Appendix G
I-25 South PEL Travel Demand Forecasting

To	Chris Bisio, Jacobs	**Memo**	
Cc	I-25 South PEL Study Team		
From	Steer Project Team		
Date	September 11, 2018		
Project	I-25 South PEL/NEPA	Project No.	23029302

I-25 PEL/NEPA Technical Memorandum - Model Calibration Update

In the fall of 2017, Steer (then doing business as Steer Davis Gleave) calibrated the travel demand model for the I-25 South PEL/NEPA study, with a particular focus on calibrating the model for the "Gap" section of I-25 that was the focus of the EA. The details of that model calibration effort are documented in a technical memo dated January 30, 2018, which is attached as an appendix.

After the completion of the EA, Steer revisited the model preparation to improve the calibration along I-25 north of the Gap. This memo presents the updated calibration values. Specifically, it presents updated Tables 13 through 18, Figures 5 through 12, and Appendix A of the January 30, 2018 calibration memo. For ease of comparison, table and figure numbers have been kept the same as in the January 30, 2018 memo.

Through this re-calibration effort, we achieved the goal to improve the calibration north of the Gap. At the same time, we made these improvements to the north without causing large changes to the already-calibrated volumes through the Gap. In general, we targeted modeled volumes within 10% of observed counts, and used the specific criteria recommended by the UK Department of Transport of 85% of count locations with GEH less than 5 and 85% of travel times within 15% (or 1 minute if higher than 15%) of observed travel times. Overall, the calibration results are in line with generally accepted traffic modeling criteria, even though some particular sections/time periods may exhibit slightly larger discrepancies than others. These differences sometimes arise from trying to match model forecasts to potential measurement errors, normal fluctuations in traffic levels and travel times, and inconsistencies between the measured values at different locations.

We also note that while the January 30, 2018 calibration memo includes a prior memo (from January 3, 2017) that noted that a TransModeler microsimulation tool would be developed for the purpose of conducting traffic operational analyses, ultimately FREEVAL was used to evaluate operations for the EA. The PEL plans to also use FREEVAL.

Table 13: Weekday Peak Period Mainline Calibration Volumes

I-25 Location		Count		Model Volume		% Difference	
		6:30 – 9 AM	3 – 7 PM	6:30 – 9 AM	3 – 7 PM	6:30 – 9 AM	3 – 7 PM
N/O Baptist Rd	NB	7,700	12,900	8,000	12,900	4%	0%
	SB	7,200	13,800	7,200	14,200	0%	3%
N/O Palmer Divide Rd	NB	6,800	9,700	6,600	9,300	-3%	-4%
	SB	4,700	11,600	4,900	11,500	4%	-1%
S/O Plum Creek Pkwy	NB	7,200	9,900	7,400	10,100	3%	2%
	SB	4,800	11,100	5,200	11,900	8%	7%
N/O Founders Pkwy	NB	14,500	15,700	14,700	15,200	1%	-3%
	SB	7,700	21,600	7,500	22,100	-3%	2%

Table 14: Weekend Peak Period Mainline Calibration Volumes

I-25 Location		Count		Model Volume		% Difference	
		Friday 3 – 7 PM	Sunday 11:30AM – 3 PM	Friday 3 – 7 PM	Sunday 11:30AM – 3 PM	Friday 3 – 7 PM	Sunday 11:30AM – 3 PM
N/O Baptist Rd	NB	14,700	12,500	14,800	13,100	1%	5%
	SB	14,700	11,800	14,500	12,200	-1%	3%
N/O Palmer Divide Rd	NB	11,800	11,100	11,200	10,900	-5%	-2%
	SB	12,100	10,200	11,700	10,100	-3%	-1%
S/O Plum Creek Pkwy	NB	11,800	10,800	12,000	11,400	2%	6%
	SB	9,300	10,000	9,300	10,700	0%	7%
N/O Founders Pkwy	NB	17,100	16,200	16,900	15,900	-1%	-2%
	SB	20,900	16,100	21,400	15,700	2%	-2%

Table15: Weekday Travel Time Calibration- Northbound

I-25 Location	Observed Travel Time (min)		Modeled Travel Time (min)	
	6:30 –9 AM	3-7 PM	6:30 –9 AM	3-7 PM
Academy to Palmer Divide	12.9	11.7	12.1	12.0
Palmer Divide to Upper Lake Gulch	8.4	7.3	8.9	8.2
Upper Lake Gulch to Plum Creek	8.2	7.7	9.8	8.8
Plum Creek to Castle Pines	8.3	6.5	7.6	6.6
Castle Pines to CO-470	8.1	5.0	5.8	5.0
Cumulative	**46**	**38**	**44**	**41**

Table16: Weekday Travel Time Calibration- Southbound

I-25 Location	Observed Travel Time (min)		Modeled Travel Time (min)	
	6:30 –9 AM	3-7 PM	6:30 –9 AM	3-7 PM
CO-470 to Castle Pines	5.8	5.6	5.2	6.1
Castle Pines to Plum Creek	6.9	6.7	6.7	7.9
Plum Creek to Upper Lake Gulch	8.4	9.4	8.4	9.4
Upper Lake Gulch to Palmer Divide	8.1	9.1	7.6	9.4
Palmer Divide to Academy	12.7	10.9	11.5	12.2
Cumulative	**42**	**42**	**39**	**45**

Figure 5: I-25 Mainline Travel Time Calibration – Weekday Northbound AM

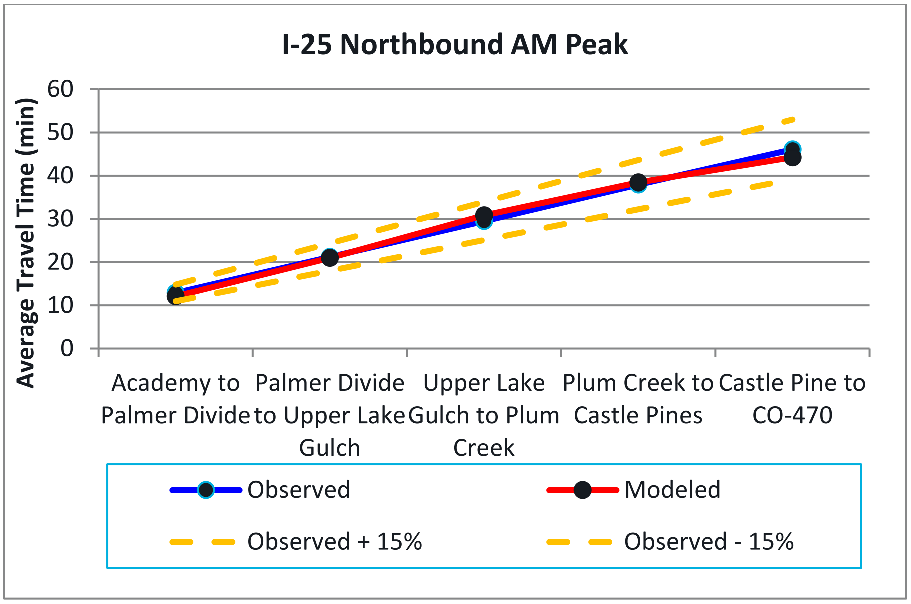


Figure 6: I-25 Mainline Travel Time Calibration – Weekday Northbound PM

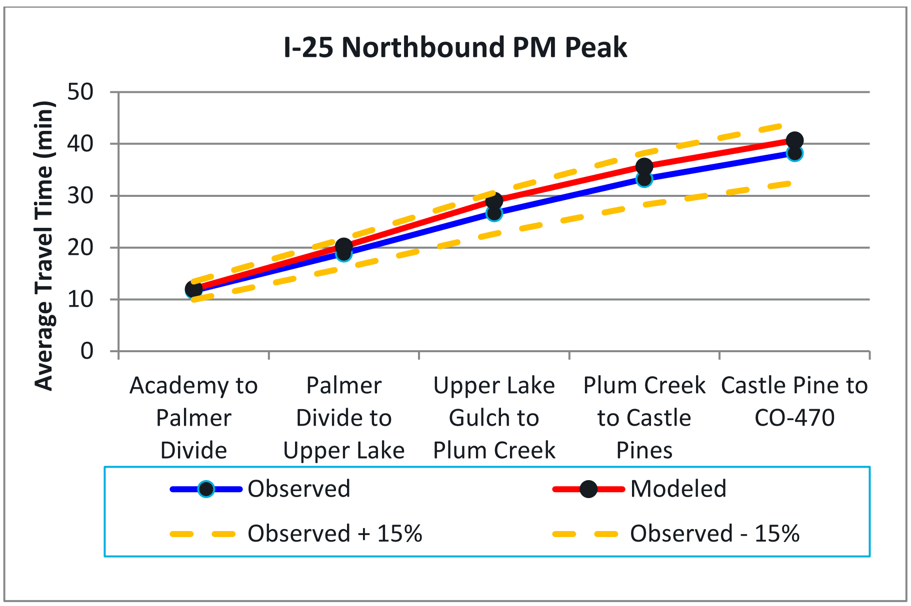


Figure 7: I-25 Mainline Travel Time Calibration – Weekday Southbound AM

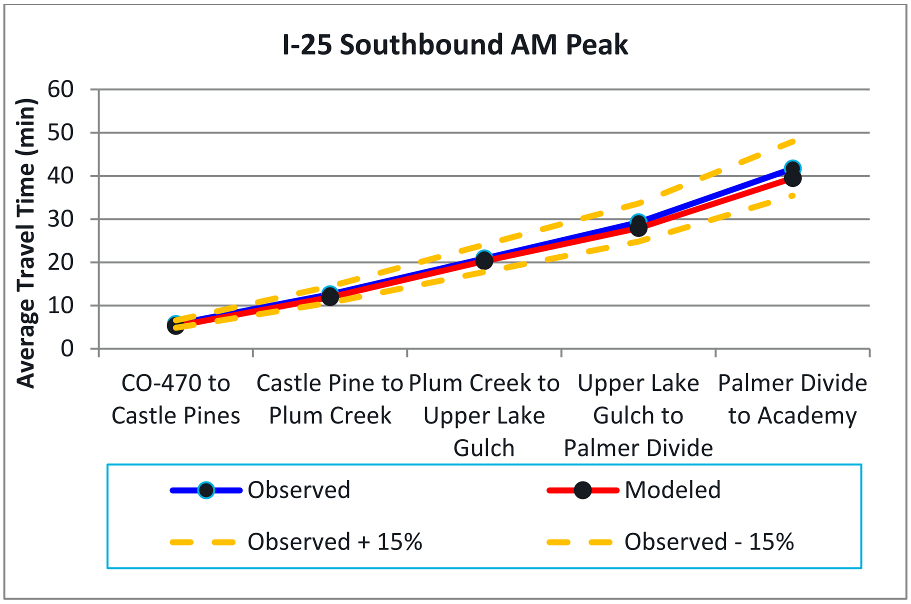


Figure 8: I-25 Mainline Travel Time Calibration – Weekday Southbound PM

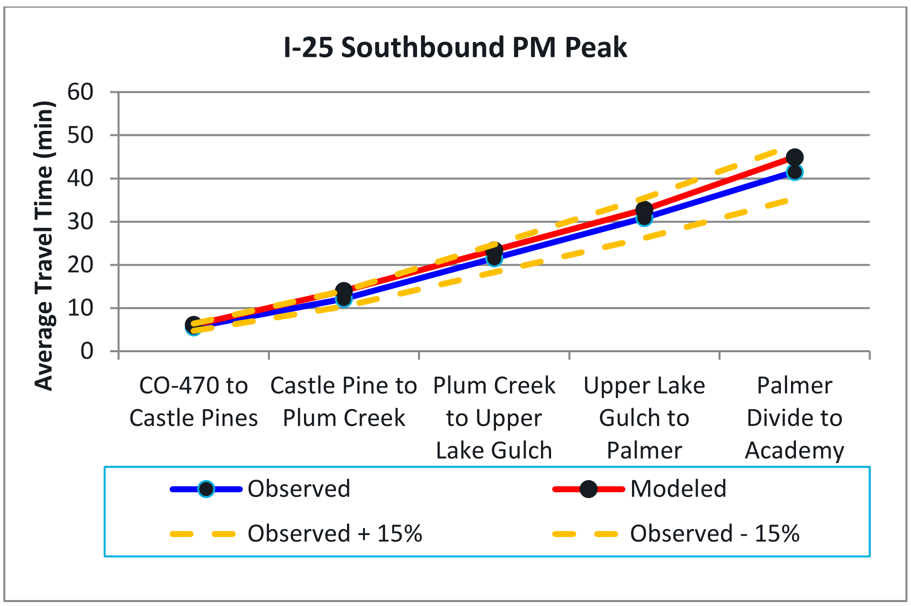


Table17: Weekend Travel Time Calibration - Northbound

I-25 Location	Observed Travel Time (min)		Modeled Travel Time (min)	
	Friday PM	Sunday PM	Friday PM	Sunday PM
Academy to Palmer Divide	12.7	12.5	12.3	12.2
Palmer Divide to Upper Lake Gulch	7.9	8.7	9.2	9.9
Upper Lake Gulch to Plum Creek	8.8	11.3	9.9	10.4
Plum Creek to Castle Pines	6.4	6.4	6.7	6.8
Castle Pines to CO-470	5.1	4.7	5.1	5.1
Cumulative	**41**	**44**	**43**	**44**

Table18: Weekend Travel Time Calibration- Southbound

I-25 Location	Observed Travel Time (min)		Modeled Travel Time (min)	
	Friday PM	Sunday PM	Friday PM	Sunday PM
CO-470 to Castle Pines	6.5	5.2	5.9	5.4
Castle Pines to Plum Creek	7.3	6.5	7.6	6.9
Plum Creek to Upper Lake Gulch	26.0	8.6	21.3	9.9
Upper Lake Gulch to Palmer Divide	8.4	8.0	9.3	9.0
Palmer Divide to Academy	11.0	10.8	12.1	11.8
Cumulative	**59**	**39**	**56**	**43**

Figure 9: I-25 Mainline Travel Time Calibration- Northbound Friday PM

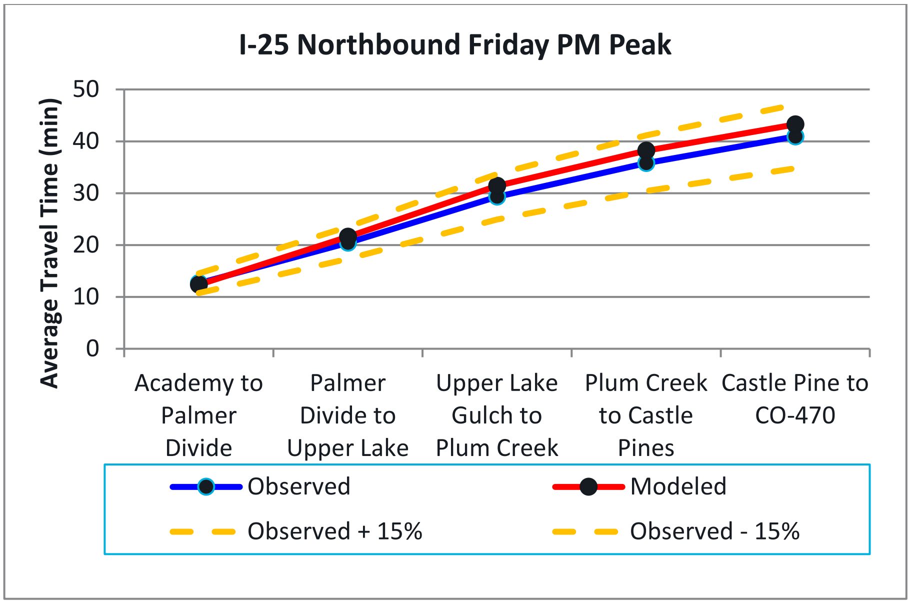


Figure 10: I-25 Mainline Travel Time Calibration- Northbound Sunday Mid-Day

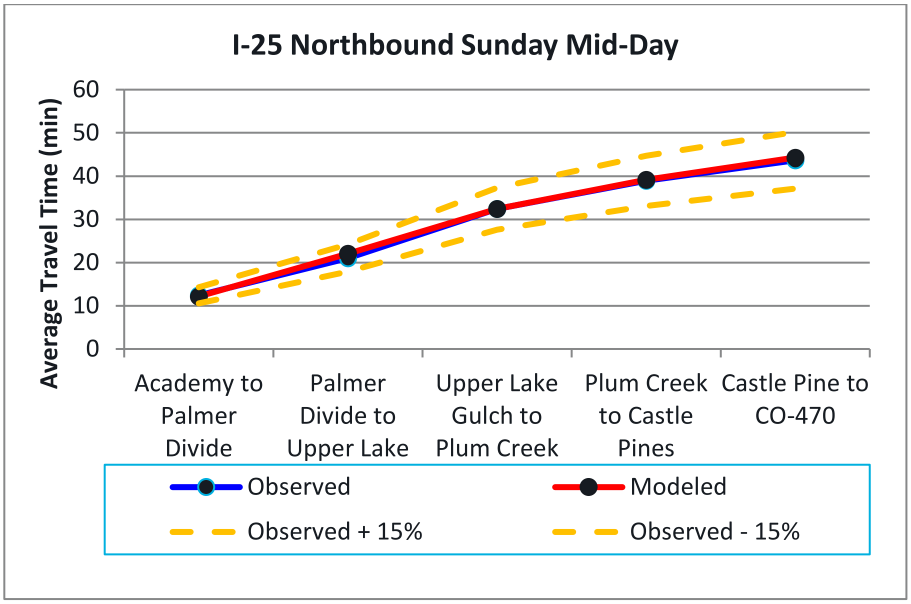


Figure 11: I-25 Mainline Travel Time Calibration- Southbound Friday PM

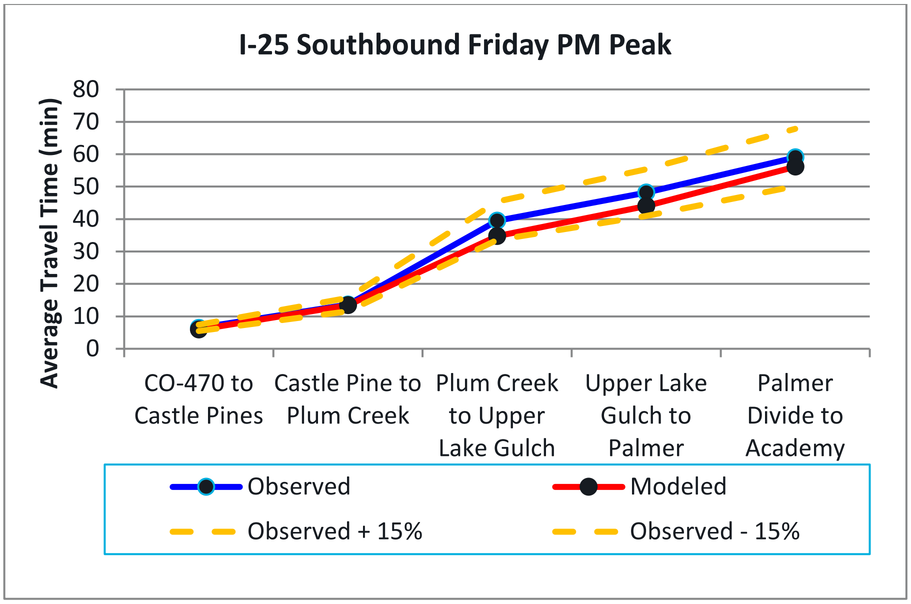
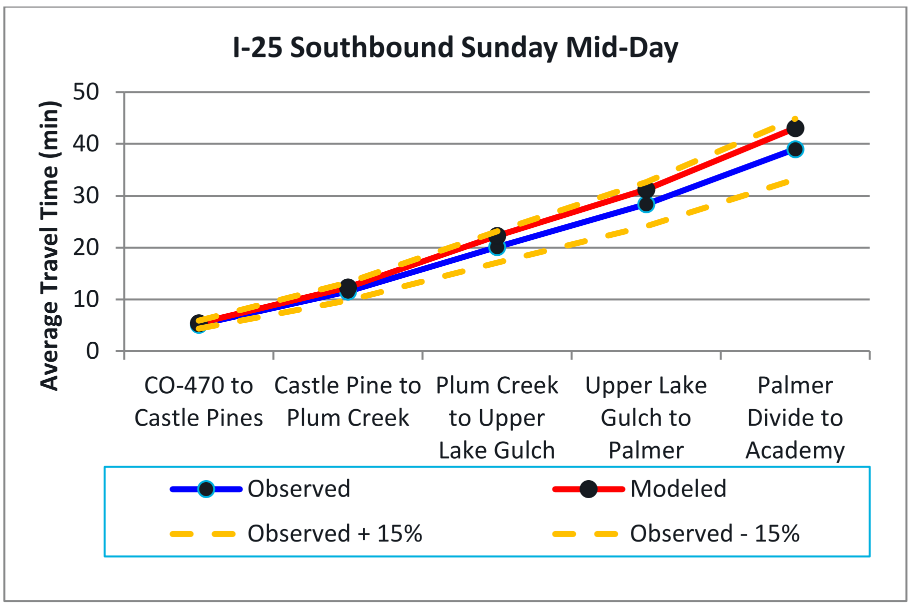


Figure 12: I-25 Mainline Travel Time Calibration- Southbound Sunday Mid-Day



Appendix A: Weekday Mainline Volumes Calibration Northbound

Start	End	Observed Volumes				Modeled Volumes				Percent Difference				Difference (GEH)			
		AM	PM	MD	NT	AM	PM	MD	NT	AM	PM	MD	NT	AM	PM	MD	NT
Exit 158 (Baptist)	Exit 161 (2nd St Monument/SH-105)	7,670	12,881	16,666	10,204	8,017	12,939	17,631	10,418	5%	0%	6%	2%	2.5	0.2	3.7	0.6
Exit 161 (2nd St Monument/SH-105)	Exit 163 (Palmer Divide)	6,254	9,681	13,728	8,830	6,422	9,867	14,346	8,807	3%	2%	5%	0%	1.3	0.8	2.6	0.1
Exit 163 (Palmer Divide)	Exit 167 (Greenland)	6,814	9,679	14,072	8,705	6,617	9,274	14,257	8,833	-3%	-4%	1%	1%	1.5	1.7	0.8	0.4
Exit 167 (Greenland)	Exit 172 (Upper Lake Gulch)	6,929	9,753	14,022	8,735	6,806	9,428	14,518	8,907	-2%	-3%	4%	2%	0.9	1.4	2.1	0.5
Exit 172 (Upper Lake Gulch)	Exit 173 (Spruce Mountain)	6,885	9,638	13,922	8,675	6,802	9,433	14,503	8,882	-1%	-2%	4%	2%	0.6	0.9	2.4	0.7
Exit 173 (Spruce Mountain)	Exit 174 (Sky View)	7,281	10,054	14,594	8,941	7,601	10,324	15,671	9,279	4%	3%	7%	4%	2.3	1.1	4.4	1.0
Exit 174 (Sky View)	Exit 179 (Crystal Valley)	7,191	9,860	14,339	8,839	7,423	10,107	15,251	9,078	3%	3%	6%	3%	1.7	1.0	3.7	0.7
Exit 179 (Crystal Valley)	Exit 181 (Plum Creek)	7,191	9,860	14,339	8,839	7,423	10,107	15,251	9,078	3%	3%	6%	3%	1.7	1.0	3.7	0.7
Exit 181 (Plum Creek)	Exit 182 (Wilcox)	9,848	11,923	17,736	10,346	9,878	11,500	16,718	9,282	0%	-4%	-6%	-10%	0.2	1.6	3.9	3.2
Exit 182 (Wilcox)	Exit 184 (Founders/ Meadows)	10,902	13,453	19,834	11,386	11,380	13,361	19,473	10,742	4%	-1%	-2%	-6%	2.9	0.3	1.3	1.8
Exit 184 (Founders/ Meadows)	Exit 185 (Castle Rock)	14,528	15,681	23,895	13,991	14,663	15,173	23,025	12,098	1%	-3%	-4%	-14%	0.7	1.7	2.8	4.9
Exit 185 (Castle Rock)	Exit 187 (Happy Canyon)	15,373	15,511	24,298	13,105	15,920	16,388	24,833	13,022	4%	6%	2%	-1%	2.8	3.5	1.4	0.2
Exit 187 (Happy Canyon)	Exit 188 (Hess/Castle Pines)	16,055	16,174	25,328	13,410	16,391	16,956	25,621	13,442	2%	5%	1%	0%	1.7	2.5	0.9	0.1
Exit 188 (Hess/Castle Pines)	Exit 192 (Ridgegate)	16,223	15,351	25,322	12,346	16,858	16,586	25,620	13,418	4%	8%	1%	9%	3.1	4.0	0.9	2.8
Exit 192 (Ridgegate)	Exit 193 (Lincoln)	16,885	16,557	27,639	14,634	17,173	16,771	27,033	14,467	2%	1%	-2%	-1%	1.4	0.7	1.8	0.4
Exit 193 (Lincoln)	Exit 195 (C-470/E-470)	19,408	23,389	34,676	19,262	20,408	21,830	33,650	16,996	5%	-7%	-3%	-12%	4.5	4.2	2.8	5.0

