

---

# NWARPC\_Model\_v3.0.5

---

Documentation and Validation of Version 3.0.5 of  
the NW Arkansas Travel Demand Model

---

Submitted by:



---

April 2021

---

# 1 Table of Contents

<b>1</b>	<b>INTRODUCTION .....</b>	<b>2</b>
<b>2</b>	<b>MODEL DESCRIPTION .....</b>	<b>3</b>
2.1	MODEL FLOW CHART .....	3
2.2	SET LINK SPEED AND CAPACITY: 01 – SPEEDCAPACITY.RSC .....	4
2.3	SKIM THE NETWORKS: 02 – HIGHWAYSKIM, 03 – TRANSITSKIM, 04 - HYBRIDSKIM .....	5
2.4	CALCULATE ACCESSIBILITIES: 05 – ACCESSIBILITY.RSC .....	6
2.5	DETERMINE AUTO-OWNERSHIP: 06 – AUTOOWNERSHIP.RSC .....	7
2.6	TRIP GENERATION: 07 – TRIPGENERATION.RSC .....	8
2.7	CALCULATE MODE CHOICE PROBABILITIES: 08 – MODECHOICE.RSC .....	13
2.8	DESTINATION CHOICE: 09 – DESTINATIONCHOICE.RSC .....	17
2.9	MODE CHOICE: 10 – MODECHOICETRIPS.RSC .....	19
2.10	SPLIT TRIPS INTO TIME PERIODS: 11 – TIMEOFDAY.RSC .....	20
2.11	DETERMINE NUMBER OF TRUCK TRIPS: 12 – TRUCKMODEL.RSC .....	21
2.12	ASSIGN HIGHWAY TRIPS: 13 – HIGHWAYASSIGNMENT.RSC .....	24
2.13	ASSIGN TRANSIT TRIPS: 14 – TRANSITASSIGNMENT.RSC .....	25
2.14	AUTOMATED REPORTS: 15 – REPORTS.RSC.....	26
	<i>Highway and Transit Assignment Summary .....</i>	<i>26</i>
	<i>LOS Mapping .....</i>	<i>28</i>
	<i>Mode Share by City .....</i>	<i>30</i>
2.15	DEVELOPMENT OF PARKING COSTS .....	32
<b>3</b>	<b>BASE YEAR MODEL CALIBRATION AND VALIDATION .....</b>	<b>37</b>
3.1	TRIP GENERATION CALIBRATION .....	37
3.2	CALIBRATION OF DESTINATION CHOICE .....	37
3.3	MODE CHOICE.....	40
3.4	HIGHWAY ASSIGNMENT VALIDATION.....	42
3.5	TRANSIT ASSIGNMENT VALIDATION.....	45
	<i>Figure 1 – Model v3.0.1 Flow .....</i>	<i>3</i>
	<i>Figure 2 – Mode Choice Model Structure.....</i>	<i>13</i>
	<i>Figure 3 - General Formula of a Logit Model .....</i>	<i>15</i>
	<i>Figure 4 – Roadways classified for LOS mapping .....</i>	<i>29</i>
	<i>Figure 5: Example of Mode Summary Report (City of Rogers) .....</i>	<i>31</i>

## 1 Introduction

The NW Arkansas Regional Planning Commission Travel Demand Model (NWA TDM) was updated in 2019-2020. It is a state-of-the-practice 4-step model that generates and assigns both highway and transit trips. The most recent release of the model can be found at [https://github.com/wsp-sag/client\\_nwarpc\\_model/releases](https://github.com/wsp-sag/client_nwarpc_model/releases). As of April 2021, version 3.0.5 is the most recent release. The model was built and validated using TransCAD version 8.0, build 22265. Results may vary, if different versions and/or builds of TransCAD are used.

The updates and current features of the NWA TDM are listed below:

- Base year is 2018
- Scenarios available with model delivery are 2018, 2025, 2035 and 2045
- Socioeconomic Forecasts were done by NWARPC based on data from the Arkansas State Demographer, Woods & Poole and Bureau of Labor Statistics data
- Highway and transit networks have been developed by NWARPC
  - 2018 highway reflects current conditions
  - 2018 transit reflects transit networks at the time of the 2018 on-board survey
  - 2045 highway networks include links within the fiscally constrained plan and the unconstrained plan.
  - 2045 transit networks include the **Connect Northwest Arkansas – 10 Year Transit Development Plan** transit improvements and the High-Capacity Transit options
- Several components of the NWA TDM have been updated or replaced and/or new components added:
  - Population Synthesis and the disaggregate Trip Generation model has been replaced by a traditional Cross-classification Trip Generation model
  - Auto-ownership model was added
  - Gravity Model Trip Distribution was replaced with Logit Model Destination Choice
  - Mode Choice model includes “Drive to Razorback” as a drive mode in the model
  - Parking cost sensitivity in the Mode Choice model was verified and tested
  - Highway Speed/Capacity methodology was simplified
  - Transit Speed Calculations were updated
- Several reporting features were added:
  - Highway and Transit assignment summaries
  - LOS mapping
  - Mode Share by City
- Highway assignment is done for 3 time periods – AM Peak (6 am to 9 am), PM Peak (3 pm to 6 pm) and Off-peak (all other hours). Transit assignments are done for Peak and Off-Peak.
- Resident trip purposes include Home-based Work (HBW), Home-based University (HBU), Home-based School (HBSC), Home-based Shopping and Personal Business (HBSB), Home-based Other (HBO), Non-Home-Based Work (NHBW), and Non-Home-Based Other (NHBO).
- All files necessary for a scenario are stored in the “*nwarpc\_model/resource*” directory. Per the User’s Guide, when a scenario is created, the appropriate files are copied from the *resource* directory into the *scenarios* directory with the given scenario name (for the sake of this

document, assume “2018\_Example”). The input table shows both the *resource* and *scenarios* directory locations. Outputs are listed according to their scenario location.

This document is divided into the following sections:

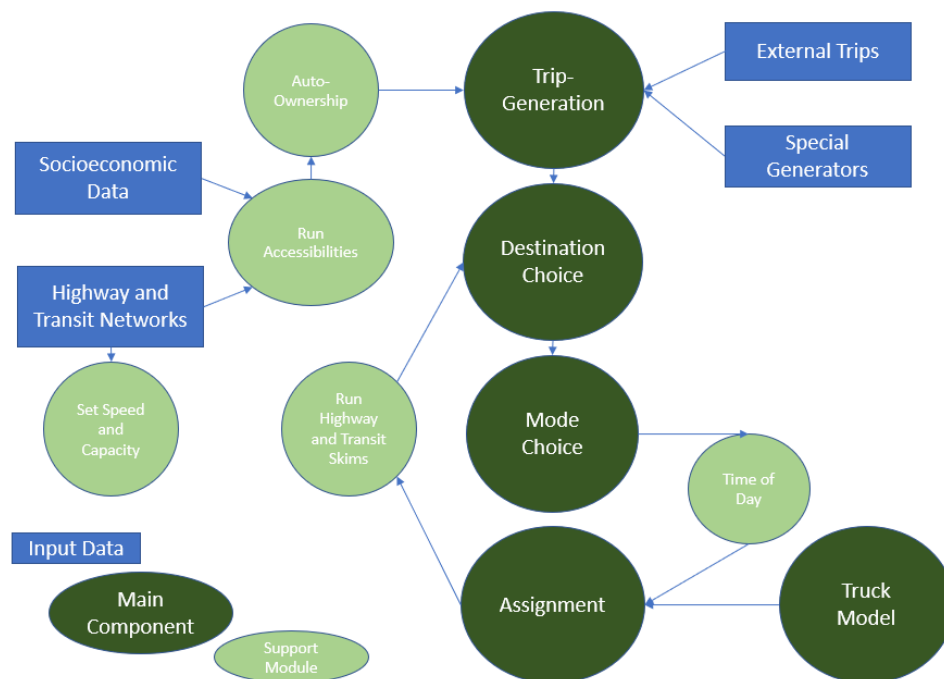
- Section 1 is this introduction
- Section 2 describes each model component, including inputs and outputs
- Section 3 describes the calibration and validation of the revised model to targets in a 2018 base year

## 2 Model Description

### 2.1 Model Flow Chart

Below is a flow-chart of the model. The main model steps are Trip Generation, Destination Choice, Mode Choice and Assignment (both highway and transit). There are several initial steps, like setting the initial speed and capacity of highway links based on area type, and determining the number of households in each zone that own 0, 1, 2 or 3+ cars, that are executed prior to the main steps. In addition, the NWA TDM models external trips, special generator trips and truck/commercial vehicle trips. Each step is explained in more detail below.

Figure 1 – Model v3.0.1 Flow



## 2.2 Set Link Speed and Capacity: 01 – SpeedCapacity.rsc

**Description:** This module determines the starting speeds and period-specific capacities for the highway links based on functional classification and area type. Several look-up tables are used to determine the speed and capacity values.

### Inputs:

File/Property Name	Scenario Location ("nwarpc_model/scenarios/")	Copied From ("nwarpc_model/resource/")	Description
Area_type.csv	.../2018_Example/inputs/speed/	.../parameters/speed/	Sets urban, suburban and rural densities and centroid connector speeds
FF_speed.csv	.../2018_Example/inputs/speed/	.../parameters/speed/	Defines adjustments to posted speeds based on Area Type and Functional Classification
Hourly_capacities.csv	.../2018_Example/inputs/speed/	.../parameters/speed/	Defines per hour, per lane capacities for level of service D and E by Functional Classification and Area Type (LOS E factors are used)
Period_capacity_factors.csv	.../2018_Example/inputs/speed/	.../parameters/speed/	Defines number of hours in each model time period – AM Peak, PM Peak and OP

**Methodology:** The AreaType of each link is determined based on the number of households and employment per TAZ square mile. The Area\_type look-up table defines the density breaks for rural, suburban and urban designations. Next, each link in the model is defined as a Freeway, Principal Arterial, Minor Arterial, Collector, Local, Ramp or Centroid Connector based on the FHWA\_FC defined in the network. The table below shows the mapping between FHWA\_FC and the Highway Capacity Manual classification used to set the capacity.

FHWA_FC – network attribute	Highway Capacity Manual Type (HCMTType)
1, 11	Freeway
2, 14	Principal Arterial
6, 16	Minor Arterial
7, 8, 17	Collector
9, 19	Local
71, 72, 73, 74, 75, 81, 82	Ramp
97, 98, 99	Centroid Connectors

With each highway link now having an area type and an HCMTType, the per lane per hour capacities are set using the hourly\_capacities.csv look-up table. The final step in setting the capacities for each link is to multiply the number of lanes by the per lane capacity and the length of the time period as defined in the period\_capacity\_factors.csv file to get the link capacities by time period. These values are set in the Highway Line Layer ("AB/BA\_AM/PM/OP\_CAP") and used when the Highway Network is built.

The final two steps in this module is to set the centroid connector speeds (based on area\_type.csv look-up table) and the free flow link speeds and times. The free flow travel speed (FFSpeed) is set for each link based on the Area Type and HCMType and the modification of the posted speed as defined in the ff\_speed.csv look-up table. The free flow time (FFTime in minutes) is calculated as the link length divided by speed, converted to minutes (i.e. “times 60”). These values are set in the Highway Line Layer and used when the Highway Network is built.

**Outputs:**

- AB\_AM\_CAP, BA\_AM\_CAP, etc. fields in the Highway Line Layer
- FFSpeed and FFTime fields in the Highway Line Layer

## 2.3 Skim the Networks: 02 – HighwaySkim, 03 – TransitSkim, 04 – HybridSkim

**Description:** The three modules listed above use the highway and transit networks to determine necessary origin to destination attributes such as in-vehicle time, distance, etc. that are used in the Auto Ownership, Destination Choice and Mode Choice models. The hybrid skim is the skim needed for the “Drive to Razorback” mode in Mode Choice. This mode describes trips where the drive-access portion of the Razorback transit trip is longer than 5 miles. All highway, transit and hybrid skims are saved in the “...scenarios/2018\_Example/outputs/skims” directory.

**Inputs:**

File/Property Name	Scenario Location (“nwarp_model/scenarios/”)	Copied From (“nwarp_model/resource/”)	Description
Streets.dbd	.../2018_Example/inputs/gis/streets/	.../data/gis/streets/NWAMPA_Master_Network.dbd	Scenario-specific Highway layer that has been extracted from the Master file
Transit.rts; transitS.dbd	.../2018_Example/inputs/gis/transit/	.../data/gis/transit/routes; route_lines; route_stops	Scenario-specific Transit route files that have been built from the CSV files in the resource directory when scenario was created.
Mode_table.bin	.../2018_Example/inputs/assignment/mode_table.bin	.../parameters/assignment/mode_table.bin	Provides transit hierarchy and defines access modes
Various walk and wait threshold properties	.../2018_Example/inputs/nwarp.properties	.../parameters/settings/nwarp.properties	20 minutes for walk/bike access to transit, 5 minutes for short-walk and wait threshold

**Methodology:** Highway networks are created from the highway line layer for each time period and each drive mode – drive-alone, shared ride 2 and shared ride 3+. These network files are then used to *skim* information from the network such as drive, walk and bike time (in minutes) between origin/destination pairs; distance (in miles) between origin/destination pairs; and drive time to the Razorback transit lines (Zone 50040). Similarly, transit networks are created from the transit route files for each time period and access mode (drive and walk). From these transit networks, transit-related information between

origin/destination pairs that are accessible via transit, such as access time, wait time, in-vehicle time, are stored in the transit skim matrices. Finally, the hybrid skims are a special set of skims used for the “Drive to Razorback” mode. This mode is unique to the NW Arkansas region because of the University of Arkansas Razorback Transit system. As documented by the recent on-board survey, many students drive more than 5 miles, park their car and use Razorback Transit to access the campus. While this is sometimes thought of as a transit trip, the NWA TDM considers it an auto trip that uses transit for the final portion of the journey.

Outputs:

- nwarpc\_models/scenarios/2018\_Example/outputs/skims/street\_skim.mtx
- nwarpc\_models/scenarios/2018\_Example/outputs/skims/transit\_am (and op and pm), drive (and walk)\_transit\_skim.mtx
- nwarpc\_models/scenarios/2018\_Example/outputs/skims/hybrid/ transit\_am (and op and pm)\_drive\_transit\_skim.mtx

## 2.4 Calculate Accessibilities: 05 – Accessibility.rsc

**Description:** This module calculates the accessibility term used in the auto-ownership model. For each origin zone, it calculates how much employment is accessible by transit across all destinations and how much employment is accessible by auto across all destinations. Households in zones that have accessibility to many jobs by transit are likely to have fewer cars.

