

9 Evaluation of Alternatives

9.1 Introduction

In Chapters 3 and 4, alternative routes and technologies were developed to support a feasibility level economic analysis to help Colorado understand the overall implications for a statewide intercity rail system. In order to evaluate these alternatives, it is important to identify the FRA feasibility criteria for public-private partnership. The FRA has defined the financial and economic criteria for public-private partnership¹ as follows:

1. **Financial Analysis:** Positive Operating Ratio, defined as Operating Revenue / Operating Cost. This measures the project's ability to be a self-sustaining and franchisable system in terms of its day-to-day finances.
2. **Economic Analysis:** Positive Cost Benefit Ratio, defined as Total Benefit/Total Cost. This measures whether the project makes a positive contribution to the economy from an economic perspective.

Operating ratios are usually expressed on a year-by-year basis, but they can also be expressed as a Present Value of Revenue / Present Value Operating cost over the lifetime of a project.

Cost Benefit ratios are usually expressed as a Present Value of Total Benefit / Present Value of Total Cost over the lifetime of a project, but if year-by-year financial cash flows are not fully available, these ratios can be approximated on the basis of a single year snapshot. Such approximations necessarily embed a typical rate of demographic growth and capital cash flows in accordance with a multi-year, phased system implementation plan. Once specific information on the rate of ridership and revenue growth, and a system implementation plan detailing the capital cash flows becomes available, then that information can be included to further refine the initial estimates of the Cost Benefit ratio. This highly detailed analysis has been completed for an alternative example and those results are presented in Chapter 10.

This chapter describes the process by which alternatives were initially developed and then evaluated, leading to the development of a number of feasible options based on the FRA economic and financial criteria. Section 9.2 further defines the measure of economic efficiency that is used to assess the FRA criteria. The remainder of the chapter describes the process and rationale used in the initial optimization of network alternatives.

¹ "High-Speed Ground Transportation for America", USDOT FRA, 1997 and "Maglev Deployment Program", USDOT FRA, 1999.

9.2 Measures of Efficiency

For each alternative being evaluated, the FRA measures of financial and economic efficiency were calculated. These assessments integrate the forecasted capital, operating, and maintenance costs with the revenue projections over the lifetime of the project. The analysis is based on the following components:

- Operating and implementation plans for the alternative passenger rail service options
- Cost estimates for operations, infrastructure and acquisition of rolling stock
- Ridership and revenue estimates based on projected travel demand and assumptions regarding fare levels and other services (on board catering, and express mail)
- Cash flow analysis that includes statements of revenues and expenses as well as sources and uses of funds, including the impact of the financing alternatives

Two measures, net present value (NPV) and Cost Benefit ratio were used to evaluate the economic returns of the system. Similar measures, net present value (NPV) and Operating ratio were used to evaluate the financial returns.

Both measures require the development of a project's year-by-year financial and economic returns, which are then discounted to a base year, to estimate present values over the lifetime of the project. The discount rate used is set by the GAO and reflects the long-term cost of money. The long-term cost of money is reflected in bond rates, and influenced by the level of risk associated with a project.

The operating ratios reported here follow FRA's criteria definition, but are different from the commercial operating ratio calculations that are typically presented by freight railroads and intercity bus companies. The FRA's criteria are also different from the fully-allocated cost reports typically produced by Amtrak. Following the FRA feasibility criteria:

1. The Operating Ratio as calculated here includes *direct operating costs only*. Unlike Amtrak's fully allocated costs, the operating ratio calculations presented here do not include capital costs, depreciation or interest.
2. The Operating Ratio presented here is defined as Revenues/Costs. It should be noted that freight railroads and intercity bus companies typically define it as the reciprocal Costs/Revenues.

As defined by the FRA, a positive operating ratio does not imply that a passenger service can attain full financial profitability by covering its capital costs, but it does allow the operation to be franchised and operated by the private sector. The FRA's definition puts passenger rail on the same basis as other passenger transportation modes, such as intercity bus and air, where the private sector operates the system but does not build or own the infrastructure it uses.

All calculations are performed using standard financial formula, as follows:

Financial Measure:

$$\text{Operating Ratio} = \frac{\text{Present Value of Revenues}}{\text{Present Value of Costs}}$$

Economic Measure:

$$\text{Net Present Value} = \text{Present Value of Benefit} - \text{Present Values of Costs}$$

$$\text{Cost Benefit Ratio} = \frac{\text{Present Value of Benefits}}{\text{Present Value of Costs}}$$

Present Value is defined as:

$$PV = \sum C_t / (1 + r)^t$$

Where:

- PV = Present value of all future cash flows
- C_t = Cash flow for period t
- r = Discount rate reflecting the opportunity cost of money
- t = Time

9.2.1 Key Assumptions

The analysis projects travel demand, operating revenues and operating and maintenance costs for all years from 2010 through 2050. Following GAO guidelines, the financial analysis has been conducted in real terms using constant 2008 dollars. Accordingly, no inflation factor has been included and a real discounting rate of 3.9 percent was used. Revenues and operating costs have also been projected in constant dollars over the time frame of the financial analysis. A summary of the key efficiency measure inputs are presented below.

Ridership and Revenue Forecasts

Ridership and revenue forecasts were prepared in ten year intervals from 2010 through 2050. Revenues in intervening years are projected based on interpolations, reflecting projected annual growth in ridership. Revenues include not only passenger fares, but also onboard service and express parcel revenues. Because of this, the revenues are slightly higher than those that were forecasted in Chapter 6.

Capital Costs

Capital costs include rolling stock, track, freight railroad right-of-way purchase or easement fees, bridges, fencing, signaling, grade crossings, maintenance facilities and station improvements. The capital cost projections are based on year-by-year projections of each cost element and include all of the capital costs, plus some selected elements of additional costs as needed to support year-by-year capacity expansion of the system. At the time of the initial screening of options a detailed system implementation plan had not yet been developed, so it was necessary to approximate the Cost Benefit ratios based on forecasted 2035 results. For the FRA Developed Option (as defined in Chapter 8, a hybrid network subjected to more detailed economic evaluation) a year-by-year implementation plan was developed which detailed the Capital cash flows and funding requirements. Using this added information the Cost Benefit calculations could be further refined. This was done in Chapter 10.

Operating Expenses

Major operating and maintenance expenses include equipment maintenance, track and right-of-way maintenance, administration, fuel and energy, train crew and other relevant expenses. Operating expenses were estimated in 2008 constant dollars so that they would remain comparable to revenues. However, these costs do reflect the year-by-year increase in expense that is needed to handle the forecasted ridership growth, in terms of not only directly variable expenses such as credit card commissions, but also the need to add train capacity and operate either larger trains, or more train-miles every year in order to accommodate anticipated ridership growth.

