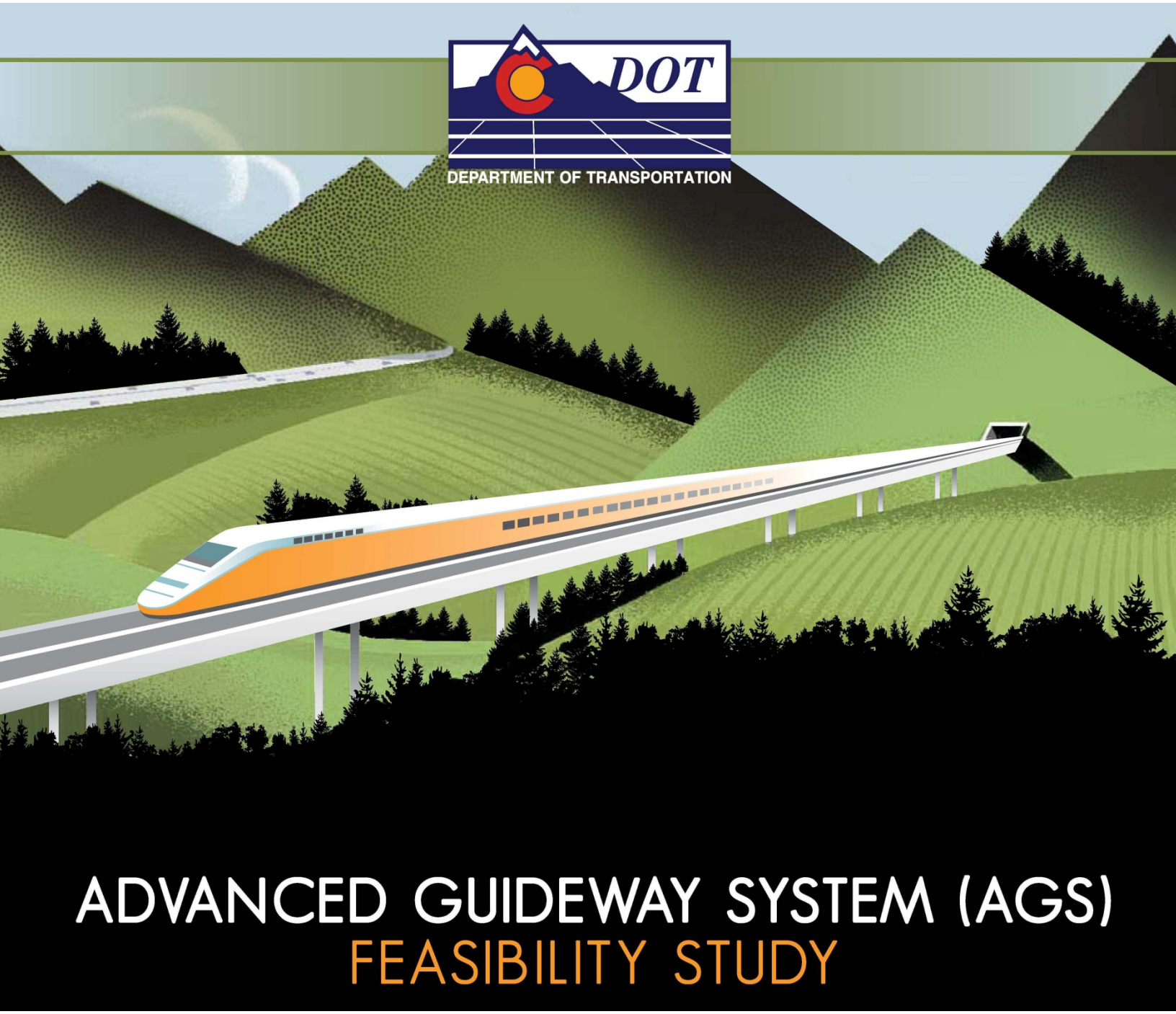

CHAPTER 6
BENEFIT/COST ANALYSIS

Chapter 6 Benefit/Cost Analysis

6.1 Introduction

A key decision by CDOT and the AGS PLT was to recognize that the AGS will need to offer statewide social, environmental, and economic benefits that are greater than the capital and operating costs of its implementation. In other words, the AGS must be a "good deal" for the citizens of Colorado. To determine this, the AGS Study Team conducted two Benefit/Cost (B/C) studies:

