CHAPTER ONE
INTRODUCTION

Washington State, in partnership with Amtrak, Oregon, Burlington Northern Santa Fe Railway and others, is incrementally upgrading intercity passenger rail service along the Pacific Northwest Rail Corridor (PNWRC). This rail corridor stretches 466 miles from Vancouver, British Columbia to Eugene, Oregon. The state's ultimate goal is to provide fast, frequent, safe and reliable intercity rail passenger service that requires no operating subsidy.

This report provides insights and answers to some crucial questions:

Should we invest in intercity passenger rail service?
How much will it cost?
How will we pay for it?

The State's vision for passenger rail in the Pacific Northwest extends over a twenty-year horizon. The vision is being implemented through an incremental approach; that is, service is being increased over time based on market demand, available partners and legislative funding.

The vision for faster and better passenger rail service in the Pacific Northwest began in the late 1980s when the Washington State legislature funded a program to improve rail depots across the state. A few years later, in 1991, the Washington State Legislature directed (SHB 1452) the Washington State Department of Transportation (WSDOT) to develop a comprehensive assessment of the feasibility of developing a high speed ground transportation system in the State of Washington.

In October 1992, the High Speed Ground Transportation Study was delivered to the Governor and the legislature. This study confirmed the feasibility of developing high speed rail in the region.

Following release of the study in April 1993, WSDOT was directed (RCW Chapter 47.79) to develop "high-quality intercity passenger rail service ... through incremental upgrading of the existing [Amtrak] service." Additional studies and analyses have been conducted as Washington State and their partners proceeded to implement improvements to existing Amtrak service.

By using an incremental (step-by-step) approach to implement higher speed service, a logical progression of infrastructure investment, service frequencies, and performance are guided by market demand. The legislature believed that this step-by-step approach would help to build a "rail culture" in the region that would eventually make rail a competitive and viable alternative to automobile and commuter air travel.

PURPOSE OF THIS ANALYSIS

The purpose of this economic analysis is to objectively analyze whether passenger rail remains a competitive and viable transportation alternative. This economic analysis employs a methodology called "cross-modal analysis". This analysis is not intended to address all of the issues regarding transportation costs and investments. It is merely aimed at establishing a framework to compare different intercity transportation systems. It is not a cost-benefit or cost-effectiveness analysis.

The purpose of this cross-modal analysis is to compare the monetary and societal costs of each mode of transportation within a consistent framework. Such a comparison allows policy makers the opportunity to determine the degree to which the public obtains benefits from their investment.

This report provides insights and answers to some crucial questions:

Should we invest in intercity passenger rail service?

The full costs of transportation – regardless of mode – are often overlooked. Many hidden costs (impacts) result from our intercity trips, such as air pollution and degradation of our water quality. As such, decision making for investment into different transportation modes is often skewed. Chapter 2 of this report examines the three primary modes of intercity travel – air, highway and rail -- and compares the operational and societal costs of each. The analysis presents the relative merits of rail so that policy makers can answer the question, *Should we invest in intercity passenger rail?*

How much will it cost?

Chapter 3 of this report presents the most recent capital and operating cost estimates for passenger rail infrastructure investment. These costs are presented in context with and compared to currently planned investments for both highway and air.

How will we pay for it?

Past and current partnerships and programs that have contributed to passenger rail improvements are discussed in Chapter 4. Potential funding sources are also identified.

CHAPTER TWO
WHY INVEST IN PASSENGER RAIL?

Intercity passenger rail has seen a resurgence in popularity over the past decade. While Europe and Asia have continually invested in their passenger rail systems, the United States began "disinvesting" decades ago. The popularity of the automobile in the 1950s and the increased availability of air travel contributed to passenger rail becoming a novelty.

> *Results reveal that passenger rail service is, using the most conservative approach, comparable to both air and highway travel.*

However, in the early 1990s, federal and state legislators began recognizing the benefits of passenger rail.[1] As such, states around the country, including our state, have begun planning and implementing passenger rail programs.

However, as with any new program, there has been some local and regional skepticism as to whether passenger rail is a good investment. This chapter presents a framework for policy makers and the public to compare the many costs of intercity travel to ultimately decide whether it makes sense to invest in passenger rail.

RAIL MAKES SENSE…A CROSS-MODAL COMPARISON

Transportation planners and economists use a technique known as a cross-modal analysis to compare different types (modes) of transportation systems and identify their operational and societal costs (impacts).

When these methods are applied to intercity passenger rail in the Pacific Northwest Rail Corridor, results reveal that passenger rail service is comparable to both air and highway travel. This approach reveals that by 2015 rail costs amount to $0.63 per passenger mile, while highway travel is estimated to cost $0.78. Adding in the value of time and external costs, rail is revealed as an even more competitive choice. This approach reveals that by 2015 rail costs amount to $0.97 to $1.27 per passenger mile, while highway travel is estimated to cost $1.42 to $1.79 per passenger mile.

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[1] Some key legislation that has prompted WSDOT's implementation and investment in the passenger rail program includes:

- SHB 1452 (1991) directed the Washington State Department of Transportation (WSDOT) to develop a comprehensive assessment of the feasibility of developing a high speed ground transportation system in the State of Washington.
- Section 1010 of the Intermodal Surface Transportation Efficiency Act (ISTEA) required that the U.S. Department of Transportation designate five high speed rail corridors that would be eligible for federal matching funds. In 1992, the PNWRC was selected as one of the five corridors.
- RCW Chapter 47.79 (1993) directed WSDOT to develop "high-quality intercity passenger rail service ... through incremental upgrading of the existing [Amtrak] service."
- The 1994 the federal Swift Rail Development Act was adopted to provide additional federal funding for research, development and demonstrations for high speed rail technology.
- The recently passed federal Transportation Equity Act for the 21st Century (TEA 21) allocates funding for high speed rail programs and improvements.

While the results may seem simple, developing a framework to compare the different transportation modes is difficult.

What Makes the Comparison So Difficult?

Overcoming the many substantial differences among rail, highways and air travel is a significant challenge. The most substantial areas of difference include:

Travel markets served
Each mode serves different travel markets.

- Commercial airlines serve an intercity function linking larger urban areas.
- Highways serve a number of markets, with most of the demand coming from regional and commuter trips.
- Passenger rail serves intercity demand, including linking smaller urban areas not served directly by air service and potentially meeting the demand for some regional and even commuter trips.

Service delivery
The way in which service is provided also varies significantly among the modes.

- Air service is provided by a combination of private for-profit commercial air carriers and public entities responsible for terminal development and operation.
- Highway trips combine the "free" use of public facilities with privately owned and operated vehicles.
- Passenger rail service is generally provided by public or not-for-profit entities, using privately-owned railroad tracks built for handling freight.

Source of funding
The mechanisms and responsibility for paying for the cost of service also varies widely.

- In general, commercial air service is fully supported by users through air fares and airport charges, though significant federal funds have been expended on airport facilities and the air traffic control system.
- Highway use is also generally supported by user charges including federal and state gas taxes, motor vehicle excise tax (MVET), and private funding of auto operation, although general tax funds have also been targeted to support this mode, such as the property tax road levy used for county arterials.
- Passenger rail is partially supported by user charges and usually requires the use of general or transportation tax revenues for operating and capital support. In some cases user charges are sufficient to meet operating cost requirements, but seldom adequate to pay the cost of capital. This has been the principal barrier to the development of a modern, private passenger rail industry.

Maturity of the Market
The markets for highway use and air travel are both mature markets and involve well-established transportation choices in the minds of the general public. In contrast, passenger rail in the Pacific Northwest Corridor is being restarted as a viable intercity mode and, to a large extent, the general public doesn't even think of train travel when making intercity transportation choices. Today, passenger rail service is in many ways analogous to a new product entering a competitive market and as such will probably take some time to build its market share.

General Approach

When asked to consider the full costs of transportation, most people would readily identify both the private and public expenditures[2] that support each travel mode. Far fewer individuals would consider the important role that travel time[3] and external costs[4] have in determining overall costs. Because these latter elements do not require out-of-pocket expenditures by either private or public groups, they are frequently overlooked. However, the hours dedicated to travel represent time lost for either work or leisure, and the external costs associated with air pollution, noise impacts, and accident losses are important policy considerations that should not be ignored.

> *The hours dedicated to travel represent time lost for either work or leisure, and the external costs associated with air pollution, noise impacts, and accident losses are important policy considerations that should not be ignored.*

What Does This Analysis Measure?

The analysis takes the out-of-pocket expenditures of operations together with the less obvious costs associated with intercity travel, and groups them into three areas. The analysis identifies the three distinct cost components as:

- direct operating costs;
- cost associated with travel time; and
- the cost of externalities.

These elements focus on the direct and indirect annual costs of intercity travel by mode.[5]

How Do We Compare The Different Modes?

After identifying the elements that will be compared, it is next necessary to identify a measurement that can be used for all modes. Since each mode relies on a different form of travel – highway travel consists of using personal cars and either driving alone or with passengers; airplanes travel in the air and can carry as many as hundreds of passengers; and trains travel on tracks and also carry hundreds of passengers – finding a uniform measurement is critical.

Economists and transportation planners have agreed, that in order to put different modes on "even playing fields", a common measurement often used, is known as a "passenger-mile". Passenger-miles offer a consistent measure of total system usage.

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[2] Such expenditures often include the costs associated with maintaining and operating the facility, often referred to as operational costs.

[3] Travel time simply refers to the amount of time it takes to get to your destination.

[4] External costs refer to the elements of your trip that aren't "out-of-pocket" expenses. These are often invisible expenses usually associated with the human environment, such as the impact to our air and water quality as a result of emissions and run-off from our transportation systems.

[5] Another direct cost, capital cost, is discussed in Chapter 3 of this report. The approach of separating capital and operating costs will allow for a direct comparison among the modes without the potentially distorting effects of the current capital costs, since passenger rail service is currently a relatively minor element in the intercity travel market, there is substantial investment required to bring it into a competitive position in terms of service frequency and travel time. The other two modes are well established and require less infusion of capital.

A passenger-mile is determined by taking the total number of passengers (in the plane, train, or in a car) and multiplying that number by the total number of miles traveled. That number of total passenger-miles is used to calculate cost per passenger-mile – the total component cost (i.e. yearly airport operational costs) is then divided by the yearly total passenger-miles. Exhibit 2-1 highlights the process and data sources for developing passenger-miles.

Exhibit 2-1
Calculating Passenger Miles

Rail

Current/Projected Annual Miles Traveled
Existing/Projected Ridership
Source: PNWRC Operating Plan, 1997

Automobile

Current/Projected Vehicle Miles Traveled * Average Vehicle Occupancy (1.4 persons per Vehicle)
Source: WSDOT, 1998

Air

Current/Projected Trips Between Each City Pair * Distance Between City Pairs
Source: FAA Enplanement Projections, 1998

TECHNICAL METHODOLOGY

The analysis is presented in "step-wise" fashion that highlights how each of the components affects the relative advantages of each mode.[6] After focusing first on the direct costs associated with out-of-pocket expenses, the analysis proceeds to incorporate the costs associated with travel time on intercity facilities, and then adds the external costs estimated for each mode. The Bibliography presents a list of studies used in the travel time and external cost analyses. The final outcome of the analysis is a comparison of all three components among the three modes of intercity travel.

Step One: Comparison of Direct Operating Costs

For this analysis direct operating costs are defined to include the expenses required to cover the variable costs of travel and the regular maintenance of all facilities associated with each travel mode. Excluded from this component of costs are all capital expenses associated with building or expanding the infrastructure needed for each mode. Below, the operating costs for each mode are first reviewed separately and then included in a general cross-modal comparison.

Assumptions

This component of total costs is designed to reflect the direct operational and maintenance costs that are associated with each mode of transportation. These are largely costs incurred directly by the user, but also include expenditures for the operation and maintenance of required facilities, both public and private. These costs are sometimes paid directly by the user, but are frequently supported by government subsidies. For example, for rail travel the estimate of direct operational costs includes all required operations and maintenance expenses, not just the portion that is covered by passenger fares. In addition, the costs associated with the preservation and maintenance of Interstate 5, Interstate 405, Interstate 205, State Route 512, and State Route 167 are a component of the direct operating costs for the auto mode of travel. Other operational costs such as insurance, vehicle, maintenance, building security, etc. are

[6] It is important to note that the analysis is based on the estimated use of the facilities and not on the basis of the facility's total capacity. This is due to the fact that each mode serves different markets and capacity can be defined differently for each mode. Though it could be argued that the availability of unused capacity has some value, it is not likely to be equivalent to the value of meeting actual travel demands.

totaled and apportioned on a per passenger mile basis.

Data Collection
A review of the existing literature provides supporting documentation for some of the less quantifiable cost elements, which, when combined with local mode-specific cost data, provides enough material to establish reasonable upper and lower bounds for each of these components of cost. Specific sources of information can be found throughout the analysis and in the Bibliography located at the end of this report.

Highway Direct Operating Costs
The analysis of highway travel costs has three major elements:

- the expenses associated with maintaining existing facilities (roadways);
- the cost of vehicle ownership and operation; and
- the costs of parking.

Facility Maintenance Costs
The analysis of highway maintenance costs is based on data for the portion of the Interstate 5 corridor that is located in the State of Washington. This includes Interstate 405, Interstate 205, State Route 512, and State Route 167. The data are taken from the recently completed Washington State System Plan and cover the period 1999-2018. Maintenance costs include all expenses associated with pavement preservation and general highway upkeep. These costs amount to $389 million and $314 million respectively in constant 1998 dollars.

To facilitate analysis of costs on a year-by-year basis, these costs were spread evenly over the 20-year period and escalated to current dollars. The cost of new and rehabilitated facilities is discussed later in the capital investment section.

Passenger miles were then calculated based on the projected number of vehicle miles that will be traveled along the corridor during the years 1998-2000. Estimates of total vehicle miles were converted to total passenger miles using WSDOT's assumption that occupancy averages 1.4 persons per vehicle. Cost per passenger mile were then calculated by dividing the annual cost by passenger miles for each year in the study horizon. The tables presented in Appendix A summarize these calculations.

Vehicle Ownership Costs
The costs of vehicle ownership were taken from the American Automobile Association's (AAA) 1997 publication "Your Driving Costs". The AAA analysis estimates the fully burdened cost of owning and operating several different types of vehicles. Based on an assumption that the automobiles are driven 15,000-20,000 miles per year and replaced on a 4-6 year/60,000 mile cycle, estimates are provided for the costs of fuel, oil, maintenance, tires, insurance, license/registration and capital depreciation.

For cars driven 15,000 miles per year, these costs range from $0.384 to $0.522 per vehicle mile. The lower end of this cost range corresponds to the cost of operating a compact Chevrolet Cavalier, while the upper end reflects ownership costs for a 2-door sport utility vehicle.

Of course, a significant number of car-owners hold their vehicle for more than 4 years, and the operating cost for these cars could differ from the range noted above. As a car ages, deprecation and insurance costs decline, but repair and maintenance costs increase. To develop operating cost estimates for older cars would require detailed information about how repair costs change through time, how depreciation affects older cars, and how insurance premiums are adjusted as a car grows older.

Data on these elements of operating costs are not readily available and it was not possible to develop specific cost estimates for older cars. However, the limited information that was found on the subject, suggests that overall operating costs do not decrease significantly through time.

In a study completed by US Fleet leasing, which manages large fleets of automobiles, the average annual repair costs associated with operating a vehicle beyond 60,000 miles exceeded $0.35 per mile. Comparing this figure with the AAA costs which emphasize newer cars suggests that operations costs for older cars may not differ significantly from newer costs, and that the range of costs developed for AAA may be generally representative of average ownership costs for the overall fleet.

Given the increasing role of sport utility vehicles (SUV) and light trucks, a weighted average for operating costs was developed using data from the Bureau of the Census. According to Census statistics, approximately 61% of the vehicle registrations in the West are automobiles, 7% are vans, 8% are SUV's, 19.5% are pickups and 4% are listed as other, including other trucks, motorcycles and RV's. Thus a composite cost was developed using 61% of the average AAA car costs plus 39% of the average AAA costs for SUV's and minivans. The result is an assumed fleet average of $0.468 per vehicle mile which is escalated at the rate of general rate of inflation (4.0%), though car costs have been growing at a rate faster than inflation in recent years. This average cost per vehicle mile was converted into a cost per passenger mile using an estimate of average vehicle occupancy and added to the cost for facility maintenance. Appendix B presents specific data sources used in this analysis.

Parking Costs

While frequently ignored because it does not always represent an out-of-pocket expense for drivers, parking is an important component of total transportation costs. Even if drivers do not pay directly, parking lots are available because employers and commercial businesses cover the costs associated with land acquisition, paving, maintenance and security.

Estimates from the Puget Sound Regional Council (PSRC) suggest that within the overall Puget Sound region the cost of parking is approximately $1 billion per year, or approximately $0.04 per passenger mile based on total annual travel in the area.

The PSRC's focus on the Puget Sound Region and its urban/suburban characteristics might lead one to conclude that this figure might be unrealistically high to be applied to all travel throughout the I-5/I-405 corridor. However, the underlying assumption in the PSRC analysis is based on one additional parking space per vehicle and excludes the cost of providing residential parking. As a result, using this figure to extrapolate to the intercity corridor offers a reasonable estimate of an element of cost that is very difficult to quantify.

To add residential parking costs to this estimate one would need to make an effort to disentangle what portion of overall housing expenditures represent the costs of building and maintaining a garage or carport. As a proxy for these costs, Hare (1991) has suggested that the $50.00 per month fee charged to many apartment dwellers can be taken as lower bound for the estimate of residential parking costs. This implies a per passenger-mile cost of approximately $0.02 for residential parking. In turn, this implies that cumulative parking costs vary from $0.04 to $0.06 per passenger mile, depending on whether residential costs are included in the total. The lower end of this range is used in the current analysis.