Appendix A: Weekday Mainline Volumes Calibration Southbound

Start	End	Observed Volumes				Modeled Volumes				Percent Difference				Difference (GEH)			
		AM	PM	MD	NT	AM	PM	MD	NT	AM	PM	MD	NT	AM	PM	MD	NT
Exit 193 (Lincoln)	Exit 195 (C-470/E-470)	13,576	31,403	33,832	20,722	13,143	32,441	35,789	20,013	-3%	3%	6%	-3%	2.4	2.4	5.2	1.5
Exit 192 (Ridgegate)	Exit 193 (Lincoln)	8,712	26,356	26,529	16,410	8,662	27,414	26,061	15,636	-1%	4%	-2%	-5%	0.3	2.6	1.4	1.8
Exit 188 (Hess/Castle Pines)	Exit 192 (Ridgegate)	7,616	25,082	24,033	14,698	8,150	27,414	24,938	15,139	7%	9%	4%	3%	3.8	5.9	2.9	1.1
Exit 187 (Happy Canyon)	Exit 188 (Hess/Castle Pines)	8,301	24,489	24,151	14,312	8,603	25,920	24,484	14,019	4%	6%	1%	-2%	2.1	3.7	1.1	0.7
Exit 185 (Castle Rock)	Exit 187 (Happy Canyon)	7,895	23,506	23,256	13,800	7,986	24,089	23,075	13,390	1%	2%	-1%	-3%	0.6	1.9	0.5	1.0
Exit 184 (Founders/Meadows)	Exit 185 (Castle Rock)	7,689	21,613	22,223	13,139	7,493	22,115	21,416	12,535	-3%	2%	-4%	-5%	1.4	1.4	2.7	1.6
Exit 182 (Wilcox)	Exit 184 (Founders/Meadows)	6,754	17,874	19,666	11,702	6,948	18,332	19,215	11,782	3%	3%	-2%	1%	1.5	1.4	1.6	0.2
Exit 181 (Plum Creek)	Exit 182 (Wilcox)	5,739	15,699	17,154	10,652	5,898	16,002	16,139	10,045	3%	2%	-6%	-6%	1.3	1.0	3.9	1.8
Exit 179 (Crystal Valley)	Exit 181 (Plum Creek)	4,810	11,083	13,846	9,036	5,233	11,922	13,870	9,270	9%	8%	0%	3%	3.8	3.2	0.1	0.7
Exit 174 (Sky View)	Exit 179 (Crystal Valley)	4,810	11,083	13,846	9,036	5,233	11,922	13,870	9,270	9%	8%	0%	3%	3.8	3.2	0.1	0.7
Exit 173 (Spruce Mountain)	Exit 174 (Sky View)	4,904	12,171	14,050	9,089	5,418	12,815	14,340	9,369	10%	5%	2%	3%	4.5	2.4	1.2	0.9
Exit 172 (Upper Lake Gulch)	Exit 173 (Spruce Mountain)	4,690	11,465	13,377	8,776	4,919	11,783	13,273	8,856	5%	3%	-1%	1%	2.1	1.2	0.5	0.2
Exit 167 (Greenland)	Exit 172 (Upper Lake Gulch)	4,746	11,579	13,545	8,826	4,933	11,784	13,286	8,865	4%	2%	-2%	0%	1.7	0.8	1.1	0.1
Exit 163 (Palmer Divide)	Exit 167 (Greenland)	4,745	11,549	13,465	8,715	4,865	11,483	13,039	8,754	3%	-1%	-3%	0%	1.1	0.3	1.8	0.1
Exit 161 (2nd St Monument/SH-105)	Exit 163 (Palmer Divide)	5,003	11,155	13,330	8,802	5,105	10,803	12,851	8,305	2%	-3%	-4%	-6%	0.9	1.4	2.1	1.6
Exit 158 (Baptist)	Exit 161 (2nd St Monument/SH-105)	7,165	13,839	16,983	10,130	7,174	14,174	16,798	10,131	0%	2%	-1%	0%	0.1	1.2	0.7	0.0

Appendix A: Weekend Mainline Volumes Calibration Northbound

Start	End	Observed Volumes		Modeled Volumes		Percent Difference		Difference (GEH)	
		Friday PM	Sunday PM	Friday PM	Sunday PM	Friday PM	Sunday PM	Friday PM	Sunday PM
Exit 158 (Baptist)	Exit 161 (2nd St Monument/SH-105)	14,654	12,522	14,828	13,067	1%	4%	0.4	1.4
Exit 161 (2nd St Monument/SH-105)	Exit 163 (Palmer Divide)	11,758	10,940	11,784	10,943	0%	0%	0.1	0.0
Exit 163 (Palmer Divide)	Exit 167 (Greenland)	11,798	11,124	11,190	10,865	-5%	-2%	1.7	0.7
Exit 167 (Greenland)	Exit 172 (Upper Lake Gulch)	11,854	11,088	11,338	11,002	-4%	-1%	1.4	0.2
Exit 172 (Upper Lake Gulch)	Exit 173 (Spruce Mountain)	11,759	10,988	11,343	10,996	-4%	0%	1.1	0.0
Exit 173 (Spruce Mountain)	Exit 174 (Sky View)	12,219	11,450	12,156	11,573	-1%	1%	0.2	0.3
Exit 174 (Sky View)	Exit 179 (Crystal Valley)	11,845	10,845	11,975	11,361	1%	5%	0.4	1.4
Exit 179 (Crystal Valley)	Exit 181 (Plum Creek)	11,845	10,845	11,975	11,361	1%	5%	0.4	1.4
Exit 181 (Plum Creek)	Exit 182 (Wilcox)	14,283	13,109	13,351	12,236	-7%	-7%	2.3	2.3
Exit 182 (Wilcox)	Exit 184 (Founders/ Meadows)	15,866	14,574	15,183	13,927	-4%	-4%	1.6	1.6
Exit 184 (Founders/ Meadows)	Exit 185 (Castle Rock)	17,130	16,207	16,895	15,921	-1%	-2%	0.5	0.7
Exit 185 (Castle Rock)	Exit 187 (Happy Canyon)	18,130	16,655	18,117	16,991	0%	2%	0.0	0.8
Exit 187 (Happy Canyon)	Exit 188 (Hess/Castle Pines)	NA	NA	18,644	17,469				
Exit 188 (Hess/Castle Pines)	Exit 192 (Ridgegate)	19,781	17,289	18,302	17,390	-7%	1%	3.2	0.2
Exit 192 (Ridgegate)	Exit 193 (Lincoln)	NA	NA	18,475	18,129				
Exit 193 (Lincoln)	Exit 195 (C-470/E-470)	NA	NA	23,449	22,080				

Appendix A: Weekend Mainline Volumes Calibration Southbound

Start	End	Observed Volumes		Modeled Volumes		Percent Difference		Difference (GEH)	
		Friday PM	Sunday PM	Friday PM	Sunday PM	Friday PM	Sunday PM	Friday PM	Sunday PM
Exit 193 (Lincoln)	Exit 195 (C-470/E-470)	NA	NA	31,757	25,149				
Exit 192 (Ridgegate)	Exit 193 (Lincoln)	NA	NA	26,441	18,982				
Exit 188 (Hess/Castle Pines)	Exit 192 (Ridgegate)	24,157	17,183	26,420	18,257	9%	6%	4.2	2.4
Exit 187 (Happy Canyon)	Exit 188 (Hess/Castle Pines)	NA	NA	24,915	17,777				
Exit 185 (Castle Rock)	Exit 187 (Happy Canyon)	23,060	16,995	23,269	16,861	1%	-1%	0.4	0.3
Exit 184 (Founders/Meadows)	Exit 185 (Castle Rock)	20,899	16,074	21,390	15,734	2%	-2%	1.0	0.8
Exit 182 (Wilcox)	Exit 184 (Founders/Meadows)	17,936	13,529	18,052	14,095	1%	4%	0.3	1.4
Exit 181 (Plum Creek)	Exit 182 (Wilcox)	15,765	12,095	15,771	12,192	0%	1%	0.0	0.3
Exit 179 (Crystal Valley)	Exit 181 (Plum Creek)	9,277	9,996	9,334	10,696	1%	7%	0.2	2.0
Exit 174 (Sky View)	Exit 179 (Crystal Valley)	9,277	9,996	9,334	10,696	1%	7%	0.2	2.0
Exit 173 (Spruce Mountain)	Exit 174 (Sky View)	12,821	10,499	12,990	10,924	1%	4%	0.4	1.2
Exit 172 (Upper Lake Gulch)	Exit 173 (Spruce Mountain)	12,108	10,126	11,994	10,249	-1%	1%	0.3	0.4
Exit 167 (Greenland)	Exit 172 (Upper Lake Gulch)	12,231	10,206	11,996	10,258	-2%	1%	0.6	0.2
Exit 163 (Palmer Divide)	Exit 167 (Greenland)	12,096	10,170	11,709	10,104	-3%	-1%	1.0	0.2
Exit 161 (2nd St Monument/SH-105)	Exit 163 (Palmer Divide)	12,059	10,197	11,106	9,873	-8%	-3%	2.6	1.0
Exit 158 (Baptist)	Exit 161 (2nd St Monument/SH-105)	14,721	11,811	14,498	12,250	-2%	4%	0.5	1.2

Appendix A: Weekday Surface Roads Volumes Calibration

Location	Direction	Observed Volumes				Modeled Volumes				Percent Difference				Difference (GEH)			
		AM	PM	MD	NT	AM	PM	MD	NT	AM	PM	MD	NT	AM	PM	MD	NT
Frontage Rd W Side of I-25 just south of Plum Creek Pkwy	NB	750	610	1,079	390	714	658	1,100	398	-5%	8%	2%	2%	0.8	0.8	0.3	0.1
Frontage Rd W Side of I-25 just south of Plum Creek Pkwy	SB	690	2,146	1,711	967	723	1,776	1,407	809	5%	-17%	-18%	-16%	0.8	3.4	3.8	1.6
Frontage Rd E Side of I-25 just south of Crystal Valley Pkwy	NB	365	438	627	180	268	225	491	194	-27%	-49%	-22%	8%	3.5	4.8	2.9	0.3
Frontage Rd E Side of I-25 just south of Crystal Valley Pkwy	SB	173	782	578	242	179	764	489	102	4%	-2%	-15%	-58%	0.3	0.3	1.9	3.1
Santa Fe Dr (US-85) just south of C-470	NB	4,981	7,304	9,036	3,605	5,450	7,575	9,078	3,814	9%	4%	0%	6%	4.1	1.3	0.2	1.0
Santa Fe Dr (US-85) just south of C-470	SB	4,619	6,842	9,054	4,416	4,927	7,686	8,489	4,703	7%	12%	-6%	7%	2.8	4.0	3.0	1.3
Perry Park Rd (SH-105) just south of Tomah Rd	NB	415	312	582	209	455	395	420	213	10%	27%	-28%	2%	1.2	1.8	3.6	0.1
Perry Park Rd (SH-105) just south of Tomah Rd	SB	119	725	523	247	210	833	395	202	76%	15%	-25%	-18%	4.5	1.6	3.0	0.9
SH-83 Just south of E-470	NB	6,854	7,109	9,376	5,968	6,887	7,372	10,214	5,983	0%	4%	9%	0%	0.3	1.3	4.2	0.1
SH-83 Just south of E-470	SB	4,617	10,942	11,466	5,761	4,301	10,345	11,184	6,275	-7%	-5%	-2%	9%	3.0	2.4	1.3	2.0
SH-83 just south of Gillian Ave	NB	559	822	889	467	663	684	847	393	19%	-17%	-5%	-16%	2.7	2.1	0.7	1.1
SH-83 just south of Gillian Ave	SB	431	1,194	907	519	340	1,149	719	369	-21%	-4%	-21%	-29%	2.9	0.5	3.3	2.1

Appendix A: Weekend Surface Roads Volumes Calibration

Location	Direction	Observed Volumes		Modeled Volumes		Percent Difference		Difference (GEH)	
		Friday PM	Sunday PM	Friday PM	Sunday PM	Friday PM	Sunday PM	Friday PM	Sunday PM
Frontage Rd W Side of I-25 just south of Plum Creek Pkwy	NB	692	705	694	682	0%	-3%	0.0	0.3
Frontage Rd W Side of I-25 just south of Plum Creek Pkwy	SB	3,149	832	2,919	877	-7%	5%	1.2	0.5
Frontage Rd E Side of I-25 just south of Crystal Valley Pkwy	NB	448	484	208	256	-54%	-47%	3.9	3.5
Frontage Rd E Side of I-25 just south of Crystal Valley Pkwy	SB	1,787	257	2,240	231	25%	-10%	3.0	0.5
Santa Fe Dr (US-85) just south of C-470	NB	NA	NA	7,508	5,561				
Santa Fe Dr (US-85) just south of C-470	SB	NA	NA	7,414	5,361				
Perry Park Rd (SH-105) just south of Tomah Rd	NB	NA	NA	487	329				
Perry Park Rd (SH-105) just south of Tomah Rd	SB	NA	NA	797	286				
SH-83 Just south of E-470	NB	NA	NA	7,392	5,963				
SH-83 Just south of E-470	SB	NA	NA	10,181	7,354				
SH-83 just south of Gillian Ave	NB	NA	NA	861	662				
SH-83 just south of Gillian Ave	SB	NA	NA	1,115	625				

Technical Note-I-25 South PEL Travel Demand Forecasting Technical Memorandum

steer davies gleave

Memo

To	Chris Bisio, CH2M / Jacobs		
Cc	Mandy Whorton, Peak Consulting Group Shane Binder, Apex Engineering Steve Cook, DRCOG Ken Prather, PPACG Nnaemeka Ezekwemba, FHWA Sam Bohluli, C&M Associates		
From	Mark Feldman		
Date	January 30th, 2018		
Project	I-25 South PEL/NEPA	Project No.	23029302

I-25 PEL/NEPA Technical Memorandum - Model Development and Calibration

Introduction

This memorandum documents both the data collection and model development, calibration and validation portions of the travel demand modeling work performed by Steer Davies Gleave (SDG), corresponding to the I-25 South travel demand modeling efforts.

The work discussed in this memo was performed in April – October 2017, and will feed into two different forecasting efforts:

- Environmental Assessment (EA) forecasts for NEPA documents, late 2017 / early 2018, focusing on the Gap Section of I-25 (between exits 161 and 181)
- Development and calibration of the model for the Planning and Environmental Linkage (PEL) study area, spanning the DRCOG and PPACG regions along the I-25 corridor, from approximately C/E-470 to Academy Blvd.

This memo contains the following sections:

- Data Collection
- Model Development
- Model Calibration and Validation
- Development of Forecast Year Model

Documentation of the NEPA/EA forecasts will occur in a separate memo after they are finalized in early 2018. The PEL forecasting will likely take place in mid-late 2018.

Data Collection

MPO Travel Demand Models

It is customary to use regional travel demand models for traffic forecasting. In a corridor study such as this, these models can forecast changes in traffic volumes to apply to existing traffic counts used in more detailed simulation models and HCM-based traffic analyses.

The project's area of influence extends through Douglas County and into northern El Paso County. Therefore, it was necessary for the travel demand model to include areas within both the DRCOG and PPACG MPOs. In late 2016, SDG proposed a modeling tool that extends DRCOG's FOCUS model into northern El Paso County, with its southern edge in the Briargate region of Colorado Springs. This was originally documented in the Modeling Approach Memo, dated January 3rd, 2017 (included as Appendix C to this memo). To create this extended travel demand model, SDG obtained a complete version of FOCUS 2.0 from DRCOG and the most current roadway network and trip matrices from PPACG. We will refer to this travel demand model, which pieces together information from the two MPOs from here on as the "I-25 Model". We will often refer to the official DRCOG (FOCUS) and PPACG models as the "MPO Models".

Both of the MPO models have 2015 and 2040 analysis years. SDG accounted for differences between 2015 and current (2017) levels of trip-making by adjusting trip matrices to validate 2017 traffic count data at the I-25 Model's southern edge in the Briargate area. This is discussed further in the calibration section of this memo. We assumed differences between 2015 and 2017 networks to be negligible.

By working exclusively with trip matrices (origin-destinations by time period and vehicle occupancy / type) and networks, SDG did not rerun or alter any of the model components prior to highway assignment. Thus, our analysis to date has assumed negligible effects of the project alternatives on trip generation, trip distribution, mode choice, or any of the activity based model components of FOCUS.

It should be noted that we performed the calibration and validation exercises with a model that contained the FOCUS region in its entirely, plus a small portion of the PPACG region, but ultimately extracted a subarea of the FOCUS region for the purposes of doing forecasts to reduce model running time. The validation results were checked and compared, and they were not significantly different after the subarea extraction compared to the validation results when the entire FOCUS region was included. Note that the validation results featured in this memo are from the subarea extraction model ("I-25 Model").

Traffic Counts

Traffic counts serve as indicators that the base year models are reasonably reflecting existing levels of traffic and congestion. We contracted All Traffic Data (ATD) to collect traffic count data at the following facilities:

- I-25 along the study corridor (from C-470 to Academy Boulevard)
- Ramps on/off I-25 along the study corridor; and
- Select locations on parallel routes (SH-105, SH-83, and I-25 Frontage Roads) on each segment separated by major intersections

Counts along I-25 were taken with video cameras and included vehicle classifications and 15-minute time intervals. Other counts were taken with traditional tubes at 30-minute time intervals. The count dates included:

- Wednesday / Thursday May 16-17 (alternate segments on I-25 between C-470 and Academy Blvd, all ramps, parallel routes)
- Friday / Saturday / Sunday August 4-6 (most segments on I-25 between Happy Canyon and Baptist Rd, all ramps, parallel routes)

For model calibration purposes, we averaged traffic counts on the two weekdays to obtain a weekday average count.

Quality Control Procedures for Traffic Count Data

SDG undertook a methodical approach to processing the traffic count data. We conducted extensive quality control procedures to ensure that the data was of good quality. This involved general scanning for anomalies and checking for the following:

- Directionally balanced daily counts on each facility[1]
- Proper count magnitude (e.g. highways should carry about 20,000-30,000 vehicles per day per lane, major arterials 10,000)
- Low volumes on rural area ramps (less than 5,000 vehicles per day, often much less)
- Time of day profiles consistent with well-recognized travel patterns (in the case of our study area, more northbound traffic towards Denver than southbound in the morning, and the reverse in the evening)
- Consistency between adjacent mainline locations and reconciliation with ramp counts in between (see example in Table 2 below)
- Consistency between Friday and weekday counts (ensuring their time profiles were generally similar with Friday having slightly more traffic overall)

For the most part, the data collected from ATD was found to be of good quality. In a few isolated cases, we found anomalous data, and those instances were all addressed to our satisfaction.

Table 1 illustrates one example of SDG's quality control uncovering anomalous count data. Checking the traffic volumes from the August Friday and Sunday data at several points along I-25, we noticed that the northbound daily volume between exits 188 and 192 looked low, given the volumes to the north and south. Both the Friday and Sunday data showed sharp decreases between adjacent locations, followed by a much sharper increase. It did not seem possible for I-25 to lose 6,000 – 9,000 vehicles and then gain 14,000 - 20,000 vehicles immediately afterwards, given the volumes of the ramps in between, although not collected in the Friday and Sunday data, were all 11,000 or less on weekdays.

We brought this to the attention of ATD, and an investigation determined that they had mistakenly not included one of the lanes in the Friday and Sunday totals. They provided corrected data, also shown below, which was more in line with the other locations and with the weekday data.

[1] The frontage roads parallel to I-25 between exits 174 and 181 are an exception to this. One expects higher southbound than northbound volumes on these facilities, due to the tendency of travelers to avoid I-25 southbound where it drops from 3 to 2 lanes.

Table 1: Northbound Daily I-25 Count Quality Control

Location	Friday	Sunday
Between Exits 185-187	77,034	60,089
Between Exits 188-192 - original	68,238	53,854
Between Exits 188-192 - corrected	84,995	65,214
South of Exit 193 Diagonal On Ramp	88,199	67,834

Due to budget constraints, counts along I-25 in some cases were taken at alternate segments[2], and we estimated the traffic counts at the locations in between by using the upstream and downstream traffic count locations on I-25 and the ramp counts in between. We calculated estimates both ways ('forwards' and 'backwards'), checked to ensure that both directions yielded similar estimates, and averaged the two. This approach yielded appropriate data and did not result in any data concerns.

Table 2 presents an example of this. In this instance, northbound counts on I-25 were collected between exits 151-153 and between exits 156-158, but not between exits 153-156.

Table 2: Data for Estimation of I-25 Segments with Adjacent Segment and Ramp Counts

Location	Daily Traffic Count
I-25 Between Exit 151 (Briargate) and Exit 153 (Interquest)	58,336
Exit 153 off	9,510
Exit 153 on	8,818
I-25 Between Exit 153 (Interquest) and Exit 156 (N Gate)	Not Collected
Exit 156 off	9,428
Exit 156 on	5,041
I-25 Between Exit 156 (N Gate) and Exit 158 (Baptist)	53,248

Source: Steer Davies Gleave

We estimated the I-25 Mainline location between Exit 153 (Interquest Pkwy) and Exit 156 (North Gate Blvd) in the forwards direction as the upstream location count – off-ramp count + on-ramp count, or:

58,336 - 9,510 + 8,818 = 57,644

Conversely, in the backwards direction, we use the downstream location, back out the on- ramp, and add back in the off-ramp, to get:

53,248 - 5,041 + 9,428 = 57,635

The 'forwards' and 'backwards' estimates are quite similar, thus passing our quality check. We used the average of the estimates, or 57,639. We performed similar estimates and checks in each time period to cover

[2] In most cases we collected counts at alternate segments. In the gap, we collected counts just north of Palmer Divide Rd and just south of Plum Creek Parkway, and estimated all segments in between in this manner, because the interchanges in between all have very low traffic volumes and thus I-25 volume differences between segments in the gap are minimal.

other segments on I-25 where counts were not collected.

The calibration tables in Appendix A contain a detailed breakdown of the I-25 and select parallel route and frontage road traffic count data by direction and time period. The complete set of traffic count data is available in spreadsheets upon request.

Travel Times

We collected INRIX historical travel time and speed data for I-25 and parallel routes (US-85 and SH-105 to the west, and SH-83 to the east). We collected these data at the individual observation level for all of calendar year 2016 and on the select days in 2017 when we conducted traffic counts. We then summarized them by the following categories:

- **Highway segment:** nine per direction on I-25, and a combined 14 per direction on the parallel routes;
- **Time of day:** ten weekday time periods that align with those used in the FOCUS model, plus three Friday afternoon / evening periods and one Sunday afternoon period;
- **Day of week:** weekdays (Mondays – Thursdays), Fridays, and Sundays; and
- **Month of year:** summer months (June – August) and non-summer months.

For each unique time-location combination, we calculated the mean travel times and speeds across all observations recorded. We aggregated mean observed travel times into longer highway segments (five per direction on I-25, and a combined six per direction on the parallel routes), which were in turn compared against modeled travel times during the model calibration process. In total, we performed three separate calibration processes:

- Weekday AM and PM peak periods on the specific days traffic counts were collected (Wednesday, May 17 and Thursday, May 18, 2017);
- Weekday midday and night time periods for the overall 2016 average; and
- The three Friday periods and one Sunday period on the specific days traffic counts were collected (Friday, August 4 and Sunday, August 6, 2017).

Travel speed data also aided us in determining free-flow speeds when setting up the model network.

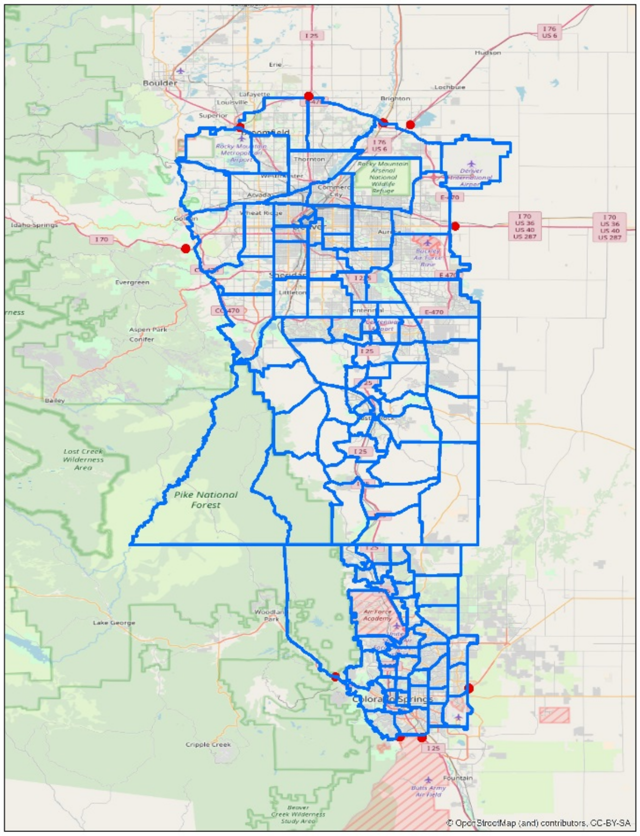
In addition, to inform our value of time analysis, we collected a further sample of similar travel time and speed data for the US-36 tolled express lanes. These data were collected for April 2017 (the month with the highest quality express lane transaction data) and averaged in 15-minute intervals. More details about this analysis are provided in a subsequent section.

Origin-Destination Data

StreetLight Data served as the primary data source for determining OD patterns. StreetLight Data offers current year information and is relatively low cost compared to other travel pattern sources.

We defined 114 zones to cover Denver, Douglas County, and Northern El Paso County down to Colorado Springs to ensure coverage of the study area. Additionally, ten pass-through zones were created to represent major external thoroughfares. These 124 zones are shown in Figure 1, below, with blue borders denoting the 114 zones and red indicating external pass-through locations.

