US36 VALUE PRICING SCENARIO ANALYSIS

TECHNICAL MEMO

PREPARED FOR COLORADO DEPARTMENT OF TRANSPORTATION

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1 INTRODUCTION

The Colorado Department of Transportation (CDOT) in cooperation with the Federal Highway Administration (FHWA) engaged the DynusT Research Laboratory at the University of Arizona to perform a Dynasmart model of proposed managed lane improvements on the US 36 corridor. The $80,000 effort was jointly funded by CDOT and FHWA and was completed in close cooperation with the modeling staff at the Denver Regional Council of Governments (DRCOG) – the region's metropolitan planning organization. An additional $20,000 was recently awarded by FHWA through the Technology Transfer program to continue refinement of the Dynasmart model and to ensure that DRCOG and CDOT staff are trained sufficiently to utilize the model to evaluate other proposed corridor improvements regionwide.

This memo provides summaries of all analyses performed for value pricing scenarios by the DynusT Research Laboratory at the University of Arizona. The report includes performance data for the managed lane concept on the U.S. 36 corridor at varying funding levels. At higher funding levels, a greater distance of managed lanes can be built. The goal of this memo is to provide useful information in a concise format to support CDOT TIGER grant proposal preparation. Detailed modeling methodologies, processes and outputs are not included in this report.

The performance measures are listed in the following chapters. They include overall simulation statistics, city-to-city travel time, average speeds for US36 corridor HOT and GP lane facilities, transit travel time in comparison with GP lane traffic, fuel consumption, and toll revenue.

OVERALL SIMULATION STATISTICS

1.1 System Boundary

The study area for the US 36 corridor analysis as shown in Figure 1-1 is approximately 250 square miles. The study area boundaries are given as follows:

- **North boundary:** Baseline Rd. from Colorado 93 to Washington St.
- **East boundary:** Washington St. from Baseline Rd. to E. 88th Ave., then Dahlia St. from E 88th Ave to E. 64th Ave.
- **South boundary:** E. 64th Ave. from Dahlia St. to Colorado 93
- **West Boundary:** Colorado 93 from E 64th St. to Baseline Rd.

