What's New? - Version 9.0.0

WFRC / MAG

2023-06-09

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Chapter 1

Wasatch Front Travel Demand Model Documentation

The Wasatch Front Travel Demand Model (WF TDM) is a macro transportation model. It forecasts daily travel patterns based on household characteristics and where people live in relation to the location of their daily activites and transportation opportunities. Travel decisions are based on a series of models that are calibrated to travel behavior of Wasatch Front residents measured from household travel diary surveys. Trips are assigned to a set of highway or transit-system routes by time of day based on where and by what mode people are likely to travel and the best route available to them.

The travel demand models are able to evaluate transportation and traffic impacts resulting from:

- transportation improvements
- provision of new modes of travel and/or enhancement of existing alternative modes
- changes in land use activity
- changes in travel behavior or policies/economic circumstances affecting behavior

As such, travel demand output is used to forecast where future travel demand is likely to exceed capacity and to assess the merits of future transportation investments. Travel demand output is also used to analyze air quality and other ancillary impacts of the transportation system.

The current WF TDM covers Weber, Davis, Salt Lake, and Utah Counties and a portion of Box Eder County. The WF TDM is jointly owned by the Wasatch Front Regional Council (WFRC) and the Mountainland Association of Governments (MAG). To request a copy of the WF TDM, please contact the following persons:

- Suzie Swim (WFRC): sswim@wfrc.org
- Matt DeLora (MAG): mdelora@magutah.org

Chapter 2

General Parameters

The changes made to the `0_GeneralParameters.block` file are discussed in this section.

2.1 Zone Parameters

With the update to the TAZ inputs, the TAZ references were made in various locations.

2.1.1 TAZ Range and Highway Node Reference

TAZ and highway node references were update with new zone numbers as shown in Table 2.1.

Table 2.1: Renumbered Range and Highway TAZs

Range	Code	TAZ
Used Zones	UsedZones	3629
Box Elder County Range	BoxElderRange	1-153
Weber County Range	WeberRange	154-581
Davis County Range	DavisRange	582-905
Salt Lake County Range	SLRange	906-2216
Utah County Range	UtahRange	2217-3546
Dummy Zones	Dummyzones	3547-3600
External Zones	Externalzones	3601-3629
North Brigham City	NorthBC	3604,3605,3606
Highway Nodes	HwyNodes	10000-99999

The following ranges were removed: RegionRange, WFRCRange, MAGRange.

2.1.2 Updated College and University Node Reference

College and university were updated with new zone numbers. See Table 2.2. Where noted, several colleges were effectively discontinued, meaning references to these schools are still in the code base, but enrollment was set to zero. ???ADD INPUTS DOC REFERENCE???

Table 2.2: Renumbered College and University Zones

College or University	Campus	Address	Code	TAZ	Status
Ensign College	Main	95 N 300 WSalt Lake City, UT 84101	Ensign	1029	Existing
Westminster College	Main	1840 S 1300 ESalt Lake City, UT 84105	Westmin	1263	Existing
University of Utah	Main	201 Presidents CirSalt Lake City, UT 84112	UOFU_Main	1051	Existing
	Medical	30 N 1900 ESalt Lake City, UT 84132	UOFU_Med	1007	Discontinued
Weber State University	Main	3848 Harrison BlvdOgden, UT 84403	WSU_Main	437	Existing
	Davis	2750 University Park BlvdLayton, UT, 84041	WSU_Davis	693	Existing
	West	5627 S 3500 WRoy, UT, 84067	WSU_West	521	Discontinued
Salt LakeCommunity College	Main	4600 S Redwood RdTaylorsville, UT 84123	SLCC_Main	1580	Existing
	South City	1575 S State StreetSalt Lake City, UT 84115	SLCC_SC	1231	Existing
	Jordan	3491 W 9000 SWest Jordan, UT 84088	SLCC_JD	1776	Existing
	Meadbrook	218 W 3900 SSalt Lake City, UT 84107	SLCC_Mead	1491	Discontinued

College or University	Campus	Address	Code	TAZ	Status
	Miller	9750 S 300 WSandy, UT 84070	SLCC_ML	1886	Existing
	Library	231 E 400 SSalt Lake City, UT 84111	SLCC_LB	1085	Discontinued
	Highland	3760 S Highland DriveSalt Lake City, UT 84106	SLCC_HL	1525	Discontinued
	Airport	551 2200 WSalt Lake City, UT 84116	SLCC_Airp	979	Discontinued
	Westpointe	2150 W Dauntless AveSalt Lake City, UT 84116	SLCC_West	959	Discontinued
	Herriman	14200 S 4000 WHerriman, UT	SLCC_HM	2031	Discontinued
Brigham Young University	Main	1 N University HillProvo, UT 84602	BYU	2939	Existing
Utah Valley University	Main	800 West University Parkway-Orem, UT 84058	UVU_Main	2848	Existing
	Geneva	951 S Geneva RdOrem, UT 84058	UVU_Geneva	2882	Discontinued
	Lehi	2301 W. Ashton BlvdLehi, UT 84043	UVU_Lehi	2606	Existing
	Vineyard	Mill RdVineyard, UT	UVU_Vine	2809	Future
	Payson	Future Nebo Belt RdPayson, UT	UVU_Payson	3336	Future

2.1.3 Updated Special Generator Node References

Special generators were updated with new zone numbers, as shown in Table 2.3.

Table 2.3: Renumbered College and University Zones

Special Generator	Code	TAZ
Lagoon Amusement Park	Lagoon	781
Salt Lake City International Airport	Aiport	965
LDS Salt Lake Temple Square	TempleSquare	1035
Salt Lake City Main Library	SLC_Library	1147

2.2 Special Trip Table Parameters

The income break points for Salt Lake City International Airport were updated as shown in Table 2.4.

Table 2.4: Airport Income Levels

Category Break Point	Code	Income
Low	Income_Lo	$45,000
Medium	Income_Md	$75,000
High	Income_Hi	$125,000

2.3 County Identification

Removed the county identification section section containing the following variables: `CountyRange`, `CountyName1`, `CountyName2`, `CountyName3`, `CountyName4`, `CountyName5`, `CO_Name1`, `CO_Name2`, `CO_Name3`, `CO_Name4`, `CO_Name5`.

2.4 Air Quality Conformity Reports

Removed the air quality conformity section containing the following variables broken down by each county and 3 cities: `RE_ID`, `WE_ID`, `DA_ID`, `SL_ID`, `UT_ID`, `BE_ID`, `OC_ID`, `SC_ID`, `PC_ID`.

2.5 Household Disaggregation Parameters

The updated regional median income was $74,946 from 2019 5-year ACS, in 2019 dollars. This represents average for just the Wasatch Front region.

2.6 Distribution, Mode Choice, and Assignment Parameters

2.6.1 Auto Occupancy

The vehicle occupancy rates were updated expanded to additional trips purposes. See Table 2.5 and Table 2.6. Variables were renamed where indicated. Auto occupancy parameters were updated based on 2012 Household Travel Survey (reprocessed). Values represent average persons per vehicle for just the

Wasatch Front model space. External trips are average for IX + XI, all other parameters are averages for II trips.

???SHOW PREVIOUS VALUES???

Table 2.5: Average Auto-Occupancy Codes and Rates

Trip Purpose	Code	Previous Code	Updated Value
Home-Based Work	VehOcc_HBW	VEH_OCCUPANCY_HBW	1.10
Home-Based Shopping	VehOcc_HBShp	VEH_OCCUPANCY_HBSHP	1.63
Home-Based Other	VehOcc_HBOth	VEH_OCCUPANCY_HBOTH	1.68
Home-Based School	VehOcc_HBSch	VEH_OCCUPANCY_HBSCH	1.76
Home-Based College	VehOcc_HBC	VEH_OCCUPANCY_HBC	1.12
Non-Home-Based Work	VehOcc_NHBW	VEH_OCCUPANCY_NHBW	1.21
Non-Home-Based Non-Work	VehOcc_NHBNW	VEH_OCCUPANCY_NHBNW	1.76
Recreation	VehOcc_Rec		1.68
Home-Based Other (sub-category)	VehOcc_HBO	VEH_OCCUPANCY_HBO	1.67
Non-Home-Based (sub-category)	VehOcc_NHB	VEH_OCCUPANCY_NHB	1.54
External Work	VehOcc_ExtWrk		1.16
External Home-Based Other	VehOcc_ExtHBO		1.82
Non-Home-Based	VehOcc_ExtNHB		1.73
External Recreation	VehOcc_ExtRec		1.73

???WE SHOULD PROBABLY SHOW PREVIOUS VALUES???

Table 2.6: Average Auto-Occupancy Codes and Rates for Vehicles with 3+ Persons

Trip Purpose	Code	Previous Code	Updated Value
Home-Based Work	VehOcc_3p_HBW	VEH_OCC_3P_HBW	3.53
Home-Based Shopping	VehOcc_3p_HBShp		3.49
Home-Based Other	VehOcc_3p_HBOth		3.73
Home-Based School	VehOcc_3p_HBSch		3.88
Home-Based College	VehOcc_3p_HBC	VEH_OCC_3P_HBC	3.24
Non-Home-Based Work	VehOcc_3p_NHBW		3.71
Non-Home-Based Non-Work	VehOcc_3p_NHBNW		3.71
Recreation	VehOcc_3p_Rec		3.73
Home-Based Other (sub-category)	VehOcc_3p_HBO	VEH_OCC_3P_HBO	3.68
Non-Home-Based (sub-category)	VehOcc_3p_NHB	VEH_OCC_3P_NHB	3.71

2.6.2 Value of Time

Value of time was updated for 2019 dollars, as shown in Table 2.7.

