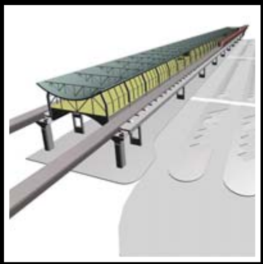
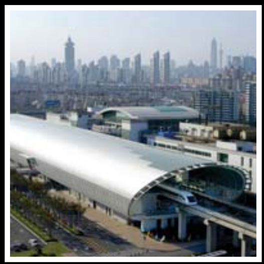
ADVANCED GUIDEWAY SYSTEM (AGS)
FEASIBILITY STUDY

August 2014





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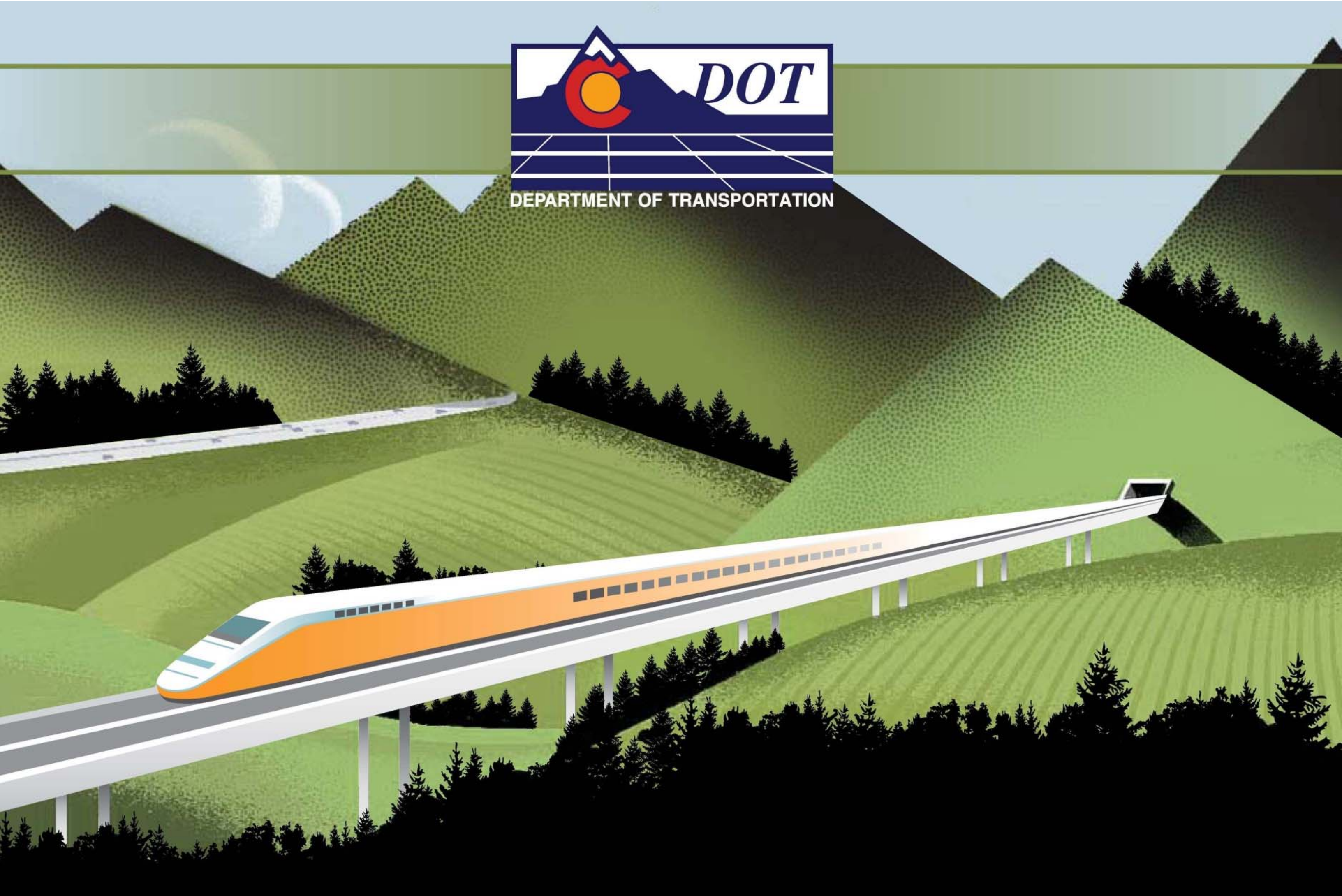
Acronym List

Acronym	Definition
AADT	Average Annual Daily Traffic
ADA	Americans with Disabilities Act
AGS	Advanced Guideway System
AMT	American Maglev Technology Inc.
ASCE	American Society of Civil Engineers
ATP	Automatic Train Protection
B	Billion
B/C	Benefit/Cost
BEA	Bureau of Economic Analysis
C-470	Colorado Highway 470
CAPEX	Capital Expenditures
CDOT	Colorado Department of Transportation
CE	Collaborative Effort
CIFGA	Colorado Intermountain Fixed Guideway Authority
CS	Cambridge Systematics
CSS	Context Sensitive Solutions
dB	Decibels
DBFOM	Design-Build-Finance-Operate-Maintain
DBOM	Design-Build-Operate-Maintain
DIA	Denver International Airport
DOE	US Department of Energy
DRCOG	Denver Regional Council of Governments
DTR	Division of Transit and Rail
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortization
ECRA	Eagle County Regional Airport
EGE	Eagle County Regional Airport
EIS	Environmental Impact Statement
EJMT	Eisenhower-Johnson Memorial Tunnel
FAR	Floor Area Ratio
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FRBSF	Federal Reserve Bank of San Francisco
ft	Feet
FTA	Federal Transit Administration

Acronym	Definition
GAO	Government Accounting Office
GHG	Greenhouse Gas
HPTE	High Performance Transportation Enterprise
HS	High-speed
HSR	High-speed Rail
HTF	Highway Trust Fund
Hz	Hertz
I-70	Interstate 70
ICS	Interregional Connectivity Study
ISI	Institute for Sustainable Infrastructure
IVTT	In-vehicle Travel Time
kWh	Kilowatts per Hour
LEED	Leadership in Energy & Environmental Design
LIM	Linear Induction Motor
LSM	Linear Synchronous Motor
M	Million
Maglev	Magnetic Levitation
MAP 21	Moving Ahead for Progress in the 21st Century Act
mi.	Miles
MIS	Major Investment Study
MOS	Minimum Operable Segment
mph	Miles Per Hour
MPO	Metropolitan Planning Organization
NA	Not Applicable
NEPA	National Environmental Protection Act
O&M	Operation and Maintenance
OCC	Operations Control Center
OCT	Operation Control Technology
OPEX	Operations Expenditures
OR	Operating Ratio
OTG	Owens Transit Group, Inc.
P3	Public-private Partnership
PEIS	Programmatic Environmental Impact Statement
PLT	Project Leadership Team
PPP	Public-private Partnership

Acronym	Definition
PPRTC	Public Personal Rapid Transit Consortium
PRIIA	Passenger Rail Investment and Improvement Act of 2008
PUC	Public Utilities Commission
R&R	Repair and Rehabilitation
RFFI	Request for Financial Information
RFP	Request for Proposals
RFSOFI	Request for Statements of Financial Information
RFSOTI	Request for Statements of Technical Information
RMRA	Rocky Mountain Rail Authority
ROD	Record of Decision
ROW	Right-of-Way
RRIF	Railroad Rehabilitation and Improvement Financing
RTD	Regional Transportation District
S&P	Standard and Poors
SDG	Steer Davies Gleave
SF	Square Feet
SH 9	State Highway 9
SOFI	Statement of Financial Information
SOTI	Statement of Technical Information
SP	Stated Preference
SPV	Special Purpose Vehicle
sq. ft.	Square Feet
TAZ	Traffic Analysis Zone
TIF	Tax-Increment Financing
TIFIA	Transportation Infrastructure Finance and Innovation Act
TOD	Transit Oriented Development
TRI	Transrapid International-USA Inc.
TRL	Technology Readiness Level
TSI	Technical Specifications of Interoperability
ULD	Uniform Loading Devices
US 6	US Highway 6
VHT	Vehicle Hours Traveled
VMT	Vehicle Miles Traveled
Wh	Watts per Hour



ADVANCED GUIDEWAY SYSTEM (AGS) FEASIBILITY STUDY

EXECUTIVE SUMMARY

Executive Summary

Introduction

The Colorado Department of Transportation (CDOT) – through its Division of Transit & Rail – commissioned the *Advanced Guideway System (AGS) Feasibility Study* (Study) in April 2012. The primary goal of the Study was to determine the technical and financial feasibility of implementing a high-speed transit system on a fixed guideway in Colorado's I-70 Mountain Corridor between Jefferson County (I-70/C-470 interchange) and the Eagle County Regional Airport.

The Study was a direct result of the *Record of Decision* (ROD) for the *I-70 Mountain Corridor Final Programmatic Environmental Impact Statement* (PEIS), signed by the Federal Highway Administration in June 2011. The Preferred Alternative in the Final PEIS is defined as a multimodal solution comprised of Non-infrastructure Components, an Advanced Guideway System, and Highway Improvements.

The ROD defines an AGS as "a central part of the Preferred Alternative" and identifies that "additional information is necessary to advance implementation of an Advanced Guideway System in the Corridor." This Study had the intent, per the ROD, to *"answer questions regarding the feasibility, cost, ridership, governance, and land use…and indicate [whether] an Advanced Guideway System cannot be funded or implemented by 2025 or is otherwise deemed unfeasible to implement."*

This Study determines the feasibility of AGS in the I-70 Mountain Corridor with a focus on three key areas:

- **Technology** – Are there high-speed transit technologies – or developing technologies likely to be in commercial operation by 2017 – that could meet the desired system performance and operational criteria?
- **Alignment and Land Use** – Are there feasible alignments and locations for stations that could

Feasibility Snapshot*

- ***73 minute** trip time*
- ***4.6 million to 6.2 million** annual riders*
- ***$13.3 billion to $16.5 billion** capital costs*
- ***$60 million to $76 million** annual operating costs*
- ***$114 million to $157 million** annual operating revenues*
- ***Technically Feasible.** Technologies exist, and alignments/stations have been identified that can exceed the AGS performance and operational criteria.*
- ***As of 2014, the AGS is not financially feasible.** There are no current local/state/ federal funding sources identified to cover the AGS capital costs.*

The AGS should be included in CDOT's Colorado State Freight and Passenger Rail Plan. Future financial feasibility would require a significant and dedicated state/local financial commitment, some level of private-sector involvement, and some level of federal government funding and/or financing.

**This Snapshot is based on Hybrid Alignment with High Speed Maglev from Eagle County Regional Airport to I-70/C-470 with the Interregional Connectivity Study System in place through Denver and along I-25 from Pueblo to Fort Collins.*

allow one or more feasible high-speed transit technology to meet system performance and operational criteria?
- **Cost, Funding, and Financing** – What are the capital costs, operating costs, and projected revenues of the system? Are there feasible funding/financing sources that could be in place by 2025?

Study Goals

The following study goals identified the specific information needed to evaluate the feasibility of an AGS. The goals were developed collaboratively among CDOT, community, business, and environmental representatives.

- **Technologies** – Determine feasible technologies that are capable of meeting the system performance and operational criteria that were set forth by the Collaborative Effort's Consensus Recommendation and further refined and supplemented by the AGS Study Team.
- **Alignments and Stations** – Determine feasible alignments and station locations along the I-70 Mountain Corridor between the Eagle County Regional Airport and I-70/C-470 for feasible technologies.
- **Capital Costs** – Estimate the capital costs for feasible alignment/technology pairs to build the infrastructure required to provide an AGS for the I-70 Mountain Corridor.
- **Operating Costs** – Estimate operations and maintenance costs for the alignment/technology pairs.
- **Ridership and Revenue** – Forecast the expected ridership and farebox revenue associated with the alignment/technology pairs.
- **Funding and Financing** – Develop possible funding and financing strategies for the AGS to assess its financial feasibility. Assess the feasibility of AGS as a standalone project and as part of a larger high-speed transit system that includes a connection to Denver International Airport and a connection between Fort Collins and Pueblo.
- **Context Sensitive Solutions** – Ensure that the I-70 Mountain Corridor Context Sensitive Solutions (CSS) process is used to conduct the Study.

Study Process

The Study was conducted in three phases that matched the three key focus areas. In the first phase, the AGS Study Team worked with private technology providers to identify existing and future technologies and to evaluate their feasibility of accommodating the I-70 Mountain Corridor challenges. In the second phase, the AGS Study Team developed and analyzed potential alignments and station sites based on the operational capabilities of the feasible technologies. The third phase involved development of cost and revenue estimates for potential alignment/technology pairs, evaluation of potential public funding sources, and working with private-sector financial and technology providers to gather information on private funding/financing options.

The Study adhered to the CSS process for engaging I-70 Mountain Corridor stakeholders, while strongly emphasizing direct engagement with private-sector representatives from the high-speed transit technology industry and the concession and financial industry. A Project Leadership Team (AGS PLT) comprised of representatives from the following I-70 Corridor stakeholder groups met regularly throughout the Study:

- City and County of Denver
- Colorado Department of Transportation
- Clear Creek County
- Club 20
- Denver Regional Council of Governments
- Eagle County
- Colorado Environmental Coalition
- COPIRG
- Federal Highway Administration
- I-70 Coalition
- Jefferson County
- Summit County

The AGS PLT also appointed representatives to serve on the Project Leadership Team for CDOT's concurrent *Interregional Connectivity Study* (ICS) that was tasked with studying and recommending high-speed transit alignments, technologies, and station locations between Fort Collins and Pueblo and between Denver International Airport and the eastern terminus of the AGS study area in Jefferson County. This collaboration led to the evaluation of additional system alternatives that extend through the Denver metropolitan area and are part of a larger high-speed transit system.

Feasibility of High-Speed Transit Technologies

In September 2012, the AGS Study Team issued a Request for Statements of Technical Information (RFSOTI) to answer the question of whether feasible technologies existed or were likely to be developed that could meet these six key system performance and operational criteria measures:

- Travel time
- Grade capabilities
- Safety
- Weather/wind
- Light freight
- Technology readiness

Eighteen technology providers responded to the RFSOTI; eleven of the technologies were found to be capable of providing a system that would meet the criteria:

- American Maglev Transit
- Flight Rail
- General Atomics/ Colorado Maglev Group
- MegaRail
- MagneMotion
- Owen Transit Group
- Public Personal Rapid Transit Consortium
- SkyTran
- Swift Tram
- Talgo
- Transrapid

These technologies represent different types of magnetic levitation (maglev) vehicles and high-speed trains, along with other less-traditional technologies. Several already are, and others could be further developed to be in commercial operation by 2017.

Based on the information provided in the SOTIs, CDOT determined that an AGS in the I-70 Mountain Corridor was technologically feasible.

Feasibility of Alignments and Local Land Uses

The AGS Study Team worked with CDOT and local communities along the I-70 Mountain Corridor to develop and evaluate alignments based on the performance capabilities of the feasible technologies to accommodate the I-70 Mountain Corridor's significant grades, curves, and environmental challenges. The four alignments that could be served by one or more of the feasible technologies are illustrated on the next two pages.

The Study determined that three of the four evaluated alignments are feasible for an AGS in the I-70 Mountain Corridor. All would require significant right-of-way acquisition and local approval. The alignments were analyzed both from beginning to

AGS Technologies


American Maglev


Flight Rail


MegaRail


Swift Tram


Talgo


Transrapid

Some of the 11 feasible AGS technologies that responded to the RFSOTI.

Figure ES-1: High Speed Rail Alignment

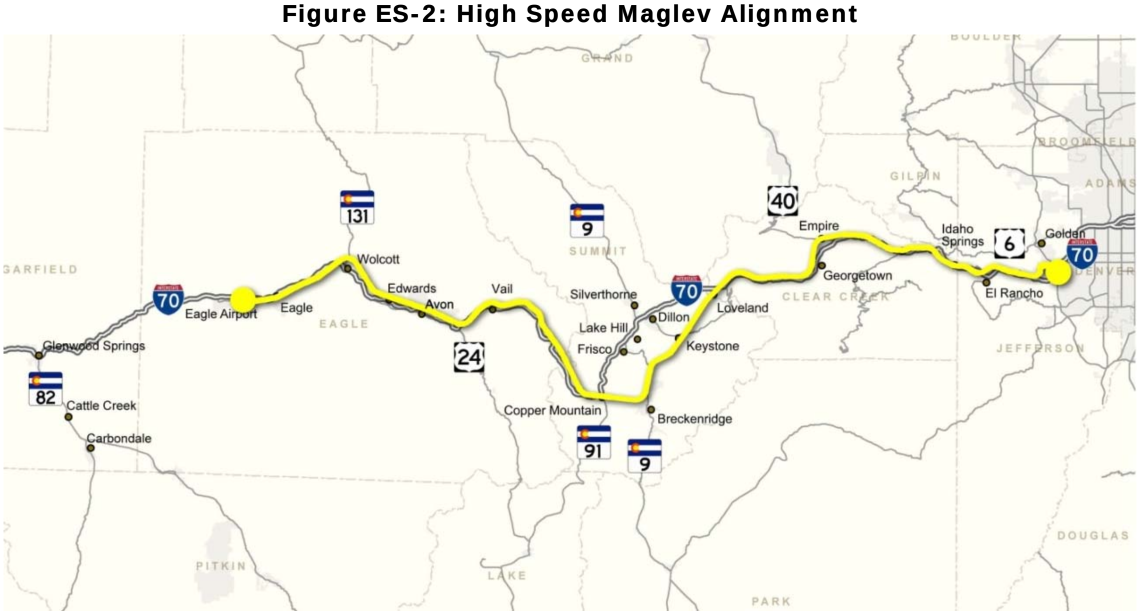
Alignment Description

- Mostly outside I-70 right-of-way
- 109 miles long
- General design speed is 150-180 mph
- Maximum grades of 2.3%
- 25 tunnels (65 miles total) to flatten and straighten alignment

Applicable Technologies

- High speed steel wheel on steel rail trains
- Maglev vehicles
- Many emerging technologies

Figure ES-2: High Speed Maglev Alignment



Alignment Description

- Mostly outside I-70 right-of-way
- 118 miles long
- General design speed is 150-180 mph
- Maximum grades of 7.0%
- 35 tunnels (40 miles total) to straighten alignment

Applicable Technologies

- Maglev vehicles
- Many emerging technologies

Figure ES-3: Hybrid Alignment

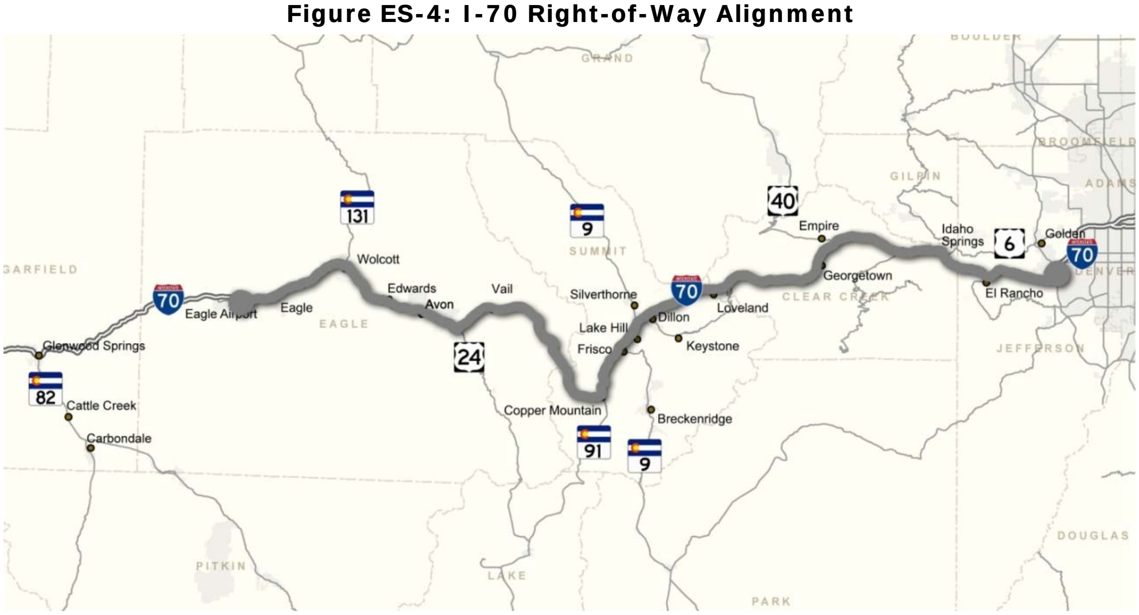
Alignment Description

- Mostly within I-70 right-of-way, except areas of significant curves/grades
- 121 miles long
- General design speed is 100-120 mph
- Maximum grades of 7.0%
- 15 tunnels (16 miles total)

Applicable Technologies

- Maglev vehicles
- Many emerging technologies

Figure ES-4: I-70 Right-of-Way Alignment



Alignment Description

- Completely within I-70 right-of-way
- 120 miles long
- General design speed is 55-120 mph
- Maximum grades of 7.0%
- 2 tunnels (1.6 miles total)

Applicable Technologies

- Not feasible – does not meet travel time criteria end, as well as a shorter potential first phase, a Minimum Operable Segment (MOS), that would operate from Breckenridge to I-70/C-470.

The alignment staying entirely within the I-70 right-of-way (I-70 Alignment) was determined not to be feasible. The combination of curves and grades that the interstate takes would require most feasible AGS technologies to operate so slowly that it results in a travel time that is not competitive with driving on the highway. While there was debate about off-line stations and skip-stop service potentially making this alignment competitive with driving on the highway, point-to-point personal rapid transit (PRT) technology submittals themselves took full advantage of the idea behind the hybrid alignment to mostly use I-70 and broaden the curves to improve travel times.

The AGS Study Team also held a series of meetings with representatives of the counties, cities, and towns along the I-70 corridor to identify possible station sites and discuss the station layout, size, and possible surrounding land use to support the stations. Multiple station location sites were evaluated to determine the following preferred station sites, which are subject to change when alignment and technology options are finalized through subsequent studies.

- Jefferson County – I-70 and C-470 in Golden.
- Clear Creek County – One station at Idaho Springs Exit 240, Empire Junction, or Georgetown Lake.
- Summit County – Keystone, Breckenridge, and Copper Mountain.
- Eagle County – Vail, Avon at Traer Creek, and Eagle County Regional Airport.

Alignment / Technology Pairs

Using the feasible technology types and feasible alignments, four alignment/technology pairs were created for more detailed analysis. Those were:

- Hybrid Alignment and 120 mph Maglev vehicles
- Hybrid Alignment and High Speed Maglev vehicles
- High Speed Maglev Alignment and High Speed Maglev vehicles
- High Speed Rail Alignment and High Speed Rail

Ridership and Travel Time

Ridership and resulting fare revenues are a critical factor in determining the financial feasibility of the AGS. Travel time, from the alignment/technology pair analysis, has a strong impact on level of ridership.

The AGS Study Team used the results of a statewide survey of more than 1,000 inter-city travelers to determine what value the travelers placed on travel time savings and the cost of the trip. Because the AGS would serve a potential ridership base of recreationists, rather than business commuters, respondents indicated a lower value placed on travel time savings.

The results of this analysis, combined with the analysis of modeled travel patterns, determined that the ideal fare per mile was $0.26. Using this as the basis for ticket pricing, the following ridership, travel times, and fare revenues are projected:

Table ES-1: Alignment / Technology Data

Alignment / Technology	Fare Per Trip ($0.26 Per Mile)	AGS Trip Time (Minutes)	Auto Trip Time (Minutes)	Annual Riders	Annual Fares $Million
Breckenridge to I-70 / C-470 *(58-61 miles)*					
High Speed Rail*	$21.77	37	78	2.7 M	$58.3
Hybrid/High Speed Maglev*	$23.03	31	78	2.9 M	$66.9
Hybrid/120 mph Maglev*	$22.63	46	78	2.5 M	$56.8
Eagle County Regional Airport to I-70 / C-470 *(109-121 miles)*					
High Speed Rail*	$25.18	65	119	6.3 M	$159.9
Hybrid/High Speed Maglev*	$25.32	73	119	6.2 M	$157.3
Hybrid/120 mph Maglev	N/A	107	119	N/A	N/A

N/A – Option was not modeled.

* With connection to DIA and Front Range ICS System.

Cost and Feasibility of Funding / Financing

Capital Costs

Capital cost estimates were developed for each of the four alignment/technology pairs. Capital cost estimates were based on unit costs of 10 key components, among them guideway/track infrastructure, right-of-way, vehicles, energy, and propulsion system.

To reflect the preliminary nature of the designs and the complexities of high-altitude mountain construction, tunnel construction, and other risks, the capital cost estimates were augmented with:

- Item-specific contingencies (e.g., tunnels, right-of-way) based on the specific alignments.
- Costs for professional services, utility relocation, and environmental mitigation.
- A standard contingency of 23 percent.

Table ES-2: Capital Cost Estimates

Alignment / Technology	Breckenridge to I-70 / C-470	Eagle County Regional Airport to I-70 / C-470
Hybrid/120 mph Maglev	$5.5 billion	$10.8 billion
High Speed Maglev	$14.1 billion	$25.3 billion
High Speed Rail	$19.0 billion	$32.4 billion
Hybrid/ High Speed Maglev	$6.8 billion	$13.3 billion

In total, the contingencies included in the capital cost estimates are between 54 to 59 percent of total capital costs.

Operating Costs and Annual Revenues

Operating costs and projected annual revenues for each alignment/technology pair were developed to understand whether the system could be profitable to operate. The key drivers of the annual operating costs are labor and power, accounting for roughly two-thirds of the total cost of any alignment/technology pair. Revenue assumptions were based on projected riders paying an average fare of $0.26 per mile.

Table ES-3: Revenue and Operating Ratios

	Eagle County Regional Airport to I-70 / C-470*			Breckenridge to I-70 / C-470*		
	High Speed Rail	Hybrid / High Speed Maglev	Hybrid / 120 mph Maglev	High Speed Rail	Hybrid / High Speed Maglev	Hybrid / 120 mph Maglev
Annual Revenue	$159.9 M	$157.3 M	N/A	$58.3 M	$66.9 M	$56.8 M
Annual O&M Cost	$72.9 M	$62.8 M	N/A	$70.4 M	$36.5 M	$51.8 M
Annual Excess Revenue	$87.0 M	$94.5 M	N/A	-$12.1 M	$15.6 M	$5.0 M
Operating Ratio	2.19	2.51	N/A	0.83	1.24	1.1

N/A – Option was not modeled.

* With connection to DIA and Front Range ICS System.

Annual Revenue Needed to Repay Debt

To assess whether or not the system could generate enough revenue to meet the annual debt service and cover the costs of construction, an analysis of the lowest-cost segment was conducted ($5.5 billion Hybrid/120 mph Maglev from Breckenridge to I-70/C-470).

The analysis assumed the project would be delivered through a design-build-finance public-private partnership (P3) structure. While it is possible that a P3 concessionaire could include operation and maintenance of the system in their proposal (shifting from design-build-finance to design-build-finance-operate-maintain finance model), its inclusion would not materially change the payments needed to repay the capital costs because it is assumed that farebox revenue would cover the costs for operations and maintenance. If this were not the case, then the payments required would increase to cover shortfalls in farebox revenue. Conversely, if excess farebox revenue is created, that money could be used to offset the payments.

Table ES-4: Funding / Financing Scenarios for $5.5 billion Hybrid / 120 mph Maglev

Federal Cash Share* $ billon (% of total)		State / Local Cash Share* $ billon (% of total)		Amount Financed $ billon (% of total)		Annual Finance Payment $ million / year
$0.0	(0%)	$0.0	(0%)	$5.5	(100%)	$484
$1.375	(25%)	$0.0	(0%)	$4.125	(75%)	$363
$2.2	(40%)	$0.0	(0%)	$3.3	(60%)	$290
$2.75	(50%)	$0.0	(0%)	$2.75	(50%)	$242
$1.375	(25%)	$2.063	(37.5%)	$2.063	(37.5%)	$182
$2.2	(40%)	$1.65	(30%)	$1.65	(30%)	$145
$2.75	(50%)	$1.375	(25%)	$1.375	(25%)	$121

Assumptions: $5.5 billion project; 30-year bond; 6.75%/year interest, 2013$.

*Note: federal and state/local shares could be reversed to fit actual funding levels.

The scenarios analyzed assumed ranges of 0 to 50 percent federal funding assistance and 0 to 100 percent of state/local funding. As the chart depicts, even in the most optimistic scenario, annual revenues would need to be in excess of $121 million, compared to a forecast $5.0 million in excess fare revenue. The capital debt repayment need far exceeds the revenue that the alignment/technology pairs are forecasted to generate through fares.

Benefit/cost ratios are used to determine how the value of a project's benefits compare with the cost of building and operating it. A ratio greater than 1.00 indicates that the value of benefits exceeds the cost, a key factor in attracting potential federal funding assistance. However, B/C ratios have nothing to do with whether the AGS is fundable or financeable. Many benefits, while good for society as a whole or good for individual travelers, do not generate revenue (money) which can be used to pay for construction or pay the costs of financed debt.

Benefit/cost (B/C) ratios were developed for a potential first phase between Breckenridge and I-70/C-470, as well as the Full System from Eagle County Regional Airport to I-70/C-470. Varying levels of federal cash shares were used in the analysis to determine that a 20 percent or higher level of federal support is required to create a positive ratio.

Table ES-5: B/C Ratios

Federal Cash Share	Eagle County Regional Airport to I-70/C-470			Breckenridge to I-70/C-470		
	High Speed Rail*	Hybrid/ High Speed Maglev*	Hybrid/ 120 mph Speed Maglev	High Speed Rail	Hybrid/ High Speed Maglev	Hybrid/ 120 mph Speed Maglev
Capital Cost	$32.4 B	$13.3 B	$10.8 B	$19.0 B	$6.8 B	$5.5 B
0%	0.71	1.00	N/A	0.59	0.84	0.85
10%	0.93	1.21	N/A	0.81	1.05	1.06
20%	1.14	1.42	N/A	1.02	1.25	1.26
30%	1.36	1.63	N/A	1.24	1.46	1.47
40%	1.57	1.84	N/A	1.45	1.67	1.67
50%	1.79	2.04	N/A	1.67	1.87	1.88

N/A – Option was not modeled.

* With connection to DIA and the ICS System.

Input from the Financial Community

As part of the study's financial analysis, CDOT and the AGS Study Team engaged private-sector concessionaires/developers, and financiers. This was formally attempted in May 2013 when CDOT issued a Request for Statements of Financial Information (RFSOFI). Similar to the intent of the RFSOTI, the RFSOFI sought information to support an initial assessment of financial feasibility and to determine if there were one or more feasible financial alternatives to fund or implement an AGS by 2025 (as prescribed by the ROD).

The six responses to the RFSOFI were from technology providers, not financiers or concessionaires/developers. While the responses contained some useful information, CDOT and the AGS Study Team directly contacted several members of the financial industry to assess the reason they did not submit responses to the RFSOFI and to gather additional input that would be useful in making a funding/financing feasibility determination.

Through these interviews, a number of themes were identified as reasons or concerns the organizations had with engaging at this particular time:

- **AGS Technology** – A selection of a preferred technology type is desired. Many voiced concerns with "untested technologies" that are not in commercial service. These concerns would likely limit the amount of financing they would be willing to offer and the level of risk they would assign to the project. Furthermore, respondents indicated that TransRapid's maglev technology currently operating in Shanghai, China, is the only maglev technology that they currently wouldn't consider "untested."

- **Ridership Concerns** – Respondents indicated that they would require more detailed ridership numbers based on a specific proposed system before seriously considering involvement with the project (technology, alignment, station locations, local transportation connections, etc.). There was also concern about the project's low ridership estimates compared to the high capital costs and whether ridership could generate sufficient farebox revenues to pay a meaningful portion of the capital cost of the project. (Note: Ridership results at this point in the Study had not been fully optimized and were roughly 46 percent lower than final ridership results.)
- **Construction and Environmental Risks** – Financiers and concessionaires were concerned about the lack of detail provided for construction and environmental mitigation. Until the specific technology, alignment, and station sites are selected, they were hesitant to speculate on the financial risks associated with these variables.
- **Likely Limits on Private Funding Capability** – Financiers and concessionaries advised CDOT that it is highly unlikely that private financial packages greater than $3 billion could be created based on available funding sources, risk tolerance, and market conditions. They went on to say that they considered $500 million to $1 billion in private funding more realistic for "typical transit projects" and that most considered this AGS project to be "atypical." Considering a $5.5 billion lowest-cost first phase, these assumptions of private-sector financial contribution would leave a gap of $2.5 to $4.5 billion that would need to be provided by federal, state, and/or local public-funding sources.
- **No Current or Foreseeable Public Funding** – Because no method for state or local funding is currently defined or able to be projected, the private sector has questions about how much – if any – money Colorado or local communities could commit to the AGS. Furthermore, the lack of current and anticipated federal financial support for high-speed transit systems was presumed to put more of the financial burden on either private or state/local funding sources.

It should be noted that even if these questions are answered, a number of outstanding actions must be accomplished before a procurement could be considered in the future:

- Establish governance structure.
- Complete environmental clearances.
- Acquire right-of-way.
- Secure voter approval for local/regional/state funding in the form of bonding and/or taxes.
- Obtain federal approval of technology.
- Obtain federal funding grant agreement.

Feasibility Determination and Next Steps

This Study determined that an AGS is technically feasible and likely to provide significant benefits to the state of Colorado and local communities. However, based on this Study's financial analysis, there is a significant funding gap between the lowest-cost project and the maximum capacity of the private sector's financing resources that cannot be bridged with existing or foreseeable future local, regional, state, or federal funding sources. As of 2014, there are no local, state or federal funds currently available for an AGS for the I-70 Mountain Corridor, and therefore it is not financially feasible at this time. Funding from local, state and federal sources would be required to advance an AGS and to obtain financing from the private sector.

For the project to become fundable and financially feasible by 2025:

- Substantial growth of the Colorado population and economy is required,
- Significant support from the public for an AGS or similar high speed transit project must be demonstrated, and
- Significant increases in federal funding for intercity rail projects are needed.

This does not mean that an AGS in the I-70 Mountain Corridor must be excluded from the state's future plans. In fact, since AGS is infeasible only from a funding perspective, it is recommended that CDOT include the AGS in the portion of the long-range *Colorado State Freight and Passenger Rail Plan* that is not fiscally constrained. The AGS also needs to be part of public- and private-sector conversations about the statewide prioritization of high-speed transit and the best use of statewide transportation resources.

With the technical and financial analyses completed for this Study, CDOT has met the intent of the I-*70 Mountain Corridor Record of Decision* to identify and collect additional information about a "central part of the Preferred Alternative" and advance the implementation of AGS in the I-70 Mountain Corridor. CDOT is now in position to take advantage of future advances in technologies that could lower capital costs and changes in the availability of funding sources that could improve the financial viability of an AGS.

ADVANCED GUIDEWAY SYSTEM (AGS)
FEASIBILITY STUDY

CHAPTER 1
STUDY OVERVIEW

Chapter 1 Study Overview

1.1 Study Purpose

The Colorado Department of Transportation (CDOT) through its Division of Transit and Rail commissioned the *Advanced Guideway System (AGS) Feasibility Study* (Study) in April 2012. The primary goal was to determine the technical and financial feasibility of implementing a high-speed transit system on a fixed guideway in Colorado's I-70 Mountain Corridor between Eagle County (Eagle County Regional Airport) and Jefferson County (at the I-70/C-470 interchange).

The Study was a direct result of the *Record of Decision* (ROD)[1] for the *I-70 Mountain Corridor Final Programmatic Environmental Impact Statement* (Final PEIS)[2], signed by the Federal Highway Administration in June 2011. The Preferred Alternative in the Final PEIS is defined as a multimodal solution that includes, among other components, an AGS.

The ROD defines the AGS as "a central part of the Preferred Alternative" and identifies that "additional information is necessary to advance implementation of an AGS in the I-70 Mountain Corridor."

The Final PEIS commits CDOT to determine the feasibility of an AGS for the I-70 Mountain Corridor prior to its implementation. This Study determines the feasibility of an AGS in the I-70 Mountain Corridor.

1.2 The I-70 Mountain Corridor

I-70 is a national interstate that begins in Utah and travels through the middle of the United States to its terminus in Maryland. Originally intended to have its west termini in Denver, it was extended to Utah. The last sections of I-70 west of Denver were constructed in the 1990s when the section through Glenwood Canyon was completed. I-70 crosses the Continental Divide at the EJMT, which is the highest point on the Federal Interstate System (11,013 feet above sea level at the east portal; 11,112 feet at the midway point; and 11,158 feet at the west portal).

Within Colorado, I-70 is the single east-west link between Denver and Denver International Airport (DIA) to the mountain communities and the western slope. It also is a primary route to major ski resorts and recreational areas.

In 2013, on average nearly 30,000 vehicles per day traveled through the Eisenhower-Johnson Memorial Tunnel (EJMT). Traffic volumes on I-70 increase to the east of the tunnel; and more than 40,000 vehicles travel through Idaho Springs every day.

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[1] I-70 Programmatic Environmental Impact Statement Record of Decision available at http://www.coloradodot.info/projects/i-70mountaincorridor/documents/Final_I70_ROD_Combined_061611maintext.pdf/view.

[2] I-70 Programmatic Environmental Impact Statement available at http://www.coloradodot.info/projects/i-70mountaincorridor/final-peis/final-peis-file-download.html.

Because I-70 is a strategic economic artery, increased traffic congestion, weather-related delays, and shutdowns have a substantial negative impact on the state's economy. High-volume travel times cause significant traffic delays on a regular basis, mostly on weekends during the summer and during ski season. However, traffic delays caused by accidents or inclement weather can occur at any time. Because large stretches of I-70 are limited to two through lanes in each direction, traffic slow-downs in any one of those lanes can cause congestion and travel delays.

To address these challenges, widening of I-70 has been considered, but the construction and environmental costs associated with widening are significant. In addition, transit and multimodal alternatives to highway widening have been proposed.

1.3 Background Studies

Since 1988, the CDOT has conducted a number of studies to determine how to improve mobility on the I-70 Mountain Corridor. A common theme of these studies has been the need to introduce an all-weather high-speed transit system to serve the recreational, commuter, and business needs of the I-70 Mountain Corridor.

***I-70 Mountain Corridor Major Investment Study* (CDOT, 1998)** – In 1998, CDOT prepared a *Major Investment Study* (MIS) for the I-70 Mountain Corridor. A key recommendation of the MIS was to provide an "innovative fixed guideway solution conforming to rigid performance specifications and tailored to the special environmental setting." The intent of the fixed guideway system was to provide a high-speed mass transit option that would be separate from the highway, which would offset the need to widen the highway to transport increasing numbers of people to the various destinations along the I-70 Mountain Corridor. It also would have the ability to move people without being impacted by incidents on the highway or by weather. The MIS predicted ridership of the fixed guideway system to be about 1.7 million passengers per year.

***I-70 Mountain Corridor Draft Programmatic Environmental Impact Statement* (CDOT, 2000-2004)** – In 2000, the Federal Highway Administration (FHWA) and CDOT, as lead agencies, published a Notice of Intent to prepare a Programmatic Environmental Impact Statement (PEIS). After four years of environmental studies, the lead agencies released the 2004 Draft PEIS. The document underwent an extended review by I-70 Mountain Corridor agencies and stakeholders. Based on the substantial public and agency comments received on the 2004 Draft PEIS, in 2007 CDOT convened a stakeholder committee, referred to as the Collaborative Effort team, to help the lead agencies shape improvements that met the purpose and need for the project and were acceptable to stakeholders. Their work was incorporated into the Final PEIS and ROD signed in 2011.

***Colorado Maglev Project* (FTA, 2004)** – The Colorado Intermountain Fixed Guideway Authority (CIFGA) was a co-author of the Colorado Maglev Project. CIFGA was formed by the Colorado State Legislature to develop a high-speed transit system for the I-70 Mountain Corridor from DIA to Eagle County Regional Airport. The study assumed use of the Chubu

High Speed Surface Transport technology. It predicted 40,000 passengers per day peak ridership.

The Impact of I-70 Congestion on Colorado – Denver to Grand Junction **(Denver Metro Chamber of Commerce and Metro Denver Economic Development Corporation, 2007)** – This study examined the financial impacts of the congestion on I-70, particularly on the missed opportunities associated with congestion on I-70 discouraging potential travelers from visiting locations west of Idaho Springs. The study concluded that approximately $839 million (in 2005 dollars) is lost annually due to the missed opportunities.

Land Use Planning Study for Rail Transit Alignment throughout the I-70 Corrido**r (I-70 Coalition, 2009)** – This study's[3] purpose was to engage local jurisdictions along the I-70 Mountain Corridor from Golden to Glenwood Springs in a conversation about future AGS service, station locations, and community land use. The study was a collaborative effort designed to address local I-70 Mountain Corridor visions, goals, and understanding of transit service implementation, along with concepts for land use development that support and integrate with future transit. The study identified local land use needs, prepared individual action plans, addressed implementation tools related to future transit land use integration, worked with agencies in assessing how land uses drive transit decisions, and determined how future transit would affect land use.

High Speed Rail Feasibility Study Business Plan **(RMRA, 2010)** – The Rocky Mountain Rail Authority's 2010 Feasibility Study[4] looked at various technologies, including conventional high speed rail and magnetic levitation (maglev) vehicles. This study considered systems along both I-70 (from DIA to Eagle County Regional Airport) and I-25 (from Pueblo to the south and Fort Collins to the north). The 2025 estimated combined ridership for I-70 and I-25 ranged from 19.1 to 28.6 million passengers per year, depending on alignments and technologies.

I***-70 Mountain Corridor Final Programmatic Environmental Impact Statement*** **and** ***Record of Decision*** **(CDOT, 2007-2011)** – The Collaborative Effort team[5] formed in 2007 to address comments on the 2004 Draft PEIS worked with the lead agencies, CDOT and FHWA, to further define and come to a consensus about the I-70 Mountain Corridor improvements.

The 27-member Collaborative Effort team represented the varied stakeholders of the I-70 Mountain Corridor, including the lead agencies. Their work resulted in the Collaborative Effort team's Consensus Recommendation, which ultimately became the Preferred Alternative for the I-70 Mountain Corridor.

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[3] I-70 Land Use Planning Study can be found at http://rockymountainrail.org/RMRA_Related_Documents.html
[4] RMRA HSR Feasibility Study can be found at http://rockymountainrail.org/RMRA_Final_Report.html
[5] Collaborative Effort Membership Roster available at http://www.coloradodot.info/projects/i-70mountaincorridor/documents/CEMembers/view

In 2010, the lead agencies released the Revised Draft PEIS. The Revised Draft PEIS replaced the 2004 Draft PEIS and was responsive to comments received on the 2004 Draft PEIS and the Collaborative Effort team's Consensus Recommendation. In March 2011, FHWA issued a Notice of Availability for the *Final I-70 Mountain Corridor PEIS* in the Federal Register. On June 16, 2011, the *Final I-70 Mountain Corridor PEIS Record of Decision* (ROD) was signed by FHWA.