Previous studies have suggested that costs could range from between $0.02 and $0.08 cents per passenger mile, so this represents a conservative estimate of parking costs. For the purposes of this analysis, the midpoint of the Puget Sound specific range is selected. Thus the assumed cost per passenger mile is $0.05, which attempts to capture both the residential and commercial requirements of parking. This cost was then added to come up with a total direct cost per passenger mile.

Air Travel Direct Operating Costs

The operating costs of commercial air travel are broken into two major components:

- the costs of operations and maintenance for the airport facilities; and
- the cost of providing the airline service between city-pairs in the PNWRC.

Separating costs into these components made it possible to identify both the private-sector costs associated with airline operations and the public-sector costs required for airport operations. The city-pairs selected for this analysis were: Seattle-Vancouver; Seattle-Portland; Seattle-Bellingham; and Vancouver-Portland. Appendix C presents back-up material used to develop costs for air travel.

Operations and Maintenance for Airport Facilities

Total airport terminal costs are based on estimates of airport revenues generated by the activities serving the air passenger market, such as parking fees and concession revenues. Since airports recover costs through user charges, including a portion of the cost of capital, it is assumed that airport revenues will be equal to the fully-allocated cost of providing airport facilities and services. Revenues that are not based on passenger activity, such as rental income from cargo operations, are excluded from the calculation of the passenger cost base.

The passenger cost base is then split into annual operating and capital components by subtracting debt service and cash-financed capital items for each of the airports. The remaining passenger-related operating costs are then divided by the projected number of enplaned passengers to arrive at an annual estimate of operating costs per enplanement.

Sea-Tac International Airport

Sea-Tac airport revenues are taken from the 1995 Master Plan and are based on capital, operating and use projections for the period 1996-2020. The capital improvements are estimated to be in excess of $2.0 billion (constant dollars) which includes the completion of the third runway. At this point of the analysis, only the costs of operating the expanded facilities are included. Capital investment requirements are discussed later in Chapter 3 of this report.

Vancouver International Airport

Airport costs for Vancouver International Airport were based on the current annual report and projections of future growth in enplaned passengers. Revenues and operating costs are projected to grow at an annual rate of 7.5%, which is generally consistent with the other airports reviewed for this study. Airport improvement fees are not adjusted for inflation, so this portion of revenues increases at the rate of projected passenger growth.

Portland International Airport

Portland International Airport cost projections were provided by the Port's Finance Department. Cost, revenue and enplanement projections were available through the year 2015.

Bellingham International Airport

Due to insufficient data regarding airport costs in Bellingham, the terminal cost element was estimated using the average of the other airports in the corridor. While this approach is not ideal, it does allow for a full comparison of all the major air travel markets.

Cost of Providing Airline Service

The city-to-city airline service (travel) cost is assumed to be equal to the commercial airline airfare. These fares should reflect each airline's operating costs such as the expenses associated with staffing, fuel, food, and maintenance and will also include the cost of capital and airline profit.

Selecting the correct airfare for use in the analysis poses a challenge since the mix of airfares on any particular flight or within a particular corridor is proprietary data that airlines will generally not share for competitive reasons. In addition, these variables are constantly in flux as a result of a number of factors including demand for travel and competition on particular routes. As a result, while airlines would like to achieve certain profitability goals for each route, the reality is that they attempt to optimize profitability throughout the system, balancing equipment utilization, market-share and profitability goals.

To estimate a reasonable average fare for each of the city-pairs in the corridor, a survey of current fares was conducted. A simple weighted-average for each flight was developed based on the following assumptions:

- Business travelers will book at least three days in advance, but will not travel with a Saturday stayover.
- Leisure travelers will book at least three days in advance and will travel with a Saturday stayover.
- The average fare for the flight is based on the estimated split among business and leisure travel and the respective fares for each.

Escalation of airfares is assumed to occur at 4.0% per year, which is equal to the rate of general inflation, which implies that competition in the commercial airline industry will result in continued emphasis on low to average fare levels. To avoid double counting, the revenues and fees charged to airlines for the use of airport facilities are subtracted from the reported airfares. These are accounted for in the estimate of airport facility costs and should be not be included in this part of the analysis.

Using airfares as a measure of city-to-city travel costs may overstate operating costs, and understate capital costs, because it treats the costs associated with aircraft as an operational rather than a capital expense for the airlines. However, this approach is consistent with our assumption that vehicle ownership costs should be considered a portion of operating costs for highway travel.

Total Costs per Passenger Mile

As described above, total city-to-city travel costs are made up of two components:

- The airport costs at either end of the trip; and
- The one-way airfare between the cities (half the round-trip fare).

The first component captures the costs associated with providing the airport and terminal services that are necessary to make air travel possible. The second portion reflects the actual costs associated with flying the aircraft and operating a private airline, including any profits derived from the service. The per-passenger-mile cost is determined by dividing the total city-to-city cost by the miles of travel.

For cross-modal comparison purposes, a corridor weighted-average is computed based on total travel among the city-pairs within the corridor. Based on statistics from the US Department of Transportation, approximately 66% of all air travel among the cities in the corridor is between Seattle and Portland. As a result, the weighted-average is significantly influenced by the cost of this segment. See Appendix D for a detailed description of this analysis.

> *By 2015 rail operating costs amount to $0.63 per passenger mile, while highway travel is estimated to cost $0.78 and air travel will be approximately $1.09 per passenger mile.*

Passenger Rail Direct Operating Costs

The operational costs of the proposed passenger rail program are taken from the Pacific Northwest Rail Corridor Operating Plan – Years 2003 and 2018. The costs are based on a program of improvements that will result in 4 round-trips per day between Vancouver and Seattle (currently 1 round-trip) and 13 round-trips per day between Seattle and Portland (currently 4 round-trips). In addition travel times will be reduced as a result of facility improvements in the corridor, increasing the competitiveness of the train service relative to the other modes. Seattle to Vancouver transit time is to be reduced by one hour, from approximately four hours to three hours. Seattle to Portland will improve by one hour, from the current three hours and thirty minutes to two-and-a-half hours.

Operating costs, as part of these overall figures include:

- the costs of operations and maintenance for rail facilities and stations; and
- The cost of providing rail service within the corridor.

Ultimately, these operating costs will be covered through ticket revenues. However, at this point in the analysis, it was not important to identify the exact source of operating revenues or to determine what portion of operating costs will be reflected in train fares. For the cross-modal comparison of costs it is only necessary that the estimates of total operating costs fully reflect all anticipated expenditures. Chapter 3 of this report provides more detailed information regarding the operating costs for passenger rail.

Total operating costs, expressed in 1997 dollars, are projected to increase from $22.6 million to approximately $72 million at buildout. These operational cost estimates have been escalated to current year dollars using an inflation factor of 4.0%. Cost data were not separately reported for every year of rail operation, but have been extrapolated from the available information, as necessary. As noted previously, the operating cost estimates exclude all expenditures targeted for one-time capital expenditures.

Conclusions

Exhibits 2-2 and 2-3, on the following page, compare the direct operating costs for each mode. These results reveal that on an operating basis, passenger rail service is comparable to both air and highway travel and by the end of the period is actually the lowest of the group.

By 2015 rail costs amount to $0.63 per passenger mile, while highway travel is estimated to cost $0.78. Moreover, these results focus only on out-of-pocket expenses and ignore the potential costs associated with travel time and externalities. The results for air travel confirm that air is most competitive on longer trips, and most of the travel in this corridor is too short to maximize this advantage. Appendix E contains full documentation and back-up information for these graphs.

Exhibit 2-2
Comparison of Direct Operating Costs
($ per passenger mile)

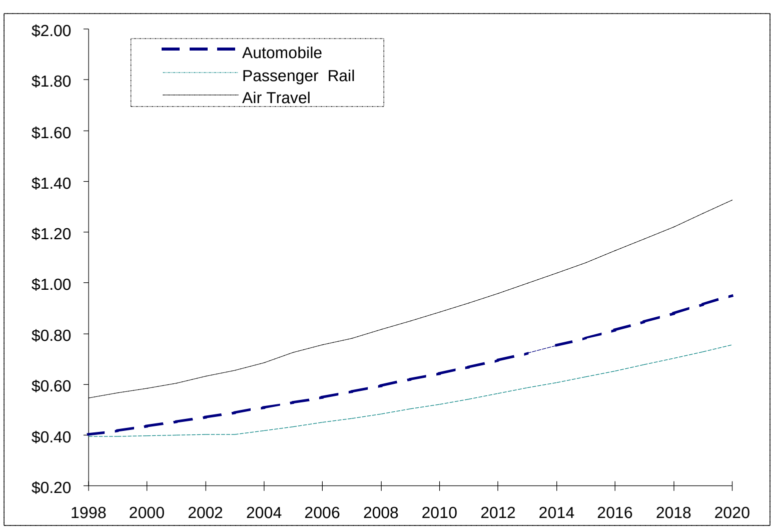
Year	Automobile	Passenger Rail	Air Travel
1998	$0.40	$0.39	$0.55
2000	$0.43	$0.40	$0.59
2005	$0.53	$0.43	$0.72
2010	$0.64	$0.52	$0.88
2015	$0.78	$0.63	$1.08
2020	$0.95	$0.75	$1.33

Source: Berk & Associates, 1998.

Step Two: Comparison of Travel Time

In addition to any direct out-of-pocket expenses, travel requires a significant commitment of time. Travel time has an implied cost because time spent in transit represents forgone opportunities for work or leisure. Although some individuals enjoy the process of travel and others are able to work while on the move, most people find that travel time is unproductive and often stressful or uncomfortable. Given that both the quantity and quality of travel time differs across modes, an accurate cross-modal comparison of costs must include a formal analysis of the opportunity cost (amount lost) associated with the time spent traveling.

Exhibit 2-3
Comparison of Direct Operating Costs
($ per passenger mile)



The challenge posed by including time in the current cost comparison is that qualitative observations about travel time must be translated to quantitative estimates of value.

Economic theory provides some insight into how estimates might be developed. For travel that occurs while on the job, or that directly reduces the hours available for work, economists recognize that an individual's wage rate provides a reasonable basis for measuring the opportunity cost of time. The wage rate reveals how an employer values the productivity of each worker and reflects the value of lost work time. Of course, every hour spent commuting or in other business related travel might not represent an hour that would otherwise be spent at work, so valuation at the full wage rate might not be appropriate.

Travel time has an implied cost because time spent in transit represents forgone opportunities for work or leisure.

As a result, to avoid overstating the value of travel time, the opportunity cost of work-related travel is often measured as some fraction of average hourly wage.

Developing Time Costs by Mode

Time spent in transit imposes costs on drivers and passengers alike, because travel time represents hours lost from work or leisure. Depending on the mode selected, transit time will imply somewhat different sacrifices in terms of productive or leisure time. Within the existing literature several different methodologies have been proposed for estimating the value of travel time.

Using the full wage rate to value the opportunity cost of travel time also assumes that travel time is wholly unproductive, but such an assumption cannot be equally applied to all modes of transportation. Research indicates that time spent in different modes of travel is not valued equally. For example, estimates derived by Waters (1992) for the British Columbia (B.C.) Ministry of Transportation indicate that time spent on a bus or as a passenger in a car pool is generally regarded more favorably than time spent behind the wheel of an automobile. This particular study recommended that the opportunity cost associated with travel as a passenger be assigned an opportunity costs that is only 70 percent of the value associated with being a driver. The lower opportunity cost associated with being a passenger is linked to the possibility of enhanced productivity and reduced discomfort as compared to driving. Extending these results to air and train travel suggests that the time spent on these modes should also be valued differently than time spent driving. Using the proportions developed for the B.C Ministry of Transportation, such an approach is adopted in the current analysis.

In the results presented below, time spent as an airline or rail passenger is assumed to have an opportunity cost equal to 70 percent of that associated with driving an automobile for work-related trips.

Work Related vs. Leisure Related Travel Time

A significant amount of travel occurs outside of work and is associated with personal errands and other leisure time activities. For this type of travel, the hours spent in transit still have an opportunity cost because they represent time lost to other tasks. Estimates for the value of this time have been developed from studies that compare how individuals make trade-offs between their work and leisure time.

Frequently these studies find a relationship between increasing income levels and increasing values of leisure time. As a result, estimates for the value of leisure-related travel time are also quoted as a fraction of income or wages. The Studies by Litman (1997), UCB-ITS (1996), and Apogee (1994) provide a thorough review of such results.

For analyses that make a distinction between work and leisure related travel time, work time is generally assumed to have an opportunity cost that is twice that of leisure related travel. This ratio is used in this analysis for all three intercity travel modes. As noted above, the current analysis also adopts the assumption that time spent traveling as a passenger has an opportunity cost that is lower than time spent as driver. For both work and leisure time, this lower value is used in estimating the opportunity cost of automobile passengers and for all those who travel by rail or air. (Appendix F provides a more detailed explanation of how the value of travel time was estimated for each mode.)

In addition to time spent traveling between cities, there is a necessary time commitment required at either end of a rail or an air trip.

Estimated Opportunity Cost of Travel

Rather than produce a single estimate for the opportunity cost of travel time, the cost estimates used in this analysis establish a range of potential values. This range reflects the varying approaches taken within the existing literature on the subject, and allows one to compare how different valuation methods can influence the overall analysis of transportation costs.

Exhibit 2-4, on the following page, summarizes the two sets of assumptions that are currently employed for estimating the opportunity cost of travel time. The estimated wage that underlies both sets of estimates reflects a population-weighted average for the nine counties of Western Washington that contain the I-5/I-405 corridor (see Appendix F for detailed breakdown).

Assumptions Used for Travel Time Estimates

Regardless of which cost assumptions are used, the overall impact of travel time on the cross-modal analysis depends on four additional factors. The following presents an overview of these factors.

Speed of Travel

First, the speed of travel will have a significant role in the total time commitment required for travel by any particular mode. As average speeds change through time (increasing for rail, decreasing for auto, constant for air) the average time cost per passenger mile will also change. For the current analysis, highway speeds were computed as a weighted-average of current urban and rural speeds, where the weights reflect the proportion of vehicle miles traveled in each area.

In projecting future speeds, it was assumed that urban traffic would continue to slow at the current rate of one percent per year, but that rural speeds would remain unchanged into the future. Rail speeds reflect the operation projections contained in the Pacific Northwest Rail Operating Plan – Years 2003 and 2018. Airline flight times are assumed to remain constant over the period of this study, so current flight times are taken as a prediction of future travel times.

Proportion of Work and Leisure Travel

Estimates of time-related costs are affected by the relative proportion of work and leisure travel predicted for each mode. Business

Exhibit 2-4
Cost Estimates for the Value of Travel Time
($ per hour)

	Value of Time	Automobile Driver	Automobile Passenger	Airplane	Rail
Low Cost Estimate					
Work-Related Time	Value = 50% of Wage Rate	$6.88	$4.81	$4.81	$4.81
Leisure Time	Value = 25% of Wage Rate	$3.44	$2.41	$2.41	$2.41
High Cost Estimate					
Work-Related Time	Value = 100% of Wage Rate	$13.75	$9.63	$9.63	$9.63
Leisure Time	Value = 50% of Wage Rate	$6.88	$4.81	$4.81	$4.81

related-travel has a higher opportunity cost than leisure travel. Therefore, as the share of business passengers increases, the average costs per passenger mile will also increase. This latter effect will be important for rail, because the current operations analysis indicates that increased speeds will attract an increasing share of business travelers.

Terminal Time

The third factor affecting the indirect costs of time spent traveling is the estimated terminal time for each mode. In addition to time spent traveling between cities, there is a necessary time commitment required at either end of a rail or an air trip. The Washington State High Speed Ground Transportation Study estimated terminal times for the major airports in the corridor based on allowances in scheduled connecting times, including an allowance for boarding time. The terminal time for rail service was assumed to be a total of 18 minutes at each end of the trip.

Time Spent on Intercity Facilities

It is also worth reiterating that the travel time projections that underlie these cost estimates only consider the cost associated with the time spent on the intercity facilities. For example, the time cost calculations for air travel are based on average flight time plus the appropriate terminal time at either end and do not include the estimated time required to/from the airport at either end of the trip.

While a true comparison of the total time cost of any individual trip would also include the time required to access the intercity facilities, quantifying this additional trip segment poses several significant challenges, including:

- *Data requirements*. The first is the lack of consistent origin and destination data for all three modes considered in this analysis.

- *Double counting costs.* Accessing Sea-Tac International Airport via I-5 for an airline trip to Portland would already be counted in the highway cost analysis.

- *Internal consistency in modal cost estimates.* The direct costs for each mode are based only on the portion of the trip that takes place on the intercity mode under consideration. Thus to maintain a consistent basis of comparison the indirect costs should be similarly defined.

As a result, it was determined that the approach offering the fairest and cleanest point of comparison was to limit the comparison to the intercity segments of each trip. Exhibit 2-5 highlights how both speed and the mix of passengers will affect the average costs associated with travel time on each mode. These cost estimates have been adjusted to reflect an assumed 4.0% rate of inflation.

Methodology

The following steps were used to convert hourly travel time rates by mode into the final estimates of cost per passenger mile:

- Calculate total travel time per passenger, including the time spent at intercity facilities. Travel times reflect the differences in speed among the various modes and how speeds are anticipated to change over the next 20 years.

- Estimate the value of travel time for both business and leisure travel.

- Weight the relative costs of business and leisure according to the share of each type of travel that occurs on each mode.