Table 2.7: Value of Time

Category	Code	Value of Time (???UNITS???)
Auto Work Trips	VOT_Auto_Wrk	22

Category	Code	Value of Time (???UNITS???)
Auto Work Trips - Low Income	VOT_Auto_Wrk_Lo	9
Auto Work Trips - High Income	VOT_Auto_Wrk_Hi	24
Auto Personal Trips	VOT_Auto_Per	17
Auto Personal Trips - Low Income	VOT_Auto_Per_Lo	7
Auto Personal Trips - High Income	VOT_Auto_Per_Hi	19
Auto External Trips	VOT_Auto_Ext	20
Light Trucks	VOT_LT	37
Medium Trucks	VOT_MD	50
Heavy Trucks	VOT_HV	63
Toll Trips	VOT_Toll	63
High-Occupancy Toll Trips	VOT_HOT_DA	63

2.6.3 Auto Operating Costs

Auto operating cost (AOC) were updated based on 2019 fuel cost & economy and vehicle maintenance. See Table 2.8.

Table 2.8: Auto Operating Costs

Category	Code	Auto Operating Cost (???UNITS???)
Personal Vehicle Auto	AOC_Auto	21.7
Commercial Vehicle - Light Truck	AOC_LT	27.3
Commercial Vehicle - Medium Truck	AOC_MD	55.5
Commercial Vehicle - Heavy Truck	AOC_HV	74.3

2.6.4 Toll and HOT Costs

Toll and HOT Costs were updated as shown in Table 2.9. Toll costs reflect a toll of approximately $5.00 for a 10.25 mi trip (average work distance) or $3.00 for a 6.5 mi trip (average trip distance of all trips) in 2019 dollars. The toll costs apply to links with a functional type of 40. HOT costs reflect a toll of approximately $3.50 for a 10.25 mi trip (average work distance) or $2.20 for a 6.5 mi trip (average trip distance of all trips) in 2019 dollars. HOT costs are applicable to links with a functional type of 38.

Table 2.9: Toll and High-Occupancy Toll Costs

Category	Code	Cost (cent/mile)
Toll Peak Cost	Cost_Toll_Pk	48
Toll Off-Peak Cost	Cost_Toll_Ok	48
High-Occupancy Toll Peak Cost	Cost_HOT_Pk	34
High-Occupancy Toll Off-Peak Cost	Cost_HOT_Ok	17

2.6.5 Prefix for Transit Skims

All transit skim prefix global variable tokens were replaced with values in scripts. Transit skim prefix variables were removed from the General Parameters file.

2.7 Calibration Adjustment K-Factors

Additional k-factors were added for calibration purposes to include work trips, truck trips, and external trips. In v8.3.2 there were only three k-factors defined for non-work personal trips. The calibration adjustment k-factors reset to 1, as shown in Table 2.10.

Table 2.10: K-Factors

County-to-County Pair	Purpose	Code	v9.0.0	v8.3.2
Salt Lake to Utah County	Work	SL_UT_KFAC_Wrk	1	–
	Other	SL_UT_KFAC_Oth	1	0.85
	Truck	SL_UT_KFAC_Trk	1	–
	External	SL_UT_KFAC_Ext	1	–
Salt Lake to Davis County	Work	SL_DA_KFAC_Wrk	1	–
	Other	SL_DA_KFAC_Oth	1	0.95
	Truck	SL_DA_KFAC_Trk	1	–
	External	SL_DA_KFAC_Ext	1	–
Weber to Box Elder County	Work	WE_BE_KFAC_Wrk	1	–
	Other	WE_BE_KFAC_Oth	1	1.00
	Truck	WE_BE_KFAC_Trk	1	–
	External	WE_BE_KFAC_Ext	1	–

2.8 Other

The rail to core bus route multiplier `RAIL2COR_MULTIPLIER` was changed from 0.40 to 0.33.

Period and Production/Attraction factors were removed.

Chapter 3

Input Data

```
//|echo: false
// setup mapping and layers
L = require('leaflet@1.2.0')
html`<link href='${resolve('leaflet@1.2.0/dist/leaflet.css')}' rel='stylesheet' />`

geojsonTazOld    = FileAttachment("data/tazOld.geojson"   ).json()
geojsonTazNew    = FileAttachment("data/tazNew.geojson"   ).json()
geojsonK12Enroll = FileAttachment("data/k12enroll.geojson").json()
geojsonCity      = FileAttachment("data/city.geojson"     ).json()
geojsonSDst      = FileAttachment("data/sdst.geojson"     ).json()
geojsonMDst      = FileAttachment("data/mdst.geojson"     ).json()
geojsonLDst      = FileAttachment("data/ldst.geojson"     ).json()
```

The changes in each `1_Inputs` subfolder are described in their respective sections.

3.1 Global Data

This section includes a discussion of any changes made within the `0_GlobalData` subfolder in the model inputs.

3.1.1 Trip Tables

The college base distribution source file `_Source - CollegeBaseDistribution - 2022-08-30.xlsx` and model lookup file `BaseDistribution.csv` were updated to the v9.0.0 Traffic Analysis Zone (TAZ) structure. The centroid of the v8.3.2 TAZ were spatially joined to the v9.0.0 TAZ to find their new TAZ designation.

3.1.2 Household Disaggregation and Auto Ownership

Using parameters developed statewide based on 2020 census block data, 2020 ACS block group data, and 2019 population by age group data, the age percent lookup files `_Source - TAZ_AgePct_Lookup - 2022-06-07.xlsb` and `Lookup - BYTAZAgePct - AllCo.csv` were updated to v9.0.0 TAZ & 2019 base year.

3.1.3 Mode Choice

Bus speed ratios were updated in the `bus_speed_ratios.csv` file. A companion file showing additional calculations is included in the new `_source - bus_speed_ratios.xlsx` file.

The factors to calculate bus speeds from congested auto speeds from the distribution loaded network were re-estimated based on General Transit Feed Specification (GTFS) data from August through November 2019. The functional groups were redefined and expanded to include area type as well as peak and off-peak time periods.

```
# Convert bus speeds input into long format
import pandas as pd

# add name data to expand model CSV
dfAreaTypes = pd.DataFrame([
  ['Rur','Rural'     ],
  ['Trn','Transition'],
  ['Sub','Suburban'  ],
  ['Urb','Urban'     ],
  ['CBD','CBD-Like'  ]
], columns=('AreaType','AreaTypeName'))

dfTimePeriods = pd.DataFrame([
  ['Pk','Peak'    ],
  ['Ok','Off-Peak'],
  ['DY','Daily'   ]
], columns=('TimePeriod','TimePeriodName'))

dfFunctionalClasses = pd.DataFrame([
  [1, 'Col', 'Collectors & Locals'],
  [2, 'Min', 'Minor Arterials'    ],
  [3, 'Maj', 'Major Arterials'    ],
  [4, 'Exp', 'Expressways'        ],
  [5, 'Fwy', 'Freeways & Ramps'   ]
], columns=('FC','FunctionalClass','FunctionalClassName'))

# read in bus speed ratios
dfBusSpeedRatios = pd.read_csv(r"A:\1 - TDM\3 - Model Dev\1 - WF\2 - Sandbox\v9.0Beta\WF TDM v9.0 - 2023

# create a list of column names to use as variable names
varCols = dfBusSpeedRatios.columns.to_list()

# remove the ID columns from variable columns list
varCols.remove('Functional Class')

# melt table to get long format using FC and FC Name as ids
dfBusSpeedRatios_long = pd.melt(dfBusSpeedRatios, id_vars=['FC'], value_vars=varCols, var_name='TimePeri

# get Time Period and Area Type from TimePeriod_AreaType field
dfBusSpeedRatios_long['TimePeriod'] = dfBusSpeedRatios_long['TimePeriod_AreaType'].str.split('_').str[0]
dfBusSpeedRatios_long['AreaType'  ] = dfBusSpeedRatios_long['TimePeriod_AreaType'].str.split('_').str[1]
```

```
dfBusSpeedRatios_long = dfBusSpeedRatios_long.merge(dfFunctionalClasses,on='FC'        )
dfBusSpeedRatios_long = dfBusSpeedRatios_long.merge(dfTimePeriods      ,on='TimePeriod')
dfBusSpeedRatios_long = dfBusSpeedRatios_long.merge(dfAreaTypes        ,on='AreaType'  )

# limit columns and export csv
dfBusSpeedRatios_long = dfBusSpeedRatios_long[['FunctionalClass','FunctionalClassName','TimePeriod','Tim

## create objects for observable js
#ojs_define(busdata = dfBusSpeedRatios_long, typed=True)
#ojs_define(fcnames = dfBusSpeedRatios_long[['FunctionalClassName']].drop_duplicates())
#ojs_define(tpnames = dfBusSpeedRatios_long[['TimePeriodName'     ]].drop_duplicates())
#ojs_define(atnames = dfBusSpeedRatios_long[['AreaTypeName'       ]].drop_duplicates())

dfBusSpeedRatios_long.to_csv(r'data\bus_speed_ratios_long.csv', index=False)

# export function class list csv
dfBusSpeedRatios_long[['FunctionalClass','FunctionalClassName']].drop_duplicates().to_csv('data\\functio
dfBusSpeedRatios_long[['TimePeriod'     ,'TimePeriodName'     ]].drop_duplicates().to_csv('data\\timeper
dfBusSpeedRatios_long[['AreaType'       ,'AreaTypeName'       ]].drop_duplicates().to_csv('data\\areatyp

dfBusSpeedRatios_Previous = pd.DataFrame([
   ['Collectors'                       , 0.60],
   ['Minor Arterials\n(Urb/CBD)'       , 0.65],
   ['Minor Arterials\n(Sub/Rur)'       , 0.65],
   ['Principal Arterials\n& Expressways', 0.55],
   ['Freeway Ramps'                    , 0.75],
   ['Freeways'                         , 0.95]
], columns=('FunctionalClass','BusSpeedRatio'))

dfBusSpeedRatios_Previous.to_csv(r'data\bus_speed_ratios_previous.csv', index=False)
```

