WHAT'S NEW? - VERSION 9.0.0

WFRC / MAG

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1Wasatch 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

2General Parameters

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

2.1 Zone Parameters

The TAZ and highway node schema was changed in version 9. The following parameters were updated to reflect these changes.

2.1 TAZ

Note, the following TAZ parameters ranges were removed from the general parameters file in v9 as they were not being used in the WF TDM:

- RegionRange
- WFRCRange
- MAGRange

2.1 Highway Nodes

Table 2.2: Renumbered Highway Nodes

Parameter	v9Value	v8Value	Notes
HwyNodes	10000-99999	3401-999999	Highway and transit node range

2.1 College Zones

Where noted, several colleges were effectively discontinued, meaning references to these schools are still in the code base, but enrollment was set to zero.

Table 2.3: Renumbered College Zones

Area	Parameter	v9Value	v8Value	Notes
WFRC Colleges	Ensign (was LDSBC)	1029	950	Ensign College
	Westmin	1263	1150	Westminster College
	UOFU_Main	1051	1075	University of Utah - Main
	UOFU_Med	1007	1076	University of Utah - Medical (removed)
	WSU_Main (was WSU_OGDEN)	437	383	Weber State University - Main
	WSU_Davis	693	525	Weber State University - Davis
	WSU_West	521	290	Weber State University - West (removed)
	SLCC_Main (was SLCC_TL)	1580	897	Salt Lake Community College - Main
	SLCC_SC	1231	1126	Salt Lake Community College - South City
	SLCC_JD	1776	1493	Salt Lake Community College - Jordan
	SLCC_Mead		1206	Salt Lake Community College - Meadbrook (remo
	SLCC_ML	1886	1516	Salt Lake Community College - Miller
	SLCC_LB	1085	989	Salt Lake Community College - Library (removed)

Area	Parameter	v9Value	v8Value	Notes
	SLCC_HL	1525	1294	Salt Lake Community College - Highland (remove
	SLCC_Airp	979	746	Salt Lake Community College - Airport (removed)
	SLCC_West	959	745	Salt Lake Community College - Westpointe (remo
	SLCC_HM	2031	1607	Salt Lake Community College - Herriman (remove
MAG Colleges	BYU	2939	2384	Brigham Young University - Main
	UVU_Main	2848	2326	Utah Valley University - Main
	UVU_Geneva	2882	2280	Utah Valley University - Geneva (removed)
	UVU_Lehi (was UVU_THANKP)	2606	2099	Utah Valley University - Lehi
	UVU_Vine	2809	2259	Utah Valley University - Vineyard
	UVU_Payson	3336	2690	Utah Valley University - Payson

Table 2.4: Renum

Parameter	v9Value
colleges	437, 521, 693, 959, 979, 1007, 1029, 1051, 1085, 1231, 1263, 1491, 1525, 1580, 1776, 1886, 2031, 2606, 2809,

2.1 Zones with Off-line Trip Tables

Table 2.5: Renumbered Off-line Trip Table Zones

Parameter	v9Value	v8Value
Lagoon	781	562
Airport	965	742

2.1 Special Generator Zones

Table 2.6: Renumbered Special Generator Zones

Parameter	v9Value	v8Value
TempleSquare	1035	966
SLC_Library	1147	1015

2.2 Exogenous Trip Table Parameters

Income break points for the airport exogenous trip table generation were updated to reflect 2019 base year income.

Table 2.7: Income Break Points for Airport Exogenous Trip Table Generation

Parameter	v9Value	v8Value	Notes
Income_Lo	45000	35000	breakpoint between Inc1 & Inc2
Income_Md	75000	70000	breakpoint between Inc2 & Inc3
Income_Hi	125000	100000	breakpoint between Inc3 & Inc4