Figure 1: StreetLight Data Zone System



Source: Steer Davies Gleave

The data enabled us to observe trip distributions between zones differentiated based on personal versus commercial vehicle type, summer versus off-season, time of day, and weekday, Friday, Saturday, and Sunday. For review, the 124 zones were aggregated into mega-zones representing Denver, Castle Rock, Larkspur, Monument, Colorado Springs, externals north of Denver, and externals south of Colorado Springs. The distributions at the mega-zone level were validated against the American Community Survey commuting flows between Colorado counties.

We applied these distributions, in Table 3 and Table 4, to join the weekday trip matrices for the separate FOCUS and PPACG MPO models. We did not modify any intra-MPO trips, but used the StreetLight Data along with traffic counts to expand the trip matrices for inter-MPO trips. The model development section of this memo contains further details on this process.

Table 3: Weekday Personal Trip Distribution

	FOCUS externals	Denver Metro	Castle Rock Area	Larkspur Area	Monument / Briargate Area	Colorado Springs Area	PPACG externals
FOCUS externals	0.04%	3.35%	0.05%	0.00%	0.01%	0.02%	0.01%
Denver Metro		77.88%	4.34%	0.06%	0.14%	0.27%	0.05%
Castle Rock Area			2.85%	0.09%	0.05%	0.08%	0.02%
Larkspur Area				0.04%	0.04%	0.04%	0.00%
Monument / Briargate Area					0.89%	1.32%	0.04%
Colorado Springs Area						7.89%	0.44%
PPACG externals							0.01%

Source: StreetLight Data

Table 4: Weekday Commercial Trip Distribution

	FOCUS externals	Denver Metro	Castle Rock Area	Larkspur Area	Monument / Briargate Area	Colorado Springs Area	PPACG externals
FOCUS externals	3.74%	18.24%	0.15%	0.04%	0.13%	0.38%	0.46%
Denver Metro		60.49%	1.95%	0.16%	0.40%	1.13%	1.48%
Castle Rock Area			1.14%	0.09%	0.08%	0.20%	0.13%
Larkspur Area				0.04%	0.06%	0.06%	0.07%
Monument / Briargate Area					0.54%	0.98%	0.30%
Colorado Springs Area						7.62%	1.68%
PPACG externals							0.27%

Source: StreetLight Data

For growing the inter-MPO portions of the trip matrices derived from StreetLight data to 2040, we used the 2017 calibrated trip matrix as a starting point for a fratar process, so the trip patterns derived from StreetLight were preserved, but also adjusted to account for projected growth at the zone level.

Transaction Data

For any study with planned tolled lanes, where modeling travelers' choices between free and tolled routes is part of traffic forecasting, it is necessary to have an assumption of travelers' values of time to model the tradeoff between time savings and increased trip cost. Stated preference (SP) surveys are sometimes conducted for this purpose, especially when there are no similar toll facilities to observe actual travel behavior. Given the planning-level of our study and the presence of similar toll facilities in the region, we relied on revealed behavior of travelers on a local facility with existing managed lanes to estimate values of time.[3] The express lanes on US-36 were the ideal candidate for this purpose, due to the presence of permanent count stations on the express lane corridor and the availability of transaction data from CDOT.

To estimate revealed values of time, one must determine (a) the time savings on the tolled facility and (b) what percentage of travelers are willing to pay to save this amount of time, and how much they are paying.

CDOT provided transaction data to SDG, including number of transactions and toll collected, for several

[3] An ongoing Traffic and Revenue study of the corridor by C&M Asssociates will include a stated preference survey on tolls specifically for this section of I-25.

months of 2016. We downloaded traffic count data by time of day from CDOT count stations #00004 and #00504 on US-36 from the CDOT website. We computed average tolls by taking the average toll paid in each transaction across the entire route for each hour.

We determined the share of traffic using managed lanes by dividing the CDOT transaction counts by the total traffic count. Because there were only two stations where transaction counts were recorded, only two segments had definite counts. Between the two count stations, we interpolated the value for managed lane share. For segments outside of the two stations, the share took the value of the closest segment with a count station on it.

The INRIX travel times for the section of US-36 with managed lanes include travel times for all vehicles on the corridor, and are unable to distinguish between vehicles using the managed lanes and the general-purpose lanes. Assuming that the INRIX data sampled vehicles randomly, we calculated the travel time and speed on the general-purpose lanes by using the average travel time from the INRIX data and the share of traffic using the managed lanes as calculated above. We assumed managed lane speeds of 70 mph for this purpose. In other words, we solved for GP travel time, using the equation

GPtt * (1 – MLShare) + MLtt*MLShare = INRIXtt

where:

- GPtt = general purpose lane travel time
- MLtt = managed lane travel time (assuming 70 mph speed)
- MLShare = managed lane share
- INRIXtt = INRIX travel time

All items in the equation above other than GPtt are known or easily calculated, as discussed above.

Finally, we calculated time savings by taking the general-purpose lane times and subtracting the managed lane travel times based on the 70mph speed assumption. Given the time savings, toll paid, and managed lane share, we estimated values of time using the procedure described in the values of time analysis section of this memo.

Model Development

Combining MPO Travel Demand Models

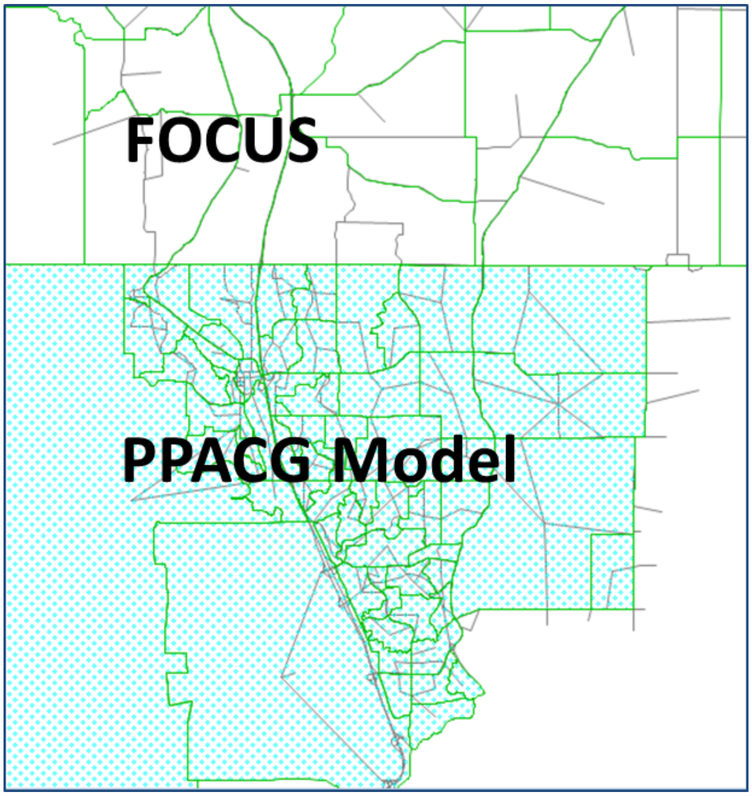
As discussed in the Data Collection section of this memo, SDG created the I-25 travel demand model by extending FOCUS into northern El Paso County. This involved combining both the networks and the trip matrices of the models from the two MPO regions, as discussed below.

Networks

Geographic Extension

Since the project study corridor extends beyond the FOCUS model project limits, SDG extended the highway network into the PPACG model region. Specifically, the FOCUS model network extends as far south as Palmer Divide Road (a.k.a. County Line Road) at the northern edge of Monument, whereas the study corridor extends a mile further south. Figure 2 shows the border between the two original MPO networks. We joined the two networks and zone systems at this border to provide a continuous network.

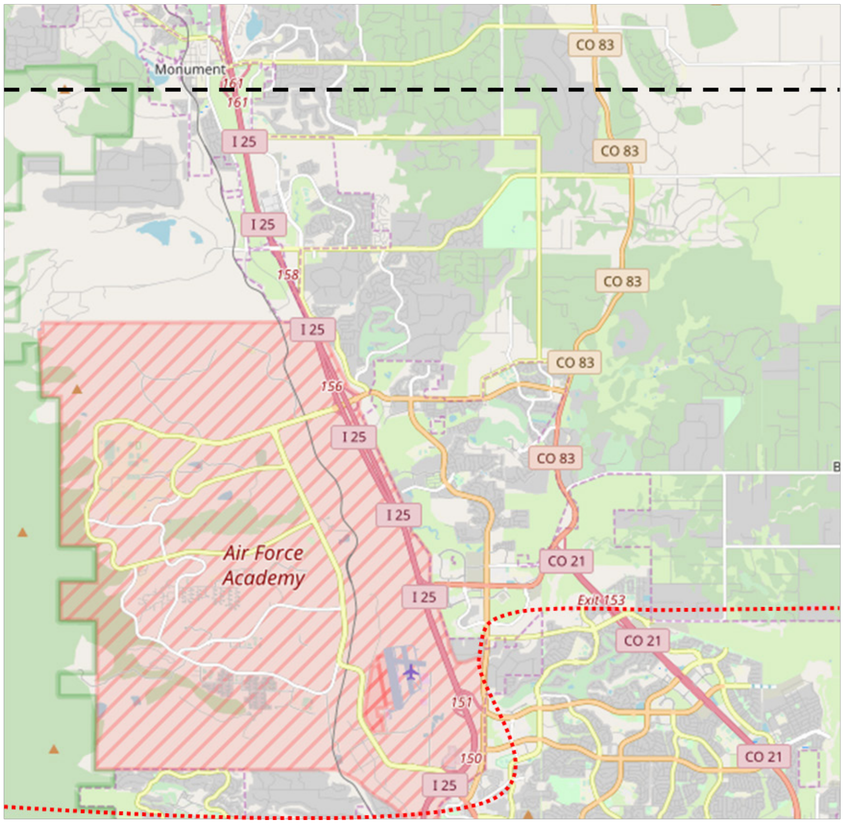
Figure 2: FOCUS/PPACG Model Network Border



Source: Steer Davies Gleave

To provide a minimal number of likely entrances and exits to the model network for ease of traffic count data collection, we picked a new southern edge of the model containing as few major roads as possible. Figure 3 depicts this new southern edge, as compared to the current FOCUS II model edge.

Figure 3: Comparison of Southern Edges of FOCUS Model to Extended Model



Approximate Edge of Current FOCUS Model

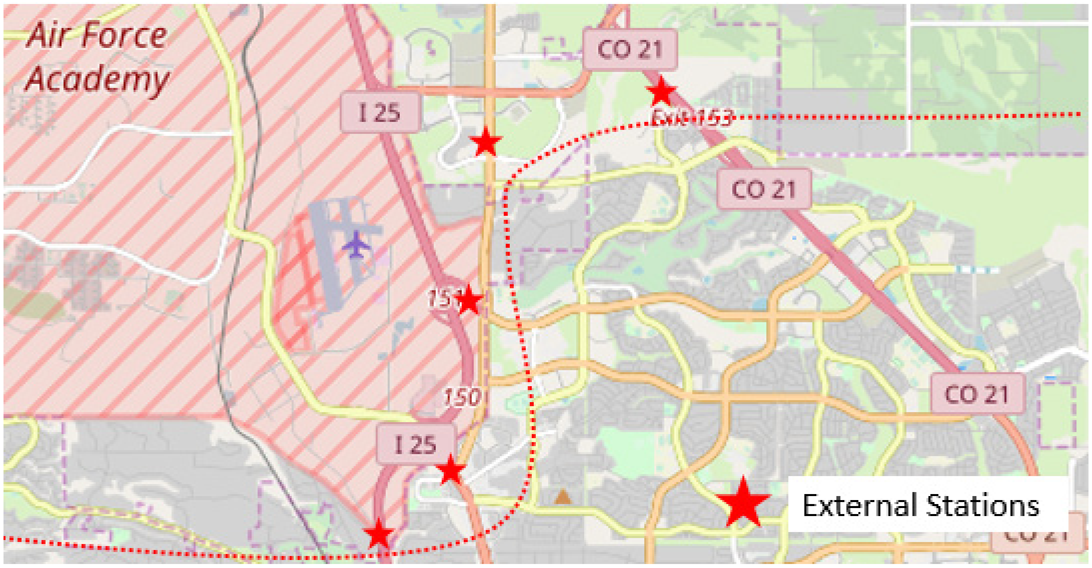
Proposed Edge of I-25 Model

Source: OpenStreetMap

Figure 4 zooms in on the extension above and shows the locations of the new external stations; the I-25 Model includes external stations at:

- I-25;
- Academy Boulevard;
- Briargate Parkway;
- Voyager Parkway; and
- North Powers Blvd (SH-21).

Figure 4: External Stations for I-25 Model Network



Source: OpenStreetMap

Attribute Translation

In addition to joining the networks geographically, we translated several network attributes from the PPACG model links into the FOCUS network attributes, as follows:

- In many cases for the attributes that were needed (e.g. link length, number of lanes), it was possible to fill in the values directly from a PPACG attribute with a different name but an identical definition.
- Free flow speed and per-lane capacity retained the lookup tables from FOCUS which depend on link area type and facility type.
- Due to the lack of an analogous attribute in the PPACG model, SDG used best judgment for the 'AREA TYPE' attribute for the new links in El Paso County. The FOCUS model assigns all zones an area type on a scale from 1 (Downtown Denver CBD) to 5 (rural), and all links get assigned a value equal to that of the zone in which they reside. Most zones in northern El Paso County were assigned a value of 4. Zones in the town of Monument were assigned a 3, and some rural zones near SH-83 were assigned a 5.

The only attribute that required a more complex translation from one set of values to another was the "FACILITY TYPE" attribute. We determined the values for this attribute from the value of the TYPENO attribute from the PPACG model. Table 5 below documents how this was done.

Table 5: Translation of PPACG TYPENO to FOCUS FACILITY TYPE Attribute

PPACG TYPENO Value	FOCUS FACILITY TYPE	Roadway Type
10-19	1	Freeway
20-29	2	Major Regional Arterial
30-39	3	Principal Arterial
40-49	4	Minor Arterial
50-59	5	Collector
75	6	Ramp
Links in connector layer	8	Centroid Connector

Source: PPACG model and FOCUS

Trip Matrices

The FOCUS II and PPACG travel demand models provided the initial trip matrices that we combined into a single matrix.

Zone / External Station Renumbering

The first step was to create a zone system for the extended network of the I-25 Model. Table 6 summarizes how this was done.

Table 6: Combining FOCUS and PPACG Zones into the I-25 Model Zone System

	I-25 Model Zone Numbers	Source	Source Model Zone Numbers
Zonal Areas	1-2804	FOCUS	1-2804 (same as in FOCUS)
	2805-2869	PPACG	Various (shaded region in Figure 1 above)
External Stations	2870-2887	FOCUS	2805-2822
	2888-2893	FOCUS	2827-2832
	2894-2898	New External Stations in Figure 3 (above)	n/a

Source: Steer Davies Gleave

The I-25 Model (prior to subarea extraction) contained 2869 zones and 29 external stations, numbered from 2870-2898. The first 24 of these external stations (numbered 2870-2893) corresponded to 24 of the 28 external stations in FOCUS, numbered 2805-2822 and 2827-2832 in the FOCUS model. Note that four of the original FOCUS external stations, 2823-2826, were located at the southern edge of Douglas County, which we joined to the PPACG model. Thus, these were not external stations in the I-25 Model. Similarly, the four PPACG model external stations with which these line up also were not external stations in the I-25 Model.

Finally, the five external stations depicted above in Figure 4 above were numbered 2894-2898.

Development of Trip Matrix

Table 7 illustrates the steps taken to create the full 2898 x 2898 zone weekday trip matrices for the I-25 Model, consistent with the zone numbers in Table 6 and with the time periods in FOCUS. To assist in the creation of the trip matrices for the I-25 Model, we collected origin-destination from StreetLight Data, following a zone system that covered most of the two MPOs. The zone system was coarser than in the MPO models, due both to StreetLight Data's pricing system (based on number of zones) and the greater level of confidence in the data with larger zones.

Table 7: Methodology for Extended Model Trip Matrix Development

<table>
<tr><th>Between TAZs…</th><th>And TAZs…</th><th>Description of Trips</th><th>Methodology</th></tr>
<tr><td rowspan="3">1-2804 or 2870-2893</td><td>1-2804 or 2870-2893</td><td>Within areas in the FOCUS model</td><td>Used trips from FOCUS model as is</td></tr>
<tr><td>2805-2869</td><td>Between FOCUS and northern El Paso County</td><td>(1) Disaggregated trips to/from original FOCUS external stations at the MPO border into zones 2805-69, based on travel patterns in StreetLight Data
(2) Disaggregated from StreetLight Data zones to MPO model zones</td></tr>
<tr><td>2894-2898</td><td>Between FOCUS and new external stations in Briargate area</td><td>(1) Computed percent of the trips to/from original FOCUS external stations at the MPO border not to/from for zones 2805-2869, based on travel patterns in StreetLight Data
(2) Disaggregated based on relative trips passing through stations 2894-2898, also based on StreetLight Data travel patterns
(3) Scaled entire rows/columns of matrix to match traffic counts in the appropriate direction</td></tr>
<tr><td rowspan="2">2805-2869</td><td>2805-2869</td><td>Within areas in the portion of PPACG model used in project extended model</td><td>Used trips from PPACG model as is</td></tr>
<tr><td>2894-2898</td><td>Between the portion of PPACG model used in project extended model and elsewhere in the PPACG model</td><td>(1) Computed the number trips to/from all other PPACG zones not used in the I-25 Model
(2) Disaggregated based on relative trips passing through stations 2894-2898, also based on StreetLight Data travel patterns
(3) Scaled entire rows/columns of matrix to match traffic counts in the appropriate direction</td></tr>
<tr><td>2894-2898</td><td>2894-2898</td><td>Between new external stations in Briargate area</td><td>Trips between I-25 and Academy Blvd or Voyager Pkwy used applicable ramp counts. Other O-D pairs assumed to be zero.</td></tr>
</table>

Source: Steer Davies Gleave

The general methodology followed these guidelines:

- As a preliminary step, we converted the PPACG matrices to the FOCUS model time periods, using multiplicative factors that reflected both the comparative lengths of the time periods and traffic count patterns within each period.

- Trips that did not cross the border between the two MPOs were not changed.
- To calculate trips between the two MPOs, we started with the trips using the former FOCUS external stations at the MPO border (2823-2826) and distributed them among the PPACG zones, using travel patterns implied by the StreetLight Data OD data.
- Due to the more aggregate geography of the zones underlying the StreetLight Data, we disaggregated trips from StreetLight Data zones into MPO model zones based on the MPO model zones' relative trip data within their respective StreetLight Data zones.
- We estimated trips going to the five new external stations (2894-2898) in three steps:
  - We computed trips going to any PPACG zone *not* included in the I-25 Model (because any trip going to one of those zones would need to cross one of the new external stations).
  - We disaggregated into the individual external stations based on the relative numbers of trips crossing through each from the StreetLight Data.
  - We scaled each row and column to match the traffic counts collected in 2017 for each of the five stations in each direction and time period.

It should be noted that the first two columns of Table 7 are reversible, i.e. each methodology listed applies to trips either from TAZs in column 1 to TAZs in column 2, or from TAZs in column 2 to TAZs in column 1.

Weekend Trip Matrices

The MPO models are both designed for average weekday conditions. Thus they do not contain the necessary trip-making levels and patterns to model the increased delay often observed on I-25 on Friday afternoons and weekends. Thus, it was necessary to adjust these matrices in such a way to be able to model these conditions. Note that throughout the memo, the term "weekend" is used to describe both the Friday afternoon and Sunday model periods.

As discussed in the travel times section above, the desired modeling periods were Friday late afternoon / evening and Sunday early afternoon. To facilitate compatibility with FOCUS, we chose the following time periods, which aligned closely with the actual time periods of greatest observed delay on I-25:

- Friday 3-5 PM (PM1)
- Friday 5-6 PM (PM2)
- Friday 6-7 PM (PM3)
- Sunday 11:30 AM – 3:00 PM (OP3)

Technical details of the weekend trip matrix adjustments are discussed in the model calibration and validation section of this memo.

Model Calibration and Validation

List of Calibration Modifications

Network

Initially the model's screenline traffic forecasts at the El Paso County Line lower than observed while screenline traffic forecasts very closely matched observed counts at Castle Rock and in the middle of the gap. Table 8 presents average weekday traffic volumes from the 2015 version of FOCUS and from the 2017 traffic counts collected on two weekdays in May of 2017 at three screenlines, corresponding roughly to the northern, middle and southern portions of the corridor being studied. The table shows the low model forecasts at the El Paso County Line, highlighting the challenge to increase this screenline traffic without disrupting the forecasted traffic levels at the other screenlines.

Table 8: Comparison of 2015 FOCUS volumes to 2017 Traffic Counts, Average Weekday

Location	2015 FOCUS	2017 Traffic Count
I-25, between exits 184 and 185	130,300	132,800
SH-105 (Perry Park Rd), south of US-85	10,100	3,100
SH-83, south of SH-86	11,300	9,100
Total Screenline – Castle Rock	**151,700**	**145,000**
I-25, between exits 174 and 181	78,000	79,000
SH-105 (Perry Park Rd), south of Tomah Rd	7,800	3,100
SH-83, south of Gillian Ave	4,400	5,700
Total Screenline – Middle of Gap	**90,200**	**87,800**
I-25, between exits 163 and 167	63,500	77,800
SH-83, north of SH-105	2,800	8,500
Total Screenline – El Paso County Line	**66,300**	**86,300**

Sources: DRCOG FOCUS model, All Traffic Data

As described previously, we collected more extensive traffic data in the study corridor, including on I-25 between every interchange, as well as all on-ramps, off-ramps and parallel routes, and used that data to establish a higher level of model accuracy within the corridor. The calibration includes four weekday time periods (AM peak, PM peak, mid-day and overnight) plus two weekend time periods (Friday PM peak and Sunday Mid-Day) which represent the periods of greatest delay observed on the weekends traffic counts were collected.

In addition to calibrating to traffic counts, we made efforts to ensure consistency with observed travel times and travel patterns, to the extent possible. It was sometimes necessary to make trade-offs to balance consistency with the various observed conditions, and to ensure that network and matrix assumptions didn't deviate too far from reasonability.

Network and matrix calibration modifications are discussed below.

Network Modifications

Network free flow speeds were set to approximate weekday overnight travel time observations on I-25 (70 mph), eastern alternative SH-83 (between 45 and 60 mph), and western alternative CO-105 (between 37 and 52 mph). This practice at SDG ensures that the model reflects observed speed conditions of major roadways and routes in the study.

A persistent challenge in calibration was the model's slow peak travel times between C-470 and Castle Rock, particularly on parallel routes. The model was sending traffic to the Eastern and Western alternative routes instead of I-25, resulting in mainline travel volumes consistently lower than observed, and certain portions of parallel routes being slower and more congested than observed. We calibrated the links to reflect observed volumes and travel times by making the following adjustments:

- Increasing capacity to 2200 vehicles per hour per lane on I-25 between Castle Pines Parkway and C-470
- Reducing the alpha volume-delay parameter on this same segment of I-25 (this increases the volume / capacity ratio threshold for delays to occur)
- Increasing capacity on C-470 and E-470 between I-25 and the alternate routes
- Incorporating a motorway bonus by adding a 20% time penalty to links not on highways or ramps to move volume from the alternate routes
- Changing the facility type from 3 (principal arterial) to 4 (minor arterial) on rural roads connecting I-25 to these parallel routes to decrease free flow speed from 55 mph to 47 mph and thus decrease trips switching between I-25 and the parallel routes.
- Significantly reducing capacity and free flow speed on the rural (mostly dirt) roads near the gap, also to decrease the number of trips switching between I-25 and parallel routes

Table 9 shows an example of the travel times in this section of the study corridor, and the improvements achieved by means of the calibration steps above.

Table 9: Average Weekday Southbound Travel Times (in minutes), 3:00 – 7:00 PM

Segment	Observed	Modeled – Pre-Calibration	Modeled – Post-Calibration
I-25 from Plum Creek to C-470	12.9	16.7	14.4
US-85 from SH-105 to C-470	17.1	23.2	19.8
SH-83 from SH-60 to E-470	12.7	18.3	14.7

Sources: INRIX, Steer Davies Gleave

We discovered some strange movements using ramps, with travelers avoiding longer loop ramps and instead turning around and taking shorter ramps in the wrong direction. In response, we updated the turn penalty databases to prohibit U-turns which helped ramp volumes become more consistent with the traffic counts.

Due to this study's focus on the gap, we paid careful attention to match traffic volumes and travel times between Plum Creek Parkway and Palmer Divide Road. To simulate the hilliness and curvature and increased potential for congestion, we reduced capacity in the gap to 1700 vehicles per hour per lane, which was also produced slower travel times that were more consistent with the travel times observed in the INRIX data. We increased frontage road free flow speed to 50 mph to help match counts. We also increased free flow speed on Palmer Divide Road to 50 mph and hourly per lane capacity to 800, because modelled counts were significantly lower than observed.

As discussed in the section below, we took additional post-processing steps to distinguish between mainline and frontage routes and to simulate the backups caused by vehicles re-entering I-25 from the exit 174 (Tomah Road interchange) on ramp in the southbound direction.

