DRCOG Focus Travel Model Calibration and Validation Report

Focus 2.4

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Focus Model

This report documents the calibration, validation, and operational framework of Focus 2.4, the activity-based travel demand model developed by the Denver Regional Council of Governments (DRCOG).

The Focus model simulates the daily travel choices of the region's residents, visitors, and workforce to support transportation planning, air quality conformity analyses, greenhouse gas assessments, and infrastructure studies. Focus 2.4 establishes a 2023 base year, representing post-COVID-19 pandemic travel conditions, and was utilized for the 2026 air quality conformity analysis associated with the 2050 Metro Vision Regional Transportation Plan (adopted in April 2021).

Travel Demand Modeling Framework: Estimation, Calibration, and Validation

The development and maintenance of the Focus model involve three distinct technical phases: Estimation, Calibration, and Validation.

Estimation

Estimation involves deriving behavioral model parameters from disaggregate (individual) choice data, typically sourced from household travel surveys.

- Historical Context: The original Focus 1.0 model was estimated in 2007 using 1997 Travel Behavior Inventory data.
- Recent Updates: For Focus 2.0 and 2.1, the Tour Mode Choice component was re-estimated using the 2010 Front Range Travel Counts (FRTC) household survey data, with model specification variables remaining unchanged (aside from substituting bicycle travel time with bicycle distance).

Calibration

Calibration adjusts estimated model parameters to address sampling limitations or biases in the household survey datasets. Model parameters fall into two categories:

- Behavioral Parameters: Multiplied by explanatory variables such as travel cost or job accessibility.
- Alternative-Specific Constants: Residual terms capturing unobserved behavior for specific transport alternatives or socioeconomic segments.

Calibration is achieved by comparing modeled socioeconomic group shares against observed behavior and iteratively adjusting constants. For Focus 2.4, calibration was tied

to the 2023 base year and the 2025 Colorado Travel Counts (CTC). While CTC survey results serve as the primary "observed" benchmark, they rely on a limited sample size with inherent challenges, such as high expansion factors, under-reporting of trips, and sparse records for niche trip types.

Validation

The Focus activity-based model generates household origin-destination matrices. Then, special trip matrices (e.g., Denver International Airport), external zone highway vehicles, and commercial vehicles are combined with the Focus origin-destination matrices. These three added matrices, often referred to as the "Tripod" package, are fed into the TransCAD traffic and transit assignment routines.

Validation evaluates how closely the final model outputs (such as traffic volumes, vehicle miles traveled, and transit ridership) match observed field data from the Colorado Department of Transportation (CDOT), toll authorities, local municipalities, and Regional Transportation District (RTD) passenger counts and on-board surveys.

Travel Demand Model Core Functions

The Focus model addresses many fundamental questions regarding daily regional mobility. Such as:

1. Where do individuals work or attend school?
2. Where and in what type of residential setting do they live?
3. What is their demographic, auto-availability, and life-stage characteristics?
4. At what times of day do they initiate trips?
5. What is the primary purpose of each trip?
6. What geographic destinations do they select?
7. Which travel mode do they choose?
8. How much travel time is required across various modes (walk, bicycle, drive-alone, ride-hailing, carpool, or public transit)?
9. What are the fixed and out-of-pocket costs associated with those modes?
10. What specific driving or transit route is taken to reach the destination?

The Focus travel model addresses each of these questions initially through a calibrated base-year version that replicates observed real-world weekday conditions. Subsequently, the model evaluates these mobility dimensions under various future scenarios that deviate from base-year assumptions. Typical scenario analyses capture factors such as 30-year population growth, new transit services, expanded roadways, shifting land-use patterns, travel cost increases, or evolving cultural trends like teleworking.

Average Weekday Baseline Outputs

The travel model generates a comprehensive range of outputs, including daily trips across all travel modes, average travel times, roadway vehicle and person volumes, and transit ridership statistics. These results provide vital insights for planners, engineers, and decision-makers. On an average weekday, the Focus model estimates:

- Total Person-Trips: 15.3 million
    - Motor Vehicles: Nearly 13 million trips in cars and trucks
    - Active Modes: 2 million pedestrian and bicycle trips
    - Transit & School Bus: About 0.5 million trips via public transit and school buses
- Vehicle Travel: Approximately 85 million vehicle miles traveled (VMT) daily within the Greater Denver area.

Growth Inputs and Long-Term Trends

Regional growth projections drive the long-term application of the model:

- Population, demographic, households, and employment: County-level estimates from the Colorado State Demography Office anchor regional growth forecasts. For the Focus 2.4 validation runs, the region is projected to add approximately 870,000 residents and 690,000 jobs between 2023 and 2050. DRCOG's Land Use model distributes this growth across more than 2,800 transportation analysis zones (TAZs).
- Vehicle Miles Traveled (VMT): Population and employment growth represent the primary catalysts for future VMT increases. Conversely, modifications to land use patterns, teleworking adoption, and driving cost increases exhibit moderate effects on VMT, while individual transportation facility upgrades yield localized shifts rather than macro-level VMT changes.

Model Application and "What-If" Scenario Analysis

The primary utility of the Focus model is evaluating the impacts of real-world infrastructure or policy changes. Standard analysis steps include:

1. No-Build Baseline: Running a future-year baseline scenario without the proposed project to establish comparative metrics.
2. Scenario Execution: Modifying network geometries, transit headways, or socioeconomic inputs to reflect the proposed change.
3. Comparative Evaluation: Assessing output differentials in VMT, transit ridership, congestion delays, and average trip lengths.

Typical Localized Variations

Because the Denver metropolitan area features a mature, highly established transportation network, project-level changes (such as adding a freeway interchange or widening a roadway) primarily generate localized adjustments with offsetting impacts:

- Localized Travel Adjustments:
    1. Individuals may shift residential, employment, or shopping locations, as well as alter trip timing and routing.
    2. Traffic volume shifts occur primarily due to motorists diverting to faster, newly optimized paths (e.g., a shorter commute route via a new interchange).
    3. Discretionary trip destinations and travel times may adjust.
    4. Commercial vehicle trips routing experience minor localized adjustments.
    5. Land use patterns remain largely consistent with baseline forecasts, though major new infrastructure can occasionally catalyze targeted private development.
- Induced Travel Demand:
    1. A small subset of travelers may shift from non-motorized or shared-ride modes to driving alone.
    2. Certain travelers may undertake longer trips for specific purposes due to improved facility speeds.
    3. New vehicle trips may be induced by reduced generalized travel costs.

Environmental and Regulatory Reporting

Beyond transportation planning, the Focus model provides detailed VMT and congestion data files to the Air Pollution Control Division of the Colorado Department of Public Health and Environment (CDPHE). These datasets serve as direct inputs for the U.S. Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) model to calculate regional mobile-source pollutant emissions.

Calibration

Observed Data Sources for Calibration

The American Community Survey (ACS)

The American Community Survey (ACS) is an ongoing annual survey conducted by the U.S. Census Bureau that provides a rich picture of local populations and changing community characteristics. It continuously gathers detailed insight into income, education, employment status, housing conditions, and daily commuting patterns across the nation.

Colorado Travel Counts (CTC)

The Colorado Travel Counts – household travel survey, conducted between 2024 and 2025, is a comprehensive data collection designed to capture the post-pandemic daily mobility patterns of residents across the state. By recording individual household trip details, such as travel modes, trip origins and destinations, departure times, route choices, and travel purposes. The survey provides a realistic foundation for regional travel demand models and activity-based forecasting. Several components of the FOCUS 2.4 model were calibrated using data from this survey. For the development of calibration targets, only datasets corresponding to the DRCOG region, including household, person, tour, and trip records were considered.

Several recent datasets, including the Colorado Travel Counts (CTC) and the American Community Survey (ACS), were used to establish calibration targets for the model. The previous model calibration was primarily based on ACS and Front Range Travel Counts (FRTC) datasets. For recent calibration effort, post-pandemic travel behavior changes were considered, resulting in the model base year shifting from 2020 to 2023.

Household Auto Availability

The Household Auto Availability component assigns each household an auto availability level: zero, one, two, three or four or more cars.

Observed Data Sources for Calibration

Both ACS and CTC provide information about household auto ownership and show comparable distribution of households by the level of available cars.

Changes to the Model

This component was calibrated for Focus 2.4 by updating four coefficient groups:

- Added Constant coefficients.
- County interactions with alternative-specific constants.
- The "at least as many cars as workers" indicator variable.
- One-car coefficient for low-income households.

Comparison of Model and Observed

Income Level Comparison

Comparisons of the regional distribution of households by auto availability are shown in Table 1. A similar comparison stratified by household size is shown Table 3 through Table 6.

