Executive Summary

Why is CDOT Conducting this Interregional Connectivity Study?

On June 23, 2009, the Federal Railroad Administration (FRA) issued a Notice of Funding Availability for the High-Speed Intercity Passenger Rail (HSIPR) Program in the Federal Register. In response, the Colorado Department of Transportation (CDOT), in concert with the Denver Regional Transportation District (RTD), submitted an application to conduct the Colorado Interregional Connectivity Study (ICS).

The Rocky Mountain Rail Authority (RMRA), a governmental authority made up of over 50 local governmental entities, completed a *High-Speed Rail Feasibility Study* (RMRA Study) in March 2010 that examined high-speed transit (HST) along the Front Range from Cheyenne, Wyoming to Trinidad, Colorado and along the I-70 mountain corridor from Denver International Airport (DIA) to Grand Junction.

The RMRA Study concluded that HST is feasible within FRA guidelines on an I-25 north-south corridor from Fort Collins to Pueblo and on an I-70 east-west corridor from DIA to the Eagle County Regional Airport. The most feasible segments and technologies for the HST were identified for the purpose of ascertaining the most favorable benefit/cost ratio; however, no specific segment or technology was selected or recommended in the study.

Because of its broad focus, the RMRA Study did not consider the environmental and political feasibilities of the segments and technologies, nor did it evaluate the interconnectivity of HST with the RTD FasTracks program or other transit systems in Colorado.

Lastly, the RMRA Study assumed that freight rail through metro Denver on the Consolidated Main Line (CML) would be moved to a new corridor on the eastern plains, something that is no longer expected to occur in the near future.

To help address these issues, and to take the analysis a step further to facilitate environmental documentation and ultimately final design plans, the RMRA Study recommended the ICS as one of the key next steps toward implementing HST in Colorado.

CDOT and RTD were awarded funds from FRA, and CDOT began the ICS in April 2012.

The Objectives of the Interregional Connectivity Study are to:

- Serve as a planning document and provide preliminary recommendations for HST segments, technologies, and station locations in the Denver metropolitan area that would maximize ridership for the existing and proposed RTD FasTracks transit system and future HST service.
- Identify potential future HST connections with the RTD FasTracks system.
- Determine optimal locations for a north-south (Front Range corridor) HST segment from Fort Collins to Pueblo and an east-west HST segment from DIA to the C-470/ I-70 interchange in Jefferson County.

What will you be Reading?

What's Involved? This document describes the planning process followed for determining the best solution, known as a Locally Preferred Alternative (LPA) for the ICS, which generally covers the Front Range from Fort Collins to Pueblo. A second parallel study, known as the Advanced Guideway System (AGS) Feasibility Study is studying HST options for the I-70 mountain corridor from Golden to Eagle County

Regional Airport. The AGS study has also produced an LPA. The combination of the ICS and AGS LPAs will become Colorado's future HST Vision.

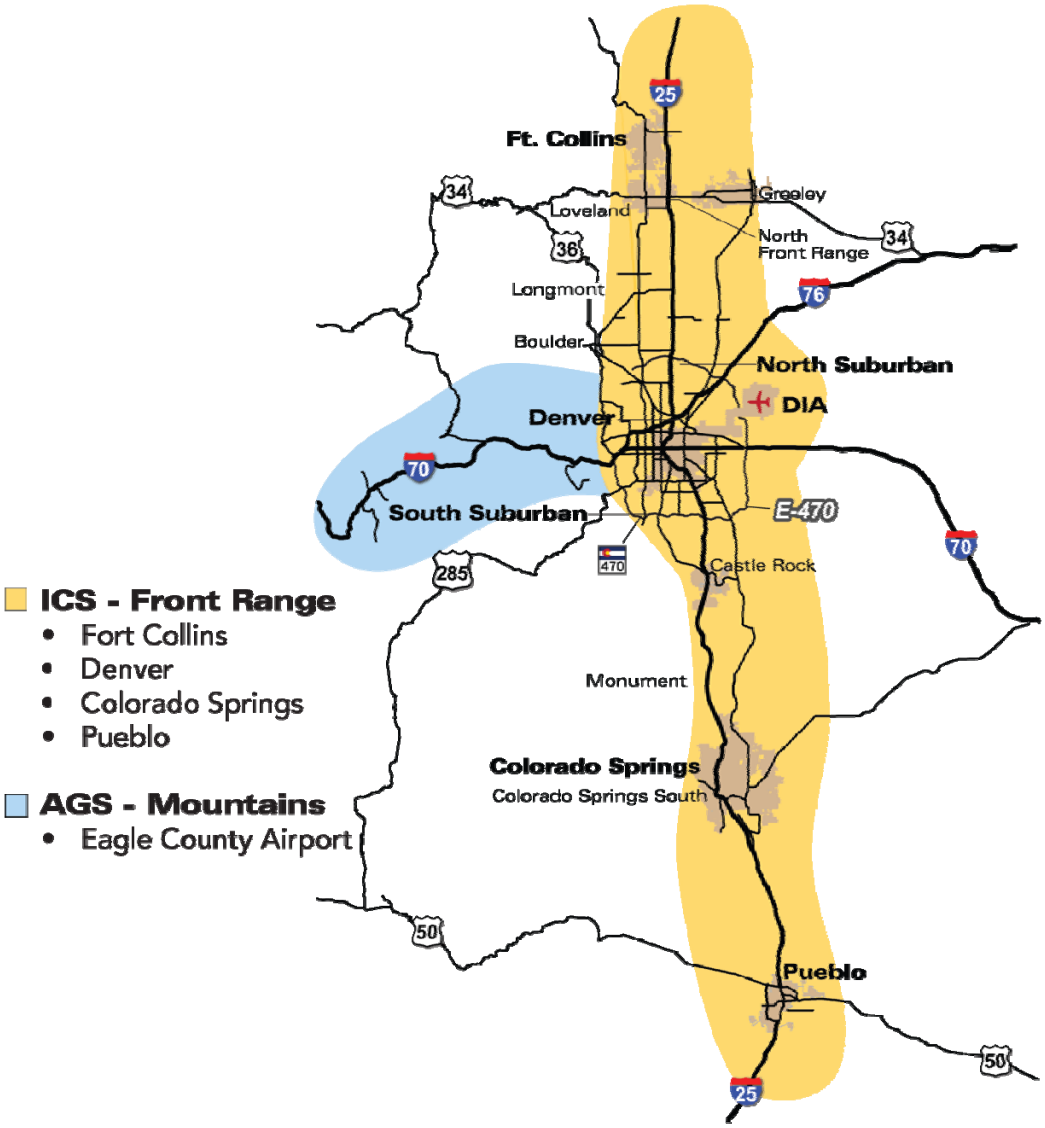
How was it done? This document generally focuses on the development of the LPA for the ICS (referred to as the ICS LPA). After explaining the background of the project, the narrative describes the three levels of evaluation done to refine the original 12 scenarios to 5 scenarios in the Level 1 Evaluation, to 3 scenarios in the Level 2 Evaluation, and ultimately the combination of parts of the final 3 scenarios into the ICS LPA in the Level 3 Evaluation.

When will it start? The final part of this document discusses possible methods to phase and fund the project to facilitate a future opening of HST along the Front Range when funding becomes available.

What is the Difference between the ICS and AGS Study Areas?

As explained earlier, there are two parallel efforts to study HST in Colorado: the ICS and the AGS. The study areas for both projects are shown on **Exhibit ES-1**. For the ICS, the study limits include DIA to the east, the C-470/I-70 interchange near Golden to the west, the City of Fort Collins to the north, and the City of Pueblo to the south. For the AGS, the study limit is from the C-470/I-70 interchange near Golden to the Eagle County Regional Airport.

Exhibit ES-1: ICS and AGS Study Areas



What is the Definition of High-Speed Transit?

HST is different than commuter rail, light rail, or streetcar projects that have been sponsored in Colorado in the recent past. The FRA defines several categories of high-speed rail, described in **Exhibit ES-2**. For the purposes of this study, the term high-speed transit (HST) has been adopted because the technologies considered include both high-speed rail (HSR) and magnetic levitation (Maglev).

What Was the Study Process?

The ICS followed the traditional transportation planning process commonly used by engineers and planners to address future mobility needs of increasing populations. The first step was to determine ways to bring local governments, public agencies, and the general public into the study process. Once methods were developed to solicit input, a project Purpose and Need was crafted to understand what mobility problems are expected and how Colorado's existing infrastructure will not meet travel demand along the Colorado front range and through the I-70 mountain corridor from the Denver metro area. A clearly stated purpose and need set the foundation to allow planners to understand what mobility problems the study needed to solve.

Before progressing into potential solutions to address the stated mobility problems, evaluation criteria were developed to help evaluate alternative solutions. After the criteria were established and agreed upon by the public, the study team began identifying alternative solutions.

Because of the large geographical area for the study and due to the complexities of the analyses, a three step evaluation process was determined to be the most effective way to narrow down dozens of potential alternatives into a handful of the most promising alternatives that address the State's future needs. After completion of a level 1, level 2, and level 3 evaluation, the best solution, referred to as the locally preferred alternative (LPA) was developed.

What follows is a high level summary of each step in the study process described above.

Exhibit ES-2: Federal Railroad Administration (FRA) High-Speed Rail Categories

Category	Service	Top Speeds/ Right of Way	Purpose
HSR Express	Frequent service between major population centers from 200 to 600 miles apart	At least 150 miles per hour (mph) on dedicated right-of-way (ROW)	Relieve air travel and highway capacity constraints
HSR Regional	Relatively frequent service between major and moderate population centers from 100 to 500 miles apart	110 to 150 mph on grade-separated track, and some shared track, with some intermediate stops	Relieve highway and, to some extent, air travel capacity constraints
Emerging HSR	Located in developing corridors from 100 to 500 miles apart with a strong potential for future HSR Regional or Express service	90 to 110 mph with either advanced grade protection or grade separation	Develop the passenger rail market and provide some relief to other travel modes
Conventional Rail	Traditional intercity passenger rail service of more than 100 miles with as little as one to as many as 12 daily runs; conventional rail may or may not have the potential for future HST service	Top speeds between 79 mph and 90 mph, generally on shared track	Provide travel options and develop passenger rail markets for future development

What is the Purpose and Need for the ICS?

Purpose

A HST system would provide Colorado with a well-supported modal option for the state's transportation network that would:

- Connect communities and destinations for interregional business and tourism travel;
- Build on and strengthen Colorado's existing transportation infrastructure;
- Support the State's HST Vision as articulated in the State Rail Plan; and

- Offer statewide social, environmental, and economic benefits that are greater than the capital and operating costs of its implementation.

Need

HST would meet the following needs for travel in Colorado:

- Address the mobility demands of future population growth
- Improve mobility and system capacity by providing another travel option
- Enhance economic growth and development through improved connectivity
- Improve the state's environmental quality and energy efficiency
- Provide economic benefits sufficient to attract new funding sources

Many of these needs address the reality Colorado faces – automobile traffic, freight movements, and general aviation are expected to roughly double between now and 2035. During this same period, the statewide population is projected to increase from 5 million to 8 million. Given this level of growth and the desire to accommodate larger populations in a sustainable manner, CDOT is evaluating travel options other than the single-occupant automobile in order to enhance the capacity of the state's transportation system to move people, goods, and information.

CDOT's adopted Colorado Rail Vision from the State Rail Plan is as follows:

Adopted Colorado Rail Vision

The Colorado rail system will improve the movement of freight and passengers in a safe, efficient, coordinated and reliable manner.
In addition, the system will contribute to a balanced transportation network, cooperative land use planning, economic growth, a better environment and energy efficiency. Rail infrastructure and service will expand to provide increased transportation capacity, cost effectiveness, accessibility and intermodal connectivity to meet freight and passenger market demands through investments which include public-private partnerships.

