.9 Summary

Trip-based travel demand models can be enhanced to capture many of the dimensions of uncertainty about CAVs. Adding a MAAS and CAV sub-modes, and including ZOV trip components can provide decision-makers with a more focused picture of what widespread CAV adoption may entail for transportation systems. Again, it should be noted that the framework implemented in the HRTPO model initially supports exploratory model analysis (EMA) and scenario planning, and later supports forecasting as data on CAV use becomes available.

As explained in detail, this framework includes many parameters and the user might need to modify some of them depending on the scenario. These parameters are stored in different files as follows:

1- CAVParams.txt: This file includes most of required network and script keys to run a CAV scenario. The definition for each key can be also found in this file.

2- CAV_CONV_SPLIT.DBF: This file includes the split between CAV and Conventional for all available auto modes by trip purpose, time period, and auto sufficiency group.

3- Mode_SHARES.DBF: This file includes mode shares by purpose and time period in case user wants to run a scenario with specific mode shares. If the file has any value for any mode and purpose, the model changes utilities to generate mode shares as specified; otherwise, mode shares are calculated based on the original approach.

4- ZOV_Gamma.DBF: This file includes the gamma function parameters used to distribute ZOV trips by ZOV type, trip purpose, and time period.

5- ZOV_Type1.DBF: This file includes percentage of private CAV trips sharing the same vehicle for their trips by purpose and time period

6- ZOV_Type2.DBF: This file includes percentage of private CAV trips going back home without any occupancy to avoid parking by purpose and time period

7- ZOV_Type3.DBF: This file includes percentage of private CAV trips going somewhere else without any occupancy to avoid parking by purpose and time period

8- ZOV_Type4.DBF: This file includes percentage of private CAV trips circulating around without any occupancy to avoid parking by purpose and time period

9- ZOV_Type6.DBF: This file includes depot capacities for shared CAV vehicles by TAZ

All of these files have the values currently based on reasonable assumptions, however, the user can change any parameter to create a new scenario. It should be also noted that the parameters can affect the trip table drastically, which might lead to model crash due to the extremely congested condition.

# 6 APPENDIX

Table 6-1: Attributes in Loaded Network

| Field | Source | Description |
|---|---|---|
| A | Scenario | Node from which flow on this link departs |
| B | Scenario | Node to which flow on this link travels |
| COUNTAM | Output | Legacy field |
| COUNTMD | Output | Legacy field |
| COUNTPM | Output | Legacy field |
| COUNTNT | Output | Legacy field |
| ZN | Output | TAZ associated with the link |
| DISTANCE | Scenario | True Shape highway link distance |
| LANES | Scenario | Number of directional through lanes. This is scenario specific |
| FACTYPE | Scenario | Facility Type of the link. This attribute is scenario specific |
| TWLTL | Scenario | Two Way Left Turn Lane indicator |
| ONEWAY | Scenario | Directionality Indicator |
| DIR | Scenario | Directionality Indicator |
| TRK_PHB | Scenario | 0 = Trucks allowed on the link<br>1 = Trucks are prohibited on the link |
| POST_SPD | POST_SPD | Posted Speed limit on the link if available |
| SPDCLASS | Output | Combination of Facility Type and Area Type computed in Highway Net Step |
| LINK_CAP | Scenario | Link Capacity in vehicles/lane/hour if known |
| CAPCLASS | Output | Combination of Facility Type and Area Type computed in Highway Net Step |
| AWDT | Scenario | Average Weekday Daily Traffic for validation year (2015) |
| AWDT_AUTO | Scenario | Average Weekday Daily Auto Traffic for validation year (2015) |
| AWDT_TRK | Scenario | Average Weekday Daily Truck Traffic for validation year (2015) |
| RTE_NAME | Scenario | Local Street Name (911) |
| RTE_NO | Scenario | Official State highway route # (Federal Aid number) |
| RTE_ID | Scenario | HTRIS Route ID |
| YR_OPEN | Scenario | Estimated year highway project open for traffic |
| YR_CLOSE | Scenario | Estimated year highway project closed to traffic |
| JURIS_NO | Scenario | City/County Jurisdiction Number |
| COUNTY | Output | County the link exists in |

