MODEL VALIDATION
WASATCH FRONT TRAVEL DEMAND MODEL
VERSION 9.1.0

MAG / WFRC

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Table of Contents

List of Figures

List of Tables

No table entries found.

1 Trip Distribution

1.1 Trip Lengths

The model used the 2012 Household Travel Survey to calibrate trip lengths for internal and external person trips. Trips were calibrated based on generalized cost trip length frequencies and validated to time and distance trip length frequencies and average trip lengths. The validation results are shown in Figure 1.1 through Figure 1.5. Trip lengths by time and distance met the validation targets and aligned closely with observed data.

No observed data was available for internal and external truck calibration. Truck trips were calibrated based on previous model estimation and validated relative to person work and other trip lengths.

1.1.1 Average Trip Length Validation

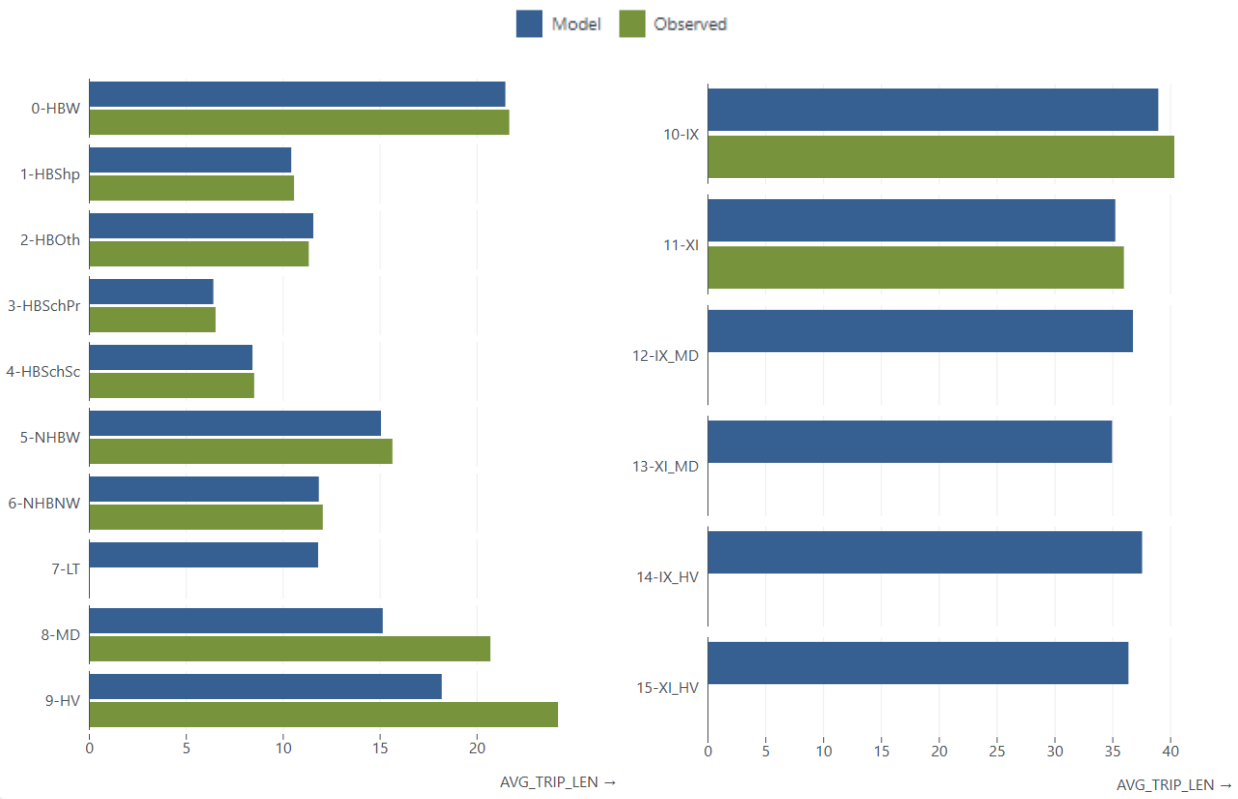


Figure 1.1 Average Trip Length (Time)

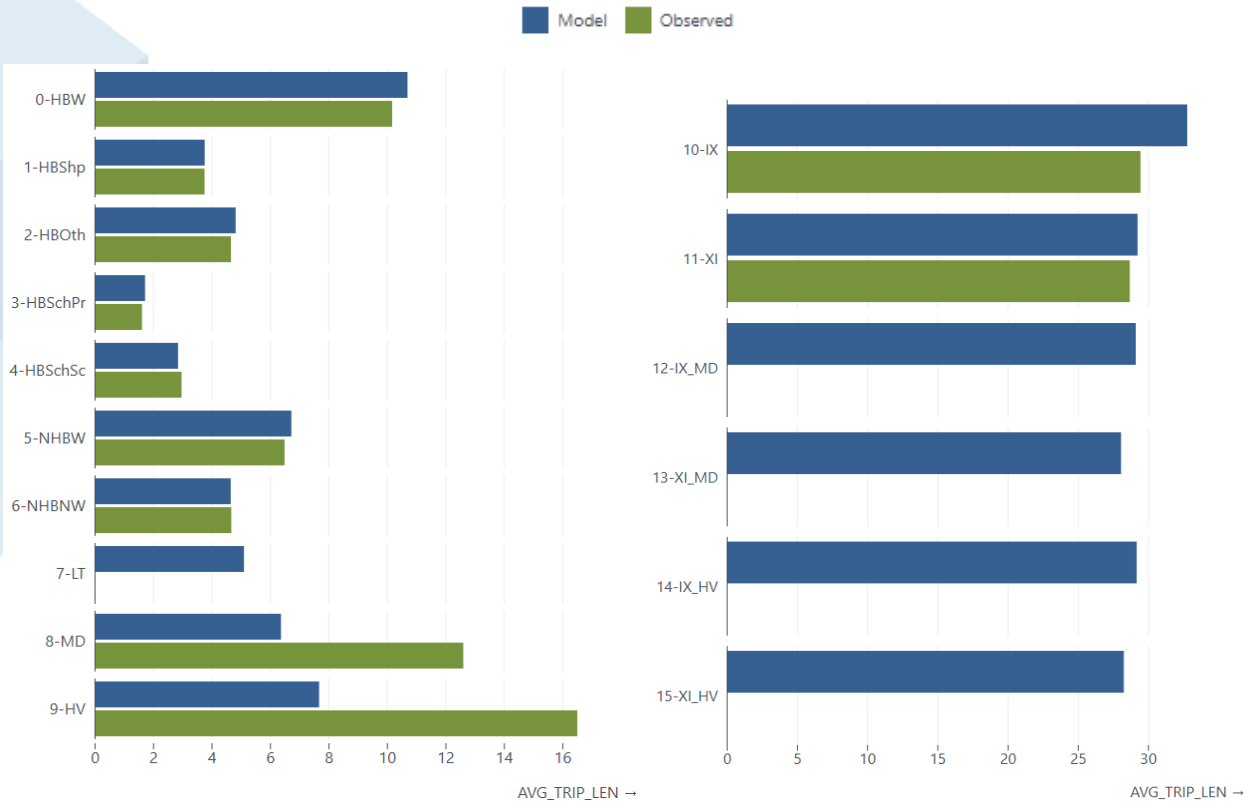


Figure 1.2 Average Trip Length (Distance)

