NWARPC_Model_v4.0.6

Documentation and Validation of Version 4.0.6 of the NW Arkansas Travel Demand Model

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December 2025

Contents

1 Introduction

The NW Arkansas Regional Planning Commission Travel Demand Model (NWA TDM) was updated in 2024-2025. 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. As of November 2025, version 4.0.6 is the most recent release. The model was built and validated using TransCAD 9 (Build 32960), 64-bit. 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:

- The base year has been updated to 2022 and the long-range forecast horizon year has been updated to 2050.
    - *The 2022 base year update details are discussed further in Appendix A: 2022 Base Year Updates*.
    - *The 2050 horizon year update details are discussed further in Appendix C: 2050 Forecast Year Updates*.
- Scenarios available in this model version are 2022, 2030, 2040 and 2050
- Socioeconomic Forecasts were done by NWARPC and WSP based on data from the Arkansas State Demographer, Woods & Poole, Data Axle, Census Bureau, and Bureau of Labor Statistics data
- Highway and transit networks have been developed by NWARPC
    - 2022 highway reflects current conditions
    - 2022 transit reflects transit networks circa 2024
        - Note: ORD and Razorback have changed from year-to-year post-COVID. 2024 routes and ridership are used as the best representation of base year conditions
    - 2050 master highway networks include links within the fiscally constrained plan and the unconstrained plan.
    - 2050 master transit network include the High-Capacity Transit options (BRT, Light Rail, and Commuter Rail) from the Transit Alternatives Study from 2025.
- The following components of the NWA TDM have been updated:
    - Mode choice model's transit choice set was expanded to include local bus, fixed guideway only, and combined local bus/fixed guideway choices.
        - *More information on the mode choice model update is available in Appendix B: Mode Choice Model Updates*.
    - Roadway capacity calculations were updated to reflect 3 hours of capacity in the AM and PM time periods.

    - Unused and deprecated GISDK macros were removed from/updated in the model code
- Several reporting features were added including:
    - PowerBI workbook and supporting scripts to further automate model reporting and facilitate easier scenario comparisons
    - Volume-to-Capacity ratio maps for all three traffic assignment time periods
    - Updated link selection sets for Level-of-Service (LOS) mapping
    - *More detail on the reporting features is available in the current model user guide "NWARPC Model Users Guide.pdf" available in the "nwarpc_model\resource\documentation" directory of the model package.*
- 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 "2022_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:

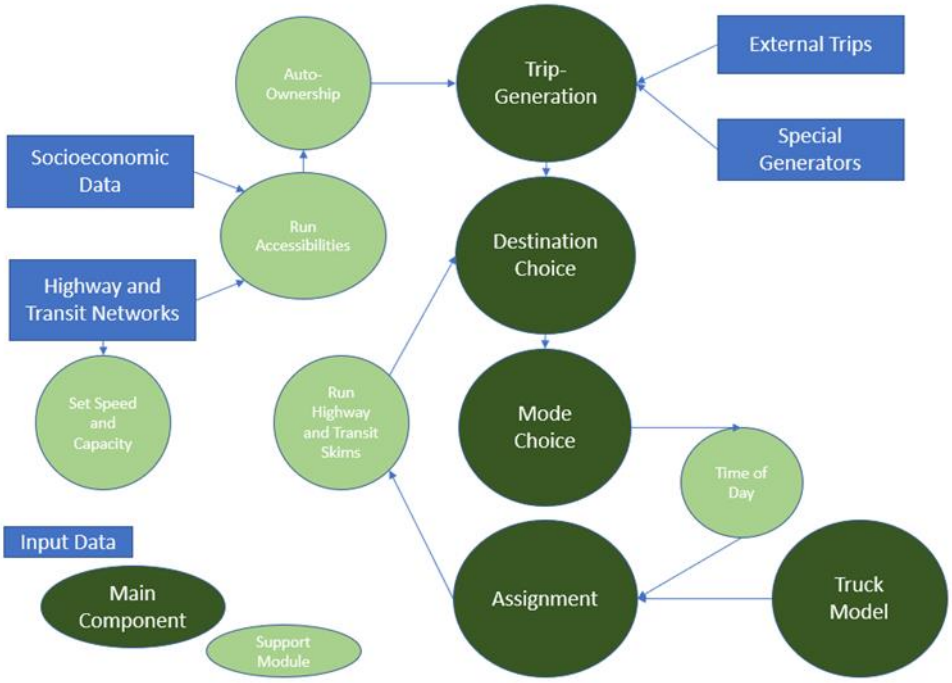
- Section 1 is this introduction
- Section 2 describes each model component, including inputs and outputs
- Section 3 describes the calibration and validation of the revised model to targets in a 2022 base year
- Appendices

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 2-1 - Model v4.0.6 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*	*Copied From ("nwarpc_model/resource/")*	*Description*

	("nwarpc_model /scenarios/")		
Area_type.csv	.../2022_Example/inputs/speed/	.../parameters/speed/	Sets urban, suburban and rural densities and centroid connector speeds
FF_speed.csv	.../2022_Example/inputs/speed/	.../parameters/speed/	Defines adjustments to posted speeds based on Area Type and Functional Classification
Hourly_capacities.csv	.../2022_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	.../2022_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 (HCMType)*
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 HCMType, 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_capacitiy_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/2022_Example/outputs/skims” directory.

Inputs:

File/Property Name	*Scenario Location (“nwarpc_model/scenarios/”)*	*Copied From (“nwarpc_model/resource/”)*	*Description*
Streets.dbd	…/2022_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	…/2022_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	…/2022_Example/inputs/assignment/mode_table.bin	…/parameters/assignment/mode_table.bin	Provides transit hierarchy and defines access modes
Various walk and wait threshold properties	…/2022_Example/inputs/nwarpc.properties	…/parameters/settings/nwarpc.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. 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/2022_Example/outputs/skims/street_skim.mtx
- nwarpc_models/scenarios/2022_Example/outputs/skims/transit_am (and op and pm), drive (and walk)_transit_skim.mtx
- nwarpc_models/scenarios/2022_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	.../2022_Example/outputs/skims/	Not applicable, this file only exists as a scenario output	Walk to transit skims
street_skim_auto_ownership.mtx	.../2022_Example/outputs/skims/	Not applicable, this file only exists as a scenario output	Highway skims
se_data.bin	.../2022_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:

- .../ 2022_Example/outputs/skims/Accessiblity.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	.../ 2022_Example/outputs/ generation	Not applicable, this file only exists as a scenario output	Data file is updated with model results

	Parameter	*Coefficient*
Constants	constant 2 (1-auto)	-0.5299
	constant 3 (2-auto)	-0.2133
	constant 4 (3+ autos)	-3.7739
Size Coefficients	k1hhsize3 (1-auto coefficient for hh size 3)	1.8808
	k2hhsize3 (2-auto coefficient for hh size 3)	2.135
	k3hhsize3 (3+ auto coefficient for hh size 3)	2.9267
	k1hhsize4 (1- auto coefficient for hh size 4+)	3.0977
	k2hhsize4 (2-auto coefficient for hh size 4+)	3.8765
	k3hhsize4 (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)	0.445
	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)	1.583
	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:

- …/2022_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	…/ 2022_Example/outputs/ generation/	Not applicable, this file only exists as a scenario output	Data file is updated with model results
Disagg_hh_joint.csv	…/2022_Example/inputs/ generation/	…/parameters/trip_generation/	Census-based joint distribution used as seed matrix
Prod_rates_work.csv	…/ 2022_Example/inputs/ generation/	…/parameters/trip_generation/	Production rates by joint distributions for work purposes (HBW and NHBW)

Prod_rates_nonwork.csv	.../ 2022_Example/inputs/generation/	.../parameters/trip_generation/	Production rates for non-work purposes (with exception of HBU)
Attr_rates.csv	.../ 2022_Example/inputs/generation/	.../parameters/trip_generation/	Formulas for determining resident trip attractions
Univ_generation.csv	.../ 2022_Example/inputs/generation/	.../parameters/trip_generation/	Formulas for determining university productions and attractions
Special_generator_data.bin	.../2022_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.

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

- 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:

l_HBWa_v0	HBW attractions for 0-car households
l_HBWa_vHi	HBW attractions for High Income, Vehicle-Insufficient households
l_HBWa_vHs	HBW attractions for High Income, Vehicle-Sufficient households
l_HBWa_vLi	HBW attractions for Low Income, Vehicle-Insufficient households
l_HBWa_vLs	HBW attractions for Low Income, Vehicle-Sufficient households
l_HBSCa	HBSC attractions
l_HBSBa	HBSB attractions
l_NHBOa	NHBO attractions
l_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 couple of combinations to note:

- 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).
- 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:

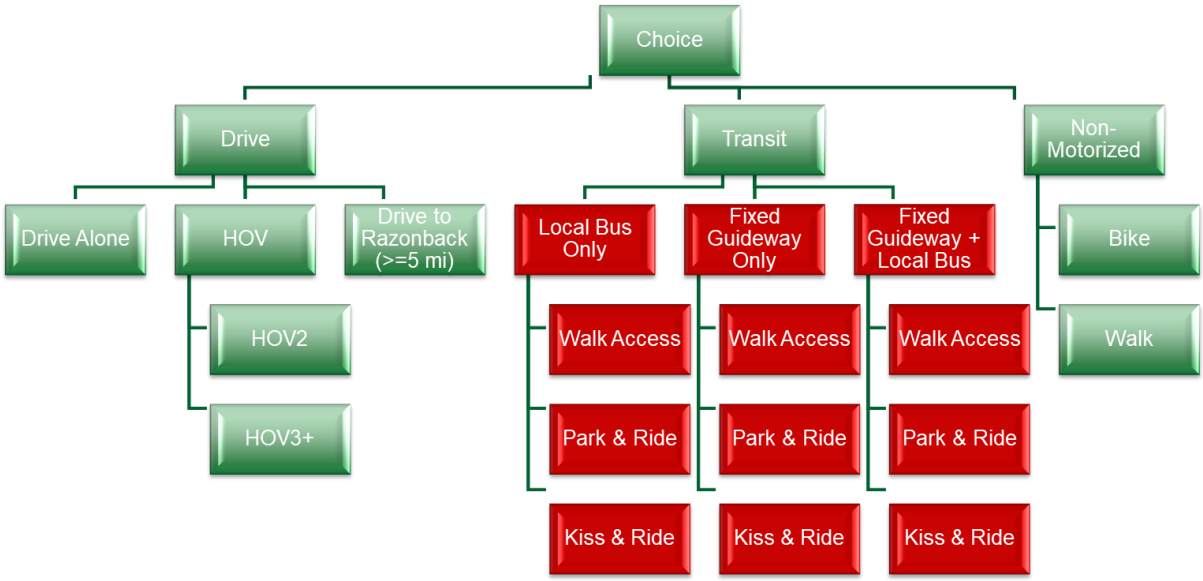
- .../ 2022_Example/outputs/generation/HHDisaggregation.csv

- .../2022_Example/outputs/generation/productions.csv
- .../2022_Example/outputs/generation/se_data.bin
- .../2022_Example/outputs/generation/balance_report.csv
- .../2022_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 2-2 - Mode Choice Model Structure



Inputs:

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.

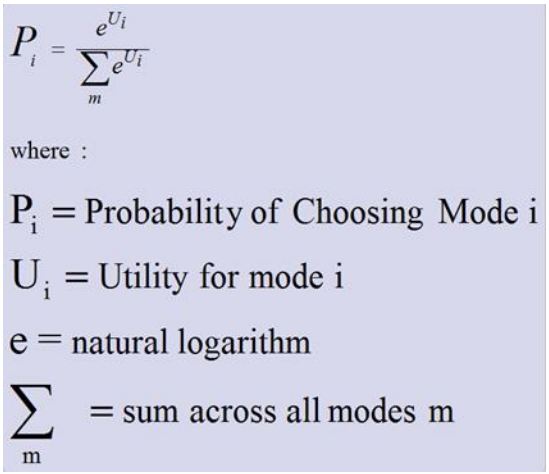
The parking costs for TAZs in Fayetteville were recently updated (they were $0 in previous datasets). There is now a "work" and "non-work" cost for eight zones in the model. The "work" cost is used in the mode choice calculations for the HBW purposes and the "non-work" cost is used for all other purposes. 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 2-3 - General Formula of a Logit Model



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.

Outputs:

Mode Choice Probability Matrices:

- .../2022_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)

- .../2022_Example/outputs/mode_choice/mode_choice_probability_X_Z.mtx (where X = hbu, hbsc, hbsb, hbo, nhbw, or nhbo; Z = short, long or none)

Model Specification Files:

- .../2022_Example/outputs/mode_choice/mode_choice_X_Y.mdl (where X = hbw; Y = zero, low_insufficient, low_sufficient, high_insufficient, or high_sufficient)
- .../2022_Example/outputs/mode_choice/mode_choice_X.mdl (where X = hbu, hbsc, hbsb, hbo, nhbw, or nhbo)

Mode Choice Log Files:

- .../2022_Example/outputs/mode_choice/mode_choice_X_Y.log (where X = hbw; Y = zero, low_insufficient, low_sufficient, high_insufficient, or high_sufficient)
- .../2022_Example/outputs/mode_choice/mode_choice_X.log (where X = hbu, hbsc, hbsb, hbo, nhbw, or nhbo)

Other Outputs:

- .../ 2022_Example/outputs/mode_choice/walk_segment_fractions.mtx
- .../ 2022_Example/outputs/mode_choice/stop_access.csv
- .../ 2022_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 ("nwarpc_model/scenarios/")*	*Copied From ("nwarpc_model/resource/")*	*Description*
d_purp_conversion.csv	.../2022_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	.../2022_Example/inputs/distribution/	.../parameters/trip_distribution/	Destination choice model parameters
dc_variables.csv	.../2022_Example/inputs/distribution/	.../parameters/trip_distribution/	Variables used in the destination choice model
template.dcm	.../2022_Example/inputs/distribution/	.../parameters/trip_distribution/	Template required by the GISDK tools for destination choice model
se_bin_file	.../2022_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	.../2022_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	.../2022_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:

- .../2022_Example/outputs/distribution/trips_resident_DL.mtx

Model Specification Files:

- .../2022_Example/outputs/distribution/DL_X_Y.dcm (X = HBW; Y = v0, vLi, vHi, vLs or vHs)
- .../2022_Example/outputs/distribution/DL_X.dcm (X = HBU, HBSC, HBSB, HBO, NHBW, NHBO)

Model Log Files:

- .../2022_Example/outputs/distribution/DL_X_Y.log (X = HBW; Y = v0, vLi, vHi, vLs or vHs)
- .../2022_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	.../2022_Example/outputs/distribution/	Not applicable, this file only exists as output	Destination choice model outputs
walk_segment_fractions.mtx	.../2022_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_hbsc_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)	.../2022_Example/outputs/mode_choice/	Not applicable, these files only exist as a scenario output	Mode choice probability matrices

mode_choice_probability_nhbw_Z.mtx (where, Z= short, long or none) mode_choice_probability_nhbo_Z.mtx (where, Z= short, long or none)			

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 ".../2022_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 ".../2022_Example/outputs/ mode_choice/" directory.