3.1.3.1 Bus Speeds Plot

```
//| echo: false

// read in CSVs
faDataBusSpeeds     = FileAttachment("data\\bus_speed_ratios_long.csv").csv({ typed: true });
faFunctionalClasses = FileAttachment("data\\functionalclass.csv"      ).csv({ typed: true });
faTimePeriods       = FileAttachment("data\\timeperiod.csv"           ).csv({ typed: true });
faAreaTypes         = FileAttachment("data\\areatype.csv"             ).csv({ typed: true });

viewof facetSelect  = Inputs.select(new Map([['Time Period', 'TimePeriodName'], ['Area Type', 'AreaTypeN
viewof domainSelect = Inputs.select(new Map([['Time Period', 'TimePeriodName'], ['Area Type', 'AreaTypeN
viewof strokeSelect = Inputs.select(new Map([['Time Period', 'TimePeriodName'], ['Area Type', 'AreaTypeN

// FILTER DATA
//viewof functionalclasses_checked = Inputs.checkbox(faFunctionalClasses.map(function(d) {return d.Funct
//                                                   {value: faFunctionalClasses.map(function(d) {return
```

```
//                                                    label: "Function Class"});
//viewof timeperiods_checked       = Inputs.checkbox(faTimePeriods      .map(function(d) {return d.TimeP
//                                                  {value: faTimePeriods      .map(function(d) {return
//                                                   label: "Time Period"   });
//filteredBusData = faDataBusSpeeds.filter(function(busspeed) {
//  return functionalclasses_checked.includes(busspeed.FunctionalClassName) &&
//         timeperiods_checked      .includes(busspeed.TimePeriodName     )// &&
//         //areatypes        .includes(busspeed.AreaTypeName  );
//});

domainFromSelect = {
  switch(domainSelect) {
    case 'TimePeriodName'     : return faTimePeriods      .map(function(d) {return d.TimePeriod     });
    case 'AreaTypeName'       : return faAreaTypes        .map(function(d) {return d.AreaType       });
    case 'FunctionalClassName': return faFunctionalClasses.map(function(d) {return d.FunctionalClass});
    default                   : return
  }
}

xPlotDomainSelect = {
  switch(domainSelect) {
    case 'TimePeriodName'     : return "TimePeriod"     ; break;
    case 'AreaTypeName'       : return "AreaType"       ; break;
    case 'FunctionalClassName': return "FunctionalClass"; break;
    default                   : return                        ;
  }
}

xLabel = {
  switch(domainSelect) {
    case 'TimePeriodName'     : return "Time Period"     ;      break;
    case 'AreaTypeName'       : return "Area Type"       ;      break;
    case 'FunctionalClassName': return "Functional Class";      break;
    default                   : return                           ;
  }
}

domainFacetSelect = {
  switch(facetSelect) {
    case 'TimePeriodName'     : return faTimePeriods      .map(function(d) {return d.TimePeriodName
    case 'AreaTypeName'       : return faAreaTypes        .map(function(d) {return d.AreaTypeName
    case 'FunctionalClassName': return faFunctionalClasses.map(function(d) {return d.FunctionalClassName
    default                   : return;  }
}

Plot.plot({
  grid: true,
  aspectRatio: 0.5,
  facet: {data: faDataBusSpeeds, x: facetSelect, label: xLabel},
```

```
  x: {label: xLabel, domain: domainFromSelect},
  y: {label: "Bus Speed Ratio" , domain: [0, 1]},
  color: { type: "categorical", legend: true, legendStyle: { fontSize: 16 } },
  style: {
    fontSize: 12
  },
  marks: [
    Plot.frame(),
    Plot.line(faDataBusSpeeds, {x: xPlotDomainSelect, y: "BusSpeedRatio", stroke: strokeSelect, strokeWi
    Plot.dot (faDataBusSpeeds, {x: xPlotDomainSelect, y: "BusSpeedRatio", stroke: strokeSelect, r: 4, fi
  ]
})
```

3.1.3.2 Bus Speeds Data

```
//| echo: false
Inputs.table(faDataBusSpeeds, {
  style: {
    fontSize: 16,
  },
  columns: [
    "FunctionalClassName",
    "TimePeriodName",
    "AreaTypeName",
    "BusSpeedRatio"
  ],
  header: {
    FunctionalClassName: "Functional Class",
    TimePeriodName: "Time Period",
    AreaTypeName: "Area Type",
    BusSpeedRatio: "Bus Speed Ratio"
  }})
```

3.1.3.3 Previous Bus Speeds

```
//| echo: false

// read in CSVs
faDataBusSpeeds_previous = FileAttachment("data\\bus_speed_ratios_previous.csv").csv({ typed: true });

Plot.plot({
  grid: true,
  aspectRatio: 0.5,
  style: {
    fontSize: 16,
  },
  x: {label: "Functional Class", tickRotate: 90, domain: faDataBusSpeeds_previous.map(function(d) {retur
      //tickFormat: (d) => {
```

```
//          const label = d.toString(); // Convert the tick value to a string
//          const maxWidth = 15; // Specify the maximum width for each label
//          const words = label.split(" "); // Split the label into words
//
//          let line = "";
//          let lines = [];
//
//          words.forEach((word) => {
//            if (line.length + word.length > maxWidth) {
//              lines.push(line);
//              line = "";
//            }
//            line += word + " ";
//          });
//
//          lines.push(line);
//
//          return lines;
//      }
    },
  y: {label: "Bus Speed Ratio" , domain: [0, 1]},
  color: { type: "categorical", legend: true },
  marks: [
    Plot.frame(),
    Plot.barY(faDataBusSpeeds_previous, {x: "FunctionalClass", y: "BusSpeedRatio", stroke: "FunctionalCl
  ]
})
```

???PERHAPS CONSOLIDATE 3 DROPDOWNS INTO SINGLE ONE TO AVOID STRANGE VIEWS OF CHARTS???

???NEED TO FIX OVERLAPPING CHART LABELS???

3.1.4 Assignment

Diurnal and production/attraction factors were calculated in `_source - Diurnal & PA factors.xlsx` and exported to a model lookup table called `Diurnal & PA factors.csv`. Corresponding factors were removed from the `0GeneralParameters.block` file.

3.2 Traffic Analysis Zones (TAZ)

The v9.0.0 TAZ zone set includes new geographies, new TAZ numbering ranges, zone attributes, and districts, as well as a new `\_Source` subfolder.

3.2.1 Geographies

Changes in TAZ geographies include both expansion of the model area and splitting and/or changing zone boundaries. The expanded model area now includes TAZs in additional portions of Box Elder County, all of western Weber County, and the entirety of Davis, Salt Lake and Utah Counties. External dummy zones (represented as quadrilaterals) were removed from the TAZ shapefile.

Additional area in the expanded WFRC and MAG areas include the following:

- Canyon areas of the Wasatch mountains up to the eastern boundary of Salt Lake, Utah, and Davis counties, and additionally the canyon areas up to eastern boundary of Box Elder County for the portion of Box Elder County that was in the v8.3.2 model.
- Canyon areas of the Wasatch mountains up to the ridge line of Weber County, excluding the Ogden Valley (Huntsville, Eden, Liberty) and other portions of eastern Weber County which remain in UDOT's transportation planning jurisdiction.
- Canyon areas of the Oquirrh mountain range up to the western boundary of Salt Lake County
- Great Salt Lake areas to the western boundary of Salt Lake, Davis, and Weber counties

The additional areas and reconfigured TAZs result in 694 additional zones, 688 internal zones and 6 new external zones. A comparison of zone counts is found in Table 3.1.

Table 3.1: TAZ Count Comparions

Category	v9.0.0	v8.3.2	Difference
Internal Used Zones	3,546	2,858	688
External Count	29	23	6
All New Used Zones	3,575	2,881	694
Internal Unused Zones	54	0	54
Max Used Zone	3,629	2,881	748

The interactive map in **?@fig-taz-compare-map** can be explored to visualize the difference in v9.0.0 and v8.3.2 TAZs.

```
//|label: fig-taz-compare-map
//|fig-cap: TAZ Geography Comparison Map
//|echo: false

mapTaz = {

  let container = DOM.element('div', { style: `width:${width}px;height:${width/1.6}px` });
  yield container;

  let map = L.map(container).setView([40.7608, -111.8910], 8.25);

  let greyLayer = L.tileLayer('https://{s}.basemaps.cartocdn.com/light_all/{z}/{x}/{y}{r}.png', {
    attribution: '&copy; <a href="https://www.openstreetmap.org/copyright">OpenStreetMap</a> contributor
  }).addTo(map);

  let lcolors = ['#0000FF'    ,'#FFFF00'   ]
  let llabels = ['v8.3.2 TAZ' ,'v9.0.0 TAZ'];

  let lyrTAZOld = L.geoJson(geojsonTazOld, { weight: 3.00, color: lcolors[0]}).addTo(map);
  let lyrTAZNew = L.geoJson(geojsonTazNew, { weight: 0.75, color: lcolors[1]}).addTo(map);

  var legend = L.control({position: 'bottomleft'});
    legend.onAdd = function (map) {
      var div = L.DomUtil.create('div', 'legend');
```

```
      div.innerHTML = '';
      for (var i = 0; i < llabels.length; i++) {
        div.innerHTML += '<i style="background:' + lcolors[i] + '"> </i> ' + llabels[i] + '<br/>';
      }

      // Add CSS style for the background color
      div.style.backgroundColor = 'lightgray';
      div.style.padding = '10px';

      return div;
    };
    legend.addTo(map);
}
```

3.2.2 TAZ Ranges

The new and previous internal and external ranges of TAZIDs by for each county are shown in Table 3.2.

Table 3.2: TAZ Ranges

County	v9.0.0 Internal	v9.0.0 External	v8.3.2 Internal	v8.3.2. External
Box Elder County	1-153	3601-3606	1-135	136-140
Weber County	154-581	3607-3609	141-420	421-423
Davis County	582-905	N/A	424-654	N/A
Salt Lake County	906-2216	3610-3615	655-1781	1782-1788
Utah County	2217-3546	3616-3629	1789-2873	2874-2881

3.2.3 Attributes

This section describes the changes made to the attributes of the TAZ shapefile.