Exhibit 2-5
Comparison of Travel Time Costs
($ per passenger mile)

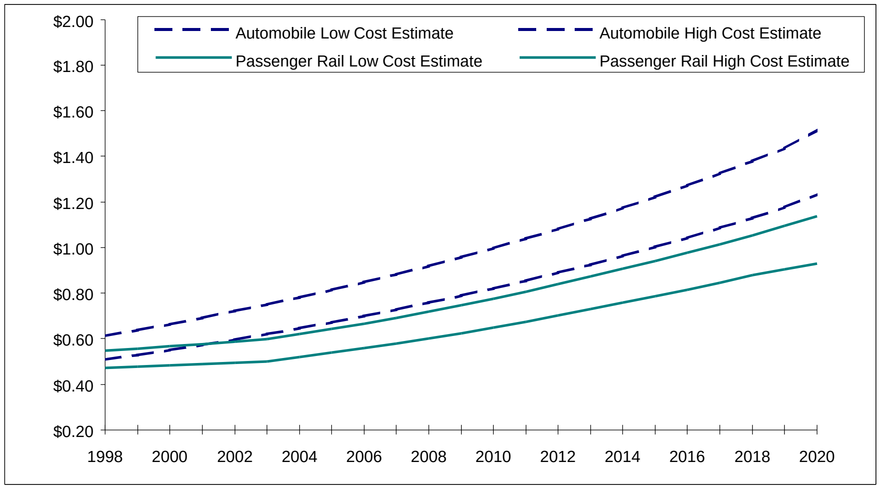
Year	Automobile		Passenger Rail		Air Travel	
	Low Cost Estimate	High Cost Estimate	Low Cost Estimate	High cost Estimate	Low Cost Estimate	High Cost Estimate
1998	$0.11	$0.21	$0.08	$0.16	$0.07	$0.15
2000	$0.11	$0.23	$0.09	$0.17	$0.08	$0.16
2005	$0.14	$0.29	$0.11	$0.22	$0.10	$0.19
2010	$0.18	$0.35	$0.13	$0.26	$0.12	$0.23
2015	$0.22	$0.44	$0.16	$0.32	$0.14	$0.28
2020	$0.28	$0.56	$0.18	$0.40	$0.17	$0.33

Source: Berk & Associates, 1998.

- Divide the total time costs by the mileage associated with each type of trip to convert costs to a per mile basis.

Appendices E and F demonstrate how these steps were used to estimate the travel costs associated with each mode.

Exhibit 2-6
A Cost Comparison Including Direct Operating Costs and Time Costs
Highway vs. Rail Travel ($ per passenger mile)



Travel time costs for rail are relatively low when compared to highway travel. This advantage for rail results from the high percentage of total highway travel that occurs during urban commuting hours, when average speeds are low. The time cost advantage for rail is predicted to increase in the future because congestion will force urban travel speeds down while rail service is improving.

Conclusions

Adding time costs to the earlier analysis of direct operating costs per mode results in a slight shift in modal advantage. The analysis of direct operating costs revealed that auto, air, and rail were essentially comparable, but including time costs reveals a relative advantage for air and rail.

As highway speeds decrease and rail speeds increase, rail travel emerges as a strong competitor to automobile travel. Although the cost estimates for auto and rail travel are comparable in the earlier years of analysis, Exhibit 2-6 demonstrates how costs begin to diverge as rail service is developed.

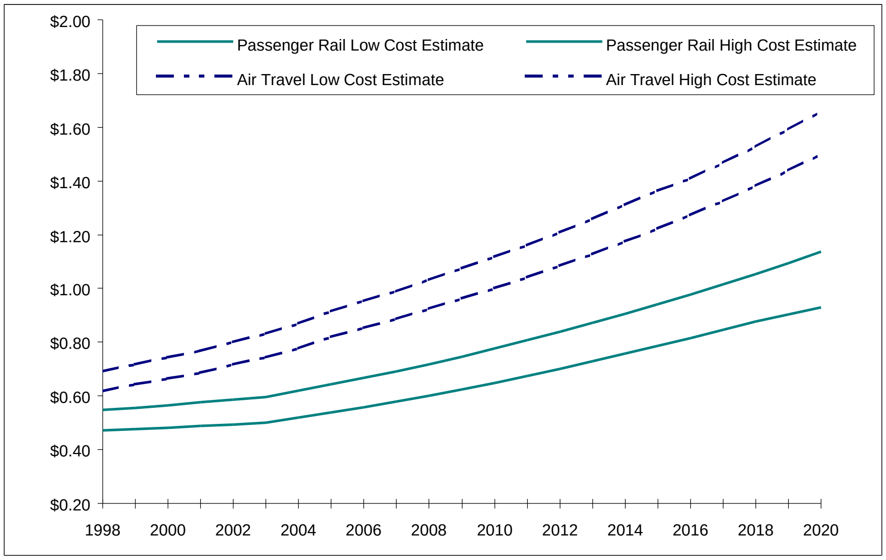
The magnitude of external costs can be large and their impacts vary from one mode to another.

While travel times are shortest for air, the higher terminal times result in rail travel times gradually moving within the estimated range for air service. Exhibit 2-7, on the following page, illustrates these differences. Appendix E contains full documentation and back-up information for these graphs.

Step Three: Comparison of External Costs

The term externality or, "external costs", is used by economists to describe an unintended consequence or indirect effect that is created by some activity. The costs associated with these unintentional actions are not directly charged to any specific individual, but are borne by society as a whole. The negative health impacts associated with air pollution are a classic example of such an externality. Although the travel by air, car, or rail creates air pollution

Exhibit 2-7
A Cost Comparison Including Direct Operating Costs and Time Costs
Air vs. Rail Travel ($ per passenger mile)



impacts, riders are not charged for their contribution to decreasing air quality.

Many previous studies have focused on examples such as this, and attempted to measure external costs associated with pollution and environmental degradation. These studies point out that excluding such costs from cross-modal comparisons can lead to misleading conclusions, because the magnitude of these costs can be large and their impacts vary from one mode to another.

In comparing external costs across modes, one should recognize that the magnitude of external effects has been changing over time. In recent years, many environmental impacts have been converted to direct costs as environmental legislation has forced users to more fully bear the costs of their activities. For example, automobile-related air pollution has been reduced by legal constraints that have forced automobile manufacturers to equip cars with more sophisticated emission control systems. In this sense, some portion of the costs that were formerly external to the user have been "internalized" and converted to a direct, out-of-pocket expense. This implies that older studies of external costs will tend to overstate the current magnitude of such effects. For this reason, the cost estimates we have drawn from the existing literature generally rely on research conducted within the past 5-10 years.

External costs are not limited to environmental issues. The accidents associated with each type of travel also impose costs that are not fully borne by the user and thus represent another significant externality. Although insurance premiums effectively internalize a portion of accident-related costs, some types of losses are not covered by insurance. Time lost from work is often not recoverable and the pain and suffering of accident victims and their relatives may not be fully compensated. These types of external costs are also included in the current cross-modal comparison.

Methodology for Developing External Costs

The existing studies of external costs generally adopt a two-step approach toward the difficult task of developing cost estimates for each externality. The first step involves a review of data that describe the link between the use of each transportation mode and the level of air pollution and noise. This link relies on engineering studies of emissions or on statistical data specific to each mode. In the second stage, an economic value or cost must be associated with each externality. Estimates of these costs are derived from direct assessments of damages or by measuring the costs of mitigating potential impacts. This same basic methodology was applied to the current analysis of the external costs associated with air, highway, and rail travel.

> *Fossil fuels generate by-products that have both immediate and long-term impacts on the environment and human health.*

Similar to the approach adopted in the analysis of travel time, estimates for external costs are presented as range of values. Reporting external costs with a single point estimate, rather than a range of values, would overstate the precision to which such costs can be measured. The following discussion provides an overview of the existing research in this field and describes the work that underlies the current estimates of external costs. Most previous analyses have been conducted as part of cross-modal analyses of total costs. As a result, estimates were either reported or easily converted to costs per passenger mile. The final estimates of total external cost reflect the individual contribution of the following factors:

- Air Pollution,
- Noise Pollution,
- Water Pollution,
- Waste Disposal, and
- Accidents.

Air Pollution

Among the potential environmental impacts, air pollution is generally thought to be associated with the largest external costs. Fossil fuels generate by-products that have both immediate and long-term impacts on the environment and human health. As noted above, measures of the external costs of air pollution rely both on models that predict the level of vehicle emissions and on separate estimates of the costs associated with the resulting levels of air contaminants. The estimates presented here have been developed by integrating the most reliable information on emissions with the best data on costs and damages.

Emission Levels

Focusing first on emissions, the most frequently cited estimates of automobile emissions were developed by Small and Kazimi (1995) for an academic study of automobile pollution in Southern California. Their figures relied on existing engineering models, but were calibrated to match data on observed levels of air pollution. The engineering models used in their work have served as the basis for previous analyses (Apogee (1994)), but their efforts to adjust the model's results to match observed levels of pollution added to the credibility of their conclusions. Their final results, which are summarized in Exhibit 2-8, on the following page, provide the basis for our analysis of automobile emissions.

The literature search also produced comparable emission estimates for air and rail travel. The most detailed estimates available for airplane emissions were provided by the University of California's Institute of Transportation Studies (UCB-ITS) 1996 cost analysis for the San-Francisco-Los Angeles-San Diego travel corridor. Emission estimates for rail travel were drawn from the cost analysis completed in 1993 by Miller and Moffet for the National Resources Defense Council (NRDC). To allow for a direct comparison across modes, Exhibit

Exhibit 2-8
Estimates of External Costs
($ per passenger mile)

EXTERNAL COST	*Automobile*	*Airplane*	*Rail*
Air Pollution	$0.031-$0.058	$0.003-$0.004	$0.014-$0.028
Noise Pollution	$0.001-$0.006	$0.002-$0.016	$0.001-$0.004
Water Pollution	Mitigation Included in Direct Costs	Mitigation Included in Direct Cost	Mitigation Included in Direct Costs
Solid Waste Disposal	$.001	N/A	N/A
Uninsured Accident Losses	$0.040-$0.045	$0.002-$0.003	$0.001-$0.032
Total	**$0.073-$0.110**	**$0.007-$0.023**	**$0.016-$0.064**

2-9 presents emission rates for all three modes on per passenger mile basis.

It must be noted that a critical factor has not been calculated into these emissions factor: the PNWRC will be utilizing new locomotives that have improved, state-of-the-art computer-controlled fuel injection systems. These locomotives are currently being used in San Diego and have exhibited emission levels below California's tough air quality standards.

These data on emissions were then combined with detailed estimates of the costs associated with direct health impacts and the potential impacts of climate change. These separate effects are described in detail, below. Detailed calculations are presented in Appendix G.

Health Impacts Due to Air Pollution

Small and Kazimi (1995) also offers the most compelling analysis of potential health impacts. The results of this work were cited by several studies that followed, including both UCB-ITS (1996) and Litman (1997). Focusing on effects in Southern California, they assessed both the illness (morbidity) and death (mortality) that could be attributed to tailpipe particulate and ozone emissions. The cost estimates they

Exhibit 2-9
Emission Rates - Grams per Passenger Mile

	Automobile	*Airplane*	*Rail*
CO_2	250	160	230
Volatile Organic Compounds	2.68	.145	.160
CO	16.4	.461	.600
NO_x	.900	.209	.900
Particulate Matter	.008	Not Available	.080
Road Dust	.879	Not Applicable	Not Applicable
SO_x	.027	Not Available	.051

Source: Small and Kazimi (1995), UCB-ITS (1996), NRDC (1993) developed reflect the increased expenditures on health care, the value of lost work time, and the number of deaths that can be attributed to each component of vehicle emissions. These results, summarized in Exhibit 2-10, on the following page, were the basis for the cost estimates applied to all travel modes in the current study.

The variation between the low and high cost estimates is driven by differing assumptions about the monetary value of the human lives lost to air pollution. The lower estimate of cost corresponds to a value of $2.1 million per life, while the higher estimate is driven by an assumption that an average human life has a value of $4.3 million.

While it may seem stark in its implications, placing a value on human life is an essential component of measuring the magnitude of external costs. If the increased mortality risks associated with pollution are not quantified, then the full costs of each mode will be systematically understated. Economists have adopted several different approaches to developing an estimate for the value of a life. How much more are construction workers paid to take on more risky job assignments? The tradeoffs made between increased pay and increased risk imply an underlying value of life. Alternatively, survey methods can also be used to develop value estimates that are more representative of the general population. Fisher's 1991 review of this literature found that these methods reveal that an average human life is valued between $2.1 million and $11.3 million. Thus, the high cost estimates cited in Exhibit 2-10 likely represent a rather conservative view on the external costs associated with air pollution.

Given the emissions data cited above, the cost estimates presented in Exhibit 2-10 are used to develop estimates of the external health costs attributable to each mode. For example, multiplying the emission rates and associated costs for each component of automobile emissions, one finds that external health impacts fall between $.029 and $0.056 per passenger mile. Although the estimates developed by Small and Kazimi reflect costs in a relatively high-density urban area, they were directly applied to the emissions data reported for each mode. This approach may somewhat overstate costs for travel in rural areas, but the overall results are generally consistent with findings in previous studies.

Exhibit 2-10
Estimated Health Impacts
Cost per Gram of Emissions

	Low Cost Estimate	***High Cost Estimate***
Volatile Organic Compounds	$0.002	$0.003
NO_x	$0.006	$0.012
Particulate Matter	$0.051	$0.110
Road Dust	$0.017	$0.037
SO_x	$0.055	$0.121

Source: Small and Kazimi (1995)

Climate Impacts/Global Warming

Beyond their immediate impact on human health, fossil fuel emissions have also been linked to changes in global climate. While global warming is clearly an area of controversy, if human activity is affecting the overall climate, then transportation is clearly a major contributory factor. Fossil fuel emissions are a major source of carbon dioxide and other "green-house" gases. That said, linking emissions to changes in climate and the economic impacts that result from such changes is a nearly impossible task.

> *For automobile travel, air pollution costs citizens between $0.031 and $0.058 per passenger mile.*
>
> *For air travel, air pollution costs are estimated to fall between $0.003 and $0.004 per passenger mile.*
>
> *Air pollution costs for rail travel range from $0.014 to $0.027 per passenger mile.*

As a result, attempts to quantify the impact of "greenhouse gases" have focused on the cost of technologies that can be used to reduce emissions. Although they use the same basic methodology, these types of analyses have produced an extremely wide range of potential impacts. At the lower end of the cost range, the UCB-ITS study relies on a cost estimate of $5.80 per ton of carbon. At the upper end, the study completed for the NRDC suggests that costs could reach $82.80 per ton. Using the lower range of these alternatives ($0.001 per gram of emissions) places our overall cost estimates well within the ranges established by previous research.

Highway Air Pollution

If carbon emissions costs are viewed conservatively, and the lower cost estimate of these effects is added to the health impacts described above, the potential impacts of air pollution from each mode can be viewed in total. For automobile travel, this estimate falls between $0.031 and $0.058 per passenger mile. This range is consistent with the $0.040 average suggested by Litman (1997) in his review of the existing literature, and falls at the lower end of the $0.038 to $0.071 range developed in the 1993 NRDC study. Our conclusions are also generally consistent with the $.005 - $0.092 range suggested by Delucchi, et al. (1996) in their extensive analysis of motor vehicle emissions.

Airplane Air Pollution

For air travel, air pollution costs are estimated to fall between $0.003 and $0.004 per passenger mile. This range is calculated from the emission data cited in Exhibit 2-9 and the cost estimates summarized in Exhibit 2-10. The pollution costs for air travel depend heavily on one's assumptions about the costs related to carbon emissions. If the NRDC's cost estimate of $82.80 per ton is used in the analysis, cost per passenger mile exceeds $0.010. However, the current analysis maintains a more conservative view of the potential costs of carbon emissions. The final range of cost estimates is somewhat higher than the $0.001 per passenger mile estimate developed for the UCB-ITS (1996) study, but this relatively low estimate relies on a extremely conservative view of both health and climate impacts.

Railroad Air Pollution

Employing the cost estimates noted in Exhibit 2-9 and the emissions figures in Exhibit 2-10, air pollution costs for rail travel range from $0.014 to $0.027 per passenger mile. These estimates fall at the lower end of the $0.016-$0.041 range that was presented in the NRDC study. A comparison to previous studies is not possible because most focused on some form of electrified rail and did not produce cost estimates for a diesel-powered service.

Noise Pollution

> *Highway noise costs society between $0.001 to $0.006 per passenger mile.*
>
> *Airplane noise costs approximately $0.002 to $0.016 per passenger mile.*
>
> *Rail noise costs society about $0.001 to $0.004 per passenger mile.*

The available estimates of noise pollution impacts are largely based on studies of how property values are affected by proximity to roads, airports, and train tracks. The impact on property values is taken as a measure of how much individuals are willing to pay to avoid exposure to high levels of noise. By focusing on property values, these studies limit impact estimates to residents and ignore the effects of noise on other users and other non-resident groups. This implies that the available studies may understate the overall impact of noise. This understatement applies to all travel modes and should not bias the overall results in favor of any particular mode. One should also note that many of these studies have been conducted in areas where some type of mitigation (insulated windows, noise walls, and berms) has been installed, so the available cost estimates already recognize that some portion of noise impacts have been internalized.

Highway Noise

Focusing on the external component of noise costs, numerous studies have analyzed the impact of highway traffic. Litman's 1997 review of the existing literature indicates that estimates of external costs range from between $0.001 and $0.013 per passenger mile. This range reflects differences in urban and rural impacts, and variations in implied costs from one region of the country to another. In his final analysis, the author recommends an average value of $0.006 per passenger mile.

The noise estimates derived in the NRDC study range from between $0.001 and $0.002 per passenger mile. In analyzing noise impacts in the San Francisco-Los Angeles-San Diego corridor, the UCB-ITS study developed cost estimates of $0.004 per passenger mile. These results suggest that a range of between $0.001 to $0.006 per passenger mile should reasonably capture the potential for external impacts created by highway noise.