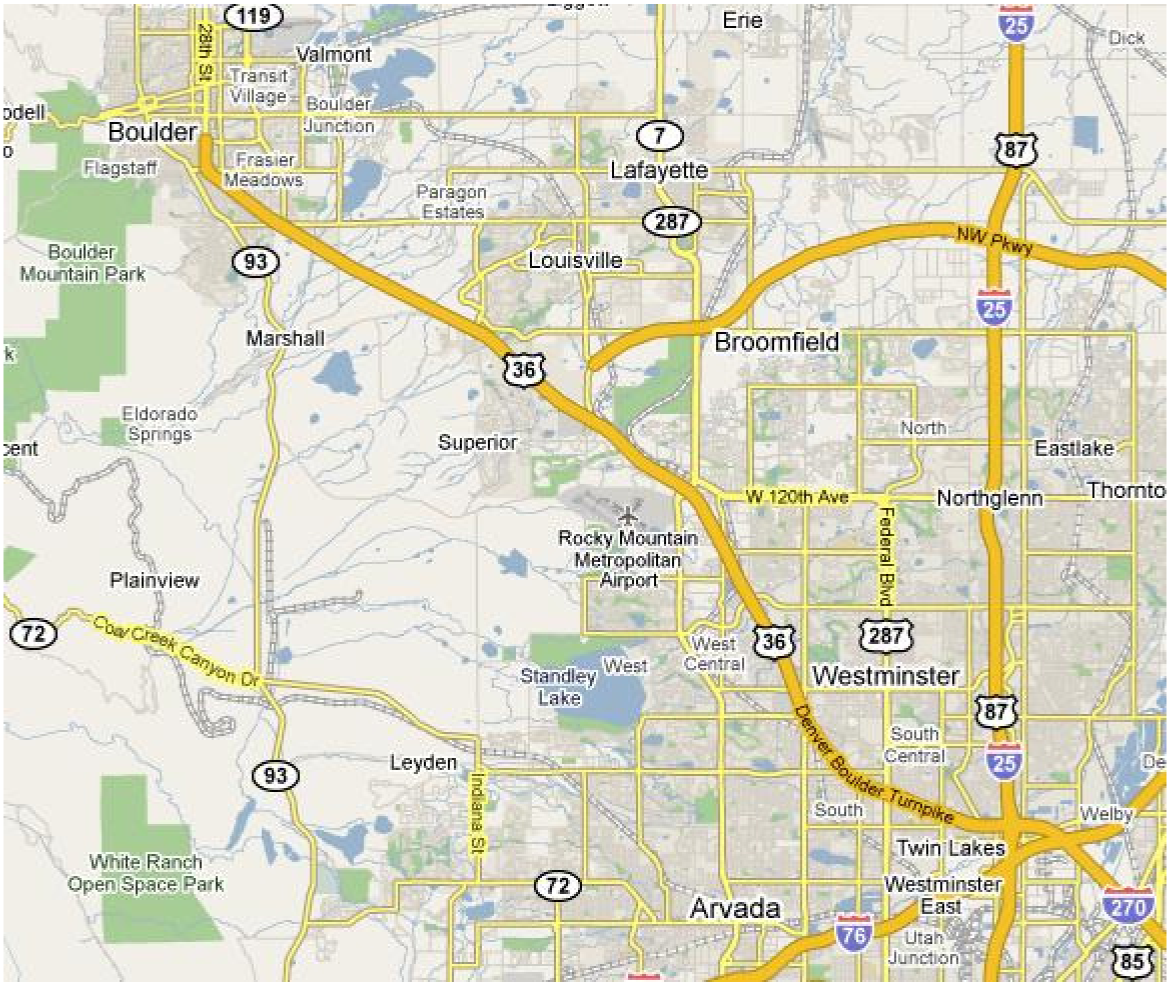

Figure 1-1 US 36 Colorado Value Pricing Study Area

1.2 BASIC SIMULATION STATISTICS

The overall modeling effort for the US 36 in total was 4 base models. This project was approached from two different planning years: 2012 representing opening year the proposed facility would be built and 2035 being a future planning year. Each planning year was split into two time periods: AM Peak and PM Peak. The following table describes each base model and network simulation statistics:

Table 1-1 Simulation Statistics for all Scenarios

Model Year	2012						2035					
Time Period	AM Peak			PM Peak			AM Peak			PM Peak		
Time Description	6:30am – 10:30am			3:30pm – 7:30pm			6:30am – 10:30am			3:30pm – 7:30pm		
# Vehicles	534,865			669,298			649,527			889,811		
Vehicle Class %	SOV	HOV	COM	SOV	HOV	COM	SOV	HOV	COM	SOV	HOV	COM
	75.1	10.3	14.6	74.4	7.7	17.9	76.6	10.7	12.7	70.3	13.0	16.7

Each base model entailed 3 scenarios, each described below:

1. No Build: Network conditions modeled as is for model year
2. $160 Million Build: HOT lanes modeled on US 36 in both directions from Federal Blvd. to Wadsworth Parkway (Broomfield)
3. $260 Million Build: HOT lanes modeled on US 36 in both directions from Federal Blvd. to Interlocken Interchange

The following are the sub area network VMT for each scenario for 2012 and 2035 AM/PM:

Table 1-2 Sub Area Network VMT for all Scenarios

	2012		2035	
	AM Peak	PM Peak	AM Peak	PM Peak
	VMT	VMT	VMT	VMT
No Build	3,051,059	3,138,360	3,456,821	3,802,004
$160 M	3,036,798	3,133,814	3,449,578	3,849,079
$260 M	3,011,370	3,146,198	3,424,753	3,832,784

AVERAGE TRAVEL TIME

1.3 CORRIDOR-WIDE AVERAGE TRAVEL TIME

Travel time information from the scenario simulations were collected from vehicles that originated among four municipalities located within about 1-mile along the US36 corridor. In the AM peak period, the travel time saving for the $160M scenario is 3.87% compared to the no-build scenario. The saving for the $260M scenario is 4.91%. The saving for the PM period drops to 1.47% and 2.54% respectively. The AM-PM difference is primarily due to spreading of departing traffic over a longer period in the AM period, leading to a lesser degree of congestion.