3.2.3.1 REMM Space

To indicate which TAZs are included in the Real Estate Market Model (REMM) space, the `REMM` field was added with a value of `1` indicating that it is part of REMM and `0` indicating it is not part of REMM, as shown in **?@fig-taz-remm-space**.

```
//|label: fig-taz-remm-space
//|fig-cap: TAZ REMM Space
//|echo: false

mapTazRemmSpace = {

  let container = DOM.element('div', { style: `width:${width}px;height:${width/1.6}px` });
  yield container;

  let map = L.map(container).setView([40.7608, -111.8910], 8.25);
```

```
  let greyLayer = L.tileLayer('https://{s}.basemaps.cartocdn.com/light_all/{z}/{x}/{y}{r}.png', {
    attribution: '&copy; <a href="https://www.openstreetmap.org/copyright">OpenStreetMap</a> contributor
  }).addTo(map);

  let remmColors = ['#00887F'   ,'#BD0026'       ]
  let remmLabels = ['REMM Space','Non-REMM Space'];

  let lyrTAZNew = L.geoJson(geojsonTazNew, {
                            style: function(feature) {
                              var d = feature.properties.REMM;
                              return d==1 ? {color:remmColors[0], weight:1, opacity:0.95} :
                                     d==0 ? {color:remmColors[1], weight:1, opacity:0.95} :
                                            {color:    '#000000', weight:1, opacity:0.95} ;
                            }
  }).addTo(map);

  var legend = L.control({position: 'bottomleft'});
  legend.onAdd = function (map) {
    var div = L.DomUtil.create('div', 'legend');
    div.innerHTML = '';
    for (var i = 0; i < remmLabels.length; i++) {
      div.innerHTML += '<i style="background:' + remmColors[i] + '"> </i> ' + remmLabels[i] + '<br/
    }

    // Add CSS style for the background color
    div.style.backgroundColor = 'lightgray';
    div.style.padding = '10px';

    return div;
  };
  legend.addTo(map);
}
```

3.2.3.2 Parking Costs

The values in the permanent parking cost field `PRKCSTPERM` and temporary parking cost field `PRKCSTTEMP` were updated based on 2022 parking rates obtained from Salt Lake City, web searches, and field visits.

A new methodology for calculating parking cost was envisioned but not implemented for v9.0.0. Accordingly, updates to parking data were done in a way to facilitate the change to the new methodology in the future. These updates include a new polygon source file for downtown and university areas. However, since the envisioned methodology removes the use of parking cost fields for Lagoon and Salt Lake City International Airport, they were not included in this new shapefile.

3.2.3.2.1 Downtown and University Areas

Parking costs were developed for downtown areas for Ogden, Salt Lake City, and Provo, as well as major university areas along the Wasatch Front. A new source polygon shapefile was developed to hold rates for Home-Based Work (HBW), Home-Based College (HBC), Home-Based Other (HBO), and Non-Home-Based (NHB) trip purposes. While rates are included for these four purposes, the v9.0.0 model only utilizes HBW

for permanent parking and HBO for temporary parking. The future methodology will incorporate all four purposes.

???WHERE IS NEW SHAPEFILE… SHOW MAP OF NEW SHAPEFILE???

3.2.3.2.2 Lagoon and Salt Lake City International Airport

The Airport & Lagoon parking costs were updated based on current parking rate information and the assumptions described in this section.

The cost of permanent parking for the Lagoon TAZ was set to `$0` based on the assumption that workers at Lagoon do not pay for parking. The temporary parking was set to `$6` as calculated by dividing the 2022 advertised parking rate of $18 per day by an assumed average occupancy of 3 people per vehicle. The cost of temporary parking in previous models was $5 in 2010 dollars. The resulting $1 increase in 2019 dollars (20%) over 9 years seems reasonable.

The cost of permanent parking at the Salt Lake City International Airport was set to *$0* based on the assumption that workers at the airport do not pay for parking. The cost of temporary parking was set to $1.25 based on a weighted average of short-term premium and economy rates and drop offs and a assumed average vehicle occupancy rate.

The 2022 the cost for the short-term premium parking in the garage is $5.00 per hour. Short-term economy rate is $2.00 per hour. And for drop-offs there is no charge for parking. The assumed occupancy rate of 2 people per vehicle would result in per-person rates of $2.50, $1.00, and $0.00, respectively. The average of the three per-person rates is $1.75. Given the unknown distribution of travelers, but assuming more drop-offs than parking, a lower value than $1.75 should be expected. The 2019 cost was chosen to be $1.25.

Compared to the previous temporary parking values of $1 in 2010 dollars, the chosen cost represents a 25 cent increase in 2019 dollars (25%) over 9 years. This growth seems reasonable, especially given the recent improvements to the airport. Additional justification for the chosen increase is the CPI adjustment, which for the 2010 value of $1.00 in results in a 2019 value of $1.18.

3.2.4 Districts

Small District definitions and names were updated to include a larger number of TAZs than previous models' small districts. There are now 129 total small districts sequentially numbered from northwest to southeast in each medium district. The small district name field `DSML_NAME` includes a prefix of Medium District index followed by a colon and then the sequential small district count (e.g. 15:1). Small districts were modified in conjunction with origin-destination data from StreetLight. Districts are shown in **?@fig-districts**.

```
//|label: fig-districts
//|fig-cap: Districts
//|echo: false

mapDistricts = {

  let container = DOM.element('div', { style: `width:${width}px;height:${width/1.6}px` });
  yield container;

  let map = L.map(container).setView([40.7608, -111.8910], 8.25);

  let greyLayer = L.tileLayer('https://{s}.basemaps.cartocdn.com/light_all/{z}/{x}/{y}{r}.png', {
    attribution: '&copy; <a href="https://www.openstreetmap.org/copyright">OpenStreetMap</a> contributor
```

```
  }).addTo(map);

  let lcolors     = ['#FF0000'       ,'#00FF00'        ,'#0000FF'        ];
  let llabels     = ['Small District','Medium District','Large District' ];

  let lyrLDst = L.geoJson(geojsonLDst, { weight: 12.00, color: lcolors[2], fillOpacity: 0}).addTo(map);
  let lyrMDst = L.geoJson(geojsonMDst, { weight:  6.00, color: lcolors[1], fillOpacity: 0}).addTo(map);
  let lyrSDst = L.geoJson(geojsonSDst, { weight:  2.00, color: lcolors[0], fillOpacity: 0}).addTo(map);

  lyrSDst.eachLayer(function(layer) {
    var name = layer.feature.properties.DSML_NAME; // Assuming the attribute field is named "DSML_NAME"
layer.bindTooltip(name); // Add tooltip
    // OR
    // layer.bindPopup(name); // Add popup
  });

  var legend = L.control({position: 'bottomleft'});
    legend.onAdd = function (map) {
      var div = L.DomUtil.create('div', 'legend');
      div.innerHTML = '';
      for (var i = 0; i < llabels.length; i++) {
        div.innerHTML += '<i style="background:' + lcolors[i] + '"> </i> ' + llabels[i] + '<br/>';
      }

      // Add CSS style for the background color
      div.style.backgroundColor = 'lightgray';
      div.style.padding = '10px';

      return div;
    };
    legend.addTo(map);
}
```

Two additional polygon shapefiles were added to the Districts subfolder:

- The Wasatch Front subarea is included in `WF_Subarea.shp`
- The REMM district areas is included in `Dist_REMM_Area.shp`

???SHOW SHAPEFILES???

3.2.5 Source

The `_Source` subfolder was added and includes the following shapefile data sets: Cities, Counties, Districts, and Environmental Constraints. Additionally, a `__ViewTAZDistricts` folder with ArcGIS Pro project & mapping files was added.

???SHOW SHAPEFILES???

3.3 Socioeconomic Data

Forecasts and control totals were updated based on new census data, updated base year parcel data, and the results of the REMM Model.

3.3.1 Forecasts

The SE forecasts were updated for the WFRC areas. Box Elder updates were taken from the UDOT SE Forecasts from June 8, 2022. The rest of the WFRC area was updated with draft *REMM - 2022-10-11* results using draft 2023 fiscally constrained plan. ???ADD REFERENCE TO REMM DOCUMENTATION??? The MAG area continues to use the 2019 fiscally constrained plan.

The updated SE forecasts can be found using the Household and Job Forecasts Web App. This map only contains the latest forecast and not any iterative step, such as the SE datasets in the model folder. Click on the *View Advanced Version* link in the header to enable the "Changes" option where you can see the change in forecasts between v8.3.2 and v9.0.0. You can explore the data in the embedded web application in **?@fig-household-job-forecast-map**

```
//|label: fig-household-job-forecast-map
//|fig-cap: Embedded Household and Job Forecast Map
//|echo: false

html`<div style="width: 765px; height: 680px; transform: scale(0.85); transform-origin: 0 0;">
         <iframe width="900" height="800" src="https://wfrc.org/household-job-forecast-map/" title="Hous
     </div>`
```

???MAYBE ADD SOME CHARTS OR MAPS IN ADDITION TO WEB APP???

3.3.2 Control Totals

Updates to the county control totals were made based on projections from the Gardner Policy Institute as found in the `ControlTotal_SE_AllCounties.csv` file. See **?@fig-county-control-totals-by-category** for a comparison chart. The comparisons show that overall projections are lower than the for the SE data in the v8.3.2 model. Also, the affect of home-based job employment from COVID-19 can be seen in the new v9.0.0 dataset.