Table 2.1: **?(caption)**

```
\begin{tabular}{llllll}
\toprule
{} &      Parameter &    v9Value &                                  v8Value &
\midrule
0 &      UsedZones &       3629 &                                     2881 &   Highest TAZ numb
1 &  BoxElderRange &      1-153 &                                    1-140 &             Box El
2 &     WeberRange &    154-581 &                                  141-423 &                 We
3 &     DavisRange &    582-905 &                                  424-654 &                 Da
4 &        SLRange &   906-2216 &                                 655-1788 &             Salt L
5 &      UtahRange &  2217-3546 &                                1789-2881 &                 U
6 &     Dummyzones &  3547-3600 &                                2882-3400 &  Placeholder for f
7 &  Externalzones &  3601-3629 &  136-140, 421-423, 1782-1788, 2874-2881 &
8 &        NorthBC &  3604-3606 &                          138, 139, 140 &  North Brigham Cit
\bottomrule
\end{tabular}
```

2.3 Household Disaggregation Parameters

The regional median income was updated using 2019 5-year ACS data and kept in 2019 dollars to reflect 2019 base year. v8 was estimated from 2015 ACS data and deflated to 2010 dollars.

Table 2.8: Household Disaggregation Parameter Income Update

Parameter	v9Value	v8Value
Reg_Median_Inc	$74,946	$58,793

2.4 Distribution, Mode Choice, and Assignment Parameters

2.4 K-Factors

K-factors were expanded by trip purpose to allow for more flexibility in calibrating distribution. All K-factors were reset to 1.

Table 2.9: Reset K-Factors

Area	v9Parameter	v9Value	v8Parameter	v8Value
between Salt Lake and Utah counties	SL_UT_KFAC_Wrk	1	SL_UT_KFAC	0.85
	SL_UT_KFAC_Oth	1		
	SL_UT_KFAC_Trk	1		
	SL_UT_KFAC_Ext	1		
between Salt Lake and Davis counties	SL_DA_KFAC_Wrk	1	SL_DA_KFAC	0.95
	SL_DA_KFAC_Oth	1		
	SL_DA_KFAC_Trk	1		
	SL_DA_KFAC_Ext	1		
between Box Elder and Weber counties	WE_BE_KFAC_Wrk	1	WE_BE_KFAC	1
	WE_BE_KFAC_Oth	1		
	WE_BE_KFAC_Trk	1		

Area	v9Parameter	v9Value	v8Parameter	v8Value
	WE_BE_KFAC_Ext	1		

2.4 Auto Occupancy

Auto or vehicle occupancy rates were expanded to include additional trips purposes and calculated based on the reprocessed 2012 Household Travel Survey. 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.

Table 2.10: Vehicle Occupancy Rates

v9Parameter	v9Value	v8Parameter	v8Value	Notes
VehOcc_HBW	1.1	VEH_OCCUPANCY_HBW	1.1	Home-Based Work
VehOcc_HBShp	1.63	VEH_OCCUPANCY_HBSHP	1.58	Home-Based Shopping
VehOcc_HBOth	1.68	VEH_OCCUPANCY_HBOTH	1.66	Home-Based Other
VehOcc_HBSch	1.76	VEH_OCCUPANCY_HBSCH	2.14	Home-Based School
VehOcc_HBC	1.12	VEH_OCCUPANCY_HBC	1.26	Home-Based College
VehOcc_NHBW	1.21	VEH_OCCUPANCY_NHBW	1.2	Non-Home-Based Work
VehOcc_NHBNW	1.76	VEH_OCCUPANCY_NHBNW	1.7	Non-Home-Based Non-Work
VehOcc_Rec	1.68	(Uses HBO)	1.64	Recreation
VehOcc_HBO	1.67	VEH_OCCUPANCY_HBO	1.64	Home-Based Other (HBShp+HBOth)
VehOcc_NHB	1.54	VEH_OCCUPANCY_NHB	1.48	Non-Home-Based (NHBW+NHBNW)
VehOcc_ExtWrk	1.16	(Uses HBW)	1.1	External Work
VehOcc_ExtHBO	1.82	(Uses HBO)	1.64	External Home-Based Other
VehOcc_ExtNHB	1.73	(Uses NHB)	1.48	Non-Home-Based
VehOcc_ExtRec	1.73	(Uses HBO)	1.64	External Recreation