- Calculation of the Operating Ratio
- Calculation of Project B/C Ratio

6.2 Methodology

6.2.1 Operating Ratio (OR)

Also referred to as the Farebox Recovery Ratio, the OR was calculated by dividing the sum of all passenger revenues by the Operation and Maintenance (O&M) cost estimate.

Operating Ratio = Farebox Revenues/O&M Costs

6.2.2 B/C Ratio

Public support for the AGS will require an undisputed B/C Ratio methodology—one that is endorsed by both the AGS PLT and the public. Therefore, the B/C methodology and results were presented to the AGS PLT and the public for comment.

It is anticipated that the introduction of the AGS will divert trips away from the highway system and, to a lesser extent, the aviation system, and it will reduce accidents and the discharge of pollutants to the atmosphere—all of which are expected to generate substantial benefits to the residents of Colorado. A B/C greater than 1.0 means that the benefits accrued from the AGS exceeds the costs required to implement the AGS. The B/C is a good measure of how beneficial a project may be. The more a project can return tangible benefits that exceed the costs, the more it is theoretically beneficial. However, it should be noted that the B/C Ratio has nothing to do with determining if the AGS is fundable or financially feasible.

The AGS B/C ratio was calculated by comparing monetized quantitative measures of benefit to the present worth of the annualized capital and O&M costs of the system.

Benefits that were considered include the following:

- Passenger revenue.
- Reductions in vehicle miles traveled (VMT).
- Reductions in vehicle hours traveled (VHT).
- Reductions in highway delay.
- Reductions in accidents and fatalities.
- Reductions in atmospheric pollution.

- Reductions in aviation delay (if any).
- Reductions in highway investment requirements.
- Reductions in aviation investment requirements.
- Increases in property tax revenue around stations (tax increment basis).
- Increases in employment income from the construction and operation of the AGS.
- Increases in state personal income through the infusion of major federal grants assumed to partially fund the selected AGS scenario.

Costs are expected to include the following:

- All annual O&M costs.
- All capital costs, including right-of-way and indirect costs.

The operating life assumed for the B/C studies is 30 years; long-term interest for bonding was assumed at 4 percent; and inflation is assumed to average 3.5 percent per year.

6.3 Benefit/Cost Analysis

Benefit/cost (B/C) analysis is a widely used analytical technique that provides a common denominator for comparing costs and benefits of public investments to assist policymakers in making decisions about public expenditures. The B/C analysis for the AGS considers the benefits and costs of alternative alignment/technology pairs and addresses whether the benefits of the AGS outweigh the costs. It considers the long-term benefits and shorter-term costs of the AGS, which is important given the multiyear timeframe of the project. The B/C analysis incorporates the time value of money to capture future values and benefits.

6.3.1 Assumptions

Dollar figures in this analysis are expressed in constant 2013 dollars. A discount rate was used to adjust the future value of cash flows. The discount rate used for the evaluation of public projects differs from the interest rate used in private investments and is not an agreed-upon rate. For this analysis, a discount rate of 4 percent over a period of 30 years was used. For comparison purposes, the 10-year U.S. Treasury bond rate is currently under 2 percent. The higher the discount rate, the lower the present value estimate.