Operating costs are included as a cost, whereas system revenues are included as a benefit in the discounting calculation over the life of the system. In this way they directly offset one another in the Net Present Value calculation and also reflect in the Cost Benefit calculation. It can be seen that a system that requires an operating subsidy, e.g. where costs exceed revenues, will tend also to reflect this in the Cost Benefit ratio. This is why 79-mph rail systems typically fail on both the Operating Ratio and Cost Benefit ratio criteria.

Implementation Period

According to the implementation plan that is stated in Chapter 10, the planning and construction period for the FRA Developed Option will take up to thirteen years with start-up of full system operations not occurring until 2024. However, this information was not yet known at the time of the initial alternatives screening, which assumed a somewhat faster build-out of the system. Because the revenues and benefits were also expected to start sooner, this timing assumption has had negligible impact on the Cost Benefit calculation result.

9.2.2 Cost Benefit Requirements

A key FRA requirement is the need for public capital investment to be supported by the economic benefit that will be generated by the rail system. For this calculation of economic benefit we include consumer surplus, revenues generated by the system environmental and external mode benefits; costs include both capital and operating cost. Similarly to the way most highway projects are

justified, the primary justification for intercity rail projects relies on time savings multiplied by the user's value of time. The consumer surplus term equates to this user's value of time savings as being the benefit an individual receives over and above the fare charged for using the system.

Calculation of cost benefit ratios requires a detailed, year-by-year forecast to support the calculation of Net Present Values for all the costs and benefits associated with the project. Specifically, a year-by-year estimate of system revenues, consumer surplus, operating costs, capital costs, and external benefits is needed to develop the FRA cost benefit analysis.

However, the rate of population growth in Colorado is very fast compared to other states, which results in significant growth in traffic over the life of the system. Our assumptions regarding the rate of traffic growth are consistent with the state demographics, MPO's, and BEA documented in Chapter 6. This has several consequences for the correct calculation of Cost Benefit ratios for this project:

- It would be inappropriate to increase the ridership and revenue of the system in future years, without also reflecting the added operating and capital costs that will be needed to accommodate this growth in traffic.
- The result is a steady improvement in the system financial performance that reflects improved economies of scale over the 30-year life of the system. While the Cost Benefit ratios calculated do take this forecast growth into account, they also add the additional capital cost for providing the capacity needed to handle it.

A ridership ramp-up factor of 50 percent was assumed for the first year and 75 percent for the second year. This leads to a need for operating support to cover the first two years' start-up losses. In the third year of operations the system starts to produce operating surpluses.

9.2.3 Estimate of Economic Benefits

The economic benefits to be used in the analysis include:

- User Benefits (Consumer Surplus)
- Other Mode and Resource Benefits

User Benefits

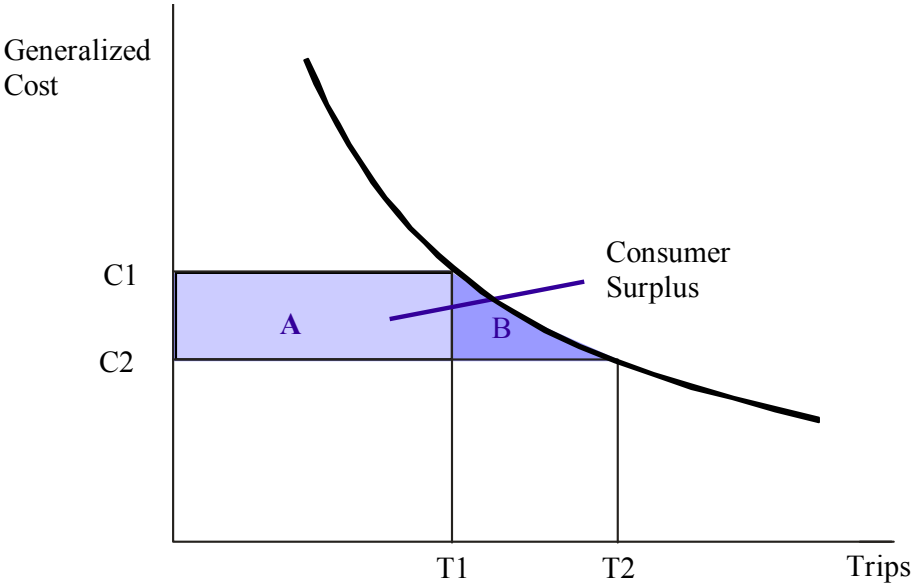
The analysis of user benefits for this study is based on the measurement of generalized cost of travel, which includes both time and money. Time is converted into money by the use of Values of Time. The Values of Time (VOT) used in this study were derived from stated preference surveys conducted in this and previous study phases and used in the *COMPASS*[™] multimodal demand model for the ridership and revenue forecasts. These VOTs are consistent with previous academic and empirical research and other transportation studies conducted by TEMS.

Benefits to users of the rail system are measured by the sum of system revenues and consumer surplus. Consumer surplus is used to measure the demand side impact of a transportation improvement on users of the service. It is defined as the additional benefit consumers (users of the

service) receive from the purchase of a commodity or service (travel), above the price actually paid for that commodity or service. Consumer surpluses exist because there are always consumers who are willing to pay a higher price than that actually charged for the commodity or service, i.e., these consumers receive more benefit than is reflected by the system revenues alone. Revenues are included in the measure of consumer surplus as a proxy measure for the consumer surplus forgone because the price of rail service is not zero. This is an equity decision made by the FRA to compensate for the fact that highway users pay zero for use of the road system (the only exception being the use of toll roads). The benefits apply to existing rail travelers as well as new travelers who are induced (those who previously did not make a trip) or diverted (those who previously used a different mode) to the new passenger rail system.

The COMPASS™ demand model estimates consumer surplus by calculating the increase in regional mobility, traffic diverted to rail, and the reduction in travel cost measured in terms of generalized cost for existing rail users. The term generalized cost refers to the combination of time and fares paid by users to make a trip. A reduction in generalized cost generates an increase in the passenger rail user benefits. A transportation improvement that leads to improved mobility reduces the generalized cost of travel, which in turn leads to an increase in consumer surplus. Exhibit 9-1 presents a typical demand curve in which Area A represents the increase in consumer surplus resulting from cost savings for existing rail users, and Area B represents the consumer surplus resulting from induced traffic and trips diverted to rail.