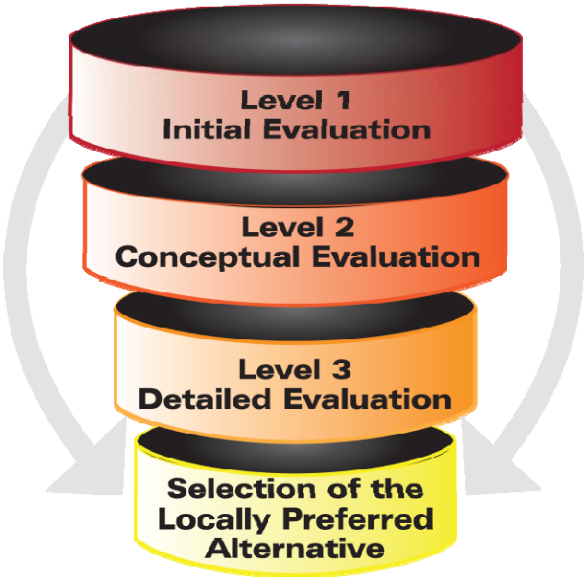
How Was the Public Made Part of the Study Process?

As discussed below, input from those most affected by a future HST system was solicited throughout the ICS planning process. To obtain this input, CDOT assembled a Project Leadership Team (PLT) of approximately 70 staff from agencies and institutions within the study area. Citizen input was provided through 12 public workshops held throughout the state, and materials available on the CDOT website.

How Were the Alternative HST Scenarios Evaluated?

As shown in **Exhibit ES-3**, the study approach for the ICS involved three levels of increasingly detailed engineering and planning evaluation. The work of each level of evaluation culminated in a milestone, and the results of each milestone were presented to the PLT and the public for comment.

EXHIBIT ES-3:Alternatives Evaluation Process



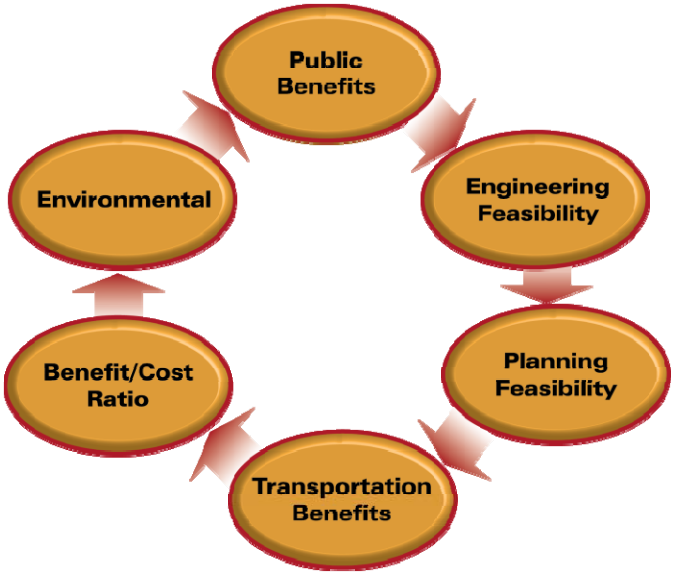
Revisions were made before the recommendations were presented to the public in three rounds of four open houses, one in each city/region: Fort Collins/North Front Range, Denver, Colorado Springs/Pikes Peak, and Pueblo. Public comments were recorded and incorporated before starting the activities of the subsequent milestone. PLT and public input was provided at each level before proceeding to the next level of evaluation.

Following the Level 1, Level 2, and Level 3 Evaluations, a Preferred Alternative was recommended for public comment in the Draft Report. After the receipt of public comments, the Preferred Alternative was refined and became the ICS LPA. The implementation plan was finalizedafter completion of the Level 3 Detailed Evaluation.

What Criteria Were Used to Evaluate the HST Scenarios?

The evaluation criteria for the ICS evaluation process were vetted through the PLT and at four public open houses during the initial stages of the study. These criteria have been modified as the study progressed, and were tailored to provide better information for determining the best scenarios for the state's HST system. Following FRA guidance, these criteria have been divided into the following categories:

- Public Benefits
- Transportation Benefits
- Environmental
- Engineering Feasibility
- Planning Feasibility
- Benefit/Cost Ratio



What Technologies Were Evaluated?

Throughout the ICS, the scenarios were configured to accommodate either high-speed electric or high-speed Maglev technologies. This is due to the high level of interest in the AGS study area in the use of Maglev technology to more effectively negotiate the curves and steep grades characteristic of the I-70 mountain corridor. The feasibility of HST was determined by public support, capital and operating costs, ridership, and revenue. Ridership and revenue forecasts were prepared for both technologies and found to be comparable. Capital costs for Maglev were found to be higher in the ICS study area but lower in the AGS study area.

Several example technologies for high-speed rail and Maglev are depicted here.

High-Speed Electric Rail

High-Speed Electric Rail

High-Speed Maglev

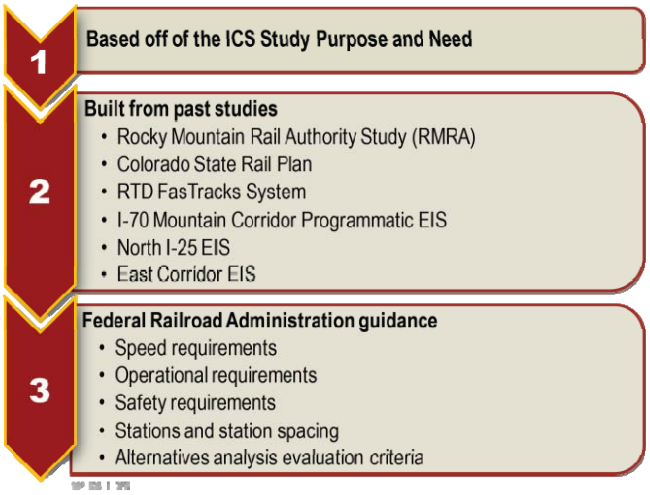
Dual Mode (Diesel-Electric) Rail

Level 1 Evaluation

How Were the Alternative HST Scenarios Developed?

The development of alternative scenarios for an HST system involved building off of past studies, using performance criteria, and considering FRA requirements. **Exhibit ES-4** lists the past studies and FRA guidance that formed the basis for the ICS effort.

EXHIBIT ES-4: Information Used to Develop Alternative Scenarios



The technical team took progressive steps to develop the best HST scenarios by:

- Defining possible segments through the Denver metro area, where a segment is defined as a possible route between two points.
- Identifying possible segments to the north to Fort Collins and to the south to Colorado Springs and Pueblo.
- Developing the best-performing HST alternative scenarios using the best segments.

As a result of this analysis, 18 segments were identified and configured into 12 possible HST scenarios. Three groupings of scenarios – A-, B-, and C-series – were considered:

- **A-series:** These scenarios go directly though the Denver metro area and continue on to Fort Collins or Colorado Springs and Pueblo. It was expected that these scenarios would be more direct, and thus have faster travel times than the B-series scenarios, which go around the metro area using existing beltways. It was also anticipated that they would have much greater community impacts due to the need to acquire right-of-way (ROW). Six possible A-series scenarios were identified, as shown in **Exhibit ES-5**.
- **B-series:** These scenarios were configured to test the impact on ridersip of circumventing the Denver metro area before continuing north to Fort Collins and south to Colorado Springs and Pueblo. It was expected that these scenarios would have fewer community impacts due to available ROW. Four possible B-series scenarios were identified, as shown in **Exhibit ES-6**.
- **C-series:** One scenario involves HST sharing RTD track within the Denver metro area, as shown in **Exhibit ES-6**. The intent of this scenario was to capitalize on RTD's existing FasTracks infrastructure and avoid new construction through the Denver metro area.

EXHIBIT ES- 5: A-Series Alternative Scenarios: Through the Denver Metropolitan Area

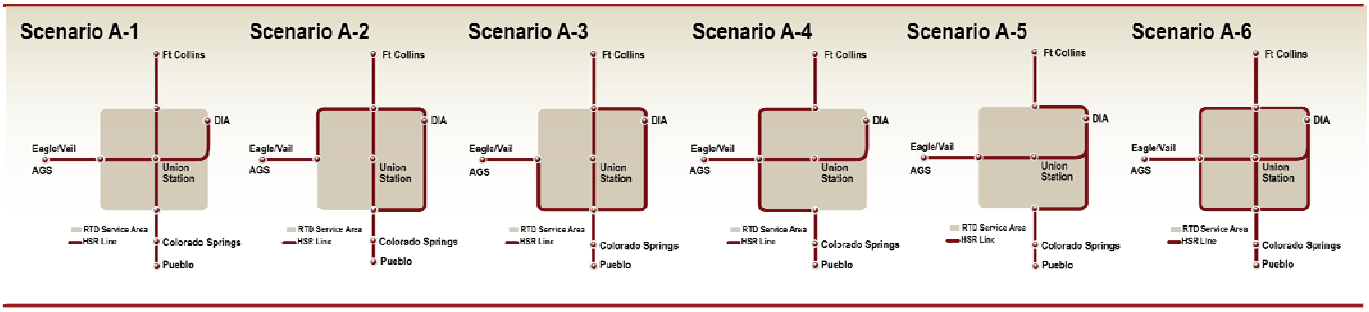
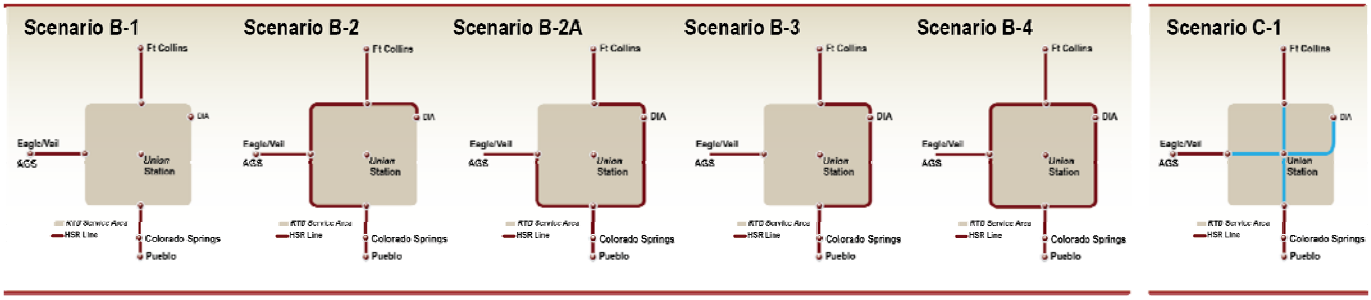


Exhibit ES- 6: B and C Series Scenarios Around the Denver Metro Area



What Were the Results of the Level 1 Evaluation?

Of the 12 alternative HST scenarios initially considered, the Level 1 Evaluation recommended five scenarios for further analysis and ridership modeling. These five alternative scenarios represent the best range of comparisons for future planning; however, the remaining seven alternative scenarios were not precluded from future consideration.

Exhibit ES-7 summarizes the five alternative scenarios that were carried forward for additional study and the seven alternative scenarios that were set aside from further consideration.

Findings for Segments North and South of the Denver Metro Area

Exhibit ES-8 and **Exhibit ES-9** depict the candidate HST segments north to Fort Collins and south to Colorado Springs and Pueblo, respectively, that were assessed during the Level 1 Evaluation.

The N-1: Railroad Segment, which shares the BNSF railroad ROW, does not technically meet the requirements of HST due to having more than 100 at-grade crossings, anticipated slow travel speeds, and high operational impacts to residential land uses in Longmont, Loveland, and Fort Collins. This segment would potentially have poor ridership and thus may not be cost effective. However, this segment is included as a future commuter rail transit (CRT) alternative in the North I-25 Environmental Impact Statement (EIS), suggesting it has local support as a rail transit route as configured in the EIS.