The ROD identified the Preferred Alternative as a multimodal solution with three main components: 1) Non-infrastructure Components, 2) the Advanced Guideway System, and 3) Highway Improvements. The Preferred Alternative included a range of improvement options from a Minimum Program of Improvements to a Maximum Program of Improvements. The Minimum Program of Improvements included:

- **Non-Infrastructure Related Components** – Non-infrastructure-related strategies were intended to begin in advance of major infrastructure improvements to address some of the issues in the I-70 Mountain Corridor as soon as practicable.
- **Advanced Guideway System (AGS)** – An AGS was a key part of the Preferred Alternative and included a commitment to the evaluation and implementation of an AGS within the I-70 Mountain Corridor, including a vision of transit connectivity beyond the Final PEIS study area and local accessibility to the system. The Final PEIS and ROD both recognized that additional information was necessary to advance implementation of an AGS in the I-70 Mountain Corridor, such as:
    - Feasibility of high-speed rail passenger service.
    - Potential station locations and local land use considerations.
    - Transit governance authority.
    - Alignment.
    - Technology.
    - Termini.
    - Funding requirements and sources.
    - Transit ridership.
    - Potential system owner/operator.
    - Interface with existing and future transit systems.
    - Role of an AGS in freight delivery both in and through the I-70 Mountain Corridor.

The Final PEIS indicated that AGS should be able to serve 4,900 passengers per hour in each direction, equating to about 25 percent of the highway volume and peak demand.

- **Highway Improvements** – The Preferred Alternative included highway improvements to address current I-70 Mountain Corridor conditions and future demands. The ROD identified a number of safety, mobility, and capacity components in two categories: 1) "specific highway improvements" and 2) "other highway projects." All of the improvements in both categories are included in the Minimum

Program of Improvements. The "specific highway improvements" are called out as part of the "triggers" for future "other highway" and non-AGS transit improvements. Triggers are defined conditions that must be met before proceeding with the "other highway" improvements. A key trigger within the ROD related to AGS is that *additional highway capacity improvements (other highway projects) will proceed if and when:*

- *The specific highway improvements are complete and an Advanced Guideway System is functioning from the Front Range to a destination beyond the Continental Divide, OR*
- *The specific highway improvements are complete and Advanced Guideway System studies that answer questions regarding the feasibility, cost, ridership, governance, and land use are complete and indicate that an Advanced Guideway System cannot be funded or implemented by 2025 or is otherwise deemed unfeasible to implement, OR*
- *Global, regional, or local trends or events have unexpected effects on travel needs, behaviors, and patterns and demonstrate a need to consider other improvements, such as climate change, resource availability, and/or technological advancements.*

Interregional Connectivity Study **(CDOT DTR, 2014)** – CDOT's Division of Transit and Rail (DTR) *Interregional Connectivity Study* (ICS) has run concurrently with and has interfaced directly with this Study. The primary purpose of the ICS has been to recommend optimal locations for high-speed transit (HST) alignments; technologies and station locations in the Denver metropolitan region with connections to the Regional Transportation District (RTD) FasTracks transit program; and along the I-25 corridor from Pueblo, Colorado, to Fort Collins, Colorado. The ICS focuses on maximizing ridership and minimizing competition between proposed HST corridors and present or future RTD FasTracks services. The ICS recommended the best locations for a north-south HST alignment from Fort Collins to Pueblo, and an east-west HST alignment from DIA to Eagle County Regional Airport. The ICS also supplied ridership and farebox revenue modeling for this Study.

The Interregional Connectivity Study and this AGS Feasibility Study have been closely coordinated from the time they both began.

1.4 AGS Feasibility Study

The Final PEIS and ROD acknowledged the performance criteria for an AGS technology, as defined by the Collaborative Effort, but recognized that the detailed alignment, station locations, and technology of the AGS had not been identified and would need to be studied in a subsequent feasibility study (this *AGS Feasibility Study*); if feasible, it would then be evaluated in one or more Tier 2 National Environmental Policy Act (NEPA) processes. CDOT will use both the ICS and this Study as a point of departure for examining an AGS on the I-70 Mountain Corridor that would provide transit connectivity to a larger regional transit system.

1.5 Study Area

The study area for the *AGS Feasibility Study* begins at the western edge of the Denver metropolitan area (at the C-470/I-70 interchange near the Jefferson County Government Center light rail station) in Jefferson County, Colorado, and continues west to the vicinity of the Eagle County Regional Airport near Eagle, Colorado, a distance of approximately 120 miles (Figure 1-1). It is important to note that any potential AGS may ultimately connect to DIA, which is located about 35 miles east of the east end of the AGS study area.

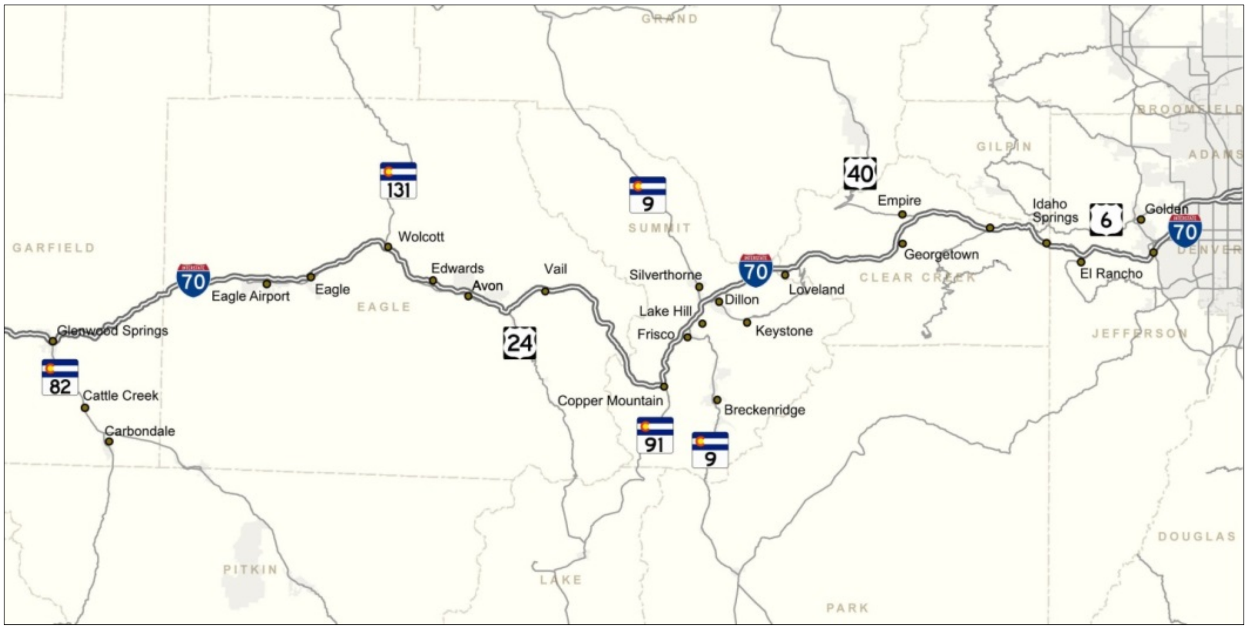

Figure 1-1: Study Area Map

Both the Final PEIS and ROD state that the AGS should follow the general alignment of I-70, but it does not necessarily have to be within the highway right-of-way. Therefore, alignments not within the right-of-way, but that serve the I-70 Mountain Corridor, are consistent with the ROD. This was confirmed by FHWA in an email dated September 12, 2013.

Developing a high-speed transit system in the I-70 Mountain Corridor presents several challenges.

1.5.1 Engineering Challenges

The I-70 Mountain Corridor presents a number of engineering challenges, including:

- **Horizontal and vertical curves with limited turning radii** – For most of its length, I-70 is posted at 55 to 65 mph due in part to the tight horizontal and vertical curves east of Vail. At the west end, once past Avon/Vail where the highway straightens, the posted speed limit increases to 75 mph.
- **Environmental impacts associated with extending the alignment outside of the existing transportation right of way** – Most of the I-70 Mountain Corridor is located within undeveloped areas and is bordered by National Forest land under the

control of the United States Forest Service (USFS). A large part of the area on the north side of I-70 is designated by USFS as Wilderness Area, where impacts and access are strictly controlled. Areas on the south side of I-70 are designated by USFS as Roadless Area, which while limiting, does not require as stringent controls as a Wilderness Area. Other than USFS lands, there is development located adjacent to and outside of the I-70 right-of-way that would need to be acquired prior to any construction.

- **Steep and lengthy grades** – The I-70 Mountain Corridor crosses the Rocky Mountains and the Continental Divide at two passes, each approximately 11,000 feet above sea level. These high elevations result in relatively long stretches of highway at steep grades, as shown in Table 1-1. Approximately 49 miles of 106 miles on I-70 (from the Eagle exit to C-470 exit) are on grades steeper than 3 percent. The steepest grade of 7 percent extends 4.2 miles on the eastbound approach to the west portal of EJMT at the Continental Divide.

Table 1-1: Grades on I-70 Mountain Corridor

Length of Highway	Grade
7.2 miles*	7%
11.8 miles	6% to 6.99%
8.6 miles	5% to 5.99%
7.5 miles	4% to 4.99%
14.2 miles	3% to 3.99%
10.4 miles	2% to 2.99%
24.6 miles	1% to 1.99%
21.6 miles	0% to 0.99%

*Includes 4.2 miles on the eastbound approach to the west portal of EJMT at the Continental Divide.

- **Areas of potential geotechnical challenges** – These are areas prone to rock- and landslides.
- **Weather patterns unique to high mountain elevations** – These include periods of severe winter conditions and potential avalanches. The dramatic climate conditions along the I-70 Mountain Corridor involve:
    - Heavy snow during spring, fall, and winter months.
    - Thunderstorms common during summer.
    - High alpine winds.
    - Ice formation, especially at lower elevations due to temperature changes.
    - Avalanches.

1.5.2 Operational Challenges

The I-70 Mountain Corridor presents unique operational challenges, such as:

- **Substantial congestion, both weekly and seasonally** – On summer weekends and during ski season, high traffic volumes cause significant travel delays on I-70. The Final PEIS demonstrated that traffic volumes are expected to continue to grow, worsening travel conditions along the I-70 Mountain Corridor. It also found that, without improvements:

- Weekend travel time on I-70 in 2035 will be about three times higher than in 2000.
- Weekday travel time on I-70 in 2035 will be more than double what weekday travel time was in 2000.
- Traffic on I-70 will be especially congested between Copper Mountain and Denver on weekends in 2035, requiring two more hours to make that trip during weekend peak periods. On weekdays, the morning and afternoon peak periods will experience an extra 1 hour and 35 minutes travel time.
- The EJMT is expected to have 55 percent more weekend traffic in 2035 than in 2000. Weekday demand is expected to increase 85 percent.

Future growth in traffic on I-70 will result in significantly longer travel times and more congestion.

- **Extreme weather events** – I-70 is sometimes closed due to inclement weather. Even when open, weather conditions can make travel hazardous and cause traffic delays and accidents.
- **Large volumes of freight transport vehicles** – I-70 is a major shipping artery across Colorado and the United States with a high volume of truck and freight traffic. Freight transport vehicles serve communities along the highway, such as Idaho Springs, Georgetown, Dillon/Silverthorne, Frisco, Vail, Avon, and others in Eagle County; and ski resorts, such as Keystone, Breckenridge, Copper Mountain, Beaver Creek, Vail, and, indirectly, Winter Park and Aspen.

1.5.3 System Technology Challenges

System technology challenges are those specific to transportation alternatives that use high speed transit and maglev technology.

- **Significant variation in trip purposes and party sizes** – These range from individual work trips to recreational activity trips made by families and groups. The average vehicle occupancy on I-70 is quite high (about 2.4 passengers per vehicle compared to 1.7 passengers per vehicle in the Denver metropolitan area).
- **Vehicles transporting various types of gear and equipment associated with recreational trips** – This includes bikes and golf clubs during summer months and skis and snowboards during winter months, as well as all types of baggage.

1.6 Framework for Determining the Feasibility of the AGS

The AGS Study Team developed the framework for determining the feasibility of the AGS with CDOT and the I-70 Mountain Corridor stakeholders through the AGS Project Leadership Team (PLT). It is focused on three key areas that answer the fundamental questions of technology, alignment, station locations and land use, capital and operating costs, funding, financing, and governance.

This AGS Feasibility Study answers key questions on Technology, Alignment, Land Use, Cost, Funding, and Financing.

- **Technology** – Are there technologies capable of operating safely and efficiently in the I-70 Mountain Corridor?
- **Alignment and Land Use** – Are there alignments for those technologies that enable them to meet the desired system performance and operational criteria? Where should stations be located and what kind of land use could they support?
- **Cost, Funding, and Financing** – If there are feasible technologies and alignments, is there a reasonable plan by which the AGS can be funded and financed?

1.7 Study Approach

CDOT and the AGS PLT set a number of goals for Study in the three key categories that form the framework for assessing the feasibility of the AGS:

- Determine technologies that are capable of meeting the performance criteria set forth by the Collaborative Effort team's Consensus Recommendation and further refined and supplemented by the AGS Study Team.
- Determine, for those technologies capable of meeting the performance criteria, feasible alignments along the I-70 Mountain Corridor between the C-470/I-70 interchange and Eagle County Regional Airport, using the actual operational characteristics of the feasible technologies.
- Combine technologies with alignments to develop estimates of the capital costs to build the infrastructure required to provide high-speed transit service for the I-70 Mountain Corridor.
- Estimate operations and maintenance costs for the various alignment/technology combinations.
- Estimate the expected ridership and farebox revenue associated with the various alignment/technology combinations. It should be noted that initial ridership and revenue estimates were completed using a ridership model developed by the ICS Team. This was necessary to be able to model the interaction of the north-south HST system and the connection from DIA to the east end of the AGS study area on ridership and revenue.
- Develop possible funding and financing strategies for the AGS to assess the financial feasibility of the AGS, both as a standalone project and combined with the ICS system.
- Ensure that the I-70 Mountain Corridor Context Sensitive Solutions (CSS)[6] process was used throughout the life of the Study.

The Study was conducted in three phases that matched the three key focus areas.

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[6] See I-70 Mountain Corridor Context Sensitive Solutions website at http://www.coloradodot.info/projects/contextsensitivesolutions

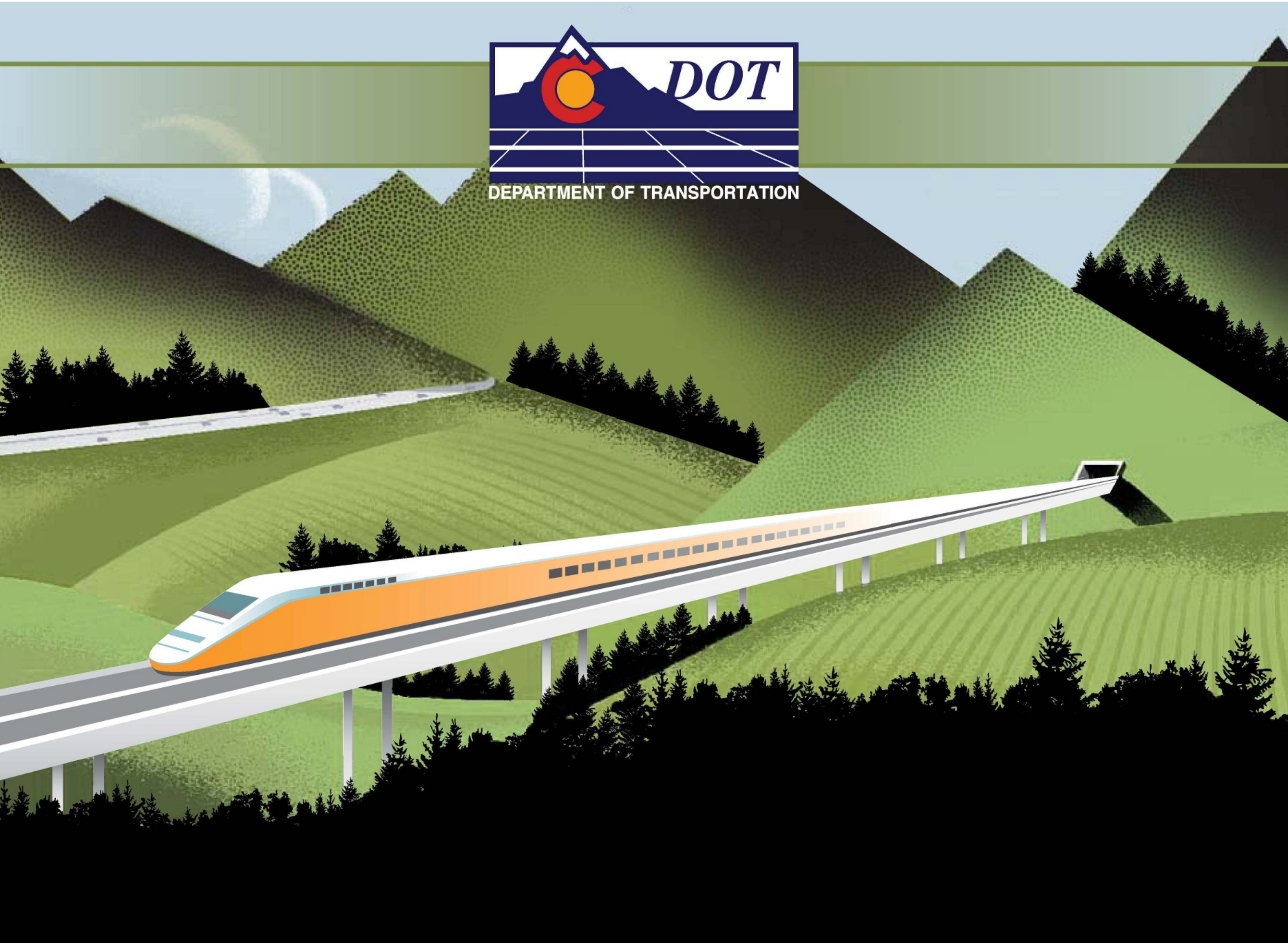
- **Technology** – In the first phase, the AGS Study Team worked with private technology providers to identify existing and future technologies and to evaluate their feasibility of accommodating the I-70 Mountain Corridor challenges.
- **Alignment and Land Use** – In the second phase, the AGS Study Team developed and analyzed potential alignments and station sites based on the operational capabilities of the feasible technologies.
- **Cost, Funding, and Financing** –The third phase involved development of cost and revenue estimates for potential alignment/technology pairs, evaluation of potential public funding sources, and working with private-sector financial and technology providers to gather information on private funding/financing options.

Development of this AGS Feasibility Study included significant coordination with the AGS Project Leadership Team.

The AGS Study Team adhered to the CSS process for engaging I-70 Mountain Corridor stakeholders, while strongly emphasizing direct engagement with private-sector representatives from the high-speed transit technology industry and the financial industry. Representatives from the AGS PLT also served on the Project Leadership Team for CDOT's concurrent ICS, which led to the evaluation of additional system alternatives that extend through the Denver metropolitan area and are part of a larger high-speed transit system.

The rest of this report is organized to document the three phases of the Study:

Chapter 2	Technology Evaluation
Chapter 3	Development of Alignments
Chapter 4	Cost Estimation
Chapter 5	Benefit to Cost Analysis
Chapter 6	Estimation of Benefits
Chapter 7	Funding and Financial Analysis
Chapter 8	Stakeholder Involvement



ADVANCED GUIDEWAY SYSTEM (AGS)
FEASIBILITY STUDY

CHAPTER 2
TECHNOLOGY EVALUATION

Chapter 2 Technology Evaluation

2.1 Overview

The first step in assessing the feasibility of an AGS was to determine if there are existing high-speed transit systems (technologies)—or systems in a sufficient stage of development—to overcome the unique challenges posed by the I-70 Mountain Corridor and that meet the desired system performance and operational criteria developed for the AGS.

The Technology Evaluation process included:

- *Development of System Performance and Operational Criteria*
- *Solicitation of Statements of Technical Information from technology providers*
- *Evaluation of the Statements of Technical Information*
- *Hosting of a Technology Forum and Technology Presentations*

This chapter documents the technology evaluation process used by the AGS Study Team to identify and evaluate high speed transit system technologies that were considered further in the development of alignments discussed in Chapter 3.

2.2 System Performance and Operational Criteria

To specify to potential technology providers what types of technology might be appropriate for the I-70 Mountain Corridor, the AGS Study Team developed a set of System Performance and Operational Criteria. The criteria describe the desired attributes of the AGS, as envisioned in the Final PEIS and ROD. The AGS Study Team worked with the AGS Technical Committee, AGS PLT, and technology providers to refine and expand the Final PEIS and ROD performance criteria.

System Performance and Operational Criteria for the AGS were developed by refining and supplementing the Collaborative Effort's Consensus Recommendation, which included AGS Technology Performance Criteria.

During the development of the Final PEIS, the I-70 Coalition Technical Committee, as part of the Collaborative Effort team's Consensus Recommendation, included in Attachment B: AGS Technology Performance Criteria, a list of performance criteria that could be useful in evaluating viable AGS technologies. The envisioned AGS technologies included both those that currently exist and those that were in the research and development phase. The criteria were not meant to be detailed, specific, and definitive, but were intended to serve as a basic evaluation tool for AGS studies. These performance criteria were used as the basis for development of the System Performance and Operational Criteria for this *AGS Feasibility Study* (Study).

The AGS Study Team reviewed the Collaborative Effort team's AGS Technology Performance Criteria with the AGS Technical Committee at two three-hour meetings held June 11 and

June 14, 2012. The purpose of the meetings was to refine, define, and develop the System Performance and Operational Criteria for evaluation of technologies.

The AGS PLT met on June 13, 2012, to discuss the proposed criteria developed by the AGS Technical Committee and endorsed the following refinements to the criteria:

Alignment – The AGS PLT recognized that the station locations were the driving factors for alignment. They concluded that the station locations were the most important criterion, not where the AGS is located in relation to I-70. This is particularly true for crossing the Continental Divide and for serving dispersed origins & destinations in Summit County.

Triggers in the ROD – The AGS PLT indicated that the 2025 trigger included in the ROD was meant to be a guide, not a drop-dead date. They explained that the Collaborative Effort did not intend for the Maximum Program of Improvements for the highway to be triggered if the AGS were deemed feasible before 2025, but not fully constructed and operational. They agreed that the AGS Study Team should challenge the industry to fund and/or complete the AGS by 2025. If an industry team could not meet that goal, the AGS Study Team should propose when and how the AGS could be completed.

Termini – The AGS PLT agreed that incremental development of the AGS would be acceptable and that the industry should determine the location of the first phase within the general parameters of the Final PEIS, which stated termini in the Denver metropolitan area and somewhere west of the Continental Divide. They also felt that the market should determine when the remainder of the system would be constructed.

Station Locations – The AGS PLT agreed that the AGS must serve the four corridor counties (Jefferson, Clear Creek, Summit, and Eagle Counties) and that the industry should propose the best solutions to serve them.

Land Use Considerations – The AGS PLT agreed that transit-oriented development (TOD) and development rights should be allowed or encouraged around stations, depending on the unique needs/situation of each community. They also indicated that rezoning most likely would need to occur. The local communities were also encouraged to begin crafting land use policies and/or plans for potential station locations if they had not already done so.

Right-of-Way – The AGS PLT agreed that it should be assumed that CDOT and the local governments would commit to obtaining all necessary right-of-way, noting that right-of-way is an important asset of the local communities.

Interface with Existing and Future Transit Systems – The AGS PLT acknowledged that it would be a responsibility of the local agencies to provide transit systems that would connect to and from the AGS station to local destinations. They also agreed that the local communities would be responsible for identifying solutions for connecting AGS passengers to other destinations, such as trail heads and campgrounds which are not typically served by conventional transit.

AGS Governance Authority – The AGS PLT agreed that the AGS would need to have some level of public oversight and asked the AGS Study Team to look into the governance options and provide details for further discussion. It was noted that the I-70 Coalition would soon be a Transportation Management Organization, and that should be considered during the evaluations.

Potential System Owner/Operator – The AGS PLT indicated that they would not support a wholly-owned private system. Rather, they would prefer a level of public ownership, like that of a transit authority.

Travel Time – The AGS PLT suggested that travel time be based on time and not speed. A suggestion was 45 minutes from Golden to Frisco and 60 minutes from Golden to Vail.

Technology Transfer – The AGS PLT indicated that allowing a technology provider to lease a proprietary technology that would eventually become publicly owned/controlled was a desirable criteria. This would increase the likelihood that a new or currently proprietary technology for the I-70 Mountain Corridor could become part of a national system. There was strong recognition that use of a proprietary technology could be a severely limiting factor in garnering private sector interest to fund and/or finance the system.

This input was taken back to the AGS Technical Committee on June 14, 2012, and the Draft AGS System Performance and Operational Criteria were prepared by the AGS Team and forwarded to the AGS PLT for review. On August 8, 2012, the AGS PLT provided final comments on the Draft AGS System Performance and Operational Criteria. The comments were addressed, and on August 31, 2012, the AGS PLT endorsed the Final AGS System Performance and Operational Criteria, which are included in Appendix A.

2.3 Request for Statements of Technical Information

To identify potential AGS technologies, CDOT used a Request for Statements of Technical Information (RFSOTI) to technology providers. The AGS Study Team began preparation of the RFSOTI in August 2012 for review. The Draft RFSOTI was forwarded to CDOT, the AGS PLT, and the AGS Technical Committee on August 22, 2012. After addressing comments, the Final RFSOTI was completed and posted on CDOT's website on September 7, 2012.

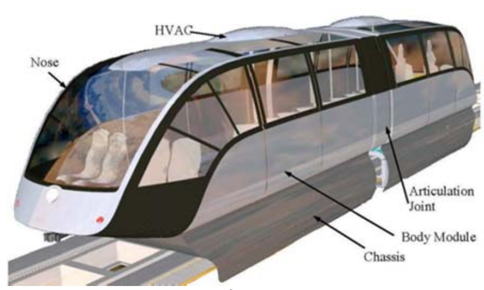
The RFSOTI requested information and data concerning the following criteria:

- Travel Time
- Vehicles
- Noise
- Footprint and Context Sensitive Solutions
- Grade (for various significant locations)
- Safety
- Weather and Wind
- Scalability and Growth
- Passenger Comfort
- Baggage Capacity
- Distribution
- Energy Efficiency
- Sustainability
- Cost
- Termini
- Right-of-Way
- Interface with Existing and Future Transit Systems
- Potential System Owner and Operator
- Technology at System Stations

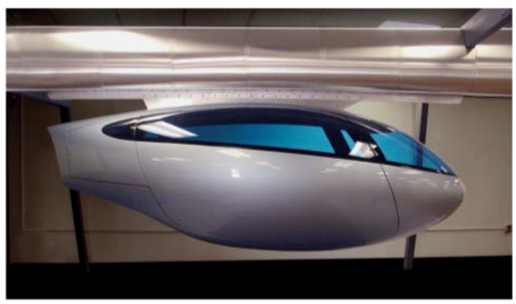
- Freight
- Tunnels
- Reliability
- Headway
- Power Generation, Transmission, and Additional Technology Information
- Propulsion System
- Operation Control System
- Performance
- Environmental Considerations
- Technology Readiness

The RFSOTI included a requirement for the technology providers to participate in a webinar conducted by CDOT and the AGS Study Team. The first webinar was held on September 19, 2012, and repeated so that all technology providers had a chance to fulfill this obligation.

American Maglev



General Atomics


SkyTran


Talgo


TransRapid

CDOT issued three addenda to address questions. The Final RFSOTI, which includes the addenda issued through September 25, 2012, is included in Appendix B.

The SOTI were due to CDOT on October 10, 2012. CDOT received 18 SOTIs from the following technology providers:

- American Maglev
- ET3
- Flight Rail
- General Atomics
- Kestrel
- MagneMotion
- Mediatrik/Techtronics
- MegaRail
- Monobeam
- Owen Transportation Group
- Personal Rapid Transit Consulting
- Public Personal Rapid Transit Consortium
- Roane Inventions (TriTrack)
- SkyTran
- Swift Tram
- Talgo
- Tubular Rail
- TransRapid

After review of the submittals, CDOT sent Requests for Clarifications to technology providers to obtain more detail or information on October 24, 2012. The clarifications were received on October 29, 2012.

2.4 Evaluation of SOTIs

The AGS Study Team developed the evaluation guidelines for the SOTIs in conjunction with the AGS Technical Committee. They are included in Appendix C. It should be noted that the RFSOTI stated that the results of this evaluation process would not preclude technology providers from future involvement in an AGS on the I-70 Mountain Corridor.

The evaluation was a two-step process conducted by a Consultant Review Team. The role of the Consultant Review Team was to make recommendations to CDOT about which technologies would meet each of the system performance criteria, the operational criteria, and the Technology Readiness Level requirements; and which technology providers would be invited to participate in a Technology Forum.

2.4.1 Qualification Criteria

The first step was an evaluation according to the technology providers' responses to six of the qualification criteria. These criteria were used because they reflected the core requirements of the ROD and the criteria established by CDOT with endorsement from the AGS PLT.

Statements of Technical Information were first evaluated for six key Qualification Criteria that needed to be met for the technology to be qualified for further review by the AGS Study Team

Qualification Criteria 1 – Travel Time (RFSOTI Section 3.1) – How the technology would meet the minimum speed requirements and provide a minimum capacity of 4,900 passengers per hour in the peak direction by 2035.

Qualification Criteria 2 – Grade (RFSOTI Section 3.5) – How the technology could cost-effectively traverse the grades within the I-70 Mountain Corridor.

Qualification Criteria 3 – Safety (RFSOTI Section 3.6) – How technology providers would meet applicable passenger safety standards and test data or system expectations concerning safety. These included how the technology addressed vehicle/system safety requirements to provide grade-separated and wildlife crossings; an access-controlled guideway; emergency egress from the vehicles and guideway, including guideway on structure and guideway in tunnels; and system security.

Qualification Criteria 4 – Weather/Wind (RFSOTI Section 3.7) – How the technology could operate in severe weather events and extreme alpine windstorms while still maintaining safety and reliability.

Qualification Criteria 5 – Light Freight (RFSOTI Section 3.11) – How the technology would be able to accommodate light freight.

Qualification Criteria 6 – Technology Readiness (RFSOTI Section 3.25) - How the technology would meet the Technology Readiness Level (TRL) requirement of TRL 9 by 2017. This was a primary requirement of the candidate technologies. The Consultant Review Team assessed the technology provider's verified plan to attain TRL 9 by 2017 and evaluated it based on the current TRL and the demonstrated ability to reach TRL 9 by 2017.

The Consultant Review Team gave a grade of either "Pass" or "Fail" for each of the criteria. If the technology did not receive a "Pass" for all six of the criteria, the SOTI was deemed incomplete/non-responsive, and it was not included in the next level of evaluation.

The Consultant Review Team provided CDOT a list of the 11 technology providers who qualified to pass to the next level of review, along with the reasons why some of the technology providers were not qualified. The results of the Qualification Criteria evaluation are shown in Table 2-1.

Table 2-1: Qualification Criteria Scoring

	Qualification Criteria						
Technology Provider	**1 Time**	**2 Grade**	**3 Safety**	**4 Weather**	**5 Freight**	**6 TRL**	**Qualified**
American Maglev	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ET3	Yes	Yes	**No**	Yes	Yes	**No**	**No**
Flight Rail	Yes	Yes	Yes	Yes	Yes	Yes	Yes
General Atomics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Kestrel	**No**	**No**	**No**	**No**	**No**	**No**	**No**
MagneMotion	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mediatrik/Techtronics	**No**	**No**	**No**	**No**	**No**	**No**	**No**
MegaRail	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Monobeam	Yes	**No**	**No**	**No**	**No**	**No**	**No**
Owen Transportation Group	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Personal Rapid Transit Consulting	**No**	Yes	Yes	Yes	Yes	Yes	**No**
Public Personal Rapid Transit Consortium	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Roane Inventions (TriTrack)	Yes	Yes	Yes	Yes	Yes	**No**	**No**
SkyTran	Yes	Yes	Yes	Yes	Yes	Yes	Yes

	Qualification Criteria						
Technology Provider	**1 Time**	**2 Grade**	**3 Safety**	**4 Weather**	**5 Freig ht**	**6 TRL**	**Qualified**
Swift Tram	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Talgo	Yes	Yes	Yes	Yes	Yes	Yes	Yes
TransRapid	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tubular Rail	**No**	**No**	**No**	Yes	Yes	**No**	**No**

2.4.2 Additional Evaluation Criteria

During the second step of the process, the Consultant Review Team reviewed and evaluated the 11 technology providers against all other criteria. Their evaluations concentrated on developing an understanding of the strengths and weaknesses of each of the technologies. During this step, a Secondary Evaluation Team divided the SOTIs into Technology Groups. Those groups were:

Technology Group 1 – Technologies that could be operated wholly within the I-70 right-of-way (except to deviate to stations). The following technology providers were included in Technology Group 1: PPRTC, SkyTran, SwiftTram.

Flight Rail

Technology Group 2 – Technologies that could not operate within the I-70 right-of-way because of grade or curvature issues. The following technology providers were included in Technology Group 2: Talgo, TransRapid. High-speed rail, represented by the Talgo submission, requires flatter grades (maximum grade of approximately 2 percent) and, therefore, cannot operate alongside I-70, which has many grades greater than 2 percent. Both high-speed rail (Talgo) and high-speed maglev (TransRapid) technologies require broader, more sweeping curves to travel at speeds of 150 to 200+ mph than the narrower highway curves in the I-70 alignment, which are limited by passenger comfort tolerances.

Swift Tram

Owen Transit Group

Technology Group 3 – A hybrid of the first two groups, these technologies could operate within the I-70 right-of-way for a significant portion of the route, but would have to deviate from the right-of-way in places because of grade or curvature. The

MegaRail

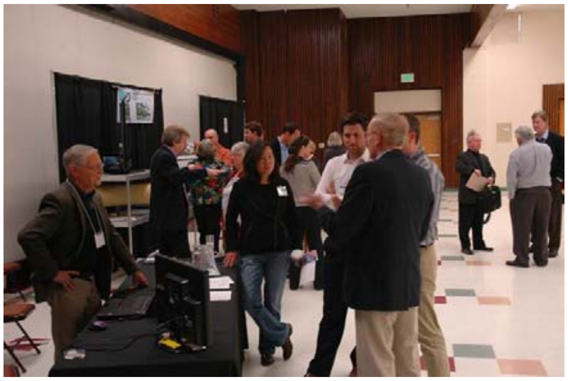
following technology providers were included in Technology Group 3: American Maglev Transit, Owen Transit Group, MegaRail, General Atomics, Flight Rail, and MagneMotion.

The Secondary Screening Team submitted a Recommendation Memo dated November 8, 2012, to CDOT DTR, the AGS PLT, and the Technical Committee describing the technology providers in each Technology Group that were recommended for further evaluation. Those recommended providers would attend a public Technology Forum and have the opportunity to present.

On November 14, 2012, the AGS Study Team presented the results of the SOTI review to the AGS PLT. The AGS PLT endorsed the evaluation and the recommendation that the 11 technology providers participate in the Technology Forum, and which 5 would present.

2.5 Technology Forum and Presentation

To allow the AGS Study Team, CDOT staff, and the public to learn more about the various technologies, a Technology Forum was held on December 13, 2012, at the Jefferson County Fairgrounds. Each of the 11 technology providers was provided space in which to exhibit their technologies and interact with the attendees. Table 2-2 shows the participants at the Technology Forum. Four of the invited technology providers did not attend the forum.



Technology Forum

Table 2-2: Technology Forum Attendees

Technology Provider	Public Forum Booth	Presented at Forum
American Maglev	Yes	Yes
FlightRail	Yes	No
General Atomics	Yes	Yes
MagneMotion	No	No
MegaRail	Yes	Yes
Owen Transit Group	No	No
PPRTC	Yes	Yes
SkyTran	Yes	No
Swift Tram	Yes	No
Talgo	No	Yes
Transrapid	No	No

The public part of the Technology Forum was well-attended by 300 members of the public. In addition, both print media and television reporters were present.

Five representative technology providers were invited to make confidential presentations to a Technical Review Panel of CDOT staff, State Transportation Commissioners, elected officials, the AGS PLT and Technical Committee, and the AGS Study Team. These presentations, which occurred on December 13 and 14, 2012, at the Jefferson County Fairgrounds, consisted of a 45-minute presentation by the technology provider followed by 60 minutes of in-depth discussion and questions.

Each of the five technology providers addressed the following during their 45-minute presentation:

Technology Forum Presentation

- Provide an overview of the technology and the SOTI.
- Describe the plan for stations and maintenance facilities, including size and possible locations.
- Describe how safety certifications will be obtained and explain the performance characteristics of the system, especially with respect to severe weather conditions and terrain (grade) challenges.
- Describe how the system will meet the operational capacities specified in the RFSOTI and how headways will be managed considering offloading of baggage and gear associated with mountain activities (bikes, skis, snowboards, etc.). Also, describe how the system could be expanded to include branch lines and additional stations.
- Describe estimates of cost for infrastructure (cost per mile) and rolling stock. Also, describe how cost efficiencies might be realized and where major system components will be built.
- Describe how the system will interface with other travel modes and how it will accommodate light and heavy freight.

Following the 45-minute presentation, the Technical Review Panel engaged the technology providers in a 60-minute interactive discussion of various elements of the technology and questions they had about the technology provider's SOTI.

2.6 Technology Evaluation Findings

After the Technology Forum, the AGS Study Team and project stakeholders determined that there were several items that would prevent a definitive recommendation for potential technology providers. These are described in the following sections.

2.6.1 Cost Estimates

The cost terms, basis, assumptions, and potential accuracy of the raw data developed by technology providers meant that the costs could not be relied upon for comparison purposes.

The AGS Study Team contacted a select number of technology providers to follow up on those items that could impact cost estimates, primarily further definition of the infrastructure components required by each system. This also gave the AGS Study Team a better understanding of the technology proposed, system elements, and technology maturity.

In many cases, the technology providers had good information about their own proprietary system components (vehicles, communications systems, propulsion systems, etc.), but did not necessarily have good cost information about the track/guideway, foundations, columns, and other items needed to build their systems in the I-70 Mountain Corridor.

Technology providers included cost data in their SOTIs, but the AGS Study Team largely developed their own cost estimates.

For reasons of due diligence, fairness, objectivity, and methodological consistency, the the AGS Study Team developed independent cost estimates using as detailed information as was available. In addition, the AGS Study Team was interested in computing a total cost, inclusive not only of construction costs, but also including right-of-way, environmental clearances & mitigation, permitting, utility relocations, and professional / management services required to deliver the project.

2.6.2 Peak Hour Capacity

A requirement of the PEIS/ROD was that the AGS accommodate the number of passengers, equivalent to the number that could be accommodated in one lane of traffic in the peak hour, peak direction. Based on the current average vehicle occupancy of I-70 and the capacity of a freeway lane in the mountains, this equated to about 4,900 passengers per hour in one direction. It became apparent that meeting the capacity requirement presented in the PEIS/ROD for 4,900 passengers per hour in the peak direction would not be as simple as expected for all technologies. Table 2-3 presents the number of consists required for each technology to provide the stated 4,900 passengers per hour in the peak direction. The higher the number of consists needed per hour, the more important technology readiness becomes to adequately demonstrate safety of operation in terms of vehicle separation, vehicle deceleration/braking, and switching.

Table 2-3: Consist Requirements

Technology Provider	Consist Capacity*	Consists Needed
American Maglev	186	26
FlightRail	800	6
General Atomics	200	25
MagneMotion	150	33
MegaRail	128	38
Owen Transit Group	48	102
PPRTC	6	817
SkyTran	2	2,450
Swift Tram	32	153
Talgo	300	16
Transrapid	960	5

* As provided in the SOTIs.

2.6.3 Off-line Stations

Some configurations of train / train-like technologies and most of the personal or pod-based technologies would require off-line stations. Analysis of the required off and on ramps for the off-line stations showed that the infrastructure required to provide off-line stations would be significant. Depending on the speed of the vehicle, from 1,800 to 5,400 feet of parallel guideway would be needed. The footprint of the guideways for stations located within developed areas would require significant property acquisition and have greater impacts than on-line stations. Figure 2-1 illustrates the length of the parallel guideways required at the off-line stations, depending on the speed of the acceleration and deceleration speeds at the stations.

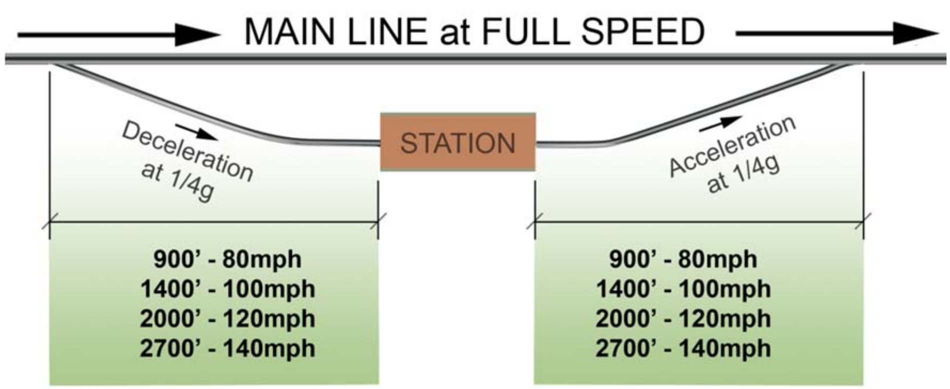
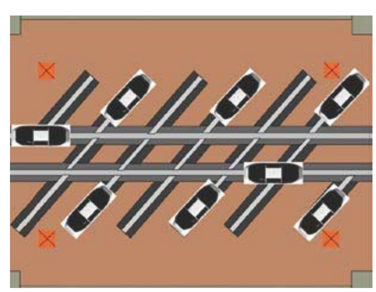


Figure 2-1: Required Parallel Guideway Lengths for Off-Line Stations

The significance of the off-line stations for the corridor project leadership team rested less with the additional length of guideway added (2-12 more miles / 1-8% more guideway if same six stations as train/train-like technologies) and more with the perceived visual impacts of adding transit “interchanges” to highway interchanges already on the ground.

Additionally, the distributed point-to-point nature of many of the pod / personal transit system concepts offered initial appeal for smaller stations in more locations. In high activity areas, this concept created some questions:

- The more personalized the level of travel becomes, the more the expectancy rises that a pod might stay with a particular user, holding the user’s belongings. This possibly creates the need for pod storage similar to auto parking.
- In locations like resort villages and regionally-serving collector park-and-rides, hundreds of pods per hour might be needed to serve thousands of persons per hour. With a single linear train-like station, station size would not be



Example of Pod Station

expected to be reduced as compared to other technologies. Curbside taxi and loading/unloading areas in large cities and airports are auto-based examples illustrating this concern. Station size might be larger if multiple "platforms" or loading areas were provided in parallel.

2.6.4 Commercial Availability

While all of the technologies presented a reasonable explanation about reaching TRL 9 by 2017, several of the technologies were either theoretical or in early research and development stages. Only high-speed rail (Talgo, among many vendors and installations worldwide) and TransRapid are commercially available at this time. TransRapid only has a single deployment in Shanghai, China. TransRapid, American Maglev, and General Atomics have full-size test facilities. FlightRail has a scaled-down test facility.

