National Center for Intermodal Transportation

&

Economic Development

Examination of Economic Competitiveness of Passenger Rail Service for Sustainable and Economically Efficient Intermodal Corridor Integration

NCITEC Project: 2013_38

Patrick Sherry Ph.D.

Waheed Uddin, PhD

Burak Eksioglou, PhD

Seth Cobb, M.A.

Revised September 15, 2016

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated under the sponsorship of the Department of Transportation University Transportation Centers Program, in the interest of information exchange. The U.S. Government assumes no liability for the contents or use thereof.

Table of Contents

List of Tables

List of Figures

1 Abstract

According to the Federal Highway Administration (FHWA), the issue of increased congestion in the United States transportation system poses a substantial threat to the U.S. economy and to the quality of life of millions of Americans[1]. Highway congestion occurs when traffic demand approaches or exceeds the capacity of the highway system. Increasing use of rail can contribute to increased mobility as well as decreased congestion as well as decrease emissions and fuel consumption.

In addition, the economic viability of many communities is dependent upon the flow of traffic and the easy exchange of commerce throughout the US. The effectiveness of the transportation system to permit the flow of goods to various communities is essential to the Maintenance of higher levels of economic activity.

Currently, Southern Colorado suffers from a lack of ready access to sufficient ground transportation especially rail, which may limit its economic competitiveness over the next twenty years as new nodes of transport such as Miami, Gulfport and Jacksonville become more developed as a result of the widening of the Panama Canal. Many factors will affect this including population, level of economic activity and the like. However, several factors may be coming in to play which could suggest a need for expanded freight and passenger traffic through Colorado.

The present report investigates the factors affecting the expansion of passenger rail into Colorado and the Economic Competitiveness of Passenger Rail Service for Sustainable and Economically Efficient Intermodal Corridor Integration. Data examined in this study review point to the fact that Colorado as a whole and to a lesser extent the southern and south eastern regions of Colorado will continue to experience both population and economic growth over the next decade and into 2040. Data from passenger ridership and proposed new passenger initiatives were found to be supported by ridership projection estimates. The political environment for an expansion into passenger rail has been demonstrated with the existing communities have contributed cash and raised additional grant monies to support the upkeep and upgrading of nearly 100 miles of existing track to support Amtrak service which requires a higher standard of infrastructure than traditional freight movements. Examination of the existing commodity flows into the state suggest that about 20% to 30% might be transferred from highway to rail which would require additional and ongoing upkeep of the rail lines over which passenger service might also travel.

Analyses by two separate group provided data which suggest that the economic cost benefits of the expansion of passenger and commuter rail into Colorado from Eastern states could be sustainable. There would be a sufficient increase in passengers to operate the equipment and a resulting increase in economic impact in the neighborhood of $3 million annually. Additional study is needed however, by the freight lines, which own and operate the existing infrastructure to determine the capital needed to fully upgrade the proposed rail lines for full passenger use.

2 Objective

The primary objective of this project is a technical and economic competiveness evaluation of selected Gulf Coast and Southwestern passenger rail/commuter intercity rail service alternative plans. The scope of University of Denver portion of the study will be limited to trains that would originate along the Mississippi Gulf Coast, intersect with southern Colorado and terminate in Los Angeles. Using data on demographics, traffic volume, transit services in the corridor, and economic indicators of cities in the corridor and surrounding regions we will estimate the extent of the viability. The project will also consider additional intercity commuter rail services and percent of commuters who can be incentivized to utilize passenger trains. This can be translated into savings in average annual travel time, and reduction in harmful vehicle emissions with quantifiable public health costs and Green House Gas (GHG) emissions. The approach of economic impact evaluation is valid for enhancement /revival of other passenger rail services, such as Southwest Chief corridor that will be evaluated by DU team members. The key to select an economically viable and safe rail strategy will be good connectivity and other incentives to use the rail service. The overall goal of the present study is to investigate economic impacts of the restoration of passenger rail service through the South to Los Angeles considering Colorado as an alternative route.

3 Introduction

The current situation for Colorado is that it is served by rail and highway as well as a major airport. The focus of our present study is on ground transportation. The Denver Metropolitan area is serviced by the I-25 and the I-70 Interstate highways. Colorado is serviced by Amtrak.

According to the Urban Mobility Score Card, traffic congestion along major interstate corridors is a widespread issue across the United States. Traffic not only impedes mobility but also has a number of negative consequences including lost time for commuters and leisure travelers, hindering economic growth through travel inefficiencies, loss of capital for businesses, and an increase in pollution. Each year Americans travel an extra 6.9 billion hours and purchase an extra 3.1 billion gallons of fuel due to congestion, creating a total traffic congestion cost of $160 billion a year. [2] Additionally, the weather, accidents, and public events (i.e. sporting events and concerts) can contribute to increases in traffic congestion on roads and cause a decrease of capacity capabilities for transportation infrastructure. The I-70 Interstate in Colorado is a particular example of the economic and health costs posed by traffic congestion along a major highway corridor in a mountain environment. Noteworthy is the fact that I-70 is the only east to west interstate highway in Colorado and I-70 is used to move 11,000 tons of commercial goods and nearly 11 million automobiles from the Great Plains across Colorado and into to Western states via Utah each year.[3]

According to the Urban Mobility Scorecard[4] the mobility data for the Denver – Aurora metropolitan area for example shows that in 2014 the urban area population was 2,615,000 with 1,307,000 commuters daily. Additionally, the city ranks 17th in population with 21,709,000 miles traveled on freeways and 21,048,000 on arterials. More importantly however is the fact that the Denver – Aurora area ranks 16th in Travel Time and 16th in Commuter Stress. Congestion costs are estimated at $2,043,000 annually. Over the last four years of data the various indices has improved slightly as congestion and travel time have dropped from a rank of 17 to 19 for congestion and from 12 to 16 for Travel Time. Taken together these statistics point to the continuing challenge of handling congestion in the Denver, Colorado region.[5] Population has continued to increase going from 1,910,000 in 2000 to 2615,000 in 2015 with a similar increase in commuters.

Freight movement is a significant portion of the overall traffic and transportation system. The movement of freight encompasses physical goods, parcels, raw materials, or finished products that are transported from one place to another. For this study, the focus is on surface freight transportation modes and facilities – highways, streets, rail, and multimodal terminals. Freight data is difficult to obtain and not often easily available to state governments and planning agencies. For example, it was only in 2015 that the Colorado Department of Transportation (CDOT) initiated a commercial vehicle survey to be conducted in 2016 and 2017. [6] Denver is the northern end of the Ports to Plains corridor connecting Colorado to Mexico via Laredo, Texas. This could lead to increasing the Denver region's role as a distribution center and freight consolidation point for goods shipped to and from Mexico via I-70, US-40, and US-287. The Colorado Department of Transportation (CDOT) has published a State Highway Freight Plan (2015)[7] that begins an important step in planning for more safe and efficient movement of goods. Safety is also a concern, during the 2010-2012 period, there were 6,800 crashes involving trucks in the Denver region, resulting in 159 serious injuries and 34 fatalities.[8] Truck-involved crashes made up about four percent of all crashes and three percent of serious injuries, but seven percent of all fatalities. Again, according to the Denver Regional Council of Governments report on Freight Movement Between 2010 and 2012, truck-involved crashes increased nine percent, while total crashes increased only three percent. Serious injuries in truck-involved crashes increased 68 percent, while total serious injuries increased nine percent. Finally, between 2010 and 2012, fatalities in truck-involved crashes decreased 23 percent compared to a six percent increase in total fatalities. It is important to note crash-related statistics can vary considerably from year to year, and comparing truck involved crash trends can be difficult because they make up such a small proportion of total crashes.

3.1 Population Growth

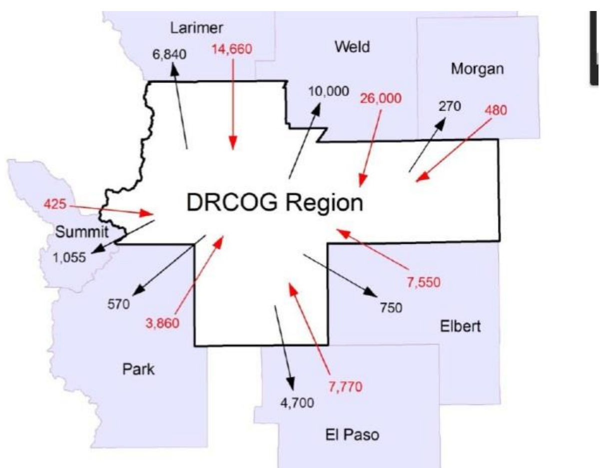
Historically, there has been much discussion about the relationship between population density and transit use. As noted in the 2040 Fiscally Constrained Regional Transportation Plan prepared by DRCOG (2015)[9] both the population and economic growth are expected to rise over the next thirty years. The population of the Denver region is expected to increase from about 3.1 million in 2015 to more than 4.3 million by 2040, an increase of almost 40 percent. The number of jobs is forecast to increase from about 1.8 million in 2015 to almost 2.4 million by 2040, an increase of about 30 percent. People living in, working in, and visiting the region in 2040 will make more than 16 million total trips (14 million vehicle trips) and drive about 105 million miles each and every weekday. Table 1 shows the past, current, and forecast population, households, and employment for the Denver region. As can be seen, considerable growth is anticipated over the next two and a half decades with an almost 30% increase in the Denver region and a smaller increase of nearly 7% in the rest of the state.

Table 1. Population of Denver Metropolitan Region.

DRCOG Region Population, Households, and Employment									
	Population			Households			Employment		
	1980	2015	2040	1980	2015	2040	1980	2015	2040
Denver TMA	1,607,400	3,091,100	4,277,900	656,000	1,261,500	1,745,900	915,100	1,807,600	2,348,300
Mountains & Plains	14,800	28,400	35,700	6,700	12,100	15,000	5,400	10,700	11,400
DRCOG Region Total	**1,622,200**	**3,119,500**	**4,313,600**	**662,700**	**1,273,600**	**1,760,900**	**920,500**	**1,818,300**	**2,359,700**

Source: DRCOG

The implications of the change in population can be seen in the metropolitan area in that increases in trips into the greater metropolitan area are expected to increase leading also to a greater number of return trips as well. Figure 1 shows the estimates by DRCOG based on census data and projects of the flows and magnitude of the traffic to and from Denver DRCOG Region (Metropolitan Denver) and the surrounding counties



Source: DRCOG

Figure 1. Illustration of Denver Metropolitan Region.

The population of Colorado has been growing since 1985. The population of the state has increased gradually due to the natural increase due to birth rates and other natural factors. In addition, Colorado has also experienced considerable migration from other states. The migration appears to be due to due an overall increase in jobs available in Colorado. The migration and population increases are focused in the metropolitan areas, but surrounding communities are also seeing some impact as well. It is estimated that Colorado’s population could increase to 7.8 million people by 2040 which would be an increase of 2.3 million people which will significantly impact the state's infrastructure, water and other natural resources.[10] It was also projected that almost half of the state's growth, 1.1 million people, will take place in the seven county Denver metro area, whose population will soar to 4.1 million by 2040. Denver will remain the second largest county, barely edging out Arapahoe County. In addition, Douglas County, will see slower growth and San Juan County will remain the state's smallest county, adding only 82 residents and have a total population of 787 by 2040. Otero and Washington counties on the Eastern Plains are expected grow the least, adding only about 5 percent to their respective populations over the next 25 years.

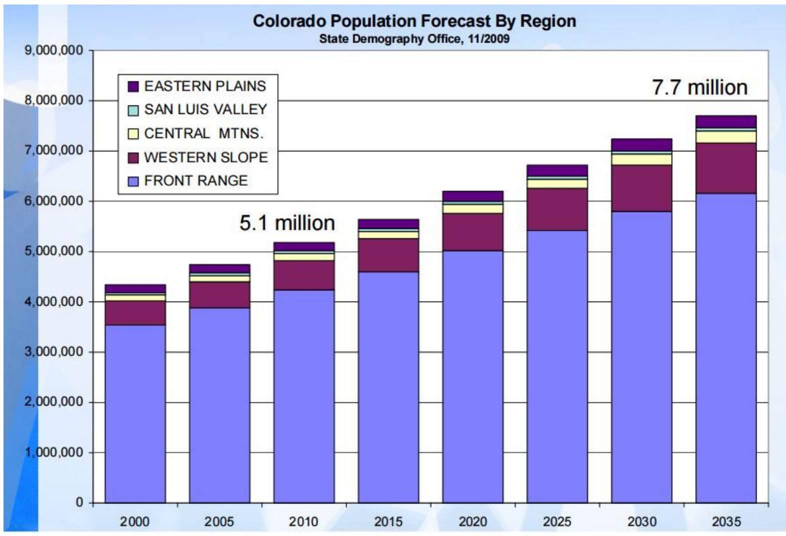


Figure 2. Colorado Population Forecast.

The display in Figure 2, prepared by the state of Colorado Demography Office in 2010, shows how the regions of the state will fare over the next 30 years. The central part of the state and the Denver Metropolitan area will increase considerably while the outlying areas in the eastern plains and the south will rise only slightly. The average increase for the eastern and south eastern counties is projected to increase by only 0% to maybe 2%.[11]

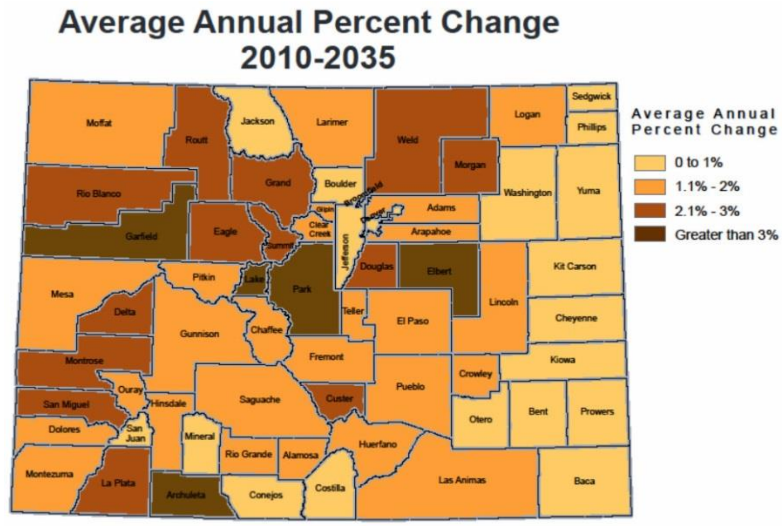


Figure 3. Population forecast by region.