???NEED TO EXPLAIN WHY PRE-2019 IS SO DIFFERENT FOR SOME CATEGORIES LIKE HBJ???

```
//|echo: false

// read in CSVs
faControlTotals = FileAttachment("data/controltotal.csv").csv({ typed: true });
faCounties      = FileAttachment("data/counties.csv"    ).csv({ typed: true });

cats = new Map([['Total Population'               , 'TOTPOP'    ],
                ['Group Quarter Population'       , 'GQ_Pop'    ],
                ['Household Population'           , 'HH_Pop'    ],
                ['Households'                     , 'HH'        ],
                ['Household Size'                 , 'HH_Size'   ],
                ['Population 0-17'                , 'POP_00_17' ],
                ['Population 18-64'               , 'POP_18_64' ],
```

```
                ['Population 65+'                 , 'POP_65P'   ],
                ['All Employment'                 , 'ALLEMP'    ],
                ['Retail Employment'              , 'RETL'      ],
                ['Food Employment'                , 'FOOD'      ],
                ['Manufacturing Employment'       , 'MANU'      ],
                ['Wholesale Employment'           , 'WSLE'      ],
                ['Office Employment'              , 'OFFI'      ],
                ['Government/Education Employment', 'GVED'      ],
                ['Health Employment'              , 'HLTH'      ],
                ['Other Employment'               , 'OTHR'      ],
                ['Agriculture Employment'         , 'AGRI'      ],
                ['Mining Employment'              , 'MING'      ],
                ['Construction Employment'        , 'CONS'      ],
                ['Home-Based Job Employment'      , 'HBJ'       ],
                ['Jobs per Household'             , 'Job_HH'    ],
                ['Working Population per Job'     , 'WrkPop_Job']])

viewof selectCounty   = Inputs.select(faCounties.map(function(d) {return d.CO_NAME}), {value: 'Salt Lake
viewof selectCategory = Inputs.select(cats, {value: 'HH_Pop', label: 'Category: '});
// FILTER DATA
filteredControlTotals = faControlTotals.filter(function(ct) {
  return selectCounty   == ct.CO_NAME &&
         selectCategory == ct.Category;
});

maxY = Math.max(...filteredControlTotals.map(item => item.ControlTotal));
```

```
//|label: fig-county-control-totals-by-category
//|fig-cap: County Control Totals by Category
//|echo: false

Plot.plot({
  grid: true,
  aspectRatio: 0.5,
  x: {label: 'Year', tickFormat: d => d},
  y: {label: 'Control Total', domain: [0, maxY]},
  color: { type: "categorical", legend: true, legendStyle: { fontSize: 16 } },
  marginLeft: 60,
  style: {
    fontSize: 12
  },
  marks: [
    Plot.line(filteredControlTotals, {x: 'YEAR', y: 'ControlTotal', stroke: 'ModelVersion', strokeWidth:
  ]
})
```

???WORK AT HOME IS EXACLTY THE SAME BETWEEN VERSIONS???.

The source worksheet for these input files are found in the `_Source - ControlTotal_SE - 2022-08-31.xlsx` file. Other files in this directory were removed.

3.3.3 Source Files

The `_Income & K-12 Source` folder was renamed as `_ source - HBSch Enroll & Med Inc` folder. The Kindergarten through 12th grade (K-12) enrollment data was updated using the 2019 statewide school enrollment database. Additionally, a point shapefile dataset was included, as shown in **?@fig-school-locations**.

```
//|label: fig-school-locations
//|fig-cap: K-12 School Locations
//|echo: false

mapK12Enroll = {

  let container = DOM.element('div', { style: `width:${width}px;height:${width/1.6}px` });
  yield container;

  let map = L.map(container).setView([40.7608, -111.8910], 8.25);

  let greyLayer = L.tileLayer('https://{s}.basemaps.cartocdn.com/light_all/{z}/{x}/{y}{r}.png', {
    attribution: '&copy; <a href="https://www.openstreetmap.org/copyright">OpenStreetMap</a> contributor
  }).addTo(map);

  var cHigh = "#FF0000"
  var cMidl = "#00FF00"
  var cElem = "#0000FF"

  var geojsonMarkerOptions_High = {
      radius: 4,
      fillColor: cHigh,
      color: cHigh,
      weight: 2,
      opacity: 1,
      fillOpacity: 1.0,
  };

  var geojsonMarkerOptions_Midl = {
      radius: 4,
      fillColor: cMidl,
      color: cMidl,
      weight: 2,
      opacity: 1,
      fillOpacity: 1.0,
  };
  var geojsonMarkerOptions_Elem = {
      radius: 4,
      fillColor: cElem,
      color: cElem,
      weight: 2,
      opacity: 1,
      fillOpacity: 1.0,
```

```
};

// function to use different icons based on number of stations
function markerByEnrollment(feature) {
  if (feature.properties.Enrol_High >= 100) {
    return geojsonMarkerOptions_High
  } else if (feature.properties.Enrol_Midl >= 100){
    return geojsonMarkerOptions_Midl;
  } else{
    return geojsonMarkerOptions_Elem;
  }
};

function getColor(c) {
  if (c=='High School') {
    return cHigh;
  } else if (c=='Middle School') {
    return cMidl;
  } else if (c=='Elementary School') {
    return cElem;
  }
};

// create the GeoJSON layer and call the styling function with each marker
var layerSchools = L.geoJSON(geojsonK12Enroll,  {
  pointToLayer: function (feature, latlng) {
    var mypopup = L.popup().setContent("<b>" + feature.properties.SchoolName + " Enrollment</b>" +
                  "<br><b>High School: </b>" + feature.properties.Enrol_High +
                  "<br><b>Middle School: </b>" + feature.properties.Enrol_Midl +
                  "<br><b>Elementary School: </b>" + feature.properties.Enrol_Elem);
    var mymarker = L.circleMarker(latlng, markerByEnrollment(feature));
    mymarker.bindPopup(mypopup);
    return mymarker;
  }
}).addTo(map);

var legend = L.control({position: 'bottomleft'});
  legend.onAdd = function (map) {
    var div = L.DomUtil.create('div', 'info legend');
    var labelsBill = []; // legend title
    var lcategories = ['High School','Middle School','Elementary School'];

    for (var i = 0; i < lcategories.length; i++) {
      div.innerHTML +=
        labelsBill.push(
          '<i class="bi bi-circle-fill" style="color:' + getColor(lcategories[i]) + '"></i> ' +
        (lcategories[i] ? lcategories[i] : '+'));
    }
    div.innerHTML = labelsBill.join('<br>');
```

```
      // Add CSS style for the background color
      div.style.backgroundColor = 'lightgray';
      div.style.padding = '10px';

      return div;
    };
    legend.addTo(map);

  //let lyrK12Enroll = L.geoJson(geojsonK12Enroll, { size: 5, color: '#FFFFFF'}).addTo(map);

}
```

In the `_Source - Med Income & Value of Time - 2022-07-16.xlsb` file, the median income & value-of-time (VOT) inputs for the model were updated with 2019 data and used to update the TAZ Median Income in the TAZ file.

3.4 Highway Network

Changes include expansion of the highway network area to the extents of the expanded TAZ areas. See TAZ Geographies All v8.3.2 highway and transit nodes are used by v9.0.0. The naming conventions for Link and node fields were set to correspond with the 2023 Regional Transportation Plan (RTP). 2019 RTP fields are also in the highway network for reference and will be dropped before model release. 2023 RTP fields were initially populated with 2019 RTP values and are being updated to reflect draft 2023 RTP.

3.4.1 Highway Node Numbering Schema

Updates to the highway node numbering schema are shown in Table 3.3. An additional reference file called `_Node Definition - v832 & v9.xlsx` is found in the `3_Highway` folder.

Table 3.3: Master Network Node Numbering Schema

MPO	Transit Nodes	Highway Nodes	v9.0.0 Expansion Areas
WFRC	10,000 - 19,999	20,000 - 49,999	90,000 - 94,999
MAG	50,000 - 59,999	60,000 - 89,999	95,000 - 99,999

3.4.2 Dated Updates

The highway network updates are listed by their file date.

3.4.2.1 2022-10-05

The 2022-10-05 master network file includes most recently updated MAG merged master network with updated 2032, 2042 & 2050 Needs fields. Snapped updated MAG network with `MasterNet - 2022-09-08.net` that included WFRC's latest changes.

???WHY IS 2022-09-08 MENTIONED BUT NOT LISTED BELOW???

3.4.2.2 2022-09-19a

This 2022-09-19a master network file includes the following changes:

- Updated Commuter-Rail Transit (CRT) Fare Zone
  - Vineyard & Orem stations were modified to have the same fare zone (similar to North Temple & Central)
  - Updated and fixed fare zone definitions in WFRC area
- Fixed small network error in Box Elder where a local road was drawn to the centroid of v8.3.2 TAZ 53
- A few edits to WFRC draft RTP project list
- Updated segment ids
  - Made consistent with the latest segment shapefile
  - Updated segments to account for recent network changes & add segment definitions to account for rail transit
- Added `SEGEX_RTP` & `SEGEX_NEED` as text fields (to be populated later when script/processing updated). These are segment ID exception fields where the future SEGIDs are different than existing SEGIDs.

Additionally, a `MergedMasterNet - 2022-09-19a` folder was added to serve as a workspace for editing and updating Merged Master Network and for exporting to v8.3.2 & v9.0.0 master networks.

3.4.2.3 2022-10-11

The 2022-10-11 master network file includes the following changes:

- Phase change for Managed Motorways in WFRC area
- A couple of phasing updates from the WFRC RTP project list
- Cleaned up `GIS23_32` and `GIS23_42` fields
- Differentiated what projects will be built by 2028 from what will be built by 2023

3.4.2.4 2023-02-02 and 2023-01-26

In the `MergedMasterNet - 2023-02-02.net` and `MasterNet_v9 - 2023-01-26.net` several link `SEGID`s were updated to create transit segments, and split some links to account for transit segmentation. Rail `SEGID` additions were made to allow for easier transit result visualization.

3.4.3 Comparison

???SHOW COMPARISON BETWEEN 2019 RTP and 2023 RTP WITH DYNAMIC MAP SELECTING SCENARIO TO COMPARE???