Trip Matrix

Weekday Trip Matrices

At a certain point in model calibration, if network modifications are not completely resolving the differences between modelled and observed traffic counts and travel times, it becomes necessary to modify trip matrices. The following trip matrix adjustments enabled us to bring model output more in line with observed data:

- Adjustment of origin-destination (OD) pairs using the gap section by time period and direction to match counts as precisely as possible (mostly increasing by 15% to 35%)
- Adjustment of OD pairs using SH-83 and not I-25, mostly downward
- Adjustment of OD pairs using US-85 and not I-25, mostly upward
- Reduction of trips to / from Larkspur TAZs, due to high volumes on the Spruce Mountain Rd ramps

Weekend Trip Matrices

For each of the weekend time periods we studied (Friday 3-7 PM and Sunday 11:30 AM – 3:00 PM), the differences between the weekend and weekday traffic counts were primarily along I-25, and fairly level (mostly between 7,000 and 9,000 vehicles per day on Friday and between 1,000 and 2,000 vehicles per day on Sunday in each direction) from the Baptist Rd interchange to Downtown Castle Rock. Furthermore, ramp counts did not differ significantly between weekday and weekend periods. Therefore, we modified the weekday trip matrices in the following manner:

- We created an indicator matrix of all origin-destination pairs in the model which would involve travel on I-25 between Castle Rock (or farther north) and Monument (or farther south). We called these “end to end” O-D pairs.
- For both the PM peak and early afternoon model time periods, we computed
  - The number of trips from the weekday calibrated matrices using end to end O-D pairs in each direction
  - The approximate number of additional vehicles counted on I-25 in each direction on Friday (in the case of the PM peak) and Sunday (in the case of early afternoon)
- Finally, we computed the ratio of the second item above (additional vehicles on I-25 on Friday or Sunday) to the first (end to end trips on the weekday), and applied that ratio as a multiplicative factor to all end to end O-D pairs in the appropriate weekday time period matrix.

Table 10 shows the ‘weekend adjustment factors’ to the end to end O-D pairs to produce Friday and Sunday matrices. Note that the same factors were used on Friday in each of the three PM subperiods.

Table 10: Weekday-to-Weekend Trip Matrix Adjustment Factors to "End to End" Origin-Destination Pairs

Weekend Period	Direction	Factor
Friday 3-7 PM	Northbound	1.43
	Southbound	1.32
Sunday 11:30 AM – 3:00 PM	Northbound	1.64
	Southbound	1.50

Source: Steer Davies Gleave

Note that this does not mean, for example, that Friday southbound traffic volumes are 32% higher than weekday, but that Friday *end to end* trips are estimated to be 32% higher as evidenced by fairly consistent higher traffic differences (by 7,000-9,000 vehicles per day) all through the gap.

We made a few minor modifications to the above process to assist in calibration / validation:

- In the case of Friday southbound, we used the factor derived from end to end trips and traffic counts from 1-7 PM, to coincide with the entire time period over which significant delay was observed. This enabled us to avoid a situation where the model was being calibrated to throughput volumes rather than demand volumes.
- The differences between weekday and weekend traffic counts were smaller at the southern end of the corridor, between Baptist Rd and Academy Blvd (exit 149). Thus, we created factors similar to those in Table 10 to apply to trips between the southern I-25 external station and zones immediately to the north. These factors ranged from 0.8 to 0.95 and improved the validation of traffic counts in the southern end of the corridor.
- We applied additional factors of 2/3 and 1/3 to truck trips on Friday and Sunday, respectively. These factors were based on count data as well.[4]

Post-Processing

The adjustments outlined above enabled the model to validate observed conditions in the corridor within acceptable levels in most cases, but the 3-7 PM conditions on I-25 between Exits 181 (Plum Creek Parkway) and 174 (Sky View Lane / Tomah Rd) in the southbound direction were a challenge for the model to reproduce and required some post-processing, as discussed below.

The 7-mile section of I-25 between exits 181 and 174 often experiences large southbound afternoon delays, especially on Friday; on the Friday of traffic count data collection (August 4th), travel times on this 7-mile section were as high as 25 minutes, corresponding to an average speed of 18 MPH. The travel demand model produced speeds only as low as 39 MPH. Conversely, the model was producing slightly slower speeds on this section on weekday afternoons than observed (49 MPH vs 60 MPH).

[4] Although RV traffic is likely higher on Fridays and Sundays, RVs are counted and modeled with trucks, and the decrease in actual trucks more than offsets the increase in RVs.

Table 11: 3-7 PM Southbound Observed and Modeled Traffic Volumes and Speeds, Prior to Post-Processing

		Weekday		Friday	
		Observed	Modeled	Observed	Modeled
Traffic Counts	I-25 North of Exit 181 (Plum Creek Pkwy)	15,700	15,800	15,800	16,600
	Exit 181 Off Ramp	5,000	3,700	6,800	3,500
	I-25 South of Exit 181 (at Lane Drop)	11,100	12,600	9,300	13,700
	Exit 174 On Ramp	1,100	400	3,900	300
	I-25 South of Exit 174 (Sky View Ln / Tomah Rd)	12,200	12,800	12,900	13,800
Slowest Southbound PM Peak Travel Speed, Exits 181 to 174 (MPH)		60	49	18	39

Source: Steer Davies Gleave

As shown in Table 11, the model was producing volumes on I-25 immediately to the north of this section that very closely replicated observed traffic counts, both on weekdays and Fridays. However, it was not fully capturing the level of diversion to frontage roads, overestimating traffic remaining on I-25 and underestimating traffic on both the Exit 181 off ramp and Exit 174 on ramp by the same magnitude. The traffic split between two parallel routes such as these is often difficult for a link-based travel demand model to replicate, because it can't directly take micro-level traffic operations considerations, such as signals, queuing or reliability, into account.

The deviance between weekday modeled and observed traffic counts and travel speeds was consistent – modeled volumes on I-25 were high and travel speeds were slower than observed, whereas the Friday ones did not – volumes on I-25 were also high, yet travel speeds were faster than observed, and both differed from observations to a greater extent than on the weekday.

However, the comparison between modeled I-25 traffic volumes on Friday vs the weekday (13,700 vs 12,600) was consistent with the delays on Friday (delays on the weekdays are minimal). The reason the difference between modeled and observed volumes were so much higher on Friday than weekdays was that traffic counts were lower on Friday (9,300 vs 11,100).

At first, this would appear counterintuitive; how could Friday traffic counts be lower than on the weekday, yet delays be higher? Elsewhere along I-25, as discussed earlier in this memo, traffic counts were largely higher on Friday than on the weekdays[5]. Friday also had much higher counts on the Exit 181 off ramp, frontage roads, and Exit 174 on ramp. Thus, we concluded that the lower observed Friday traffic count on I-25 between exits 181 and 174 compared to the weekdays was not a case of reduced demand, but of reduced throughput due to queuing and turbulence.

[5] In some cases near this critical section, Friday traffic counts from 3-7 PM were approximately equal to weekday traffic counts; we believe this is also due to the demand vs throughput effect, most easily observed just south of exit 181, but still present elsewhere. Friday delays began between 1 and 2 PM and end around 7 PM; traffic counts over the six hour 1-7 PM period, during which demand and throughput equalize, were uniformly higher on Friday than on the weekdays

The other reason that volumes could be too high on Friday and yet speeds could still be too fast is that the delays are caused not just by increased demand, but by the diversion to frontage roads itself. Travel speeds, obtained from INRIX data, on Friday August 4th, 2017, began to slow at the Exit 174 on ramp, i.e. the point where vehicles which diverted to the frontage roads merged back onto I-25, between 1:00 and 2:00 PM. These slower speeds gradually moved upstream, as far north as Exit 182, reaching their peak delay at about 5:00 PM, before gradually improving. Appendix B shows the INRIX data that illustrate this trend, and also shows that the level of delay moved closely in tandem with the observed traffic volumes on the Exit 174 on ramp.

Thus, we concluded that the delays and queuing in this direction were also a consequence of the high volumes and turbulence inducement of merging traffic from the frontage roads at the exit 174 on ramp. These delays can't easily be captured by a link-based travel demand model where individual links' delays are independent from each other, and queue spillback can't be modeled explicitly.

We determined that best way to enable the model to reproduce these conditions would be with two post-processing steps:

1. Shifting some traffic away from I-25 onto the Exit 181 off ramp, the frontage roads, and the Exit 174 on ramp, consistent with observed conditions
2. Reducing capacity on I-25, by an amount which depends on the amount of traffic on the Exit 174 on ramp to reflect the added friction caused by high levels of merging traffic.

Table 12 shows the capacity modifications that were necessary to validate the observed travel times and speeds on this 7-mile section of I-25, both on the weekdays and Friday.

Table 12: Calibration Post-Processing of Capacities on I-25, Southbound 3-7 PM

	Weekday			Friday		
	3-5 PM	5-6 PM	6-7 PM	3-5 PM	5-6 PM	6-7 PM
Exit 174 On Ramp PCE Per Hour	250	500	150	975	1050	875
I-25 Hourly Vehicle Capacity						
3-lane section s/o Exit 181	5,250	5,100	6,000	2,450	2,450	2,100
2-lane section s/o Exit 181 after lane drop	3,500	3,300	4,000	2,450	2,450	2,100
Immediate downstream of Exit 174 on ramp	4,000	4,000	4,000	3,400	3,400	3,400

Note: All capacities shown are total directional I-25 capacity per hour

Source: Steer Davies Gleave

This post-processing along with improved free-flow speeds enabled us to use a consistent methodology to both decrease the modeled speed on this portion of I-25 significantly on Friday, but also increase the modeled speed slightly on weekdays, to bring the modeled speed in line with observed speed in both cases. With the post-processing steps outlined above, shifting a large amount of traffic off I-25 on Friday increased delay, because that traffic was not shifted off the corridor completely, but instead shifted to a diversion route that involved merging back onto I-25 at Exit 174. Due to the capacity reduction for the mainline, this caused more delay than if it the traffic had stayed on I-25. Conversely, on the weekday, only a small amount of traffic was shifted in this way, so the Exit 174 merge had little effect, and travel speeds on I-25 improved slightly.

Making the changes to capacities shown in Table 12, along with shifting volumes from I-25 to the appropriate ramps and frontage roads (about 750 vehicles on the weekday and 3,500 on Friday) enabled us to validate both traffic counts and travel times. On the weekday, shifting a small number of vehicles to the frontage road increased speeds moderately, and not enough new vehicles were re-entering on the Sky View on ramp to warrant capacity reductions on I-25. On Friday, however, we shifted a much larger number of vehicles to the frontage road and subsequent Sky View re-entry, enough to warrant a significant capacity reduction on I-25. This more than offset the volume reduction from the shift, and decreased speeds significantly.

The post-processing was discussed in detail with a group that included travel demand modelers from both the DRCOG (Scott Ramming) and PPACG (Ken Prather) MPOs as well as CDOT (Erik Sabina) in a phone call on October 23rd, 2017. The group agreed that this approach was reasonable to deal with this unique set of conditions that apply to the southbound direction of I-25 in the afternoon and evening.

Model Validation Results

Traffic Counts

Table 13 and Table 14 present the traffic counts on the mainline for weekday peak periods and weekend (Friday and Sunday) periods, respectively. As a general rule, our target is for most modeled volumes on key highway facilities to fall within 10% of the observed volumes, with an emphasis in the areas of interest.

Validation between Palmer Divide Road and Plum Creek Parkway is particularly refined, reflecting how we prioritized calibrating the gap for this study. Appendix A contains complete volume calibration results for all segments of I-25 collected, as well as several critical frontage roads and parallel route segments. The modeled volumes on the frontage roads includes gap diversion adjustments.

Table 13: Weekday Peak Period Mainline Calibration Volumes

I-25 Location		Count		Model Volume		% Difference	
		6:30 – 9 AM	3-7 PM	6:30 – 9 AM	3-7 PM	6:30 – 9 AM	3-7 PM
N/O Baptist Rd	NB	7,700	12,900	8,400	14,000	9%	9%
	SB	7,200	13,800	7,400	14,800	3%	7%
N/O Palmer Divide Rd	NB	6,800	9,700	6,600	9,800	-2%	1%
	SB	4,700	11,600	4,800	11,600	2%	0%
S/O Plum Creek Pkwy	NB	7,200	9,900	7,500	10,600	4%	7%
	SB	4,800	11,100	5,200	11,900	8%	7%
N/O Founders Pkwy	NB	14,500	15,700	15,300	17,400	5%	11%
	SB	7,700	21,600	8,700	22,900	13%	6%

Source: Steer Davies Gleave

Table 14: Weekend Mainline Calibration Volumes

I-25 Location		Count		Model Volume		% Difference	
		Friday 3-7 PM	Sunday 11:30 AM – 3 PM	Friday 3-7 PM	Sunday 11:30 AM – 3 PM	Friday 3-7 PM	Sunday 11:30 AM – 3 PM
N/O Baptist Rd	NB	14,700	12,500	15,700	13,500	7%	8%
	SB	14,700	11,800	16,100	12,500	9%	6%
N/O Palmer Divide Rd	NB	11,800	11,100	11,400	10,900	-3%	-2%
	SB	12,100	10,200	12,700	10,000	5%	-2%
S/O Plum Creek Pkwy	NB	11,800	10,800	12,200	11,400	3%	6%
	SB	9,300	10,000	10,200	10,600	10%	6%
N/O Founders Pkwy	NB	17,100	16,200	18,900	16,100	10%	-1%
	SB	20,900	16,100	24,100	15,400	15%	-4%

Source: Steer Davies Gleave

Travel Times

We calibrated travel times to match INRIX travel time data on I-25 from Academy Blvd. to C-470, shown for the AM and PM periods northbound in Table 15 and southbound in **Error! Reference source not found.**.

Table 15: Weekday Travel Time Calibration- Northbound

I-25 Location	Observed Travel Time (min)		Modeled Travel Time (min)	
	6:30 –9 AM	3-7 PM	6:30 –9 AM	3-7 PM
Academy to Palmer Divide	12.9	11.7	12.2	12.2
Palmer Divide to Upper Lake Gulch	8.3	7.2	8.9	8.5
Upper Lake Gulch to Plum Creek	8.3	7.8	9.9	9.1
Plum Creek to Castle Pines	8.4	6.6	7.9	6.9
Castle Pines to CO-470	8.2	5.0	6.6	5.2
CUMULATIVE	**46.1**	**38.2**	**45.4**	**41.8**

Source: Steer Davies Gleave

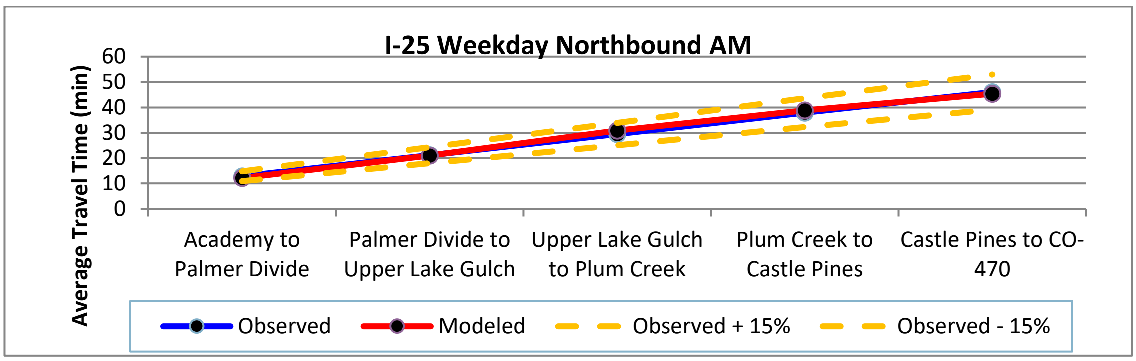
Table 16: Weekday Travel Time Calibration- Southbound

I-25 Location	Observed Travel Time (min)		Modeled Travel Time (min)	
	6:30 –9 AM	3-7 PM	6:30 –9 AM	3-7 PM
CO-470 to Castle Pines	5.7	5.6	5.3	6.3
Castle Pine to Plum Creek	6.8	6.6	6.7	8.2
Plum Creek to Upper Lake Gulch	8.4	9.4	8.4	9.5
Upper Lake Gulch to Palmer Divide	8.3	9.3	7.6	9.4
Palmer Divide to Academy	12.5	10.7	11.6	12.3
CUMULATIVE	**41.7**	**41.5**	**39.5**	**45.7**

Source: Steer Davies Gleave

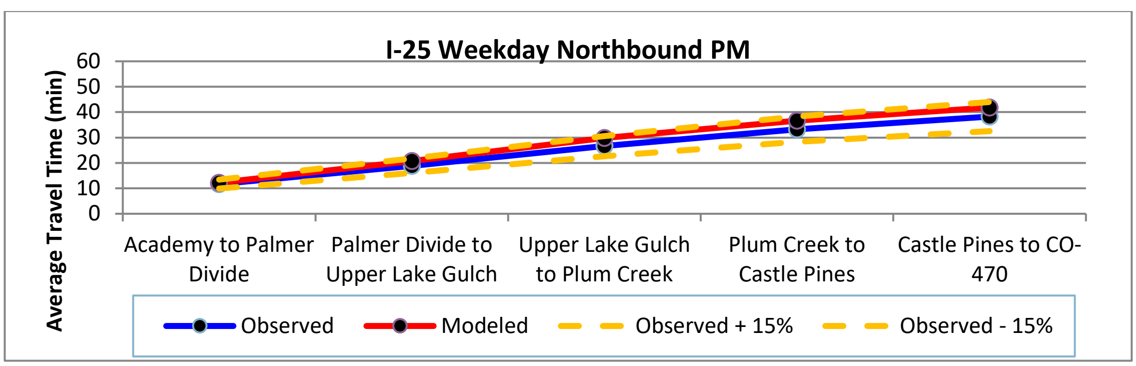
The next four figures show that the model falls within the target range of 15% for observed travel times in both directions during weekday peak periods.

Figure 5: I-25 Mainline Travel Time Calibration – Weekday Northbound AM



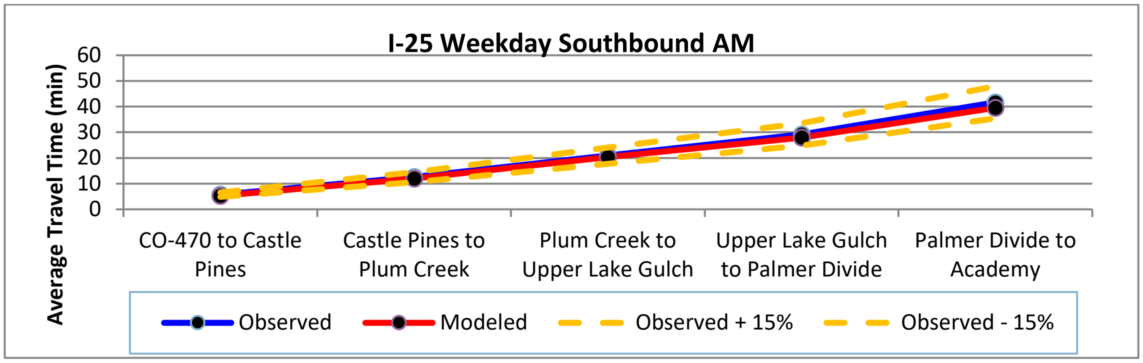
Source: Steer Davies Gleave

Figure 6: I-25 Mainline Travel Time Calibration – Weekday Northbound PM



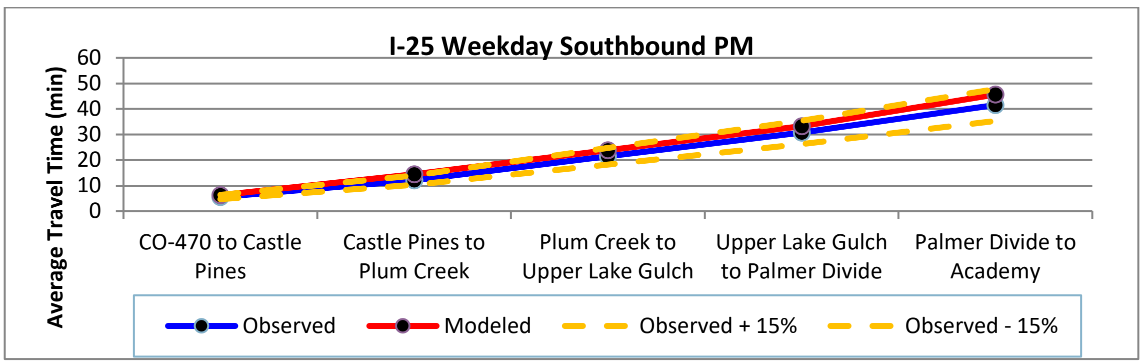
Source: Steer Davies Gleave

Figure 7: I-25 Mainline Travel Time Calibration – Weekday Southbound AM



Source: Steer Davies Gleave

Figure 8: I-25 Mainline Travel Time Calibration – Weekday Southbound PM



Source: Steer Davies Gleave

Weekend travel time calibration is presented in Table 17 and Table 18. We gave special attention to calibrating the PM peak southbound on Friday afternoons, given the high congestion in the gap during that period.

Table 17: Weekend Travel Time Calibration - Northbound

I-25 Location	Observed Travel Time (min)		Modeled Travel Time (min)	
	Fri 3-7 PM	Sun 11:30 AM – 3 PM	Fri 3-7 PM	Sun 11:30 AM – 3 PM
Academy to Palmer Divide	12.6	12.4	12.5	12.2
Palmer Divide to Upper Lake Gulch	7.8	8.6	9.5	9.9
Upper Lake Gulch to Plum Creek	8.9	11.4	10.1	10.4
Plum Creek to Castle Pines	6.5	6.5	7.0	6.8
Castle Pine to CO-470	5.1	4.8	5.2	5.1
CUMULATIVE	**40.9**	**43.7**	**44.3**	**44.5**

Source: Steer Davies Gleave

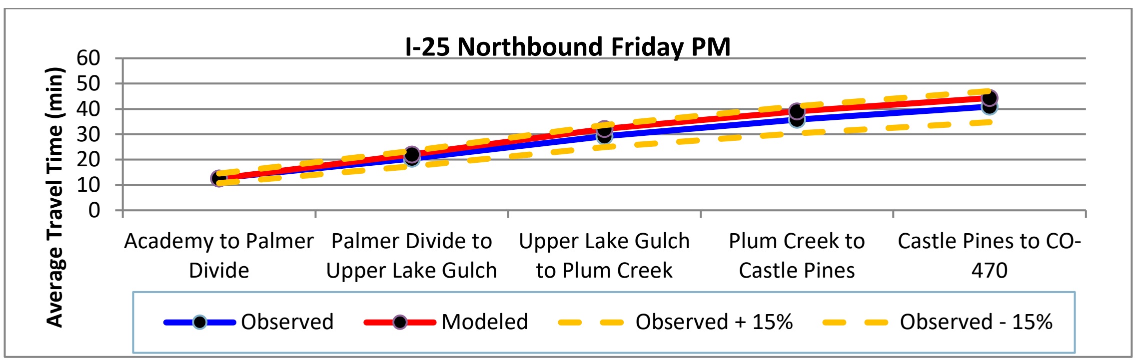
Table 18: Weekend Travel Time Calibration- Southbound

I-25 Location	Observed Travel Time (min)		Modeled Travel Time (min)	
	Fri 3-7 PM	Sun 11:30 AM – 3 PM	Fri 3-7 PM	Sun 11:30 AM – 3 PM
CO-470 to Castle Pines	6.4	5.1	6.4	5.4
Castle Pine to Plum Creek	7.2	6.4	8.3	6.9
Plum Creek to Upper Lake Gulch	25.9	8.6	20.6	9.8
Upper Lake Gulch to Palmer Divide	8.7	8.3	10.4	8.9
Palmer Divide to Academy	10.8	10.6	12.7	11.9
CUMULATIVE	**59.0**	**39.0**	**58.3**	**42.8**

Source: Steer Davies Gleave

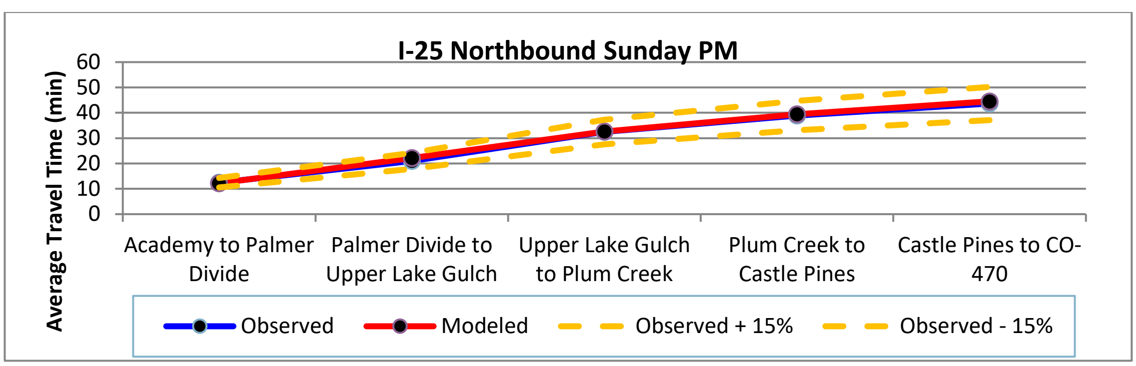
The next four figures show that the model falls within the 15% range of observed travel times in both directions during weekend peak periods.