| Field | Source | Description |
|---|---|---|
| FEDFUNC | Scenario | Federal Functional Class |
| AREATYPE | Output | Area Type calculated using land use. This attribute is scenario specific |
| FEDAT | Scenario | Federal Area Type |
| VDOT_AT | Scenario | VDOT Area Type |
| MPO_ID | Scenario | "HR" for all links in the Hampton Roads highway network |
| SCRLN_ID | Scenario | Screenline Identifier |
| CORD_ID | Scenario | Cordon Line Identifier |
| CUTLN_ID | Scenario | Cutline Identifier |
| COUNT_FLAG | Scenario | Count location indicator |
| TMS_ID | Scenario | TMS Count Station ID if available |
| CMPID | Scenario | CMP Section ID |
| BEGIN_MP | Scenario | Beginning Milepoint of a link |
| END_MP | Scenario | Ending Milepoint of a link |
| HOVTYPE | Scenario | HOV Type Identifier. This is scenario specific |
| TOLL_GRP | Scenario | 1 = George P. Coleman Bridge (Northbound)<br>2 = Chesapeake Expressway<br>X = index for other scenario specific toll facilities coded in the network. Note that Toll.txt input file needs to be in sync with this field coding. This is scenario specific |
| TOLLGATE | Scenario | Toll gate Group representing delay at toll barrier. This is scenario specific |
| R_AREATYPE | Scenario | Area Type that can be manually coded by the user |
| R_LINK_CAP | Scenario | Link capacity that can be manually coded by the user |
| LINKFLAG | Scenario | Legacy field |
| LENGTH | Scenario | Straight line distance between A and B nodes |
| PROJ_ID | Scenario | Project ID used by VDOT and/or MPO |
| REVERSIBLELANE | Scenario | 1=Reversible |
| R_FFLOWSPEED | Scenario | Free flow speed that can be manually coded by the user |
| VT15 | Scenario | Legacy field |
| VT15DIF | Scenario | Legacy field |
| AREA_TYPE | Output | Link Area Type |
| SPEEDCAPFAC | Output | Factor Adjustment |
| VMTAM | Output | VMT calculated for AM Peak Period |
| VMTMD | Output | VMT calculated for Midday Period |

| Field | Source | Description |
|---|---|---|
| VMTPM | Output | VMT calculated for PM Peak Period |
| VMTNT | Output | VMT calculated for Overnight Period |
| FDBK_V1 | Output | Feedback Volume |
| FDBKTRK | Output | Feedback Truck Volume |
| VMT | Output | Vehicle Miles Traveled |
| AM_FFLOWSPEED | Output | Resulting period assignment speed |
| PM_FFLOWSPEED | Output | Resulting period assignment speed |
| MD_FFLOWSPEED | Output | Resulting period assignment speed |
| NT_FFLOWSPEED | Output | Resulting period assignment speed |
| AM_FFTIME | Output | Input period link time |
| PM_FFTIME | Output | Input period link time |
| MD_FFTIME | Output | Input period link time |
| NT_FFTIME | Output | Input period link time |
| AM_LINK_CAP | Output | Period link capacity |
| PM_LINK_CAP | Output | Period link capacity |
| MD_LINK_CAP | Output | Period link capacity |
| NT_LINK_CAP | Output | Period link capacity |
| AM_V_1 | Output | Period Volume |
| PM_V_1 | Output | Period Volume |
| MD_V_1 | Output | Period Volume |
| NT_V_1 | Output | Period Volume |
| AM_TIME_1 | Output | Resulting assignment link time |
| PM_TIME_1 | Output | Resulting assignment link time |
| MD_TIME_1 | Output | Resulting assignment link time |
| NT_TIME_1 | Output | Resulting assignment link time |
| AM_VC_1 | Output | Period Volume to Capacity |
| PM_VC_1 | Output | Period Volume to Capacity |
| MD_VC_1 | Output | Period Volume to Capacity |
| NT_VC_1 | Output | Period Volume to Capacity |
| AM_CSPD_1 | Output | Resulting period assignment speed |
| PM_CSPD_1 | Output | Resulting period assignment speed |
| MD_CSPD_1 | Output | Resulting period assignment speed |
| NT_CSPD_1 | Output | Resulting period assignment speed |
| AM_VDT_1 | Output | Period distance traveled |
| PM_VDT_1 | Output | Period distance traveled |
| MD_VDT_1 | Output | Period distance traveled |
| NT_VDT_1 | Output | Period distance traveled |
| AM_VHT_1 | Output | Period hours traveled |
| PM_VHT_1 | Output | Period hours traveled |
| MD_VHT_1 | Output | Period hours traveled |