The AM no-build scenario for 2035 was found to perform better than the 2012 scenario. Further investigation found that future improvements on I-25 (capacity expansion) and US36 (interchange improvement) result in considerable improvement in traffic flow on I-25, which directly alleviates the traffic spillback into US36 from the US36-I25 interchange. Overall with these improvement projects, the AM travel time is about the same as the 2012 level. However, it is noteworthy that the PM travel time is significantly longer than the 2012 PM travel time. Compared with the no-build scenario, both build-out scenarios improve travel time by 3.26% and 2.3% respectively.

Table 1-3 Summaries of Corridor-Wide Average Travel Time

	2012				2035			
	AM Peak		PM Peak		AM Peak		PM Peak	
	Avg. TT	Saving (%)	Avg. TT	Savings (%)	Avg. TT	Saving (%)	Avg. TT	Saving (%)
No Build	15.69	--	9.21	--	14.66	--	27.36	--
$160 M	15.08	3.87%	9.08	1.47%	14.67	-0.02%	26.47	3.26%
$260 M	14.92	4.91%	8.98	2.54%	14.65	0.10%	26.73	2.30%

Considering 250 days/year, these saving can be translated into total annual travel time saving as shown in Table 1-4. The $160M scenario would yield 1.47 and 2.75 million hours savings in 2012 and 2035 respectively, while $260M yields a higher 2.0 million and 1.98 million hours saving.

Table 1-4 Annual Travel Time Saving Compared with No-Build Scenario

Scenario	Year 2012 (million hours)	Year 2035 (million hours)
$160 M	1.47	2.75
$260 M	2.00	1.98

2 AVERAGE SPEED

This section describes the average speeds along the US36 corridor. The east limit of analysis was the Federal Hwy/US36 Interchange, and the western limit of analysis was the Baseline/US36 Interchange. The speeds were collected for each link along EB and WB separately, and averaged over the respective peak hour.

The tables below show the averaged speeds over the entire corridor. The overall observations across all scenarios are:

- For each Peak/Year, the average speed of the GP lane increased as the limits of construction increased.
- The 2012 AM and PM show that no improvement was present for GP lane speeds in the $160 Million build scenario. It was observed that traffic at the Wadsworth Interchange is still rather congested. However, the limits for the $260 Million scenario allowed traffic to experience higher speed at this interchange, increasing the average travel speed.
- Most of the scenarios had an average speed for the HOT lanes around 65 mph, well above the target minimum speed of 50 mph.
- The eastbound speeds in 2035 are much higher compared to 2012, which can be attributed to the increase in lanes on I-25.

2.1 2012 - AM PEAK

In this scenario, HOT lanes exceed the target minimum speed of 50 mph for all build scenarios. No significant GP lane speed improvements are observed with the build scenarios over the No-Build scenario; in some cases a slight reduction in GP lane speeds was observed.

Table 2-1 2012 AM Peak Average Speed

Scenario	Facility (HOT/GP)	Direction	Scenario Average Speed (mph)	No-build Average Speed (mph)	Speed Improvement (mph)
$160 Million	HOT	Eastbound	62.79[1]	-	-
$160 Million	GP	Eastbound	40.82	41.92	NI*[2]
$160 Million	HOT	Westbound	63.10	-	-
$160 Million	GP	Westbound	45.66	45.80	NI*
$260 Million	HOT	Eastbound	62.31	-	-
$260 Million	GP	Eastbound	43.36	41.92	+1.44
$260 Million	HOT	Westbound	58.27	-	-
$260 Million	GP	Westbound	44.93	45.80	NI*

*Asterisk stand for no improvement observed

2.2 2012 – PM Peak

The 2012 PM peak scenarios exhibit similar trends to the AM peak scenarios, with the $260M project exhibiting slight improvement in GP speed in the WB direction. $160M performs slightly worse than the No-Build scenario for GP lane speed, but only by a small margin. Overall, HOT lanes operate at above target speed.