Outputs:

Final Trip Matrices:

- .../2022_Example/outputs/mode_choice/mc_trips_X.mtx (where X = hbw, hbu, hbsc, hbsb, hbo, nhbw or nhbo)

Trip Matrices Before Aggregation:

- .../2022_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)
- .../2022_Example/outputs/mode_choice/mc_trips_X_Z.mtx (where X = hbu, hbsc, 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 ".../2022_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_hbsc.mtx mc_trips_hbsb.mtx mc_trips_hbo.mtx mc_trips_nhbw.mtx mc_trips_nhbo.mtx	.../2022_Example/outputs/mode_choice/	ot applicable, these files only exist as a scenario output	Mode choice trips by purpose
tod_split.csv tod_split_transit.csv	.../2022_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	.../2022_Example/inputs/tod/	.../parameters/tod/	PA and AP factors used to convert the auto trip tables from PA to OD format
Ext_Summary.bin	.../2022_Example/inputs/external/	.../data/external/	2010 ADT by external station, split into trucks, commercial vehicles and cars
EE_Car_Base.mtx	.../2022_Example/inputs/external/	.../data/external/	2010 External-External (E-E) auto trips
sce_ext_year; data_year	.../2022_Example/inputs/nwarpc.properties	.../parameters/settings/nwarpc.properties	Scenario specific model year and data year for the external data
Car_EE_Marginals.dbf	.../2022_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 ".../2022_Example/outputs/mode_choice/mc_trips_X_Y.mtx" files (where, where X = hbw, hbu, hbsc, 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:

- .../2022_Example/outputs/tod/trips_X.mtx (where X = am, pm, or op)
- .../2022_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	.../2022_Example/inputs/generation/truck/	.../parameters/trip_generation/truck/	Truck (single-unit and multi- unit) and commercial vehicle (CV) trip rates
taz.dbd	.../2022_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	.../2022_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	.../2022_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	.../2022_Example/inputs/generation/spgenerator/	.../data/trip_generation/	ITE trip rates for various land-use types
special_gen_splits.csv	.../2022_Example/inputs/generation/spgenerator	.../parameters/trip_generation/	Shares by trip purpose and truck types to split the special generator trips
truck_ffactor.bin	.../2022_Example/inputs/distribution/	.../parameters/trip_distribution/	Friction factors used in truck trip balancing procedure
Ext_Summary.bin	.../2022_Example/inputs/external/	.../data/external/	2010_ADT by external station, split into trucks, commercial vehicles and cars
EE_ComVeh_Base.mtx	.../2022_Example/inputs/external/	.../data/external/	2010 External-External (E-E) truck trips
ComVeh_EE_Marginals.dbf	.../2022_Example/inputs/external/	.../data/external/	External-External (E-E) commercial vehicle trip marginals
street_skim.mtx	.../2022_Example/outputs/skims/	Not applicable, this file only exists as a scenario output	Highway skim file
tod_split.csv	.../2022_Example/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 ".../2022_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 ".../2022_Example/outputs/tod/" directory. See the tables "Trucks" and "ComVeh4T" in the "trips_X.mtx" files (where X = am, pm, or op).

Outputs:

- .../2022_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	.../2022_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	.../2022_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	.../2022_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	.../2022_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:

- .../2022_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)
- .../2022_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 ".../2022_Example/outputs/assignment/transit" directory.

Inputs:

File/Property Name	*Scenario Location ("nwarpc_model/scenarios/")*	*Copied From ("nwarpc_model/resource/")*	*Description*
mode_table.bin	.../2022_Example/inputs/ assignment/	.../parameters/assignment/	Provides transit hierarchy and defines access modes
transit.rts; transitS.bin	.../2022_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	.../2022_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 "…/2022_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:

- …/2022_Example/outputs/assignment/transit/transit_assignment_"X"_"Y". tnw (where X = walk, pnr or knr; Y = pk or op)

Transit Assignment Outputs:

- …/2022_Example/outputs/assignment/transit/"X"_transit_"Y"_aggregate_flow.bin (where X = walk, pnr or knr; Y = pk or op)
- …/2022_Example/outputs/assignment/transit/"X"_transit_"Y"_on_off.bin (where X = walk, pnr or knr; Y = pk or op)
- …/2022_Example/outputs/assignment/transit/"X"_transit_"Y"_flow.bin (where X = walk, pnr or knr; Y = pk or op)
- …/2022_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 "…/2022_Example/outputs/reports" directory.

Inputs:

File/Property Name	*Scenario Location ("nwarpc_model/scenarios/")*	*Copied From ("nwarpc_model/resource/")*	*Description*
Streets.dbd	.../2022_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
assignment_"X"_"Y".bin (where X = am, pm or op; Y = iteration4 if the max iteration is set to 4)	.../2022_Example/outputs /assignment/	Not applicable, these files only exist as scenario outputs	Highway assignment outputs
transitS.dbd; transitR.bin	.../2022_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)	.../2022_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:

- .../2022_Example/outputs/reports/assignment_X.dbd (where, X = am, pm, op or daily). – see the fields listed above

Transit Assignment Summary:

- .../2022_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, 6, or 8 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.

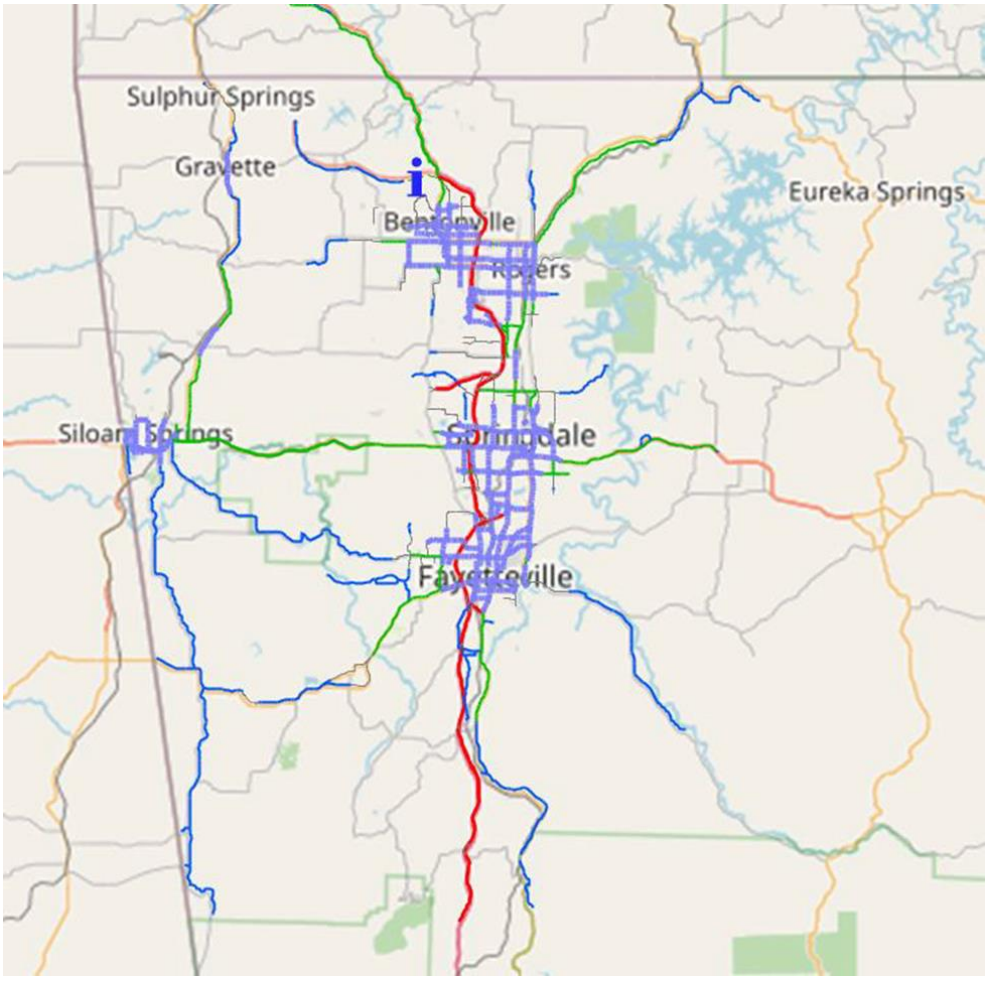
Table 14 Multi-lane Highway is segmented by Rural/Urban; 4,6,8,10,12 lanes; 0,10,20,30% trucks – the links in this selection criteria are Rural and have at least 4 lanes (2 in each direction). The Rural, 4, 5, or 6-lane, 20% trucks service levels were used.

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 2, 4 or 6 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 - (HCMType = "PrArterial" or HCMType = "MinArterial") and (AreaType = "Urban") and ramp != "Yes" (PURPLE LINKs in the Figure below).

Figure 2-4 - Roadways classified for LOS mapping



The LOS maps by default will not show Centroids. 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	.../2022_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	.../2022_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:

- .../2022_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.

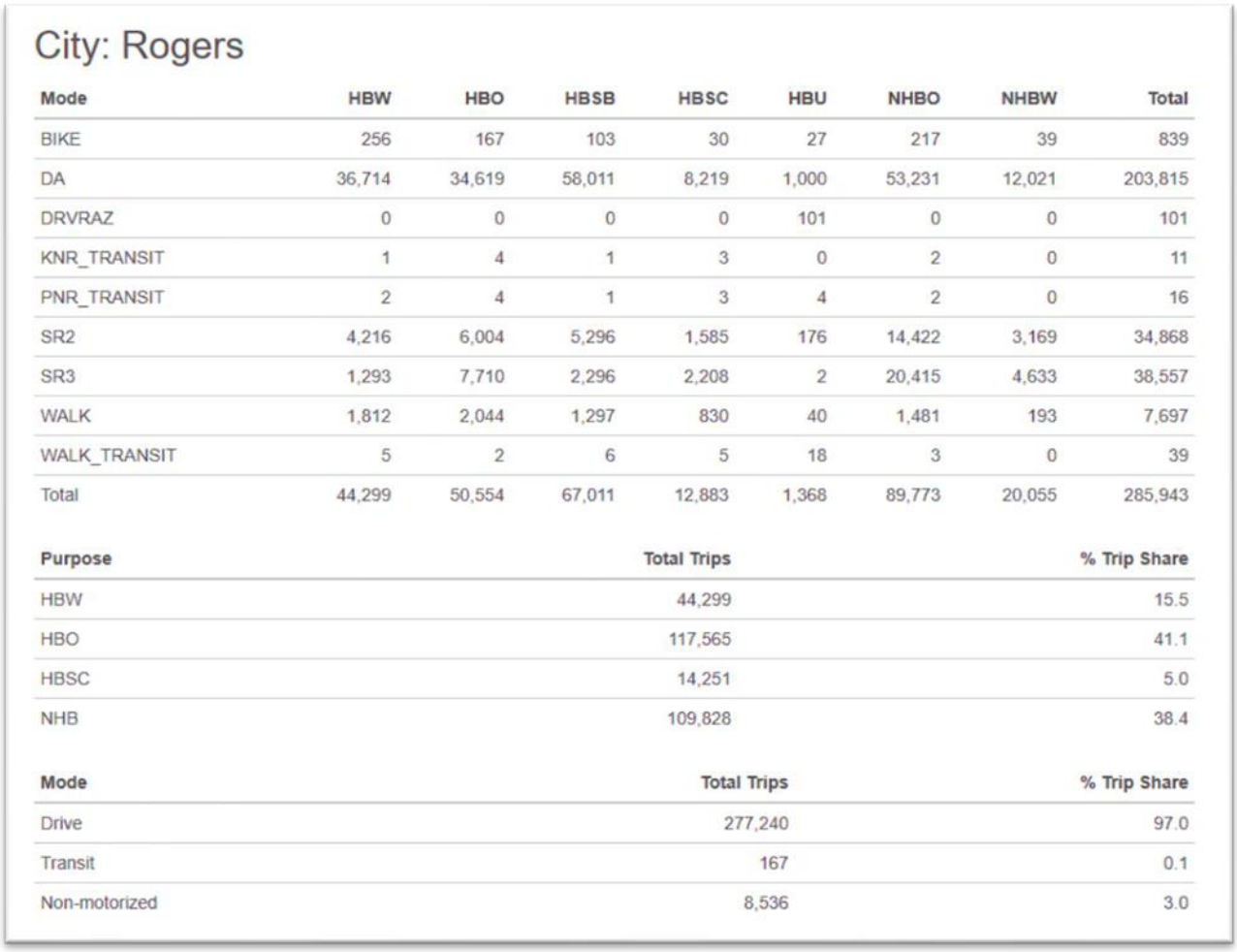
There are three parts to the summary:

- 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 2-5 - Example of Mode Summary Report (City of Rogers)



City: Rogers

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	/2022_Example/inputs/gis/taz.dbd	/data/gis/NWAMPA_Master_TAZ.dbd	Scenario-specific TAZ file (TAZ spec)
mc_trips_{purpose}.mtx"	.../2022_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:

- .../2022_Example/outputs/reports/ mode_choice_summary_P_based.html
- .../2022_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:

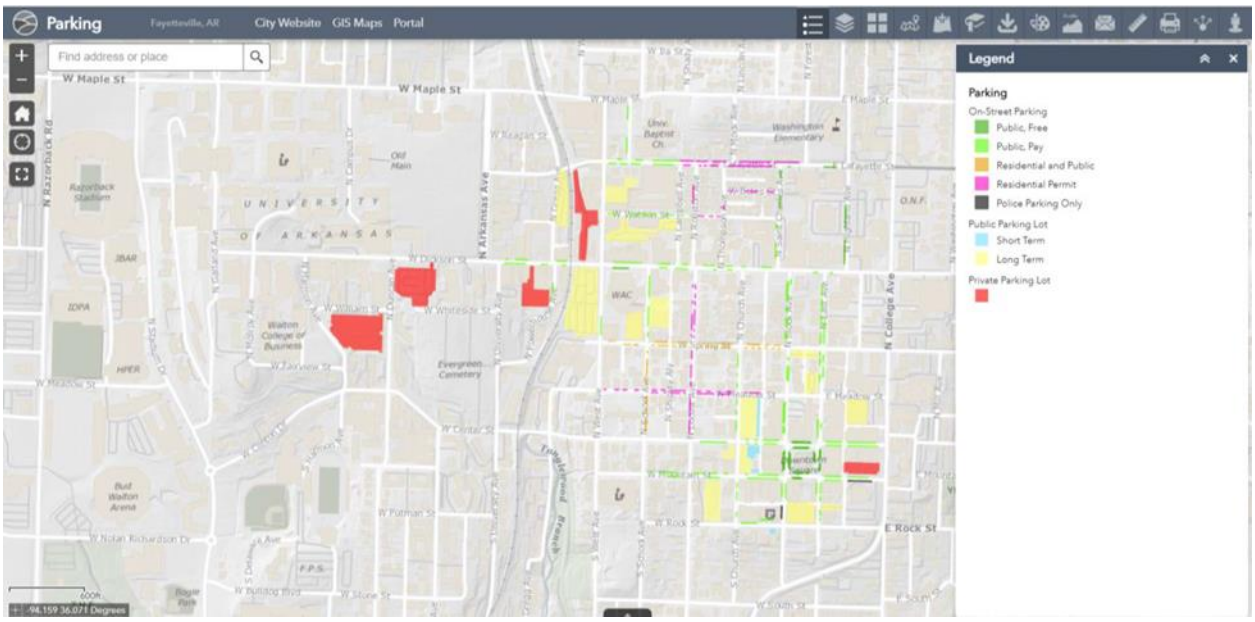
1. Identify the parking facilities within each zone, including single- and multi-level parking garages, parking lots, metered and non-metered street parking.
2. Collect information on the fee structure and/or permit requirements for each facility.
3. Develop an estimate of the parking cost associated 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 TAZ 50021.