| Field | Source | Description |
|---|---|---|
| NT_VHT_1 | Output | Period hours traveled |
| ALLDAY_V_1 | Output | Total link volume |
| ALLDAY_VDT_1 | Output | Total distance traveled |
| ALLDAY_VHT_1 | Output | Total hours traveled |
| VC24 | Output | Daily volume to capacity |
| HBWAM | Output | Period trips for Home Based Work |
| HBWPM | Output | Period trips for Home Based Work |
| HBWMD | Output | Period trips for Home Based Work |
| HBWNT | Output | Period trips for Home Based Work |
| HBW24 | Output | Daily trips for Home Based Work |
| HBOAM | Output | Period trips for Home Based Other |
| HBOPM | Output | Period trips for Home Based Other |
| HBOMD | Output | Period trips for Home Based Other |
| HBONT | Output | Period trips for Home Based Other |
| HBO24 | Output | Daily trips for Home Based Other |
| NHBAM | Output | Period trips for Non-Home Based |
| NHBPM | Output | Period trips for Non-Home Based |
| NHBMD | Output | Period trips for Non-Home Based |
| NHBNT | Output | Period trips for Non-Home Based |
| NHB24 | Output | Daily trips for Non-Home Based |
| VISITORAM | Output | Period trips for Visitor |
| VISITORPM | Output | Period trips for Visitor |
| VISITORMD | Output | Period trips for Visitor |
| VISITORNT | Output | Period trips for Visitor |
| VISITOR24 | Output | Daily trips for Visitor |
| EIIEAM | Output | Period trips for External-Local/Local-External |
| EIIEPM | Output | Period trips for External-Local/Local-External |
| EIIEMD | Output | Period trips for External-Local/Local-External |
| EIIENT | Output | Period trips for External-Local/Local-External |
| EIIE24 | Output | Daily trips for External-Local/Local-External |
| EEAM | Output | Period trips for External- External |
| EEPM | Output | Period trips for External- External |
| EEMD | Output | Period trips for External- External |
| EENT | Output | Period trips for External- External |
| EE24 | Output | Daily trips for External- External |
| TRUCKAM | Output | Period trips for Trucks |
| TRUCKPM | Output | Period trips for Trucks |
| TRUCKMD | Output | Period trips for Trucks |
| TRUCKNT | Output | Period trips for Trucks |
| TRUCK24 | Output | Daily trips for Trucks |

Table 6-2: Master Highway Network Coding Rules

| No. | Link Variable | Description | Data Type | Coding Rule |
|---|---|---|---|---|
| 1 | ANODE | Beginning node of model network link | Numeric | Node number |
| 2 | BNODE | Ending node of model network link | Numeric | Node number |
| 3 | DISTANCE | Highway Link distance in miles | Numeric | Distance in miles |
| 4 | ID | Link ID | Numeric | N/A |
| 5 | LANES | Number of DIRECTIONAL through lanes in Base Year 2009 | Numeric | Number of lanes |
| 6 | FACTYPE | Facility Type used for Modeling Only in Base Year 2009 | Character | 1 if Interstate/Principal Freeway |
| | | | | 2 if Minor Freeway |
| | | | | 3 if Principal Arterial/Highway |
| | | | | 4 if Major Arterial/Highway |
| | | | | 5 if Minor Arterial/Highway |
| | | | | 6 if Major Collector |
| | | | | 7 if Minor Collector |
| | | | | 8 if Local |
| | | | | 9 if High Speed Ramp |
| | | | | 10 if Low Speed Ramp |
| | | | | 11 if Centroid Connector |
| | | | | 12 if External Station Connector |
| 7 | TWLTL | Two Way Left Turn Lane | Character | 1 if Two Way Left Turn Lane |
| | | | | Leave Blank if Not Applicable |
| 8 | ONEWAY | Directionality Indicator | Numeric | 1 if Oneway |
| | | | | 2 if Twoway |
| 9 | REVERSIBLELANE | | Numeric | 0 - Not Reversible |