Exhibit 9-1: Consumer Surplus Concept



The formula for consumer surplus is as follows:

$$\text{Consumer Surplus} = (C_1 - C_2) * T_1 + ((C_1 - C_2) * (T_2 - T_1)) / 2$$

Where:

- C₁ = Generalized Cost users incur before the implementation of the system
- C₂ = Generalized Cost users incur after the implementation of the system
- T₁ = Number of trips before operation of the system
- T₂ = Number of trips during operation of the system

The passenger rail fares used in this analysis are the average optimal fares derived from the revenue-maximization analysis that was performed for each corridor. User benefits incorporate the measured consumer surplus, as well as the system revenues, since these are benefits transferred from the rail user to the rail operator.

Other Mode and Resource Benefits

In addition to rail-user benefits, travelers using auto or air will also benefit from the rail investment, since the system will contribute to highway congestion relief and reduce travel times for users of these other modes. For purposes of this analysis, these benefits were measured by identifying the estimated number of air and auto passenger trips diverted to rail and multiplying each by the updated monetary values used in the FRA/USDOT study, *High-Speed Ground Transportation in America*.

Air Benefits: The air benefits that are allowed by the FRA methodology could not be applied to the Colorado system, since the trip length distribution of Colorado trips is too short, and the markets served are really not air-competitive. In Colorado, rail would serve more as a feeder to air than as a competitor. Although the Colorado system still projects significant highway benefits, because the air benefits are missing, the overall level of Other Mode benefit benchmarks at a somewhat lower level than those estimated for other high-speed rail projects across the nation, such as in the Midwest.

Highway Congestion: There will be reduced congestion and delays on highways due to auto travelers diverting to the RMRA rail system. The benefit was measured by estimating the time saved and multiplying it by the auto travelers' value of time. In addition, in the I-70 corridor the impact of reduced reliability due to weather conditions was assessed both in terms of its impact on travel demand and diversion.

Resources Benefits: The implementation of any transportation project has an impact on the resources used by travelers. The consequent reduction in highway congestion will result in resource savings to vehicle operators and reduced emissions of air pollutants for all non-rail modes.

Vehicle operating cost savings for non-business travelers could be included as an additional resource benefit. This reflects the fact that social/leisure travelers do not accurately value the full cost of driving when making trips. As a result, the consumer surplus calculation for commuters, social,

leisure and tourist travelers has not fully reflected the real cost of operations of an automobile, but only the cost of gas. The difference between the cost of gas and the full cost of driving reflects a real savings that could be included in a Cost Benefit analysis. It has not been included here, however, because the FRA did not include it in their 1997 study. If it were included, the addition of this benefit would increase the overall Other Mode and Resource Benefits estimate by approximately 20 percent.

Emissions: The diversion of travelers to rail from the auto and air modes generates emissions savings. The FRA calculated emissions savings based on changes in energy use with and without the proposed rail service. Their methodology takes into account the region of the country, air quality regulation compliance of the counties served by the proposed rail service, the projection year, and the modes of travel used for access/egress as well as the line-haul portion of the trip. For this study, it was assumed that emissions savings would be proportional to the number of diverted auto vehicle-miles. Consistent with the approach used by the FRA, the number of vehicle-miles saved was calculated by multiplying the number of diverted auto trips, times average trip length, divided by an average vehicle occupancy factor.

9.3 Results of Preliminary Analysis

The alternatives developed for evaluation were assessed to develop a preliminary estimation of the FRA Efficiency measures, i.e., operating ratio and cost benefit ratio based on year 2035 forecast results. In developing the representative routes for the I-25 and I-70 corridor, the following types of alignment are considered:

- **Existing rail** – a route using either the tracks or right-of-way of an existing rail corridor
- **Constrained/Highway Right-of-Way** – a route that is solely within or contiguous to the rights-of-way of the I-70 or I-25 highway
- **Unconstrained/Greenfield** – a route that is outside the I-70 and I-25 highway Rights-of-Way

Exhibits 9-2 and 9-3 show the results for the six base alternatives. In Exhibit 9-2 it can be seen that the two I-25 diesel alternatives fail the operating ratio test, but that the electric alternatives pass. It can be seen that the operating ratios increase as speed increases. In Exhibit 9-3 it can be seen that all the alternatives fail the cost benefit test with the best results being 0.83 for 110-mph diesel I-25 corridor only, and the 220-mph I-70 and 0.7 for the I-25 greenfield route. As a result, none of the preliminary alternatives pass the FRA requirement and clearly the alternatives need to be modified.

Exhibit 9-2: Operating Ratio Results: Full-Network – 2035 – Central Case (Millions \$2008)

	79 mph I-25 Existing Rail only	110 mph I-25 Existing Rail only	125 mph I-70 Constrained (7%) I-25 Greenfield	150 mph I-70 Unconstrained (4%) I-25 Existing Rail	220 mph I-70 Constrained (7%) I-25 Greenfield	300 mph I-70 Constrained (7%) I-25 Greenfield
Revenue	36.46	117.00	600.66	586.33	795.79	893.10
Operating Costs	68.94	132.36	373.10	416.09	484.43	448.38
2035 Operating Ratio	0.53	0.88	1.61	1.41	1.64	1.99

Exhibit 9-3: Economic Evaluation of Full Network – 2035 – Central Case (Millions \$2008)

	79 mph I-25 Existing Rail Only	110 mph I-25 Existing Rail Only	125 mph I-70 Constrained (7%) I-25 Greenfield	150 mph I-70 Unconstrained (4%) I-25 Existing Rail	220 mph I-70 Constrained (7%) I-25 Greenfield	300 mph I-70 Constrained (7%) I-25 Greenfield
BENEFITS	Option 1a/b	Option 2a/b	Option 3a	Option 4	Option 5b	Option 6a
Revenue	36.46	117.00	600.66	586.33	795.79	893.10
Consumer Surplus	7.74	117.45	513.80	543.87	720.81	682.55
Resource Savings	3.39	72.66	312.18	312.18	390.22	444.05
Total Benefits	47.59	307.11	1426.64	1442.38	1906.82	2019.70
COSTS						
Operating Costs	68.94	132.36	373.10	416.09	484.43	448.38
Capital Costs	230.74	237.22	4241.84	1799.59	2255.20	4827.45
Total Costs	299.68	369.58	4614.94	2215.68	2739.63	5275.83
Cost Benefit Ratio	0.16	0.83	0.31	0.65	0.70	0.38

9.4 Refinement of Base Alternatives

A number of strategies were used to modify the base alternatives:

- **Truncation:** Elimination of the weakest elements of the networks
- **Mix and Match:** Combine different technologies to reduce capital cost and maintain service
- **Western Strategies:** To evaluate the impact of a diesel option for the western extensions beyond Eagle Airport
- **Selection of FRA Developed Option:** Using FRA efficiency criteria, Steering Committee and public information input.