Table 2-1 - 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
50010	**All parking in 50010**					**$2.33**	**$2.58**
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
50021	**All parking in 50021**					**$2.50**	**$1.00**
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
50023	**All parking in 50021**					**$2.78**	**$1.74**
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
50024	**All parking in 50024**					**$4.00**	**$1.58**
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
50025	**All parking in 50025**					**$1.95**	**$0.71**
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
50031	**All parking in 50031**					**$6.39**	**$4.27**
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
50032	**All parking in 50032**					**$1.76**	**$7.08**

50060	Residential Permit	PUBLIC	$0.00	$0.00			
50060	**All parking in 50060**					**$2.50**	**$1.00**

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 4.0.6 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 2022 base year.

The following sections document the 2022 updated base model performance against the acceptance criteria by category. Many validation targets from the 2017 NHTS[1] which were used in the previous model update from April 2021 were carried over as targets for this model update. However, if a validation metric could be calculated from the 2022 Replica data, that was done. Mode choice validation targets based on the 2018 on-board survey were carried over to this model update. In the absence of a recent household travel survey for the region, the 2017 NHTS, 2018 on-board survey, and 2022 Replica estimates were the best available data sources for demand model (trip generation, distribution, and mode choice) validation and calibration. For network assignments (traffic and transit), more recent traffic counts and transit boardings were used.

With Replica 2022 and NHTS 2017 being used as validation targets, this presents many cases where the model estimates can be compared to a range, rather than a single metric. Given that Replica is another model of the regional travel behavior, and NHTS 2017 covers larger geographies, it's difficult to declare one data source more authoritative than the other. Ideally, for a given submodel, the NWARPC model estimate would be between NHTS 2017 and Replica 2022. However, in some cases the model falls outside the bounds of Replica and NHTS.

3.1 Trip Generation: Person Trips by Purpose

Trip generation model results in the table below show the percentage of trips by purpose versus the same distributions from NHTS 2017 and Replica 2022. The model's Home-Based Other share slightly lags NHTS and Replica, while the model's home-based work share leads NHTS and Replica. Because Replica does not have the university trip purpose, its share of Home-Based School trips is higher.

Table 3-1: Share of Person Trips by Purpose and Source

Trip Purpose	Model (N=2,023,364)	NHTS (N=60,059,694)	Replica (N=1,975,530)
Home-Based Other	18.9%	20.3%	23.9%
Home-Based School	4.6%	2.7%	10.6%

[1] As with the model validation in 2021, NHTS 2017 sample records from Louisiana, Missouri, and Mississippi will be used.

Home-Based Shopping and Business	24.8%	25.9%	17.7%
Home-Based University	1.7%	0.7%	0.0%
Home-Based Work	17.8%	15.1%	15.8%
Non-Home-Base Work	6.6%	6.5%	11.4%
Non-Home-Based Other	25.6%	28.8%	20.7%
Total	**100.0%**	**100.0%**	**100.0%**

3.2 Destination Choice: Average Trip Length by Purpose

The model estimates for average trip length by purpose fall within or near the bounds of the NHTS and Replica metrics. The model exceeds NHTS and Replica metrics for Home-Based School and lags Home-Based Shopping and Business. As noted above Replica lacks a university trip purpose, and trips for that purpose may be grouped with Home-Based School.

Table 3-2: Average Trip Length (miles) by Purpose and Source

Trip Purpose	Model	NHTS	Replica
Home-Based Other	6.9	9.1	6.9
Home-Based School	6.7	5.8	4.8
Home-Based Shopping and Business	4.6	6.7	6.4
Home-Based University	5.2	7.6	
Home-Based Work	9.8	11.9	9.2
Non-Home-Base Work	9.1	11.5	5.7
Non-Home-Based Other	6.8	7.4	6.6

3.3 Destination Choice: Trip Length Frequency Distributions by Purpose

The following series of trip length distributions show the model versus trip length distributions from NHTS and Replica.

Figure 3-1: Trip Length Distribution by Source: Home-Based Other Trips

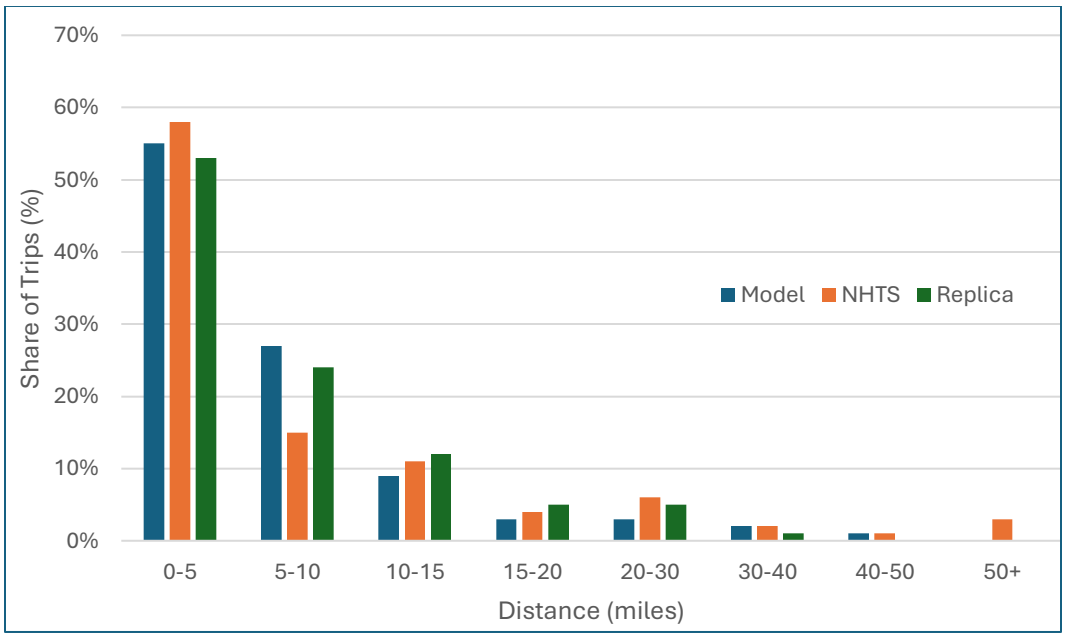


Figure 3-2: Trip Length Distribution by Source: Home-Based School Trips

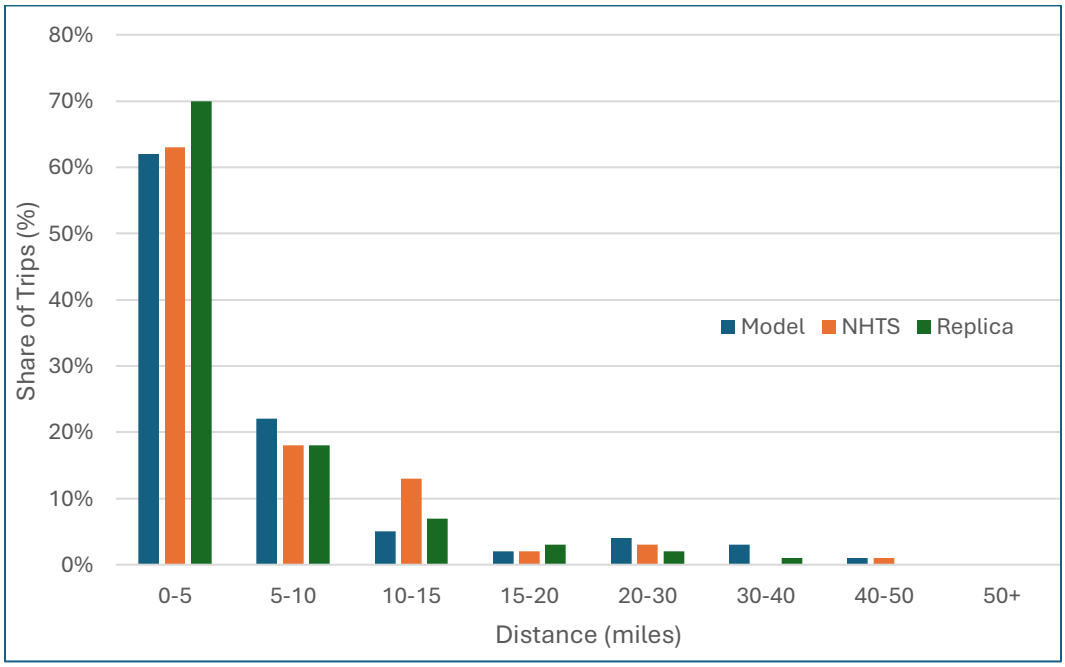


Figure 3-3: Trip Length Distribution by Source: Home-Based Shopping and Business Trips