3.5 Transit

The transit line files and CUBE Public Transport (PT) files were updated.

3.5.1 Transit Line Files

The following updates were made to correspond with the 2023 RTP:

- 2019 was thoroughly vetted to represent Aug 2019 change day
- 2023: updated route alignment, headways & stops based on Aug 2022 change day (WFRC & MAG)
- 2028: updated route alignment, headways & stops based on UTA 5-Year Service Plan (WFRC & MAG)

- RTP 2032, 2042 & 2050: rolled 2028 changes forward into plan phased years & updated based on 2023 draft plan
- Needs 2032, 2042 & 2050: rolled 2028 changes forward into plan phased years & updated based on 2023 draft plan

The transit line files were renumbered according to new highway node numbering schema.

Route S902 in `wfrc_sl_exp_xxxx.lin` files were updated so route no longer goes to the I-80 Parleys Canyon external node.

3.5.2 Public Transport (PT) Parameters

The node numbers in the transit factor files were updated to correspond with the new highway network nodes. The fare files were updated with 2019 fare data. The fares were updated to match the actual advertised fares, whereas the v8.3.2 model contained a 46% adjustment fares. This reduction accounts for monthly pass, education, fare-pay, senior, employer paid, and other discounts. This adjustment will be added into the General Parameters file and incorporated into the scripts in a future version. ???ADD REFERENCE??? As such, an additional set of fare files with a `Discounted` suffix were created and are being used consistent v8.3.2 and methodology.

3.5.3 General Hand-Coded Support Links

General_hand_coded_walk_links.NTL files were updated to account for new highway node numbering and TAZs.

3.5.4 Transit Route Tester

A `_chk Transit Compile on Net` folder was added with a separate route tester script for each model scenario. The script checks to see if transit line files for the respective scenario compile on the scenario highway network. The scripts create scenario networks in the `_temp - Scenario Net` folder. A `.VPR` file has scenario transit lines pre-loaded onto the network. This can be used for easy transit line edits.

The scripts create error reports (e.g. `check - 1 - BY_2023.txt`) that contain any issues if the transit network fails to compile on the highway network. Opening this file and searching for 'F(' will indicate any inconsistencies.

3.5.5 Comparison

???SHOW COMPARISON BETWEEN 2019 RTP and 2023 RTP WITH DYNAMIC MAP SELECTING SCENARIO TO COMPARE???

3.6 Externals

With the change in model extents, a corresponding change in external locations was necessitated. Additionally, the forecasts were updated with additional years of observed data.

3.6.1 Location

The locations of the former and updated location of externals is shown in **?@fig-externals**.

```
//|echo: false
geojsonExternalOld   = FileAttachment("data/externalold.geojson"  ).json()
geojsonExternalNew   = FileAttachment("data/externalnew.geojson"  ).json()
geojsonMasterNetLink = FileAttachment("data/masternetlink.geojson").json()
```

```
//|label: fig-externals
//|fig-cap: Externals
//|echo: false

mapExternals = {

  let container = DOM.element('div', { style: `width:${width}px;height:${width/1.6}px` });
  yield container;

  let map = L.map(container).setView([40.7608, -111.8910], 8.25);

  let osmLayer = L.tileLayer('https://{s}.tile.openstreetmap.org/{z}/{x}/{y}.png', {
      attribution: '&copy; <a href="https://www.openstreetmap.org/copyright">OpenStreetMap</a> contribut
  }).addTo(map);

  var cNew = "#FF0000";
  var cOld = "#00FF00";

  var squareIcon_New = L.icon({
    iconUrl: 'https://wfrc.org/wftdm-docs/_pictures/square_green.png',  // Replace with the path to your
    iconSize: [15, 15],          // Adjust the size of the square-like icon
    iconAnchor: [5, 5],          // Adjust the anchor point if needed
  });

  var squareIcon_Old = L.icon({
    iconUrl: 'https://wfrc.org/wftdm-docs/_pictures/square_red.png',       // Replace with the path to y
    iconSize: [15, 15],          // Adjust the size of the square-like icon
    iconAnchor: [5, 5],          // Adjust the anchor point if needed
  });

  var cCommon = "#FF0000"
  var cAdded  = "#00FF00"
  var cOther  = "#888888"

  var geolineCommon = {
      color: cCommon,
      weight: 2,
      opacity: 1,
  };

  var geoLineAdded = {
      color: cAdded,
      weight: 2,
```

```
    opacity: 1,
};
var geoLineOther = {
    color: cOther,
    weight: 2,
    opacity: 1,
};

// function to use different icons based on number of stations
function markerByNewNet(feature) {
  if (feature.properties.FLG_NEWNET==3) {
    return geolineCommon;
  } else if (feature.properties.FLG_NEWNET==23){
    return geoLineAdded;
  } else{
    return geoLineOther;
  }
};

function getColor(c) {
  if        (c=='Common') {
    return cCommon;
  } else if (c=='Added') {
    return cAdded;
  } else if (c=='Other') {
    return cOther;
  }
};

//let lyrNetwork = L.geoJson(geojsonMasterNetLink, { weight: 0.75, color: "#888888", fillOpacity: 0}).

// create the GeoJSON layer and call the styling function with each marker
//  var lyrNetwork = L.geoJson(geojsonMasterNetLink,  { function (markerByNewNet(feature))}).addTo(map);

// create the GeoJSON layer and call the styling function with each marker
var externalNewLayer = L.geoJSON(geojsonExternalNew, {
  pointToLayer: function (feature, latlng) {
    var mypopup = L.popup().setContent("<b>Node: " + feature.properties.N + "</b>");
    var mymarker = L.marker(latlng, { icon: squareIcon_New });
    mymarker.bindPopup(mypopup);
    return mymarker;
  }
}).addTo(map);

// create the GeoJSON layer and call the styling function with each marker
var externalOldLayer = L.geoJSON(geojsonExternalOld, {
  pointToLayer: function (feature, latlng) {
    var mypopup = L.popup().setContent("<b>Node: " + feature.properties.N + "</b>");
    var mymarker = L.marker(latlng, { icon: squareIcon_Old });
```

```
      mymarker.bindPopup(mypopup);
      return mymarker;
    }
  }).addTo(map);

  var legend = L.control({position: 'bottomleft'});
    legend.onAdd = function (map) {
      var div = L.DomUtil.create('div', 'info legend');
      var labelsBill = []; // legend title
      var lcategories = ['v8.3.2','v9.0.0'];
      var lcolors     = [cOld    ,cNew    ];

      for (var i = 0; i < lcategories.length; i++) {
        div.innerHTML +=
          labelsBill.push(
            '<i style="background:' + lcolors[i] + '"> </i> ' +
          (lcategories[i] ? lcategories[i] : '+'));
      }
      div.innerHTML = labelsBill.join('<br>');

      // Add CSS style for the background color
      div.style.backgroundColor = 'lightgray';
      div.style.padding = '10px';

      return div;
    };
    legend.addTo(map);
}
```

The updated numbering scheme can be found in the Figure 3.1, Figure 3.2, and Figure 3.3.

3.6.2 Forecasts

Forecasts through 2060 were generated for the updated external locations using historical data through 2019. The files can be found in the `Ext_Vol_Control` folder. The `_Source_ExternalTAZ_HistoricalAADT v9 - 2022-04-04a.xlsx` file contains the spreadsheet used to generate the forecast file used in the model: `external_year_vol.csv`.

???ADD DYNAMIC CHART SHOWING HISTORIC AND FORECAST DATA WITH DROPDOWN FOR EXTERNAL # AND NAME???

3.6.3 Subarea Extraction Matrices

The external matrices from USTM were updated. `AM`, `MD`, `PM`, `EV`, and `DY` external matrices were replaced from USTM's subarea extraction process for the following years: - 2015 – copied `DY` matrix from 2019 - 2019 - 2023 – copied `DY` matrix from 2019 - 2028 – copied `DY` matrix from 2032 - 2032 - 2042 - 2050 - USTM version used: 'USTM_v3.0 - 2022-09-15' which included TAZ, MasterNet, SE & loaded nets from 'WF TDM v9.0 - 2022-10-05'

County	v9	Location
Box Elder	3601	FAR-1082 Bird Refuge
	3602	SR-13/83 to Corinne
	3603	FAR-1112 to Bear River
	3604	I-15 to Tremonton
	3605	SR-38 to Riverside
	3606	SR-91 to Logan
Weber	3607	FAR-3462 N Ogden Pass
	3608	SR-39 Ogden Canyon
	3609	I-84 to Summit
Salt Lake	3610	FAR-2688 Butterfield Cyn to Tooele
	3611	SR-201 to Tooele
	3612	I-80 to Tooele
	3613	SR-65 Mountain Dell Canyon
	3614	I-80 East Parley's
	3615	SR-190 Guardsman Pass
Utah	3616	FAR-1828 Goshen Canyon
	3617	US-6 Eureka
	3618	SR-73 Rush Valley
	3619	FAR-3108 Cascade Springs
	3620	SR-189 Provo Canyon
	3621	FAR-2865 Sixth Water / Horse Creek
	3622	FAR-2863 Sheep Creek
	3623	US-6 Price Canyon
	3624	SR-96 Scofield
	3625	FAR-2495 Skyline Dr
	3626	US-89 Thistle
	3627	FAR-1822 Nebo Loop
	3628	I-15 to Juab
	3629	FAR-1826 South Ridge Farms

Figure 3.1: v9 External Description.