The Focus model assumes all one-person households are composed of adults and therefore eligible to be drivers. Moreover, Table 7 through Table 10 provide comparisons stratified by number of workers. Furthermore, Table 11 through Table 17 provide the distribution of households by auto availability stratified by county.

Table 1: Auto Ownership Distribution by Household Income

Income	Autos % CTC [1]	Autos/HH CTC [1]	Autos % Model [2]	Autos/HH Model [2]	Autos % Model - CTC	Autos/HH Model - CTC
< 15K	5.4%	1.05	5.7%	0.80	0.4%	-0.25
15K - 35K	15.8%	1.49	16.2%	1.35	0.4%	-0.14
35K - 75K	39.1%	2.03	33.3%	1.89	-5.8%	-0.14
≥ 75K	39.7%	2.36	44.7%	2.87	5.0%	0.50
Total	**100%**	**1.93**	**100%**	**1.91**	**0%**	**-0.02**

Sources:

1. *Colorado Travel Counts (CTC).*
2. *Model results by DRCOG, RTP-2026, Year 2023.*

Note: Totals may not add up to 100% because of rounding. Weld and Elbert counties are excluded. Income is expressed in 1996 dollar value.

Auto Availability Comparisons

Comparisons of the regional distribution of households by auto availability are shown in Table 2.

Table 2. Comparison of Regional Auto Availability Distributions

Cars	ACS (%) [1]	CTC (%) [2]	Model (%) [3]
0	5.9%	5.7%	6.2%
1	32.1%	31.7%	31.5%
2	38.9%	40.1%	38.4%
3	15.4%	14.7%	16.0%
≥ 4	7.6%	7.8%	7.9%

Sources:

1. *American Community Survey (ACS), 5-year 2023.*
2. *2025 Statewide Colorado Travel Counts (CTC).*
3. *Model results by DRCOG, RTP-2026, Year 2023.*

Note: Totals may not add up to 100% because of rounding. Weld and Elbert counties are excluded.

Auto Availability: Household Size

Comparisons of the regional distribution of households by household size are shown in Table 3 through Table 6. The Focus model assumes all one-person households are composed of adults and therefore eligible to be drivers.

Table 3. Comparison of Auto Availability Distribution for 1 Member Households

Household Autos Available	ACS (%) [1]	Model (%) [2]	Difference (Model - ACS)
0	13.8%	15.2%	1.4%
1	71.1%	68.2%	-2.9%
2	11.7%	12.2%	0.5%
3	2.4%	3.3%	0.8%
≥ 4	1.0%	1.1%	0.2%

Table 4. Comparison of Auto Availability Distribution for 2 Members Households

Household Autos Available	ACS (%) [1]	Model (%) [2]	% Difference (Model - ACS)
0	3.2%	2.3%	-0.9%
1	20.2%	20.8%	0.6%
2	58.6%	52.2%	-6.4%
3	14.0%	18.2%	4.2%
≥ 4	4.0%	6.5%	2.5%

Table 5. Comparison of Auto Availability Distribution for 3 Members Households

Household Autos Available	ACS (%) [1]	Model (%) [2]	% Difference (Model - ACS)
0	2.0%	3.1%	1.1%
1	15.1%	13.2%	-1.9%
2	41.8%	49.7%	7.9%
3	30.7%	25.9%	-4.8%
≥ 4	10.3%	8.1%	-2.3%

Table 6. Comparison of Auto Availability Distribution for 4 or More Members Households

Household Autos Available	ACS (%) [1]	Model (%) [2]	% Difference (Model - ACS)
0	1.9%	1.5%	-0.4%
1	9.1%	7.9%	-1.2%
2	42.4%	46.6%	4.1%
3	25.3%	24.8%	-0.5%
>= 4	21.3%	19.2%	-2.1%

Sources:

1. *American Community Survey (ACS), 5-year 2023.*
2. *Model results by DRCOG, RTP-2026, Year 2023.*

Note: Totals may not add up to 100% because of rounding. Weld and Elbert counties are excluded.

Auto Availability: Number of Workers in the Household

Comparisons of the regional distribution of households by auto availability and number of workers in the households are shown in Table 7 through Table 10.

Table 7. Comparison of Auto Availability Distribution for 0 Worker Households

Household Autos Available	ACS (%)[1]	Model (%)[2]	Difference (Model - ACS)
0	15.3%	16.8%	1.5%
1	46.0%	54.3%	8.4%
2	28.4%	22.3%	-6.2%
3	7.8%	5.1%	-2.8%
>= 4	2.5%	1.5%	-1.0%

Table 8. Comparison of Auto Availability Distribution for 1 worker Households

Household Autos Available	ACS (%) [1]	Model (%) [2]	% Difference (Model - ACS)
0	5.5%	7.3%	1.9%
1	49.7%	50.2%	0.5%
2	31.1%	30.2%	-0.9%
3	10.2%	9.1%	-1.1%
>= 4	3.6%	3.1%	-0.5%

Table 9. Comparison of Auto Availability Distribution for 2 workers Households

Household Autos Available	ACS (%) [1]	Model (%) [2]	% Difference (Model - ACS)
0	1.7%	0.8%	-0.9%
1	10.8%	9.0%	-1.8%
2	59.3%	56.8%	-2.4%
3	20.4%	24.4%	4.0%
>= 4	7.8%	9.0%	1.1%

Table 10. Comparison of Auto Availability Distribution for 3 or more members Households

Household Autos Available	ACS (%) [1]	Model (%) [2]	% Difference (Model - ACS)
0	1.9%	0.1%	-1.8%
1	4.0%	1.2%	-2.9%
2	15.5%	21.5%	5.9%
3	38.7%	33.5%	-5.2%
>= 4	39.7%	43.7%	4.0%

Sources:

1. *American Community Survey (ACS), 5-year 2023.*
2. *Model results by DRCOG, RTP-2026, Year 2023.*

Note: Totals may not add up to 100% because of rounding. Weld and Elbert counties are excluded.

Auto Availability: County Level

Comparisons of the county distribution of households by auto availability are shown in Table 11 through Table 17.

Table 11. Comparison of Auto Availability Distribution in Adams County

Household Autos Available	ACS (%) [1]	Model (%) [2]	% Difference (Model - ACS)
0	4.9%	4.8%	-0.1%
1	25.9%	30.3%	4.4%
2	38.4%	42.7%	4.4%
3	18.4%	13.8%	-4.6%
>= 4	12.4%	8.5%	-4.0%

Table 12. Comparison of Auto Availability Distribution in Arapahoe County

Household Autos Available	ACS (%) [1]	Model (%) [2]	% Difference (Model - ACS)
0	5.2%	5.1%	-0.1%
1	31.6%	31.9%	0.3%
2	39.8%	39.5%	-0.3%
3	15.3%	15.4%	0.1%
>= 4	8.0%	8.0%	0.0%

Table 13. Comparison of Auto Availability Distribution in Boulder County

Household Autos Available	ACS (%) [1]	Model (%) [2]	% Difference (Model - ACS)
0	5.1%	9.0%	3.9%
1	32.8%	30.0%	-2.7%
2	40.3%	37.5%	-2.8%
3	15.8%	16.3%	0.5%
>= 4	6.1%	7.1%	1.0%

Table 14. Comparison of Auto Availability Distribution in Broomfield County

Household Autos Available	ACS (%) [1]	Model (%) [2]	% Difference (Model - ACS)
0	3.6%	1.6%	-2.0%
1	30.6%	26.4%	-4.2%
2	42.4%	42.1%	-0.2%
3	16.4%	20.1%	3.7%
>= 4	7.0%	9.7%	2.8%

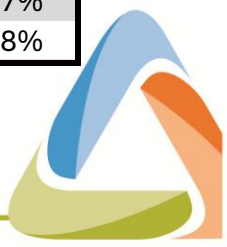


Table 15. Comparison of Auto Availability Distribution in Denver County

Household Autos Available	ACS (%) [1]	Model (%) [2]	% Difference (Model - ACS)
0	10.3%	10.4%	0.1%
1	42.6%	37.6%	-4.9%
2	33.1%	31.8%	-1.3%
3	10.2%	13.7%	3.6%
>= 4	3.8%	6.4%	2.6%

Table 16. Comparison of Auto Availability Distribution in Douglas County

Household Autos Available	ACS (%) [1]	Model (%) [2]	% Difference (Model - ACS)
0	2.3%	1.2%	-1.1%
1	22.7%	21.4%	-1.3%
2	46.4%	44.2%	-2.1%
3	19.5%	22.8%	3.3%
>= 4	9.1%	10.3%	1.3%

Table 17. Comparison of Auto Availability Distribution in Jefferson County

Household Autos Available	ACS (%) [1]	Model (%) [2]	% Difference (Model - ACS)
0	3.9%	4.4%	0.5%
1	28.5%	31.5%	3.0%
2	41.1%	39.6%	-1.5%
3	17.7%	16.5%	-1.2%
>= 4	8.9%	8.0%	-0.9%

Sources:

1. *American Community Survey (ACS), 5-year 2023.*
2. *Model results by DRCOG, RTP-2026, Year 2023.*

Note: Totals may not sum to 100% because of rounding.