1.1.2 Trip Length Frequency Validation

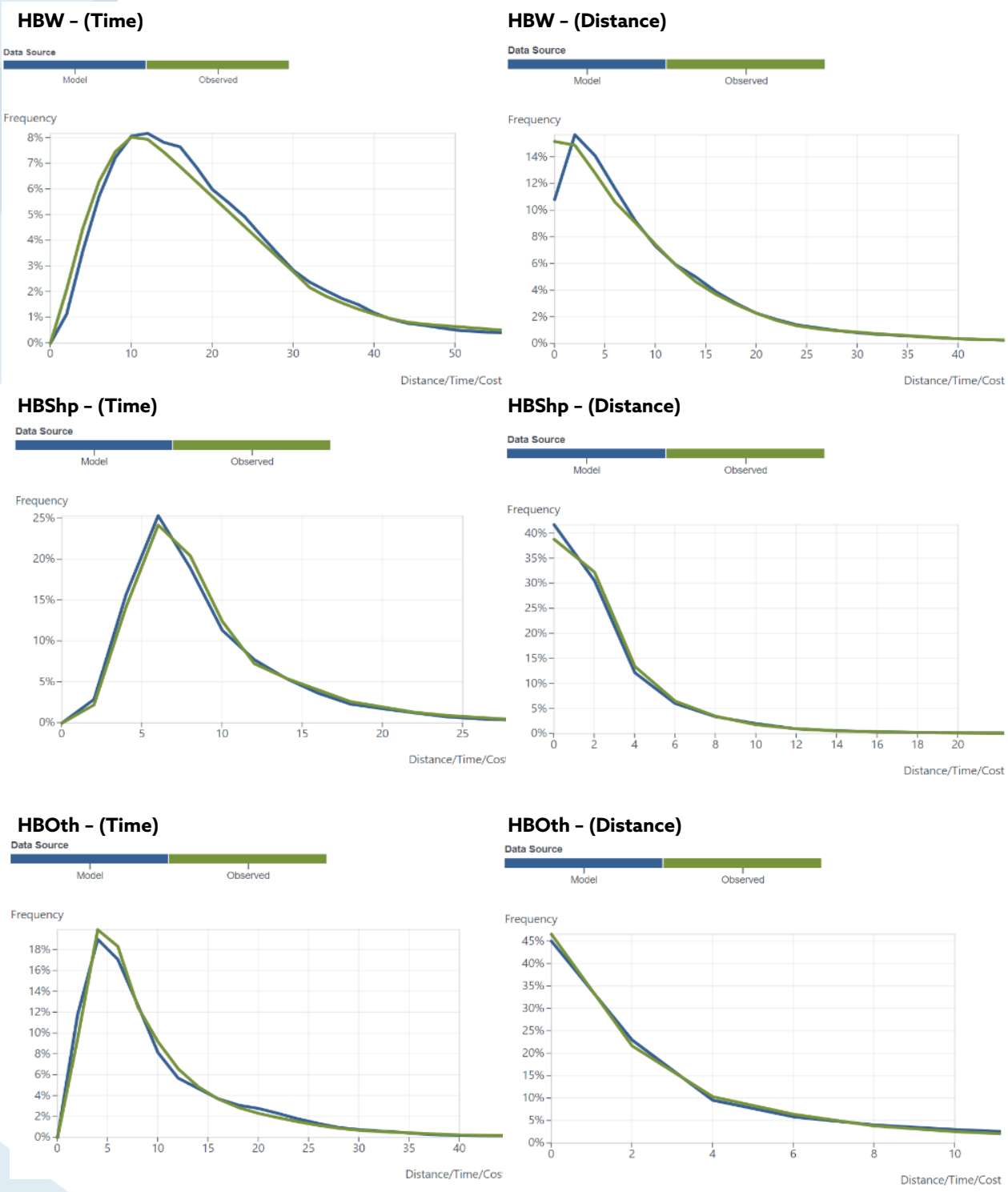


Figure 1.3 Trip Length Frequency - Beginning (HBW, HBShp, HBOth)

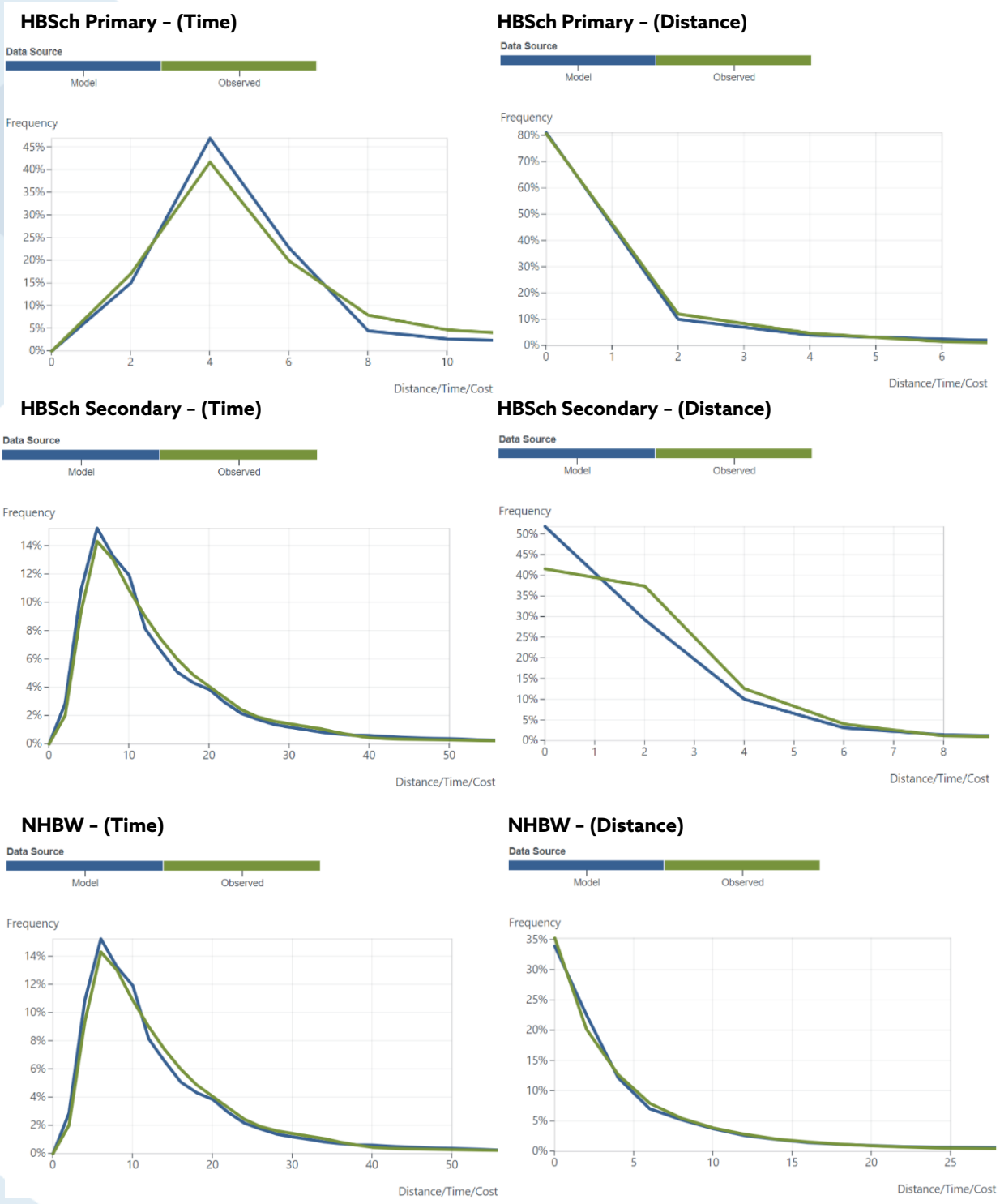


Figure 1.4 Trip Length Frequency (HBSch Primary, HBSch Secondary, NHBW)