Costs

- **Capital Costs and Annual O&M Costs** – were based on the estimates presented in Chapter 4.
- **Interest payments** – were assumed at 4 percent interest and a 30-year repayment time period, using a simple amortization schedule for 50 percent of the capital costs. The analysis is assuming that half of the upfront capital costs for the AGS will be bonded and repaid to a governmental entity. It should be noted that repayment does not typically follow a simple principal and interest schedule for these types of large capital projects; however, at this level of analysis, it was deemed an appropriate

method for calculating interest. The repayment schedule is often based on the timing of grants and other factors.

Benefits

Basic Data

- **Ridership** – is calculated based on the travel demand mode and is quantified in Chapter 5.
- **Ticket revenue** – is based on an assumption of fares of either $0.35 or $0.26 per mile and is quantified in Chapter 5.
- **Reduction in VMT** – and the associated benefits calculations are based on the results of the travel demand model and are driven by the impacts of individuals switching from other modes to the AGS. These are quantified in Chapter 5.
- **Reduction in VHT** – relate to the amount of time individuals spend traveling to their destinations. These are also quantified in Chapter 5. In order for benefits to be counted, vehicle-hours were translated into dollar figures. While time can be valued at different rates depending on the activity (leisure, work, etc.), the average wage rate of $23 per hour was used for purposes of this analysis. The average wage rates for Colorado and the United States were similar, at approximately $23 per hour.[1]
- **Fatalities avoided** – results from a reduction in VMT and the corresponding reduction in automobile accidents and associated fatalities. The number of fatalities is based on 1.1 fatalities per 100 million miles driven.[2] Fatalities are valued at $6.2 million per life saved.[3]
- **Pollution benefits** – With decreased VMT, there would be fewer harmful particulates and greenhouse gas emissions. Both businesses and the general public would benefit from a better environment and better overall public health. The benefits are estimated at $0.199 per reduction in VMT based on research into public health and environmental benefits by the Victoria Transportation Policy Institute.[4]

Calculated Benefits (Present Worth Basis)

The Present Worth for most of the benefits was calculated based on a 4 percent discount rate over a 30-year period. Any exceptions are noted in the narrative.

- **Increase in real estate value** – In discussions with the County representatives during the land use meetings discussed in Chapter 3, there was agreement that inclusion of transit-oriented development (TOD) around the stations was desirable. The inclusion of TOD around the stations will generate financial benefits due to

[1] Bureau of Labor Statistics, 2012 for Colorado and the U.S.
[2] National Highway Traffic Safety Administration 2011 estimates
[3] Trottenberg, Polly, Assistant Secretary for Transportation Policy, U.S. Department of Transportation. "Memorandum re: Treatment of the Economic Value of a Statistical Life in Departmental Analysis – 2011 Interim Adjustment", July 29, 2011.
[4] Victoria Transportation Policy Institute, "Transportation Cost and Benefit Analysis II – Air Pollution Costs," February 22, 2012.

increased land values and increased property, sales, and other types of taxes. The economist for the *Interregional Connectivity Study*, Ms. Arleen Taniwaki, places the value of a station in the I-70 Mountain Corridor at $370 million over a 30-year period.

- **Operations jobs** – It was assumed that the value of labor or jobs was half of the overall operations expenditures estimate (Operation and Maintenance). It was also valued at a 4 percent discount rate over a 30-year period.
- **Non-basic jobs** – For every operations job, a total of 1.5 jobs would be created (including the original operations jobs) based on Bureau of Economic Analysis (BEA) Rims II multipliers. These impacts include the jobs, incomes, and output of individuals involved in operating the system; the additional jobs and earnings created by the operations; and an estimate of the induced impact related to the spending of operations workers.
- **50 percent federal funding and multiplier effect** – It was assumed that 50 percent of the capital expenditures would come from the federal government. Because the funding source is from outside of the state's economy, it would have a potentially higher multiplier than funds from local sources. Recent research conducted by economists at the Federal Reserve Bank in San Francisco estimates the overall multiplier for these types of projects at 3.[5]
- **50 percent construction jobs and multiplier effect** – It was assumed that half of the capital construction costs would be for labor and that construction would take place over 10 years. The present worth calculation was adjusted accordingly. For every construction job, two jobs would be created.[6]

