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STATEWIDE ECONOMIC BENEFITS OF TRANSPORTATION INVESTMENT

Todd Pickton, Janet Clements, Robert Felsburg

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16. Abstract

This study evaluates the statewide economic benefits of future transportation investment in Colorado using available data and benefits studies conducted in other states. Objectives of this study are to provide Colorado stakeholders results consistent with their guidance in the CDOT Economic Benefits of Transportation Research Scoping Study (May 2006) and to identify data needs and other information necessary to perform a future in-depth analysis of benefits by region within the state.

This research focuses on the benefits of additional transportation spending above a baseline investment scenario. The scenarios chosen for evaluation represent different levels of investment identified in CDOT's 2030 Statewide Transportation Plan (2030 Plan). The baseline or "Forecast Revenue" investment scenario represents current revenue projections through 2030. The alternative "Sustain Current Performance" scenario represents an additional investment of $48 billion. This is the level of investment necessary to maintain current transportation system performance levels.

Research findings indicate that over the 26-year investment timeframe, the economic benefits of this additional investment amount to $59.6 billion in travel cost savings and additional income for Colorado residents arising from business expansion and attraction benefits. Of the economic benefits the study team was able to quantify, the benefits exceed the required investment by $11.6 billion (2005 constant values). Further, by 2030 this additional investment would reduce the time Colorado residents spend in congestion-related delays by 72 percent compared to the Forecast Revenue Scenario. Better pavement quality would lower annual per vehicle operating costs by 6 percent and safety improvements would reduce the number of fatalities on public roadways by 14 percent.

The study team also examined benefits associated with the level of investment identified in the 2030 Plan as the amount necessary to implement the 2030 Transportation Vision of the citizens of Colorado. To incorporate the 2030 Vision into this research, the study team qualitatively evaluated specific improvements within corridors of statewide significance (as identified in the 2030 Plan) to demonstrate the magnitude of potential benefits.

The economic benefits quantified in this study represent only a portion of the total benefits of additional investment. Quality of life improvements, new jobs, better access to recreation and other improvements are difficult to quantify but also have positive implications for Colorado. Additionally, benefits of increased investment will continue well beyond 2030 (the end date for this analysis). These benefits were not quantified in this study.

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Prepared for:

Colorado Department of Transportation
Division of Transportation Development
4201 East Arkansas Avenue
Denver, Colorado 80222

Prepared by:

BBC Research & Consulting
3773 Cherry Creek N. Drive, Suite 850
Denver, Colorado 80209-3827
303.321.2547 fax 303.399.0448

and

Felsburg Holt & Ullevig
6300 South Syracuse Way, Suite 600
Centennial, CO 80111
303.721.1440

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EXECUTIVE SUMMARY

In 2006 the Colorado Department of Transportation (CDOT) researched numerous studies from across the country and conducted focus group sessions throughout Colorado to begin to explore the economic benefits of transportation investment. Based on the findings of the Economic Benefits Research Scoping Study, CDOT retained BBC Research and Consulting (BBC), an economics research firm, and Felsburg Holt & Ullevig (FHU), a transportation engineering firm, to evaluate statewide economic benefits under alternative transportation investment scenarios in order to establish the link between transportation investment and economic growth in Colorado.

The objectives of this study are:

- Estimate the statewide economic benefits of future transportation investment using available data and benefits studies conducted in other states;
- Provide Colorado stakeholders with statewide study results consistent with their guidance in the CDOT Economic Benefits of Transportation Research Scoping Study (May 2006); and
- Identify data needs and other information necessary to perform a future in-depth analysis of benefits by region within Colorado.

Summary of Results

The 2030 Statewide Transportation Plan indicates that between now and 2030 Colorado will need an additional investment of $48 billion beyond current revenue projections to sustain current levels of transportation system performance. Over the 26-year investment timeframe, the economic benefits of this additional investment amount to $59.6 billion in travel cost savings and additional income for Colorado residents arising from business expansion and attraction benefits.

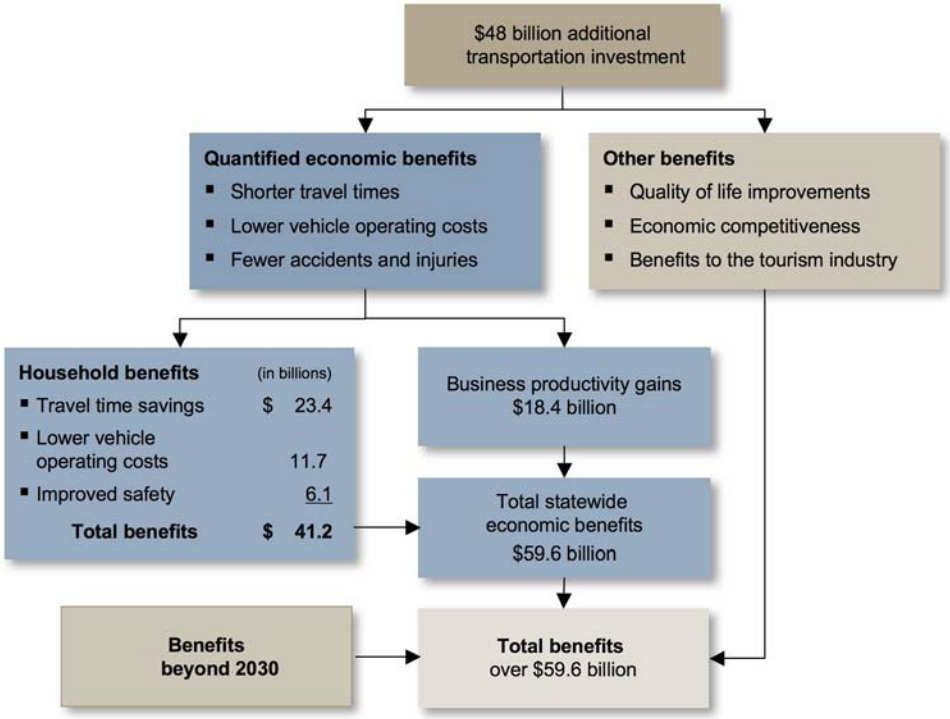
By 2030, this additional investment would reduce the time Colorado residents spend in congestion-related delays by 72 percent compared to current revenue projections. Better pavement quality would lower annual per vehicle operating costs by 6 percent, and safety improvements would reduce the number of fatalities on public roadways by 14 percent.

The economic benefits quantified here represent only a portion of the total benefits of additional investment. Quality of life improvements, new jobs, better access to recreation and other improvements are difficult to quantify but also have positive implications for Colorado. Additionally, the benefits of increased investment will continue well beyond 2030; this analysis does not quantify these additional benefits.

Of the economic benefits the study team was able to quantify, the benefits exceed the required investment by $11.6 billion (2005 constant values). To account for the difference in the timing of costs and benefits, the study team also compared the total value of future investments and benefits through 2030 in “present value” form. This analysis shows that even with the most

conservative of estimates, total benefits still exceed the additional investment costs. **Figure ES-1** summarizes total economic benefits over the 26-year investment timeframe.

Figure ES-1. Statewide Benefits of Increased Transportation Investment through 2030



Source: BBC Research and Consulting, 2007.

Approach

The study team's general approach included the following steps.

Establish a project steering committee. The study team established a project steering committee to serve as an advisory council throughout the course of this research. Steering committee members represented a variety of backgrounds and regions throughout the state. The committee met three times during the project.

Select baseline and alternative investment scenarios. This research focuses on the benefits of additional transportation spending above a baseline investment scenario. The scenarios chosen for evaluation represent the different levels of investment identified in CDOT's 2030 Statewide Transportation Plan (2030 Plan). The baseline "Forecast Revenue" scenario represents investments that can be made with current revenue projections. The alternative "Sustain Current Performance" scenario assumes that Colorado can raise additional funds to keep transportation system performance at current levels. **Table ES-A** summarizes the characteristics of these two investment scenarios.

Table ES-A. Baseline and Alternative Investment Scenarios

Forecast Revenue	Sustain Current Performance
$75 billion	$123 billion
CDOT's current revenue projections through 2030	Sustains existing system performance
System deterioration	Addresses backlog of maintenance issues
Does not meet CDOT's 2030 Vision	Does not meet CDOT's 2030 Vision

Source: CDOT 2030 Transportation Plan, 2005.

Evaluate benefits of additional investment. The study team evaluated the economic benefits associated with transportation investment under the Sustain Current Performance scenario in comparison to the Forecast Revenue scenario. The study team used available CDOT data, findings from other states and other secondary sources to estimate these effects. Many of the benefits could not be quantified in this preliminary study. Such benefits are qualitatively addressed.

Incorporate a vision for the future. Throughout the previous Research Scoping Study for CDOT, Colorado residents communicated their desires for a future with improved transportation. Therefore, the study team examined a third investment scenario: the $178 billion investment identified in the 2030 Plan as the amount necessary to implement the 2030 Transportation Vision of the citizens of Colorado.

To incorporate the 2030 Vision into this research, the study team qualitatively evaluated specific improvements within corridors of statewide significance (as identified in the 2030 Plan) to demonstrate the magnitude of potential benefits.

Quantifiable Benefits of Transportation Investment

If CDOT's current resource projections are the only funds available, conditions on the transportation system will continue to degrade in the future. Under this scenario, by 2030 the pavement condition of only 32 percent of the state's highways will be rated good or fair, and 25 percent of the lane miles on state highways will be congested. Peak period drivers will spend an average of 53 hours in congestion related delays in 2030 at an annual cost of about $500 per driver, and popular recreation destinations will become more difficult to reach. Further, as transportation costs and delays increase, Colorado will become a less attractive place to do business. It is estimated that in 2030 the cost of this delay will amount to more than $0.74 billion in wasted time and fuel for Colorado businesses.

Colorado residents and business owners are interested in the types of benefits that affect them on a daily basis. These benefits include safer roads, less time wasted in traffic, more money in their pockets and more jobs. By the year 2030, additional transportation investment would have an average annual benefit to each Colorado household of $1,578, or $624 per Colorado resident. **Table ES-B** presents these types of benefits for the year 2030 under the Sustain Current

Performance scenario. Benefits presented here represent annual benefits in 2030 compared to the Forecast Revenue scenario.

Table ES-B. 2030 Benefits of Increased Transportation Spending Under the Sustain Current Performance Investment Scenario

Benefit	Annual Benefit to Colorado in 2030
Reduced congestion	• 26 hours of time saved (per resident) • 30 gallons of fuel saved (per resident) • $1.7 billion in travel time savings for households • $240 in travel time savings (per resident) • $0.6 billion in savings for Colorado businesses
Better pavement quality	• $0.9 billion in reduced vehicle operating costs for households • $205 in savings (per vehicle) ($120 per resident) • $0.2 billion in savings for Colorado businesses
Safety improvements	• 12,100 fewer accidents • 4,300 fewer accidents involving injuries • 140 lives saved • $0.5 billion in reduced economic losses
General system improvements	• 10,900 new long-term jobs • $0.7 billion in increased personal incomes • 28,000 additional construction-related jobs • Increased economic competitiveness • Improved access to health and human services • Increased visitation to tourist destinations

Source: BBC Research and Consulting, 2007.

Shorter travel times. Under the Sustain Current Performance scenario, Colorado residents would save 26 hours per year from reduced congestion-related delays and improved pavement quality. Less time spent in stop-and-go traffic would reduce annual fuel consumption by 30 gallons per resident. The value of these savings total more than $1.7 billion for Colorado households ($240 per resident) and $0.6 billion for Colorado businesses in 2030.

Reduced vehicle operating costs. Compared to current revenue projections, sustaining the current transportation system would significantly improve roadway conditions. This would reduce general wear and tear on vehicles and would result in lower vehicle repair, maintenance, insurance and depreciation costs. In 2030, improved pavement conditions under the Sustain Current Performance investment scenario would save Colorado residents $0.9 billion in vehicle operating costs ($205 per vehicle). Colorado businesses would save $0.2 billion from reduced vehicle operating costs.

Fewer accidents and injuries. Additional investments that improve the safety of Colorado's roads could result in 12,100 fewer accidents in 2030. This includes 4,300 fewer accidents involving injuries. There could be 140 fewer fatalities in that year. In turn, Colorado residents and businesses would save $0.5 billion in medical care and insurance expenses, lost workplace productivity and personal property damage in 2030. Improved safety conditions under the Sustain Current Performance scenario could also lead to lower automobile insurance rates for Colorado residents.

Business expansion and attraction. The benefits described above reduce the cost of doing business in Colorado and improve business productivity. Local businesses would expand and new businesses would locate to the state, creating more jobs, higher incomes and greater overall economic productivity. On an average annual basis, these benefits would create 10,900 new long-term jobs for Colorado residents, increasing personal incomes by $0.7 billion compared to the Forecast Revenue scenario. This does not include construction-related jobs from additional transportation spending.

Non-quantifiable Benefits of Transportation Investment

Additional benefits of transportation investment under the Sustain Current Performance scenario include improved quality of life for Colorado residents and a healthier state economy. Although it is difficult to place a dollar value on many of these types of benefits, recent studies can demonstrate the importance of these benefits for Colorado.

Economic competitiveness. The quantified benefits of business expansion and attraction include the direct and indirect effects of the reduced cost of doing business in Colorado. The study team did not capture benefits for businesses associated with increased access to inputs or expanded market areas. These factors are difficult to determine because states throughout the U.S. are facing similar transportation funding challenges. If other states choose to improve their transportation systems, this will reduce the gains in economic competitiveness of Colorado.

Benefits to the tourism industry. Transportation improvements can encourage Colorado residents and out-of-state visitors to make more frequent and longer trips to Colorado's tourist attractions and recreation areas. This is particularly important in Colorado, where tourism is an $8.3 billion industry that constitutes over 12 percent of the state economy.

Findings from the I-70 Programmatic Environmental Impact Statement (I-70 PEIS) demonstrate the importance of transportation investment for Colorado's tourism industry. The I-70 PEIS indicates that accommodating for tourism growth in the I-70 corridor would increase visitation to surrounding recreation areas by up to 8 percent in the summer and 5 percent in the winter in 2030. This could increase out-of-state visitor spending by more than $0.4 billion in the I-70 corridor in the year 2030. Transportation investment in other parts of the state would generate additional recreation and tourism benefits.

Quality of life. Under the Sustain Current Performance scenario, system reliability and mobility improvements would provide Colorado residents with greater freedom of travel, including choice of route, time of day, destination and mode. Public transportation improvements in metropolitan areas would increase access to jobs and other services, provide more travel options and result in cost savings for Colorado residents. Improved public transit systems would also serve a broader population of seniors, disabled citizens and economically disadvantaged residents.

Short-term construction benefits. Additional transportation investment creates immediate demand for construction services, raw materials and other goods and services. This demand ripples through the economy, creating secondary effects. Conservative estimates from studies in other states indicate that transportation expenditures under the Sustain Current Performance investment scenario could support more than 28,000 new jobs per year through 2030, increasing personal incomes in Colorado by more than $1.0 billion. (Consistent with economic impact and benefits literature, these impacts are not included in the measure of total economic benefits.)

Efficient transportation investment. Under current revenue projections, CDOT and local authorities will not be able keep pace with the maintenance requirements of the state's transportation system. This would result in the costly rebuilding of roads and other infrastructure that deteriorate beyond the point of repair. With additional transportation investment under the Sustain Current Performance scenario, preventative maintenance would replace costly reconstruction, saving Coloradans money. The cost savings from keeping up with required maintenance would accrue beyond 2030, but are not quantified here.

Benefits of the 2030 Vision

The 2030 Statewide Transportation Vision balances local, regional and statewide transportation needs through an integrated system of statewide corridor investments. These investments extend beyond what is included in the Sustain Current Performance scenario, and would require an additional $55 billion.

The 2030 Vision improves the state's economic competitiveness and enhances the quality of life of Colorado residents beyond what would be achieved under the Sustain Current Performance scenario.

Improved safety. Additional transportation investment under the Vision scenario would further reduce the number of accidents, injuries and fatalities on public roadways throughout the state. Compared to the Sustain Current Performance scenario, safety improvements under the Vision would save an additional 55 lives in 2030. Fewer accidents on public roadways would further support the efficient movement of goods and improve recreational travel in many corridors.

Economic development. Improved pavement quality and increased capacity on heavily traveled freight corridors would promote economic development and improve farm-to-market commercial activity in rural areas of the state. Examples of potentially affected corridors include US 385 and portions of US 50 and I-70. Further, investments in the Ports-to-Plains Corridor and the Heartland Expressway would increase Colorado's importance in north-south movement of goods and generate additional economic activity. More frequent air service and other aviation improvements would increase economic competitiveness in many regions.