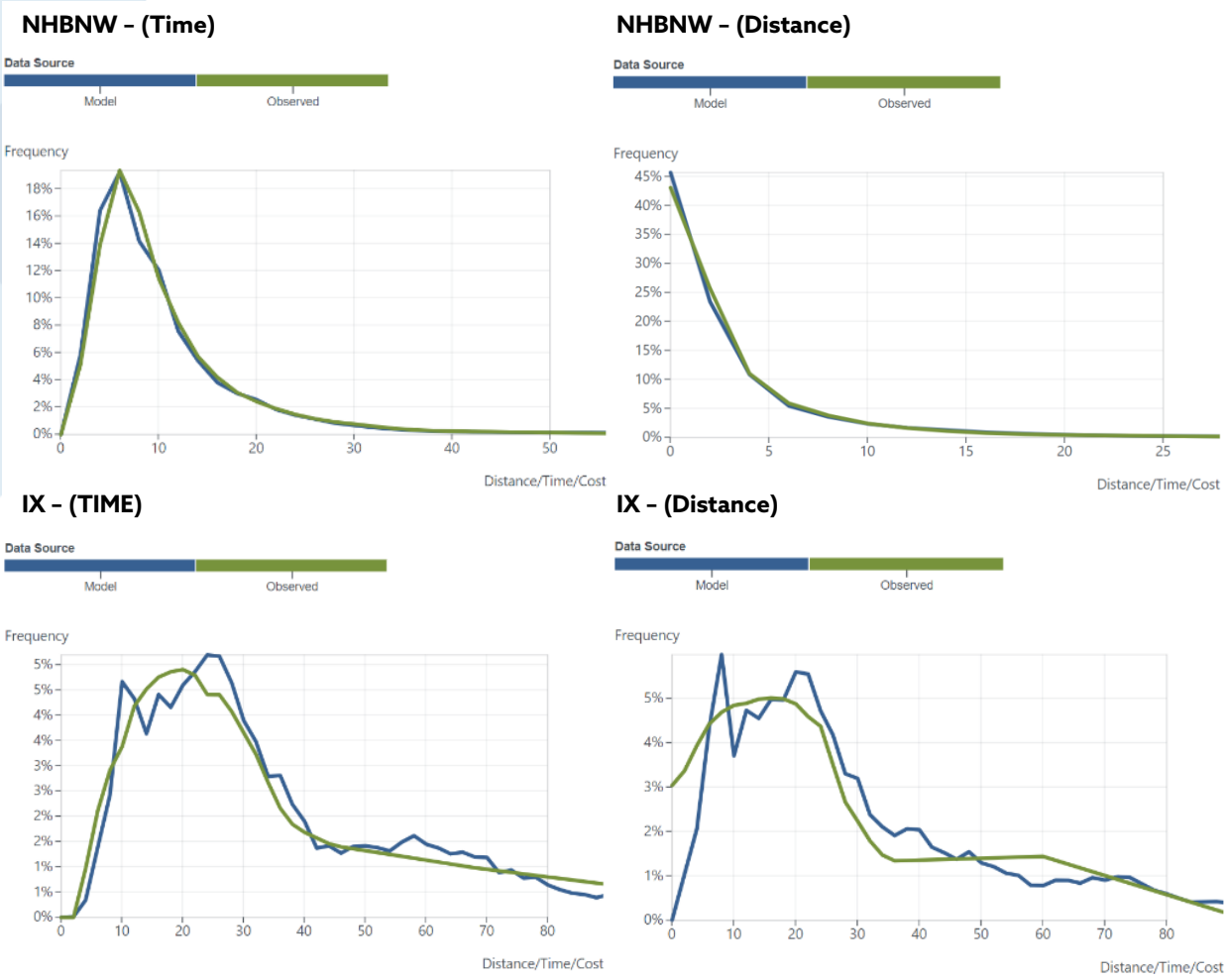


Figure 1.5 Trip Length Frequency (NHBNW, IX)

2 Mode Choice

2.1 Mode Share

The mode choice model was calibrated to observed mode shares from the 2012 Household Travel Survey and the 2019 Transit On-Board Survey. The results of this calibration effort are shown in Figure 2.1 through Figure 2.6. All mode shares were calibrated to within 5% of observed data.

2.1.1 Mode Share Calibration Results (Daily, All Purposes)

Motorized / Non-Motorized	Model	Observed	Difference
Motorized	91.5%	91.6%	-0.1%
Non-Motorized	8.5%	8.4%	0.1%

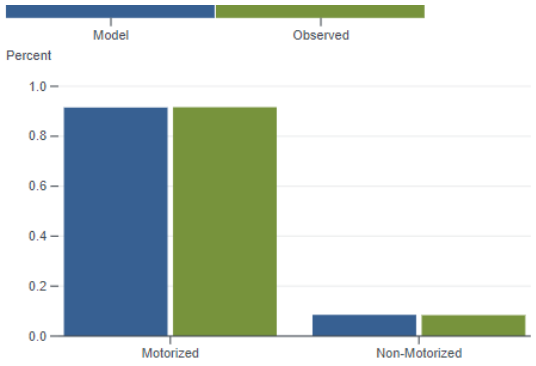


Figure 2.1 Mode Share Calibration Results - Motorized / Non-Motorized (Daily, All Purposes)

Auto / Transit	Model	Observed	Difference
Auto	98.5%	98.0%	0.5%
Transit	1.5%	2.0%	-0.5%

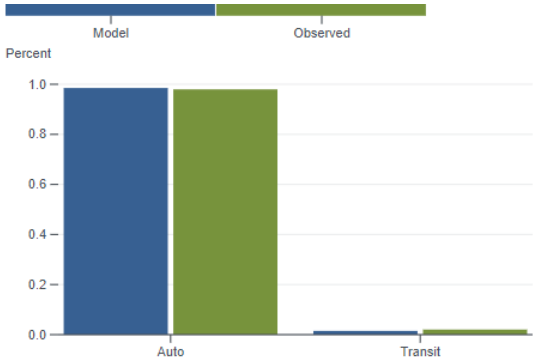


Figure 2.2 Mode Share Calibration Results - Auto / Transit (Daily, All Purposes)

Drive Alone / Shared Ride	Model	Observed	Difference
Drive Alone	46.9%	46.5%	0.4%
Shared Ride	53.1%	53.5%	-0.4%

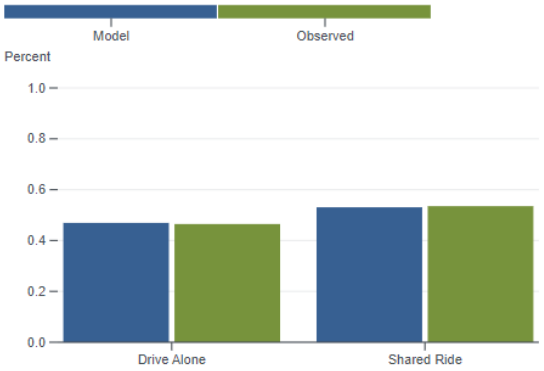


Figure 2.3 Mode Share Calibration Results - Drive Alone / Shared Ride (Daily, All Purposes)

Shared Ride # of Occupants	Model	Observed	Difference
Shared Ride 2 Occupants	42.6%	42.6%	0.0%
Shared Ride 3+ Occupants	57.4%	57.4%	-0.0%