Issues to be Addressed in the Level 2 Evaluation

At the conclusion of the Level 1 Evaluation, a few key issues were identified to be addressed in the Level 2 Evaluation:

- What is the effect of stopping at Denver Union Station (DUS) versus some other central Denver station location?
- What are the differences in travel time, ridership, and cost-effectiveness between scenarios that pass through the Denver metro area versus those that circumvent these areas?
- What is the effect on ridership if HST is constructed as a complete beltway around the Denver metro area versus only a partial beltway or a beltway that traverses only the east or west portions of the metro area?
- What are the impacts of following existing railroad lines north to Fort Collins or south to Colorado Springs compared to straighter, faster segments that do not follow the railroad.

EXHIBIT ES-7: Summary of Level 1 HST Alternative Scenarios

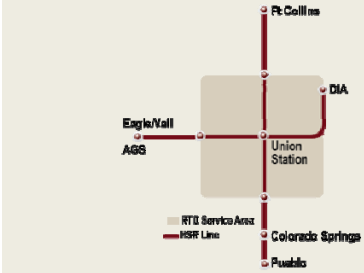
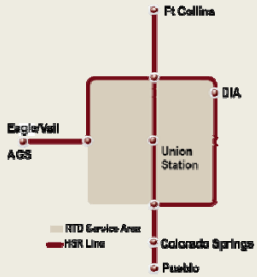
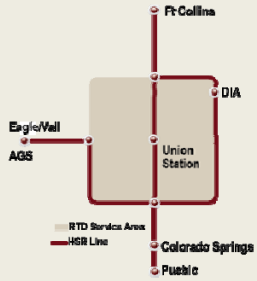
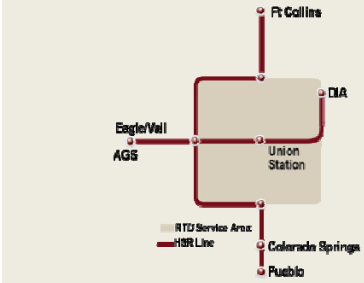
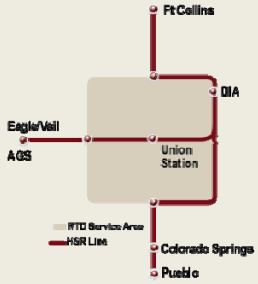
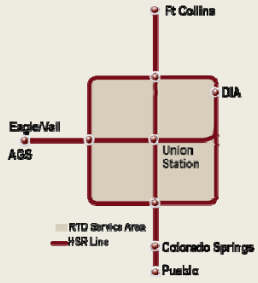
Description and Recommendation: A-Series Scenarios		
		
A-1: Direct through Denver **CARRY FORWARD**: This scenario will be carried forward to test the ridership of a direct connection through the Denver metro area. The scenario is also highly supported by the I-70 mountain corridor stakeholders as it is considered critical to the success of the AGS. Other benefits include: ▪ Shortest and possibly fastest scenario ▪ Provides one-seat ride to the most destinations ▪ Provides contrast to beltway option ▪ Allows consideration of all technologies	**A-2: Beltway Excluding the Southwest Quadrant** **SET ASIDE:** This scenario is not recommended for modeling because scenarios A-1, A-5, and A-6 are anticipated to provide a better test of ridership.	**A-3: Beltway Excluding the Northwest Quadrant** **SET ASIDE**: This scenario is not recommended for modeling because scenarios A-1, A-6 and B-2A are anticipated to provide a better test of ridership.
		
A-4: Western Beltway **SET ASIDE:** This scenario is not recommended for modeling because scenarios A-1 and A-6 are anticipated to provide a better test of ridership.	**A-5: Eastern Beltway** **CARRY FORWARD**: This scenario is recommended for modeling because it is anticipated to be the lowest-cost option of the A-series scenarios. Other benefits include: ▪ Provides one-seat ride to DIA ▪ Supportive of the AGS ridership ▪ Allows consideration of all technologies	**A-6: Complete Beltway** **CARRY FORWARD**: This scenario is recommended for modeling because it is anticipated to provide the highest ridership of the alternative scenarios considered at the Level 1 Evaluation. Other benefits include: ▪ Provides one-seat ride to the most destinations ▪ Supportive of the AGS ridership ▪ Potential for highest ridership ▪ Test as a comparison to all others ▪ Demonstrates the case for diminishing returns in ridership versus cost ▪ Allows consideration of all technologies

EXHIBIT ES-7: Summary of Level 1 HST Alternative Scenarios

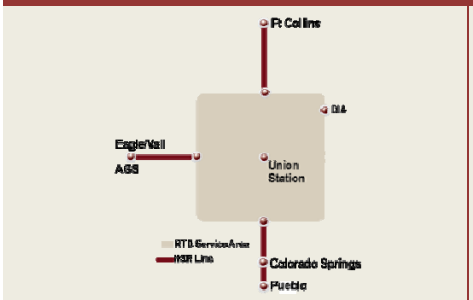
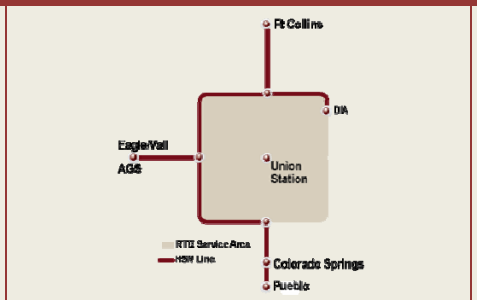
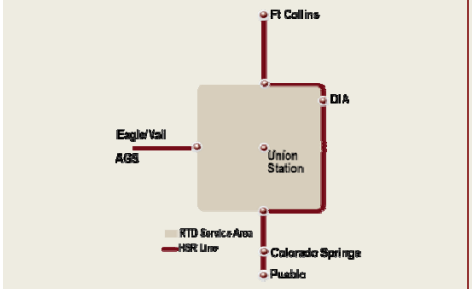
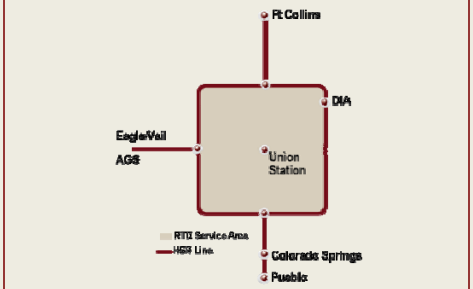
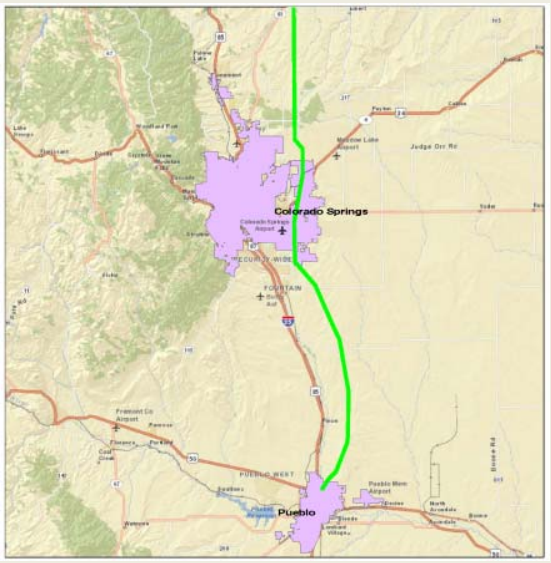
Description and Recommendation: B- and C-Series Scenarios		
		
B-1: Denver Periphery **SET ASIDE:** This scenario will not be modeled because scenario C-1 would be more representative of the project Purpose and Need and would provide continuous HST service through the Denver metro area to other portions of the state.	**B-2: Denver Periphery Including the Southeast Quadrant** **SET ASIDE:** This scenario is not recommended for modeling because scenarios A-2 and B-2A are anticipated to perform better due to the fact that both provide service to southeast Denver, whereas B-2 does not.	**B-2A: Denver Periphery Excluding the Northwest Quadrant** **CARRY FORWARD**: This scenario is recommended for modeling because it is important to test a peripheral scenario around the Denver metro area against a direct east-west scenario through Denver such as provided by A-1, A-4, A-5, and A-6. Other benefits include: ▪ Anticipated to be the best performing of the B-series scenarios ▪ Avoids the less well-defined Northwest Quadrant ▪ Allows consideration of all technologies outside of the RTD system
		
B-3: Denver Periphery Eastern Beltway **SET ASIDE:** This scenario is not recommended for modeling because ridership information on the effectiveness of the eastern beltway scenario will be provided through the modeling of A-5.	**B-4: Denver Periphery Full Beltway** **SET ASIDE:** This scenario is not recommended for modeling because A-6 will be used to test the ridership effectiveness of a full beltway scenario.	**C-1: Shared Track with RTD** **CARRY FORWARD**: This scenario is recommended for modeling because it tests the effectiveness of HST sharing existing RTD track. Other benefitsinclude: ▪ Second lowest-cost scenario ▪ Low environmental impact ▪ Provides one-seat ride

EXHIBIT ES-8: Summary of North Segment Evaluation

Segment Name and Disposition	
N-1: Railroad Segment	**N-2: Greenfield**
	
CARRY FORWARD: Incorporate into a HST scenario.	**CARRY FORWARD**: Incorporate into a HST scenario.

EXHIBIT ES-9: Summary of South Segment Evaluation

S-1: Railroad Segment	**S-2: Greenfield**
	
CARRY FORWARD: Incorporate into a HST scenario.	**SET ASIDE:** Configure a new greenfield segment to replace S-2.

Level 2 Evaluation

The Level 2 Evaluation built upon the technical analysis and public input received during the Level 1 Evaluation. Level 2 involved more quantitative assessment of the ridership, cost, and environmental consequences of each of the five remaining scenarios.

What Scenarios were Carried into the Level 2 Evaluation?

As discussed earlier, five scenarios were recommended for further analysis and were carried forward into the Level 2 Evaluation:

- A-1: Direct through Denver
- A-5: Eastern Beltway
- A-6: Complete Beltway
- B-2A: Denver Periphery Excluding the Northwest Quadrant
- C-1: Shared Track with RTD

Additional Alternatives Resulting from the Level 1 Evaluation

As a result of the public process supporting the Level 1 Evaluation, three new segments were recommended for Level 2 Evaluation:

- **I-70 ROW/I-76 ROW/96th Avenue/DIA –** Use of the I-76 ROW from I-70 traveling east to 96th Avenue to DIA. A new station would be provided near the intersection of the North Metro Commuter Rail Line and I-76, hereafter referenced as the I-76/72nd Station. DUS would not be accessed in the east-west direction. This became Option A for the A-1 and A-5 scenarios.
- **New Greenfield Segment from Denver metro area to Colorado Springs and Pueblo –** Due to concerns about impacts to the Black Forest community north of Colorado Springs, a new HST Greenfield segment was defined that generally follows the I-25 south and BNSF railroad ROWs from south Denver to Colorado Springs and Pueblo. This segment was re-engineered as part of the Level 2 Evaluation.
- **Revisions to Scenario C-1: Shared Track with RTD –** Because it may not be possible to share either the RTD Southeast or Southwest light rail transit (LRT) track with HST technologies, a new routing to connect DUS to the South Suburban Station via DIA was recommended. This new segment follows the E-470 alignment.
- **Sharing track** with RTD's East Commuter Rail to DIA, North Metro Commuter Rail from DUS to the north, and Gold Line Commuter Rail from DUS to Golden is still being considered as part of this scenario.