County	v832	Location
Box Elder	136	FAR-1082 Bird Refuge
	137	SR-13/83 to Corinne
	138	I-15 to Tremonton
	139	SR-38 to Riverside
	140	SR-89 to Logan
Weber	421	FAR-3462 N Ogden Pass
	422	SR-39 Ogden Canyon
	423	I-84 to Summit
Salt Lake	1782	I-80 to Tooele
	1783	SR-201 to Tooele
	1784	FAR-2292 Emigration Canyon
	1785	I-80 East Parley's
	1786	FAR-2192 Millcreek Canyon
	1787	SR-190 Big Cottonwood
	1788	SR-210 Little Cottonwood
Utah	2874	SR-92 AF Canyon
	2875	SR-189 Provo Canyon
	2876	FAR-2865 Hobble Ck. Can (Springville)
	2877	US-6 SF Canyon
	2878	FAR-2822 Payson Canyon
	2879	I-15 to Juab
	2880	US-6 Goshen
	2881	SR-73 to Tooele (Cedar Fort)

Figure 3.2: v8.3.2 External Description.

County	v9	v832	Location	*Notes*
Box Elder	3601	136	FAR-1082 Bird Refuge	
	3602	137	SR-13/83 to Corinne	
	3603	NA	FAR-1112 to Bear River	*New External*
	3604	138	I-15 to Tremonton	
	3605	139	SR-38 to Riverside	
	3606	140	SR-91 to Logan	*Moved for Area Expansion*
Weber	3607	421	FAR-3462 N Ogden Pass	*Moved for Area Expansion*
	3608	422	SR-39 Ogden Canyon	*Moved for Area Expansion*
	3609	423	I-84 to Summit	*Moved for Area Expansion*
Salt Lake	3610	NA	FAR-2688 Butterfield Cyn to Tooele	*New External*
	3611	1783	SR-201 to Tooele	
	3612	1782	I-80 to Tooele	
	3613	1784	SR-65 Mountain Dell Canyon	*Moved for Area Expansion*
	3614	1785	I-80 East Parley's	*Moved for Area Expansion*
	NA	*1786*	*FAR-2192 Millcreek Canyon*	*Removed for Area Expansion*
	3615	1787	SR-190 Guardsman Pass	
	NA	*1788*	*SR-210 Little Cottonwood*	*Removed for Area Expansion*
Utah	3616	NA	FAR-1828 Goshen Canyon	*New External*
	3617	2880	US-6 Eureka	
	3618	2881	SR-73 Rush Valley	
	3619	2874	FAR-3108 Cascade Springs	*Moved for Area Expansion*
	3620	2875	SR-189 Provo Canyon	*Moved for Area Expansion*
	3621	2876	FAR-2865 Sixth Water / Horse Creek	*Moved for Area Expansion*
	3622	NA	FAR-2863 Sheep Creek	*New External*
	3623	2877	US-6 Price Canyon	*Moved for Area Expansion*
	3624	NA	SR-96 Scofield	*New External*
	3625	NA	FAR-2495 Skyline Dr	*New External*
	3626	NA	US-89 Thistle	*New External*
	3627	2878	FAR-1822 Nebo Loop	*Moved for Area Expansion*
	3628	2879	I-15 to Juab	
	3629	NA	FAR-1826 South Ridge Farms	*New External*

Figure 3.3: v9 & v8.3.2 External Description.

3.7 Segment

The `Master_Segs_withFactors_20220915.shp` file contains the updated segments to align with 2023 RTP network changes. Additional segments were added to account for rail transit corridors. The corresponding `Stamping_Polygons\SegmentPolygon_forTDM_20220915.shp` file was also updated.

Chapter 4

Input Processing

The changes in the input processing scripts are listed here by their corresponding subfolder.

4.1 Setup

The `0_FolderSetup.s` script was updated, renamed, and added to the `HailMary.s` script. Additionally, `UpdatedMasterNet` and `UpdatedMasterNet\GIS` folders were added to `0_InputProcessing` folder. These changes were also made to `_CreateOutputFolders.s` and `_BlankFolderSetup` in the `Scenarios\_default` folder.

To account for removal of the fields from the TAZ shapefile, the references to `CITY` and `COUNTY` fields were removed from the `1_InputSetup.s` script.

The copied locations of a few files in the `\_CopyToFolders` folder were updated. VPR files in the `2_ModelScripts\_CopyToFolders\Distrib_ConvVPR` folder are now copied to the `Temp\3_Distribute` folder. The `_Urbanization.mxd` and `_WalkBuffer.mxd` in the `2_ModelScripts\_CopyToFolders\ArcMap_mxd` folder are copied to the `0_InputProcessing` folder.

4.2 SE Processing

The `1_DemographicsAnalysis.s` script was updated to read `ControlTotal_SE_AllCounties.csv`. The control total lookup index calculation was updated to account for Weber County indexing between two sub-areas. The `9057` prefix is for the UDOT Subarea and `9157` prefix for the WFRC Subarea.

4.3 Network Processing

The `0_Update_TAZID_Distance.s` script was updated to export out true shape link and node shapefiles.

To account for the removal of `CITY` and `COUNTY` fields from the TAZ shapefile, the `1_NetProcessor.s` and `4_Create_walk_xfer_access_links.s` script was updated to remove references to those fields and the `COUNTY` field in the `c_PNR_nodes.dbf` output was changed to `CO_FIPS`.

The `1_NetProcessor.s` was updated script to export out true shape Link/Node shapefiles.

A bug in the Connected-and-Autonomous Vehicle (CAV) calculation was fixed where the column index was needed to be incremented by 1 to link up with lookup tables.

The hard-coded turn penalty node numbers in the `3_TurnPenalty.s` script were updated to the new v8.3.2/v9.0.0 master network node numbering.

4.4 Trip Table

The `EXTERNAL` field reference in the `2_External_TripTables.s` script was replaced with a reference to the `General_Parameters.block` token `@external_zones@` to account for removal of field from TAZ shapefile.

4.5 Time of Day Factors

A new folder called `e_TimeOfDayFactors` was added with a `1_CalculateTimeOfDayFac.s` script to output a new file with time of day factors for use in following scripts.

Chapter 5

Household Disaggregation and Auto Ownership

The `1_LifeCycle.s` was modified to account for removal of the `COUNTY` field from the TAZ shapefile and respective ids for county-specific variables removed from `0_GeneralParameters.block`.

Chapter 6

Distribution

The changes described in this section were made in the `1_Distribution.s` script.

6.1 Convergence

The convergence criteria was updated for trip table and link convergences, as well as the check criteria.

6.1.1 Trip Table Convergence

For trip table convergence, the percent change threshold was reduced from 10% to 7.5%. For each iteration, only cells where the trips in the current iterations are greater than zero are considered. Cells with trips greater than zero are counted as significant trips and form the denominator in the percent converged calculation.

The trip matrix cell is considered converged if:

1. Percent change from previous iteration is within 7.5%, or
2. Trips from the current iteration are less than 1

With the exception that the cell is not converged if the trips from the current iteration is greater than zero and the trips from the previous iteration equals zero.

6.1.2 Link Convergence

For link volume convergence, the percent change threshold was increased from 5% to 7.5%. Centroid connectors are not considered when determining convergence. For each iteration, only cells where the trips in the current iterations are greater than zero are considered. Cells with trips greater than zero are counted as significant trips and form the denominator in the percent converged calculation.

The link is considered converged if:

1. Percent change from previous iteration is within 7.5%, or
2. Volume from current iteration equals zero and volume from previous iteration equals zero.

With the exception that the link is not converged if:

1. Volume from the current iteration is greater than zero and the volume from the previous iteration equals zero, or

2. Volume from the current iteration is zero and the volume from the previous iteration is greater than zero.

6.1.3 Check Criteria

The convergence check criteria was updated. The minimum of 5 iterations requirement was removed. The `RGAP` parameter passthrough variable from moved from the block file to main script just before each assignment call The `EV RGAP` parameter to value in `0GeneralParameters.block` divided by 10.

6.2 Reports

The initializing and logging of trip, vehicle-miles traveled (VMT), and vehicle-hours traveled (VHT) variables were removed from the log file. The trip table and link convergence reports in the log file were updated.

The following new reports were added to better track convergence:

- `_Stats - Distrib Assign - @RID@.csv`
- `_Stats - Distrib Loaded Net - @RID@.csv`
- `_Stats - Distrib Trip Table - @RID@.csv`

6.3 Other

A `@unloadednetprefix@_@n@_convg.net` file was added to `Temp\3_Distribute` folder. It includes following fields (`li.1`=current iteration, `li.2`=previous iteration):

- `AM_Cur = li.1.AM_VOL`
- `MD_Cur = li.1.MD_VOL`
- `PM_Cur = li.1.PM_VOL`
- `EV_Cur = li.1.EV_VOL`
- `DY_Cur = li.1.DY_VOL`
- `AM_Pre = li.2.AM_VOL`
- `MD_Pre = li.2.MD_VOL`
- `PM_Pre = li.2.PM_VOL`
- `EV_Pre = li.2.EV_VOL`
- `DY_Pre = li.2.DY_VOL`
- `AM_Diff = AM_Cur - AM_Pre`
- `MD_Diff = MD_Cur - MD_Pre`
- `PM_Diff = PM_Cur - PM_Pre`
- `EV_Diff = EV_Cur - EV_Pre`
- `DY_Diff = DY_Cur - DY_Pre`
- `AM_PctDiff = ABS(AM_Diff) / AM_Pre`
- `MD_PctDiff = ABS(MD_Diff) / MD_Pre`
- `PM_PctDiff = ABS(PM_Diff) / PM_Pre`
- `EV_PctDiff = ABS(EV_Diff) / EV_Pre`
- `DY_PctDiff = ABS(DY_Diff) / DY_Pre`
- `CONVLINK (if (DY_PctDiff<=_ConvThreshold)  CONVLINK = 1)`

???NOT SURE WHAT THIS WAS SUPPOSED TO MEAN. IT IS ALL ALONE IN DOCUMENT: `4pd_mainbody_distribution.block`

Chapter 7

Mode Choice

Updates to the Mode Choice portion of the model include drive access links, transit skims, and district summaries.