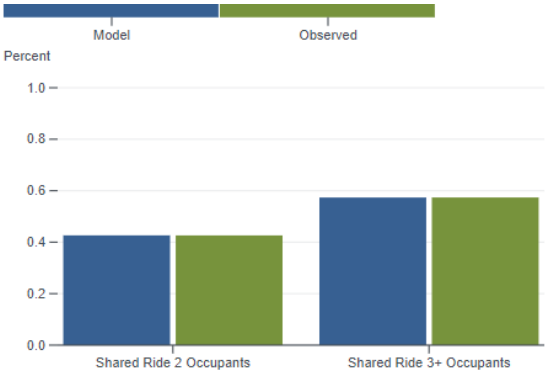


Figure 2.4 Mode Share Calibration Results - Shared Ride 2 / Shared Ride 3 (Daily, All Purposes)

Transit Access Mode	Model	Observed	Difference
Drive	22.5%	26.3%	-3.8%
Walk	77.5%	73.7%	3.8%

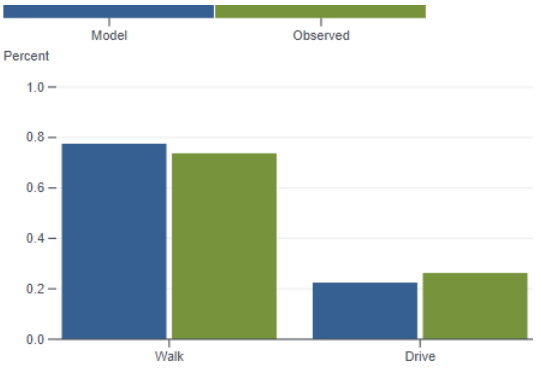


Figure 2.5 Mode Share Calibration Results - Transit Access Mode (Daily, All Purposes)

Transit Mode	Model	Observed	Difference
BRT	8.1%	9.0%	-1.0%
CRT	16.5%	17.3%	-0.8%
Core Bus	0.6%	0.7%	-0.1%
Express Bus	0.8%	0.8%	0.0%
LRT	41.2%	40.0%	1.2%
Local Bus	32.9%	32.2%	0.7%

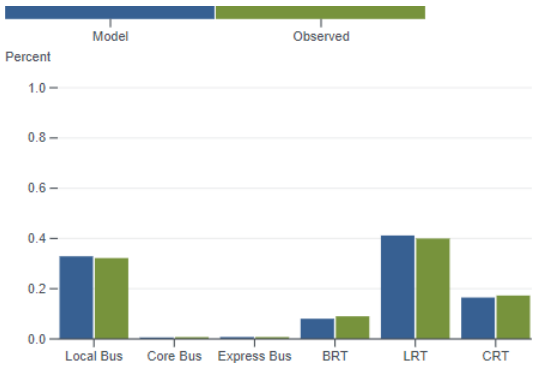


Figure 2.6 Mode Share Calibration Results - Transit Mode (Daily, All Purposes)

2.2 Transit Trips and Boardings

Transit trips were validated to the 2019 Transit On-Board Survey and 2019 observed boarding data. To facilitate model calibration, transit trips, boardings, and transfers were validated by the model's hierarchical mode. Boardings were also validated based on the mode where the boarding was actually observed. Transit validation results are shown in Figure 2.7.

Total transit trips and boardings were calibrated to within 5% of observed data (trips 1.6%, boardings -0.8%). Overall transfers were all within an acceptable range.

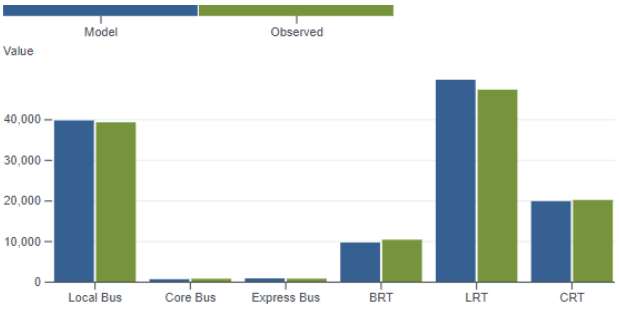
Transit trips and boardings by mode were calibrated to acceptable ranges for modes with significant ridership. Modes with low ridership were allowed to have a higher difference when compared to observed data if calibrating to increase base year accuracy resulted in too large alternative specific constants (i.e. over calibrating these modes). However, the following suggestions may help guide when using the model and interpreting model results:

- BRT validation results were low (between -6.7% and -12.6%). However, only one BRT route (UVX) was available in 2019 to calibrate this mode. Partly due to this, additional rounds of calibration to improve BRT resulted in large constants. This in turn would have the effect of making the base year validation better but overpredicting BRT in future forecasts, particularly as there is significantly more BRT in future plan phases. The decision was made to allow BRT to show lower than expected ridership in the earlier years of the model in favor of more reasonable BRT future-year forecasts.
- Core Route has a similar issue to BRT where only 1 Core Route (3500 S) was available in 2019 to calibrate this mode. Core Route had a much lower ridership in 2019 (roughly a tenth of the BRT ridership) which tends to show more extreme validation results. Core Route validation showed a similar pattern to BRT with lower trips and boardings (-14.4% and -14.0%, respectively) with the exception that the model was overpredicting total Core Route boardings (24.5%) resulting from slightly too many trips using this mode to transfer to a higher mode (LRT or CRT). Similar to BRT, the decision was made to not over calibrate this mode, in particular as there is also significantly more Core Route in future plan phases, in favor of more reasonable Core Route future-year forecasts.
- Express Bus trip and boarding validation results are higher than desired (8.5% and 11.6%, respectively). However, Express Bus ridership in 2019 is not significant and Express Bus

service is expected to decrease in future plan phases. Note that the model underpredicts overall boardings (-17.2%) largely due to the observed data showing trips in the downtown area are transferring from other modes (e.g. CRT) to use Express Bus more as a local downtown circulator. The model does not capture this behavior.

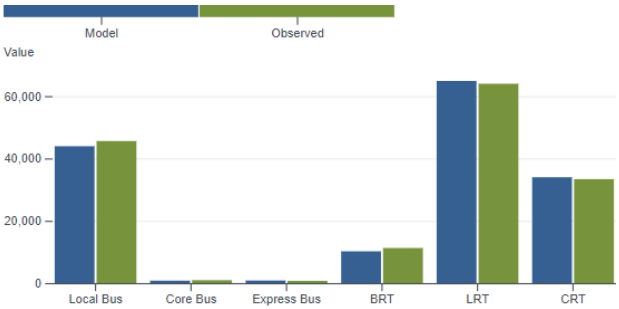
Trips by Hierarchical Mode

Mode	Model	Observed	Difference	% Difference
BRT	9,772	10,471	-699	-6.7%
CRT	19,966	20,266	-300	-1.5%
Core Bus	737	861	-124	-14.4%
Express Bus	949	875	74	8.5%
LRT	49,864	47,419	2,445	5.2%
Local Bus	39,839	39,385	454	1.2%
Total	**121,127**	**119,276**	**1,851**	**1.6%**