Scenarios A-1 and A-5 were carried into the Level 2 Evaluation with few changes. Because it was not possible to define the most acceptable east-west segment through the Denver metro area, two design options were retained for these scenarios:

- Option A: I-76
- Option B: US 6

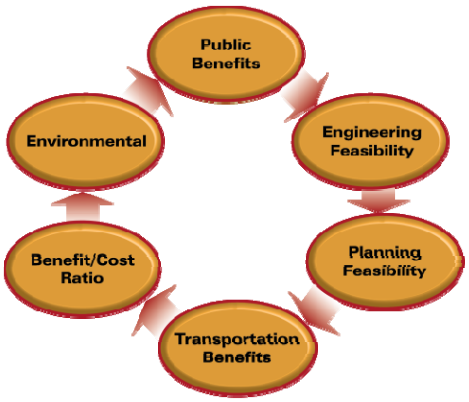
At over $20 billion, Scenario A-6 was found to be too costly during the initial phase of the Level 2 Evaluation and was dismissed. It was replaced with a different scenario, B-5: Denver Periphery – Northwest, on the advisement of the PLT representatives from the northwestern Denver metro area.

Scenario B-2A was carried forward into the Level 2 Evaluation with no changes from Level 1.

As discussed above, Scenario C-1 was modified by adding construction of HST on the E-470 ROW (defined as Segment B-3 in the Level 1 Evaluation Report) from DIA to the South Suburban Station. This change addresses the fact that HST vehicles likely can not share track with RTD's Southeast Corridor due to incompatible technology.

What were the Results of the Level 2 Evaluation?

A high-level summary of the benefits and costs associated with the implementation of the possible HST scenarios is presented below.



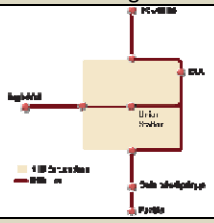
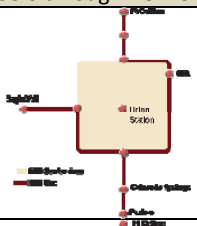
Public Benefits

- **Project Purpose and Need –** At this level of evaluation, all of the scenarios fulfill the elements of the Purpose and Need statement. A key element of the Purpose and Need is that the HST offers statewide social, environmental, and economic benefits that are greater than the capital and operating costs of its implementation.

All five scenarios have benefit/cost (B/C) ratios of approximately 2.0 or slightly better.

Likewise, all five scenarios have operating ratios of greater than 1.0, as shown in **Exhibit ES-10**. A positive operating ratio is important because the surpluses can be used to help defray the annualized capital payment for the system. Compared to the B/C ratios, there is more variability with the operating ratios realized by the five scenarios, which range from a high of 1.45 for A-1B (US 6) to 1.05 for C-1. Scenarios B-2A and B-5 have lower ratios because their beltway alignments generate additional annual train miles, and hence a higher operating cost.

Exhibit ES-10: Operating Ratio by Scenario

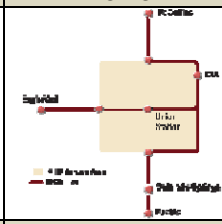
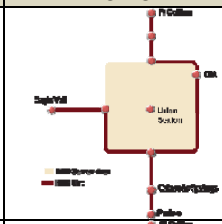
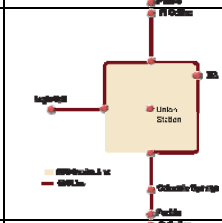
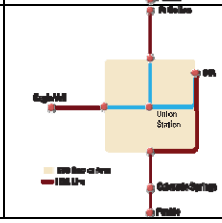
Scenario		Operating Ratio
A-1A		1.32
A-1B	Same as A-1A but follows US 6 through Denver	1.45
A-5A		1.32
A-5B	Same as A-5A but follows US 6 through Denver	1.35
B-2A		1.21
B-5		1.19
C-1		1.05

- **Public and PLT Support –**In general, the support for HST has been strong based on the PLT and public workshop processes. That being said, with some exceptions, routes traveling around the Denver metro area (B-2A and B-5) appear to be better supported than those that travel through the metro area (A-1, A-5, A-6). Because the alignments for all of the scenarios are the same once they leave the Denver metro area, there is no public preference. The main area of public concern has been funding for the HST.
- **Livable Communities –** All of the scenarios will support livable communities and Transit Oriented Development (TOD), with only minor differences in benefits among the scenarios. The scenarios are expected to range between $2.75 billion and $3.3 billion in real estate development.
- **Employment –** All of the scenarios would produce a large employment benefit. Since the capital costs of the full-build scenarios are within 10 percent of one another, the employment benefits will have a similar range. It is anticipated that the average construction force to build one of these scenarios would be about 11,000 jobs per year during a 10-year construction period. An additional 16,000 'spinoff' jobs are predicted as a result of the multiplier effect (multiplier = 2.0). Likewise, about 1,200 permanent jobs will be required to operate and maintain any of the scenarios considered. An additional 600 permanent jobs would be created as a result of the multiplier effect (multiplier = 1.5).

Transportation Benefits

- **System Ridership –** The expected ridership for all of the full-build scenarios (A- and B- series) is comparable, as shown in **Exhibit ES-11**. The scenarios that travel through the Denver metro area (A-1 and A-5) both have annual 2035 ridership of about 13 million per year. The scenarios that travel around the Denver metro area (B-2A and B-5) are projected to have ridership of 13.8 and 13.7 million per year, respectively. This result confirms that traveling around the developed metro area will not hurt ridership, and is actually expected to improve the results.
- **Connections to Local Transit –** Connections to local transit are largely the same for all of the Level 2 scenarios because they all share similar stations.

Exhibit ES-11: System Ridership and Revenue (Full System)

Scenario		Ridership (millions/year)	Revenue (million$/year)
A-1A		12.1	$293.8
A-1B	Same as A-1A but follows US 6 through Denver	13.1	$323.1
A-5A		12.9	$305.0
A-5B	Same as A-5A but follows US 6 through Denver	13.1	$306.8
B-2A		13.8	$318.9
B-5		13.7	$310.3
C-1		10.8	$242.7

However, there are several exceptions. The scenarios that travel around the periphery of the Denver metro area (B-2A and B-5) do not stop at DUS or at the proposed I-76/72nd Station associated with an alignment on I-76.

Outside of the Denver metro area, all of the scenarios have stops at Longmont/Berthoud, Fort Collins, Colorado Springs, Fort Carson/Fountain, and Pueblo. The final locations of these stations have not been determined under the assumption that the final sites selected will be based on local preference and strong connectivity with transit.

Environmental

- **Impacts -** Construction of any of the scenarios would have environmental impacts. On average, all of the scenarios involve about 214 miles of guideway construction and, with stations, would require about 1,430 acres of property acquisition. Scenario C-1, which shares track with RTD in the Denver metro area, would disturb about 1,154 acres, or 276 acres less than the other scenarios. However, Scenario B-2A, which provides the highest ridership at 13.8 million/year, would only require 87 more acres of disturbance than Scenario C-1. Further, assuming that the total construction footprint is not as important as the location of the impact, the scenarios that travel through the Denver metro area (A-1 and A-5) are predicted to have a much greater impact than those that travel around the periphery (B-2A and B-5).

  Conversely, the operation of all the scenarios would encourage more compact development around the HST stations, reducing urban sprawl and encouraging the use of transit. Both benefits would reduce vehicle miles traveled, resulting in a modest positive impact on air quality. Because the ridership among the full-build scenarios differs by only about 6 percent, the relative differences in benefits are also expected to be modest.

Engineering Feasibility

- **Constructability -** All of the proposed scenarios are constructible. However, Scenarios A-1 and A-5 present the greatest challenges. Of the two, A-1 is the most challenging. The north-to-south alignment parallel to the Brush/CML/Joint Line freight railroad corridor would require extensive private ROW acquisition through congested urban areas, as well as construction of large quantities of elevated structure. Similarly, the east-to-west segment along US 6 also requires acquisition of private ROW, including many single-family homes. Further, the guideway would need to be elevated over much of the alignment, increasing both cost and noise. Conversely, the construction of Scenarios B-2A and B-5 would occur largely in public ROWs in open, uncongested areas.
- Construction of the segments north to Fort Collins and south to Pueblo is not a discriminator since those segments are common to all five scenarios.

However, as configured in Level 2, construction to the north is much less complicated since the majority of the construction is anticipated to take place in the I-25 ROW. (As shown in the Level 3 Evaluation, the alignment was later moved to the east side of I-25.)

- Construction to the south from the South Suburban Station in Lone Tree to Colorado Springs will be much more complicated due to severe topography and restricted ROW through Castle Rock and Colorado Springs. As such, the construction cost per mile of this segment ($52.6 million) is about 44 percent more than for the segment north to Fort Collins ($36.6 million). Construction from Colorado Springs to Pueblo will be less topographically constrained and much less complicated.
- **Cost Feasibility - Exhibit ES-12** presents the Level 2 Evaluation estimated capital expenditures (CAPEX) and operating expenditures (OPEX) for each scenario. The capital estimates do not include the cost of vehicles because a technology has not been selected. It is anticipated that 25 train sets would be required at approximately $20 million each. Thus, an allowance of $500 million should be added to the costs presented in Exhibit ES-12.

Exhibit ES-12: CAPEX and OPEX Costs by Scenario (ICS Only)

Scenario	CAPEX	OPEX
A-1A: Direct through Denver (I-76)	$15.3 B	$183.0 M
A-1B: Direct through Denver (US 6)	$14.6 B	$183.0 M
A-5A: Eastern Beltway (I-76)	$14.1 B	$186.0 M
A-5B: Eastern Beltway (US 6)	$14.3 B	$186.0 M
B-2A: Denver Periphery Excluding the Northwest Quadrant	$13.4 B	$205.0 M
B-5: Denver Periphery Excluding the Southwest Quadrant	$13.9 B	$207.0 M
C-1: Shared Track with RTD	$11.5 B	$189.2 M

Planning Feasibility

- **Planning and Priorities -** Any of the proposed scenarios are feasible from a planning standpoint; all are in conformance with the State Rail Plan, and the concept of HST is consistent with regional planning documents, all of which endorse the concept of increased mode share by transit. The degree to which the scenarios will fulfill local land use plans will depend on station location. At the Level 2 Evaluation, station location specifics have not been addressed other than for general locations for the purpose of travel demand modeling.

  The greatest determinant of planning feasibility will be measured by the political will to fund any of the proposed scenarios. The implementation of any scenario will require a major non-federal funding source, such as an increase in sales tax, fuel tax, property tax, etc. Funding from sources other than the federal government will likely need to approach 50 percent of the total capital cost of the scenario to attract private and/or federal funding. Absent the political will to increase revenues, a HST system for Colorado will not be feasible. This conclusion holds true for all of the scenarios and is not a discriminator for selection.

Scenarios Retained

Based on the Level 2 Evaluation, three of the five scenarios were recommended for further refinement in the Level 3 Evaluation:

- Scenario A-5A (I-76)
- Scenario B-2A
- Scenario C-1

Scenario A-5A (I-76) is retained because it best serves DIA with a one-seat ride from all markets and provides better connections to central Denver than does B-2A. While it requires a transfer from RTD's North Metro Commuter Rail Transit (CRT) to DUS, it could also provide a strong connection to the Gold Line and eventual Northwest Rail project at the Pecos Station for an alternate trip to DUS. Option A (I-76) is recommended because it results in fewer community impacts than Option B (US 6). The PLT felt that one "through Denver" scenario needed to be carried into the Level 3 Evaluation, and A-5 has lower costs and fewer impacts that A-1 while producing comparable ridership.

Scenario B-2A is recommended for the Level 3 Evaluation because it produces the best ridership at the lowest cost of all scenarios with the exception of C-1. It would avoid the impacts of construction through the Denver metro area, and it provides the best access for populations from the southern markets, as well as strong access from the northern markets. This is partially offset by the fact that travel from the mountains, while still a one-seat ride, is longer than with the A-series scenarios.

Scenario C-1 is retained because it accommodates phasing of a HST program for the state.