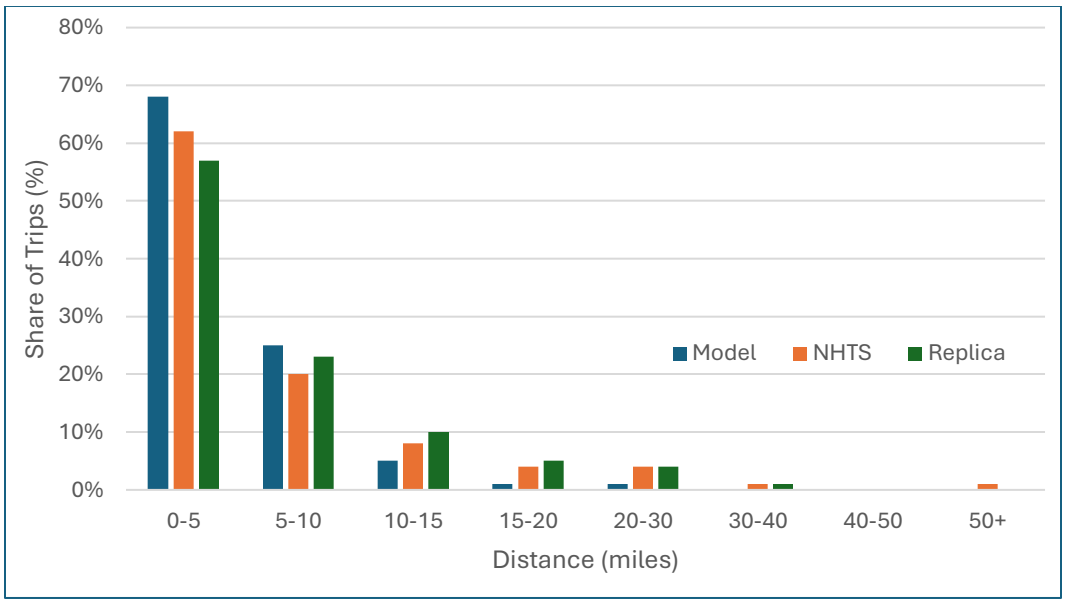


Figure 3-4: Trip Length Distribution by Source: Home-Based University Trips

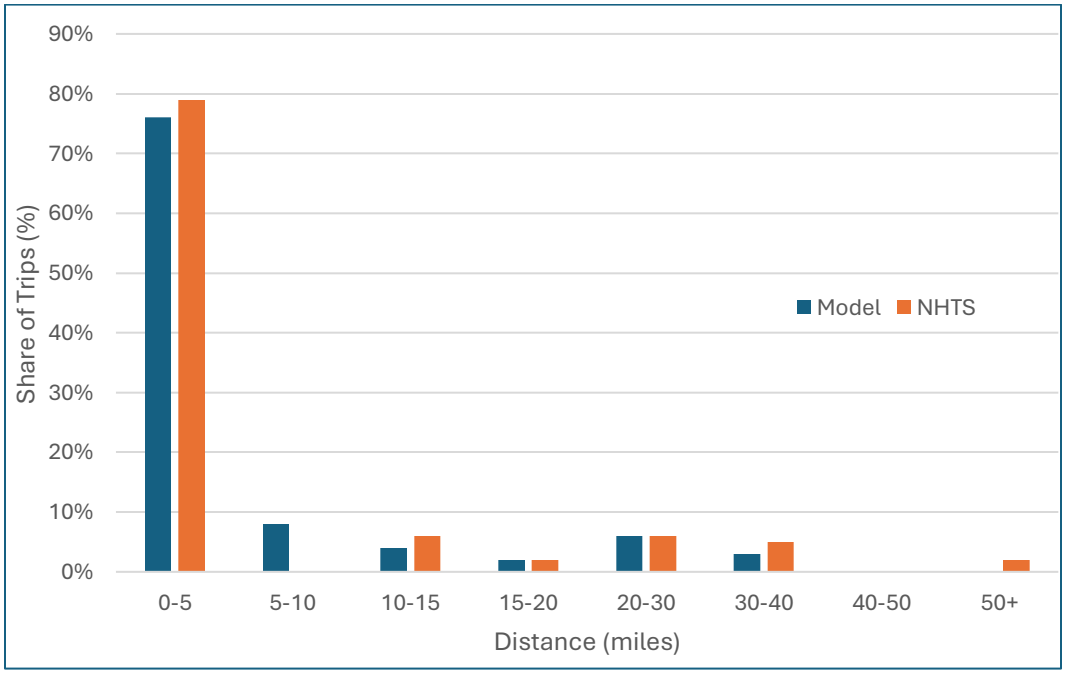


Figure 3-5: Trip Length Distribution by Source: Home-Based Work Trips

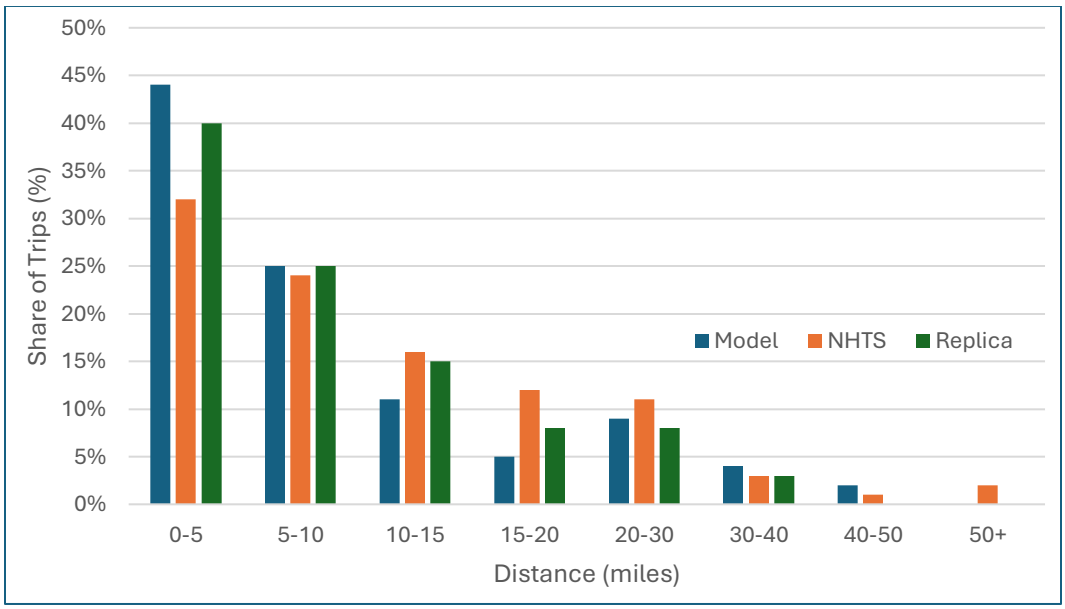


Figure 3-6: Trip Length Distribution by Source: Non-Home-Based Work Trips

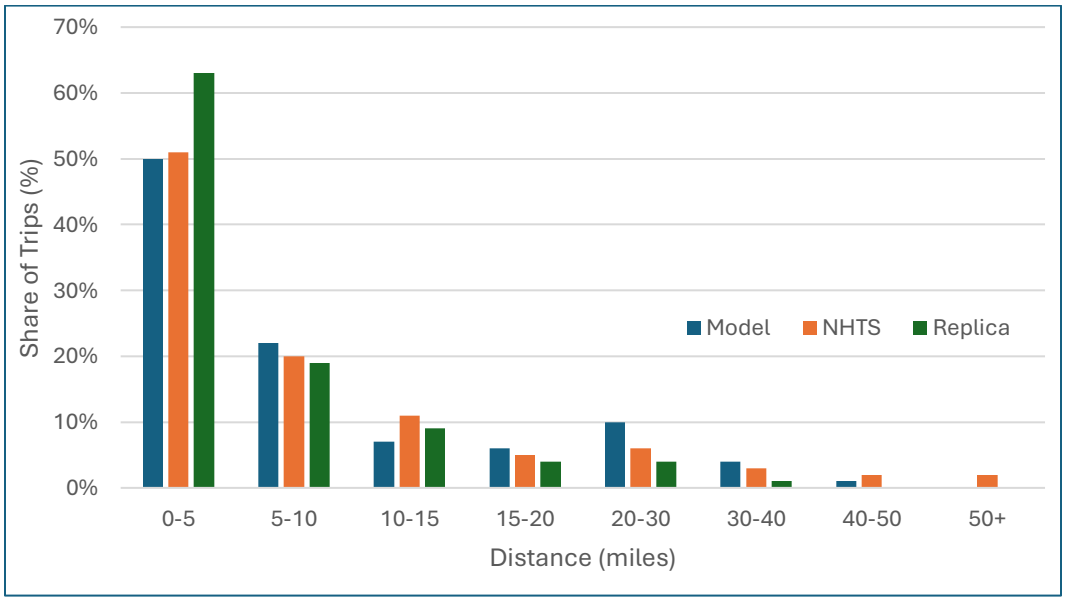
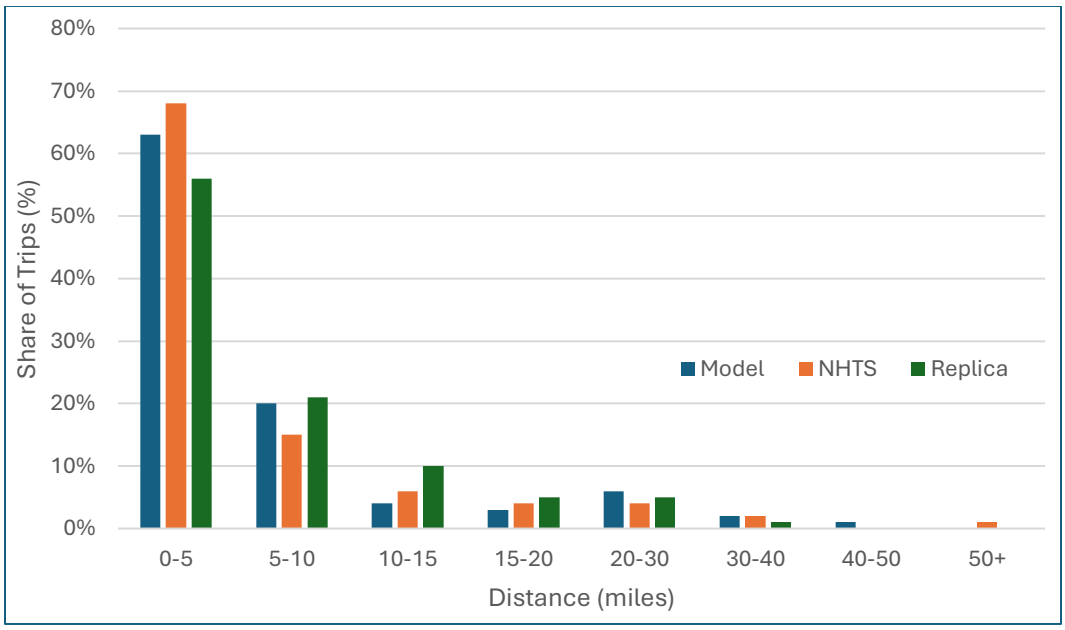


Figure 3-7: Trip Length Distribution by Source: Non-Home-Based Other Trips



3.4 Mode Choice: Aggregate Mode Share

For mode choice, modeled auto, transit, and non-motorized mode shares in the region were compared to the mode shares developed from the 2018 on-board survey. An attempt was made to update the 2018 mode shares by reviewing changes in Replica trip estimates between 2018 and 2022. Replica trips from 2018 and 2022 were summarized for district-to-district pairs to evaluate if person trip demand patterns had changed significantly in percentages, which would require incremental adjustment of mode share targets. No remarkable shifts were observed, and so the mode share targets derived from the 2018 survey were used for this model update.

Table 3-3: Aggregate Mode Shares (Observed versus Modeled)

Mode	Observed	Estimated
Auto	97.1%	96.2%
Transit	0.6%	0.3%
Non-motorized (walk + bike)	2.3%	3.5%
Total	100.0%	0.0%

3.5 Mode Choice: Mode Share by Purpose

Modeled mode shares by purpose were compared to the mode shares developed from the 2018 on-board survey (which were kept for this model update as explained in the prior section).

Table 3-4: Mode Shares by Purpose (Observed versus Modeled)

Observed

Trip Mode	Observed Trip Pecent						
	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%

Trip Mode	Modeled Trip Percent						
	HBW	HBU	HBSC	HBSB	HBO	NHB	Total
Drive Alone	77%	55%	61%	86%	66%	56%	69%
Shared Ride 2	13%	10%	14%	8%	13%	17%	13%
Shared Ride 3	5%	0%	20%	4%	16%	24%	14%
Drive to Razorback (>=5 miles)	0%	1%	0%	0%	0%	0%	0%
Walk to Transit	0%	2%	0%	0%	0%	0%	0%
PnR to Transit (<5 miles)	0%	11%	0%	0%	0%	0%	0%
KnR to Transit	0%	0%	0%	0%	0%	0%	0%
Walk	5%	17%	5%	2%	4%	2%	3%
Bike	1%	3%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%

3.6 Roadway Validation: Error in Regionwide, 24-hour VMT

Observed AADT values from 2022 and onward from Arkansas DOT were acquired and conflated with the NWARPC model network in order to compare observed VMT versus daily model VMT. The preferred validation metric for regionwide traffic assignment was 24-hour VMT percent error of less than +/- 3%. As shown in the table below, the model's regionwide VMT metric is 3.6% lower than target.

Table 3-5: Traffic Assignment Statistics by Roadway Volume Group

Volume Group	N	Observed VMT	Model VMT	% Error
(0 - 5000]	342	452,827	421,742	-6.9%
(5,000 – 10,000]	201	664,303	507,755	-23.6%
(10,000 – 20,000]	187	1,501,009	1,208,247	-19.5%
(20,000 – 30,000]	90	609,822	581,917	-4.6%
(30,000 – 40,000]	35	400,808	420,379	4.9%
(40,000 – 999,999]	28	1,235,242	1,550,003	25.5%
Total	**883**	**4,864,012**	**4,690,044**	**-3.6%**

3.7 Roadway Validation: Error in 24-hour VMT by Facility Type

Observed AADT values from 2022 and onward from Arkansas DOT were acquired and conflated with the NWARPC model network in order to compare observed AADT. The preferred validation metrics for traffic assignment were 24-hour VMT percent errors of:

- Less than 7 percent on Freeways;
- Less than 10 percent on Arterials;
- Less than 15 percent on other roads.

The following two tables show the observed versus model VMT by facility type. The first table uses the major facility types from the model network. Percent errors on Freeways and Principal Arterials (the two categories with the highest VMT) are both within +/- 3% error. Lower functional classes have lower VMT that falls just outside the 10% and 15% categories. The second table groups the VMT into three general categories. In each category, the model VMT is within the preferred percent error range listed above (7, 10, and 15 % thresholds).

Table 3-6: Traffic Assignment Statistics by Detailed Facility Type

Facility Type	N	Observed VMT	Model VMT	% Error
Collector	353	728,372	604,577	-17.0%
Freeway	57	2,157,031	2,193,974	1.7%
Local	12	16,461	14,388	-12.6%
Minor Arterial	159	573,474	470,405	-18.0%
Principal Arterial	244	1,311,510	1,317,190	0.4%
Ramp	58	77,166	89,510	16.0%
Total	**883**	**4,864,014**	**4,690,044**	**-3.6%**

Table 3-7: Traffic Assignment Statistics by General Facility Type

Facility Type	N	Observed VMT	Model VMT	% Error
Freeways	57	2,157,031	2,193,974	1.7%
Arterials	403	1,884,984	1,787,595	-5.2%
Minor Roads	423	821,999	708,475	-13.8%
Total	**883**	**4,864,012**	**4,690,044**	**-3.6%**

3.8 Transit Validation: Percent Error of Boardings by Transit Operator (ORT and Razorback)

A common transit validation goal is to be within 10% error of observed boardings by mode or region. The calibrated 2022 NWARPC scenario exceeds this goal for Razorback and for the region. While getting within 10% is ideal, doing so requires further penalizing transit (by increasing the transit alternative specifics constants) to force additional trips off of transit. This would make the model more insensitive to improvements in transit level of service in the transit alternatives study scenarios.

Table 3-8: Transit Boardings by Transit Operator

Operator	Observed Boardings	Scenario Boardings	% Error
Ozark	482	492	2.0%
Razorback	3,986	5,228	23.8%
Total	**4,468**	**5,720**	**21.9%**

3.9 Sensitivity Tests

3.9.1 Percent Change in Mode Shares Due to Parking Cost Increase

A sensitivity test was performed with the updated model (with new 2022 base year inputs and the updated mode choice model) where paid parking in Fayetteville was removed. The following two tables show the results for the scenario without parking cost, followed by the scenario with parking cost (the existing condition). As one would expect, the drive mode share increases as parking cost decreases. This confirmed a previous sensitivity test result from the prior model update in 2021.

Table 3-9: Mode Share without Parking Cost Increase (Fayetteville)

Mode	Total Trips	% Trip Share
Drive	324,672	92.4
Transit	4,822	1.4
Non-motorized	21,893	6.2
Total	**351,387**	**100**

Table 3-10: Mode Share with Parking Cost Increase (Fayetteville; $5 short term/$20 long term)

Mode	Total Trips	% Trip Share
Drive	319,857	91.5
Transit	4,818	1.4
Non-motorized	24,792	7.1
Total	**349,467**	**100**

3.9.2 Sensitivity Test: Percent Increase in Forecast (2050) Year Transit Boardings Relative to Base

Another sensitivity test was conducted to verify that in a future no-build scenario, that a reasonable increase in future transit boardings is observed given the planned land use and no-build network changes. For the default growth trend in 2050, seeing boarding increase by a similar magnitude with population and employment growth is expected. If growth in transit boardings severely lags or exceeds the population or employment growth, then it may be due to congestion that is too severe in the future scenario, which may cause transit boardings growth to exceed population or employment trends. Alternatively, if transit growth lags population and employment growth, it may be that transit constants are overly punitive and cause transit boarding growth to lag.