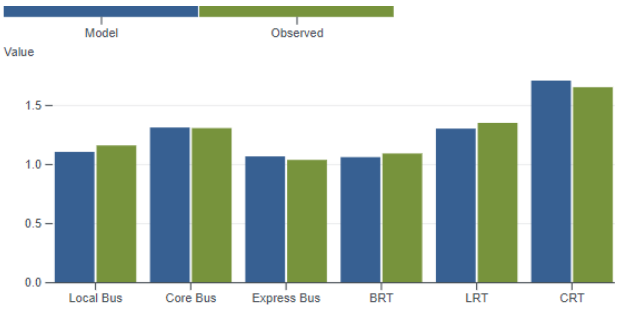
Boardings by Hierarchical Mode

Mode	Model	Observed	Difference	% Difference
BRT	10,388	11,456	-1,068	-9.3%
CRT	34,162	33,546	616	1.8%
Core Bus	968	1,126	-158	-14.0%
Express Bus	1,015	910	105	11.6%
LRT	65,054	64,149	905	1.4%
Local Bus	44,111	45,774	-1,663	-3.6%
Total	**155,698**	**156,961**	**-1,263**	**-0.8%**



Transfer Ratio by Hierarchical Mode

Mode	Model	Observed	Difference	% Difference
BRT	1.06	1.09	-0.03	-2.8%
CRT	1.71	1.66	0.06	3.4%
Core Bus	1.31	1.31	0.01	0.4%
Express Bus	1.07	1.04	0.03	2.8%
LRT	1.30	1.35	-0.05	-3.6%
Local Bus	1.11	1.16	-0.05	-4.7%
Total	**1.29**	**1.32**	**-0.03**	**-2.3%**



Boardings by Observed Mode

Mode	Model	Observed	Difference	% Difference
BRT	11,203	12,821	-1,618	-12.6%
CRT	19,966	20,387	-420	-2.1%
Core Bus	2,185	1,754	430	24.5%
Express Bus	969	1,170	-201	-17.2%
LRT	60,271	58,897	1,374	2.3%
Local Bus	61,104	61,931	-827	-1.3%
Total	**155,698**	**156,961**	**-1,263**	**-0.8%**

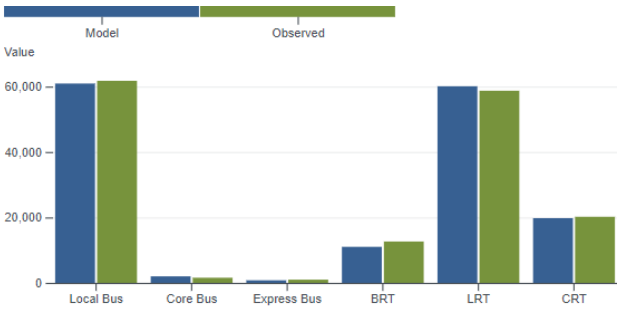


Figure 2.7 Trips and Boardings by Mode Surveyed - Model vs. Observed Comparison

3 Highway Assignment

3.1 Volumes

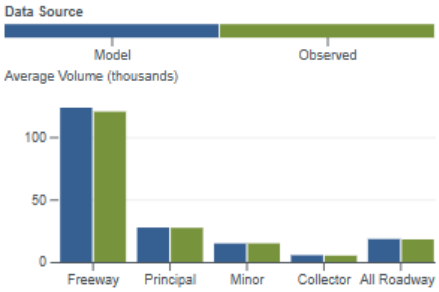
Model volumes and vehicle-miles travel (VMT) were validated against observed data. The observed data for 2019 volumes is taken from the Utah Department of Transportation (UDOT) Average Annual Daily Traffic (AADT) History and associated with their respective model segments. Observed VMT was calculated by multiplying the observed volume by the model segment distances.

Figure 3.1, Figure 3.2, and Figure 3.3 show model and observed values for the region at the all vehicle, medium truck, and heavy truck levels. The comparisons are shown in four different types of charts and tables:

- *Average Daily Volume by Roadway Class (2a)*: The daily volume is averaged across all segments within their respective geography and vehicle type.
- *Total VMT by Roadway Class (2b)*: For each segment, the daily volume is multiplied by segment distance and then summed across all segments within their respective geography and vehicle type.
- *Model vs Count Segment Volume (2c)*: This is a scatter plot of segment daily volume with the x-axis as the observed volume and the y-axis as the model volume. The gray line shows the location of where model and observed volumes are equal. The dashed blue line shows a least-squares linear regression. The further the blue line moved away from the gray line, the further the model is from observed.
- *Segment Percent Error (2d)*: This is a scatter plot showing the amount of error (percent difference) between the observed volume and the model volume. The observed volume is the x-axis and the percent error is the y-axis. The gray lines are a bounding box that shows the control target. As volume increases, it is expected that the percent error should decrease.

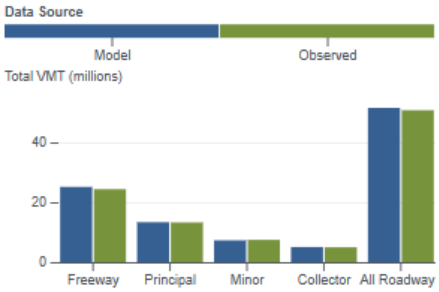
2a. Average Daily Volume by Roadway Class

Roadway Class	# Segs	Volume	Observed	Difference	Percent Difference	RMSE	Percent RMSE
Local	1	279	450	-171	-38.1%		
Freeway	165	123,895	120,773	3,122	2.6%	22,537	18.7%
Principal	897	28,081	27,840	241	0.9%	9,643	34.6%
Minor	1,110	15,344	15,420	-77	-0.5%	8,144	52.8%
Collector	1,666	5,955	5,620	335	6.0%	5,111	90.9%
All Roadways	**3,839**	**18,907**	**18,593**	**314**	**1.7%**	**8,510**	**45.8%**

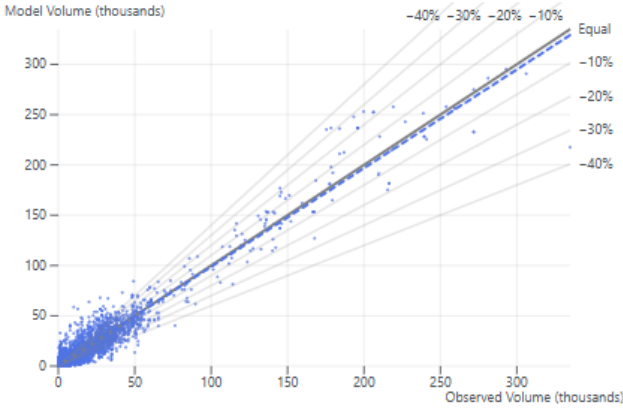


2b. Total Daily VMT by Roadway Class

Roadway Class	Model	Observed	Difference	Percent Difference
Local	1,671	2,698	-1,027	-38.1%
Freeway	25,384,862	24,594,051	790,811	3.2%
Principal	13,573,160	13,492,126	81,034	0.6%
Minor	7,508,343	7,673,254	-164,911	-2.1%
Collector	5,284,207	5,202,212	81,995	1.6%
All Roadways	**51,752,244**	**50,964,341**	**787,903**	**1.5%**



2c. Model vs Observed Volumes



2d. Model vs Observed Percent Error

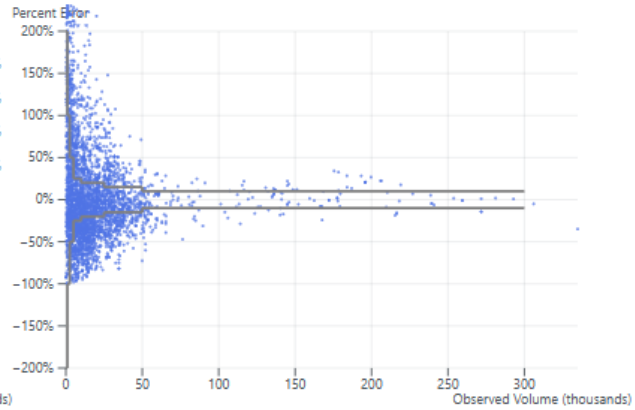
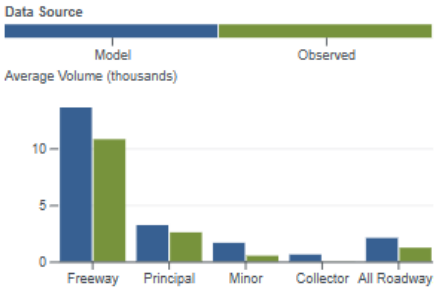