| No. | Link Variable | Description | Data Type | Coding Rule |
|---|---|---|---|---|
| | | Reversible Lane Designation | | 1 - AM |
| | | | | 2 - PM |
| 10 | DIR | Directionality Indicator | Numeric | 0 - All Links |
| 11 | TRK_PHB | Truck Prohibition Identifier | Character | A if Truck Prohibition in AM peak |
| | | | | M if Truck Prohibition in Midday |
| | | | | P if Truck Prohibition in PM peak |
| | | | | T if Truck Prohibition in Night |
| | | | | Y if Truck Prohibition All Day |
| | | | | N if No Truck Restriction |
| 12 | POST_SPD | Posted Speed Limit in miles per hour (mph) | Character | Speed in miles/hour |
| | | | | Leave Blank if no data available |
| 13 | SPDCLASS | Speed class code from speed lookup table for the region | Character | 2-character Facility Type followed by 2-character Area Type. Example: Facility Type 7 and Area Type 2 will have SPDCLASS as 0702. The model calculates this on the fly. User may or may not code this value. |
| 14 | LINK_CAP | Link Capacity in vehicles/lane/hour if known for Base Year 2009 | Numeric | Model calculates this as a numeric value on the fly using Speed Capacity Table. |

| No. | Link Variable | Description | Data Type | Coding Rule |
|---|---|---|---|---|
| 15 | CAPCLASS | Capacity class code from capacity lookup table for the region | Character | 2-character Facility Type followed by 2-character Area Type. Example: Facility Type 7 and Area Type 2 will have SPDCLASS as 0702. The model calculates this on the fly. User may or may not code this value. |
| 16 | AWDT | Observed 24 hour average weekday count for Base Year | Numeric | Observed Avg Weekday Counts |
| 17 | AWDT_AUTO | Observed 24 hour average weekday count for Base Year | Numeric | Observed Avg Weekday Counts |
| 18 | AWDT_TRK | Observed 24 hour average weekday count for Base Year | Numeric | Observed Avg Weekday Counts |
| 19 | RTE_NAME | Local street name (911) | Character | Name of the route. Leave Blank if data not available. |
| 20 | RTE_NO | Official State highway route # (Federal Aid Number) | Character | Route number. Leave Blank if data not available. |
| 21 | RTE_ID | HTRIS Route ID | Character | State Database Connection |
| 22 | PROJ_ID | Project ID used by VDOT and/or MPO | Character | Leave Blank if Not Applicable. |
| 23 | PROJ_NAME | Name for Projects added to network | Character | Leave Blank if Not Applicable. |
| 24 | YR_OPEN | Estimated year highway project open for traffic | Character | Leave Blank if Not Applicable. |
| 25 | YR_CLOSE | Estimated year highway project closed to traffic | Character | Leave Blank if Not Applicable. |
| 26 | JURIS_NO | VDOT's city/county jurisdiction code | Numeric | Jurisdiction Number |
| 27 | COUNTY | County Number | Numeric | 1 - Chesapeake |
| | | | | 2 - Norfolk |
| | | | | 3 - Portsmouth |

| No. | Link Variable | Description | Data Type | Coding Rule |
|---|---|---|---|---|
| | | | | 4 - Suffolk<br>5 - Virginia Beach<br>6 - Isle of Wight<br>7 - Newport News<br>8 - Hampton<br>9 - Poquoson<br>10 - Williamsburg<br>11 - James City<br>12 - York<br>13 - Gloucester<br>14 - Franklin<br>15 - Southampton |
| 28 | FEDFUNC | Federal functional class | Character | 1 if Interstate<br>2 if Other Principal Arterial<br>6 if Minor Arterial<br>7 if Major Collector<br>8 if Minor Collector<br>9 if Rural Local<br>11 if Urban Interstate<br>12 if Urban Freeways/Expressways<br>14 if Urban Other Principal Arterials<br>16 if Urban Minor Arterial<br>17 if Urban Collector<br>19 if Urban Local |
| 29 | AREATYPE | Land use ID: Five types | Character | 1 if CBD. User should define this through R_AREATYPE<br>2 if Urban<br>3 if Dense Suburban<br>4 if Suburban |