Airplane Noise

Data on the noise impacts created by air travel were somewhat more difficult to obtain. Although property value analyses have probably been completed for many individual airports, few studies have taken a comprehensive view and attempted to estimate costs on a per passenger mile basis. The UCB-ITS study relied on European and Canadian studies that indicated a range of $0.002 to $0.016 per passenger mile, with an average value of approximately $0.070. The UCB-ITS analysis used this average value, but the results presented here rely on the full $0.002 to $0.016 range. This range of values highlights the true uncertainty that underlies the available estimates.

Railroad Noise
In estimating the potential impacts one must be careful to distinguish between studies that focus on electrified rail systems and those that attempt to measure the impact of diesel powered passenger service. Cost estimates exist for urban rail systems such as San Francisco's BART system, but the noise generated by an electrified system with frequent service is very different than that created by an infrequent, diesel powered service such as that experienced in the PNWRC.

The only comparable estimates for rail related noise impacts were developed for Apogee's 1994 study of transportation alternatives in the Boston, Massachusetts area. A portion of the Boston rail system is served by diesel powered trains so the estimates derived for this study might shed some light on the potential impact of expanded service within the Pacific Northwest. The cost estimates used in the Apogee study were quite small, ranging from $0.001 to $0.004 per passenger mile.

However, given that freight service will remain a significant portion of total track use, this range of estimates may still overstate the noise impacts of passenger rail service.

Water Pollution
Fuel spills, fluid leaks, and particulate waste from all three modes of travel have the potential to significantly degrade water quality. The potential costs of this pollution depend on how well the source of contamination is controlled and how effectively contaminated water is captured and treated.

In reviewing the data that was used to develop estimates of the capital and operating expenses for each travel mode, it becomes apparent that a large portion of the costs associated with water pollution have already been captured in the analysis of direct costs. Environmental regulations now require that a significant effort be made to prevent run-off from contaminating nearby sources of water. For example, WSDOT's current system plan identifies over $10 million in projects designed to control run-off in the I-5 corridor. In addition, SEA-TAC airport has developed an on-site water treatment facility to capture and treat environmentally hazardous materials such as fuel and deicing fluids. Some external water pollution costs probably still exist for each mode, but their impact is likely to be small. Therefore, an explicit monetary estimate of such costs is not included in the current analysis.

Waste Disposal
All three modes of travel have the potential to create a significant quantity of waste material. Used oil, worn tires, and dead batteries all require some form of disposal or recycling. Most of these disposal costs are absorbed directly by the users of each mode. Airlines must pay for proper disposal of their waste materials and ticket prices reflect these types of operating costs. Likewise, some portion of rail operations costs will reflect the expenditures related to waste disposal and recycling. Automobile owners pay indirectly for disposal costs when they have their car serviced or repaired.

Nonetheless, the waste created by privately owned automobiles are generally thought to be less well managed than those created by airline and rail travel, mostly due the significantly larger number of responsible parties. Some portion of automobile waste is disposed of improperly and sent to municipal landfill facilities that are not designed for such materials.

The only available estimate for the external component of automobile waste disposal costs suggests that the total impacts can be valued at approximately $0.001 per passenger mile (Lee (1995)). The waste disposal costs for air and rail travel are assumed to be fully internalized and, thus captured in the estimates of direct operating costs.

Accidents

Accidents impose external costs because a significant portion of accident related losses are not covered by the insurance payments that are accounted for in the estimates of direct operating costs. Although insurance will reimburse for material damage (less a deductible) and immediate health care expenses, the costs associated with lost productivity, long-term disability, pain, and grief are not generally covered. The research cited by Litman (1997) suggests that these uncovered losses amount to between 25% and 75% of total accident costs.

Automobile Accidents

Estimating the value of these losses requires detailed data on both the rate of accidents and the costs associated with the uninsured components of accident losses. The existing studies of accident related external costs use slightly different accident data and rely on varying estimates of accident cost. Interestingly, their overall estimates of external accident costs are remarkably similar, amounting to approximately $0.040-$0.045 per passenger mile.

Research completed by the Transportation Research Center at Indiana University (1996) highlights a very simple and direct approach toward estimating external costs. Given separate data on the rate of fatal and non-fatal highway accidents, the researchers made assumptions about the cost associated with each type of accident. Each fatality was assumed to impose an external cost of $1.5 million. Although this estimate of the value of life somewhat is lower than the estimates used in the analysis of pollution costs, it represents only the external portion of the losses associated with each fatality. If insurance companies bear approximately 50 percent of total costs, then $1.5 million in external costs implies a total value of $3 million. This latter value is generally consistent with the range of estimates ($2.4-$4.2 million) used in the air pollution analysis.

For non-fatal accidents, the authors assigned a cost estimate of $50,000 to reflect the uninsured component of each automobile-related injury. Assuming that insurance also covers 50 percent of total injury losses, this estimate is consistent with research cited in the NRDC (1993) study that shows individuals are willing to pay approximately $100,000 to avoid a serious injury. These assumptions imply external accident costs of approximately $0.045 per passenger mile.

A more detailed approach was taken in the work completed for the UCB-ITS study of transportation alternatives in California. Using data developed in a 1991 Federal Highway Administration study, the authors tried to separately account for the accident losses associated with health care, lost wages, emergency services, property damage, pain and suffering, and other minor external costs. Their research suggested that these costs amounted to $120,000 for rural crashes and $70,000 for urban incidents. These estimates then imply an overall external cost of $0.040 per passenger mile resulting from automobile accidents.

The range of estimates established by these two studies ($.040-$0.045 per passenger mile) is generally representative of previous research. For example, Litman's qualitative review of the existing literature suggests that external costs range from $0.007 to $0.070 per passenger mile. NRDC's cost analysis suggests a value of $0.033 per passenger mile, but the authors indicated that this is a very conservative estimate of total costs.

A review piece completed by the Office of Technology Assessment indicated that external accident costs might reach to $0.054 per passenger mile, but the authors did not provide a full explanation of how this higher value was established.

Airplane Accidents
Estimates for the external costs of airline accidents have been developed using the same basic methodologies as those analyzing automobile accidents. Given the availability of data on accident rates for large aircraft and smaller commuter airplanes, the focus of the analysis has been on assigning an appropriate external cost to the predicted number of fatalities and injuries.

In the research completed at Indiana University it was assumed the portion of cost covered by the airline or its insurance company would be the same as that covered by automobile insurance. Applying the same external costs estimates for injuries and fatalities that were used in their analysis of automobile accidents, this implies a total external accident costs of $0.0035 and $0.0002 per passenger mile for commuter and major carrier service, respectively. A weighted average cost factor was developed using corridor travel statistics provided by the FAA showing total passengers between city-pairs for jet and commuter aircraft. Since the vast majority of travel in the corridor takes place on jets, the average approaches the major carrier service rate.

Using accident statistics from a different year and a somewhat larger estimate for the uninsured losses attributable to each fatality ($2.4 million), the UCB-ITS study concluded that external accident costs could amount to $0.0003 and $0.005 for commuter and large airline service, respectively. This implies a composite cost of $0.003 per passenger mile, if service is evenly divided between commuter and major airline carriers. These two analyses define the overall $0.002 to $0.003 range that is used in the current analysis of external accident costs.

Railroad Accidents
In developing estimates of the external costs of rail travel, accident data provided directly by Amtrak formed the basis for this analysis. These data were more current and comprehensive than those used in any existing study, so the current cost estimates were calculated directly and do not rely solely on previous research. Exhibit 2-11, on the following page, summarizes the information available on the rate of fatalities associated with Amtrak's service. Notice that most fatal railway accidents are associated with rail-crossing incidents and trespassing, and did not involve passengers. Depending on how one

Exhibit 2-11
Accident Rates for Rail Travel

	Fatalities per Million Passenger Miles
Amtrak Passenger	0.0007
Automobile drivers (rail crossing incidents)	0.0107
Trespassers	0.0096

accounts for these accidents, external costs can vary significantly.

Using the cost estimates proposed in the research conducted at Indiana University's Transportation Research Center, the external accident costs of onboard fatalities amount to just $0.001 per passenger mile. Estimates of a similar magnitude were cited in the literature as representing the total external accident costs associated with rail travel (NRDC (1993), Litman (1997). However, if one adds the costs associated with rail-crossing and trespass accidents, the indirect cost of rail accidents increases to $0.032 per passenger mile.

Given this large range, only onboard and trespasser accidents are included in the high cost range. Therefore, a range of $0.001 to $0.015 per passenger mile is used summarize the external costs of railroad accidents. It should also be noted that these estimates may somewhat understate actual costs, because the accident data from Amtrak only reflect fatalities and did not include information about serious injury accidents.

Final External Cost Estimates

Exhibit 2-12 summarizes the range of cost estimates that were used as a base for each external factor considered in the cross-modal cost analysis.

The results presented in this table have been escalated at the rate of inflation and represent current dollar estimates of costs for each year in the planning horizon. Notice that external costs are significantly larger for highway travel than for either rail or air. In 1997, highway costs are estimated to range from $0.08-$0.11 per passenger mile, while rail costs are estimated to be $0.02-$0.05 per passenger mile. External cost for air travel amount to just $0.01-$0.02 per passenger mile. Air pollution and accident costs represent the largest share of the external cost associated with highway travel.

Exhibit 2-12
Comparison of External Costs
($ per passenger mile)

Year	**Automobile**		**Passenger Rail**		**Air Travel**	
	Low Cost Estimate	High Cost Estimate	Low Cost Estimate	High cost Estimate	Low Cost Estimate	High Cost Estimate
1998	$0.08	$0.12	$0.02	$0.05	$0.01	$0.02
2000	$0.09	$0.13	$0.02	$0.06	$0.01	$0.02
2005	$0.10	$0.16	$0.02	$0.07	$0.01	$0.03
2010	$0.13	$0.19	$0.03	$0.08	$0.01	$0.04
2015	$0.15	$0.23	$0.03	$0.10	$0.01	$0.04
2020	$0.19	$0.28	$0.04	$0.12	$0.01	$0.05

Source: Berk & Associates, 1998.

Conclusions

Returning to the step-wise analysis of full operating costs, external costs can now be added to the previous estimates of direct operating costs and travel time costs. External costs are largest for highway travel, so the cost advantages of rail versus highway travel that were identified earlier are reinforced when externalities are added to the analysis.

Exhibit 2-13 presents a direct comparison between the full operating costs of highway and rail travel. The pattern of these results matches those observed in the analysis of time costs, but the total magnitude of the cost estimates, and the divergence between highway and rail are somewhat larger. Exhibit 2-14 presents a direct comparison between the full operating costs of air and rail travel.

Exhibit 2-13
A Cost Comparison, Including Direct Costs, Travel Time, and Externalities
Highway vs. Rail Travel
($ per passenger mile)

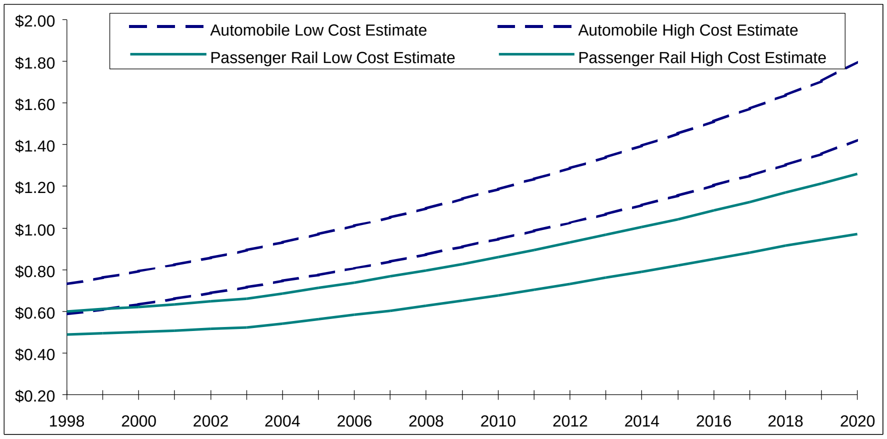
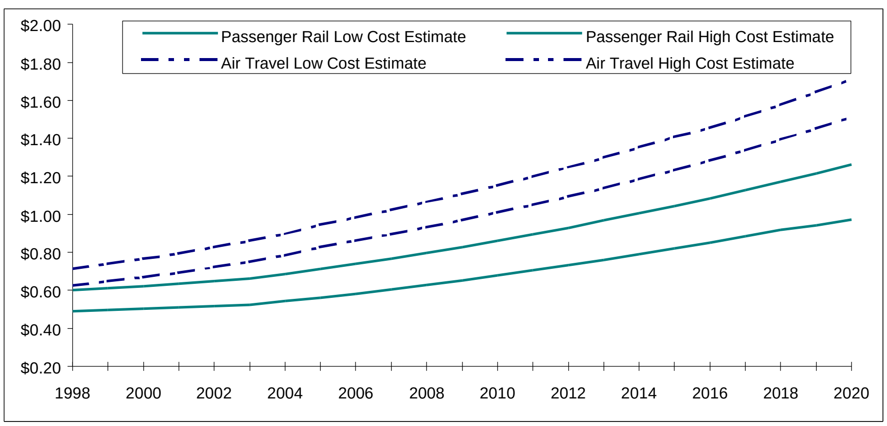


Exhibit 2-14
A Cost Comparison, Including Direct Costs, Travel Time, and Externalities
Air vs. Rail Travel
($ per passenger mile)



The addition of external costs does not alter the conclusions that air travel is generally a less cost-effective choice for short distance travel in the corridor. External costs are lowest for air travel, so the relative cost advantage for rail over air travel decreases somewhat when externalities are considered. Appendix E contains full documentation and back-up information for these graphs.

CHAPTER THREE
HOW MUCH WILL IT COST?

Having reviewed the issues associated with the merits of investing in passenger rail, the next major question is how much will it cost?

Existing intercity passenger rail service in the state of Washington utilizes rail infrastructure owned by BNSF. Extensive analysis of current and future railroad operations reveals that there are many infrastructure improvements needed to meet WSDOT's vision of increased passenger rail service while maintaining freight capacity needs. To meet service and capacity demands, WSDOT is working with its partners to identify projects, their costs, and financing.

> *At the end of the twenty-year period, it is assumed that no major capital requirements will remain for intercity passenger rail service and ticket buying passengers will fund annual operating costs.*

WHAT TYPES OF COSTS WILL BE REQUIRED TO MEET WSDOT'S VISION?

The PNWRC Passenger Rail program will require different types of investments. These investments are categorized as operational costs and capital costs.

Operational Costs

Operational costs are a direct function of operating the train service every year. Costs include fuel, labor, maintenance of trains and facilities, insurance, marketing and sales, and general administrative costs. The operational costs identified in this chapter are for operating passenger rail service in the entire corridor.

A passenger rail system not only incurs operating costs but also collects revenue from tickets purchased by passengers. Therefore, some costs are offset by revenue. By the year 2018, it is estimated that all operational costs will be offset by revenue.

Capital Costs

Capital Costs generally represent investment for improvements to railroad infrastructure and facilities. They normally result from a long-range plan that identifies the need for certain expenditures in certain years. Track improvements along the corridor – for passenger rail, freight rail and commuter rail – are all considered capital costs. Station improvements and land acquisition, along with the purchase of new trainsets (the new Talgo train equipment) are also a capital cost (however, these costs are only to the benefit of passenger rail).

CAPITAL COST SHARING

The most recent capital cost estimates call for a $1.9 billion investment in the corridor. However, this cost estimate is for the corridor as a whole – a corridor that includes intercity passenger rail along with freight rail and commuter rail.

As such, many of the proposed corridor investments will provide significant benefits not only to intercity passenger rail, but to commuter service, and freight traffic as well. Therefore, it would be inappropriate to identify the full $1.9 billion in corridor investments as a capital cost for passenger rail.

According to the Intercity Passenger Rail Plan, for a $1.9 billion investment in capital:

- planned Sound Transit commuter rail would carry 3.2 million passengers annually;
- freight rail traffic could increase more than fifty percent; and
- approximately 2.0 million passengers would take intercity passenger rail trips annually.[7]

At the end of the twenty-year period, it is assumed that no major capital requirements will remain for intercity passenger rail service and ticket buying passengers will fund annual operating costs.

Exhibit 3-1
Corridor Capital Costs with Passenger Rail Allocation
(in millions of 1997 dollars)

	2003	2018	Total
Corridor Capital Investments			
Oregon	$36	$156	$192
Washington	$164	$448	$612
British Columbia	$45	$610	$655
Total Corridor Capital Investments	*$245*	*$1,214*	*$1,459*
PASSENGER RAIL SHARE OF CORRIDOR CAPITAL INVESTMENTS 75%			
Passenger Rail Total	**$184**	**$911**	**$1,094**
Miscellaneous Capital Costs			
Trainsets	$90	$135	$225
Land Acquisition	$13	$25	$38
Station Improvements	$12	$131	$143
Total Miscellaneous Capital Costs	*$115*	*$291*	*$406*
Total Passenger Rail Costs	$299	$1,202	$1,500

Source: Draft PNWRC Passenger Rail Plan, January 1998.

CAPITAL INVESTMENTS

In order to achieve WSDOT's vision of faster and more frequent service, it is imperative that improvements and investments be made throughout the corridor, from Oregon to British Columbia. In addition to the three jurisdictions, our other partners -- BNSF, Sound Transit, and Amtrak -- will also need to make capital investments in the corridor. To fulfill the rail system needs of all users over the next twenty-years, annual public and private investments in the corridor will start at approximately $85 million and grow to over $167 million in the final phase of the program (years 2017-2020). However, it should be recognized that given the uncertainties involved in projecting future expenses, total costs can only be broadly estimated.

Exhibit 3-1 provides an overview of capital investments required in the corridor over the next twenty years. These investments include planned track and facility improvements, in addition to other corridor track investments, such as new trains and station improvements. As indicated in Exhibit 3-1, only a portion of the total corridor investment will primarily benefit passenger rail.