Inputs:

File/Property Name	Scenario Location ("nwarpc_model/scenarios/")	Copied From ("nwarpc_model/resource/")	Description
transit_am_walk_transit_skim.mtx	.../2018_Example/outputs/skims/	Not applicable, this file only exists as a scenario output	Walk to transit skims
street_skim_auto_ownership.mtx	.../2018_Example/outputs/skims/	Not applicable, this file only exists as a scenario output	Highway skims
se_data.bin	.../ 2018_Example/outputs/generation/	Not applicable, this file only exists as a scenario output	Working copy of the socio-economic data that is updated as the model progresses

**Methodology:** A matrix of transit and drive accessibilities to employment is created. Logsums are created by summing across the rows and the final accessibilities used are transit logsum minus drive logsum. These are stored in a table to use in the Auto Ownership model but also written out to the ../outputs/generation/se\_data.bin file (see field called “accessibility”).

Outputs:

- .../ 2018\_Example/outputs/skims/Accessibility.bin

## 2.5 Determine Auto-Ownership: 06 – AutoOwnership.rsc

**Description:** The purpose of the auto ownership model is to estimate the number of autos owned by households in each TAZ, either 0, 1, 2 or 3+. The auto ownership model considers household size, household income, number of workers, and accessibility to employment as calculated above.

### Inputs:

File/Property Name	Scenario Location ("nwarpc_model/scenarios/")	Copied From ("nwarpc_model/resource/")	Description
se_data.bin	.../ 2018_Example/outputs/ generation	Not applicable, this file only exists as a scenario output	Data file is updated with model results

	Parameter	Coeff
Constants	constant 2 (1-auto)	-.5299
	constant 3 (2-auto)	-.2133
	constant 4 (3+ autos)	-3.7739
Size Coefficients	k1hhsz3 (1-auto coefficient for hh size 3)	1.8808
	k2hhsz3 (2-auto coefficient for hh size 3)	2.1350
	k3hhsz3 (3+ auto coefficient for hh size 3)	2.9267
	k1hhsz4 (1- auto coefficient for hh size 4+)	3.0977
	k2hhsz4 (2-auto coefficient for hh size 4+)	3.8765
	k3hhsz4 (3+ auto coefficient for hh size 4+)	4.5004
Worker Coefficients	k1nwork1 (1-auto coefficient for 1 worker )	1.1297
	k2nwork1 (2-auto coefficient for 1 worker )	0.4450
	k1nwork2 (1-auto coefficient for 2 worker )	0.8572
	k2nwork2 (2-auto coefficient for 2 workers )	0.4841
	k3nwork2 (3-auto coefficient for 2 workers )	-0.8808
	k1nwork3 (1-auto coefficient for 3 workers )	0.8979
	k2nwork3 (2-auto coefficient for 3 workers )	2.0246
	k3nwork3 (3-auto coefficient for 3 workers )	0.3904
Income Coefficients	k1income2 (1-auto coefficient for medium income)	0.9203
	k2income2 (2-auto coefficient for medium income)	0.2229
	k3income2 (3-auto coefficient for medium income)	0.6077
	k1income3 (1-auto coefficient for high income)	1.5830
	k2income3 (2-auto coefficient for high income)	1.7644
	k3income3 (3+ auto coefficient for high income)	2.3278
Accessibility Coefficients	k1colsum (1-auto coefficient for auto logsum )	0.0278
	k2colsum (2-auto coefficient for auto logsum )	0.0193
	k3colsum (3+ auto coefficient for auto logsum )	-0.2652



**Methodology:** For each zone, the percentage of households owning 0, 1, 2 or 3+ autos are calculated based on a utility function that includes household size, household income, household workers and the accessibility calculation done in the previous module. The estimated coefficients were transferred from Asheville, North Carolina. These percentages are written out to the se\_data.bin file (see fields called “pctAutoX”, where X = 0, 1, 2 or 3). The total number of households in each zone are then multiplied by the percentages to get the number of households by auto-ownership category which are written out to the se\_data.bin file (see fields called “vehX”, where X = 0, 1, 2 or 3).

**Outputs:**

- .../2018\_Example/outputs/generation/se\_data.bin – see fields listed above

## 2.6 Trip Generation: 07 – TripGeneration.rsc

**Description:** The trip generation model determines the number of trips for each resident trip purpose in the model (HBW, HBO, etc.), along with special generator auto trips, and external auto trips. Truck trips are generated in the Truck Model component. The resident trip production rates are based on the household size, number of autos owned and the income level of the household in each origin zone. The resident trip attraction rates are based on the number of households, employment and school/university enrollment in the destination zones. The special generator trips are based on ITE trip generation rates of the land-use types specified in the special generator file. And the external trips are based on observed values at the external stations and a projected annual growth rate.

**Inputs:**

File/Property Name	Scenario Location ("nwarpc_model/scenarios/")	Copied From ("nwarpc_model/resource/")	Description
se_data.bin	.../ 2018_Example/outputs/ generation/	Not applicable, this file only exists as a scenario output	Data file is updated with model results
Disagg_hh_joint.csv	.../2018_Example/inputs/ generation/	.../parameters/trip_generation/	Census-based joint distribution used as seed matrix
Prod_rates_work.csv	.../ 2018_Example/inputs/ generation/	.../parameters/trip_generation/	Production rates by joint distributions for work purposes (HBW and NHBW)
Prod_rates_nonwork.csv	.../ 2018_Example/inputs/ generation/	.../parameters/trip_generation/	Production rates for non-work purposes (with exception of HBU)
Attr_rates.csv	.../ 2018_Example/inputs/ generation/	.../parameters/trip_generation/	Formulas for determining resident trip attractions
Univ_generation.csv	.../ 2018_Example/inputs/ generation/	.../parameters/trip_generation/	Formulas for determining university productions and attractions
Special_generator_data.bin	.../2018_Example/inputs/ generation/spgenerator/	.../data/trip_generation/	Special generator data files exist for each model year in reference directory. User specifies file during scenario creation.

ltdata7.bin	.../2018_Example/inputs/ generation/spgenerator/	.../data/trip_generation/	ITE trip rates for various land-use types.
Special_gen_splits	.../2018_Example/inputs/ generation/spgenerator/	.../parameters/trip_generation/	Shares by trip purpose and truck types to split the special generator trips
Ext_Summary.bin	.../2018_Example/inputs/ external/	.../data/external/	2010_ADT by external station, split into trucks, commercial vehicles and cars
Ext_trip_pa_split	.../2018_Example/inputs/ external/	.../parameters/external/	Split of externals between productions and attractions
Ext_trip_purpose_split	.../2018_Example/inputs/ external/	.../parameters/external/	Split of externals into trip purposes
Add_all_trips.csv	.../2018_Example/inputs/ generation/	.../parameters/trip_generation/	Defines the trip purposes to combine and the fields in the se_data.bin file to store them in
Balance.csv	.../2018_Example/inputs/ generation/	.../parameters/trip_generation/	Defines the balancing procedure for each purpose – either balancing productions to attractions or vice-versa

**Methodology:** The first step of this module is to determine the number of households by cross-classification. Up to this step, the se\_data.bin file has the number of households by size, the number of households by income, the number of households by workers and the number of households by auto. A joint distribution of those categories is formed using a multi-dimensional matrix balancing routine. The categories listed above are used as marginals and census data is used as a seed matrix. The 4 size categories, 3 income groupings, 4 worker sizes, and 4 auto-ownership categories results in 192 (4 x 3 x 4 x 4) household categories (ex. Households with 1 person (who is a worker, i.e. 1 worker), low income, and owns 1 car is an example of a joint distribution. There are 191 more written out to HHDisaggregation.csv (see list of outputs)).

Trip productions and trip attractions for the various trip purposes are then calculated. Different methodologies are used for different purposes. Each methodology is described below:

- Unbalanced HBW and NHBW trip productions – these trip rates are based on the number of workers, number of autos and income levels. Three household segments are considered – households without vehicles, households with more workers than vehicles which are considered “vehicle-insufficient”, and households that have as many or more vehicles than workers which are considered “vehicle-sufficient” households. High, medium and low-income levels for auto-insufficient and auto-sufficient households are also part of the trip production rate segmentation. In general, households with more workers make more work trips. Similarly, vehicle-sufficient households tend to make more work trips. Households with 0 vehicles make fewer trips; and households with 0 workers do not make any work trips. University student work trips are calculated separately. The HBW and NHBW trip production rates are found in prod\_rates\_work.csv (see Input table above). The resulting trips by TAZ are in the productions.csv output file in the following fields:

Field	Description
HBW_v0	HBW trips by HHs with 0 vehicles
HBW_vHi	HBW trips by High Income, Vehicle-Insufficient households
HBW_vHs	HBW trips by High Income, Vehicle-Sufficient households
HBW_vLfi	HBW trips by Low Income, Vehicle-Insufficient households
HBW_vLFs	HBW trips by Low Income, Vehicle-Sufficient households
HBW_vMfi	HBW trips by Medium Income, Vehicle-Insufficient households
HBW_vMFs	HBW trips by Medium Income, Vehicle-Sufficient households

NOTE: the HBW\_vLfi and HBW\_vMfi trips are later collapsed into a single category – I\_HBW\_vLi. Same with HBW\_vLFs and HBW\_vMFs that are collapsed into I\_HBW\_vLs. They are then stored in se\_data.bin.

- Unbalanced HBO, HBSC, HBSB, NHBO trip productions – these trip rates vary by purpose and are based on household size, number of autos and income levels. In the non-work case, vehicle-insufficient households are ones where household size is greater than number of vehicles and vehicle-sufficient households are ones where the number of vehicles is greater than or equal to household size. As with work trips, the number of trips per household increases with household size, increases with vehicle-sufficiency and tends to increase with income. The non-work trip productions rates are found in the prod\_rates\_nonwork.csv file. While different household segments have different number of trips, the segmentation is not maintained and the trips by segment are summed up in productions.csv by purpose.
- Unbalanced HBW, NHBW, HBO, HBSC, HBSB, NHBO trip attractions – the trip attractions are used later in the destination choice model as size terms. Zones with more activity – in the form of households, employment or enrollment – will see more trips ends. The trip attractions are calculated based on the se\_data fields and factors defined in the attr\_rates.csv file. The number of attractions for each purpose (to\_field) is calculated by multiplying the se\_data value in the from\_field and the factor for each TAZ. The calculated attractions are stored in the se\_data.bin file in the following fields:

I_HBWa_v0	HBW attractions for 0-car households
I_HBWa_vHi	HBW attractions for High Income, Vehicle-Insufficient households
I_HBWa_vHs	HBW attractions for High Income, Vehicle-Sufficient households
I_HBWa_vLi	HBW attractions for Low Income, Vehicle-Insufficient households
I_HBWa_vLs	HBW attractions for Low Income, Vehicle-Sufficient households
I_HBSCa	HBSC attractions
I_HBSBa	HBSB attractions
I_NHBOa	NHBO attractions
I_NHBWa	NHBW attractions

- Unbalanced HBU Trip Productions and Attractions – University students make university trips as well as home-based work, home-based other and non-home-based trips. These are all defined in the univ\_generation.csv file. The UAEnrollOff (UA students living off-campus) and UAEnrollOn (UA students living on-campus) values in the se\_data.bin file are multiplied by the factors shown in the file. The results are written back to the se\_data.bin file in the following fields:

sHBW	University student home-based work trips
sHBO	University student home-based other trips
sNHB	University student non-home-based trips
I_HBU	Home-based University Trip Productions
I_HBUa	Home-based University Trip Attractions

- Unbalanced Special Generator Trip Productions and Attractions – The special generators are a set of user defined land types that generate/attract trips at rates that are not always consistent with zonal data such as households or employment. Examples of special generators are museums, distribution centers, etc. For each special generator listed in the file, the ITE trip rate by land-use code is used to calculate trip productions and trip attractions. These are added to the se\_data.bin file in the fields below:

HBW_P_SPGEN	HBW special generator production
HBU_P_SPGEN	HBU special generator production
HBSC_P_SPGEN	HBSC special generator production
HBSB_P_SPGEN	HBSB special generator production
HBO_P_SPGEN	HBO special generator production
NHBW_P_SPGEN	NHBW special generator production
NHBO_P_SPGEN	NHBO special generator production
HBW_A_SPGEN	HBW special generator attraction
HBU_A_SPGEN	HBU special generator attraction
HBSC_A_SPGEN	HBSC special generator attraction
HBSB_A_SPGEN	HBSB special generator attraction
HBO_A_SPGEN	HBO special generator attraction
NHBW_A_SPGEN	NHBW special generator attraction
NHBO_A_SPGEN	NHBO special generator attraction

- Unbalanced Internal-External (IE) and External-Internal (EI) Car Trip Productions and Attractions – The external car trips are calculated based on observed external station counts in 2010. The external trucks and commercial vehicles are handled in the Truck model, described later. For cars, the number of IE\_EI car trips at each external station is factored up to the scenario year based on the annual car growth rate specified in the file (1%). These trips are then split into trip purposes and trip productions and attractions based on the percentage splits in the ext\_trip\_purpose\_split and ext\_trip\_pa\_split files respectively. These trips are then added to the se\_data.bin file in the fields below:

HBW_P_EXT	External HBW productions
HBU_P_EXT	External HBU productions
HBSC_P_EXT	External HBSC productions
HBSB_P_EXT	External HBSB productions
HBO_P_EXT	External HBO productions
NHBW_P_EXT	External NHBW productions
NHBO_P_EXT	External NHBO productions
HBW_A_EXT	External HBW attractions

HBU_A_EXT	External HBU attractions
HBSC_A_EXT	External HBSC attractions
HBSB_A_EXT	External HBSB attractions
HBO_A_EXT	External HBO attractions
NHBW_A_EXT	External NHBW attractions
NHBO_A_EXT	External NHBO attractions

The next step in the Trip Generation module is to combine all the Trip Productions and Attractions by purpose so that they can be balanced in the final step. The aggregated groups are stored in the se\_data.bin file. A few combinations to note:

1. Because there are five HBW segments (no cars, high income insufficient, high income sufficient, low income insufficient and low income sufficient), the external HBW productions/attractions are split evenly into each segment (20% to each).
2. The NHB trips made by University students (sNHB) are combined with the NHBO trip productions.