Figure 3.1 Model vs Observed Volume and VMT Comparison (Region, All Vehicles)

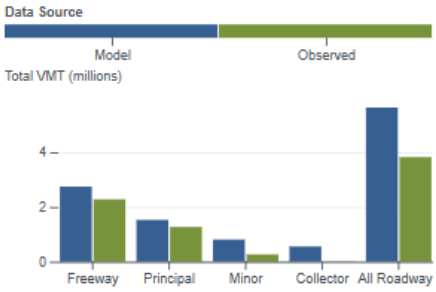
2a. Average Daily Volume by Roadway Class

Roadway Class	# Segs	Volume	Observed	Difference	Percent Difference	RMSE	Percent RMSE
Local	1	27	56	-29	-51.6%		
Freeway	165	13,601	10,796	2,805	26.0%	6,420	59.5%
Principal	897	3,221	2,582	640	24.8%	2,392	92.7%
Minor	1,110	1,656	517	1,139	220.1%	1,821	352.0%
Collector	1,662	622	14	608	4220.9%	812	5641.3%
All Roadways	**3,835**	**2,088**	**1,224**	**863**	**70.5%**	**2,077**	**169.6%**

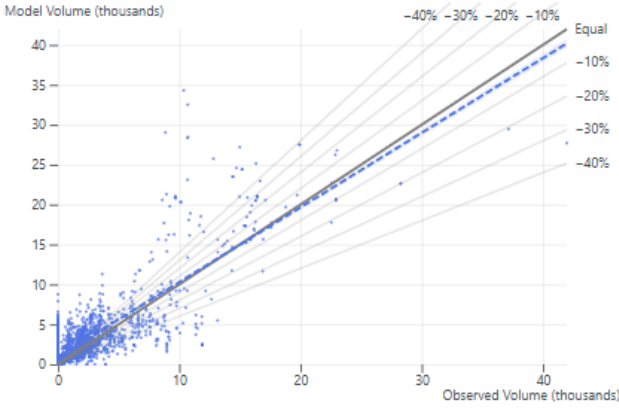


2b. Total Daily VMT by Roadway Class

Roadway Class	Model	Observed	Difference	Percent Difference
Local	162	334	-173	-51.6%
Freeway	2,744,541	2,278,308	466,233	20.5%
Principal	1,526,811	1,266,602	260,209	20.5%
Minor	808,764	264,337	544,427	206.0%
Collector	554,820	12,755	542,064	4249.7%
All Roadways	**5,635,097**	**3,822,337**	**1,812,760**	**47.4%**



2c. Model vs Observed Volumes



2d. Model vs Observed Percent Error

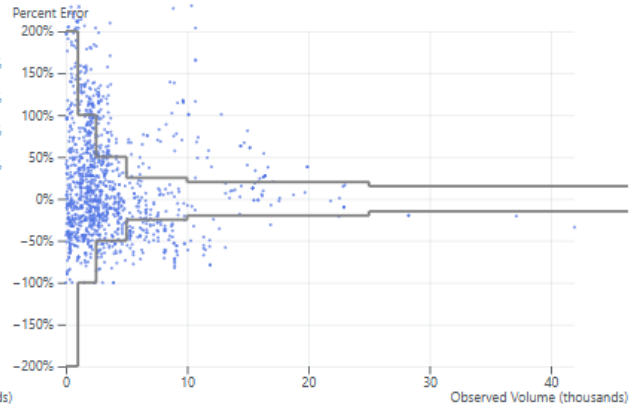
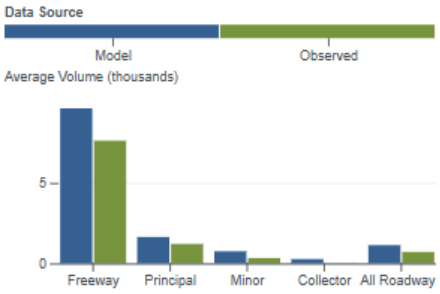


Figure 3.2 Model vs Observed Volume and VMT Comparison (Region, Medium (MD) Trucks)

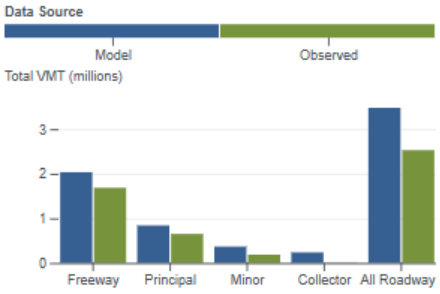
2a. Average Daily Volume by Roadway Class

Roadway Class	# Segs	Volume	Observed	Difference	Percent Difference	RMSE	Percent RMSE
Local	1	10	19	-9	-47.1%		
Freeway	165	9,631	7,622	2,009	26.4%	3,318	43.5%
Principal	897	1,642	1,207	435	36.0%	1,635	135.5%
Minor	1,110	753	332	421	126.9%	954	287.3%
Collector	1,662	267	16	251	1537.9%	435	2662.2%
All Roadways	**3,835**	**1,132**	**713**	**419**	**58.7%**	**1,228**	**172.2%**

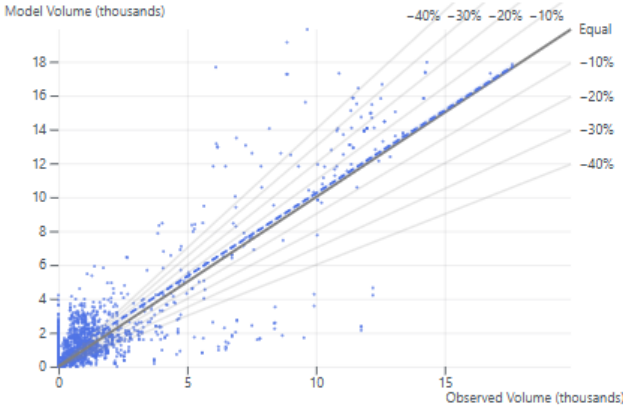


2b. Total Daily VMT by Roadway Class

Roadway Class	Model	Observed	Difference	Percent Difference
Local	60	113	-53	-47.1%
Freeway	2,035,463	1,685,186	350,277	20.8%
Principal	839,847	648,930	190,916	29.4%
Minor	366,122	183,775	182,347	99.2%
Collector	235,699	9,977	225,722	2262.3%
All Roadways	**3,477,191**	**2,527,981**	**949,209**	**37.5%**



2c. Model vs Observed Volumes



2d. Model vs Observed Percent Error

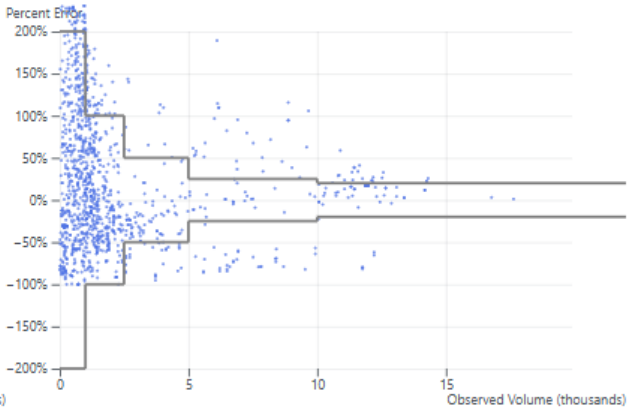


Figure 3.3 Model vs Observed Volume and VMT Comparison (Region, Heavy (HV) Trucks)

As shown in Figure 3.1, the volume and VMT of all vehicles at the region-wide level closely matches the validation targets. Volume for all roadways is only 1.7% higher than observed and VMT for all roadways is only 1.5% higher than observed.