Public transportation demand. Under the 2030 Vision, improved public transit systems would meet a far greater portion of residents' demand for this service. Public transportation improvements benefit Colorado residents throughout the state by providing access to higher paying jobs, health and human services and competitively-priced consumer goods. In urban and rural areas of the state, public transportation systems provide a vital community link for seniors, the disabled and children.

Public transportation investments can also serve to increase the economic competitiveness of metropolitan areas. For example, investments in public transportation along the I-25 corridor would allow employers in Metro Denver and Colorado Springs to attract skilled employees from a larger total workforce. A well-developed public transportation system also improves air quality.

Access to recreation destinations. Additional capacity and improved public transit services on I-70 west, SH 82 and US 160 would provide access to many of Colorado's key recreation sites. This would not only improve quality of life for Colorado residents but would encourage out-of-state visitors to make longer and more frequent trips to Colorado's tourist destinations. For example, in the I-70 corridor, highway and transit improvements under the Vision scenario would increase trips to recreation areas by an estimated 10 to 14 percent above the Sustain Current Performance scenario. This could increase out-of-state visitor spending by more than $0.6 billion in 2030.

Next Steps

This study provides a foundation for analyzing the economic benefits of transportation investment by region within the state. A series of transportation benefit studies by region would further explore the economic benefits and communicate the importance of transportation investment to each region. These regional studies could be tied to specific funding initiatives.

Local businesses, transportation authorities, Transportation Planning Regions and Metropolitan Planning Organizations could lead this effort. CDOT and other state agencies could help coordinate traffic and economic modeling analyses. Specific projects, associated performance levels and local road data would need to be a part of any regional study.

1.0 INTRODUCTION

The Colorado Department of Transportation (CDOT) recently examined whether Colorado stakeholders would be interested in learning more about the economic benefits of transportation investment (Economic Benefits Research Scoping Study, 2006). Based on the findings of this research, CDOT retained BBC Research and Consulting (BBC), an economics research firm, and Felsburg Holt and Ullevig (FHU), a transportation engineering firm, to evaluate statewide economic benefits under alternative transportation investment scenarios.

The goal of this study is to communicate the importance of transportation investment to Colorado residents by establishing the link between transportation investment and economic growth in Colorado. Pursuant to findings from the Scoping Study, this research also lays the groundwork for a series of more in-depth analyses of the economic benefits of transportation by region within the State.

The objectives of this study are as follows:

- Use available data and similar studies conducted in other states to estimate the statewide economic benefits to Colorado under future transportation investment scenarios;
- Provide Colorado stakeholders with statewide study results consistent with their guidance in the initial Economic Benefits of Transportation Research Scoping Study; and
- Identify data gaps and other information necessary to perform an in-depth analysis of benefits from transportation investment by region within Colorado.

1.1 Background

The quality of life and economic successes that Colorado residents enjoy are made possible by an affordable, safe and efficient transportation network. Manufacturers rely on this network to access markets and receive supplies. Businesses rely on it to conduct face-to-face meetings with customers and business associates. Residents rely on it to reach jobs, shopping destinations, schools, health care facilities, and leisure travelers to reach recreational and tourist sites. Colorado's economic health and its ability to remain competitive with other states depend on the efficient transport of people and goods.

Colorado's transportation system is supported largely by public expenditures. These investments have tangible benefits, ranging from travel time-savings for commuters to reduced shipping costs for manufacturers. However, CDOT revenue projections through the year 2030 show that transportation investment will not be able to keep pace with expected needs. Without alternative modes of transportation, increased capacity and additional maintenance, levels of expected growth in many areas will push Colorado's transportation system beyond its limits.

The goal of this study is not to describe the negative consequences of allowing the State's transportation system to deteriorate, but to demonstrate how investments in transportation can benefit Colorado's economy. This report describes the positive economic impacts of alternative future transportation investment scenarios through both quantitative and qualitative research.

1.2 Approach

The study team's general approach included the following:

Establish a project steering committee. The study team established a project steering committee to serve as an advisory council throughout the course of this research. The primary role of the steering committee was to provide input and guidance on topics such as study methodology and presentation of benefits. Steering committee members represented a variety of backgrounds and regions throughout the state. **Appendix A** contains a list of steering committee representatives.

Select baseline and alternative investment scenarios. As a first step to this analysis, the study team identified two levels of investment: one consistent with current revenue forecasts, and an alternative, higher level of investment that would maintain current system performance. The investment scenarios define types of transportation improvements and the timeframe for investment.

The scenarios chosen for evaluation represent the different levels of investment identified in CDOT's 2030 Statewide Transportation Plan (2030 Plan). The baseline investment reflects CDOT's current resource allocation projections through 2030, a total investment of $75 billion. As detailed in the 2030 Plan, the "Forecast Revenue" investment not only falls short of being able to meet the needs of the state's "2030 Transportation Vision," it does not even sustain the system's present-day quality and performance.

The "Sustain Current Performance" scenario represents the level of investment necessary to sustain existing performance levels through 2030 and address the backlog of current maintenance issues on the state's transportation system. This level of investment amounts to an additional investment of $48 billion beyond current revenue projections, or a total investment of $123 billion through 2030.

Much of this report focuses on the increased economic benefits resulting from additional transportation spending under the Sustain Current Performance investment scenario.

Incorporate a vision for the future. Throughout the Research Scoping Study, Colorado residents overwhelmingly communicated their desires for a future with an improved transportation system. Therefore, the study team examined a third investment scenario: the $178 billion investment identified in the 2030 Plan as the amount necessary to implement the 2030 Transportation Vision of the citizens of Colorado.

The "Vision" investment scenario demonstrates the importance of not only maintaining current system performance but also of improving the quality of life for Colorado residents through further transportation investment. To incorporate the 2030 Vision into this research, the study team focused on the corridors of statewide significance identified in the 2030 Plan.

The study team qualitatively addressed improvements under the vision for corridors of statewide significance and evaluated specific improvements within several corridors to demonstrate the magnitude of potential benefits. We emphasize differences between the Sustain Current Performance and Vision scenarios and identify how these differences translate into benefits for Colorado residents.

Although the Vision investment scenario is not evaluated to the same extent as the Forecast Revenue and Sustain Current Performance investment scenarios, its incorporation is intended to help Colorado residents better understand what an improved transportation system would mean for them personally and for Colorado in general.

Identify benefits of additional transportation spending. To identify the benefits of increased transportation spending, the study team drew upon extensive research conducted as part of the May 2006 Research Scoping Study. This research consisted of a series of focus groups with Colorado stakeholders, a review of statewide and national transportation benefit studies and key person interviews.

The Scoping Study identified benefits typically evaluated in transportation studies, the types of benefits most important to Colorado residents and how best to measure and communicate those benefits. Based on these findings, the study team identified the following framework for this research:

- Communicate how transportation investment affects Colorado residents on a daily basis;
- Evaluate how transportation investment contributes to the economic competitiveness of Colorado compared to other states;
- Communicate benefits in both monetary and non-monetary terms;
- Focus on long-term economic impacts versus the short-term effects of construction; and
- Evaluate benefits of investment in a multi-modal transportation system including highways, local roadways, transit and aviation.

Table A presents the specific types of benefits evaluated as part of this research. The benefits presented below include direct benefits for Colorado residents and businesses that use the transportation system and secondary benefits to the Colorado economy as a whole.

Table A. Benefits of Transportation Investment

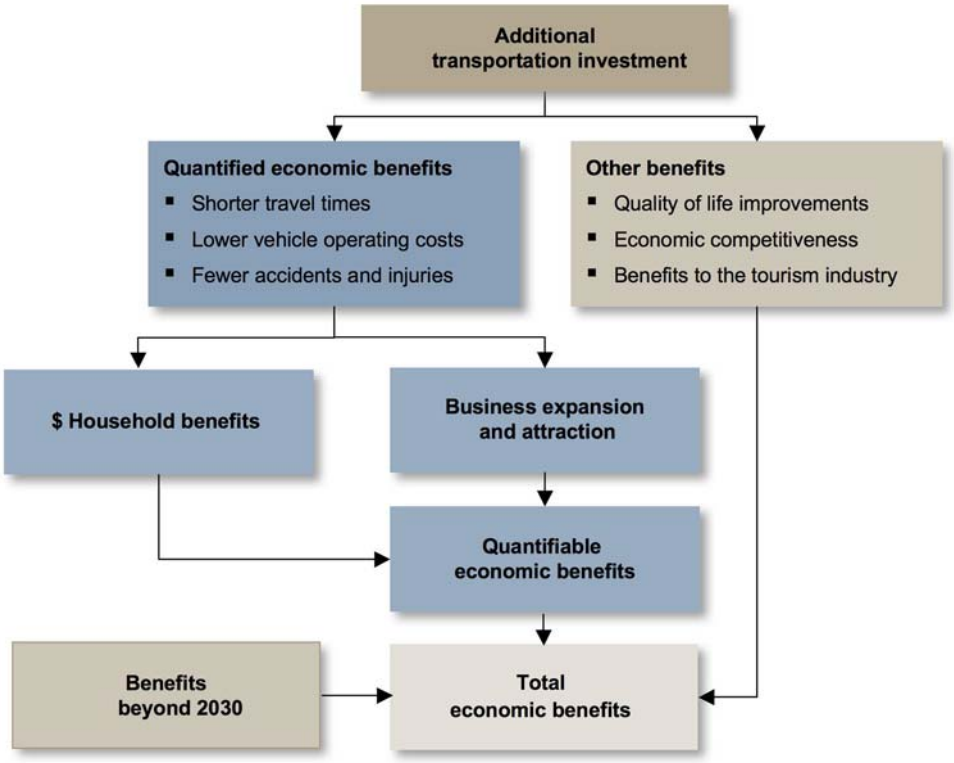
Transportation Benefit	Benefit Measure(s)
Travel time savings	Dollar value of time spent commuting
Reduced vehicle operating costs	Dollar value of repair and maintenance costs
Improved safety conditions	Number of accidents, including fatalities and injury crashes Accident expenses and dollar value of personal property damage
Business expansion and attraction	Personal incomes and employment
Air quality changes	Total emissions
Improved quality of life	Qualitatively addressed

Source: BBC Research and Consulting, 2007

Collect available data. The study team drew upon past research and met with CDOT representatives to create an inventory of current data and available studies relevant to each of the benefits identified in **Table A**. Throughout the data collection process, the study team identified data gaps and other information that would be necessary to conduct a more in-depth study of economic benefits by region within the state.

Quantify benefits of additional investment. The study team evaluated the economic benefits associated with increased investment under the Sustain Current Performance investment scenario. The study team used available CDOT data, findings from other states and other secondary sources to estimate these effects. Many of the benefits could not be quantified in this preliminary study. Such benefits are qualitatively addressed. **Figure 1** provides a summary of the framework used to determine total investment impact of additional transportation spending.

Figure 1. Process to Identify Statewide Benefits of Additional Transportation Investment



Source: BBC Research and Consulting, CDOT Statewide Economic Benefit Study 2007.

1.3 Report Organization

Section 1 of this report introduces this study and the study team's general methodology. Section 2 presents the quantified economic benefits of additional transportation investment under the Sustain Current Performance investment scenario. Section 3 focuses on the benefits of transportation investment that are not quantifiable within the scope of this research, and Section 4 discusses different aspects of the 2030 Transportation Vision. Section 5 identifies next steps and information necessary to perform an in-depth analysis of benefits from transportation investment by region within Colorado.

There are several appendices supporting this report. **Appendix A** contains a list of Project Steering Committee members. **Appendices B through D** contain technical discussions on methodology for determining statewide benefits of travel time savings, reduced vehicle operating costs and improved safety conditions.

2.0 STATEWIDE ECONOMIC BENEFITS OF ADDITIONAL TRANSPORTATION INVESTMENT

This section of the report provides an overview of methodology used in estimating the statewide benefits of additional transportation investment and presents the results of this research. **Appendices B through D** contain a more detailed description of methodology used to determine each of the benefits discussed below.

2.1 Baseline and Alternative Transportation Investment Scenarios

The study team identified two levels of investment in Colorado's transportation system: one consistent with current revenue forecasts, and an alternative, higher level of investment that would maintain current system performance. This report focuses on the benefits associated with the additional transportation investment necessary to maintain current system performance.

The scenarios chosen for evaluation represent the different levels of investment identified in CDOT's 2030 Statewide Transportation Plan (2030 Plan).[1] The "Forecast Revenue" investment scenario reflects CDOT's current resource allocation projections through 2030, a total investment of $75 billion. As detailed in the 2030 Plan, this level of investment not only falls short of being able to meet the needs of the state's "2030 Transportation Vision," it does not sustain the system's present-day quality and performance.

The "Sustain Current Performance" scenario represents the level of investment necessary to sustain existing performance levels and to address the backlog of maintenance issues on the state's transportation system. This level of investment amounts to a total of $123 billion, or $48 billion beyond currently forecasted revenues through 2030.

Table B summarizes the funding categories under the Forecast Revenue and Sustain Current Performance investment scenarios.

Table B. Funding Categories for Each Investment Scenario, Through 2030

Funding category	Forecast Revenues (billions)	Sustain Current Performance (billions)
CDOT maintained roadways	$28.3	$65.9
Local roadways	$19.0	$31.0
Transit/rail	$23.4	$22.0
Aviation	$ 4.2	$ 3.8
Total investment	$74.9	$122.7

Source: CDOT 2030 Statewide Transportation Plan, 2005.

[1] Colorado Department of Transportation. 2005. 2030 Statewide Transportation Plan. *Moving Colorado: Vision for the Future.*

Table C presents performance measures for each level of investment.

Table C. Transportation System Performance in 2030

	Forecast Revenue ($75 billion)	Sustain Current Performance ($123 billion)
System quality		
Pavement quality	32% Good/fair	60% Good/fair
Bridge quality	80% Good/fair	96% Good/fair
Mobility	25% of lane miles on state highways are congested	10% of lane miles on state highways are congested
Safety	1.47 fatalities/100 million VMT*	1.27 fatality rate
Local roadways	Worsening performance	Sustain current levels of service
Transit/rail	Meets 48% of demand	Meets 48% of demand
Aviation	Worsening performance	Sustain current levels of service

Note: *Vehicle miles traveled.
Source: CDOT 2030 Statewide Transportation Plan, 2005.

2.2 Quantifiable Economic Benefits of Additional Investment

When quantifying benefits of the Sustain Current Performance scenario over the Forecast Revenue scenario, the study team considered:

- Travel time;
- Vehicle operating costs;
- Safety effects; and
- Business expansion and attraction.

Results presented below pertain to benefits in the year 2030. Total benefits through the entire study period ending in 2030 are discussed at the end of this section.

The economic benefits quantified here represent only a portion of the total benefits of additional investment. Quality of life improvements, new jobs, better access to recreation and other improvements may be difficult to quantify but have positive implications for Colorado. These benefits are qualitatively addressed in Section 3 of this report.

Travel time savings. Additional highway capacity, improved roadway geometry, better pavement conditions and investments in public transportation in metropolitan areas under the Sustain Current Performance scenario would reduce congestion and increase speeds on public roadways. These types of improvements benefit Colorado residents who value increased leisure time and

improved quality of life resulting from less time spent in traffic. For businesses, reduced travel times generate cost savings associated with production and distribution. Households and businesses also benefit from reduced fuel consumption associated with less time spent in stop-and-go conditions.

Current resource allocation projections lead to congestion on approximately 25 percent of CDOT-maintained lane miles by 2030. Additional transportation investment under the Sustain Current Performance investment scenario would allow CDOT to maintain congestion at current levels – 10 percent of total lane miles. With additional investment, congestion on local roadways would also improve.

Figure 2 compares congested highways in 2030 under the Forecast Revenue investment scenario to current levels of congestion. It shows that I-25 would be congested from Fort Collins to Pueblo in 2030. Interstate 70 would be congested from Denver to Vail. Significant stretches of U.S. 50 would be congested from Pueblo to Grand Junction. U.S. 160 from Alamosa to Cortez would also see congested sections. Under the Sustain Current Performance investment scenario, future congestion approximates what is shown for 2003.

Figure 2. 2003 and 2030, Colorado Congested State Highways under the Forecast Revenue Investment Scenario

Note: Congestion is defined as volume that exceeds 85 percent of a road's capacity.
Source: Colorado Department of Transportation 2030 Statewide Transportation Plan, February 2005.