Table 3-11: Transit Rides by Transit Operator, 2022 versus 2050

Operator	2022 Base	2050 Forecast	% Change
Ozark	482	878	82.2%
Razorback	3,986	7510	88.4%
Total	**4,468**	8388	87.7%

4 Appendix A: 2022 Base Year Updates

This appendix describes the process of updating the model base year data to represent 2022 socio-economic and network conditions.

4.1 Network Updates

NWARPC staff provided an updated 2022 roadway network to reflect local projects implemented between 2018 and 2022.

The 2022 transit network was updated using GTFS feeds from circa 2023-2024 from ORT and Razorback. Post-COVID service provision and ridership has been recovering steadily, and using the most recently available GTFS data reflected a more stable base year condition.

4.2 TAZ Additions

The model TAZs increased from 711 to 734, with all changes being for internal TAZs, not externals. Where TAZs were split or merged, the network centroid connectors were edited to reflect realistic connectivity to the roadway network.

4.3 Household Data

The household data was updated using the ACS 2022 5-year estimates. The source data tables from ACS were:

- For households by number of workers: B08202
- For households by size: B11016
- For households by income: B19001

For each ACS table, the data was read at the tract level or block group level. To allocate data from tracts or block groups to TAZs, 2020 decennial census block population was used to proportionally disaggregate values, which were then summarized to TAZ geographies.

As with the previous model version, households were summarized into the following categories:

- By number of persons: 1, 2, 3, and 4+
- By number of workers: 0, 1, 2, and 3+
- By annual income: low (< $50k), middle (>= $50k and < $100k), and high (>= $100k)

4.4 Employment Data

Employment data was updated using data from Data Axle[2] (year 2024) and the Longitudinal Employment Household Dynamics (LEHD) 2022 dataset from the Census Bureau. The Data Axle dataset is point-level establishment records and had 23,865 records, with 238,552 employees in total. The regional control total is 267,852 from LEHD.

4.4.1 Data Cleaning

Using the point shapefile of Data Axle and the TAZ polygon shapefile, a correspondence table was created to identify which TAZ each Data Axle record belonged to. Out of 23,865 records, 6 were not assigned to any TAZ. These 6 records were manually assigned to the nearest TAZ and are shown in Table 4-1.

Table 4-1. Records manually assigned to the nearest TAZ

contact_na	company_na	actual_loc	latitude	longitude	TAZ_ID
DONNA FLANT	GEORGIA POULTRY	4	36.176501	-94.565259	74461
MARK SCHULZ	CAMPGROUND AT THE FALLS	2	36.583669	-94.371685	70300
RYAN KINNAMAN	CROSSFIT SILOAM SPRINGS	3	36.176501	-94.565259	74461
ANGIE BREWER	PINEVILLE PRIMARY	16	36.609729	-94.406789	70400
MIKE LUCARIELLO	HOGSLAT	3	36.176501	-94.565259	74461
BLAYKE SNOW	LOCKE SUPPLY CO	5	36.167186	-94.563742	74450

To allocate the employment to the model's four industry categories (i.e., [2022_emp_industry], [2022_emp_retail], [2022_emp_office], and [2022_emp_service]), all of the records were classified based on the first 2 digits of the 'naics_code' field in the Data Axle dataset. Also, 761 of the establishment records were labeled as 'UNCLASSIFIED ESTABLISHMENTS' in the 'naics_desc' field. The employment for these unclassified establishments was proportionally allocated according to the office, retail, service, and industry employment in the TAZ. All records with meaningful 'naics_code' values were assigned based on the following table of 2-digit NAICS codes with model industry category.

Table 4-2. 2-digit NAICS codes with model industry category

Sector	Description	Model Employment Category
11	Agriculture, Forestry, Fishing and Hunting	Industry

[2] Data Axle is formerly known as InfoUSA

21	Mining, Quarrying, and Oil and Gas Extraction	industry
22	Utilities	industry
23	Construction	industry
31-33	Manufacturing	industry
42	Wholesale Trade	industry
44-45	Retail Trade	retail
48-49	Transportation and Warehousing	industry
51	Information	office
52	Finance and Insurance	office
53	Real Estate and Rental and Leasing	office
54	Professional, Scientific, and Technical Services	office
55	Management of Companies and Enterprises	office
56	Administrative and Support and Waste Management and Remediation Services	office
61	Educational Services	service
62	Health Care and Social Assistance	service
71	Arts, Entertainment, and Recreation	retail
72	Accommodation and Food Services	service
81	Other Services (except Public Administration)	service
92	Public Administration (not covered in economic census)	office
Source: https://www.census.gov/programs-surveys/economic-census/year/2022/guidance/understanding-naics.html		

The following manual adjustments were made for the following zones after review from NWARPC staff:

- For zone 50162, service employment was set to 100, office employment to 100, and total employment to 200.

- For zone 60483, service employment reduced from 1,340 to 340, industry from 1,345 to 445, and total employment from 3,362 to 1,462.
- For zone 60481, service employment increased from 2,178 to 3,178 and total employment from 2,178 to 3,178.
- For zone 60551, industry employment increased from 188 to 1,088 and total employment from 353 to 1,253.
- For zone 71970, office employment increased from 121 to 10,121 and total employment from 7,244 to 17,244.
- For zone 20480, industry employment increased from 35 to 1,235 and total employment from 73 to 1,273.

After adjusting values for the zones above, the remaining zonal employment values were scaled accordingly to ensure that the regional total employment matched the control total of 267,852.

The following additional employment updates were completed:

- In the special generator files for 2022, 2030, 2040, and 2050:
  - For zones 72023 & 72030 (new Walmart HQ), set employment to 0
  - For zone 71970 (JB Hunt HQ), set employment to 0
- For the 2022 base year, manual adjustments to the following zones:
  - For zone 72070, retail reduced from 12,275 to 1,275, and increased office from 839 to 11,839 - total employment stayed at 13,889.
  - For zone 80436, retail reduced from 5,803 to 803, and increased office from 101 to 5,101 - total employment stayed at 6,261.
- In the 2050 future year:
  - Moved 11k * [2022 to 2050 growth_factor] from zone 72070 (old Walmart HQ) to zones 72023 & 72030 (new Walmart HQ)
    - The “office” category growth factor (“2022 to 2050 growth_factor”) for county 05007 (Benton) is 1.804
    - 11,000 * 1.804 = 19,844 employment
  - For zone 72070 (old Walmart HQ), office employment reduced from 21,357 to 1,513 and total employment from 25,233 to 5,379.

4.5 K-12 Enrollment

Based on the shapefile of NWA Schools Enrollment and the new TAZ polygons, a correspondence table was created to identify which TAZ each NWA Schools Enrollment record belonged to. K-12 enrollment for each school was summed to the TAZ geography for

the base year. For future years, enrollment was scaled by the county level population growth rate from 2022 to the forecast year.

4.6 Post-Secondary Data

4.6.1 Enrollment

Base year post-secondary enrollment was provided by NWARPC. The model base year (2022) assumes the following enrollment for the University of Arkansas, NWACC, and John Brown University:

- University of Arkansas: 30,936 (Fall 2022)
- NWACC: 8,804 (Fall 2023)
- John Brown: 2,253 (Fall 2023)

4.6.2 On/Off Campus Student Resident Population

The residential population of post-secondary students (student housing locations) were allocated in two stages. The on-campus student values for the University of Arkansas and John Brown University TAZs were adjusted proportionally, based on the total enrollment growth on each campus from 2018 to 2022. The remaining student population was distributed to all other TAZs as off-campus students, proportional to the distribution of 2018 off-campus students by TAZ.

- For example, John Brown University had 2,316 students in 2018, with 944 of them being on-campus students. By 2023, enrollment decreased to 2,253 students. The growth rate of enrolled students was calculated as 2,253/2,316 = 0.972798. The 2023 estimate of on-campus students iss 0.972798 * 944 = 918. The remaining 1,335 students were allocated as off-campus students, following the 2018 off-campus distribution by TAZ.

5 Appendix B: Mode Choice Model Updates

The updated mode choice model was a key task for using the new model in the Transit Alternatives Study. As such, careful design decisions and implementation were required. To this end, the following tasks were completed to update the mode choice model.

Prior model sensitivity test: The prior mode choice model was tested by adding the future high-capacity transit fixed-guideway projects to the transit network and then documenting the mode choice results for the base and test scenarios. Table 5-1 documents the results.

Table 5-1: Initial Sensitivity (Add HCT Routes in 2018 Scenario) Test Mode Shares

		Base Scenario		Test Scenario	
Policy Test	**Mode**	**Trips**	**% Mode Share**	**Trips**	**% Mode Share**
Add High Capacity Transit Routes	Drive	1,848,642	96.2	1,846,756	96.1
	Transit	8,470	0.4	10,682	0.6
	Non-motorized	63,927	3.3	63,464	3.3
	Subtotal	***1,921,039***	***100.0***	***1,920,902***	***100.0***

Discuss model design alternatives: Various mode choice structures were discussed with pros and cons for NWARPC's context.

Figure 5-1 shows the prior mode choice structure. In the interest of being consistent with FTA's STOPS mode choice structure, the mode choice structure in

Figure 5-2 was implemented.

Figure 5-1: Prior Mode Choice Structure

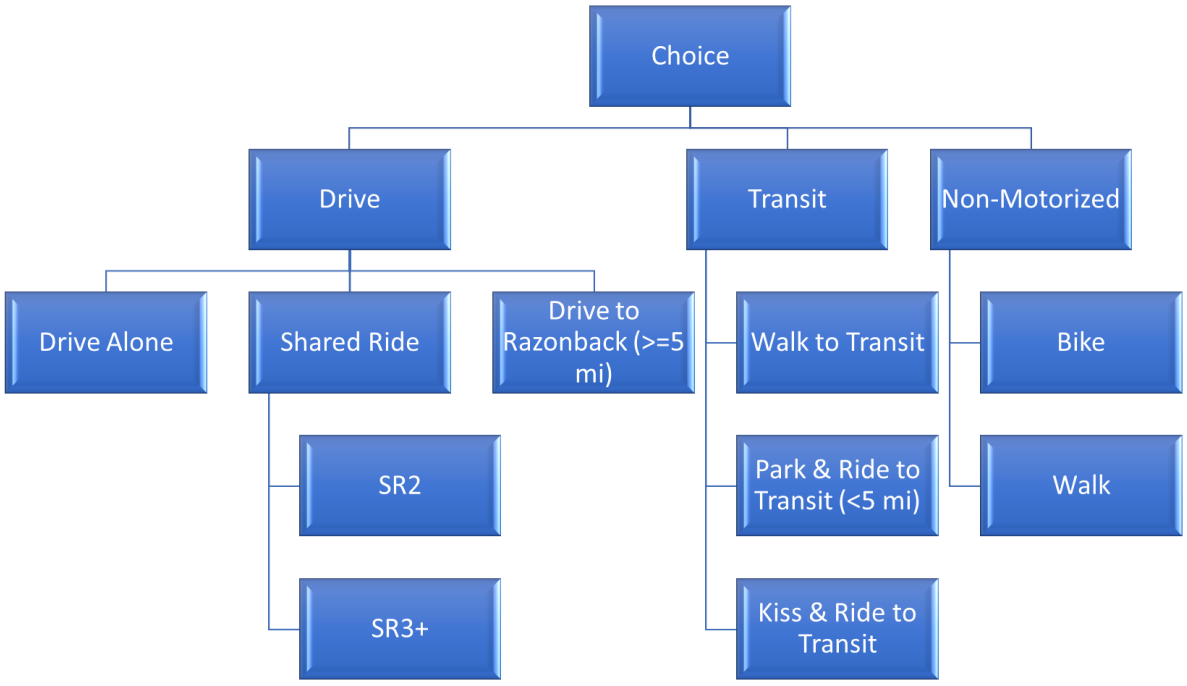
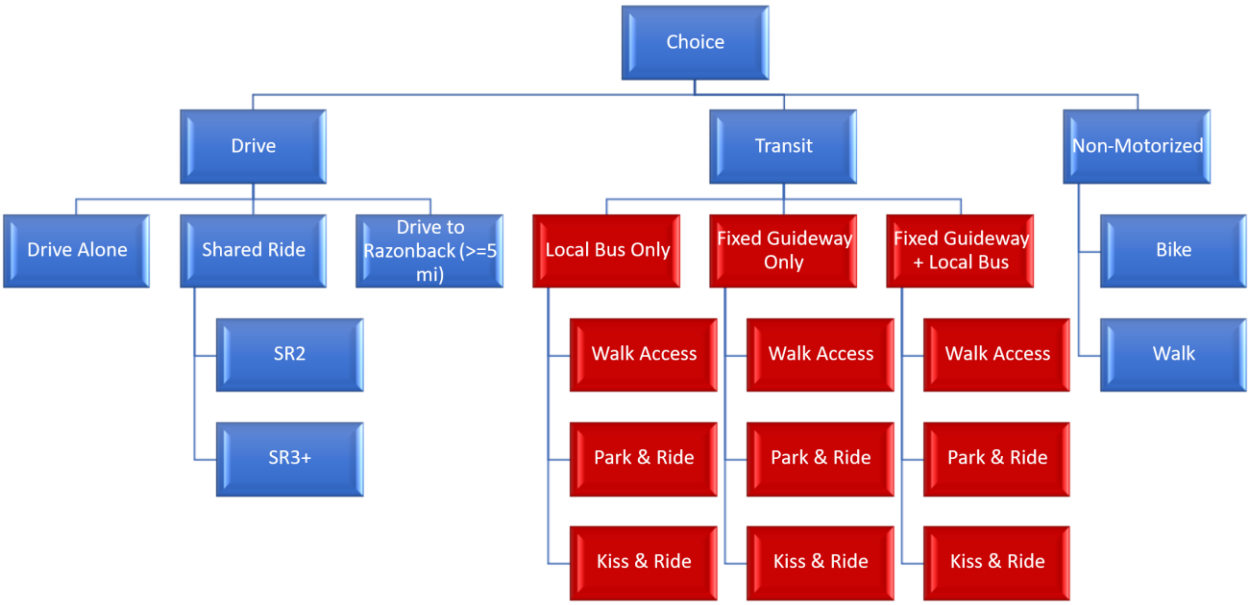


Figure 5-2: New Mode Choice Structure (STOPS-like)



Calibration: An attempt was made to update the 2018 on-board survey derived mode shares by reviewing changes in Replica's trip estimates between 2018 and 2022. Replica trips from 2018 and 2022 were summarized for district-to-district pairs to evaluate if person trip demand patterns had changed significantly in percentages, which would require incremental adjustment of mode share targets. No remarkable shifts were observed, and so the mode share targets derived from the 2018 on-board survey were used for this model update.