The above review shows that there is a considerable amount of data which points to increasing population growth and associated with that based on the projected increase in the Colorado population it would seem that additional utilization of passenger rail could be expected. These increases would be expected to occur most likely in the denser urban areas.

3.1.1.1 Summary

In summary, the results of these analyses point to a continued steady increase in the population of Colorado with a larger rate of increase in the urban metropolitan Denver area and a slower smaller rate of increase in the southern and western Colorado region.

3.2 Economic Outlook

Colorado's economic growth in the last two years has been very good, better that the rest of the nation in 2014, ranking fifth in real Gross Domestic Product (GDP) growth, behind North Dakota, Texas, Wyoming, and West Virginia. Employment growth ranked third in 2014, again behind only North Dakota and Nevada. Per capita personal income and average annual pay remain above the national average in terms of both absolute growth and growth rates. Also, GDP in 2014 increased to $306.7 billion in Colorado. Real GDP increased 4.7% year-over-year compared to 2.4% growth nationally. Personal income jumped 6.2% in 2014. Per capita personal income rose 4.5% compared to 3.6% nationally.[12]

The economic forecasts of population and job growth are linked according to the Colorado State Demographer.[13] Additional data provided suggests that forecasts for shows that people follow jobs and that there is an expected slight decrease in new job growth and population increase occurring from 2020 to 2035.

According to the Leeds[14] report sustained growth in new business formation in Colorado overall since the Great Recession has helped generate economic and job growth for the state. Based on data from the Colorado Department of Labor and Employment on businesses that file with the state's unemployment insurance system (generally, every new business with at least one paid employee must file with the state's unemployment insurance system), the number of new businesses grew 59.1% from the first quarter of 2010, when about 3,800 new businesses started, to the first quarter of 2015, when about 6,000 new businesses started, the latest data available at the time of publication. The number of new businesses in Colorado increased 14.1% in the first quarter of 2015 over the level in the first quarter of 2014. Additionally, data on filings of new business entities with the Colorado Secretary of State's Office suggest continued growth through the third quarter of 2015. New business growth indicates that entrepreneurs in Colorado see increased opportunities and are pursuing more projects, which is leading to new jobs and a broader increase in economic activity.

Summarizing the Leeds report Colorado's economic outlook, employment growth will place Colorado in the top 10 states in 2016. In addition, home prices will continue to creep higher in Colorado as inventory is absorbed, making housing affordability a detriment to some communities in the state. • In terms of population, Colorado is the fifth-fastest growing state in the nation in percentage terms, and the state will continue to attract people from out of state, which will contribute to population growth of 1.7%. over the next few years. In summary, it is projected that Colorado will sustain a 4% unemployment rate in the next year. Finally, the report concludes that "with Colorado's skilled workforce; high-tech, diversified economy; relatively low cost of doing business; global economic access; and exceptional quality of life, the state remains poised for long-term economic growth." (Leeds, 2015, page 109)[15]

3.2.1.1 Summary

Taken together the long term economic outlook for Colorado seems stable and is likely to continue to grow at a small but steady rate. These data would suggest that the state can expect to continue to expect a reasonable amount of economic activity and GDP a percentage of which might be able to be allocated to increased support or even expansion of rail service.

3.3 Long Distance Passenger Rail

The existing passenger rail system into the state consists exclusively of Amtrak which runs the Southwest Chief and the California Zephyr.

The infrastructure for passenger rail was described largely by Amtrak. As can be seen in Figure 4, the Amtrak system map includes two major lines into Colorado.

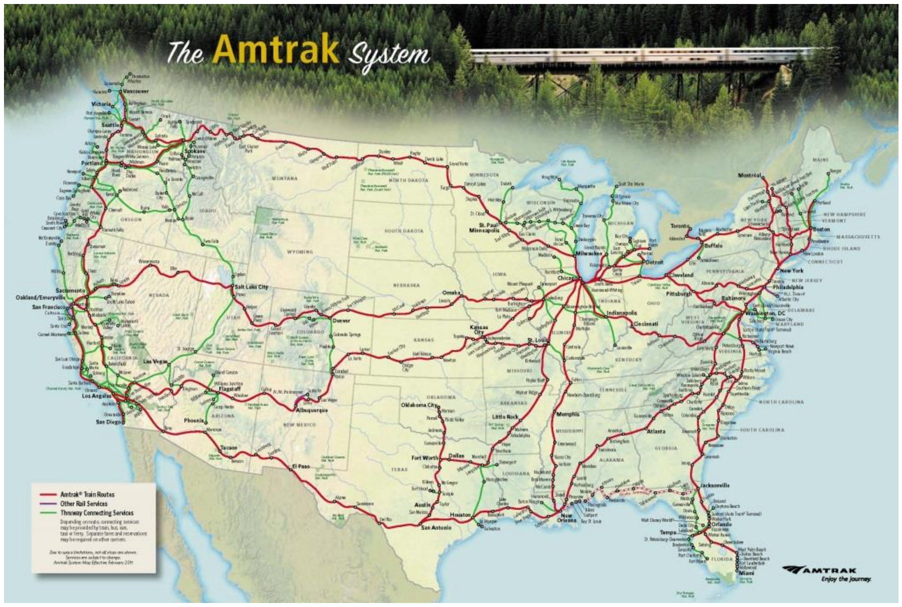
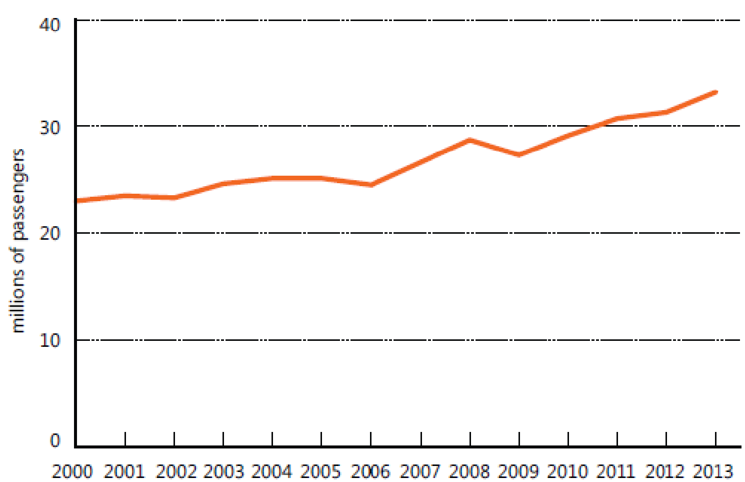


Figure 4. Amtrak System Map.

Amtrak ridership has increased steadily since FY 2000 and on into FY 2013 according to data provided by US DOT Federal Railroad Association[16] as shown in Figure 5. Accordingly, if these trends continue we can anticipate similar trends for passenger rail being expanded in Colorado.



Source: U.S. Department of Transportation, Federal Railroad Administration, available at safetydata.fra.dot.gov/OfficeofSafety as of September 2014.

Figure 5. Amtrak passenger growth since FY 2000.

Looking at the two main Amtrak lines that come into Colorado, is seen in Figure 6. As can be seen these lines go through Denver and into the southern region of Colorado. The routes extend from

Omaha to Denver, Grand Junction, and further west via the California Zephyr line. The southern route extends from Chicago to Kansas City and through La Junta, Trinidad and then on into Albuquerque.

Data obtained from Amtrak annual reports on ridership and revenue indicates that passenger traffic nationwide has general increased over the last several years. In addition, revenues have also increased. The overall national statistics however are not reflective of travel using Amtrak in Colorado. Most of the traffic is long distance and not within the state. However, the main purpose of this paper is to consider passenger rail expansion as it might connect to other parts of the country and as a natural extension of additional increased traffic from the Gulf of Mexico region. Consequently, a better comparisons is to examine the use of Amtrak for long distance travel as an indicator of increased passenger rail use from outside of Colorado to Colorado. Data was obtained from the annual reports published each year. The data in Figure 7 represent the ridership on the South Western Chief and the California Zephyr during the years from FY 2007 to FY2015. Trend line analysis reveals a steadily increasing ridership with a fairly stable rate over the previous eight years. On the average ridership grew at about 1.8% per year for the Zephyr and 1.9% for the SW Chief. (See Figure 7).

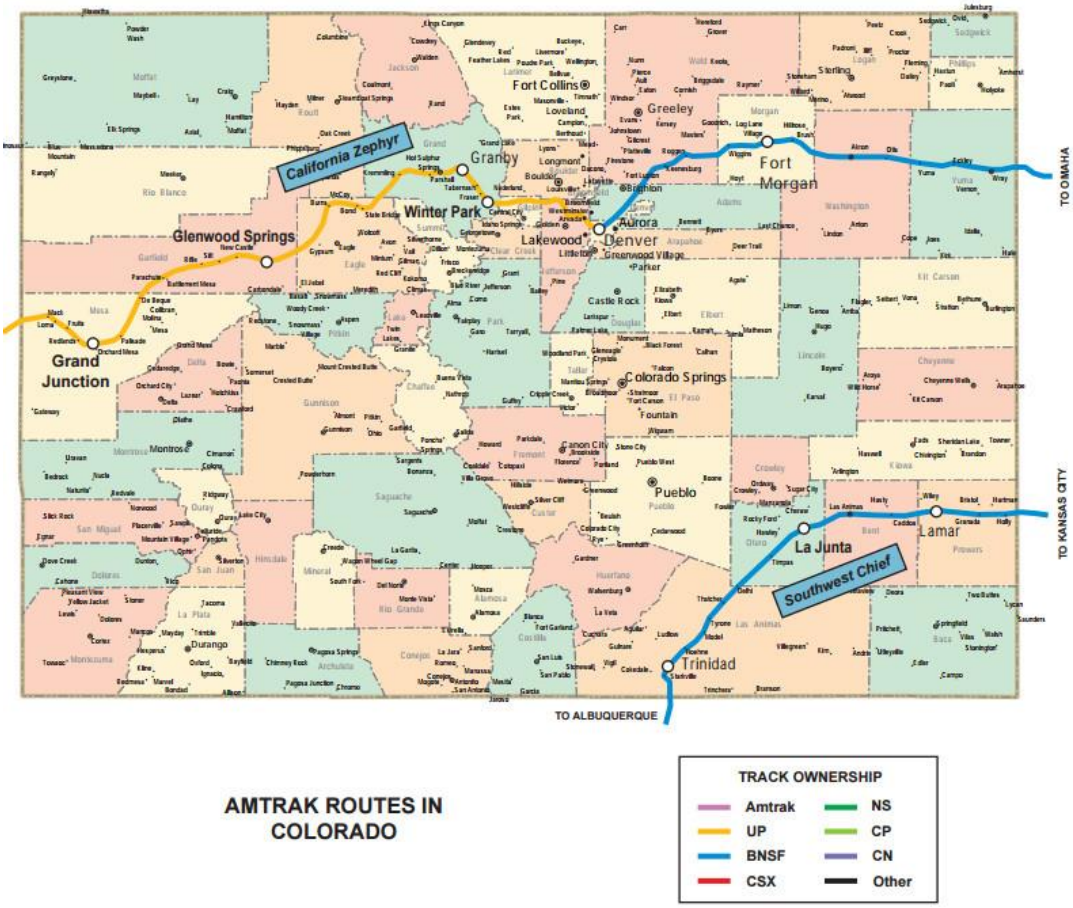


Figure 6. Amtrak routes in Colorado.

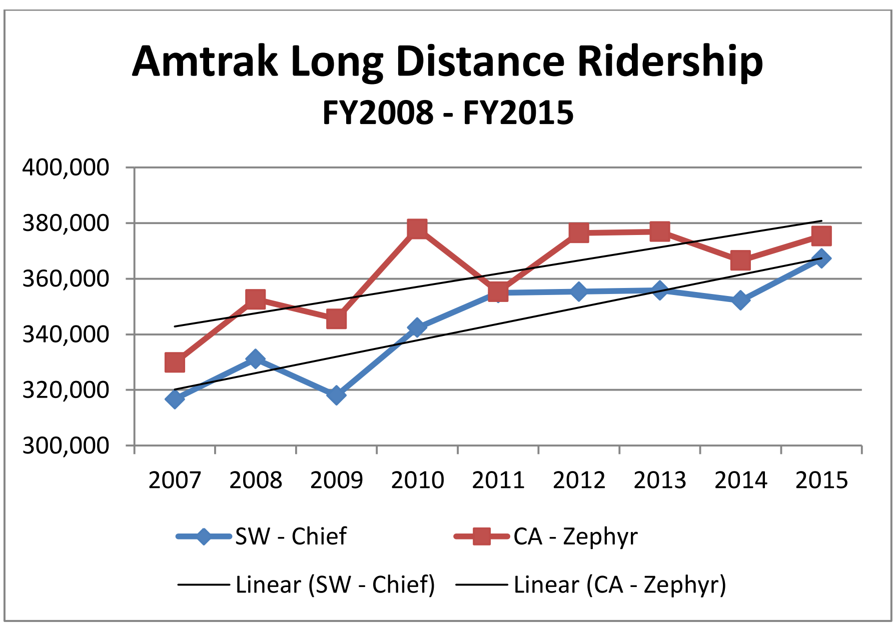


Figure 7. Amtrak Long Distance Ridership FY2007-FY2015

Projects based on the observed growth rate of 2% show in data from Amtrak (See Figure 7) were used to project potential ridership using long distance Amtrak service out to the year 2025. Results of the analysis indicate an overall growth in ridership of approximately 20% over the 10 year period. This rate is plotted in Figure 8 below.