Methodology. To translate congested lane miles into benefits associated with shorter travel times, the study team drew upon methodology developed by the Texas Transportation Institute (TTI) to calculate the delay associated with different levels of congestion under the Forecast Revenue and Sustain Current Performance investment scenarios.[2] The study team used CDOT traffic data to divide congested roadways under each scenario into five different levels of congestion: uncongested, moderate, heavy, severe and extreme congestion. Based on vehicle-miles-traveled (VMT) in each category, the study team compared travel times under each scenario to free-flow conditions. This methodology takes into account recurring and incident delay (caused by accidents, vehicle breakdowns, etc.) as well as reduced fuel consumption from less time spent in stop-and-go conditions. Findings were extrapolated to include local roadways.

Cost savings associated with reduced fuel consumption are based on a fuel price of $1.75 per gallon, the price used by TTI in their Annual Urban Mobility Report. The study team assumed this conservative estimate due to the uncertainty associated with forecasting fuel prices through 2030.

Results presented on the following page also reflect travel time savings from improved pavement conditions. These savings were determined from findings of a study conducted by the Michigan Department of Transportation[3].

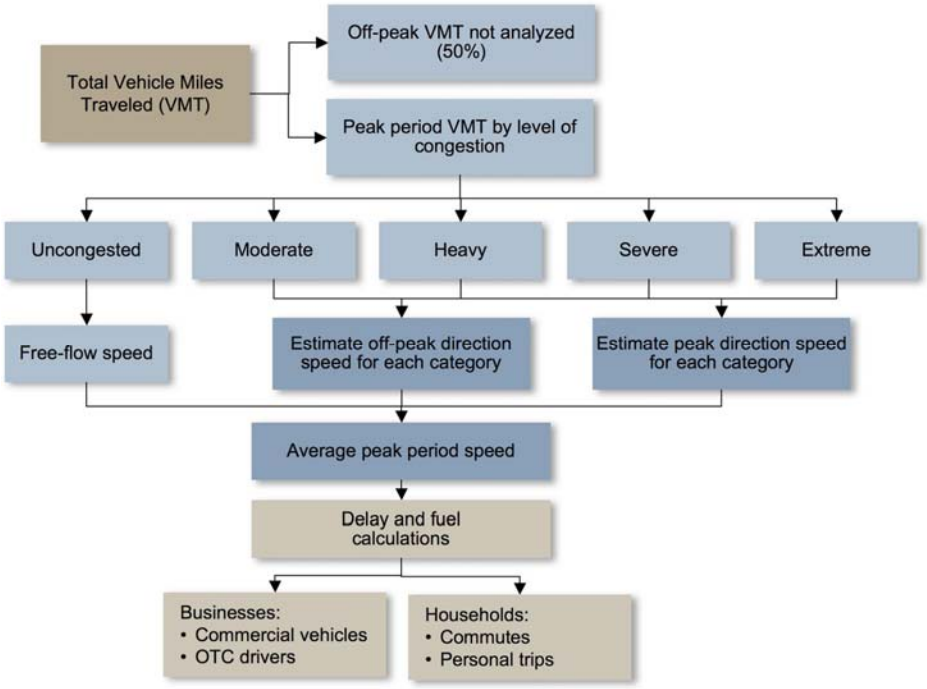
The study team allocated the time spent in traffic due to congestion and poor pavement conditions across non-work related trips, commuters, "on-the-clock" (OTC) business travel and commercial vehicles. For each of these groups, we estimated the value of time saved under the Sustain Current Performance investment based on generally accepted methodology developed by the U.S. Department of Transportation.

Figure 3 provides an overview of the study team's methodology for estimating travel time benefits of additional transportation investment under the Sustain Current Performance investment scenario. **Appendix B** contains a more detailed description.

2 David Schrank and Tim Lomax. 2005. "The 2005 Urban Mobility Report. Texas Transportation Institute."

3 Economic Development Research Group, Inc. and the Institute of Labor and Industry Relations, University of Michigan. 2005. "Economic Benefits of the Michigan Department of Transportation's 2005-2009 Highway Program." Prepared for the Michigan Department of Transportation.

Figure 3. Methodology for Determining Travel Time Savings



Source: BBC Research and Consulting, 2007 adapted from Texas Transportation Urban Mobility Report, 2005.

Benefits to Colorado households. Under the Forecast Revenue scenario, Colorado residents would experience an average of 36 hours of delay from congested conditions and poor pavement quality in 2030. Extra time spent in stop-and-go conditions would result in additional annual fuel consumption of about 58 gallons per Colorado resident. Under the Sustain Current Performance scenario, less congestion and better pavement quality would reduce this delay to 10 hours per resident in 2030. Additional fuel consumption would fall to 17 gallons. Compared to the Forecast Revenue investment scenario, travel time savings under the Sustain Current Performance scenario would amount to about $243 per resident in 2030.

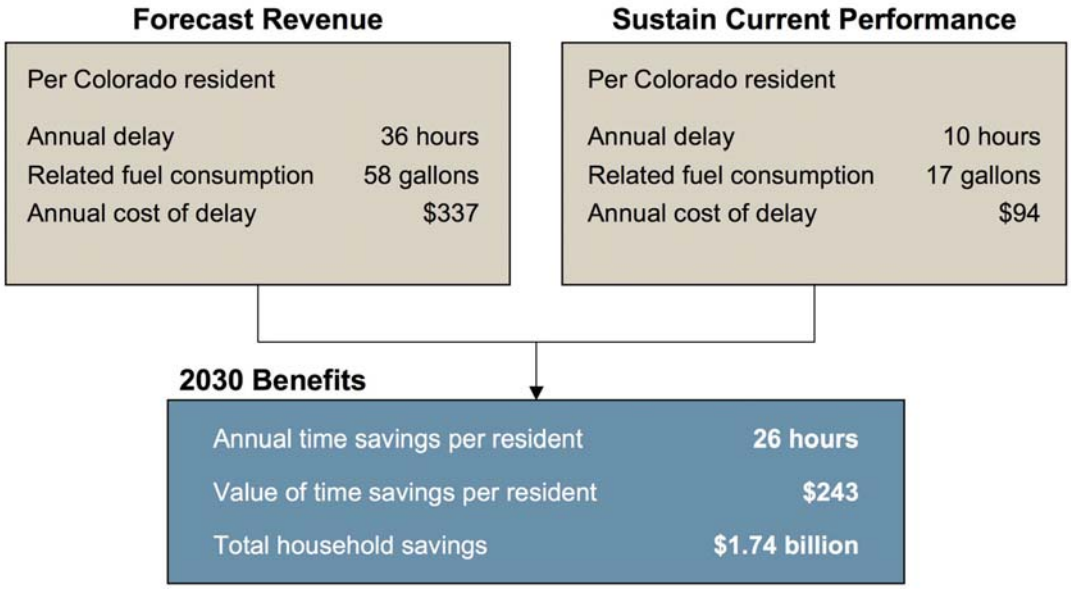
Travel time benefits accrue primarily to Colorado residents who drive during peak commute periods. Under current revenue projections, peak period drivers will experience an average of 52.9 hours of congestion-related delay while commuting to and from work and making non-work related trips in 2030. This compares to 14.4 hours of delay under the Sustain Current Performance scenario. Including the benefits of reduced fuel consumption, travel time savings during peak periods amount to $1.4 billion for Colorado households – about $500 per peak period driver in 2030 ($202 per resident).

Colorado residents also benefit from less time spent in congestion during non-peak periods (outside of the busiest commute times) in 2030. On weekends, less time spent running errands, traveling to Colorado's recreation destinations and making other personal trips would save Colorado residents an additional $0.29 billion ($41 per resident) under the Sustain Current Performance investment scenario. Pavement quality improvements also shorten travel times by allowing vehicles to increase speeds. Under the Sustain Current Performance scenario, travel time savings from improved surface conditions amount to $0.02 billion in 2030.

In total, travel time savings associated with additional transportation investment amount to almost $1.74 billion in 2030. The benefits of this investment will continue beyond 2030. The end of the period the study team used for quantifying benefits is 2030.

Figure 4 summarizes the 2030 benefits of additional transportation investment for Colorado residents under the Sustain Current Performance investment scenario.

Figure 4. Travel Time Savings for Colorado Residents, 2030



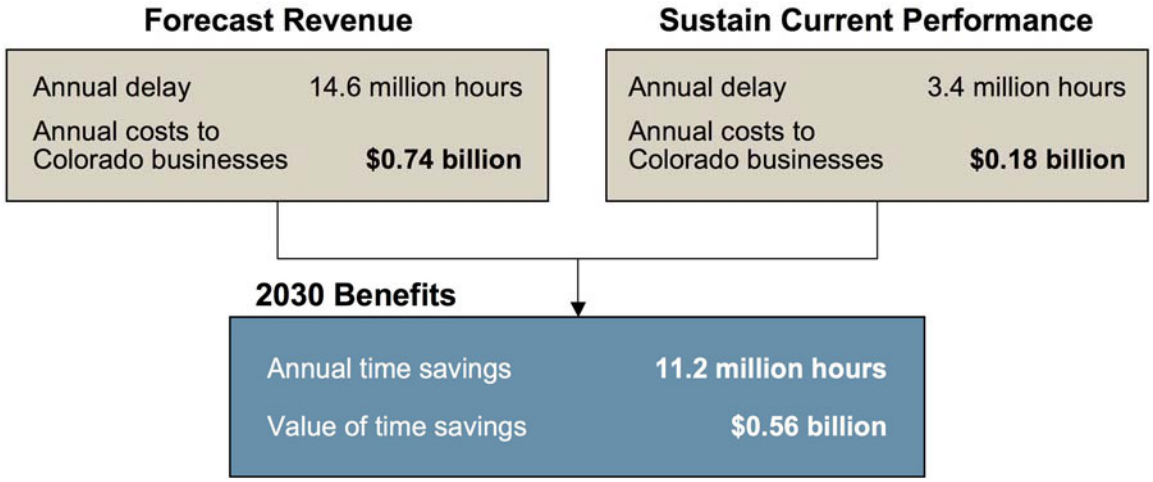
Source: BBC Research and Consulting, 2007.

Benefits to Colorado businesses. Shorter travel times under the Sustain Current Performance investment scenario result in substantial savings for Colorado businesses. Under current revenue projections, on-the-clock drivers and commercial vehicles will spend an estimated 14.6 million hours in congestion-related delay in 2030. Under the Sustain Current Performance investment scenario, the amount of time spent in congestion would decrease by more than 76 percent (11.2 million hours).

As a result, Colorado businesses would save an estimated $0.56 billion. This includes cost savings from reduced employee time devoted to on-the-clock travel and the value of wasted time and fuel for business autos and commercial vehicles.

Figure 5 summarizes the 2030 travel time savings for Colorado businesses from additional transportation investment under the Sustain Current Performance investment scenario.

Figure 5. Travel Time Savings for Colorado Businesses, 2030



Source: BBC Research and Consulting, 2007.

Reduced vehicle operating costs. Transportation investment can significantly improve roadway conditions through re-construction and resurfacing, thereby reducing general wear and tear on vehicles and the costs associated with vehicle repair, maintenance, insurance and depreciation.

Under spending levels consistent with the current revenue forecast, today's approximately 60 percent good/fair rating for roadway surfaces on the state highway system will fall to 32 percent. Improved roadway conditions under the Sustain Current Performance investment scenario would result in cost savings for Colorado residents and businesses alike.

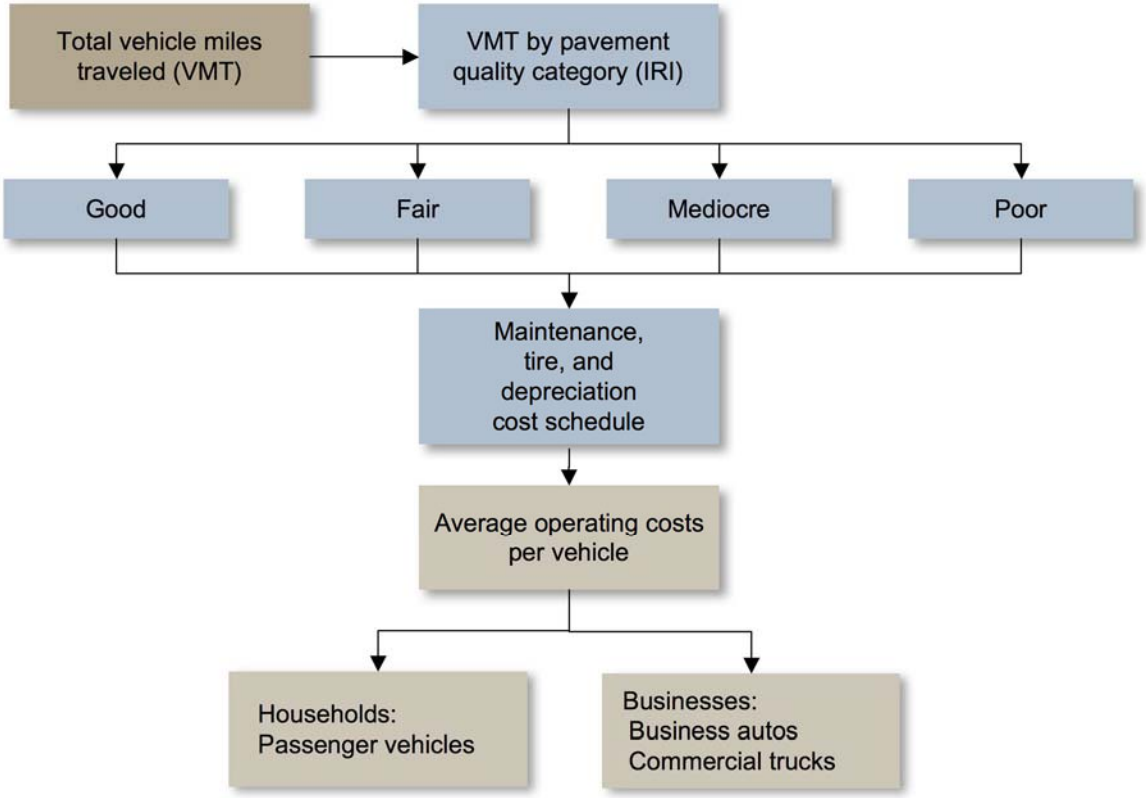
Methodology. To estimate the effects of improved pavement quality under the Sustain Current Performance investment scenario, the study team compared vehicle miles traveled by passenger vehicles and commercial trucks on good, fair, mediocre and poor quality roads under both scenarios. These categories are based on the International Roughness Index (IRI) measure for road segments throughout the state.

Based on research conducted by the Minnesota Department of Transportation,[4] the study team associated per-mile vehicle operating costs with different levels of pavement quality. Per-mile costs include maintenance, tires and depreciation for passenger vehicles and commercial trucks. Using this same research, the study team also determined reduced vehicle operating costs associated with less time spent in stop-and-go conditions. Findings were extrapolated to include off-system roadways.

[4] Barnes, Gary and Peter Langworthy. 2003. "Per-mile Costs of Operating Automobiles and Trucks." University of Minnesota, Humphrey Institute of Public Affairs. Prepared for the Minnesota Department of Transportation.

Figure 6 summarizes the study team's methodology used to determine the benefits of reduced vehicle operating costs under the Sustain Current Performance investment scenario.