Tour Mode Choice

The Tour Mode choice component assigns a main mode to each tour, from one of eight possible modes.

Changes to the Model

This component was updated for Focus 2.4 by recalibrating the alternative-specific constants for the Tour Mode Choice models across Work, School, and Other (all other purposes excluding Escort) tour purposes. Specifically, the constants were adjusted for

non-SOV (Single-Occupancy Vehicle) modes. These modes include Bike, Walk, Transit-Drive-Access, Transit-Walk-Access, Shared Ride 2, Shared Ride 3+, and School Bus for school-related tours, to align predicted mode shares with target calibration data.

Comparison of Targets and Models

Unless otherwise specified, the following modes are available, with the following abbreviations:

- Auto, Drive Alone: DA (SOV).
- Auto, Shared Ride 2: SR2 (HOV2).
- Auto, Shared Ride 3+: SR3+ (HOV 3+).
- Transit: Both walk and drive access.
- Walk.
- Bike.

In nested models, the three auto occupancy levels form an auto nest, the two transit access modes form a transit nest, and the walk and bike alternatives form a non-motorized nest.

Comparison of Model and Observed

Total Tours

Calibration is typically required after model estimation for several reasons: The estimation sample may not be truly representative of the larger population. The sample may have been collected during days that do not fully represent the range of days from which the target was developed. Even aggregate measures such as traffic counts or transit boarding counts can have their own implicit errors. Table 18 confirms that the modeled commute shares reflect observed shares to within 2.7% of all such tours.

Table 18. Comparison of Tours Mode Shares

Tour Mode	CTC (%) [1]	Model (%) [2]	% Difference (Model - CTC)
Bike	2.4%	2.9%	0.5%
Walk	10.8%	10.4%	-0.4%
Drive Alone	42.6%	43.5%	0.9%
Shared Ride 2	23.4%	22.7%	-0.7%
Shared Ride 3+	19.1%	16.4%	-2.7%
Transit	1.3%	1.6%	0.3%
School Bus	0.4%	2.6%	2.2%

Sources: 1. Colorado Travel Counts (CTC). 2. Model results by DRCOG, RTP-2026, Year 2023.
Note: Weld and Elbert counties are excluded.

Home-Based Work Tour

Table 19 confirms that the modeled commute shares reflect observed shares to within 2% of all such tours.

Table 19. Comparison of Work Tour Mode Choice Shares

Tour Mode	CTC (%) [1]	Model (%) [2]	% Difference (Model - CTC)
Bike	3.1%	3.4%	0.3%
Walk	3.3%	4.2%	0.9%
Drive Alone	81.5%	79.4%	-2.1%
Shared Ride 2	6.6%	7.7%	1.1%
Shared Ride 3+	2.4%	2.9%	0.5%
Transit	2.9%	2.4%	-0.5%

Sources:

1. *Colorado Travel Counts (CTC).*
2. *Model results by DRCOG, RTP-2026, Year 2023.*

Notes:

1. *Tabulations include a small number of Work-Based Subtours to work destinations.*
2. *Weld and Elbert counties are excluded.*

Non-Work Tours and Subtours

Mode shares for non-work tours and subtours are shown in Table 20. As expected, auto occupancies are considerably higher for non-work tours than for work tours since many non-work tours may reflect household activities.

Table 20. Comparison of Non-Work Tour Mode Choice Shares

Tour Mode	CTC (%) [1]	Model (%) [2]	% Difference (Model - CTC)
Bicycle	2.8%	2.6%	-0.2%
Walk	14.4%	13.0%	-1.4%
Drive Alone	37.5%	27.9%	-9.6%
Shared Ride 2	25.2%	29.2%	4.0%
Shared Ride 3+	17.5%	22.2%	4.7%
Transit	1.8%	1.3%	-0.5%
School Bus	0.8%	3.7%	2.9%

Sources:

1. *Colorado Travel Counts (CTC).*
2. *Model results by DRCOG, RTP-2026, Year 2023.*

Notes:

1. *Tabulations include a small number of Work-Based Subtours to work destinations.*
2. *Weld and Elbert counties are excluded.*

Trip Mode Choice

The Tour and Trip Mode Choice components use a hierarchy of travel modes. This hierarchy is based on mode availability. The mode choice with the most specialized mode availability is Drive to Transit, which includes both Park-and-Ride and Kiss-and-Ride (being dropped off at a transit stop or station). The mode with the most broadly available mode availability is Walk, which is the slowest mode.

The mode hierarchy, from most specialized to most broadly available is:

- Transit.
- School Bus (only available to students of K-12 schools).
- Auto, Shared Ride 3+: SR3+ (HOV 3+).
- Auto, Shared Ride 2: SR2 (HOV2).
- Auto, Drive Alone: DA (SOV).
- Bike.
- Walk.

This modeling convention allows Focus to reflect observed behavior, such as a commuter using Drive to Transit in the morning but getting a ride home with a colleague in the evening (Shared Ride 2 or 3+).

Observed Data Sources for Calibration

Table 21 shows of the modeled tour mode (column labels) and trip mode (row label). Recall that modes are defined in a hierarchy such that trip modes may be of the same hierarchy level or lower than tour mode. Switching to a lower vehicle occupancy is one of the most common trip mode changes.

Table 21. Model Target Tour Mode and Trip Mode Distribution

Tour Mode / Trip Mode	Walk	Bike	Drive Alone	Shared Ride 2	Shared Ride 3+	School Bus	Transit	Total
Walk	9.1%	0.2%	0.6%	1.3%	0.4%	0.2%	0.2%	**11.8%**
Bike		2.4%	0.3%	0.1%	0.0%	0.2%	0.0%	**3.0%**
Drive Alone			41.2%	1.5%	0.2%	0.0%	0.0%	**42.9%**
Shared Ride 2				22.1%	0.9%	0.1%	0.1%	**23.2%**
Shared Ride 3+					16.1%	0.1%	0.0%	**16.2%**
School Bus						1.7%	0.0%	**1.7%**
Transit							0.9%	**1.1%**
Total	**9.1%**	**2.5%**	**42.1%**	**25.0%**	**17.6%**	**2.2%**	**1.2%**	**100%**

Sources:
DRCOG model, RTP-2026, Year 2023

Notes:

1. *Blank cells are not available, as they violate the mode hierarchy.*
2. *Cells with value 0.0% represent allowed options, but the model results show very small numbers.*
3. *Totals may not add because of rounding.*

Changes to the Model

This component was updated by recalibrating parameters within the Trip Mode Choice model. Specifically, adjustments were made to the alternative-specific constants for Drive Alone, Shared Ride 2, Shared Ride 3+, Walk modes, and tour-specific utility terms for Shared Ride 2 and Shared Ride 3+ on Work tours, to better align modeled trip-level mode shares with observed targets.

Comparison of Model and Observed

Total Trips

A comparison of target and modeled trip mode shares for all trip types and all people, is presented in Table 22. Since shares are expressed as percentages, the final column is the difference in percentages, rather than a relative difference. The total share must equal 100%. The Transit row shows the combined transit share, calculated as the sum of Drive to Transit and Walk to Transit. The results show that the modeled shares are within 2.4% of the CTC shares.

Table 22. Comparison of Observed and Modeled Trip Mode Shares

Trip Mode	CTC [1]	Model [2]	Difference (Model – CTC)
Bike	2.7%	3.1%	0.4%
Walk	11.2%	12.2%	1.0%
Drive Alone	42.8%	42.7%	-0.1%
Shared Ride 2	23.2%	23.2%	0.0%
Shared Ride 3+	18.4%	16.1%	-2.3%
Transit	1.3%	1.1%	-0.2%
School Bus	0.4%	1.6%	1.2%

Sources:

1. *Colorado Travel Counts (CTC), 2025.*
2. *Model results by DRCOG, 2023.*

Work Trips

Similarly, Table 23 Shows that the modeled work trip shares are within 5.2% of the surveyed CTC work trip shares.

Table 23. Comparison of Observed and Modeled Work Trips Mode Shares

Trip Mode	CTC [1]	Model [2]	Difference (Model – CTC)
Bike	3.3%	3.7%	0.4%
Walk	8.0%	5.3%	-2.7%
Drive Alone	73.9%	79.2%	5.2%
Shared Ride 2	9.7%	7.4%	-2.3%
Shared Ride 3+	3.5%	2.7%	-0.8%
Transit	1.5%	1.8%	0.3%

Sources:

1. *Colorado Travel Counts (CTC), 2025.*
2. *Model results by DRCOG, 2023.*

Notes:

1. *Only closed tours are considered.*
2. *Totals may not add up to 100% due to rounding.*
3. *Weld and Elbert counties are excluded.*

Non-Work Trips

Finaly, Table 24 Shows the modeled non-work trip shares compared to Colorado Travel Counts (CTC) findings.