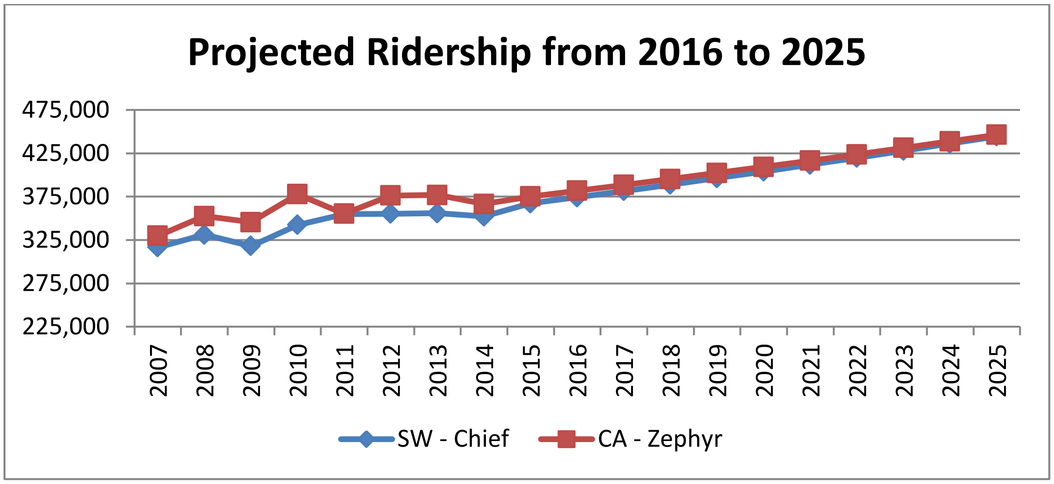


Figure 8. Project Amtrak Long Distance Ridership 2015 to 2025.

During FY12 Amtrak served the following nine Colorado locations: Denver , Fort Morgan, Glenwood Springs , Granby, Grand Junction, La Junta, Lamar, Trinidad , Winter Park-Fraser Total Colorado Station Usage: 205,942 (down 0.2% from FY11). See Table 2. Only limited data are available on the loadings within Colorado. However, as can be seen from the Table 2 there is also a corresponding increase in ridership/Boardings at the nine Colorado Amtrak stations.

Table 2. Amtrak City Boardings in Colorado 2012-2015.

City Boardings	**2012**	**2013**	**2014**	**2015**
1. Denver	113,393	108124	111426	126403
2. Fort Morgan	3343	3196	3551	3705
3. Glenwood Springs	33245	33113	34489	39713
4. Granby	3528	3408	3347	3945
5. Grand Junction	31999	29826	29672	29811
6. La Junta	6566	6711	6918	7256
7. Lamar	1936	1823	1812	1928
8. Trinidad	4770	4765	4592	5158
9. Winter Parl	7162	7250	6911	8445
Total	205,942	198216	202718	226364
		Down 3.8%	Up 2.3%	Up 11.7%

SOURCE: https://www.amtrak.com/pdf/factsheets/COLORADO14.pdf

These figures show a consistent and fairly stable pattern of use over the last four years, for which data is available. These data suggest that demand is steady and that if we project over time we might also see a steady increase in use. Regression analysis indicates that the projected ridership in 2020 might be as high as 245,619 assuming a steady 1.2% increase in ridership over the next several years. (See Figure 9).

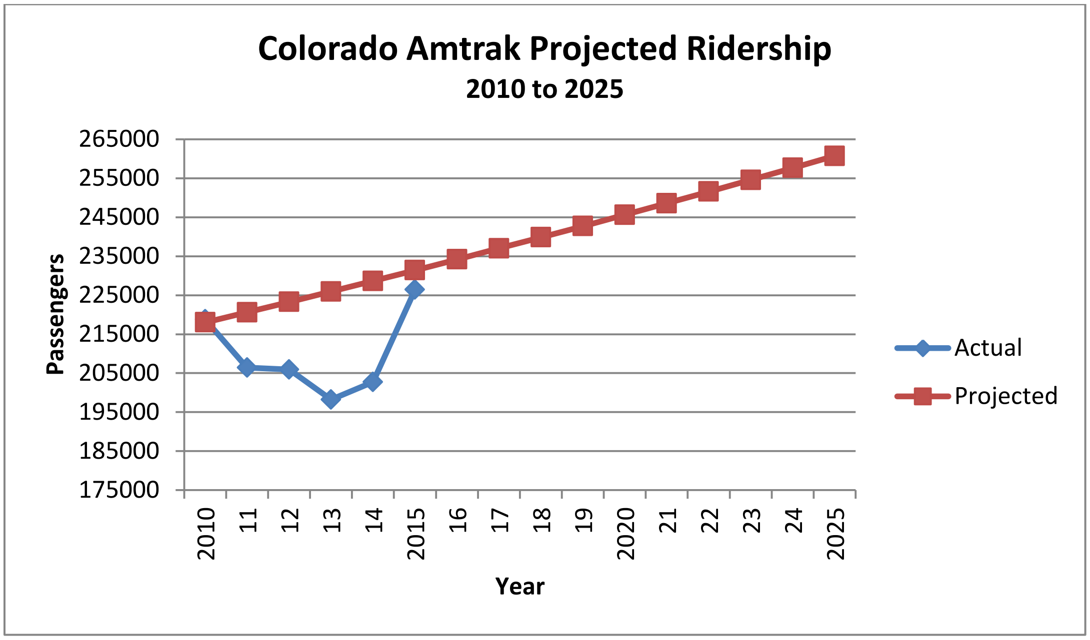


Figure 9. Projected Amtrak Ridership in Colorado 2010 to 2025.

3.3.1.1 Summary

In summary, simply looking at the ridership data, results of these analyses suggest that a small but steady increase in Colorado long-distance passenger rail can be expected over the next ten years. Many factors will contribute to the overall numbers however and other sources of data need to be considered.

3.3.2 Southwest Chief

The only passenger service into Colorado is provided by Amtrak. In 2012 both Amtrak and BNSF acknowledged deteriorating infrastructure that would have caused Amtrak cease the Southwest Chief service and slow BNSF freight speeds drastically. However, the local officials from Kansas Colorado and New Mexico each took steps to resolve the issues and obtain funding to upgrade the tracks. Successful grant applications from Garden City, Kan., and La Junta, Colo., provided $27.6 million in federal TIGER funding in the past two years. Recently Amtrak CEO Joe Boardman visited Colorado and said, "Since my service as Amtrak CEO began in 2008, Amtrak and BNSF have worked together to match federal grants with investments from both of our railroads, states and towns,"[17] According to *Railway Age*, in 2014, Garden City was awarded a $12.4 million TIGER grant, which was combined with $9.3 million of private, local and state funding to renovate nearly 47 of the 158 miles of bolted rail sections between Pierceville, Kan., and Las Animas, Colo. The grant funding enabled upgrades which permit Amtrak to travel at 79 mph. In addition, continuous welded rail, new grade crossings and turnouts were also added. La Junta received a TIGER award of $15.2 million to restore the BNSF La Junta Subdivision in Colorado and included over 20 miles of roadbed with new ties and ballast on New Mexico's Albuquerque Subdivision and 39 miles of new continuously welded rail. BNSF is also expected to maintain the track at a maximum speed of 79 mph for Amtrak and 60 mph for freight trains where the jointed rail has been substituted. The replacement rail was installed by BNSF crews and is from a Pueblo, Colo., plant. These upgrades were possible because of matching state and community support, contributions of $8 million from Amtrak, $4 million from BNSF and more from other communities combined with the $12.4 million in TIGER grants, totaling $46.2 million to replace 127 miles of old rails and ties between Hutchinson, Kan., and Waldo, New Mexico. [18]

A report provided by Amtrak in June of 2016[19] included two forecasts of 1) service between LaJunta and Pueblo at current speeds and 2) service between LaJunta and Pueblo at increased speeds following track upgrades. Option # 2 would be 21 minutes faster than option #1. The proposal would involve splitting the train at LaJunta. A portion of the train would split off and travel to Pueblo while the remaining train would continue on to Los Angeles. On the return trip, the split portion would originate in Pueblo and merge with the train as it headed back to Chicago.[20]

Table 3. Amtrak Ridership Projections for SW Chief routed to Pueblo.

	Option #1 - Pueblo to La Junta[21]			
	FY2016		Proposed	
	Annual Totals		Annual Totals	
	Ridership	Revenue	Ridership	Revenue
Coach	NA	NA	12900	$179000
Sleep	NA	NA	1100	$266000
Total	NA	NA	14000	$1445000
	Option #2 – Pueblo to La Junta – Option #2			
	FY2016		Proposed	
	Ridership	Revenue	Ridership	Revenue
Coach	NA	NA	13500	$1212000
Sleep	NA	NA	1200	$271000
Total	NA	NA	14700	$1483000

Source: M. Franke, AMTRAK, June 10, 2016.

These projections of ridership are substantial and show that a considerable amount of revenue would be generated by adding an extension or route adjustment to this line.

In addition, the economic impact study by Duncan showed that the Southwest Chief service has an economic impact due to the influx of passengers from out of state. Based on data published by Amtrak the stations in Lamar, La Junta, and Trinidad served approximately 3,200 out-of-state tourists during fiscal year 2013. These tourists visited the state for about one week. “Using data from the Colorado Tourism Office, we estimate that these visitors spent an average of $550 during their stay.” [22] The economic impact of $1.8 million (3,200 visitors x $550 per visitor) in rail tourism spending induces another $1.1 million in economic activity for a total impact of $2.9 million. The spending multiplier indicates that one more dollar in tourism spending is associated with a $1.63 increase in state-level economic activity.[23]

An economic impact of as high as $1.8 million (3,200 visitors x $550 per visitor) in rail tourism spending could be achieved. In addition, the economic impact of these additional visitors could create another $1.1 million in economic activity for a total impact of $2.9 million. According to Duncan and Wakefield[24], a spending multiplier effect occurs that such that one dollar in tourism spending is associated with a $1.63 increase in state-level economic activity. Thus, the of $1.8 million in visitor spending could create approximately 18 tourism jobs and the spending by these employees supports an additional 10 jobs in the state. The employment multiplier indicates that each new job directly related to rail tourism supports an additional 0.55 jobs in Colorado, or one more job serving rail tourism results in the creation of 1.55 total jobs. Finally, the economic activity associated with rail tourism generates an additional $175,000 in state and local tax revenue. Finally, Colorado’s share of rail repairs over 10 years is expected to be approximately $40 million. The economic impact of out-of-state visitors over a 10-year period is about $29 million. Benefits, measured in terms of the economic impact of current service, will equal expected repair costs in approximately 14 years.[25]

3.3.2.1 Summary

In summary, simply looking at the ridership data, results of these analyses suggest that a small but steady increase in Colorado long-distance passenger rail can be expected over the next ten years. Many factors will contribute to the overall numbers however and other sources of data need to be considered. Results of the recent Amtrak study of projected ridership should new extension line be developed into Pueblo is also promising and points to sufficient revenue to operate the line assuming the investment in line upgrade by BNSF.

3.3.3 Government Officials

The communities of Western and Southern Colorado are deeply committed to maintaining and expanding the commuter passenger rail service. The Southern Colorado communities support greater rail traffic and have been attempting to acquire greater investment.

To maintain the SW Chief, Colorado, Kansas and New Mexico must contribute $4 million annually for the next 10 years towards the maintenance and upkeep of the rails. IF the SW Chief is eliminated the state could lose nearly $3 million in economic activity annually brought on by the route. “It’s a no-brainer to me,” said Rep. Leroy Garcia, D-Pueblo. “I don’t see how we can just let the state lose this rail service.”[26]

Representative Garcia was the sponsor of a measure that has since been approved that formed a commission to find funding and figure out the cost for an additional stop to be added in Pueblo. According to Amtrak, the Southwest Chief serves about 13,000 riders annually in Colorado — much lower than the almost 18,000 and 34,000 it serves in Kansas and New Mexico, respectively. The commission outlined in the bill works with the neighboring states, Amtrak and BNSF to keep the train in the state. A mix of lawmakers, residents of La Junta, Lamar and Trinidad and representatives from rail and tourist industries would sit on the commission.[27]

In an interview for this report, Jonathan Taylor, in charge of economic development for the city of Trinidad, Colorado said, “We are actually trying to expand the multi-modal system between Amtrak and Greyhound. We have 125,000 people on trains and buses coming through Trinidad.”[28] In addition, they have seen a nearly 10% increase in their economic activity over the last several years. Consequently, they are hopeful that additional passenger rail service will be available.

Regarding the future of the SW Chief, “We’ll need a way forward by the end of this year, or else in the calendar year 2015 we’ll need to spend time working on rerouting the train,” said Marc Magliari, a spokesman for Amtrak, who notes the formation of this commission in Colorado would be a “positive step forward.”[29] A recent interview with Mr. Magliari, for this report, indicated that Amtrak studies suggest additional ridership. However, additional information from BNSF will be needed to determine the cost of the upgrade to the line to Pueblo.[30]

Sal Pace, County Commissioner for Pueblo, was Sal Pace was appointed to the Southwest Chief Rail Line Economic Development, Rural Tourism, and Infrastructure Repair & Maintenance Commission representing Pueblo and Huerfano Counties, areas that the legislation proposed expanded service to. The Commission coordinates and oversees efforts by the state and local governments, and cooperates with the states of Kansas and New Mexico, Amtrak, and the

Burlington Northern and Santa Fe railway to ensure continuation of existing Amtrak Southwest Chief Rail Line service in the state, expansion of such service to include a stop in Pueblo, and exploration of the benefits of adding an additional stop in Walsenburg. In a recent interview for this report Mr. Pace indicated that "I am in support of the expansion of the SW Chief to Pueblo."[31] Mr. Pace is the Chair of the SW Chief Commission Chair and recently testified before the Colorado Transportation Legislative Review Committee August 31st, 2016 in support of the upgrade and of the SW Chief rail line and the development of a station and stop in Pueblo, CO.

James Souby, President of Colorado Rail Passenger Association, indicated that his organization has three major goals. Save and expand SW Chief service to Pueblo, restore ski train service up the I-70 Mountain Corridor, and develop passenger rail along the front range. The SW Chief effort is a building block to front range rail and will provide needed connectivity. Most importantly, in a recent interview for this report, Mr. Souby stated that he hopes to encourage the legislature to establish a permanent authority and mechanism that will "create a fund to receive moneys for future appropriations and funding sources."[32]

3.3.3.1 Summary

In summary, there are a number of communities and public officials that are working hard to develop and expand passenger rail service to Colorado. These efforts have results in a considerable amount of funding from USDOT as well as funding from local communities AMTRAK and BNSF.