2.7 Technologies Advanced in the *AGS Feasibility Study*

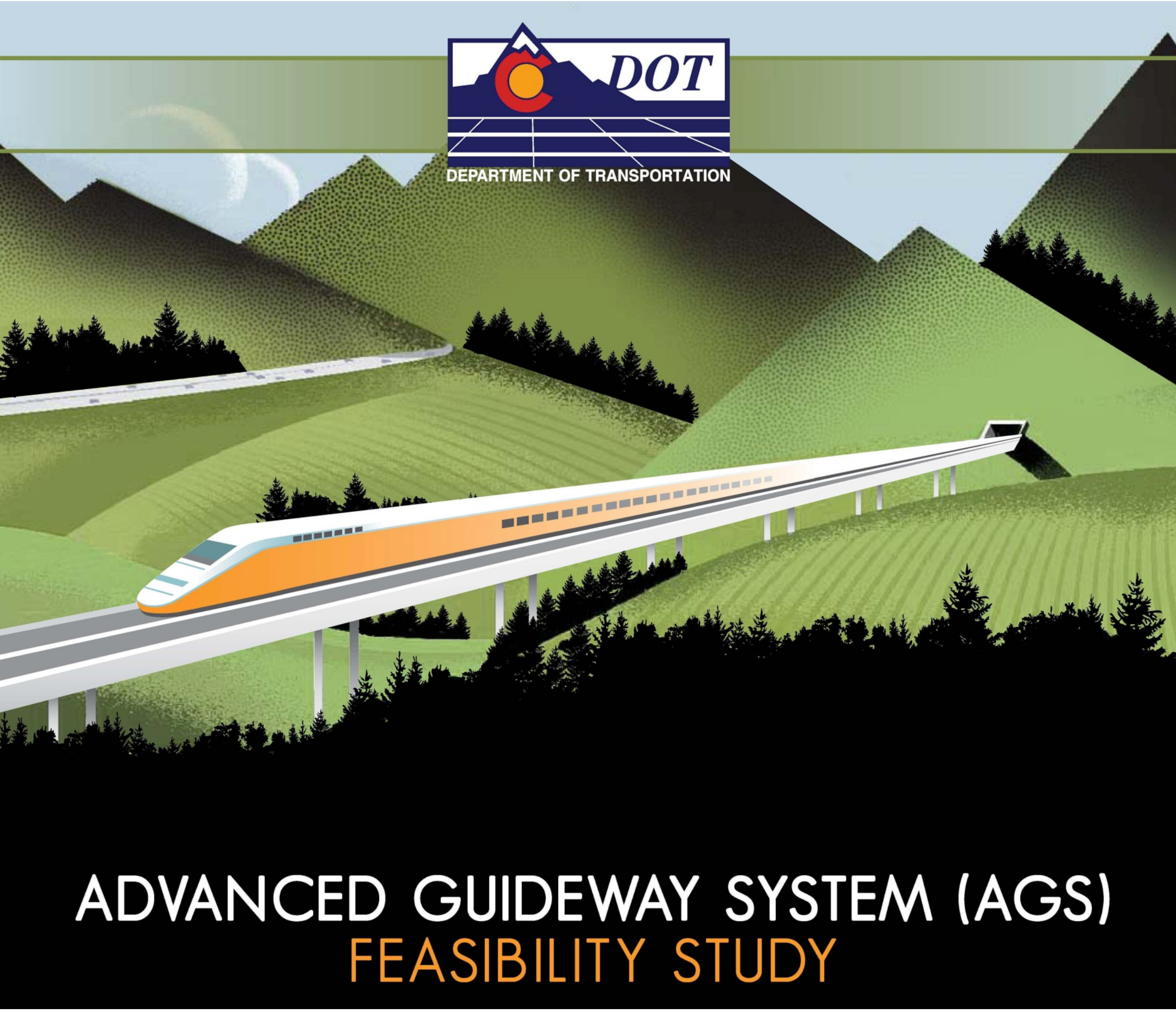
Because of their current status of commercial availability, it was decided that a more detailed analysis for this Study would focus on three technologies:

- 120 mph Maglev – American Maglev or General Atomics
- High Speed Maglev – Transrapid
- High Speed Rail – Talgo

These technologies would also require the most significant infrastructure (guideway, structures, and tunnels), so they would generate the most conservative cost estimates. Any of the emerging technologies' costs could be re-evaluated to determine possible "savings" relative to rail and maglev costs, when their commercial/technology readiness improves the availability and reliability of information.

Technologies that are either commercially available or far into research and development were selected for more detailed analysis, but no technologies have been precluded from future implementation of the AGS.

As was stated in the RFSOTI, technologies not advanced in this Study are not precluded from being used in the ultimate implementation of the AGS. Any of these technologies could be implemented on one or more of the proposed alignments that are presented in the next chapter.



CHAPTER 3
DEVELOPMENT OF ALIGNMENTS AND STATION LOCATIONS

Chapter 3 Development of Alignments and Station Locations

More than any other characteristic of an Advanced Guideway System (AGS), the alignment, or its physical location, is the one most likely to be noticed by the traveling public. The alignment also would have the greatest potential to affect the project cost, and it would have more bearing on the number of impacts to I-70 Mountain Corridor and the adjacent communities. The AGS Study Team developed the alignments with this in mind, while meeting the goals of a Context Sensitive Solution and a design for the AGS that is practical and makes best use of funds.

The alignments presented in this chapter represent the AGS Study Team's initial design options developed with the AGS Project Leadership Team (PLT). It is anticipated that further refinement of the alignments will occur when the AGS is implemented.

3.1 Alignment Location Considerations

There are several potential alignment locations between the two termini of the study area. To develop alignment options, the AGS Study Team took the following into consideration.

3.1.1 Technologies

Based on the results of the technology evaluations presented in Chapter 2, initial alignment design focused on the three technology groups that were either commercially available or were well along in development. The three technology groups below also represent other technologies through speed characteristics, and grade climbing capability, as explained later in this chapter.

- 120 mph Maglev – American Maglev or General Atomics
- High Speed Maglev – Transrapid
- High Speed Rail – Talgo

3.1.2 Station Locations

To determine potential alignments for the AGS, the AGS Study Team first determined where stations could plausibly be located. Stations would provide the sole point of access to the AGS and would need to be located where they could best serve the demand and attract passengers who normally would use the I-70 Mountain Corridor.

Three main factors had a bearing on the possible station locations: geography, economics, and station spacing.

Geography – Any alignment needed to consider the physical location of the possible destinations and the actual terrain to be navigated. This was of particular importance in Summit County, where the crossing of the Continental Divide and steep grades determined where it made the most sense to locate the AGS alignment and, therefore, where any stations might be located along that alignment.

Economics – Economics were considered in terms of the cost of construction, but more importantly in terms of future revenues and operating costs. Any possible AGS alignment was intended to serve the maximum number of passengers, and the stations would need to be located where they could achieve this goal. The better locations in terms of economics would:

- Generate more revenue, i.e., sales or property taxes, which would greatly contribute to the financial viability of the AGS.
- Minimize environmental impacts, which would lower project costs.
- Provide badly needed relief for congestion on I-70, particularly on weekends.
- Allow passengers to more quickly arrive at their destinations and enjoy those amenities, thereby adding to the appeal (and likely use) of the AGS.

Spacing between stations – This issue would likely impact the overall capacity of a high-speed corridor. Stations spaced too closely could artificially limit the maximum operating speed of a vehicle consist; and a vehicle may not have enough distance to accelerate to and decelerate from the speed at which it is capable of operating. Conversely, stations spaced too far apart would mean fewer stations along the alignment. This could limit ridership numbers for two reasons. First, fewer stations would reduce the number of possible destinations and reasons to use the AGS. Secondly, with fewer locations to board the AGS, each vehicle consist would need to be larger/longer to carry more passengers.

Based on these main considerations and the I-70 Coalition's 2009 *Land Use Planning Study for Rail Transit Alignment throughout the I-70 Corridor*, the AGS Study Team and PLT generated a list of locations where a station seemed plausible and also had local support:

- Eagle County Regional Airport
- Town of Eagle
- Wolcott
- Avon
- Vail
- Copper Mountain
- Breckenridge
- South Dillon Lake
- Frisco
- Lake Hill (Between Frisco and Silverthorne)
- Silverthorne
- Keystone
- Loveland Ski Basin
- Silver Plume
- Georgetown
- Idaho Springs
- El Rancho/I-70 Evergreen Interchange
- I-70/C-470 in Golden

Additional factors in determining plausible station locations included:

- Desire for the most cost-efficient design in light of the stated goals for the AGS system.
- Various technology types and their design parameters, based on the information provided by technology providers.
- Input of local communities.
- Impacts to cost and the environment.

One area along the potential alignments presented a unique set of challenges. In Summit County, all alignments originally roughly paralleled the I-70 Mountain Corridor, passing north of the Dillon Reservoir and through the Silverthorne area. However, the likely generators of revenue and ridership for the AGS in this area are located south of I-70, particularly the ski areas in and around Breckenridge and Keystone. The AGS Study Team discussed how to best serve this area and had broad agreement on several items:

- No one alignment would to be able to serve all the locations in Summit County.
- Connecting bus services transport passengers to a wider geographical area. However, considering ridership appeal and environmental impacts, it was best to avoid relying on supplemental transportation and transfers wherever possible. A station in Silverthorne, Frisco, or any location on the north side of the Dillon Reservoir would have a greater need for a connecting bus service.
- I-70 passes through Silverthorne largely because of the location of the Eisenhower-Johnson Memorial Tunnel (EJMT). Because the AGS would require its own tunnel under the Continental Divide, it would be worth considering alternate tunnel locations if they resulted in an alignment more likely to directly serve a greater ridership volume to and from Summit County.

As a result of these discussions and as each technology type permitted, the AGS Study Team rerouted some of the preliminary alignments south of Dillon Reservoir.

3.1.3 Alignments

The AGS Study Team identified four alignments that could be used by one or more of the feasible technologies. They were:

- **I-70 Alignment** – This alignment stays strictly within the I-70 right-of-way and has an anticipated lower operating speed of between 85 and 120 mph. The sharper curves and steeper grades of this alignment limit the number of technologies that could operate along it. Medium speed maglev is representative of a group of technologies with these speed & grade climbing characteristics.
- **Hybrid Alignment** – This alignment uses the I-70 right-of-way as much as possible, but deviates, as needed, to accommodate higher speeds or to lower design and construction costs. Like the I-70 alignment, capabilities to handle steep grades are required for this alignment. It is anticipated to run at a speed of about 120 mph, which could accommodate several technology types, including medium-speed and high-speed maglev, among others.
- **High Speed Maglev Alignment** – This alignment is largely independent of I-70 right-of-way. Like the I-70 and Hybrid alignments, capabilities to handle steep grades are required for this alignment. It would run at a speed of approximately 200 mph and could accommodate a variety of technologies, including high-speed maglev.

- **High Speed Rail Alignment** – This alignment would be outside the I-70 right-of-way. It would use high-speed steel wheel on rail and would operate at a speed of approximately 200 to 220 mph. Because it has gentle grades, it could accommodate any technology, including maglev.

Each alignment had its own set of design criteria, based upon the technology type being considered for the alignment. The horizontal and vertical geometry and grade limitations of the I-70 Mountain Corridor had a great impact on where the alignments were located.

The AGS Study Team paired the three technologies with alignments, as follows:

- I-70 Alignment with 120 mph Maglev vehicles (I-70 Alignment)
- Hybrid Alignment with 120 mph Maglev vehicles (Hybrid/120 mph Maglev)
- High Speed Maglev Alignment with High Speed Maglev vehicles (High Speed Maglev)
- High Speed Rail Alignment with High Speed Rail (High Speed Rail)

Table 3-1 summarizes the design criteria used for each alignment.

Table 3-1: Alignment Design Criteria

Parameter	I-70	Hybrid	High Speed Maglev	High Speed Rail
Acceleration	0.06g	0.06g	0.06g	0.06g
Deceleration	0.06g	0.06g	0.06g	0.06g
Headway Minimums	2 minutes	2 minutes	6 minutes	6 minutes
Height	33 ft.	33 ft.	33 ft.	33 ft.
Width	60 ft.	60 ft.	40 ft.	50 ft.
Minimum Vertical Radii	10,000 ft.	10,000 ft.	52,000 ft. (Crest) 26,000 ft. (Sag)	40,000 ft.
Maximum Sustained Grade	7%	7%	7%	3%
Minimum Horizontal Radii (Operating)	4,000 ft.	4,000 ft.	10,500 ft.	11,500 ft.
Minimum Tangent Between Reversing Curves	200 ft.	400 ft.	400 ft.	600 ft.
Maximum Operating Speed	120 mph	120 mph	200 mph	200 mph
Minimum Normal Span	88 ft.	88 ft.	100 ft.	Not applicable
Maximum Normal Span	162 ft.	162 ft.	210 ft.	Not applicable
Foundation Size (Diameter)	9 ft.	9 ft.	10 ft.	Not applicable
Minimum Station Footprint	54,000 sq. ft.	54,000 sq. ft.	54,000 sq. ft.	54,000 sq. ft.
Desired Station Footprint	100,000 sq. ft.	100,000 sq. ft.	100,000 sq. ft.	100,000 sq. ft.
Minimum Operations and Maintenance Facility Footprint	80,000 sq. ft.	80,000 sq. ft.	80,000 sq. ft.	80,000 sq. ft.
Minimum Substation Footprint	3,500 sq. ft.	3,500 sq. ft.	3,500 sq. ft.	3,500 sq. ft.

It should be noted that in the vicinity of stations, the design criteria were relaxed and allowed for much tighter horizontal and vertical curves than would otherwise be desired because the vehicles are traveling at a much lower speed at the approach and departure. Also, for the I-70 Alignment, the design criteria were held as much as possible, but overridden where necessary to keep the alignment within the I-70 right-of-way.

3.2 Alignment Descriptions and Analysis

3.2.1 I-70 Alignment

The I-70 Alignment in Figure 3-1 could be built and operated entirely within the I-70 right-of-way, with very limited exceptions at individual stations and at the east and west ends of the study area. It would likely use a medium-speed maglev technology or other emerging technology.

The I-70 Alignment begins at the Eagle County Regional Airport and immediately proceeds northeast, past the east end of the airport to the I-70 right-of-way and remains in the I-70 right-of-way through Eagle, Avon, Vail, Copper Mountain, Frisco, Silverthorne, Silver Plume, Georgetown, Idaho Springs, and to Golden. The I-70 Alignment would have two tunnels paralleling the existing tunnels on I-70: a 1.8-mile bore near EJMT, and an 800-foot bore near the Twin Tunnels east of Idaho Springs.

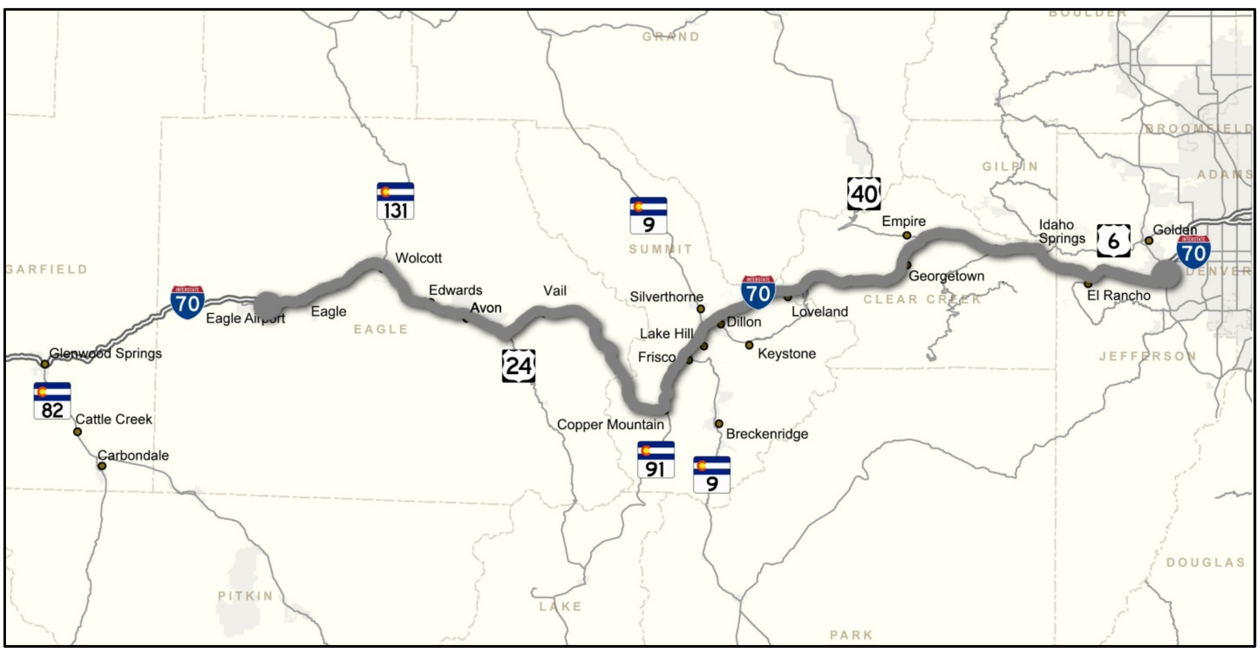


Figure 3-1: I-70 Alignment

The *I-70 Mountain Corridor Final Programmatic Environmental Impact Statement* had anticipated that the AGS would run down the center median of I-70; however, to decrease costs, improve constructability, and increase curve radii, the I-70 Alignment developed for this Study was typically located to one side of and parallel to the highway. Keeping the alignment off the I-70 median was easier for station access.

Avoiding the median also helps limit the number of highly skewed crossings of I-70 along the alignment. While not completely avoidable, these crossings are undesirable because they typically require straddle bents. Straddle bents are supports for a bridge skewed at a very acute angle across one or both directions of I-70 and require bridge piers on both sides of the highway. Straddle bents are costly to build and are aesthetically unpleasing. Further, they are detrimental from the standpoint of driver expectancy, particularly in rural environments, at night, or in inclement weather, all of which could happen together on I-70. These overhead crossings appear very suddenly in the driver's field of view, causing momentary distraction, at best, or an overreaction by the vehicle operator, at worst.

Possible station locations along the I-70 Alignment were:

- Eagle County Regional Airport
- Avon
- Vail
- Copper Mountain
- Silverthorne or Lake Hill
- Georgetown or Idaho Springs
- Golden/Jefferson County

Station locations off of I-70 could potentially be reached by supplementary services or by adding spur track/guideway to the overall system.

I-70 Alignment Analysis

There are numerous locations along the I-70 Alignment where the minimum horizontal radius design criteria of 4,000 feet would not be possible within the I-70 right-of-way. One of the 120 mph maglev technology providers pointed out that horizontal curves under 4,000 feet would limit how fast the AGS would be able to travel. The sharper curves would result in an average speed of approximately 45 mph when station dwell time was included. This low operating speed would mean the travel times would be longer than those of vehicles currently using I-70. Despite its anticipated lower cost compared to the other three alignments, because of this limitation, the AGS Study Team decided the I-70 Alignment would not be a feasible alternative.

Even with pod-based/PRT technologies and/or with all off-line stations, the best this alignment could do would be to match the speed of existing autos during uncongested travel along I-70. Costs would increase to provide all off-line stations and/or to extend the system network length to achieve the auto-competitive travel times proposed by pod-based/PRT technologies.

For these reasons, the I-70 Alignment was not carried forward for further consideration, nor were costs estimated for it. The Hybrid Alignment became the lower-bound alignment representing lowest cost, medium speed, grade-capable technologies.

3.2.2 Hybrid Alignment

The Hybrid Alignment illustrated in Figure 3-2 would use the I-70 right-of-way as much as possible, but would leave the right-of-way where necessary to increase curve radii to accommodate higher speeds. It would leave I-70 at Copper Mountain and proceed under the Ten-Mile Range in a tunnel to Breckenridge. It would then cross to Keystone where it would parallel US 6 to the Arapahoe Basin Ski Area, cross under Grizzly Peak, and then follow the alignment of Grizzly Gulch Road and Stevens Gulch Road back to I-70 just east of the Bakersville interchange.

The Hybrid Alignment is assumed to have stations at:

- Eagle County Regional Airport
- Avon
- Vail
- Copper Mountain
- Breckenridge
- Keystone
- Idaho Springs
- Golden/Jefferson County

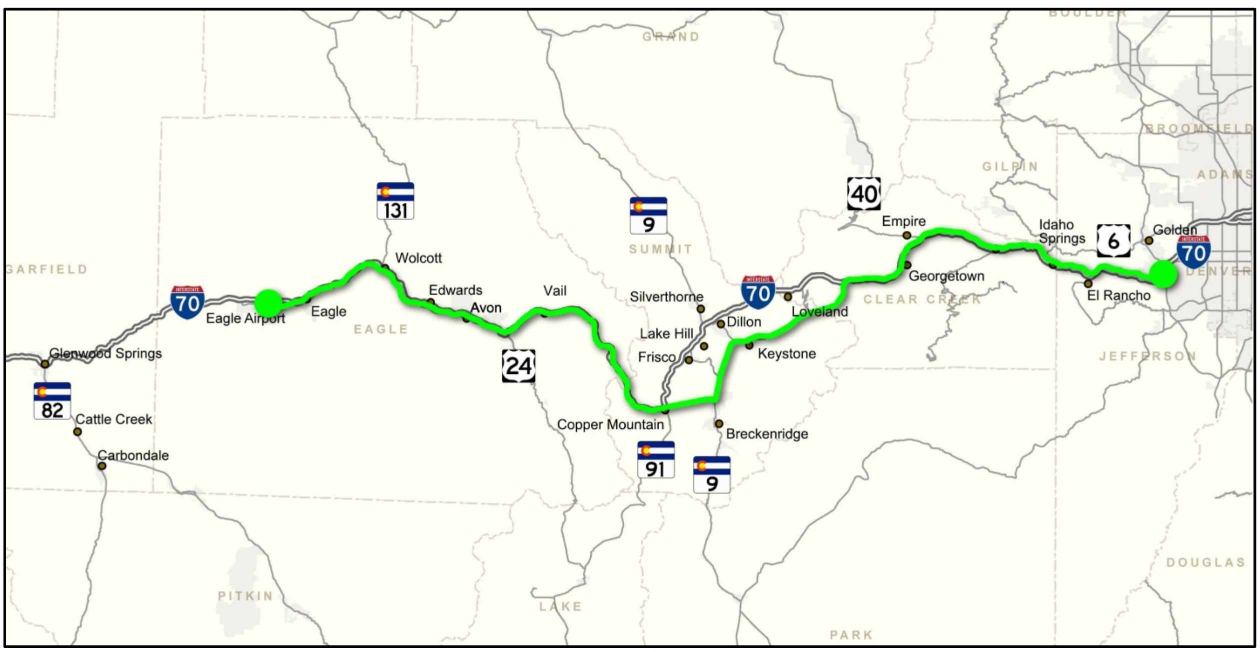


Figure 3-2: Hybrid Alignment

Hybrid Alignment Analysis

The Hybrid Alignment operates at lower speeds (maximum 120 mph) than the High Speed Maglev or High Speed Rail Alignments. This offers several advantages. The geometric design criteria are significantly more forgiving than those of the High Speed Maglev or High Speed Rail Alignments and, therefore, require fewer tunnels. It is inherently the most flexible in terms of being able to fit the land or be directed to a specific area. Although it is the longest alignment, it is significantly less costly to build because of fewer tunnels.

The AGS PLT asked the design team if it were possible to use the Hybrid Alignment with high-speed maglev technology. The design team determined that the high-speed maglev technology could run on the Hybrid Alignment, and would bring the cost for high-speed maglev technology closer to the Hybrid Alignment cost. However, it would force the high-speed maglev to run at a much lower speed than it was designed for, likely close to 120 mph. More information on the Hybrid Alignment/high-speed maglev technology combination is presented in Chapter 4.

3.2.3 High Speed Maglev Alignment

The High Speed Maglev Alignment illustrated in Figure 3-3 generally follows I-70, but is mostly outside the I-70 right-of-way. Like the Hybrid Alignment, it leaves I-70 to reach the stations in Breckenridge and Keystone and rejoins I-70 near the Loveland Ski Area. The alignment would operate at a maximum speed close to 200 mph and must be straighter to accommodate these higher speeds.

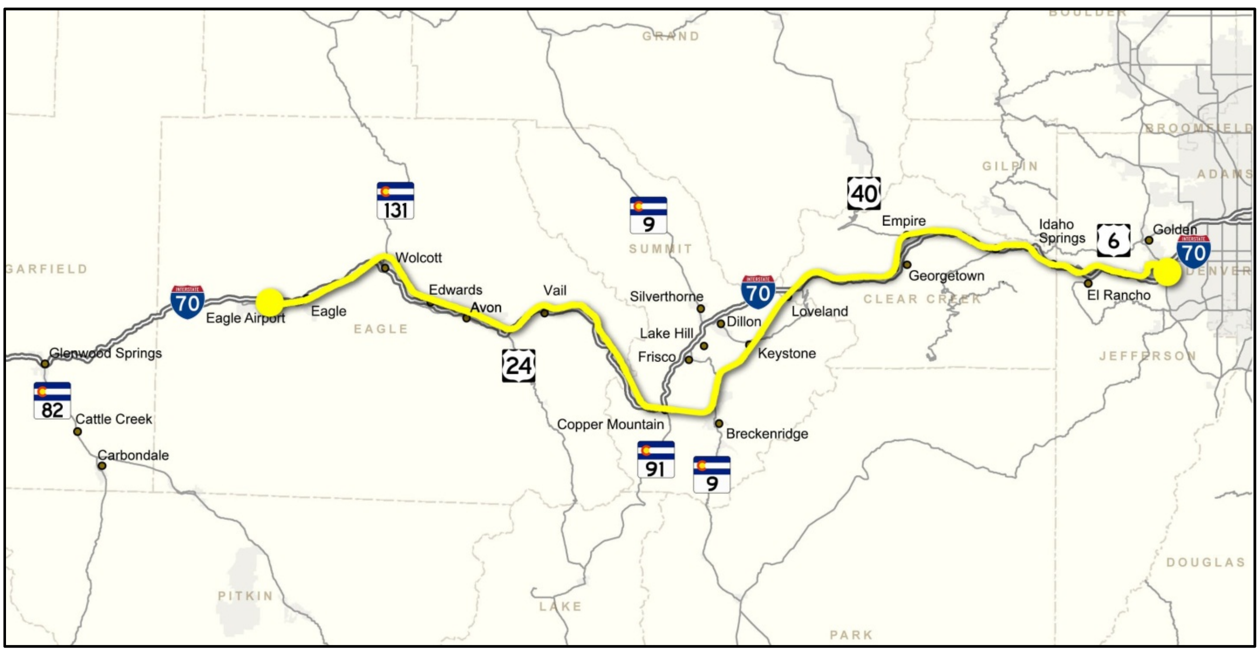


Figure 3-3: High Speed Maglev Alignment

The High Speed Maglev Alignment is assumed to have stations at:

- Eagle County Regional Airport
- Avon
- Vail
- Breckenridge
- Keystone
- Idaho Springs
- Golden/Jefferson County

High Speed Maglev Alignment Analysis

The High Speed Maglev Alignment strikes a balance in terms of costs between the Hybrid Alignment and the High Speed Rail Alignment. High-speed maglev technology can match or exceed the speed of high-speed rail, and unlike high-speed rail, has some flexibility with regard to grade. Compared to the Hybrid Alignment, the High Speed Maglev Alignment requires fewer straddle bent crossings as it does not cross I-70 as often. It also avoids the Clear Creek Canyon area.

The High Speed Maglev Alignment has significantly higher costs than the Hybrid Alignment. To accommodate the higher speeds, very flat horizontal and vertical curve radii are required. This geometry, combined with the high relief and steep grades of the I-70 Mountain Corridor, results in needing many more miles of tunnel compared to the Hybrid Alignment at a correspondingly higher cost.

3.2.4 High Speed Rail Alignment

An alignment utilizing High Speed Rail technology is illustrated in Figure 3-4, and would operate at a maximum speed close to 200 mph. Similar to the High Speed Maglev Alignment, the High Speed Rail Alignment has much stricter geometric requirements because of its anticipated operating speed. Because the maximum grade for high-speed rail is 3 percent, it requires a significant number of tunnels to maintain the desired speeds, some of them quite long. The High Speed Rail Alignment diverges the most from I-70, including a long tunnel to avoid the grades at Vail Pass that cuts off Copper Mountain from the alignment and routing in the general vicinity of Clear Creek/US 6 from the base of Floyd Hill to Golden. It includes a spur from the Frisco/Silverthorne area to Breckenridge.

The High Speed Rail Alignment uses a proven technology on the shortest of all the alignment alternatives. It also requires the fewest straddle bent crossings of I-70 compared to any other alignment. The alignment operates at a maximum speed close to 200 mph and must be flatter and straighter to accommodate these higher speeds.

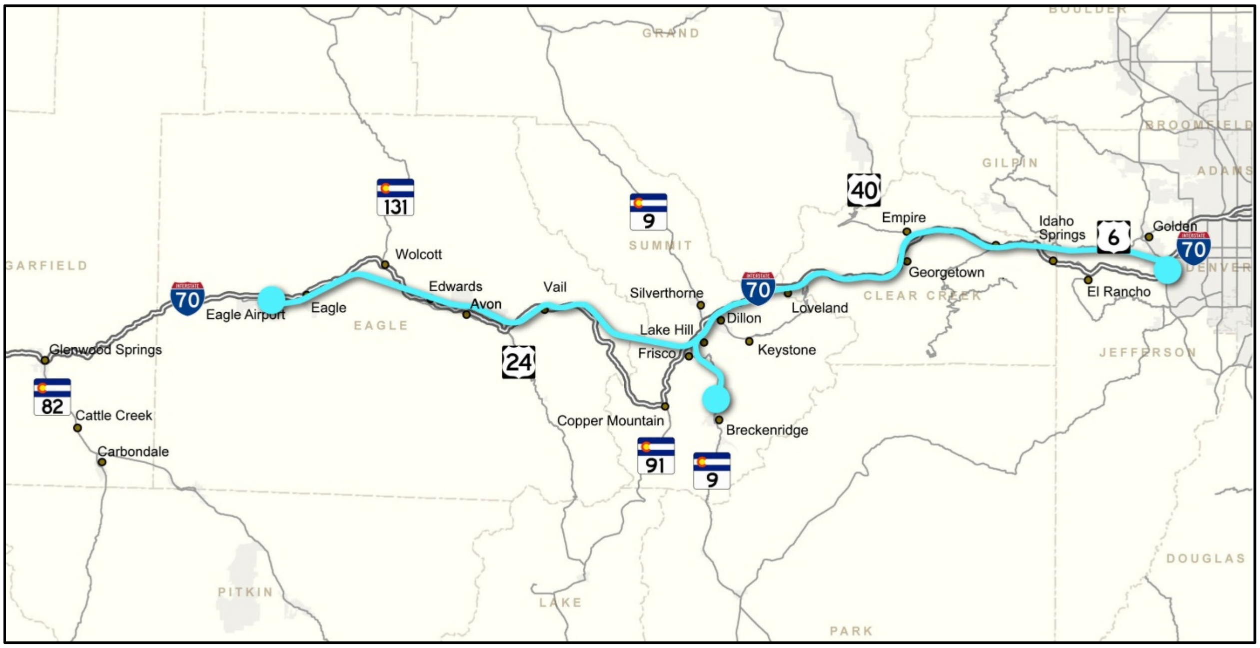


Figure 3-4: High Speed Rail Alignment

The High Speed Rail Alignment is assumed to have stations at:

- Eagle County Regional Airport
- Vail
- Lake Hill (between Frisco and Silverthorne)
- Breckenridge (via spur from Lake Hill station)
- Georgetown or Idaho Springs
- Golden/Jefferson County

High Speed Rail Alignment Analysis

High-speed rail is limited by grade; it can climb at a rate less than half that of maglev. Because Floyd Hill is too steep for high-speed rail, this alignment must run parallel to the Clear Creek Canyon area. This grade restriction results in the need for many tunnels. It should be noted that the numerous tunnels would be connected by short bridges; therefore, keeping the alignment off the Clear Creek Canyon valley floor. Because of the high number of tunnels, the High Speed Rail Alignment is the most expensive alternative.

The grades over Vail Pass are too steep for high-speed rail to connect directly from Breckenridge to Vail. Constructing another tunnel some 20 miles long is an undesirable, expensive solution. Therefore, this alignment includes a spur line to service Breckenridge, which would result in a longer travel time than a direct connection.

3.2.5 Alignment Summary

The metrics for the three feasible alignments are summarized in Table 3-2.

Table 3-2: Alignment Metrics

Alignment	System Length (ft.)	System Length (mi.)	Tunnel Length (mi.)	Tunnel Length as % of Total Length
Hybrid	636,401	120.5	15.7	13%
High Speed Maglev	625,538	118.5	40.1	34%
High Speed Rail	575,097	108.9	65.0	60%

3.3 Station Sites

To determine specific station sites along each of the alignment options, the next phase of work involved working with the Counties. Several station sites were considered in each County and weighed against comprehensive evaluation criteria. Each County's station preferences were combined with alignment options and technology to determine how technology choice and performance matched up with the station site. The process used to coordinate with the Counties is described in Chapter 8.

Each County began its discussion with a range of possible station sites described below:

Jefferson County – I-70 and 6th Avenue triangle near current big box development of office park; just south of I-70 at current Colorado Mills site; along I-70 at Morrison in currently undeveloped land; just west of I-70 at SH 58 in undeveloped land.

Clear Creek County – Idaho Springs at the current baseball field; Idaho Springs Argo Mine site; Idaho Springs football field; Downieville; Dumont; Empire Junction both north and south of I-70; Georgetown at the undeveloped land adjacent to the lake; and Loveland Ski area.

Summit County – Silverthorne south of the interchange fitting with alignments; Frisco along SH 9 south of the interchange; Keystone adjacent to River Run parking lot; the south end of Dillon Reservoir adjacent to SH 9 heading into Breckenridge; in north Breckenridge undeveloped area west of SH 9; near the Breckenridge Central Business District; and Copper Mountain adjacent to I-70 at the foot of the mountain.

Eagle County – Vail in the Central Valley; Vail at Timber Ridge; Avon at Traer Creek undeveloped land just south of I-70; Edwards just south of the I-70 interchange and Eagle County Regional Airport.

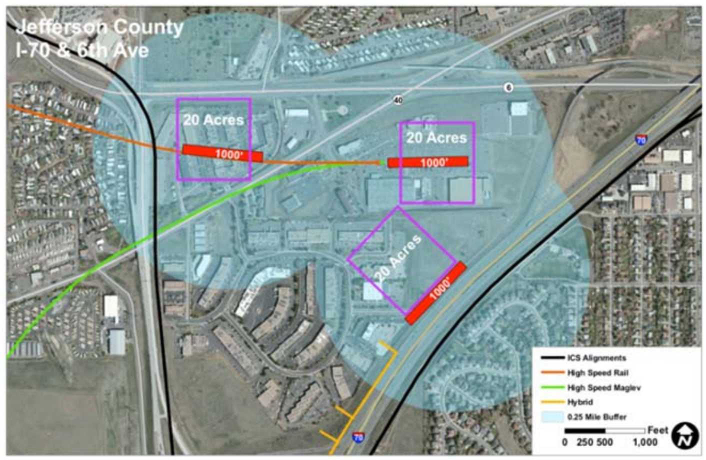
Station sites sized 10 to 20 acres were laid into mapping at each station location, along with alignment options through that location. Initial impressions of the feasibility of each site were supplemented with a review of evaluation criteria and associated findings. The major categories of evaluation criteria considered or analyzed by each County and the AGS Study Team are described in the following sections.

3.3.1 Land Use / Developability

This category included such factors as:

- Availability of land for both the station and surrounding supporting development.
- Location of that land relative to serving local population, visitors, and employees.
- Infrastructure capacity of the site in support of future station and development.
- Compatibility of the location with local land use plans and local mountain or historic character.

The ability to support development around the station is not only good for the local economy but is often a funding mechanism for the development of the station, and it contributes to the greater value of the system to the region and to the state. The available development acreage or infill was evaluated at priority locations in each County to determine if the sites were suitable for further consideration. In some of the priority locations, a high-level value was estimated based on the methodology derived in the *Interregional Connectivity Study*, representing a composite square footage value from sample Denver metropolitan area developments and conservative density assumptions. An example priority station site, potential future AGS station siting, and an estimated value of redevelopment of the surrounding property is shown in Figure 3-5.



Potential West Suburban station location in Jefferson County: Assumption of 60 acres of available infill development at 35% developable area and a Floor Area Ratio (FAR) of 3 would mean over 5 million square feet of development valued at over $900 million. FAR is the ratio of a building's total floor area (gross floor area) to the size of the piece of land upon which it is built.

Figure 3-5: Example Priority Station Site

3.3.2 Transportation Access and Capacity

This category included such factors as:

- Existing infrastructure capacity and local roadway access.
- Ability to provide for infrastructure improvements to support increased travel demand.
- Regional access to the location.
- Ease of use by regional market.

3.3.3 Transit Distribution

This category included such factors as:

- Transit travel time to local activity centers or resorts from the station location.
- The directness of travel from that location to surrounding destinations once the passenger had arrived or was making a return trip.

A transit system assessment was mapped for priority locations indicating the travel time to adjacent towns or resorts—10 minutes, 20 minutes, 25 minutes, 50 minutes, and over 60 minutes. This assessment illustrated that a central location within each county typically provided a more equitable transit distribution network and the least out-of-direction travel for most of the passengers.

Transit connectivity options for Clear Creek, Summit, and Eagle Counties are shown in Figure 3-6, Figure 3-7, and Figure 3-8. No transit connectivity analysis was done for Jefferson County because it is already served by the Regional Transportation District (RTD) with buses and the recently completed FasTracks West Line light rail.

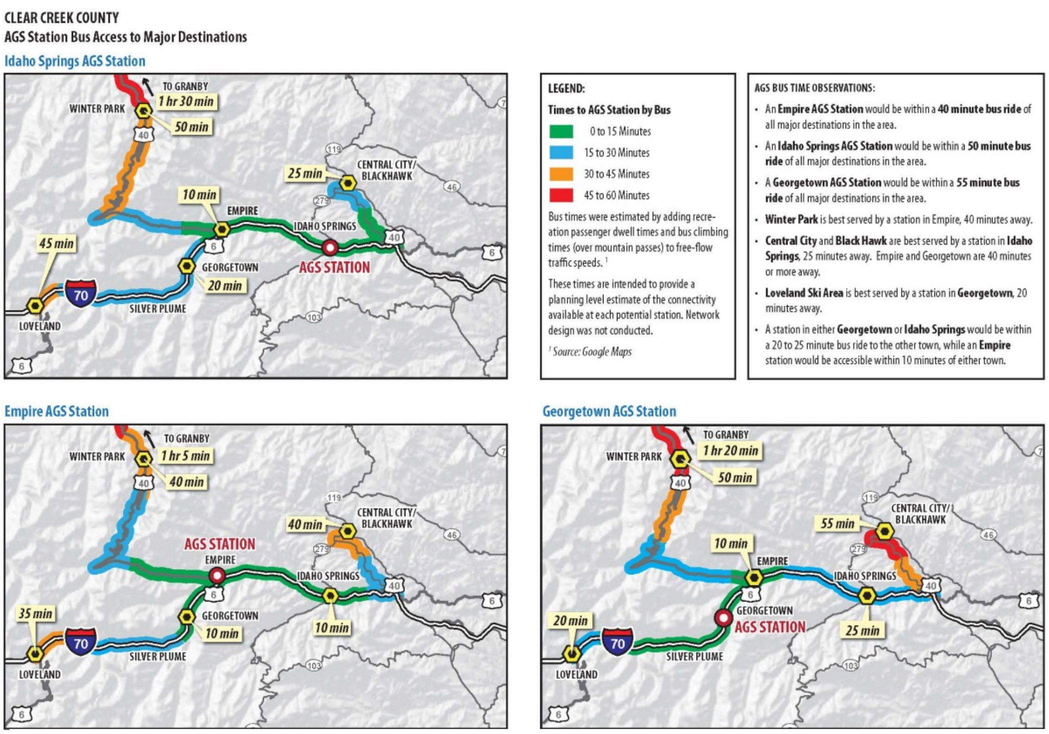


Figure 3-6: Transit Connectivity Options – Clear Creek County

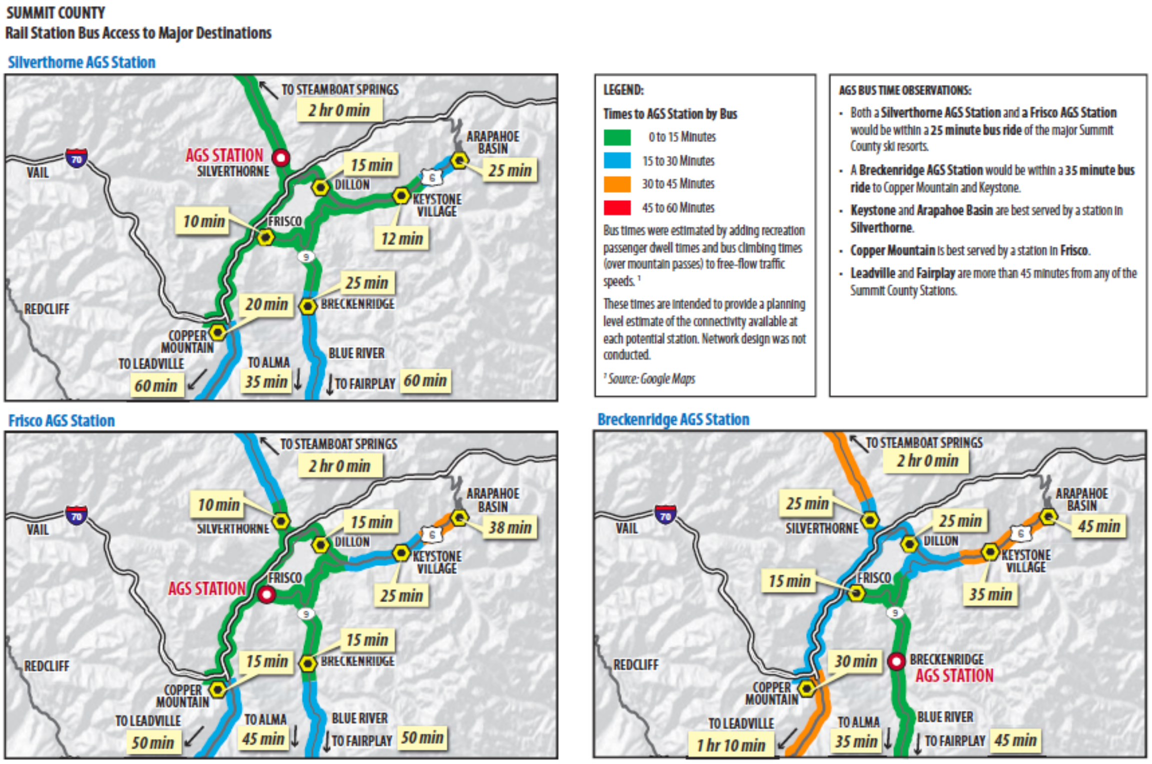


Figure 3-7: Transit Connectivity Options – Summit County

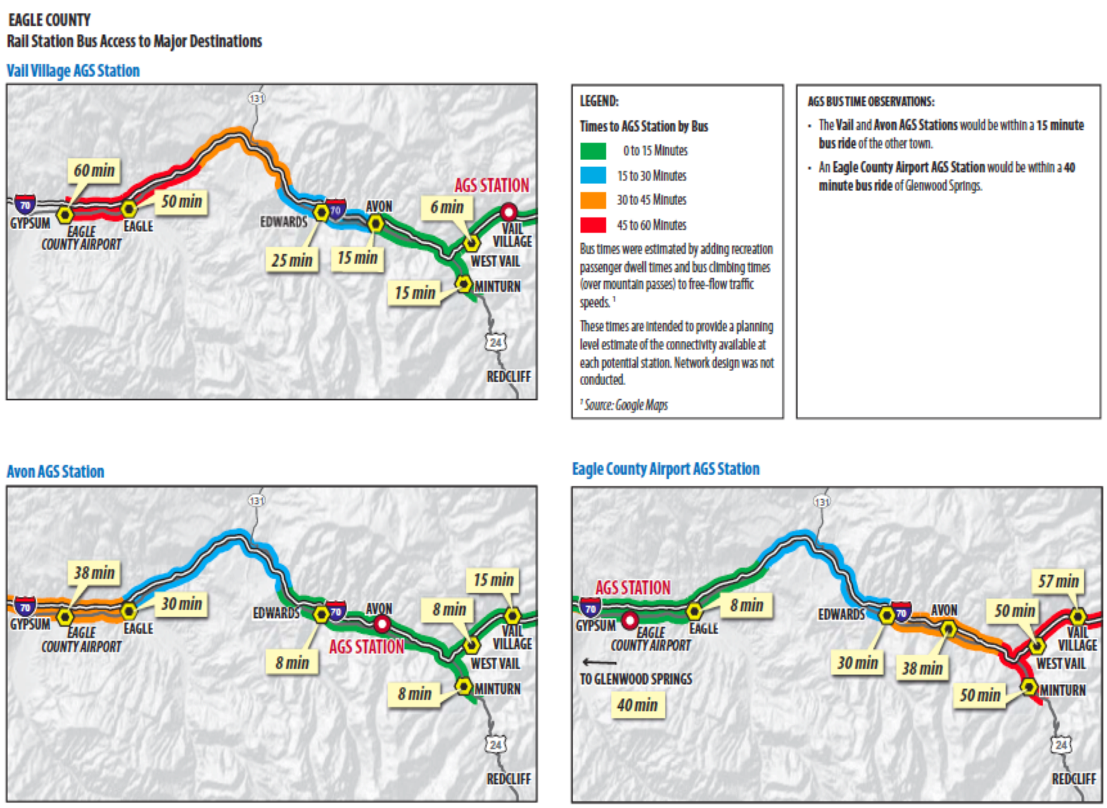


Figure 3-8: Transit Connectivity Options – Eagle County

3.3.4 Community and Regional Support

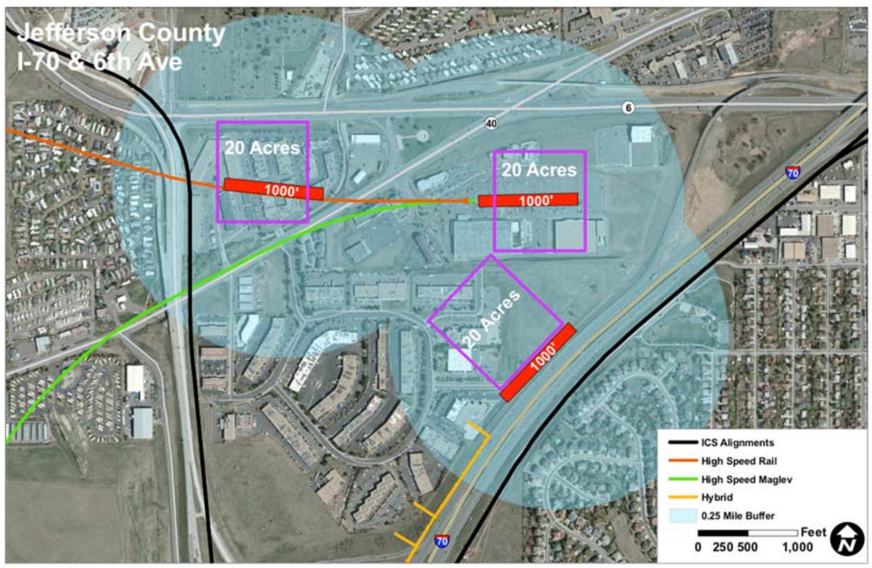
Input for this evaluation category came from County representatives. This category included such factors as:

- The likelihood of community and political support for the location.
- Any environmental red flags that might make that support difficult.