Table 2.11: Vehicle Occupancy 3+ Rates

v9Parameter	v9Value	v8Parameter	v8Value	Notes
VehOcc_3p_HBW	3.53	VEH_OCC_3P_HBW	3.4	3+ Person Home-Based Work
VehOcc_3p_HBShp	3.49	(Uses HBO)	3.55	3+ Person Home-Based Shopping
VehOcc_3p_HBOth	3.73	(Uses HBO)	3.55	3+ Person Home-Based Other
VehOcc_3p_HBSch	3.88	(Uses HBO)	3.55	3+ Person Home-Based School
VehOcc_3p_HBC	3.24	VEH_OCC_3P_HBC	3.53	3+ Person Home-Based College
VehOcc_3p_NHBW	3.71	(Uses NHB)	3.51	3+ Person Non-Home-Based Work
VehOcc_3p_NHBNW	3.71	(Uses NHB)	3.51	3+ Person Non-Home-Based Non-Work
VehOcc_3p_Rec	3.73	(Uses HBO)	3.55	3+ Person Recreation
VehOcc_3p_HBO	3.68	VEH_OCC_3P_HBO	3.55	3+ Person Home-Based Other (HBShp+HBOth)
VehOcc_3p_NHB	3.71	VEH_OCC_3P_NHB	3.51	3+ Person Non-Home-Based (NHBW+NHBNW)

2.4 Value of Time

Value of time parameters were updated using 2019 5-year ACS data and previous model assumptions and are in 2019 dollars. v8 parameters were calibrated to 2015 ACS data and deflated to 2010 dollars. Values of time are in cents/minute.

Table 2.12: Value of Time Rates

v9Parameter	v9Value	v8Parameter	v8Value	Notes
VOT_Auto_Wrk	22	VOT_Auto_Wrk	18	work trips (HBW)
VOT_Auto_Per	17	VOT_Auto_Per	14	non-work trips
VOT_Auto_Ext	20	VOT_Auto_Ext	16	external
VOT_LT	37	VOT_LT	30	light truck
VOT_MD	50	VOT_MD	40	medium truck
VOT_HV	63	VOT_HV	50	heavy truck
VOT_Toll	63	VOT_Toll	50	all vehicles on tollway
VOT_HOT_DA	63	VOT_HOT_DA	50	drive alone on HOT
VOT_Auto_Wrk_Lo	9			work trips - low income (added)
VOT_Auto_Wrk_Hi	24			work trips - high income (added)
VOT_Auto_Per_Lo	7			non-work trips - loc income (added)
VOT_Auto_Per_Hi	19			non-work trips - high income (added)

2.4 Auto Operating Costs

Auto operating costs were updated to reflect 2019 fuel cost, average fuel economy, and cost of vehicle maintenance and are in 2019 dollars. v8 parameters were calibrated to 2015 data and deflated to 2010 dollars. Costs are in cents/mile.

Table 2.13: Auto Operating Cost Rates

Parameter	v9Value	v8Value	Notes
AOC_Auto	21.7	18.3	auto
AOC_LT	27.3	24.6	light truck
AOC_MD	55.5	47.8	medium truck
AOC_HV	74.3	63.7	heavy truck

2.4 Managed Lane Costs

Tolls on managed lanes were updated to reflect approximately a $5.00 toll for work trips and a $3.00 toll for non-work trips for tollways (FT=40) and approximately a $3.50 toll for work trips and $2.20 for non-work trips for HOT (FT=38) and reliability lanes. Distances of 10.25 miles (length of average work trip) and 6.5 miles (average length of all trips) were used to determine the work/non-work toll costs in cents per mile in 2019 dollars. Toll costs for v8 are in 2010 dollars.

Table 2.14: Managed Lane Cost Rates

Parameter	v9Value	v8Value	Notes
Cost_Toll_Pk	48	24	Tollways (FT 40) cost - Peak
Cost_Toll_Ok	48	24	Tollways (FT 40) cost - Off-peak
Cost_HOT_Pk	34	10	HOT (FT 38) cost - Peak
Cost_HOT_Ok	17	5	HOT (FT 38) cost - Off-peak
Cost_REL_Pk	34	10	Reliability lane cost - Peak
Cost_REL_Ok	17	5	Reliability lane cost - Off-peak

2.4 Core Bus Constant Multiplier

The parameter used to set the Core Bus constant was renamed and updated in v9.

