

# 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**



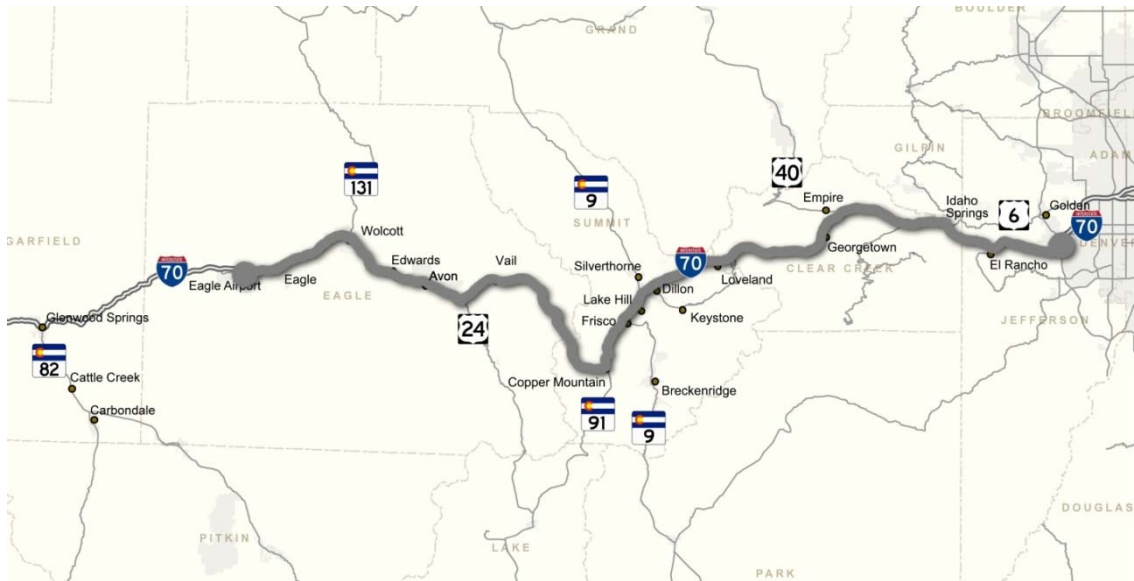
**Alignment Description**

- 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
<b>Breckenridge to I-70/C-470 (58-61 miles)</b>					
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
<b>Eagle County Regional Airport to I-70/C-470 (109-121 miles)</b>					
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* \$ billion (% of total)		State/Local Cash Share* \$ billion (% of total)		Amount Financed \$ billion (% 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
<b>Capital Cost</b>	\$32.4 B	\$13.3 B	\$10.8 B	\$19.0 B	\$6.8 B	\$5.5 B
<b>0%</b>	0.71	1.00	N/A	0.59	0.84	0.85
<b>10%</b>	0.93	1.21	N/A	0.81	1.05	1.06
<b>20%</b>	1.14	1.42	N/A	1.02	1.25	1.26
<b>30%</b>	1.36	1.63	N/A	1.24	1.46	1.47
<b>40%</b>	1.57	1.84	N/A	1.45	1.67	1.67
<b>50%</b>	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 concessionaires 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.