Table 2-2 2012 PM Peak Average Speed

Scenario	Facility (HOT/GP)	Direction	Scenario Average Speed (mph)	No-build Average Speed (mph)	Speed Improvement (mph)
$160 Million	HOT	Eastbound	64.98	-	-
$160 Million	GP	Eastbound	42.51	45.52	NI*
$160 Million	HOT	Westbound	64.98	-	-
$160 Million	GP	Westbound	49.16	50.20	NI*
$260 Million	HOT	Eastbound	64.96	-	-
$260 Million	GP	Eastbound	42.48	45.52	NI*
$260 Million	HOT	Westbound	64.77	-	-
$260 Million	GP	Westbound	50.69	50.20	+0.49

* Asterisk stand for no improvement observed

[1] HOT lanes are above the 50 mph target speed

[2] GP does not yield significant improvement because congestion still exists downstream near the I-25 Interchange

2.3 2035 - AM PEAK

In 2035 AM period, both build-out scenarios exhibit GP lane speed improvement from 2.86% ($160M) to 5.58% ($260M). HOT lanes achieve above target speeds. However, WB traffic appears to be underperforming for the reason explained in the footnote section.

Table 2-3 2035 AM Peak Average Speed

Scenario	Facility (HOT/GP)	Direction	Scenario Average Speed (mph)	No-build Average Speed (mph)	Speed Improvement (mph)
$160 Million	HOT	Eastbound	64.41	-	-
$160 Million	GP	Eastbound	47.69	44.83	+2.86
$160 Million	HOT	Westbound	63.00	-	-
$160 Million	GP	Westbound	41.39	45.73	NI*[3]
$260 Million	HOT	Eastbound	64.70	-	-
$260 Million	GP	Eastbound	50.68	44.83	+5.83
$260 Million	HOT	Westbound	64.10	-	-
$260 Million	GP	Westbound	41.47	45.73	NI*

* Asterisk stand for no improvement observed

2.4 2035 – PM PEAK

In the 2035 PM peak period, improvement for EB traffic continues for both build-out scenarios. The WB speed generally reduces to a lower level compared with the AM traffic.

Table 2-4 2035 PM Peak Average Speed

Scenario	Facility (HOT/GP)	Direction	Scenario Average Speed (mph)	No-build Average Speed (mph)	Speed Improvement (mph)
$160 Million	HOT	Eastbound	54.88	-	-
$160 Million	GP	Eastbound	41.26	39.14	+2.12
$160 Million	HOT	Westbound	64.60	-	-
$160 Million	GP	Westbound	34.42	39.80	NI*[4]
$260 Million	HOT	Eastbound	57.62	-	-
$260 Million	GP	Eastbound	42.55	39.14	+3.41
$260 Million	HOT	Westbound	64.60	-	-
$260 Million	GP	Westbound	35.73	39.80	NI*

* Asterisk stand for no improvement observed

[3] With the new improvements to the Wadsworth Interchange, more traffic goes west towards Boulder, which increase the density and congests US36. The limits of construction on the $160 Million build and $260 Million build are close to this interchange, and discharge traffic from the HOT lane into the general purpose lane. The additional traffic plus the already congested roadway yields the above results.

[4] This drop in speed is consistent with the AM Peak, but has a higher demand which gives lower speeds.

3 TRANSIT TRAVEL TIME VS AUTO GP LANE TRAVEL TIME

This section provides comparative results between several transit routes taking the HOT lane and an alternative auto route between the same O-D pair but taking a GP lane facility. All the transit routes over the AM and PM peak periods along the US36 corridor were coded into the model and the travel time was extracted from bus vehicles' actual experienced travel time from simulation. All bus routes traversing US36 are assumed to take the HOT lane facilities. Buses also get on and off US36 at designated locations to pick up passengers. However, the travel times reported in this section include only the running time, excluding the dwell time at each bus stop to ensure consistent comparison.