Table 2.15: Core Bus Constant Multiplier

v9Parameter	v9Value	v8Parameter	v8Value	Notes
RAIL2COR_MULTIPLIER	0.33	RAIL2BRT_MULTIPLIER	0.4	factor to set Core Route constant relative to LRT

2.4 CRT Adjustment Factors

The following parameters were added to adjust CRT ridership for Davis and Utah Counties. The parameters are applied in the mode choice utility calculation and represent a penalty/incentive in equivalent minutes.

- ADJ_CONST_UT = 0 ;place holder
- ADJ_CONST_CRT_UT = -5 ;encourge CRT in UT County
- ADJ_CONST_CRT_DA = 5 ;discourage CRT in Davis County
- ADJ_CONST_BRT = 0 ;place holder

2.4 Transit Fare Discount Factor

Added a transit fare discount factor to adjust transit fares in PT fare input file to calculate effective transit fares (effective fares include discounts for transit passes and other discounts). Transit fares are in v9 are encoded as the standard 2019 fares (in 2019 dollars). Fares in v8 are encoded as discounted 2015 fares deflated to 2010 dollars. The discounted fare in v8 was approximately 54% of the standard fare. This ratio was carried forward into v9.

- FARE_DISCOUNT = 0.54

2.5 Removed Parameters

The following parameters were removed from the 0_GeneralParameters.block file.

2.5 County Identification Parameters

The following county identification parameters are no longer used in v9 and were removed:

- CountyRange = '1-5'
- CountyName1 = 'Weber'
- CountyName2 = 'Davis'
- CountyName3 = 'SaltLake'
- CountyName4 = 'Utah'
- CountyName5 = 'BoxElder'
- CO_Name1 = 'WE'
- CO_Name2 = 'DA'
- CO_Name3 = 'SL'

- CO_Name4 = 'UT'
- CO_Name5 = 'BE'

2.5 Air Quality Conformity Report Parameters

The following air quality conformity reporting parameters are no longer used in v9 and were removed:

- RE_ID = 0 ;Entire region
- WE_ID = 1 ;Weber
- DA_ID = 2 ;Davis
- SL_ID = 3 ;Salt Lake
- UT_ID = 4 ;Utah
- BE_ID = 5 ;BoxElder
- OC_ID = 55980 ;Ogden
- SC_ID = 67000 ;Salt Lake City
- PC_ID = 62470 ;Provo

2.5 Bus Speed Ratios

Bus speed ratios were updated in v9 and bus speed ratio parameters are now input via a file. The following bus speed ratio parameters were removed from the `0_GeneralParameters.block` file:

- ratio_fway = 0.95 ;bus speed to auto speed - freeways
- ratio_ramp = 0.75 ;bus speed to auto speed - freeway ramps
- ratio_part = 0.60 ;bus speed to auto speed - principal arterials
- ratio_mart_urbcbd = 0.55 ;bus speed to auto speed - minor arterials, urban/cbd
- ratio_mart_subrur = 0.65 ;bus speed to auto speed - minor arterials, suburban/rural
- ratio_collector = 0.60 ;bus speed to auto speed - collectors
- minimum_bus_speed = 10.0 ;mph

2.5 Prefixes for Transit Skims

Prefixes to identify transit skim output files are coded directly into the scripts in v9. The following transit skim prefix parameters were removed from the `0_GeneralParameters.block` file:

- W_LCL_skims = 'skm_w4' ;walk-to-local skims
- D_LCL_skims = 'skm_d4' ;drive-to-local skims
- W_BRT_skims = 'skm_w5' ;walk-to-BRT skims
- D_BRT_skims = 'skm_d5' ;drive-to-BRT skims
- W_EXP_skims = 'skm_w6' ;walk-to-express bus skims
- D_EXP_skims = 'skm_d6' ;drive-to-express bus skims
- W_LRT_skims = 'skm_w7' ;walk-to-light rail skims
- D_LRT_skims = 'skm_d7' ;drive-to-light rail skims
- W_CRT_skims = 'skm_w8' ;walk-to-commuter rail skims
- D_CRT_skims = 'skm_d8' ;drive-to-commuter rail skims
- W_mode9_skims = 'skm_w9'
- D_mode9_skims = 'skm_d9'

2.5 Diurnal Factors

Diurnal factors were updated in v9 and diurnal factor parameters are now input via a file. The following diurnal factor parameters were removed from the `0_GeneralParameters.block` file:

% of trips in period

- HBW_AM_Pct = 0.3254
- HBW_MD_Pct = 0.1831
- HBW_PM_Pct = 0.3074
- HBW_EV_Pct = 0.1841
- HBC_AM_Pct = 0.2592
- HBC_MD_Pct = 0.3374
- HBC_PM_Pct = 0.1853
- HBC_EV_Pct = 0.2181
- HBSch_AM_Pct = 0.3784
- HBSch_MD_Pct = 0.2931
- HBSch_PM_Pct = 0.2941
- HBSch_EV_Pct = 0.0344
- HBShp_AM_Pct = 0.0192
- HBShp_MD_Pct = 0.4391
- HBShp_PM_Pct = 0.2496
- HBShp_EV_Pct = 0.2921
- HBOth_AM_Pct = 0.0997
- HBOth_MD_Pct = 0.3129
- HBOth_PM_Pct = 0.2367
- HBOth_EV_Pct = 0.3507
- NHBW_AM_Pct = 0.0697
- NHBW_MD_Pct = 0.5582
- NHBW_PM_Pct = 0.2597
- NHBW_EV_Pct = 0.1124
- NHBNW_AM_Pct = 0.0498
- NHBNW_MD_Pct = 0.4752
- NHBNW_PM_Pct = 0.2426
- NHBNW_EV_Pct = 0.2324
- IX_AM_Pct = 0.1786
- IX_MD_Pct = 0.3291
- IX_PM_Pct = 0.2604
- IX_EV_Pct = 0.2319
- XI_AM_Pct = 0.1786
- XI_MD_Pct = 0.3291
- XI_PM_Pct = 0.2604
- XI_EV_Pct = 0.2319
- XX_AM_Pct = 0.1786
- XX_MD_Pct = 0.3291
- XX_PM_Pct = 0.2604
- XX_EV_Pct = 0.2319
- TR_AM_Pct = 0.1590
- TR_MD_Pct = 0.3522
- TR_PM_Pct = 0.2274
- TR_EV_Pct = 0.2614

- HBO_AM_Pct = 0.0840

- HBO_MD_Pct = 0.3383
- HBO_PM_Pct = 0.2401
- HBO_EV_Pct = 0.3376
- NHB_AM_Pct = 0.0563
- NHB_MD_Pct = 0.5024
- NHB_PM_Pct = 0.2482
- NHB_EV_Pct = 0.1931

% of trips in PA direction

- HBW_AM_PA = 0.9706
- HBW_MD_PA = 0.5690
- HBW_PM_PA = 0.0871
- HBW_EV_PA = 0.2891
- HBC_AM_PA = 0.9828
- HBC_MD_PA = 0.5259
- HBC_PM_PA = 0.2420
- HBC_EV_PA = 0.1057
- HBSch_AM_PA = 0.7899
- HBSch_MD_PA = 0.4306
- HBSch_PM_PA = 0.2268
- HBSch_EV_PA = 0.2391
- HBShp_AM_PA = 0.7826
- HBShp_MD_PA = 0.5615
- HBShp_PM_PA = 0.4604
- HBShp_EV_PA = 0.4228
- HBOth_AM_PA = 0.7147
- HBOth_MD_PA = 0.5517
- HBOth_PM_PA = 0.5181
- HBOth_EV_PA = 0.3806
- NHBW_AM_PA = 0.5000
- NHBW_MD_PA = 0.5000
- NHBW_PM_PA = 0.5000
- NHBW_EV_PA = 0.5000
- NHBNW_AM_PA = 0.5000
- NHBNW_MD_PA = 0.5000
- NHBNW_PM_PA = 0.5000
- NHBNW_EV_PA = 0.5000
- IX_AM_PA = 0.8563
- IX_MD_PA = 0.5627
- IX_PM_PA = 0.3288
- IX_EV_PA = 0.3290
- XI_AM_PA = 0.8563
- XI_MD_PA = 0.5627
- XI_PM_PA = 0.3288
- XI_EV_PA = 0.3290
- XX_AM_PA = 0.8563
- XX_MD_PA = 0.5627
- XX_PM_PA = 0.3288
- XX_EV_PA = 0.3290
- TR_AM_PA = 0.5000
- TR_MD_PA = 0.5000
- TR_PM_PA = 0.5000
- TR_EV_PA = 0.5000