9.4.1 Truncation Analysis

An evaluation of the volume of riders of the networks showed that the traffic demand beyond Fort Collins in the north I-25 corridor, south of Pueblo in the south I-25 corridor, and west of Eagle airport in the I-70 corridor was very weak. As described in Chapter 8, the capital cost for the more remote parts of the system is 40-50 percent of the total cost, but generates only 3 to 6 percent of the revenue. As such, it was decided to truncate the networks. The financial results of this truncation are shown in Exhibit 9-4.

The results of the truncation analysis show a considerable improvement over the base alternatives. For the truncated network, 110-mph I-25 diesel alternative, the 150-mph electric alternative, and the 220-mph electric alternative all achieve the FRA efficiency targets. Even the maglev options do better particularly the 300-mph maglev, although none of the maglev options are able to quite achieve the positive cost benefit ratio.

Exhibit 9-4: Operating Ratio Results: Truncated – 2035 – Central Case (Millions \$2008)

	79 mph I-25 Existing Rail	110 mph I-25 Existing Rail	125 mph I-70 Constrained (7%) I-25 Greenfield	150 mph I-70 Unconstrained (4%) I-25 Existing Rail	220 mph 7% I-70 Constrained (7%) I-25 Greenfield	300 mph I-70 Constrained (7%) I-25 Greenfield
Revenue	33.29	107.64	600.29	544.25	754.58	874.03
Operating Costs	51.74	94.68	319.60	344.25	409.60	357.90
2035 Operating Ratio	0.64	1.14	1.88	1.58	1.84	2.44

Exhibit 9-5: Economic Evaluation: Truncated – 2035 – Central Case (Millions \$2008)

	79 mph I-25 Existing Rail	110 mph I-25 Existing Rail	125 mph I-70 Constrained (7%) I-25 Greenfield	150 mph I-70 Unconstrained (4%) I-25 Existing Rail	220 mph 7% I-70 Constrained (7%) I-25 Greenfield	300 mph I-70 Constrained (7%) I-25 Greenfield
BENEFITS	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Revenue	33.29	107.64	600.29	544.25	754.58	874.03
Consumer Surplus	7.07	112.23	792.95	700.02	960.66	955.30
Resource Savings	3.10	64.59	296.57	296.57	370.71	421.85
Total Benefits	43.45	284.46	1689.81	1540.84	2085.95	2251.18
COSTS						
Operating Costs	51.74	94.68	319.60	344.25	409.60	357.90
Capital Costs	173.75	178.64	1946.56	1164.24	1225.84	2254.56
Total Costs	225.49	273.32	2266.16	1508.49	1635.44	2612.46
Cost Benefit Ratio	0.19	1.04	0.75	1.02	1.28	0.86

9.4.2 Mix and Match Analysis

In order to evaluate if a combination of technologies that might work better, a Mix and Match analysis was carried out that defined three new alternatives. These combinations were all applied to the truncated networks:

Option 7 – 110-mph diesel on I-25, Fort Collins to Pueblo with 220 mph on I-70, DIA to Eagle Airport.

Option 8 – 150-mph electric on I-25, Fort Collins to Pueblo with 220 mph on I-70, DIA to Eagle Airport.

Option 9 – 110-mph diesel on I-25, Fort Collins to Pueblo with 300-mph maglev on I-70, DIA to Eagle Airport.

The results for the Mix and Match options all produced positive operating ratio and cost benefit results, a 1.02 Cost Benefit for Option 7, a 1.20 for Option 8, and 1.04 for Option 9. However, all these results are lower than the truncated 220-mph electric option, which has a 1.28 Cost Benefit result. See Exhibits 9-6 through 9-8.

Exhibit 9-6: Mix-and-Match Applied to Truncated Networks

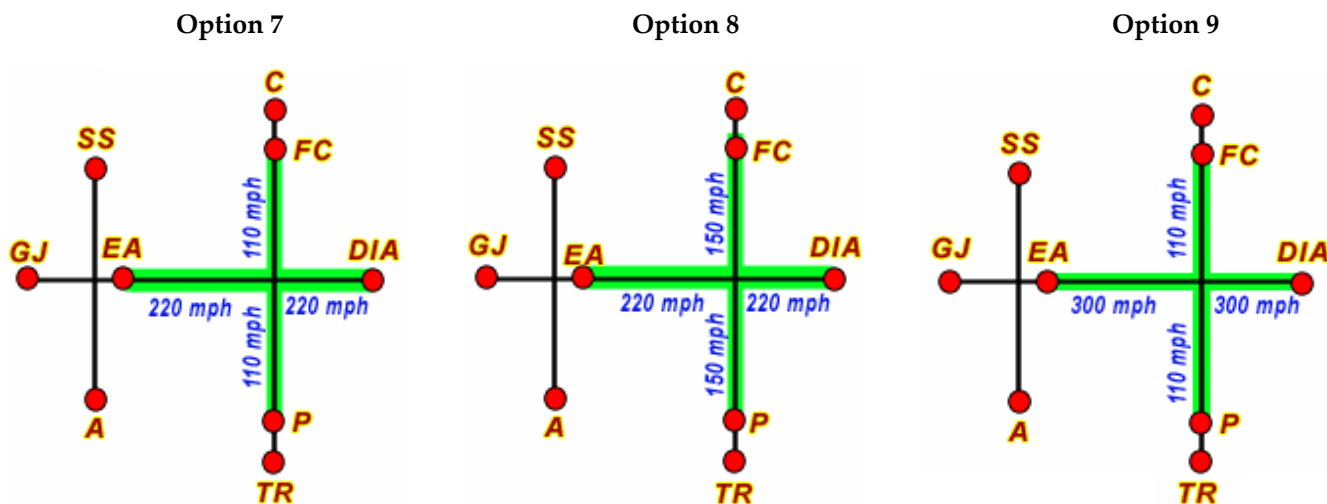


Exhibit 9-7: Operating Ratio Results: Mix and Match – 2035 – Central Case (Millions \$2008)