Table 24. Comparison of Observed and Modeled Non-Work Trips Mode Shares

Trip Mode	CTC [1]	Model [2]	Difference (Model – CTC)
Bike	2.6%	2.9%	0.3%
Walk	12.2%	14.4%	2.2%
Drive Alone	33.4%	30.9%	-2.5%
Shared Ride 2	27.2%	28.3%	1.1%
Shared Ride 3+	22.9%	20.5%	-2.4%
Transit	1.3%	0.9%	-0.4%
School Bus	0.5%	2.2%	1.7%

Sources:

1. *Colorado Travel Counts (CTC), 2025.*
2. *Model results by DRCOG, RTP-2026, Year 2023.*

Notes:

1. *Only closed tours are considered.*
2. *Totals may not add up to 100% due to rounding.*
3. *Weld and Elbert counties are excluded.*

Transit Boardings by Access Mode

Every few years, RTD conducts an on-board survey with transit passengers to gather information on riders' trip characteristics, including their boarding and alighting stops/stations. Table *25* below shows the Focus model's boardings by service type compared to the results of RTD's more recent on-board Customer Satisfaction Survey for walk access trips.

Regional Transit District, the transit authority in Denver metropolitan area conducted an On-Board Origin Destination Survey in 2024. For calibration purposes, access mode share distribution for the transit users has been developed from the survey. In the survey, four modes were available - Walk, Bike, Rideshare and Drive alone. For the calibration purpose, active modes (walk and bike) are considered Walk Access and other considered as Drive access as these modes are available in Focus 2.4.

Table *25*. Transit Boardings by Access Mode

Access Mode	Observed [1]	Model [2]	Percent Difference
Walk or bike	91%	82%	-9%
Drive or shuttle	9%	18%	9%
Total	**100%**	**100%**	

Sources:

1. RTD, 2023.
2. Model results by DRCOG, RTP-2026, Year 2023.

Validation

Vehicle Assignment Validation

The vehicle assignment process assigns travel paths for nearly 10 million daily trips throughout the region. The model sums all the trips traveling on each highway network link to estimate the daily traffic volume. Traffic volumes can range from over 250,000 per day for major freeways to less than 100 for local streets. To demonstrate that the model is estimating traffic accurately, modeled traffic volumes are compared with observed data at the link level. The model validation for vehicle assignment compares 2020 observed or reported traffic conditions with the base year model results.

The DRCOG model uses TransCAD's Multi-Modal Multi-Class assignment procedure It is a user-equilibrium algorithm in which each driver (or vehicle) chooses the shorter (travel time) path, subject to every other driver doing the same. And no traveler can further improve their travel time (or generalized cost) when the assigned speeds have sufficiently converged with the speeds assumed at the beginning of each iteration. The model uses critical gap convergence criteria of 0.001 for both the peak and the off-peak periods. The algorithm stops after 200 iterations if the convergence criteria have not been met.

Hourly traffic assignments are performed for ten separate time periods:

- AM1: 6-7 a.m.
- AM2: 7-8 a.m.
- AM3: 8-9 a.m.
- PM1: 3-5 p.m.
- PM2: 5-6 p.m.
- PM3: 6-7 p.m.
- OP1: 11 p.m. - 6 a.m.
- OP2: 9-11 a.m.
- OP3: 11-3 p.m.
- OP4: 7-11 p.m.

For each of these time periods, heavy trucks are preloaded before assigning passenger vehicles. Passenger vehicles are assigned in three occupancy classes: Drive-Alone, Shared Ride 2 and Shared Ride 3+. Value-of-time for drivers and passengers are also assigned. In lieu of having up-to-date travel survey information regarding ride-hailing passenger trips (e.g. Uber and Lyft), such trips are embedded within Drive-Alone (single-passenger) and Shared Ride (2+ passengers) trips.

Network Links

Model Validation by Facility and Area Type and County

The following tables show the 2023 modeled traffic volumes compared to observed traffic counts. The counts were blended from 2022, 2023 and 2024 observed results to represent post-pandemic "a new normal" conditions.

Table *26*. Model Validation of Traffic Counts by Facility Type

Facility Type	Number of links	Daily Traffic Counts [1]	Modeled Traffic Volumes [2]	Percent Difference
Freeway	176	8,122,768	8,628,598	6.2%
Expressway	62	2,172,405	2,399,765	10.5%
Principal Arterial	1,086	26,156,321	29,453,799	12.6%
Minor Arterial	626	7,786,456	7,293,716	-6.3%
Collector	442	3,058,581	2,362,427	-22.8%
Total	**2,392**	**47,296,531**	**50,138,305**	**6.0%**

Table *27*. Model Validation of Traffic Counts by Area Type

Area Type	Number of Links	Daily Traffic Counts [1]	Modeled Traffic Volumes [2]	Percent Difference
Downtown Denver (Central Business District)	41	522,847	423,794	-18.9%
Central Business District Fringe Outlying Central Business District	119	2,781,070	2,668,849	-4.0%
Urban	326	7,797,717	8,647,178	10.9%
Suburban	1,738	34,074,823	36,336,966	6.6%
Rural (Non-Mountainous)	93	1,073,581	1,037,700	-3.3%
Rural (Mountainous)	75	1,046,493	1,023,818	-2.2%
Total	**2,392**	**47,296,531**	**50,138,305**	**6.0%**

Table *28*. Model Validation of Traffic Counts by County

Facility Type	Number of Links	Daily Traffic Counts [1]	Modeled Traffic Volumes [2]	Percent Difference
Adams	468	8,849,017	9,264,013	4.7%
Arapahoe	417	8,768,963	10,226,606	16.6%
Boulder	301	4,795,461	4,589,854	-4.3%
Broomfield	113	1,830,623	1,936,680	5.8%
Clear Creek Gilpin Elbert	22	326,447	349,564	7.1%
Denver	365	9,196,838	10,187,628	10.8%
Douglas	241	4,419,353	4,314,709	-2.4%
Jefferson	422	8,200,608	8,418,684	2.7%
Weld	43	909,221	850,566	-6.5%
Total	**2,392**	**47,296,531**	**50,138,305**	**6.0%**

Sources:

1. *DRCOG Regional Traffic Counts, 2022 - 2024.*
2. *Model results by DRCOG, RTP-2026, Year 2023.*

Model Validation Guidelines

Table *29* and Table *30* show sample guideline validation values used by other agencies acknowledged by the Federal Highway Administration compared with the Focus 2.4 model results.

Table *29*. Validation Guidelines by Facility Type

Facility Type	Ohio [1]	Florida [1] Accepted	Florida [1] Preferred	Michigan [1]	FHWA [1]	DRCOG [2]
Freeway	± 7%	± 7%	± 6%	± 6%	± 7%	6.2%
Expressway	± 7%	± 7%	± 6%	± 6%	± 7%	10.5%
Principal Arterial	± 10%	± 15%	± 10%	± 7%	± 10%	12.6%
Minor Arterial	± 10%	± 15%	± 10%	± 10%	± 15%	-6.3%
Collector	± 15%	± 20%	± 20%	± 20%	± 20%	-22.8%
All Links	**-**	**± 5%**	**± 2%**	**-**	**-**	**6.0%**

Table *30*. Validation Guidelines by Area Type

Area Type	Ohio [1]	Florida [1] Accepted	Florida [1] Preferred	DRCOG [2]
Downtown Denver	± 10%	± 25%	± 15%	-18.9%
Central Business District Fringe 0utlying Central Business District	± 10%	± 25%	± 15%	-4.0%
Urban	± 10%	± 25%	± 15%	10.9%
Suburban	± 10%	± 25%	± 15%	6.6%
Rural	± 10%	± 25%	± 15%	-2.8%

Sources:

1. *Federal Highway Administration (FHWA), 1990.* https://www.fhwa.dot.gov/planning/tmip/publications/other_reports/validation_and_reasonableness_2010/fhwahep10042.pdf (Table 9.2 on 9-19)
2. *Model results by DRCOG, RTP-2026, Year 2023.*

Screenline Link Summaries

A screenline analysis represents a geographic line which a combination of roadways crosses in a general direction. The sum of the observed traffic count volumes on links that cross a screenline are compared with the sum of the modeled volumes across the same screenline to judge generalized flows of travel in north-south or east-west directions.

Primary Regional Screenlines

Figure 1 shows the location of primary regional screenlines and Table *31* shows the sum of the number of links which cross the screenline and the comparative number of vehicles on those links with daily counts.