The final step is to balance the Trip Productions and Trip Attractions by purpose. For all purposes except NHBW and NHBO, the trip attractions are scaled to the trip productions. The scaling factor is the sum across all zones of trip productions by purpose divided by the sum of trip attractions by purpose. For the NHB purposes, the trip attractions are set to the trip productions for each zone. The final balanced productions and attractions are written to the se\_data.bin file in the following fields:

Balanced Trip Production Field	Balanced Trip Attraction Field
HBW_v0	HBWa_v0
HBW_vHi	HBWa_vHi
HBW_vHs	HBWa_vHs
HBW_vLi	HBWa_vLi
HBW_vLs	HBWa_vLs
HBU	HBUa
HBSC	HBSCa
HBSB	HBSBa
HBO	HBOa
NHBW	NHBWa
NHBO	NHBOa

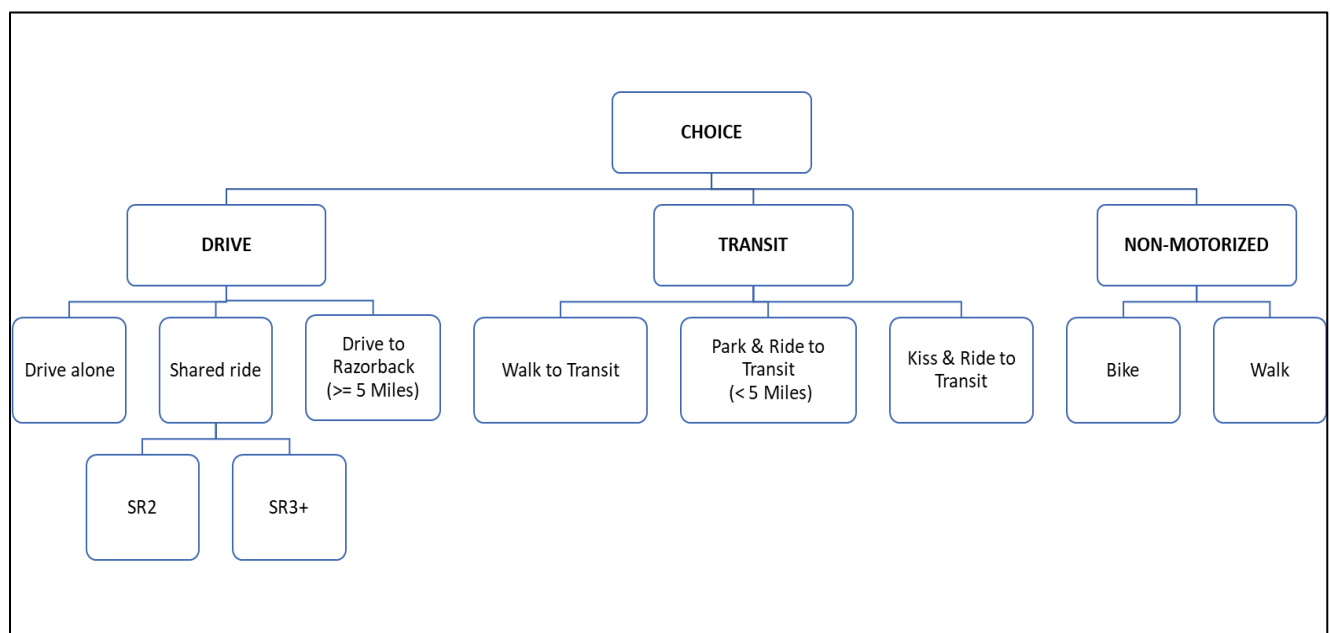
#### Outputs:

- .../2018\_Example/outputs/generation/HHDisaggregation.csv
- .../2018\_Example/outputs/generation/productions.csv
- .../2018\_Example/outputs/generation/se\_data.bin
- .../2018\_Example/outputs/generation/balance\_report.csv
- .../2018\_Example/outputs/generation/unbalanced\_pa.csv

## 2.7 Calculate Mode Choice Probabilities: 08 – ModeChoice.rsc

**Description:** This module calculates the mode choice probability for each origin/destination pair in the model region by using different variables (e.g., in-vehicle travel time and value of time) and coefficients defined in the model files (see the inputs table for the details). This module does not actually apply the probabilities to the trip tables, that is done after Destination Choice – but the probabilities (and logsums) are calculated here so that they can be used as a variable in the Destination Choice logit model. The figure below shows the nesting structure used in the probability calculations. As discussed previously and shown in the figure below, the drive to Razorback trips with drive distance more than 5 miles are considered in the auto/drive nest of the nesting structure. The module also creates mode choice logsums which are later used in the destination choice model.

**Figure 2 – Mode Choice Model Structure**



### Inputs:

File/Property Name	Scenario Location ("nwarpc_model/scenarios/")	Copied From ("nwarpc_model/resource/")	Description
Walk distance threshold properties	.../2018_Example/inputs/ nwarpc.properties	.../parameters/settings/ nwarpc.properties	0.25 mile for short walk and 0.5 mile for long walk to transit
taz.dbd	.../2018_Example/inputs/ gis/taz/	.../data/gis/taz/ NWAMPA_Master_TAZ.dbd	Scenario-specific TAZ layer that has been extracted from the Master file

Streets.dbd	.../2018_Example/inputs/ gis/streets/	.../data/gis/streets/NWAMPA _Master_Network.dbd	Scenario-specific Highway layer that has been extracted from the Master file
transitS.dbd	.../2018_Example/inputs/ gis/transit/	.../data/gis/transit/routes; route_lines; route_stops	Scenario-specific Transit stop file that has been built from the CSV files in the resource directory when scenario was created.
street_skim.mtx	.../2018_Example/outputs/ skims/	Not applicable, this file only exists as a scenario output	Highway skim file
transit_am_walk_transit_skim.mtx transit_am_drive_transit_skim.mtx transit_op_walk_transit_skim.mtx transit_op_drive_transit_skim.mtx	.../2018_Example/outputs/ skims/	Not applicable, these files only exist as scenario outputs	Transit skim files by time period and access mode
mode_table.bin	.../2018_Example/inputs/ assignment/	.../parameters/assignment/	Provides transit hierarchy and defines access modes
mode_choice_parameters.csv	.../2018_Example/inputs/ mode_choice/	.../parameters/mode_choice/	Mode choice coefficients used in the utility calculation

**Methodology:** The first step in this module is to create a matrix that determines, for each Production-Attraction zone pair, the combination of long/short walk access and egress to transit. This is determined using the transit stop file, short and long-distance walk distance thresholds set in the model property file and scenario-specific TAZ layer. Based on the combination of the access/egress distance thresholds (i.e., short, long and none), nine cores are created in this matrix (i.e., short-short, short-long, short-none, long-short, long-long, long-none, none-short, none-long, none-none). Later, these nine cores are collapsed into three tables - short, long and none. The matrix is used as one of the inputs to the mode choice model.

The mode choice model parameters can be found in the directory shown in the inputs table. The coefficients listed in this file should not be modified as they are calibrated values, but for informational purposes, the first column lists the variables and the columns give the coefficient values for each purpose. 'Nest' refers to the nesting coefficient which is a parameter used in the nested logit model. 'Asc' is the alternative specific constant which is simply a number that represents un-included attributes of each mode (for example, feelings of safety on a mode). 'Value\_of\_time', which should more appropriately be named "cost coefficient", captures the sensitivity of the traveler to travel costs. It is this coefficient that is applied to the parking cost, fares, and auto-operating cost variables. The parameters file also includes the coefficients on in-vehicle time (ivt) and coefficients on the various transit attributes such as wait time and walk time to and from the transit stop to the destination.

Additional parameters used in the mode-choice model such as 'sr2\_persons' and 'sr3\_persons' are used to convert the value of time or cost coefficient for SR2 and SR3+ modes.

Note that for the home-based work purposes, there are different coefficients for income and auto sufficiency segments. For income segmentation, the 2010 Census puts Washington County's median income at \$41,000 and Benton County's at \$53,000. The survey also allows people to select "above \$50,000" or "below \$50,000" if they do not wish to disclose their income more precisely, so we decided to use \$50,000 as the division between low and high incomes. "Sufficient" means that the number of autos in a household is either greater than or equal to the number of workers in the household. "Insufficient" means that the number of vehicles is less than the number of workers.

The parking costs for TAZs in Fayetteville were recently updated (they were \$0 in previous datasets). There is now a "work" and "non-work" cost for eight zones in the model. The "work" cost is used in the mode choice calculations for the HBW purposes and the "non-work" cost is used for all other purposes. The development of the parking costs is detailed in Section 2.15 below.

The coefficients in the model were originally transferred from models developed for Indianapolis, IN and Austin, TX and they have not been re-estimated in this update as household survey data is not available. It is common to use asserted mode choice parameters as the FTA provides guidelines for parameters that this model adheres to. For this update, we did adjust the alternative specific constants slightly to account for the new on-board survey results, namely the transit and drive-to-razorback mode shares.

For each trip purpose and walk segment, the mode choice model calculates the utility (the desirability) of each mode of a given origin/destination pair by using the variables and the coefficients defined in the model. The calculated utilities are then converted into a probability of each trip using each mode for a given origin/destination pair using the nested logit model formulation.

**Figure 3 - General Formula of a Logit Model**

$$P_i = \frac{e^{U_i}}{\sum_m e^{U_i}}$$

where :

$P_i$  = Probability of Choosing Mode i

$U_i$  = Utility for mode i

e = natural logarithm

$\sum_m$  = sum across all modes m

The mode choice model is sensitive to changes in the highway network as well as the transit network. With the current mode choice model, congestion levels, which result in slower auto times, will affect the



transit shares, as will additional routes, more frequent service on existing routes, or any combination of transit and/or highway network changes. This allows NWARPC to test numerous scenarios.

Additionally, while there are not currently HOV lanes present in the NWA highway network, the mode choice model is able to forecast potential users of such a system if it is introduced since all trips using SR2 or SR3 modes are eligible to use an HOV lane. To use this feature, the network will have to have HOV lanes coded and the network and assignment procedures will need to be modified, but the basic capability is there.

The ConnectArkansas transit plan does include high-capacity transit (i.e., BRT) and the current version of the model does include future year transit networks with those lines coded.

#### Outputs:

##### Mode Choice Probability Matrices:

- .../2018\_Example/outputs/mode\_choice/mode\_choice\_probability\_X\_Y\_Z.mtx (where X = hbw; Y = zero, low\_insufficient, low\_sufficient, high\_insufficient, or high\_sufficient; Z = short, long or none)
- .../2018\_Example/outputs/mode\_choice/mode\_choice\_probability\_X\_Z.mtx (where X = hbu, hbbsc, hbsb, hbo, nhbw, or nhbo; Z = short, long or none)

##### Model Specification Files:

- .../2018\_Example/outputs/mode\_choice/mode\_choice\_X\_Y.mdl (where X = hbw; Y = zero, low\_insufficient, low\_sufficient, high\_insufficient, or high\_sufficient)
- .../2018\_Example/outputs/mode\_choice/mode\_choice\_X.mdl (where X = hbu, hbbsc, hbsb, hbo, nhbw, or nhbo)

##### Mode Choice Log Files:

- .../2018\_Example/outputs/mode\_choice/mode\_choice\_X\_Y.log (where X = hbw; Y = zero, low\_insufficient, low\_sufficient, high\_insufficient, or high\_sufficient)
- .../2018\_Example/outputs/mode\_choice/mode\_choice\_X.log (where X = hbu, hbbsc, hbsb, hbo, nhbw, or nhbo)

##### Other Outputs:

- .../ 2018\_Example/outputs/mode\_choice/walk\_segment\_fractions.mtx
- .../ 2018\_Example/outputs/mode\_choice/stop\_access.csv
- .../ 2018\_Example/outputs/mode\_choice/\_mc\_logsums\_DL.mtx

## 2.8 Destination Choice: 09 – DestinationChoice.rsc

**Description:** The destination choice model links the trip productions and attractions created in the Trip Generation step. The logit-based destination choice model incorporated in the model set up uses several variables such as distance, size terms and mode choice logsums. The size terms may be considered equivalent to the attractions in the gravity model. The mode choice logsums represent accessibilities between the origin and destination zones of the model region – the more modes that serve a particular OD pair, the more accessible that pairing is. To use mode choice logsums in the destination choice model, this module is run after the mode choice probability creation step.

### Inputs:

File/Property Name	Scenario Location ("nwarp_model/scenarios/")	Copied From ("nwarp_model/resource/")	Description
d_purp_conversion.csv	.../2018_Example/inputs/ distribution/	.../parameters/trip_distribution/	Defines the trip purposes to combine and the fields in the se_data.bin file to store them in for destination choice model
dc_parameters.csv	.../2018_Example/inputs/ distribution/	.../parameters/trip_distribution/	Destination choice model parameters
dc_variables.csv	.../2018_Example/inputs/ distribution/	.../parameters/trip_distribution/	Variables used in the destination choice model
template.dcm	.../2018_Example/inputs/ distribution/	.../parameters/trip_distribution/	Template required by the GISDK tools for destination choice model
se_bin_file	.../2018_Example/outputs/ generation/	Not applicable, this file only exists as a scenario output	Working copy of the socio-economic data that is updated as the model progresses
_hwy_skim_DL.mtx	.../2018_Example/outputs/ skims/	Not applicable, this file only exists as a scenario output	Renamed "street_skim.mtx" for use in the destination choice model
_mc_logsums_DL.mtx	.../2018_Example/outputs/ mode_choice/	Not applicable, this file only exists as a scenario output	Mode choice logsums created by "ModeChoice.rsc"

**Methodology:** The first step of this module is to collapse Trip Generation purposes into the purposes for the Destination Choice model by using an equivalency table (see “d\_purp\_conversion.csv” for the details) if needed. In the current version, the destination choice model uses the same segmentation as the Trip Generation step; therefore, aggregation is not required. The capability was kept for future use if needed. The Trip Generation productions and attractions are copied into the “se\_data.bin” file in the fields listed below:

Trip Productions Used in the Destination Model	Trip Attractions Used in the Destination Model
d_HBW_v0_DL	d_HBWa_v0_DL
d_HBW_vLi_DL	d_HBWa_vLi_DL
d_HBW_vHi_DL	d_HBWa_vHi_DL

d_HBW_vLs_DL	d_HBWa_vLs_DL
d_HBW_vHs_DL	d_HBWa_vHs_DL
d_HBU_all_DL	d_HBUa_all_DL
d_HBSC_all_DL	d_HBSCa_all_DL
d_HBSB_all_DL	d_HBSBa_all_DL
d_HBO_all_DL	d_HBOa_all_DL
d_NHBW_all_DL	d_NHBWa_all_DL
d_NHBO_all_DL	d_NHBOa_all_DL

NOTE: DL indicates Daily

The next step in this module is to run the destination choice model for each trip purpose. The model coefficients can be found in the “dc\_parameters.csv” file (see the inputs table). The coefficients listed in this file should not be modified as they are calibrated values, but for informational purposes, the first column lists the trip purposes and the second column lists the auto sufficiency categories (for HBW trip purpose). The fifth column “value” lists the coefficients, parameters and the trip production and attraction field names in the “se\_data.bin” file required by the destination choice model.