6.3.2 Benefit/Cost Analysis Results

The results from the B/C studies are shown in Table 6-1. Complete B/C worksheets are included in Appendix I. The scenarios have B/C ratios from 1.69 to 2.04. This is because the largest contributing benefits – employment and the multiplier effects of large federal grants – are comparable among the scenarios. The higher capital construction cost for High Speed Rail results in its lower B/C ratio.

Table 6-1: Benefit/Cost Analysis Results

Technology	Alignment	Fare ($ per Mile)	B/C Ratio
High Speed Maglev	ECRA to DIA, ICS System + AGS, I-76	$0.35	1.93
	ECRA to DIA, ICS System + AGS, I-76	$0.26	1.94
	ECRA to I-70/C-470, ICS System + AGS, C-470/E-470	$0.26	2.04

[5] Leduc, Sylvain and Daniel Wilson, "Highway Grants: Roads to Prosperity", FRBSF Economic Newsletter, November 26, 2012
[6] Bureau of Economic Analysis RIMS II multipliers

Table 6-1: Benefit/Cost Analysis Results

Technology	Alignment	Fare ($ per Mile)	B/C Ratio
	ECRA to DIA, I-76, No ICS System	$0.26	1.85
	Breckenridge to I-70/C-470, No ICS System	$0.35	1.8
	Breckenridge to I-70/C-470, No ICS System	$0.26	1.81
	Breckenridge to DIA, ICS System + AGS, I-76	$0.26	1.87
	Breckenridge to DIA, No ICS System, I-76	$0.26	1.79
120 mph Maglev	Breckenridge to I-70/C-470, No ICS System	$0.35	1.81
	Breckenridge to I-70/C-470, No ICS System	$0.26	1.83
	Breckenridge to DIA, ICS System + AGS, I-76	$0.26	1.88
High Speed Rail	ECRA to I-70/C-470, ICS System + AGS, C-470/E-470	$0.35	1.74
	ECRA to I-70/C-470, ICS System + AGS, C-470/E-470	$0.26	1.79
	Breckenridge to DIA, ICS System + AGS, I-76	$0.26	1.67

ECRA = Eagle County Regional Airport.

To determine what effect smaller federal grants would have on the B/C ratio, calculations were made of the B/C ratio for federal grants ranging from 0 percent to 50 percent. The results of that analysis are shown in Table 6-2. The data shows that at 10 percent federal funding many of the B/C ratios approach or fall below 1.0. It appears that at least 10 percent federal funding would be required to have a project that has more benefits than cost, and more federal funding would be required depending on the scenario. If 20 percent federal funding were available, all scenarios would have more benefit than cost.

Table 6-2: B/C Ratio Based on Federal Grant Levels

			Federal Grant Level					
Technology	Alternative	Fare ($/mile)	0%	10%	20%	30%	40%	50%
High Speed Maglev	ECRA to DIA, ICS System + AGS, I-76	$0.35	0.89	1.10	1.31	1.52	1.72	1.93
	ECRA to DIA, ICS System + AGS, I-76	$0.26	0.90	1.11	1.32	1.53	1.74	1.94
	ECRA to I-70/C-470, ICS System + AGS, C-470/E-470	$0.26	1.00	1.21	1.42	1.63	1.84	2.04
	ECRA to DIA, I-76, No ICS System	$0.26	0.81	1.02	1.23	1.44	1.64	1.85
	Breckenridge to I-70/C-470, No ICS System	$0.35	0.76	0.97	1.18	1.38	1.59	1.80
	Breckenridge to I-70/C-470, No ICS System	$0.26	0.78	0.98	1.19	1.40	1.60	1.81
	Breckenridge to DIA, ICS System + AGS, I-76	$0.26	0.84	1.05	1.25	1.46	1.67	1.87
	Breckenridge to DIA, No ICS System, I-76	$0.26	0.76	0.97	1.17	1.38	1.59	1.79