- HBO_AM_PA = 0.7283
- HBO_MD_PA = 0.5495
- HBO_PM_PA = 0.5050
- HBo_EV_PA = 0.3901
- NHB_AM_PA = 0.5000
- NHB_MD_PA = 0.5000
- NHB_PM_PA = 0.5000
- NHB_EV_PA = 0.5000

2.5 Assignment Type Flag

The assignment type parameter is no longer used in v9 and was removed:

- AssignType = ‘managed’

3Input Data

Changes made to the `1_Inputs` folder are discussed in this section.

```
//|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()
```

3.1 Global Data

This section includes the changes made within the `0_GlobalData` subfolder.

3.1 Trip Tables

The college base distribution file `BaseDistribution.csv` that contains the household locations of students in the base year was updated using new enrollment data sources. Enrollment totals by zip code for public schools were obtained from the Utah System of Higher Education (USHE). After assigning dormitory populations to TAZs based on group quarter data from the census, the remaining enrollment distributions were done using StreetLight origin-destination data with public schools being control at the zip-code level based on USHE enrollment data.

3.1 Household Disaggregation and Auto Ownership

The age percent lookup file `Lookup - BYTAZAgePct - AllCo.csv` used in household disaggregation was updated using parameters developed statewide based on 2020 census block data, 2020 ACS block group data, and 2019 population by age group data.

3.1 Mode Choice

The bus speed ratios in the model were further categorized and refined using actual bus speed data. The resulting bus speeds ratios were removed from the model scripts, as detailed in the *General Parameters* section, and included in a new bus speed ratios file `bus_speed_ratios.csv`. The ratios were estimated based on 2019 General Transit Feed Specification (GTFS) data, which includes scheduled time and stop locations for all bus routes.

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

// FILTER DATA
//viewof functionalclasses_checked = Inputs.checkbox(faFunctionalClasses.map(function(d) {re
//                                                   {value: faFunctionalClasses.map(functio
//                                                    label: "Function Class"});
//viewof timeperiods_checked       = Inputs.checkbox(faTimePeriods      .map(function(d) {re
//                                                   {value: faTimePeriods      .map(functio
//                                                    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.TimePer
    case 'AreaTypeName'       : return faAreaTypes        .map(function(d) {return d.AreaTyp
    case 'FunctionalClassName': return faFunctionalClasses.map(function(d) {return d.Functio
    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.TimePer
    case 'AreaTypeName'       : return faAreaTypes        .map(function(d) {return d.AreaTyp
    case 'FunctionalClassName': return faFunctionalClasses.map(function(d) {return d.Functio
    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: strokeSele
    Plot.dot (faDataBusSpeeds, {x: xPlotDomainSelect, y: "BusSpeedRatio", stroke: strokeSele
  ]
})
```

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

Plot.plot({
  grid: true,
  aspectRatio: 0.5,
  style: {
    fontSize: 16,
  },
  x: {label: "Functional Class", tickRotate: 90, domain: faDataBusSpeeds_previous.map(functi
      //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: '
  ]
})
```

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

3.1 Assignment

As described in the *General Parameters* section, diurnal and production/attraction factors were moved out of the `0_GeneralParameters.block` file to an input file. The factors are now found in the `Diurnal & PA factors.csv` file.

3.2 Traffic Analysis Zones (TAZ)

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

3.2 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 **?@tbl-taz-count-comparison**.

The interactive map in **?@fig-taz-compare-map** can be explored to visualize the difference in v9 and v8 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}.pr
    attribution: '&copy; <a href="https://www.openstreetmap.org/copyright">OpenStreetMap</a>
  }).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]
      }

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

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

3.2 TAZ Ranges

The new and previous internal and external ranges of TAZIDs by for each county are shown in **?@tbl-new-taz-ranges**.

3.2 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}.pr
    attribution: '&copy; <a href="https://www.openstreetmap.org/copyright">OpenStreetMap</a>
  }).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> ' + remmLabel
    }

    // 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

Parking costs 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. 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.