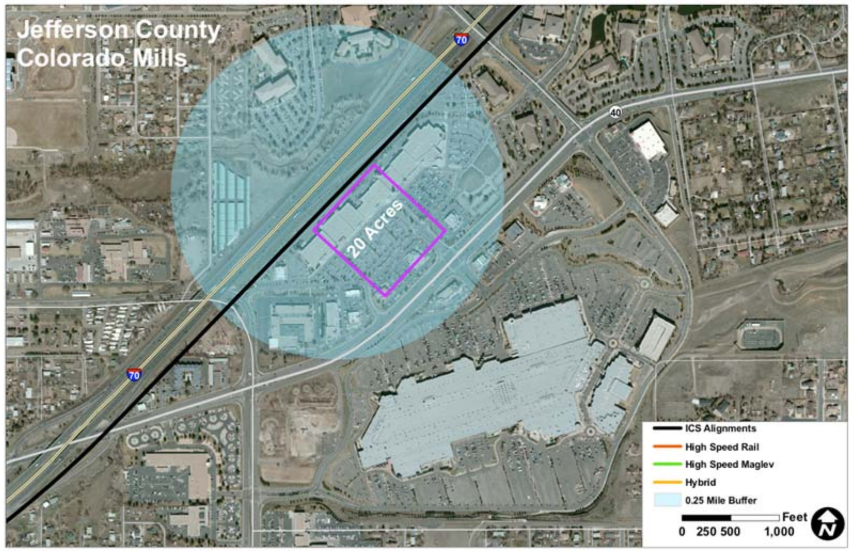
3.4 Priority Station Sites

Based on the evaluation of the sites initially presented by the Counties, priority station sites for each County were identified and are presented in the following sections. These priority station sites were later compared to alignment options with the greatest performance and ridership estimation results for those alignment/station alternatives.

3.4.1 Jefferson County



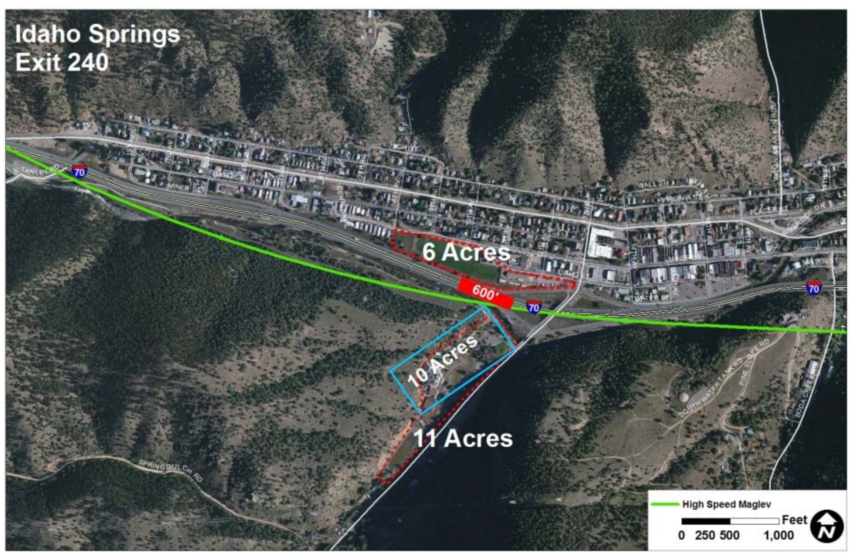
The location at I-70 and 6th Avenue offers significant potential for redevelopment and infill for Golden and Jefferson County, is consistent with local land use plans allowing for a mix of uses and higher densities, and can be supported locally. The site is sufficient in size to meet potential sizing requirements of the I–70/C-470 station as a regional collector station in the AGS and *Interregional Connectivity Study* System. Regional highway access and local circulation improvements would be needed to increase access to the site. Consideration of pedestrian or transit linkages to the RTD West Line station at Jefferson County would also be critical to enabling transfers between the two systems.



The Colorado Mills site, south of I-70, remains a possible location for Jefferson County, offering redevelopment potential and consistency with existing land use plans, much the same as the other site. This site has better vehicular access, however, from the Denver West/I-70 interchange, the Colfax/I-70 Interchange, and local circulation along Colfax Avenue directly to the site from either access point. Easy linkages between the West Suburban station and RTD's West Line station at Jefferson County would not be possible.

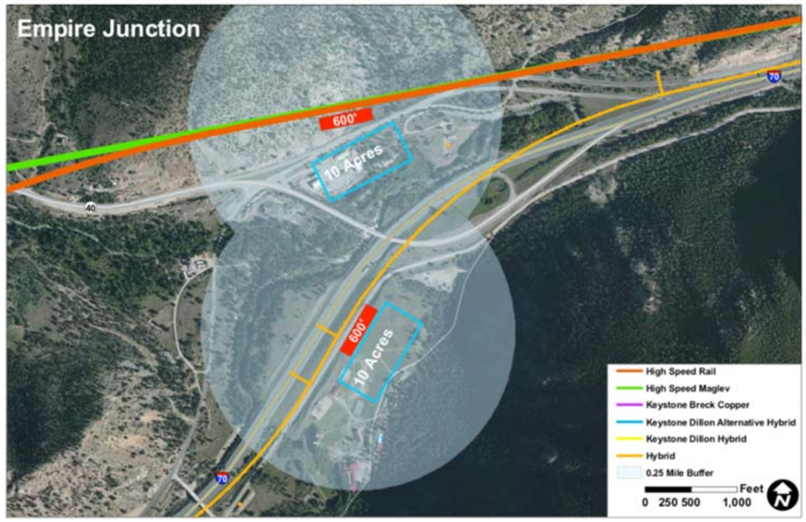
3.4.2 Clear Creek County

There are three priority sites in Clear Creek County, and the communities would need to weigh in on these locations prior to final decision-making. They are the Idaho Springs Exit 240 location, Empire Junction, and Georgetown Lake.

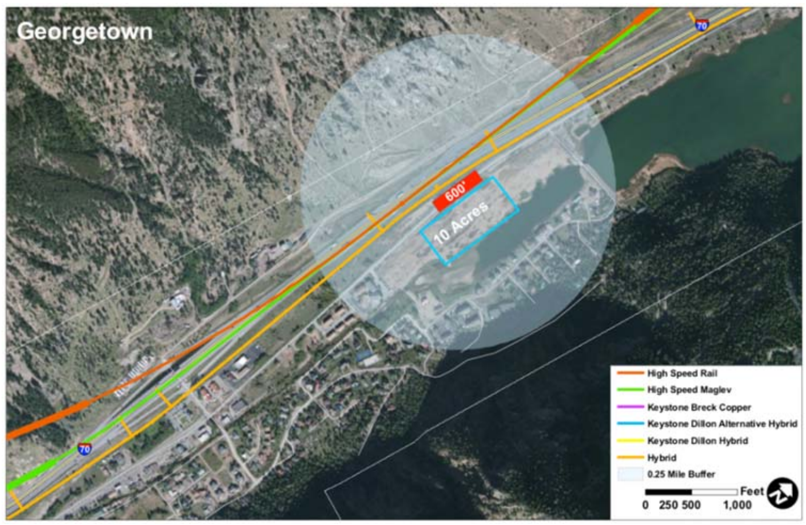


The Idaho Springs Exit 240 location is centrally located within Idaho Springs and adjacent, but not within, the historic downtown. This means the setting offers the appropriate community context and protection of the historic character downtown. This location supports visitors and residents alike and allows for residential infill development for the anticipated increase in commuter population in Idaho Springs. The site is accessible from the interchange at I-70; local traffic circulation in place today would potentially require capacity modifications. Transit distribution is longer to neighboring destinations from an Idaho Springs location than the other two priority locations, including Winter Park and Grand County.

The Empire Junction location offers easy regional and local access and is situated well to act as a transit distribution system transfer point to Winter Park and Grand County. While there is likely room to accommodate a station, surrounding land use development is limited by availability and topography. This factor would need further evaluation and community buy-in because development may be important to support the funding for the station.

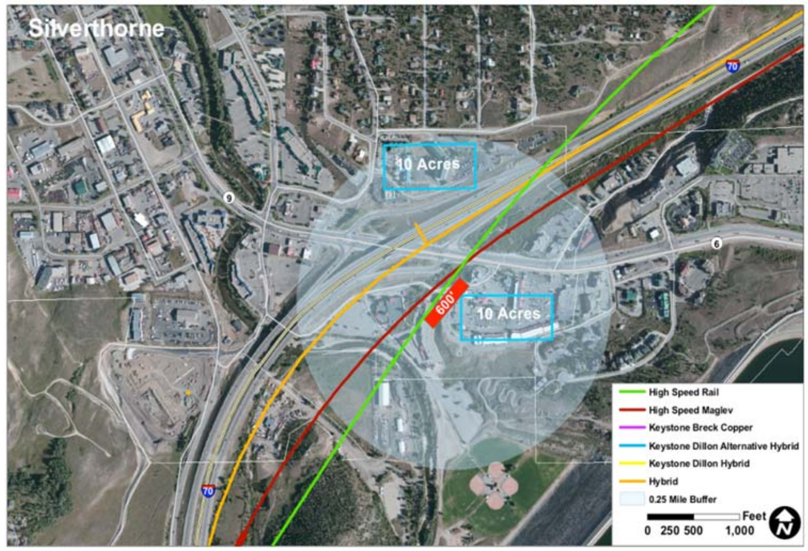


Georgetown Lake offers similar opportunities for infill development and town support as Idaho Springs. It is regionally accessible by the I-70/ Georgetown interchange. Local roadway capacity improvements would be needed to support new development and station needs adjacent to the lake. This location requires the most out-of-direction travel for transit connections back to Clear Creek County communities or Winter Park and Grand County.

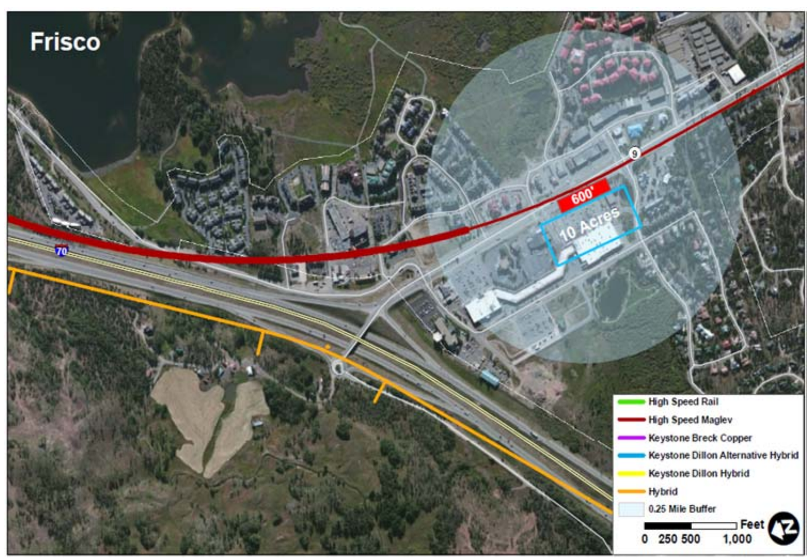


3.4.3 Summit County

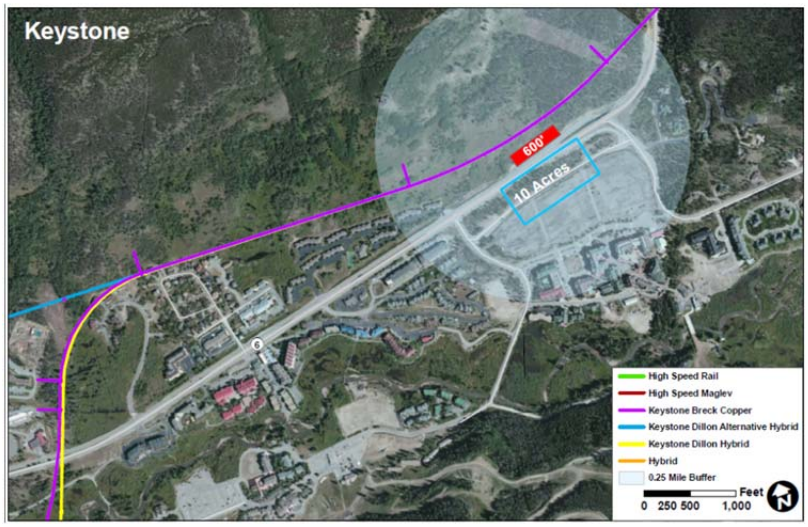
Summit County priority station sites are identified, but the County has retained options that will depend on final technology and alignment decisions and associated ridership.



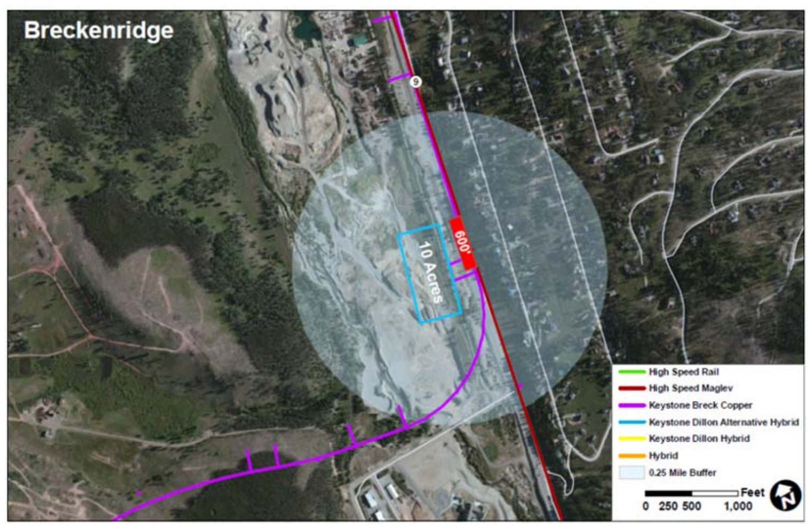
The land surrounding the Silverthorne interchange is currently outlet mall shopping and has the opportunity for higher-density redevelopment and infill consistent with Silverthorne's land use plans. The acreage available would enable station operations, a significant Summit County transit distribution operation, and regional access and local traffic circulation along US 6. Development opportunities appear to be highest in Summit County at this site. Transit travel times for passengers to Summit County resort destinations are the longest from this location, but somewhat shorter for residents in Silverthorne, Dillon, and Frisco. All technologies could reach a station in Silverthorne. However, only the High Speed Rail Alignment is currently situated to have a Silverthorne station.



Adequate land is available within the Town of Frisco at the north Frisco location. The location is accessed easily from the I-70/Frisco interchange, and SH 9 provides good local circulation. Redevelopment and infill would be consistent with local land use plans, and the site is supportive of a transit distribution network (currently served by Summit Stage and Greyhound at the Transit Center). Transit travel times to Copper Mountain and Breckenridge would be shorter than from Silverthorne, and it would be out of direction and somewhat longer back to Keystone and Arapahoe Basin. All technologies could reach a station in Frisco. However, only the High Speed Rail Alignment currently is situated to have a Frisco station.



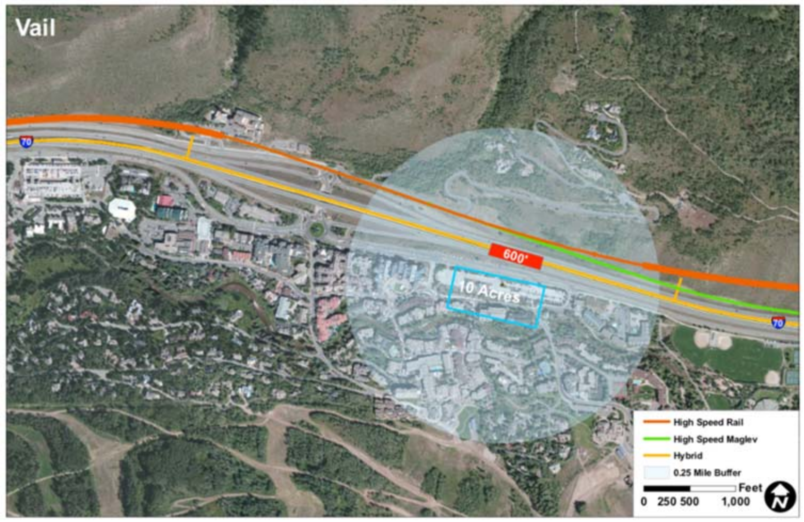
A combination of stations in Keystone and north Breckenridge is proposed to bring AGS further back into Summit County and more directly serve the resort communities. The most ideal location at Keystone would be within the River Run neighborhood in the location of the existing 18-acre parking lot. Additional high-density development in the area would be consistent with current land use patterns and land use plans. Vehicular access is limited to local circulation along US 6, and transit distribution to other Summit County communities would likely be to Dillon and Silverthorne. The High Speed Maglev and Hybrid/120 mph Maglev Alignments can both reach a Keystone station.



The north Breckenridge site located at SH 9 and Coyne Valley Road also works with an alignment that brings AGS further back into Summit County. This location is accessible by SH 9 and fairly far removed from surrounding Summit County communities. Infill development at this site would be consistent with local land use plans and support existing densities and transit systems in Breckenridge. Transit distribution from this location would likely serve Frisco and Copper Mountain. The High Speed Maglev and Hybrid/120 mph Maglev Alignments can reach the Breckenridge station via an on-line station. The High Speed Rail Alignment would reach Breckenridge via a spur coming off the mainline track in the Frisco area.

3.4.4 Eagle County

Eagle County has identified three sites that serve the resort communities of Vail and Avon and an end-of-the line station at Eagle County Regional Airport. This number of stations exceeds what was originally assumed in Eagle County, but until implementation phasing and operations are further refined, all three locations are considered priority stations.



The Vail station is preferred to be located within the highway right-of-way with supporting development and connected to a transit distribution system located just south of I-70 within the existing Town of Vail development. The current land use densities and destination activities provide a strong land use pattern for this station. Access from I-70, local circulation along the frontage road, and transit operations are supportive of good access and distribution for this station.

The Traer Creek site was proposed specifically by the Town of Avon. The site is linked by an extension of the local roadway network, and regional access is available from I-70. The site can support significant development densities and mix of uses consistent with local land use plans and supportive of station activities. Transit operations would link residents, employees, and visitors with resort destinations at Beaver Creek and Vail.

Eagle County Regional Airport is proposed to be the end-of-the line station. There is strong support from Airport management to locate the AGS station within Airport property, which is consistent with Airport redevelopment plans. Close proximity of the station would enable an easy transfer from the terminal to the AGS platform for visitors to the area.

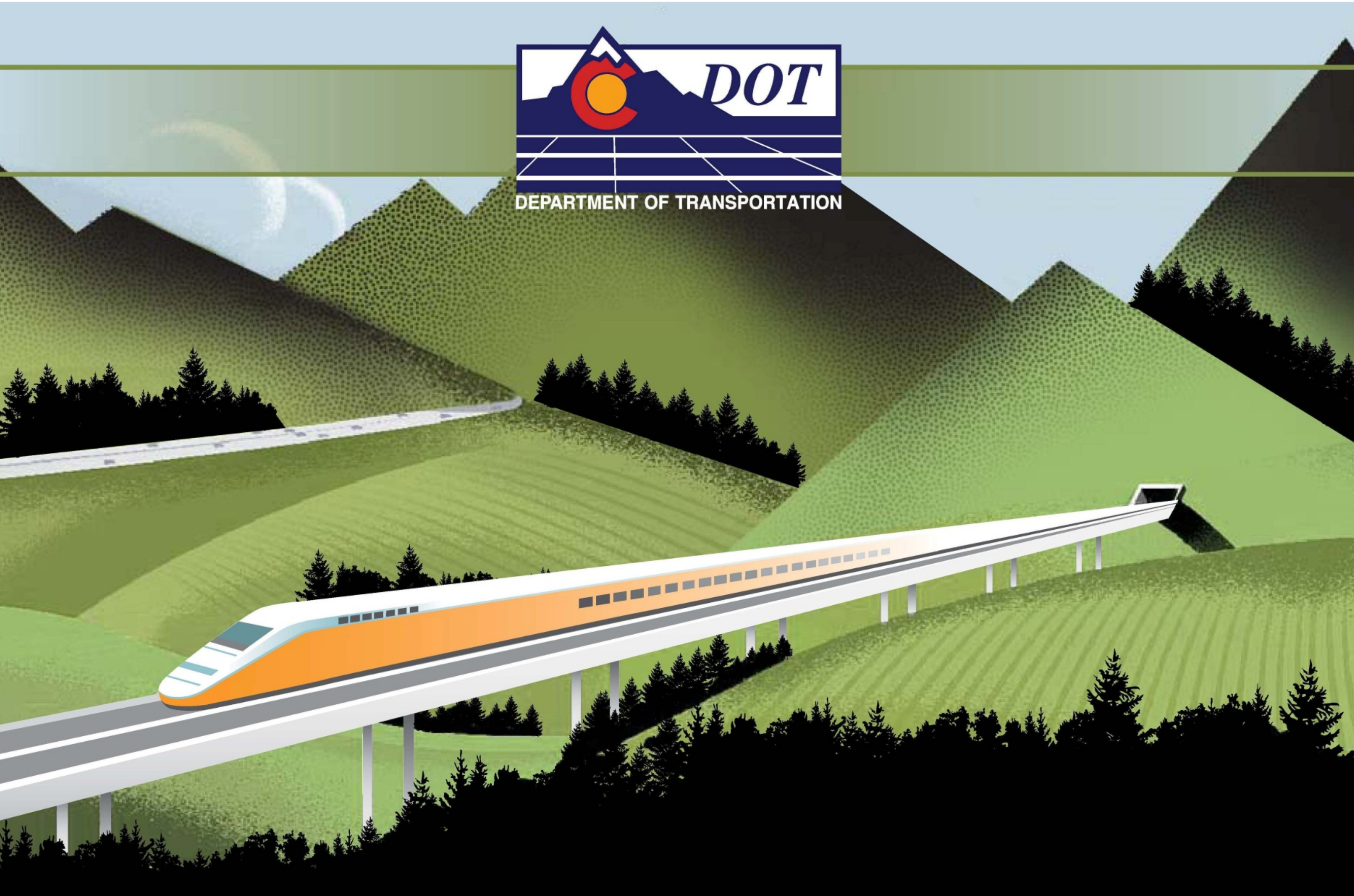
3.5 Conclusion

The AGS Study Team developed three viable alignment options for the AGS—the Hybrid Alignment, High Speed Maglev Alignment, and High Speed Rail Alignment. The I-70 Alignment is not viable for 120 mph Maglev, but could be viable for other technologies in the future.

The alignments were designed specifically for the three technologies being considered. 120 mph Maglev could use any of the three alignments (as could most of the other feasible technologies discussed in Chapter 2). High Speed Maglev could use either the alignment developed for it or the alignment developed for High Speed Rail. High Speed Rail can use only its specific alignment.

These alignments are preliminary in nature. Further refinement will be required in the future based on the current design standards associated with the technologies being considered.

A number of potential station sites were identified for each of the four counties along the AGS. It will be necessary to refine the alignment designs based on the final locations of the stations.



ADVANCED GUIDEWAY SYSTEM (AGS) FEASIBILITY STUDY

CHAPTER 4
COST ESTIMATION

Chapter 4 Cost Estimation

4.1 Introduction

The cost of the design and construction of the AGS is an important means of comparing alternatives and determining the affordability of the investment. This section describes the capital cost components and estimates for the four alignment/technology pairs operating on a Full System from Eagle County Regional Airport to I-70/C-470.

4.2 Overview

The AGS Study Team developed detailed costs for these four alignment/technology pairs:

- Hybrid Alignment with 120 mph Maglev
- Hybrid Alignment with High Speed Maglev
- High Speed Maglev Alignment
- High Speed Rail Alignment

Appendix D documents these estimates. Maps of these alignments can be found in Appendix E.

The cost estimates included direct costs (costs associated directly with building the capital infrastructure associated with the AGS) and indirect costs (contingencies, professional services, environmental mitigation, and utility relocations). Indirect costs are expressed as a percentage of the direct costs.

4.2.1 Direct Costs

Vehicles – The number of vehicles was estimated based on the operating scenario and round-trip time for technology and alignment, the 30-minute service headway, the capacity of the standard consist for the technology, and the peak passenger load.

- For the Hybrid/120 mph Maglev, the standard consist is a two-car "married pair." The total estimate for this technology is 18 pairs (or 36 total single vehicles), including spares.
- For High Speed Maglev, the standard consist is five cars coupled semi-permanently. Five High Speed Maglev consists were estimated.
- For High Speed Rail, high-speed trains are multi-car consists, including locomotive units and passenger cars. Six multi-car consists were estimated, including a spare.

Propulsion System – This includes such items as substation civil structures, substation propulsion blocks, wayside equipment, power

Direct costs included:

- *Vehicles*
- *Propulsion Systems*
- *Energy Supply*
- *Operational Control Technology*
- *Communication/Control Technology*
- *Guideway/Track Infrastructure*
- *Stations*
- *Operations and Maintenance Facilities*
- *Construction Support*
- *Right-of-Way and Utilities*

systems, and similar items. This cost area is unique to maglev technology and each maglev technology provider since the propulsion systems for rail systems are integral in the locomotive units.


Hybrid/High Speed Hybrid LSM on Guideway

Energy Supply – This includes such items as energy supply substations, operating facilities, wayside equipment, energy supply at passenger stations, and similar items. This cost area was used for high-speed maglev technology and high-speed rail systems. For high-speed rail, it includes overhead contact systems, third rail, or other power transfer systems. For high-speed maglev, it includes the equipment necessary to power the linear synchronous motor (LSM) that is part of the guideway. For 120-mph maglev, the energy systems are integral in the on-board linear induction motor (LIM) propulsion and vehicle systems.

Operation Control Technology – This is the safety-related portion of the operation control system. The operation control technology includes operation control/safety technology, stationary data transmission, radio data transmission, and vehicle location components (guideway mounted digital flags).

Communication/Control Technology – This includes the emergency system, closed circuit television, public information and address systems, and other monitoring and detection devices needed for safe and efficient operation.

Guideway/Track Infrastructure

- **Guideway/Track** – The major guideway infrastructure elements for maglev technologies are guideway beams, guideway switches, and guideway equipment. The guideway costs were estimated for a double-track guideway (with some single-guideway areas, including stations), based on an average for guideway superstructures, assuming the Transrapid design for guideway beams (Type I beams) and for concrete elements (Type III on bridges and in tunnels). High-speed rail track items include ballast; rails; ties; fasteners; and special track work, such as sidings and turnouts. All track costs are for dual-tracked alignment. Direct fixation track was assumed for elevated and tunnel areas, while ballasted track was used for at-grade sections. Sound walls along the outside of the guideway are intended to reduce noise from passing train sets. An allowance for sound walls was included to cover areas where the alignment travels through residential areas, such as Idaho Springs, Eagle, Avon and Vail. Safety fencing was assumed along the full length of the alignments (surface and elevated sections, and at stations and facilities). Landscaping would be provided in developed areas.
- **Bridges and Viaducts** – The system infrastructure includes structures that carry guideways, straddle bent crossings of I-70, special foundations/caissons, support columns, bridges, and viaducts. The costs for guideway structures were estimated for a double- and single-track guideway. The structure cost per route length for track was based on column height and construction complexity. The AGS Study Team

developed 28 different bridge and viaduct options for costing maglev structures, including viaduct, high viaduct, and long span. The team developed 16 different bridge and viaduct options for costing high-speed rail structures.

- **Tunnels** – Tunnel structure work includes boring/drilling/digging costs, ventilation systems, limited spoils disposal, and tunnel electrical systems (lighting, fans, etc.). Twelve tunnel options were developed, including a cut-and-cover option for both high-speed rail and maglev systems.
- **Other** – This item includes drainage and earthwork.

Stations – Each station includes platforms, circulation, lighting, security measures, and auxiliary spaces for ticket sales, passenger information, station administration, baggage handling, and commercial use. Many station designs show a two-story building with circulation on the ground floor and transport platforms. However, station designs differ, depending on demand and terrain.

Operations and Maintenance Facilities – These include the operation control center, maintenance facilities, and maintenance vehicles required for the operation and maintenance of the system. The Central Maintenance Facility is assumed to be near I–70/C–470 and would house an Operations Control Center. A secondary maintenance facility is assumed near Eagle County Regional Airport.

Construction Support – This includes special construction equipment, such as gantries and one-time beam fabrication facilities that are beyond the normal requirements of commercial construction or fabrication vendors.

Right-of-Way and Utilities – This includes costs associated with the purchase of land or easement rights, including relocation assistance, demolition costs, acquisition services, and the purchase cost. It also includes costs for utility relocation based on the land use categories from the right-of-way estimates. More densely built-up areas would be expected to have more utility conflicts with a new transportation system. This cost is the actual cost related to moving utilities, and not professional services.

4.2.2 Indirect Costs

Indirect costs included:

- *Contingencies*
- *Professional Services*
- *Utility Relocation*
- *Environmental Impact Mitigation*

Contingencies – These are allowances added to construction cost estimates at the conceptual planning/engineering stage to account for design details not yet determined, and to accommodate quantity and unit cost variances that would arise during later phases of project development.

- **Standard** – A standard 10 percent contingency related to project elements that have uncertainties and mountain construction (except switches).
- **Switch** – A special 20 percent contingency related to maglev switches because of the uncertainty in these items.

- **Right-of-Way** – A special 20 percent contingency related to right-of-way and the uncertainty in land prices across lengthy corridor segments.
- **Tunnel** – A special 30 percent contingency related to tunnel construction because of the uncertainty in preliminary design, geology, and other risk items.
- **Emergency Tunnel** – A special 20 percent contingency related to tunnel construction of escape shafts and corridors and other emergency items that will be detailed during the design phase.
- **Overall** – A special 30 percent contingency added to the entire cost estimate until more details are determined in the design and construction phases and costs are dramatically refined.

Professional Services – These costs cover the management, procurement, oversight, and overhead costs associated with planning, engineering, and implementation of the project. They include the cost for the technical planning and approval of the project prior to and during construction, manufacturing, installation, commissioning, certification, and acceptance.

Utility Relocation – The cost for professional services related to planning, design, and implementation of utilities relocation.

Environmental Impact Mitigation – This accounts for environmental impact mitigation measures that would be identified during a formal environmental study process. These measures would mitigate site-specific environmental impacts and include such items as replacement of displaced natural, recreational, or cultural resources; removal of hazardous materials; and replacement of habitat.

4.3 Capital Cost Estimates

Table 4-1shows the capital cost estimates for each of the alignment/technology pairs for the Full System AGS from Eagle County Regional Airport to I-70/C-470. Complete cost estimate spreadsheets and a complete explanation of how capital costs were determined are included in Appendix F.

Table 4-1: Capital Cost Estimates for Full System AGS

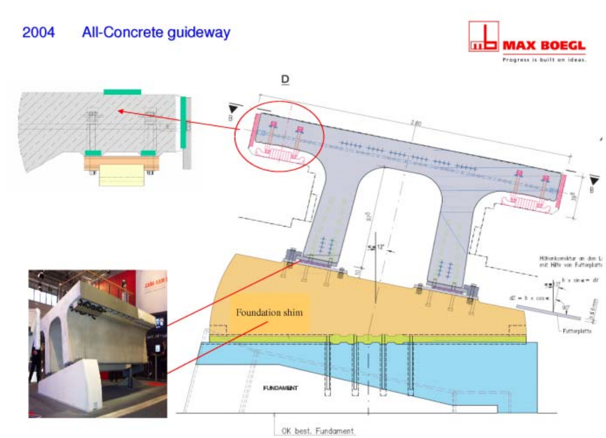
	Hybrid / 120 mph Maglev ($)	Hybrid / High Speed Maglev ($)	High Speed Maglev ($)	High Speed Rail ($)
Direct Costs				
Vehicles	240,000,000	240,200,000	240,200,000	180,000,000
Propulsion System	156,000,000	748,300,000	748,300,000	0
Energy Supply	Included in Propulsion System	235,000,000	235,000,000	280,463,479
Operation Control Technology	198,000,000	115,557,991	114,701,631	219,112,093
Communication/ Control Technology	Included in Operation Control Technology	7,653,800	7,653,800	61,351,386
Guideway/Track	1,065,325,171	1,558,715,098	1,711,594,292	1,032,256,862

Table 4-1: Capital Cost Estimates for Full System AGS

	Hybrid/ 120 mph Maglev ($)	Hybrid/ High Speed Maglev ($)	High Speed Maglev ($)	High Speed Rail ($)
Bridges and Viaducts	208,721,824	208,721,824	118,329,180	652,490,948
Tunnels	2,227,678,781	2,227,678,781	6,636,376,201	9,743,773,973
Other	221,962,502	221,962,502	217,232,268	338,009,250
Stations	140,000,000	140,000,000	140,000,000	110,000,000
Operations and Maintenance Facilities	15,200,000	49,000,000	49,250,000	49,250,000
Construction Support	50,000,000	50,000,000	50,000,000	50,000,000
Right-of-Way and Utilities	329,494,912	329,494,912	223,904,348	268,005,695
Subtotal Direct Costs	**4,852,383,191**	**6,132,284,908**	**10,492,541,720**	**12,984,713,687**
Indirect Costs				
Professional Services	1,581,270,000	1,940,000,000	3,681,480,000	4,711,680,000
Utility Relocation	547,360,000	671,540,000	1,274,360,000	1,630,970,000
Environmental Mitigation	152,050,000	186,540,000	353,990,000	453,050,000
Other Contingencies	1,229,422,402	1,329,253,581	3,666,979,980	5,137,127,519
Overall Contingency	2,508,740,000	3,077,880,000	5,840,810,000	7,475,260,000
Subtotal Indirect Costs	6,018,842,402	7,205,213,581	14,817,619,980	19,408,087,519
Total Costs	**10,871,225,593**	**13,337,498,489**	**25,310,161,700**	**32,392,801,206**
Cost Per Mile	**90,217,640**	**110,684,635**	**213,587,862**	**297,454,557**

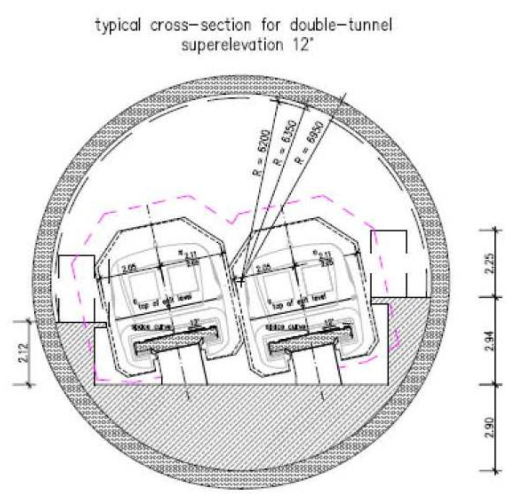
The following conclusions can be drawn from the capital cost estimates:

- The indirect costs contribute more to the total cost than the direct costs. This is not unusual at this preliminary level of alignment design. As the design progresses and more unknowns become known, the percentage of indirect costs will drop.
- The Hybrid/120 mph Maglev represents the least costly alternative. A Hybrid/High Speed Maglev is more costly, but comparable at this stage of the analysis.



High Speed Maglev Guideway

- The High Speed Maglev and High Speed Rail are significantly higher in cost. This is due primarily to higher tunnel costs and related contingencies, as well as technology-related costs (e.g., energy supply, communications, etc.).
- The High Speed Maglev and High Speed Rail capital costs are consistently higher because of their greater complexity. These technologies have ten or more years of commercial service. The 120 mph Maglev technology is theoretical at this point. Therefore, costs for the high-speed technologies have more credibility.
- The costs separate out the individual contingencies and indirect costs. This makes clear that the Hybrid/120 mph Maglev and the Hybrid/High Speed Maglev are fairly close in cost. Their costs per mile are similar to those of urban light rail systems in the United States. In each case, the indirect costs represent over 50% percent of the total capital investment. Within those, contingencies are high, but will decrease as the design is refined and construction estimates, right-of-way needs, and procurement costs are finalized.
- Maglev guideways have a substantial concrete section around which the vehicle wraps; therefore, a large percentage of the maglev guideway cost is associated with structures (Guideway/Track and Bridges and Viaducts). Rail tracks are not as complex, so a greater percentage of the high-speed rail cost is in Bridges and Viaducts and Tunnels.
- A single maglev vehicle is more expensive than a single high-speed rail vehicle, but has higher capacity.
- High-speed rail stations could be longer than maglev stations because the trains need to be longer to accommodate the same capacity as maglev vehicles.



Hybrid/High Speed Hybrid
Tunnel Section

4.4 Key Cost Drivers

Table 4-2 illustrates the key cost drivers for the alignment/technology pairs as a percentage of the total of direct costs and indirect costs. The direct cost for Tunnels and Guideway/Track is the highest cost driver for all alignment/technology pairs.

Table 4-2: Key Cost Drivers by Alignment/Technology Pair

	Hybrid/ 120 mph Maglev	Hybrid/ High Speed Maglev	High Speed Maglev	High Speed Rail
Direct Costs				
Tunnels	**46%**	**36%**	**63%**	**75%**
Guideway/Track	**22%**	**25%**	**16%**	**8%**
Right-of-Way and Utilities	**7%**	**5%**	2%	2%

Table 4-2: Key Cost Drivers by Alignment/Technology Pair

	Hybrid/ 120 mph Maglev	Hybrid/ High Speed Maglev	High Speed Maglev	High Speed Rail
Direct Costs				
Vehicles	5%	4%	2%	1%
Other	5%	4%	2%	3%
Operation Control Technology	4%	2%	1%	2%
Bridges and Viaducts	4%	3%	1%	**5%**
Propulsion System	3%	**12%**	**7%**	0%
Stations	3%	2%	1%	1%
Construction Support	1%	1%	0%	0%
Energy Supply	0%	4%	2%	2%
Communication/Control Technology	0%	0%	0%	0%
Operations and Maintenance Facilities	0%	1%	0%	0%
Subtotal	100%	100%	100%	100%
Indirect Costs				
Overall Contingency	42%	43%	39%	39%
Professional Services	26%	27%	25%	24%
Other Contingencies	20%	18%	25%	26%
Utility Relocation	9%	9%	9%	8%
Environmental Mitigation	3%	3%	2%	2%
Subtotal	100%	100%	100%	100%

Bold = the highest cost drivers based on direct costs of each alignment/technology pair.

Note: Percentages represent the percentage of the cost drivers of the total of direct and indirect costs.

4.4.1 Tunnels

The most costly element for all alignment/technologies is Tunnels. The degree to which tunnels are key cost drivers varies with the number and length of the tunnels associated with the alignment. Table 4-3 compares the tunnel data of each alignment.

Table 4-3: Tunnel Data by Alignment

Alignment/ Technology	System Length (ft.)	System Length (mi.)	Tunnel Length (ft.)	Tunnel Length (mi.)	Tunnel Length as % of Total System Length	Number of Tunnels
Hybrid/120 mph Maglev*	636,401	120.5	82,737	15.7	13%	15
Hybrid/ High Speed Maglev*	636,401	120.5	82,737	15.7	13%	15
High Speed Maglev*	625,538	118.5	211,956	40.1	34%	31
High Speed Rail**	575,097	108.9	343,045	65.0	60%	25

* Single bore tunnel was assumed for all maglev alignments.

** Twin bores were assumed for high-speed rail, except for tunnels less than 500 feet long.

Tunnel lengths compared to the total alignment lengths are greater for the High Speed Maglev and High Speed Rail Alignments. Longer-length tunnels are required to accommodate the desired straighter alignments and less significant grades (and grade changes). These tunnels are costly, and having 34 to 60 percent of the system length underground may not be desirable for passengers who want to view the Colorado scenery.

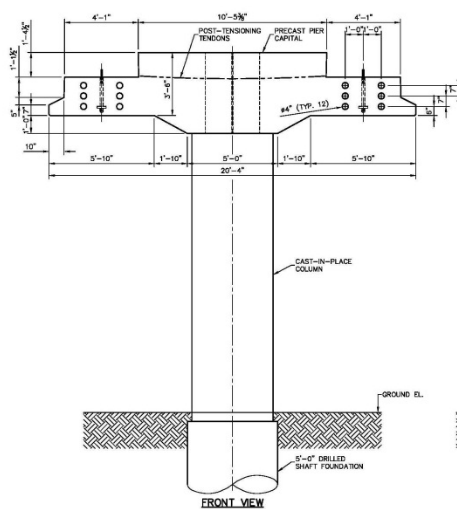
Table 4-4 compares the tunnel costs by alignment. It should be noted that for all maglev tunnels, it was assumed that a single bore would suffice.