Figure 6. Methodology for Determining Reduced Vehicle Operating Costs

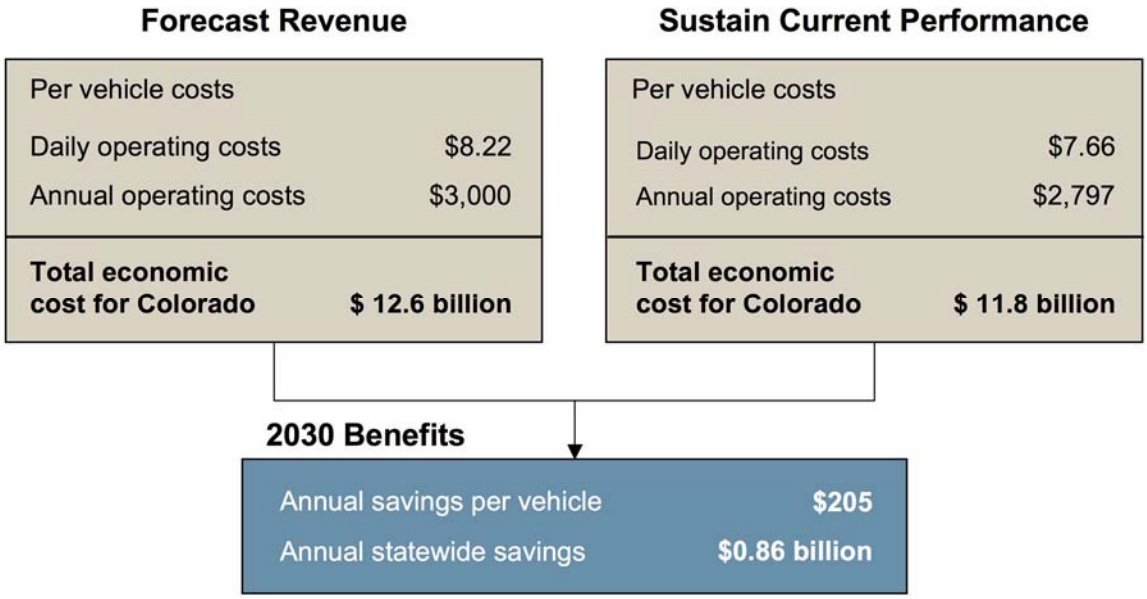


Source: BBC Research and Consulting, 2006.

Benefits to Colorado households. As a result of increased transportation spending under the Sustain Current Performance investment scenario, Colorado households would save an average of $205 per registered vehicle in 2030 ($120 per resident) in costs associated with maintenance, tires and depreciation. This represents a total statewide savings of $0.86 billion in 2030.

Figure 7 shows per vehicle operating costs under the Forecast Revenue and Sustain Current Performance investment scenarios and the savings associated with increased transportation spending.

Figure 7. Reduced Vehicle Operating Costs for Colorado Households, 2030



Source: BBC Research and Consulting, 2007.

Benefits to Colorado businesses. Colorado businesses would save approximately $0.14 billion in 2030 from improved pavement conditions under the Sustain Current Performance investment scenario. This is particularly important for businesses in rural areas, who throughout the Research Scoping Study communicated the need for improved pavement quality on heavily traveled freight corridors.

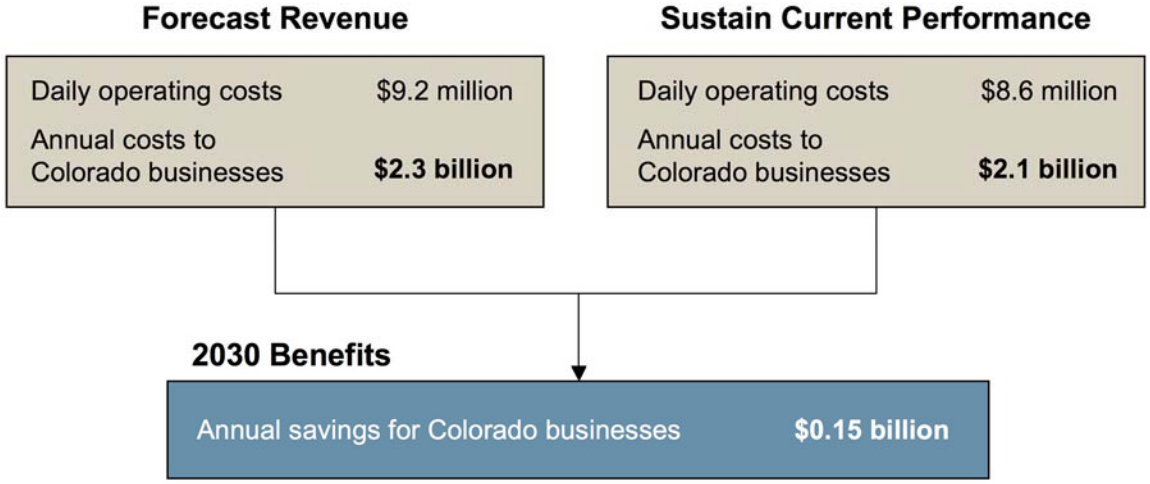
In Colorado, industries most likely to benefit from pavement quality improvements include agriculture and mining. According to the Bureau of Transportation Statistics Commodity Flow Survey,[5] these industries are responsible for three of the top five commodities shipped to, from and within Colorado. Additionally, these industries experience the highest transportation costs per dollar of output among industries analyzed in a 2002 study by NCHRP.[6]

Figure 8 shows vehicle operating cost savings for Colorado businesses under the Sustain Current Performance investment scenario.

5 BTS Commodity Flow Survey website. http://www.bts.gov/publications/commodity_flow_survey/2002/state_summaries/

6 Cambridge Systematics, Inc. 2002. "Economic Benefits of Transportation Investment." Published as NCHRP Project 8-36, Task 22: Demonstrating Positive Benefits from Transportation Investment.

Figure 8. Reduced Vehicle Operating Costs for Colorado Businesses, 2030



Source: BBC Research and Consulting, 2007.

Reduced accidents and injuries. Investments to improve the safety of Colorado's transportation system can result in fewer accidents, fatalities and injuries. This in turn can help to mitigate economic losses associated with crashes including medical care and insurance expenses, lost workplace productivity and personal property damage.

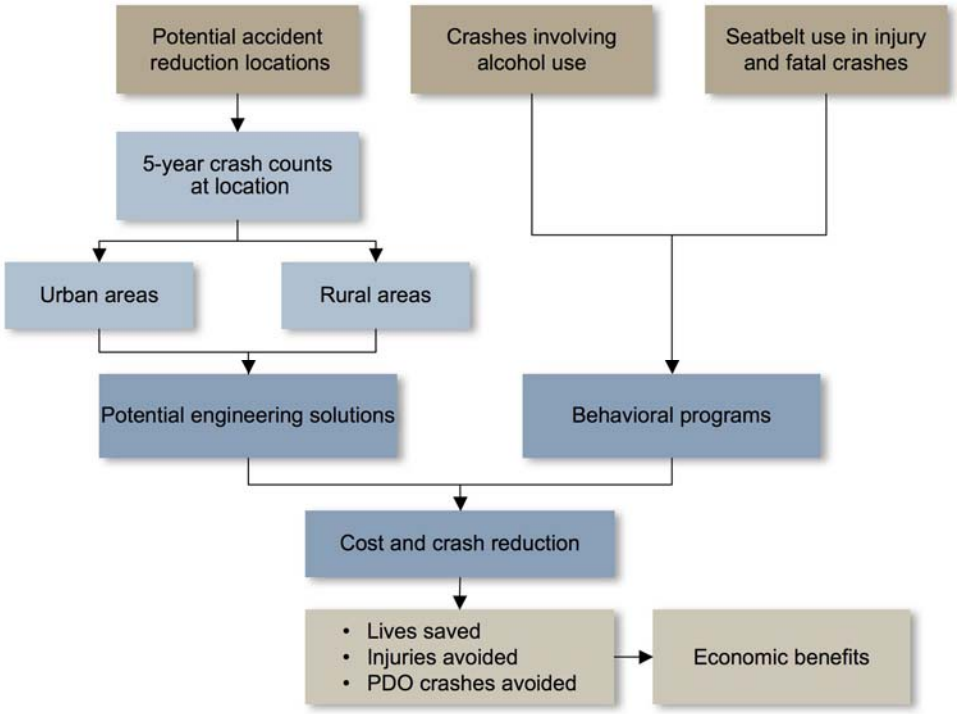
Methodology. The study team determined the number of fatal accidents under each investment scenario based on fatality rates reported in the 2030 Plan. To estimate how increased transportation spending would reduce injury and personal property damage only (PDO) crashes, the study team drew upon past research conducted for CDOT. This research analyzed the effects of investment in safety improvements, including both engineering solutions and behavioral programs. As portrayed in **Figure 9**, this research takes into account differences in the effects of safety improvements in urban and rural areas.

The study team used data from the Colorado State Highway Patrol[7] to extrapolate findings from the model to include off-system impacts. This provided the study team with an estimate of the total number of fatalities, injuries and PDO crashes under each investment scenario.
To estimate the economic losses associated with the number of accidents under each investment scenario, the study team applied costs developed by the National Highway Safety Council for each type of accident. Based on CDOT VMT data, this analysis assumes that 10 percent of total safety benefits accrue to Colorado businesses.

Figure 10 provides a summary of the study team's methodology. **Appendix D** contains a more detailed description of methodology and data sources used in determining the benefits of improved safety conditions.

7 Colorado State Patrol website. 2007. http://csp.state.co.us/trafficsafety.

Figure 9. Methodology Used to Determine Safety Effects



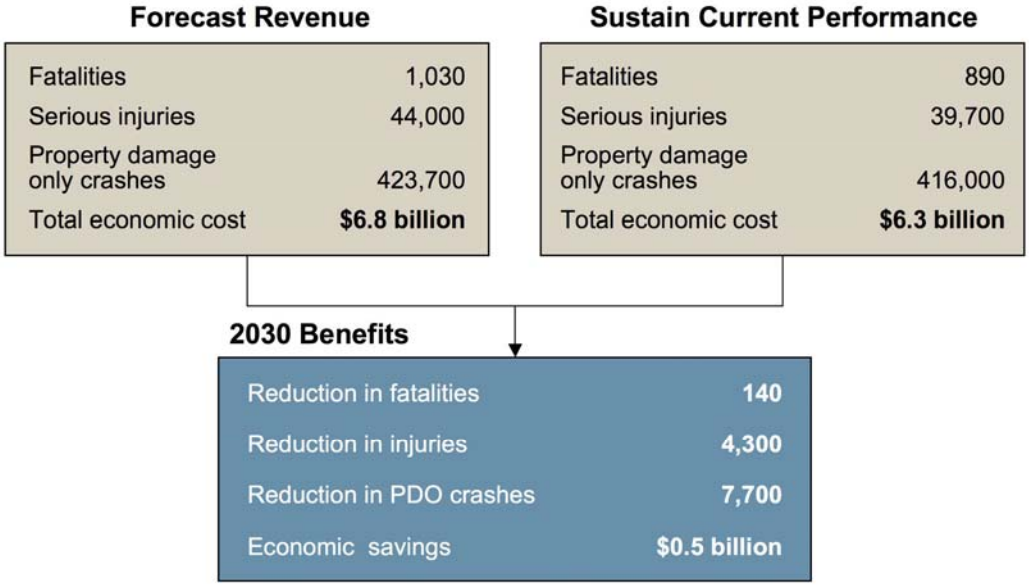
Source: BBC Research and Consulting, 2007.

Benefits to Colorado households and businesses. Analysis indicates that under the Forecast Revenue investment scenario, there will be approximately 1,030 fatal accidents in 2030. Under the Sustain Current Performance investment scenario, the number of fatal accidents on Colorado's roadways would be reduced to 890, resulting in about 140 lives saved in that year. Increased transportation investment would also result in 4,300 fewer injuries and would reduce the number of PDO crashes by approximately 7,700. This amounts to $0.50 billion dollars in cost savings for Colorado residents and businesses in avoided medical care and insurance expenses, lost workplace productivity and personal property damage. About $0.05 billion of this amount will accrue to Colorado businesses.

Although difficult to quantify, improved safety conditions and fewer accidents under the Sustain Current Performance scenario could also lead to lower automobile insurance rates for Colorado residents. According to the International Insurance Institute, fewer accidents, in part due to safer roads, is a primary reason for declining insurance rates in many areas.

Figure 10 presents the benefits associated with improved safety conditions under the Sustain Current Performance investment scenario.

Figure 10 Fewer Accidents, Injuries and Fatalities, 2030



Source: BBC Research and Consulting, 2007.

Business expansion and attraction. The business-related travel cost savings described above reduce the cost of doing business in Colorado. Additionally, investments that improve mobility and system reliability allow businesses to reduce their warehousing and logistics costs, and to lower expenses by consolidating operations. These effects increase business productivity and improve the competitive position of firms, making them better able to expand and increase market share. Lower transportation costs can also influence business location decisions, attracting new businesses to the state.

As firms expand and new businesses locate within Colorado, they require additional inputs from suppliers of raw materials, parts, supplies, equipment and machinery. These are the "indirect benefits" of transportation investment – the response of suppliers and equipment manufacturers to increase their own output and hire new workers. Delivery services and couriers, logistics firms, printers, and other providers of business services also benefit indirectly from transportation system improvements. For example, reliable transportation has allowed Internet and mail-order shopping to expand within the United States. While retailers and consumers benefit directly from lower delivery costs, the firms that carry products to consumers' doorsteps, such as Federal Express, United Parcel Service, and the U.S. Postal Service, benefit indirectly from increased sales.

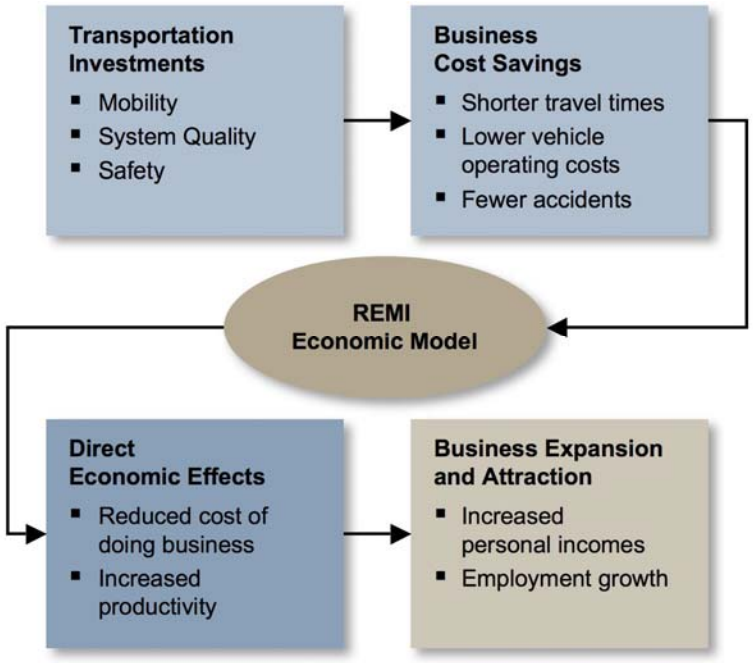
Together, the direct and indirect effects of transportation investment lead to more jobs, higher incomes and overall greater economic production. The benefits of this additional economic activity are measured in terms of increased personal incomes for Colorado residents.

Methodology. The study team applied findings from a study conducted on the benefits of increased investment in Wisconsin's state highway system.[8] The Wisconsin study used REMI (Regional Economic Models, Inc.), a regional economic model, to estimate the productivity gains and resulting business expansion and attraction impacts of transportation investment over a 21-year period.

The authors of the study first determined the travel cost savings associated with increased transportation investment in Wisconsin. The business-related portion of these benefits were input into the REMI economic simulation model. REMI determines the extent to which business travel cost savings reduce the cost of doing business in Colorado. Unlike most input-output models, REMI provides a way to reflect business cost reductions over a number of years and examine how these savings increase the competitiveness of a region's economy, leading to greater economic output, employment and income.

Figure 11 summarizes the basic framework used in Wisconsin to determine the economic activity generated through additional transportation investment.

Figure 11. Methodology for Estimating the Macroeconomic Benefits of Additional Transportation Investment



Source: Cambridge Systematics, Inc. 2003. "Transportation Improvements Grow Wisconsin's Economy: The Economic Benefits of Transportation Investments."

8 Cambridge Systematics, Inc. 2003. "Transportation Improvements Grow Wisconsin's Economy: The Economic Benefits of Transportation Investments." Prepared for the Transportation Development Association of Wisconsin.

Benefits for Colorado. In 2030, the reduced cost of doing business in Colorado under the Sustain Current Performance scenario multiplies to $1.4 billion in increased personal income for Colorado residents. These benefits are expected to accrue over time. On an average annual basis, the business expansion and attraction that occurs because of additional transportation investment would support 10,900 new long-term jobs for Colorado residents and increase personal incomes by $0.73 billion. This does not include construction-related jobs from additional transportation spending.

It is important to note that the quantified benefits of business expansion and attraction include only the direct and indirect effects of the reduced cost of doing business in Colorado. Additional benefits occur as businesses gain increased access to inputs and are able to expand their market areas. These factors are difficult to determine because states throughout the U.S. are facing similar transportation funding challenges. These states will choose to invest in their transportation system to varying degrees, which will impact the relative economic position of Colorado.

Additionally, results presented above are not specific to Colorado and serve only to provide an estimate of the economic activity generated through additional transportation investment. The benefits of increased productivity will vary by state and by region. A study specific to Colorado may find different levels of productivity growth from transportation investment.