	New Mix and Match Alternatives			
	220 mph I-70 Constrained (7%) I-25 Greenfield Truncated	110 mph I-25 Existing Rail Truncated on I-25 w/ 220 mph 7% I-70 Constrained Truncated on I-70	150 mph I-25 Existing Rail Truncated on I-25 w/ 220 mph 7% I-70 Constrained Truncated on I- 70	110 mph I-25 Existing Rail Truncated on I-25 w/ 300 mph 7% I-70 Constrained Truncated on I-70
	Option 5	Option 7	Option 8	Option 9
Revenue	754.58	492.56	633.74	511.83
Operating Costs	409.60	341.21	377.16	270.13
2035 Operating Ratio	1.84	1.44	1.68	1.89

Exhibit 9-8: Economic Evaluation of Mix and Match – 2035 – Central Case (Millions \$2008)

	New Mix and Match Alternatives			
	220 mph I-70 Constrained (7%) I-25 Greenfield Truncated	110 mph I-25 Existing Rail Truncated on I-25 w/ 220 mph 7% I-70 Constrained Truncated on I-70	150 mph I-25 Existing Rail Truncated on I-25 w/ 220 mph 7% I-70 Constrained Truncated on I-70	110 mph I-25 Existing Rail Truncated on I-25 w/ 300 mph 7% I-70 Constrained Truncated on I-70
BENEFITS	Option 5	Option 7	Option 8	Option 9
Revenue	754.58	492.56	633.74	511.83
Consumer Surplus	960.66	646.2	717.76	609.29
Resource Savings	370.71	241.50	340.98	407.00
Total Benefits	2085.95	1380.26	1692.48	1528.12
COSTS				
Operating Costs	409.60	341.21	377.16	270.13
Capital Costs	1225.84	1010.24	1034.88	1201.20
Total Costs	1635.44	1351.45	1412.04	1471.33
Cost Benefit Ratio	1.28	1.02	1.20	1.04

9.4.3 Western Strategies

A hypothetical 79/110-mph diesel service was considered beyond Eagle Airport to Steamboat Springs, Aspen, and Glenwood Junction. The aim was to use \$1-2 billion to provide a baseline service of about 4 trains per day, which would be comparable with demand. Since these trains could also run as far east as Silverthorne and Keystone, they could provide service “under the wire” of the 220-mph electric service. This would enhance the economics of these trains. To test this possibility, two options were developed, Options 5W and 9W. These are simply options 5 and 9 with the western lines added. See Exhibits 9-9 through 9-11.

Option 5W - 220 mph on Core System, 110 mph west of Eagle Airport

Option 9W - 300 mph on I-70, 110 mph west of Eagle Airport, and 110 mph on I-25

Exhibit 9-9: Western Expansion Phase Alternatives

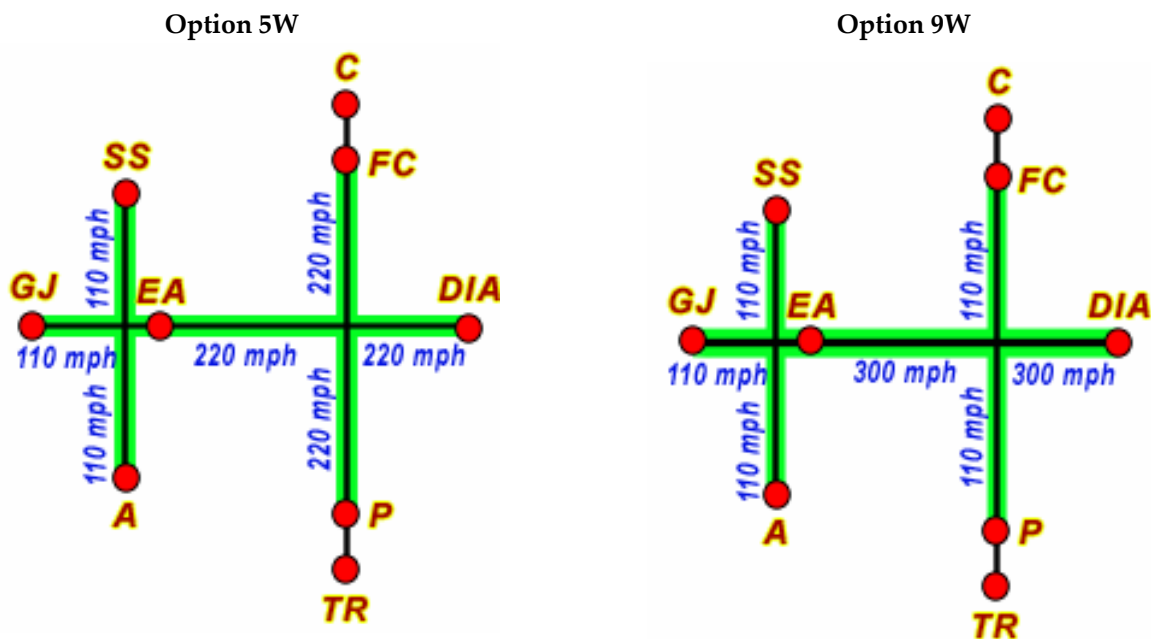


Exhibit 9-10: Operating Ratio Results: Western Expansion – 2035 – Central Case (Millions \$2008)

	220 mph I-70 Constrained (7%) I-25 Greenfield Truncated w/ 110 W of Eagle	300 mph I-70 Constrained (7%) on I-70 w/ 110 on I-25 and W of Eagle
BENEFITS	Option 5W	Option 9W
Revenue	781.27	569.18
Operating Costs	469.60	320.13
2035 Operating Ratio	1.66	1.78

Exhibit 9-11: Economic Evaluation of Western Expansion – 2035 – Central Case (Millions \$2008)

	220 mph I-70 Constrained (7%) Greenfield Truncated w/ 110 W of Eagle	300 mph I-70 Constrained (7%) on I-70 w/ 110 on I-25 and W of Eagle
BENEFITS	Option 5W	Option 9W
Revenue	781.27	569.18
Consumer Surplus	980.08	637.37
Resource Savings	380.67	430.78
Total Benefits	2142.02	1637.33
COSTS		
Operating Costs	469.60	320.13
Capital Costs	1299.76	1275.12
Total Costs	1769.36	1595.25
Cost Benefit Ratio	1.21	1.03

The results of the analysis show that both options 5W and 9W could support western extensions if the capital cost were limited to \$1 billion. However, the 300-mph maglev option has its Cost Benefit reduced to 1.03, which is very small given the error range in the estimates. The 220-mph Electric still shows a good return, and could probably sustain \$2 billion in added costs if the 110-mph diesel were to run under the wire as far as Keystone and Silverthorne.