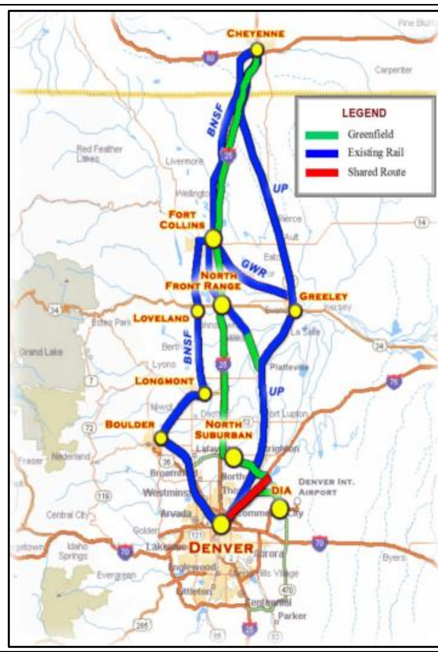
3.3.4 Rocky Mountain Rail Authority Study

A previous study of the possibility of high speed rail in Colorado was conducted in 2008 and published in 201033. Results of the analysis suggested that a number of factors would influence the possible use of high –speed rail in Colorado were it to become available. The Rocky Mountain Rail Authority (RMRA), is a multi-jurisdictional government body consisting of nearly 50 cities, towns, counties and transit authorities in the state of Colorado. The RMRA report concluded that high-speed rail, defined by the Federal Railroad Administration criteria as rail traveling at greater than 90 miles per hour was feasible along Colorado's I-70 and I-25 corridors.

The study concluded that the I-25 and I-70 corridors had intercity travel patterns of consisting of business, commuter and social trip making with both local and out of state sources. The study considered conventional Amtrak service (with maximum speeds of 79 mph) through high-speed train and magnetic levitation technologies that have maximum speeds of up to 300 mph.

The study evaluated three different scenarios including routes that would utilize: Existing rail, Highway Right or Way contiguous with either I-70 or I-25 and new or unconstrained construction. The study generated geospatial data and maps for illustrating the most feasible routes. The I-25 corridor map is presented in Figure 10. As can be seen the routes range from Denver and the Denver International Airport (DIA) south to Trinidad Colorado.34 A Northern route along I-25 was also developed and is depicted in Figure 10. Figures 11 and 12 show potential routes in the I-70 corridor.

Potential Routes within the I-25 North Corridor



Potential Routes within the I-25 South Corridor

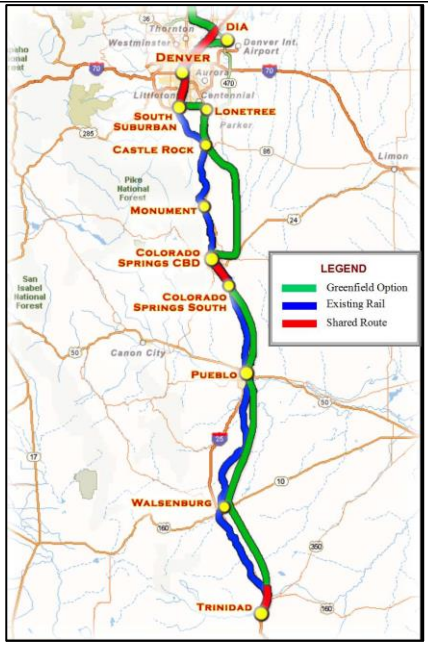


Figure 10. Potential in state Passenger Routes.

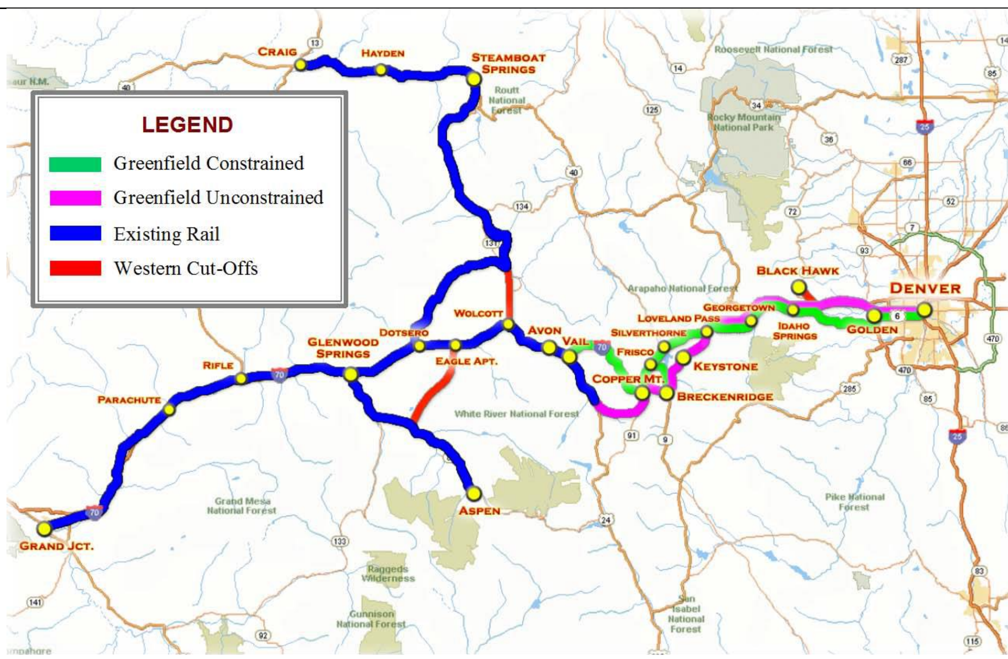


Figure 11. Potential Routes in I-70 Corridor -Denver to Grand Junction, Aspen and Craig.

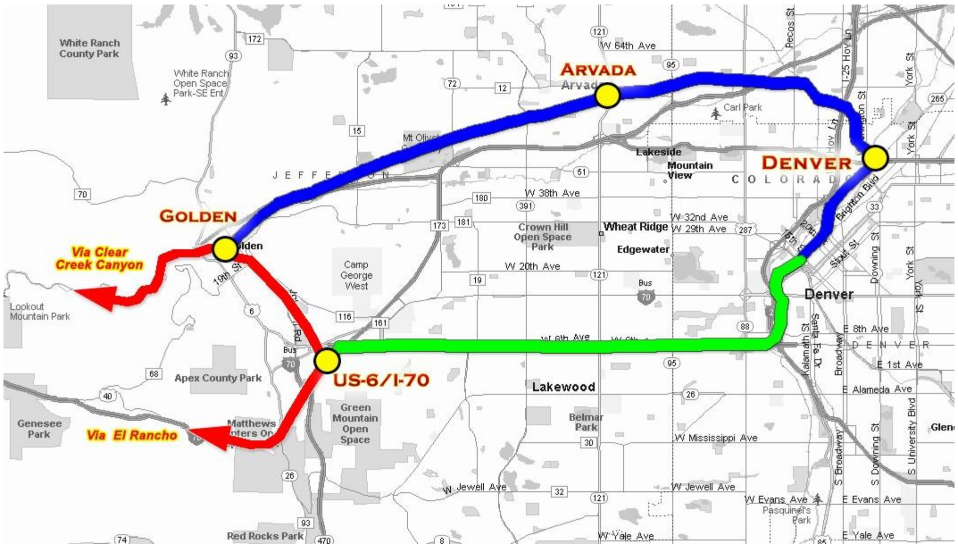


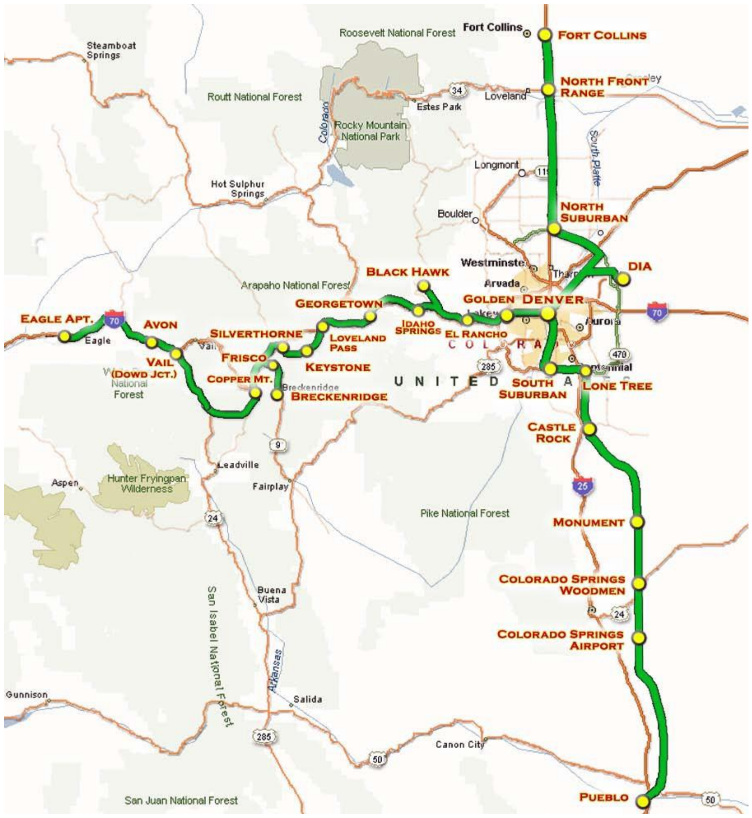
Figure 12. Potential Routes in I-70 Corridor from Denver to Golden

3.3.4.1 Summary

Results of the RMRA (2010) study indicated that each of these corridors could be feasible based on the anticipated ridership, population and economic cost projections (Figure 13). The details of these projections are numerous and can be viewed in the original documents. Following the determination that a number of options were feasible, the option that best met or exceeded FRA feasibility criteria, called the FRA Developed Option (FRAD Option) consisted of a very high-speed electric train (with average speeds of 120 to 200 mph and a maximum speed of 220 mph) in the I-70 Highway Right-of-Way and I-25 Unconstrained routes.

The cost of the FRAD Option (depicted below) was estimated to be $21.13 billion with estimated cost-benefit ratio (benefits divided by cost) of 1.49 and the operating ratio (revenues divided by operating costs) at 1.90. Finally, it was also estimated that by 2035, the proposed route is estimated to annually carry nearly 35 million passengers and generate more than $750 million in revenue.

FRA Developed Option High-Speed Rail Route



SOURCE: RMRA page ES-16.

Figure 13. FRA Developed Option Route

3.3.5 Ridership Increases

In support of these proposals several studies have reviewed the increase in ridership nationwide. Many argue that buses should be increased as they are more economical. However, recent research suggests that overall ridership and transit use increases when new rail service is introduced.

Rail in comparison to BRT, according to Yonah Freemark particularly in the form of frequent and relatively fast light and heavy rail, may be more effective in attracting riders. BRT or Bus Rapid Transit, can offer many of the same advantages as those offered by rail. [35] Comparing the ridership data from the American Public Transportation Association with vehicle revenue data from the National Transit Database, Freemark (2014) assumed that vehicle revenue hours can be used as a proxy for service provided and that in theory, an increase in revenue hours should reflect increasing ridership.[36] A shown in Figure 14 when examining considering the 27 transit systems included in the APTA data base the x axis indicates the change in bus or rail revenue hours as a share of total change between 2001 and 2012; the y axis indicates the change in bus or rail ridership as a share of total change. The results of the study show that the correlation between service increases is stronger for rail services (r-squared of 0.51) than buses (0.40) for this limited sample. The overall conclusion, reflected by the trend lines, shows that increasing availability of rail service is related to higher ridership gains on rail than on buses. The trend lines indicate that, on average, a 20% increase in revenue hours would produce a 10% increase in bus ridership and a 27% increase in rail ridership. In other words, "rail appears to be more than twice as effective in generating ridership growth than traditional bus service."[37]

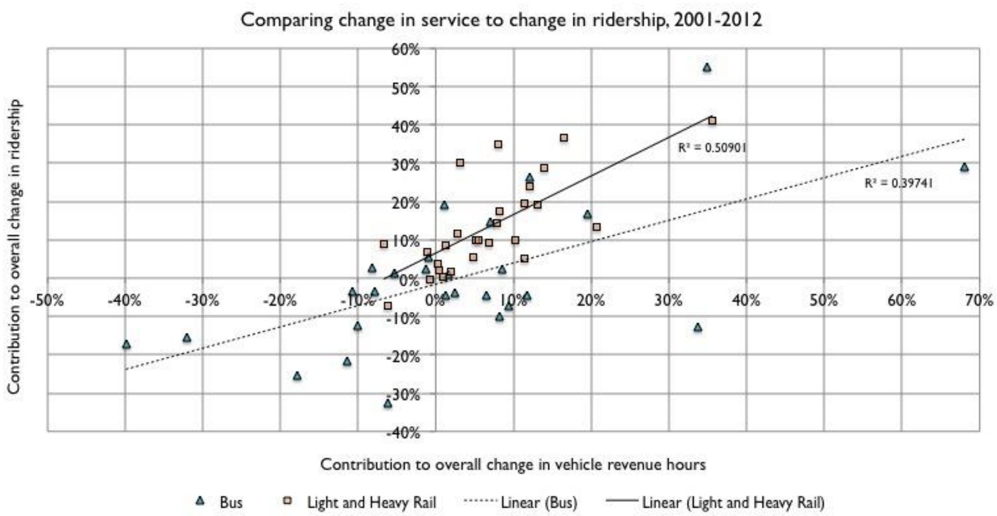


Figure 14. Comparison of rail vs bus ridership over time.

These data cannot be extrapolated to assert a "guarantee" that rail service improvements are more effective in generating ridership than bus service improvements. But there appears to be a strong preference for rail services over bus, and that from a policy standpoint, ridership is more likely to grow with increases in rail service.

A study by Tennyson[38] noted that while transit riding has declined 75 percent over the past 40 years in 11 areas with updated rail transit facilities, ridership has increased markedly, often by more than 100 percent. In two of these areas, the transit systems are attracting more ridership than they did when gasoline and tires were rationed. It appears that rail transit makes a great difference in ridership attraction, with attendant benefits. When travel time, fare, frequency of service, population, and density, increased transit use are equal, it is evident that rail transit is likely to attract from 34 percent to 43 percent more riders than will equivalent bus service.