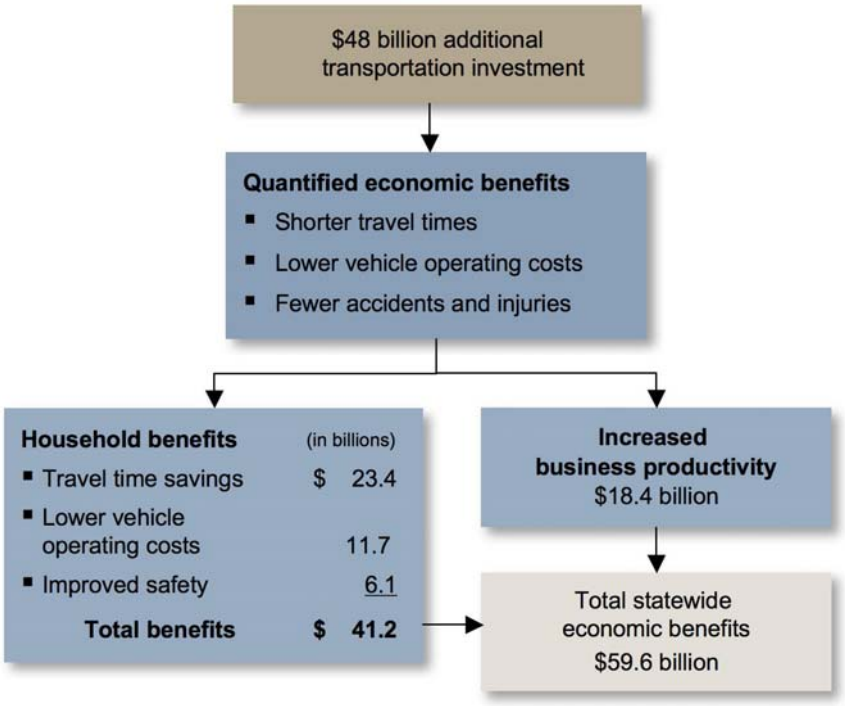
2.3 Total Quantifiable Economic Benefits of Additional Investment

Over the 26-year investment time frame, total economic benefits from the $48 billion additional transportation investment amount to $59.6 billion (2005 dollars). Total benefits reflect direct savings for Colorado households and increased personal incomes that stem from the business expansion and attraction from additional transportation investment.

Direct benefits to Colorado households include $23.4 billion in travel time savings, $11.7 billion in lower vehicle operating costs and $6.1 billion in reduced economic losses associated with crashes. Direct business travel cost savings increase business productivity, allowing Colorado businesses to expand and attracting new businesses to the state. The benefits of this additional economic activity total $18.4 billion in increased personal incomes for Colorado residents.

Figure 12 summarizes the total quantifiable economic benefits of additional transportation investment under the Sustain Current Performance investment scenario.

Figure 12. Total Economic Benefits of Increased Transportation Investment through 2030



Source: BBC Research and Consulting, 2007.

The economic benefits quantified here represent only a portion of the total benefits of additional investment. Quality of life improvements, new jobs, better access to recreation and other improvements are difficult to quantify but also have positive implications for Colorado. Additionally, the benefits of increased investment will continue well beyond 2030, the end date for our analysis. These benefits are qualitatively addressed in Section 3 of this report.

Of the economic benefits the study team was able to quantify, the benefits exceed the required investment by $11.6 billion (2005 constant values). To account for the difference in the timing of costs and benefits, the study team also compared the total value of future investments and benefits through 2030 in "present value" form. This analysis shows that even with the most conservative of estimates, total benefits still exceed the additional investment costs.

2.4 Personalized Benefits of Additional Investment

Results presented above also include measures of how transportation investment will affect Colorado residents on a daily basis. These benefits include safer roads, less time wasted in traffic, higher personal incomes and more jobs. **Table D** presents "personalized" 2030 benefits of increased transportation spending under the Sustain Current Performance scenario.

Table D. 2030 Benefits of Increased Transportation Investment

Benefit	Annual Benefit to Colorado in 2030
Reduced congestion	• 26 hours of time saved (per resident) • 30 gallons of fuel saved (per resident) • $1.7 billion in travel time savings for households • $240 in travel time savings (per resident) • $0.6 billion in savings for Colorado businesses
Better pavement quality	• $0.9 billion in reduced vehicle operating costs for households • $205 in savings (per vehicle) ($120 per resident) • $0.2 billion in savings for Colorado businesses
Safety improvements	• 12,100 fewer accidents • 4,300 fewer accidents involving injuries • 140 lives saved • $63 in reduced economic losses (per resident) • $0.5 billion in reduced economic losses (residents and businesses)
General system improvements	• 10,900 permanent new jobs • $0.73 billion in increased personal income

Source: BBC Research and Consulting, 2007.

Including increased personal income, the average annual value of the benefits presented above would amount to $624 per resident, or about $1,578 per Colorado household by the year 2030.

2.5 Overview of Conditions Under the Forecast Revenue Investment Scenario

The number of people living in Colorado is projected to increase from 4.7 million in 2005 to 7.1 million in 2030. During this period, the number of vehicle miles traveled on state highways is expected to grow by 67 percent, increasing the amount of congested lane miles by 161 percent. Freight hauls on Colorado highways and rail lines are expected to double. Over the next two decades, this growth will increase the demands and stresses on Colorado's transportation system.

Under the Forecast Revenue investment scenario, only 32 percent of the state's highways will have a pavement condition rating of good or fair, and 25 percent of the lane miles on the state highway system will be congested. Peak period drivers will spend an average of 53 hours in congestion related delays in 2030 at an annual cost of about $500 per driver. Reaching popular recreation destinations will also become more difficult. CDOT estimates that by 2025, travel time along westbound I-70 will increase on a Saturday in the winter by almost two hours, making the drive from Denver to Vail a 4-hour trip. By 2030, travel demand is expected to grow by 67.5 percent in the corridor, resulting in daily congestion conditions comparable to current holiday or ski weekend levels.

As transportation costs and delays increase, Colorado also becomes a less attractive place to do business. Under the Forecast Revenue investment scenario, on-the-clock business drivers and freight vehicle operators will spend 14.6 million hours in annual congestion related delay by 2030. The cost of this delay will amount to more than $0.74 billion in wasted time and fuel for Colorado businesses. Further, as the quality and efficiency of commuting networks begin to decline, the availability of appropriately skilled labor will diminish. Deterioration of the transportation system will also negatively affect businesses that depend on timely and efficient access to natural resources, transportation hubs and markets throughout the state.

3.0 NON-QUANTIFIABLE BENEFITS OF TRANSPORTATION INVESTMENT

The economic benefits quantified in Section 2 of this report represent only a portion of the total benefits of additional investment in Colorado's transportation system. Additional benefits under the Sustain Current Performance scenario include improved quality of life for Colorado residents and a healthier state economy. Although it is difficult to place a dollar value on many of these benefits, they have very real and important implications for Colorado.

This section discusses the benefits of additional transportation investment that are not included in total economic benefits as quantified in Section 2. They include:

- Increased economic competitiveness;
- Benefits to the tourism industry;
- Other quality of life improvements;
- Short-term construction impacts; and
- Benefits beyond 2030.

3.1 Economic Competitiveness

The quantified benefits of business expansion and attraction include the direct and indirect effects of the reduced cost of doing business in Colorado. The study team did not capture benefits for businesses associated with increased access to inputs or expanded market areas. These factors contribute to the overall economic competitiveness of the state. They are difficult to determine because states throughout the U.S. are facing similar transportation funding challenges. These states will choose to invest in their transportation system to varying degrees, which will impact the relative economic position of Colorado.

In Colorado, transportation investment affects economic competitiveness in both rural and urban areas. For example, the eastern plains region directly competes with Nebraska and Kansas for freight transportation services and associated economic development. More efficient travel in Denver and Colorado Springs can influence business location decisions of firms and attract a higher quality labor force. These factors directly contribute to the state's overall economic competitiveness.

Increased access to labor and other inputs. Transportation system improvements can increase the geographic area and number of potential employees from which employers recruit labor. This expanded labor pool encourages a better match of jobs and workers, leading to improved productivity and higher wages. Weisbrod, Vary and Treyz analyzed the effects of hypothetical

congestion-reduction in the Chicago and Philadelphia metropolitan areas.[9] Their models suggest that doubling the effective labor market size through transportation improvements would produce a 6 percent increase in labor productivity.

Where transportation costs are low, businesses gain access to a more diverse selection of raw materials and other inputs. This not only enhances the quality of a firm's goods and services, but also allows businesses to achieve "economies of scale" (their production costs decrease on a per unit basis as output increases). This occurs as suppliers are forced to become more competitive, lowering the costs of production for firms.

As Weisbrod, Vary and Treyz point out, if there is an optimal mix of specialized labor and other inputs for a given business, the larger the area from which the business can draw these inputs, the more likely the business can achieve that optimal mix. If the effective market area for these inputs shrinks, the less likely the business can achieve the optimal mix, thereby reducing productivity of that business.

An improved transportation system not only increases the area from which businesses can access supplies, but can also induce "agglomeration economies," or benefits from firms locating near each other. Being located geographically close to one another allows firms to share inputs, draw a specialized labor pool to the region and easily share important industry knowledge. Even when competitors cluster, there may be advantages to each firm. The cluster may attract more suppliers and customers than a single firm could alone. Classic examples of industries with agglomeration economies are the technology industry in Silicon Valley, the film industry in Los Angeles, or the financial industry on Wall Street.

Expanded market reach. Accepting the theory that many businesses produce at least slightly differentiated products and services, low travel costs can increase the effective market size for a firm's product.

Changes in infrastructure allowing a firm to provide goods to a wider geographic area will decrease marginal costs of production. In many regions this reduction in costs may also induce agglomeration economies in certain industries. In turn, this will stimulate further economies to scale as firms realize the full potential of their product's market. The literature surrounding agglomeration effects illustrates the value of transportation investments not only for businesses but also for future economic growth of cities or regions. In the same study cited above, Weisbrod, Vary and Treyz found that Chicago businesses would benefit by $980 million per year if travel times were reduced region wide by 10 percent.[10]

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9 Weisbrod, Glenn, Donald Vary and George Treyz. 2001. *Economic Implications of Congestion.* Published as NCHRP Report #463. Washington, D.C.: Transportation Research Board, National Research Council.

10 Weisbrod, Vary and Treyz.

3.2 Benefits to the Tourism Industry

Both business and leisure travelers depend on Colorado's transportation infrastructure for access to conferences, trade shows, national parks, mountain resorts, and everyday business meetings and social events. Perception about accessibility influences the decisions of event coordinators and travel agents, business people and tourists. Whether to schedule a meeting in city A or city B, or to take the family on a skiing trip to Mountain X or Y, depends heavily on quality – perceived or actual – of the travel experience. The travel experience also influences whether travelers recommend a destination to others or choose to make a return trip in the future.

Transportation improvements can encourage Colorado residents and out-of-state visitors to make more frequent and longer trips to Colorado's tourist attractions and recreation areas, which translates into increased spending on related goods and services, such as meals, lodging, fuel and gifts. This is particularly important in Colorado, where tourism is an $8.3 billion industry that constitutes over 12 percent of the State economy.[11] In 2005, Colorado attracted 22.5 million domestic visitors (the most since tracking began in 1992).[12] System quality and mobility improvements under the Sustain Current Performance investment scenario will accommodate additional visitation to Colorado's recreation and tourist destinations through 2030.

Findings from the I-70 Programmatic Environmental Impact Statement (PEIS) demonstrate the importance of transportation investment for Colorado's tourism industry. The PEIS indicates that accommodating for tourism growth in the I-70 corridor would increase visitation to surrounding recreation areas by up to 8 percent in the summer and 5 percent in the winter by 2030. Corresponding increases in out-of-state visitor spending could amount to more than $0.4 billion in that year. This would significantly impact the tourism industry as a whole along the I-70 corridor, which employed 125,000 people and generated $4.8 billion in total annual personal income in 2000.[13]

A study in Indiana estimated benefits to the tourism industry from a $1.1 billion investment in the U.S. Highway Corridor 31 Improvement Project.[14] The study found that tourism in the affected region would increase by 2 percent, or 90,000 annual visitor days. These findings do not directly apply to a statewide study in Colorado because they are based on regional effects (i.e. include increased visitation from Indiana residents visiting the area instead of going somewhere else in the state). However, they do demonstrate the important link between transportation investment and growth in the tourism industry.

[11] I-70 Mountain Corridor Programmatic EIS.

[12] Longwoods International. 2006. "Visitor Profile Study: Colorado Travel Year 2005."

[13] I-70 Mountain Corridor Programmatic EIS.

[14] Cambridge Systematics, Inc. 1999. "Major Corridor Investment-Benefit Analysis System." Prepared for the Seventh TRB Conference on the Application of Transportation Planning Methods.

3.3 Quality of Life Improvements

Additional transportation investment under the Sustain Current Performance scenario would enhance the quality of life for Colorado residents in a variety of ways.

Air quality. Any transportation investment that has a significant influence on traffic flow can affect the air pollution created by this traffic. However, quantifying the economic impact of changes in air quality is extremely difficult. Estimates of the costs of air pollution caused by cars – tailpipe emissions, but also airborne particulate matter from tires, brakes and roadways – range from 1 to 8 cents per vehicle mile traveled, depending on study assumptions.[15] Quantifying changes in the economic value of air pollution caused by an investment in transportation often leads to ambiguous results. For example, a Kansas Department of Transportation study found that a statewide investment in highways most likely reduced pollution in Kansas. [16] However, under a "worst-case scenario," pollution from highway traffic actually increased.

The study team roughly estimated changes in air quality using a model developed by the US Environmental Protection Agency (EPA). Model results indicate that there would be minimal increases (less than 5 percent) in total emissions under the Sustain Current Performance investment scenario. As speeds begin to increase as a result of decreased congestion, emissions typically begin to fall until reaching 35 to 40 mph). Past that point, emissions begin to rise with increased speeds. The air quality analysis is based on average statewide changes and does not account for local improvements associated with improved mobility at specific congestion points.

The study team did not analyze the air quality effects of improved transit services in the metropolitan areas of Colorado under the Sustain Current Performance investment scenario. According to the American Public Transit Authority, public transportation reduces annual emissions of the pollutants that create smog – volatile organic compounds (VOCs) and nitrogen oxides (NOx) – by more than 70,000 tons and 27,000 tons in the United States, respectively.[17] This saves between $130 and $200 million a year in regulatory costs.

Increased access to jobs and other services. Under the Sustain Current Performance scenario, transportation improvements will provide access to a broader range of higher-paying jobs, a wider selection of competitively-priced consumer goods and housing options, and a convenient selection of health and human services.

For example, the economic growth that occurs from additional transportation investment may increase employment opportunities and the number of possible destinations for shopping or entertainment, leaving Colorado residents better off than they would be without the additional

[15] Litman, Todd. 2002. "Transportation Cost Analysis: Techniques, Estimates and Implications." Written for the Victoria Transportation Policy Institute, Victoria, British Columbia.

[16] Burress, David, Patricia Oslund. 1999. "Benefits and Costs of the Kansas Comprehensive Highway Program." For the Kansas Department of Transportation.

[17] Cambridge Systematics, Inc. 2002. "The Benefits of Public Transportation: An Overview." Prepared for the American Public Transit Authority.

investment. As travel times decrease, Colorado residents may also expand their choice of housing options.

Mobility and system quality improvement will not only benefit out-of-state tourists but will provide Colorado residents with improved access to Colorado's key recreation destinations. For example, under the Forecast Revenue scenario, CDOT estimates that by 2025, travel time along westbound I-70 is expected to increase on a Saturday in the winter by almost two hours, making the trip from Denver to Vail a four hour journey.[18] Additional transportation investment under the Sustain Current Performance scenario will help to mitigate these effects, improving quality of life for Colorado residents.

Improved public transportation in metropolitan areas. Under the Sustain Current Performance investment scenario, anticipated levels of funding for transit will improve current levels of service in the Denver and Colorado Springs metro areas. Many of the benefits of improved public transportation, including reduced congestion and business expansion and attraction, are indirectly captured in the benefits described in Section 2. However, public transportation improvements have additional quality of life benefits for Colorado residents that are difficult to quantify.