Scenarios Set Aside

Based on the Level 2 Evaluation, the following scenarios have been set aside:

- Scenario A-1 (both Options A and B)
- Scenario A-6
- Scenario B-5

Scenario A-1 was not carried forward due to the anticipated high community impacts of constructing a HST system north-south and east-west through the Denver metro area. This system is also more likely to be construed as competition and redundancy to RTD's FasTracks program. Using the less impactful Option A (I-76), the ridership is the lowest of the full-build scenarios. With Option B (US 6), the ridership is competitive but the impacts are too damaging. Further, the PLT has advised the study team that the implementation of HST through the core of the Denver metro area is likely to be unimplementable due to a long and contentious environmental process.

Scenario A-6 was eliminated early in the Level 2 Evaluation because the $20-billion cost was considered unimplementable. Further, the community impact of this scenario would replicate that of A-1, with the addition of the impacts associated with the beltway segments.

Scenario B-5 was set aside because of a lack of support from the City of Golden and because it provided poor connections for travelers from the southern markets, which account for nearly twice the ridership of the northern markets.

Segments Set Aside

Based on the Level 2 Evaluation, the following segments have been placed aside:

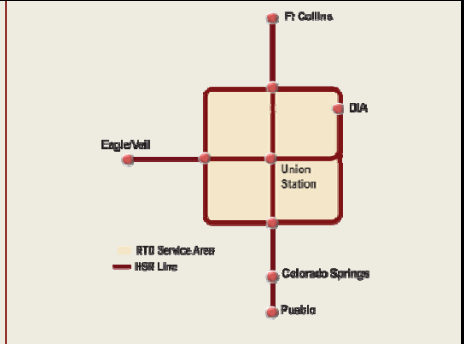
- Segment S-1 (Greenfield)
- Segment N-1 (EIS)

Segment S-1 (Greenfield) south to Colorado Springs and Pueblo was eliminated because of intensive public opposition for constructing HST through the Black Forest community north of Colorado Springs. It was replaced with Segment S-3, which closely follows the I-25 alignment.

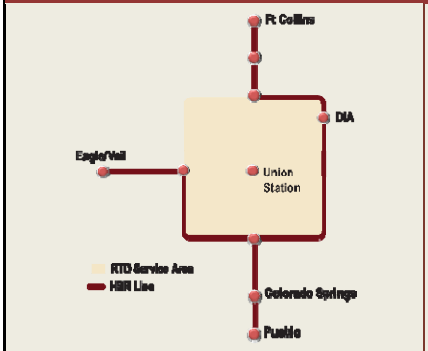
Segment N-1 (EIS) was eliminated because it is not suitable for HST. Constructing HST with competitive travel times through the cities of Longmont, Berthoud, Loveland, and Fort Collins would have required extensive elevated structure and private property acquisition, increasing community impacts to unacceptable levels and escalating the cost to over three times that of Segment N-2 (I-25). The operation of HST was also considered unacceptable in this area due to anticipated high levels of noise. Further, the North I-25 EIS Record of Decision (ROD) has committed the SH-287 corridor to Commuter Rail Transit, which is supported publicly and will remain in place to be implemented separately as funds become available.

Exhibit ES-13 provides a summary of the HST scenarios recommended to be set aside or carried forward into the Level 3 Evaluation.

Exhibit ES-13: Summary of Level 2 Evaluation of the HST Scenarios (Cost Values are for ICS only)

Scenario Recommendations for Level 3 Evaluation		
		
A-1 (Options A & B): Direct Routing through Denver • CAPEX - $14.6 - $15.3 billion • OPEX - $183 million/year • Ridership - 12.1 to 13.1 million/year • Revenue - $250 million/year • OPEX Ratio - 1.32/Option A to 1.45/Option B • B/C Ratio – 1.98/Option A to 2.03/Option B **SET ASIDE**: ▪ Performs well but results in high community impacts to the Denver metro area with either Option A or B. ▪ Scenarios A-5, B-2A, and B-5 perform as well or better and generally cost less. ▪ Obtaining NEPA clearances though the Denver metro area would be time consuming and contentious, eroding public support for the HST program. ▪ Does not serve DIA from north or south well due to a lengthy transfer at DUS and competition from RTD's lower fares and good travel times.	**A-5 (Options A & B): Eastern Beltway** • CAPEX - $14.1 - $14.3 billion • OPEX - $186 million/year • Ridership - 12.9 to 13.1 million/year • Revenue - $257 million/year • OPEX Ratio - 1.32/Option A to 1.35/Option B • B/C Ratio - 2.0/with either Option A or Option B **CARRY FORWARD (Option A only)**: ▪ Performs as well as A-1 at lower cost and with fewer impacts, at least in the north-south direction through Denver. ▪ Impacts will be greater than for B-2A, B-5, or C-1 because it still involves construction through the Denver metro area in the east-west direction. ▪ Serves DIA best with one-seat ride from all markets, but requires more out-of-direction travel to the mountains from the north and south markets. ▪ Works well with either Option A (I-76) or Option B (US 6), but Option A has fewer community impacts.	**A-6: Complete Beltway** • CAPEX: $20.3 billion • OPEX: $588 million/year • Ridership – Not evaluated • Revenue - Not evaluated • OPEX Ratio - Not evaluated • B/C Ratio - Not evaluated **SET ASIDE**: ▪ While it would provide the most thorough transit coverage of the scenarios considered, it has extremely high capital and operating costs. ▪ Community and environmental impact of construction through and around the Denver metro area would be the highest of all of the scenarios considered and would likely prevent the implementation of this scenario. ▪ Evaluation of the Northwest Quadrant was provided with the consideration of Scenario B-5.

Scenario Recommendations for Level 3 Evaluation

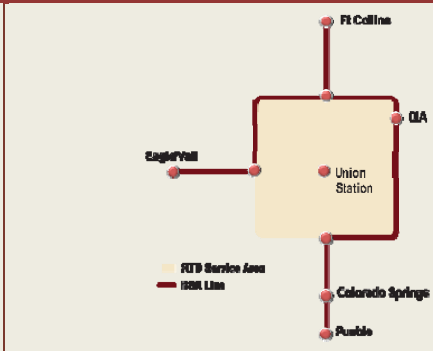


B-2A: Denver Periphery Excluding the Northwest Quadrant

- CAPEX - $13.4 billion
- OPEX - ~$205.0 million/year
- Ridership – 13.8 million/year
- Revenue - $249.0 million/year
- OPEX Ratio – 1.21
- B/C Ratio – 2.01

CARRY FORWARD:

- Generates the highest ridership and highest revenue; however, the operating ratio is lower than for A-1 or A-5.
- Lowest capital cost of any of the full-build scenarios.
- Avoids the community and environmental impacts of construction and operation through the Denver metro area.
- The key disadvantage of this scenario is that it does not provide service to DUS.



B-5: Denver Periphery Excluding the Southwest Quadrant

- CAPEX - ~$13.9 billion
- OPEX – $207.0 million
- Ridership – 13.7 million/year
- Revenue - ~$248.0 million/year
- OPEX Ratio – 1.19
- B/C Ratio – 1.99

SET ASIDE:

- While this scenario has many of the benefits of B-2A, it is not supported by many of the Northwest Quadrant stakeholders and is considered to be much more difficult to implement than Scenario B-2A.

The benefits of B-5 include:

- Generates the second highest ridership and the second highest revenue; like B-2A, the operating ratio is lower than either A-1 or A-5.
- Second lowest capital cost of any of the full-build scenarios.
- Like B-2A, avoids the community and environmental impacts of construction and operation through the Denver metro area.
- Like B-2A, the key disadvantage of this scenario is that it does not provide service to DUS.

C-1: Shared Track with RTD

- CAPEX: - $11.5 billion
- OPEX - $189.2 million/year
- Ridership - 10.8 million/year
- Revenue - $205 million/year
- OPEX Ratio – 1.05
- B/C Ratio – 1.97

CARRY FORWARD:

- Represents a possible phasing strategy to the other full-build scenarios.
- Has the lowest capital cost, but also the weakest ridership and lowest OPEX ratio.
- Maintains a B/C ratio comparable to the other scenarios.
- Provides very strong access to DIA from southeast Denver, Colorado Springs, and Pueblo due to the one-seat ride available to these locations. Because it requires a transfer to communities north and west, its ridership is weaker.

Level 3 Evaluation

At the end of Level 2 Evaluations, there were three scenarios carried forward: Scenario A-5A, Scenario B-2A, and Scenario C-1. For the Level 3 Evaluation, the three remaining scenarios were packaged into an LPA with two design options. The selection of either design option can logically be postponed until a future time without any effect on near-term phasing.

The LPA has been refined by undertaking additional engineering using digital terrain mapping and conducting further analysis of environmental issues. The refined LPA was then re-modeled to determine the impact of refinements on ridership and operations. Additional environmental analyses were conducted to determine "show-stoppers" to avoid and consider impacts to mitigate.

How Was the ICS LPA Selected?

At the beginning of the Level 3 Evaluation, three scenarios had PLT endorsement for Level 3 Evaluation, as shown in **Exhibit ES-14.**

Exhibit ES-14: Remaining Scenarios

Scenario	Concept
A-5A (I-76): Eastern Beltway	
B-2A : Denver Periphery Excluding the Northwest Quadrant	
C-1: Shared Track with RTD	

Combining the Remaining Three Scenarios into the ICS LPA

During the initial Level 3 Evaluation, it was determined that the three remaining scenarios could more logically be packaged as a single scenario with two design options: B-2A as the LPA, and A-5A and C-1 as design options. This is possible because all scenarios share the same north and south alignments; A-5A serves as a Denver metro area alternative, and C-1 is a possible phasing scenario. Combining these three scenarios into a single LPA is justified due to the fact that:

- All three share the same north-to-south alignment from Fort Collins to Pueblo, at approximately 190 miles
- All three share the same mountain corridor alignment from the West Suburban Station to Eagle County Regional Airport, at approximately 140 miles
- All three share the same general station locations

Of the three finalist scenarios, B-2A, which follows the the C-470 alignment (shown as LPA-Base in **Exhibit ES-15 on the following page**) performed the best, with the highest ridership and lowest capital cost. The evaluation team determined that this scenario would serve as the logical basis for a future vision for HST in Colorado. It was presented to the PLT and the public for endorsement as the LPA, recognizing that the future decision on routing HST east to west through the Denver metro area to the mountains could deploy any of the following options:

- **ICS LPA B-2A Base (LPA-Base; Exhibit ES-15).** This option uses the E-470 segment from east to west and assumes a transfer to AGS technology (Maglev) at the West Suburban Station.
- **ICS LPA B-2A with I-76 (LPA-I-76; Exhibit ES-16).** This option is preferred by the AGS study team because they believe it provides a more direct trip to DIA deploying Maglev technology from Eagle County Regional Airport to DIA. However, under this option, the cost of the DIA to West Suburban segment is carried by the AGS project since it would be part of the mountain corridor Maglev system. This subtracts about $1.9 billion from the ICS program and adds about $3.2 billion to the AGS system. (The segment cost for the AGS is greater because Maglev would be more costly to construct.)

- **ICS LPA B-2A with Northwest Quadrant (LPA-NWQ; Exhibit ES-17).** This option would use the Northwest Quadrant segment and assumes a transfer to AGS technology (Maglev) at the West Suburban Station. At the writing of the final report, this option had the least PLT support of the three. The reasons for retaining it are given below.

  Originally set aside, the Northwest Quadrant was brought back as a future east-to-west option because it proved effective during the Level 2 Evaluation, realizing the second highest ridership (as Scenario B-5 from the Level 2 Evaluation) of all the scenarios investigated. While the Northwest Quadrant segment was not endorsed by the City of Golden, it is possible that the City's position could change in the future, or the AGS alignment adapted to a north-of-Golden connection to address concerns.

Scenario C-1: Shared Track with RTD, was considered a phasing strategy that would be deployed as a part of the ICS program, but was not carried forward as a stand-alone LPA option. Further, any of the HST configurations assume connectivity to the RTD system at the North Suburban, West Suburban, South Suburban, and DIA stations. This would apply regardless of the east-to-west design option selected. Interconnectivity with central Denver is a high priority from the City and County of Denver; assuring a high level of connection between the City and a future HST system will remain a priority.