| No. | Link Variable | Description | Data Type | Coding Rule |
|---|---|---|---|---|
| | | | | 5 if Rural |
| 30 | FEDAT | Federal Area Type: Urban or Rural | Numeric | 1 if Urban |
| | | | | 2 if Rural |
| 31 | VDOT_AT | VDOT Area Type | Numeric | from VDOT |
| 32 | MPO_ID | Identifier for which MPO region link belongs to. | Character | 2-character code for MPO ID |
| 33 | SCRLN_ID | Screenline Identifier | Character | 3-character Screenline ID. Leave Blank if Not Applicable |
| 34 | CORD_ID | Cordon Line Identifier | Character | 3-character Cordonline ID. Leave Blank if Not Applicable |
| 35 | CUTLN_ID | Cutline Identifier | Character | 3-character Cutline ID. Leave Blank if Not Applicable |
| 36 | TMS_ID | TMS Count Station ID | Character | 6-character TMS Count Station ID. Leave Blank if Not Applicable |
| 37 | CMPID | CMP Section ID | Character | Populated by HRTPO |
| 38 | REGCOR | | Character | Leave Blank if Not Applicable |
| 39 | JRSTAG | | Numeric | Leave Blank if Not Applicable |
| 40 | BEGIN_MP | Beginning Milepoint of a link | Numeric | State Database Connection |
| 41 | END_MP | Ending Milepoint of a link | Numeric | State Database Connection |
| 42 | HOVTYPE | HOV Type Identifier | Character | 4-character where each character represents the period. First character represents AM, Second represents MD, Third represents PM and Fourth represents Nt. |

| No. | Link Variable | Description | Data Type | Coding Rule |
|---|---|---|---|---|
| | | | | 1 if All Vehicles Allowed |
| | | | | 2 if HOV2+ |
| | | | | 3 if HOV3+ |
| | | | | 9 if Closed to All |
| | | | | Example: 9121 represents a lane closed to traffic in AM, open to all vehicles in Midday, HOV2 in PM and open to all vehicles at Night |
| | | | | Coded as '9999' for transit-only links to prevent highway movements. |
| 43 | TOLL_GRP | Toll Group | Numeric | 1, 2, 3, etc depending on the toll value and type. |
| | | | | In Base Year, 1 is used for Coleman Bridge, 2 is used for Chesapeake Expressway. If there are more tolls to be coded, the user can code unique toll group values and define the tolls in the Toll.txt input file. Also, toll values can be changed in the Toll.txt file for the existing toll facilities. |
| 44 | TOLLGATE | Toll Gate Group representing delay at toll barrier | Numeric | Value will be updated in toll.txt file |
| 45 | ZN | Zone Number | Numeric | Link to Associated TAZ Zone |

| No. | Link Variable | Description | Data Type | Coding Rule |
|---|---|---|---|---|
| 46 | R_AREATYPE | Land use ID: Five types, as defined by the user for Base_2009 (override of the value computed during model run) | Character | CBD AreaType=1 must be defined by the user through this attribute. The areatype of Freeways (FACTYPE 1 and 2) should also be defined by the user. If R_AREATYPE is left blank or un-coded, the model calculates the areatype on the fly. Note that CBD areatype is not calculated on the fly and must be defined by the user using R_AREATYPE. |
| 47 | R_FFLOWSPEED | Free Flow Speed as coded by user for Base_2009 | Numeric | Free Flow Speed in miles/hr. If left Blank, the model calculates free flow speed on the fly using Speed Capacity Table.<br><br>Note: For transit only links R_FFLOWSPEED is used to compute transit travel time |
| 48 | R_LINK_CAP | Link Capacity in vehicles/lane/hour as coded by user for Base_2009 | Numeric | Link Capacity in vehicle/hour/lane. If left Blank, the model calculates link capacity on the fly using Speed Capacity Table. |
| 49 | LINKFLAG | Flag to define transit-only links | Numeric | 0 if highway link |