Improved public transportation in metropolitan areas can provide access to higher paying jobs, healthcare and other human services. National ridership figures indicate that public transportation is critical for many Americans including seniors, citizens with disabilities and the economically disadvantaged. A 2000 study by the American Public Transit Authority (APTA) found that over 20 percent of transit riders nationwide would not have made the trip without transit, and nearly 70 percent do not have access to cars at the time their trip is made. One-third of transit riders have yearly household incomes below $15,000 – well below $17,600, the poverty level for a family of four in 2000. Additionally, nearly 94 percent of public assistance recipients do not own cars and rely on public transportation.[19]

Improved public transportation would provide Colorado residents better access to higher education facilities. A recent survey of Wisconsin public transportation found that of 22.6 million education-related trips, 2.8 million of those trips would not have occurred if not for public transportation.[20]

Public transportation use can lower household commuting expenses and frees up more income for other needs. APTA estimates that for every dollar earned, the average household spends 18 cents on transportation, 98 percent of which is for buying, maintaining and operating cars, the largest source of household debt after mortgages. For the poorest households, transportation

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18 Colorado Department of Transportation. 2005. 2030 Statewide Transportation Plan. *Moving Colorado: Vision for the Future.*

19 Cambridge Systematics, Inc.

20 HLB Decision Economics. 2003. "The Socio-Economic Benefit of Transit in Wisconsin." Prepared for the Wisconsin Department of Transportation.

costs can exceed 35 percent of income. Savings with public transportation are substantial. According to APTA, Americans living in transit-intensive metropolitan areas save $22 billion annually in transportation costs. Plus, transit availability can reduce the need for additional cars, a yearly expense of between $4,800 and $9,700.[21]

Other considerations. Transportation investment under the Sustain Current Performance scenario can improve system reliability and decrease the need for behavior modifications in response to increased congestion. As congestion increases, commuters often shift their commute time, mode of transportation or route of travel. For example, by leaving for work a half hour later than usual commuters may miss peak commute hours.[22] Even though these shifts may result in time savings for the commuter, there is a cost imposed by having to travel at sub-optimal times.

System reliability is another important benefit of additional transportation investment. For example, a commute that always takes 30 minutes may be preferable than one that on average takes 30 minutes, but regularly varies between 20 and 40 minutes. In a study completed for the California Department of Transportation, 44 percent of Californians indicated that it would be better to reduce surprise delays on highways than to decrease the normal time of a trip.[23] For many Colorado residents, travel time reliability can translate into less time spent commuting and additional time for other activities.

3.4 Short-Term Construction Impacts

The immediate economic impact from investment in transportation is the positive effect on the economy from additional construction and maintenance activities. As money is injected into the economy, it creates demand for construction services, raw materials, labor and other goods. This demand then "ripples" through the economy (called the "multiplier effect") as businesses purchase goods from one another and employed workers spend their newly earned money.

The short-term effects of transportation investment are known as "economic impacts" and do not represent "economic benefits" in the traditional sense. The key distinction between benefits and impacts is in the perspective taken on society as a whole. Economic benefits reflect the overall economic efficiency of a policy, measured by the change in total net benefit of the policy to society as a whole. Specifically the critical question is, "Do the policy's total benefits to the overall society (the 'social benefits') outweigh the total 'social costs?'"

Economic impacts describe the distribution of positive and negative effects to various components of the economy in terms of output, employment, income, tax revenues or other elements of value added, such as payments to owners and investors. Economic impacts are the changes imposed on industries that produce and deliver goods and services and the institutions

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21 Cambridge Systematics, Inc.

22 McCann, P. 1993. "The Logistics-Cost Location-Production Problem." *Journal of Regional Science*, Vol. 33(4).

23 BBC Research & Consulting. 2001. "Caltrans External Customer Survey – Telephone Survey." Prepared for the California Department of Transportation.

(e.g., households or governments) that ultimately consume them. Economic impact analysis assists in informing policy makers and stakeholders by understanding the distribution of the negative and positive effects associated with the policy.

Most analyses of transportation investment include some estimate of the economic impact of construction and operational expenditures. Recent studies demonstrate the magnitude of the more short-term impacts of additional transportation investment. A study done for the South Carolina Department of Transportation (SCDOT) shows that the $950 million per year that the SCDOT spends on road construction and maintenance produce a total of $2.1 billion in economic output and supports 24,000 jobs in the state.[24] A study in Wisconsin found that an additional investment of $275 million per year would annually support 4,300 jobs, increasing personal incomes by $156 million.[25]

Based on the most conservative of these estimates found in Wisconsin, transportation spending under the Sustain Current Performance investment scenario might support close to 29,000 jobs each year, increasing personal incomes for Colorado residents by more than $1.0 billion annually.

3.5 Benefits Beyond 2030

The benefits of increased investment will continue well beyond 2030. Under the Sustain Current Performance scenario, Colorado residents and businesses will continue to experience travel cost savings above what they would under current revenue forecasts. Economic activity will also continue to grow in relation to a future without this additional investment. Our analysis does not capture these additional benefits.

Under current revenue projections, CDOT and local authorities will not be able keep pace with the maintenance requirements of the state's transportation system. This would result in the costly rebuilding of roads and other infrastructure that deteriorate beyond the point of repair. With additional transportation investment under the Sustain Current Performance scenario, preventative maintenance replaces costly reconstruction, saving Coloradans money. The cost savings from keeping up with required maintenance accrue beyond 2030, but are not quantified here.

3.6 Summary

Transportation improvements under the Sustain Current Performance scenario will improve the quality of life for Colorado residents and lead to a more robust state economy. Short-term construction benefits, increased economic competitiveness, benefits to the tourism industry and quality of life improvements are substantial benefits of transportation investment. While the

[24] Moore School of Business, University of South Carolina. 2003. "The South Carolina Department of Transportation and its Economic Impact on the State of South Carolina." Prepared for the South Carolina Department of Transportation.

[25] Cambridge Systematics, Inc. 2003. "Transportation Improvements Grow Wisconsin's Economy: The Economic Benefits of Transportation Investments." Prepared for the Transportation Development Association of Wisconsin.

economic impact of these benefits is largely unknown, these benefits are important in the evaluation of additional transportation investment. **Table E** summarizes these additional benefits.

Table E. Other 2030 Benefits of Increased Transportation Investment

Benefit	
Economic competitiveness	Increased access to labor and other inputs Expanded market reach Depends on level of investment in other states
Benefits to the tourism industry	Increased visitor days Increased out-of-state visitor spending
Quality of life improvements	Local air quality improvements Access to jobs and services Improved public transportation in metropolitan areas Increased leisure time
Short-term construction impacts	Up to 29,000 jobs (annual average) $1.0 billion increased personal income (annual average) Not included in total economic benefits

Source: BBC Research and Consulting, 2007.

The benefits of increased investment will also continue well beyond 2030, the end date for this analysis. Future maintenance and improvement costs will also greatly depend on investments made over the next two decades. Under the Sustain Current Performance investment scenario, preventive maintenance would replace costly reconstruction, saving Coloradans money. The cost savings from not deferring maintenance also accrue beyond 2030.

4.0 BENEFITS OF THE 2030 VISION

Throughout the Research Scoping Study, Colorado residents overwhelmingly communicated their desires for a future with an improved transportation system. Therefore, the study team examined a third investment scenario: the $178 billion investment identified in the 2030 Plan as the amount necessary to implement the 2030 Transportation Vision of the citizens of Colorado.[26]

The "Vision" investment scenario demonstrates the importance of not only maintaining current system performance but also of improving the quality of life for Colorado residents through further transportation investment. To incorporate the 2030 Vision into this research, the study team focused on the corridors of statewide significance identified in the 2030 Plan.

Although the Vision investment scenario is not evaluated to the same extent as the Forecast Revenue and Sustain Current Performance investment scenarios, its incorporation is intended to help Colorado residents better understand what an improved transportation system will mean for them personally and for Colorado in general.

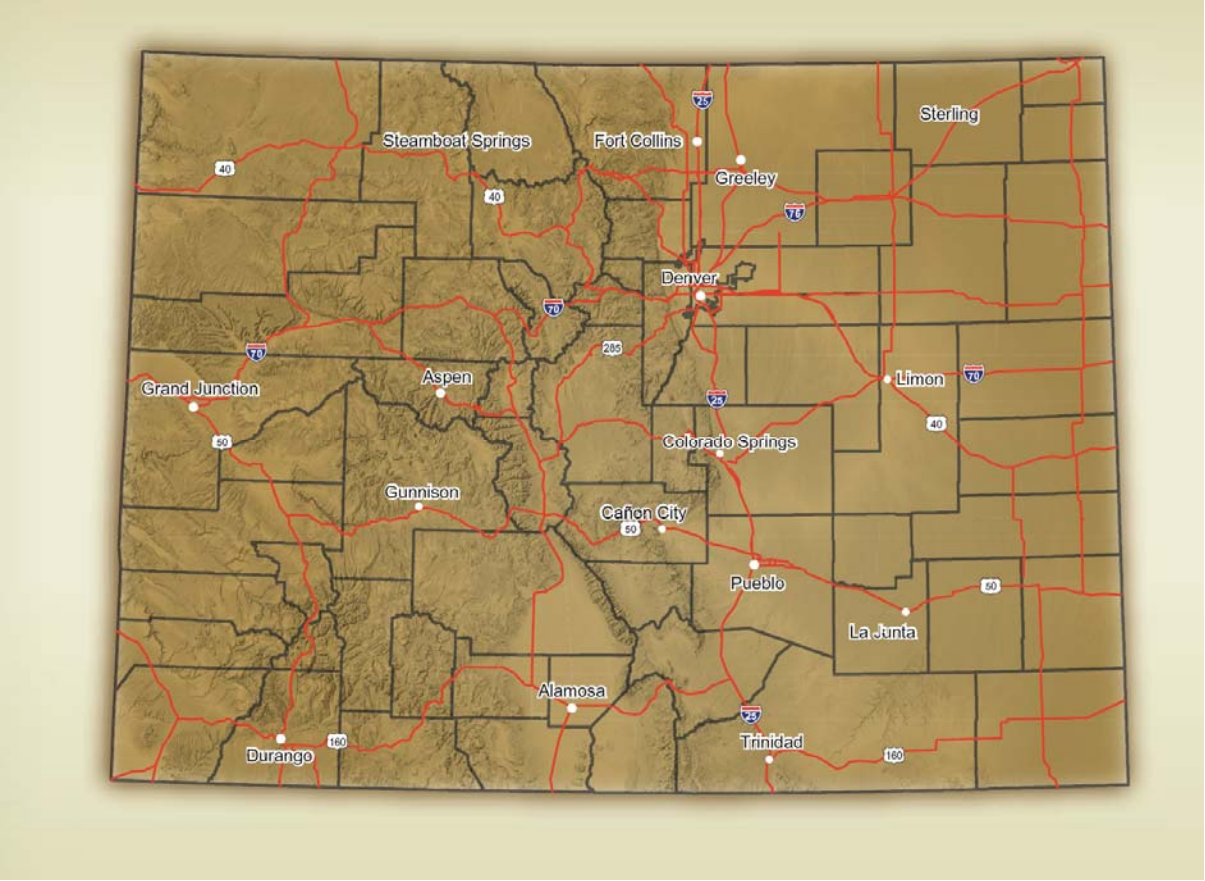
4.1 Corridors of Statewide Significance

The statewide system of corridor visions serves as the basis for meeting future transportation demands across all of Colorado. Corridor visions expand beyond highway segments to include local roads and any number of transportation modes such as transit and rail improvements, freight lines, bicycle and pedestrian facilities and air travel. These multi-modal corridor visions form the backbone of the 2030 Statewide Transportation Plan. Goals identified for each corridor were developed by transportation groups, CDOT and other stakeholders from 15 Transportation Planning Regions. These corridor visions support broader economic visions for corresponding regions throughout the state.

Figure 13 highlights the corridors of statewide significance.

[26] Colorado Department of Transportation. 2005. 2030 Statewide Transportation Plan. *Moving Colorado: Vision for the Future.*

Figure 13. Corridors of Statewide Significance



Source: CDOT 2030 Statewide Transportation Plan, February 2005.

4.2 Vision Investment Scenario

To achieve the 2030 Vision would require $55 billion beyond the Sustain Current Performance investment, or a total investment of $178 billion through 2030. Transportation improvements associated with this level of investment would significantly improve performance levels on the state's transportation system. Under the Vision, all appropriate safety measures would be implemented. Transit services would grow to meet almost 100 percent of demand. New runways would be constructed and other improvements would be made at airports around the state. This additional investment would improve the state's economic competitiveness and enhance the quality of life of Colorado residents beyond what would be achieved under the Sustain Current Performance scenario.

4.3 Benefits of Achieving the 2030 Vision

In addition to greater travel cost savings and productivity benefits, additional transportation investment under the Vision investment scenario would result in substantial benefits related to:

- Improved safety;
- Economic development;
- Meeting public transportation demand; and
- Access to recreation.

Improved safety. Additional transportation investment under the Vision investment scenario would further reduce the number of accidents, injuries and fatalities on public roadways in Colorado. Compared to the Sustain Current Performance scenario, safety improvements under the Vision would save 55 more lives in 2030.

Investments to improve the safety of Colorado's transportation system would be concentrated in the more rural and mountainous areas of the state. For example, the corridor vision for U.S. 24 in the Intermountain and San Luis Valley Transportation Planning Regions (TPRs) identifies safety as the primary investment category. Safety is also a primary area of concern on State Highway (S.H.) 13 and on the south central and western portions of U.S. 50 and U.S. 160. On heavily traveled freight corridors, including U.S. 24 and U.S. 50, improved safety conditions are important for Colorado businesses and the efficient movement of goods. On S.H. 13 and U.S. 160, safety improvements would further support recreational travel in these corridors.

Public transportation improvements under the Vision investment scenario would also improve safety conditions for Colorado residents. The National Safety Council estimates that riding the bus is over 170 times safer than automobile travel. According to the American Public Transit Authority, trips with similar destinations made by public transit rather than by car annually result in 200,000 fewer deaths, injuries and accidents nationwide, amounting to between $2 billion and $5 billion per year in safety benefits.[27]

Economic development. Additional transportation investment under the Vision scenario would improve regional trade opportunities and further economic development throughout the state.

System quality improvements and increased capacity on heavily traveled freight corridors would promote economic development and improve farm-to-market commercial activity in rural areas of the state. Potentially affected corridors include U.S. 385 and portions of U.S. 50 and I-70.

[27] Cambridge Systematics, Inc. 2002. "The Benefits of Public Transportation: An Overview." Prepared for the American Public Transit Authority.

A re-focusing of freight transportation hubs east of the Front Range would potentially provide economic development-related growth throughout Colorado. For example, the Front Range Railroad Infrastructure Rationalization Project would relocate freight rail infrastructure, moving through freight train service east, away from the Front Range urban corridor. A recent study estimates that the project would result in more than $719 million in direct economic development benefits for the Eastern Plains, Front Range and Western Slope. These direct benefits would generate substantial indirect economic activity.[28]

Additionally, investments in the Ports-to-Plains Trade Corridor and the Heartland Expressway would increase Colorado's importance in north-south movement of goods and generate additional economic activity. For example, the Ports-to-Plains Trade Corridor offers opportunities for economic development in eastern plains communities as well as expanded truck and distribution operations along the Front Range[29].

Improved public transportation systems can also create additional economic opportunities for Colorado residents and businesses. For example, in metropolitan areas throughout the United States, developers are investing millions in new construction around transit stations. In Denver, development surrounding the region's newly expanded light rail system has already begun.

Increased investment in Colorado's aviation network would also increase Colorado's economic competitiveness under the Vision scenario. Airport improvements that lead to increased competition and more frequent commercial air service can help attract new business. Aviation improvements would also benefit tourism industries throughout the state.

Meeting public transportation demand. A strong public transportation network benefits Colorado residents by providing access to higher paying jobs and essential health and human services. In many areas, public transportation systems provide a vital link for seniors, the disabled and children.

Public transportation improvements account for more than 40 percent of the $55 billion additional transportation investment under the Vision investment scenario. Because of these improvements, the 2030 Vision would meet 92 percent of total transit demand in 2030. Much of this investment would be focused in the Denver Metropolitan Area, the North Front Range and the Intermountain region of the state.

Jobs. Expanding transit service can help the transportation-disadvantaged gain access to jobs and improve their standard of living. A recent report from the Wisconsin Urban and Rural Transit Association identified unmet transportation needs and assessed the cost and benefit of providing additional transportation services to meet the needs of Wisconsin welfare recipients. This analysis identified the geographic mismatch between welfare recipients living in Milwaukee and potential job sites located outside of Milwaukee County (and outside of the range of current

[28] DMJM Harris and HDR. 2005. "Public Benefits and Costs Study of the Proposed BNSF/UP Front Range Railroad Infrastructure Rationalization Project." CDOT Project No. C SWOO-242.