Table 4-4: Tunnel Costs by Alignment / Technology Pair

	Hybrid / 120 mph Maglev	Hybrid / High Speed Maglev	High Speed Maglev	High Speed Rail
	$2,227,678,781	$2,227,678,781	$6,636,376,201	$9,743,773,973
Tunnel Contingency	$668,303,634	$668,303,634	$1,990,912,860	$2,923,132,192
Emergency Tunnel Contingency	$445,535,756	$445,535,756	$1,327,275,240	$1,948,754,795
Total Tunnel Cost	**$3,341,518,172**	**$3,341,518,172**	**$9,954,564,302**	**$14,615,660,960**
Tunnel Cost as Percentage of Total Cost as shown in Table 4-1	**30.7%**	**25.1%**	**39.3%**	**45.1%**

4.4.2 Guideway / Track

The second most costly element for all alignment/technology pairs is the Guideway/Track. Both the 120 mph Maglev and the High Speed Maglev have proprietary guideways specific to their system. For instance, Transrapid and General Atomics use an LSM where the stator is incorporated in the guideway; American Maglev uses an LIM where the stator is onboard the vehicle. This results in different designs for the guideway. In general, the LIM guideway is simpler and less expensive.



AMT Guideway

High-speed rail uses slab track with special concrete ties for the slab track and rail. Because of its relative simplicity, the costs for Guideway/Track for the High Speed Rail Alignment are lower than for either of the maglev alignments and are a lower percentage of overall costs. Table 4-5 compares Guideway/Track costs by alignment/technology pair.

Table 4-5: Guideway/Track Costs by Alignment/Technology Pair

	Hybrid/ 120 mph Maglev	Hybrid/ High Speed Maglev	High Speed Maglev	High Speed Rail
Guideway/Track	$1,065,325,171	$1,558,715,098	$1,711,594,292	$1,032,256,862
% of Direct Costs	22.0	25.4	16.3	7.9
% of Total Cost	9.8	11.7	6.8	3.2

4.4.3 Right-of-Way and Utilities

Right-of-way and Utilities is a key cost driver for the Hybrid Alignment. Each alignment has a different breakdown of public versus private lands. Each alignment also has a different breakdown of tunnel segments versus elevated and surface guideway/track segments. These factors directly affect the cost of right-of-way.

Cost estimates used $1 per square foot for all public land (tunnel or surface or elevated), $5 per square foot for private subsurface rights, and $22 per square foot for private surface and elevated segments. The High Speed Rail Alignment right-of-way cost is higher than for the Hybrid or High Speed Maglev Alignments because it has a wider footprint, even though the High Speed Rail Alignment has a greater tunnel length (i.e., more subsurface length). The analysis was done by system segment for each alignment. Table 4-6 provides the right-of-way requirements for each alignment/technology pair.

Table 4-6: Right-of-Way Requirements by Alignment/Technology

Alignment	% on Private Properties	% on Public Lands
Hybrid (AMT and TRI)	42.30	57.70
High Speed Maglev (Transrapid - TRI)	55.20	44.80
High Speed Rail (Talgo 250)	57.70	42.30
High Speed Rail Spur (to Breckenridge)	60.50	39.50
Right-of-Way Width		
Maglev (AMT and TRI)	40 feet wide	
High Speed Rail (Talgo 250)	75 feet wide	

Major utility relocations include overhead power lines and underground facilities, such as pipelines, water and sewer mains, and underground duct banks and vaults. Costs for utility relocation were estimated using the land use categories from the right-of-way estimates. More densely built-up areas would be expected to have more utility conflicts with a new transportation system.

Table 4-7 shows the Right-of-Way and Utilities costs of each alignment/technology pair and the percentage they are of the total costs.

Table 4-7: Right-of-Way and Utilities Costs by Alignment / Technology Pair

	Hybrid / 120 mph Maglev	Hybrid / High Speed Maglev	High Speed Maglev	High Speed Rail
Right-of-Way and Utilities	$329,494,912	$329,494,912	$223,904,348	$268,005,695
% of Direct Costs	6.8%	5.4%	2.1%	2.1%
% of Total Cost	3.0%	2.5%	0.9%	0.8%

4.4.4 Propulsion System

The Propulsion System is a key cost driver for High Speed Maglev. Since Transrapid uses an LSM, the infrastructure required to place the stator on the guideway is significant. This same system is also used for the General Atomics 120 mph Maglev. AMT has permanent magnets placed within the guideway and has its stator on board the vehicle (LIM) so propulsion costs are less.

High-speed rail is propelled by the vehicles so all costs associated with propulsion are included in the vehicle costs.

Table 4-8 compares the propulsion costs by alignment/technology pair and the percentage they are of the total costs.

Table 4-8: Propulsion Costs by Alignment / Technology Pair

	Hybrid / 120 mph Maglev	Hybrid / High Speed Maglev	High Speed Maglev	High Speed Rail
Propulsion System	$156,000,000	$748,300,000	$748,300,000	$0
% of Direct Costs	3.2%	12.2%	7.1%	0.0%
% of Total Cost	1.4%	5.6%	3.0%	0.0%

4.4.5 Bridges and Viaducts

Bridges and Viaducts costs are a key cost driver for the High Speed Rail Alignment. This is because to maintain a flat grade, the alignment uses many tunnels connected by bridges or viaducts. This is especially true in the area east of Floyd Hill where the alignment diverges from I-70 to traverses the Clear Creek Canyon in tunnels connected by bridges. Table 4-9 compares bridge and viaduct costs by alignment/technology pair and the percentage they are of the total costs.

Table 4-9: Bridge and Viaduct Costs by Alignment / Technology Pair

	Hybrid / 120 mph Maglev	Hybrid / High Speed Maglev	High Speed Maglev	High Speed Rail
Bridges and Viaducts	$208,721,824	$208,721,824	$118,329,180	$652,490,948
% of Direct Costs	4.3%	3.4%	1.1%	5.0%
% of Total Cost	1.9%	1.6%	0.5%	2.0%

4.4.6 Design Refinement

As the AGS proceeds through final design, many of the key cost drivers can be value-engineered to reduce costs. This includes the Tunnels, the Guideway/Track, Right-of-Way and Utilities, and Bridges and Viaducts. Many of the other costs also will be reduced through design refinement.

Major Station

4.5 Station Costs

Costs for AGS stations were estimated based on past work on other high-speed rail and maglev projects. There are two classes of stations: major stations and minor stations. Major stations were assumed to be the two end-of-line stations at Eagle County Regional Airport and at I-70/C-470. Because these stations are anticipated to have large parking structures that accommodate riders from a larger geographical area than intermediate stations, the cost for a major station was assumed to be $25 million.

Minor stations were assumed at intermediate stations, such as Idaho Springs, Keystone, Breckenridge, Vail, Avon, etc. They will have more modest parking structures than the major stations. The cost for a minor station was assumed to be $15 million.

Table 4-10 includes a breakdown of the costs for the two station types. These costs do not include any transit-oriented development around the station.

Table 4-10: Station Costs

Element	Unit Cost	Major Station	Minor Station
Terminal	$250/square foot	12,000 square feet $3.0 million	10,000 square feet $2.5 million
Parking Structure	$15,000/space	1,200 spaces $18.0 million	600 spaces $9.0 million
Roadway/Site Improvements	Not applicable	$2.0 million	$1.5 million
Miscellaneous – Furnishings, Utility Infrastructure, etc.	Not applicable	$2.0 million	$2.0 million
Total		**$25.0 million**	**$15.0 million**

4.6 Minimum Operable Segment

The Minimum Operable Segment (MOS) is the portion of the total system that must be built to meet requirements of the *I-70 Mountain Corridor Record of Decision* (*ROD*), or to effectively operate as an independent system. The *ROD* requires the evaluation of the feasibility of an AGS from the Front Range to a point west of the Continental Divide. For the purposes of this Study, the MOS is defined as Breckenridge to I-70/C-470, which can also represent a first starter segment for the AGS.

The cost estimates prepared for the MOS for each alignment/technology pair are summarized in Table 4-11. The estimates indicate that the total represents between 51 and 59 percent of the total system capital cost, and between 49 and 56 percent of the MOS system length. This is understandable since the MOS is in the eastern part of the system where the topography is most challenging and there are higher costs for such items as tunnels and special structures.

Table 4-11: Minimum Operable Segment Cost Comparison (Breckenridge to I-70/C-470)

MOS	Hybrid / 120 mph Maglev	Hybrid / High Speed Maglev	High Speed Maglev	High Speed Rail
Eagle County Regional Airport to I-70/C-470 System Cost	$10,871,220,000	$13,337,490,000	$25,310,170,000	$32,392,800,000
Minimum Operable Segment (MOS) Cost	$ 5,544,560,000	$ 6,801,840,000	$14,141,730,000	$19,009,540,000
MOS as % of Total Cost	51.00%	51.00%	55.90%	58.70%
MOS as % of Total Length	50.40%	50.40%	49.20%	56.00%

The *Interregional Connectivity Study* determined that the cost to extend High Speed Maglev from I-70/C-470 to DIA along the I-76/I-70 alignment is about $3.2 billion. If it is assumed that Hybrid/120 mph Maglev and the High Speed Rail capital costs are similar, the costs for the extended MOS of DIA to Breckenridge are shown in Table 4-12.

Table 4-12: Extended Minimum Operable Segment Cost Comparison (Breckenridge to DIA)

	Hybrid / 120 mph Maglev	Hybrid / High Speed Maglev	High Speed Maglev	High Speed Rail
Eagle County Regional Airport to DIA System Cost	$14,071,220,000	$16,537,490,000	$28,510,170,000	$35,592,800,000
Minimum Operable Segment (MOS) Cost	$ 8,744,560,000	$10,001,840,000	$17,341,730,000	$22,209,540,000
MOS as % of Total Cost	62.15%	60.48%	60.83%	62.40%
MOS as % of Total Length	62.05%	62.05%	61.76%	70.72%

4.7 Operation and Maintenance Costs

Operation and maintenance (O&M) costs are the annual costs associated with operating, maintaining, and administering a system. O&M costs include employee earnings and fringe benefits, contract services, materials and supplies, utilities, and other day-to-day expenses.

The methodology for O&M costing of the alignment/technology pairs was based on the principal assumption that annual operation and maintenance costs vary according to labor productivity, consumption rates, and system characteristics related to service and facilities.

The operating scenario for costing purposes was determined to be:

- 18-hour operating days.
- 365-day operating years.
- 30-minute peak/60-minute off-peak headways between trains or vehicle consists.
- About 5-car train sets or maglev consists (with some exceptions).
- Station numbers and location determined by technology and alignment.
- For all alignment/technology pairs, the Full System east end station was at the C-470/I-70 interchange in Golden and the west end station was at Eagle County Regional Airport.
- For all alignment/technology pairs, the MOS east end station was at the C-470/I-70 interchange in Golden and the west end station was at Breckenridge.
- For the Hybrid/120 mph Maglev, an additional O&M estimate was prepared assuming 15-minute peak /60-minute off-peak headways between two-car married pair consists (due to possible need to accommodate peak demand).

Table 4-13 summarizes the O&M cost model results for the Full System and the MOS. A complete description of the O&M cost model and O&M costs for the various alignment/technology pairs can be found in Appendix G.

Table 4-13: Operation and Maintenance Cost Estimates

	Hybrid/ 120 mph Maglev (15-Minute Peak/60-Minute Off-Peak)	Hybrid/120 mph Maglev (30-Minute Peak/60-Minute Off Peak)	High Speed Maglev (30-Minute Peak/60-Minute Off-Peak)	High Speed Rail (30-Minute Peak/60-Minute Off-Peak)
ECRA to I-70/C-470 - Low Cost	$52,694,000	$45,213,000	$47,209,000	$55,382,000
ECRA to I-70/C-470 - High Cost	$69,473,000	$60,440,000	$62,762,000	$72,882,000
Breckenridge to I-70/ C-470 - Low Cost	$29,485,000	$26,072,000	$27,258,000	$36,191,000
Breckenridge to I-70/ C-470 - High Cost	$39,230,000	$35,103,000	$36,466,000	$47,704,000
Breckenridge to DIA - Low Cost	$43,819,000	$38,746,000	$40,509,000	$53,785,000
Breckenridge to DIA - High Cost	$57,877,000	$51,788,000	$53,799,000	$70,379,000
ECRA to DIA - Low Cost	$65,980,000	$56,613,000	$59,112,000	$69,346,000
ECRA to DIA - High Cost	$86,873,000	$75,577,000	$78,481,000	$91,136,000

ECRA = Eagle County Regional Airport.

- O&M costs for the Full System from Eagle County Regional Airport to I-70/C-470 to range from $45.2 million to $72.9 million annually. The highest O&M costs are associated with the High Speed Rail alignment/technology pair.
    - O&M costs for the Full System High Speed Maglev alignment/technology pair from Eagle County Regional Airport to DIA range $47.2 million to $62.8 million annually because of its longer alignment and associated longer travel time.
- O&M costs for the MOS options from Breckenridge to I-70/C-470 range from $26.1 million to $47.7 million. Again, the highest O&M costs are associated with the High Speed Rail alignment/technology pair.
- If the MOS is extended from I-70/C-470 to DIA, the O&M costs for High Speed Maglev increases by $11.9 million to $15.7 million. Similar increases could be expected for the Hybrid/120 mph Maglev and High Speed Rail.

In the O&M cost model, the Hybrid/120-mph Maglev assumes the same labor rates as High Speed Maglev for vehicle and track maintenance. Information provided by AMT indicates that these rates could be significantly lower, which would reduce the O&M cost estimates for the Hybrid/120 mph Maglev.

Finally, it should be noted that O&M costs are based on a defined service plan that assumes 24 round trips per day on high-volume days. Preliminary analysis suggests that more frequent service may be needed during peak use. While much of the demand can be accommodated by scheduling more of the 24 round trips during peak periods, it may be advisable to add more trips overall, which would increase the estimated O&M costs.

4.8 Conclusion

The total capital costs for the Full System between Eagle County Regional Airport and I‑70/C-470 range from $10.8 billion to $32.4 billion. Extending the service from I-70/C-470 to DIA adds another $3.2 billion. Alternatives that use the Hybrid Alignment are less costly than the High Speed Alignments, principally because they have fewer tunnels than the High Speed Alignments. Contingency costs for all alignment/technology pairs are high at this point in the analysis because of the numerous uncertainties and unknown factors.

The key direct cost drivers - Tunnels, Guideway/Track, and Right-of-Way and Utilities - represent between 66 and 85 percent of the total direct costs for each of the four alignment/technology pairs. These three key cost drivers can be value engineered as design progresses. Because indirect costs were calculated as a percentage of direct costs, lowering the costs of the key direct cost drivers will also lower indirect costs, and thereby total costs.

Table 4-14 provides a breakdown of costs for the maglev alignment alternatives by segment. The segments are defined by the stations at either end of the segment. Table 4-15 provides segment costs for the High Speed Rail Alignment.

The costs for the MOS are lower, but still range from $5.5 to $19.1 billion. Again, as design progresses, these cost estimates will likely be lowered.

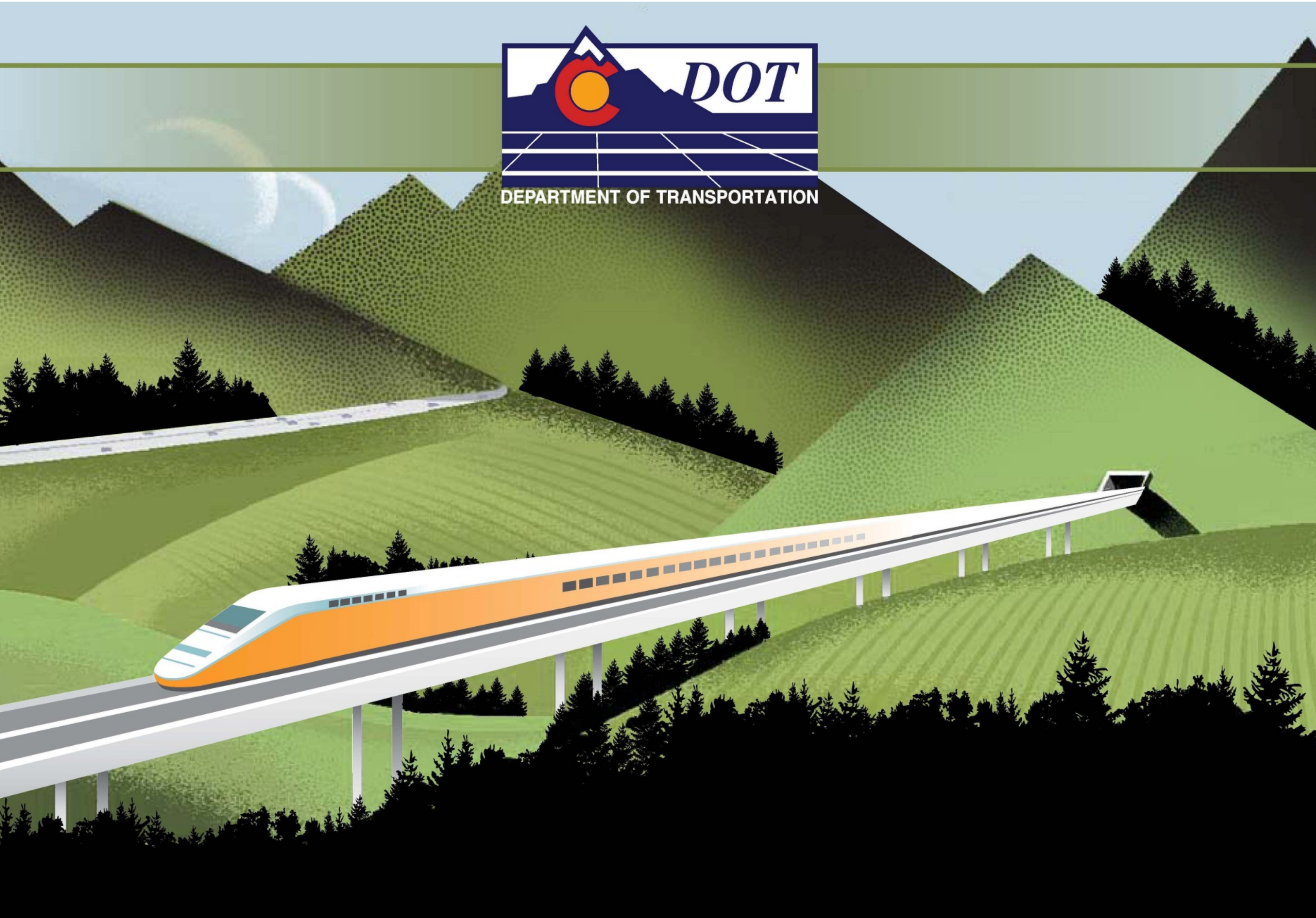
Table 4-14: Segment Costs for Maglev Alignments

Segment Number	Stations	Hybrid / 120 mph Maglev	Hybrid / High Speed Maglev	High Speed Maglev
1	Eagle County Regional Airport to Avon	$1,590,227,527	$2,094,427,584	$3,772,410,843
2	Avon to Vail	$ 693,476,591	$ 858,226,718	$1,572,607,724
3	Vail to Copper Mountain	$1,607,701,781	$2,013,023,249	$3,979,894,250
4	Copper Mountain to Breckenridge	$1,435,264,415	$1,569,981,039	$1,843,519,765
5	Breckenridge to Keystone	$1,259,980,487	$1,483,979,909	$2,294,997,612*
6	Keystone to Idaho Springs/Georgetown	$2,039,111,254	$2,675,421,152	$4,435,515,756*
7	Idaho Springs/ Georgetown to I-70/ C-470	$2,245,465,217	$2,642,436,323	$7,211,233,260
Total		**$10,871,220,000**	**$13,337,490,000**	**$25,310,170,000**

* Differs from Appendix F because of segment quantity overlap.

Table 4-15: Segment Costs for High Speed Rail Alignment

Segment Number	Stations	High Speed Rail Segment
1	Eagle County Regional Airport to Vail	$ 8,309,163,067
2	Vail to Lake Hill	$ 5,074,098,165
3	Lake Hill to Georgetown	$ 7,538,967,858
3b (Spur)	Lake Hill to Breckenridge	$ 1,854,484,113
4	Georgetown to I-70/C-470	$ 9,616,088,003
Total		**$32,392,800,000**



ADVANCED GUIDEWAY SYSTEM (AGS) FEASIBILITY STUDY

CHAPTER 5
ESTIMATION OF BENEFITS

Chapter 5 Estimation of Benefits

5.1 Introduction

The most obvious benefit of the Advanced Guideway System (AGS) to travelers in the I-70 Mountain Corridor will be the ease in which a person will be able to travel from the Front Range to desirable destinations in the mountains. Currently, the trip to and from the mountains can be time-consuming and, in winter, sometimes impossible when I-70 is closed. A fast and all-weather AGS provides:

- Much quicker travel times – meaning more time for other destination activities.
- More comfortable travel – AGS vehicles will have comfortable seats and phone and internet access. Some technologies accommodate food and drink service.
- Less stress and anxiety – The AGS technologies have very high levels of reliability, combined with very high safety standards. This is a particular contrast to the delay issues due to congestion and weather facing motorists on the I-70 Mountain Corridor today.

The AGS will also have other benefits. These benefits, which are discussed in more detail in Chapter 6, include:

- Reduction in air pollutants associated with reduction in automobile trips.
- Reduction in accidents associated with reduction in automobile trips.
- Increases in land value associated with new AGS stations.
- Increases in direct jobs, both to build the system and then to operate and maintain it.

In this chapter, important metrics by which these benefits are measured are estimated:

- Ridership and farebox revenue estimates
- Reduction in Vehicle Miles Traveled (VMT)
- Reduction in Vehicle Hours Traveled (VHT)

In Chapter 6, the farebox recovery ratio and benefit/cost ratio will be calculated.

5.2 Ridership and Farebox Revenue

To create certain efficiencies and a systemwide travel model, the *Interregional Connectivity Study* (ICS) Team performed all ridership modeling for both the ICS and the AGS. Later in the Study, the AGS Study Team obtained the ICS ridership model and used it to model further scenarios.

The ICS Team applied a well-established travel demand forecasting methodology to analyze ridership and revenue for the ICS Level 2 alternatives. This methodology is quite detailed and is well-suited to a preliminary model that is a precursor to an "investment grade" ridership study. Figure 5-1 graphically illustrates the forecasting approach.

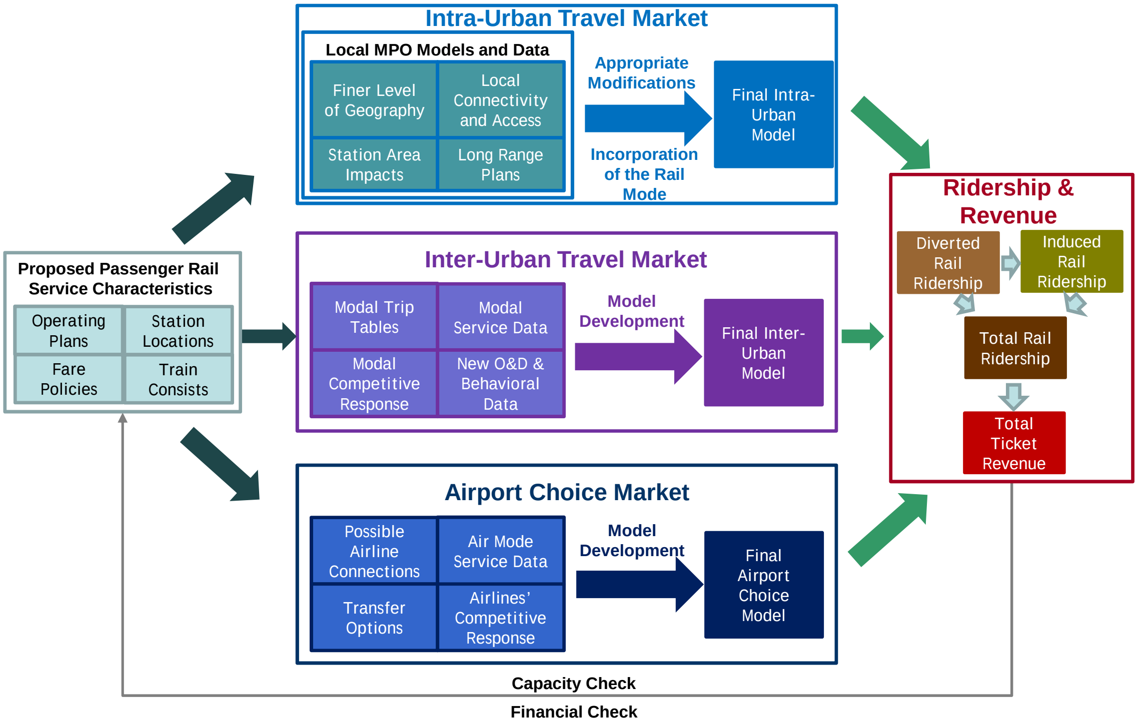


Figure 5-1: General Ridership and Revenue Forecasting Framework

As can be seen, the methodology addresses four distinct travel markets in the study area:

- Inter-urban travel market.
- Denver area intra-urban travel market, including access to Denver International Airport.
- Airport choice market.
- Induced demand market.

The demand forecasting steps for each of these travel markets are briefly described below. An analysis of the ridership model is provided in Appendix H.

To forecast demand for the combined technology, speed, alignment, and stopping pattern of an AGS + ICS System, the model used the following service characteristics of the alternatives:

- Operating characteristics (stopping patterns, running and dwell times, schedule or frequency).
- Station-to-station fares.
- Station sites and connectivity/accessibility/parking.

5.2.1 Inter-Urban Travel

The process that the demand model applies to forecast the inter-urban ridership and revenue of a proposed rail service entails five broad steps:

Step 1 Establish the study area geographic scope and its zone structure – The inter-urban model covers a geographic area that generally follows the AGS + ICS

System corridors and extends approximately 50 miles on each side of the proposed alignments. The study area is split into 3,142 zones. In Metropolitan Planning Organization (MPO) areas, the zones are based on the MPO model traffic analysis zones (TAZ) or some aggregation of them; in other areas, they are based on zones used in the *I-70 Mountain Corridor Final Programmatic Environmental Impact Statement*.

Step 2 **Develop input data including service characteristics for each mode and zone pair** – Modeling input data includes the study area network, historic and future socio-economic variables (population, employment, income, general economic conditions, information on visitors, commuters, etc.), and information about the service characteristics of existing and future travel modes.

Step 3 **Estimate the current in-scope travel market** – The inter-urban travel market includes trips by air, bus, and private automobile; and for different travel purposes. As part of the forecasting model development, data on the patterns and levels of trip making in these markets is prepared on a detailed zone-to-zone basis. While inter-urban air volume data is available from well-established sources, and inter-urban bus volumes can be adequately estimated from published schedules, there is little current information on inter-urban automobile travel in the I-70 Mountain Corridor, resulting in a large data gap. This prompted the AGS Study Team to undertake a program of original travel data collection, using anonymous cell phone data to understand the origins and destinations of auto travelers in the study corridors.

Step 4 **Estimate how each market will grow in the future** – This step involves the development of econometric travel growth models for the auto and bus modes, reflecting trends in socioeconomic variables, such as population and employment. Future year air trip tables are prepared based on published Federal Aviation Administration Terminal Area forecasts of total annual airport enplanements for each of the study area airports.

Step 5 **Estimate the potential market share that the new AGS + ICS System service will capture (i.e., the ridership)** – A standard model form, called a nested logit model, is used to predict the market share of each inter-urban mode based on the respective service characteristics of the modes in competition between each zone pair. Service characteristics include time, cost, frequency, reliability, and quality of service, with time and cost broken down into their access, egress, transfer, terminal, and line haul components. Mode-specific constants account for the effects of other (not explicitly modeled) characteristics of the AGS + ICS System relative to other modes. These shares are then applied to the total zone-to-zone travel volume to predict the volume of travel by each mode, including the new AGS + ICS System mode. This process is carried out separately for the different trip purposes, and the results aggregated.

The nested logit model incorporates information about how travelers assess and trade off different modal service characteristics (cost, time, etc.) based on traveler characteristics (income, size of travel group, etc). This information was obtained from the Stated Preference (SP) Survey of I-70 Mountain Corridor travelers that was conducted as part of the forecasting effort. This type of survey is routinely used to elicit traveler preferences and tradeoffs involving different modal attributes.

5.2.2 Intra-Urban Travel

Because some of the alternatives include multiple stations in the Denver metropolitan area, they provide intra-urban as well as inter-urban service. The travel forecasting activity considers interactions between the AGS + ICS System and the Denver metropolitan transportation system, both the metropolitan access/egress portion of inter-urban AGS + ICS System trips and the intra-urban AGS + ICS System as a local travel mode within the Denver area. The forecasting activity uses the Denver Regional Council of Governments (DRCOG) Compass model to forecast Denver-area AGS + ICS System travel demand, treating the AGS + ICS System as an additional travel mode within the already-defined mix of available urban modes and making adjustments as required. This approach makes maximum use of the detailed understanding of Denver-area travel patterns and behavior embodied in the Compass model system.

5.2.3 Airport Choice

Denver International Airport (DIA) is an important national and international hub because it serves a large number of destinations, and there are several major carriers operating from DIA. Locally, it provides connection options for air trips that begin or end at the study area regional airports in Colorado Springs, Pueblo, and Eagle County. Because some of the alternatives include an AGS + ICS System station at DIA, air travelers who begin or end their trip at Colorado Springs Airport or Eagle County Regional Airport and change planes at DIA will also have the option to access DIA by the AGS + ICS System. The AGS + ICS System travel demand forecasting effort develops an airport choice model to forecast these potential shifts by connecting air travelers.

5.2.4 Induced Demand

Induced travel refers to trips that were not made before a project opens, but that come to be made as a result of a project’s mobility and accessibility improvements. Induced travel resulting from the introduction of the AGS + ICS System is forecasted using a simple elasticity-based approach, where the elasticity is expressed as the percentage impact on travel volumes resulting from a percent change in accessibility. Accessibility, in turn, is defined in terms of a generalized cost or logsum variable computed from the nested logit model developed for this Study from the SP Survey data.

5.2.5 Travel Time

A key factor in ridership is the speed of the system that translates to travel time. The model data clearly shows that the shorter the travel time, the higher the ridership. Travel times for each of the alignment/technology pairs were developed. For High Speed Rail, travel time was simulated using proprietary software developed by one of the AGS Study Team members, using actual operating data for a Talgo 250 vehicle. For Hybrid/120 mph Maglev, travel times were estimated by American Maglev Transport (AMT). For High Speed Maglev, travel times were estimated by Transrapid. The estimated travel times for the Full System (Eagle County Regional Airport to I–70/C-470 or DIA) are shown in Table 5-1.

Table 5-1: Travel Characteristics for Full System

Eagle County Regional Airport to I-70/C–470	Travel Time (minutes)	Distance (miles)	Average Speed (mph)
High Speed Rail	65.0	100.8	93.0
High Speed Maglev	79.0	121.7	92.4
Hybrid/High Speed Maglev	73.0	115.2	94.7
Hybrid/120 mph Maglev	107.4	115.2	64.4
Eagle County Regional Airport to DIA	**Travel Time (minutes)**	**Distance (miles)**	**Average Speed (mph)**
Hybrid/High Speed Maglev	95.0	152.2	96.1

Estimated travel times for the Minimum Operable Segment (MOS) (Breckenridge to I–70/C–470 or DIA) are shown in Table 5-2.

Table 5-2: Travel Characteristics for MOS

Breckenridge to I-70/C-470	Travel Time (minutes)	Distance (miles)	Average Speed (mph)
High Speed Rail	37.0	60.8	98.6
High Speed Maglev	33.0	63.5	115.5
Hybrid/High Speed Maglev	31.0	58.2	112.6
Hybrid/120 mph Maglev	46.2	57.9	75.2
Breckenridge to DIA	**Travel Time (minutes)**	**Distance (miles)**	**Average Speed (mph)**
Hybrid/High Speed Maglev	55.0	94.0	102.5

For context, Table 5-3 compares the travel time from key AGS stations to the I-70/C-470 station using an unimpeded passenger automobile and the Hybrid/High Speed Maglev alignment/technology pair.

Time savings with the Hybrid/High Speed Maglev from Eagle County Regional Airport to Keystone and Breckenridge are much greater because an automobile has to travel some distance from I-70 to reach those stations. The Vail station is along I-70.

Table 5-3: Travel Time Comparison, Automobile vs. AGS

	Travel Time (minutes) from Originating Station to I-70/C–470 Station		
	Automobile*	**Hybrid High Speed Maglev**	**Time Savings**
Eagle County Regional Airport	119	73	46
Vail	86	50	36
Breckenridge	78	33	45
Keystone	68	24	44

* Based on Google Maps calculations of travel time.

5.2.6 Operating Plans

Another key factor in ridership is the frequency of service. In conjunction with the ICS Team, operating scenarios were developed. All scenarios are based on an 18-hour daily span of service, 7 days a week. For highest-demand days (considered Thursday through Sunday for the AGS), hourly service is assumed for 12 hours of the day and 30-minute frequencies during 6 hours of the day. For lighter days (Monday through Wednesday), an hourly frequency is assumed for most of the day.

High Speed Rail – The High Speed Rail Alignment serves Breckenridge with a separate branch, so there are two line patterns. The main line serves Eagle County Regional Airport, Georgetown, Lakeside (between Frisco and Silverthorne), and Vail; it ends at I-70/C-470. The spur line proceeds from Georgetown, Lakeside, and Breckenridge to I-70/C-470. The basic operating plan assumes 24 round trips daily from Thursday through Sunday (18 on mainline, 6 on branch), and 15 round trips Monday through Wednesday (9 on mainline, 6 on branch).

High Speed Rail and Hybrid/120 mph Maglev from Eagle County Regional Airport to I-70/C-470 – This alignment is assumed to operate between Eagle County Regional Airport and I-70/C-470, with intermediate stations Avon, Vail, Copper Mountain (for Hybrid/120 mph Maglev only), Breckenridge, Keystone, and Idaho Springs. The basic operating plan assumes 24 round trips daily from Thursday through Sunday, and 15 round trips daily from Monday through Wednesday.

High Speed Rail and Hybrid/120 mph Maglev from Eagle County Regional Airport to DIA – This alignment operates between Eagle County Regional Airport and DIA, with additional stations at DIA and I-76/72nd Avenue in the Denver area. The basic operating plan assumes 24 round trips daily from Thursday through Sunday, and 15 round trips daily from Monday through Wednesday.

MOS (All Technologies) – This alignment operates between Breckenridge and I-70/C-470. There would be four stations for all alignment/technology pairs. The basic operating plan assumes 24 round trips daily Thursday through Sunday, and 15 round trips Monday through Wednesday.

5.2.7 Fares

Fares were developed on a cost per mile basis, priced for individual travel. Initially, a fare of $0.35 per mile per person was assumed. Subsequently, a sensitivity analysis showed that a fare of $0.26 per mile would result in optimized ridership and revenue.

5.2.8 Ridership and Revenue

Many different scenarios were modeled. In the initial phases, the modeling focused on a combination of the AGS with a number of ICS System options through the Denver metropolitan area. Those options included various alignments to travel from I-70/C-470 station DIA to, as well as ways for the ICS System to travel north-south through the metropolitan area.

After significant analysis, two options remained. The first option is the one that best suits AGS because it would allow a one-seat ride from the I-70 Mountain Corridor to DIA (a key goal of the AGS PLT). The alignment leaves DIA, travels to I-76, and then follows I-76 to I-70 to the I-70/C-470 station. The ICS north-south system would tie into this east-west system at a station at DIA.

In the second option, the ICS System alignment accesses DIA from C-470 and E-470. It links to AGS at the I-70/C-470 station. If the AGS used a different technology than the ICS System, this option would require a transfer at the I-70/C-470 station. Only if the same technologies were used would a one-seat ride be possible (unless parallel systems were built, which would be cost prohibitive).

Three technologies with different assumptions were modeled, as follows:

- High Speed Rail was modeled for the ICS System + AGS and as a standalone from Eagle County Regional Airport to I-70/C-470.
- High Speed Maglev was modeled for Eagle County Regional Airport to I-70/C-470 and for Eagle County Regional Airport to DIA with and without a connection to the ICS System at I-70/C-470.
- The 120 mph Maglev was modeled only for Eagle County Regional Airport to I-70/C-470 with and without a connection to the ICS System at I-70/C-470 station.

For those scenarios where the AGS and the ICS System are combined, ridership and revenue are assigned to the AGS for any trip that has an origin or destination within the I-70 Mountain Corridor. For instance, a trip originating in Colorado Springs and ending in Breckenridge would be counted as an AGS trip. The reverse trip from Breckenridge to Colorado Springs would also be an AGS trip.

Table 5-4 and Table 5-5 present annual ridership and revenue estimates for a variety of alignment/ technology pairs at the initial $0.35/mile and the optimized $0.26/mile fares.

Table 5-4: 2035 Forecast Annual Ridership and Revenue Data, $0.35 / Mile Fare

Alignment Through Denver Metro	Alignment / Technology	Fare / Mile	Coverage	Ridership (Passengers / Year)	Revenue ($ / Year)
I-76	Hybrid/ High Speed Maglev	$0.35	ECRA to I–70/C-470 ICS System + AGS*	3,636,914	$123,745,259
Not applicable	Hybrid/ High Speed Maglev	$0.35	Breckenridge to I–70/C-470 No ICS System	1,236,174	$22,247,496
Not applicable	Hybrid/ 120 mph Maglev	$0.35	Breckenridge to I–70/C-470 No ICS System	1,026,172	$18,408,144
C–470/ E–470	High Speed Rail	$0.35	ECRA to I-70/C-470 ICS System + AGS	4,340,584	$137,364,179

* Maglev from Eagle County Regional Airport to DIA.

ECRA = Eagle County Regional Airport. Revenues are in 2013$.

Table 5-5: 2035 Forecast Annual Ridership and Revenue Data, $0.26 / Mile Fare

Alignment Through Denver Metro	Alignment / Technology	Fare / Mile	Coverage	Ridership (Passengers / Year)	Revenue ($ / Year)
I-76	Hybrid/ High Speed Maglev	$0.26	ECRA to DIA ICS System + AGS*	4,635,464	$113,911,654
C–470/ E–470	Hybrid/ High Speed Maglev	$0.26	ECRA to DIA ICS System + AGS**	6,211,251	$157,280,243
I-76	Hybrid/ High Speed Maglev	$0.26	ECRA to DIA No ICS System *	3,585,120	$79,037,296
Not applicable	Hybrid/ High Speed Maglev	$0.26	Breckenridge to I–70/C-470 No ICS System	1,535,031	$20,851,174
Not applicable	Hybrid/ 120 mph Maglev	$0.26	Breckenridge to I-70/C-470 No ICS System	1,284,913	$17,418,946
C–470/ E–470	High Speed Rail	$0.26	ECRA to DIA ICS System + AGS	6,349,807	$159,912,578
I-76	Hybrid/ High Speed Maglev	$0.26	Breckenridge to DIA ICS System + AGS	2,906,471	$66,943,427
I-76	High Speed Rail	$0.26	Breckenridge to DIA ICS System + AGS	2,676,462	$58,278,195
I-76	Hybrid/ High Speed Maglev	$0.26	Breckenridge to DIA No ICS System	1,775,726	$28,723,660
I-76	Hybrid/ 120 mph Maglev	$0.26	Breckenridge to DIA ICS System + AGS	2,508,416	$56,779,587

* Maglev from Eagle County Regional Airport to DIA.

** Maglev from Eagle County Regional Airport to I-70/C-470.

ECRA = Eagle County Regional Airport. Revenues are in 2013$.

As can be seen, decreasing the fare from $0.35/mile to $0.26/mile has a significant effect on ridership but not a significant change in revenue. This is because of lower overall trip fares between destinations. In one case, the revenue actually decreases because the increase in ridership is not enough to support the decrease in trip fares.

The other important takeaway from Table 5-4 and Table 5-5 is that ridership is very dependent on speed. A shorter trip time definitely attracts ridership. As a result, the 120 mph Maglev has significantly lower ridership than either of the two high-speed technologies.

To put the AGS ridership into context, consider the following:

- In 2035, about 12.41 million automobiles will travel through the Eisenhower-Johnson Memorial Tunnel (EJMT). Assuming that the average annual vehicle occupancy is 2.42 persons, there will be about 30 million person trips through the EJMT in 2035. Excluding truck and through trips, which equate to about 20 percent of the total trips, there will be about 24 million person trips through the EJMT in 2035 that could potentially divert to the AGS.
- Based on the lowest ridership estimate of 1.54 million passengers per year (120 mph Maglev MOS, Breckenridge to I-70/C-470), about 6.4 percent of eligible person trips would divert from automobiles to the AGS.
- Using the ridership estimates of 2.9 to 3.6 million passengers per year (Full System/High Speed Maglev with or without the ICS System on the Front Range, I-70/I-76 alignment through Denver, Eagle County Regional Airport to DIA), about 12 to 15 percent of eligible person trips would divert from automobiles to the AGS.
- Based on the ridership estimate of 6.2 million passengers per year (High Speed Maglev, AGS with ICS on the Front Range on the C-470/E-470 alignment), about 26 percent of eligible person trips would divert from automobiles to the AGS.

5.3 Reductions in Vehicle Miles Traveled

Vehicle miles traveled (VMT) are associated with higher emissions of air pollutants and greenhouse gases (GHG) and increased congestion. As people divert from private automobiles, buses, and shuttles to the AGS, fewer of these vehicles will be on the highway system. This will result in a reduction in VMT. The model was used to estimate the reductions in annual VMT. The results are shown in Table 5-6 and Table 5-7. Similar to ridership and revenue, VMT are measured for any trip having its origin or destination in the I-70 Mountain Corridor.

To put the reductions into perspective, using the 120-mile trip from Eagle County Regional Airport to I-70/C-470 as a basis, the AGS will result in the equivalent of between 266,000 and 2,410,000 120-mile trips removed from the I-70 Mountain Corridor per year.

Table 5-6: 2035 Forecast Reductions in Annual Vehicle Miles Traveled, $0.35 / Mile Fare

Alignment Through Denver	Alignment / Technology	Fare / Mile	Coverage	Reduction in VMT
I-76	Hybrid/ High Speed Maglev	$0.35	ECRA to DIA ICS System + AGS*	162,980,029
Not applicable	Hybrid/ High Speed Maglev	$0.35	Breckenridge to I-70/C-470 No ICS System	38,624,456
Not applicable	Hybrid/ 120 mph Maglev	$0.35	Breckenridge to I-70/C-470 No ICS System	31,873,037
C-470/E-470	High Speed Rail	$0.35	ECRA to I-70/C-470 ICS System + AGS	186,041,118

* Maglev from Eagle County Regional Airport to DIA.

ECRA = Eagle County Regional Airport.