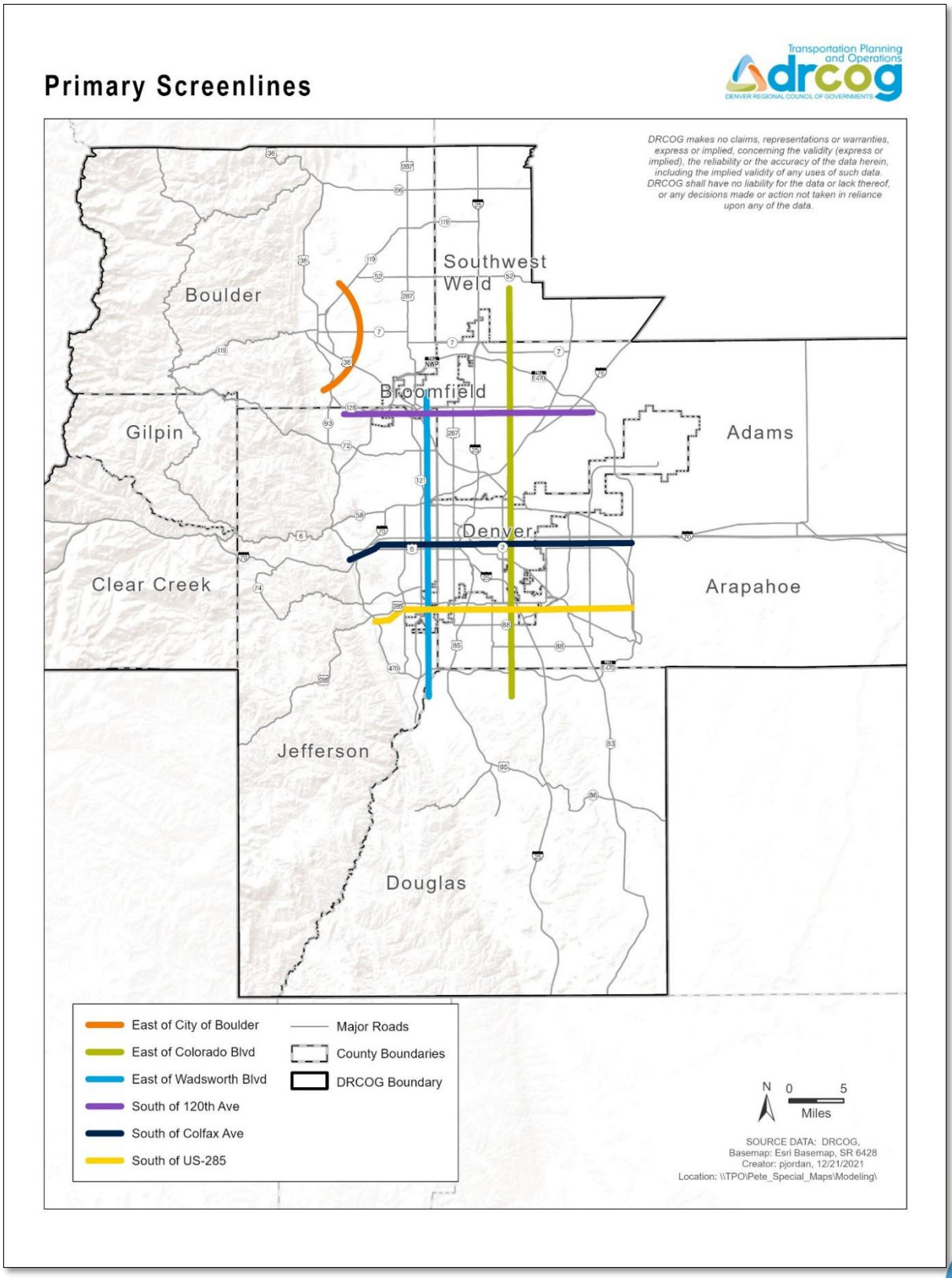
Table *31*. Primary Screenline Comparison – Observed Counts vs. Modeled Volumes

Screenline	Number of Links	Traffic Counts [1]	Volume (Model) [2]	Percent Difference
South of 120th Avenue	10	130,048	118,114	-9.2%
East of City of Boulder	11	270,043	281,320	4.2%
South of Colfax Avenue	15	323,163	344,542	6.6%
East of Colorado Boulevard	36	801,669	824,461	2.8%
South of US-285	12	470,811	495,717	5.3%
East of Wadsworth Boulevard	28	562,825	606,807	7.8%
Overall	**112**	**2,558,559**	**2,670,961**	**4.4%**

Sources:

1. *DRCOG Regional Traffic Counts, 2022 - 2024.*
2. *Model results by DRCOG, RTP-2026, Year 2023.*

Figure 1. Regional Screenlines

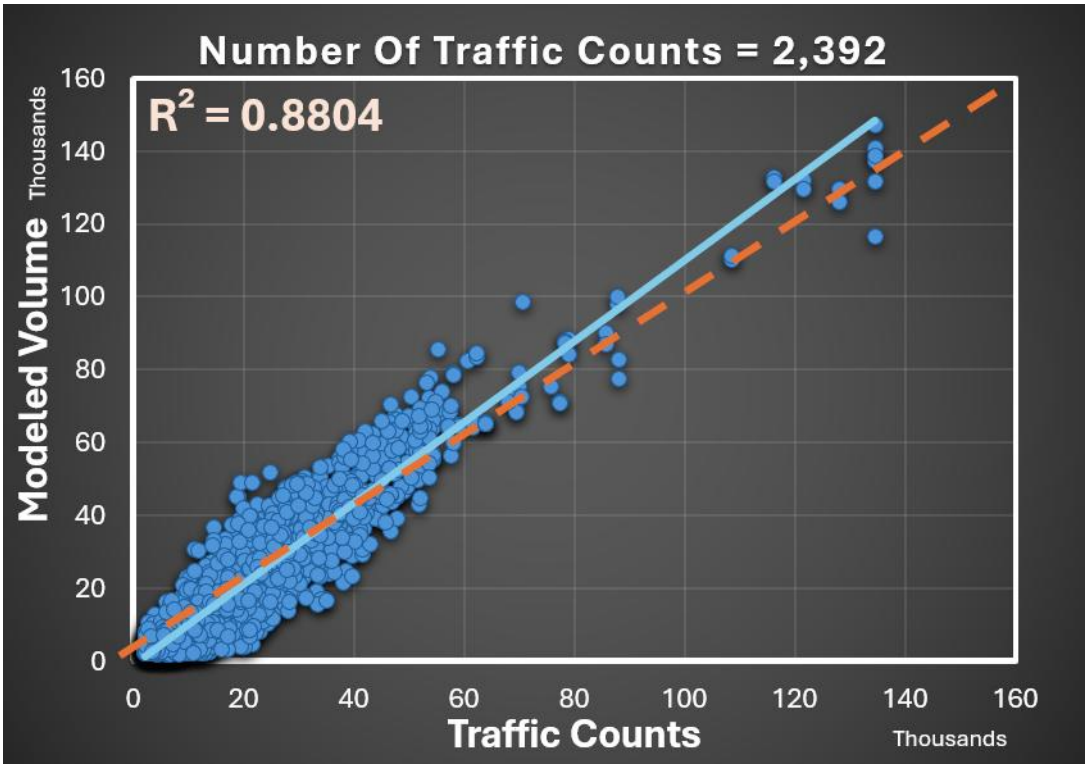


Scatterplots

The following series of figures show the scatterplots of observed versus modeled vehicle traffic volumes for specific locations. The x-axis represents the observed 2022, 2023, and 2024 traffic counts and y-axis represent the 2023 modeled volumes. The coefficient of determination (R^2) between the observed and modeled values also shows the relative accuracy of the model assignment. The various scatterplots are arranged by roadway facility types and by area type. The regression line is shown in blue. The 45-degree reference line (in red) depicts the exact match between an observed count and the modeled volume.

It should be noted that lower volume streets (e.g., under 5,000 vehicles per day) are more difficult to replicate with a regional scale model. Extremely high-volume roadways (e.g., over 150,000 per day) may be overestimated partially because real-world traffic-counts frequently undercount such large and busy highways.