7.1 Drive Access Links

The `04_Create_drive_access_links.s` script was modified to reference the new `ControlTotal_SE_AllCounties.csv` input file. The control total lookup index calculation was updated to account for Weber County indexing between two sub-areas. The `9057` prefix is for the UDOT Subarea and `9157` prefix for the WFRC Subarea.

7.2 Transit Skims

The `05_Skim_Tran.s` script was modified to account for the new bus speeds inputs. ???INCLUDE REFERENCE HERE TO INPUT DATA - BUS SPEEDS??? The lookup index is based on updated Functional Class groups shown in Table 7.1.

Table 7.1: Updated Functional Class Groups for Bus Speed

Functional Class	FT
Collectors & Locals	1, 4-10
Minor Arterials	3
Principal Arterials	2
Expressways	11-19
Freeways & Ramps	20-49

7.3 District Summaries

The `18_SumToDistricts_FinalTripTables.s` script was modified to change `COUNTY` field references to `CO_FIPS` for county summaries due to removal of field from TAZ shapefile.

Chapter 8

Highway Assignment

The `4_SummarizeLoadedNetworks.s` script was modified to point the GEOMI reference to `0_InputProcessing\UpdatedMasterN - Link.shp` instead of the `1_Inputs\3_Highway` folder.

Chapter 9

Model Results - Comparison with v8.3.2

This section compares the model results between v9.0.0 and v8.3.2 for roadway volumes and transit.

9.1 Road Volume Comparisons

The comparison between daily volumes at the segment level can be found in Figure 9.1 for 2019 and 2050. Decreases in volume in v9.0.0 compared to v8.3.2 are shown in blue, while increases are shown in red. Salt Lake and northern Davis counties display a drop in roadway volumes, most apparent on I-15. Weber, southern Davis, and Utah Counties show increases. Most of the changes are relatively minor, with the largest decreases occurring on the freeways in Salt Lake County. However, given the large daily volume for these roadways, the percent change is relatively low.

???WOULD BE BETTER TO REMOVE LINKS THAT HAVE ZERO LANES, NOTE MUTLIPLE UTAH LAKE CROSSING LINKS IN BOTH 2019 and 2050.

???MAY BE GOOD TO INCLUDE TRUCK VOLUME COMPARISON???

```
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```

```
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```
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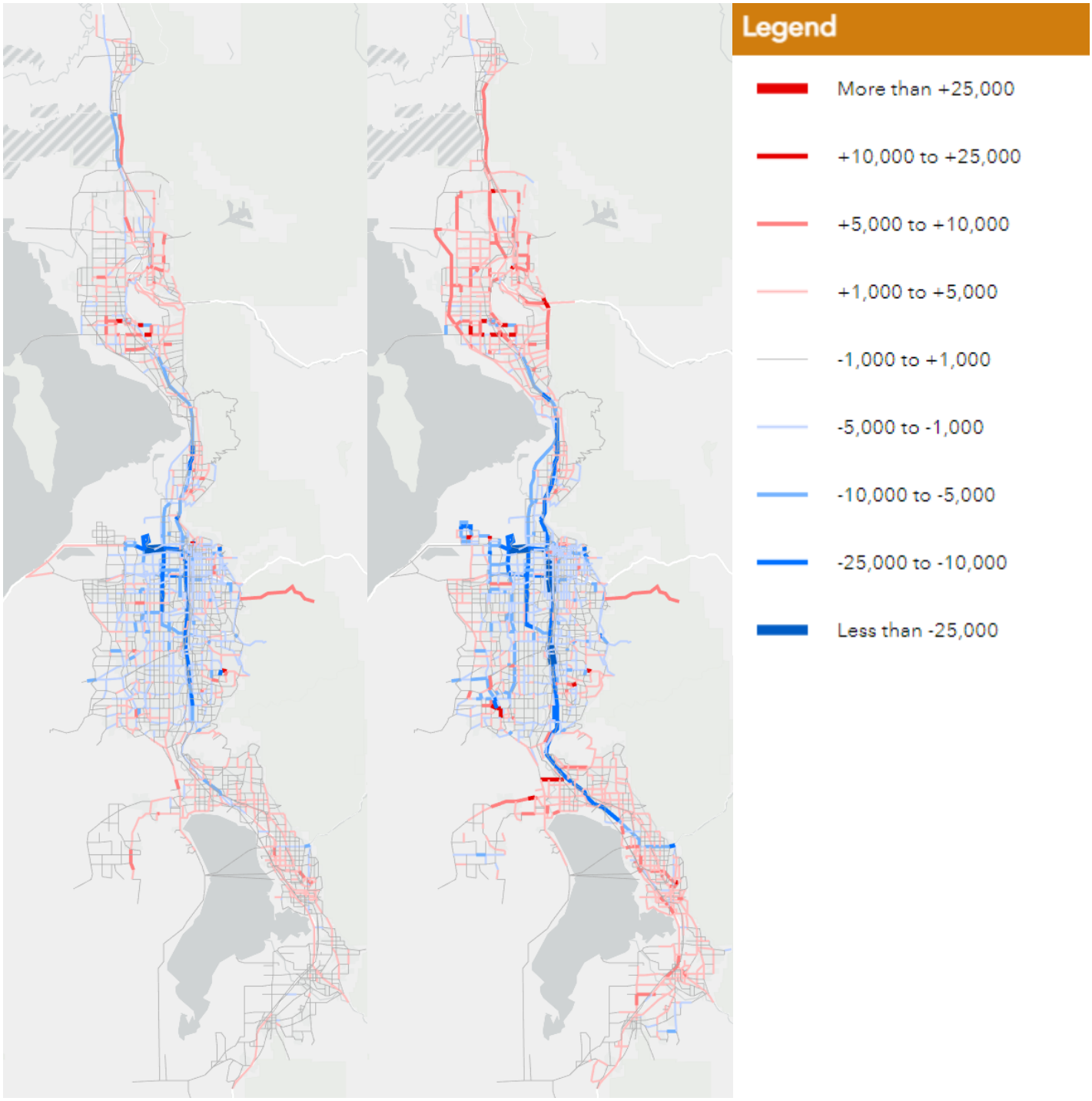
```

9.2 Transit Comparisons

Transit comparisons were done with ridership, trips mode share, and boardings mode share. Overall ridership increases significantly in v9.0.0, and Core Bus ridership takes a larger share of trips and boardings than in v8.3.2.

9.2.1 Transit Ridership

Transit ridership in v9.0.0 compared to v8.3.2 shows significant increase in 2032, 2042, and 2050. See Figure 9.2. The total ridership in 2050 for v9.0.0 is 332,000 daily trips compared to the v8.3.2 model that



(a) 2019 (b) 2050

Figure 9.1: Model Daily Volumes Comparison (v9.0 vs v8.3.2)

showed 258,000 daily trips, which represents a 29% increase. The increase is largely due to the improvements in commuter rail with increased frequency and speed. ???VERIFY!!???

```
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```

re 9.2: Daily Transit Ridership - All Purposes

???NEED TO GET RID OF DATE TIME STAMP AND OTHER 'CODE'S IN MODEL LEGEND "Transit" instead of "4: Transit"???

For Home-Based College (HBC) trips, the v9.0.0 model shows lower projections. See Figure 9.3. This is mostly due to many of the lower enrollment colleges being removed from the trips tables. The uptick in HBC trips in 2042 and 2050 in v9.0.0 follow similar increases the updated enrollment trends. ???ADD REFERENCE TO COLLEGES SECTION IN INPUTS???

```
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```

re 9.3: Daily Transit Ridership - Home-Based College

9.2.2 Transit Share

A comparison of the share of trips amongst the various modes of transit was done for both Trips and Boardings.

9.2.2.1 Trips

The transit ridership trip shares by mode can be found in Figure 9.4 for v9.0.0 and Figure 9.5 for v8.3.2. The main difference in v9.0.0 trip share by mode is the large increase in Core Bus trips in 2032 from almost nothing in 2028, while in v8.3.2 the increase in Core Bus trips is spread out between 2024 and 2030. This large increase is consistent with the transit inputs into the model with a large number of Core Bus routes coming into production in 2032, replacing mostly local bus service. The new Core Buy takes most of the local bus ridership it is replacing, but also quite a lot of ridership from Light Rail Transit (Mode 7).

???MAP SHOWING TRANSIT CHANGES, LIKE ROADWAY VOLUMES WOULD BE USEFUL???

```
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```

re 9.4: Transit Trips Share by Mode - v9.0

???ANYWAY TO GET THESE CHARTS SIDE-BY-SIDE… ALSO LOT OF WHITE SPACE BETWEEN CHART AND CAPTION, WHICH MAKES IT A LITTLE CONFUSING???

9.2.3 Transit Boardings

Transit boardings for v9.0.0 are found in Figure 9.6 and for v8.3.2 are found in Figure 9.7. Boardings follow the same pattern as trips, but boardings are able to differentiate between modes better than trips that are categorized hierarchically.

???SAME COMMENTS FOR THESE TWO AS THE TWO ABOVE???

9.3 Commuter Rail Station Boardings

The comparison of base year (2019) station-level boardings for commuter-rail transit (CRT) is found in Figure 9.8. CRT boardings were found to be higher than observed for Davis County and lower than

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Figure 9.5: Transit Trips Share by Mode - v8.3.2

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Figure 9.6: Transit Boardings Share by Mode - v9.0

observed for Utah County. An adjustment of 5 additional minutes to in-vehicle-time for trips to/from Davis County and 5 fewer minute to in-vehicle-time for Utah County was made to attempt to bring the model more in-line with observations. ???VERIFY!!!???

Additional investigation was conducted into why Provo and Lehi were particularly low in the model. The findings did not turn up any obvious errors in the transit or model network. So, the conclusion is that further adjustments to CRT will be possible in the Mode Choice Update project that is currently being undertaken for the next release of the model.

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Figure 9.7: Transit Boardings Share by Mode - v8.3.2

```
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```

re 9.8: 2019 Daily CRT Boardings by Station - Model vs Observed