The three LPA options are shown in **Exhibits ES-15**, **ES-16**, and **ES-17**, respectively.

How Does the ICS LPA Fit Into the State HST Vision?

The LPAs for the ICS and AGS projects make up the State HST Vision. In general, the following narrative focuses on the affects of the ICS LPA, with the AGS LPA discussed in a separate document. However, in some instances such as ridership and revenue calculations, comparative benefit/cost analysis, and phasing priorities, the effects of the combined HST Vision and its subparts need to be addressed.

Description of the ICS LPA

Technology

Two technology types are assumed for the ICS LPA, as described earlier: HSR and high-speed Maglev. For the purposes of service planning and OPEX estimating, the assumed HSR technology is the Siemens Velaro HSR vehicle. The service plan is based on 14 trainsets with 8 cars. Assuming 70 seated passengers per car, each train would carry up to 560 passengers. This translates into a total fleet of 17 trainsets, including a 20 percent spare ratio of three trainsets.

For high-speed Maglev, the Transrapid International (TRI) technology has been assumed. No cost estimates for Maglev vehicles are provided in the ICS.

Exhibit ES-15: LPA-Base

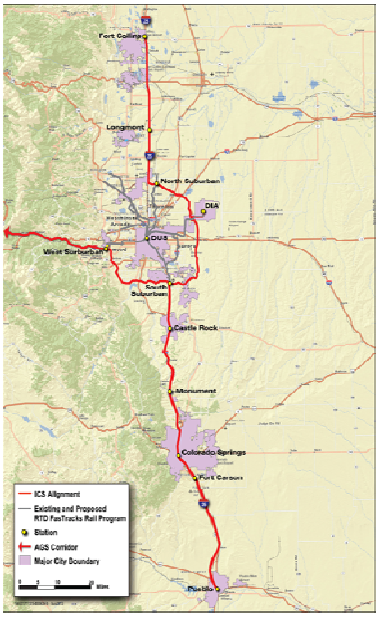


Exhibit ES-16: LPA-I-76

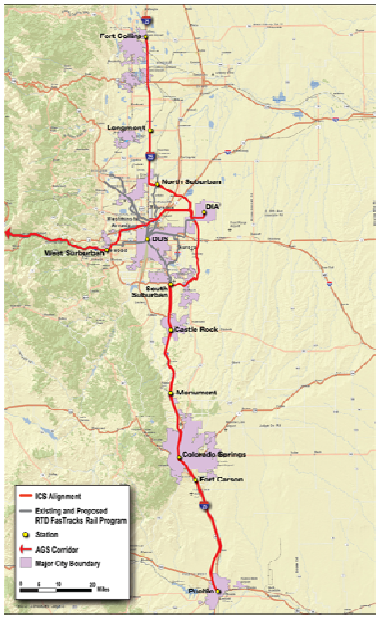
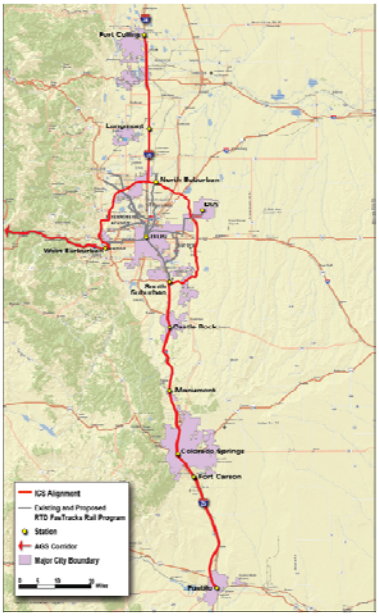


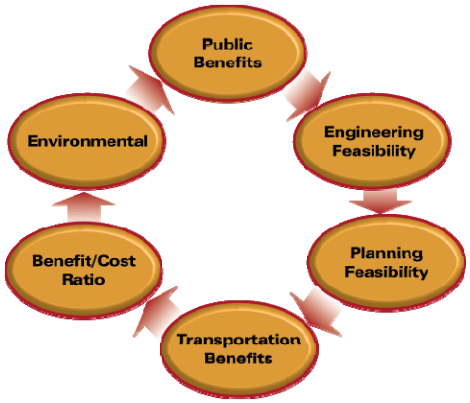
Exhibit ES-17: LPA-NWQ



Alignment

The general alignment for the ICS LPA travels from DIA north to Fort Collins, south to Colorado Springs and Pueblo, and west along any of the three east-to-west options referenced above in subsection titled "Combining the Remaining Three Scenarios into the ICS LPA." With LPA-I-76, the DIA to West Suburban Station (about 35 miles) reverts to the AGS project since it would carry Maglev technology, which is not envisioned for the ICS project due to current Front Range preferences for rail.

During the Level 3 Evaluation, other refinements were made to this alignment to reduce costs or respond to program changes. These changes are discussed below.



North to Fort Collins

This segment experienced the greatest changes during the Level 3 Evaluation. Due to programmatic agreements made by CDOT for managed lanes in the median of I-25, the HST needed to be moved from the median to the east side of the highway. This change increased the cost of the segment from Level 2 to Level 3 by approximately $1.1 billion.

Denver Metro Area

The alignment following E-470 from the North Suburban Station to the South Suburban Station has remained essentially the same, as has the alignment along C-470 to the West Suburban Station. However, refinements were made to the vertical infrastructure based on additional base mapping information.

South to Colorado Springs and Pueblo

South of Denver to Colorado Springs and Pueblo, value engineering resulted in the elimination of several flyover structures over I-25 interchanges. (A detailed discussion is provided in Section 6.4 of the report.)

Stations

Station locations were further evaluated during Level 3. For ICS LPA-I-76, one additional station located at I-76/72nd Avenue would be required. Otherwise, the station configurations are exactly the same as evaluated during Level 2. (Discussion of changes made to station locations is included in Section 6.4.2 of the ICS report, and stations locations are shown in Exhibits 6-2 to 6-4.)

Operating Strategy

The operating strategy has not changed from that recommended for Scenario B-2A (now LPA-Base) during the Level 2 Evaluation – 30-minute service during the 3-hour morning and 3-hour evening peak periods and 60-minute service for the remaining 12 hours of service.

What are the Results of the Level 3 Evaluation?

Public Benefits

Evaluation of the public benefits criterion at Level 3 is the same as for Level 2; however, due to revisions to the LPA, some of the values have changed, as discussed below under two categories:

- Project Purpose and Need
- Public and PLT Support

Project Purpose and Need

The LPA meets the project Purpose and Need statement the best of any of the scenarios evaluated. The LPA "offers statewide social, environmental, and economic benefits that are greater than the capital and operating costs of its implementation" with a final benefit/cost analysis of 1.4 and an OPEX ratio of 1.7.

Public and PLT Support

The degree of public support statewide for HST appears to be highly positive, but how the system will be funded presents concerns. In general, support has been strong based on our PLT and public workshop processes. The ICS LPA was selected in part due to the greater support for alignments that travel around the Denver metro area versus those that travel through the metro area.

Regarding the implementation of a first phase of the HST, the PLT has offered the following insights:

- The first phase needs to be successful to attract support for future phases.
- The first phase has to have wide geographic public support in order to gain commitment for a new tax initiative.
- Although they are easier to fund, smaller phases (for example, North Suburban to Fort Collins) will realize insufficient public support for a new tax.

- Given the above, a larger first phase is thought to be needed to gain the needed level of public support.
- While the majority of the population and ridership is in the Front Range of Colorado, the mountain corridor provides a visionary segment that will continue to have a high level of public support in the future.
- The Front Range and mountain corridor stakeholders need to maintain a collaborative relationship to position for future federal funding.
- Any first phase HST sytem needs to connect to DIA.

Transportation Benefits

System Ridership and Revenue

System ridership and revenue were estimated based on the assumption that the ICS and the AGS would work as a statewide HST system. Definitively splitting out the ridership between the two projects is difficult because, to some extent, each project supports the other. For example, ridership to the mountains is higher if people from Pueblo, Colorado Spring, and Fort Collins can access the system and travel west. Likewise, ICS ridership is higher if Front Range residents and visitors can travel to the mountains.

When the LPA-Base includes the AGS system, the combined project provides over 18 million riders per year in 2035, with a corresponding revenue of $342 million to $380 million annually. In general, the ICS represents 70 to 80 percent of the total ridership, and the AGS represents 20 to 30 percent.

As a test of the cost-effectiveness of the ICS LPA, several permutations incorporating different alignment and technologies were considered:

- LPA-Base
- LPA-I-76
- LPA-NWQ
- LPA-Base – All-Maglev Technology

As shown in **Exhibit ES-18**, the differences in ridership and revenue are modest for the LPA options, unless an all-Maglev system is assumed. When the LPA-Base deploys all-Maglev technology, the ridership and revenue increase by about 5 percent and 11 percent, respectively. However, use of all-Maglev technology increases the capital cost of the ICS alignments by approximately $15 million to $20 million per mile, depending on the location, increasing capital costs by 20 to 25 percent per mile.

Exhibit ES-18: 2035 Ridership Forecast Summary including both the ICS and AGS Projects

Scenario	Ridership (millions/year)	Revenue (millions/year)
LPA-Base	18.3	$344
LPA-I-76	18.2	$342
LPA-NWQ	17.7	$330
LPA-Base(all Maglev)	19.1	$381

Travel Time Improvements

Travel times are critical to the ridership success of the LPA. In essentially all instances, travel to destinations on the LPA is projected to be twice as fast as the automobile in 2035. Examples of travel times on HST in 2035 are estimated to be:

- Fort Collins to DIA = 37 minutes
- Fort Collins to Colorado Springs = 94 minutes
- Colorado Springs to DIA = 55 minutes
- Colorado Springs to Eagle County Regional Airport (ECRA) = 151 minutes
- Pueblo to DIA = 82 minutes
- ECRA to DIA = 133 minutes

Revenue Maximizing Analysis

The ICS has revealed that ridership is highly sensitive to the cost of a trip. In an effort to maximize both ridership and revenue, elasticity studies were modeled, revealing that both ridership and revenue would be enhanced by reducing fares from $0.35 to $0.26 per mile (2013 dollars). This reduction increased ridership approximately 33 percent while maintaining revenues of $330 million to $381 million per year, as shown above.

Environmental

The ICS included environmental impacts as an evaluation criterion at each level of analysis. The concept of directing HST through the Denver metro area (Scenario A-1) was elimated due to the high potential for impacts and PLT concerns about the ability to obtain environmental clearances through the National Environmental Policy Act (NEPA) process. The remaining known environmental issues associated with implementing the ICS LPA-Base will require minimization and, to the extent possible, avoidance. The issues, both positive and negative, identified in the ICS include:

- The ICS LPA, regardless of the option, will modestly improve air quality and reduce consumption of fossil fuels by eliminating some vehicle trips. It will also provide land use and quality of life advantages by attracting multi-family residential development around its stations. The project will provide a transportation option for persons who either do not own a car or do not want to drive.
- The project is anticipated to result in ROW impacts during construction and operation. Construction and operation is estimated to require approximately 1,200 acres for the LPA-Base option, 1,400 acres for LPA-I-76, and 1500 acres for LPA-NWQ. The number of private property acquisitions is not known at this time and will depend on which east-to-west option is selected.
- The impacts associated with the LPA-Base alignment are likely to be much less than the impacts associated with the LPA-I-76 alignment. However, possible parkland impacts along the C-470 alignment may be a challenge. While public acceptance of the LPA-NWQ option is unknown, other transportation projects following this general alignment have been rejected.
- Construction north to Fort Collins is anticipated to have few community or environmental impacts.
- Construction south to Colorado Springs will have few community impacts, but impacts to wetlands south of Larkspur are possible.
- Construction from Briargate south through the City of Colorado Springs will be challenging and will need to be planned carefully to minimize and avoid community impacts.
- Construction from Fort Carson south to Pueblo is anticipated to have few impacts.
- The operation of HST will involve the construction of elevated structures, catenary (assuming steel wheel technology), substations, and stations that will change the visual character of surrounding communities.
- The operation of HST will also increase local noise. Noise impacts north to Fort Collins and along the beltways around the Denver metro area are expected to be minimal. The potential for noise impacts will be the greatest through Castle Rock and south of Briargate through the City of Colorado Springs to Fort Carson. Noise impacts south to Pueblo are expected to be minimal.