Cervero and Guerra (2011) found that light-rail systems need around 30 people per gross acre around stations and heavy rail systems need 50 percent higher densities than this to place them in the top one-quarter of cost-effective rail investments in the U.S. When these criteria are met, the ridership gains from such increases, the authors showed, would be substantial, especially when jobs are concentrated within ¼ mile of a station and housing within a half mile.[39]

3.3.5.1 Summary

The overall conclusion, reflected by the data, shows that increasing availability of rail service is related to higher ridership gains on rail than on buses. The trend analyses indicate that, on average, a 20% increase in revenue hours would produce a 10% increase in bus ridership and a 27% increase in rail ridership. Furthermore, when travel time, fare, frequency of service, population, and density, increased transit use are equal, it is evident that rail transit is likely to attract from 34 percent to 43 percent more riders than will equivalent bus service. Overall, the data suggest that the while the Denver metropolitan area is the seventeenth largest in the country it may be able to support additional increases in transit and commuter rail.

3.3.6 Existing Freight Rail Capacity

Development of additional passenger rail in Colorado is highly related to the degree of freight rail capacity currently in existence. Freight rail capacity might be shared with passenger rail o a limited basis. Freight rail capacity in the Denver Metro includes both public (Figure 2) and private facilities; the latter include railroad tracks, loading docks, production warehouses, and other similar components. (See Figure 15)

Source: DRCOG Metro Vision Regional Transportation Plan, , DRCOG, 2015.

Figure 15. Denver Metropolitan Region Multimodal Freght Network.

Freight capacity has been examined by FHWA in their Freight analysis Framework (2013) as shown in Figure 16. The data suggest that currently there are a number of highly utilized routes and corridors which support much of the existing tonnage and freight capacity. However, at the same time there are noticeable gaps in the existing infrastructure and noticeable routes which have low levels of freight tonnage.

Figure 16. Existing freight flows in US.

Freight rail traffic in the Denver metropolitan region is predominantly managed by two Class I railroads: Union Pacific (UP) and Burlington Northern Santa Fe (BNSF). Class I railroads are the largest carriers and are designated as such by the Surface Transportation Board of the U.S. Department of Transportation. Two Class III railroads also operate within the Denver region: Denver Rock Island Railroad (DRIR) and Great Western Railway of Colorado (GWR). Active rail lines in the region are illustrated in Figure 17 along with switching yards, multimodal terminals, and major transfer facilities. [40]

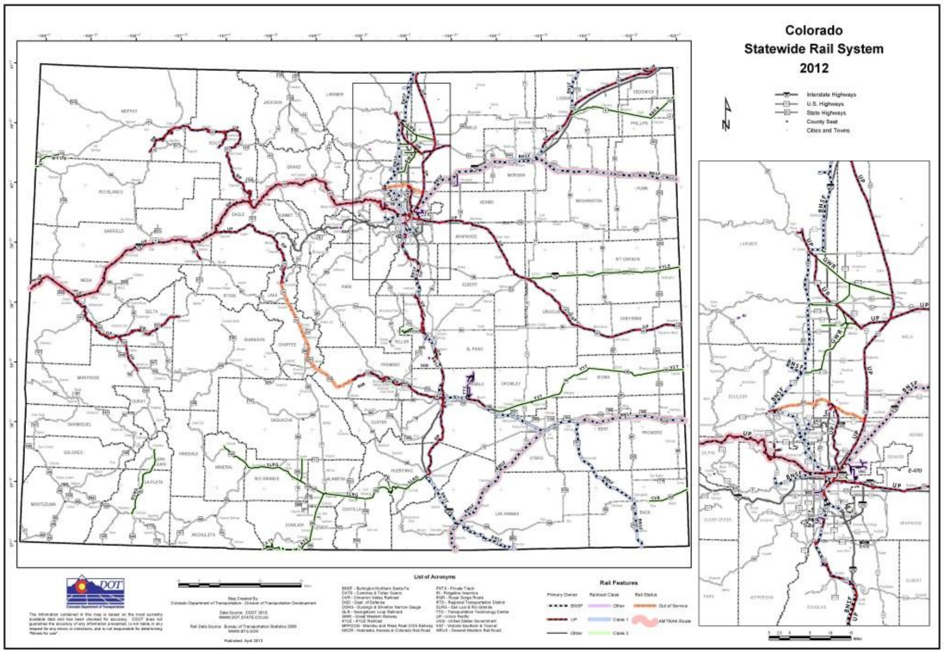


Figure 17. Colorado Statewide Rail System.

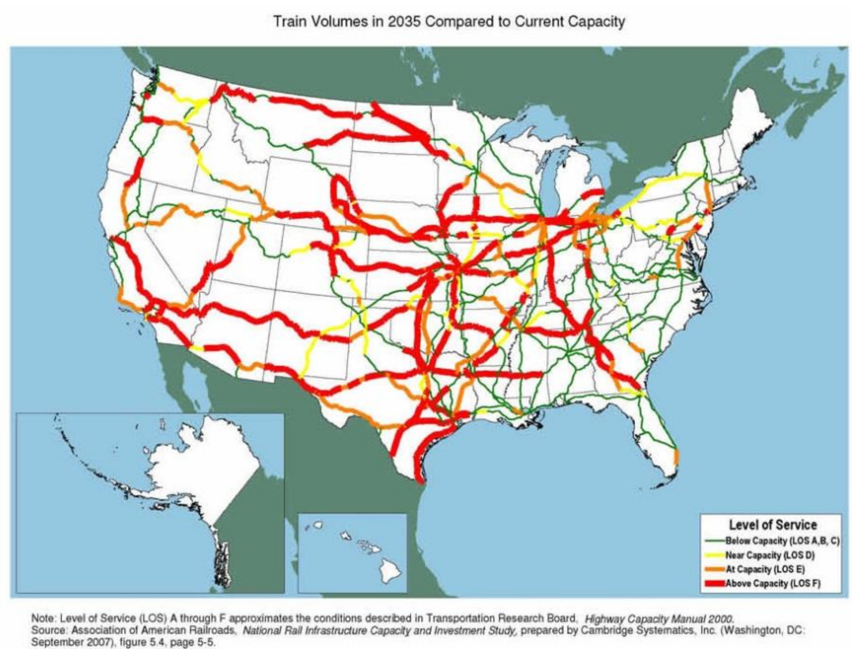


Figure 18. Projected freight flows in US.

Another projection, for 2035 however shows that many of the existing freight rail lines will be operating at considerably above capacity for which they were originally constructed (Figure 18).

Moreover, there also appears to be significant gaps between existing population centers such as Denver to Los Angeles and Denver to Phoenix and Denver to Texas.

3.3.6.1 Summary

There is considerable freight rail capacity in Colorado and the Denver metropolitan area. Most of the lines are owned by BNSF and Union Pacific. However, the lines are not maintained to the degree necessary to operate passenger trains. Such trains need to operate at just below 79 miles per hour. Considerable effort would need to be offered in order to raise the rail lines to the level of integrity needed to operate at that level. This is the missing link in our study. Only the private railroads can provide an estimate of how much it would cost to upgrade those lines. Nevertheless, the lines exist and if upgraded could support passenger rail from the gulf coast and eastern states into Colorado and beyond.

3.3.7 Commodity Flow Analysis

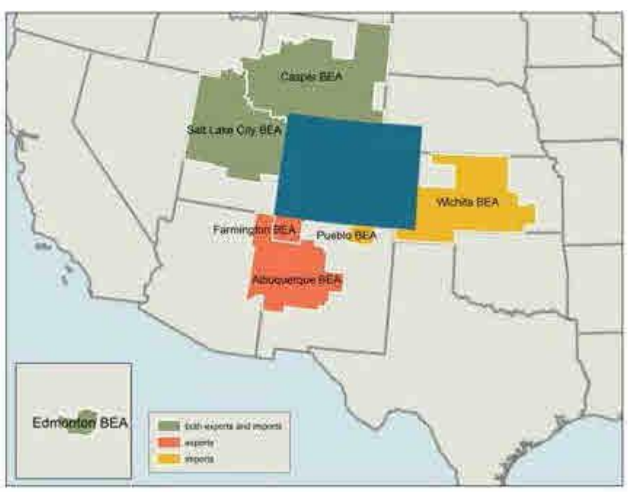
To assist in the determination of the feasibility of additional passenger rail in the Colorado area the examination of freight commodity flows sheds some light on the whether the existing freight traffic will continue to add to the need for additional freight capacity.

Using the Transearch 2010 database, which was also used by CDOT to develop the State of Colorado Highway Freight Plan[41] to prepare the commodity flow analysis which focuses on the top commodities transported by truck by weight in class for 2010 and forecast for 2040 various analyses were conducted. The Transearch database combines the primary shipment data obtained from many of the nation's largest rail and truck freight carriers with information from public, commercial, and proprietary sources to generate a base year estimate of freight flows at the county level. The Transearch forecast produces a tonnage and a value forecast. In preparing the commodity flow data profiles, CDOT determined the top commodities being transported and the top locations where they are being transported to and from. Based on CDOT's analysis, the following tables and maps highlight the top commodities transported within the DRCOG region. Inspection of the data shown in Figures 19, 20 and 21 indicate that the primary sources of goods shipped into the state originate in the surrounding states and California. Some of the interpretation of the data may be representative of the fact that there are major switching and transloading stations and facilities in the surrounding region which facilitate transfer and transport. Consequently, these data may reflect throughput to some extent.

Additional analyses provided by DRCOG, also using the Transearch 2010 data base are shown in Table 4 and Figure 22.[42] These data also show that the majority of the imported high value goods are shipped from California and Utah and to some extent Edmonton Alberta. The main commodities as shown in Table 7 are crude petroleum, gravel, sand, and concrete products are some of the top individual commodities by weight that are transported into Colorado and the Denver region by truck. Crude petroleum is also one of the top commodities by value, along with petroleum refining products, plastics products, and electronic data processing equipment.[43] The estimates suggest that these commodities will continue to be shipped to Colorado in 2040 (Figure 23).

Source: DRCOG

Figure 19. Leading Trading Partners by Weight in 2010.



Source: DRCOG

Figure 20. Leading Trading Partners by Weight in 2025

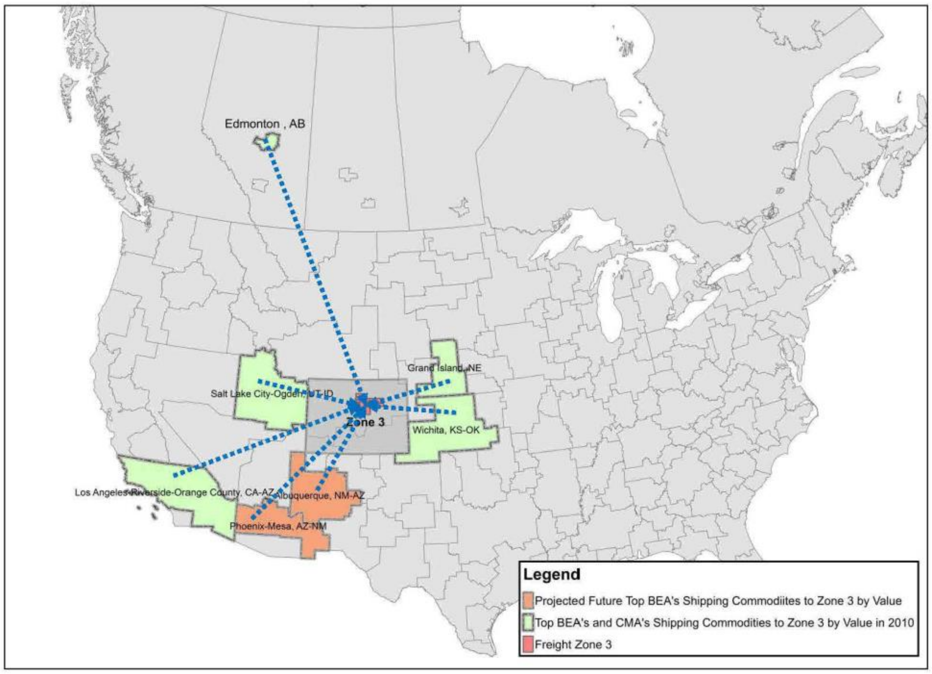
Source: DRCOG

Figure 21. Leading Trading Partners by Weight in 2040.

Looking at the import and export commodity flows to and from Colorado it is interesting to note that most of the imports come from surrounding states and Canada and Los Angeles. These are expected to continue to grow steadily into 2040.

Table 4. Estimates of Origins of Imports to Colorado 2010 and 2040.

Business Economic Area (BEA)	2010 Existing		2040 Forecast	
	Value	Percent	Value	Percent
California Portion of Los Angeles BEA	$7,489,348,240	18%	$18,790,425,150	17%
Utah Portion of Salt Lake City BEA	$4,999,349,150	12%	$20,284,254,420	19%
Edmonton, Alberta CMA	$2,362,353,550	6%	$3,351,652,410	3%
Kansas Portion of Wichita BEA	$1,676,616,910	4%	$3,769,683,340	3%
Grand Island, Nebraska BEA	$1,278,166,320	3%	$2,551,631,130	2%
New Mexico Portion of Albuquerque BEA	$681,291,780	2%	$5,523,340,610	5%
Arizona Portion of Phoenix BEA	$439,420,810	1%	$4,848,587,270	4%
Other Origins	$21,929,858,150	54%	$48,805,180,950	45%
Total Value	$40,856,404,910	100%	$107,924,755,280	100%

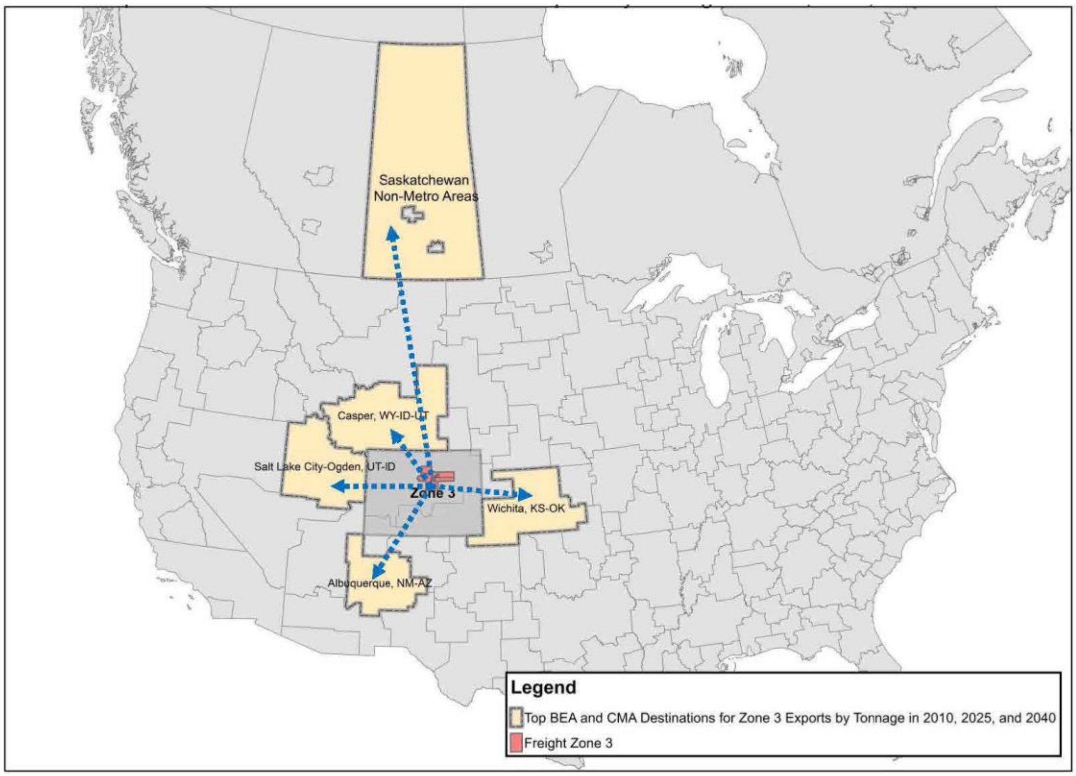


Source: DRCOG

Figure 22. Estimates of Origins of Imports by Value to Colorado 2010 and 2040.