Figure 9: I-25 Mainline Travel Time Calibration- Northbound Friday PM



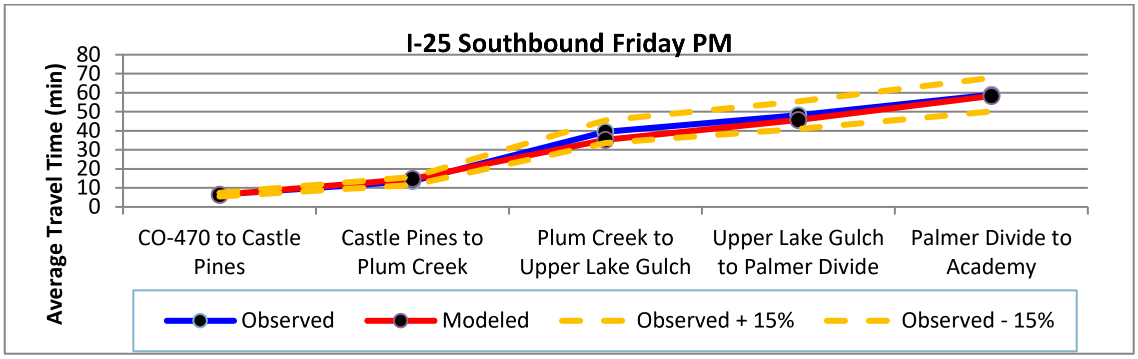
Source: Steer Davies Gleave

Figure 10: I-25 Mainline Travel Time Calibration- Northbound Sunday PM



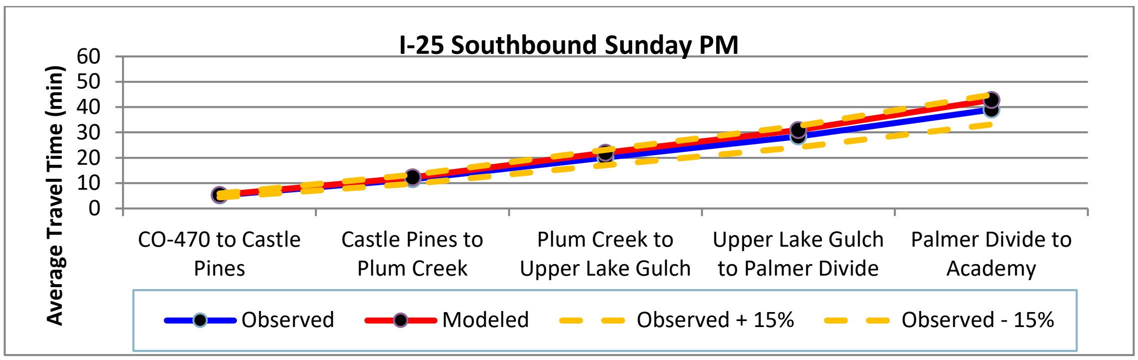
Source: Steer Davies Gleave

Figure 11: I-25 Mainline Travel Time Calibration- Southbound Friday PM



Source: Steer Davies Gleave

Figure 12: I-25 Mainline Travel Time Calibration- Southbound Sunday PM



Source: Steer Davies Gleave

Development of Forecast Year Model

SDG is developing both horizon year (2040) and opening year (2021) forecasts for the Environmental Assessment document.

Horizon Year (2040) Network

Starting with the calibrated 2017 network, we modified the following attributes to reflect their 2040 network values from the MPO model network files as received:

- Area type
- Facility Type
- Number of Lanes
- Toll Charge on C/E-470

Additionally, we included (in both the No Build and Build 2040 networks) all roadway facilities present in the 2040 networks but not in the 2015 networks. Those in the project study area included:

- Managed lanes on C-470 between I-25 and Kipling Pkwy
- New diamond interchange at I-25 and Crystal Valley Pkwy
- N/S connector between Lincoln Ave and Ridgegate Pkwy to the east of I-25 (and to the west of Peoria St)

- E/W connector from Sky Ridge Medical Center to Peoria St, between Lincoln Ave and Ridgegate Pkwy
- Two N/S connectors from Hess Ave to Crowfoot Valley Rd (one near I-25, one near SH-83)
- Woodlands Blvd N/S connector between Black Feather Tr and Scott Blvd (in Castle Rock)
- Valley Dr N/S connector between South St and Plum Creek Parkway (in Castle Rock)
- SH-21 northward / westward extension to new diamond interchange with I-25 between Interquest Pkwy and N Gate Rd

Horizon Year (2040) Trip Matrix

We derived 2040 trip matrices by applying a pivot method to the calibrated 2017 trip matrices, as follows:

- For all zones other than the five new external stations (2894-2898), we computed “target” total origins and destinations for each time period, by adding the difference between the 2040 and 2015 totals in the MPO model matrices to the 2017 calibrated matrix totals.
- For the five new external stations, we computed the targets by adding the origins from (or destinations to) all zones in the PPACG model other than those which were included in the I-25 and disaggregated to the relative traffic counts from (or to) each of the five stations in the StreetLight Data OD data.
- We applied an iterative “fratar” process to the 2017 matrices, using the 2040 row and column targets computed in the above steps.

To obtain 2040 weekend matrices, we applied the same adjustment factors used in the development of 2017 weekend matrices to the appropriate weekday time periods.

Value of Time Estimates (all forecasts with express lanes)

As described in the data collection section of this memo, the US-36 Express lanes transaction data provided continuous traffic count data and allowed us to estimate the portion of traffic using managed lanes and their travel time savings. In combination with toll rate data and managed lane share analysis, this enabled us to estimate value of time for the upper-percentile travelers, i.e. those with the highest values of time, who were willing to pay the toll to save travel time.

Table 19: Value of Time Classes

Class	Value of Time ($/hour)
1	3.00
2	7.20
3	12.00
4	16.20
5	21.00
6	27.60
7	36.00
8	60.00

Source: Steer Davies Gleave

However, this only provides values of time for those travelers who are willing to pay the toll charged for the time savings realized at some point during the day, which is roughly 24% of traffic[6]. We estimated the values of time for the remaining travelers based upon Denver MSA census income setting a median value of time of $18 per hour, consistent with the original FOCUS model input and the upper-percentile results calculated from the US-36 toll transactions. Table 19 presents the results of the value of time analysis. The decision to use eight classes specifically was based on a trade-off between representing variation of traveler preferences and model run time. The classes represent the midpoints of eight equally sized groups, each with 12.5% of trips.

It is now well accepted that managed lanes users are not only paying for travel time savings, but are also paying for increased reliability and other perceived benefits such as safety improvements and comfort. The FOCUS model includes a “toll bonus” of 8 cents per mile on tolled facilities, and we retained this assumption for the I-25 managed lanes. This effectively reduces the cost of the managed lanes by 8 cents per mile during the highway assignment step, where travelers are assigned to routes based on minimizing their generalized trip costs.

Post-Processing (all forecasts, including No Build)

On I-25 between Plum Creek Parkway and Sky View Lane in the Weekday and Friday PM periods, SDG applied the two southbound post-processing steps from calibration discussed earlier in this memo, in the following manner:

1. Shifting the same volume of traffic away from I-25 onto the Exit 181 off ramp, frontage roads and Exit 174 on ramp that was shifted in base year calibration
2. Reducing capacity by amounts which vary, depending on the volumes on the Exit 174 on ramp. These reductions were equal to or greater than in the base year, due to the higher overall level of traffic. We ensured consistent capacities among the various alternatives we ran.

Opening Year (2021)

The assumptions supporting 2021 forecasts were:

- We interpolated trip matrices linearly between 2017 and 2021.
- As an exception to the above, we did not grow trips to or from the model zones containing planned development projects in several TAZs in southern Castle Rock near Crystal Valley Parkway and Plum Creek Parkway, i.e. we would assume those development projects not to begin before 2021.
- We retained the highway network from 2017 as is for the No Build forecasts, adding only the proposed I-25 improvements for the Build forecasts.

[6] In other words, 24% is the highest capture rate observed on US-36, when the value of time threshold for choosing the express lanes is at its lowest. The remaining 76% of travelers do not have a high enough value of time for the express lanes ever to be an attractive route choice.

Appendix A: Traffic Count Calibration

Weekday Mainline Volumes Calibration Northbound

Start	End	Observed Volumes AM	PM	MD	NT	Modeled Volumes AM	PM	MD	NT	Percent Difference AM	PM	MD	NT	Difference (GEH) AM	PM	MD	NT
Exit 158 (Baptist)	Exit 161 (2nd St Monument/SH-105)	7,670	12,881	16,666	10,204	8,370	13,985	18,269	10,754	9%	9%	10%	5%	4.9	4.8	5.0	1.6
Exit 161 (2nd St Monument/SH-105)	Exit 163 (Palmer Divide)	6,254	9,681	13,728	8,830	6,668	10,701	14,633	8,999	7%	11%	7%	2%	3.3	5.1	3.1	0.5
Exit 163 (Palmer Divide)	Exit 167 (Greenland)	6,814	9,679	14,072	8,705	6,649	9,774	14,193	8,792	-2%	1%	1%	1%	1.3	0.5	0.4	0.3
Exit 167 (Greenland)	Exit 172 (Upper Lake Gulch)	6,929	9,753	14,022	8,735	6,818	9,909	14,421	8,859	-2%	2%	3%	1%	0.8	0.8	1.4	0.4
Exit 172 (Upper Lake Gulch)	Exit 173 (Spruce Mountain)	6,885	9,638	13,922	8,675	6,804	9,895	14,398	8,832	-1%	3%	3%	2%	0.6	1.3	1.6	0.5
Exit 173 (Spruce Mountain)	Exit 174 (Sky View)	7,281	10,054	14,594	8,941	7,523	10,699	15,422	9,193	3%	6%	6%	3%	1.8	3.2	2.8	0.8
Exit 174 (Sky View)	Exit 179 (Crystal Valley)	7,191	9,860	14,339	8,839	7,498	10,560	15,290	9,083	4%	7%	7%	3%	2.3	3.5	3.2	0.8
Exit 179 (Crystal Valley)	Exit 181 (Plum Creek)	7,191	9,860	14,339	8,839	7,498	10,560	15,290	9,083	4%	7%	7%	3%	2.3	3.5	3.2	0.8
Exit 181 (Plum Creek)	Exit 182 (Wilcox)	9,848	11,923	17,736	10,346	9,635	12,634	17,478	9,712	-2%	6%	-1%	-6%	1.4	3.2	0.8	1.9
Exit 182 (Wilcox)	Exit 184 (Founders/ Meadows)	10,902	13,453	19,834	11,386	11,634	15,416	20,636	11,735	7%	15%	4%	3%	4.4	8.2	2.3	1.0
Exit 184 (Founders/ Meadows)	Exit 185 (Castle Rock)	14,528	15,681	23,895	13,991	15,288	17,391	23,110	12,442	5%	11%	-3%	-11%	3.9	6.6	2.1	4.0
Exit 185 (Castle Rock)	Exit 187 (Happy Canyon)	15,373	15,511	24,298	13,105	16,581	18,659	24,819	13,185	8%	20%	2%	1%	6.0	12.0	1.4	0.2
Exit 187 (Happy Canyon)	Exit 188 (Hess/Castle Pines)	16,055	16,174	25,328	13,410	17,942	20,251	26,355	13,709	12%	25%	4%	2%	9.2	15.1	2.6	0.8
Exit 188 (Hess/Castle Pines)	Exit 192 (Ridgegate)	16,223	15,351	25,322	12,346	20,102	21,328	28,830	14,680	24%	39%	14%	19%	18.2	22.1	8.7	5.9
Exit 192 (Ridgegate)	Exit 193 (Lincoln)	16,885	16,557	27,639	14,634	19,685	20,638	29,032	16,166	17%	25%	5%	10%	13.1	15.0	3.4	3.6
Exit 193 (Lincoln)	Exit 195 (C-470/E-470)	19,408	23,389	34,676	19,262	22,238	24,239	33,191	18,067	15%	4%	-4%	-6%	12.4	2.8	3.3	2.6

Source: Steer Davies Gleave

Weekday Mainline Volumes Calibration Southbound

Start	End	Observed Volumes AM	Observed Volumes PM	Observed Volumes MD	Observed Volumes NT	Modeled Volumes AM	Modeled Volumes PM	Modeled Volumes MD	Modeled Volumes NT	Percent Difference AM	Percent Difference PM	Percent Difference MD	Percent Difference NT	Difference (GEH) AM	Difference (GEH) PM	Difference (GEH) MD	Difference (GEH) NT
Exit 193 (Lincoln)	Exit 195 (C-470/E-470)	13,576	31,403	33,832	20,722	11,441	32,292	30,930	19,043	-16%	3%	-9%	-8%	12.1	2.5	6.6	3.5
Exit 192 (Ridgegate)	Exit 193 (Lincoln)	8,712	26,356	26,529	16,410	9,399	28,448	25,047	16,320	8%	8%	-6%	-1%	4.6	6.3	3.8	0.2
Exit 188 (Hess/Castle Pines)	Exit 192 (Ridgegate)	7,616	25,082	24,033	14,698	10,211	29,759	25,383	16,076	34%	19%	6%	9%	17.4	14.1	3.5	3.3
Exit 187 (Happy Canyon)	Exit 188 (Hess/Castle Pines)	8,301	24,489	24,151	14,312	10,170	27,090	23,563	14,588	23%	11%	-2%	2%	12.3	8.1	1.6	0.7
Exit 185 (Castle Rock)	Exit 187 (Happy Canyon)	7,895	23,506	23,256	13,800	9,202	24,928	22,157	13,889	17%	6%	-5%	1%	8.9	4.6	3.0	0.2
Exit 184 (Founders/Meadows)	Exit 185 (Castle Rock)	7,689	21,613	22,223	13,139	8,660	22,945	20,563	12,987	13%	6%	-7%	-1%	6.8	4.5	4.6	0.4
Exit 182 (Wilcox)	Exit 184 (Founders/Meadows)	6,754	17,874	19,666	11,702	7,787	18,721	18,493	12,154	15%	5%	-6%	4%	7.7	3.1	3.5	1.2
Exit 181 (Plum Creek)	Exit 182 (Wilcox)	5,739	15,699	17,154	10,652	5,949	15,715	15,058	9,854	4%	0%	-12%	-7%	1.7	0.1	6.7	2.3
Exit 179 (Crystal Valley)	Exit 181 (Plum Creek)	4,810	11,083	13,846	9,036	5,213	11,882	13,301	9,234	8%	7%	-4%	2%	3.6	3.7	1.9	0.6
Exit 174 (Sky View)	Exit 179 (Crystal Valley)	4,810	11,083	13,846	9,036	5,213	11,882	13,301	9,234	8%	7%	-4%	2%	3.6	3.7	1.9	0.6
Exit 173 (Spruce Mountain)	Exit 174 (Sky View)	4,904	12,171	14,050	9,089	5,307	12,782	13,465	9,346	8%	5%	-4%	3%	3.6	2.7	2.0	0.8
Exit 172 (Upper Lake Gulch)	Exit 173 (Spruce Mountain)	4,690	11,465	13,377	8,776	4,865	11,817	12,590	8,871	4%	3%	-6%	1%	1.6	1.6	2.8	0.3
Exit 167 (Greenland)	Exit 172 (Upper Lake Gulch)	4,746	11,579	13,545	8,826	4,885	11,826	12,619	8,881	3%	2%	-7%	1%	1.3	1.1	3.3	0.2
Exit 163 (Palmer Divide)	Exit 167 (Greenland)	4,745	11,549	13,465	8,715	4,829	11,555	12,438	8,779	2%	0%	-8%	1%	0.8	0.0	3.7	0.2
Exit 161 (2nd St Monument/SH-105)	Exit 163 (Palmer Divide)	5,003	11,155	13,330	8,802	5,279	11,373	12,820	8,673	6%	2%	-4%	-1%	2.4	1.0	1.8	0.4
Exit 158 (Baptist)	Exit 161 (2nd St Monument/SH-105)	7,165	13,839	16,983	10,130	7,375	14,778	16,852	10,465	3%	7%	-1%	3%	1.6	3.9	0.4	1.0

Source: Steer Davies Gleave

Weekend Mainline Volumes Calibration Northbound

Start	End	Observed Volumes		Modeled Volumes		Percent Difference		Difference (GEH)	
		FR	SU	FR	SU	FR	SU	FR	SU
Exit 158 (Baptist)	Exit 161 (2nd St Monument/SH-105)	14,654	12,522	15,654	13,533	7%	8%	4.1	4.7
Exit 161 (2nd St Monument/SH-105)	Exit 163 (Palmer Divide)	11,758	10,940	12,317	11,158	5%	2%	2.5	1.1
Exit 163 (Palmer Divide)	Exit 167 (Greenland)	11,798	11,124	11,433	10,872	-3%	-2%	1.7	1.3
Exit 167 (Greenland)	Exit 172 (Upper Lake Gulch)	11,854	11,088	11,565	10,995	-2%	-1%	1.3	0.5
Exit 172 (Upper Lake Gulch)	Exit 173 (Spruce Mountain)	11,759	10,988	11,554	10,986	-2%	0%	0.9	0.0
Exit 173 (Spruce Mountain)	Exit 174 (Sky View)	12,219	11,450	12,281	11,519	1%	1%	0.3	0.3
Exit 174 (Sky View)	Exit 179 (Crystal Valley)	11,845	10,845	12,173	11,447	3%	6%	1.5	3.0
Exit 179 (Crystal Valley)	Exit 181 (Plum Creek)	11,845	10,845	12,173	11,447	3%	6%	1.5	3.0
Exit 181 (Plum Creek)	Exit 182 (Wilcox)	14,283	13,109	14,111	12,696	-1%	-3%	0.7	1.9
Exit 182 (Wilcox)	Exit 184 (Founders/Meadows)	15,866	14,574	16,913	14,616	7%	0%	4.1	0.2
Exit 184 (Founders/Meadows)	Exit 185 (Castle Rock)	17,130	16,207	18,880	16,076	10%	-1%	6.5	0.5
Exit 185 (Castle Rock)	Exit 187 (Happy Canyon)	18,130	16,655	20,134	17,041	11%	2%	7.2	1.6
Exit 187 (Happy Canyon)	Exit 188 (Hess/Castle Pines)	-	-	21,704	17,959	-	-	-	-
Exit 188 (Hess/Castle Pines)	Exit 192 (Ridgegate)	19,781	17,289	22,815	19,275	15%	11%	10.4	7.9
Exit 192 (Ridgegate)	Exit 193 (Lincoln)	-	-	22,156	19,366	-	-	-	-
Exit 193 (Lincoln)	Exit 195 (C-470/E-470)	-	-	25,439	21,800	-	-	-	-

Source: Steer Davies Gleave

Weekend Mainline Volumes Calibration Southbound

Start	End	Observed Volumes		Modeled Volumes		Percent Difference		Difference (GEH)	
		FR	SU	FR	SU	FR	SU	FR	SU
Exit 193 (Lincoln)	Exit 195 (C-470/E-470)	-	-	33,170	22,288	-	-	-	-
Exit 192 (Ridgegate)	Exit 193 (Lincoln)	-	-	29,606	18,480	-	-	121.7	102.8
Exit 188 (Hess/Castle Pines)	Exit 192 (Ridgegate)	24,157	17,183	30,917	18,722	28%	9%	20.4	6.1
Exit 187 (Happy Canyon)	Exit 188 (Hess/Castle Pines)	-	-	28,184	17,379	-	-	-	-
Exit 185 (Castle Rock)	Exit 187 (Happy Canyon)	23,060	16,995	26,047	16,488	13%	-3%	9.5	2.1
Exit 184 (Founders/Meadows)	Exit 185 (Castle Rock)	20,899	16,074	24,082	15,400	15%	-4%	10.6	2.9
Exit 182 (Wilcox)	Exit 184 (Founders/Meadows)	17,936	13,529	19,736	13,878	10%	3%	6.6	1.6
Exit 181 (Plum Creek)	Exit 182 (Wilcox)	15,765	12,095	16,697	11,696	6%	-3%	3.7	2.0
Exit 179 (Crystal Valley)	Exit 181 (Plum Creek)	9,277	9,996	10,182	10,595	10%	6%	4.6	3.2
Exit 174 (Sky View)	Exit 179 (Crystal Valley)	9,277	9,996	10,182	10,595	10%	6%	4.6	3.2
Exit 173 (Spruce Mountain)	Exit 174 (Sky View)	12,821	10,499	13,844	10,705	8%	2%	4.4	1.1
Exit 172 (Upper Lake Gulch)	Exit 173 (Spruce Mountain)	12,108	10,126	13,011	10,117	7%	0%	4.0	0.0
Exit 167 (Greenland)	Exit 172 (Upper Lake Gulch)	12,231	10,206	13,018	10,134	6%	-1%	3.5	0.4
Exit 163 (Palmer Divide)	Exit 167 (Greenland)	12,096	10,170	12,748	10,009	5%	-2%	2.9	0.9
Exit 161 (2nd St Monument/SH-105)	Exit 163 (Palmer Divide)	12,059	10,197	12,574	10,188	4%	0%	2.3	0.0
Exit 158 (Baptist)	Exit 161 (2nd St Monument/SH-105)	14,721	11,811	16,075	12,524	9%	6%	5.5	3.5

Source: Steer Davies Gleave

Table 1:Weekday Surface Roads Volumes Calibration

Location		Observed Volumes				Modeled Volumes				Percent Difference				Difference (GEH)			
		AM	PM	MD	NT	AM	PM	MD	NT	AM	PM	MD	NT	AM	PM	MD	NT
Frontage Rd W Side of I-25 just south of Plum Creek Pkwy	NB	750	610	1,079	390	407	695	606	222	-46%	14%	-44%	-43%	9.0	1.7	6.7	2.8
Frontage Rd W Side of I-25 just south of Plum Creek Pkwy	SB	690	2,146	1,711	967	678	2,021	1,196	699	-2%	-6%	-30%	-28%	0.3	1.4	5.5	2.7
Frontage Rd E Side of I-25 just south of Crystal Valley Pkwy	NB	365	438	627	180	85	133	165	88	-77%	-70%	-74%	-51%	11.8	9.0	9.5	2.3
Frontage Rd E Side of I-25 just south of Crystal Valley Pkwy	SB	173	782	578	242	71	394	143	98	-59%	-50%	-75%	-59%	5.8	8.0	9.4	3.2
Santa Fe Dr (US-85) just south of C-470	NB	4,981	7,304	9,036	3,605	5,342	7,595	8,808	3,641	7%	4%	-3%	1%	3.2	1.7	1.0	0.2
Santa Fe Dr (US-85) just south of C-470	SB	4,619	6,842	9,054	4,416	4,677	7,702	8,103	4,563	1%	13%	-10%	3%	0.5	5.0	4.2	0.6
Perry Park Rd (SH-105) just south of Tomah Rd	NB	415	312	582	209	451	380	381	194	9%	22%	-35%	-7%	1.1	1.8	3.7	0.3
Perry Park Rd (SH-105) just south of Tomah Rd	SB	119	725	523	247	192	809	352	189	62%	12%	-33%	-23%	3.7	1.5	3.3	1.2
SH-83 Just south of E-470	NB	6,854	7,109	9,376	5,968	7,472	7,680	10,400	5,328	9%	8%	11%	-11%	4.6	3.3	4.2	2.5
SH-83 Just south of E-470	SB	4,617	10,942	11,466	5,761	4,422	11,001	12,527	6,337	-4%	1%	9%	10%	1.8	0.3	4.0	2.2
SH-83 just south of Gillian Ave	NB	559	822	889	467	640	636	773	320	15%	-23%	-13%	-31%	2.1	3.4	1.6	2.2
SH-83 just south of Gillian Ave	SB	431	1,194	907	519	265	993	552	302	-38%	-17%	-39%	-42%	5.6	3.0	5.4	3.1

Source: Steer Davies Gleave

Table 2: Weekend Surface Roads Volumes Calibration

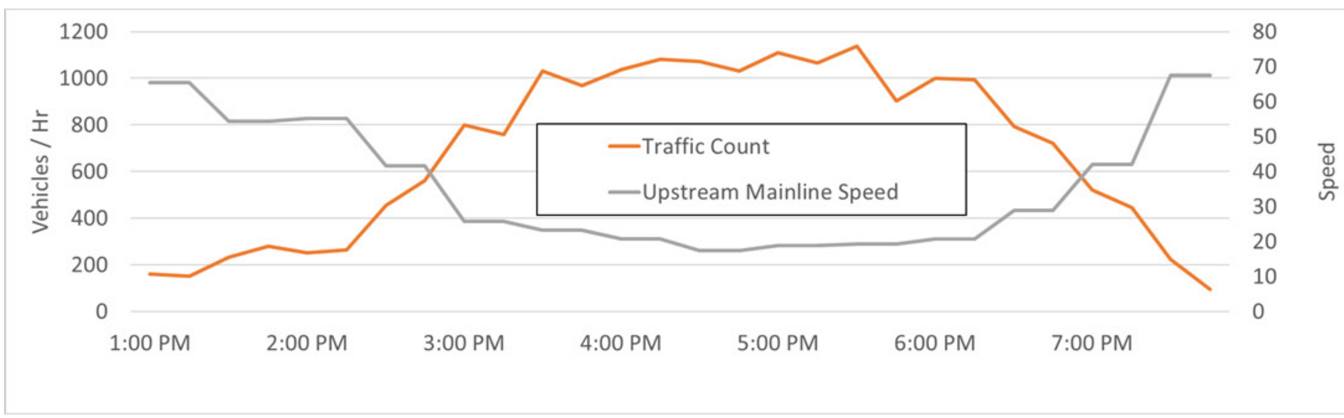
Location		Observed Volumes		Modeled Volumes		Percent Difference		Difference (GEH)	
		AM	PM	AM	PM	AM	PM	AM	PM
Frontage Rd W Side of I-25 just south of Plum Creek Pkwy	NB	750	610	407	695	-46%	14%	9.0	1.7
Frontage Rd W Side of I-25 just south of Plum Creek Pkwy	SB	690	2,146	678	2,021	-2%	-6%	0.3	1.4
Frontage Rd E Side of I-25 just south of Crystal Valley Pkwy	NB	365	438	85	133	-77%	-70%	11.8	9.0
Frontage Rd E Side of I-25 just south of Crystal Valley Pkwy	SB	173	782	71	394	-59%	-50%	5.8	8.0
Santa Fe Dr (US-85) just south of C-470	NB	4,981	7,304	5,342	7,595	7%	4%	3.2	1.7
Santa Fe Dr (US-85) just south of C-470	SB	4,619	6,842	4,677	7,702	1%	13%	0.5	5.0
Perry Park Rd (SH-105) just south of Tomah Rd	NB	415	312	451	380	9%	22%	1.1	1.8
Perry Park Rd (SH-105) just south of Tomah Rd	SB	119	725	192	809	62%	12%	3.7	1.5
SH-83 Just south of E-470	NB	6,854	7,109	7,472	7,680	9%	8%	4.6	3.3
SH-83 Just south of E-470	SB	4,617	10,942	4,422	11,001	-4%	1%	1.8	0.3
SH-83 just south of Gillian Ave	NB	559	822	640	636	15%	-23%	2.1	3.4
SH-83 just south of Gillian Ave	SB	431	1,194	265	993	-38%	-17%	5.6	3.0

Source: Steer Davies Gleave

Appendix B: Illustration of Southbound PM Delays on Friday August 4th, 2017

Friday August 4, 2017														
Location	1:00 PM	1:30 PM	2:00 PM	2:30 PM	3:00 PM	3:30 PM	4:00 PM	4:30 PM	5:00 PM	5:30 PM	6:00 PM	6:30 PM	7:00 PM	7:30 PM
US-85 to Wolfensberger Rd	70	53	67	69	65	60	50	66	67	70	69	66	69	69
Wolfensberger Rd Exit 182	70	66	65	69	66	65	61	61	67	62	66	67	69	69
Wolfensberger Rd to Plum Creek Pkwy	70	66	66	66	63	60	58	34	53	36	57	67	68	69
Plum Creek Pkwy Exit 181	72	61	65	39	50	21	28	16	21	26	35	59	65	66
Plum Creek Pkwy to Tomah Rd	64	51	52	40	23	21	18	15	16	17	18	26	41	68
Tomah Rd Exit 174	69	69	65	34	22	19	17	17	17	17	22	21	26	68
Tomah Rd to Spruce Mtn Rd	69	67	64	49	41	40	39	39	41	42	41	39	43	68
Spruce Mountain Rd Exit 173	67	68	64	62	57	61	61	59	61	62	61	62	61	65
Spruce Mtn Rd to Upper Lake Gulch Rd	68	68	64	63	58	62	62	59	61	62	61	61	62	66
Upper Lake Gulch Rd Exit 172	67	67	56	64	58	62	63	60	62	63	62	62	62	65
Upper Lake Gulch Rd to Greenland Rd	70	66	57	52	65	65	65	66	65	56	63	55	44	36
Greenland Rd Exit 167	72	66	55	42	70	61	65	66	65	62	60	49	29	34
Greenland Rd to County Line Rd	71	63	53	53	66	56	64	66	63	61	49	44	45	50

Exit 174 On Ramp PM Detail ➔



Source: Steer Davies Gleave

Appendix C: Modeling Approach Memo

Memo

To	Mandy Whorton
Cc	Zeke Lynch, David Cuneo
From	Mark Feldman
Date	3 January 2017
Project	I-25 C-470 to Monument PEL
Project No.	23029301

Introduction

Steer Davies Gleave's role in task order 1 for the I-25 PEL is to give an overview of the available models and recommendation of the preferred model to use for performing the project's travel demand forecasting.