Table 5-7: 2035 Forecast Reductions in Annual Vehicle Miles Traveled, $0.26 / Mile Fare

Alignment Through Denver	Alignment / Technology	Fare / Mile	Coverage	Reduction in VMT
I-76	Hybrid/ High Speed Maglev	$0.26	ECRA to DIA ICS System + AGS*	191,432,412
C-470/E-470	Hybrid/ High Speed Maglev	$0.26	ECRA to DIA ICS System + AGS**	266,031,869
I-76	Hybrid/ High Speed Maglev	$0.26	DIA to ECRA No ICS System*	152,226,347
Not applicable	Hybrid/ High Speed Maglev	$0.26	Breckenridge to I-70/C-470 No ICS System	47,583,933
Not applicable	Hybrid/ 120 mph Maglev	$0.26	Breckenridge to I-70/C-470 No ICS System	39,696,174
C-470/E-470	High Speed Rail	$0.26	ECRA to I-70/C-470 ICS System + AGS	289,257,126
I-76	Hybrid/ High Speed Maglev	$0.26	Breckenridge to DIA ICS System + AGS	96,935,072
I-76	High Speed Rail	$0.26	Breckenridge to DIA ICS System + AGS	89,843,332
I-76	Hybrid/ High Speed Maglev	$0.26	Breckenridge to DIA No ICS System	57,495,203
I-76	Hybrid/ 120 mph Maglev	$0.26	Breckenridge to DIA ICS System + AGS	82,730,444

* Maglev from Eagle County Regional Airport to DIA.

** Maglev from Eagle County Regional Airport to I-70/C-470.

ECRA = Eagle County Regional Airport.

5.4 Reductions in Vehicle Hours Traveled (VHT)

As people divert from private automobiles, buses, and shuttles to the AGS, there are fewer vehicles and less congestion. This allows average speeds to increase, which lowers VHT.

The model was used to estimate the reductions in annual VHT. The results are shown in Tables 5-8 and 5-9. Similar to ridership and revenue, VHT are measured for any trip having an origin or destination in the I-70 Mountain Corridor.

Table 5-8: 2035 Forecast Reductions in Annual Vehicle Hours Traveled, $0.35 / Mile Fare

Alignment Through Denver	Alignment / Technology	Fare / Mile	Coverage	Reduction in VHT
I-76	Hybrid/ High Speed Maglev	$0.35	ECRA to DIA ICS System + AGS*	640,580
Not applicable	Hybrid/ High Speed Maglev	$0.35	Breckenridge to I-70/C-470 No ICS System	175,603
Not applicable	Hybrid/ 120 mph Maglev	$0.35	Breckenridge to I-70/C-470 No ICS System	56,846
C-470/E-470	High Speed Rail	$0.35	ECRA to I-70/C-470 ICS System + AGS	812,467

* Maglev from Eagle County Regional Airport to DIA.

ECRA = Eagle County Regional Airport.

Table 5-9: 2035 Forecast Reductions in Annual Vehicle Hours Traveled, $0.26 / Mile Fare

Alignment Through Denver	Alignment / Technology	Fare / Mile	Coverage	Reduction in VHT
I-76	Hybrid/ High Speed Maglev	$0.26	ECRA to DIA ICS System + AGS*	675,455
C-470/E-470	Hybrid/ High Speed Maglev	$0.26	ECRA to DIA ICS System + AGS**	950,985
I-76	Hybrid/ High Speed Maglev	$0.26	ECRA to DIA No ICS System*	852,987
Not applicable	Hybrid/ High Speed Maglev	$0.26	Breckenridge to I-70/C-470	215,174
Not applicable	Hybrid/ 120 mph Maglev	$0.26	Breckenridge to I-70/C-470	69,402
C-470/E-470	High Speed Rail	$0.26	ECRA to I-70/C-470 ICS System + AGS	1,151,656
I-76	Hybrid/ High Speed Maglev	$0.26	Breckenridge to DIA ICS System + AGS	29,116
I-76	High Speed Rail	$0.26	Breckenridge to DIA ICS System + AGS	(28,874)
I-76	Hybrid/ High Speed Maglev	$0.26	Breckenridge to DIA No ICS System	210,468
I-76	Hybrid/ 120 mph Maglev	$0.26	Breckenridge to DIA ICS System + AGS	(148,742)

* Maglev from Eagle County Regional Airport to DIA.

** Maglev from Eagle County Regional Airport to I-70/C-470.

ECRA = Eagle County Regional Airport.

For most of the MOS runs, the model system suggests there will be VHT savings in 2035. This is reasonable because travelers formerly using autos are diverted to AGS. However, the results from the Breckenridge to DIA scenarios with the Full ICS System indicate there will be a negative VHT savings. The increase in VHT for these scenarios is due to the way VHT savings are calculated in the AGS model system. VHT is calculated by subtracting the total end-to-end AGS travel time from the total end-to-end auto travel time of those same diverted auto trips. With the Full ICS System in the background, there are enough trip interchanges where long auto trips are diverted to a longer AGS trip. Travelers ride AGS not only for shorter travel times, but also for comfort, reliability, and other undefined attributes. Therefore, while the results are in the correct direction (i.e., there is a VHT savings with AGS) for most scenarios, some results are counter-intuitive. This is not incorrect, but strictly the result of how VHT is calculated in the I-70 AGS model system.

5.5 Air Quality Savings

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.[1] The estimated benefit in annual air quality is shown in Table 5-10 and 5-11.

5.6 Benefit of Travel Time Savings

Reductions in travel time can be equated with increased productivity. 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[2]. Table 5-12 and 5-13 presents the yearly value of the VHT reductions associated with the AGS.

Table 5-10: 2035 Forecast Annual Air Quality Benefits, $0.35 / Mile Fare (2013$)

Alignment Through Denver	Technology	Fare / Mile	Coverage	Annual Air Quality Savings
I-76	Hybrid High Speed Maglev	$0.35	ECRA to DIA ICS System + AGS*	$32,433,026
Not applicable	Hybrid High Speed Maglev	$0.35	Breckenridge to I-70/C-470 No ICS System	$7,686,267
Not applicable	Hybrid 120 mph Maglev	$0.35	Breckenridge to I-70/C-470 No ICS System	$6,342,734
C-470/E-470	High Speed Rail	$0.35	ECRA to I-70/C-470 ICS System + AGS	$37,022,182

* Maglev from Eagle County Regional Airport to DIA.

ECRA = Eagle County Regional Airport.

[1] Victoria Transportation Policy Institute, "Transportation Cost and Benefit Analysis II – Air Pollution Costs", February 22, 2012

[2] Bureau of Labor Statistics, 2012 for Colorado and the U.S.

Table 5-11: 2035 Forecast Annual Air Quality Benefits, $0.26 / Mile Fare (2013$)

Alignment Through Denver	Technology	Fare / Mile	Coverage	Annual Air Quality Savings
I-76	Hybrid High Speed Maglev	$0.26	ECRA to DIA ICS System + AGS*	$38,095,050
C-470/E-470	Hybrid High Speed Maglev	$0.26	ECRA to DIA ICS System + AGS**	$52,940,342
I-76	Hybrid High Speed Maglev	$0.26	ECRA to DIA No ICS System*	$30,293,043
Not applicable	Hybrid High Speed Maglev	$0.26	Breckenridge to I-70/C-470	$9,469,203
Not applicable	Hybrid 120 mph Maglev	$0.26	Breckenridge to I-70/C-470	$7,899,539
C-470/E-470	High Speed Rail	$0.26	ECRA to I-70/C-470 ICS System + AGS	$57,562,168
I-76	Hybrid High Speed Maglev	$0.26	Breckenridge to DIA ICS System + AGS	$19,290,079
I-76	High Speed Rail	$0.26	Breckenridge to DIA ICS System + AGS	$17,878,823
I-76	Hybrid High Speed Maglev	$0.26	Breckenridge to DIA No ICS System	$11,441,545
I-76	Hybrid 120 mph Maglev	$0.26	Breckenridge to DIA ICS System + AGS	$16,463,358

* Maglev from Eagle County Regional Airport to DIA.

** Maglev from Eagle County Regional Airport to I-70/C-470.

ECRA = Eagle County Regional Airport.

Table 5-12: 2035 Forecast Annual Travel Time Benefits, $0.35 / Mile Fare (2013$)

Alignment Through Denver	Technology	Fare / Mile	Coverage	Annual Value of VHT Reduction
I-76	Hybrid High Speed Maglev	$0.35	Full System ICS System + AGS*	$14,733,340
Not applicable	Hybrid High Speed Maglev	$0.35	Breckenridge to I-70/C-470 No ICS System	$4,038,869
Not applicable	Hybrid 120 mph Maglev	$0.35	Breckenridge to I-70/C-470 No ICS System	$1,307,458
C-470/E-470	High Speed Rail	$0.35	Full System ICS System + AGS	$18,686,741

* Maglev from DIA to Eagle County Regional Airport.

Table 5-13: 2035 Forecast Annual Travel Time Benefits, $0.26 / Mile Fare (2013$)

Alignment Through Denver	Technology	Fare / Mile	Coverage	Annual Value of VHT Reduction
I-76	Hybrid High Speed Maglev	$0.26	Full System ICS System + AGS*	$15,535,465
C-470/E-470	Hybrid High Speed Maglev	$0.26	Full System ICS System + AGS**	$21,872,655
I-76	Hybrid High Speed Maglev	$0.26	ECRA to DIA No ICS System*	$19,618,701
Not applicable	Hybrid High Speed Maglev	$0.26	Breckenridge to I-70/C-470	$4,949,002
Not applicable	Hybrid 120 mph Maglev	$0.26	Breckenridge to I-70/C-470	$1,596,246
C-470/E-470	High Speed Rail	$0.26	Full System ICS System + AGS	$26,488,088
I-76	Hybrid High Speed Maglev	$0.26	Full System ICS System + AGS	$669,668
I-76	High Speed Rail	$0.26	Full System ICS System + AGS	-$664,102
I-76	Hybrid High Speed Maglev	$0.26	Breckenridge to DIA No ICS	$4,840,764
I-76	Hybrid 120 mph Maglev	$0.26	Breckenridge to DIA ICS System + AGS	-$3,421,066

* Maglev from Eagle County Regional Airport to DIA.

** Maglev from Eagle County Regional Airport to I-70/C-470.

ECRA = Eagle County Regional Airport.

5.7 Benefit of Stations

New AGS stations have the potential to create new economic benefits in the communities in which they are sited. The benefits can come from:

- Increased visitor traffic.
- New jobs.
- Area-wide population increases due to faster commutes.
- Development potential around the stations.

In discussions with the I-70 Mountain Corridor counties through 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 from increased land values and associated increased property taxes, sales taxes, and other types of taxes. The economist for the ICS, Ms. Arleen Taniwaki, places the value of a station in the I-70 Mountain Corridor at $370 million per station, over a 30-year period. Table 5-14 provides the expected economic benefits of the AGS stations.

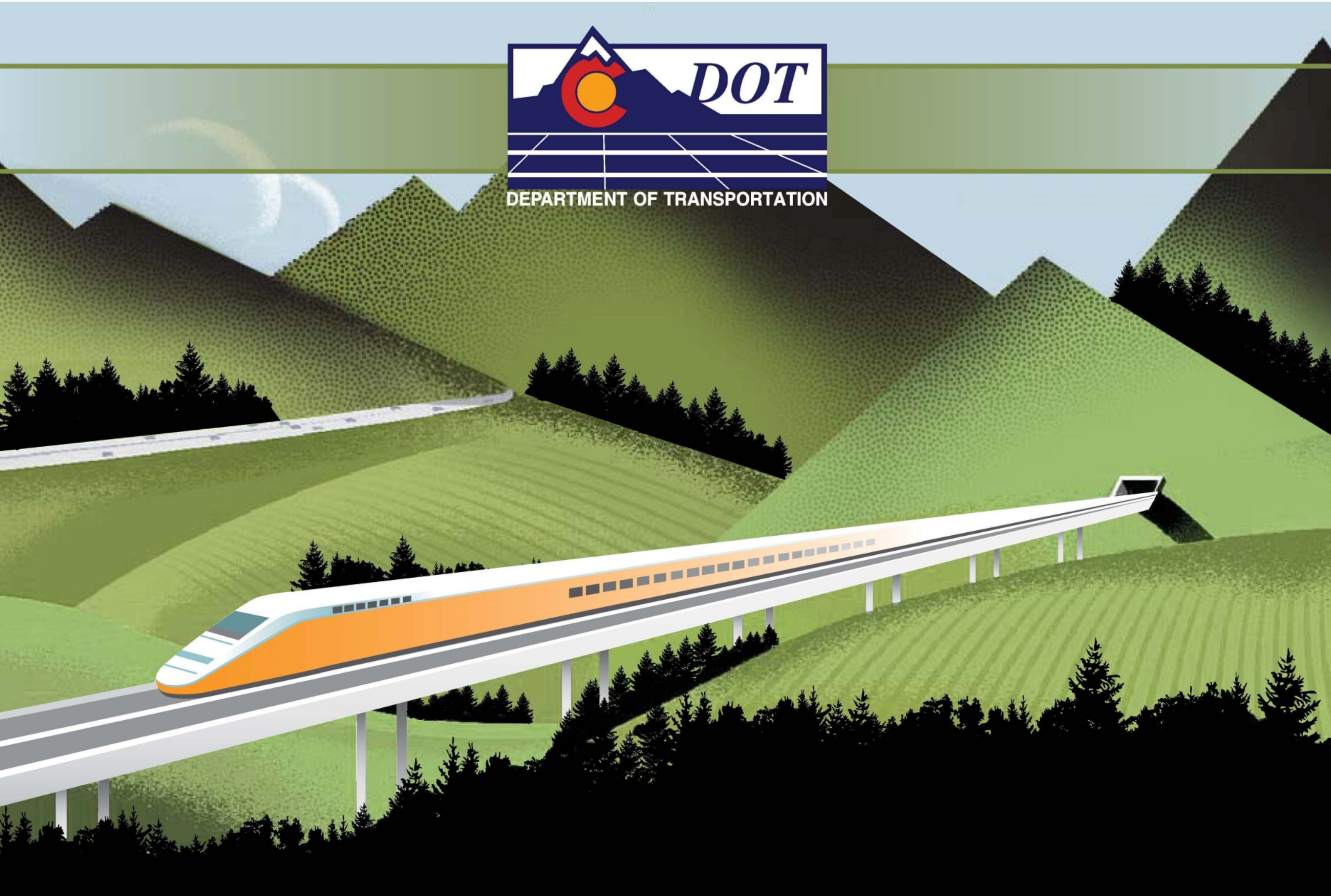
Table 5-14: Economic Benefits of AGS Stations (2013$)

Alignment/Technology	Number of Stations	Economic Value of Stations (30 years)
Hybrid/120 mph Maglev	8	$2,960,000,000
Hybrid/High Speed Maglev	7	$2,590,000,000
High Speed Maglev	8	$2,960,000,000
High Speed Rail	6	$2,220,000,000

5.8 Conclusions

The results of the ridership modeling can be summarized as follows:

- The High Speed Maglev has shorter travel times than the slower Hybrid/120 mph Maglev.
- As a standalone system (no connection to the ICS System), AGS ridership is low.
- The ridership for the MOS is also low. This is true even if it is assumed the MOS runs from Breckenridge to DIA.
- When combined with the ICS System, ridership on the AGS for both the Eagle County Regional Airport to I-70/C-470 or DIA and the MOS from Breckenridge to I–70/C-470 or DIA increases to a point where it becomes more viable. It is clear that to be viable the AGS needs to be linked to the ICS System via a direct route or via transfers at DIA or the I-70/C-470 station.



ADVANCED GUIDEWAY SYSTEM (AGS) FEASIBILITY STUDY

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

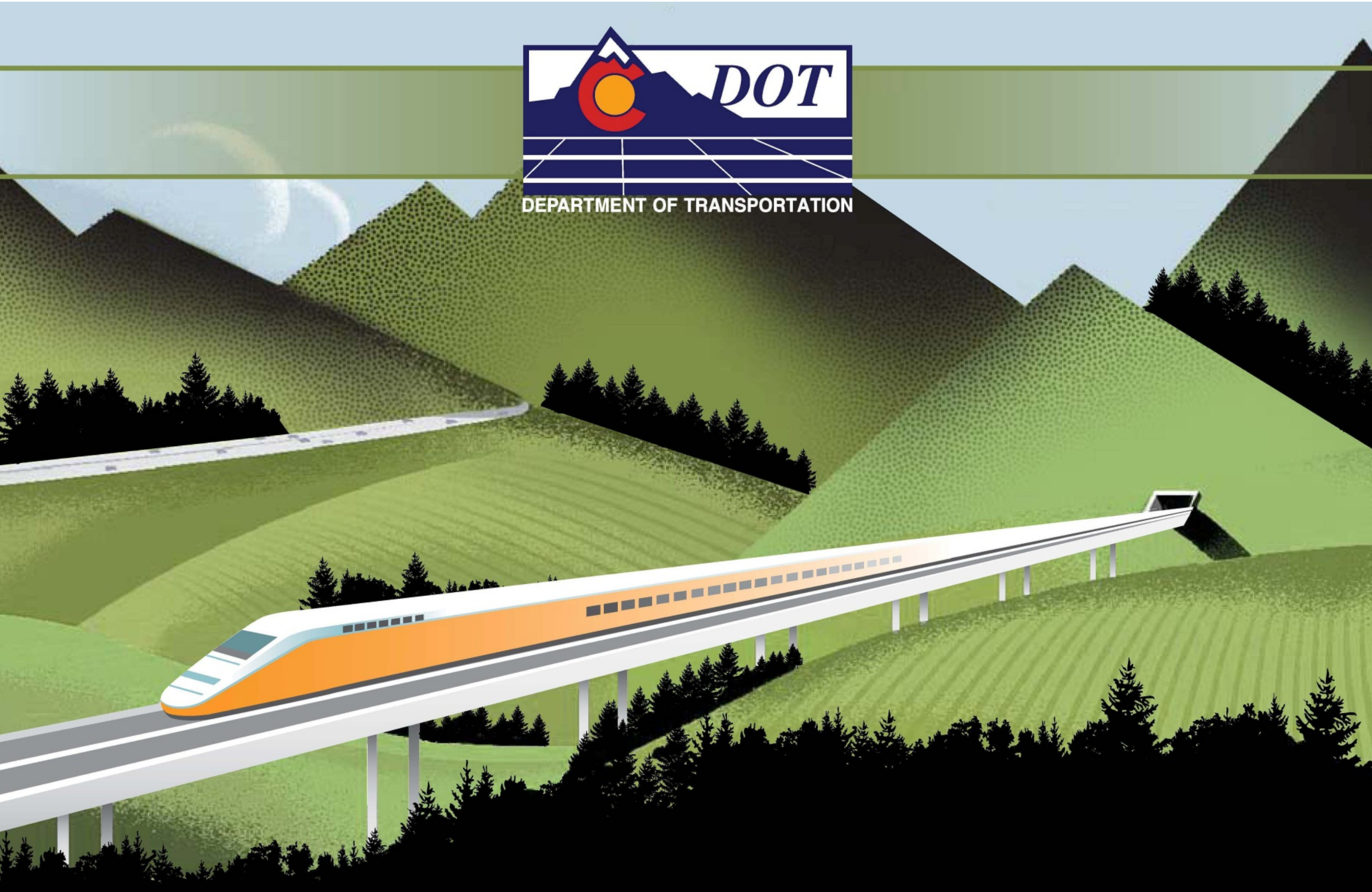
ECRA = Eagle County Regional Airport

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

DOT
DEPARTMENT OF TRANSPORTATION



ADVANCED GUIDEWAY SYSTEM (AGS) FEASIBILITY STUDY

CHAPTER 7
FUNDING AND FINANCIAL ANALYSIS

Chapter 7 Funding and Financial Analysis

The final step in assessing the feasibility of the Advanced Guideway System (AGS) is to determine if there is a way that the AGS can be funded and financed. The funding and financial analysis assessed the options for available funding streams, both those that currently exist and those that would require new funding sources. It then examined how an AGS might be financed publically with local, state, or federal funds; or as a public-private-partnership (P3).

7.1 Approach

The approach to the funding and financial analysis included the following:

- Development of capital cost requirements.
- Determination of debt service requirements.
- Identification of potential funding sources.
- Outreach to technology and financial industries.

7.2 Capital Cost Requirements

The funding and financial analysis initially focused on the lowest-cost $5.5 billion Hybrid/120 mph Maglev Minimum Operating Segment (MOS). Ultimately, three sets of capital costs were developed (two variations on the MOS and one for the Full System). The costs (year 2013 dollars) by segment are shown in Table 7-1.

Table 7-1: AGS Capital Cost Requirements

Federal Funding	Breckenridge to I-70/C-470 Hybrid/120 mph Maglev	Breckenridge to I-70/C-470 Hybrid/High Speed Maglev	ECRA to I-70/C-470 – Hybrid/High Speed Maglev
0%	$5,317,858,000	$6,801,837,000	$13,337,490,000
20%	$4,254,286,400	$5,441,469,600	$10,669,992,000
50%	$2,658,929,000	$3,400,918,500	$6,668,745,000
Capital Cost Estimates by Segment			
Capital Expenditures	$5,317,858,000	$6,801,837,000	$13,337,490,000

MOS = Minimum Operable Segment.

7.3 Debt Service Requirements

If it is assumed that CDOT (or another governmental entity) directly finances the capital costs using debt-backed by sales tax revenues (and assumes construction cost and delay risk), a debt service coverage of at least 1.2x would be required, depending on ratings targets. It should be noted that RTD currently provides a "coverage" level on its regional FasTracks sales tax of 2.48x maximum annual debt service with a 2.00x additional debt test for an AA-category rating. This means that, on an annual basis, the RTD revenues that are pledged to the bonds are 2.48 times the required debt service payments. Lower ratings commensurate with lower coverages and greater leverage would likely be targeted for the AGS because of the substantial capital need. The annual debt service numbers below are based on an investment grade rating (BBB) with an average interest rate of approximately 5.6 percent for the 30-year bonds and 5.8 percent for the 40-year bonds. Depending on the revenue source, the required debt service coverage ratios could range between 1.2 to 2.0x, meaning the required annual revenues would need to be at those multiples of the annual debt service requirements found in Table 7-2.

Based on a range of capital costs and federal funding options for the three alignment/technology pairs, one set of financial analysis was performed based on a 30-year debt term and another on a 40-year debt term. It is important to note that these numbers are based on the current year dollar estimates and do not take into consideration any escalation of capital costs. The results of the calculations are presented in Table 7-2.

Table 7-2: Annual Debt Service Requirements

Federal Funding	Average Annual Payment 30 Years	Average Annual Payment 40 Years
Breckenridge to I-70/C-470 – Hybrid/120 mph Maglev, $5.5 Billion Principal		
0%	$413,100,000	$385,802,000
20%	$330,480,000	$308,641,000
50%	$206,550,000	$192,901,000
Breckenridge to I-70/C-470 – Hybrid/High Speed Maglev, $6.8 Billion Principal		
0%	$528,378,000	$493,462,000
20%	$422,703,000	$394,770,000
50%	$264,189, 000	$246,731,000
ECRA to I-70/C-470 – Hybrid/High Speed Maglev, $13.3 Billion Principal		
0%	$1,036,079,000	$967,613,000
20%	$ 828,863,000	$774,090,000
50%	$ 518,039,000	$483,806,000

7.4 Potential Funding Sources

The AGS Study Team worked closely with a Funding and Financing Work Group to develop a list of possible funding sources for the AGS. The group was comprised of CDOT and representatives of the ICS Team, staff from CDOT's High Performance Transportation Enterprise, and representatives from the financing industry. Additional details on the work of this group can be found in Section 7.8.1.

From the list of potential sources, various preliminary, hypothetical assumptions were tested that showed the magnitude of funding that could be generated from each source. Revenue generation levels are based on a more realistic 25 percent capture rate of the preliminary revenues were calculated for comparison. This lower rate could represent a lower capture rate of the revenues or a lower tax or fee increase, i.e. a $.0625 fuel tax increase instead of a $0.25 increase. In Table 7-3, that lower number is then extrapolated out for 10 years to determine what revenues could be generated over that period. The 30-year number might be used to back a long-term financing commitment. It should be noted that since the capital costs were not escalated, no corresponding calculation was made as to how these revenue levels might change over time. Once candidate revenue/funding sources have been identified and decisions have been made about how to proceed with securing those sources, a more detailed future revenue stream calculation can be conducted.

Table 7-3: Analysis of Possible AGS Funding Sources

Source	Preliminary Assumption	1-Year Total ($M)	25% Capture ($M)	10-Year Total @ 25% ($M)	30-Year Total @ 25% ($M)	Advantages	Disadvantages
Motor Fuel Tax Increase	$0.25 per gallon increase statewide	$447	$112	$1,118	$3,353	• Existing revenue source	• More fuel efficient vehicles decreases potential funding, especially over the long-term so declining effectiveness, 30-year number likely much less • Political acceptability
New Vehicle Miles Traveled Fee	$0.01 per mile increase statewide	$393	$98	$982	$2,947	• New revenue source	• Potential high collection costs • Difficult to implement in near future • Political acceptability
Vehicle Registration Fee Increase	$100 per vehicle Increase statewide	$391	$98	$978	$2,933	• Stable revenue stream	• Dependent on vehicle sales • Political acceptability
New Utility Fee	$15 per household per month statewide	$294	$74	$735	$2,205	• New revenue source • Improved infra-structure	• Significant new systems required to collect • Political acceptability • Diversion of funds to streets and/or other sectors
Sales Tax Increase	1% increase in a 16-county study area	$572	$143	$1,430	$4,290	• Has been accepted politically in the past, such as for	• Regressive • Referendum may encounter opposition due to previous increases

Table 7-3: Analysis of Possible AGS Funding Sources

Source	Preliminary Assumption	1-Year Total ($M)	25% Capture ($M)	10-Year Total @ 25% ($M)	30-Year Total @ 25% ($M)	Advantages	Disadvantages
						FasTracks program	• Direct competition with FasTracks in Denver metropolitan area
Property Tax Increase	2 mills increase in 16-county area for cities and counties	$200	$50	$500	$1,500	• Existing revenue generation method • TIF financing	• Significant legal hurdles • Significant competition with schools and local government initiatives
Income Tax	1% increase in 16-county study area	$1,044	$261	$2,610	$7,830	• Strong and stable revenue stream	• Political acceptability very difficult • Significant competition from a wide array of other government needs
Lodging Tax	1% of current statewide lodging spending	$26.50	$6.63	$66	$199	• Mostly impacts out-of-state visitor • Non-obtrusive	• Hotel and tourism industry may lobby against • Relatively small revenue source
Lottery	Reallocation of 10% of existing lottery program profits	$11	$2.75	$28	$83	• Voluntary • Election not required	• Historically, lottery funds have been 100% committed to other expenditure categories
Developer Fee	$10,000 per new residence & 1% fee on commercial development	$169	$42	$423	$1,268	• Politically acceptable • Election not required • Taxes future residents	• Raises costs to new buyers • Construction and home building industry may lobby against • Very difficult to finance based on speculative future development

Other possible funding sources that were considered, but are not represented above, because they were considered to not generate sufficiently robust revenues or were politically infeasible include:

- **Lift ticket taxes** – This would not generate a significant amount of funding, and it is not likely to be considered acceptable to the ski area operators because it would make Colorado lift ticket prices less competitive with those in other states. Further, the fluctuations in numbers of ski area visitors may make this an inconsistent source of funding.
- **Airline ticket surcharges** – According to the Denver International Airport's (DIA) 2012 Annual Financial Report[1], in 2012 about 53.2 million passengers were served at DIA. Of these, about 55.3 percent originated or terminated their air travel at DIA. This equates to about 29.4 million passengers. A $1.00 per ticket charge would generate only $882 million over a 30-year period, which is sizable, but insufficient as a stand-alone funding source for the AGS. Also, there is considerable competition for airport revenue sources.

As can be seen, relatively few funding sources have a significant ability to generate billions in revenue and provide the necessary funding levels needed for the AGS. Also, any increases in these taxes and fees would compete with other programs seeking increases in these same funding sources, and there is no assurance that they would be supported by elected officials or the public.

7.5 Local Funding Sources

There are several ways that local counties, cities, and towns could help fund the AGS. They include:

- **Capturing the value of the stations through tax-increment financing (TIF)** – TIF and similar value capture strategies are public financing methods used as a subsidy for redevelopment, infrastructure, and other community-improvement projects in many countries, including the United States (U.S.). TIF uses future gains in taxes to subsidize current improvements that are projected to create the conditions for the future gains. In the case of the AGS, completion of the stations would result in an increase in the value of surrounding real estate, which would then generate additional tax revenue. Sales tax revenue may also increase, and jobs may be added; however, these factors and their multipliers usually do not influence the structure of TIF.
- **Funding or paying for the stations** – The counties, cities, or towns could fund the construction of the stations out of existing sources of local funds. Including contingencies, stations average about $220 million of the total cost of the various

[1] http://business.flydenver.com/stats/financials/reports/2012_finrpt.pdf.

alignment/technology pairs, or roughly in the range of $23.6 to $39.3 million per station.

- **New local sales taxes, property taxes, or fees** – These would be in addition to any other taxes specifically identified for the AGS.

7.6 State Funding

The total budget of the State of Colorado was $24 billion in 2014. The annual CDOT budget is about $1.1 billion[2]. With a required debt service of between $193 million and over $1 billion, capital costs for a project of this size would seriously impact the capacity of CDOT to meet its major maintenance, capital investment, and operations responsibilities. Long-term debt service alone would consume between 18 and almost 100 percent of the total CDOT budget. In its most recent budget year, the CDOT budget is already fully allocated to existing operations, maintenance, and debt service needs leaving no capacity for system expansion capital projects. Going forward, there is a statement in the 2013-2014 budget that there is limited additional capital funding expected to be available in the future.[3] While financing the AGS project with long-term bonds would ease near-term cash requirements, CDOT's budget does not have the capacity to pay the substantial required debt service for 30 to 40 years.

7.7 Federal Funding

Although the development of alternative transportation technologies, such as high-speed rail or maglev, has enjoyed federal policy support, funding has been sporadic and constrained. Over the near to medium term, federal funding is expected to be limited given the constraints facing the Highway Trust Fund (HTF), which is further constrained by deficit reduction initiatives. In recent years, the HTF has become dependent upon transfers from the General Fund to support funding for the federal highway and transit programs, and funding levels are not assured from year to year. Current prospects for raising the federal motor fuel tax are unlikely. Further constraints are placed by the increasing motor vehicle fuel efficiency, which while providing important environmental and energy independence benefits, will further contribute towards a flat or declining trend for motor fuel tax revenues. The United States Energy Information Administration projects in its 2013 Annual Energy Outlook[4] that average fuel efficiency will increase 2 percent annually through 2040, with a corresponding gasoline fuel consumption decline by 0.9 percent annually over this period.

As mentioned, although motor fuel tax revenues have been impacted by challenging economic conditions and improving motor vehicle fuel efficiency, federal officials have taken actions to provide supplemental resources to support transportation funding. MAP-21 provides $18 billion in General Fund transfers to the HTF. Although these efforts to provide

[2] Colorado Department of Transportation – Fiscal Year 2014 Final Budget.
[3] Colorado Department of Transportation – Fiscal Year 2014 Narrative Budget.
[4] http://www.eia.gov/forecasts/aeo/er/index.cfm.

additional resources demonstrate the importance of sustained transportation funding to policy makers and elected officials under a challenging financial environment, resource constraints are expected to continue. With sequestration, this presents an even greater challenge for securing federal funds.

The Congressional Budget Office estimates the HTF will require substantial external support just to maintain the existing Federal Highway Administration and Federal Transit Administration programs at current levels. This does not take into consideration new programs, such as for the Federal Railroad Administration (FRA), which would be necessary to expand the high-speed transit initiative and provide needed funding for such projects as AGS. As a result, federal spending priorities, without a significant increase in funding, will remain focused on state of good repair of the existing transportation network with selected system expansions.

Although this poses a challenge for the AGS, CDOT could potentially attract federal funding by a demonstrating strong state, regional, and local financial commitment to the project. A demonstrated commitment would provide the foundation for seeking federal and private funding/financing.

CDOT would likely be eligible to apply for certain federal loan programs, such as the Transportation Infrastructure Finance and Innovation Act (TIFIA) or the Railroad Rehabilitation and Improvement Financing (RRIF) loan, to finance a portion of the AGS capital costs at an attractive interest rate equivalent to long-term treasuries and flexible repayment terms. However, these are loans that must be repaid, not a grant. Given the magnitude of the AGS capital costs, it is highly unlikely CDOT would secure a loan amount equal to the 33 to 49 percent of project costs allowable under TIFIA. Based on the financing of other projects, a TIFIA loan would likely be in the magnitude of $500 million to $1 billion so long as the AGS meets TIFIA's project and creditworthiness requirements. Project readiness is a critical component for receiving TIFIA approval, so the AGS would need to have completed environmental approvals and have funding sources in place prior to submitting an application.

Given the lack of any federal programs that could provide 100 percent funding for the AGS, the starting point for discussion for an appropriate ratio of federal funding would be within the range of 0 to 50 percent. The reality of current federal budget debates could greatly impact the funds available for AGS. A reauthorization of the federal transportation budget with significant rail funding would be required for any federal sources to be potentially available.

7.7.1 Federal Funding Programs

New Starts Funding

Under current law, the Federal Transit Administration has funds available for major transit projects under the MAP-21 Fixed-Guideway Capital Investment Grants Program (5309), also known as New Starts/Small Starts. The program provides grants for new and expanded rail, bus rapid transit, and ferry systems that reflect local priorities to improve transportation options in key corridors.

Depending on its final design, alignment, and economic and environmental impacts, the AGS could be eligible for some funding under New Starts. To be successful in receiving New Starts funds, the AGS would need to meet the program criteria, including justifying the project through mobility improvements, environmental benefit, cost-effectiveness, operating efficiencies, transit-supportive land use/future patterns, and economic impacts. CDOT or a similar state-created entity would also need to demonstrate a strong local financial commitment to the AGS.

New Starts Program Positives

The New Starts program represents a source of federal project funding that would require no repayment by CDOT. The AGS meets the intent of New Starts because it originates from a regional multimodal transportation planning process. The congestion relief criterion could be beneficial for the AGS.

New Starts Program Negatives

Only $1.9 billion in total funds were available for New Starts funding in 2013. The AGS would traditionally follow the three-phased project development requirements of New Starts—Alternatives Analysis, Preliminary Engineering, and Final Design. This is not consistent with a P3 concession approach (if that is the approach pursued) and would require special accommodations from FTA similar to what was received for the RTD FasTracks Eagle P3 project.

The FTA is currently reviewing new rules for the New Starts program. The new project funding criteria may work against the AGS being successful in receiving funding because of a new focus on 'fix-it-first,' or maintaining current systems before building new systems. The new criteria are also focused on new trips generated. Further, the non-urban portions of the AGS are unlikely to be candidates for FTA funding. Finally, there would be a significant burden of proof placed on CDOT or similar state-created entity to substantiate the need for infrastructure that duplicates some of the Eagle P3 project's service.

FRA High-Speed Rail

The FRA supports the development of passenger rail and high-speed passenger rail throughout the U.S. While the FRA has had programs in the past for the development of a passenger rail network in the U.S., the High Speed Intercity Passenger Rail Program has gained the most interest. This program is reviewed below because none of the other FRA programs are accepting funding applications at this time according to the FRA website[5]. Any decision that federal funds will be available to CDOT will need to consider the likelihood and level of possible future funding for high-speed rail.

High-Speed Rail Positives

Beginning in 2009, the High Speed Intercity Passenger Rail Program was implemented to give 80 percent of Americans access to high-speed rail within the next 25 years. A total of $10.1 billion was made available for high speed rail development and rail improvements, which illustrates a major commitment to this type of transportation.

High-Speed Rail Negatives

Nearly 99 percent of the $10.1 billion available for high-speed rail development has been obligated. Colorado received a total of $1.4 million for the *Colorado State Freight and Passenger Rail Plan* prepared in 2012 and the *Interregional Connectivity Study*. It is unlikely that additional funds will be made available under this program without the Passenger Rail Investment and Improvement Act of 2008 (PRIIA) reauthorization.

7.8 Industry Outreach and Involvement

The two main outreach activities related to the financial analysis are described in this section.

7.8.1 Funding and Financing Work Group Meetings

A Funding and Financing Work Group held three meetings in collaboration with the ICS Team and the High Performance Transportation Enterprise financial consultants to develop possible financing/funding strategies. The goal of the Funding and Financing Work Group was to evaluate and recommend the most viable funding alternatives available to the AGS for project delivery. To achieve this goal, the Work Group:

- Determined which viable funding alternatives should be included in its report.
- Developed evaluation methods and reported the results of the evaluations of the alternatives, including an assessment of funding alternative options and considerations for the most viable options.
- Developed strategies for passing a vote for new tax funds, including whether these should be combined with other infrastructure projects.
- Implemented strategies for including input from the AGS PLT.

The final result of the Working Group's activities was a set of recommendations for the funding and financing of the AGS that was issued to the AGS PLT during the development of

5 http://www.fra.dot.gov/Page/P0021

the Request for Statements of Financial Information (RFSOFI). The funding and financing recommendations were included in the RFSOFI.

7.8.2 Request for Statements of Financial Information (RFSOFI)

CDOT issued a RFSOFI on May 17, 2013, and responses were received on June 28, 2013. The RFSOFI solicited Statements of Financial Information (SOFI) from the financial community, which included public-private partnership concessionaires/developers, and financiers. Technology providers, constructors, and operators were also included. The RFSOFI is included in Appendix J.

The stated goal of the RFSOFI was to establish if there were one or more feasible financial alternatives to fund or implement an AGS by 2025, as prescribed by the *I-70 Mountain Corridor PEIS Record of Decision*. The SOFIs were to address the financial feasibility of the AGS, as developed using the technologies that each technology provider had proposed in their SOTI. The RFSOFI noted that the AGS Study Team had completed capital cost estimates for the various alignment and technology alternatives that had been provided under the SOTI.

SOFI Response Summary

The following six technology providers submitted SOFIs.

- Colorado MAGLEV Group
- Maglev Trans
- Owens Transit Group, Inc.
- Public Personal Rapid Transit Consortium
- SkyTran Incorporated (only responded to Section 2)
- Swift Tram, Inc.

The compiled responses and the conclusions regarding them are summarized in the following sections, along with input gained from members of the concession and financial community. Included in Appendix K is a detailed analysis of the responses.

Respondents' Financial Background

The respondents were all technology providers who had previously responded to the RFSOTI. Because none of the respondents were concessionaires or financial providers, follow-up discussions were held with various members of the financial community. The concessionaires/ financial providers indicated their reluctance to respond because the AGS is in the early stage of development, and key issues surrounding technology, demand, constructability and funding had not yet been defined. They were unwilling to submit on a purely speculative basis because the submittals would reflect on their reputation in the industry.

This lack of responses emphasizes that securing and demonstrating state, regional, and local financial commitment for AGS is essential to attracting the attention of the private sector. It is also essential to obtaining federal funds. Additional activities needed to further the AGS such as a Tier 2 NEPA analysis, acquisition of right-of-way, and definition of the project sponsor (CDOT, entity like RTD, or other) with authorized funding sources are needed to establish a credible financial plan. Once a detailed and credible sponsor's base case financial plan is proposed (with the details of the state and local funding strategy), the private sector will have more information and be more inclined to provide meaningful feedback.

SOFI Responses on Funding and Financing Components

Responders were asked to provide recommendations regarding the funding streams needed for successful financing of AGS. Their responses are categorized by type of funding/financing, and in many cases reflect a wide range of opinions and approaches.

Federal Funding Opinions & Approaches

- 50 percent federal funding match with a 50/50 chance for future high-speed rail funding being approved for appropriation.
- Federal funding for the project must only be 2 percent of project costs to cover due diligence, legal, establishment, and commitment fees.
- CDOT must underwrite 100 percent funding for the AGS (0 percent federal funding).
- Federal funding is not required for the AGS, but bonds issued for the project would be secured by the federal government under the America Fast Forward program.
- AGS is not a New Starts candidate and other federal funding is unlikely.
- AGS is a good candidate for several federal funding sources, including MAP-21 Formula Programs, Department of Energy energy-efficiency in transport grants, and FRA grants.

Additional Public Funding Opinions and Approaches

- Special transportation district assessment.
- Self-taxing economic development zones around stations.
- Savings from highway lanes not developed redeployed into state funding payments.
- Gasoline tax.
- Vehicle Miles Traveled tax.

Opinions and Approaches Regarding Other Project Revenue Sources

- Station development and other fees.
- High-value freight, light freight.
- Leased telecommunication fiber space, other telecommunication revenue.
- Solar and wind power generation.

- Rights of the gravel generated during construction and development rights, value of removed materials during construction.
- Transmission of power and telecommunications along the right-of-way.
- Station naming rights, advertising in stations.

Financing Opinions and Approaches

- Concessionaires and market participants are highly unlikely to accept farebox and travel demand risk.
- Concessionaires and market participants will rely on only a portion of fare revenues given the uncertainties regarding demand and technology risk which may interfere with the reliable operation of AGS service.
- Financing of the project will need to be supported by one or more predictable revenue sources derived from broad-based tax sources such as a sales tax, income tax and/or motor fuel or vehicle tax.

SOFI Conclusions

- The level of federal funding potentially available for high-speed transit systems is highly speculative at this time.
- At this time it is unclear which agency would control a new generation technology such as maglev – it is most likely to be the FRA.
- While some additional revenues beyond the farebox could be generated from the project, they are unlikely to provide material support for the AGS.
- Substantial new public revenues from one or more predictable revenue sources are needed for capital costs, as well as potentially for a portion of operations and maintenance (O&M) plus long-term renewal and replacement (R&R).
- The required revenues will need to be broad-based tax sources (sales tax, income tax and/or motor fuel or vehicle tax) requiring public vote of to impose tax and issue debt.

Responses on Financing Capacity

SOFI Responses

- With adequate preparation, there is no reason to believe the financing of the AGS cannot be achieved, but more study is needed.
- If 100 percent backed by sovereign credit rating of S&P A-/Moody's A3, the Capital Lease Infrastructure Program can provide an absolute dollar amount of $3.9 billion, dependent on the current return on investment. All options described in the AGS RFSOFI would be impossible to fund. The project must generate minimum 7 percent return after stabilization for it to be considered fundable.
- Under one proposed model, the project would be funded through small, community specific builds and special purpose authorities resulting in lower costs.

- A recommendation was made that bonds be based on dedicated revenue sources with an estimated need of $7.222 billion, or 87.7 percent of the total construction budget.

Financial Industry Responses

- Given the magnitude of the AGS project costs for either the Minimum Operable Segment (MOS) or the Full System, it is likely that the financing will need to be staged over a period of time to allow the market to absorb the transaction and to ensure the cost-effectiveness of the financing.
- In today's market, large public transit deals financed in the tax exempt markets are typically no more than $1 billion. This could potentially be extended to as much as $2 to 3 billion with exceptionally strong commitments and revenue sources.
- To maximize the available financing, it is preferable that several debt and credit structures be used to attract broad market participation and maximize investor interest.
- For a potential P3 like the AGS, private activity bonds would be a viable option, such as those used for the Eagle P3 project.

Critical Security Features for Cost-Effective Financing

- The preferable structure is a design-build-operate-maintain contract that provides fixed-price/fixed-schedule construction contract with appropriate incentives and disincentives to ensure the on-budget/on-time completion of the project, as well as predictable annual operations and maintenance costs.
- Ridership and fare revenue risk will be expected to be retained by the public sponsor and is not an element of the financing.
- Availability payments would be expected to secure the debt and pay O&M, future R&R, capital expenditures, and other project-related expenses. These payments must be derived from a predictable, creditworthy source, such as a sales tax.
- Availability payments would provide sufficient coverage to address potential cash flow and project performance variability. Since availability payments are predictable if they are derived from stable sources that have a collection history and the amounts paid are clearly defined in the concession agreement, minimum debt service coverage ratios as low as 1.20 could be reasonable if a very high-quality bond rating could be achieved, or they may require higher coverage ratios, as was the case for RTD's Eagle P3 financing (1.56x minimum on the Private Activity Bonds of $398 million).
- The terms and conditions under which the availability payment is provided to the concessionaire must be clearly defined in the concession agreement and the documents governing the debt.