3.1 2012 – AM PEAK

The AM peak in 2012 shows general purpose (GP) lane improvements in average travel time savings when compared with the No Build scenario for the $260 m case. With the $160 M scenario, GP travel times decline, but only slightly. There is significant time savings for bus routes employing HOT lanes versus the GP lanes in both scenarios. The savings for $160M and $260M scenarios are 54.31% and 51.94% respectively.

Table 3-1 2012 AM GP vs. HOT/Bus Travel Time

Scenario	Facility (BUS/GP)	Scenario Average Travel Time (min)	No-build Average Travel Time (min)	Scenario GP vs. No Build (%)	Scenario BUS Savings vs. Scenario GP (%)	Scenario BUS Savings vs. No Build (%)
$160 Million	BUS	10.85	-	-	54.31	-
	GP	23.74	23.33	-1.76	-	53.51
$260 Million	BUS	9.80	-	-	51.94	-
	GP	20.39	23.33	12.61	-	58.01

3.2 2012 – PM PEAK

Similar to 2012 AM Peak, the $260 Million case demonstrates GP lane travel time improvements. The $160 Million case gave GP lane travel time improvement only for those travelling from Denver to Broomfield and Westminster. Overall, an 8.89% decline in GP travel speeds was observed with the $160 M case. However, bus routes illustrate positive improvements with $260 Million case showing the greatest improvement.

Table 3-2 2012 PM GP vs. HOT/Bus Travel Time

Scenario	Facility (BUS/GP)	Scenario Average Travel Time (min)	No-build Average Travel Time (min)	Scenario GP vs. No Build (%)	Scenario BUS Savings vs. Scenario GP (%)	Scenario BUS Savings vs. No Build (%)
$160 Million	BUS	13.74	-	-	29.18	-
	GP	19.40	17.82	-8.89	-	22.89
$260 Million	BUS	10.52	-	-	34.72	-
	GP	16.12	17.82	9.54	-	40.95

3.3 2035 – AM Peak

Travel along HOT lanes for bus routes demonstrate significant travel time savings, but travel time in the GP lanes declines somewhat for each scenario.

Table 3-3 2035 AM GP vs. HOT/Bus Travel Time

Scenario	Facility (BUS/GP)	Scenario Average Travel Time (min)	No-build Average Travel Time (min)	Scenario GP vs. No Build (%)	Scenario BUS Savings vs. Scenario GP (%)	Scenario BUS Savings vs. No Build (%)
$100 Million	BUS	12.12	-	-	56.13	-
	GP	27.64	22.74	-21.50	-	46.70
$200 Million	BUS	10.75	-	-	59.65	-
	GP	26.65	22.74	-17.16	-	52.73

3.4 2035 – PM Peak

Overall, the scenarios proposed do provide travel time savings, particularly along the HOT lanes. In all cases, the GP lanes are also marginally improved.

Table 3-4 2035 PM GP vs. HOT/Bus Travel Time

Scenario	Facility (BUS/GP)	Scenario Average Travel Time (min)	No-build Average Travel Time (min)	Scenario GP vs. No Build (%)	Scenario BUS Savings vs. Scenario GP (%)	Scenario BUS Savings vs. No Build (%)
$100 Million	BUS	21.62	-	-	37.70	-
	GP	34.70	40.91	15.19	-	47.16
$200 Million	BUS	17.62	-	-	53.55	-
	GP	37.93	40.91	7.29	-	56.94

4 FUEL CONSUMPTION

The fuel consumption results as displayed in Table 4-1 (for 2012) and Table 4-2 (for 2035) include the average fuel consumption for both auto and trucks over the simulated AM and PM periods. The average fuel consumption for auto in the 2012 AM no-build scenario is 0.2378 gallons, whereas that for trucks is 0.397 gallons. The total fuel consumption for AM and PM periods in the no-build scenario is 139,128 and 137,904 gallons, respectively. After computing the fuel consumption statistics for the \$160M and \$260M scenarios, it was found that \$160M scenario would save 556,350 gallons of fuel annually compared with the no-build scenario. The annual fuel saving form the \$260M scenario is 1.11 million gallons.