In a prior memo, dated November 14th, 2016, we recommended the use of a version of DRCOG's 4-step travel demand model (COMPASS) that was modified to incorporate high speed rail transit for the ongoing Interregional Connectivity Study (ICS). We primarily recommended this model because of its inclusion of high speed rail, and because of its faster run time compared to activity based models such as DRCOG's newer FOCUS model.

In the past month, however, conversations among the project team and with technical stakeholders and advisors have brought to light a desire to use the most current forecasting tools in the region, i.e. FOCUS, as the newest version (FOCUS II) has substantially reduced run times. We have also learned that the ability to include and analyze high speed rail is not essential for the PEL.

Discussions have also highlighted interest in using a TransModeler (microscopic) model to potentially analyze elements of alternatives. The TransModeler model has also been identified as a critical component of work downstream of the PEL.

Therefore, we have revised our recommendation to 1) develop a macroscopic travel demand model as the main tool for analysis ; the macroscopic model will use FOCUS II as its core component and be supplemented by an interregional trip distribution model, and 2) develop a Transmodeler model to provide more detailed analysis of some alternatives. The details of the development of these models are described in the subsequent sections of this memo.

Macroscopic Travel Demand Model

We will use the latest version of the DRCOG model, FOCUS II, as the core travel demand forecasting tool.

DRCOG FOCUS Component

We will run the full FOCUS II model as the starting point of our model. This will provide the initial trip matrices that we will then modify using the trip distribution model described below.

We will perform a detailed calibration and validation of the model's forecasts to observed traffic counts in the study corridor. According to the FOCUS Model Calibration memo[7], the model overstates traffic by about

[7] FOCUS Model Calibration 1.0, DRCOG, 8/5/2010, Pages 47-48, Figure 13 and Table 52

21% on a screenline which passes through the northern edge of the I-25 PEL study corridor (Castle Rock), and includes counts on two links as part of that screenline. We would collect more extensive traffic data in the study corridor, including on I-25 between every interchange, as well as all on ramps, off ramps and parallel routes, and use that data to establish a higher level model accuracy within the corridor.

After running and calibrating the FOCUS model for our study area, we will extend the highway network for this project since the PEL study corridor extends beyond the FOCUS model project limits. Specifically, the FOCUS model network extends as far south as Palmer Divide Road at the northern edge of Monument, whereas the study corridor extends a mile further south.

To provide a minimal number of likely entrances / exits to the model network for trips passing between the DRCOG and PPACG regions, we propose extending the FOCUS model network. Figure 3 depicts this extension, as compared to the current FOCUS model edge:

Figure 13: Comparison of Southern Edges of FOCUS Model to Proposed Extended Model

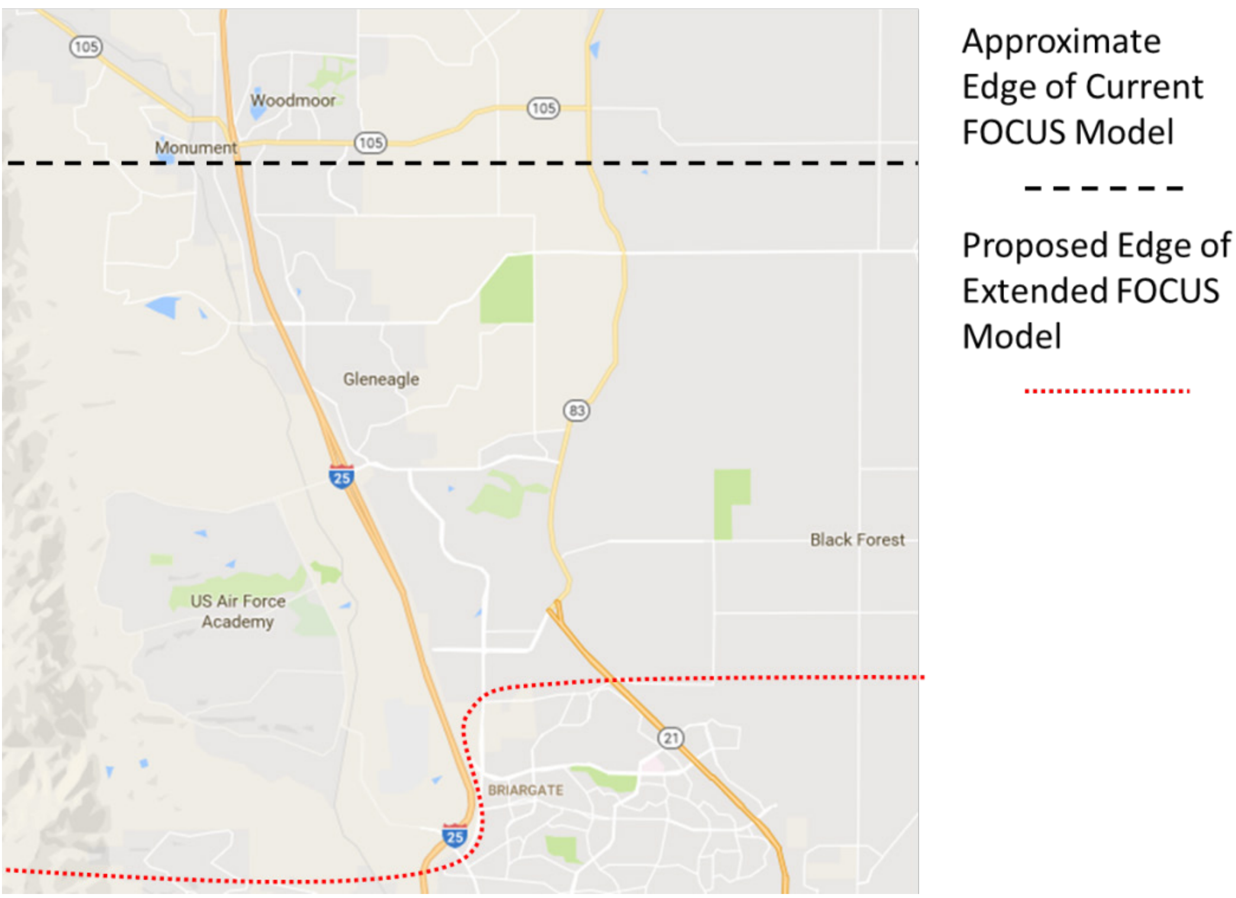
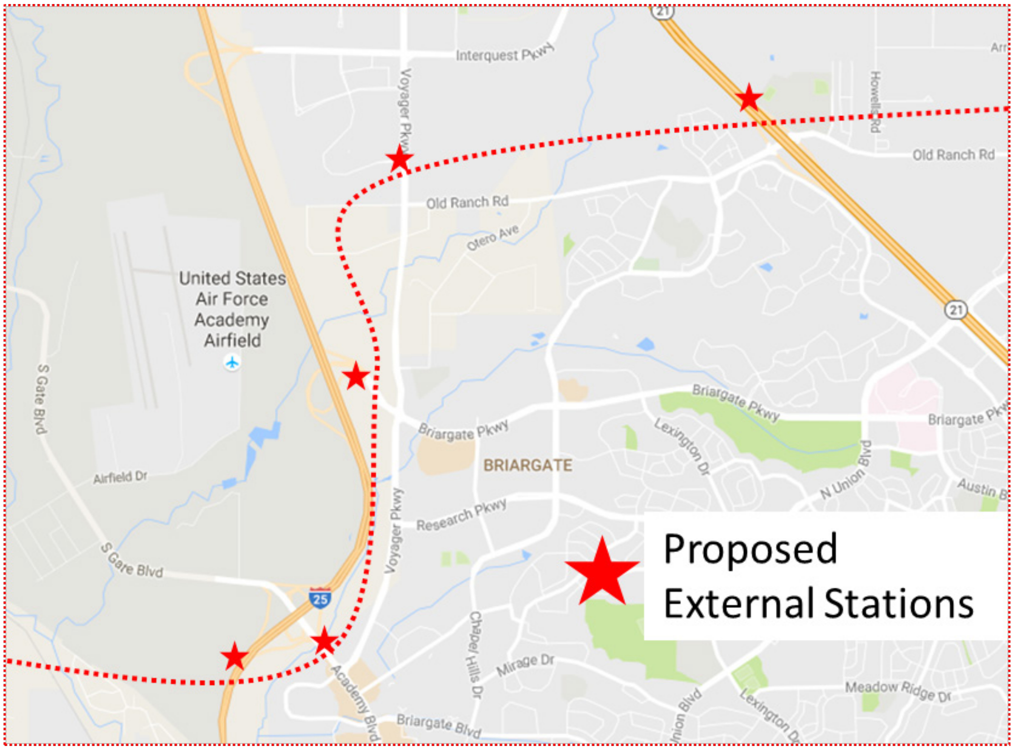


Figure 4 zooms in on the proposed extension above and shows the locations of the proposed external stations, from :

- I-25
- Academy Boulevard
- Briargate Parkway

- Voyager Parkway
- North Powers Blvd (C-21)

Figure 14: Proposed External Stations for Extended FOCUS Model Network



We will obtain network attributes for the extended network (beyond the FOCUS model) and land uses for zones in the appended model region from the most current available version of the PPACG region's travel demand model.

Interregional Trip Distribution Model

To simply incorporate socioeconomic projections in the appended PPACG region is not sufficient by itself, because it can distort the model's trip distribution (allocation of zonal trip generation into origin-destination (OD) pairs using relative zone pair travel impedances) by treating all trip ends in the PPACG region as occurring at the same zone.

To address this issue while still including a method to analyze how an alternative may impact trip patterns, we will develop an interregional trip distribution model. We will estimate the parameters of this trip distribution model to fit observed regional travel patterns, which we will establish from one or more of the following sources:

- Interregional trip matrices from the Interregional Connectivity Study (ICS);
- AirSage cell phone OD data obtained in 2013 for the ICS;
- Streetlight OD data: either already collected by CDOT or new data obtained for this project; and
- Front Range regional household survey data

Note that the OD data will have larger zones than the FOCUS model. If new data is obtained, we propose to define zones with the FOCUS model boundaries along the study corridor.

The observed travel patterns will be fit to a trip distribution gravity model, which relates interzonal impedance to a set of factors that monotonically decrease with increasing impedance.

We will develop future trip matrices using the zone system of the OD data source from the above list and each zone's total trips generated as estimated from the regional travel demand models, socioeconomic projections from local sources and/or projections from national sources such as Moody's.

After calibrating the trip distribution gravity model, we will use it as an input to running alternative improvements. We will update future network impedances corresponding to the alternative being run, and then rerun the distribution model to figure out how much to adjust the external zone traffic. We will apply the gravity model to each zone's trip total, with a procedure known as iterative proportional fitting (IPF).

Finally, the future trip matrix will be adjusted to the zone system in the slightly-extended DRCOG focus model, as follows:

- Trip ends to the south of the model (in the PPACG region or further south) will be assigned to one of the external gateway zones in Figure 3, with most being assigned to the I-25 gateway.
- Trip ends within the model and on the study corridor will be disaggregated from the coarser OD data zone system into the more refined FOCUS zone system (if new data is collected, the OD data zones will be the same as the FOCUS zones on the study corridor and this won't be necessary).
- Outside the study corridor, the FOCUS zones will be aggregated into the OD data zone system, to reduce model run time.

Microsimulation

Along with the macroscopic travel demand model, we will develop a microsimulation in TransModeler. This tool will be used primarily to analyze details that are not covered by macroscopic travel demand models, such as roadway geometry, steepness, weaving and merging, and traffic signal operations.

When we embark on this TransModeler model development, we will determine the geographical extent of the model as it could cover the entire corridor, or may focus on the key sections with the most significant operational concerns.

A further motivation for developing the TransModeler model now, is that the data collection and set-up time of these sorts of models can be considerable, and thus it would be better to begin developing in advance of when the model could be needed for activities downstream of the PEL. Therefore, data collection can occur in parallel with that for the macroscopic model, and development can occur in tandem to the extent possible, to increase project efficiency, reduce costs, and enable the project to stay on schedule for the purposes of eventually obtaining financing.

Appendix A: *I-25 PEL/NEPA Technical Memorandum - Model Calibration Update*

I-25 PEL/NEPA Technical Memorandum - Model Calibration Update

Technical Note - I-25 South PEL Travel Demand Forecasting

This technical note documents the travel demand forecasting work conducted by Steer for the I-25 South PEL, which follows the EA study completed for the Gap. It contains the following sections:

1. Introduction
2. Project Scenarios
3. Modeling Framework and Assumptions
4. Performance Measures
5. Forecasts
6. Summary of Performance

1. Introduction

In 2017 and early 2018, Steer (previously doing business as Steer Davies Gleave) developed a travel modeling tool and produced traffic forecasts for the I-25 South EA, which focused on the I-25 "Gap" section between exits 160 and 181. Starting in the summer of 2018, Steer further calibrated the travel modeling tool for the larger area covered by the PEL and used it to analyze a series of improvement scenarios (which included the "Gap" final alternative in the baseline).

A. Travel Model Development

Because the geographic area considered by the PEL includes portions of both the Denver Regional Council of Governments (DRCOG) and the Pikes Peak Area Council of Governments (PPACG) metropolitan planning areas, Steer created a travel demand model for this project by extending DRCOG's FOCUS 2.0 model into northern El Paso County. This involved combining both the networks and the trip matrices of the models from the two MPO regions.

Specifically, we developed the travel modeling tool by undertaking the following tasks:

- An extensive data collection effort, including
  - Traffic counts on both weekdays and weekends along I-25 (between C-470 and Monument) and on parallel routes (SH-105 and SH-83);
  - Travel times from INRIX (calendar year 2016, as well as on the days that traffic counts were collected in 2017);
  - Travel patterns from StreetLight Data (calendar year 2016) to assist in creation of an inter-MPO trip matrix; and
  - Toll transaction data on US-36 to estimate local travelers' values of time on an existing express lane facility.
- Assembly of the model network and trip matrices from a combination of the two local MPOs' (DRCOG and PPACG) travel demand models.
- Calibration of the model and validation to observed traffic conditions.

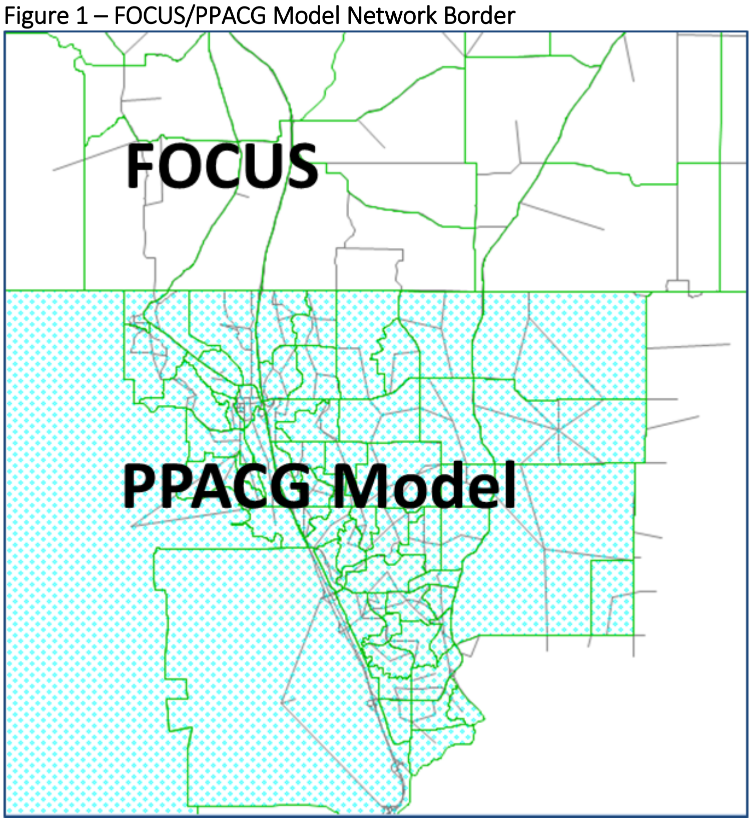
In the following sections, we provide more details on the preparation of the model network and trip matrices.

1. Network

The southern edge of the FOCUS network is at the Douglas / El Paso county line; Steer extended this south to the Briargate area of Colorado Springs, with the major external stations including I-25 just south of the Academy Boulevard interchange and SH-21 just south of SH-83. This extension was necessary to ensure that the full study corridor was included in the model in its entirety.

We joined the applicable portion of the PPACG model network with the FOCUS network to create the I-25 model network, and translated PPACG model network attributes into their FOCUS counterparts. Figure 1 shows the southern edge of the I-25 model network and illustrates the border between the original MPO model networks.

Figure 1 – FOCUS/PPACG Model Network Border



Source: Steer

2. Trip Matrix

Initially, we combined the trip matrices of the two MPO models, eliminating the rows and columns corresponding to the entry and exit links at the Douglas / El Paso County border in the original MPO models, and adding rows and columns for the new external stations at the southern edge of the network in the Briargate region.

Subsequently, we distributed the trips that previously used external stations at the Douglas / El Paso County border into 'inter-MPO' trips, some remaining internal, having their origin or destination in the northern PPACG model portion of the network, and some becoming external trips, ultimately leaving the network via one of the new external stations in the Briargate region. The travel pattern data collected from StreetLight Data was the key to this procedure. Trips remaining in a single MPO were unchanged from the original MPO model trip matrices as received.

3. Subarea Extraction

We extracted a subarea of the FOCUS region to reduce model running time to forecast future conditions. The subarea extended about 5 miles north of C-470 approximately to Belleview Avenue, which we believe is beyond the area of significant project influence. Figure 2 depicts the subarea model network used in the forecasting.

Figure 2 – I-25 Subarea Model Network

Source: Steer

We reported the model validation work in detail in the document titled *I-25 PEL/NEPA Technical Memorandum - Model Calibration Update*, dated September 11, 2018, included as an appendix to this technical note.

2. Modeling Framework and Assumptions

As noted above, we built the travel modeling tool from a base of the DRCOG FOCUS model, and it preserves much of the FOCUS model structure. This section describes some of those model details along with other assumptions that were necessary to evaluate the project scenarios which are described in the following section.

A. Time Periods Modeled

The weekday time periods modeled in these forecasts were consistent with FOCUS's 10-period structure, as follows:

- OP1: 11 PM – 6:30 AM
- AM1: 6:30 – 7 AM
- AM2: 7-8 AM
- AM3: 8-9 AM
- OP2: 9-11:30 AM
- OP3: 11:30 AM – 3 PM
- PM1: 3-5 PM
- PM2: 5-6 PM
- PM3: 6-7 PM
- OP4: 7-11 PM

B. Horizon Year (2040) Network

We established the 2040 network by starting with the extraction of a subarea that has the same subarea boundaries depicted in Figure 2. We then incorporated both the network modifications from base year calibration and the network differences between the MPOs' 2015 and 2040 networks and included in DRCOG's RTP. The major future network projects in the study area include:

- Managed lanes on C-470 between I-25 and Kipling Pkwy;
- Widening of sections of US-85 (from Meadows Parkway to Louviers Avenue and from Titan Road to County Line Road);
- New diamond interchange at I-25 and Crystal Valley Pkwy;
- N/S roadway between Lincoln Ave and RidgeGate Pkwy to the east of I-25 (and to the west of Peoria St);
- E/W roadway from Sky Ridge Medical Center to Peoria St, between Lincoln Ave and RidgeGate Pkwy;
- Two N/S roadways from Hess Rd to Crowfoot Valley Rd (one near I-25, one near SH-83);
- Woodlands Blvd N/S roadway between Black Feather Tr and Scott Blvd (in Castle Rock);
- Valley Dr N/S roadway between South St and Plum Creek Parkway (in Castle Rock); and
- SH-21 northward / westward extension to new diamond interchange with I-25 between Interquest Pkwy and North Gate Blvd.

In addition to the above improvements which are contained in the 2040 RTP network and were included in the EA analysis performed in 2017/early 2018, for the PEL analysis we also modified the 2040 network to reflect No Action conditions by adding the following network improvements:

- 1 TEL through the Gap (specifically from about one mile south of Plum Creek Parkway at the northern terminus to just north of Palmer Divide Road at the southern terminus);
- A southbound climbing lane south of the Greenland interchange (specifically 1.15 miles long starting at milepost 166.86);
- A southbound auxiliary lane between Sky View and Spruce Mountain interchanges; and

C. Horizon Year (2040) Trip Matrix

Steer derived 2040 trip matrices by applying a pivot method to the calibrated 2017 trip matrices, as follows:

- For all zones other than the new external stations, the "target" total origins and destinations for each time period were computed by adding the difference between the 2040 and 2015 corresponding period totals in the MPO model matrices to the 2017 calibrated matrix totals.
- For the new external stations, the targets were computed by combining the trips from all corresponding zones in the PPACG model and disaggregated to the relative traffic counts from (or to) each of the stations in the StreetLight Data OD data.
- An iterative "Fratar"[1] process was applied to the 2017 matrices, using the 2040 row and column targets computed in the above steps.

To obtain 2040 weekend matrices, we applied the same adjustment factors used in the development of 2017 weekend matrices to the appropriate weekday time periods.

The same study area 2040 matrices were used for all scenarios.

D. Post-Processing of Southbound Weekday PM Time Period

On I-25 between Plum Creek Parkway and Sky View Lane in the Weekday PM periods, we applied the two southbound post-processing steps that we originally developed for the base year calibration. This procedure involved the following steps:

- Update the GP lane capacity through the Gap for a given Scenario
- Consider the level of congestion on the GP lane, and shift traffic away from I-25 onto the Exit 181 off ramp, frontage roads and Exit 174 (Sky View Lane) on ramp as was shifted in base year calibration
- Reduce effective GP lane capacity by amounts that vary depending on the volumes on the Exit 174 on ramp. These reductions were equal to or greater than in the base year, due to the higher overall level of traffic. We ensured consistent capacities among the various alternatives we ran.