Figure 2. Scatterplot of Model Volumes vs. Observed Counts – Overall

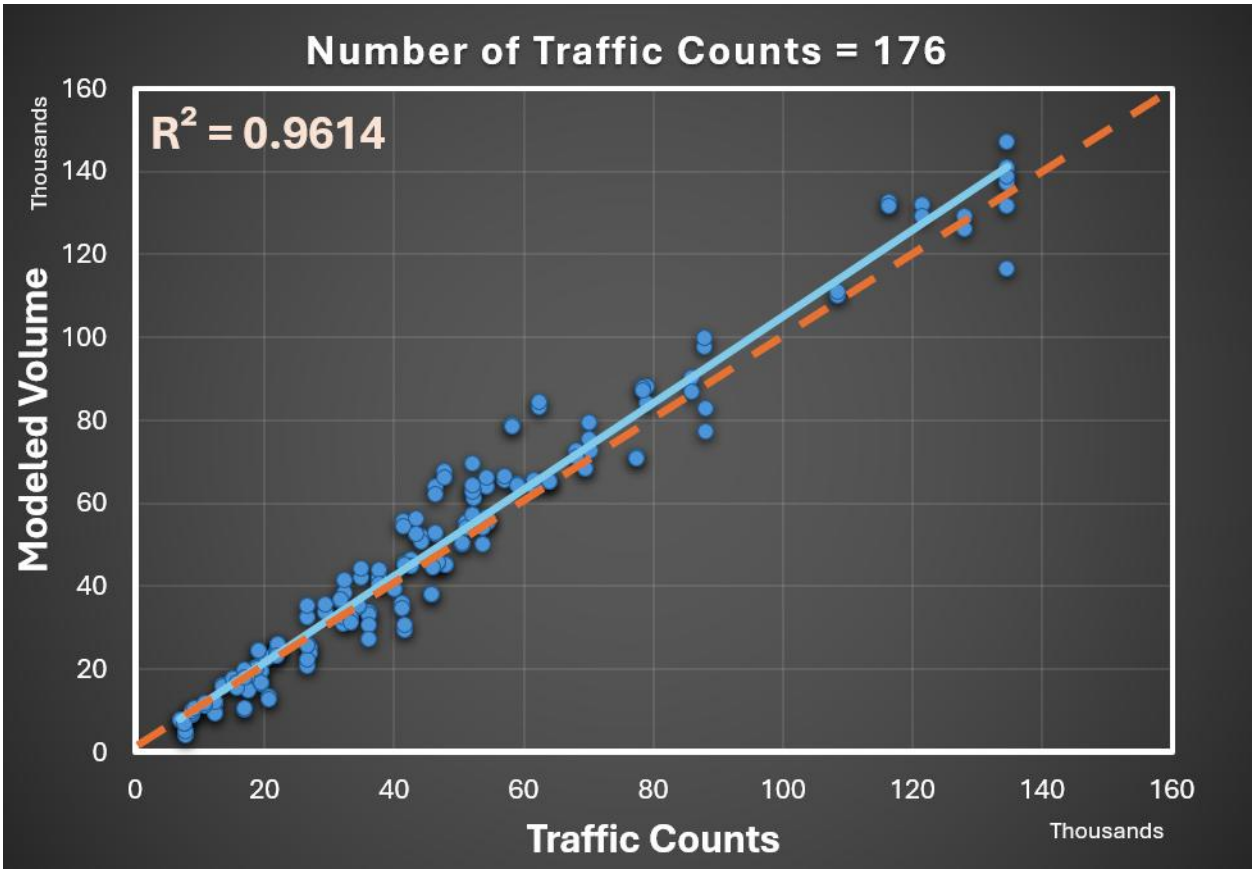


Sources:

1. *DRCOG Regional Traffic Counts, 2022 - 2024.*
2. *Model results by DRCOG, RTP-2026, Year 2023.*

Scatterplots by Facility Type

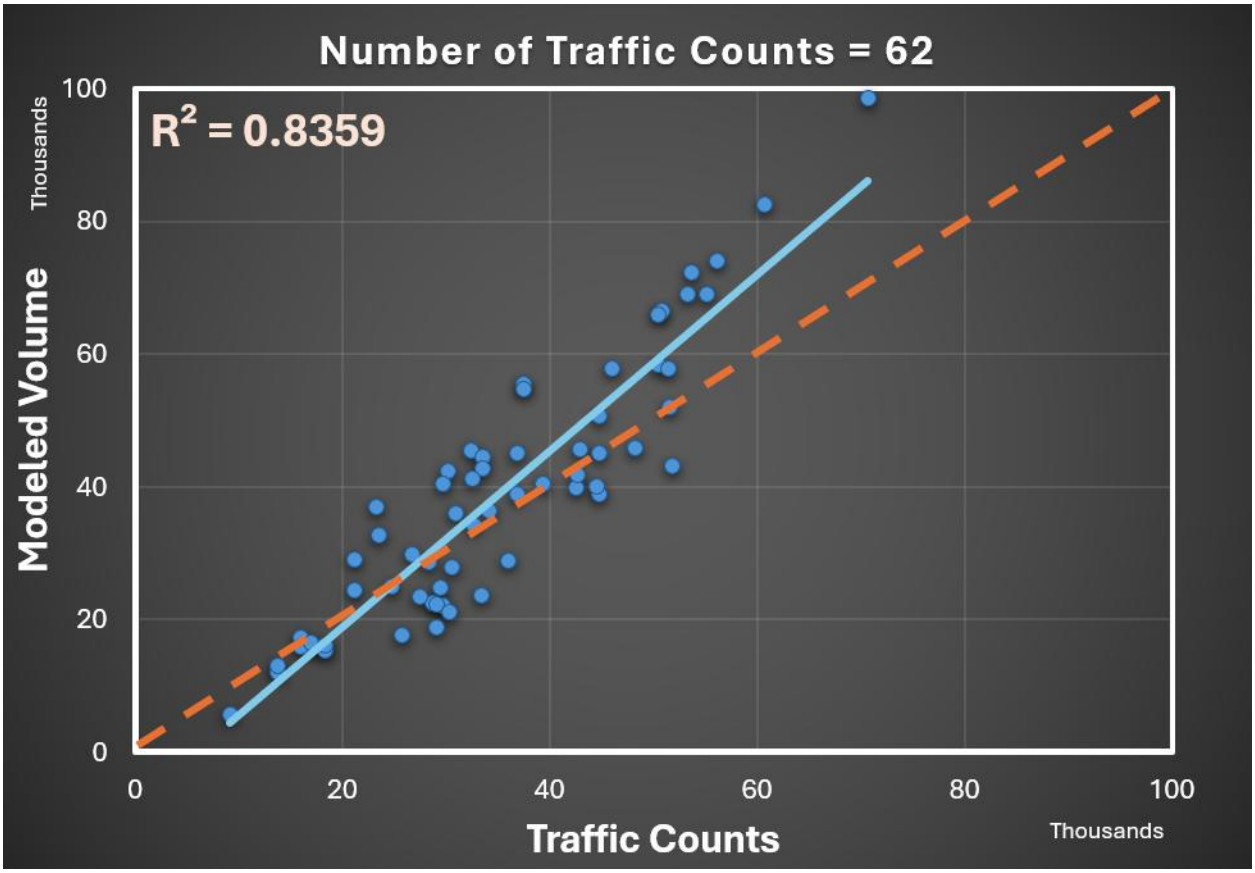
Figure *3*. Scatterplot of Model Volumes vs. Observed Counts – Freeway



Sources:

1. *DRCOG Regional Traffic Counts, 2022 - 2024.*
2. *Model results by DRCOG, RTP-2026, Year 2023.*