[7] Intercity passenger rail travelers could choose among 13 round trips per day connecting Seattle and Portland with stops in between. Frequent service extending north to Vancouver, BC and south to Eugene would also be available. Travelers would ride European-style trains between Seattle and Portland in as little as 2.5 hours and between Seattle and Vancouver, BC in as little as 3 hours.

Cost Allocation

A significant share of the $1.9 billion invested in the corridor will be directed towards general corridor improvements such as bridge replacements and crossing upgrades that will serve passenger rail, commuter rail, and freight traffic. A planning-level review of the projects proposed for the corridor indicated that approximately 75% of the total projected costs can be attributed to passenger rail.[8] This implies that approximately $1.5 billion of the total $1.9 billion in corridor investments is associated with improving passenger rail service.

OPERATING COSTS

According to the PNWRC Operating Plan, the total annual cost of providing intercity rail service (operations and maintenance) is projected to range from approximately $23 million currently and increase with the level-of-service to over $72 million at project buildout, excluding the effects of inflation. Operating revenues, which include income from passenger fares and on-board food and beverages sales, are currently meeting approximately 60% of regional costs.[9]

Exhibit 3-2, on the following page, provides a snapshot of the program's projected performance during representative years throughout the planning horizon. These estimates highlight how the anticipated growth in ridership will build operating revenues, improve the system's farebox recovery, and reduce the required operational subsidy. Looking forward, operating revenues are expected to jump to approximately 65% of operating costs by the year 2003 and increase to better than 100% by program completion. This results in operating subsidy requirements of approximately $18.0 million per year to start, and gradually decreasing until all operations costs are expected to be recovered from operating revenues. These estimates are expressed in constant 1997 dollars and are based on current operating experience and comparable corridor activity elsewhere in the Amtrak system.

The totals reported in the last column of Exhibit 3-2 reflect total costs and revenues over the entire 20-year planning period, not just the four snapshots presented in the other columns. During this period, 27 million passengers are projected to travel a total of nearly 4.2 billion passenger miles. The cost and revenue estimates indicate that over this timeframe the program will operate with an average farebox recovery of nearly 80% and require just under $265 million in total operational subsidies.

Subsidy Requirements and Cost Recovery Rate

It is useful to put the subsidy requirements into a policy context. The cost recovery rate measures the percent of operating costs covered by user fees with the balance coming from public subsidy. The estimated cost recovery rate begins at approximately 60% and improves over time until all operating costs are expected to be recovered at project buildout.

[8] Chapter 4 of this report discusses the specifics of this cost allocation.

[9] It should be noted that this analysis excludes the impact of Amtrak's Coast Starlight service. Although this train does serve passengers traveling within the corridor, it is primarily designed to serve the major cities of the west coast and therefore was not included in the analysis of corridor costs and subsidies. However, currently 140,000 passengers use this train each year for intercity travel within the Northwest corridor. This implies that expanded passenger service will be building from an existing customer base of more than 480,000 passengers per year.

Exhibit 3-2
Estimated Operating Costs and Subsidy
(millions of 1997 US dollars)

	Current	2003	2008	2013	2018	TOTAL
Annual Operating Costs	$22.6	$50.4	$56.8	$63.9	$72.0	$1,165
Annual Operating Revenue	$6.8	$32.6	$42.9	$56.6	$74.5	$901
Subsidy Requirements	($15.8)	($17.9)	($13.9)	($7.4)	$2.5	($264.0)
Amtrak contribution	$11.5	$0.0	$0.0	$0.0	$0.0	$38.5
Regional Contribution	$4.8	$17.9	$13.9	$7.4	$0.0	$225.5
Farebox Recovery*	61.3%	64.6%	75.6%	88.5%	103.5%	80.0%
Passengers (millions)	.03	1.1	1.3	1.6	1.9	27.0
Passenger-miles (millions)	53.4	167.0	202.8	246.3	299.1	4,176.2
Average trip length (miles)	161.3	152.8	153.8	154.8	155.8	154.8

*Farebox recovery is defined as the percent of regional costs recovered by operations. Regional costs are total costs less Amtrak contributions.

SOURCE: PNWRC OPERATING PLAN, 1997

The subsidy estimate for the early years of the program is a conservative planning estimate based on current operating experience in the corridor. As such it provides a good basis for decision making regarding the next increment of service improvement. In subsequent years there are projected changes in assumptions, which may or may not be realized, that will have a significant bearing on the size of the subsidy requirements at these levels of service. As a point of comparison, the current, systemwide farebox recovery rate for Washington State Ferries is just over 60%.

Passenger Rail: Viewed within the Context of the Overall Transportation System

The previous Chapter presented a comparison of the direct, indirect and external costs of the three principal modes of intercity travel in the I-5 corridor between Vancouver B.C. and Portland, Oregon. As was mentioned earlier, the capital costs were explicitly excluded from the analysis. This was done to ensure that the operational characteristics of each mode were not overshadowed by the potentially large investments in capital facilities.

> *The rail system is just beginning the process of investing in facilities and equipment to offer a competitive alternative to driving or flying. . . the markets for both highway use and air travel are both mature, and have benefited from a long history of public and private investment.*

This is particularly true in the current comparison, where the rail system is just beginning the process of investing in facilities and equipment to offer a competitive alternative to driving or flying. Thus, the operational cross modal analysis assumes that each mode will have the necessary capital infrastructure to meet future demands, within some reasonable financial constraint.

The balance of this Chapter will address the relevant capital cost items for each mode and add these to the cross modal analysis of operational costs. The result will be a fully-allocated cost comparison of travel in the corridor.

Adding Capital Costs to the Cross Modal Comparison

The comparison of capital costs poses a series of complications that are not raised in the analysis of operating costs. Operating costs represent recurring expenses that can be easily identified and tracked through time. Although capital investments may be incurred at a particular point in time, they must also be allocated across time because they have useful lives of 30 years. In addition, facilities support both passenger and freight traffic, so costs must be appropriately divided among all uses. Furthermore, because the current planning horizon is less than 20 years, current expenditure plans may not capture the full capital costs of each mode. The following are additional observations regarding the integration of capital into the overall analysis of cost effectiveness:

Rather then reflecting the inherent advantages of one mode over another, short-term capital investment requirements can be heavily influenced by past investment decisions. If infrastructure and facilities have been allowed to age and deteriorate, then significant capital expenditures may be needed in the immediate future. These expenditures could increase the apparent costs of the affected mode of travel, but may not accurately reflect its long-term cost effectiveness.

Required capital investments also reflect differences in the relative maturity of each transportation alternative. As discussed earlier, the markets for both highway use and air travel are both mature, and have benefited from a long history of public and private investment. In contrast, the objective of the PNWRC program is to reintroduce intercity passenger rail as a viable alternative in the I-5 corridor. It will probably take some time to build its market share. If rail travel is to successfully compete with both air and highway travel, public investment may be needed in the short term to build the necessary infrastructure to offer competitive service.

A comparison of planned capital expenditures can be misleading because it does not offer direct insight into the long term levels of capacity that will be available for each mode. Planned improvements in air and rail facilities might be used to support an expansion of service in the years beyond 2015. The current analysis relies on projections of demand to estimate relative cost effectiveness. However, the availability of unused capacity will have value in the years beyond the current planning horizon and the cost of expanding capacity will also be different for each mode.

> *A comparison of planned capital expenditures can be misleading because it does not offer direct insight into the long term levels of capacity that will be available for each mode.*

Nonetheless, each mode does require a basic infrastructure in order to operate and each will require significant capital investments over then next 15-20 years. To fully compare the costs associated with each mode of travel the analysis must also account for this aspect of total costs. In the discussion that follows, the treatment of capital costs are identified and as well as associated assumptions.

Estimating Capital Costs

The capital costs included in the analysis reflect all one-time investment expenditures that are planned through the year 2015. Capital expenditures were converted to annualized costs by using a discount factor of 6.5% and the assumed useful life of each investment.[10]
The only exception to this approach is for the analysis of air travel. The capital expenditures related to air travel were measured by totaling the debt service payments and cash funded capital improvements that are scheduled to occur through the year 2015.

A simplifying assumption was made about the treatment of the existing infrastructure for each mode. Since the investment decision that is currently under consideration is how best to address future travel demand needs, the cost of the existing facilities and equipment were considered to be sunk costs and not included in the cost effectiveness analysis. The only exception to this assumption is in the case of the air travel analysis, where the cost of some of the existing capital base is reflected in debt service payments and in the calculation of airport rental charges. This is discussed in more detail in the air travel analysis.

Highway

Data on planned capital expenditures for the Interstate 5 corridor are taken from the 1998 Washington State Highway System Plan. The

[10] For example, investing $10 million in a new building would be converted to an annualized cost of $766,000, using a factor of 0.0766, which is determined by amortizing the costs over a useful life of 30 years at 6.5%. The 6.5% discount rate accounts for the opportunity cost of capital, and is roughly equivalent to the current cost of money for a public entity such as the State of Washington.

capital costs identified in the System Plan include expenses for projects related to safety enhancements, environmental retrofits, economic initiatives and mobility improvements. In addition, the anticipated costs of retrofitting bridges for seismic integrity have also been included in the capital cost estimates.

In developing an estimate of planned investments in the corridor, projects planned for Interstate 5, Interstate 405, Interstate 205, State Route 167, and State Route 512 were all included in the total. Discussion with WSDOT staff indicated that these would comprise the likely routes for north-south travel over the next twenty years.

The capital expenditures planned for these routes over the next twenty years total $3.4 billion in current 1998 dollars. These costs were spread evenly over the twenty-year period from 1999-2018 and escalated to current dollars under the assumption that inflation will average 4% per year. The resulting estimates were then converted to a measure of annualized costs under the assumption that highway improvements have a useful life of 30 years. Cost projections for the years 2019-2020 are based on the average level of spending projected for 1999-2018.

Projections for total corridor travel were then used to convert annualized capital investments to a per passenger mile estimate of annualized capital costs. WSDOT staff provided vehicle mile projections for the relevant sections of each highway in the corridor. Using WSDOT's estimate that occupancy averages 1.4 persons per vehicle these vehicle mile estimates were then converted to projections of total passenger miles. Appendix E provides a summary of the calculations that were used to estimate the annual capital costs per passenger mile.

Air Travel

Total airport costs are based on an estimate of airport revenues generated by activities that are directly related to the air passenger market. Since airports recover their full costs through user charges, a portion of these revenues are used to cover capital investments. Smaller capital projects are funded directly from retained earnings or grant funding, while the costs of larger projects are reflected in the airports' annual debt service payments. Rather than annualize costs, as was done with the other modes, estimates of these two sources of financing were taken as a measure of annual capital costs.

Among the relevant airports, annual capital costs vary significantly, but all anticipate significant expansions and major capital investments over the next 20 years:

- At present, SeaTac Airport allocates nearly $100 million per year to capital costs, and with inflation and new capital projects this is expected to grow to more than $350 million by 2020 (inflation adjusted dollars).

- Vancouver International Airport currently spends $49 million (U.S.) per year to finance capital projects and projections indicate that this could reach $140 (U.S.) by 2020.

- Portland International Airport's current budget allocates approximately $40 million per year for capital costs. Looking forward, this could increase to more than $60 million over the next ten years before declining slightly as major capital projects are paid off.

- Although specific estimates of annual capital costs were not available for Bellingham International Airport, the

Port's current master plan identifies more than $33 million (1997 dollars) in capital improvements that will be needed before 2015.

Using the percentage of total revenue attributable to passenger travel, capital costs were then allocated to passenger and non-passenger investments. Summing the resulting total annual expenses and removing the effects of inflation, the capital costs associated with passenger travel at the corridor's four major airports are expected to total more than $4.1 billion in 1997 dollars over the 20 twenty-year period from 1998-2017. These costs reflect significant expansions including the addition of new runways at Sea-Tac and Vancouver International Airport.[11]

Passenger Rail

Capital cost estimates for passenger rail were obtained from information provided in the Rail Options Report. This report identifies the capital costs associated with purchasing new trains, improving station facilities, acquiring necessary land, and upgrading the existing track network.

Although it is clear that the costs of new trains and upgrading existing stations will be driven exclusively by the passenger rail program, many of the proposed corridor investments will provide significant benefit to passenger rail, commuter service, and freight traffic. Therefore, it would be inappropriate to identify the full $1.9 billion in corridor investments as a capital cost for passenger rail.

To be consistent with the approach used in analyzing air travel, it was necessary to identify what portion of the total costs is associated with passenger rail and what share is driven by other users. An exact allocation is impossible because many of the projects involve general improvements such as bridge replacements and crossing upgrades that will benefit all types of users. However, a general review of the proposed projects suggested that approximately 75% of the total costs could be attributed to passenger rail. This reflects an assumption that:

- passenger rail should bear the full costs of improvements targeted specifically for passenger service, but should be burdened with only a share of projects that will also serve commuter trains and freight traffic.

The following are the other major assumptions made in the analysis:

- The capital expenditures were phased over a 20-year period to roughly coincide with the assumptions underlying the operations analysis. Thus, the capital needs were spread over a 5-year period and escalated at an annual rate of 4.0%.

[11] The current approach to estimating annual capital costs will likely overstate the annualized costs associated with air travel. Debt issued for capital improvements are generally amortized over a period of time that is shorter than the useful life, so debt service payments will tend to overstate a true measure of annualized costs. In addition, projects funded from retained earnings or grant funds are treated as an annual expense, although the projects will likely have useful lives significantly greater than one year. However, this potential overstatement does not have an important impact on the general conclusions of the analysis. Even with this upward bias in estimated costs, air transportation proves to be a very cost-effective mode for intercity travel.

As was true in the analysis of operating costs, data on projected enplanements were used to convert total capital expenditures to estimates of costs per enplanement. These costs were then spread over the total mileage of each intercity trip to develop an estimate of capital costs per passenger mile.

- The period over which the capital costs are amortized varies according to the type of improvement. Corridor improvements are assumed to have a useful of 30 years, buildings 30 years, and equipment 20 years. Since land does not depreciate, the land acquisition costs are amortized over 99 years.

> *The cost per passenger mile for rail travel will begin to decrease in the years beyond the current planning horizon, because the rate of capital investment is expected to be significantly lower in the years beyond 2015.*

Final Capital Cost Estimates

Exhibit 3-3 compares the capital cost estimates that have been derived for each mode.

Over the current period of study, highway capital costs do not exceed $0.012 per passenger mile, but they reach more than $0.60 per passenger mile for rail. This variation is largely driven by three key factors:

- Rail is in a different place in the investment cycle. While highway and air are mature systems, rail is still in the midst of building a system infrastructure.

- Differences in projected levels of ridership for each mode. Total highway capital costs ($2.3 billion) exceed those for rail ($1.5 billion), however, given the 15.5 billion vehicle miles that are projected for the I-5 corridor in 2015, average costs are significantly lower for highway travel; and

- The level of investment in rail and highway are designed to meet different level-of-service (LOS) goals.

The investment in the rail system will result in significant improvements in the level-of-service, both in terms of frequency of service and reduced travel times. The investments in the highway system will not have a significant impact on the degradation in the overall level-of-service, as average speeds are projected to continue to slow throughout the period. As a result, a significant portion of the cost effectiveness advantage for highway comes at the expense of a significant decrease in the level-of-service.

Exhibit 3-3
Comparison of Capital Costs
($ per passenger mile)

Year	Automobile	Passenger Rail	Air Travel
1998	$0.00	$0.11	$0.09
2000	$0.00	$0.21	$0.10
2005	$0.01	$0.30	$0.11
2010	$0.01	$0.41	$0.11
2015	$0.01	$0.56	$1.12
2020	$0.02	$0.55	$0.15

Source: Berk & Associates, 1998.

The cost per passenger mile for rail travel will begin to decrease in the years beyond the current planning horizon. This is due to the fact that the rate of capital investment is expected to be significantly lower in the years beyond 2015. The improvements identified in the Options Report would be complete and the service objectives met, therefore, future capital needs are likely to be limited to rehabilitation and maintenance needs.

Exhibits 3-4 and 3-5 (Exhibit 3-5 is located on the following page) present a comparison of the full cost associated with each mode of travel. The estimates reflect operating costs, travel time, externalities, and capital costs for each of the three modes. Notice that the overall costs of passenger rail service are comparable to both alternative modes of travel.