- The debt structure is likely to require reserves to provide liquidity in the event of disruption of the availability payments—these would include a debt service reserve fund, an O&M reserve, and R&R/mandatory capital expenditure funds.
- The selected concessionaire must have the necessary experience and expertise to design, construct, operate, and maintain the project.

Conclusions

- There are significant challenges to achieving financing at the level of $3 billion or greater.
- The maximum level of financing requires a significant level of government backing, plus a very strong revenue stream. Any financing will require minimum debt service coverage ratios of at least 1.2x, but more likely at higher levels.
- Up-front grants will need to be in place for a significant portion of project costs.
- There will be significant perceived risks by the financial community if the selected technology is unproven.

Responses on Financing Cost

SOFI Responses

- A broad range of responses advocated that the project be 100 percent underwritten by CDOT.
- Other responses were well below known government financing costs of 3 to 4 percent.

Financial Industry Responses

- The financing costs will depend upon the credit, term, and tax status of the bonds issued.
- It is important that the plan of finance include sufficient cushion to accommodate potential market volatility.

Conclusions

- The ultimate financing costs depend on credit, term, and tax status of debt.
- The plan of finance must include sufficient cushion (i.e., coverage ratio) to create a financing structure that is acceptable in the marketplace.
- Current interest rates remain close to historic lows; long-term tax exempt rates are approaching a ten-year average.
- 30-year maturity for an AA tax exempt credit as of July 22, 2013, 4.46 percent; 5.34 percent for BBB.
- Private debt has higher interest rates even when using Private Activity Bonds – up to 200 basis points and equity returns of usually 12 percent or higher.
- The annual debt payments provided assumed true interest cost of 5.628 percent for 30-year debt and 5.839 percent for 40-year debt.

SOFI Responses on Recommended Term

Responses on the recommended term varied from 20 to 99 years. The general financial industry consensus is that for private financing an optimal concession term for the public agency is probably 50 years. If it is a tax-exempt financing, the likely term is 30 to 40 years.

SOFI Responses on Availability Payment Structure

Availability payment structures are the most likely approach for a transit project. This is a financing approach where the private sector issues the debt for a project, but the repayment is guaranteed by regular payments from the public partner.

- Responses varied and included supporting the approach, supporting it with construction milestone payments with a preference for design-build-finance; and one firm did not support this approach.
- This approach would likely require substantial milestone payments to the concessionaire during the construction phase to buy down the amount of long-term debt to a financeable level.
- Recent financing activity for P3 availability payment structures in the U.S. are requiring substantial milestone payments. Recent examples have seen 51 to 69 percent of design-build cost, meaning as the net amount financing varies from 49 to 31 percent.

SOFI Responses on General Terms

A well-defined and committed funding strategy of federal, state, regional and/or local revenues is needed to attract both private sector and federal interest. As AGS is further developed, it is recommended that CDOT or the designated governance entity craft a more specific financing assumption in a sponsor's case financial plan. This plan would define its strategy for funding, financing, and implementation on a year-by-year basis.

SOFI Responses on Recommendations on Governance Structure

There was no consensus on the most appropriate governance structure. Responses ranged from full control by CDOT to a fully privatized model.

SOFI Responses on Recommended Delivery Structure

There was general consensus on the P3 delivery structure, including financing capital plus O&M components, based on a private delivery model with guaranteed payments from the public sector. One firm recommended splitting the capital and O&M components as different risk pools.

SOFI Responses on Technology Selection

Because the respondents were technology providers, each of them advocated their own technology solution. The financial community wants proven technology that does not present a material constructability risk/failure to perform. The use of availability payments further emphasizes technology risk because payments are often not made until a project is available for use.

Responses on Roles and Responsibilities

The RFSOFI divided this question into which roles/risk should be transferred to the private sector partner and which roles/risks the public sector should retain. The resulting recommendations covered a range of ideas.

SOFI Responses

- The private sector is willing to take responsibility for design, engineering, construction cost, schedule, O&M; assuring operating performance; closing the necessary financing; and adhering to the budget for delivery of the AGS.
- The public sector should provide the necessary revenues and funding to support the capital costs because these will belong to the public sector. The public sector partner should also take responsibility for achieving environmental approvals, assembling needed right- of- way, and obtaining the necessary legal authorities to implement the procurement and deliver the project.
- One responder suggested the following would be risks shared between the public and private sector: utilities costs, right-of-way, hazardous materials, security, public relations, marketing, financing, farebox rates, and force majeure.
- The respondents suggested that the public sector should manage system specification, change in scope, environmental approvals and ridership projections.

Financial Industry Responses

- The private sector must have sufficient payment guarantees to obtain necessary bank or capital markets financing.
- Any scenario that requires the private sector to take revenue risk will increase the cost of private financing.
- The private sector will require clear design, build, operations and maintenance criteria to maintain control over the delivery of the project.

SOFI Responses on Revenue Generation Risk – Fare Box

There was no consensus on this aspect. One group of respondents would “require” the control of farebox pricing. Others would retain excess fares but require CDOT guarantees of debt in case of a fare revenue shortfall. Others insisted this risk should be fully on CDOT.

SOFI Responses on Revenue Generation Risk – Other Revenue Streams

This is another response that resulted in a wide range of opinions. One group required control of station rents and freight rates. Some would retain excess revenues as long as CDOT underwrites all revenue shortfall. Some gave general statements on possible revenue streams but no specifics on conditions.

SOFI Responses on Project Components

The respondents were asked to comment on whether including the AGS with either future managed lanes or tolls on I-70 would be beneficial. They were also asked if the AGS and the ICS System should be combined. The following summarizes their responses.

- Two respondents recommended AGS and highway project should be coupled.
- One respondent suggested an option of first right of refusal to undertake the highway project if the AGS provides insufficient congestion relief.
- One respondent stated that tolls on I-70 are not necessary.
- Two respondents indicated that they did not see any synergies between the ICS System and AGS.
- One respondent would require a first right of refusal on the ICS System.
- One respondent indicated that the projects should be combined as one if it makes both projects more feasible.
- One respondent said any combination could be beneficial.

7.8.3 Key Takeaways from the SOFI Responses and Financial Industry Input

- There is no clarity on what constitutes realistic expectations for federal funding.
- There is very little potential for project-generated revenue sources.
- No consensus was provided on the requirements for additional public funding.
- SOFI respondents were not able to provide meaningful responses on financing capacity.
- Many respondents were not able to provide meaningful input as to financing costs.
- The recommended term ranges from 20 to 99 years.
- There was general support for availability payment structure.
- There was a broad range of views on appropriate terms and conditions.
- The governance question resulted in a broad range of responses.
- The technology solution input was not meaningful because each SOFI respondent was pushing their own specific technology solution.

7.9 Financing Analysis

As a supplement to the information received from the respondents, two sets of financing analysis were prepared for the three alignments—a 30-year debt term (Table 7-4) and a 40-year debt term (Table 7-5), with varying levels of federal grant funding. While the financial community indicated that a 50-year term would be optimal, current market conditions indicate that a 40-year debt term would be the maximum available at this time for such a large financing.

When reviewing the results of the analysis, it is important to note that the amount of Total Bond Proceeds shown includes the funds needed to pay back the capital costs plus interest, as well as the costs to issue and underwrite the bonds. It is also important to note that these results do not include the costs associated with funding the shortfall between farebox revenues and O&M costs for the MOS or the expected surplus revenue likely to be generated by the Full System.

Table 7-4: AGS Financing (30-Year Scenario)

	0% Federal Grants	20% Federal Grants	50% Federal Grants
Breckenridge to I-70/C-470 – Hybrid/120 mph Maglev, $5.5 Billion Principal			
Total Bond Proceeds	$ 5,949,265,000	$ 4,759,410,000	$ 2,974,633,000
Bond Proceeds Project Fund Deposit	$ 5,317,858,000	$ 4,254,286,000	$ 2,658,929,000
Debt Service Reserve Fund	$ 584,634,000	$ 467,707,000	$ 292,317,000
Cost of Issuance	$ 17,539,000	$ 14,031,000	$ 8,770,000
Underwriter's Discount	$ 29,232,000	$ 23,385,000	$ 14,616,000
Average Annual Debt Service	$ 413,100,000	$ 330,480,000	$ 206,550,000
Total Debt Service - 30 Years	$ 12,393,002,000	$ 9,914,402,000	$ 6,196,509,000
Breckenridge to I-70/C-470 – Hybrid/High Speed Maglev, $6.8 Billion Principal			
Total Bond Proceeds	$ 7,609,442,000	$ 6,087,553,000	$ 3,804,724,000
Bond Proceeds Project Fund Deposit	$ 6,801,837,000	$ 5,441,470,000	$ 3,400,919,000
Debt Service Reserve Fund	$ 747,780,000	$ 598,224,000	$ 373,890,000
Cost of Issuance	$22,433,000	$ 17,947,000	$ 11,217,000
Underwriter's Discount	$ 37,389,000	$ 29,911,000	$ 18,695,000
Average Annual Debt Service	$ 528,378,000	$ 422,703,000	$ 264,189,000
Total Debt Service, 30 Years	$ 15,851,346,000	$ 12,681,085,000	$ 7,925,681,000
ECRA to I-70/C-470 – Hybrid/High Speed Maglev, $13.3 Billion Principal			
Total Bond Proceeds	$ 14,921,092,000	$ 11,936,874,000	$ 7,460,546,000
Bond Proceeds Project Fund Deposit	$ 13,337,490,000	$ 10,669,992,000	$ 6,668,745,000
Debt Service Reserve Fund	$ 1,466,295,000	$ 1,173,036,000	$ 733,148,000
Cost of Issuance	$ 43,989,000	$ 35,191,000	$ 21,994,000
Underwriter's Discount	$ 73,315,000	$ 58,652,000	$ 36,657,000
Average Annual Debt Service	$ 1,036,079,000	$ 828,863,000	$ 518,039,000
Total Debt Service, 30 Years	$ 31,082,368,000	$ 24,865,892,000	$ 15,541,177,000

Table 7-5: AGS Financing (40-Year Scenario)

	0% Federal Grants	20% Federal Grants	50% Federal Grants
Breckenridge to I-70/C-470 – Hybrid/120 mph Maglev, $5.5 Billion Principal			
Total Bond Proceeds	$ 5,953,806,000	$ 4,763,045,000	$ 2,976,906,000
Bond Proceeds Project Fund Deposit	$ 5,317,858,000	$ 4,254,286,000	$ 2,658,929,000
Debt Service Reserve Fund	$ 588,838,000	$ 471,070,000	$ 294,419,000
Cost of Issuance	$ 17,665,000	$ 14,132,000	$ 8,833,000
Underwriter's Discount	$ 29,442,000	$ 23,554,000	$ 14,721,000
Average Annual Debt Service	$ 385,802,000	$ 308,641,000	$ 192,901,000
Total Debt Service, 40 Years	$ 15,432,070,000	$ 12,345,655,000	$ 7,716,059,000
Breckenridge to I-70/C-470 – Hybrid/High Speed Maglev, $6.8 Billion Principal			
Total Bond Proceeds	$ 7,615,245,000	$ 6,092,197,000	$ 3,807,625,000
Bond Proceeds Project Fund Deposit	$ 6,801,837,000	$ 5,441,470,000	$ 3,400,919,000
Debt Service Reserve Fund	$ 753,156,000	$ 602,525,000	$ 376,578,000
Cost of Issuance	$ 22,595,000	$ 18,076,000	$ 11,297,000
Underwriter's Discount	$ 37,658,000	$ 30,126,000	$ 18,829,000
Average Annual Debt Service	$ 493,462,000	$ 394,770,000	$ 246,731,000
Total Debt Service, 40 Years	$ 19,738,474	$ 15,790,792	$ 9,869,235,000
ECRA to I-70/C-470 – Hybrid/High Speed Maglev, $13.3 Billion Principal			
Total Bond Proceeds	$ 14,932,475,000	$ 11,945,984,000	$ 7,466,237,000
Bond Proceeds Project Fund Deposit	$ 13,337,490,000	$ 10,669,992,000	$ 6,668,745,000
Debt Service Reserve Fund	$ 1,476,837,000	$1,181,470,000	$ 738,419,000
Cost of Issuance	$ 44,305,000	$ 35,444,000	$ 22,153,000
Underwriter's Discount	$ 73,842,000	$ 59,074,000	$ 36,921,000
Average Annual Debt Service	$ 967,613,000	$ 774,090,000	$ 483,806,000
Total Debt Service, 40 Years	$ 38,704,506,000	$ 30,963,611,000	$ 19,352,253,000

7.10 Key Considerations for Financing AGS

Regardless of whether financing of the AGS is accomplished through taxable or tax-exempt financing, the following would apply:

- Some level of up-front payments would be required during the construction period. On some recent P3 projects, the up-front payments (commonly known as milestone payments) have ranged from 33 to 52 percent of total project costs and from 51 to 69 percent of design and construction costs.
- A limit would apply on the absolute amount of funds that could be financed, both on the public financing/bonding side, as well as the private financing side.

- A definitive and reliable funding stream would be required to be in place to repay the debt. For a transit financing, this would typically be government taxes that might be supplemented by dedicated user fees.
- Capital markets financings require ratings from at least one of three rating agencies: S&P, Moody's, and/or Fitch.
- "Private" financing rates would apply for a project structured as Design-Build-Finance-Operate-Maintain. The equity portion is likely to be in the range of 20 to 25 percent. The remainder would be taxable bonds, bank debt, Private Activity Bonds, and/or TIFIA. Equity carries the highest return, at least 12 percent interest.
- The most likely structure for a concession would be an availability payment structure with milestone payments during the construction period.

7.11 Conclusions

As of 2014, there are no local, state or federal funds currently available for an AGS for the I-70 Mountain Corridor, and therefore it is not financially feasible at this time. Funding from local, state, and federal sources would be required to advance an AGS and to obtain financing from the private sector:

- The capital cost of the Full System AGS is estimated at $13.3 billion based on the most-developed alignment/technology pairing.
- The capital cost of the AGS MOS is estimated at $6.8 billion based on the most-developed alignment/technology pairing.
- Concessionaires/public-private partnerships could offer financing in the range of $1 to 3 billion.
- With private concession/P3 money potentially available, a gap of at least $10.3 Billion must be filled by local, state and federal dollars just to cover capital costs for the Full System AGS, or at least $3.8 billion just to cover capital costs for the MOS.

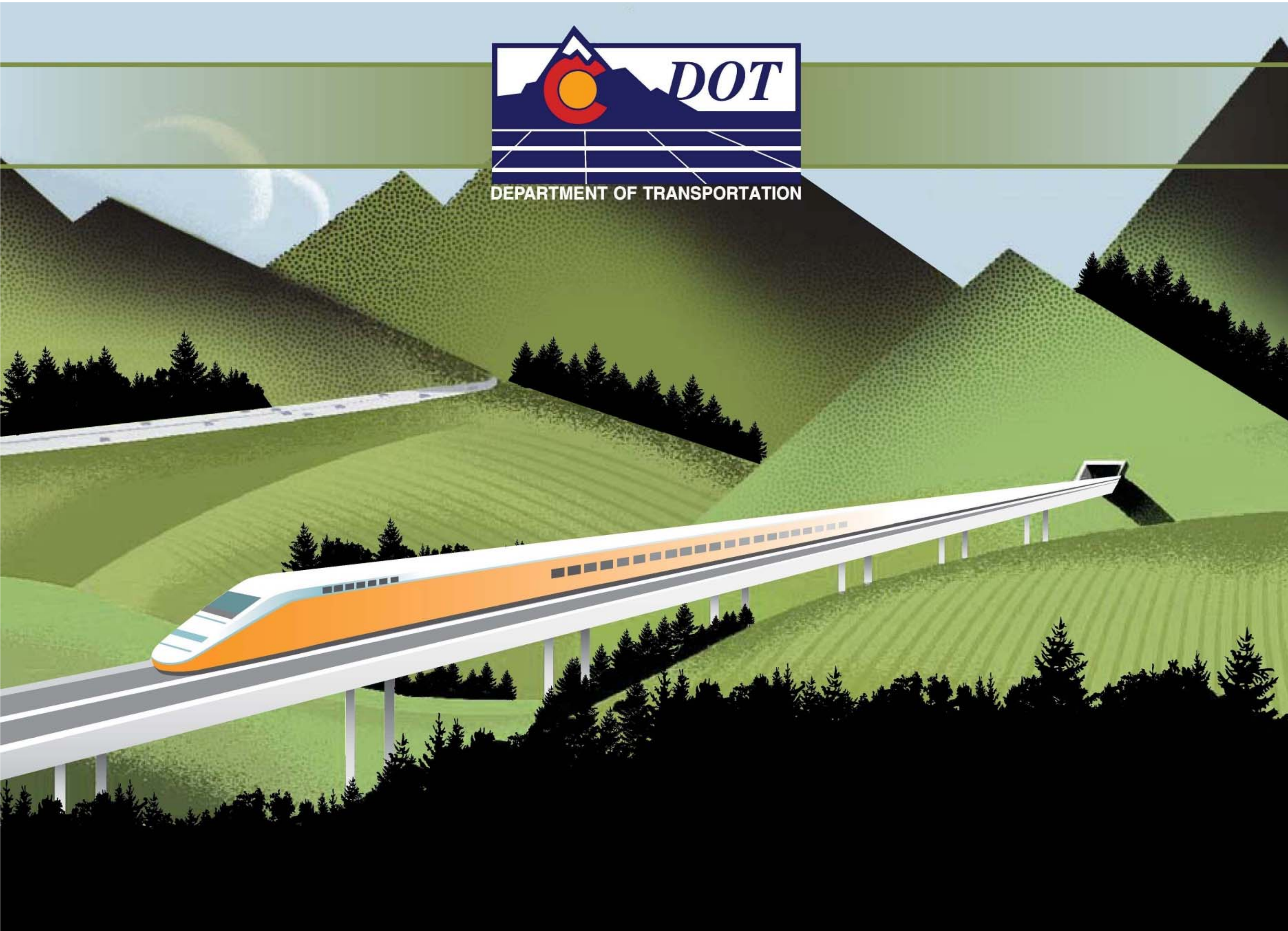
A number of outstanding actions must be accomplished before a project could be considered in the future:

- Establish governance structure.
- Complete environmental clearances.
- Acquire right-of-way.
- Secure voter approval for local/regional/state funding in the form of bonding &/or taxes.
- Obtain federal approval of technology.
- Obtain federal funding grant agreement.

In the meantime, the following can be concluded:

- The AGS currently has no identified funding for capital construction.

- The Full System, once implemented, would generate sufficient operating revenues through the farebox to pay for operations and maintenance expenses, but there would not be sufficient revenues to provide material contributions toward financing the capital costs of the project.
- The AGS MOS (Breckenridge to I-70/C-470) would not generate sufficient farebox revenue to cover O&M costs, and would require an operating subsidy. With the level of funding and financing required, the AGS MOS at estimated capital costs between at $6.8 billion is challenging as a "starter project."
- For an AGS to become fundable by 2025:
    - Substantial growth of the Colorado population and economy is required,
    - Significant support from the public for an AGS or similar high-speed transit project must be demonstrated, and
    - Significant increases in federal investment for intercity rail projects are needed.



ADVANCED GUIDEWAY SYSTEM (AGS)
FEASIBILITY STUDY

CHAPTER 8
STAKEHOLDER INVOLVEMENT

Chapter 8 Stakeholder Involvement

8.1 Introduction

The Federal Highway Administration (FHWA) defines Context Sensitive Solutions as: *a collaborative, interdisciplinary approach that involves all stakeholders to develop a transportation facility that fits its physical setting and preserves scenic, aesthetic, historic and environmental resources, while maintaining safety and mobility. Context Sensitive Solutions is an approach that considers the total context within which a transportation improvement project will exist. Context Sensitive Solutions principles include the employment of early, continuous and meaningful involvement of the public and all stakeholders throughout the project development process.*

The AGS Study Team engaged stakeholders throughout development of the Study.

During the *I-70 Mountain Corridor Programmatic Environmental Impact Statement* (PEIS), CDOT developed a Context Sensitive Solutions (CSS) process to be used on all projects within the I-70 Mountain Corridor. As used by CDOT, CSS is an approach based on the idea that transportation projects should consider the total "context" of their existence – not just the study's physical boundaries. Further, the I-70 Mountain CSS is built on a commitment to collaborative decision making that is: principle-based, outcome-driven, and multidisciplinary. The AGS Study Team extensively used the six-step I-70 Mountain Corridor CSS process in conducting the *AGS Feasibility Study* (Study). The AGS Study Team partnered with mountain corridor communities and stakeholders, using the I-70 Mountain Corridor CSS process to ensure that the direction of the Study was in line with the expectations of the stakeholders and met the requirements of the Final PEIS and *Record of Decision* (ROD).

8.2 AGS Project Leadership Team (PLT)

As required by the I-70 Mountain Corridor CSS process, CDOT formed a Project Leadership Team (AGS PLT) prior to initiation of the Study. The AGS PLT ensured that the I-70 Mountain Corridor CSS process was followed and that conclusions from the Study were developed in an open, collaborative process.

8.2.1 AGS PLT Membership

The AGS PLT was comprised of representatives of key stakeholder agencies and organizations along the I-70 Mountain Corridor. During the course of the study, some AGS PLT members were replaced, due to a variety of reasons, by others within their agency or organization. The following organizations were represented on the PLT.

- CDOT Office of Policy & Government Relations
- Club 20
- City and County of Denver
- Clear Creek County
- COPIRG
- CDOT Region 1
- Clear Creek Watershed Foundation
- Summit County
- Colorado Environmental Coalition
- Towns of Frisco, Georgetown, and Idaho Springs
- Denver Regional Council of Governments (DRCOG)
- I-70 Coalition
- Denver Metro Chamber of Commerce
- CDOT Division of Transit & Rail
- AZTEC-TYPSA
- CDOT Region 3
- Eagle County
- FHWA
- Jefferson County

8.2.2 AGS PLT Roles

The AGS PLT's primary roles were to:

Lead the Project – The AGS PLT helped identify relevant materials for the Study—such as the CSS Guidance, Final PEIS, other environmental documents, and local plans. The AGS PLT discussed the surrounding context, established project goals, and identified the actions and decisions needed to reach those goals. These elements were documented in the Context Statement for the project. In addition, the AGS PLT assisted in developing the Request for Proposals (RFP) for the Study and joined the consultant selection team. The AGS PLT also assisted in staffing Technical Committees formed to work with the AGS Study Team on a variety of technical issues.

Champion CSS – The AGS PLT ensured that the CSS Guidance, the Context Statement, the Core Values, and the 6-Step Process were integrated into the Study process. The AGS PLT had the primary responsibility for ensuring that Step 1: Define Desired Outcomes and Actions and Step 2: Endorsing the Process was determined with participation from all stakeholders. They also reviewed and endorsed the required CSS documentation, such as the Study Work Plan and associated Study Schedule, the Stakeholder Involvement Plan, and the Public Information Plan.

Enable Decision-Making – The AGS PLT approved the project-specific decision-making process for the Study. This process detailed the interaction between teams, the Stakeholder Involvement Plan, and the Public Information Plan. The AGS PLT was responsible for keeping the Study on track with each of these plans.

8.2.3 AGS PLT Meetings

A total of 18 PLT meetings were held, including 2 prior to the selection of the AGS consulting team, and 16 with the AGS Study team. Table 8-1 summarizes the meetings, the dates they were held, and the main subjects covered. Meeting agendas, presentations and meeting notes can be found at the AGS Study website: http://www.coloradodot.info/projects/AGSstudy/project-leadership-team-plt.html.

Table 8-1: AGS PLT Meeting Summary

Meeting Number	Meeting Date	Meeting Location	Subjects of Meeting
Pre-Project	6/9/2011	Frisco	Project Leadership Team, Review of Proposed Scope, Technical Advisory Teams, Schedule
Pre-Project	9/15/2011	Silverthorne	Request for Consultant Proposal, Changes to PLT, Review of PLT Commitments, Review AGS Scope of Work
1	4/11/2012	Silverthorne	PLT Roles, Responsibilities and Ground Rules, Project Overview, Critical Success Factors, Project Draft Context Statement Discussion, Project Core Values Discussion, AGS/ICS/Co-Development Project Coordination
2	5/9/2012	Frisco	Review and Endorse Context Statement, Review and Endorse Core Values, Review and Endorse Critical Success Factors, Review and Endorse Desired Outcomes and Actions, Review and Endorse Chartering Agreement, AGS/ICS/Co-Development Project Coordination
3	6/13/2012	Idaho Springs	Review and Endorse Project Work Plan & Stakeholder Involvement Plan, Review Draft System Performance and Operational Criteria, AGS/ICS/Co-Development Project Coordination
4	7/18/2012	Idaho Springs	Debrief from High Speed Rail Conference Attendees, Review Land Use & Station Criteria, Review Industry Comments on Draft System Performance and Operational Criteria, Feasibility Discussion, AGS/ICS/Co-Development Project Coordination
5	8/8/2012	Frisco	Feasibility Discussion, Review Revised Project Process, Review Changes to Draft System Performance & Operational Criteria, Update on Land Use & Station Criteria, Presentation on Local Transit System Planning, AGS/ICS/Co-Development Project Coordination
6	9/12/2012	Golden	Update on Request for Statement of Technology Information (RFSOTI), Update on Technology Forum, Update on Land Use & Station Criteria, AGS/ICS/Co-Development Project Coordination
7	11/14/2012	Eagle	Consultant Team's Review of Statements of Technology Information (SOTI), Selection of Technology Providers to Participate in Technology Forum, Planning for Technology Forum, Update on Land Use & Station Criteria Meetings, AGS/ICS/Co-Development Project Coordination
8	2/13/2013	Frisco	Technology Forum Recap & Next Steps, Update on County Land-Use Meetings, Key Themes/Issues in Developing Alignments, Funding & Financial Task Force Update, AGS/ICS/Co-Development Project Coordination
9	3/14/2013	Idaho Springs	Discussion of Preliminary Alignments, Update on Station/Land Use Meetings, Presentation on Maglev Performance, Funding/Finance Workgroup Update, AGS/ICS/Co-Development Project Coordination
10	4/10/2013	Golden	Preliminary Modeling Review, Operating Scenarios, RFSOTI. Development and Report out from Workgroup/Technical Meeting, Land Use/Station Meeting Summary & Conclusions, AGS/ICS/Co-Development Project Coordination
11	6/11/2013	Silverthorne	Presentation of Capital Cost Estimates, Operation and Maintenance Cost Estimating Process/Progress,

Table 8-1: AGS PLT Meeting Summary

Meeting Number	Meeting Date	Meeting Location	Subjects of Meeting
			Presentation of Ridership Estimates, RFSOTI Update, AGS/ICS/Co-Development Project Coordination, Steps Leading to Project Conclusion
12	7/17/2013	Denver	Ridership Modeling, Statement of Financial Information (SOFI) Preliminary Information, Cost Estimate Update, AGS/ICS/Co-Development Project Coordination
13	8/14/2013	Avon	AGS Study Findings To Date/PLT Roles & Responsibilities, Statements of Financial Interest - Detailed Review, PLT Input: Leading the Study & Enabling Decisions, Next Steps
14	9/11/2013	Idaho Springs	Summary of August Meeting / Approve Meeting Minutes, Ridership Refinements & Minimum Operable Segment (MOS) Ridership Analysis, Funding / Financial Determination, Next Steps
15	11/1/2013	Webinar	Ridership Context and Reasonableness. Summarize Third Round of County Meetings. Discussion of Study Finalization.
16	1/24/2014	Idaho Springs	Review of AGS Draft Report

8.3 CSS Documents

In the first PLT meetings, the AGS PLT was tasked with developing a number of CSS documents. They included:

- Context Statement
- Core Values
- Critical Success Factors
- Desired Outcomes and Actions
- Chartering Agreement

8.3.1 Context Statement

According to the CSS website, a *context statement seeks to capture in words the special qualities and attributes that define a place as unique. A context statement should capture in words that which was true fifty years ago and that which must be considered during the development of improvements in order to sustain truth in those same words for fifty years to come.*

The AGS PLT developed and endorsed the following Context Statement:

The I-70 Mountain Corridor is a magnificent scenic place. Human elements are woven through breathtaking natural features and ecosystems. The integration of these diverse elements has occurred over the course of time.

This corridor is a recreational and heritage tourism destination for the world and a unique place to live. It is a route of national, regional and local economic importance as both an interstate highway and an intercommunity connection.

Corridor communities are active participants in transportation considerations. A historic collaborative agreement exists for solutions in the I-70 Mountain Corridor.

The I-70 Mountain Corridor has unique engineering, operational, and aesthetic challenges, including:

- *Challenging horizontal and vertical curvature of highway and steep and lengthy grades*
- *Sensitive environmental and cultural areas*
- *Areas of potential geotechnical challenges such as rock slides, mines, faults, etc.*
- *Weather conditions unique to high mountain elevations, including periods of severe winter conditions and potential avalanches*
- *Substantial congestion variation, both weekly and seasonally*
- *Significant variation in trip purposes and party sizes; ranging from individual work trips to recreational activity trips made by families and groups*
- *Large volumes of freight transport*
- *Connecting to and through existing communities*

8.3.2 Core Values

According to the CSS website, a *Core Value describes something of significant importance to stakeholders—something they respect and will work to protect and preserve. Core Values must be honored and understood. Decisions and choices made along the I-70 Mountain Corridor should be influenced by and support the Core Values*.

The AGS PLT developed and endorsed the following Core Values:

- ***Sustainability** is an overarching value that creates solutions for today without diminishing resources for future generations. Industry solutions proposed for the AGS should endeavor to generate long-term benefits to economic strength, scenic character, community vitality, ecosystem integrity, and both energy conservation and production.*
- ***Openness, honesty, collaboration and transparency** are critically important to the credibility and ultimate endorsement of the AGS Feasibility Study's process and results.*
- ***Safety** for passengers, motorists and the public must be built into the AGS.*
- *A **healthy environment** requires taking responsibility to preserve, restore and enhance community, cultural and natural resources.*
- *The corridor's broad **historic context** is foundational to its identity. As industry develops proposed AGS solutions for the corridor, it should always respect and protect what the past has contributed to the sense of place.*
- *The individuality of **communities** must be respected in a manner that promotes their livability. The character of the corridor is realized in the differences and commonalities of its communities.*

- ***Mobility and accessibility*** *must address local, regional and national travel by providing reliability, efficiency and interconnectivity between systems and communities.*
- ***Aesthetics*** *of a successful AGS system should be inspired by the surroundings and incorporate the context of place. The system should protect viewsheds and scenic character while exhibiting timeless design that continues the corridor's legacy.*
- *The AGS System will serve as a* ***global model*** *for innovation and excellence.*

8.3.3 Critical Success Factors

According to the CSS website, "Critical Success Factors should reflect the objectives of the team in terms of project success. They should include those things that indicate success for the project and for the PLT."

The AGS PLT developed and endorsed the Following Critical Success Factors:

- *Assess the economic, environmental, technological and financial feasibility of an AGS.*
- *Investigate all pertinent AGS technologies that meet the criteria.*
- *Receive responsive proposals.*
- *PLT members understand and build on past work and accomplishments.*
- *Insuring close coordination and collaboration with ICS and Co-development project.*
- *Insure that Context Sensitive Solution is included in all aspects of the PLT process.*
- *Insuring the PLT continues to support and champion the study process.*
- *Insuring the process is consistent with Collaborative Effort criteria.*
- *Keeping local governments and representatives informed on project, sooner rather than later.*
- *Insuring the I-70 Coalition Technical Committee is properly and effectively engaged.*
- *Insure a successful public outreach program.*

8.3.4 Desired Outcomes and Actions

Although not technically a part of the CSS process, the AGS PLT developed the following Desired Outcomes and Actions:

- *Identify technologies that can meet the system performance & operational criteria.*
- *Complete AGS Feasibility Study and gain consensus on questions of feasibility, cost, ridership, land use and governance.*
- *Identify technological & financial feasibility of AGS in relationship to I-70 Mountain Corridor Record of Decision.*
- *Consistent and close coordination between AGS, ICS and Co-Development, including but not limited to a transfer-free connection to Denver International Airport.*
- *Endorsement from the local, state and federal levels for conclusions of the study document.*

8.3.5 Chartering Agreement

The AGS PLT developed and endorsed a Chartering Agreement, which can be found on the AGS Study webpage (http://www.coloradodot.info/projects/AGSstudy/study-materials.html). The Chartering Agreement included the following sections:

1. *Purpose of the AGS Feasibility Study Project Leadership Team*
2. *Established Vision and Goals for the AGS Feasibility Study*
3. *Membership and Attendance*
4. *Roles and Responsibilities*
5. *Team Performance Assessment*
6. *Discussions and Deliberations*
7. *E-mail Communication*
8. *Schedule and Milestones*
9. *Meeting Summaries*
10. *Public Coordination*
11. *Communication with Other Organizations, Individuals, and the Media*
12. *Constituent Communication*
13. *Measuring the Success of the AGS Feasibility Study Project*

8.4 Technical Committees

8.4.1 I-70 Coalition Technical Committee

Because the AGS PLT was not intended to provide technical evaluation and consultation related to the AGS, the I-70 Coalition's Technical Committee was used in that capacity. The Technical Committee was comprised of representatives of CDOT and counties and cities along the I-70 Mountain Corridor. The following organizations were represented on the Technical Committee:

- Eagle County
- Summit Stage
- Summit County
- Town of Breckenridge
- Town of Dillon
- Town of Empire
- Town of Silverthorne
- Town of Vail
- Garfield County
- Clear Creek County
- U.S. Forest Service
- CDOT

AGS PLT members routinely attended Technical Committee meetings. A total of nine Technical Committee Meetings were held. Table 8-2 summarizes the meetings, the dates they were held and the main subjects covered.

Table 8-2: Technical Committee Meetings

Meeting Number	Meeting Date	Meeting Location	Subjects of Meeting
1	6/11/12	Idaho Springs	System Performance & Operational Criteria
2	6/14/12	Idaho Springs	System Performance & Operational Criteria
3	7/11/12	Idaho Springs	Station Sizing
4	9/12/12	Golden	RFSOTI Scoring & Technical Forum
5	10/24/12	Idaho Springs	Alignment
6	11/19/12	Web Survey	Stated Preference Survey Review for Modeling
7	12/4/12	Idaho Springs	Technology Forum Questions
8	3/11/13	Frisco	Station Locations
9	3/20/13	Webinar / Conference Call	Ridership Modeling Approach & Methods

8.4.2 Funding and Financing Work Group

A Funding and Financing Work Group was formed specifically to discuss options on how to fund and finance the AGS. The Funding and Financing Work Group included representatives from the following organizations:

- ArLand Land Use Economics
- CDOT
- Jacobs
- The PFM Group
- Colorado Ski Country USA
- I-70 Coalition
- Summit County
- CH2M Hill
- Nossaman
- AZTEC-TYPSA
- Clear Creek County
- High Performance Transportation Enterprise (HPTE)

Table 8-3 summarizes the three meetings of the Funding and Financing Work Group.

Table 8-3: Funding and Financing Work Group Meetings

Meeting Number	Meeting Date	Meeting Location	Subjects of Meeting
1	1/29/13	CDOT Headquarters	Discuss Revenue Source Data, Framing of Revenue Needs, Financial Feasibility Definition, & Next Steps
2	2/28/13	CDOT Headquarters	Discuss Work Group Recommendations, Request for Statements of Financial Information (RFSOFI), Financial Feasibility Definition, Scope/Role of PLT, Federal Funding, Scope and Timing of Vote for Revenue Sources & Evaluation of Funding Options
3	4/8/13	CDOT Headquarters	Discuss AGS Funding Scenarios & AGS RFSOFI

8.5 Public Meetings

The scope of the Study did not include public meetings specifically. All AGS PLT meetings were open to the public except the meeting on November 14, 2012, that was closed to the public because of discussions of confidential information related to the Statements of Technical Information (SOTI). In general, there were between 5 and 15 members of the public at each AGS PLT meeting.

8.5.1 *Interregional Connectivity Study* Public Meetings

The CDOT *Interregional Connectivity Study* (ICS) was underway at the same time as the *AGS Feasibility Study* and was tasked with examining high-speed rail options for the Front Range from Fort Collins to Pueblo. The AGS Study Team collaborated closely with the ICS Team, and members of the AGS PLT attended ICS PLT meetings. The ICS had a series of public meetings. Although those meetings were focused on the ICS, AGS Study progress was discussed. The ICS public meetings were held as follows:

- July 16, 2012, Colorado Springs
- July 17, 2012, Pueblo
- July 18, 2012, Windsor
- July 19, 2012, Golden
- May 29, 2013, Colorado Springs
- May 30, 2013, Pueblo
- June 5, 2013, Windsor
- June 6, 2013, Denver
- June 11, 2013, Silverthorne
- November 4, 2013 Windsor
- November 19, 2013 Golden
- November 20, 2013 Colorado Springs
- November 21, 2013 Pueblo

Meeting materials for the ICS public meetings can be found at the ICS webpage: http://www.coloradodot.info/projects/ICS.

8.6 County Land Use / Station Meetings

Prior studies conducted for the I-70 Mountain Corridor had identified station locations. The Rocky Mountain Rail Authority's *High Speed Rail Feasibility Study*[1] concluded that 14 stations should be provided between Golden and Eagle County Regional Airport. Similarly, the I-70 Coalition *Land Use Planning Study for Rail Transit Alignment Throughout the I-70 Corridor*[2] identified station options in numerous locations from Golden to Glenwood Springs.

Based on input from the AGS PLT and Technical Committee, the AGS Study Team began discussions with Jefferson, Clear Creek, Summit, and Eagle Counties to facilitate the

[1] RMRA HSR Feasibility Study http://rockymountainrail.org/RMRA_Final_Report.html
[2] I-70 Coalition Transit and Land Use http://www.i70solutions.org/docs

narrowing of the number of station site options, and the planning of stations within the mountain communities.

Each County Land Use/Station Working Group held three meetings during the course of the Study. The first time was to provide an overview of the Study and gather input on potential station locations and County interests. The second meeting was to review station elements, operational characteristics, and sizing parameters; and to review evaluation criteria for station sites. The third meeting was held to review technology, alignment, and ridership cumulative findings; and to obtain final County input on station sites.

The following meetings were held:

- September 10, 2012 – Summit County Meeting #1
- October 12, 2012 – Jefferson County Meeting #1
- October 24, 2012 – Clear Creek County Meeting #1
- October 30, 2012 – Eagle County Meeting #1
- March 11, 2013 – Summit County Meeting #2
- March 12, 2013 – Jefferson County Meeting #2
- March 14, 2013 – Clear Creek County Meeting #2
- March 25, 2013 – Eagle County Meeting #2
- November 12, 2013 – Summit County Meeting #3
- November 12, 2013 – Eagle County Meeting #3
- November 13, 2013 – Jefferson County Meeting #3
- November 18, 2013 – Clear Creek County Meeting #3

8.6.1 County Meeting #1

The AGS Study Team met with the County Working Groups and reviewed recent I-70 Mountain Corridor transportation studies and outcomes, as well as the AGS Study purpose, scope, and planned timeline. Additionally, the AGS Study Team shared information about the concurrent ICS that was examining high-speed rail options for the Front Range from Fort Collins to Pueblo.

The AGS Study Team reviewed parameters for station development with each County. Stations in a high-speed transit system are typically spaced 30 to 40 miles apart and are designed to accommodate regional travel. Station spacing that is too tight does not allow the high-speed transit vehicles to accelerate and hold a high speed for any appreciable distance before having to decelerate to pull into the next station. Fewer stations mean higher speeds and faster travel times, which in turn means higher ridership numbers. The AGS Study Team recommended that the number of stations for the 120-mile-long segment be limited to approximately six: one station in Jefferson County, one station in Clear Creek County, two in Summit County, and two in Eagle County including one at the Eagle County Regional Airport.

Based on the Final PEIS and ROD, the key system performance and operational criteria for feasible technologies for the AGS include the ability to meet the travel demand needs in the I-70 Mountain Corridor, also known as the design capacity. Transit must have the capacity to serve 25 percent of the trip demand, which equates to a minimum of 4,900 AGS passengers per hour, peak direction in 2035, during peak travel times (defined as summer Sundays, which represents the highest average traffic volumes).

These requirements resulted in discussion of stations with a bigger operating capacity, and potentially larger footprint than was originally contemplated. While station elements and configuration depend on technology type and architectural design, some basic requirements are considered station building blocks and were reviewed with each County.

Platform length was determined to be as much as 1,000 – 1,300 feet long to accommodate a 9-car consist with a capacity of 900 riders every 10 minutes during peak times (900 passengers per consist x 6 consists/hour = 5,400 capacity) or a 13-car consist with a capacity of 1,300 riders every 15 minutes during peak times (1,300 passengers per consist x 4 consists/hour = 5,200 capacity). At-grade, structured, or below-grade parking facilities should be large enough to accommodate regional travel demand to each station because the geography from which the station will draw passengers will be significant. Regional highway facility access and local roadway and traffic circulation are critical to increasing travel demand to a site and integrating that site into a community. The integration of transit service at the station can be a determining factor especially if it is to be sized to accommodate regional demand to and from the station, or if resort destination transit for visitors and employees is required, as with most of the corridor station locations. Bicycle and pedestrian facilities to and within the site enable strong multimodal mobility within the community. Finally, the potential for the integration of development with the parking facilities was addressed as a way of modifying site development to fit each community.

Typical Station Site Plan

County representatives provided suggestions on a range of potential station locations within their county that were carried forward for consideration in alignment development.

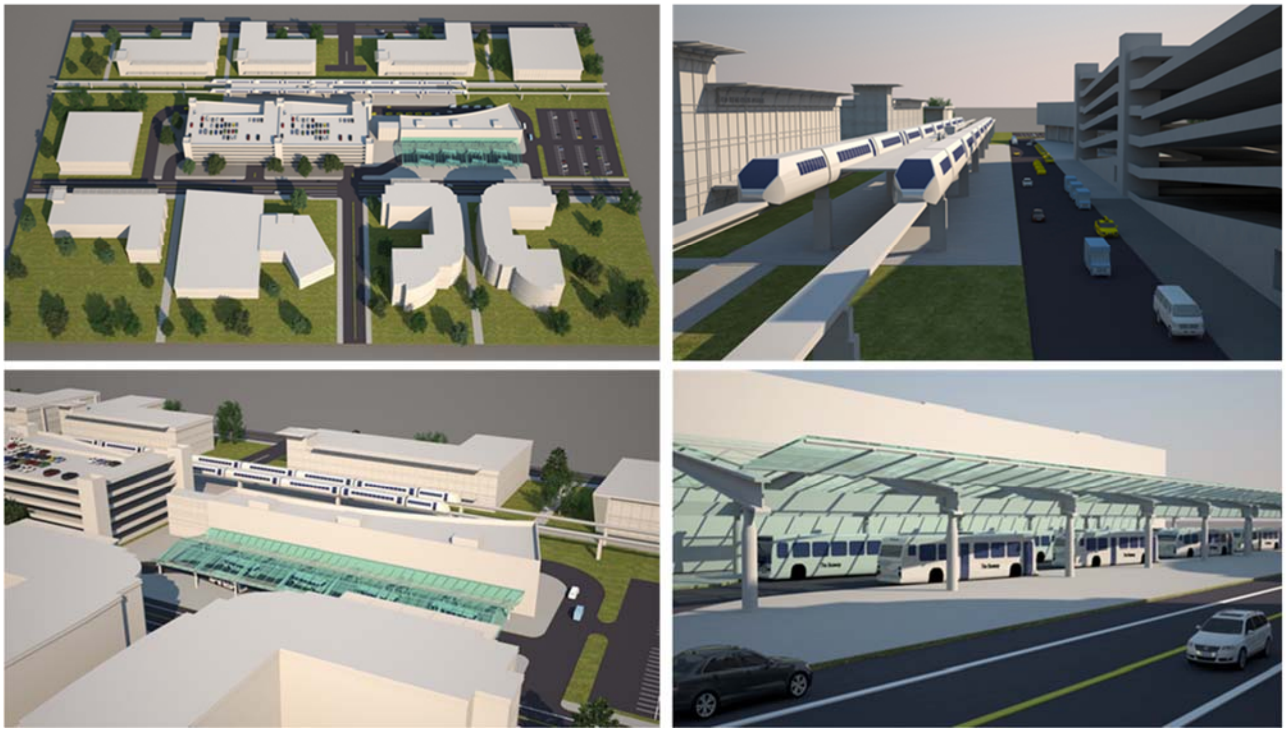
8.6.2 County Meeting #2

The AGS Study Team discussed with the County representatives how the choice in AGS technology and alignment through the corridor was being examined and would ultimately affect station locations. County representatives expressed concern about the acreage requirements for potential AGS stations, so the AGS Study Team reviewed these key factors related to individual station sizing: the anticipated level of ridership activity at the station, the role the station plays in the system as either a destination or collector station and the associated parking needs, the operational needs of the secondary transit system and the technology chosen for that system, and the desired level of development surrounding the station site. There are many architectural styles and design factors that can influence the footprint and massing of a station; therefore, the AGS Study Team created renderings of two example stations to illustrate sizing and probable acreage needs depending on location and role of station.