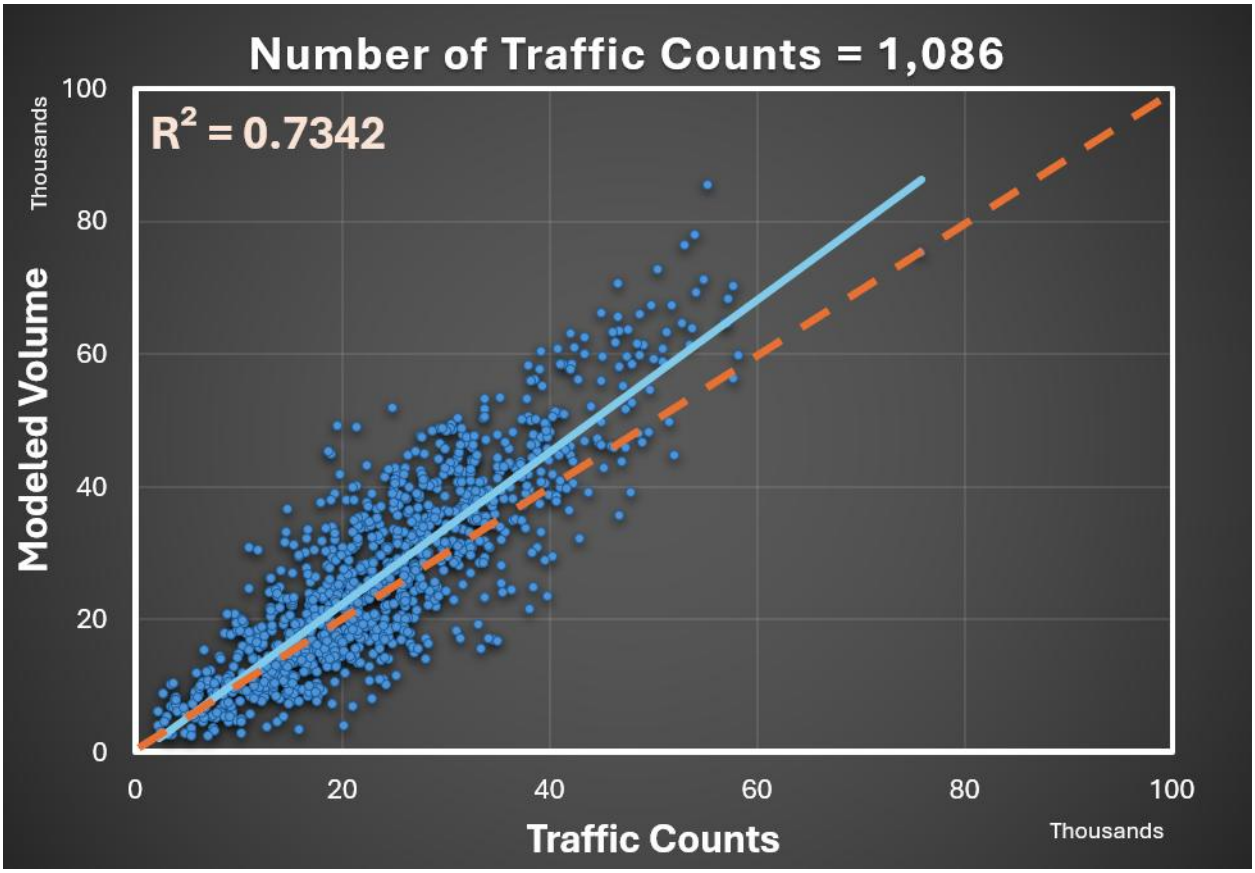
Figure *4*. Scatterplot of Model Volumes vs. Observed Coun*ts* – *Expressway*



Sources:

1. *DRCOG Regional Traffic Counts, 2022 - 2024.*
2. *Model results by DRCOG, RTP-2026, Year 2023.*

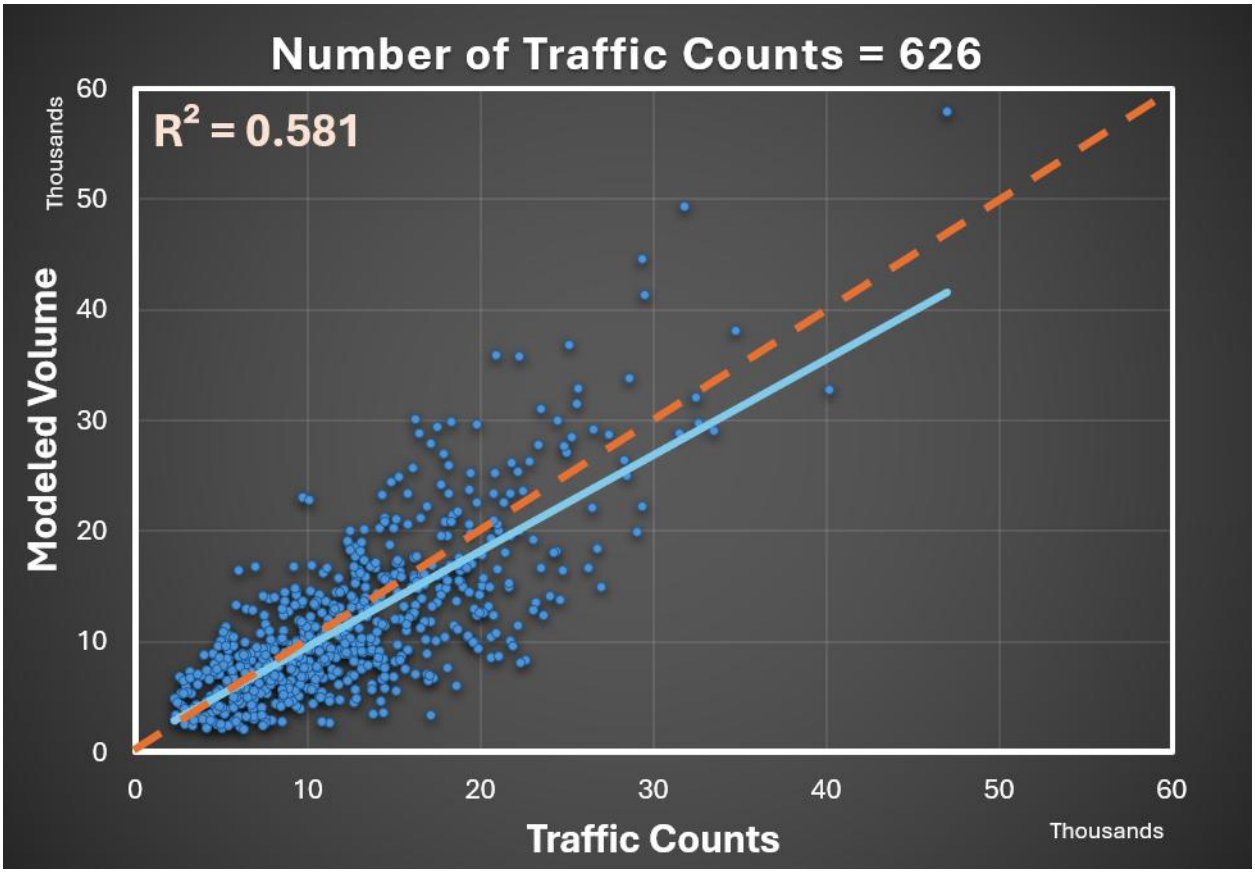
Figure 5. Scatterplot of Model Volumes vs. Observed Counts – Principal Arterial



Sources:

1. *DRCOG Regional Traffic Counts, 2022 - 2024.*
2. *Model results by DRCOG, RTP-2026, Year 2023.*

Figure *6*. Scatterplot of Model Volumes vs. Observed Counts – Minor Arterial



Sources:

1. *DRCOG Regional Traffic Counts, 2022 - 2024.*
2. *Model results by DRCOG, RTP-2026, Year 2023.*

Vehicle Miles Traveled (VMT)

The number of vehicles on a roadway link multiplied by the length of the link equals the VMT. For example, if 5,000 vehicles travel on a 2-mile link, they would create 10,000 VMT. The VMT is calculated for all links which are then summed for specific geographic or categorical areas of interest. To validate model results, the modeled VMT is compared to observed VMT by time of day, facility type and specific geographies.

Vehicle Miles Traveled by Time of Day

The time period distribution of model-estimated VMT is compared to the distribution of VMT obtained from a traffic count analysis conducted for DRCOG's Congestion Management Process as shown in Table *32*.

Table *32*. Vehicles Miles Traveled by Time of Day – Greater Denver area

Time of Day	Volume (Model) [1]	Percent Distribution (Model) [1]	CMP Percent Distribution [2]
AM1 (6-7 a.m.)	3,687,185	4.3%	5.3%
AM2 (7-8 a.m.)	6,985,527	8.2%	7.0%
AM3 (8-9 a.m.)	6,267,860	7.3%	6.4%
PM1 (3-5 p.m.)	12,026,183	14.1%	14.7%
PM2 (5-6 p.m.)	7,019,710	8.2%	7.8%
PM3 (6-7 p.m.)	5,609,988	6.6%	6.2%
OP1 (11 p.m. - 6 a.m.)	3,863,953	4.5%	6.5%
OP2 (9-11 a.m.)	8,681,148	10.2%	10.6%
OP3 (11 a.m. - 3 p.m.)	20,815,030	24.3%	23.2%
OP4 (7-11 p.m.)	10,560,307	12.3%	12.4%
Total	**85,516,891**	**100%**	**100%**

Sources:

1. *Model results by DRCOG, RTP-2026, Year 2023.*
2. *DRCOG Congestion Management Process, 2024.*

CDOT Vehicles Miles Traveled by County

CDOT produces estimates of VMT on CDOT-maintained roadways for the Highway Performance Monitoring System. Table *33* compares the Focus Model's VMT by county on those facilities compared with CDOT's estimates.