Test the new mode choice model: Using the same high-capacity transit fixed guideway service as tested in the prior model sensitivity test, the new model was run with and without the transit service. The mode share results were very similar to the prior model sensitivity test results

6 Appendix C: 2050 Forecast Year Updates

6.1 Overview

This memo summarizes the process of updating the forecast TAZ data for the NWARPC model, using the base year data 2022 to create input data for the years 2030, 2040, and 2050. While Woods & Poole data was used for updating employment variables, the UAEDI (Arkansas Economic Development Institute, 2024) was used for other sociodemographic variables.

6.2 Data and Methods

This task used employment data procured by NWARPC (Woods & Poole, Data Axle) as well as LEHD/LODES data, in addition to base year TAZ socio-economic variables. Then, UAEDI data was used to forecast household and sociodemographic variables. First, summaries were conducted for the 2022 base year at the county level for the three counties that comprise the study area: Benton County and Washington County, Arkansas, and McDonald County, Missouri:

- **Woods & Poole**: County-level employment, income, retail sales, household, earnings, and basic population data. Additional files included population by single year of age, race, and gender. Data was available from 1969 to 2060.
- **LEHD/LODES 8.3**: Census block-level data containing the number of jobs for workers by age, earnings, industry, race, ethnicity, education, gender, employment tenure, and employment size. The latest data available were for the year 2022.
- **Base Year TAZ Data**: Exported from updated *NWAMPA_Master_TAZ.dbd* file, contained TAZ-level data regarding the number of households by size, workers, income, as well as employment by industry, school and university enrollment, and parking costs. Data was available for years 2022, 2030, 2040, and 2050.

Next, household variables were factored to future year values using the UAEDI forecast. The base TAZ data was for the year 2022, and the UAEDI dataset was available for 2020 and 2025. Thus, an interpolation of the UAEDI dataset was done first to produce numbers for 2022. As a result, proper growth rates for the 2022-2030, 2022-2040, and 2022-2050 periods were calculated. Similarly, the same growth rates were produced from the Woods & Poole data for employment data. The employment growth rates were calculated for the three counties in the study area: Washington, Benton, and McDonald. The household and population growth rates were calculated for Washington and Benton counties only, and, due to data unavailability, the McDonald County household and population growth rates

were assumed to be the same as the ones from Benton County, given their proximity and similar land-use characteristics.

The TAZ data had the following employment category variables: industry, retail, office, service, and total employment. Based on the categories available in the Woods & Poole data, as well as their frequencies by year, the following Woods & Poole employment categories could appropriately represent these five TAZ employment variables:

- Industry: Manufacturing Employment
- Retail: Retail Trade Employment
- Office: Administrative and Waste Services Employment
- Service: Other Services, Except Public Administration Employment
- Total Employment: Total Employment

The future year data for the years 2030, 2040, and 2050 were calculated by multiplying the base 2022 numbers by the relevant county-level growth rate. The two parking cost variables were kept unchanged for all years, the five employment-related variables used their relative employment category growth rate, and all the other variables used the UAEDI data growth rate for all years.

To avoid mismatching numbers due to rounding processes following multiplication, the last household category was computed as a subtraction of the total by the lower categories computed for each household variable type. For instance, after calculating the 2030 total number of households, and the number of households sizes 1, 2, and 3, the total number of households 4+ (instead of simply multiplying the 2022 number of households 4+ by the growth rate, as done for their counterpart variables) was derived from the computed 2030 total number of households subtracted by the computed households for the other three categories. This procedure was also done for the number of workers per household and the number of households by income category. As a result, the sum of the number of households produced for each category would perfectly match the total number of households for each TAZ.

Data was prepared and summarized using an R script to prepare, clean the data, and produce summary tables for several variables of interest. The updated TAZ file included the original 2022 base year variables along with their projections for 2030, 2040, and 2050.

6.3 Results

After cleaning the datasets for the three counties of interest, an initial summary table (Table 6-1) of total employment was created to compare three data sources while assessing the consistency and precision of Woods & Poole data.

Table 6-1: 2022 Comparison of Total Employment by Data Source

County	FIPS	Total Employment		
		Base Year TAZ	LEHD/LODES	Woods & Poole
Benton	05007	124,159	144,456	191,744
Washington	05143	112,624	122,376	168,402
McDonald	29119	1,760	6,895	10,319
Total		**238,543**	**273,727**	**370,465**

Table 6-2 and Table 6-3 below show additional household characteristics at the county level available for the base year TAZ.

Table 6-2: 2022 Base Year TAZ HH Size and School Enrollment by County

County	FIPS	HH Size 1	HH Size 2	HH Size 3	HH Size 4+	K12 Enroll.	Univ. Enroll.
Benton	05007	23,129	34,867	17,460	28,703	57,159	11,057
Washington	05143	26,053	30,998	15,995	20,731	44,562	30,936
McDonald	29119	153	214	111	230	591	-
Total		**49,335**	**66,079**	**33,566**	**49,664**	**102,312**	**41,993**

Table 6-3: 2022 Base Year TAZ HH Workers and Income by County

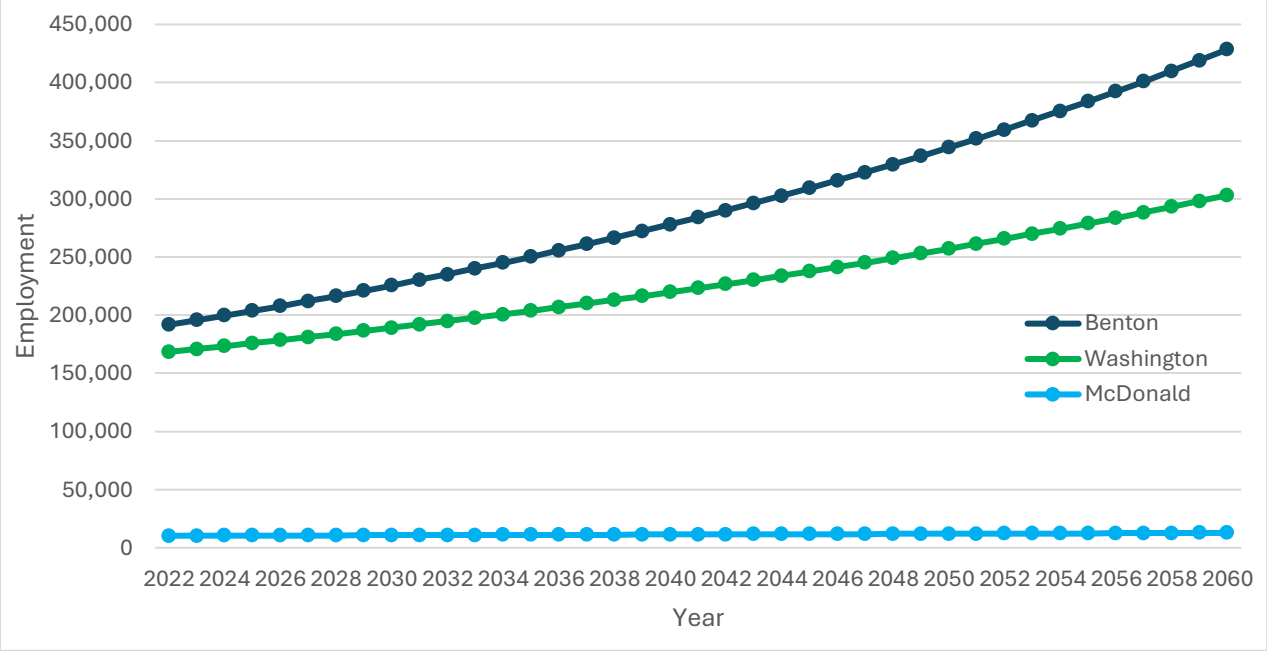
County	FIPS	0 Workers	1 Worker	2 Workers	3 Workers	Low Income	Medium Income	High Income
Benton	05007	21,508	39,047	35,816	7,788	27,638	45,837	30,684
Washington	05143	20,163	38,671	29,174	5,769	38,010	37,116	18,651
McDonald	29119	219	244	211	34	341	274	93
Total		**41,890**	**77,962**	**65,201**	**13,591**	**65,989**	**83,227**	**49,428**

Further exploration of the Woods & Poole data shows employment breakdown by category and county (Table 6-4). Additionally, Figure 6-1 approaches the expected temporal patterns of employment numbers for all three counties for future years.

Table 6-4: 2022 Woods & Poole Employment Data by Employment Category

Employment Category	County			Total
	Benton	Washington	McDonald	
ACCOMMODATION and FOOD SERVICES EMPLOYMENT	13,633	13,432	419	**27,484**
ADMINISTRATIVE and WASTE SERVICES EMPLOYMENT	10,381	10,010	517	**20,908**
ARTS, ENTERTAINMENT, and RECREATION EMPLOYMENT	3,428	2,953	68	**6,449**
CONSTRUCTION EMPLOYMENT	12,060	12,577	906	**25,543**
EDUCATIONAL SERVICES EMPLOYMENT	3,055	1,821	23	**4,899**
FARM EMPLOYMENT	2,345	2,575	884	**5,804**
FEDERAL CIVILIAN GOVERNMENT EMPLOYMENT	491	2,297	72	**2,860**
FEDERAL MILITARY EMPLOYMENT	1,122	936	72	**2,130**
FINANCE and INSURANCE EMPLOYMENT	7,014	5,735	199	**12,948**
FORESTRY, FISHING, RELATED ACTIVITIES and OTHER EMPLOYMENT	436	476	161	**1,073**
HEALTH CARE and SOCIAL ASSISTANCE EMPLOYMENT	13,720	18,104	371	**32,195**
INFORMATION EMPLOYMENT	1,870	1,694	50	**3,614**
MANAGEMENT of COMPANIES and ENTERPRISES EMPLOYMENT	22,025	4,153	-	**26,178**
MANUFACTURING EMPLOYMENT	13,678	14,779	2,983	**31,440**
MINING EMPLOYMENT	377	374	21	**772**
NON-FARM EMPLOYMENT	189,399	165,827	9,435	**364,661**
OTHER SERVICES, EXCEPT PUBLIC ADMINISTRATION EMPLOYMENT	9,090	7,849	530	**17,469**
PRIVATE NON-FARM EMPLOYMENT	177,883	143,176	8,491	**329,550**
PROFESSIONAL and TECHNICAL SERVICES EMPLOYMENT	15,663	9,125	230	**25,018**
REAL ESTATE and RENTAL and LEASE EMPLOYMENT	9,358	9,795	228	**19,381**
RETAIL TRADE EMPLOYMENT	16,866	16,011	1,206	**34,083**
STATE and LOCAL GOVERNMENT EMPLOYMENT	9,903	19,418	800	**30,121**
TOTAL GOVERNMENT EMPLOYMENT	11,516	22,651	944	**35,111**
TRANSPORTATION and WAREHOUSING EMPLOYMENT	15,682	8,882	406	**24,970**
UTILITIES EMPLOYMENT	433	468	19	**920**
WHOLESALE TRADE EMPLOYMENT	9,114	4,938	154	**14,206**
TOTAL EMPLOYMENT	**191,744**	**168,402**	**10,319**	**370,465**

Figure 6-1: Woods & Poole Total Employment Data by Year and by County



Finally, the projected growth rates were applied to the 2022 base TAZ variables to estimate values for 2030, 2040, and 2050. Figure 6-2 below shows a summary of the population comparison between the projected data and the UAEDI future estimates.

Figure 6-2: Population Estimates for UAEDI and Model ("TAZ") by Year and by County

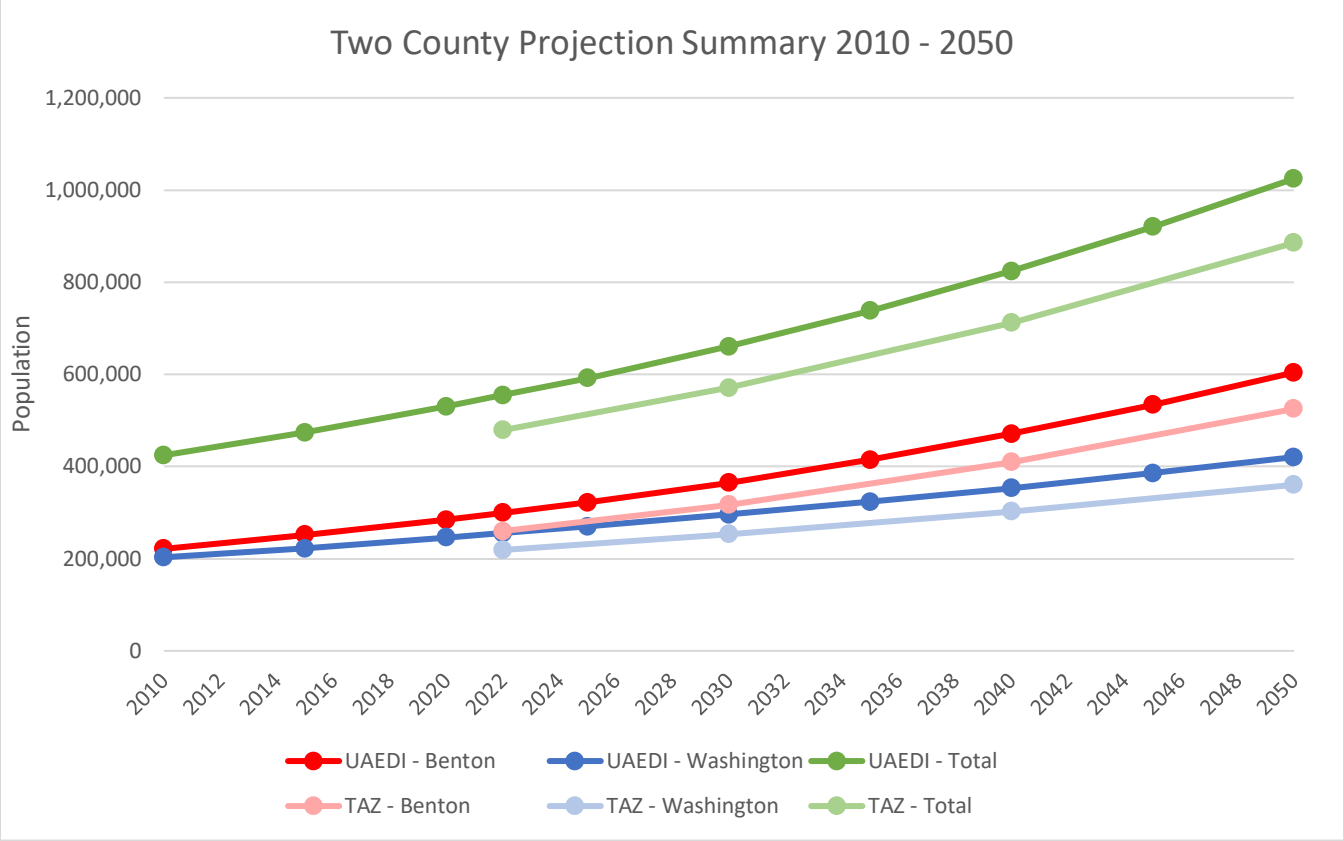


Table 6-5 and Table 6-6 present household and employment totals, along with percentages, by county for the base year 2022, with projections for 2030, 2040, and 2050.