For each trip generated in the trip generation step, the model first calculates the utility from the origin to different destination zones by using the variables and coefficients defined in the destination choice model files listed in the inputs table. The calculated utilities are then converted into a probability of the trip going to each destination zone for a given origin zone using the logit model formulation. To improve the performance of the model, a shadow pricing mechanism is used in the destination choice model. This is an iterative procedure that attempts to match the total number of trips attracted to the destination zones with the size term of those zones (ex. if a zone has 100 jobs, shadow pricing ensures that the number of HBW trips is close to 100). The iterative procedure is controlled by a maximum number of iterations set in the parameter file. The module produces zone-to-zone trip matrices for each trip purpose and stores them in a file called “trips\_resident\_DL.mtx”. The file contains the following trip matrices:

Trip Matrices (Destination Choice Model Outputs)
HBW_zero
HBW_low_insufficient
HBW_high_insufficient
HBW_low_sufficient
HBW_high_sufficient
HBU_all
HBSC_all
HBSB_all
HBO_all
NHBW_all
NHBO_all

Outputs:

## Trip Outputs:

- .../2018\_Example/outputs/distribution/trips\_resident\_DL.mtx

## Model Specification Files:

- .../2018\_Example/outputs/distribution/DL\_X\_Y.dcm (X = HBW; Y = v0, vLi, vHi, vLs or vHs)
- .../2018\_Example/outputs/distribution/DL\_X.dcm (X = HBU, HBSC, HBSB, HBO, NHBW, NHBO)

## Model Log Files:

- .../2018\_Example/outputs/distribution/DL\_X\_Y.log (X = HBW; Y = v0, vLi, vHi, vLs or vHs)
- .../2018\_Example/outputs/distribution/DL\_X.log (X = HBU, HBSC, HBSB, HBO, NHBW, NHBO)

**2.9 Mode Choice: 10 – ModeChoiceTrips.rsc**

Description: This module multiplies the mode choice probabilities by the number of trips distributed to different zones by the destination choice model and creates trip matrices by mode for each trip purpose considered in the model.

Inputs:

File/Property Name	Scenario Location ("nwarpc_model/ scenarios/")	Copied From ("nwarpc_model/ resource/")	Description
trips_resident_DL.mtx	.../2018_Example/ outputs/distribution/	Not applicable, this file only exists as output	Destination choice model outputs
walk_segment_fractions.mtx	.../2018_Example/ outputs/mode_choice/	Not applicable, this file only exists as output	Used to split the destination choice model outputs into three walk segments - short, long, none.
mode_choice_probability_hbw_Y_Z.mtx (where Y = zero, low_sufficient, high_sufficient, low_insufficient, or high_insufficient; Z= short, long or none) mode_choice_probability_hbu_Z.mtx (where, Z= short, long or none) mode_choice_probability_hbhc_Z.mtx (where, Z= short, long or none) mode_choice_probability_hbsb_Z.mtx (where, Z= short, long or none) mode_choice_probability_hbo_Z.mtx (where, Z= short, long or none) mode_choice_probability_nhbw_Z.mtx (where, Z= short, long or none) mode_choice_probability_nhbo_Z.mtx (where, Z= short, long or none)	.../2018_Example/ outputs/mode_choice/	Not applicable, these files only exist as a scenario output	Mode choice probability matrices

**Methodology:** This module first splits the destination choice model outputs into three walk segments (i.e., short, long and none) by multiplying them with the walk segment fraction matrix (discussed in section 2.4) so that the dimensions of the trip matrices match with the dimensions of the mode choice probability matrices. The resulting trip matrices are written out to the “trips\_X\_Y.mtx” files (where X = HBW, HBU, HBSC, HBSB, HBO, NHBW or NHBO, and Y = zero, low\_sufficient, high\_sufficient, low\_insufficient or high\_insufficient when X = HBW) in the “.../2018\_Example/outputs/distribution/” directory. Each of these files contains three matrices – short, long and none. The mode choice probabilities are then multiplied by these matrices to get the total number of trips by mode for each purpose, market segment and walk segment in each origin/destination pair. Next, for each trip purpose, the trip matrices for all walk segments and market segments are combined, and the final trip matrices are written out to the “mc\_trips\_X.mtx” files (where X = HBW, HBU, HBSC, HBSB, HBO, NHBW or NHBO) in the “.../2018\_Example/outputs/ mode\_choice/” directory.

#### Outputs:

##### Final Trip Matrices:

- .../2018\_Example/outputs/mode\_choice/mc\_trips\_X.mtx (where X = hbw, hbu, hbwc, hbsb, hbo, nhbw or nhbo)

##### Trip Matrices Before Aggregation:

- .../2018\_Example/outputs/mode\_choice/mc\_trips\_X\_Y\_Z.mtx (where X = hbw; Y = zero, low\_sufficient, high\_sufficient, low\_insufficient, or high\_insufficient; Z = short, long or none)
- .../2018\_Example/outputs/mode\_choice/mc\_trips\_X\_Z.mtx (where X = hbu, hbwc, hbsb, hbo, nhbw or nhbo; Z = short, long or none)

## 2.10 Split Trips into Time Periods: 11 – TimeOfDay.rsc

**Description:** This module splits the auto trips into three time periods (AM Peak, PM Peak and OP) and transit trips into two time periods (Peak and Off-peak). The output files are saved in the “.../2018\_Example/outputs/tod/” directory.

#### Inputs:

File/Property Name	Scenario Location (“nwarpc_model/scenarios/”)	Copied From (“nwarpc_model/resource/”)	Description
mc_trips_hbw.mtx mc_trips_hbu.mtx mc_trips_hbwc.mtx mc_trips_hbsb.mtx mc_trips_hbo.mtx mc_trips_nhbwc.mtx mc_trips_nhbo.mtx	.../2018_Example/outputs/ mode_choice/	Not applicable, these files only exist as a scenario output	Mode choice trips by purpose
tod_split.csv tod_split_transit.csv	.../2018_Example/inputs/tod/	.../parameters/tod/	Time-of-day factor files used to split the auto, truck, commercial vehicle and transit trips into different time periods

PAOD_AM.bin PAOD_PM.bin PAOD_OP.bin	.../2018_Example/inputs/tod/	.../parameters/tod/	PA and AP factors used to convert the auto trip tables from PA to OD format
Ext_Summary.bin	.../2018_Example/inputs/external/	.../data/external/	2010 ADT by external station, split into trucks, commercial vehicles and cars
EE_Car_Base.mtx	.../2018_Example/inputs/external/	.../data/external/	2010 External-External (E-E) auto trips
sce_ext_year; data_year	.../2018_Example/inputs/ nwarpc.properties	.../parameters/settings/ nwarpc.properties	Scenario specific model year and data year for the external data
Car_EE_Marginals.dbf	.../2018_Example/inputs/external/	.../data/external/	Marginals used to grow the 2010 E-E auto trips

**Methodology:** The model uses different time-of-day (TOD) factors for auto and transit trips. To apply different TOD factors, the module first splits the trip tables into auto and transit trip tables. The trip tables are saved in “.../2018\_Example/outputs/mode\_choice/mc\_trips\_X\_Y.mtx” files (where, where X = hbw, hbu, hbwc, hbsb, hbo, nhbw or nhbo; Y = auto or transit). Next, the auto trips are multiplied by the auto TOD factors in “tod\_split.csv” file to split them into three time periods – AM Peak, PM Peak and Off-peak. Up to this point, the auto trips are person trips and they are in PA (production-attraction) format. The SR2 and SR3+ auto person trips are converted to vehicle trips using vehicle occupancies of 2 and 3.5 respectively. In addition to the vehicle trips, the highway assignment requires the trip tables in OD (origin-destination) format. To convert the auto trip tables from PA to OD format, the PA and AP factors in “PAOD\_X.bin” (where X = AM, PM or OP) are used. Next, the 2010 auto E-E (External-External) trip marginals are factored up to the scenario year based on the annual car growth rate (1%) specified in the external data file (i.e., Ext\_Summary.bin) and the factored marginals are used to grow the 2010 auto E-E matrix to the scenario year. This matrix is then added to the drive alone trips in the auto trip tables.

The transit trips in the trip files are split into two time periods (Peak and Off-peak) using the TOD factors in the “tod\_split\_transit.csv” file. These factors were developed from the transit on-board survey.

**Outputs:**

- .../2018\_Example/outputs/tod/trips\_X.mtx (where X = am, pm, or op)
- .../2018\_Example/outputs/tod/trips\_transit\_Y.mtx (where Y = pk or op)

## 2.11 Determine Number of Truck Trips: 12 – TruckModel.rsc

**Description:** The truck model determines the number of truck and commercial vehicle (CV) trips in the model. The truck and CV trip rates vary by employment type (e.g., industry, office, retail, and service) and truck type (i.e., single-unit vs. multi-unit). The special generator truck trips are based on ITE trip generation rates of the land-use types specified in the special generator file. And the external truck and CV trips are based on observed values at the external stations and a projected annual growth rate.

Inputs:

File/Property Name	Scenario Location ("nwarpc_model/scenarios/")	Copied From ("nwarpc_model/resource/")	Description
truck_trip_rates.csv	.../2018_Example/inputs/ generation/truck/	.../parameters/trip_generation /truck/	Truck (single-unit and multi-unit) and commercial vehicle (CV) trip rates
taz.dbd	.../2018_Example/inputs/gis/ taz/	Not applicable, this file only exists as a scenario output	Employment data from this layer is used to calculate the truck and CV trips
Truck trip generation adjustment factor, ext.trk.data.year	.../2018_Example/inputs /nwarpc.properties	.../parameters/settings/ nwarpc.properties	Adjustment factors used to adjust the CV and truck trips; Truck data year is used to calculate the scenario- specific growth year to extrapolate the 2010 external data
special_generator_data.bin	.../2018_Example/inputs/ generation/spgenerator/	.../data/trip_generation/	Special generator data files exist for each model year in reference directory. User specifies file during scenario creation.
itedata7.bin	.../2018_Example/inputs/ generation/spgenerator/	.../data/trip_generation/	ITE trip rates for various land-use types
special_gen_splits.csv	.../2018_Example/inputs/ generation/spgenerator	.../parameters/trip_generation/	Shares by trip purpose and truck types to split the special generator trips
truck_ffactor.bin	.../2018_Example/inputs/ distribution/	.../parameters/trip_distribution/	Friction factors used in truck trip balancing procedure
Ext_Summary.bin	.../2018_Example/inputs/ external/	.../data/external/	2010_ADT by external station, split into trucks, commercial vehicles and cars
EE_ComVeh_Base.mtx	.../2018_Base/inputs/ external/	.../data/external/	2010 External-External (E-E) truck trips
ComVeh_EE_Marginals.dbf	.../2018_Base/inputs/ external/	.../data/external/	External-External (E-E) commercial vehicle trip marginals
street_skim.mtx	.../2018_Example/outputs/ skims/	Not applicable, this file only exists as a scenario output	Highway skim file
tod_split.csv	.../2018_Base/inputs/tod/	.../parameters/tod/	Time-of-day factor file used to split the truck trips into three time periods – am peak, pm peak and off-peak.

**Methodology:** The first step of this module is to calculate the truck and CV trips based on the truck and CV trip rates and employment of the TAZs in the model region. As discussed in the Trip Generation module, the special generators are a set of user defined land types that generate/attract trips at rates that are not always consistent with zonal data such as households or employment. Truck trips are also generated by the special generators. The special generators truck trips are calculated using the ITE trip

rates by land-use code listed in the special generator file (i.e., special\_generator\_data.bin) and added to the regular truck trips calculated based on the trip rates and employment type. The single and multi-unit truck trips from these steps are combined to get the total truck trips. To calculate the internal-external (I-E) and external-internal (E-I) trips for truck and CV, the number of I-E\_E-I truck and CV trips at each external station is factored up to the scenario year based on the annual truck growth rate (1%) specified in the external data file (Ext\_Summary.bin). The Internal-Internal (I-I) truck trips are calculated by subtracting the I-E and E-I trips from the total truck trips. All these trips are then added to the truck trip generation file (TruckTripGeneration.bin) in the fields below:

SUT_O	Single-unit truck trip origins
MUT_O	Multi-unit truck trip origins
Truck_II_O	Internal-Internal truck trip origins
Truck_IE_O	Internal-External truck trip origins
Truck_EI_O	External-Internal truck trip origins
TotalT_O	Total truck trip origins
ComVeh4T_O	Commercial vehicle trip origins
SUT_D	Single-unit truck trip destinations
MUT_D	Multi-unit truck trip destinations
Truck_II_D	Internal-Internal truck trip destinations
Truck_IE_D	Internal-External truck trip destinations
Truck_EI_D	External-Internal truck trip destinations
TotalT_D	Total truck trip destinations
ComVeh4T_D	Commercial vehicle trip destinations

The next step in this module is to balance the truck and CV trips. The balanced I-I truck trips and CV trips are saved in a separate file called "TruckTripGeneration\_Balanced.bin". After balancing, a Gravity Model is used to distribute these trips as well as the truck External-External (E-E) trips among different origin-destination (O-D) pairs in the model region. Next, all the truck trip matrices are combined as "Trucks" and the CV trip matrices are combined as "ComVeh4T". They are saved in a file called "truck\_trips.mtx" in the ".../2018\_Example/outputs/distribution/truck" directory. Finally, the time-of-day factors in "tod\_split.csv" file are applied to these truck and CV trips to split them into three time periods (am peak, pm peak and off-peak) and the split truck and CV trips are added to the auto trip matrices in the ".../2018\_Example/outputs/tod/" directory. See the tables "Trucks" and "ComVeh4T" in the "trips\_X.mtx" files (where X = am, pm, or op).