9.5 The FRA “Developed” Option

Following discussions with the Steering Committee on the potential for serving the I-25 and I-70 corridors with an intercity passenger rail system, a decision was made to select the 220-mph Electric Rail option for further development which included truncation west of Eagle County Airport, truncation north of Fort Collins, and truncation south of Pueblo. This option has the advantage of producing the best operating and cost benefit results with minimal capital cost compared to the other alternatives.

Given this direction the study team fine-tuned the 220-mph Electric Rail option by considering how it might be best fitted to the I-70 and I-25 corridors. The result of this fine-tuning was called the FRA “Developed” option since it was developed by the study team for presentation to FRA as a network combination that could meet FRA’s economic and financial feasibility criteria. For the development of a final set of financial projections for this feasibility study, a composite network selecting the best features of the earlier Constrained and Unconstrained networks, shown in Exhibit 9-12, was developed. In the longer term, development of an expanded network with Western Extensions as shown in Exhibit 9-13 could be considered. With the involvement and support of Wyoming and New Mexico, even the north and south extensions on I-25 could be added in the future. Exhibit 9-14 shows a more detailed map of the proposed FRA Developed rail system.

For developing a network for more detailed evaluation, called the FRA Developed Option, the results of the preliminary screening suggested the following:

- For the I-25 corridor the Greenfield alignments performed best, primarily because of the strength of the added Lone Tree and North Suburban stations, which improve system access in the Denver suburban market. The Freight Rail risk analysis described in section 10.6 determined that it was advantageous to extend the I-25 Greenfield all the way around Colorado Springs with stops at Woodmen Road and Colorado Springs airport, rather than using the existing freight rail alignment through town, as described in Appendix I.
- For the I-70 corridor from Denver to Eagle Airport, the unconstrained alignment offered the best train operations and served the resorts more directly. However, some portions of the proposed route raised environmental concerns, and construction would also require a great deal of costly tunneling.

In the I-70 corridor, a combination of segments from the original I-70 Right-of-Way and unconstrained alignments were retained in the FRA Developed Option. This reflects the input received from the RMRA Steering Committee, Public Input meetings and from members of the I-70 Coalition. The objectives for definition of the FRA Developed Option were to:

- Minimize the environmental intrusiveness of the rail system
- Minimize construction impacts on the I-70 highway
- Reduce the amount of costly tunneling that was recommended in the original plan
- Minimize or eliminate the use of 7 percent gradients if possible
- Improve rail access to local communities while preserving direct service to the ski resorts