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 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). Districts are shown in **?@fig-districts**. Two additional polygon shapefiles were added to the Districts subfolder to represent the Wasatch Front sub area and the REMM area.

```
//|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}.pr
    attribution: '&copy; <a href="https://www.openstreetmap.org/copyright">OpenStreetMap</a>
  }).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}).
  let lyrMDst = L.geoJson(geojsonMDst, { weight:  6.00, color: lcolors[1], fillOpacity: 0}).
  let lyrSDst = L.geoJson(geojsonSDst, { weight:  2.00, color: lcolors[0], fillOpacity: 0}).
```

```
  lyrSDst.eachLayer(function(layer) {
    var name = layer.feature.properties.DSML_NAME; // Assuming the attribute field is named
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]
      }

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

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

3.2 Source

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

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 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 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/"
    </div>`
```

3.3 Control Totals

Updates to the county control totals were made based on projections from the Gardner Policy Institute. See **?@fig-county-control-totals-by-category** for a comparison between v8 and v9 by county for any given socioeconomic category.

```
//|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
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',
  ]
})
```

3.3 School Enrollment

The Kindergarten through 12th grade (K-12) enrollment data was updated using the 2019 statewide school enrollment database. This was done at the state-wide level and then applied to the Wasatch Front. Additionally, a point shapefile of the state-wide dataset is included with the TDM, 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}.pr
    attribution: '&copy; <a href="https://www.openstreetmap.org/copyright">OpenStreetMap</a>
  }).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 + " Enrollmer
                  "<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);

}
```

3.3 Median Income

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

The highway network was expanded to incorporate the new model areas. See TAZ Geographies. The 2023 RTP fields have been updated to reflect the adopted 2023 RTP.

3.4 Highway Node Numbering Schema

Updates to the highway node numbering schema are shown in **?@tbl-master-network-node-numbering-schema**. An additional reference file called `_Node Definition - v832 & v9.xlsx` is found in the `3_Highway` folder.

The highway network updates include the following:

- 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.
- 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
- Rail `SEGID` additions were made to allow for easier transit result visualization.

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 master networks.

3.5 Transit

The transit line files and CUBE Public Transport (PT) files were updated to correspond with the 2023 RTP:

- 2019 was thoroughly vetted to represent Aug 2019 change day
- 2023: updated route alignment, headways & stops based on August 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

Route S902 was updated so route no longer go to the I-80 Parleys Canyon external node.

3.5 Public Transport (PT) Parameters

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 is now explicitly defined, as was discussed in the *General Parameters* section.

3.5 General Hand-Coded Support Links

`General_hand_coded_walk_links.NTL` files were reviewed and updated.

3.5 Transit Route Tester

A route tester script was added in the `_chk Transit Compile on Net` folder. The script checks to see if transit line files for the respective scenario compile on the scenario highway network. This can be used for reviewing transit line edits outside of the model stream.

3.6 Externals

External locations and forecasts were updated. The locations of the former and updated location of externals is shown in **?@fig-externals**. Forecasts through 2060 were generated for the updated external locations using historical data through 2019.

```
//|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</
  }).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
    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 t
    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", fillO

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

  // 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 Figure 3.1, Figure 3.2, and Figure 3.3.

3.7 Segment

The `Master_Segs_withFactors_20220915.shp` file contains the updated segments to align with 2023 RTP network changes. Additional segments for rail transit corridors were added in the Wasatch Front area.

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.

4InputProcessing

The changes in the input processing scripts are listed here by their corresponding sub-folder.

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.

5Household 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`.

6Distribution

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 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 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 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`

7Mode 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.