Table 5. Estimates of Destinations of Out of State Exports by Weight 2010 and 2040.

Business Economic Area (BEA)	2010 Existing		2040 Forecast	
	Tons	Percent	Tons	Percent
Wyoming Portion of Casper BEA	1,318,840	16%	2,176,950	15%
Utah Portion of Salt Lake City BEA	949,770	12%	1,565,610	11%
New Mexico Portion of Albuquerque BEA	375,840	5%	634,920	4%
Kansas Portion of Wichita BEA	329,690	4%	664,540	5%
Non-CMA Saskatchewan	239,770	3%	428,960	3%
Other Destinations	4,899,770	60%	8,777,940	62%
Total Tonnage	8,113,680	100%	14,248,920	100%



Source: DRCOG

Figure 23. Estimates of Out of State Destinations of Exports by Weight 2010 and 2040.

Additional analyses of the commodity data was obtained from the FHWA Freight Analysis Framework (FAF).[44] Colorado is located right at the center of the Midwest portion of the U.S. This allows Colorado to act somewhat as a freight hub connecting the eastern and middle U.S. to the western portion. For this reason, Colorado was chosen as a site of focus for freight traffic for this case study. Colorado could be used as a major freight hub in the freight transportation network due to its centralized location in the U.S. However, the Rocky Mountains present logistical challenges which have led some carriers to take either the northern route through Wyoming or the southern route through New Mexico. Commodity flow analysis was completed with a focus on non-perishable, bulk freight coming to and from Colorado. The FHWA Freight Analysis Framework (FAF) uses classification systems to divide transported goods into commodity categories. FAF uses different coding levels ranging from 2-digit codes to 5-digit codes, with 2-digit being the most general with 42 categories and 5-digit being the most detailed with 504 categories. For this analysis, the 2-digit coding system was used, which provides an analytical overview of the freight. This system provides enough information to determine non-perishable, bulk materials from time-sensitive materials.

The FAF data on freight originating and arriving in each state, by mode and commodity type was obtained from the FAF database. Analysis were conducted to determine what type of freight was leaving Colorado, by what mode it was going, and the state the freight was going to. By analyzing commodities it was hoped that a case could be made for greater use of rail and therefore a greater likelihood that the infrastructure could be supported. The analysis began with the outbound freight leaving Colorado. The top three commodities going to each state from Colorado were analyzed and commodities that were bulk, non-perishable items that had less than 20% going by rail were separated from the rest (Table 6). Those that were greater than 20% were highlighted in magenta. The distance from the center point of Colorado to the center point of each state was calculated and then categorized into the following categories using different highlight colors: less than 1,000 km (yellow), 1,000 km to 1,500 km (blue), 1,500 km to 2,000 km (green), and more than 2,000 km (purple). These distances were categorized because those goods that travel further provide greater opportunity to be moved to rail, and the color code provides an easy visual to determine further distances. Non-perishable bulk commodities that shipped over 60,000 tons of freight were than selected and placed into a table. Table 6 shows the states that provide the greatest opportunity for being transferred from highway to rail based on the distances, the amount of freight being shipped, and which mode the freight is currently being shipped by. Several commodities were not analyzed due to limitations on transport equipment availability and other considerations. No foodstuffs agricultural products, alcoholic beverages, machinery, pharmaceutical s due to time limitations. Eight states that met the criteria provided in the commodity flow analysis, and those states were Georgia, Kansas, Nebraska, South Carolina, Tennessee, California, Oregon, and Washington. Thus The commodities that provided opportunity for integration include cereal grains, coal, animal feed, electronics, and agriculture.

The same process was completed for the inbound freight coming to Colorado from surrounding states. The same criteria were used in selecting which commodities would provide the best opportunity for transfer from highway to rail. The results of the commodity analysis can be seen in Table 7. There were 13 states that met the criteria provided in the commodity flow analysis, and those were Illinois, Indiana, Kansas, Louisiana, Michigan, Missouri, Nebraska, Ohio, Wisconsin, California, Oregon, and Washington. The commodities shipped among these states were found to be base metals, coal, cereal grains, nonmetal mineral products, wood products, vehicles, natural sands, chemicals, gravel, animal feed, fertilizers, nonmetallic minerals, base metals, and plastic/rubber.

Table 6. Outbound Commodity Exports from Colorado.

(Outbound) From	To	Distance (km)	1st			2nd			3rd		
			10^3 Tons	% Truck	% Rail	10^3 Tons	% Truck	% Rail	10^3 Tons	% Truck	% Rail
Colorado	Georgia	2,097.9				**03** (Agriculture)					
						100.2	100.0%	0.0%			
Colorado	Kansas	619.8	**02** (Cereal grains)								
			911.3	71.0%	28.7%						
Colorado	Nebraska	562.3	**02** (Cereal grains)								
			904.9	100.0%	0.0%						
Colorado	South Carolina	2,255.6	**15** (Coal)								
			285.8	100.0%	0.0%						
Colorado	Tennessee	1,717.5	**15** (Coal)			**04** (Animal feed)					
			346.1	94.4%	0.0%	66.7	98.7%	0.0%			
Colorado	California	1,264.9							**35** (Electronics)		
									160.5	97.9%	0.0%
Colorado	Oregon	1,369.9	**04** (Animal feed)								
			237.3	100.0%	0.0%						
Colorado	Washington	1,522.8				**35** (Electronics)					
						173.2	99.4%	0.0%			
Colorado	8 States	Total	2685.4			340.1			160.5		

< 1,000 km
1,000 - 1,500 km
1,500 - 2,000 km
> 2,000 km
% transported by rail ≥ 20%

Notes:
No foodstuffs (time limitation)
No alcoholic beverages (tend to break)
No pharmaceuticals stuffs (perishable material)
No machinery (not in bulk, preffered transported by truck)
No agriculture products (time limitation)
Only commodities weighted > 60,000 tons are considered

Source: Uddin, Sherry, Eksioglu (2016)[45]

Table 7. Inbound Commodity Flow to Colorado.

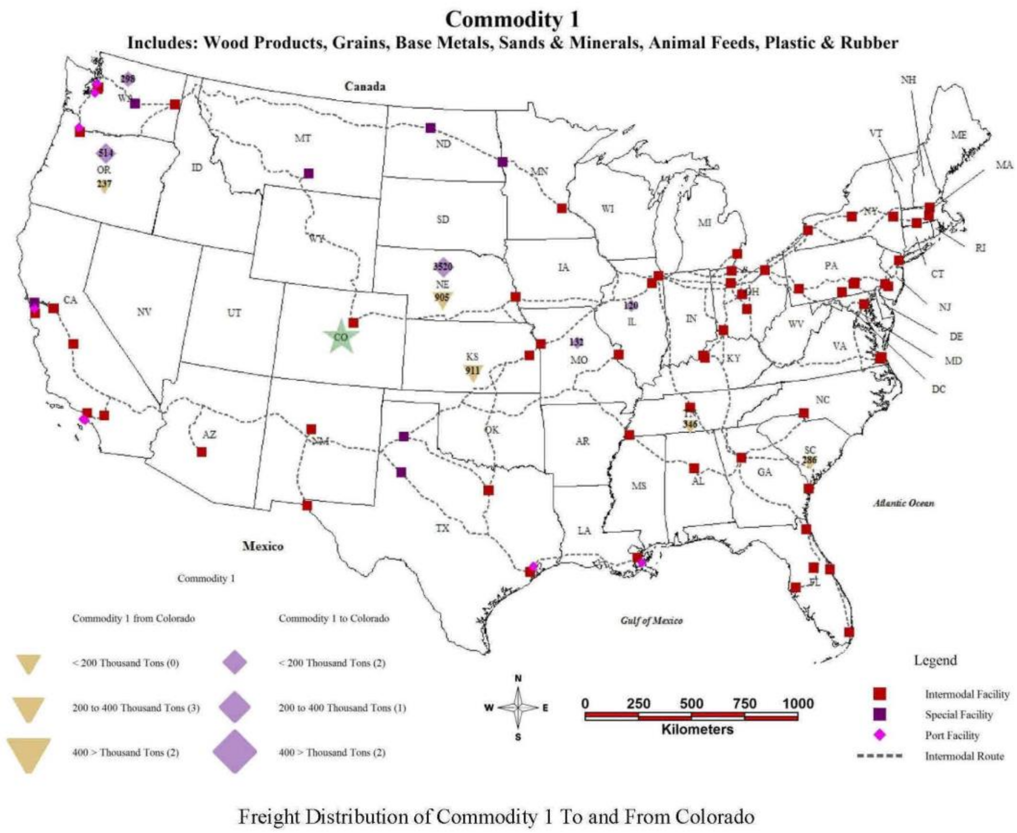
From	(Inbound) To	Distance (km)	1st			2nd			3rd		
			Thousand Tons	% Truck	% Rail	Thousand Tons	% Truck	% Rail	Thousand Tons	% Truck	% Rail
Illinois	Colorado	2,097.9	**32** (Base metals)			**33** (Articles-base metal)					
			120.3	90.1%	0.0%	73.0	97.7%	1.5%			
Indiana	Colorado	619.8				**15** (Coal)					
						82.9	96.2%	0.0%			
Kansas	Colorado	1,581.9							**04** (Animal feed)		
									212.9	88.7%	0.0%
Lousiana	Colorado	562.3							**22** (Fertilizers)		
									85.0	85.9%	14.1%
Michigan	Colorado	2,255.6				**36** (Motorized vehicles)			**13** (Nonmetallic minerals)		
						119.0	31.2%	6.8%	64.3	99.1%	0.0%
Missouri	Colorado	1,717.5	**31** (Nonmetal mineral products)			**12** (Gravel)					
			131.6	97.6%	0.0%	82.4	100.0%	0.0%			
Nebraska	Colorado	1,264.9	**02** (Cereak grains)						**04** (Animal feed)		
			3,520.0	61.4%	31.7%				305.0	79.4%	20.6%
Ohio	Colorado	1,369.9							**32** (Base metals)		
									101.7	92.7%	0.0%
Wisconsin	Colorado	1,522.8				**11** (Natural sands)			**32** (Base metals)		
						648.1	0.0%	8.2%	66.0	98.5%	0.0%
Wyoming	Colorado	477.4				**20** (Basic chemicals)			**02** (Cereal grains)		
						3,088.7	18.4%	22.6%	1,263.2	100.0%	0.0%
California	Colorado	1,264.9				**31** (Nonmetal mineral products)			**24** (Plastic/rubber)		
						435.3	62.8%	35.9%	141.8	94.4%	0.0%
Oregon	Colorado	1,369.9	**26** (Wood products)			**31** (Nonmetal mineral products)					
			513.8	36.0%	55.0%	144.4	94.9%	0.0%			
Washington	Colorado	1,522.8	**26** (Wood products)								
			297.7	57.2%	25.0%						
13 States	Colorado	**Total**	4,583.4			4,673.8			2,239.9		

< 1,000 km
1,000 - 1,500 km
1,500 - 2,000 km
> 2,500 km
% transported by rail ≥ 20%

Notes: No foodstuffs (time limitation)
No alcoholic beverages (tend to break)
No pharmaceuticals stuffs (perishable material)
No machinery (not in bulk, preffered transported by truck)
No agriculture products (time limitation)
Only commodities weighted > 60,000 tons are considered

Source: Uddin, Sherry, Eksioglu (2016)[46]

The information gathered from the commodity flow analysis was also used to develop geo spatial maps for the most frequently shipped commodities. This visual representation shows how freight moves to and from Colorado. The map uses the existing BNSF intermodal network overlaid on the map. The spatial map can be seen in Figures 15.