Table 6-5: Total Household and Employment Projections by Year and by County

County	2022 HHs	2022 Emp.	2030 HHs	2030 Emp.	2040 HHs	2040 Emp.	2050 HHs	2050 Emp.
Benton	104,159	14,5460	138,075	175,788	180,538	221,197	222,870	276,405
Washington	93,777	120,494	114,095	148,076	139,552	175,218	164,897	192,432
McDonald	708	1,898	791	2,053	898	2,143	999	2,143
Total	**198,644**	**267,852**	**252,961**	**325,917**	**320,988**	**398,558**	**388,766**	**470,980**

Table 6-6: Share of Household and Employment Projections by Year and by County

County	2022 HHs	2022 Emp.	2030 HHs	2030 Emp.	2040 HHs	2040 Emp.	2050 HHs	2050 Emp.
Benton	52.4%	54.3%	54.6%	53.9%	56.2%	55.5%	57.3%	58.7%
Washington	47.2%	45.0%	45.1%	45.4%	43.5%	44.0%	42.4%	40.9%
McDonald	0.4%	0.7%	0.3%	0.6%	0.3%	0.5%	0.3%	0.5%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

7 Appendix D: 2050 Alternative Land User Forecasts

7.1 Overview

NWARPC's long-range plan utilized three future land use scenarios to evaluate transportation project performance. Similar to efforts in other MPOs, the intention was to consider how different land use development trajectories interact with transportation projects evaluated for the long-range plan.

WSP assisted NWARPC with preparing the baseline 2050 forecasts using growth rates for household and employment derived from AEDI and Woods & Poole.

NWARPC designated two "bookend" scenarios for 2050:

1) Urban Scenario: characterized by higher proportion of household and employment growth occurring in the urban core of the region.
2) Suburban Scenario: characterized by higher proportion of household and employment growth occurring in the suburban parts of the region.

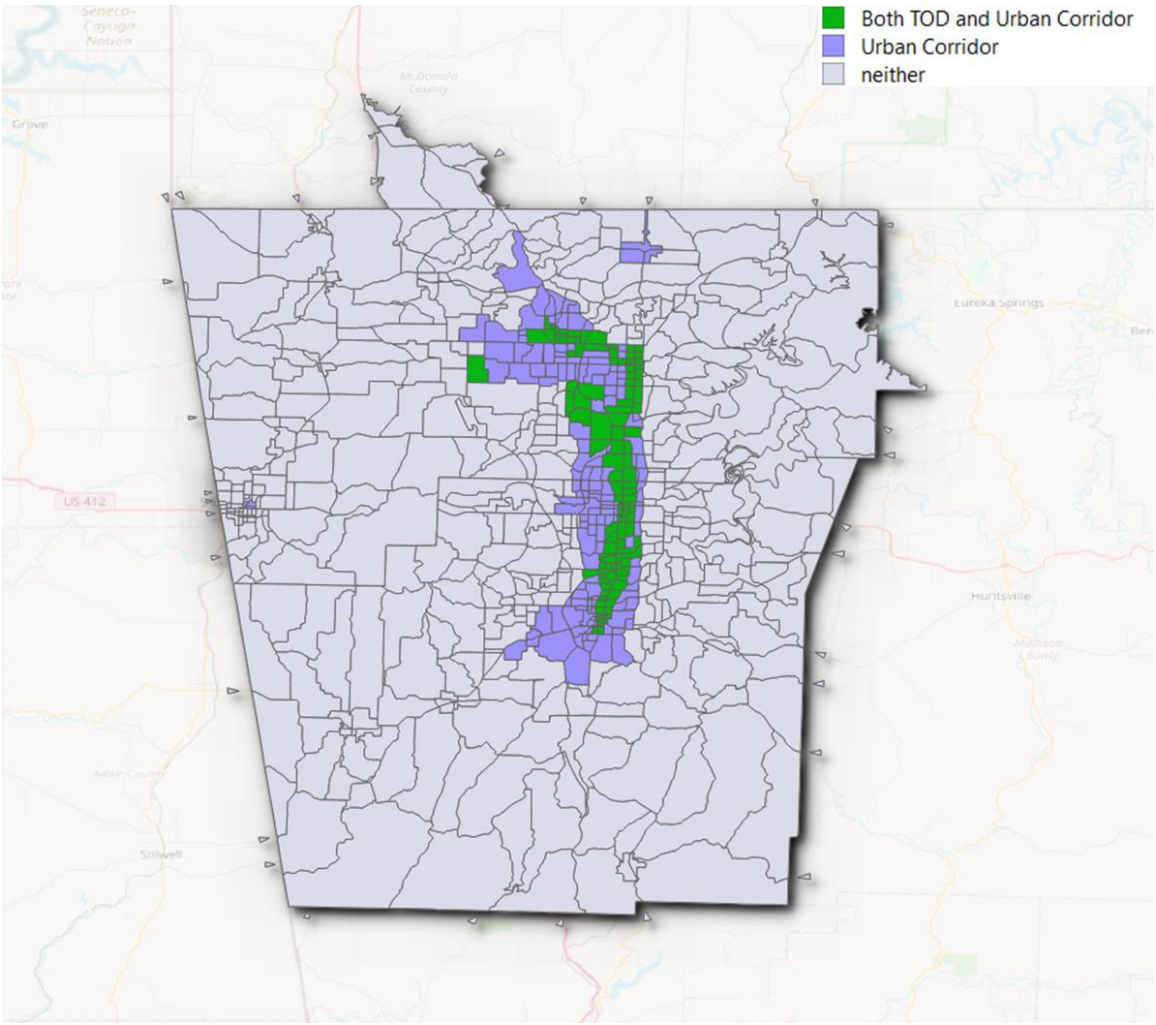
As the names suggest, these reflect growth patterns that diverged in opposite directions from the baseline 2050 forecast trends.

7.2 Methodology

NWARPC staff designated two areas of growth in the Urban Scenario: the Urban Corridor and the TOD (transit-oriented development) Corridor.

URBAN SCENARIO METHODOLOGY

Figure 7-1: Urban and TOD Corridors Map



Referring to Figure 7-1, in the Urban Scenario, the urban corridors received more household and employment growth in 2050, while areas outside of these corridors received little or no household and employment growth.

Employment and Household adjustments used separate methods due to different desired behavior, as well as differing initial distributions. The methodologies discussed below conserved total households and total employment across all TAZs in the region while re-distributing new employment and households to the target TAZs for the Urban or Suburban scenarios.

Urban Scenario - Household Adjustments

1) Each of the Urban TAZs' number of households was set to 1.1 times the 2050 households unless the TAZ was tagged as a low growth / no growth area.
2) The TOD TAZs' number of households was set to 1.3 times the 2050 households unless the TAZ was tagged as a low growth / no growth area.
3) The low growth and no growth TAZs were set to their 2050 projection with no change.
4) To prevent the 2050 adjusted households from being less than 2022 households, the TAZs 80180, 80111, 80171, 80164, 80020, 80121, 80080, 80023, 80211, 80242, 80310, 50220, 74450, 74436, 80014, 20182, 80441, 74431, 74433, 80320, 71870, 80354, 80331, 20091, 70100, 20391, 20361, 70300, 60560, 60631, 80012, 80323, 50380, 60841, 20254, 60830, 74440, 60540, 20382, were set to their 2022 number of households.
5) The remaining TAZs, which were not affected in steps 1-4, were proportionally drawn down by a common factor equal to:

$$\frac{total\ households\ in\ zones\ neither\ urban\ nor\ TOD - change\ in\ households\ in\ zones\ from\ step\ 1\ to\ 4}{total\ households\ in\ zones\ neither\ urban\ nor\ TOD}$$

This conserved the total households in the region.

6) Finally, for two TAZs, households were moved between donor TAZs and recipient TAZs due to known future developments.

Donor Zone	Recipient Zone	Total Households Moved
20262	20253	445
20411	20423	573

Urban Scenario - Employment Adjustments

1) TAZs 50040 and 20480, as well as TAZs tagged as low/no growth, were set to the 2050 employment. These TAZs were excluded in the calculation below.
2) Employment in non-urban, non-TOD TAZs were kept at 2022 levels with no projected growth. The total employment removed, when compared to the 2050 employment, was then calculated.

3) Add 60% of the removed employment from step 2 to the TOD TAZs (excluding low or no growth) by proportionally scaling their 2050 employment with a common factor equal to:

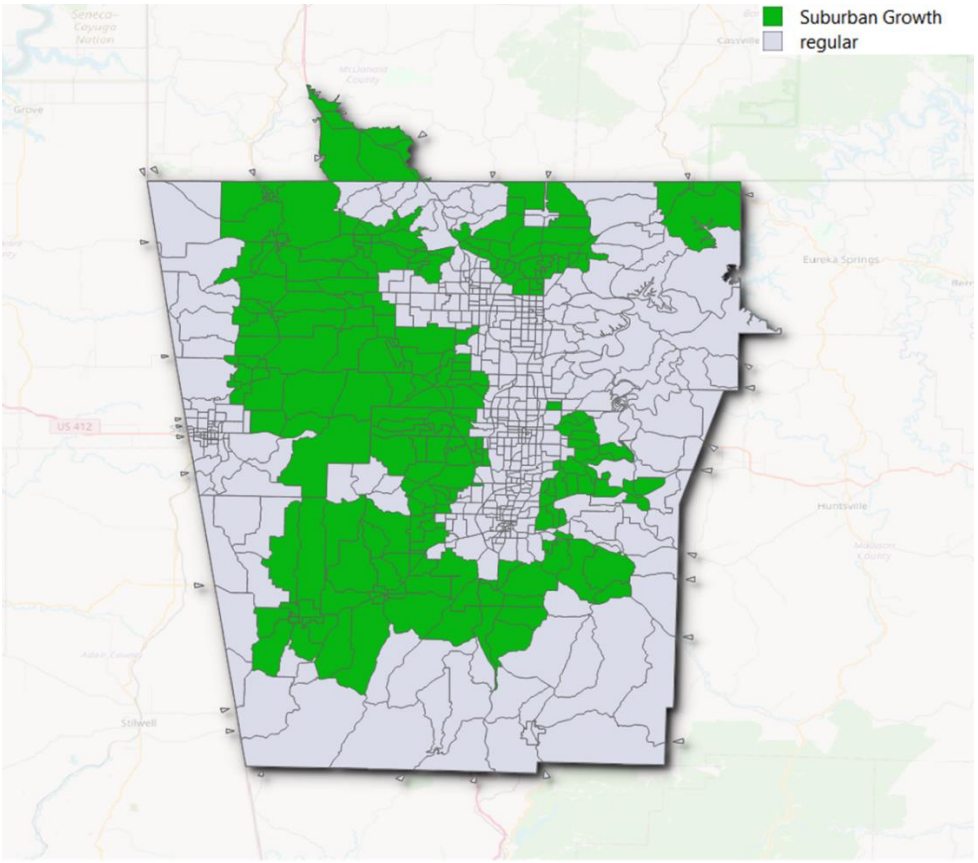
$$\frac{total\ employment\ in\ TOD\ zones + 60\%\ of\ employment\ change\ \ calculated\ in\ step\ 2}{total\ employment\ in\ TOD\ zones}$$

4) Similarly to step 2, add 40% of the removed employment from step 2 to Urban TAZs (excluding low or no growth) by proportionally scaling their 2050 employment with a common factor equal to:

$$\frac{total\ employment\ in\ urban\ zones + 40\%\ of\ employment\ change\ \ calculated\ in\ step\ 2}{total\ employment\ in\ urban\ zones}$$

SUBURBAN SCENARIO METHODOLOGY

Figure 7-2: Suburban Scenario Focus Areas Map



Referring to Figure 7-2, in the Low-Density suburban scenario, the household and employment growth was tilted toward the non-Urban Corridor and non-TOD Corridor TAZs, except for areas that were off-limits for development due to conservation and preservation priorities.

Reallocation of employment and household growth used similar but separate methods due to different desired behavior, as well as differing initial distributions. The methodologies below conserved number of household and total employment across all TAZs in the region, as they were only relocated rather than increased or decreased.

Suburban Scenario - Households Adjustments

1) The adjusted households for the TAZs below were manually adjusted using the below factors applied to the projected 2050 households.

TAZ Zone	2050 Growth Factor
80361	2
80351	2
70301	3.5
80370	2
80360	2
70101	3.5
70102	3.5
70100	2.5
70300	2
20230	2
60710	2
20240	2
20503	2.2
20241	2
20244	2
20511	2.2
20242	2
80362	2
70400	2

2) The adjusted household for the remaining (not listed in step 1) *regular* TAZs (primarily Urban and TOD TAZs) were then set to the 2022 households.

3) For the zones calculated in step 1 and 2, the total change was calculated as the difference between the projected 2050 households and the 2050 adjusted households.

4) The remaining number of households in the *Suburban Growth* TAZs were then adjusted with the following factor:

$$\frac{total\ 2050\ households\ in\ suburban\ growth\ \ zones + change\ in\ households\ calculated\ in\ step\ 3}{total\ 2050\ households\ in\ suburban\ growth\ \ zones}$$

Such that the total number of households in the base scenario and suburban scenario was conserved.

Suburban Scenario - Employment Adjustments

The following process generated adjusted employment for 2050, where a larger proportion of the growth occurred in suburban areas than the base scenario.