Table *33*. Comparison of Vehicle Miles Traveled (VMT) by County

County	CDOT VMT [1]	Modeled VMT [2]
Adams	8,525	8,793
Arapahoe	6,358	7,174
Boulder	3,348	3,696
Broomfield	1,173	1,496
Clear Creek	1,611	1,651
Denver	8,452	8,497
Douglas	5,997	6,321
Gilpin	156	66
Jefferson	8,050	8,562
Total	**43,670**	**46,256**

Sources:

1. *Colorado Department of Transportation (CDOT), 2023. Accessed to https://dtdapps.codot.gov/otis/FileReports*
2. *Model results by DRCOG, RTP-2026, Year 2023.*

Note:

1. *VMT Numbers are in thousands.*
2. *These statistics apply to all highways in Colorado including Interstates, United States (US) Highways, toll roads, and numbered.*

Highway Performance Monitoring System VMT on Urbanized Areas

Additionally, CDOT reports the VMT on sample roadway segments for the urbanized areas annually for the federal Highway Performance Monitoring System. In the Greater Denver area, there are four urbanized areas: Boulder, Denver-Aurora, Lafayette-Louisville-Erie and Longmont. Table *34* compares the Focus model's VMT by Urbanized area compared to the Highway Performance Monitoring System report.

Table *34*. Highway Performance Monitoring System VMT *by Urbanized Area*

Urbanized Area	VMT (Reported) [1]	VMT (Model) [2]
Boulder	2,077,230	1,823,947
Denver-Aurora	59,556,905	60,111,511
Lafayette-Louisville-Erie	1,537,075	1,552,306
Longmont	1,636,569	1,323,843
Total	**64,807,778**	**64,811,607**

Sources:

1. *Highway Performance Monitoring System report (HPMS), 2023.*
2. *Model results by DRCOG, RTP-2026, Year 2023.*

Transit Assignment Validation

TransCAD's Pathfinder algorithm is used to calculate the shortest transit paths. If the Pathfinder finds two paths with the same or similar generalized costs, it will allocate the share of travelers using each path in proportion to the frequency of service on each path. DRCOG uses a transit path combination factor of 0.3, meaning that paths will only be combined when their generalized costs are within 30% of each other. This multi-pathing allows headways for similar routes to be combined, reducing wait time and providing added realism over simple shortest-path algorithms.

Transit assignment is performed over four time periods and two modes of access: walk and drive. Drive to transit includes being dropped off (aka kiss-and-ride). The four transit categories for summaries are:

- Peak walk to transit.
- Peak drive to transit.
- Off-Peak walk to transit.
- Off-Peak drive to transit.

Transit Boardings

Observed transit boardings from 2015, 2019, and 2023 obtained from RTD, are shown in Table *35*. Overall, the observed boardings indicate that transit ridership had not fully recovered to pre-pandemic ridership levels by 2023. Free shuttle ridership was particularly affected by ongoing downtown Denver construction projects and associated disruptions to transit operations.

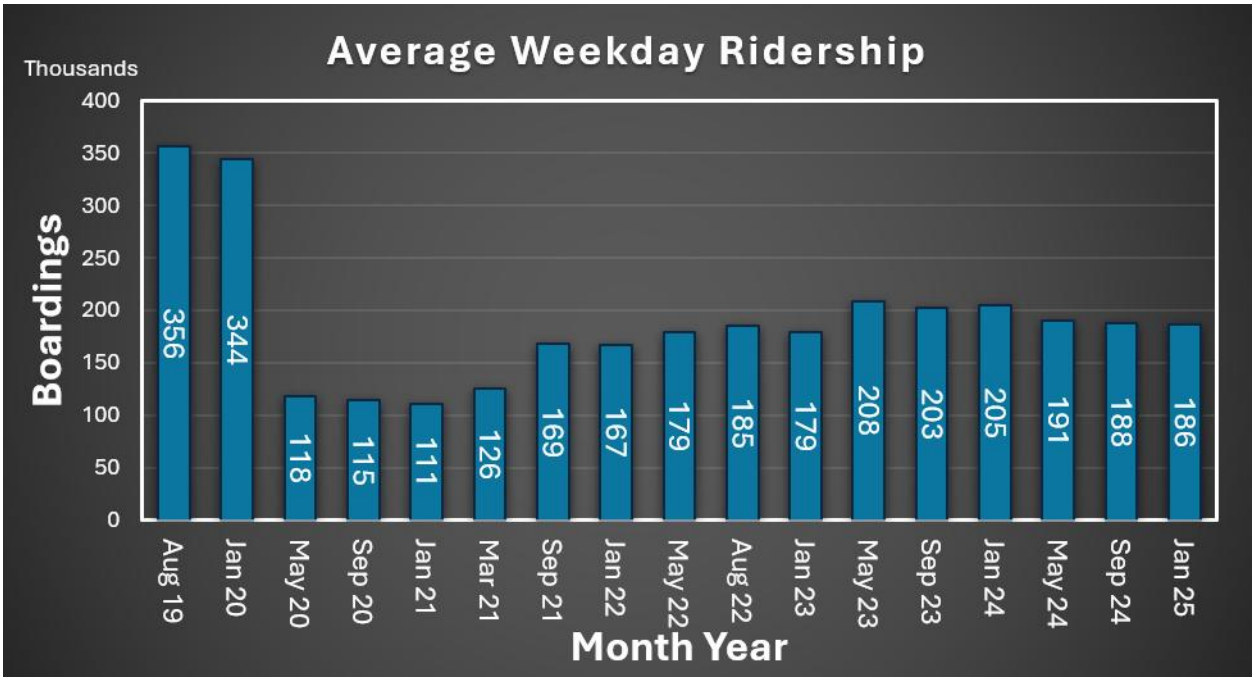
Table *35*. Historical Average Observed Weekday Boardings

Service Type	2015	2019	2023
Free Shuttle	46,891	32,331	5,102
Denver Local Bus	128,304	137,054	94,745
Limited Bus	23,529	19,659	15,802
Express Bus	8,146	6,051	1,850
Regional Bus	13,383	17,430	1,074
Light/Commuter Rail	81,673	103,706	37,039
SkyRide Bus	7,020	3,491	3,631
Longmont Local Bus	1,115	2,089	1752
Boulder Local Bus	21,136	18,956	11,531
Total	**331,197**	**340,767**	**201,902**

Sources: RTD

As illustrated in Figure *7*, transit ridership continued to recover between 2021 and 2025. Following additional coordination with RTD, the 2023 target ridership was established at 201,902 average weekday boardings.

Figure 7. RTD Observed Transit Boardings



Sources: RTD

Transit Boardings by Type of Service

Table 36 compares the model estimated daily transit boardings for the service type with the observed transit boardings for 2023.

Table *36*. Year 2023 Daily Transit Boardings by Type of Service

Service Type	Observed [1]	Model [2]	Percent Difference
Bus	139,708	129,443	-7.3%
Rail	62,194	76,228	22.6%
Total	**201,902**	**205,671**	**1.9%**

Sources:

1. RTD, 2023.
2. Model results by DRCOG, RTP-2026, Year 2023.

Transit Passenger Miles Traveled

Transit Passenger Miles Traveled is a measure of service utilization which represents the cumulative sum of the distance ridden by each passenger. It is calculated by summing passenger load times and the distance between individual bus stops[1], and rail stations.

[1]: Glossary of Terms from TCRP Synthesis #10, Appendix H

National Transit Database (NTD) is a federal reporting program for transit agencies and serves as a primary repository for all transit-related data and statistics in the U.S. Transit performance data is also publicly available and 2023 passenger miles traveled data reported by RTD was obtained from the National Transit Database.

Table *37* compares the Focus model's estimated passenger miles traveled (PMT) for the service type with the reported passenger miles traveled (PMT) in the National Transit Database for 2023.

Table *37*. Transit Passenger Miles Traveled (PMT) by Type of Service

Service Type	PMT (Reported)[1]	PMT (Model)[2]	Percent Difference
Buses	576,307	561,409	-2.6%
Light Rail	241,411	297,989	23.4%
Commuter Rail	298,281	305,544	2.4%
Total	**1,115,999**	**1,164,942**	**4.4%**

Sources:

1. RTD via NTD, 2023.
2. Model results by DRCOG, RTP-2026, Year 2023.

Useful Acronyms

Some of these acronyms are used in the report and some are spelled out in the report but used commonly in conversations or other documents related to the model.

ABM	Activity Based Model
ACS	American Community Survey
APCD	Air Pollution Control Division
BPR	Bureau of Public Roads
CBD	Central Business District
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Health and Environment
CHPTE	Colorado High-Performance Transportation Enterprise
CMP	Congestion Management Process
DRCOG	Denver Regional Council of Governments
DTT	Drive to Transit
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
FRTC	Front Range Travel Counts
GHG	Greenhouse Gas
HOV	High Occupancy Vehicle
HPMS	Highway Performance Monitoring System
CTC	Colorado Travel Counts
LRT	Light Rail Transit
MOVES	Motor Vehicle Emission Simulator
NTD	National Transit Database
O-D	Origin Destination
PMT	Passenger Miles Traveled
RTD	Regional Transportation District
SOV	Single Occupancy Vehicle
TAZ	Transportation Analysis Zone
TBI	Travel Behavior Inventory
TMIP	Travel Model Improvement Program
VMT	Vehicle Miles Traveled