Source: Uddin, Sherry, Eksioglu (2016)[47] from BNSF Intermodal Map.
http://www.bnsf.com/customers/pdf/maps/small-intermodal-map.pdf

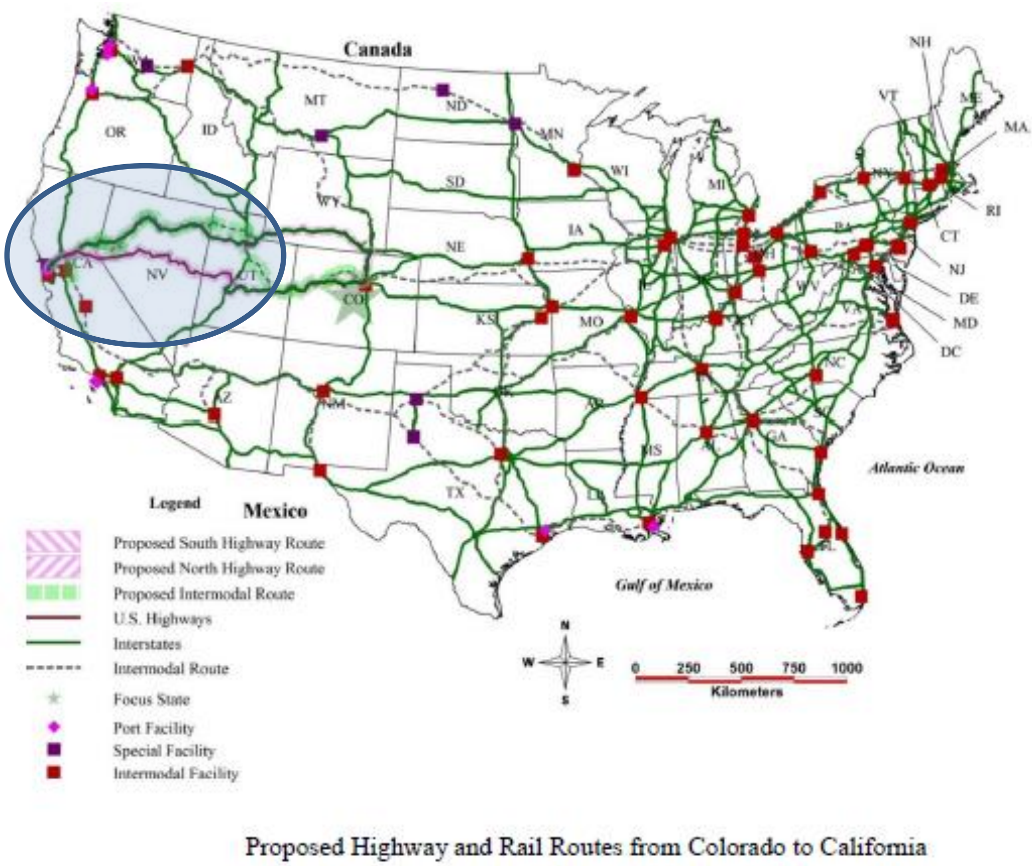
Figure 24. Intermodal network showing commodity distribution points.

By showing the commodity data to and from Colorado on the map with the BNSF intermodal network, the opportunities for new intermodal lines can easily be seen based on where high amounts of freight are going. The freight distribution in Figures 15 shows much of the freight going to surrounding states such as Wyoming, Nebraska, and Kansas, but due to their close proximity to Colorado, competition with short haul trucking is steep and may not warrant switching to rail as yet. However, additional capacity could change that scenario of more rail capacity were available speed and proximity could improve. The decision criteria for moving from highway to rail are usually a route under 500 miles in length. With higher fuel prices and speedier service rail might be a more desirable option. Results of these analyses suggest that there may be increased opportunity was for intermodal integration to Washington and Oregon. However that will have to wait for future study. There remain two opportunities for intermodal integration and the opening of a new intermodal line which are to Wisconsin and to California. Due to the time constraints of this study, only one analysis was performed, and that was for

California. Future work may include performing the benefit analysis of opening an intermodal line directly to Wisconsin.

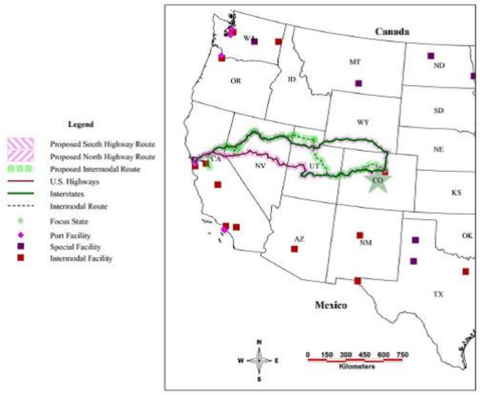
3.3.7.1 Summary

Based on the analyses a proposed freight route was proposed that utilized additional rail capacity. Figure 25 shows the spatial map of the proposed routes for cost and benefit analysis. The intermodal network to which the proposed rail line would be added is shown along with the entire Interstate Highway System. This was done to show how the routes were selected and fit into the current transportation systems. The two proposed highway routes for study are shown in the pink diagonal buffer zone. Each was labeled "North Route" and "South Route" based on where they are located with respect to the rail line. The proposed line selected from the AAR freight rail network to be added to the BNSF intermodal network is highlighted in a light green dashed line. For easier viewing, Figure 26 provides a clearer map of just the proposed routes without other existing infrastructure.



Source: Uddin, Sherry, Eksioglu (2016)[48]

Figure 25. Proposed intermodal integration routes superimposed on existing rail lines.



Proposed Routes without Other Existing Infrastructure

Figure 26. Close-up of proposed intermodal integration route.

Based on these analyses it is clear that additional commodity capacity would support the development and utilization of an additional rail line from Colorado to California thus supporting the thesis of the paper that additional infrastructure is needed to develop commuter and passenger rail lines. The data suggest that an additional rail line would be supported largely by existing freight needs, but could also be made available for passenger use. Figure 27 shows equations used for cost and benefit analysis.

$$\text{Number of Trips} = \frac{\text{Total Freight (Tons)}}{\text{Capacity (Tons per Vehicle)}} \quad (1)$$

$$\text{Travel Time per Trip (hrs)} = \frac{\text{Length (miles)}}{\text{Speed (mph)}} + \text{Time for Stops (hrs)} \quad (2)$$

$$\text{Ton} - \text{Mile Cost per Year (\$)} = (\text{Tonnage x Length})\text{x}\left(\frac{\text{Average Ton} - \text{Mile Cost (Cents)}}{100}\right) \quad (3)$$

$$CO_2 \text{ Emissions (Tons)} = \left(\frac{\text{Tonnage x Length (Miles) x Emissions per Gal of Diesel}\left(\frac{\text{lb}}{\text{gal}}\right)}{\text{Net Freight Ton} - \text{Miles per Gallon}\left(\frac{\text{Ton} - \text{Mile}}{\text{Gal}}\right)}\right)/2000\text{ lb} \quad (4)$$

Figure 27. Equations used for calculations.

3.3.8 Cost and Benefit Analysis of Revised Routes to Colorado

The cost and benefit analysis of the proposed routes from Denver to California are described as follows.

3.3.8.1 Travel Time Savings

Trips were calculated using Equation 1, and travel time per trip was calculated using Equation 2 shown in the previous section. These calculations are made to compare the travel time savings from moving 30% of the total bulk, non-perishable freight shipped between Colorado and California along the three routes. The following given data and assumptions were used in calculating the travel time for the two highway and one rail corridor selected between Colorado and California.

- Total Freight Amount: 612,000 Tons
  - 30% of Freight Moved to Rail: 183,600 Tons
  - Assumptions for Base Scenario Trucks:
    - 25-Ton Truck Capacity
    - 55 mph Average Speed
    - 8 hours of stops for rest, fuel, and food per trip.
  - Assumptions for Rail Scenario:
    - 100-Ton Rail Car Capacity
    - 25 mph Average Speed
    - 4 hours of stops for rest, fuel, and food per trip.
    - 10 cars per train trip dedicated to freight moved to rail from highway.
    - Train car carries 4.4 truckloads, 44 cars per train trip.

Using the data above, the following calculations were made for each of the proposed corridors:

- North Highway Freight Route: Travel Time Calculations
  - Total Number of Truck Trips 30% of Total Freight between CA and CO (Eq 1):
    - 183,600 Tons/25 Tons per Truck =

    7,344 Trips
  - Total Time taken per Truck to Travel from CA to CO (Equation 2):
    - (1,231 Miles/55 mph) + 8 hours (stops, fuel, food) =

    30.4 hrs per Truck Trip
  - Total Travel Time for 7,344 Truck Trips (30% of Freight):
    - (30.4 hours x 7,344 Trips) (Travel) + (8 hours x 7,344 Trips) (Stops) =

    223,111 Hours

- South Highway Freight Route: Travel Time Calculations
  - Total Number of Truck Trips 30% of Total Freight between CA and CO (Eq 1):
    - 183,600 Tons/25 Tons per Truck =

    7,344 Trips

   - Total Time taken per Truck to Travel from CA to CO (Equation 2):
      - (1,201 Miles/55 mph) + 8 hours (stops, fuel, food) =

        29.8 hrs per Truck Trip
   - Total Travel Time for 7,344 Truck Trips (30% of Freight):
      - (29.8 hours x 7,344 Trips) (Travel) + (8 hours x 7,344 Trips) (Stops) =

        219,118 Hours
- Proposed Rail Intermodal Route: Travel Time Calculations
   - Total Number of Rail Trips for 30% of Total Freight from CA to CO (Equation 1):
      - (183,600 Tons/110 Tons per rail car)/44 Cars per Train Trip=

        42 Trips
   - Total Time taken per Train to Travel from CA to CO (Eq. 2):
      - (1,353 Miles/25 mph) + 4 hours (stops, fuel, food) =

        58.1 hours per Train Trip
   - Total Travel Time for 42 Train Trips (30% of Freight):
      - (58.1 hours x 42 Trips)(Travel) + (4 hours x 42 Trips)(Stops) =

        2,436 Hours

3.3.8.2 Ton-Mile Cost Savings

Total ton-mile cost was calculated using Equation 3. Average ton-mile costs for each surface mode used in the following ton-mile cost calculations.

- North Highway Freight Route: Ton-Mile Cost Calculations
   - Total Ton-Mile Cost for Trucks Carrying 30% of Total Freight (Equation 3):
      - (183,600 Tons x 1,231 Miles) x (34.39 cents/100) = **$259 Million**
- South Highway Freight Route: Ton-Mile Cost Calculations
   - Total Ton-Mile Cost for Trucks Carrying 30% of Total Freight (Equation 3):
      - (183,600 Tons x 1,201 Miles) x (34.39 cents/100) = **$253 Million**
- Proposed Rail Intermodal Route: Ton-Mile Cost Calculations
   - Total Ton-Mile Cost for Trucks Carrying 30% of Total Freight (Equation 3):
      - (183,600 Tons x 1,353 Miles) x (3.95 cents/100) = **$33 Million**

3.3.8.3 CO2 Emission Reduction

CO_2 emissions were calculated using Equation 4. Also, the net freight ton-miles per gallon values were used in these calculations. According to the EPA, the average CO_2 emissions per gallon of diesel fuel are 22.2 lbs/gal.

- North Highway Freight Route: CO_2 Emission Calculations
   - CO_2 Emission for Trucks Carrying 30% of Total Freight (Equation 4):
      - (183,600 Tons x 1,231 Miles x 22.2 lbs/gal / 155 Ton-Miles/gal)/2000 lbs = **53,947 Tons**
- South Highway Freight Route: CO_2 Emission Calculations
   - CO_2 Emission for Trucks Carrying 30% of Total Freight (Equation 4):
      - (183,600 Tons x 1,201 Miles x 22.2 lbs/gal / 155 Ton-Miles/gal)/2000 lbs = **52,636 Tons**
- Proposed Rail Intermodal Route: CO_2 Emission Calculations

- CO_2 Emission for Trucks Carrying 30% of Total Freight (Equation 4):
  - (183,600 Tons x 1,353 Miles x 22.2 lbs/gal / 413 Ton-Miles/gal)/2000 lbs = **22,250 Tons**

3.3.8.4 Fuel Cost Savings for Colorado/California Corridor

Another indirect benefit of intermodal integration is fuel cost savings from diverting trucks from highways to other fuel efficient modes. This savings was calculated for each case study using the following Equation 5:

$$\text{Fuel Cost Savings per Truck} = \left(\frac{\text{Route Length}}{\text{Fuel Efficiency}}\right) \text{x Fuel Cost} \qquad (5)$$

According to Uddin (2012)[49], the average fuel efficiency for a diesel engine heavy duty truck is 5.9 miles per gallon. The fuel cost for these calculations used $2.50 per gallon at the general market price in 2015. Although diesel prices may be slightly higher, the larger the increase in price, the more the amount of savings will increase.

By diverting 30% of the non-perishable, bulk freight between Colorado and California from highway to rail, there will be a significant savings in fuel cost. By diverting 30% of truck freight from the North highway route, $522 per truck can be saved; and by diverting 30% of freight form the South highway route, $509 per truck can be saved. The total savings and ton-mile data for integration each highway route with rail are shown in Tables 8, 9 and 10.

Table 8. Fuel Cost Savings from Diverting 30% of Freight from Highway Corridors

Route	Total Fuel Cost Savings for Intermodal integration
Highway Freight Route – North	$3,830,394
Highway Freight Route – South	$3,737,349

Table 9. Proposed Corridor Data

Proposed Corridor Data

Route	Length (miles)	Freight between CA and CO (Tons)	Ton-Miles
Highway Freight Route – North	1,231	183,600	225,993,240
Highway Freight Route – South	1,201		220,503,600
Proposed Intermodal Route	1,353		248,355,720

Table 10. Summary of Colorado Corridor Data and Results

Route	Total Ton-Mile Cost, Million $	Total Travel Time per Year (hours)	Total CO_2 Emissions per Year (Tons)
Highway Freight Route – North	$259	223,111	53,947
Highway Freight Route – South	$253	219,118	52,636
Proposed Rail Intermodal Route	$33	2,436	22,250

Based on the results from the above calculations, significant savings can be obtained by moving just 30% of the total non-perishable, bulk freight from highway to rail between Colorado and California. Table 10 compares the various options that could be taken between the two states. In Table 10, the rail intermodal route showed a significant reduction in travel time per year at just over 2,400 hours, where the highway routes were each well over 219,000 hours. This is due to such a small capacity of the trucks causing the need to make many more truck trips, whereas the rail cars have a much larger capacity. Therefore there is no need to make near as many trips as the trucks. Ton-mile costs to move 30% of the proposed freight amount were also significantly lower for the rail route at just over $10 million, whereas both highway routes were over $75 million. The CO2 emissions for the rail route were 42% that of the highway route at 22,250 tons of CO2. The highway routes both emitted just over 52,600 tons of CO2 each. Based on the results, the commodity flow analysis shows opportunity to move some freight to rail between Colorado and California. By utilizing existing rail infrastructure, there would be a significant reduction in total travel time, total ton-mile cost, and in CO2 emissions.