#### Outputs:

- .../2018\_Example/outputs/tod/trips\_X.mtx (where X = am, pm, or op) (see the matrix names listed above)



## 2.12 Assign Highway Trips: 13 – HighwayAssignment.rsc

**Description:** This module loads the travel demand represented by vehicle trip tables to the highway network. In addition, it also updates the highway network with the predicted congested travel time and checks the convergence of the model based on the Percent RMSE (root mean square error) calculated from the highway assignment results.

**Inputs:**

File/Property Name	Scenario Location ("nwarpc_model/scenarios/")	Copied From ("nwarpc_model/resource/")	Description
Streets.dbd	.../2018_Example/inputs/gis/Streets/	.../data/gis/streets/NWAMPA_Master_Network.dbd	Scenario-specific Highway layer that has been extracted from the Master file
streets_am.net streets_pm.net streets_op.net	.../2018_Example/outputs/assignment/	Not applicable, these files only exist as a scenario output	These networks are created by "02 – HighwaySkim.rsc" and are required for highway assignment
trips_am.mtx trips_op.mtx trips_pm.mtx	.../2018_Example/outputs/tod/	Not applicable, these files only exist as a scenario output	Contains auto, truck and commercial trip matrices by time period (am peak, pm peak and off-peak)
Feedback convergence threshold	.../2018_Example/inputs/nwarpc.properties	.../parameters/settings/nwarpc.properties	Threshold (0.01) set for checking the convergence before starting a new feedback loop

**Methodology:** This module assigns auto, truck and commercial vehicle trips to the highway network. In one of the previous modules, the vehicle trip tables were created by three time periods - AM peak, PM peak and Off-peak. In this module, they are assigned to their corresponding highway networks (i.e., streets\_am.net, streets\_pm.net and streets\_op.net). NWARPC model uses "User Equilibrium" as the highway assignment algorithm. This minimizes the travel cost for all vehicle trips assigned to the network in such a way that no traveler can improve their travel time by changing the paths in the network. This is an iterative assignment algorithm that calculates congested travel time as a function of link volume and shifts travelers to the shortest path. After each iteration within the highway assignment, the user equilibrium traffic assignment algorithm computes a relative gap based on the difference between the previous and current iteration volumes. The algorithm stops when a pre-selected relative gap/convergence criteria is achieved, indicating the network has reached equilibrium and users have found their optimal paths. In the user equilibrium procedure, the Bureau of Public Roads (BPR) curve was used as the cost delay function. The alpha and beta values required in the BPR curve were set to 0.15 and 4. After the highway assignment, to convert the traffic flows into passenger car equivalent flows, the PCE (passenger car equivalent) factors in the table below was used for truck and commercial

vehicles. The convergence criteria set within the highway assignment is 0.0001 and the maximum iteration specified is 1000.

Vehicle Class	PCE Factor
Truck	2.1
Commercial Vehicle	1.5

In this module, a travel time feedback loop was also implemented to ensure that the destination choice and mode choice models are exposed to the level-of-service predicted by the assignment module. After the highway assignment, the average congested travel time on the highway links is calculated using the Method of Successive Averages (MSA) procedure and the highway network is updated with the average travel time for use in the next feedback loop. Although the user sets the maximum number of iterations for feedback loops, the model can converge before that depending on the percent root-mean square error (PRMSE) calculated from the highway assignment results. Specifically, after each iteration, percent root mean square error (PRMSE) is calculated and compared with the convergence threshold set (0.01) in the property file. If the convergence criteria are met (i.e.,  $PRMSE < 0.01$ ), the model run stops.

#### Outputs:

- .../2018\_Example/outputs/assignment/assignment\_"X"\_iteration"Y".bin (where X = am, pm, or op; Y = 1 to 10 depending on the max number of iterations set by the user in the GUI or when the model converges)
- .../2018\_Example/outputs/assignment/assignment\_rmse\_"X".csv (where X = am, pm, or op)

## 2.13 Assign Transit Trips: 14 – TransitAssignment.rsc

**Description:** This module assigns transit trips to the transit network. The output files are saved in the ".../2018\_Example/outputs/assignment/transit" directory.

#### Inputs:

File/Property Name	Scenario Location ("nwarpc_model/scenarios/")	Copied From ("nwarpc_model/resource/")	Description
mode_table.bin	.../2018_Example/inputs/assignment/	.../parameters/assignment/	Provides transit hierarchy and defines access modes
transit.rts; transitS.bin	.../2018_Example/inputs/gis/transit/	.../data/gis/transit/routes; route_lines; route_stops	Scenario-specific Transit route files that have been built from the CSV files in the resource directory when scenario was created.
trips_transit_pk.mtx trips_transit_op.mtx	.../2018_Example/outputs/tod/	Not applicable, these files only exist as a scenario output	Transit trips by time period (peak and off-peak)

**Methodology:** This module first creates transit networks for each time period (AM Peak, PM Peak and Off-peak) and each access mode (walk and drive). Headway and fare information from the route file (transit.rts) and stop information (e.g., presence of park and ride options) from the stop file (transitS.bin) are used to create these networks. The network files (transit\_assignment\_X\_Y.tnw where X = am, pm or op; Y = walk, pnr or knr) are saved in the ".../2018\_Example/outputs/assignment/transit/" directory. Next, the previously split transit trip tables by time period are assigned to their corresponding transit networks in production-attraction (PA) format. Specifically, the peak transit trips are assigned to AM network (the PM network is not used) and the off-peak transit trips are assigned to the Off-peak network. A mode table which provides transit hierarchy and defines access modes is used in building the transit paths for transit assignment.

#### Outputs:

Transit Networks for Assignment:

- .../2018\_Example/outputs/assignment/transit/transit\_assignment\_"X"\_"Y".tnw (where X = walk, pnr or knr; Y = pk or op)

Transit Assignment Outputs:

- .../2018\_Example/outputs/assignment/transit/"X"\_transit\_"Y"\_aggregate\_flow.bin (where X = walk, pnr or knr; Y = pk or op)
- .../2018\_Example/outputs/assignment/transit/"X"\_transit\_"Y"\_on\_off.bin (where X = walk, pnr or knr; Y = pk or op)
- .../2018\_Example/outputs/assignment/transit/"X"\_transit\_"Y"\_flow.bin (where X = walk, pnr or knr; Y = pk or op)
- .../2018\_Example/outputs/assignment/transit/"X"\_transit\_"Y"\_walk\_flow.bin (where X = walk, pnr or knr; Y = pk or op)

## 2.14 Automated Reports: 15 – Reports.rsc

**Description:** This module encapsulates several reporting procedures and each is described below:

**Highway and Transit Assignment Summary** – the assignment module produces results for each iteration so the output directory has many files. This summary includes the relevant information in a line layer that can be used for reporting and mapping results. The processed summaries are saved in the ".../2018\_Example/outputs/reports" directory.

#### Inputs:

File/Property Name	Scenario Location ("nwarp_model/scenarios/")	Copied From ("nwarp_model/resource/")	Description
Streets.dbd	.../2018_Example/inputs/gis/streets/	Not applicable, this file only exists as a scenario output	Scenario-specific Highway layer that has been extracted from the Master file

## Northwest Arkansas Regional Planning Commission

assignment_"X"_"Y".bin (where X = am, pm or op; Y = iteration4 if the max iteration is set to 4)	.../2018_Example/outputs /assignment/	Not applicable, these files only exist as scenario outputs	Highway assignment outputs
transitS.dbd; transitR.bin	.../2018_Example/inputs /gis/transit/	.../data/gis/transit/routes; route_lines; route_stops	Scenario-specific Transit route files that have been built from the CSV files in the resource directory when scenario was created
"X"_transit_"Y"_on_off.bin (where X = walk, pnr or knr; Y = pk or op)	.../2018_Example/outputs /assignment/transit/	Not applicable, these files only exist as scenario outputs	Transit assignment outputs

**Methodology:** The highway assignment module generates the outputs by three time periods – AM peak, PM peak and Off-peak. The output files contain traffic volumes by different modes such as drive alone, shared ride 2, shared ride 3+, commercial vehicle and truck. The volumes are aggregated by main mode (e.g., auto and truck) and attached to the highway line layer. Depending on the requirements, the user can summarize the volumes by time period or for the entire day. The following fields are added to the “assignment\_X.dbd” (where, X = am, pm, op or daily) files.

Fields	Description
total_flow_pce	Passenger Car Equivalent Volume
total_flow_da	Drive Alone Volume
total_flow_sr2	Shared Ride 2 Volume
total_flow_sr3	Shared Ride 3+ Volume
total_flow_drvraz	Drive to Razorback Volume
total_flow_comveh	Commercial Vehicle Volume
total_flow_autos	Auto Volume (da+sr2+sr3+drvraz+comveh)
total_flow_trucks	Truck Volume
total_flow	Total Volume (autos + trucks)

As discussed in the previous section, the transit assignment module generates the outputs by time period (peak and off-peak) and access mode (walk, pnr and knr). The output files contain boardings and alightings at different stops of the Ozark and Razorback routes. In this module, the boardings/alightings at different stops are aggregated by transit route and the daily ridership is attached to the route file in a field called “Daily\_Ridership”.

### Outputs:

#### Highway Assignment Summary:

- .../2018\_Example/outputs/reports/assignment\_X.dbd (where, X = am, pm, op or daily). – see the fields listed above

#### Transit Assignment Summary:

- .../2018\_Example/outputs/reports/TransitRidershipSummary.bin – see the field listed above

**LOS Mapping** – In order to evaluate the effectiveness of future system improvements and transportation policies, DAILY level-of-service (LOS) maps are created for the Freeways, Multi-lane Highways, Rural 2-lane Highways, and Signalized Principal Arterials. The FHWA Tables ([Simplified Highway Capacity Calculation Method - Appendix A - Policy | Federal Highway Administration \(dot.gov\)](#)) were used for determining a daily capacity and for the definition of LOS breakpoints. There are 4 tables relevant for this exercise:

1. Table 13 – Freeway Generalized Service
2. Table 14 – Multi-lane Highway
3. Table 15 – Signalized Highway
4. Table 17 – Rural 2-lane Highway

Below is a description of how each is mapped to the roadways in the NWARPC network. The tables are described below in increasing order of difficulty.

**Table 13 Freeway Generalized Service** is segmented by Rural/Urban; 4,6,8,10,12 lanes; and 0,10,20,30% trucks – the Urban, 4 or 6 lanes, 10% trucks service levels were used.

The links that fall in the Freeway Generalized Service category are defined by the following SELECTION CRITERIA: HCMType = "Freeway" and ramp != "Yes" (see RED LINKS in Figure below).

**Table 17 Rural 2-lane Highways** is segmented by speed limit, terrain (flat, rolling, mountainous), and % trucks (0-10) – the 50mph, flat, 10% truck service levels were used. These are Rural arterials that have 1 lane in each direction. Note that Table 17 only has breakpoints for LOS B, C and D (not E or F).

SELECTION CRITERIA: (HCMType = "PrArterial" or HCMType = "MinArterial") and AreaType = "Rural" and ((DIR=0 and total\_lanes = 2) or (DIR != 0 and total\_lanes = 1)) and ramp != "Yes" (BLUE LINKS in Figure below).

The split between Multi-lane Highway and Signalized Highway basically comes down to AreaType. The Multi-lane Highways are at least 2 lanes in each direction and are not in the Urban areas where there are traffic signals.

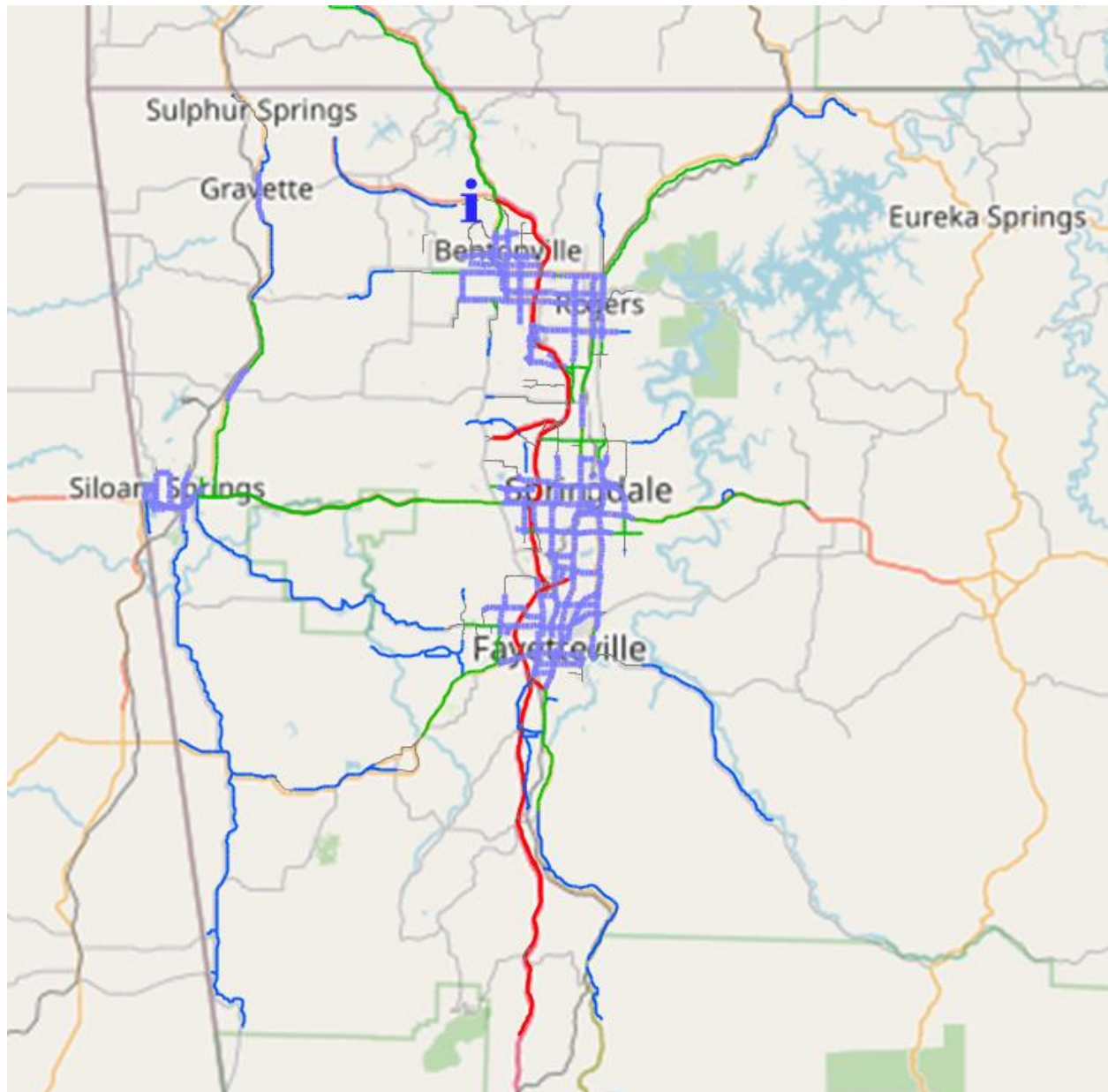
**Table 14 Multi-lane Highway** is segmented by Rural/Urban; 4,6,8,10,12 lanes; 0,10,20,30% trucks – the links in this selection criteria are Rural and have at least 4 lanes (2 in each direction). The Rural, 4-lane, 20% trucks service levels were used.