Engineering Feasibility

Capital Cost Estimates

The capital expenditures (CAPEX) for the ICS LPA and its design options were revised from the Level 2 estimate based on the design revisions developed in Level 3. LPA-I-76 is the lowest cost option because the I-76 portion (DIA to West Suburban) of the alignment ($1.93 billion) is subtracted from the ICS estimate and moved into the AGS estimate, becoming part of the mountain corridor Maglev system. The cost of the DIA to West Suburban segment using Maglev technology is $3.2 billion. Additionally, the estimates represent a higher level of engineering due to the incorporation of Digital Terrain Model (DTM) topographic information, which allowed refinements both horizontally and vertically.

The CAPEX estimates in 2013 dollars are given in **Exhibit ES-19**.

Exhibit ES-19: Final CAPEX Estimates for the ICS LPA Plus the AGS LPA

ICS LPA Options	ICS LPA CAPEX	AGS LPA CAPEX	Total "HST Vision" CAPEX
LPA-Base	$16.6 B	$13.4 B	$30.0 B
LPA-I-76	$13.4 B	$16.7 B	$30.1 B
LPA-NWQ	$17.8 B	$13.4 B	$31.2 B

Operating Cost Estimates

The operating expenditures (OPEX) for the ICS LPA were also updated from the planning level values provided in Level 2 Evaluation. The revised OPEX estimates assumed a build-up of a HST operations and maintenance organization including staffing, materials and energy costs. Both 'most likely' and 'high' estimates were provided. The high estimate was calculated by placing contingencies on all the high risk line items in the OPEX estimate. The high estimate has been assumed for all analyses shown in **Exhibit ES-20**. Annual OPEX costs are estimated to be $144 million for the LPA-Base option, $120 million for the LPA-I-76 option, and $146 million for the LPA-NWQ option. The LPA-I-76 option is lower because the DIA to West Suburban segment is operated as part of the AGS Maglev system.

Exhibit ES-20: OPEX Estimates for the ICS and AGS

ICS LPA Options	ICS LPA OPEX	AGS LPA OPEX	Total "HST Vision" OPEX
LPA-Basic	$144 M	$63 M	$207 M
LPA-I-76	$120 M	$78 M	$198 M
LPA-NWQ	$146 M	$63 M	$209 M

Planning Feasibility

The ICS LPA ,regardless of the option, is feasible from a transportation planning standpoint. It is in conformance with the State Rail Plan and will be consistent with the State Transit Plan now under preparation. Likewise, while not in the Regional Transportation Plans of the five member Metropolitan Planning Organizations within the ICS study area, these organizations support the ICS LPA. As discussed below, the greatest challenge to the planning feasibility of the ICS LPA will be the ability to gain voter support to fund it.

How do the Benefits Compare to the Costs?

As discussed under the Project Purpose and Need, the HST program must generate benefits that are greater than its cost of implementation. **Exhibit ES-21** presents the benefit/cost analysis (BCA) prepared for the ICS. The BCA was run for the entire HST Vision (ICS + AGS), each of the LPA options, and for the proposed Initial Operating Segment (IOS) for the ICS system (Fort Collins to DIA to Briargate), which is described in the following section. With an assumption of 50 percent federal funding, all Benefit/Cost (B/C) ratios for the scenarios are above 1.0. The LPA-I-76 option performs the best with a B/C of 1.75, compared to the LPA-Base and LPA-NWQ options with respective values of 1.54 and 1.48. This is because the capital cost of the I-76 segment (DIA to West Suburban Station near Golden) is included in the AGS project since it is part of the Maglev system traveling to the mountain communities.

With no federal funding, the LPA-76 option is the only option that remains above B/C ratio 1.0; the B/C ratios for all other options are below 1.0. (See next section for IOS versus MOS.)

How Would the HST Vision LPA be Implemented?

Implementation of Colorado's HST Vision must be phased due to the large investment required. While HST would be new to Colorado, its phasing program can be modeled after decades of experience in other parts of the world and by the California High Speed Rail program. As the economic success of the program is demonstrated, private investors may be incented to participate.

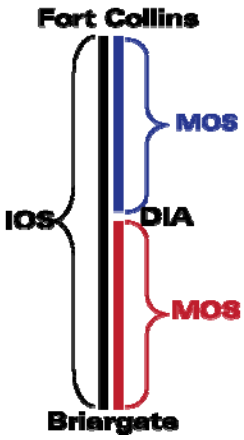
On the advice of the PLT, the first phase of Colorado's HST system needs to be a successful and exciting step forward into the future, sufficient to generate support for the needed revenue enhancements that would be required for implementation. Any initial phase should have a positive operating ratio, B/C ratio great than 1, benefits greater than costs, and high levels of ridership.

Two levels of phasing are considered, as summarized in **Exhibit ES-22**:

1. **Minimum Operating Segment (MOS)** – This is defined as a smaller piece of the ICS LPA, which would serve as a component of an IOS.

   a. MOS Fort Collins to DIA (shown in blue)

   b. MOS DIA to Briargate (shown in red)



2. **Initial Operating Segment (IOS)** – This is a larger project of the ICS LPA, with broad geographic representation, with the intent of meeting the PLT requirements listed above. Two IOS projects are considered:

   a. IOS – ICS: Fort Collins to DIA to Briargate (IOS – ICS)

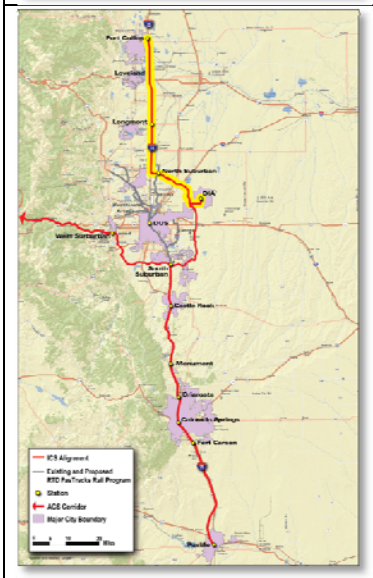
   b. IOS – AGS: DIA to Eagle County Regional Airport (IOS – AGS)

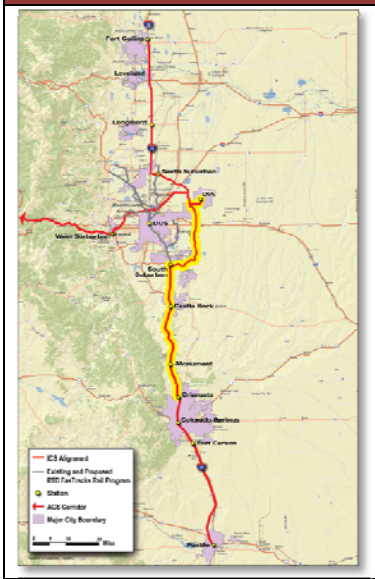
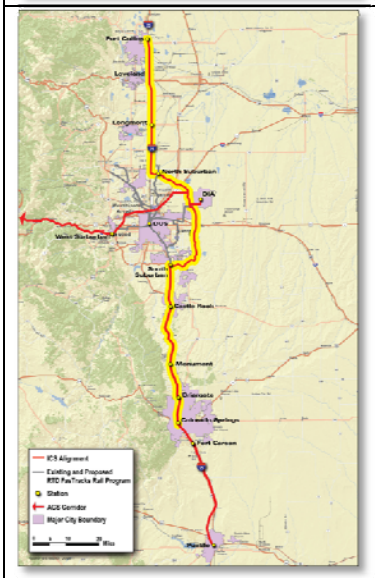
The IOS – ICS was terminated at Briargate to save approximately $4 billion in capital cost, including avoiding the anticipated high impact of construction through Colorado Springs (estimated at $1 billion) and phasing the lower ridership segment to Pueblo (estimated at $3 billion).

Exhibit ES-21: Benefit/Cost Analysis Results

B/C Element	LPA-Base	LPA-I-76	LPA-NWQ	HST Vision	IOS for ICS FC/DIA/Briargate
Costs					
CAPEX	$16,600,000,000	$13,400,000,000	$17,800,000,000	$30,100,000,000	$ 9,810,000,000
PW Rebuild Vehicles (Year 18)	$ 271,480,000	$ 190,036,000	$ 271,480,000	$ 351,443,200	280,000,000
PW CAPEX Replacement Systems @3.3% Systems CAPEX	1,041,860,820	841,020,180	1,117,176,060	1,889,157,270	615,702,087
CAPEX Replacement Guideway @.005%	875,392,700	706,642,300	938,674,100	1,587,308,450	517,325,445
Annual OPEX	$ 144,000,000	$ 120,000,000	$ 146,000,000	$ 198,485,000	$ 88,000,000
OPEX Cost (30 year)	$ 2,489,760,000	$ 2,074,800,000	$ 2,524,340,000	$ 3,431,805,650	$ 1,521,520,000
Interest payments on 50% locally funded	$ 5,965,127,000	$ 4,815,223,000	$ 6,396,341,000	$ 10,816,284,500	$ 3,525,174,450
Finance during construction @ 5%	$ 830,000,000	$ 670,000,000	$ 890,000,000	$ 1,505,000,000	$ 490,500,000
Total Cost	**$ 28,073,620,520**	**$ 22,697,721,480**	**$ 29,938,011,160**	**$ 49,680,999,070**	**$ 16,760,221,982**
Benefits					
Calculated Benefits (PW basis)					
Increase in Real Estate Value - one time deal, no PW calc.	$6,931,267,200	$7,746,710,400	$6,931,267,200	$ 10,626,244,200	$ 4,790,728,800
Pw of Fare Box Revenue (30 year)	$ 5,952,543,241	$ 6,101,534,002	$ 5,790,455,874	$ 5,905,455,927	$ 3,425,783,975
PW of Ancillary Revenue	$ 178,576,297	$ 183,046,020	$ 173,713,676	$ 177,163,678	$ 102,773,519
PW of VMT	$ 5,328,904,037	$ 5,204,368,863	$ 5,095,130,196	$ 5,104,029,000	$ 2,970,132,038
PW of VHT	$ 734,892,967	$ 609,857,566	$ 686,060,284	$ 655,097,300	$ 431,759,465
PW of Fatality Avoided	$ 648,984,385	$ 633,817,779	$ 620,514,070	$ 621,597,817	$ 361,719,652
Pollution benefits	$ 1,893,664,113	$ 1,849,409,650	$ 1,810,590,909	$ 1,813,753,162	$ 1,055,457,635
PW of Non-basic jobs (1.5 multiplier)	$ 622,440,000	$ 518,700,000	$ 631,085,000	$ 857,951,413	$ 380,380,000
Multiplier effect of Federal funding (3.0 multiplier)	$ 16,600,000,000	$ 13,400,000,000	$ 17,800,000,000	$ 30,100,000,000	$ 9,810,000,000
Non-basic jobs (2.0 multiplier)	$ 4,442,658,000	$ 3,586,242,000	$ 4,763,814,000	$ 8,055,663,000	$ 2,625,450,300
Total Benefits	**$ 43,333,930,240**	**$ 39,833,686,280**	**$ 44,302,631,210**	**$ 63,916,955,497**	**$ 25,851,411,894**
Sum of Benefits (PW Cost Basis)	**$ 43,333,930,240**	**$ 39,833,686,280**	**$ 44,302,631,210**	**$ 63,916,955,497**	**$ 25,851,411,894**
Sum of Costs (PW Cost Basis)	**$ 28,073,620,520**	**$ 22,697,721,480**	**$ 29,938,011,160**	**$ 49,680,999,070**	**$ 16,760,221,982**
B/C Ratio with Federal Funding Benefit	**1.54**	**1.75**	**1.48**	**1.29**	**1.54**
Operating Ratio	**2.39**	**2.94**	**2.29**	**1.72**	**2.25**
Without Federal Funding					
Sum of Benefits (PW Cost Basis)	**$ 26,733,930,240**	**$ 26,433,686,280**	**$ 26,502,631,210**	**$ 33,816,955,497**	**$ 16,144,185,385**
Sum of Costs (PW Cost Basis)	**$ 28,073,620,520**	**$ 22,697,721,480**	**$ 29,938,011,160**	**$ 49,680,999,070**	**$ 16,760,221,982**
B/C Ratio w/o Federal Funding Benefit	**0.95**	**1.16**	**0.89**	**0.68**	**0.96**