Exhibit 3-4
A Full Cost Comparison of Automobile vs. Rail Travel Including Direct Costs, Travel Time, Externalities, and Capital Expenditures ($ per passenger mile)

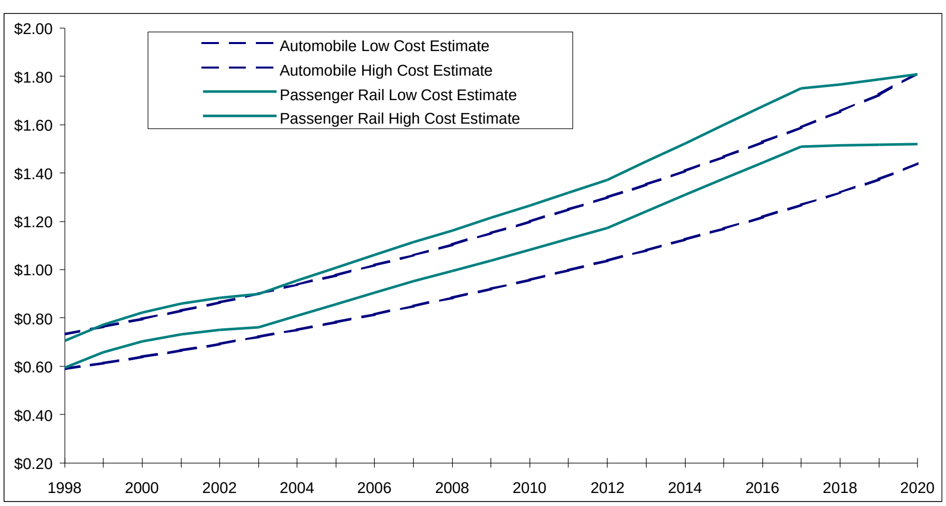
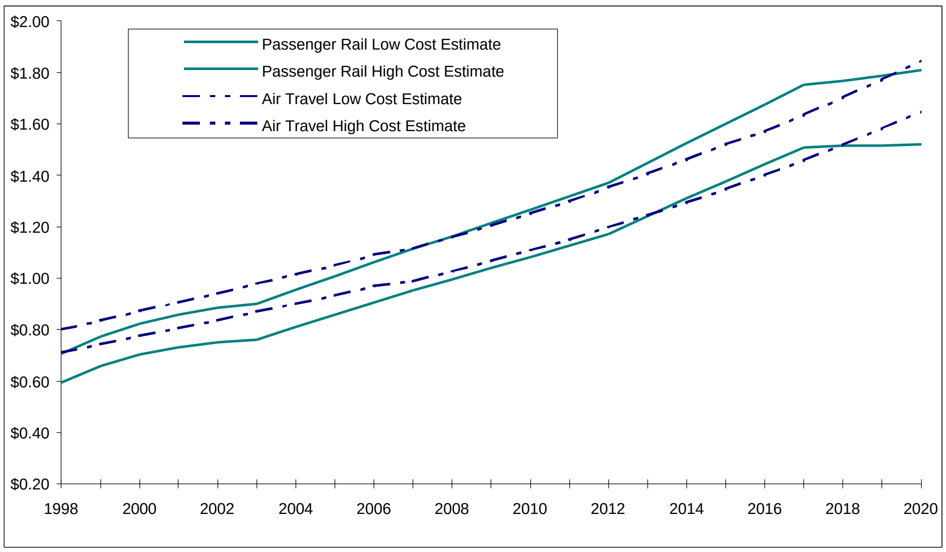


Exhibit 3-5
A Full Cost Comparison of Air vs. Rail Travel Including Direct Costs, Travel Time, Externalities, and Capital Expenditures
($ per passenger mile)



CHAPTER FOUR

HOW WILL WE PAY FOR IT?

To answer the question of how we will pay for the expansion of passenger rail service, we must first identify who is being asked to make the investment. For the purposes of this evaluation, the State of Washington is assumed to be asking this question, thus, the analysis is focused on the elements of the program that WSDOT may be responsible. The balance of the funding is expected to come from the other principal partners, in particular British Columbia and the State of Oregon plus in-state partners such as Sound Transit and the freight railroads. However, it is important to note that no long-term financial commitments have yet been made by any of these entities.

The purpose of this baseline financial analysis is to review existing funding commitments, compare these commitments to the estimated requirements and, where necessary, provide an evaluation of potential funding opportunities and constraints for potentially unmet needs.

COST ALLOCATION

At this time the issue of cost allocation has not been resolved. Therefore, for the purposes of analyzing the financial implications for the State of Washington, a division of cost responsibility among the principal partners was made. It is assumed that WSDOT will be responsible for the facility improvements located in the State of Washington, plus half of the rolling stock requirements and half of the annual operating subsidies. The rolling stock and operating subsidy requirements assume that these costs are shared equally between Washington and BC for the Seattle-Vancouver service and between Oregon and Washington for the Seattle-Portland/Eugene service.

Many projects will be to the benefit of the state as well as our partners. Thus, the actual cost allocation will be determined on a project-by-project basis and will be the result of negotiations among WSDOT, Sound Transit and the railroads.

Having allocated corridor costs among the principal partners, a second allocation of the in-state costs is necessary. The program costs include all necessary improvements to ensure the efficient movement of intercity passenger rail and freight rail in the corridor plus new commuter rail service in the Central Puget Sound area. Many projects will be to the benefit of all of these entities. Thus, the actual cost allocation will be determined on a project-by-project basis and will be the result of negotiations among WSDOT, Sound Transit and the railroads.

However, for planning purposes, a rough allocation was prepared. Exhibit 4-1, on the following page, presents the criteria that were applied to the corridor projects in the state of Washington.

Exhibit 4-2, also on the following page, shows a preliminary cost allocation for the state of Washington based on the identified criteria. It is important to note that this allocation is for illustrative purposes only. At this time, there has not been any formal agreement among the various interested parties regarding the issue of

Exhibit 4-1
Cost Allocation Criteria for Capital Costs in Washington State

Project Location	Primary Project Goal	Washington's Share	Partners' Share
Outside of the RTA District	To meet passenger rail requirements	100%	
Outside of the RTA District	To meet general capacity requirements	50%	50%
Within the RTA District	To meet passenger rail requirements	50%	50%
Within the RTA District	To benefit all rail users	33%	66%

cost sharing for proposed improvements. These figures are only for use in developing a preliminary financial analysis for the Washington elements of the proposed program. The total funding commitment required during the development of the program is $2.1 billion, expressed in 1997 dollars. Of this amount approximately 42%, or $873.5 million can reasonably be allocated to WSDOT.

PAST AND FUTURE PARTNERSHIPS

One of the features of the PNWRC program is the fact that the passenger rail service will connect three major metropolitan areas across two states and one Canadian province. In addition, rail service is provided by Amtrak on right-of-way owned by the Burlington Northern Santa Fe Railroad (BNSF). As such, the responsibility for funding the corridor improvements and any operating subsidies does not automatically fall to a single jurisdiction.

The States of Washington and Oregon, the Province of British Columbia, Amtrak, and BNSF have been participants in the planning and funding efforts to date and each will likely have a role in funding future program requirements.

Exhibit 4-2
Preliminary Washington Cost Allocation
(Millions of 1997 US Dollars)

	Corridor Total	*WA's % Share*	WA 98-03	WA 04-18	WA Total
Facilities	*$1,459*	*32%*	$125.0	$340.0	$465.0
Land and Stations	*$181*	*100%*	$25.0	$156.0	$181.0
Trainsets	*$225*	*50%*	$45.0	$67.5	$112.5
Total	*$1,865*	*41%*	$195.0	$563.5	$758.5
Operating subsidies (1998-2018)	*$225.5*	*50%*			$112.75
Total requirements	*$2,095*	*42%*			**$871.25**

In the past five years, these partners have invested hundreds of millions of dollars to reduce travel times, increase train frequency, and improve customer service, safety, and transportation connections. Almost $500 million have been infused into the rail system between 1993 to 1998. Exhibit 4-3 provides an overview of commitments made by some of our partners.

Exhibit 4-3
Partner Contributions and Commitments
1993-1998

Washington State	$122 million
Amtrak	$80 million
Railroads	$225+ million
Others, including Oregon	$45+ million

Amtrak and the railroads have already committed more than $64 million in improvements for 1999 and the states of Washington and Oregon are expected to continue to support the partnership.

WASHINGTON'S COMMITMENT

In April 1996, WSDOT published Washington's Transportation Plan 1997-2016 (WTP). The purpose of this plan is to address "transportation facilities owned and operated by the state, including state highways, the Washington State Ferries, and state-owned airports. It addresses facilities and services that the state does not own, but has an interest in, as they are vital to the entire transportation system. These include public transportation, freight rail, intercity passenger rail, marine ports and navigation, nonmotorized transportation, and aviation." For each of these elements of the statewide transportation system, the WTP identifies the long-term needs, sets financially realistic targets and identifies responsibilities for implementation.

Amtrak and the railroads have already committed more than $64 million in improvements for 1999.

The realistic financial targets were adopted by the Washington State Transportation Commission and reflect a continuation of historical expenditure trends for established programs and specific service objectives for relatively new programs. By adopting these targets, the Transportation Commission established a policy framework for transportation funding priorities that is intended to provide a long-term perspective for near-term funding decisions.

The next step in the funding process is the development of 6-Year Implementation Plans. The 6-Year Implementation Plan for the passenger rail program is currently under development and will provide a short-term program of actions to be accomplished in the initial implementation period in moving toward the overall system plan targets. The collection of 6-Year plans will become the principal supporting element in the development of the next biennial budget in 1997. The final funding decisions will be made by the legislature during the biennial budget deliberations.

In the case of passenger rail, the determining factors for the WTP financial target were the same service objectives that underlie the investment requirements spelled out in the Intercity Passenger Rail Plan for Washington State. Thus, the program elements are consistent with the current planning assumptions.

Exhibit 4-4
Planning Level Sources and Uses of Funds
(Millions of 1997 U.S. dollars)

	1997$
Total capital needs	$758.50
Total operating subsidies	$112.75
Total investment needs	$871.25
Current law funds (adjusted to 1997$)	$416.0
New State revenues (adjusted to 1997$)	$900.0
Surplus/(deficit)	$444.75

Adequacy of Financial Resources

To evaluate the adequacy of the programmed funds to address the Washington share of program requirements, a simple sources and uses analysis was prepared. Exhibit 4-4, on the following page, presents the results of this effort. The estimated Washington share of program needs is just over $0.75 billion, in non-inflation adjusted dollars. This is equal to the total capital share for Washington State, less shares for freight and commuter rail, plus the 50% of the operating subsidy requirements, as presented in Exhibit 4-2. If only the current law revenues are assumed to be a firm commitment, then WSDOT would be facing a program deficit of almost $460 million. Adding the projected revenues from expected new monies, the program would appear to be adequately funded.

This analysis implies that, at least on a policy-level, the intercity passenger rail program can be fully funded. While this may be an encouraging finding, there are a number of factors which could contribute to actual funding falling below full program needs, not the least of which is the fact that a significant component of the State's policy-level commitment s is based on future increases in transportation taxes. The following is a brief discussion of other factors that may affect funding for intercity passenger rail.

Cash Flow Issues

The previous analysis considers the full 20-year program needs and resources. When it comes time to implement the program objectives, there may be cash flow issues that could severely delay some elements. For instance, since a large component of the funding commitment is coming from future tax increases it may be difficult to secure funding for significant capital outlays in the early phases of implementation. Another issue that is not addressed in this analysis is the potential impact of inflation on these estimates, in particular, the question of whether revenues and costs will be similarly affected by future inflation. A more detailed cash flow analysis will need to be prepared to more fully evaluate the potential cash flow risks in the funding plan.

Reliability of Cost Estimates

It is likely that the cost estimates prepared to date do not accurately account for the full program requirements, even with the inclusion of appropriate contingencies. At a minimum, general program administration costs are not reflected in these figures and environmental mitigation is only partially reflected in some of the project cost estimates. As a result, it is likely that the program requirements will increase as the engineering level-of-detail is improved. In addition, since the policy-level funding commitment is based on the achievement of service objectives, addressing program deficits by deferring projects would likely be counter to the underlying policy rationale.

Competition for Scarce Funds

While there is a policy-level commitment to fund intercity passenger rail up to $1.3 billion, the actual funding decisions will still be made by the legislature on a biennial basis. There are no guarantees that the Commission’s policy intent will eventually be implemented, as there will always be many more transportation funding needs than resources to address them and short-term budget funding priorities may result in deferrals for programs that do not have large constituencies or significant legislative support. In the heat of biennial budget deliberations it may be difficult for the rail program to compete with larger, well-established state transportation programs.

OTHER POTENTIAL FUNDING SOURCES

Strategically, there are two general approaches to securing additional funding: seek discretionary grant funds for which certain program elements may be eligible; or, seek out partners which might share in the potential benefits of a project or program element.

Strategically, there are two general approaches to securing additional funding: seek discretionary grant funds for which certain program elements may be eligible; or, seek out partners which might share in the potential benefits of a project or program element.

This report has made several planning-level assumptions about future cost sharing among the many interested parties in the corridor. The following discussion highlights these potential financial partners as well as discusses additional potential sources of funds beyond the logical partners.

Partnerships

Given the size of the investments required, securing timely and adequate funding will be a major challenge for each of the principal participants. It will be important to look for opportunities to pool capital funds with funds from other potential program beneficiaries.

Public-public partnerships

While public-private partnerships may attract the most public attention, the most common type of partnerships are public-public partnerships. A public-public partnership is a union of two or more public entities for the purpose of jointly developing a project or providing some public service.

Sound Transit (Regional Transit Authority)

Generally the opportunities for cost sharing with local governments are probably limited. However, in the case where joint use of facilities is possible, opportunities may exist where costs can be shared with local jurisdictions. The best example of this scenario is the proposed commuter rail development plan in the Puget Sound region. Projects which will add to the rail capacity in King, Snohomish and Pierce Counties will benefit both the intercity service and future commuter service and should be considered for joint local/state funding. The passenger rail plan identifies over $140 million of project improvements within the RTA district, excluding any potential station improvements. Sound Transit is currently in the process of completing planning and engineering studies for the commuter rail program. Preliminary discussion regarding future funding decisions have begun, however, Sound Transit's financial commitment to projects of mutual benefit will be subject to negotiation with the other interested parties.

Private railroads

The private railroads, in particular Burlington Northern Santa Fe, have an interest in maintaining and expanding the capacity in the corridor to meet the growing demands of the intermodal freight system. A number of the improvements identified in the PNWRC Passenger Rail Plan will benefit freight movement through increased capacity or overall system enhancements. It is assumed that any freight specific improvements will be the responsibility of the railroad. However, there will be opportunities for joint financing of some of the identified improvements, where freight rail users will clearly also would benefit. Pursuing joint financing may be necessary in cases where joint benefits can be clearly identified, to ensure that the State Constitution barring the lending of public credit to private entities is not compromised.

Real estate interests

Often one of the best opportunities to attract private capital to public transportation projects is by targeting the potential benefits that could accrue to real estate interests. In the case of intercity rail service, these opportunities will likely be limited to station areas. By providing a point of convergence for traffic, these station areas offer economic benefits to adjoining land-owners. The redevelopment of Union Station and the potential tie-in with a redeveloped King Street Station may offer such an opportunity.

Contract service provider

Anything that could result in decreased operating costs would contribute to the overall financial picture by reducing the need for operating subsidies. While Amtrak has exclusive rights to provide intercity passenger rail service, there may be opportunities to subcontract elements of the service and reduce overall operating costs. This has been the subject of considerable debate in Congress. Additional operating flexibility may be offered to Amtrak as part of the drive to self-sufficiency.

Port Districts

Local port districts have a significant interest in the reliability and capacity of the freight rail system, since their competitiveness is determined in large measure on their ability to offer fast and convenient trans-shipment opportunities. Therefore a project that could be demonstrated to provide significant joint benefits, could potentially be funded through a combination of passenger rail funds, port funds and some private railroad funds. The onus, however, will likely rest with the state to demonstrate the joint benefit and propose a joint funding program.

Other local options

Another potential opportunity to attract local funding may exist at station sites. Many of the communities along the corridor have been developing multimodal transportation centers which would provide connections between the intercity rail system and other local and regional transportation systems. With a few exceptions, most notably in Bellingham, these efforts have not yet addressed the question of project funding and many cities are looking to the passenger rail program as a potential source of capital funding. As a result, station development is a good candidate for public-public partnerships, however, the amount of local funding that could be attracted to the program is probably limited, as all local jurisdictions grapple with transportation funding needs.

Discretionary Federal and State Transportation Funds

There are a number of separately administered discretionary funding sources that could be tapped for elements of the intercity rail program. The competition for these funds is fierce and, given the current fiscal environment, should remain so for the foreseeable future. The following is a brief description of the major programs and sources of potential discretionary transportation funding:

Federal grant sources

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 set a new direction for federal transportation policy. Instead of narrow funding categories emphasizing highway construction, ISTEA shifted priority to intermodal connections and increased flexibility to meet state and regional mobility and environmental goals. The recently enacted TEA-21 (Transportation Efficiency Actor for the 21st Century) continues the multimodal emphasis and adds for the first time a guaranteed minimum level of funding for surface transportation. TEA-21 guarantees that $198 billion will be available over the next 6 years and authorizes Congress to appropriate up to $218 billion for surface transportation programs.

Federal transportation funds generally are either allocated by formula to states and programs or they are "discretionary," meaning they are authorized based on the personal request of a member of Congress. Within the formula allocated funds, some flexibility is available to the state and the Metropolitan Planning Organizations (MPOs) in funding decisions. Major applicable categories of program funding are the Surface Transportation Program (STP), National Highway System (NHS), and, Congestion Management and Air Quality (CMAQ).

Federal Transit Administration

Capital and operating funds are available for transit projects in urban and rural areas and for the elderly and disabled. The main categories are Section 3, transit capital, and Section 9, transit formula funds for capital and operations. Where regional transit and intercity rail mutually benefit, such as intermodal facility development, there may be an opportunity to leverage existing resources with transit funds.

Federal Railroad Administration

The Federal Railroad Administration is the lead agency for a number of programs that could benefit passenger rail in Washington State, including: planning assistance; technology demonstration projects; next generation HSR technology development; and, grade crossing hazard elimination.

Swift Rail Development Act

The Swift Rail Development Act of 1994 identifies the PNWRC as one of 5 high-speed passenger rail corridors in the United States. The act clearly places the responsibility for corridor development on state and local interests and encourages the participation of private entities. The role of the federal government has been defined primarily as a facilitator for technology development and assistance in corridor planning. While the high speed corridor designation does not guarantee federal participation in system development, it may offer an opportunity for attracting federal capital funds, should they become available in future appropriations.