SELECTION CRITERIA – (HCMType = "PrArterial" or HCMType = "MinArterial") and (AreaType = "Rural" or AreaType = "Suburban") and (DIR=0 and total\_lanes > 2 or DIR != 0 and total\_lanes >= 2) and ramp != "Yes" (GREEN LINKS in Figure below).

**Table 15 Signalized Highway** is segmented by 2,4,6,8 lanes; seconds of Green Time for signals, and Speed Limit (35-60). These links are Urban or Suburban and have either 6, 4 or 2 lanes, with speed limits that vary between 65 and 25. The 2-, 4-, 6-lane, 50 seconds of Green Time, Speed Limit 40 service levels were used.

SELECTION CRITERIA - (HCMTType = "PrArterial" or HCMTType = "MinArterial") and (AreaType = "Urban") and ramp != "Yes" (PURPLE LINKs in the Figure below).

**Figure 4 – Roadways classified for LOS mapping**



The LOS maps by default will not show Centroids, or Local and Collector roadways. And “Open Street Map” is used as the imagery behind the map to show the study area.

Inputs:

File/Property Name	Scenario Location ("nwarpc_model/scenarios/")	Copied From ("nwarpc_model/resource/")	Description
Assignment_daily.dbd	.../2018_Example/outputs /reports	Not applicable, this file only exists as a scenario output	Daily summary of assignment results – either produced as a result of user running the summary or as part of this procedure if the summary wasn't already run.
Level_of_service_volumes.bin	.../2018_Example/inputs /assignment/	parameters/assignment	Relevant rows from the FHWA LOS tables referenced above

Methodology: The procedure uses the AreaType, HCMType, and number of lanes functional classifications in the scenario street layer to create the selection sets defined above. Using the LOS breakpoints from the tables, that are copied into the level\_of\_service\_volumes.bin file, the LOS is designated for each link. A thematic map is then created of the LOS levels – LOS C or better, LOS D, LOS E and LOS F.

Outputs:

## LOS Mapping:

- .../2018\_Example/outputs/reports/LOS.map

**Mode Share by City** – City and county leaders within the NWARPC jurisdiction were interested in understanding the modes used for trip making with their boundaries. This report provides several summaries:

- Mode\_choice\_summary\_P\_based.html – this summarizes the mode choice results based on the production end of the trip, without consideration of the attraction end. The trips by mode in this summary are trips with the “home” end (i.e. the “production” end) of the trip in the city or county boundary – i.e., summarizes mode of all trips starting in Fayetteville, **ending anywhere in model area.**
- Mode\_choice\_summary\_PA\_based.html – this summarizes the mode choice results based on both the production and attraction end of the trip. The trips by mode in this summary are trips with the “home” end and the “non-home” end in the city or county boundary – i.e., summarizes mode of all trips starting **and ending** in Bentonville.

These reports can be opened in a browser, like Edge or Chrome, but they can also be opened in Word or Excel for further processing or editing. Both files start out with a summary of the entire model area and then a similar summary for each city/county designated.



**There are three parts to the summary:**

- Trips by individual mode and purpose
- Total number of trips and share of trips by collapsed purposes
  - HBO is a combination of HBO and HBSB (shopping and personal business).
  - HBSC (school) is a combination of HBSC and HBU (university)
  - NHB is a combination of NHBO (other) and NHBW (work)
- Total trips and total share of trips by mode
  - Drive is a combination of DA, SR2, SR3 and DRVRAZ (drive to Razorback transit)
  - Transit is a combination of WALK\_TRANSIT (walk to transit), PNR\_TRANSIT (park-n-ride) & KNR\_TRANSIT (kiss-n-ride)
  - Non-motorized is a combination of BIKE and WALK.

Below is an example for Rogers:

**Figure 5: Example of Mode Summary Report (City of Rogers)**

<b>City: Rogers</b>								
Mode	HBW	HBO	HBSB	HBSC	HBU	NHBO	NHBW	Total
BIKE	256	167	103	30	27	217	39	839
DA	36,714	34,619	58,011	8,219	1,000	53,231	12,021	203,815
DRVRAZ	0	0	0	0	101	0	0	101
KNR_TRANSIT	1	4	1	3	0	2	0	11
PNR_TRANSIT	2	4	1	3	4	2	0	16
SR2	4,216	6,004	5,296	1,585	176	14,422	3,169	34,868
SR3	1,293	7,710	2,296	2,208	2	20,415	4,633	38,557
WALK	1,812	2,044	1,297	830	40	1,481	193	7,697
WALK_TRANSIT	5	2	6	5	18	3	0	39
Total	44,299	50,554	67,011	12,883	1,368	89,773	20,055	285,943
Purpose	Total Trips							% Trip Share
HBW	44,299							15.5
HBO	117,565							41.1
HBSC	14,251							5.0
NHB	109,828							38.4
Mode	Total Trips							% Trip Share
Drive	277,240							97.0
Transit	167							0.1
Non-motorized	8,536							3.0



Inputs:

File/Property Name	Scenario Location ("nwarpc_model/scenarios/")	Copied From ("nwarpc_model/resource/")	Description
taz.dbd	/2018_Example/inputs/gis/taz.dbd	/data/gis/NWAMPA_Master_TAZ.dbd	Scenario-specific TAZ file (TAZ spec)
mc_trips_{purpose}.mtx"	.../2018_Example/outputs/mode_choice	Not applicable, only exists as a model output	Matrices in Production/Attraction format that contain the results of the mode choice model. One matrix for each purpose, one core for each mode.

**Methodology:** There are two fields in the Master TAZ file that are copied into the scenario TAZ file when the scenario is created – they are “county” and “city”. The summary uses those fields to determine the production and attraction zones to include for the P\_based and the PA\_based summaries. The code the runs the summary is written in R and requires the Pandoc library. All required executables come packaged with the NWARPC model and are in the nwarpc\_model/resource/runtime directory. The summary will be run for the selected scenario when the User presses the “Mode Choice Summary” button on the Post Process tab of the NWARPC model interface.

Outputs:

Mode Share by City:

.../2018\_Example/outputs/reports/mode\_choice\_summary\_P\_based.html

.../2018\_Example/outputs/reports/mode\_choice\_summary\_PA\_based.html

## 2.15 Development of Parking Costs

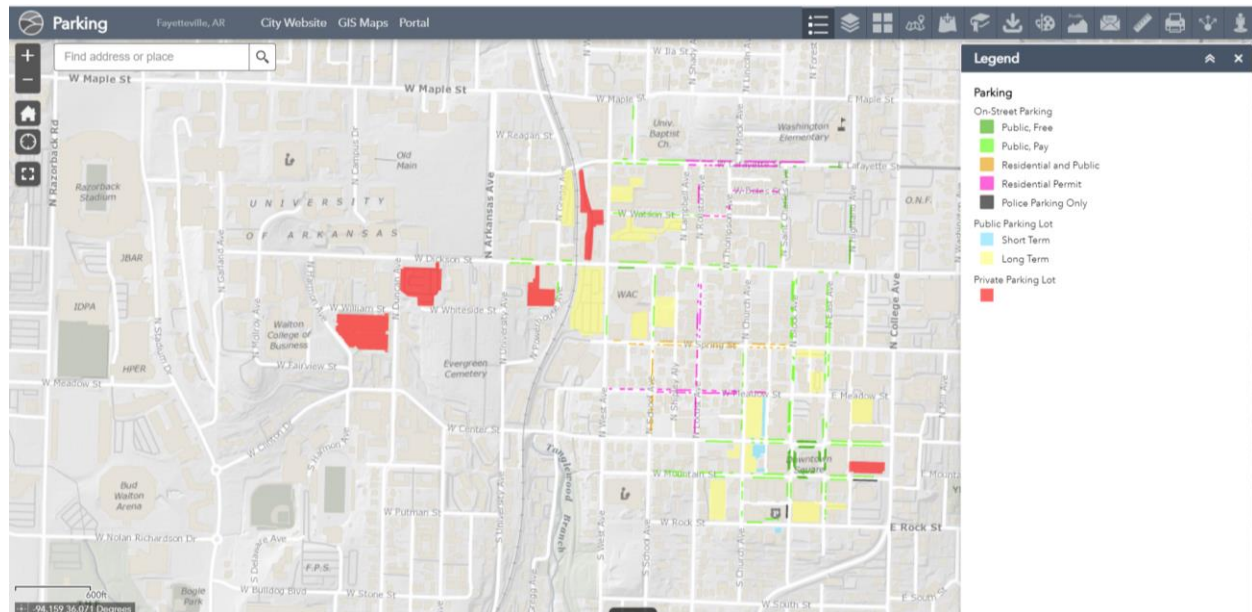
To estimate the average parking cost for work and non-work trips in zones with paid parking, the following procedure was used:

1. Identify the parking facilities within each zone, including single- and multi-level parking garages, parking lots, metered and non-metered street parking.
2. Collect information on the fee structure and/or permit requirements for each facility.
3. Develop an estimate of the parking cost associated with a typical work and a typical non-work trip during a weekday at each facility.
4. Estimate the number of parking spaces at each facility.
5. Develop a weighted average parking cost for work and work trips associated with each zone based on the cost per facility (from step 3) and the spaces per facility (from step 4) in the zone.

The steps of the procedure are explained in the more detail below.

## Step 1 - Identify parking facilities

In downtown Fayetteville there are public and private parking lots and garages as well as on-street parking spaces. On-street parking includes paid (metered) parking, free parking and parking for which a residential permit is required. A map of the parking in downtown Fayetteville can be accessed via the City of Fayetteville GIS Portal (<https://maps.fayetteville-ar.gov/portal/home/index.html>)



Source: <https://maps.fayetteville-ar.gov/viewer/index.html?webmap=e9aa8a59892a48479f085778c9d3774c>

## Step 2 – Collect data on parking cost and restrictions for each parking facility

The GIS Portal parking map used in Step 1 includes attribute data on the parking fee structure during weekdays and weekends for each facility. For some paid facilities, the parking fee varies throughout the day. Some facilities are reserved for permit holders all or part of the day.

## Step 3 - Estimate parking cost for work and non-work trip for each facility

Based on a review of the fee structure in Step 2, estimate the cost of parking for a typical work trip and a typical non-work trip at each facility. The current parking cost estimates were based on the following assumptions:

**Work Trip:** A work trip was assumed to require 8 hours of parking during business hours. The parking cost for work trips was calculated by multiplying the facility's hourly cost between 8AM and 5PM by 8 or, if available, the full-day parking cost. For some facilities, the cost was adjusted to reflect the 2-hour free parking that is offered for some facilities. For University of Arkansas (UA) facilities, a permit is required during business hours. The cost of UA parking for a work trips was assumed to equal the average daily cost of a UA parking permit, which was estimated by dividing the annual parking permit

cost for UA faculty and students by 180 school days. For garages with a monthly rental fee, the average daily cost for work trips was estimated by dividing the monthly cost by 20 workdays.

**Non-Work Trip:** A non-work trip was assumed to require 4 hours of parking and was assumed to occur during business hours or in the evening. The parking cost for a non-work trip was calculated by multiplying the facility's hourly cost by 4. For some facilities the cost was reduced because the facility offers 2 hour free parking. In some locations the cost of street parking after 5PM is higher than during business hours while in other locations street parking become free after 6PM. To estimate an average parking cost associated with non-work trips, it was assumed that a portion of the non-work parking at each facility would occur after 5PM or 6PM. The portion ranged from 50 percent of trips after 5PM to 25 percent of trips after 6PM.

#### **Step 4 – Estimate number of spaces by facility**

Estimates of the number of spaces at each parking lot and garage were obtained from Parkopedia (<https://en.parkopedia.com>). The number spaces were summarized by TAZ. For each TAZ, the number of spaces was increased to reflect the on-street parking spaces not included in the Parkopedia data. If detailed data on the number of street parking spaces becomes available, the information can be added to this parking inventory to refine the estimate of the total number of parking spaces by facility and by TAZ.

#### **Step 5 – Develop weighted average work and non-work parking cost by TAZ**

At the start of this step, facilities with the same fee structure that are located within the same TAZ were grouped (see Table 1: Estimated Parking Cost by TAZ.) For each facility group, the number of spaces in the group as a percent of the total number of spaces in the TAZ was calculated and then multiplied by the work trip parking cost for that group.

Next, the resulting weighted work trip parking costs were summed at the TAZ level. The calculations were repeated for non-work trips.

The result, which is shown in bold in the parking cost columns in Table 1, is the weighted average parking cost for work and non-work trips for each TAZ with paid parking. Because no parking cost information was available for TAZ 50600, it was assumed that the average parking cost for TAZ 50600 was the same as for TAZ50021.