Table 6-2: B/C Ratio Based on Federal Grant Levels

			Federal Grant Level					
Technology	**Alternative**	**Fare ($/mile)**	**0%**	**10%**	**20%**	**30%**	**40%**	**50%**
120 mph Maglev	Breckenridge to I-70/C-470, No ICS System	$0.35	0.79	1.00	1.20	1.41	1.61	1.81
	Breckenridge to I-70/C-470, No ICS System	$0.26	0.81	1.01	1.21	1.42	1.62	1.83
	Breckenridge to DIA, ICS System + AGS, I-76	$0.26	0.85	1.06	1.26	1.47	1.67	1.88
High Speed Rail	ECRA to I-70/C-470, ICS System + AGS, C-470/E-470	$0.35	0.67	0.88	1.10	1.31	1.53	1.74
	ECRA to I-70/C-470, ICS System + AGS, C-470/E-470	$0.26	0.71	0.93	1.14	1.36	1.57	1.79
	Breckenridge to DIA, ICS System + AGS, I-76	$0.26	0.59	0.81	1.02	1.24	1.45	1.67

ECRA = Eagle County Regional Airport.

6.3.3 Operating Ratio Results

A positive operating ratio is important because it means that no subsidy from passengers is required, as is typical of urban transit systems, and the surpluses can be used to help pay for the annualized capital payment for the system. Compared to the B/C, there is more variability with the Operating Ratios realized by the scenarios. For the Full System scenarios, the Operating Ratio is above 1.0, meaning that the scenarios would generate surplus revenue. For the standalone Minimum Operable Segment scenarios (those operating to Breckenridge only), the Operating Ratios are under 1.0, meaning that additional funds (subsidies) would be needed, beyond those for the capital improvements, to pay for the O&M deficit. Table 6-3 and Table 6-4 on pages 6-8 and 6-9 show the Operating Ratio and expected surplus or deficit for the scenarios using both the low and the high O&M costs.

Surplus revenue could be bonded against, assuming that an investment-grade ridership study is completed and accepted by financiers. Financiers typically are willing to bond on a 14:1 ratio to the surplus revenue. For a 30-year period, the revenue would be available to cover more than twice the amount of the bonds (30/14 = 2.14). Based on a 14:1 ratio, as much as $1.54 billion could be raised with the High Speed Maglev, Full System, ICS + AGS, C-470/E-470 at the $0.26/mile fare scenario. If additional revenue is recognized, through such items as freight or use of the guideway to convey utilities, this amount could increase; however, it is unlikely to be large enough to cover even a small part of the AGS capital costs. Further, even with an investment-grade ridership study, variations in farebox revenue may make bonding based on excess revenue difficult for financiers.

6.4 Conclusion

If federal grants of at least 20 percent of the capital costs are available, the benefits of the AGS to the State of Colorado will outweigh the costs. Increased federal grant levels increase the benefit.

Full System scenarios will generate adequate farebox revenue to cover O&M costs, leading to surplus revenues that could be used to finance the capital costs. The MOS scenarios, while having B/C ratio of greater than 1.0, do not generate sufficient farebox revenue to cover O&M costs, requiring that funding for these systems include both the capital costs and the Operating Ratio deficits for the life of the financing period and beyond.