As shown in Figure 3.2 and Figure 3.3, the model currently overpredicts Medium and Heavy trucks. A good amount of effort was spent attempting to bring model truck volumes closer to observed. However, due to truck data limitations and other model resource considerations, further calibration was stopped. Truck modeling remains a future priority for model improvement.

In addition to the charts, the maps in Figure 3.4 shows a comparison of segment level model vs observed volumes by vehicle types. Blue represents model lower than observed and red represents model volume higher than observed.

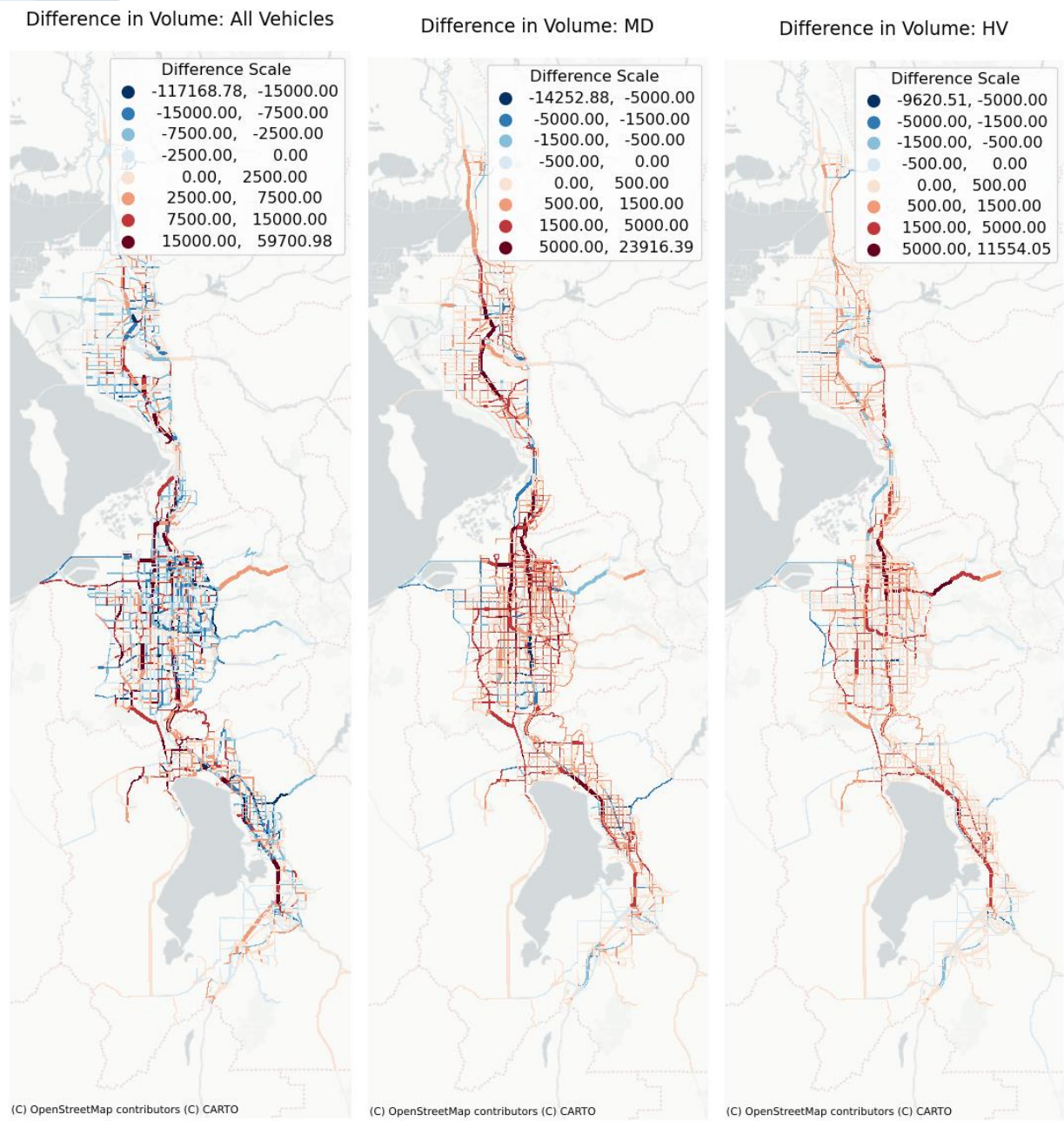


Figure 3.4 Segment-Level Model vs Observed Volume Comparison by Vehicle Type

Looking at the *All Vehicles* map, the model volumes are lower than observed for by more than 7,500 vehicles per day for the east side of I-215 and by more than 15,000 vehicles per day for I-15 through northern Utah County. Model volumes are higher than observed volumes by more than 15,000 vehicles for I-15 in southern Salt Lake County and for I-15 in Utah County between Springville and Spanish Fork. When looking at these areas by vehicle type, volumes for both *Medium Trucks* and

Heavy Trucks are slightly greater than observed. Overall, the volume differences between model and observed are relatively minor.

The lower arterial model vs observed volumes of *Heavy Trucks* on 9000 South in Salt Lake County was further investigated. The *Heavy Truck* observed volume for this roadway seemed much higher than expected for this roadway. The lower volumes are likely due to the observed data and not anything in the model.

3.2 Average Travel Time

The model's average travel time was compared to observed data between (how many) various origin and destination locations throughout the model space. Observed travel times came from the Google API for various times throughout 2019. All observed data was collected on Tuesday through Thursday. Due to a data collection issue, observed average travel times were only available for the WFRC area. Model data came from the final network skims that report travel times between every TAZ by period.

The validation results for average travel time are shown in Figure 3.5 through Figure 3.8. Looking at Figure 3.8 and knowing that evening speeds are similar to freeflow, we can deduce that in general the model's freeflow speeds are about 10% faster than observed. In addition, a pattern exists in Figure 3.5 through Figure 3.7 where shorter trips (under 20 minutes) have shorter travel times than observed and longer trips (30-60 minutes) have longer travel times than observed. This suggests that the volume-delay function (VDF) curves are slightly too aggressive on higher end facility types (freeways and arterials). Overall, while these charts show an acceptable range of error, improvements to freeflow speeds and to the VDF curves are adjustments we will consider making in future models.