[29] Longwoods International. 2006. "Visitor Profile Study: Colorado Travel Year 2005."

transit service). At least one scenario in this study showed the potential to generate a possible return of $1.66 for every $1.00 invested in proposed transit service adjustments. These types of benefits are directly applicable to corridors of statewide significance throughout Colorado.

Public transportation investments can also serve to increase the area from which businesses access specialized labor. For example, investments in public transportation along the I-25 corridor, would allow employers in Metro Denver and Colorado Springs to pull from a larger labor pool. Public transportation can also improve employee reliability and result in less absenteeism and turnover.

Health and human services. In many areas, public transportation systems provide a vital link to health and human services for seniors, the disabled and economically disadvantaged citizens of Colorado.

The availability of public transportation can also help health and human services agencies to avoid medical expenses for the economically disadvantaged, reduce demand for more expensive and oversubscribed paratransit services, provide an option to the costly use of ambulance and EMS services, and relieve other public agencies of transportation responsibility, thereby increasing their productivity. According to APTA, savings to social programs from transit use may be as high as $1.3 billion to $2 billion per year in the United States.[30] Human services-oriented transit programs can be found in urban and rural communities around the country.

Improved access to recreation destinations. Additional capacity and improved public transit services on I-70 west, S.H. 82 and U.S. 160 would provide access to many of Colorado's key recreation sites. This would not only improve quality of life for Colorado residents but would encourage out-of-state visitors to make longer and more frequent trips to Colorado's tourist destinations.

I -70 corridor improvements under the vision scenario exemplify the importance of this relationship. The I-70 corridor houses over 200 recreation sites including some of the most popular ski resorts in the world. The tourism industry along the corridor employs 125,000 people, generates $4.8 billion in total annual personal income.[31] This translates to $77.2 million in local taxes for the Mountain Resort economy (including Clear Creek, Eagle, Garfield, Gilpin, Grand, Lake, Park, Pitkin and Summit Counties) and $59.2 million in tax revenues for the state.

The investment schedule under the Vision scenario would provide the means to implement an I-70 corridor-wide public transit system, which currently does not exist. The transit system, in conjunction with lane expansion along the highway, would contribute to the mobility and safety along the corridor, improving accessibility to winter and summer recreation destinations. In 2030, highway and transit improvements under the Vision would increase trips to surrounding

[30] Cambridge Systematics, 2002.

[31] I-70 Mountain Corridor Programmatic EIS.

recreation areas by an estimated 10 to 14 percent above the Sustain Current Performance scenario. This could increase out-of-state visitor spending by more than $0.6 billion in 2030.

This is particularly applicable to the resort counties of Eagle, Summit, Pitkin and Garfield, who are most reliant on tourism and most vulnerable to changes that reduce the attractiveness of the tourism industry to out-of-state visitors.

4.4 Summary

The level of investment necessary to achieve the 2030 Transportation Vision of the citizens of Colorado amounts to $55 billion above the level of investment needed to simply maintain current system performance. This additional investment would improve quality of life for Colorado residents and increase state economic competitiveness to levels well beyond those under the Sustain Current Performance investment scenario. The benefits of this additional investment include increased safety, economic development, better public transportation and access to recreation.

5.0 NEXT STEPS

This section provides recommendations and identifies information necessary to perform an in-depth analysis of transportation benefits by region within Colorado.

5.1 Why Regional Studies?

To implement the goals of the 2030 Transportation Vision or even just maintain current transportation system performance requires creative approaches to increasing transportation funding. Economic benefit studies by region within the state would help Colorado residents and businesses understand the importance of transportation investment to their communities.

In the May 2006 Research Scoping Study, Colorado stakeholders agreed that research on the economic benefits of transportation investment should focus on the returns to individual regions within the state:

- Different regions within Colorado have different transportation needs. The Front Range may be interested in reduced congestion while the Eastern Plains may be more interested in job creation.
- Regional impacts may become lost in a statewide study. For example, two hundred new jobs created across Colorado may not be significant, while 200 jobs created in Pueblo would have a large impact on the local economy.
- Residents and businesses in many parts of the state question whether transportation investments will benefit areas outside of the Front Range. A regional level analysis would help to identify where benefits occur.
- A regional analysis would increase study credibility and support at the local level, particularly where new tax dollars are tied to specific projects.

5.2 What Additional Data Are Needed?

Several data limitations constrained the study team's ability to make a precise portrayal of the benefits and costs of additional transportation investment at the statewide level. A more in-depth analysis of benefits at the local or regional level may present a fuller picture of the relationship between transportation investments and economic well being.

A regional study of transportation benefits would require local data, enhanced traffic and economic modeling capabilities and additional information:

- Specific local project information and associated performance measures;
- Truck and commercial vehicle data including origin-destination patterns;
- Changes in vehicle miles traveled as a result of additional investment;

- Local road data;
- More detailed economic data for specific regions; and
- Timing of costs and benefits.

5.3 Who Would Lead These Study Efforts?

Local businesses, transportation authorities, Transportation Planning Regions and Metropolitan Planning Organizations could lead these regional efforts. CDOT and other state agencies could help coordinate studies and provide a consistent framework for analysis and traffic and economic modeling capabilities.

A study by region within the state could include analyses of transportation investment benefits on the Front Range, Eastern Plains and the Western Slope. Regional boundaries could follow Transportation Planning Region (TPR) and Metropolitan Planning Organization (MPO) boundaries. The geographic scope for analysis, or regions analyzed, will ultimately depend on the goals and target audience of the study. For example, individual TPRs or localities may choose to conduct studies as a way of tying benefits to specific transportation funding initiatives.

CDOT and regional and local authorities will need to decide the appropriate level of analysis based on available data, modeling capabilities and study goals

APPENDIX A. STEERING COMMITTEE MEMBERS

Chuck Berry
President
Colorado Association
of Commerce and Industry

Garin Bray
Director of State Affairs
Colorado Farm Bureau

Larry Burkhardt
President/CEO
Upstate Colorado

Ken Conyers
Appointee to Executive Committee
Action 22

Randy Harrison
Move Colorado

Leslie Jones
Chair of Transportation Committee
Club 20

C.A. Lane
Intrawest
Colorado Ski U.S.A

Rachel Nance
Government Relations Director
Colorado Association of Realtors

Carla Perez
Senior Policy Analyst for Transportation
Governor's Office of Policy and
Initiatives

Vince Rogalski
Chair
Statewide Transportation
Advisory Committee

Cathy Shull
Executive Director
Progressive 15

Gaye Stockman
President/CEO
Loveland Chamber of Commerce

Will Temby
Chief Executive Officer
The Greater Colorado Springs
Chamber of Commerce

APPENDIX B. METHODOLOGY—TRAVEL TIME SAVINGS

This appendix summarizes the methodology used to calculate travel time savings under the Forecast Revenue and Sustain Current Performance investment scenarios. The study team's methodology was adapted from methodology developed by the Texas Transportation Institute (TTI) for the Annual Urban Mobility Report.

Data Sources

To determine travel time savings under the Sustain Current Performance investment scenario, the study team used the data sources in **Table B-1**.

Table B-1 Data Sources for Determining Travel Time Savings

Estimate	Data Source
Total vehicle miles traveled in 2030 (VMT)	CDOT Traffic Data
VMT on roadways with a volume to capacity ratio greater than 0.85 (measure of congestion)	CDOT Traffic Data
Value of time spent commuting	U.S. Department of Transportation
Value of time for commercial trucks	TTI 2005 Urban Mobility Report
2030 population estimates	U.S. Census Bureau
Number of people that commute to work	U.S. Census Economic Profile
Average number of people per vehicle	U.S. Census Economic Profile
Local road data	CDOT Traffic Data

Source: BBC Research and Consulting, 2007.

Methodology

The study team's methodology includes calculation of the following:

- Travel delay;
- Wasted fuel; and
- Travel time costs.

Travel delay. The travel time performance measures presented in this report are primarily based on travel time delay – the amount of extra time spent traveling due to congestion or poor pavement. The study team estimated travel time delay from vehicle traffic per lane and traffic speed equations developed by TTI. This process is summarized below:

- Collect 2005 and estimated 2030 travel and roadway characteristics from CDOT traffic database;
- Reduce the travel miles examined to peak period travel (50 percent of daily vehicle miles traveled (DVMT));
- Place DVMT for each route into one of five levels of congestion;
- Separate congested travel into peak and off-peak directions;
- Calculate a speed for each category of congested travel and peak and off-peak directions based on TTI speed equations shown in Exhibit B-3;
- Compare travel times to non-congested conditions to determine total delay;
- Calculate reductions in travel time from poor pavement quality; and
- Apply findings to local roadways and weekend travel.

Collect travel and roadway characteristics. The study team used CDOT traffic data estimates to determine 2030 congestion levels under the Forecast Revenue (based on CDOT projections) and Sustain Current Performance (based on current 2005 conditions) investment scenarios. For each congested route (volume-to-capacity ratio greater than 0.85), the study team determined roadway designation (freeway vs. arterial), volume-to-capacity ratio, average daily traffic (ADT), number of lanes and DVMT for trucks and automobiles.

Isolate peak-period travel. The times of the day outside of the peak-period are typically uncongested. Even though some sections of road in larger areas can be congested during other times of the day, the study team examined the peak-periods—estimated as 6:00 to 9:30 a.m. and 3:30 to 7:00 p.m. These time periods are estimated to include 50 percent of the daily vehicle travel. The rationale for eliminating the remainder of the day is that an area's mobility statistics should not be "credited" for having an uncongested system at 3:00 a.m.

Identify congestion level for each section of roadway. The study team assigned each section of roadway to one of five congestion levels—uncongested, moderate, heavy, severe or extreme. Congestion levels are based on CDOT data for average daily traffic (ADT) per lane. **Table B-2** defines this relationship.

Table B-2 Levels of Congestion Based on Volume Capacity Ratio

Road Type	Level of Congestion	ADT per Lane
Freeway	Uncongested	Under 15,000
	Moderate	15,001–17,500
	Heavy	17,501–20,000
	Severe	20,001–25,000
	Extreme	Over 25,000
Arterial	Uncongested	Under 5,500
	Moderate	5,501–7,000
	Heavy	7,001–8,500
	Severe	8,501–10,000
	Extreme	Over 10,000

Note: ADT/lane in thousands.
Source: Texas Transportation Institute, 2004.

Separate travel into peak and off-peak direction. The portion of this traffic that is considered peak direction was separated from the portion considered off-peak. For the purposes of this analysis, the study team assumed that 60 percent of miles traveled in congestion were in peak direction and 40 percent in off-peak direction.

Apply speed estimates to each congestion group. **Table B-3** presents the relationships used to estimate the speed for each congestion level and direction on freeways and arterials. These speeds were developed by TTI based on a combination of travel time data from several traffic management centers across the U.S. and computer simulation speed estimating methodologies. These speeds include the effects of incidents on congestion.

Table B-3 Speed Equations Developed by TTI

Type of road	Direction	Congestion level	Speed function	Note
Freeway/Expressway	Peak	Uncongested	60	
		Moderate	74.45-(1.09 ADT/lane)	
		Heavy	109.76-(3.10 ADT/Lane)	
		Severe	135.08-(4.33 ADT/Lane)	
		Extreme	72.03-(1.75 ADT/Lane)	Set floor at 20
	Off-peak	Uncongested	60	
		Moderate	68.72-(0.65 ADT/Lane)	
		Heavy	72.46-(0.88 ADT/Lane)	
		Severe	103.54-(2.44 ADT//Lane)	
		Extreme	123.57-(3.21 ADT/Lane)	Set floor at 25
Arterial	Peak	Uncongested	35	
		Moderate	33.58-(0.74 ADT/lane)	
		Heavy	33.80-(0.77 ADT/Lane)	
		Severe	31.65-(0.51 ADT/Lane)	
		Extreme	32.57-(0.62 ADT/Lane)	Set floor at 25
	Off-peak	Uncongested	35	
		Moderate	33.82-(0.59 ADT/Lane)	
		Heavy	33.90-(0.59 ADT/Lane)	
		Severe	30.10-(0.15 ADT//Lane)	
		Extreme	31.23-(0.27 ADT/Lane)	Set floor at 27

Note: ADT/Lane in thousands.
Source: Texas Transportation Institute, 2004. 2004 Urban Mobility Report.

Estimate travel delay. The difference in the amount of time it takes to travel the peak-period vehicle miles in congested conditions and at free-flow speeds is the total delay. The study team calculated this delay under the Forecast Revenue and Sustain Current Performance investment scenarios. The daily vehicle hours of delay is the sum of the delay resulting from all four levels of congestion on freeways and arterials.

Using CDOT traffic data and estimates from other studies for business autos, total delay was allocated across personal vehicles, business autos and commercial trucks. To calculate the annual person-hours of delay for passenger vehicles, the study team multiplied the daily delay estimates by the average vehicle occupancy (1.18 persons per vehicle) and by 250 working days per year.

Apply to weekend travel. The study team calculated the average delay per mile of congested roadway for peak periods and applied it to 20 percent of VMT on congested roadways during the weekend. This provides a conservative estimate of additional delay outside of the busiest commute times.

Calculate delay associated with poor pavement quality. The study team used CDOT traffic data to identify roadways with "poor" pavement quality under the Forecast Revenue and Sustain Current Performance investment scenarios. Roadways are defined as having poor pavement quality if they have an International Roughness Index (IRI) of over 170. The study team applied a 2.5 mph delay to all VMT on roadways with poor pavement quality. This methodology is based on a study conducted by the Michigan Department of Transportation.[32] To determine total delay, the study team compared travel times on poor quality roads to what they would be with better pavement quality.

Apply findings to local roads. The study team used CDOT local road data for total city and county lane miles to apply findings to local roads. This methodology assumes that investment in local roadways will result in proportional benefits to CDOT lane miles.

Wasted fuel. Based on TTI equations, the study team first determined the average fuel economy of the vehicles operating in congested conditions under each investment scenario. Fuel economy is based on the overall average speed in congested conditions. It is a linear regression applied to a modified version of fuel consumption reported by Raus, 2001:[33]

$$\text{Average fuel economy in congestion} = 8.8 + 0.25 \times \text{Average congested speed}$$

Source: TTI Urban Mobility Report, 2004

[32] Economic Development Research Group, Inc. and the Institute of Labor and Industry Relations, University of Michigan. 2005. "Economic Benefits of the Michigan Department of Transportation's 2005-2009 Highway Program." Prepared for the Michigan Department of Transportation.

[33] Raus, J. 1981. "A Method for Estimating Fuel Consumption and Vehicle Emissions on Urban Arterials and Networks." Report No. FHWA-TS-81-210.

The study team calculated annual wasted fuel due to vehicles moving at slower speeds as follows:

Annual wasted fuel (gallons)	=	Travel delay (vehicle-hours)	x	Average congested speed	/	Average fuel economy

Source: TTI Urban Mobility Report, 2004.

Travel costs. Two cost components are associated with congestion: delay cost and fuel cost. These values are directly related to the travel speed calculations. The following sections describe how the study team calculated the costs associated with each component.

Passenger vehicle delay cost. The delay cost is an estimate of the value of lost time in passenger vehicles, including lost time for "on-the-clock" employees traveling on business. Per U.S. Department of Transportation (USDOT) guidance, the value of time for personal trips, including commuting to and from work is one-half the average wage rate in Colorado, or $10.72 per hour of delay. For business employees (5% of passenger vehicle VMT), lost time while on-the-clock is valued at the average wage rate, or $21.56 per hour. Total costs to Colorado households and businesses are determined by multiplying annual total delay by the appropriate time value.

Passenger vehicle fuel cost. Based on TTI methods, the study team determined fuel costs associated with congestion for passenger vehicles. The study team used average fuel costs of $1.75 per gallon to estimate the total cost of wasted fuel. This number is largely speculative as estimates for the cost of fuel in 2030 are unavailable.

Commercial vehicle cost. The cost of both wasted time and fuel are included in the value of commercial vehicle time. Thus, there is not a separate value for wasted time and fuel. Based on TTI's estimates, the study team used $74.65 per hour of delay to determine commercial vehicle costs under the two investment scenarios.