**Table 1: Estimated Parking Cost by TAZ**

TAZID	Type of Parking	Owner	Parking Cost Work Trip	Parking Cost Non-Work Trip	Estimated % of Spaces	Parking Cost Work Trip (in bold)	Parking Cost Non-Work Trip (in bold)
			a	b	c	d	e
50010	Parking Lot	PUBLIC	\$2.00	\$0.75	33%	\$0.67	\$0.25
50010	Parking Lot	PUBLIC	\$2.50	\$3.50	67%	\$1.67	\$2.33
<b>50010</b>	<b>All parking in 50010</b>					<b>\$2.33</b>	<b>\$2.58</b>
50021	On-Street Parking	PUBLIC	\$5.00	\$2.00	50%	\$2.50	\$1.00
50021	Residential Permit	PUBLIC	\$0.00	\$0.00	50%	\$0.00	\$0.00
<b>50021</b>	<b>All parking in 50021</b>					<b>\$2.50</b>	<b>\$1.00</b>
50023	On-Street Parking	PUBLIC	\$2.00	\$0.75	40%	\$0.80	\$0.30
50023	On-Street Parking	PUBLIC	\$1.50	\$0.38	9%	\$0.14	\$0.03
50023	Parking Lot	PUBLIC	\$1.33	\$4.00	19%	\$0.26	\$0.77
50023	Parking Lot	PUBLIC	\$5.00	\$2.00	32%	\$1.59	\$0.64
<b>50023</b>	<b>All parking in 50021</b>					<b>\$2.78</b>	<b>\$1.74</b>
50024	Parking Lot	PUBLIC	\$5.00	\$2.00	67%	\$3.33	\$1.33
50024	On-Street Parking	PUBLIC	\$2.00	\$0.75	33%	\$0.67	\$0.25
<b>50024</b>	<b>All parking in 50024</b>					<b>\$4.00</b>	<b>\$1.58</b>
50025	On-Street Parking	PUBLIC	\$1.50	\$0.38	10%	\$0.15	\$0.04
50025	On-Street Parking	PUBLIC	\$2.00	\$0.75	10%	\$0.21	\$0.08
50025	Parking Lot	PUBLIC	\$2.00	\$0.75	79%	\$1.59	\$0.60
<b>50025</b>	<b>All parking in 50025</b>					<b>\$1.95</b>	<b>\$0.71</b>
50031	Parking Lot	PUBLIC	\$4.00	\$2.00	32%	\$1.27	\$0.64
50031	Parking Lot	PRIVATE	\$8.00	\$6.00	57%	\$4.55	\$3.41
50031	On-Street Parking	PUBLIC	\$5.00	\$2.00	11%	\$0.57	\$0.23
<b>50031</b>	<b>All parking in 50031</b>					<b>\$6.39</b>	<b>\$4.27</b>

## Northwest Arkansas Regional Planning Commission

TAZID	Type of Parking	Owner	Parking Cost Work Trip	Parking Cost Non-Work Trip	Estimated % of Spaces	Parking Cost Work Trip (in bold)	Parking Cost Non-Work Trip (in bold)
50032	Parking Lot	PRIVATE	\$1.33	\$7.40	88%	\$1.17	\$6.51
50032	Parking Lot	PRIVATE	\$5.00	\$5.00	11%	\$0.56	\$0.56
50032	On-Street Parking	PUBLIC	\$5.00	\$2.00	1%	\$0.04	\$0.01
<b>50032</b>	<b>All parking in 50032</b>					<b>\$1.76</b>	<b>\$7.08</b>
50060	Residential Permit	PUBLIC	\$0.00	\$0.00			
<b>50060</b>	<b>All parking in 50060</b>					<b>\$2.50</b>	<b>\$1.00</b>

Note:

non-bold entries in column d = column a times column c;

non-bold entries in column e = column b times column c.

### 3 Base Year Model Calibration and Validation

Version 3.0.0 of the NWA TDM was calibrated and validated to confirm that the changes made to the model subcomponents still provided highway and transit assignments that could be validated against observed data in the 2018 base year.

#### 3.1 Trip Generation Calibration

The 2018 trip generation results were calibrated to match the percentage of trip productions by purpose and trip rates by household observed in the 2017 NHTS data. Due to the small number of Arkansas households, the targets also include households from Mississippi, Missouri and Louisiana.

The comparison is shown in Table below. Clearly, the total trips from the survey doesn't match but the percentage of trips by purpose matches reasonably well.

**Table 3-1: 2018 Trip Comparison**

Trip Purpose	Observed (2017 NHTS)		Estimated (Model)	
	Trips	Percent	Trips	Percent
Home-based Work (HBW)	8,901,384	15%	327,342	17%
Home-based University (HBU)	412,322	1%	27,899	1%
Home-based School (HBSC)	1,606,200	3%	88,235	5%
Home-based Shopping Business (HBS)	15,530,720	26%	469,221	24%
Home-based Other (HBO)	12,206,072	20%	373,616	19%
Non-home Based Work (NHBW)	3,971,321	7%	132,722	7%
Non-home Based Other (NHBO)	17,468,043	29%	503,012	26%
All	60,096,062	100%	1,922,047	100%

The observed trips per household were 9.9 and the modeled trips per household were 9.8. This aligns with values in other regions which range between 8 and 10 daily trips per household on average.

#### 3.2 Calibration of Destination Choice

The calibration of the destination choice model focused on trip-length frequency distributions by purpose and average trip lengths by purpose. The 2017 NHTS data was used to develop the targets. The first table shows average trip lengths by purpose.

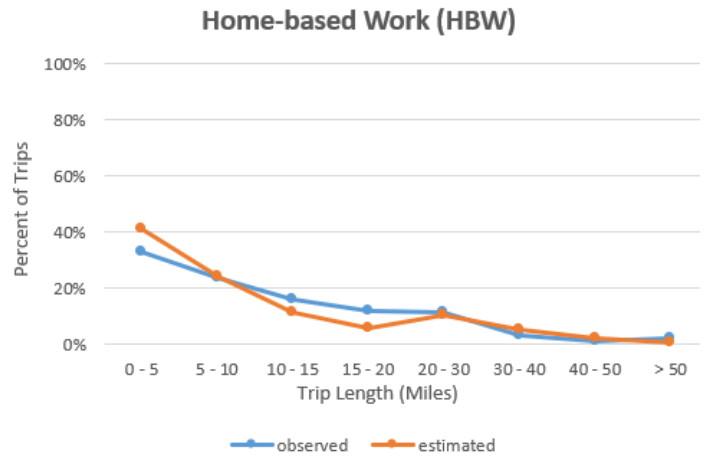
**Table 3-2: Average Trip Length (Miles) by Trip Purpose**

Trip Purpose	Observed Average Length	Estimated Average Length
Home-based Work (HBW)	11.9	10.6
Home-based University (HBU)	7.6	5.3
Home-based School (HBSC)	5.8	6.8
Home-based Shopping Business (HBSB)	6.7	4.9
Home-based Other (HBO)	9.1	7.1
Non-home Based Work (NHBW)	11.5	8.7
Non-home Based Other (NHBO)	7.4	6.3

The figures below show the percentage of trips in each distance bin and the observed vs. estimated graphs.

**Figure 3-1 – Home-based Work**

<b>Figure 1: Trip Length Frequency Distributions (TLFD) by Purpose</b>		
<b>Home-based Work (HBW)</b>		
Distance Categories (Miles)	Percentage	
	Observed	Estimated
0 - 5	33%	41%
5 - 10	24%	24%
10 - 15	16%	11%
15 - 20	12%	6%
20 - 30	11%	10%
30 - 40	3%	5%
40 - 50	1%	2%
> 50	2%	1%
Total	100%	100%



**Figure 3-2: Home-based University**

<b>Home-based University (HBU)</b>		
Distance Categories (Miles)	Percentage	
	Observed	Estimated
0 - 5	79%	76%
5 - 10	0%	8%
10 - 15	6%	4%
15 - 20	2%	2%
20 - 30	6%	6%
30 - 40	5%	3%
40 - 50	0%	0%
> 50	2%	0%
Total	100%	100%