Table 4-1 2012 Scenario fuel consumption improvement for the study area

Year	Scenario	Auto (gal/veh)	Improve. (%)	Truck (gal/veh)	Improve. (%)	Total (gal/day)	Improve. (%)	Improve. (gal/day)	Improve. (gal/yr)
AM	NB	0.2378	-	0.3907	-	139,128	-	**-**	**-**
PM	NB	0.1820	-	0.3165	-	137,904	-		
AM	\$160M	0.2356	0.91%	0.3871	0.91%	137,857	0.90%	**2225.4**	**556,350**
PM	\$160M	0.1811	0.49%	0.3126	1.21%	136,949	0.60%		
AM	\$260M	0.2367	0.47%	0.3891	0.42%	138,492	0.45%	**4435.0**	**1,108,750**
PM	\$260M	0.1788	1.76%	0.2995	5.37%	134,104	2.68%		

The annual fuel savings for the build-out scenarios at the Year 2035 is 198K and 780K. The fuel savings of the \$260M scenario is significantly higher than the \$160M scenario.

Table 4-2 2035 Scenario fuel consumption improvement for the study area

Year	Scenario	Auto (gal/veh)	Improve. (%)	Truck (gal/veh)	Improve. (%)	Total (gal/day)	Improve. (%)	Improve. (gal/day)	Improve. (gal/yr)
AM	NB	0.2275	-	0.4200	-	163,645	-	-	-
PM	NB	0.2274	-	0.5202	-	245,841	-		
AM	$160M	0.2254	0.90%	0.4103	2.30%	161,682	1.20%	**3192.6**	**198,150**
PM	$160M	0.2267	0.32%	0.5156	0.89%	244,612	0.50%		
AM	$260M	0.2247	1.23%	0.4095	2.49%	161,200	1.49%	**3119.1**	**779,750**
PM	$260M	0.2268	0.23%	0.5183	0.37%	245,167	0.27%		

5 TOLL REVENUE

The calculation of the toll revenue was performed by tracking individual vehicles which traverse HOT lanes with various prices set by the HOT lane pricing algorithm. These are collected from the locations of the proposed gantries given in the implementation plan. The toll rate was based on a variable tolling scheme that used a congestion pricing algorithm. Whenever the link would hit a certain density or drop below a certain speed, the toll rate would increase. This would keep the vehicles moving at a minimal speed of 50 mph. Since the toll was congestion responsive, the toll rate is directly dependant on the adjoined general purpose lanes and the HOT lane speed. Furthermore, the variable toll rate was set at a minimum of $0.25 per mile, in order to not compete with RTD's regional express bus fare.

Table 5-1 shows the total revenue and vehicle miles traveled (VMT) generated by the new HOT lane. One can see that in 2012, the daily VMT is 23K miles, equivalent to 5.8M miles annually. The daily VMT for the $260M scenario increases to 45K miles daily, equivalent to 11.2M VMT annually. The annual revenue for the HOT lanes is predicted to be nearly $5M for the $160M scenario and this figure increases to over $8 M for the $260M scenario.

The annual VMT for 2035 does not necessarily increase, so daily revenue stays in the same range as observed for 2012. Likewise the annual revenue for both scenarios is similar to those for 2012.

One should note that based on DRCOG's suggestion, the value-of-time (VOT) used for 2035 was set as the same as that used for 2012 ($15.5 for auto and $46.5 for trucks). Future VOT is likely to increase, resulting in a higher revenue forecast. That is to say that the *current revenue figures for 2035 shown* in Table 5-1 *could be considered as a conservative estimate and are reported in current year dollars.*

Table 5-1 Toll Revenue

Year	Scenario	Daily VMT (veh-miles)	Daily Revenue ($)	Annual VMT (veh-miles)	Annual Revenue ($)	Minimum Toll Rate ($/mile)	Maximum Toll Rate ($/mile)
2012	$160M	23,458	$19,961	5,864,425	$4,990,250	$0.25	$2.00
2012	$260M	45,172	$32,146	11,292,975	$8,036,550	$0.25	$2.00
2035	$160M	27,314	$20,251	6,828,400	$5,062,825	$0.25	$2.00
2035	$260M	38,554	$29,509	9,638,475	$7,377,200	$0.25	$2.00