Amtrak

Historically, Amtrak has invested in passenger rail facilities in high priority intercity rail corridors. Since Amtrak service beyond the

PNWRC would benefit from many of the capacity and speed improvements there may be an opportunity for federal participation in the funding of these improvements. Current policy direction suggests that Amtrak's federal support will shift from operating subsidies to capital investment. The Corporation has been given until 2003 to become profitable on an operating basis, at which time federal operating support will end. With future emphasis on profitability and investing in productive corridors, the most appropriate strategy will likely be investment partnerships that can be demonstrated to improve the financial performance in the corridor

Central Puget Sound Public Transportation Account

This fund was created by the 1990 Legislature as a new funding source specifically for public transportation in the Central Puget Sound area. Funds are allocated in a competitive process by a 21-member Multimodal Committee that includes representatives of cities, counties, transit, WSDOT and other interests. During the just completed biennium, approximately $17 million was awarded to 18 projects. The largest award was $3.6 million, with most allocations in the $200,000 to $400,000 range. The applicant for these funds must be one of the local transit agencies, therefore if the commuter rail program were started, there may be an opportunity to match funds from this account with other passenger rail funds for rail improvements in the central Puget Sound area.

Transportation Improvement Board (TIB)

The TIB is an independent agency founded in 1988 that distributes funds through the Urban Arterial Trust Account (UATA) and the Transportation Improvement Account (TIA). Competition for funding is fierce and projects are ranked based on specific criteria. The UATA funds city and urban county road and street projects to reduce congestion, improve safety, and address geometric and structural problems. The TIA funds projects to alleviate congestion resulting from economic development and population growth.

Rural Mobility Grant Program

The Rural Mobility Grant Program provides funding for projects designed to improve rural communities' access to basic services. A total of $2.5 - $3.0 million is available through the program in each biennium. Typically, 20 to 25 projects are funded, with no more than $300,000 available for any single project. In the past, grants for improving intercity access have typically been targeted at improving bus service, with funding available for capital projects, planning, or operational needs. Projects that would exclusively benefit rail service are not likely to be funded, but a proposal designed to improve intermodal connectivity in rural areas could qualify for future funding. For example, a project that involved improvements to a station facility that serves both rail and bus passengers could fit within the overall goals of the program. Looking forward, the quantity of funding available from this source is likely to be limited. New funding criteria are now under development and in the future a significant portion of the available funds will be specifically directed towards under-served intercity corridors. Given the existing network of intercity trains and buses, the I-5 corridor has not been identified as an under-served area and will not be a major focus of the Rural Mobility Grant Program.

BIBLIOGRAPHY

Apogee Research (1994): *The Costs of Transportation: Final Report.* Prepared for the Conservation Law Foundation.

Focusing on two specific case studies, this study provided a cross-model comparison or urban transportation costs. Although the results of this work did provide some general guidance in our work, the study was designed to address the costs associated with urban transportation, rather than inter-city travel.

American Automobile Association (1997): *Your Driving Costs: 1997 Edition.* Prepared with the assistance of Runzheimer International.

This annual report provided a complete analysis of the direct ownership costs for several makes and models of automobiles. The analysis includes a consideration of purchase costs, regular maintenance, insurance, etc. The results presented in this report provided the basis for estimating the direct costs of automobile ownership.

Amtrak (1996): *Twenty-Fifth Annual Report, Leading the Way into the 21st Century.*

Amtrak's annual report provided summary level information about passenger rail operations. This included some information about accident control programs now being implemented throughout the country.

Black, William R. and Dean L. Munn, Richard J. Black, Jirong Xie (1996): *Modal Choices: An Approach to Comparing the Costs of Transportation Alternatives.* Transportation Research Center, Indiana University.

The work of Black et al. was designed to offer a general review of the full costs of transportation and to provide a methodology for comparing costs across different modes. The study includes specific estimates for the individual cost components for each mode, including important elements of direct, indirect, and external costs. These results were used to verify the range of costs that summarize the current analysis. In addition, the author's analysis of accident costs and the value of human life provided the foundation for our analysis of this same issue.

Brand, Daniel (1996): *The Value of Time Savings for Intercity Air and Auto Travelers for Trips Under 500 Miles in the U.S.* Prepared by Charles River Associates for the U.S. DOT, Office of the Secretary of Transportation, Panel on the Value of Time for Use in Transportation Investment Evaluation.

Although the data used in this analysis were drawn from areas outside the Pacific Northwest, the results of this study were used to help verify the value of time estimates used in the current analysis.

California Intercity High Speed Rail Commission (1996): *High-Speed Rail Summary Report and Action Plan.*

This study provides an analysis of the high speed rail project that has been proposed for the State of California. The work does not include a detailed assessment of full costs, but rather includes information about proposed operations, potential ridership, and projected revenues. This study provided useful background information and a list of valuable references.

Delucchi, Mark A. (1997): *The Annualized Social Cost of Motor-Vehicle Use in the U.S. 1990-1991: Summary of Theory, Data, Methods, and Results.* Institute of Transportation Studies, University of California Davis. UCD-ITS-RR-96-3

As the title indicates, this report provided a thorough review of the external costs associated with automobile transportation. The results of this study and Delucchi's other work (see below) helped establish the range of estimates used in our assessment of the external costs of automobile transportation.

Delucchi, Mark A. (1996): "Total Cost of Motor Vehicle Use." ***Access,*** **number 8, pp. 7-13.**
Deluchhi's work provides a review of the total costs associated with automobile transportation, including an assessment of direct personal costs, air pollution, accidents, parking, etc. These estimates helped establish the range of estimates used in our assessment of the external costs of automobile transportation.

Economics Research Associates (1996): ***Economic Impact and Benefit/Cost of High Speed Rail for California.*** **Submitted to the California Intercity High Speed Rail Commission, Project no. 11475, Contract no. 75w230.**
This study provided a general review of the methodologies used in assessing the potential costs and benefits of high-speed rail in California.

Federal Aviation Administration (1997): ***Treatment of Values of Passenger Time in Economic Analysis.*** **U.S. Department of Transportation, Office of Aviation Policy and Plans.**
Following a review of several other studies, the methodology presented in this memorandum formed the foundation for our analysis of the value of travel time.

Gannet Fleming (1992): ***High Speed Ground Transportation Study.*** **Report to the Governor, Washington State Legislature, and the Washington State Transportation Commission.**
This detailed analysis of the potential for operating high-speed rail service within the Pacific Northwest provided data essential for our analysis of the rail alternative. In addition, this analysis included information about the factors driving mode choice decisions and the direct and indirect costs associated with other modes.

Hare, Patrick (1991): "Trip Reduction and Affordable Housing." ***Transportation Research Board***.
Hare's work was directly used in the analysis of parking costs. This article includes an estimate that parking represents approximately 10% of the rental costs for a typical apartment.

IBI Group (1995): ***Full Cost Transportation and Cost-Based Pricing Strategies.*** **Prepared for the Ontario Round Table on Environment Economy.**
While this report focused on estimating transportation costs for Canada, it also provided a review of previous work conducted worldwide. The report included estimates for various aspects of total cost, but the authors' work on the external costs associated with air pollution were of the greatest value for the current study.

Litman, Todd (1997): ***Transportation Cost Analysis: Techniques, Estimates, and Implications.*** **Victoria Transport Policy Institute.**
This report provided a comprehensive review of previous work in estimating the full costs of transportation. This included a detailed review of the direct, indirect, and external costs associated with train, air, and automobile travel. This work directly informed our analysis and provided a range of cost estimates with which to compare our final results.

Natural Resources Defense Council (1993): ***The Price of Mobility, Uncovering the Hidden Costs of Transportation.*** **Prepared by Peter Miller and John Miffed.**
Focusing most directly on the external costs associated with accidents, noise, air pollution, water pollution, etc., this analysis provided a thorough cross-modal assessment of total costs. The results of this work helped to establish the range of costs cited in the current study.

National Highway Traffic Safety Administration (1994): ***Estimating Crash Costs in State or Local Jurisdictions.*** **Office of Regulatory Analysis**

Plans and Policy, U.S. Department of Transportation.

This report provided a detailed analysis of the costs associated with both fatal and serious injury accidents. This includes an assessment of direct property value losses as well as the costs associated with health care and lost wages. These results formed our analysis of accident costs, and specifically the costs associated with automobile transportation.

National Highway Traffic Safety Administration (1993): *Saving Lives and Dollars, Highway Safety Contribution to Health Care Reform and Deficit Reduction.* U.S. Department of Transportation.

This report provided estimates of the direct health care costs associated with automobile injuries and fatalities. The information in this study was used to confirm the results cited in several broader studies of the overall costs associated with transportation accidents.

Pickrell, Don and Paul Schimek (1998): *Trends in Personal Motor Vehicle Ownership and Use: Evidence from the Nationwide Personal Transportation Survey.* U.S. Department of Transportation, Volpe Center.

The Volpe Center's analysis of the age and composition of the current fleet of motor vehicles was used in conjunction with cost estimates provided by the AAA to estimate the average costs of vehicle ownership in the United States.

Port of Bellingham: (1998): *Annual Report - 1997.*

This summary financial report provided direct information about current airport revenues and projected future costs.

Port of Portland (1997): *1996 Business Report*.

This summary financial report provided direct information about current airport revenues and projected future costs. When supplemented with more detailed information provided by Port personnel, these data were used to develop estimates for the terminal costs associated with air travel to and from the Portland airport.

Port of Seattle (1994): *Airport Master Plan Update.* Prepared for the Port of Seattle by P&D Aviation.

This report, along with detailed financial projections of the Port's future operations were used to estimate the costs associated with passenger travel through Sea-Tac Airport. This included a separate analysis of on-going operational costs and anticipated capital investments.

Puget Sound Regional Council (1996): *The Costs of Transportation: Expenditures on Surface Transportation in the Central Puget Sound Region for 1995.* Prepared with the assistance of the Underhill Company.

The PSRC's analysis of the relative costs of automobile, public transit, and other modes provided valuable information about the direct and indirect costs of automobile ownership. The reports estimates regarding parking were included in the current analysis, and its general conclusions were used to verify our results regarding the costs of automobile operation.

Qin, Jiefeng, Jose Weismann, Mark A. Euritt, and Michael Martello (1996): "Evaluating the Full Costs of Urban Transportation." *Transportation Research Record, 1518.*

This article described a computer model that has been developed to evaluate the full costs of urban transportation. Given its focus on urban, rather than inter-city travel, the model itself was not useful for the current analysis. However, a review of the methodology developed by the authors did provide useful starting point.

Small, K.A. and C. Kazimi (1995): "On the Costs of Air Pollution from Motor Vehicles." *Journal of Transport Economics and Policy,* vol. 45, pp. 7-32

This paper provided a thorough analysis of both emission levels and the social costs associated with these emissions. The results of this study provided the basis for our analysis of the eternality costs associated with air pollution.

Texas Transportation Institute (1996): ***Urban Roadway Congestion - 1982-1993, Volume 1: Annual Report.*** **Texas Transportation Institute, Texas A&M University.**

Texas Transportation Institute (1996): ***Urban Roadway Congestion - 1982-1993, Volume 2: Methodology and Urbanized Area Data.*** **Texas Transportation Institute, Texas A&M University.**
These two volumes provided an assessment of congestion within urbanized areas, including Seattle and Portland. These results helped to develop projections for average highway speeds in these areas and thus contributed to our analysis of automobile travel times.

University of California at Berkeley, Institute of Transportation Studies (UCB-ITS) (1996): ***The Full Cost of Intercity Transportation - A Comparison of High Speed Rail, Air and Highway Transportation in California.*** **Prepared by Levinson, David and David Gillen, Adib Kanafani, and Jean-Michel Mathieu.**
A comparable assessment of the overall costs of different transportation modes, this study provided a review of previous cost estimates as well as an analysis of different research methodologies. Because it included an analysis of rail, air and highway transportation, this work provided a valuable benchmark for our analysis.

U.S. Congress, Office of Technology Assessment (1994): ***Saving Energy in U.S. Transportation.***
This study included a review of previous work on estimating the external costs associated with various modes of travel. This review provided some valuable background information and included references to other useful materials.

Vancouver International Airport Authority (1996): ***Annual Report: 1996.***
This report provided direct information about current airport revenues and projected future costs. These data were used to develop estimates for the terminal costs associated with air travel to and from Vancouver, B.C.

Wardman, Mark (1996): ***A Review of Evidence on the Value of Travel Time in Great Britain.*** **HETA Division, Department of Transport, Great Britain.**
Wardman's analysis of travel time provided a useful review of the different methodologies that have been used to assess the value of travel time. However, the specific estimates presented in his study applied to Great Britain and were not used in the current analysis.

Washington State Department of Ecology (1993): ***1992 Washington State Waste Characterization Study.*** **Solid Waste Services Program Publication #93-45.**
The Department of Ecology's review of the waste generated in the State of Washington provided some direct evidence about the volume of waste attributable to automobiles and other modes of transportation.

Washington State Department of Ecology (1990): ***Moderate Risk Waste, A Progress Report.*** **Volume 2-1 of the Problem Waste Study.**
This report provided further evidence about the volume of waste attributable to automobiles and other modes of transportation.

Waters, W. (1992): ***The Value of Time Savings for The Evaluation of Highway Investments in British Columbia.*** **Prepared for the British Columbia Ministry of Transportation and Highways.**
This report included a thorough review of the issues surrounding the valuation of travel time. The author's recommendations regarding the differential valuation of driver's and passenger's travel time were integrated into the current analysis.

APPENDIX A
SUMMARY OF PASSENGER MILE CALCULATIONS

In order to standardize costs and develop a methodology that allows for comparisons across modes, the current analysis views costs on a per passenger mile basis. This approach places very different modes of travel on a common footing, allowing for simple, direct comparisons. For each mode, slightly different sets of calculations were needed to convert the available data into terms that were appropriate for a per passenger mile comparison of costs. These calculations are reviewed below:

Automobile Travel. For automobile travel, estimates of future travel where based on vehicle counts for sub-sections of existing roads and projections about how vehicle travel is expected to grow over the next 20 years. These estimates of total vehicle miles were then converted to estimates of total passenger miles under the assumption that vehicle occupancy averages 1.4 persons. The table below summarizes these calculations for the highways considered in the current analysis.

Exhibit A-1
Total Passenger Miles Traveled in Interstate 5 Corridor

Highway	Annual Growth Rate	Vehicle Miles Traveled in 1995	Vehicle Miles Projected for 2020
Interstate 5	1.03	8,176,954,909	15,400,558,994
Interstate 405	1.02	1,355,221,936	2,112,356,366
Interstate 205	1.03	226,966,275	420,782,785
State Route 512	1.03	227,982,814	422,667,393
State Route 167	1.02	614,935,542	979,831,493
Total Vehicle Miles		**10,602,061,476**	**19,336,197,032**
Passengers per Vehicle		1.4	1.4
Total Passenger Miles		**14,842,886,066**	**27,070,675,844**

These estimates were then used to convert the costs associated with road maintenance and preservation, as well as the capital cost projections for the Interstate 5 corridor, into per passenger mile terms.

Estimates of the direct costs of vehicle ownership were gathered from sources that reported costs on the basis of vehicle miles. These estimates were converted to a passenger mile basis under the assumption that occupancy averages 1.4 persons per vehicle. This occupancy figure is consistent with estimates reported by WSDOT, the Puget Sound Regional Council, and other national studies.

The same approach was used in converting estimates of external costs to a per passenger mile bases; available estimates of costs per vehicle mile were directly converted to costs per passenger mile.

Passenger Rail. Estimates for the current and projected levels of patronage for intercity rail were gathered from Wilber Smith Associates' report "Operational Analysis: Pacific Northwest Rail Corridor". This analysis included projections of the number of passengers expected over each set of city pairs within the overall corridor. These estimates were developed from origin and destination data provided by Amtrak and independent projections of the future demand for rail travel. From these data it was possible to calculate the number of passengers and number of passenger miles associated with each pair of cities. This figures were then totaled in order to estimate the overall number of a passenger miles. Exhibit A-2 summarizes the total estimates of passenger traffic that underlie the analysis of rail travel.

Exhibit A-2
Total Passenger Miles Traveled on Passenger Rail

	1996	Phase 1	Phase 2	Phase 3	Phase 4
Total Passengers	296,671	1,127,557	1,412,413	1,757,344	2,159,995
Total Passenger miles	48,870,000	168,853,476	213,274,325	265,358,971	330,123,084

These estimates were used in the analysis of the operating and capital costs associated with passenger rail. Total costs were divided by total passenger miles to produce estimates of cost per passenger mile.

Air Travel. For the analysis of air travel it was not actually necessary to develop estimates of the total mileage traveled within the corridor. Instead, flights between city pairs were viewed on an individual basis and costs were allocated over the mileage associated with each specific city pair. An example of such calculations is presented in Exhibit A-3, below.

Exhibit A-3
Air Travel Between Portland and Seattle
Direct Costs per Passenger Mile

	Costs
Airfare	$90
Terminal Costs	
Seattle (Operating and Capital)	*$16*
Portland (Operating and Capital)	*$12*
Total Terminal Costs	$28
Airline Coverage of Terminal Costs	($14)
Total Costs	**$103**
Total Mileage	170
Total Direct Costs per Mile	**$0.61**

However, as shown in Exhibit A-3, a complete analysis of the costs associated with travel did require a consideration of the costs required to provide air terminal services at either end of the trip. These costs were calculated on a per enplanement basis from data provided by each of the relevant airports. The total operating and capital costs associated with providing passenger air services was divided by the total number of enplanements to allocate overall costs to individual passengers. As shown in Exhibit A-

3, these terminal costs are then divided by the total number of miles to convert costs to a per passenger mile basis. These calculations also recognize that a portion of the terminal costs are absorbed directly by the airline and are already reflected in the ticket price. A more detailed presentation of the analysis of air travel costs can be found in the summary tables located in Appendix E.

APPENDIX B

DIRECT COSTS OF AUTOMOBILE TRAVEL

Vehicle Ownership Costs. Estimates of average vehicle ownership costs were derived from the 1997 edition of the American Automobile Association's (AAA) annual publication "Your Driving Costs". This summary report provides a comprehensive analysis of the direct costs associated with owning and operating various types of vehicles. As the Exhibit B-1 shows, the approach developed in the AAA report includes day-to-day costs such as gasoline, oil and maintenance, as well as the expenses associated with insuring, licensing, and financing a personal automobile. Financing costs are estimated under the assumption that the car is purchased with a 20% down payment and financed at rate of 9.0%. Depreciation costs reflect the difference between purchase price and resale value.