Exhibit ES-22: Comparison of MOS/IOS Options

Concept	Name	Length (Miles)	CAPEX (Billions)	Annual OPEX (Millions)	Annual Ridership (Millions)	Annual Revenue (Millions)	OPEX Ratio
	**MOS 1**: North Suburban to Fort Collins	39	$3.17	$33.1	2.2	$28.0	<1.0
	**MOS 1A**: DIA to Fort Collins	61	$4.52	$45.0	4.0	$46.0	1.02
	**MOS 2**: South Suburban to Briargate	39	$3.58	$33.0	5.1	$39.8	1.2

Concept	Name	Length (Miles)	CAPEX (Billions)	Annual OPEX (Millions)	Annual Ridership (Millions)	Annual Revenue (Millions)	OPEX Ratio
	**MOS 3**: DIA to Briargate	61	$6.03	$52.0	7.0	$84.3	1.6
	**IOS – ICS**: Fort Collins to Briargate	132	$9.81	$88.2	13.6	$198.0	2.3
	**IOS – AGS**: DIA to Eagle County Regional Airport	151	$16.5	$78.5	3.5	$79.3	1.01

The IOS – AGS was included for comparison purposes to determine whether the initial phase should be located on the Front Range or travel into the mountain communities. The MOS options were competitively evaluated for:

- Capital Cost
- OPEX
- OPEX Ratio
- Ridership
- Revenue
- Sales Tax Impact

The IOS – ICS project is significantly more cost-effective than the IOS – AGS project: The capital cost of the IOS – ICS is less than 50 percent, the ridership is nearly four times higher, and the operating ratio is 2.3 versus 1.01 for the IOS – AGS. Conversely, the IOS – AGS enjoys very strong local support. However, because the success of the ICS program is dependent on meeting competitive financial metrics, the IOS – ICS option is recommended for initial implementation.

Recommendations

Under ideal financial conditions, the entire IOS – ICS would be constructed at once. However, based on the anticipated cost of $9.8 billion, it will likey need to be phased. Based on the metrics used throughout the ICS project, the strongest phasing program would be:

- Phase 1: DIA to Briargate
- Phase 2: DIA to Fort Collins
- Future: Briargate to Pueblo
- Future: IOS – AGS, DIA to Eagle County Region Airport

The completion of phases 1 and 2 would fully implement the IOS – ICS, which realizes the strongest financial performance of the project phases evaluated. Note that it also shows stronger financial performance than the HST Vision (ICS + AGS).

It is likely that the start of construction for either Phase 1 or Phase 2 could not occur until 2020 under a best-case scenario. This assumes that a Tier 1 NEPA document could be completed in 2015 and a Tier 2 NEPA document providing environmental clearance could be completed by 2018. It also assumes 1.5 years for the preparation of the Request for Proposals and bidding of the project. In order to start construction in 2020, design-build project delivery is assumed.

Under a best-case scenario, the project could be constructed in 5 years, but 6 years is more likely. This would result in an opening day of no sooner than 2025 if all of the optimistic assumptions above are met.

The start dates for the two Future phases will depend on funding sources and political support. The phase to Pueblo has an estimated cost of $3.5 billion and an accompanying ridership of about 1 million per year in 2035. The IOS - AGS to the mountain communities has a cost of $17 billion and an additional annual ridership of 3.5 to 4 million.

How Would HST be Financed?

Funding and financing HST in Colorado is challenging. The financial analysis for the ICS program concludes that:

- HST will not likely be implementable without significant federal funding. Significant is defined as 50 percent of CAPEX. Given the current financial condition of existing federal transit programs, grants of this magnitude are not anticipated in the near future.
- A new major source of State funding will be required to implement any portion of the HST system. The support for a new State sales (or similar) tax for HST is unknown.
- A sales tax increase of 0.50 to 1.0 percent (½ to 1 cent per dollar) will be required to fund the IOS – ICS, depending on the level of federal funding.
- Public support for a new funding source is critical to successfully obtaining a federal grant and both sources will be needed to attract private capital.
- All 16 counties that would benefit from the HST would need to participate as the leverage of the populated Front Range is needed.
- Low interest funding from Railroad Rehabilitation & Improvement Financing (RRIF) administered by the FRA and possibly the Transportation Infrastructure Finance and Innovation Act (TIFIA) Program administered by the Federal Transit Administration (FTA) could be used to keep interest rates below 4 percent.

- Local government contributions will optimistically be limited to covering station costs.

Conceptual Cash Flow Demonstrates the Challenge

As described below, the IOS – ICS (Fort Collins to Briargate) option, would be much easier to fund and finance than the IOS – AGS or the HST Vision (ICS + AGS) Scenario.

IOS - ICS Project

As shown in **Exhibit ES-23**, implementation of the IOS – ICS would require a total capital outlay of $12.54 billion, including $10.30 billion of initial capital investment and $2.24 billion of subsequent capital replacement. Of the $10.30 billion initial capital investment, federal funding at 50 percent would cover $5.15 billion, leaving $7.22 billion to be financed. At 4 percent interest this would result in a capital recovery requirement of $417.16 million per year. After operating revenues are included (discussed earlier), the projected shortfall is as much as $368.74 million in the initial year of operation, levels off to $301.42 million annually by year 10, and remains at this value for the remainder of the project life. The sales tax equivalent required to fund the project shortfall is 1.0 percent assuming no federal funding and 0.50 percent with 50 percent federal funding.

HST Vision (ICS + AGS)

As shown in **Exhibit ES-24**, implementation of the HST Vision would require a total capital outlay of $37.94 billion. Of this amount, federal funding would cover $15.80 billion, leaving $21.71 billion to be financed. At 4 percent interest, this would result in a capital recovery requirement of $1.26 billion per year.

After operating revenues are included (discussed earlier), the projected shortfall is as much as $1.22 billion in the initial year of operation, leveling off to $1.10 billion by year 10 and remaining at this level for the remainder of the project life. The sales tax equivalent required to fund the project shortfall is 3.5 percent assuming no federal funding and 1.8 percent with 50 percent federal funding.

Exhibit ES-25 shows the proposed HST Vision Program.

Conclusion

The ICS analysis has shown that the HST Vision is feasible for the State of Colorado based on the following FRA criteria:

- Both the operating ratio and the B/C ratio are positive assuming federal funding for a portion of the capital cost.
- No subsidies would be required to obtain a positive operating ratio.

The segments that serve the Front Range perform the best because they connect the highest-density populations.

Based on input received from the public during regional open houses in Fort Collins/North Front Range, Denver, Colorado Springs/Pikes Peak, and Pueblo, there is strong support for the HST Vision program. Independently, there is support for projects in both the ICS and AGS study areas.

From a financial standpoint, the ideal first project would be to implement the IOS – ICS spanning the Front Range from Fort Collins to Briargate. This would require an annual expenditure of approximately $300 million per year for the 30 year planning period.

With an OPEX ratio of 2.3 and a Benefit/Cost ratio of 1.7, the study shows this to be a sound investment for the state. It would improve mobility on the most congested 132 mile north to south transportation corridor in the State, would improve air quality and environmental sustainability and would support state, regional, and local land use goals by promoting denser development around its eight stations.

The project would also elevate the State's national status as an innovative front-runner in solving mobility challenges for the 21st Century. The beneficial impact to commerce associated with this level of national leadership in innovation is something that is difficult to monetize but intuitively apparent.

The full study results are presented in this Interregional Connectivity Study Final Report, along with supporting appendices that present the technical analysis.

Exhibit ES-23: Conceptual Cash Flow for ICS Initial Operating Segment

Inputs	Total	Start 2026	2035	2041	2042	2043	2044	Finish 2055
Requirements								
CAPEX	$9,810.0							
CAPEX Replacement - Vehicles (Yr 17 - 20)	$280.0			$70.0	$70.0	$70.0	$70.0	
CAPEX Replacement - Systems @ 3.3% of Systems CAPEX	$1,079.1	$36.0	$36.0	$36.0	$36.0	$36.0	$36.0	$36.0
CAPEX Replacement - Guideway @.005% CAPEX	$882.9	$29.4	$29.4	$29.4	$29.4	$29.4	$29.4	$29.4
Financial Cost During Construction @5%	$490.5							
Total CAPEX	$12,542.5							
Funding Sources								
Federal Funding **@ 50%**	$5,150.3							
Local Contributions (stations)	$175.0							
Remaining CAPEX	$7,217.3							
Capital Recovery	$417.16	$417.16	$417.16	$417.16	$417.16	$417.16	$417.16	$417.16
Income								
Fare Box	$5,619.2	130.68	198	$198.0	$198.0	$198.0	$198.0	$198.0
Ancillary Revenue @ 3% of fare box	$178.2	5.94	5.94	5.94	5.94	5.94	5.94	5.94
Less: OPEX	$2,646.0	$88.2	$88.2	$88.2	$88.2	$88.2	$88.2	$88.2
Net Cash	$3,151.0	$48.4	$115.7	$115.7	$115.7	$115.7	$115.7	$115.7
Shortfall		**-$368.74**	**-$301.42**	**-$301.42**	**-$301.42**	**-$301.46**	**-$301.46**	**-$301.46**

Exhibit ES-24: Conceptual Cash Flow for HST Vision (ICS + AGS)

Inputs	Total	Start 2026	2035	2041	2042	2043	2044	Finish 2055
Requirements								
CAPEX	$30,100.0							
CAPEX Replacement - Vehicles (Yr 17 - 20)	$550.0			$137.5	$137.5	$137.5	$137.5	
CAPEX Replacement - Systems @ 3.3% of Systems CAPEX	$3,168.5	$109.3	$109.3	$109.3	$109.3	$109.3	$109.3	$109.3
CAPEX Replacement - Guideway @.005% CAPEX	$2,618.7	$90.3	$90.3	$90.3	$90.3	$90.3	$90.3	$90.3
Financial Cost During Construction @5%	$1,505.0							
Total CAPEX	$37,942.2							
Funding Sources								
Federal Funding **@ 50%**	$15,802.5							
Local Contributions (stations)	$425.0							
Remaining CAPEX	$21,714.7							
Capital Recovery	$1,255.11	$1,255.11	$1,255.11	$1,255.11	$1,255.11	$1,255.11	$1,255.11	$1,255.11
Income								
Fare Box	$9,349.20	224.4	342	342	342	342	342	342
Ancillary Revenue	$295.8	10.2	10.2	10.2	10.2	10.2	10.2	10.2
Less: OPEX	$5,753.6	198.4	198.4	198.4	198.4	198.4	198.4	198.4
Net Cash	$3,891.4	$36.2	$153.8	$153.8	$153.8	$153.8	$153.8	$153.8
Shortfall		**-$1,218.91**	**-$1,101.31**	**-$1,101.31**	**-$1,101.31**	**-$1,101.31**	**-$1,101.31**	**-$1,101.31**

Exhibit ES-25: Proposed HST Vision Program