



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*.