The first example assumed a ten-acre station site with most of the AGS, transit system, and parking facilities occupying roughly six acres, depending on design; the surrounding acreage offers room for supporting development based on local interest. This example assumes a four-story, one-acre parking structure with approximately 600 spaces (150 spaces per deck acre) and transit services modest enough to be integrated below the elevated platform and in line with the passenger plaza and drop-off area. This example is best suited for lower demand locations.

10-acre Station Site

The second example illustrates a 20-acre or larger site, with the AGS, transit system, and parking facilities occupying approximately 10 to 12 acres. In this example, a 6-story, 2-acre parking structure supporting roughly 1,500 spaces meets sizing requirements for higher-demand parking locations. In this example, transit bus operations or other technology connections are assumed to have higher ridership demand and warrant a separate facility on site. Surrounding development is significantly bigger in scale, density, and use level.



20-acre or Larger Station Site

In addition to the basic elements and sizing parameters associated with station location decision-making, a number of guiding principles were discussed to further the conversation and guide station site decision-making at a local level. A station location should:

- Optimize use by all segments of the population, including residents, employees and visitors.
- Support the potential for compact and infill development and limit demand on natural resources in the I-70 Mountain Corridor.
- Leverage existing infrastructure investment.
- Maximize connectivity between the AGS and transit, bicycle, and pedestrian facilities within the community and to/from key destinations.
- Minimize the parking footprint by integrating and potentially sharing parking supply with supporting development where possible.

The AGS Study Team reviewed the developing alternative alignments by technology type and the assumptions about station sites associated with each alignment. Lastly, station evaluation criteria were discussed and County representatives were asked to provide input for each potential station location in their county based on the following criteria:

- Land availability/developability.
- Local and regional transportation access/capacity.
- Infrastructure capacity.
- Compatibility with local plans.
- Compatibility with mountain/community/historic character.
- Population served: local, visitor, employee.

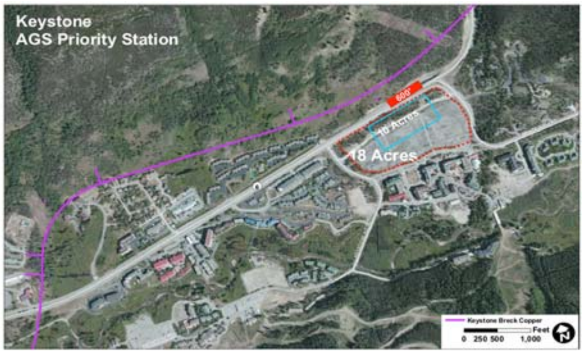
8.6.3 County Meeting #3

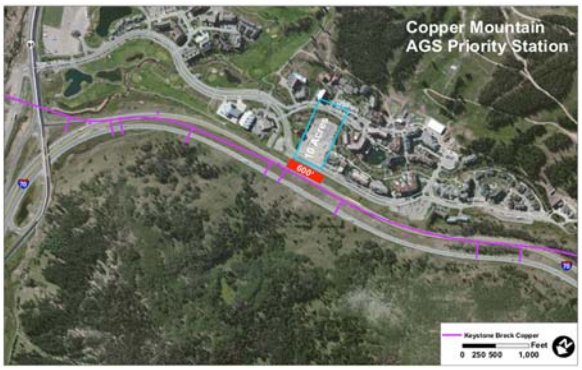
The AGS Study Team held the third and final round of County Working Group meetings to review the Study findings on technology, alignment, and ridership; and to refine station site within each County based on the combination of technical findings and input on the evaluation criteria from County representatives. The AGS Study Team reviewed the alternative alignments for high-speed rail and maglev, along with the cost and ridership associated with each. The Hybrid Maglev Alignment was shown to provide the best performance in relation to cost with travel speeds between 120 and 150 mph, reduced tunnel requirements, and a cost of roughly $13.4 billion. Because the alignment provides direct service to the resort communities of Keystone, Breckenridge, and Copper Mountain within Summit County, it subsequently generates stronger ridership for the system than does high-speed rail.

Summit County

Summit County priority station sites were identified as Keystone, Breckenridge and Copper Mountain based primarily on the Study’s technical alignment findings. County representatives agreed that these station sites offer the greatest possibility of diverting traffic from I-70 and to AGS, and are generally supported. The implementation of AGS and land use development around these station locations is consistent with local land use plans. Total acreage available for development at the three locations combined is approximately 20 acres. Local access to and from the stations would rely heavily on an expanded secondary transit system that would carry residents, employees, and visitors between the stations and numerous destinations in Summit County.

The Town of Breckenridge retains an interest in locating the station at the base of the gondola within town, rather than at the alternative location along SH 9 and Coyne Valley Road.





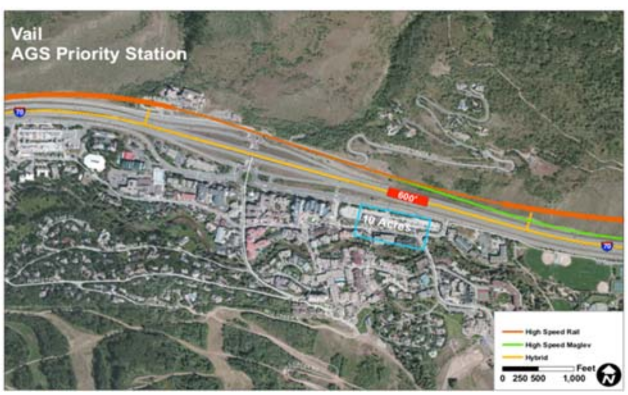
The Towns of Silverthorne and Frisco would prefer station locations within their communities, and note the following criteria evaluation in support of these locations: ease of regional vehicular access from the highway and local roadway network to the sites; the general compatibility of station operations and land development with current local plans for these locations; the jurisdictional support of redevelopment, intensification of land uses, and mix of uses at the sites; and the acreage availability to size station operations to support a significant secondary transit system at either location.

Silverthorne, in particular, offers up to 62 acres of land surrounding the interchange that could potentially support mixed-use commercial, office, or residential development. Frisco's site is roughly 35 acres. Summit County attendees requested that Silverthorne and Frisco both be noted for further consideration in later studies, as alignment decisions are finalized.

Eagle County

The Hybrid Maglev Alignment through Eagle County generally follows I-70, making the Town of Vail and Eagle County Regional Airport priority stations that support alignment and ridership. The stations meet the criteria of strong local and regional transportation access; sufficient infrastructure capacity; compatibility with local area plans and land use development opportunities (or existing development patterns); and access to local, visitor, and employee populations. Vail requests that the station be positioned over the I-70 right-of-way and that the existing Vail transit center site be configured as the AGS station. Eagle County Regional Airport remains concerned about whether AGS would ultimately reduce flight demand into the regional airport, but is supportive of a multimodal connection that offers air passengers arriving in Eagle a high-speed service to area resorts.

Avon expressed interest in a third station location along the line at Traer Creek, located adjacent to I-70. This site meets the evaluation criteria and offers significant development potential with over 70 acres of land to be accessible from the highway and local roadway network. Attendees at the Eagle County Working Group voiced concern over the realities of implementation, but are looking forward to continued progress of the AGS for the I-70 Mountain Corridor.

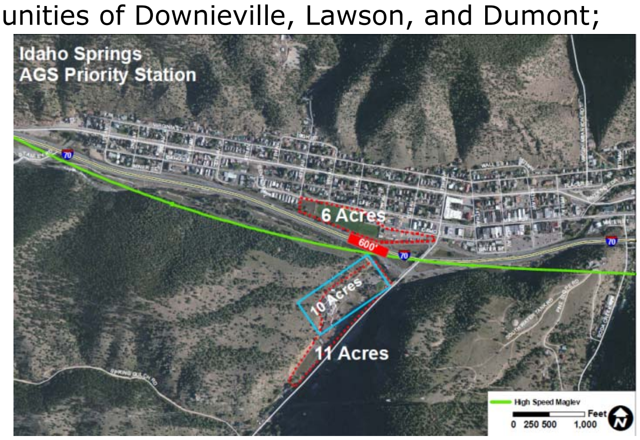


Jefferson County

The priority station site for Jefferson County lies at I-70 and 6th Avenue and was referred to as the Golden West Suburban station. This location is suitable for AGS alignment requirements and Denver metropolitan high-speed rail alignments being studied under the ICS. The site provides over 80 acres of land for potential future redevelopment opportunities and offers the most direct connection to the RTD West Line light rail station at the Jefferson County Administration Building. County Working Group members felt the link with the existing light rail system was critical to the location and configuration of the I-70/C-470 Station. This station is anticipated to have significant regional ridership and require substantial parking and vehicular access, in addition to transit and light rail connectivity. Working Group members recognized that current vehicular access to the site is limited to US 40 and will likely require infrastructure improvements to function adequately with anticipated ridership demand at this station. The location is compatible with local planning efforts for the County and Golden; has sufficient infrastructure capacity; and is well situated to serve local, visitor, and employee populations on the west side of the Denver metropolitan area. Working Group members voiced support for moving AGS plans forward so that land use planning efforts could be identified for funding. Generally, support for the system, alignment, and station location was high from the Jefferson County Working Group.

Clear Creek County

Clear Creek County identified numerous station locations early in the planning process, including several in Idaho Springs; the communities of Downieville, Lawson, and Dumont; Empire Junction; Georgetown; and Loveland ski area. Through the evaluation process, the County settled on three primary locations to retain for further design decisions—Idaho Springs, Empire Junction and Georgetown— and will ultimately select one of the three for design.



The potential Idaho Springs priority station is assumed to straddle the highway at I-70 and Water Street. The placement of the station over the highway right-of-way opens up the school district property to the south of the highway for redevelopment and the high school football field to the north of the highway. Development on both sides of the highway would help to minimize the barrier currently created by I-70 and increase station-related development acreage to 15 plus acres. Station operations and higher-density, mixed-use development is generally consistent with local and Clear Creek County plans for the community, and increased infrastructure capacity is thought to be available within Idaho Springs. Vehicular access to the sites is available through the local roadway network and the I-70 interchange. Current transit operations between Idaho Springs and Gilpin County offer a link to the gaming community. Future transit service to Empire Junction, Winter Park and Grand County, and Georgetown would follow the direction of travel for passengers coming from the Denver metropolitan area or Denver International Airport.

The Empire Junction priority station location was considered by the County Working Group to provide the most convenient transit connections to Winter Park and Grand County. The Empire Junction site is accessible by car and transit from the I-70/C-470 interchange. The site, while capable of accommodating the station footprint, does not have the same development potential as the other Clear Creek County options. Infrastructure capacity is minimal and would need to be extended to the site to support development. Future development at the site would compete with the station itself and the acreage devoted to recreational uses. Based on current County land use plans, high-density, mixed-use development supportive of an AGS station would be integrated with recreational uses and limited in terms of acreage.

The Georgetown priority station is positioned on roughly 14 acres along I-70 adjacent to Georgetown Lake. The site is accessible from the local roadway network and the I-70 interchange. When traveling to and from Denver, out-of-direction transit connections would be required from this station back to Empire Junction, Idaho Springs, or other communities within Clear Creek County. Approximately eight acres would be available for development surrounding the station; and current plans support a higher-density, mixed-use development pattern at this location. Infrastructure capacity is available in Georgetown.

8.6.4 Potential Station Development

At the final round of County Working Group meetings, the AGS Study Team discussed the opportunity for development and investment surrounding the stations and touched on the role that development and related tax revenues might play in offsetting the cost of future stations. The AGS Study Team estimated the value of station-related land development associated with a Hybrid Maglev Alignment based on:

- An estimate of acreage around each priority station location.
- A developable building area of 65 percent associated with that acreage (i.e., 35 percent reduction for non-building uses like roads, etc.).
- A Floor Area Ratio (FAR) of 3 (i.e., 3-to 5-story building heights depending on land reserved for landscaping, etc.).
- A square footage value of $180/square foot, based on a representative value of multiple Denver-area properties (I-70 Mountain Corridor properties may differ in value; the Eagle County Vail station assumes development densities already in place surrounding station).

Table 8-4 illustrates that roughly 97 acres or $2.3 billion in future development value may be possible along the AGS alignment.

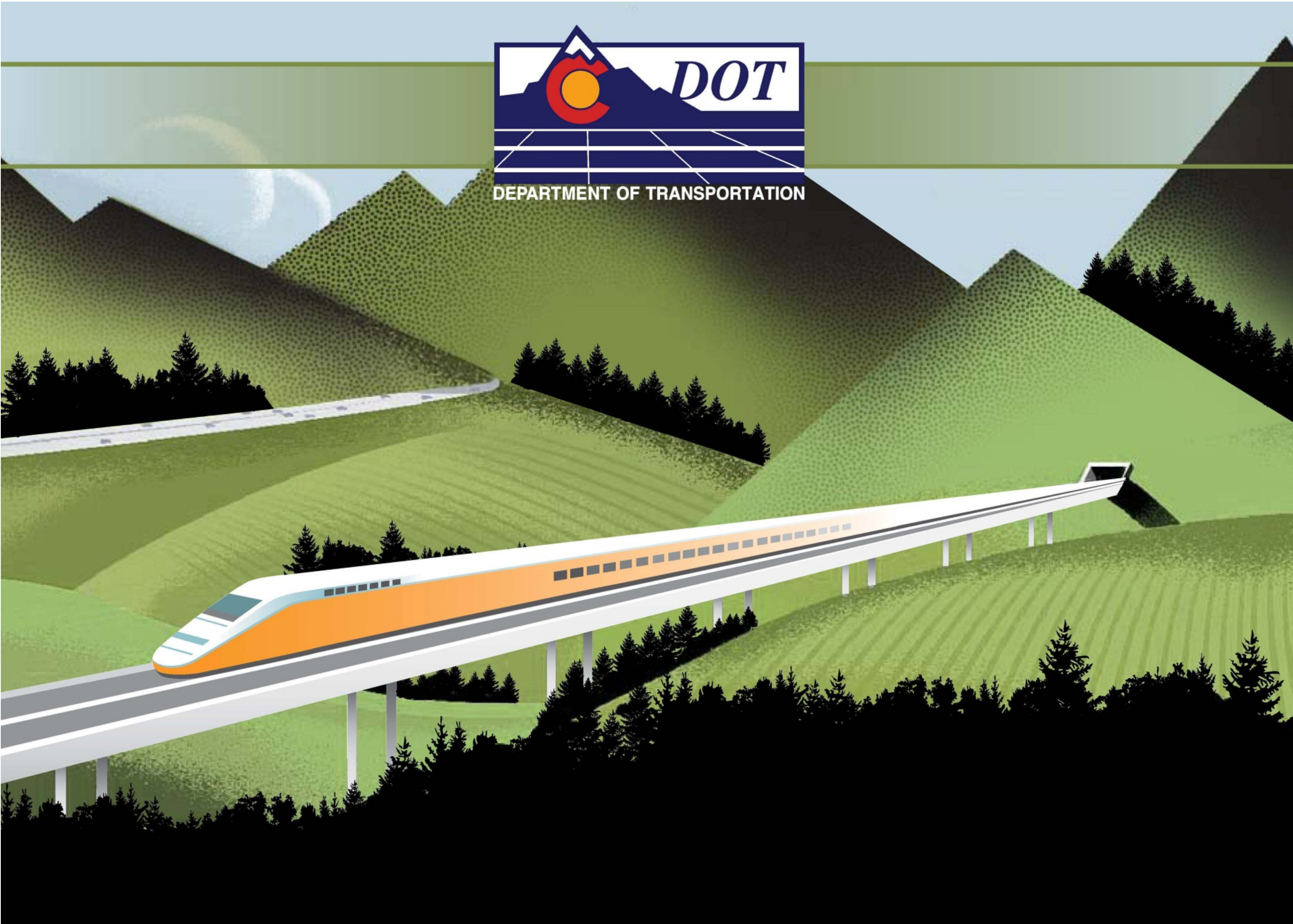
Table 8-4: Potential Station Development

Station Location	Potential Development Acreage	Developable Area (65%)	Value (FAR 3) ($180/SF)
Jefferson County: I-70 & 6th Avenue	50 acres	32.5 acres	4.2 million sq. ft. $764 million
Clear Creek County: Idaho Springs – Georgetown -Empire Junction	10 acres	6.5 acres	849,420 sq. ft. $153 million
Summit County: Keystone	8 acres	5.2 acres	679,536 sq. ft. $122 million
Summit County: Breckenridge	8 acres	5.2 acres	679,536 sq. ft. $122 million
Summit County: Copper Mountain	4 acres	2.6 acres	339,768 sq. ft. $61 million
Eagle County: Vail	0 acres	N/A	N/A
Eagle County: Avon Traer Creek	30 acres	19.5 acres	2.5 million sq. ft. $458 million
Eagle County: Eagle County Regional Airport	40 acres	26 acres	3.4 million sq. ft. $611 million
Total	**150 acres**	**97.5 acres**	**$2.3 billion**

8.7 Conclusion

Throughout development of the Study, the AGS Study Team used the CSS process to involve stakeholders. Additionally, the I-70 Coalition Technical Committee helped make technical decisions, and a Funding and Finance Workgroup was convened to explore possible funding and financing strategies.

To begin the process of determining possible AGS station sites, the AGS Study Team conducted three meetings with each of the four counties along the I-70 Mountain Corridor. Through these meetings, potential station locations were identified.



ADVANCED GUIDEWAY SYSTEM (AGS)
FEASIBILITY STUDY

CHAPTER 9
CONCLUSIONS

Chapter 9 Conclusions

9.1 Introduction

CDOT and the Advanced Guideway System Project Leadership Team (AGS PLT) set a number of goals for the *AGS Feasibility Study* (Study) in the three key categories that form the framework for assessing the feasibility of the AGS. They are as follows:

Technology

- Determine if there are technologies that can meet the desired system performance and operational criteria.

Alignments and Land Use

- For feasible technologies, develop possible alignments beginning at Eagle County Regional Airport on the west and ending at the C-470/I-70 interchange area on the east (alignment/technology pairs).
- Identify possible locations for AGS stations, taking into account the technologies and the alignment limitations and opportunities.

Cost, Funding, and Financing

- Estimate 2035 ridership for the AGS alignment/technology pairs.
- Estimate the capital costs and operations and maintenance costs for the alignment/technology pairs.
- Determine the Operating Ratio and Benefit to Cost Ratio for the alignment/technology pairs.
- Assess possible funding sources for the AGS and how it might be financed.

The AGS Study Team addressed all of these goals through a Context Sensitive Solution (CSS) process with CDOT, stakeholders, technology providers, and the concession and financial community; and it reached the following conclusions.

9.2 Technology

✓ ***There are technologies that can meet the required system performance and operational criteria.***

Eleven technology providers provided responsive and qualified Statements of Technical Information. The technologies included conventional high-speed rail, high-speed and 120 mph maglev, and a variety of other systems. The AGS PLT assessed the feasibility of the technologies and identified three of them for detailed analysis in the Study. They were chosen because they were either already commercially available or were far enough along in development to be viable. The three technologies and their key operating parameters are shown in Table 9-1.

Table 9-1: Technology Operating Parameters

Operating Parameter	120 mph Maglev	High Speed Maglev	High Speed Rail
Top Speed	120 mph	330 mph	155 mph
Design Operating Speed	120 mph	200 mph	150 mph
Maximum Grade	7%	7%	3%
Minimum Curve	4,000 ft.	10,500 ft.	11,500 ft.
Example Technology	American Maglev, General Atomics	TransRapid	Talgo 250

The choice of these technologies for use in this Study's detailed analysis does not preclude other technologies from being considered in the future.

9.3 Alignments and Land Use

✓ ***Alignments were identified for each of the three technologies. Each alignment is representative of a group of technologies which can meet the speed & grade climbing characteristics of the alignment.***

The AGS Study Team developed four alignments for the AGS that could be used by one or more of the feasible technologies. The four alignments are shown in Figure 9-1.

- **I-70 Alignment** – This alignment stays entirely within the I-70 right-of-way. Based on independent estimates and discussions with the 120 mph maglev technology providers, it was decided that this alignment was too curvilinear and that travel times would be greater than an average car trip. For these reasons, a detailed analysis was not done on this alignment.
- **Hybrid/120 mph Maglev Alignment** – This alignment stays in the I-70 right-of-way as much as possible. It leaves the right-of-way where necessary to increase curve radii or reach station locations that are not adjacent to I-70 (Breckenridge and Keystone). It is similar to the High Speed Maglev Alignment between Eagle County Regional Airport and Keystone. East of Keystone, it diverges from the High Speed Maglev Alignment to follow US 6 to Arapahoe Basin Ski Area, and it then crosses under Grizzly Peak and follows the alignment of Grizzly Gulch Road and Stevens Gulch Road back to I-70 just east of the Bakersville interchange. It then generally follows I-70 to the C-470/I-70 interchange area in Golden. The Hybrid/120 mph Maglev can have tighter curves because of its slower speed. As a result, this 120.5-mile alignment has 15.7 miles of tunnels.
- **High Speed Maglev Alignment** – This alignment begins at Eagle County Regional Airport and generally follows I-70 to Copper Mountain where it crosses in a tunnel under the Ten-Mile Range to Breckenridge and Keystone. It then crosses under the Continental Divide in a tunnel, rejoining I-70 near Loveland Ski Area. From this

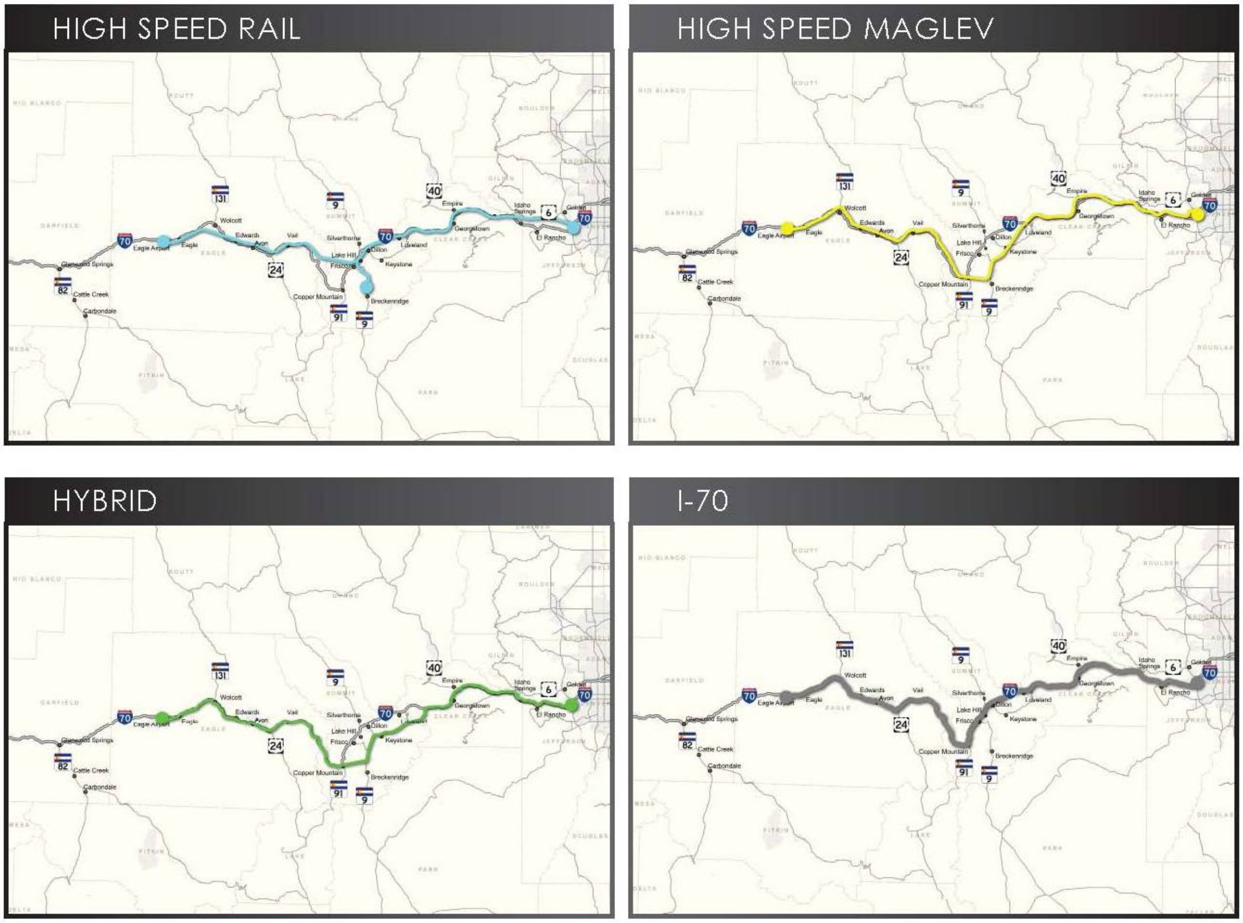


Figure 9-1: AGS Alignments

point, it generally follows I-70 to the C-470/I-70 interchange area in Golden. While High Speed Maglev technology can climb grades in excess of 7 percent, to maximize its 200 mph + top speed, the alignment has to be somewhat straight with large radius curves. Of its total length of 118.5 miles, 40.1 miles is in tunnels. The AGS Study Team determined that, with minor changes and some reductions in speed, the High Speed Maglev technology could operate on the Hybrid/120 mph Maglev Alignment.

- **High Speed Rail Alignment** – This alignment begins at Eagle County Regional Airport and generally follows I-70 to Vail, where it crosses the mountains north of Vail Pass in a long tunnel to Frisco and then generally follows I-70 to the base of Floyd Hill where it diverges from I-70 to travel through the Clear Creek Canyon area in a series of tunnels and bridges. A second long tunnel between Silverthorne and Georgetown under the Continental Divide is part of this alignment, and there is a spur running from Frisco to Breckenridge. The alignment terminates in Golden near the C-470/I-70 interchange. Because high-speed rail cannot climb any significant grades (3 percent for short periods and not more than 2.3 percent for sustained grades), and because curve radii must be wide enough to operate at high-speed "greenfield" alignments, the 108.9-mile alignment requires 65 miles of tunnels.

FHWA confirmed that the three alignments carried forward are consistent with the *I-70 Mountain Corridor Final Programmatic Environmental Assessment* (PEIS) and *Record of Decision* (ROD).

✓ ***Station sites were identified for the each of the alignment/technology pairs.***

The PEIS, the *Land Use Planning Study for Rail Transit Alignment throughout the I–70 Corridor*, and the *High-Speed Rail Feasibility Study Business Plan* discussed up to 20 possible station sites along the I-70 Mountain Corridor. Through the Study process, the AGS Study Team refined the potential sites to eight by balancing community interests, land use development, technical alignment results, travel speeds, and ridership estimates. The number of sites for the Hybrid Alignment was determined to be one in Jefferson County, one in Clear Creek County, two to three in Summit County, and three in Eagle County.

- **Jefferson County** – The best possible site is at I-70 and 6th Avenue because of its proximity to RTD West Line light rail station and the potential for redevelopment at the site.
- **Clear Creek County** – The preferred station options are Idaho Springs Football Field, Empire Junction, and Georgetown Lake. One of these three would be selected later.
- **Summit County** – The preferred station sites are Keystone, Breckenridge, and Copper Mountain.
- **Eagle County** – The preferred station sites are Vail, end-of-line Eagle County Regional Airport, and Avon at Traer Creek to support future mixed-use development in the County.

Local governments strongly supported the station site evaluation process and the preferred site locations. Alternate station sites that might serve alignments that are different from the three developed in this Study were documented should future alignment decisions or future land use development or growth patterns warrant their reconsideration.

9.4 Ridership

✓ ***Ridership estimates for the AGS range from 1.28 to 6.35 million passengers per year in 2035***

Using a travel demand model developed specifically for the AGS and the ICS studies, 2035 ridership data for the alignments was generated. Variations included different combinations of alignments and technologies, different Minimum Operable Segments (MOS), and a standalone system and combined with the ICS System corridors. These are presented in Table 9-2.

Table 9-2: 2035 Forecast Annual Ridership, $0.26 / Mile Fare

Alignment Through Denver	Alignment / Technology	Coverage	Ridership (Passengers / Year)
C-470/E-470	Hybrid/ High Speed Maglev	ECRA to I-70/C-470 ICS System + AGS**	6,211,251
I-76	Hybrid/ High Speed Maglev	ECRA to DIA ICS System + AGS*	4,635,464
I-76	Hybrid/ High Speed Maglev	ECRA to DIA No ICS System	3,585,120
I-76	Hybrid/ High Speed Maglev	Breckenridge to DIA ICS System + AGS	2,906,471
I-76	Hybrid/ High Speed Maglev	Breckenridge to DIA No ICS System	1,775,726
N/A	Hybrid/ High Speed Maglev	Breckenridge to I-70/C-470 No ICS System	1,535,031
N/A	Hybrid/ 120 mph Maglev	Breckenridge to I-70/C-470 No ICS System	1,284,913
I-76	Hybrid/ 120 mph Maglev	Breckenridge to DIA ICS System + AGS	2,508,416
C-470/E-470	High Speed Rail	ECRA to DIA ICS System + AGS	6,349,807
I-76	High Speed Rail	Breckenridge to DIA ICS System + AGS	2,676,462

* Maglev from DIA to Eagle County Regional Airport or Breckenridge.

** Maglev from West Suburban to Eagle County Regional Airport.

ECRA = Eagle County Regional Airport.

As can be seen, combining the ICS System with the AGS alignments results in significantly higher ridership than a standalone AGS, even if the AGS is extended across the Denver metropolitan area to connect to a station at DIA.

9.5 Capital and Operation and Maintenance (O&M) Cost Estimates

✓ ***The AGS Study Team developed detailed Capital and Operation and Maintenance costs for the various alignments and technologies***

The cost estimates included direct costs (associated directly with building the capital infrastructure associated with the AGS) and indirect costs (contingencies, professional services, environmental mitigation, and utility relocations). Table 9-3 presents the capital costs for the various alignment/technology pairs.

Table 9-3: AGS Capital Costs (2013$)

	Hybrid / 120 mph Maglev $(billion)	Hybrid / High Speed Maglev $(billion)	Hybrid / High Speed Maglev with extension to DIA $(billion)	High Speed Maglev $(billion)	High Speed Rail $(billion)
Eagle County Regional Airport to I-70/C-470	$10.871	$13.337	$16.537	$25.310	$32.393
Breckenridge to I–70/C-470	$5.545	$6.801	N/A	$14.142	$19.010

Table 9-4 shows the estimates of the O&M costs by alignment/technology pair for the Full System (Eagle County Regional Airport to I-70/C-470) and for the MOS (Breckenridge to I–70/C-470).

Table 9-4: Operation and Maintenance Cost Estimates (2013$)

	Hybrid / 120 mph Maglev, (15-Minute Peak / 60-Minute Off-Peak)	Hybrid / 120 mph Maglev (30-Minute Peak / 60-Minute Off Peak)	High Speed Maglev 30-Minute Peak / 60-Minute Off-Peak)	High Speed Rail (30-Minute Peak / 60-Minute Off-Peak)
ECRA to I-70/C-470 - Low Cost	$52,694,000	$45,213,000	$47,209,000	$55,382,000
ECRA to I-70/C-470 - High Cost	$69,473,000	$60,440,000	$62,762,000	$72,882,000
Breckenridge to I–70/C-470 - Low Cost	$29,485,000	$26,072,000	$27,258,000	$36,191,000
Breckenridge to I–70/C-470 - High Cost	$39,230,000	$35,103,000	$36,466,000	$47,704,000

ECRA = Eagle County Regional Airport.

If an I-70/C-470 to DIA segment were added to the MOS, the O&M cost increases for High Speed Maglev by $11.9 million to $15.7 million. Similar increases could be expected for the Hybrid/120 mph Maglev and High Speed Rail.

9.6 Funding and Financing

✓ ***An AGS is expensive and does not have a current funding source for implementation.***

Using the ridership model, estimates of farebox revenue were made for the various alignment/ technology pairs. Table 9-5 shows the estimated 2035 farebox revenues.

Table 9-5: 2035 Forecast Annual Farebox Revenues, $0.26 / Mile Fare

Alignment Through Denver	Alignment / Technology	Coverage	Revenue
C-470/E-470	Hybrid/ High Speed Maglev	ECRA to I-70/C-470 ICS System + AGS**	$157,280,243
I-76	Hybrid/ High Speed Maglev	ECRA to DIA ICS System + AGS*	$113,911,654
I-76	Hybrid/ High Speed Maglev	ECRA to DIA No ICS System	$79,037,296
I-76	Hybrid/ High Speed Maglev	Breckenridge to DIA ICS System + AGS	$66,943,427
I-76	Hybrid/ High Speed Maglev	Breckenridge to DIA ICS System + AGS	$28,723,660
N/A	Hybrid/ High Speed Maglev	Breckenridge to I-70/C–470 No ICS System	$20,851,174
I-76	Hybrid/ 120 mph Maglev	Breckenridge to DIA No ICS System	$56,779,587
N/A	Hybrid/ 120 mph Maglev	Breckenridge to I-70/ C–470 No ICS System	$17,418,946
C-470/E-470	High Speed Rail	ECRA to DIA ICS System + AGS	$159,912,578
I-76	High Speed Rail	Breckenridge to DIA ICS System + AGS	$58,278,195

* Maglev from DIA to Eagle County Regional Airport or Breckenridge.

** Maglev from West Suburban to Eagle County Regional Airport.

ECRA = Eagle County Regional Airport.

The Operating Ratio (also known as the farebox recovery ratio) is obtained by dividing the farebox revenue by the O&M costs. Table 9-6 highlights the Operating Ratio analysis results.

Table 9-6: 2035 Forecast Annual Operating Ratios

Technology	Alignment	Operating Ratio
High Speed Maglev	Eagle County Regional Airport to I-70/C-470, ICS System + AGS, C-470/E-470	2.51
	Eagle County Regional Airport to DIA, ICS System + AGS, I–76	1.81
	Breckenridge to DIA, ICS System + AGS, I-76	1.24
	Eagle County Regional Airport to DIA, I-76, No ICS System	1.01
	Breckenridge to I-70/C-470, No ICS System	0.57
	Breckenridge to DIA, No ICS System, I-76	0.53
120 mph Maglev	Breckenridge to DIA, ICS System + AGS, I-76	1.1
	Breckenridge to I-70/C-470, No ICS System	0.5
High Speed Rail	Eagle County Regional Airport to I-70/C-470, ICS System + AGS, C-470/E-470	2.19
	Breckenridge to DIA, ICS System + AGS, I-76	0.83

- The Operating Ratios for the Breckenridge to I-70/C-470 MOS for High Speed Maglev and Hybrid/120 mph Maglev are both below 1.0, indicating that additional funds would be required to cover O&M cost shortfalls.
- The Operating Ratio for the High Speed Maglev from DIA to Eagle County Regional Airport without the ICS System is 1.01, indicating that farebox revenue just covers the O&M costs.
- Adding the ICS System to either the Breckenridge to I-70/C-470 MOS or the Full System AGS results in Operating Ratios greater than 1.0. In fact, for High Speed Maglev coupled with the ICS System C-470/E-470 alignment, the Operating Ratio would be 2.51, indicating surplus revenue that could be used to pay for a portion of the capital costs (about $94.5 million per year).

Using the capital costs developed for each alignment/technology pair, annual debt service requirements were developed for 30 and 40 years, assuming different levels of federal grants. The following highlights the annual debt service requirements:

- For the $5.5 billion 120 mph Maglev, Hybrid Alignment MOS, the annual debt service would range from $496 million per year (30 years, 0 percent federal grants) to $231 million per year (40 years, 50 percent federal grants).
- For the $6.8 billion High Speed Maglev, Hybrid Alignment MOS, the annual debt service would range from $634 million per year (30 years, 0 percent federal grants) to $296 million per year (40 years, 50 percent federal grants).
- For the $13.4 billion High Speed Maglev, Hybrid Alignment Full System, the annual debt service would range from $1.24 billion per year (30 years, 0 percent federal grants) to $581 million per year (40 years, 50 percent federal grants).

✓ ***As of 2014, there are no local, state, or federal funds currently available for an AGS for the I-70 Mountain Corridor, and therefore the AGS is not financially feasible at this time.***

Even with substantial federal grants, an additional, new source of funding to cover the debt service is necessary. The following highlights potential new funding sources and their advantages and disadvantages:

- A $0.25 increase in the state gas tax would generate about $447 million per year. While it is an existing revenue source, increasing fuel efficiency and political acceptability of this funding source makes it less desirable.
- A $100 increase in the state vehicle registration fee would generate about $393 million per year. This is a stable existing revenue source but would be contingent on continued automobile sales, and it faces political resistance.
- A 1 percent increase in the county sales taxes in the 16 counties along the AGS and ICS System alignments would generate about $572 million per year. While such a tax increase has been supported in the past for projects like FasTracks, this would face opposition from other referenda for tax increases to support other expenditures,

would be in direct competition with FasTracks in the Denver metropolitan area, and would face skepticism for investments occurring in the I-70 Mountain Corridor but not the I-25 Front Range Corridor.

- A 1 percent increase in income tax for the 16 counties along the AGS and ICS System alignments would generate $371 million per year. While a strong and stable revenue source, it may not be politically acceptable and would compete with a wide array of other government needs.

Additional possible ways that local counties, cities, and towns could help fund the AGS include:

- Capturing the value of station area development through tax-increment financing.
- Funding or paying for the stations.
- Local sales taxes or property taxes, in addition to any other taxes identified for the AGS.

Allocating State funds for debt service would be difficult. The total budget of the State of Colorado was $24 billion in 2014. The current annual CDOT budget is about $1.1 billion. With a required debt service of between $206.55 million and $1.24 billion *per year*, capital investment for a project of this magnitude is not possible; long-term debt service alone would consume between 19 and 100 percent of the total CDOT budget. While financing the project with long-term bonds would ease near-term cash requirements, it would require a large portion of the budget to pay debt service for the next 30 years.

Federal sources for capital costs include both funding and financing programs. However, the AGS eligibility for some of these programs is doubtful, and no new federal funding for high-speed transit is anticipated in the near term. The reality of current federal budget debates could greatly impact the funds available for AGS. Reauthorization of MAP-21 (the Federal Transportation Budget) would be required for any sources of funding to be available.

Private financing of the AGS to the degree necessary is likewise not promising. Based on feedback obtained from financiers and public-private partnership (P3) developers / concessionaires, private financing likely would be capped at a maximum of $2 to $3 billion, and more realistically offered at the $0.5 to $1 billion level. Further, the costs of private financing would increase the debt service payments dramatically, decreasing the financial feasibility of the AGS. Minimizing private financing would reduce the financing costs as much as possible.

9.7 Steps Forward

✓ ***Strong local commitment is required to advance an AGS.***

CDOT does not have the financial resources to implement an AGS.

The following critical steps must be completed before the financial feasibility an AGS project can be determined:

- Establish governance structure.
- Complete environmental clearances.
- Acquire right-of-way.
- Secure voter approval for bonding/taxes.
- Obtain federal approval of technology.
- Obtain federal funding grant agreement.

9.8 Conclusions

The *AGS Feasibility Study* had the intent, per the ROD, to *"answer questions regarding the feasibility, cost, ridership, governance, and land use are complete and indicate that an Advanced Guideway System cannot be funded or implemented by 2025 or is otherwise deemed unfeasible to implement,"* as follows:

- Feasible technologies exist that can provide the desired performance and operations.
- The cost of the Full System, from Eagle County Regional Airport to C-470/I-70 interchange, is $13.3 billion; the cost of the MOS (Breckenridge to I-70/C-470) is $6.8 billion.
    - The cost of the Full System ranges between $10.8 and $32.4 billion, with the most developed alignment/technology pair at $13.3 billion.
    - The cost of the MOS ranges between $5.5 and $19.0 billion, with the most developed alignment/technology pair at $6.8 billion.
- Ridership for the corridor ranges from 1.2 to 6.3 million riders per year.
    - The Full System ranges between 2.9 and 3.6 million riders per year.
    - The Full System, when connected to the ICS System, has a ridership of 4.6 to 6.3 million riders per year.
    - The MOS ranges between 1.2 and 1.5 million riders per year.
    - The MOS, when connected to DIA but not the ICS System, ranges between 1.8 and 2.5 million riders per year.
- Governance discussions indicated that:
    - At a minimum, an intergovernmental agreement (IGA) would be needed among the four I-70 Mountain Corridor Counties to implement an AGS.
    - More likely, a state-enabled regional authority, department, or similar (covering the I-70 Mountain Corridor and parts of Denver metropolitan counties) would be needed to generate sufficient funding.

  - A multiregional authority of up to 16 counties (12 Front Range, and 4 mountain counties) was discussed as a possibility for implementing a high-speed transit system of which AGS is a part.
  - If provided the necessary funding and institutional support, the Division of Transit & Rail within CDOT has the authority to build and operate such a system.
  - A statewide authority was viewed as unlikely because entities outside the immediate environs of the I-70 Mountain Corridor would be less likely to have a financial interest in supporting it.
- Land use analyses have established acceptable alignments and station locations that can be used by the feasible technologies.
- As of 2014, there are no local, state, or federal funds currently available for an AGS for the I-70 Mountain Corridor, and therefore it is not financially feasible at this time. Funding from local, state and federal sources would be required to advance an AGS and to obtain financing from the private sector.
- For the project to become fundable and financially feasible by 2025:
  - Substantial growth of the Colorado population and economy is required,
  - Significant support from the public for an AGS or similar high-speed transit project must be demonstrated, and
  - Significant increases in federal funding for intercity rail projects are needed.

In addition:

- For the benefits of AGS to be optimized, it needs to be developed in conjunction with the ICS System alignments along the Front Range and in the Denver metropolitan area.
- If developed as a stand-alone project, an alignment from Eagle County Regional Airport to I-70/C-470 offers the best benefit to cost ratio, with benefits exceeding costs.
- The MOS from Breckenridge to I-70/C-470 would require operating subsidies to cover shortfalls between the farebox revenue and its operations and maintenance costs.
- Under any scenario, the funding and financing analysis indicates that the AGS debt service is too large to be funded with existing revenues. Currently, there are no federal, state, regional, or local funding sources available.

The AGS should be incorporated into CDOT's *Colorado State Freight & Passenger Rail Plan* as an integrated high-speed transit system with the ICS recommendations, and as an element in the unconstrained funding section of CDOT's *Statewide Transportation Plan*.