



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 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.

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."

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.

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 Corridor (I-70 Coalition, 2009) – This study's³ 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 Study⁴ 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 team⁵ 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.

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.

- **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.

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.

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.
- **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.

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

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.

- **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?

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

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.

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.

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.

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

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