Exhibit 9-12: FRA Developed Rail Network for Detailed Evaluation

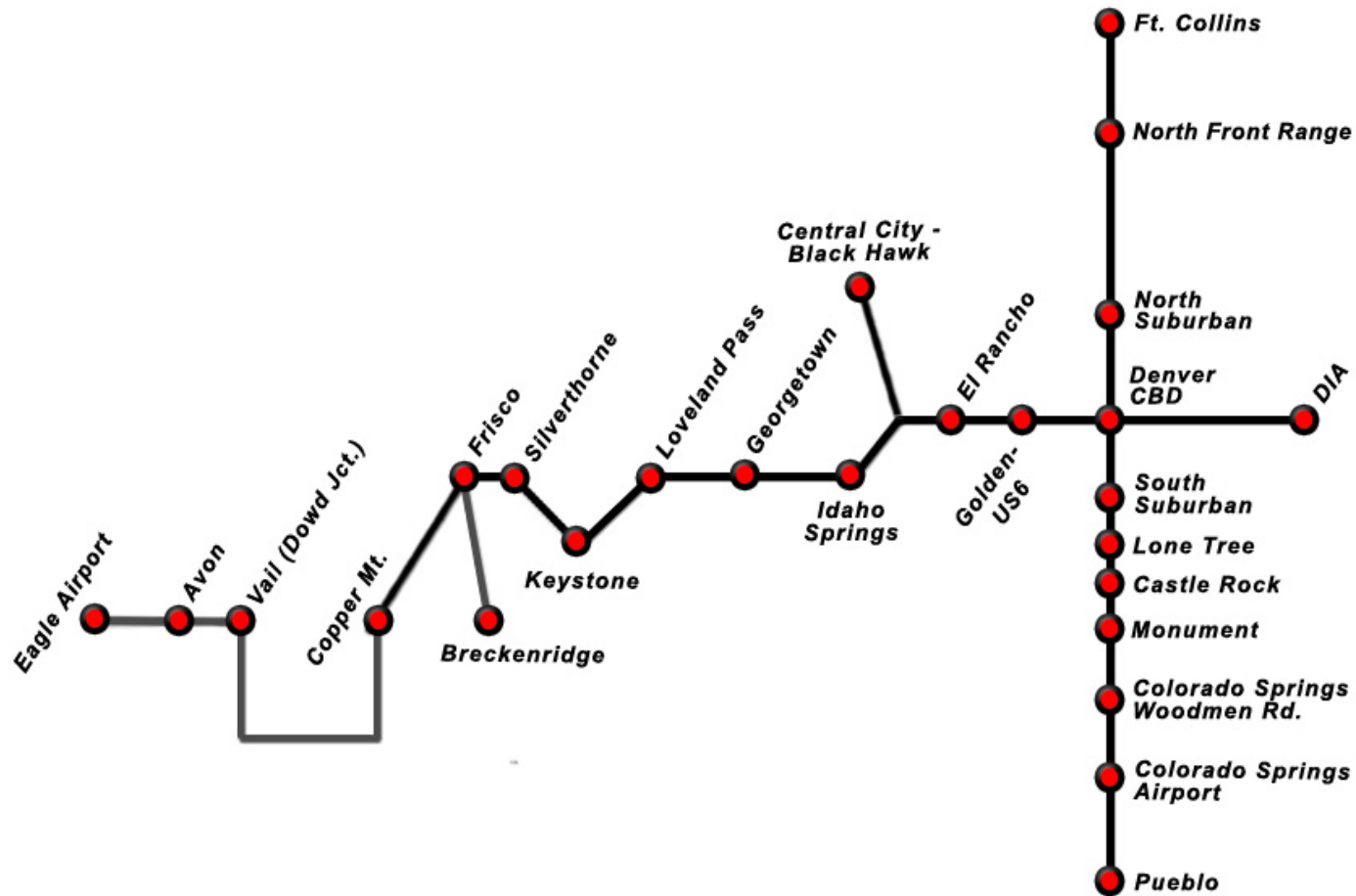


Exhibit 9-13: FRA Developed Network with Western Extensions

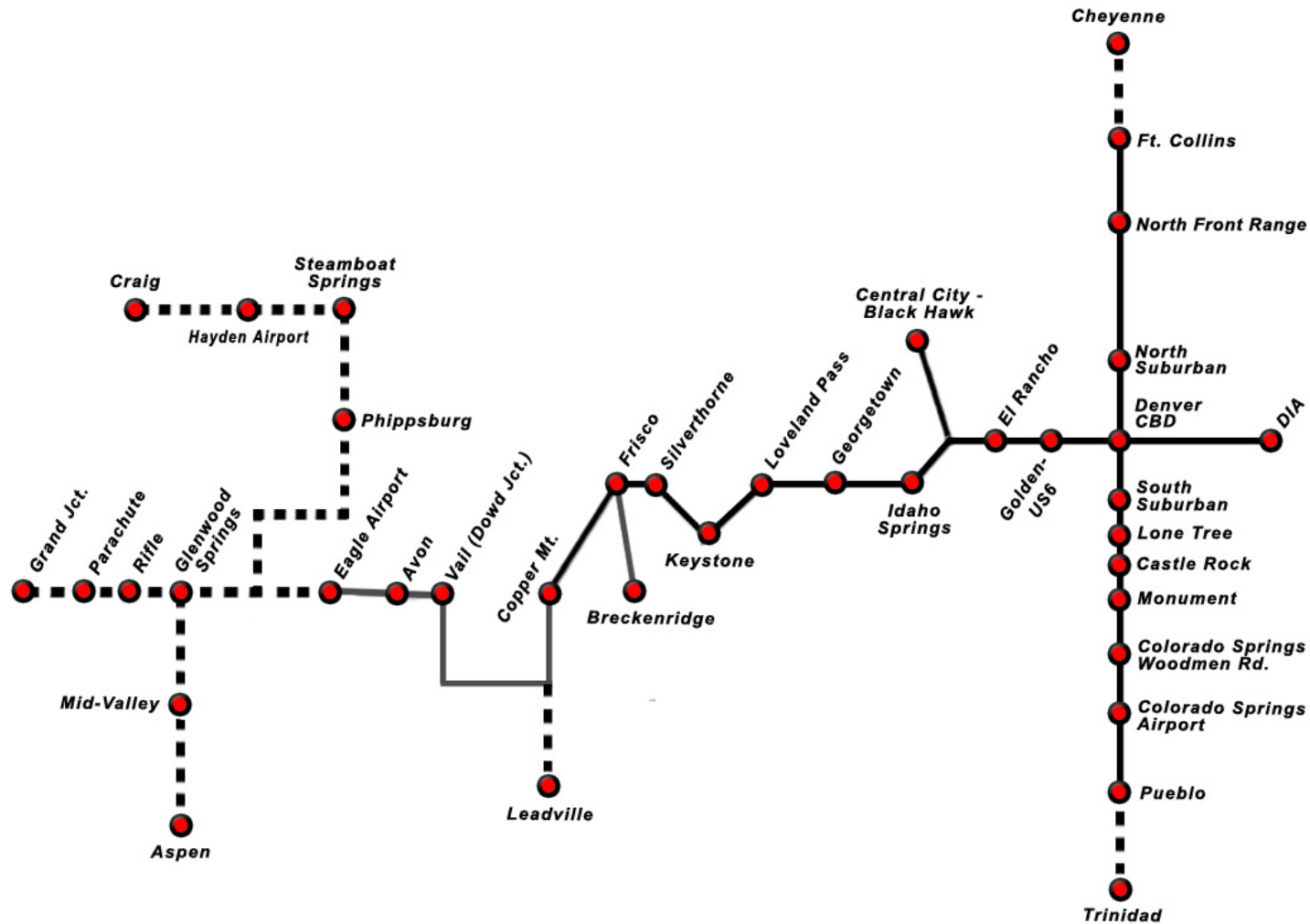
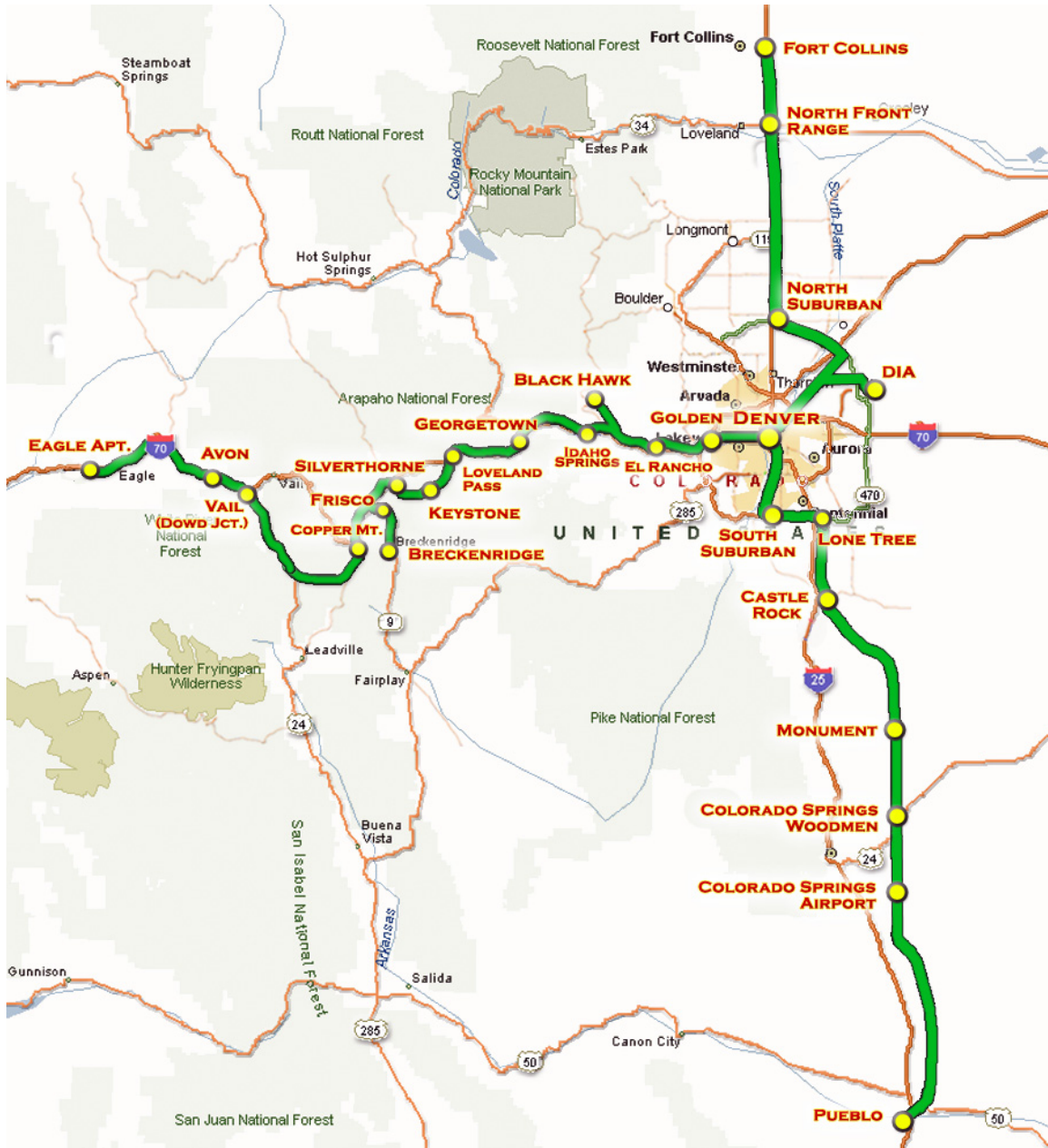