Cost reductions and benefits for 30% trucks diverted to rail from the shorter highway route (South) are:

Travel Time Reduction	Ton-Mile Cost Savings	CO_2 Reduction	Fuel Savings
98.9%	87%	57.7%	$3,737,349

The same results are valid for diverting 10, 20, or 100% of freight to rail shipping. These cost-benefit calculations determined that the proposed intermodal rail route provides a good opportunity for utilizing the existing rail line for diverting a portion or all of selected freight between Colorado and California. Future research work may include performing the cost-benefit analysis of opening an intermodal line directly to Wisconsin if not planned already by the rail industry.

3.3.8.5 Summary

Based on the study results, the commodity flow analysis shows opportunity to divert some freight to rail between Colorado and California. By utilizing existing rail infrastructure, there would be a significant reduction in total travel time, total ton-mile cost, CO_2 emissions, and fuel costs. Rail is a slower alternative, so by shipping non-perishable, bulk freight, time would be not an issue. More importantly, this shows the viability of the rail routes that could also be used, if appropriate upgrades are made, to possibly add passenger traffic as well.

3.3.9 BNSF Intermodal

A recent announcement by BNSF regarding its intermodal routes and traffic points to even greater support for the expansion of the rail network in Colorado. Reportedly BNSF plans to expand rail intermodal. For example, "BNSF intermodal executives also are convinced that huge opportunities abound to build domestic volume. There are about 8 million truckloads in the West that could be converted from highway to rail, according to BNSF estimates. With a more fluid network and more dependable estimated times of arrival (ETAs) of late, the railroad is poised to capture some of it, the execs say."[50]

In an encouraging sign for BNSF's 2016 ledger, consumer products traffic made hay in the first quarter. Volume climbed 7 percent to 1.27 million units compared with first-quarter 2015's total, according to AAR data. Consumer products volume rose 9 percent in 1Q to 1.23 million units, according to BNSF's first-quarter performance summary released May 6. BNSF's intermodal volume rose 6 percent in the quarter versus the industry average of 1 percent, says Ben Hartford, a Robert W. Baird & Co. Inc. analyst who follows Class Is.[51]

In terms of operational performance, BNSF is working on its reliability and speed to be just as good as what long-haul trucks offer, says VP of Domestic Intermodal Todd Carter. The railroad can cover 600 miles per day for standard container services, and 800 miles per day for expedited container and trailer services, he says. [52]

The railroad's service now can be characterized as "very good," especially in terms of speed, says Katie Farmer, BNSF's group VP of consumer products. As of mid-April, the railroad's weekly intermodal train velocity averaged 36.7 mph versus the U.S. Class I average of 31.4 mph, according to the Association of American Railroads (AAR). "Our velocity is 17 percent faster than the Class I average," says Farmer.[53]

Recently, BNSF also announced new intermodal service from Fort Worth to Seattle. The railroad says the new intermodal service will reduce transit times by up to two days in comparison to current service available. Shipments will originate in Dallas-Fort Worth and will travel to the Pacific Northwest running Monday through Friday in both directions. BNSF said that this new service offering leverages underutilized capacity in the central section of its network, with the company offering expedited service for customers who wish to have their shipments arrive in Dallas/Fort Worth on the morning of the fifth transit day. And from its intermodal facility north of Fort Worth, it said customers can reach any of the major Texas or Oklahoma markets with a short-haul trucking option to move containers and trailers for dry or refrigerated goods. What's more, it said that northbound service will also be faster operating with both expedited service arriving on the sixth morning and standard service reaching its destination on the sixth day.[54]

Figure 28. BNSF Dallas to Seattle Intermodal Route.

3.3.10 Summary and Conclusions

The feasibility of adding additional passenger rail to the Colorado region represents a significant opportunity to enhance the quality of life, increase mobility and contribute to a long term sustainable infrastructure. The present study has reviewed existing data sources, consulted with key officials, and drawn upon various sources of analysis and opinion to reach its conclusions. The end result is that there appears to be sufficient economic activity, population growth, ridership, and anticipated utilization of resources and economic cost benefit balances to warrant further study and investment in developing additional passenger rail infrastructure and options.

Utilization of a dedicated higher speed rail line from Pueblo to Cheyenne would make the most sense initially. High speed rail or maglev appears to be feasible but too costly. Thus, the will to implement such a solution would likely not be sustainable. Additional information regarding the energy consumption requirements of a maglev solution suggests that there are major hurdles to be met and that the prospect of maglev is unlikely.

High-speed rail can provide a more efficient and cost-effective means of connecting Colorado's commercial centers with one another as well as the national and international destinations served by the state's airports. High-speed rail also provides a more reliable, enjoyable and convenient way for tourists from all over the globe to get to some of the most important and popular recreational resort destinations in North America and the world. The economic benefits of such an investment are considerable. While the costs of implementing high-speed rail are large, as would be expected given the mountainous conditions in the I-70 corridor ($16 billion to $21 billion for service in both corridors), analysis indicates that investing in high-speed rail would generate an impressive $33 billion of benefits to Colorado. These benefits are generated by the rapid growth of the state and its need to accommodate a doubling of its population over the next 30-40 years. High-speed rail is by no means the silver bullet that solves all of Colorado's transportation challenges. But, as this study clearly shows, it is a critical part of that solution and will be invaluable to the growth of the state's economy.

Data and analyses examined in this study point to the strong potential for the expansion of passenger rail in Colorado. The population base of the Denver metropolitan area, the political climate for transit and rail, the economic indicators and the current level of congestion would provide additional impetus for the continued expansion and growth. Clearly the Amtrak ridership projections and the economic impact analyses for the extension of the SW Chief into Pueblo are both very promising. However, the financial issues remain significant. The suggestion by members of the SW Chief Commission to develop a permanent mechanism to fund passenger rail in the state would be a huge step in the right direction and would build investor confidence.

The most interesting findings from our study look at the commodity analysis. Results of an examination suggest that a sizeable portion of existing freight traffic might be moved from highway to truck. Obviously a number of factors contribute to such a decision, however, looking at the types of commodities suggests that such a move would be feasible. Moreover, since the beginning of our study, BNSF has proposed and just very recently began a new intermodal service dedicated to moving high value perishables to intermodal traffic. This is an extremely important development since if further connects the southern states and ports to Colorado and if it is to be successful will necessitate that BNSF maintain these lines at a level closer to what is needed to support passenger rail traffic.

Further study is definitely needed. While the material and analyses in this report represent a major step forward there is an additional need for more detailed cost analyses to assess the economic costs of actually upgrading the existing freight lines for the movement of passenger equipment. In addition, there will be additional costs to develop and maintain the lines at operating potential.

The present study points to the need for additional passenger rail service which can be operated by adapting current freight routes. However, a significant amount of additional research will be needed to bring the final project to fruition. Cost estimates from BNSF for track improvements and estimates for the construction and maintenance of a new station at Pueblo, CO for example.

Endnotes

[1] "Congestion Pricing A Primer: Overview." U.S. Department of Transportation, Federal Highway Administration. http://ops.fhwa.dot.gov/publications/fhwahop08039 /fhwahop08039.pdf. Accessed on May 26, 2015.

[2] "2015 Urban Mobility Scorecard," accessed February 6, 2016, http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/mobility-scorecard-2015.pdf.

[3] "Freight Analysis Framework (FAF)," accessed February 6, 2016, http://faf.ornl.gov/fafweb/FUT.aspx.

[4] Urban Score Card (2015). http://mobility.tamu.edu/ums/

[5] Urban Score Card (2015). http://d2dtl5nnlpfr0r.cloudfront.net/tti.tamu.edu/documents/ums/congestion-data/denver.pdf

[6] DRCOG. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0ahUKEwjVgs3p7urOAhVD8mMKHb7pBv0QFggkMAE&url=https%3A%2F%2Fdrcog.org%2Fprograms%2Ftransportation-planning%2Fplanning-process%2Ffreight-and-goods-movement&usg=AFQjCNEQ6NTx3yRwLNHDWGmtYEGaWF6prQ&sig2=TQ6IfkBTOiIlvy90BlnJ0g

[7] CDOT (2015). http://coloradotransportationmatters.com/wp-content/uploads/2013/04/Colorado-State-Highway-Freight-Plan.pdf

[8] DRCOG (2015). DRCOG Metro Vision Regional Transportation Plan Freight & Goods Movement Component. https://drcog.org/sites/drcog/files/resources/Draft%20Freight%20and%20Goods%20Movement%20Component%20Nov%202015.pdf

[9] DRCOG (2015)2040 Fiscally Constrained Regional Transportation Plan. Adopted February 18, 2015 . https://drcog.org/sites/drcog/files/resources/2040%20Fiscally%20Constrained%20Regional%20Transportation%20Plan.pdf

[10] Rocky Mountain news (Dec 14, 2015) Birkeland, B. & Hubbard, B. http://inewsnetwork.org/2015/12/14/a-growing-colorado-anticipates-a-2040-population-of-7-8-million-people/

[11] https://raqc.org/postfiles/board_meetings/2010/may07/StateDemographer050710.pdf

[12] http://www.colorado.edu/business/sites/default/files/attached-files/colo_business_econ_outlook_2016.pdf

[13] https://raqc.org/postfiles/board_meetings/2010/may07/StateDemographer050710.pdf

[14] Ibid.

[15] Ibid.

[16] U.S. Department of Transportation, Federal Railroad Administration, available at safetydata.fra.dot.gov/OfficeofSafety as of September 2014.

[17] http://www.railwayage.com/index.php/passenger/intercity/three-states-see-southwest-chief-renovations.html

[18] Ibid.

[19] Franke, M. W. (2016). Personal communication to Mr. Sal Pace.

[20] Ibid.

[21] Ibid.

[22] Duncan, K., & Wakefield, M. (2014) The Economic impact of Amtrak's Southwest Chief Rail Service on the Colorado Economy.

[23] Ibid.

[24] Ibid.

[25] Ibid.

[26] http://www.denverpost.com/2014/04/05/southwest-chief-could-be-rerouted-from-rural-colorado-in-two-years/

[27] http://www.denverpost.com/2014/04/05/southwest-chief-could-be-rerouted-from-rural-colorado-in-two-years/

[28] Taylor, Jonathan. (August 29, 2016). Personal communication. See also http://www.thechronicle-news.com/local/taylor-hired-fills-new-economic-development-director-s-position/article_94c62ccc-dc9c-11e5-a8bd-2f1652c737ca.html

[29] Denver Post, Ibid. http://www.denverpost.com/2014/04/05/southwest-chief-could-be-rerouted-from-rural-colorado-in-two-years/

[30] Magliari, M. (October 21, 2016). Personal communication.

[31] Pace, Sal (August 31, 2016). Personal communication.

[32] Souby, James (August 31, 2016). Personal communication.

[33] Rocky Mountain Rail Authority . (2010). High Speed Rail Feasibility Study. (Executive Summary). http://rockymountainrail.org/documents/RMRAExecutiveSummary-FINAL.pdf

[34] IBID. page ES-2

[35] http://www.citylab.com/commute/2014/02/why-more-us-cities-need-embrace-bus-rapid-transit/8480/

[36] Freemark, Yonah, (2014) Recent Trends in Bus and Rail Ridership. March 3rd, 2014 , The Transport Politic, http://www.thetransportpolitic.com/2014/03/03/recent-trends-in-bus-and-rail-ridership/

[37] Ibid.

[38] Tennyson, Edson L., "Impact on Transit Patronage of Cessation or Inauguration of Rail Service", Transportation Research Record, 1221 http://www.publictransit.us/ptlibrary/TRB1221.htm

[39] Robert Cervero and Erick Guerra (2011). Urban Densities and Transit: A Multi-dimensional Perspective, INSTITUTE OF TRANSPORTATION STUDIES UNIVERSITY OF CALIFORNIA, BERKELEY, WORKING PAPER UCB-ITS-VWP-2011-6, http://www.its.berkeley.edu/sites/default/files/publications/UCB/2011/VWP/UCB-ITS-VWP-2011-6.pdf

[40] DRCOG Metro Vision Regional Transportation Plan Freight & Goods Movement Component, https://drcog.org/sites/drcog/files/resources/Draft%20Freight%20and%20Goods%20Movement%20Component%20Nov%202015.pdf

[41] Colorado Department of Transportation State Highway Freight Plan, (July 2015). http://coloradotransportationmatters.com/wp-content/uploads/2013/04/Colorado-State-Highway-Freight-Plan.pdf

[42] DRCOG Metro Vision Regional Transportation Plan Freight & Goods Movement Component, https://drcog.org/sites/drcog/files/resources/Draft%20Freight%20and%20Goods%20Movement%20Component%20Nov%202015.pdf . Page 23.

[43] DRCOG, page 31.

[44] Freight Analysis Framework. http://faf.ornl.gov/fafweb/Extraction2.aspx

[45] Uddin., Sherry, P., Eksioglou, B. (2016). Integrated Intermodal Transportation Corridors for Economically Viable and Safe Global Supply Chain. NCITEC Project # 2012-27.

[46] Uddin, W., Sherry, P., Eksioglou, B. (2016). Integrated Intermodal Transportation Corridors for Economically Viable and Safe Global Supply Chain. NCITEC Project # 2012-27.

[47] Uddin, W., Sherry, P., Eksioglou, B. (2016). Integrated Intermodal Transportation Corridors for Economically Viable and Safe Global Supply Chain. NCITEC Project # 2012-27.

[48] Uddin, W., Sherry, P., Eksioglou, B. (2016). Integrated Intermodal Transportation Corridors for Economically Viable and Safe Global Supply Chain. NCITEC Project # 2012-27.

[49] Uddin, W. (2012). Mobile and Area Sources of Greenhouse Gases and Abatement Strategies. Chapter 23, Handbook of Climate Change Mitigation, (Editors: Wei-Yin Chen, John M. Seiner, Toshio Suzuki and Maximilian Lackner), Springer, 2012, pp. 775-839.

[50]Stagl,J. (2016). “BNSF Railway's domestic intermodal push.” http://www.progressiverailroading.com/bnsf_railway/article/BNSF-Railways-domestic-intermodal-push--48174?source=pr_digital5/11/2016&email=railbob@q.com

[51] Ibid.

[52] IBId.

[53] Ibid.

54 Berman, J. (2016). “BNSF set to roll out new Pacific Northwest-Texas intermodal service” Logistics Management. http://www.logisticsmgmt.com/article/bnsf_set_to_roll_out_new_pacific_northwest_texas_intermodal_service