Table 6-3: Operating Ratios (OR), Low O&M Cost

Technology	Alignment	Fare ($/mile)	Revenue ($)	O&M Low ($)	OR	Net Revenue Per Year – Low ($)
High Speed Maglev	ECRA to DIA, ICS System + AGS, I-76	$0.35	123,745,259	47,209,000	2.62	76,536,259
	ECRA to DIA, ICS System + AGS, I-76	$0.26	113,911,654	47,209,000	2.41	66,702,654
	ECRA to I-70/C-470, ICS System + AGS, C-470/E-470	$0.26	157,280,243	47,209,000	3.33	110,071,243
	ECRA to DIA, I-76, No ICS System	$0.26	79,037,296	59,112,000	1.34	19,925,296
	Breckenridge to I-70/C-470, No ICS System	$0.35	22,247,496	27,258,000	0.82	-5,010,504
	Breckenridge to I-70/C-470, No ICS System	$0.26	20,851,174	27,258,000	0.76	-6,406,826
	Breckenridge to DIA, ICS System + AGS, I-76	$0.26	66,493,427	47,209,000	1.41	19,284,427
	Breckenridge to DIA, No ICS System, I-76	$0.26	28,723,660	47,309,000	0.61	-18,585,340
120 mph Maglev	Breckenridge to I-70/C-470, No ICS System	$0.35	18,408,144	26,072,000	0.71	-7,663,856
	Breckenridge to I-70/C-470, No ICS System	$0.26	17,418,946	26,072,000	0.67	-8,653,054
	Breckenridge to DIA, ICS System + AGS, I-76	$0.26	56,779,587	44,947,370	1.26	11,832,217
High Speed Rail	ECRA to I-70/C-470, ICS System + AGS, C-470/E-470	$0.35	137,364,179	55,382,000	2.48	81,982,179
	ECRA to I-70/C-470, ICS System + AGS, C-470/E-470	$0.26	159,912,578	55,382,000	2.89	104,530,578
	Breckenridge to DIA, ICS System + AGS, I-76	$0.26	58,278,195	53,009,600	1.10	5,268,595

ECRA = Eagle County Regional Airport

Table 6-4: Operating Ratios (OR), High O&M Cost

Technology	Alignment	Fare ($/mile)	Revenue ($)	O&M High ($)	OR	Net Revenue Per Year – High ($)
High Speed Maglev	ECRA to DIA, ICS System + AGS, I-76	$0.35	123,745,259	62,762,000	1.97	60,983,259
	ECRA to DIA, ICS System + AGS, I-76	$0.26	113,911,654	62,762,000	1.81	51,149,654
	ECRA to I-70/C-470, ICS System + AGS, C-470/E-470	$0.26	157,280,243	62,762,000	2.51	94,518,243
	ECRA to DIA, I-76, No ICS System	$0.26	79,037,296	78,481,000	1.01	556,296
	Breckenridge to I-70/C-470, No ICS System	$0.35	22,247,496	36,466,000	0.61	-14,218,504
	Breckenridge to I-70/C-470, No ICS System	$0.26	20,851,174	36,466,000	0.57	-15,614,826
	Breckenridge to DIA, ICS System + AGS, I-76	$0.26	66,943,427	53,799,000	1.24	13,144,427
	Breckenridge to DIA, No ICS System, I-76	$0.26	28,723,660	53,799,000	0.53	-25,075,340
120 MPH Maglev	Breckenridge to I-70/C-470, No ICS System	$0.35	18,408,144	35,103,000	0.52	-16,694,856
	Breckenridge to I-70/C-470, No ICS System	$0.26	17,418,946	35,103,000	0.50	-17,684,054
	Breckenridge to DIA, ICS System + AGS, I-76	$0.26	56,779,587	51,788,000	1.1	4,991,587
High Speed Rail	ECRA to I-70/C-470, ICS System + AGS, C-470/E-470	$0.35	137,364,179	72,882,000	1.88	64,482,179
	ECRA to I-70/C-470, ICS System + AGS, C-470/E-470	$0.26	159,912,578	72,882,000	2.19	87,030,578
	Breckenridge to DIA, ICS System + AGS, I-76	$0.26	58,278,195	70,379,000	0.83	-12,100,805

ECRA = Eagle County Regional Airport