Exhibit 9-14: FRA Developed Rail Network Alignments Map



The selection of segments comprising the FRA Developed Option has tried to balance these sometimes-conflicting objectives in a reasonable way, and as such it may not represent the final solution. However, it is moving the development of the feasible options towards a consensus solution that reflects community goals. One alternative will be used for the purpose of financial evaluation in the current Feasibility study, but should not be considered the only possibility. In any following Program Development work, the proposed route needs to be subject to a detailed preliminary engineering and environmental analysis. Appendix H further discusses the definition of the FRA Developed Option highlighting the value of retaining 4 percent rather than 7 percent gradients where possible. Appendix I refines the Colorado Springs options.

In the I-25 corridor, the FRA Developed Option consists of the Greenfield alternative that was used for the 220-mph Truncated network evaluation. No modifications have been made to the routes presented in the original alternative. It is possible that a hybrid solution for I-25 could be developed based on a greater use of existing rail lines. Without an I-70 corridor connection, a passenger system based on existing rail lines in the corridor may be all that Colorado could afford. However, with the added boost from I-70 connecting traffic, the I-25 market improves to the point where it could support the development of Greenfield routes. Therefore Greenfield routes are used in I-25 for the purpose of the current evaluation, without prejudice to the NEPA process or other route possibilities, including the existing rail option. The routes included in the FRA Developed Option, both with and without possible Western Extensions, are shown in Exhibits 9-12 and 9-13.

As shown in Exhibit 9-12, in the I-70 corridor, a composite of I-70 Right-of-Way and unconstrained alignment segments have been assembled:

- From downtown Denver, the proposed corridor follows US-6 to the junction of I-70 and US-6 near Golden.
- Although the Clear Creek Canyon would provide better rail operations, because of community concerns the I-70 alignment via El Rancho was assumed to Floyd Hill. This segment involves some sections of 7 percent gradient, which should be eliminated or reduced as much as possible in the development of a final rail alignment. At Floyd Hill a branch line to Black Hawk would diverge into a new rail tunnel constructed in the vicinity of the proposed highway gaming tunnel, to reach the State Route 119 corridor on the backside of the mountain.
- From Floyd Hill up to Loveland Pass, the route within or contiguous to I-70 between Floyd Hill and Loveland Pass was used, with the exception of the Georgetown tunnel. The unconstrained segments offer better geometry and higher speed potential, are less costly to construct, and minimize maintenance of traffic concerns on the parallel I-70 highway corridor. If it proves feasible to use the Clear Creek Canyon or as an alternative, develop a 4 percent gradient option via El Rancho (which would probably involve a tunnel option) then the Georgetown tunnel should be added back into this segment to limit the maximum grade to just 4 percent all the way from Denver to Eagle Airport.
- From Loveland Pass to Silverthorne, the proposed North Fork tunnel using 4 percent grades to Keystone was used along with a connecting line that follows US-6 from Keystone back to Silverthorne. This avoids rail tunnel construction parallel to the EJMT and bypasses a steep

and difficult segment where the highway is constructed on the side of a mountain with 7 percent grades. It puts Keystone on the main line, making it easy to stop as many trains as desired there, and limits to one the number of branch lines that are needed to serve Summit County, simplifying and allowing for more efficient rail operations.

- Because of extensive tunneling that would be needed to implement a rail alignment along the south side of Lake Dillon, to reduce the tunneling expense and improve access to local communities, the proposed rail corridor has been routed back north to rejoin the I-70 highway corridor at Silverthorne. It would then follow the I-70 highway through Frisco and on to Copper Mountain using the PEIS alignment. This alignment currently has some short segments of 7 percent grade. It is assumed that by making minor route diversions off the highway right-of-way it may be possible to ease the worst grades down to 4 percent on a corridor north of Lake Dillon, although a detailed engineering assessment of unconstrained alignments has not been conducted here. West of Frisco, a branch line would tunnel back through Royal Mountain to avoid the built up part of Frisco, and to head south to Breckenridge.
- West of Copper Mountain the Pando option was assumed, for avoiding difficult 7 percent gradients on Vail Pass, and to minimize construction impacts on I-70.
- West of Pando to Avon and Eagle Airport the existing rail alignment has been assumed.

The FRA Developed Option, based on 220-mph Electric Rail technology has a capital cost of \$21.13 billion, up from \$19.84 Billion that was estimated for the original truncated 220-mph system. It is higher than the cost of the 220-mph system because the Developed Option includes additional tunnel segments for reducing gradients, improving market access, improving operations and reducing project implementation risks.

Chapter 10 presents an analysis of the FRA Developed Option, based on a detailed plan that allows identification of the specific cash flows and benefit streams associated with implementation of the system. This Business Plan approach allows for calculation of precise Net Present Values, Cost Benefit criteria and Operating Ratios associated with the prospective implementation and operation of the rail system. Exhibit 9-15 previews the key results of this analysis.

Exhibit 9-15: FRA Developed Option, Summary of Key Results

COST BENEFIT RATIO (Total Benefits ÷ Total Cost)	1.49
OPERATING RATIO (Revenue ÷ Operating Costs)	1.90

As a result, the refinements incorporated into the FRA Developed Option have improved the Cost Benefit ratio from 1.28 to 1.49, as a result of the optimized implementation plan and the full detailed Business Plan assessment. The economic assumptions that led to this improvement will be more fully described in the next chapter.