The estimates reported by the AAA separately address the costs associated with sedans and light trucks. The analysis of sedans offers specific cost estimates for three different makes and models, varying from the low-end Chevrolet Cavalier to the higher-end Mercury Grand Marquis. AAA develops a composite estimate for a typical sedan by averaging the costs associated with these three different models.

The AAA report also provides cost estimates for a specific sport utility vehicle (Chevrolet Blazer) and a particular minivan (Plymouth Caravan). The AAA's cost estimates confirm the expectation that these types of vehicles are generally more expensive to operate than standard automobiles. On average, these vehicles cost nearly $0.50 per mile to operate, while the average sedan costs less than $0.45 per mile.

Exhibit B-1, on the following page, details the individual factors that underlie the overall costs estimates for each type of vehicle:

Mix of Vehicles in Current Fleet. Given separate estimates for the cost of sedans and other automobiles, information about the current mix of vehicles was needed in order to develop a composite measure of direct costs. The required data were provided in a report developed by the U.S. DOT's Volpe Center (Pickrell and Schimek (1998)). This report analyzed census reports regarding vehicle choice and provided a detailed breakdown of private automobile ownership in the western U.S. As Exhibit B-2 on the following page, shows the result of this analysis demonstrated that 61% of the vehicle fleet in the western U.S. is composed of sedans, while the remaining 39% is made up of pickup's, sport utility vehicles, minivans and other vehicles.

Using these percentages, a composite cost was calculated by taking a weighted average of the cost associated with each type of vehicle. This calculation is summarized in Exhibit B-1.

Converting to Cost per Passenger Mile. Data on average vehicle occupancy was then used to convert estimates of costs per vehicle mile into estimates of costs per passenger mile. Information from WSDOT indicated that occupancy averages 1.4 persons per vehicle. Using this estimate, the composite cost of $0.468 per vehicle mile becomes $0.335 per passenger mile. When parking costs of $0.050 per passenger mile are added, the final estimate of direct vehicle costs for 1997 reaches $0.385 per passenger mile.

Exhibit B-1

Vehicle Ownership Costs:

Based on a 4-Year Retention Cycle and 15,000 Miles per Year

Sedans - Represent 61% of Total Vehicles	**Cavalier**	**Taurus**	**Grand Marquis**	**Average**
Operating Costs (Gas, Oil, M	$1,425	$1,635	$1,815	$1,620
Ownership Costs				
Insurance	*$832*	*$809*	*$901*	*$847*
License, Registration, Taxes	*$170*	*$220*	*$255*	*$216*
ciation and Finance Charge	*$3,335*	*$4,061*	*$4,726*	*$4,040*
Total Operating Costs	$4,337	$5,090	$5,882	$5,103
Total Costs	**$5,762**	**$6,725**	**$7,697**	**$6,723**
Total Miles	15,000	15,000	15,000	15,000
Cost per Mile	$0.384	$0.448	$0.513	$0.448

Pickups/SUV's/Minivans - Represent 39% of Total Vehicles	**Blazer**	**Caravan**	**Average**
Operating Costs (Gas, Oil, M	$1,815	$1,710	$1,763
Ownership Costs			
Insurance	*$1,214*	*$876*	$1,045
License, Registration, Taxes	*$366*	*$348*	$357
ciation and Finance Charge	*$4,415*	*$4,216*	$4,316
Total Operating Costs	$5,995	$5,440	$5,718
Total Costs	**$7,810**	**$7,150**	**$7,480**
Total Miles	15,000	15,000	15,000
Cost per Mile	$0.521	$0.477	$0.499
Weighted Average Cost per			**$0.468**

Source: Your Driving Costs, American Automobile Association, 1997

Exhibit B-2

Vehicle Ownership in the Western U.S.

Vehicle Type	**Percentage of Fleet**
Passenger Cars	61%
Pickup	20%
Sport/Utility	8%
Van	7%
Other	4%
Total	100%

Source: U.S. DOT

APPENDIX C
LISTING OF CITY-TO-CITY AIRFARE DATA

Comparison of Airfares - Seattle to Portland

Fare Data

Type of Ticket	For Immediate Purchase:	At Least 3 Days Advance Booking:
No Saturday Stay Over *(One-Way based on Round-Trip Ticket)*	$128	$111
Saturday Stay Over *(One-Way based on Round-Trip Ticket)*	$120	$34
One-Way	$128	$111

Calculation of Average Fare

Type of Fare	Percentage of Trips	Fare
Business	73%	$111
Non-Business	27%	$34
Weighted Average		**$90**

Comparison of Airfares - Seattle to Vancouver

Fare Data

Type of Ticket	For Immediate Purchase:	At Least 3 Days Advance Booking:
No Saturday Stay Over *(One-Way based on Round-Trip Ticket)*	$118	$106
Saturday Stay Over *(One-Way based on Round-Trip Ticket)*	$118	$43
One-Way	$113	$101

Calculation of Average Fare

Type of Fare	Percentage of Trips	Fare
Business	73%	$106
Non-Business	27%	$43
Weighted Average		**$89**

Comparison of Airfares - Portland to Vancouver

Fare Data

Type of Ticket	For Immediate Purchase:	At Least 3 Days Advance Booking:
No Saturday Stay Over *(One-Way based on Round-Trip Ticket)*	$193	$123
Saturday Stay Over *(One-Way based on Round-Trip Ticket)*	$193	$63
One-Way	$186	$117

Calculation of Average Fare

Type of Fare	Percentage of Trips	Fare
Business	73%	$123
Non-Business	27%	$63
Weighted Average		**$106**

Comparison of Airfares - Seattle to Bellingham

Fare Data

Type of Ticket	For Immediate Purchase:	At Least 3 Days Advance Booking:
No Saturday Stay Over *(One-Way based on Round-Trip Ticket)*	$78	$67
Saturday Stay Over *(One-Way based on Round-Trip Ticket)*	$78	$43
One-Way	$108	$54

Calculation of Average Fare

Type of Fare	Percentage of Trips	Fare
Business	73%	$67
Non-Business	27%	$43
Weighted Average		**$60**

APPENDIX D
AIRLINE FARES

In estimating the direct costs of air travel, data were collected on current airline fares in the Pacific Northwest. The availability of Internet reservation services make it relatively easy to search across airlines for the range of possible fares. As expected, this analysis found that fares were contingent upon the departure date, the length of stay, and the time of the flight.

Exhibit D-1 summarizes the range of fares for flights from Seattle to Portland. Notice that the cost of travel varies significantly, from a low of $34 to a high of nearly $130. A comparable range of fares was also found for the other city pairs.

EXHIBIT D-1
AIR FARES FOR TRAVEL BETWEEN SEATTLE AND PORTLAND
(One-Way Fares)

Type of Ticket	For Immediate Purchase:	At Least 3 Days Advance Booking:
No Saturday Stay Over *(One-Way based on Round-Trip Ticket)*	$128	$111
Saturday Stay Over *(One-Way based on Round-Trip Ticket)*	$120	$34
One-Way	$128	$111

Ideally, average fares would have been calculated by weighting each of these fares according to the percentage of travelers who book under each distinct set of conditions. However, as a practical matter, this was not possible. Airlines regularly adjust their fares in an effort to maximize revenues and the fares summarized above only highlight the range of fares offered on any given flight. In addition, more specific ridership data would need to come directly from the airlines themselves, and this is proprietary information that they are not generally willing to share.

In order to provide a realistic estimate that does not over- or under-state the direct costs associated with intercity air travel, the current analysis is based on average of the fares faced by business and non-business travelers. It was assumed that business travel would not be booked with a Saturday stay over, but would be made on 3 days notice. Those traveling on vacation or for personal reasons were assumed to book tickets in advance and take advantage of the discount available with a Saturday stay over. Research conducted by Gannet Fleming in its assessment of the potential demand for high speed rail found that 73% of the airline trips taken within the Portland-Seattle-Vancouver corridor are associated with business travel, while the remaining 27% are completed for non-business reasons.

Using these weights, a composite average fare was calculated for each relevant city pair. Using the fares between Seattle and Portland as an example, this calculation is summarized below:

EXHIBIT D-2
WEIGHTED AVERAGE FARE FOR

Travel Between Portland and Seattle

Type of Fare	Percentage of Trips	Fare
Business	73%	$111
Non-Business	27%	$34
Weighted Average		**$90**

This average fare was then combined with estimates of each airports operating and capital costs to develop an overall estimate of the direct costs of air travel. Continuing with the Portland-Seattle example, these calculations are summarized in Table D-3.

Table D-3
Direct Costs of Air Travel
Between Portland and Seattle

Airport Operating Costs - 1998			
Seattle		**Portland**	
Operating Costs	$73,430,217	*Operating Costs*	$41,969,923
Capital Costs	$82,865,155	*Capital Costs*	$40,416,515
Total Costs	$156,295,372	Total Costs	$82,386,438
Enplanements	$10,738,393	*Enplanements*	$6,838,514
Cost Per Enplanement	$14.55	Cost Per Enplanement	$12.05
Airlines Share of Costs	$7.13	Airlines Share of Costs	$5.76
Net Costs Per Enplanment	**$7.43**	**Net Costs Per Enplanment**	**$6.29**
Air Fare			
Seattle-Portland	**$89.83**		
Total Direct Costs	**$103.55**		
Miles	170		
Costs Per Passenger Mile	**$0.61**	(Includes Airport Capital Costs)	

The costs associated with each airport are estimated on a per enplanement basis. The costs reported in Table D-3 include both the operating and capital costs associated with each terminal. This calculations also recognizes that a portion of the terminal costs are charged directly to airlines and are thus included in the airfare itself. Therefore, the airlines contribution to airport operations are deducted before final enplanement costs are calculated. These costs were then added to the airfare before being divided by the mileage associated with each trip to complete the calculation of direct costs per passenger mile. For the analysis of direct operating costs, the airport capital cost estimates were excluded from the analysis.

APPENDIX E

CROSS-MODAL ANALYSIS DETAILED WORKSHEETS

APPENDIX F

AVERAGE WAGES AND THE VALUE OF TRAVEL TIME BY MODE

Average Wage. As noted in the main body of the report, estimates of the value of travel time are generally expressed as percentage of average hourly wage. In applying this approach to the current study, it was necessary to develop an estimate of average local wages. Data provided by the Department of Employment Securities summarized average monthly wages in each of the counties within the I-5 corridor. To develop a composite measure of average wages, the county-level data reported by employment securities was weighted according to each county's share of the corridor's total population. This estimate of average monthly wages was then converted to a direct estimate of hourly pay. This analysis is summarized in Exhibit F-1.

Exhibit F-1

Average Monthly Wages by County

County	Population	Percentage of Corridor Population	Average Monthly Wage (1997)
Whatcom	152,800	4%	$1,863
Skagit	95,500	3%	$1,851
Snohomomish	538,100	14%	$2,414
King	1,628,800	44%	$2,684
Pierce	665,200	18%	$2,056
Thurston	193,100	5%	$2,172
Lewis	66,700	2%	$1,870
Cowlitz	90,800	2%	$2,213
Clark	303,500	8%	$2,129
Total =	**3,734,500**	**100%**	
Weighted Average Monthly Wage			**$2,381**
Hourly Wage (Assumes Full-Time Employment)			**$13.74**

Source: Washington State Department of Employment Securities

Value of Travel Time by Mode. This final estimate of hourly wages was then used as an input into the analysis of travel time for each individual mode. Although previous research linked the value of travel time to wages, it also indicated travel time should be valued somewhat differently across modes. The difference is based on the observation that passengers are able to make better use of their travel time than are drivers. This implies that travel time costs are lower for air and rail, where driving is not required and travel time can be put to more productive uses. Exhibit F-2 demonstrates the calculations that were used to formalize this relationship. Following the recommendations offered in Water's (1992) study for the B.C. Ministry of Transportation, travel time for passengers was valued at 70% of the rate assigned to vehicle drivers.

Exhibit F-2

Value of Travel Time by Mode

Travel Mode	High Cost Estimate - Business Travel Time				Low Cost Estimate - Business Travel Time			
	Wage Rate ($ per hour)	Percent of Wage Rate Used to Value Travel Time	Adjustment for Travel as a Passenger	Value of Travel Time ($ per hour)	Wage Rate ($ per hour)	Percent of Wage Rate Used to Value Travel Time	Adjustment for Travel as a Passenger	Value of Travel Time ($ per hour)
Automobile								
Driver	$13.75	100%	-----	**$13.75**	$13.75	50%	-----	**$6.88**
Passenger	$13.75	100%	70%	**$9.63**	$13.75	50%	70%	**$4.81**
Rail	$13.75	100%	70%	**$9.63**	$13.75	50%	70%	**$4.81**
Air	$13.75	100%	70%	**$9.63**	$13.75	50%	70%	**$4.81**

- Notice that separate estimates were derived for automobile passengers and drivers. The composite cost for automobile travel relies on the earlier assumption that vehicle occupancy averages 1.4 persons.

- Exhibit F-2 focuses on the value of business travel time, but similar calculations were used to estimate the value of leisure travel time. Following standard approach taken in the literature, leisure travel was value at one half the rate assessed for business travel.

- In order to complete the valuation of travel time, information was collected about the share of business and leisure travel that occurs on each alternative mode. These data were gathered as part of Gannet Fleming's 1992 High Speed Ground Transportation Study. This information were then used to weight the relative costs associated with business and leisure travel. The detail of these calculations can be found in the summary tables in Appendix E.

APPENDIX G

AIR QUALITY AND POLLUTION EXTERNALITIES

Estimating the externality cost associated with air pollution involved a two step process. Initially, emissions data were be gathered for all three modes. These data summarized the quantity of pollution that is associated with each travel mode. To facilitate comparisons across modes, emissions levels were standardized to grams of pollutant per passenger mile. The final set of emission estimates are summarized in Exhibit G-1.

Exhibit G-1

Emission Rates – Grams per Passenger Mile

	Automobile	*Airplane (Jet Aircraft)*	*Rail (Diesel)*
CO_2	250	160	230
Volatile Organic Compounds	2.68	.145	.160
CO	16.4	.461	.600
NO_x	.900	.209	.900
Particulate Matter	.008	Not Available	.080
Road Dust	.879	Not Applicable	Not Applicable
SO_x	.027	Not Available	.051

Source: Small and Kazimi (1995), UCB-ITS (1996), NRDC (1993)

- As described in the full report, the emission rates for automobiles reflect the estimates presented in Small and Kazimi's (1995) analysis of automobile pollution in southern California. Their figures are based on engineering models of vehicle emission but were adjusted by the authors to reflect the existing mix of vehicles and actual pollution levels.

- Estimates of airplane pollution were obtained from UCB-ITS (1996) study of intercity travel in California. They reflect emissions from jet aircraft rather than smaller propeller driven commuter planes. Given that 96% of air travel within the Northwest Corridor occurs on larger jet aircraft, these estimates should be representative of local air travel.

- The most complete set of emission data for diesel rail was compiled as part an NRDC study completed 1993. The authors of this reported collected separate sets of data for different types of rail, including diesel, electric, light rail (diesel), and transit (electric). The figures cited above represent emissions associated with a heavy rail system powered by diesel fuel.

Given this data on emissions, the second step of the analysis involved assigning an appropriate economic cost to each type of pollutant. These costs were driven by two different factors: immediate impacts to human health; and the long-term implications for global warming and climate change. In order to maintain comparability across modes, the same cost estimates (on a per gram basis) were applied to the analysis of each mode. The most complete assessment of the potential health impacts of air pollution was provided in Small and Kazimi's analysis of auto travel. Because the estimates develop in this study apply to conditions in an urban area, they may somewhat overstate the pollution impacts associated with intercity travel and emissions in rural areas. However, the overall results generated with these estimates were generally consistent with findings in previous studies.

Research into the external costs associated with climate change is in area of significant controversy and disagreement. Estimates of the costs associated with global warming range from less than $5.00 per ton of carbon to more than $100.00 per ton. Using the lower range of the available estimates ($5.80 per metric ton), our final results were consistent with previous analyses of pollution costs.

Exhibit G-2 summarizes the cost estimates applied to each component of air pollution.

Exhibit G-2
Costs Per Gram 0f Emissions

	Low Cost Estimate	*High Cost Estimate*
Health Impacts		
Volatile Organic Compounds	$0.002	$0.003
CO	$0.001	$0.001
NO_x	$0.001	$0.012
Particulate Matter	$0.051	$0.110
Road Dust	$0.017	$0.037
SO_x	$0.055	$0.121
Climate Change		
CO_2	$0.000 ($5.80 per metric ton)	$0.000 ($5.80 per metric ton)

To complete the calculation of external costs, the per gram estimate of costs was multiplied by the emission estimates cited in Exhibit G-1. A sample of such a calculation is present in Exhibit G-3. Similar calculations were completed for both air and automobile travel as well.

Exhibit G-3
Air Pollution Costs Associated with Diesel Rail

	Rail Emissions (Grams per Pass. Mile)	*Cost per Gram (Low)*	*Cost per Gram (High)*	*External Cost (Low)*	*External Cost (High)*
Volatile Organic Compounds	.160	$0.002	$0.003	$0.000	$0.001
CO	.600	$0.001	$0.001	$0.001	$0.001
NO_x	.900	$0.006	$0.012	$0.006	$0.011
Particulate Matter	.080	$0.051	$0.110	$0.004	$0.009
Road Dust	Not Applicable	$0.017	$0.037	-----	-----
SO_x	.051	$0.055	$0.121	$.003	$0.006
CO_2	230	$0.000	$0.000	$.000	$0.000
Total				$0.014	$0.028