Issues

The study team faced data limitations and other issues in estimating travel time savings across investment scenarios. Assumptions and caveats associated with these issues are summarized below:

- The analysis assumes that under the Sustain Current Performance investment scenario, congestion patterns would be the same as they are today. Although overall performance levels would be the same (10% of lane miles are congested), the distribution of this congestion may differ in 2030. Improvements targeting highly congested areas may result in larger benefits.

- Land-use patterns, socio-economic data and times of travel are held constant across investment scenarios. In reality, an improved transportation system would most likely lead to more employment and population growth as well as shifts in local development patterns. Less peak hour congestion may also cause some commuters to change the timing of their commute or the destination of non-work related trips. Each of these adaptations to an improved transportation system would have associated costs and benefits, and could mitigate some of the benefits of transportation improvements.
- The study team assumes that performance measures for local roads are the same as those for CDOT-maintained roads.
- Investment in local roads is assumed to yield the same per dollar travel time benefits as investment in on-system roads.
- Costs associated with wasted fuel are $1.75 per gallon (2005 constant dollars). Fuel costs in 2030 are subject to much uncertainty. The study team believes that $1.75 per gallon provides a conservative estimate of fuel savings under the Sustain Current Performance investment scenario.
- The study team assumes that 60 percent of commercial vehicle VMT is traveled by Colorado businesses. This approximation is loosely based on Commodity Flow Survey data, however, no true estimate exists.
- The model assumes a linear growth in benefits. Factors that cause variations in the benefits growth pattern, such as construction impacts, are not taken into account.

APPENDIX C. METHODOLOGY–VEHICLE OPERATING COSTS

This appendix describes the methodology used for estimating vehicle operating costs under the Forecast Revenue and Sustain Current Performance investment scenarios. The study team quantified benefits for Colorado households and businesses using methodology from a study conducted by the Minnesota Department of Transportation (MnDOT).

Data Sources

To isolate household and business impacts, the study team collected and analyzed data separately for passenger and commercial vehicles. **Table C-1** provides a summary of data sources.

Table C-1 Data Sources

Estimate	Source
Total vehicle miles traveled (VMT)	CDOT Traffic Data
International Roughness Index (IRI) by route	CDOT Traffic Data
Number of registered passenger and commercial vehicles	CDOT Traffic Data—Bureau of Transportation Statistics
IRI costs multiplier for good, fair, mediocre, and poor pavement quality	Minnesota Department of Transportation TRIP
Baseline vehicle operation costs for passenger vehicles	AAA Association
Baseline vehicle operation costs for commercial vehicles	AAA Association–Federal Motor Carrier Safety Administration–Berwick, 1996
Source: BBC Research and Consulting, 2007.	

Methodology

The study team quantified vehicle operating costs under the Forecast Revenue and Sustain Current Performance investment scenarios based on the International Roughness Index (IRI). This measure exclusively accounts for the smoothness of the road, whereas other measures of system quality include the condition of the entire infrastructure and other factors that may not directly affect vehicle operating costs. The following summarizes the methodology used to calculate vehicle operating costs:

- Adjust 2005 traffic data to determine 2030 VMT per route;
- Distribute VMT among four pavement quality categories (based on IRI) for both investment scenarios;

- Establish baseline vehicle operating costs for vehicles traveling on smooth pavement;
- Apply adjustment multipliers as shown in **Table C-2** to VMT in corresponding pavement quality categories to determine vehicle operating costs under each scenario; and
- Apply findings to local roadways.

The study team's methodology is described in further detail below.

Determine total vehicle miles traveled. The study team analyzed CDOT data for VMT per route for all vehicles, including trucks built on a single chassis and trucks with three or more axles. The study team combined VMT for both types of trucks into one "total VMT trucks" category. Based on studies in other states, the study team allocated 95 percent of passenger vehicle VMT to personal vehicles and 5 percent to automobile use for business.

Assign International Roughness Index (IRI) and pavement quality category. Under the Forecast Revenue investment scenario, CDOT anticipates 32 percent of roads will have a good/fair rating in 2030 (measured by remaining service life (RSL)). Under the Sustain Current Performance investment scenario, approximately 60 percent of roads would have a good/fair rating.

Using CDOT traffic data, the study team calculated a weighted average IRI per route and distributed the routes into four IRI-defined categories: good, fair, mediocre, and poor.[34] These categories are defined in the MnDOT study. They represent IRI ranges that correspond to per mile vehicle operating costs for different pavement conditions.

To determine the VMT allocation for the Forecast Revenue investment scenario, the study team adjusted the amounts in each category using a ratio provided by CDOT. The reported ratios are estimates of changes to the combined amount of good and fair roads. The study team weighted the ratios to obtain a conservative VMT for the four categories.[35]

Estimate number of registered passenger and commercial vehicles in 2030. The study team collected data from the Colorado Department of Transportation and the Bureau of Transportation Statistics to determine number of vehicles by vehicle type. The study team computed a ratio of vehicle miles traveled per vehicle to estimate the number of vehicles in 2030 using projected VMT for that year. It is difficult to predict the future car market, so the study team maintained the 2006 ratio of sedans, vans, sport utility vehicles, pick-up trucks and commercial trucks for the 2030 estimates. Due to limited data availability and small sample sizes, the study team excluded registered buses, motorcycles, and "other" vehicles from the analysis.

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34 Barnes, G. and P. Langworhty. (2003). "The Per-Mile Costs of Operating Automobiles and Trucks." University of Minnesota, Minnesota Department of Transportation.

35 The ratios are based on remaining service life, not IRI. The assumption is that differences in RSL are directly proportional to differences in IRI.

Determine baseline vehicle operating cost data. The study team collected data on per mile maintenance, tire and depreciation costs of driving on smooth pavement. Data are in 2005 dollars.

Passenger vehicles. The American Automobile Association (AAA) provides average, per mile vehicle operating costs for the top five selling sedans, sport utility vehicles, and minivans each year. The study team used unadjusted figures from 2006 as baseline maintenance, tire and depreciation costs.[36]

Depreciation is a factor of both age and vehicle use. AAA data includes per mile depreciation adjustments based on the average annual car mileage. The study team used this information to isolate depreciation costs solely based on vehicle use.

Commercial trucks. Limited data are available on vehicle operating costs for commercial trucks. The study team drew on various sources to establish conservative estimates of these costs.

A 1997 study reported commercial truck maintenance costs of 10 cents per mile.[37] The study team applied a 3 percent inflationary increase to determine the cost in 2005 dollars. The baseline per mile tire cost reported by the Federal Motor Carrier Safety Administration is 1.9 cents for commercial trucks. The MnDOT study suggests deriving the depreciation rate for trucks from the rate of the most expensive cars. The highest depreciation rate from AAA was applied to all commercial trucks.[38]

Apply IRI multiplier for good, fair, mediocre, and poor pavement quality. The study team used the IRI multiplier from the MnDOT study to adjust costs according to each pavement roughness category. The multiplier is based on a study done by the Texas Transportation Institute, and was applied to both passenger and commercial vehicles.[39] The road category schedule and multipliers are in **Table C-2.**

[36] From the publication *Your Driving Costs 2006.* TRIP used 2004 AAA data for baseline vehicle operating costs in a similar study.

[37] Berwick, M. D. (1997). "Truck Costs for Owner/Operators." Upper Great Plains Transportation Institute, North Dakota State University.

[38] Sport utility vehicles have the highest reported depreciation rates according to AAA.

[39] Barnes and Langworthy, 2003.

Table C-2 Pavement Condition Classification

Pavement Condition	International Roughness Index (IRI)	Adjustment Multiplier
Good	0-94	1.00
Fair	95-119	1.05
Mediocre	120-170	1.15
Poor	Above 170	1.25

Source: MnDOT (2003) TRIP (2005)

Apply findings to local roads. The results of this analysis were used to calculate vehicle operating costs on local roadways under both investment scenarios. Using the ratios provided by CDOT, the study team estimated the number of vehicle miles traveled on local roadways within each pavement quality category. The study team assumed that that the investment in local roadways would result in proportional benefits to CDOT lane miles.

Issues

BBC faced data limitations and other issues in estimating vehicle operating costs across investment scenarios. Assumptions and caveats associated with these issues are summarized below:

- The analysis holds VMT per route constant across investment scenarios. However, drivers may choose alternate routes in the face of deteriorating roads. It is also possible that different road conditions may encourage or discourage driving in general, resulting in differences in total VMT under each scenario. Each of these issues has associated benefits and costs.
- The analysis uses IRI as a proxy for road conditions. Other factors that affect road conditions, such as gradient curves, are not included.
- Due to the limited amount of information available for specific system quality improvement projects, the study team assumed a proportional change in pavement roughness to overall changes in system quality.
- Baseline vehicle operating cost data are not specific to vehicles driven in Colorado. The costs also do not account for the age of the vehicle, which affects maintenance and depreciation costs.
- The study team assumed that performance measures for local roads are the same as those for CDOT-maintained roads.
- Investment in local roads is assumed to yield the same per dollar travel time benefits as investment in on-system roads.

- The study team assumed that 60 percent of truck VMT on Colorado roads are traveled by Colorado businesses.
- The model assumes a linear growth in benefits. Factors that cause variations in the benefits growth pattern, such as construction impacts, are not taken into account.

APPENDIX D. METHODOLOGY–SAFETY ESTIMATES

To estimate the safety returns to investment in physical infrastructure and behavioral programs, the study team used performance measures provided by CDOT and a methodology developed by BBC Research and Consulting for a 2003 project for CDOT. This appendix describes the methodology and assumptions as adapted for this study.

Objectives

In 2003, BBC designed this "returns to safety investment" methodology to meet the following objectives:

- Determine the optimal mix of programs to reduce fatalities;
- Examine the effectiveness of different packages of safety programs;
- Hold constant legislative outcomes (e.g., a primary seat belt law); and
- Estimate the economic savings from avoided crashes.

The original study was presented to the Colorado Transportation Commission.

Methodology

The study team quantified the number of accidents and injuries under the Forecast Revenue and Sustain Current Performance investment scenarios based on CDOT performance measures and a previous study conducted for CDOT.

To determine the number of fatalities under the Forecast Revenue and Sustain Current Performance investment scenarios, the study team used fatality rates (fatal crashes per 100 million VMT) identified with each level of investment in the 2030 Transportation Plan. The study team applied the fatality rate under each scenario to total VMT in 2030.

BBC combined information on both engineering and behavioral programs to determine the optimal investment strategy. Our original 2003 study focused on very specific behavioral programs and engineering countermeasures. The 2030 Transportation Plan does not provide this specific level of information on safety expenditures. Therefore, we adapted the results of the original study to the 2030 Transportation Plan spending levels with the assumption that a similar mix of safety projects would occur.

Engineering improvements. BBC collected information on accident and injury reduction and other economic returns from different types of engineering improvements on rural and urban roads. This information included:

- U.S. DOT Federal Highway Administration studies, including: "1996 Annual Report on Highway Safety Improvement Programs" and "The Effectiveness and Use of Continuous Shoulder Rumble Strips";
- NHTSA Fatal Analysis Reporting System;
- CDOT Crash Databases;
- National Safety Council's "Estimating the Costs of Unintentional Injuries, 2001";
- CDOT reports and studies, including: "Colorado Integrated Safety Plan: 2004-2006," "Colorado Safety Investment Strategy (Based on the Analysis of Existing Safety Problems)," and "Safety Assessment Report Intersection Reconstruction/Improvement Project SH 30 (Hampden Avenue) and Monaco Parkway"; and
- Other state department of transportation studies, including: "Vermont Agency of Transportation Highway Safety Improvement Program, August 2002", the Maine Department of Transportation's "Maine Transportation Safety Trends: Reporting of Maine Ten-Year Crash Trends" and the Maine DOT's "Highway Safety Improvement Program."

BBC worked with CDOT safety engineers to identify locations with clusters of accidents that might be susceptible to engineering improvements. CDOT has an advanced program to identify these locations and the types of accidents that occur at each location (e.g., head-on crashes, sideswipe crashes and hitting a foreign object such as a deer).

CDOT safety engineers estimate that 8 percent of accidents across the state have the potential for remediation by engineering improvements and that these improvements will only reduce certain types of crashes. BBC used nationally determined accident reduction factors (ARFs) to describe the crash reduction effect an available countermeasure (e.g., guardrail or dedicated left turn lane) would have on the accident rate at a location.

Behavioral programs. BBC then performed an initial evaluation of the returns to three behavioral programs/outcomes: Click It or Ticket, 90 percent seatbelt usage, and The Heat Is On! Support for this analysis came from:

- CDOT's Problem Identification study;
- Interviews with CDOT behavioral program coordinators;
- CDOT reports and studies, including: "Colorado Integrated Safety Plan 2004-2006;"

- Washington Traffic Safety Commission, Traffic Research & Data Center's: "Drunk Driving Trends in Washington State: Evaluation of the 1998 DUI Laws" and "Ninety Three Percent: An Evaluation of the Primary Seat Belt Law and the Click It or Ticket Project in Washington State;"
- NHTSA Fatal Analysis Reporting System;
- CDOT 2002 Crash Database; and
- National Safety Council's "Estimating the Costs of Unintentional Injuries, 2001."

Primary seat belt law. Based on previous studies and findings in other states, BBC assumed that a primary seat belt law would result in a 44 percent reduction in non-use of seat belts. Of those fatalities where the occupant was not wearing a seat belt, an estimated 45 percent would survive if they were wearing a seat belt.[40]

There are no additional media or enforcement costs required for this measure, and it results in a permanent change in behavior.

Additional seat belt educational programs. BBC estimated that increasing existing seat belt enforcement and educational programs, such as Click It or Ticket, would also have a measurable outcome on seatbelt usage. The actual increase in seat belt usage would depend on investment levels. As an example, BBC found that CDOT could achieve an initial 17 percent reduction in seat belt non-use, and maintain this level, with a $0.8 million increase in the existing Click It or Ticket budget. Again, an estimated 45 percent of non-seat belt wearing fatalities would survive if they were wearing a seat belt.

Additional alcohol educational programs. BBC found that increasing existing alcohol enforcement and educational programs, such as LEAF and The Heat is On!, would reduce alcohol related fatal crashes. As an example of the returns to this investment, BBC estimated that increasing these program budgets by $2.4 million annually would reduce alcohol related fatal crashes by 10 percent of projected levels.

Economic losses by crash events. BBC relied on the National Safety Council's (NSC) study "Estimating the Costs of Unintentional Injuries" to calculate the economic loss of various crash outcomes. We weighted the NSC's estimates by the frequency of injury types for Colorado drivers to determine the losses associated with an injury crash. **Table D-1** provides the loss levels by crash outcome.

[40] Sources: Washington Traffic Safety Commission, (2002) "An Evaluation of the Primary Seat Belt Law and the Click It or Ticket Project in Washington State;" NHTSA (2002) "Evaluation of Click It or Ticket Model Programs;" and NHTSA (1999) "Technical Report DOT HS 808 945."

Table D-1 Economic Losses by Crash Events

Event	Economic Loss (2005 $s)
Crashes:	
Fatal crash	1,291,640
Injury crash	62,370
Property damage only crash	6,480

Source: BBC Research and Consulting, 2006 and National Safety Council "Estimating the Costs of Unintentional Injury.

Iterative ranking of investment options. BBC used the costs and estimated outcomes of each behavioral and engineering investment to determine the project or program with the best return. We selected this investment and then recalculated the returns on the remaining investments. This recalculation was necessary because some investments, for example seat belt programs, would reduce the projected avoided economic losses of other investments (because higher seat belt use would have already saved lives). This procedure was done iteratively until a schedule of "optimal" investments was created.

Adjustment to 2030 Transportation Plan investment levels. The study team used the previously developed safety investment schedule and returns to estimate the returns to specific investment levels in the 2030 Transportation Plan. This required updating the economic loss information to the most recent NSC study of the economic losses of crash events and adjusting for the recent passage of the .08 BAC law, which also reduced the returns to other available safety investments.

Application to local roadways. The study team applied findings to local roadways based on levels of funding and outcomes.

Issues

BBC faced several issues in estimating the returns to safety investment:

- Avoided economic losses of safety investments are based on national cost estimates that may differ from Colorado savings due to our unique economy;
- Lack of individual engineering project costs at specific accident locations;
- Inability to account for all behavioral factors involved in crashes;
- No urban versus rural differentiation of seatbelt non-use;
- Specific safety investments across the next 25 years will likely differ from those examined in this study; and

- Inability to account for safety improvements from further investment in public transportation in Colorado Springs and Denver.