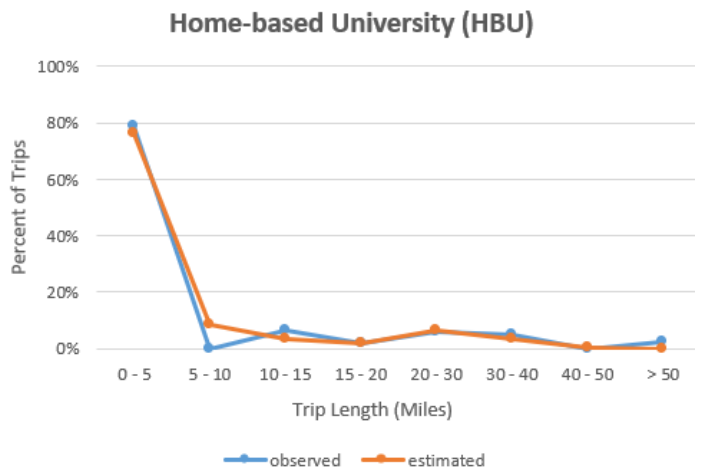


Figure 3-3: Home-based School

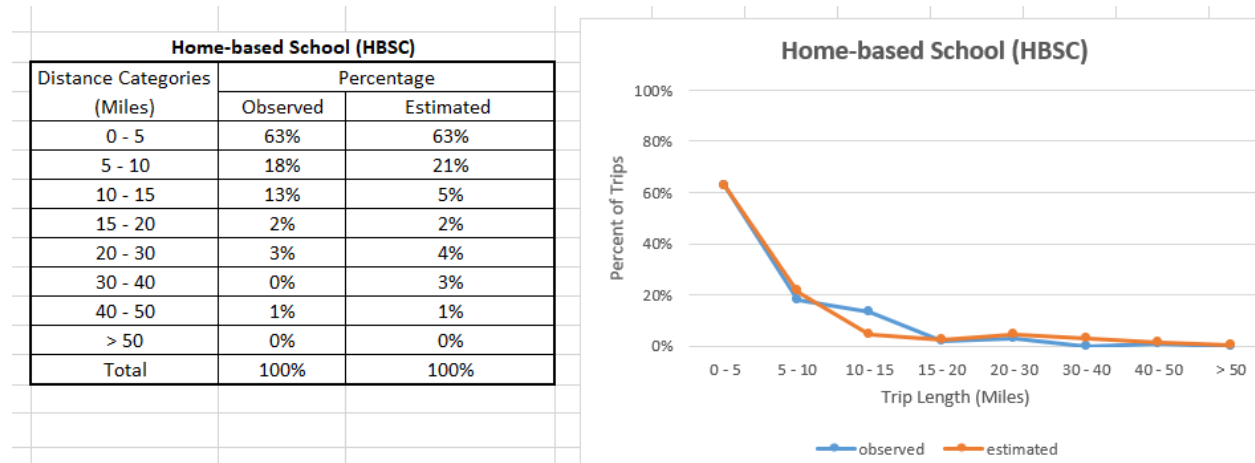


Figure 3-4: Home-based Shopping and Personal Business

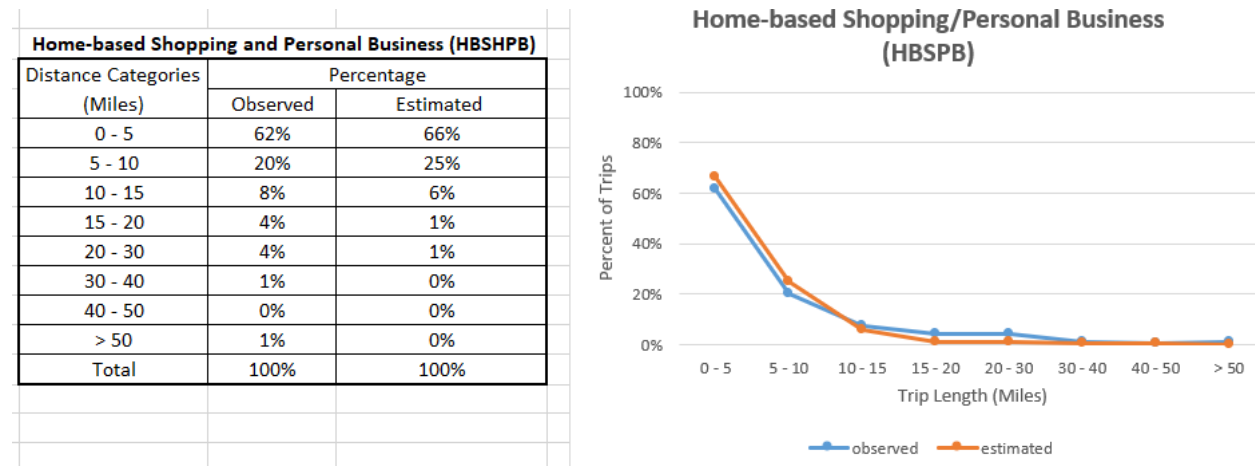
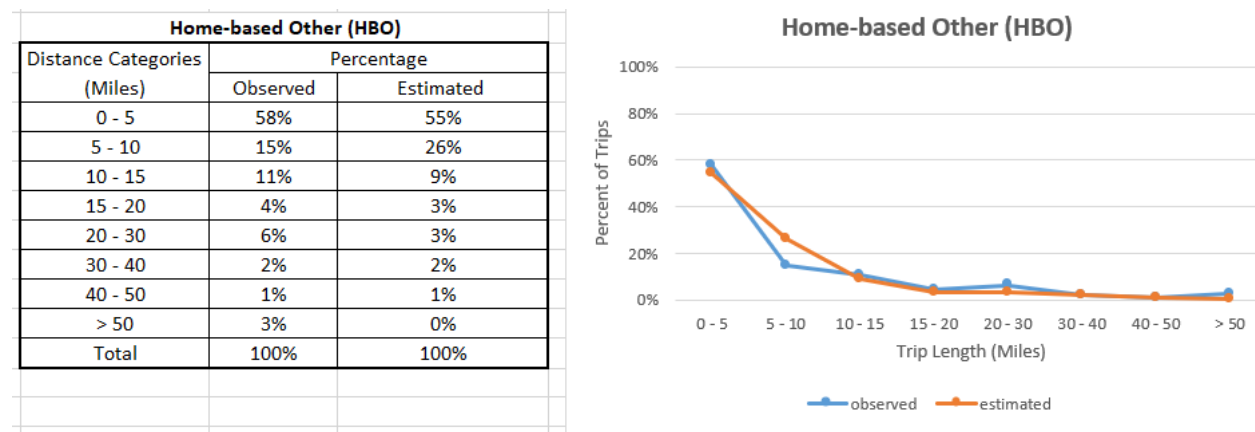
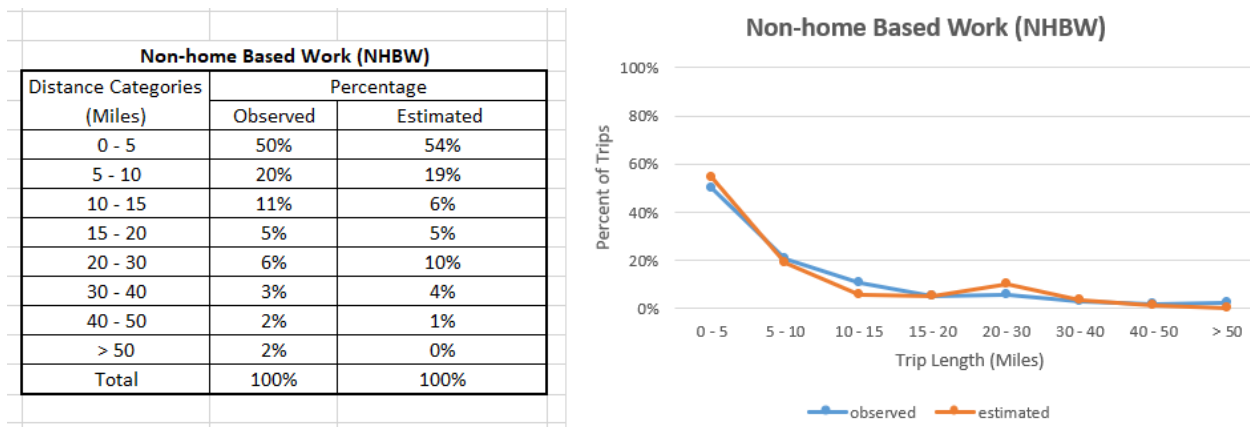
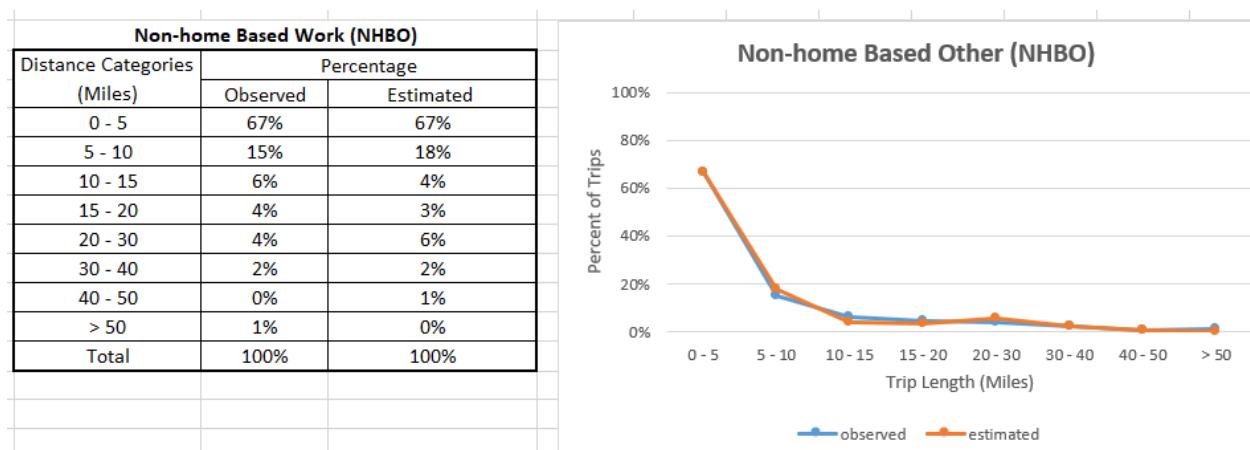


Figure 3-5: Home-based Other





**Figure 3-6: Non-home-based Work****Figure 3-7: Non-home-based Other**

### 3.3 Mode Choice

NWARPC hired ETC in 2017 to complete a transit on-board survey. This survey data was used to calibrate the mode choice model for the 2018 base year. Below are some model comparisons after calibration.

**Table 3-3: Observed to Estimated Mode Shares in NW Arkansas**

Mode	Observed	Estimated
Auto	97.1%	96.2%
Transit	0.6%	0.5%
Non-motorized (walk + bike)	2.3%	3.3%
Total	100.0%	100.0%

Table 3-4: Detailed Observed Mode Shares to Modeled Shares

Observed							
Trip Mode	Observed Trip Percent						
	HBW	HBU	HBSC	HBSB	HBO	NHB	Total
Drive Alone	87%	47%	61%	87%	69%	58%	68%
Shared Ride 2	8%	9%	13%	8%	11%	16%	13%
Shared Ride 3	3%	1%	20%	4%	17%	24%	17%
Drive to Razorback (>= 5 miles)	0%	4%	0%	0%	0%	0%	0%
Walk to Transit	0%	21%	0%	1%	0%	0%	0%
PnR to Transit (<5 miles)	0%	4%	0%	0%	0%	0%	0%
KnR to Transit	0%	0%	0%	0%	0%	0%	0%
Walk	2%	11%	5%	1%	3%	2%	2%
Bike	0%	2%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%
Estimated							
Trip Mode	Estimated Trip Percent						
	HBW	HBU	HBSC	HBSB	HBO	NHB	Total
Drive Alone	82%	46%	62%	87%	68%	58%	71%
Shared Ride 2	10%	9%	13%	8%	12%	16%	12%
Shared Ride 3	3%	0%	20%	3%	16%	23%	13%
Drive to Razorback (>= 5 miles)	0%	2%	0%	0%	0%	0%	0%
Walk to Transit	0%	23%	0%	0%	0%	0%	0%
PnR to Transit (<5 miles)	0%	5%	0%	0%	0%	0%	0%
KnR to Transit	0%	0%	0%	0%	0%	0%	0%
Walk	4%	12%	5%	2%	4%	2%	3%
Bike	0%	2%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%

As part of the mode choice update, it was confirmed that the mode choice model (and the destination choice model via the mode choice logsums) is sensitive to parking costs. Eight zones in Fayetteville require drivers to pay to park. These zones have a mix of on-street parking and parking garages with rates ranging from 25 cents per hour up to \$5 for all day parking. To test the sensitivity of the model, a cost of \$20 for work trips (in all zones) and \$5 for non-work trips (in all zones) was modeled and compared to the results with parking costs set to \$0. The Mode Share by City (PA) results for Fayetteville illustrate that the overall percentage of drive trips decreases by 1% and the transit and non-motorized percentages increase from 7.6% to 8.9%. These results indicate that parking costs are not a significant deterrent to driving but do impact the mode shares slightly.

**WITHOUT PARKING COST**

Mode	Total Trips	% Trip Share
Drive	323,855	92.4
Transit	7,892	2.3
Non-motorized	18,589	5.3

**WITH PARKING COST (\$20 for Work and \$5 for Non-Work Purposes)**

Mode	Total Trips	% Trip Share
Drive	316,542	91.1
Transit	8,232	2.4
Non-motorized	22,505	6.5

**3.4 Highway Assignment Validation**

The trip generation, trip distribution and mode choice models were calibrated to observed data and the resulting trips were assigned to either the highway or the transit network, depending on the mode chosen.

There were 900 count locations used to compare the model results to however it should be noted that the NWARPC lacked confidence in the observed highway volumes. The model shows higher freeway volumes but it was decided to leave the validation alone since the observed counts were thought to be low. Table below shows the number of observations by facility type within rural and urban TAZs, the sum of the counts on those links, and the corresponding modeled volumes.

**Table 3-5: Observed vs. Modeled Volumes by Facility Type**

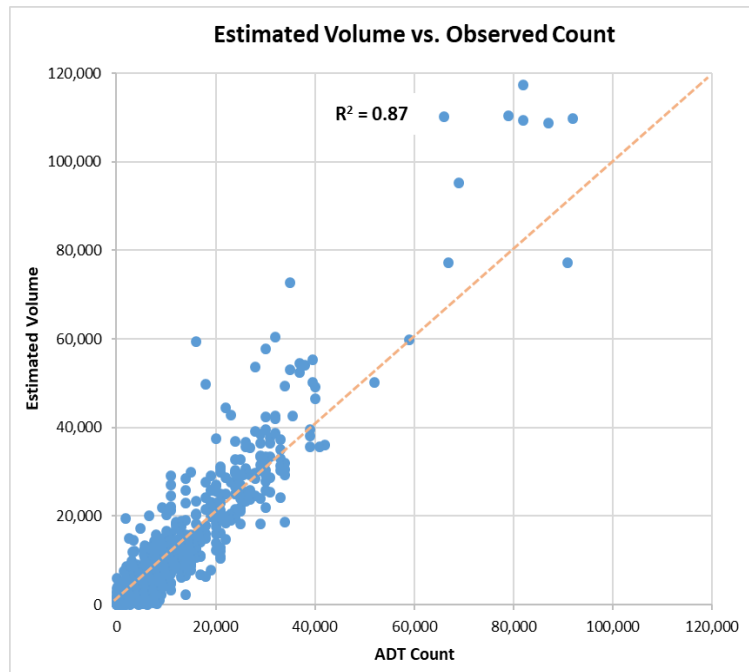
Facility Type	Number of Links with Counts	Observed Count	Estimated Volume	Percent Difference	Percent RMSE
Interstate	24	1,172,500	1,433,455	22%	40%
Principal Arterial	222	4,177,167	4,528,738	8%	37%
Minor Arterial	171	1,328,284	1,434,671	8%	65%
Collector	368	1,528,015	1,411,706	-8%	71%
Local	15	45,790	40,710	-11%	49%
Ramp & Median Cross-over	100	572,630	675,586	18%	57%
<b>Total</b>	<b>900</b>	<b>8,824,386</b>	<b>9,524,867</b>	<b>8%</b>	

Table shows the validation statistics by volume group. The largest variation is again in the high-count links (i.e. the freeways) which is believed to be a problem with the counts, not the modeled values.

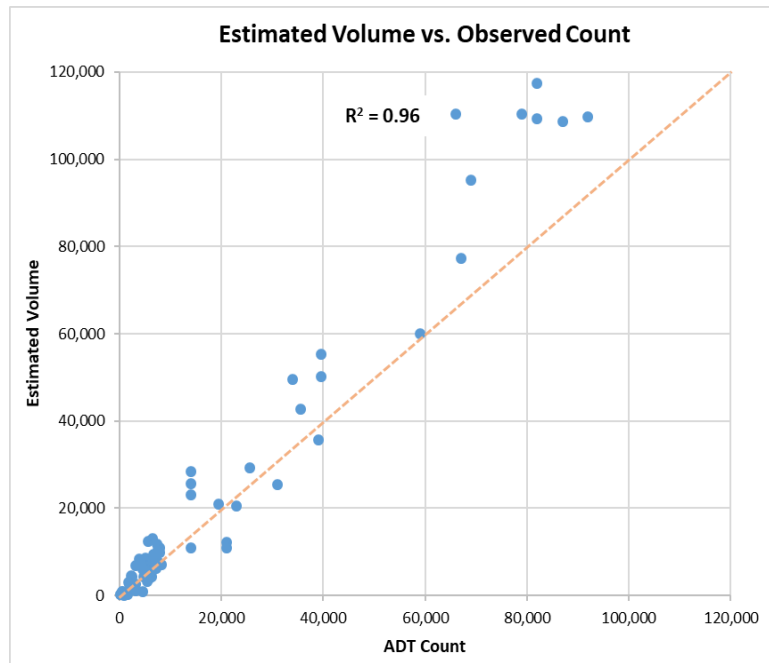
**Table 3-6: Observed vs. Modeled by Volume Group**

Count Range	Number of Links with Counts	Observed Count	Estimated Volume	Percent Difference
< 5000	399	893,464	1,022,824	14%
5000 - 10000	216	1,551,422	1,434,730	-8%
10000 - 20000	143	1,971,500	2,066,158	5%
20000 - 30000	86	2,054,500	2,222,394	8%
30000 - 40000	41	1,364,500	1,585,788	16%
40000 - 50000	4	163,000	167,148	3%
> 50000	11	826,000	1,025,824	24%
<b>Total</b>	<b>900</b>	<b>8,824,386</b>	<b>9,524,867</b>	<b>8%</b>

The scatterplot in Figure below shows the observed count vs. the modeled volume at each count location. If the model replicated the observed counts exactly, then the points on the graph would all lie on the regression line and the R-squared value would be 1.0. The results again are skewed by the freeway counts that may not fully reflect the daily flow. In Figure 3-9, the I-49 counts vs. the I-49 modeled volumes are shown.

**Figure 3-8: Scatterplot and R-squared Value for the 2018 Base Year Model**

**Figure 3-9: Scatterplot and R-squared Value for I-49 Count Locations**



### 3.5 Transit Assignment Validation

The transit validation was done by looking at observed boardings by route for both Razorback and Ozark. Several of the Ozark lines had very low observed boardings which leads to large percent differences when compared to the model values.

**Table 3-7 Observed Boardings Compared to ETC On-board Survey**

Agency	Route	Observed Boardings/Ridership (2018)	Estimated Boardings/Ridership	Percent Difference
Ozark	Route 1	154	38	
	Route 2	83	167	
	Route 3	58	92	
	Route 4	171	127	
	Route 11	86	157	
	Route 51	63	129	
	Route 52	28	56	
	Route 61	87	166	
	Route 62	75	74	
	Route 63	57	91	
	Route 64	14	81	
	Route 490	207	219	
	<b>Ozark Total</b>	<b>1,083</b>	<b>1,397</b>	
				<b>29%</b>
Razorback	Route 1	141	1	
	Route 4	141	0	
	Route 7	20	323	
	Route 11	2,237	2,082	
	Route 13	939	1,479	
	Route 17	122	493	
	Route 22	1,794	1,027	
	Route 26	1,342	2,063	
	Route 33	834	273	
	Route 35	596	202	
	Route 48	1,175	1,712	
	<b>Razorback Total</b>	<b>9,341</b>	<b>9,655</b>	
				<b>3%</b>
	<b>Total</b>	<b>10,424</b>	<b>11,052</b>	<b>6%</b>