8Highway Assignment

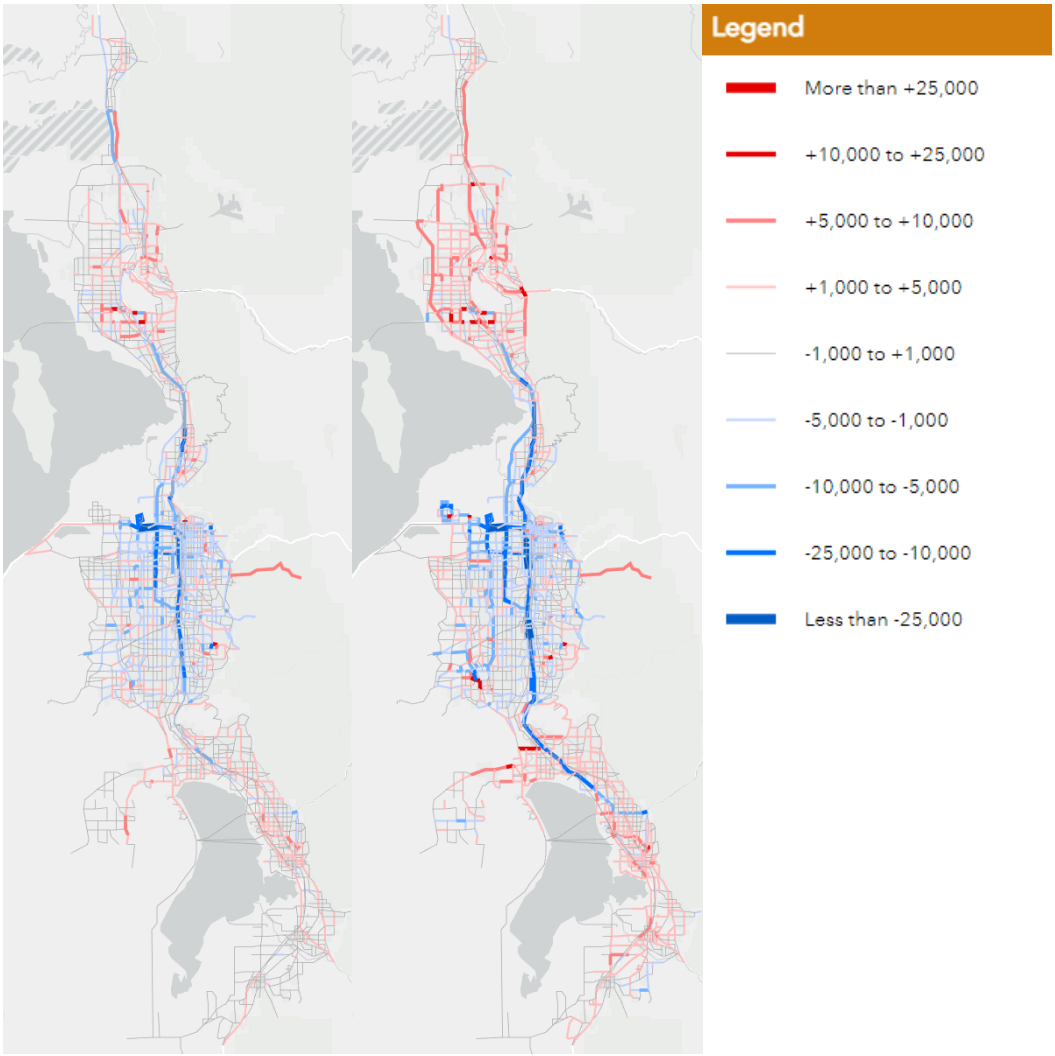
The 4_SummarizeLoadedNetworks.s script was modified to point the GEOMI reference to 0_InputProcessing\UpdatedMasterNet\GIS\@MasterPrefix@ - Link.shp instead of the 1_Inputs\3_Highway folder.

9Model 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.



(a) 2019 (b) 2050

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

???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 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 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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```

Figure 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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```

Figure 9.3: Daily Transit Ridership - Home-Based College

9.2 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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```

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

```
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```

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

???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 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.

```
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```

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

???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 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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```

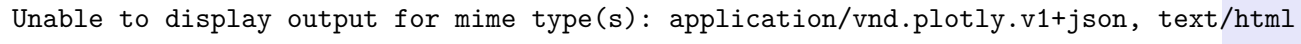

Figure 9.7: Transit Boardings Share by Mode - v8.3.2

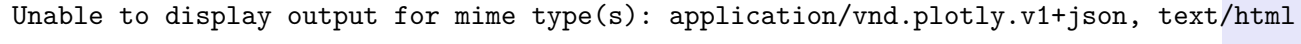

Figure 9.8: 2019 Daily CRT Boardings by Station - Model vs Observed