1) The adjusted employment for the TAZs below were manually adjusted using the factors below applied to the projected 2050 employment.

TAZ Zone	2050 Growth Factor
80361	2
80351	2
70301	3.5
80370	2
80360	2
70101	3.5
70102	3.5
70100	2.5
70300	2
20230	2
60710	2
20240	2
20503	2.2
20241	2
20244	2
20511	2.2
20242	2
80362	2
70400	2
72070	1
72023	1
72030	1
20421	3.5
20422	3.5
20423	3.5
20430	3.5
20483	3.5
20512	3.5
80423	3.5

74510	1

2) The adjusted employment for the remaining *regular* TAZs (primarily Urban and TOD TAZs) was linearly interpolated between the 2022 employment and 2050 projected employment with a 70% weight on 2050 employment.
3) For the zones calculated in step 1 and 2, the total change was calculated as the difference between the projected 2050 households and the 2050 adjusted households.
4) The remaining employment in the *Suburban Growth* TAZs was adjusted with the following factor:

$$\frac{total\ 2050\ employment\ in\ suburban\ growth\ \ zones + \ change\ in\ employment\ calculated\ in\ step\ 3}{total\ 2050\ employment\ in\ suburban\ growth\ \ zones}$$

Such that the total number of households in the base scenario and suburban scenario was conserved.

7.3 Results

7.3.1 Density Checks

For reasonableness checks, the population density and employment densities were calculated over the entire region for the base, urban and suburban scenarios. They are visualized below in Figure 7-3 and Figure 7-4.

Figure 7-3: 2050 Population Density (Baseline vs. Urban Scenario vs. Suburban Scenario)

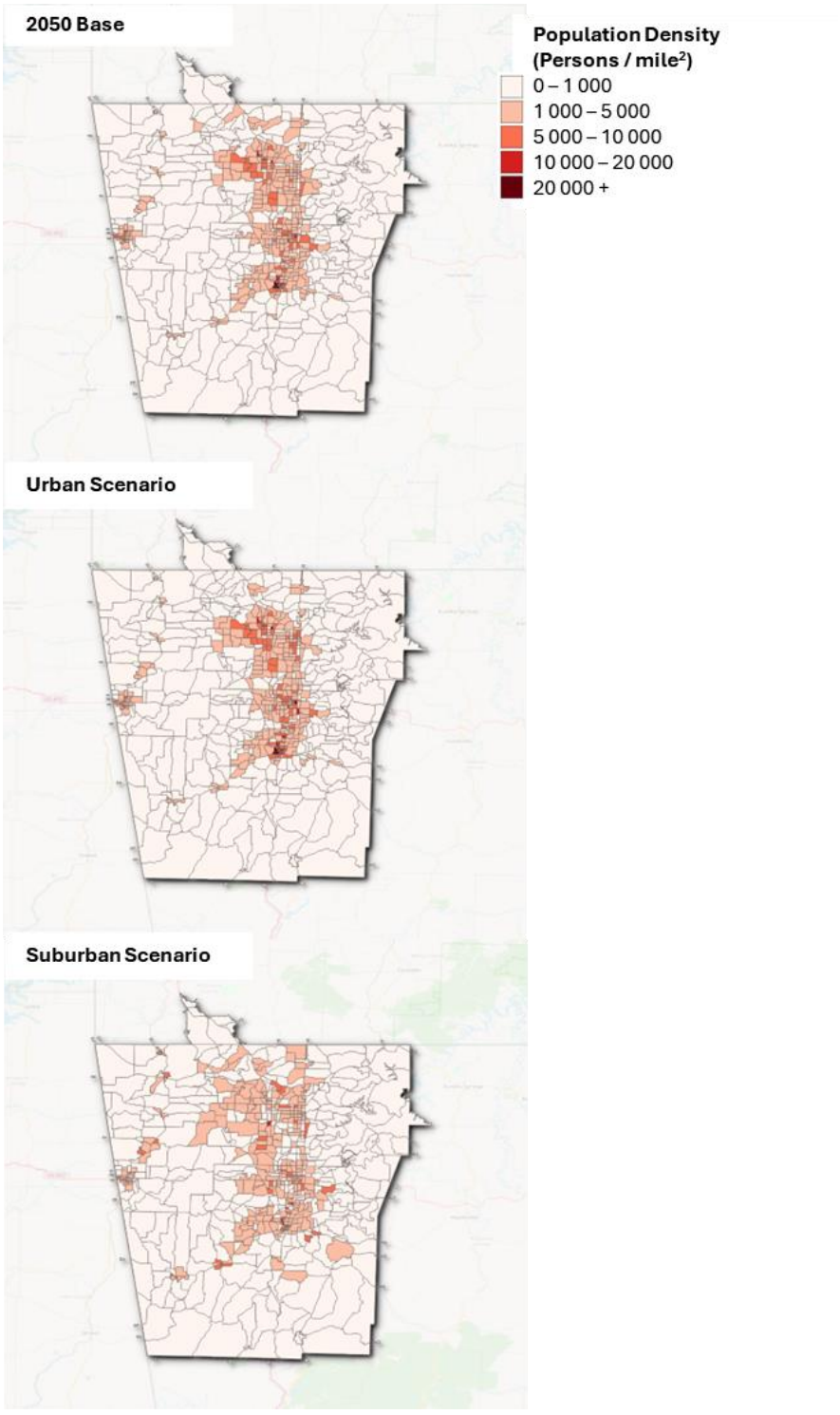
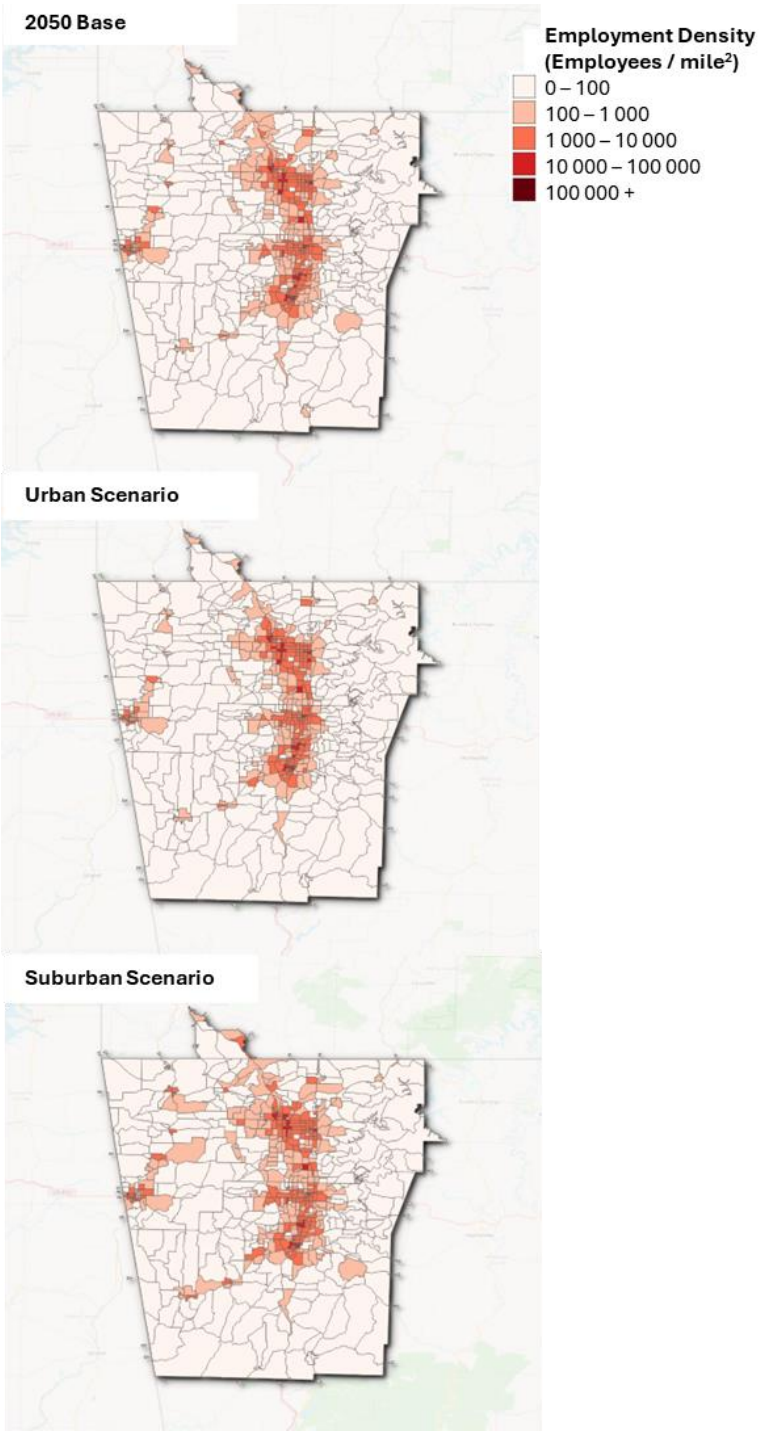


Figure 7-4: 2050 Employment Density (Baseline vs. Urban Scenario vs. Suburban Scenario)



7.3.2 Sensitivity test runs

The 2050 Urban and Suburban scenarios were run in the model and compared with the default 2050 scenario.

Trip Generation

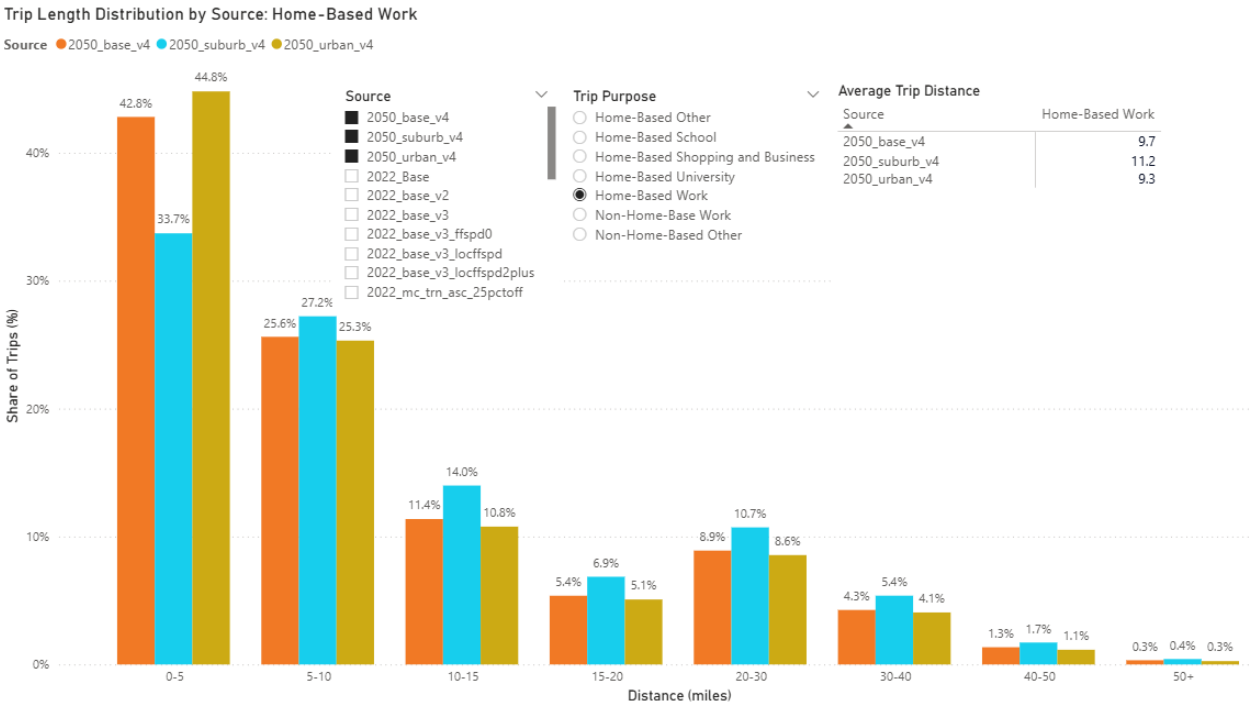
The table below shows trips by purpose across the three 2050 scenarios. The amount of trips by purpose should be fairly stable, which is what is observed.

Number of Trips by Purpose and Source

Trip Purpose	2050_base_v4	2050_suburb_v4	2050_urban_v4
Home-Based Other	706,558	720,203	702,164
Home-Based School	179,102	183,448	177,697
Home-Based Shopping and Business	945,233	957,981	940,803
Home-Based University	47,520	47,520	47,520
Home-Based Work	671,589	665,593	672,521
Non-Home-Base Work	251,841	249,971	252,205
Non-Home-Based Other	964,706	976,774	960,494
Total	**3,766,550**	**3,801,490**	**3,753,404**

Trip Distribution

The chart below shows the trips length distribution and average trip distance for home-based work trips across the three scenarios. As expected, the Urban scenario tends toward shorter trips and the Suburban scenario tends toward longer trips.



Mode Choice

The table below shows the mode choice results across the three scenarios. While the changes are modest, the Urban scenario sees absolute and relative increases in bike, walk, and all transit modes. The Suburban scenario sees reduced share for walk, bike, and all transit modes, while auto modes increase in absolute trips but keep similar drive alone share and increased shared ride mode share.

Number of Trips by Mode	**Scenarios**		
Mode	**2050 Base**	**2050 Suburban**	**2050 Urban**
BIKE	11,725	10,338	12,132
DA	2,639,413	2,659,531	2,630,236
DRVRAZ	496	496	500
KNR_BUS	495	392	537
PNR_BUS	5,570	5,473	5,610
SR2	483,593	491,810	480,862
SR3	511,739	523,601	507,289
WALK	111,919	108,541	114,512
WALK_BUS	1,600	1,307	1,727
Grand Total	**3,766,550**	**3,801,489**	**3,753,405**

Share of Trips by Mode	**Scenarios**		
Mode	**2050 Base**	**2050 Suburban**	**2050 Urban**
BIKE	0.31%	0.27%	0.32%
DA	70.08%	69.96%	70.08%
DRVRAZ	0.01%	0.01%	0.01%
KNR_BUS	0.01%	0.01%	0.01%
PNR_BUS	0.15%	0.14%	0.15%
SR2	12.84%	12.94%	12.81%
SR3	13.59%	13.77%	13.52%
WALK	2.97%	2.86%	3.05%
WALK_BUS	0.04%	0.03%	0.05%
Grand Total	**100.00%**	**100.00%**	**100.00%**