E. Assumptions Supporting Express Lanes

This section describes modeling assumptions specifically related to the forecasts of scenarios with express lanes. Separately, the design of the express lanes is covered later in this technical note.

1. Values of Time

We obtained US 36 Express Lanes transaction data to help understand current traveler behavior on a comparable express lane facility in the study region. This data provided continuous traffic count data and, in conjunction with other data, allowed us to estimate the portion of total US 36 traffic using the TELs and their travel time savings. In combination with toll rate data, TEL traffic share, and travel time savings,

[1] A mathematical process that iteratively adjusts entire rows and columns of a matrix to bring each row and column total as close to a set of target values as possible.

we were able to estimate values of time (VOTs) for the upper-percentile travelers (i.e., those with the highest VOTs, who were willing to pay the toll to save travel time).

However, this information only provides VOTs for those travelers who are willing to pay the toll charged for the time savings realized at the corresponding time during the day. Overall, this is roughly 24% of total US 36 traffic. The VOTs for the remaining travelers were estimated based upon Denver MSA census income, setting a median value of time of $18 per hour, consistent with the original FOCUS model input and the upper-percentile results calculated from the US 36 toll transactions. Table 1 presents the results of the VOT analysis. The decision to use eight classes specifically was based on a trade-off between representing variation of traveler preferences and model run time. The VOTs for each class represent the midpoints of eight equally sized groups, each with 12.5% of trips.

Table 1. Value of Time Classes

Note: Each class represents 1/8 of the trips

Class	Percentile	Value of Time ($/hour)
1	6.25%	3.00
2	18.75%	7.20
3	31.25%	12.00
4	43.75%	16.20
5	56.25%	21.00
6	68.75%	27.60
7	81.25%	36.00
8	93.75%	60.00

Source: Steer

It is now well accepted that express lane users pay not only for travel time savings, but also for increased reliability and other perceived benefits such as safety improvements and comfort. As a result, the FOCUS model includes a “toll bonus” of 8 cents per mile on tolled facilities. We retained this assumption for the I-25 TELs, which effectively reduces the cost of the TELs by 8 cents per mile during the highway assignment step, where travelers are assigned to routes based on minimizing their generalized trip costs.[2]

2. Tolling Structure

Based on discussions with the I-25 South PEL study design and traffic engineering teams, we focused the TEL tolling and performance measures on the following segments:

- Between C/E-470 and RidgeGate Parkway;
- Between RidgeGate Parkway and Happy Canyon Road;
- Between Happy Canyon Road and Crystal Valley Parkway; and
- Between Crystal Valley Parkway and Palmer Divide Road.

The toll charges modeled were expressed as lump sum toll amounts for the segment, as opposed to per-mile charges. Tolls varied by model time period and direction, to simulate the operation of variable

[2] “Generalized trip costs” combine monetary cost and travel time, with the latter converted into monetary units with values of time.

tolling in the express lanes (i.e., toll rates were higher in the peak periods in accordance with the tolling objectives described below).

3. TEL Access/Egress

For scenarios that included TELs, we added access/egress to/from the TELs. For scenarios that include the TELs as they are in the No Action, we have preserved the access/egress points from the EA. Specifically, the following access/egress locations were included:

- North of Crystal Valley Parkway;
- North of Spruce Mountain Road;
- South of Upper Lake Gulch Road; and
- North of Palmer Divide Road.

In addition, for scenarios that added TELs north of the Gap, we removed the access/egress point north of Crystal Valley Parkway and added the following access/egress locations:

- At C/E-470, including direct connections with C/E-470;
- South of RidgeGate Parkway; and
- South of Happy Canyon.

For Scenario E that converts all lanes to TELs, we preserved the location of the current I-25 ramps and allowed for access to the TELs.

4. Tolling Objective

At the direction of CDOT, we modeled the TELs with a *throughput maximization* objective. The technical assumptions supporting this objective are to charge as low a toll as possible, to allow as many vehicles as possible to use the express lanes, with the following two constraints:

- The express lanes had to operate at congested speeds of 45 mph or higher
- The minimum toll charged in any time period was set to be 20 cents / mile, which is a typical and reasonable amount to charge outside of peak times of travel, and is similar to tolls currently charged on I-70 and US-36.[3]

5. Other Assumptions

Other key modeling assumptions related to the express lanes include the following:

- Vehicles with occupancy 1 or 2 must pay a toll
- Vehicles with occupancy 3 or higher, including transit, are allowed to use the TELs free of charge
- Trucks were charged a very high toll surcharge to discourage them from using the TELs[4]

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[3] The toll pricing and minimum toll assumptions in this work represent modeling practices for initial studies. A level 2 traffic and revenue study, conducted by the Colorado High Performance Transportation Enterprise (HPTE), is currently underway and will contain more refined assumptions about toll pricing. The performance of the express lanes in the off-peak periods where the minimum toll is in effect is not likely to vary significantly with the minimum toll assumption, since the general purpose lanes are performing well in those periods.

[4] Truck traffic is managed in other Colorado express lanes with a surcharge such that truck volumes are small enough to be considered zero for modelling purposes.

F. Analysis of Non-Modeled Scenarios

As discussed above, Scenario C and Scenario F were not modeled using the travel modeling tool; instead, we inferred their performance based upon the performance of other scenarios.

Scenario C, the peak period shoulder lane, is assumed to operate with 7/8 the capacity of a TEL. For AM and PM periods, we calculated its performance as 7/8 of the values from Scenario B and 1/8 the values from the No Action. For MD and Nighttime periods, we set its values the same as the No Action

Scenario F is 1 TEL that operates in the peak direction during the peak periods. Northbound AM and Southbound PM results are taken from Scenario B, while all other results are set equal to those of the No Action scenario. AM and PM VMT/VHT calculations were based on 85% of Scenario B and 15% of the No Action scenario.

3. Project Scenarios

A number of improvement scenarios were evaluated for I-25. These scenarios were developed to evaluate the impacts that different types of improvements would have to the project corridor. They were all added on top of a No Action scenario that considers I-25 as it is now plus the Tolled Express Lane (TEL) that is under construction in the Gap as a result of the EA.

Below we define each of these improvements.

A. Scenario A: Add 1 General Purpose Lane

This scenario adds 1 general purpose (GP) lane in each direction to I-25 from C/E-470 to north of the Gap (where the presently under-construction Express Lanes would begin/end). The logic motivating this scenario is to identify the impact of adding basic GP lane capacity to the section of I-25 that was not previously addressed in the EA.

B. Scenario B: Add 1 Tolled Express Lane

This scenario adds 1 tolled express lane (TEL) in each direction to I-25 from C/E-470 to north of the Gap. The logic behind this scenario is to examine the impact of adding TEL capacity to the section of I-25 that was not previously addressed in the EA. In this way, the TELs will be extended to run the full length of the corridor from C/E-470 to the Douglas/El Paso county line.

C. Scenario C: Add 1 Peak Period Shoulder Lane

This scenario utilizes the existing shoulder lanes during the peak periods, with the lanes operating as TELs. As discussed in more detail later, this scenario is not analyzed through the travel modeling tool; rather its results are inferred from the results of Scenario B.

D. Scenario D: Convert 1 General Purpose Lane to Tolled Express Lane

This scenario converts 1 GP lane north of the Gap to a TEL. The concept of this scenario is to make use of the existing highway footprint while offering a TEL for the full length from C/E-470 to the Douglas/El Paso county line.

E. Scenario E: Convert All General Purpose Lanes to Tolled Express Lanes

This scenario converts all GP lanes, including in the Gap, to TELs. This scenario's concept is to utilize the existing highway footprint while ensuring that all travel using I-25 will be at the reliable travel speeds of TELs.

F. Scenario F: Add 1 Reversible Lane

This scenario adds 1 reversible lane north of the Gap TELs that is operated as a tolled facility in the peak direction for the peak periods. It would add a TEL northbound in the AM only and southbound in the PM only. The motivation for this scenario is to utilize the existing highway footprint while adding additional capacity in the peak direction of travel. As discussed in more detail later, this scenario is not analyzed through the travel modeling tool; instead its results are inferred from the results of Scenario B.

G. Scenario G: Add 2 General Purpose Lanes

This scenario adds 2 GP lanes in each direction to I-25 from C/E-470 to north of the Gap, and 1 additional GP lane in the Gap. The logic of this scenario is to add an additional GP lane to Scenario A.

H. Scenario H: Add Maximum General Purpose Lanes

This scenario adds as many GP lanes as needed to I-25 in order to ensure that the Volume to Capacity ratio does not exceed 0.85 in the peak periods of the design year (2040). The motivation of this scenario is to understand the performance that could be achieved by adding capacity to the corridor.

I. Scenario I: Scenario B plus 1 GP Lane in Gap

This scenario starts with Scenario B, which adds 1 TEL to I-25 from C/E-470 to north of the Gap, and adds 1 GP lane in each direction through the Gap. The logic of this scenario is to extend Scenario B, which offers a TEL for the complete length, to provide a common cross section for the Gap and the section north of the Gap.

J. Scenario J: Scenario A plus 1 GP Lane in Gap

This scenario extends the 1 GP lane added in each direction to I-25 from C/E-470 to north of the Gap in Scenario A, through the Gap. The logic of this scenario is to add 1 GP lane in each direction the full length of the corridor.

K. Scenario K: Add 2 Tolled Express Lanes

This scenario adds 2 TELs in each direction to I-25 from C/E-470 to north of the Gap and 1 TEL through the Gap. The logic of this scenario is to gauge the impact of adding 2 TELs throughout the full length of the corridor.

Table 2 below summarizes the number of GP lane and TEL lanes modeled for each scenario.

Table 2. Number of Lanes in Each Direction by Scenario

Section	Number of Lanes[5]			Number of Lanes		
	GP	TEL	Total	GP	TEL	Total
	No Action			Scenario A - Add 1 GP Lane		
North of Meadows/Founders	4	0	4	5	0	5
Plum Creek to Meadows/Founders	3	0	3	4	0	4
Gap	2	1	3	2	1	3
South of Gap	3	0	3	3	0	3
	Scenario B - Add 1 TEL			Scenario D - Convert 1 GP Lane to TEL		
North of Meadows/Founders	4	1	5	3	1	4
Plum Creek to Meadows/Founders	3	1	4	2	1	3
Gap	2	1	3	2	1	3
South of Gap	3	0	3	3	0	3
	Scenario E - Convert ALL GP to TEL			Scenario G – Add 2 GP Lanes		
North of Meadows/Founders	0	4	4	6	0	6
Plum Creek to Meadows/Founders	0	3	3	5	0	5
Gap	0	3	3	3	1	4
South of Gap	3	0	3	3	0	3
	Scenario H - Add Max GP Lanes			Scenario I - "B" plus 1 GP Lane in Gap		
North of Meadows/Founders	7-9	0	7-9	4	1	5
Plum Creek to Meadows/Founders	7-8	0	7-8	3	1	4
Gap	5-7	1	6-8	3	1	4
South of Gap	3	0	3	3	0	3
	Scenario J - "A" plus 1 GP Lane in Gap			Scenario K - add 2 TEL		
North of Meadows/Founders	5	0	5	4	2	6
Plum Creek to Meadows/Founders	4	0	4	3	2	5
Gap	3	1	4	2	2	4
South of Gap	3	0	3	3	0	3

[5] Auxiliary lanes and climbing lanes were included in the network coding, but not reflected in the lane count

4. Performance Measures

Through coordination with the PEL traffic working group, the following measures of effectiveness were selected for the scenario evaluation:

- Vehicle Hours of Travel (VHT) and Vehicle Miles (VMT) of Travel in 2040;
- I-25 corridor travel demand (daily traffic volume) in 2040; and
- I-25 travel time (minutes) in 2040.

More detailed traffic operations performance will be evaluated later in the project.

Below we further describe each of these performance measures.

A. VHT / VMT

VHT and the associated VMT are performance measures that assess system-wide travel performance and quality. They provide a good indication of how conditions in the overall study area are impacted by a scenario. VHT is a good measure to understand the overall time savings of the study area, considering the impact on the local street system beyond just the changes in highway performance. Results were determined for the geographical area of the entire subarea model shown earlier in Figure 2, and roughly bounded by:

- Belleview Avenue in the north;
- Kiowa-Bennett Road and Elbert Road in the east;
- US-85 and SH-105 in the west; and
- Interquest Parkway in the south.

B. I-25 Corridor Travel Demand

The volume of traffic on I-25 provides an indication of how much of the corridor demand is accommodated in a scenario. A secondary measure is the traffic levels on the other nearby roads. Accordingly, Steer calculated the 2-way daily traffic forecasts for segments of the I-25 corridor, as well as for nearby roads, as a performance measure.

C. I-25 Travel Time

Travel times on the I-25 GP lanes and TELs provide an indication of the quality of travel that I-25 travelers will experience. We calculated the future 2040 peak period travel times on I-25, from Monument to C-470, for each of the scenarios. These travel times represent the expected freeway performance on a typical workday (northbound AM and southbound PM) barring any major incidents, and are calculated separately for the GP lanes and the non-GP lanes (tolled express lanes, peak period shoulder lanes, reversible lanes). Because the travel times were calculated for the entire length of the corridor, portions of some of the travel times presented as TEL do occur in the GP lanes depending on the scenario. We summarized the travel time performance of the GP lanes and the non-GP lanes by the following three segments:

- Between SH-105 and Plum Creek Parkway;
- Between Plum Creek Parkway and Meadows Parkway; and
- Between Meadows Parkway and C/E-470.

5. Forecasts

In this section, we summarize the forecasts of the performance measure results for each scenario.

A. VMT/VHT

Table 3 presents the VMT and VHT for No Action through Scenario E while Table 4 presents the results for Scenario F through K. As noted before, these VMT and VHT calculations are for the entire modeled study area presented in Figure 2. These tables show that VHT grows by a large amount (over 75%) from 2017 to 2040 No Action. All the scenarios with the exception of Scenarios D and E (both convert GP lane to TEL) see decreases in VHT, although with small increases in VMT. This occurs because the improvement to the highest speed route, I-25 in this case, causes some trips to travel further (increase VMT) to get a faster travel time (decrease in VHT). Of the scenarios, the largest VHT reduction relative to the No Action is from Scenario H (add max GP lanes), followed by Scenario G (add 2 GP lanes) and Scenario K (add 2 TEL).

Table 3. VMT and VHT from Scenario No Action to Scenario E

	2017 Model Forecast	2040 No Action	2040 Scenario A - add 1 GP Lane	2040 Scenario B - add 1 TEL	2040 Scenario C - add PPSL	2040 Scenario D - convert 1 GP Lane to TEL	2040 Scenario E - convert all GP Lanes to TEL
Study Area VMT	17,961,448	27,039,456	27,063,881	27,065,909	27,055,019	27,038,625	27,210,117
Study Area VHT	488,197	861,773	849,713	850,581	853,749	866,636	910,437
VMT % Change from No Action	NA	NA	0.09%	0.10%	0.06%	0.00%	0.63%
VHT % Change from No Action	NA	NA	-1.40%	-1.30%	-0.93%	0.56%	5.65%

Source: Steer

Table 4. VMT and VHT from Scenario F to Scenario K

	2017 Model Forecast	2040 Scenario F - add reversible lane	2040 Scenario G - add 2 GP Lanes	2040 Scenario H - add max GP Lanes	2040 Scenario I - B + add 1 GP Lane in Gap	2040 Scenario J - A + add 1 GP Lane in Gap	2040 Scenario K - add 2 TEL
Study Area VMT	17,961,448	27,054,575	27,084,914	27,101,048	27,072,676	27,071,982	27,078,536
Study Area VHT	488,197	853,978	838,550	831,327	844,900	843,948	842,572
VMT % Change from No Action	NA	0.06%	0.17%	0.23%	0.12%	0.12%	0.14%
VHT % Change from No Action	NA	-0.90%	-2.69%	-3.53%	-1.96%	-2.07%	-2.23%

Source: Steer

B. I-25 Corridor Traffic Volumes

The following tables provide the 2-way traffic volumes that were forecast for 2040 in each scenario. Tables 5 and 6 provide the I-25 GP lane traffic volumes while Tables 7 and 8 provide the traffic volumes in the TELs. To further understand traffic conditions, Tables 9 and 10 provide the daily traffic volumes for other nearby roads.

Table 5 shows that daily traffic grows from 2017 to 2040 No Action, with the highest traffic level reaching 270,000 between Lincoln Ave and C/E-470. As expected, the scenarios that add GP lanes, experience daily traffic level growth on the GP lanes compared to the No Action, while scenarios that add TELs, see the TEL traffic levels increase and GP lanes traffic levels decrease. One slight exception is Scenario B (add 1 TEL north of the Gap) that sees a slight increase in GP lane traffic through the Gap due to the higher combined GP lane and TEL level of traffic on I-25 north of the Gap.

The highest increases to GP lane traffic come from Scenarios G (add 2 GP lanes) and H (add max GP lanes). Both of these scenarios have much larger increases in the Gap than north of the Gap. In general, all the scenarios that add a GP lane in the Gap (Scenarios G, H, I, and J) have large increases in GP lane traffic through the Gap, highlighting a future need.

Regarding the TELs, as expected, Scenario E (convert all lanes to TEL) has the largest TEL traffic increase. The scenarios that add a GP lane through the Gap (Scenarios G, H, I, and J) all see a decrease in the TEL traffic through the Gap.

For the other adjacent local roads, Scenario E (convert all lanes to TEL) causes the largest increase in traffic, while Scenario H (add max GP lanes) causes the largest decrease in traffic.

Table 5. 2-Way Daily Traffic Volumes on GP Lanes from Scenario No Action to Scenario E

From	To	2017 Observed	2040 No Action	2040 Scenario A - add 1 GP Lane	2040 Scenario B - add 1 TEL	2040 Scenario C - add PPSL	2040 Scenario D - convert 1 GP Lane to TEL	2040 Scenario E - convert all GP Lanes to TEL
Baptist Rd	SH-105	95,540	145,340	145,940	145,580	145,480	144,660	
SH-105	Palmer Divide Rd	76,780	121,280	122,030	121,590	121,484	120,430	
Palmer Divide Rd	Greenland Rd	77,740	93,950	94,290	94,610	94,213	92,660	
Greenland Rd	Upper Lake Gulch Rd	78,140	94,840	95,160	95,490	95,084	93,520	
Upper Lake Gulch Rd	Spruce Mountain Rd	77,430	94,230	94,550	95,080	94,556	93,170	
Spruce Mountain Rd	Sky View Ln	81,080	100,100	100,450	100,870	100,371	98,800	
Sky View Ln	Crystal Valley Pkwy	79,000	95,990	96,390	96,630	96,286	94,950	
Crystal Valley Pkwy	Plum Creek Pkwy	79,000	151,740	155,200	131,230	141,039	117,600	
Plum Creek Pkwy	Wilcox St / Wolfensberger Rd	99,090	168,330	178,040	152,610	160,620	128,450	
Wilcox St / Wolfensberger Rd	Founders Pkwy / Meadows Pkwy	111,570	175,020	186,440	160,070	168,144	133,710	
Founders Pkwy / Meadows Pkwy	Castle Rock Pkwy	132,750	195,130	202,890	178,850	187,300	160,020	
Castle Rock Pkwy	Happy Canyon Rd	136,750	205,740	213,410	189,100	197,881	169,710	
Happy Canyon Rd	Castle Pines Pkwy / Hess Rd	142,220	205,110	212,900	192,870	198,619	171,810	
Castle Pines Pkwy / Hess Rd	RidgeGate Pkwy	140,670	222,890	229,160	202,430	212,958	186,290	
RidgeGate Pkwy	Lincoln Ave	153,720	229,370	234,510	209,510	220,051	196,190	
Lincoln Ave	C/E-470	196,260	270,100	272,800	253,610	262,461	242,840	
Change from No Action in Gap		n/a	n/a	340	660	263	-1,290	n/a
Change from No Action South of C/E-470		n/a	n/a	2,700	-16,490	-7,639	-27,260	n/a

Source: Steer

Table 6. 2-Way Daily Traffic Volumes on GP Lanes from Scenario F to Scenario K

From	To	2017 Observed	2040 Scenario F - add Reversible Lane	2040 Scenario G - add 2 GP Lanes	2040 Scenario H - add Max GP Lanes	2040 Scenario I - B + add 1 GP Lane in Gap	2040 Scenario J - A + add 1 GP lane in Gap	2040 Scenario K - add 2 TEL
Baptist Rd	SH-105	95,540	145,400	147,020	147,520	146,550	146,810	146,000
SH-105	Palmer Divide Rd	76,780	121,410	123,430	124,060	122,850	123,140	122,260
Palmer Divide Rd	Greenland Rd	77,740	93,910	111,250	119,010	109,920	110,980	91,740
Greenland Rd	Upper Lake Gulch Rd	78,140	94,780	112,580	121,080	111,030	112,320	92,650
Upper Lake Gulch Rd	Spruce Mountain Rd	77,430	94,190	112,090	121,640	110,780	111,830	92,380
Spruce Mountain Rd	Sky View Ln	81,080	100,010	119,400	129,750	117,810	119,080	97,900
Sky View Ln	Crystal Valley Pkwy	79,000	96,010	118,650	129,740	117,160	118,340	94,660
Crystal Valley Pkwy	Plum Creek Pkwy	79,000	144,200	160,860	163,140	140,170	159,720	128,410
Plum Creek Pkwy	Wilcox St / Wolfensberger Rd	99,090	163,350	183,690	186,500	158,110	180,270	150,220
Wilcox St / Wolfensberger Rd	Founders Pkwy / Meadows Pkwy	111,570	170,940	192,310	195,740	164,830	187,950	157,870
Founders Pkwy / Meadows Pkwy	Castle Rock Pkwy	132,750	189,900	207,330	210,670	183,840	204,030	176,410
Castle Rock Pkwy	Happy Canyon Rd	136,750	200,310	217,820	220,750	192,410	214,490	185,310
Happy Canyon Rd	Castle Pines Pkwy / Hess Rd	142,220	200,410	217,160	220,050	193,430	213,960	188,670
Castle Pines Pkwy / Hess Rd	RidgeGate Pkwy	140,670	216,980	232,700	234,900	203,050	230,140	194,730
RidgeGate Pkwy	Lincoln Ave	153,720	224,500	237,230	238,990	209,410	235,210	201,030
Lincoln Ave	C/E-470	196,260	266,160	274,150	275,000	253,380	273,120	246,250
Change from No Action in Gap		n/a	-40	17,300	25,060	15,970	17,030	-2,210
Change from No Action South of C/E-470		n/a	-3,940	4,050	4,900	-16,720	3,020	-23,850

Source: Steer

Table 7. 2-Way Daily Traffic Volumes on Express Lanes from Scenario No Action to Scenario E

From	To	2017 Observed	2040 No Action	2040 Scenario A - add 1 GP lane	2040 Scenario B - add 1 TEL	2040 Scenario C - add PPSL	2040 Scenario D - convert 1 GP Lane to TEL	2040 Scenario E - convert all GP Lanes to TEL
Palmer Divide Rd	Crystal Valley Pkwy	n/a	25,460	26,480	25,470	25,874	25,700	91,860
Crystal Valley Pkwy	Happy Canyon Rd	n/a	n/a	n/a	23,520	13,029	32,230	164,020
Happy Canyon Rd	RidgeGate Pkwy	n/a	n/a	n/a	18,940	11,183	29,330	173,580
RidgeGate Pkwy	C/E-470	n/a	n/a	n/a	27,720	14,429	32,970	234,770
Change from No Action in Gap		n/a	n/a	1,020	10	414	240	66,400
Change from No Action South of C/E-470		n/a	n/a	n/a	27,720	14,429	32,970	234,770

Source: Steer

Table 8. 2-Way Daily Traffic Volumes on Express Lanes from Scenario F to Scenario K

From	To	2017 Observed	2040 Scenario F - add Reversible Lane	2040 Scenario G - add 2 GP Lanes	2040 Scenario H - add Max GP Lanes	2040 Scenario I - B + add 1 GP Lane in Gap	2040 Scenario J - A + add 1 GP Lane in Gap	2040 Scenario K - add 2 TEL
Palmer Divide Rd	Crystal Valley Pkwy	n/a	26,210	11,500	4,190	12,650	11,370	30,200
Crystal Valley Pkwy	Happy Canyon Rd	n/a	9,700	n/a	n/a	20,880	n/a	30,330
Happy Canyon Rd	RidgeGate Pkwy	n/a	8,810	n/a	n/a	19,180	n/a	26,380
RidgeGate Pkwy	C/E-470	n/a	8,870	n/a	n/a	29,070	n/a	40,200
Change from No Action in Gap		n/a	n/a	-13,960	-21,270	-12,810	-14,090	4,740
Change from No Action South of C/E-470		n/a	n/a	n/a	n/a	29,070	n/a	40,200

Source: Steer

Table 9. 2-Way Daily Traffic Volumes on Other Nearby Roads from Scenario No Action to Scenario E

Location	2017 Observed	2040 No Action	2040 Scenario A - add 1 GP Lane	2040 Scenario B - add 1 TEL	2040 Scenario C - add PPSL	2040 Scenario D - convert 1 GP Lane to TEL	2040 Scenario E - convert all GP Lanes to TEL
West Frontage Rd just south of Plum Creek Pkwy	8,340	35,700	35,070	35,230	35,218	38,440	39,250
East Frontage Rd just south of Crystal Valley Rd	3,390	4,500	4,540	5,010	4,743	4,210	18,990
Santa Fe Dr (US-85) Just south of C-470	49,860	74,610	73,090	72,830	73,401	74,820	80,380
Perry Park Rd (SH-105) just south of Tomah Rd	3,130	9,090	8,690	8,890	8,925	9,440	21,340
SH-83 just south of E-470	62,100	93,900	92,940	92,960	93,218	94,410	101,510
SH-83 just south of Gillian Ave	5,790	12,060	11,160	11,400	11,613	12,810	30,880

Source: Steer

Table 10. 2-Way Daily Traffic Volumes on Other Nearby Roads from Scenario F to Scenario K

Location	2017 Observed	2040 Scenario F - add Reversible Lane	2040 Scenario G - add 2 GP Lanes	2040 Scenario H - add Max GP Lanes	2040 Scenario I - B + add 1 GP Lane in Gap	2040 Scenario J - A + add 1 GP Lane in Gap	2040 Scenario K - add 2 TEL
West Frontage Rd just south of Plum Creek Pkwy	8,340	35,120	35,010	34,990	35,330	35,170	35,200
East Frontage Rd just south of Crystal Valley Rd	3,390	4,620	1,530	1,110	1,540	1,490	3,930
Santa Fe Dr (US-85) Just south of C-470	49,860	73,620	72,320	71,810	72,680	72,860	72,030
Perry Park Rd (SH-105) just south of Tomah Rd	3,130	8,900	6,200	5,090	6,250	6,310	7,910
SH-83 just south of E-470	62,100	93,290	92,080	91,630	92,540	92,490	92,370
SH-83 just south of Gillian Ave	5,790	11,710	9,340	8,410	9,930	9,670	10,610

Source: Steer

C. Travel Times

Steer calculated the travel times along three segments of I-25. Tables 11 and 12 present the northbound travel times i during the AM peak, while Tables 13 and 14 present the southbound travel times in the PM peak.