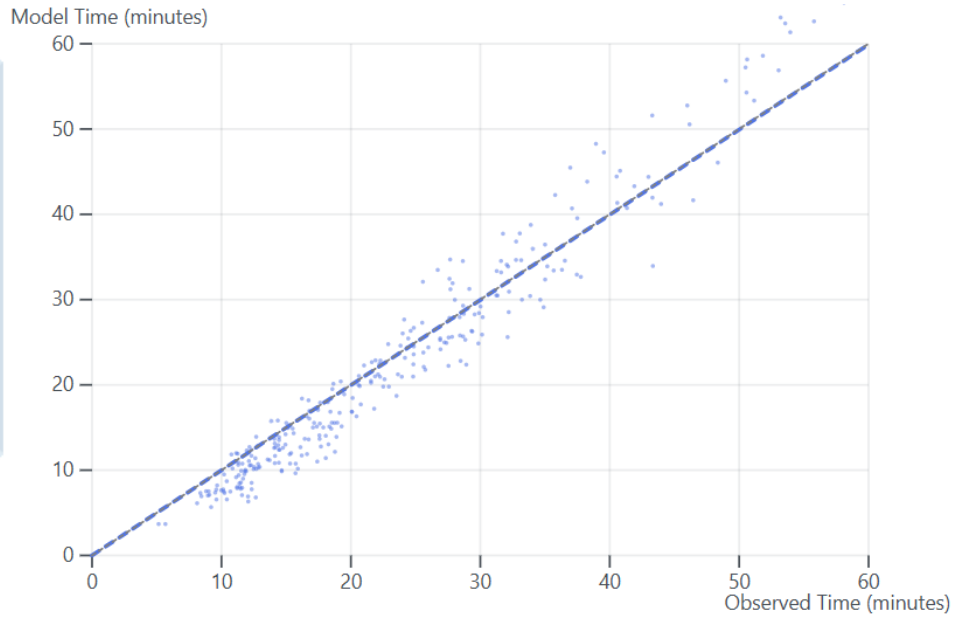


Figure 3.5 Model vs Observed Times AM Period

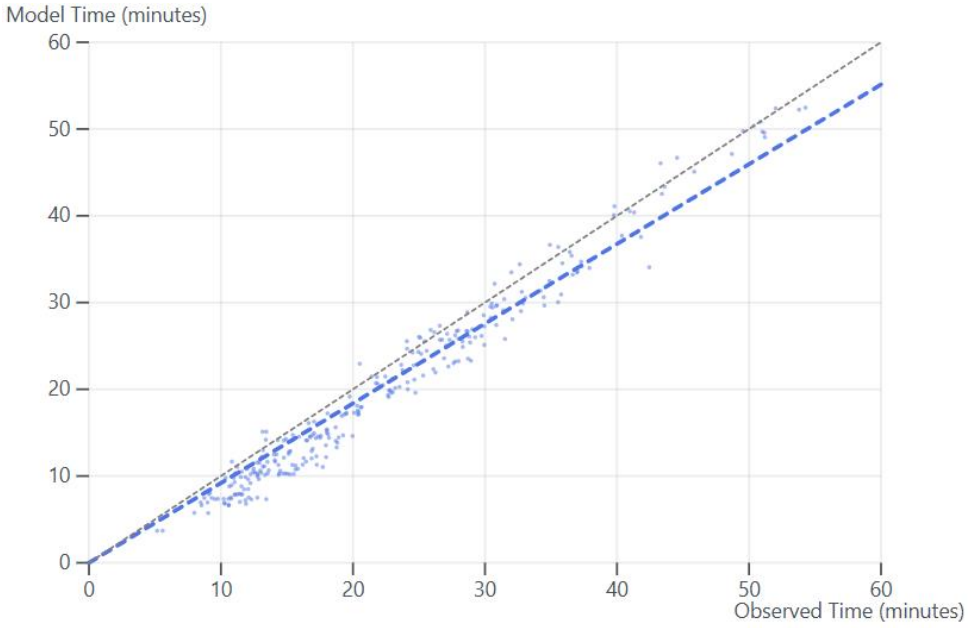


Figure 3.6 Model vs Observed Times Midday Period

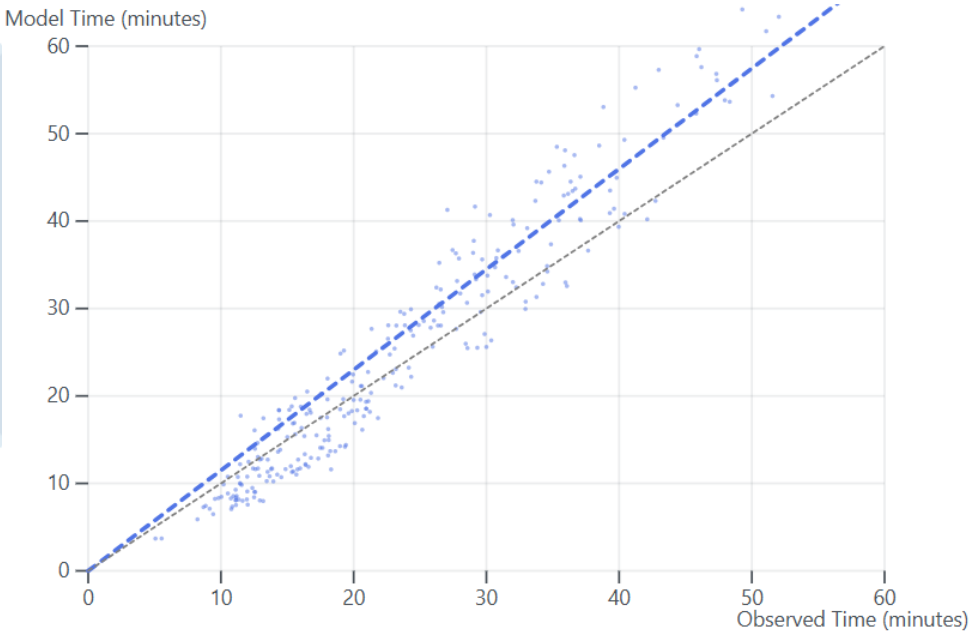


Figure 3.7 Model vs Observed Times PM Period

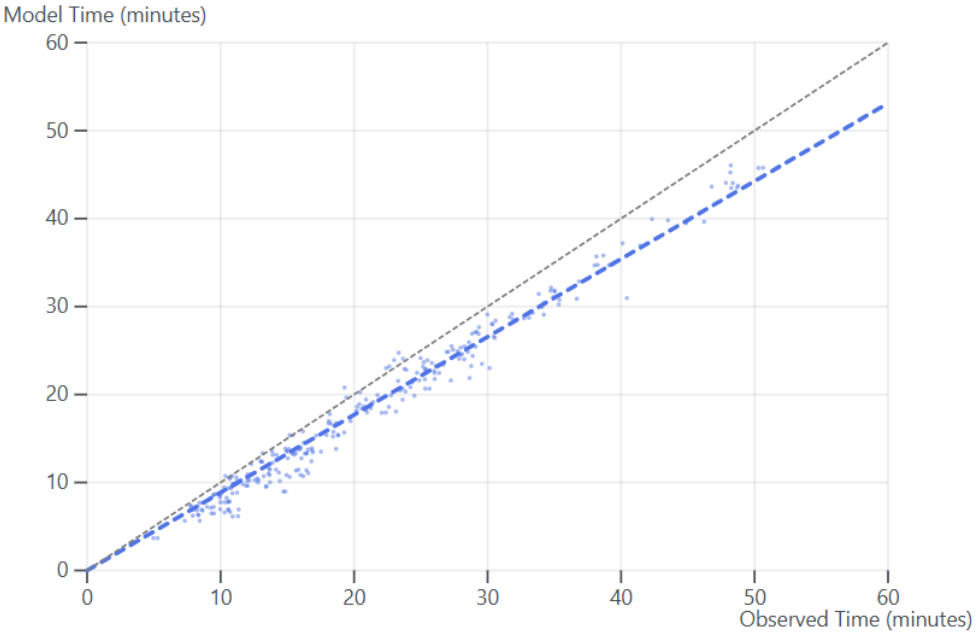


Figure 3.8 Model vs Observed Times Evening Period