| No. | Link Variable | Description | Data Type | Coding Rule |
|---|---|---|---|---|
| | | | | 1 if Transit Access links (for e.g. walk access links to LRT) |
| | | | | 2-3 not used currently |
| | | | | 4 if Transit only links for transit lines |
| | | | | 5 if Ferry |
| | | | | 6 if LRT transit links |
| **Alternative/Future Scenario /Project Specific Attributes:** | | | | |
| | NETxx | Boolean flag to represent the alternative/future scenario 'xx' | Numeric | 0 if link is not included for alternative 'xx' |
| | | | | 1 if link is included for alternative 'xx' |
| | | | | For all Base Year linksNET09=1, NET18=1, NET28=1 etc. For a new link added for 2018, NET09=0, NET18=1, NET28=1 etc. |
| | LANESxx | Number of directional through lanes for (future) alternative 'xx' | Numeric | Number of Lanes |
| | LANESPRJ | Number of directional through lanes for specific project PROJ_ID | Numeric | Number of Lanes |
| | FACTYPExx | Facility Type used for modeling for (future) alternative 'xx' | Character | See FACTYPE above |
| | FACTYPEPRJ | Facility Type used for modeling for (future/test) specific project PROJ_ID | Character | See FACTYPE above |
| | HOVTYPExx | HOV Type Identifier for (future) alternative 'xx' | Character | See HOVTYPE above |
| | HOVTYPEPRJ | HOV Type Identifier for (future/test) specific project PROJ_ID | Character | See HOVTYPE above |

| No. | Link Variable | Description | Data Type | Coding Rule |
|---|---|---|---|---|
| | TOLL_GRPxx, TOLLGATExx | Toll Group and Toll Gate group for (future) alternative ‘xx’ | Numeric | See TOLL_GRP, TOLLGATE above |
| | TOLL_GRPPRJ, TOLLGATEPRJ | Toll Group and Toll Gate group for (future/test) specific project PROJ_ID | Numeric | See TOLL_GRP, TOLLGATE above |
| | R_AREATYPExx | Land use ID, as defined by user for (future) alternative ‘xx’ | Character | See R_AREATYPE above |
| | R_AREATYPEPRJ | Land use ID, as defined by user for (future/test) specific project PROJ_ID | Character | See R_AREATYPE above |
| | R_FFLOWSPEEDxx | Free Flow Speed as coded by user for (future) alternative ‘xx’ | Numeric | See R_FFLOWSPEED above |
| | R_FFLOWSPEEDPRJ | Free Flow Speed as coded by user for (future/test) specific project PROJ_ID | Numeric | See R_FFLOWSPEED above |
| | R_LINK_CAPxx | Link Capacity as coded by user for (future) alternative ‘xx’ | Numeric | See R_LINK_CAP above |
| | R_LINK_CAPPRJ | Link Capacity as coded by user for (future/test) specific project PROJ_ID | Numeric | See R_LINK_CAP above |

Table 6-3: List of Common Errors during Model Run

| Common Errors | Possible Cause/Resolution |
|---|---|
| Application Manager Message: Errors Encountered checking execution order and file existence. Create a Batch Job anyway? | This may happen if one or more input files are missing or have been renamed without being updated in the Scenario Keys. To resolve this, click “No” on the Message Window and check the files listed. Make sure the files listed are present in the relevant directories. |
| Error Message: Required files for this program are not specified. Press OK to see report of errors | Missing links in the catalog or required data in the input file is missing. Check the file linkages from the previous modules to the current module. Fix the linkage if it is broken. Make sure that there is required data in the input files defined. |
| Cluster Related Error: Model stops running or pauses | This may happen due to closing cluster windows or not enough disk space or the hard disk goes into hibernation. The user should not close the popping cluster windows during the model run. If the model pauses at a particular module for an unknown reason, then stop running the model, try running that particular module individually and then check for fatal errors to trace back the cause. |
| Fatal Errors during running scripts | Several reasons for this error including insufficient data, syntax errors, division by zero error. To identify the exact reason, the user should look at the listing file of that module and trace back the error. |
| Cube Task Monitor has encountered a problem and needs to close | This could happen if one or more files generated during the model run have got corrupted. If this error occurs during a full model run, then try deleting the output files and run the model again. If that doesn’t work, copy the model setup to a different folder and re-run. |
| Error for incorrect values in catalog keys | If the “Base Year Run” catalog key flag is left blank, the model will not run. The flag should be defined as 1 for base year scenario and 0 for future year scenarios. |
| Note: The above lists some common types of errors. There are several other reasons due to which errors can occur. The best solution is to find out when the error occurs, identify that module, look at the listing file and try to trace it back. | |