These tables show that peak period travel times in the GP lanes are expected to increase substantially from 2017 to 2040. The scenarios then improve these peak period travel times in varying ways. As expected, the scenarios that add GP lanes provide travel times savings to the GP lanes (and the TEL options that require travel in the GP lanes), while the scenarios that add TELs improve travel times in the TELs, with minor improvements to the GP lane travel times. In particular, the scenarios that add GP lanes through the Gap provide greater travel time improvements to the GP lanes.

Scenario D, which converts one GP lane to TEL, increases the GP lane travel time while improving the travel time using the TELs.

Tables 15 and 16, combine the travel from the GP lane and TELs, showing the total VMT and VHT along the combined I-25, as well as the measure of average corridor speed calculated by dividing the total I-25 VMT divided by total I-25 VHT.

Table 11. Northbound Travel Times by Segments from Scenario No Action to Scenario E (Minutes)

Northbound GP Lanes only	Peak	Length	2017 Observed	2040 No Action	2040 Scenario A - add 1 GP Lane	2040 Scenario B - add 1 TEL	2040 Scenario C - add PPSL	2040 Scenario D - convert 1 GP Lane to TEL	2040 Scenario E - convert all GP Lanes to TEL
Using GP lanes									
SH-105 to Plum Creek	AM	20.7	20.1	29.0	29.0	29.9	29.8	30.3	n/a
Plum Creek to Meadows	AM	3.3	3.7	7.7	5.4	5.9	6.2	9.2	n/a
Meadows to C-470	AM	9.6	12.5	20.0	15.2	17.0	17.3	24.1	n/a
TOTAL CORRIDOR	**AM**	**33.6**	**36.3**	**56.7**	**49.7**	**52.8**	**53.3**	**63.6**	**n/a**
Using TELs where available (GP if no TEL)									
SH-105 to Plum Creek	AM	20.7	n/a	21.1	21.4	20.8	20.8	19.9	17.7
Plum Creek to Meadows	AM	3.3	n/a	7.7	5.4	3.9	4.4	4.1	4.4
Meadows to C-470	AM	9.6	n/a	20.0	15.2	10.2	11.4	10.8	12.8
TOTAL CORRIDOR	**AM**	**33.6**	**n/a**	**48.8**	**42.0**	**34.9**	**36.6**	**34.8**	**34.9**

Source: Steer

Table 12. Northbound Travel Times by Segments from Scenario F to Scenario K (Minutes)

Northbound GP Lanes only	Peak	Length	2017 Observed	2040 Scenario F - add Reversible Lane	2040 Scenario G - add 2 GP Lane	2040 Scenario H - add Max GP Lanes	2040 Scenario I - B + add 1 GP Lane in Gap	2040 Scenario J - A + add 1 GP Lane in Gap	2040 Scenario K - add 2 TEL
Using GP lanes									
SH-105 to Plum Creek	AM	20.7	20.1	29.9	21.6	17.9	22.4	21.6	24.8
Plum Creek to Meadows	AM	3.3	3.7	5.9	4.3	3.4	6.3	5.6	5.0
Meadows to C-470	AM	9.6	12.5	17.0	13.1	11.4	17.2	15.5	14.6
TOTAL CORRIDOR	**AM**	**33.6**	**36.3**	**52.8**	**38.9**	**32.7**	**45.9**	**42.7**	**44.4**
Using TELs where available (GP if no TEL)									
SH-105 to Plum Creek	AM	20.7	n/a	20.8	19.5	17.4	19.0	19.4	20.0
Plum Creek to Meadows	AM	3.3	n/a	3.9	4.3	3.4	3.5	5.6	3.6
Meadows to C-470	AM	9.6	n/a	10.2	13.1	11.4	10.3	15.5	10.5
TOTAL CORRIDOR	**AM**	**33.6**	**n/a**	**34.9**	**36.8**	**32.2**	**32.9**	**40.5**	**34.1**

Source: Steer

Table 13. Southbound Travel Times on GP Lanes by Segments from Scenario No Action to Scenario E (Minutes)

Southbound GP lanes only	Peak	Length	2017 Observed	2040 No Action	2040 Scenario A - add 1 GP Lane	2040 Scenario B - add 1 TEL	2040 Scenario C - add PPSL	2040 Scenario D - convert 1 GP Lane to TEL	2040 Scenario E - convert all GP Lanes to TEL
Using GP lanes									
SH-105 to Plum Creek	PM	9.6	8.7	15.6	11.5	12.7	13.0	19.2	n/a
Plum Creek to Meadows	PM	3.3	2.9	6.6	4.3	5.0	5.2	8.5	n/a
Meadows to C-470	PM	20.7	21.2	49.0	53.2	46.6	46.9	42.0	n/a
TOTAL CORRIDOR	**PM**	**33.6**	**32.7**	**71.2**	**69.0**	**64.3**	**65.1**	**69.7**	**n/a**
Using TELs where available (GP if no TEL)									
SH-105 to Plum Creek	PM	9.6	n/a	15.6	11.5	10.9	11.5	10.4	12.8
Plum Creek to Meadows	PM	3.3	n/a	6.6	4.3	3.3	3.7	3.1	4.4
Meadows to C-470	PM	20.7	n/a	26.5	27.2	18.7	19.7	18.0	18.9
TOTAL CORRIDOR	**PM**	**33.6**	**n/a**	**48.7**	**43.0**	**32.9**	**34.8**	**31.6**	**36.1**

Source: Steer

Table 14. Southbound Travel Times by Segments from Scenario F to Scenario K (Minutes)

Southbound GP lanes only	Peak	Length	2017 Observed	2040 Scenario F - add Reversible Lane	2040 Scenario G - add 2 GP Lanes	2040 Scenario H - add Max GP Lanes	2040 Scenario I - B + add 1 GP Lane in Gap	2040 Scenario J - A + add 1 GP Lane in Gap	2040 Scenario K - add 2 TEL
Using GP lanes									
SH-105 to Plum Creek	PM	9.6	8.7	12.7	9.8	9.0	13.0	11.7	11.1
Plum Creek to Meadows	PM	3.3	2.9	5.0	3.2	2.8	5.3	4.4	4.4
Meadows to C-470	PM	20.7	21.2	46.6	27.3	18.9	21.3	26.6	29.4
TOTAL CORRIDOR	**PM**	**33.6**	**32.7**	**64.3**	**40.2**	**30.7**	**39.6**	**42.7**	**44.9**
Using TELs where available (GP if no TEL)									
SH-105 to Plum Creek	PM	9.6	n/a	10.9	9.8	9.0	11.5	11.7	9.3
Plum Creek to Meadows	PM	3.3	n/a	3.3	3.2	2.8	3.4	4.4	2.8
Meadows to C-470	PM	20.7	n/a	18.7	23.7	18.4	18.7	23.3	17.4
TOTAL CORRIDOR	**PM**	**33.6**	**n/a**	**32.9**	**36.6**	**30.3**	**33.6**	**39.4**	**29.4**

Source: Steer

Table 15. Peak Period – Peak Direction I-25 Corridor VMT and VHT from Scenario No Action to Scenario E

Measure	2017 Observed	2040 No Action	2040 Scenario A - add 1 GP Lane	2040 Scenario B - add 1 TEL	2040 Scenario C - add PPSL	2040 Scenario D - convert 1 GP Lane to TEL	2040 Scenario E - convert all GP Lanes to TEL
Northbound - AM							
VMT	361,641	532,593	562,450	551,809	549,407	511,510	316,711
VHT	6,424	15,592	13,901	14,039	14,233	15,604	5,183
Ave Speed (mph)	56.3	34.2	40.5	39.3	38.6	32.8	61.1
Southbound - PM							
VMT	591,627	845,793	892,469	886,796	881,670	814,481	508,822
VHT	10,718	23,435	20,824	21,032	21,333	23,569	8,381
Ave Speed (mph)	55.2	36.1	42.9	42.2	41.3	34.6	60.7

Source: Steer

Table 16. Peak Period – Peak Direction I-25 Corridor VMT and VHT from Scenario F to Scenario K (Minutes)

Measure	2017 Observed	2040 Scenario F - add Reversible Lane	2040 Scenario G - add 2 GP Lanes	2040 Scenario H - add Max GP Lanes	2040 Scenario I - B + add 1 GP Lane in Gap	2040 Scenario J - A + add 1 GP Lane in Gap	2040 Scenario K - add 2 TEL
Northbound - AM							
VMT	361,641	551,809	594,793	614,365	569,059	580,529	648,110
VHT	6,424	14,039	12,100	10,491	13,314	13,322	13,255
Ave Speed (mph)	56.3	39.3	49.2	58.6	42.7	43.6	48.9
Southbound - PM							
VMT	591,627	886,796	937,948	962,497	911,991	917,765	1,009,894
VHT	10,718	21,032	18,247	16,286	20,259	19,982	20,010
Ave Speed (mph)	55.2	42.2	51.4	59.1	45.0	45.9	50.5

Source: Steer

6. Summary of Performance

A. Scenario-Specific Observations

Below we provide highlight observations from this analysis for each scenario. Scenario A-K observations are in relation to 2040 No Action.

- No Action
  - On average, daily traffic volume is forecast to increase nearly 50% from 2017 to 2040 and, without additional improvements, the corridor travel time will double by 2040.
  - Daily traffic volumes range from 94,000 in the Gap to 270,000 near C/E-470 on the GP lane, and about 25,000 in the Gap TEL.
  - Corridor travel times will double from current levels in the peak periods.
- Scenario A: Add 1 GP
  - Study area VHT decreases by 1.4%.
  - Daily traffic volumes increase 3,000-11,000 north of the Gap.
  - Peak period travel times decrease 2-7 minutes.
- Scenario B: Add 1 TEL
  - Study area VHT decreases by 1.3%.
  - North of Gap, TEL daily traffic volumes increase by more than GP lanes decrease (averages of 23,000 vs. 17,000).
  - Peak period travel times decrease by 4-7 minutes in GP lanes and by 14-16 minutes in TELs.

- Scenario C: Add PPSL Lane
    - Study area VHT decreases by 0.9%.
    - North of Gap, TEL daily traffic volumes increase by more than GP lanes decrease (13,000 vs. 8,000).
    - Peak period travel times decrease by 3-6 minutes in GP lanes and by 12-14 minutes in TELs.
- Scenario D: Convert 1 GP to TEL
    - Study area VHT increases by 0.6%.
    - North of Gap, TEL daily traffic volumes increase by less than GP lanes decrease (32,000 vs. 35,000).
    - Peak period travel times increase in GP lanes by as much as 7 minutes but decrease by as much as 17 minutes in TELs.
- Scenario E: Convert ALL GP to TEL
    - Causes significant traffic diversion to the local road system, doubles traffic on SH-105 and 3x more traffic on SH-83.
    - Study area VHT increases by 5.7%.
- Scenario F: Add Reversible Lane
    - Study area VHT decreases by 0.9%.
    - North of Gap, TEL daily traffic volumes increase by more than GP lanes decrease (9,000 vs. 5,000).
    - Peak period travel times decrease by 4-7 minutes in GP lanes and by up to 16 minutes in TELs.
- Scenario G: Add 2 GP
    - Study area VHT decreases by 2.7%.
    - Daily traffic volumes increase 4,000-17,000 north of the Gap and by 17,000-22,000 through the Gap.
    - Peak period travel times decrease by 18-31 minutes in GP lanes and by 12 minutes in TELs.
- Scenario H: Add Max GP
    - Study area VHT decreases by 3.5%.
    - Daily traffic volumes increase 5,000-21,000 north of the Gap and by 25,000-34,000 through the Gap.
    - Peak period travel times decrease by up to 31 minutes in GP lanes and by 8-9 minutes in TELs.
- Scenario I: "B" plus 1 GP in Gap
    - Study area VHT decreases by 2.0%.
    - North of Gap, TEL daily traffic volumes increase by more than GP lanes decrease (23,000 vs. 14,000).
    - Daily traffic volumes through the Gap increase by 16,000-21,000.

  - Peak period travel times decrease by 11-32 minutes in GP lanes and by 15-16 minutes in TELs.
- Scenario J: "A" plus 1 GP in Gap
  - Study area VHT decreases by 2.1%.
  - Daily traffic volumes increase 3,000-12,000 north of the Gap and 17,000-22,000 through the Gap.
  - Peak period travel times decrease by up to 29 minutes in GP lanes and by 8-9 minutes in TELs.
- Scenario K: Add 2 TEL
  - Study area VHT decreases by 2.2%.
  - Daily traffic volumes decrease by 16,000-28,000 north of the Gap and 1,000-2,000 through the Gap.
  - Peak period travel times decrease by up to 26 minutes in GP lanes and by up to 19 minutes in TELs.

B. General Observations

In addition to the scenario-specific observations noted above, there are some general observations about the performance:

- The scenarios with the greatest increases in capacity, whether GP lane or TEL, have the best traffic performance (G, H, I, J, & K).
- Those with TELs, have the benefit of providing a continuous reliable trip choice from Monument to C/E-470 (B, C, D, E, F, I, & K).
- Scenario E, which converts all GP lanes to TEL, causes significant traffic diversion to the local road system (doubles traffic on SH-105 and increases traffic on Hwy 83 threefold) and overall does not accommodate as much traffic demand as the other scenarios.
- Adding just one GP lane north of the Gap, as in Scenario A, does not provide much travel time improvement.

7. Additional Scenarios

A. Overview

After the analysis of the initial scenarios described above, a couple additional scenarios were developed to further analyze solutions for the corridor. Specifically, we analyzed 2 additional scenarios:

1. Scenario L: Add 1 Tolled Express Lane North of Gap and 1 GP Lane Throughout Corridor

This scenario adds 1 tolled express lane in each direction to I-25 from C/E-470 to north of the Gap, plus 1 GP Lane throughout the corridor. This scenario is an addition to Scenario B (TEL north of the GAP) and Scenario I which adds 1 GP Lane in the Gap to Scenario B.

2. Scenario M: Scenario L plus New Directional Ramps to Santa Fe

This scenario starts with Scenario L and adds a new interchange to the GP Lanes from US 85/Santa Fe. The logic behind this scenario is that because US 85 is another regional route connecting with the south and central portions of the Denver area, adding a more direct connector with the southern end of the regional route may divert traffic from I-25.

Table 17 below summarizes the number of lanes by section for these scenarios.

Table 17. Number of Lanes in Each Direction by Scenario

Section	Number of Lanes[6]			Number of Lanes		
	GP	TEL	Total	GP	TEL	Total
	Scenario L – Scenario B + 1 GP Lane			Scenario M – Scenario L plus New Directional Ramps to Santa Fe		
North of Meadows/Founders	5	1	6	5	1	6
Plum Creek to Meadows/Founders	4	1	5	4	1	5
Gap	3	1	4	3	1	4
South of Gap	3	0	3	3	0	3

B. Results

Below we provide the results for these new scenarios, including Scenario B and Scenario I results as a reference. The results show the additional improvement of Scenarios L and M in the various performance measures over Scenario B and I. The results also highlight the little difference in performance between Scenarios L and M.

Table 18. VMT and VHT from Scenarios L and M

	2017 Model Forecast	2040 No Action	2040 Scenario B - add 1 TEL	2040 Scenario I - B + add 1 GP Lane including in Gap	2040 Scenario L – Scenario B + 1 GP Lane	Scenario M – Scenario L plus New Directional Ramps to Santa Fe
Study Area VMT	17,961,448	27,039,456	27,065,909	27,072,676	27,090,892	27,087,990
Study Area VHT	488,197	861,773	850,581	844,900	837,695	837,500
VMT % Change from No Action	NA	NA	0.10%	0.12%	0.19%	0.18%
VHT % Change from No Action	NA	NA	-1.30%	-1.96%	-2.79%	-2.82%

Source: Steer

[6] Auxiliary lanes and climbing lanes were included in the network coding, but not reflected in the lane count

Table 19. 2-Way Daily Traffic Volumes on GP Lanes from Scenarios L and M

From	To	2017 Observed	2040 No Action	2040 Scenario B - add 1 TEL	2040 Scenario I - B + add 1 GP Lane including in Gap	2040 Scenario L – Scenario B + 1 GP Lane	2040 Scenario M – Scenario L plus New Directional Ramps to Santa Fe
Baptist Rd	SH-105	95,540	145,340	145,580	146,550	146,960	146,960
SH-105	Palmer Divide Rd	76,780	121,280	121,590	122,850	123,360	123,370
Palmer Divide Rd	Greenland Rd	77,740	93,950	94,610	109,920	111,180	111,280
Greenland Rd	Upper Lake Gulch Rd	78,140	94,840	95,490	111,030	112,350	112,460
Upper Lake Gulch Rd	Spruce Mountain Rd	77,430	94,230	95,080	110,780	111,960	112,060
Spruce Mountain Rd	Sky View Ln	81,080	100,100	100,870	117,810	119,160	119,280
Sky View Ln	Crystal Valley Pkwy	79,000	95,990	96,630	117,160	118,560	118,670
Crystal Valley Pkwy	Plum Creek Pkwy	79,000	151,740	131,230	140,170	148,930	149,140
Plum Creek Pkwy	Wilcox St / Wolfensberger Rd	99,090	168,330	152,610	158,110	170,930	172,510
Wilcox St / Wolfensberger Rd	Founders Pkwy / Meadows Pkwy	111,570	175,020	160,070	164,830	179,060	177,810
Founders Pkwy / Meadows Pkwy	Castle Rock Pkwy	132,750	195,130	178,850	183,840	195,450	195,310
Castle Rock Pkwy	Happy Canyon Rd	136,750	205,740	189,100	192,410	203,540	203,480
Happy Canyon Rd	Castle Pines Pkwy / Hess Rd	142,220	205,110	192,870	193,430	202,140	202,140
Castle Pines Pkwy / Hess Rd	RidgeGate Pkwy	140,670	222,890	202,430	203,050	209,380	209,350
RidgeGate Pkwy	Lincoln Ave	153,720	229,370	209,510	209,410	212,730	212,560
Lincoln Ave	C/E-470	196,260	270,100	253,610	253,380	255,560	255,500
Change from No Action in Gap		n/a	n/a	660	15,970	17,230	17,330
Change from No Action South of C/E-470		n/a	n/a	-16,490	-16,720	-14,540	-14,600

Source: Steer

Table 20. 2-Way Daily Traffic Volumes on Express Lanes from Scenarios L and M

From	To	2017 Observed	2040 No Action	2040 Scenario B - add 1 TEL	2040 Scenario I - B + add 1 GP Lane including in Gap	2040 Scenario L – Scenario B + 1 GP Lane	2040 Scenario M – Scenario L plus New Directional Ramps to Santa Fe
Palmer Divide Rd	Crystal Valley Pkwy	n/a	25,460	25,470	12,650	11,950	11,850
Crystal Valley Pkwy	Happy Canyon Rd	n/a	n/a	23,520	20,880	14,570	14,570
Happy Canyon Rd	RidgeGate Pkwy	n/a	n/a	18,940	19,180	15,430	15,420
RidgeGate Pkwy	C/E-470	n/a	n/a	27,720	29,070	29,120	29,180
Change from No Action in Gap		n/a	n/a	10	-12,810	-13,510	-13,610
Change from No Action South of C/E-470		n/a	n/a	27,720	29,070	29,120	29,180

Source: Steer

Table 21. 2-Way Daily Traffic Volumes on Other Nearby Roads from Scenarios L and M

Location	2017 Observed	2040 No Action	2040 Scenario B - add 1 TEL	2040 Scenario I - B + add 1 GP Lane including in Gap	2040 Scenario L – Scenario B + 1 GP Lane	2040 Scenario M – Scenario L plus New Directional Ramps to Santa Fe
West Frontage Rd just south of Plum Creek Pkwy	8,340	35,700	35,230	35,330	35,080	34,670
East Frontage Rd just south of Crystal Valley Rd	3,390	4,500	5,010	1,540	1,550	1,550
Santa Fe Dr (US-85) Just south of C-470	49,860	74,610	72,830	72,680	71,710	71,710
Perry Park Rd (SH-105) just south of Tomah Rd	3,130	9,090	8,890	6,250	6,130	6,130
SH-83 just south of E-470	62,100	93,900	92,960	92,540	91,840	91,820
SH-83 just south of Gillian Ave	5,790	12,060	11,400	9,930	9,330	9,320

Source: Steer

Table 22. Northbound Travel Times by Segments from Scenarios L and M

Northbound GP Lanes only	Peak	Length	2017 Observed	2040 No Action	2040 Scenario B - add 1 TEL	2040 Scenario I - B + add 1 GP Lane including in Gap	2040 Scenario L – Scenario B + 1 GP Lane	2040 Scenario M – Scenario L plus New Directional Ramps to Santa Fe
Using GP lanes								
SH-105 to Plum Creek	AM	20.7	20.1	29.0	29.9	22.4	22.0	22.0
Plum Creek to Meadows	AM	3.3	3.7	7.7	5.9	6.3	4.6	4.6
Meadows to C-470	AM	9.6	12.5	20.0	17.0	17.2	13.8	13.7
TOTAL CORRIDOR	**AM**	**33.6**	**36.3**	**56.7**	**52.8**	45.9	40.4	40.4
Using TELs where available (GP if no TEL)								
SH-105 to Plum Creek	AM	20.7	n/a	21.1	20.8	19.0	18.8	18.8
Plum Creek to Meadows	AM	3.3	n/a	7.7	3.9	3.5	3.3	3.3
Meadows to C-470	AM	9.6	n/a	20.0	10.2	10.3	10.1	10.1
TOTAL CORRIDOR	**AM**	**33.6**	**n/a**	**48.8**	**34.9**	**32.9**	**32.2**	**32.2**

Source: Steer

Table 23. Southbound Travel Times on GP Lanes by Segments from Scenarios L and M

Southbound GP lanes only	Peak	Length	2017 Observed	2040 No Action	2040 Scenario B - add 1 TEL	2040 Scenario I - B + add 1 GP Lane including in Gap	2040 Scenario L – Scenario B + 1 GP Lane	2040 Scenario M – Scenario L plus New Directional Ramps to Santa Fe
Using GP lanes								
SH-105 to Plum Creek	PM	9.6	8.7	15.6	12.7	13.0	10.2	10.2
Plum Creek to Meadows	PM	3.3	2.9	6.6	5.0	5.3	3.7	3.7
Meadows to C-470	PM	20.7	21.2	49.0	46.6	21.3	23.1	23.3
TOTAL CORRIDOR	**PM**	**33.6**	**32.7**	**71.2**	**64.3**	**39.6**	**37.0**	**37.2**
Using TELs where available (GP if no TEL)								
SH-105 to Plum Creek	PM	9.6	n/a	15.6	10.9	11.5	10.1	10.1
Plum Creek to Meadows	PM	3.3	n/a	6.6	3.3	3.4	2.9	2.9
Meadows to C-470	PM	20.7	n/a	26.5	18.7	18.7	17.7	17.7
TOTAL CORRIDOR	**PM**	**33.6**	**n/a**	**48.7**	**32.9**	**33.6**	**30.7**	**30.7**

Source: Steer

Table 24. Peak Period – Peak Direction I-25 Corridor VMT and VHT from Scenarios L and M

Measure	2017 Observed	2040 No Action	2040 Scenario B - add 1 TEL	2040 Scenario I - B + add 1 GP Lane including in Gap	2040 Scenario L – Scenario B + 1 GP Lane	2040 Scenario M – Scenario L plus New Directional Ramps to Santa Fe
Northbound - AM						
VMT	361,641	532,593	551,809	569,059	591,558	590,998
VHT	6,424	15,592	14,039	13,314	12,041	12,015
Ave Speed (mph)	56.3	34.2	39.3	42.7	49.1	49.2
Southbound - PM						
VMT	591,627	845,793	886,796	911,991	938,115	938,065
VHT	10,718	23,435	21,032	20,259	18,413	18,454
Ave Speed (mph)	55.2	36.1	42.2	45.0	50.9	50.8

Source: Steer