Benefit-Cost Analysis of the Proposed Monorail Green Line

For the

Elevated Transportation Company

Seattle, Washington

By

DJM Consulting

&

ECONorthwest

Revised

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Executive Summary

With proposed capital costs of $1.3 billion in 2002 dollars, the proposed "Green Line" of the Seattle Monorail Project represents a major public investment in transit for Seattle. Seattle voters will go to the ballot in November of this year to decide whether to construct a 14-mile monorail line that would serve Seattle Center, downtown, and the stadium district from Ballard and West Seattle.

The Elevated Transportation Company commissioned this study to answer a very basic question: "Is the proposed monorail a good transportation investment?" The monorail will yield real benefits to the community including faster, more frequent, and more reliable travel times compared to buses, savings in auto operating and parking costs for those who switch their trip-making from cars to monorail, and a reduction in accidents. The key public investment issue is whether the value of these and other benefits of the monorail over the life of the project will exceed its significant costs.

This analysis shows that the monorail's benefits do exceed its cost and the proposed Green Line represents a prudent investment in transportation capacity for the City of Seattle. The project generates economic returns of 8.0%, a level that is competitive with the current return on long-term corporate bonds. The net benefits of the project are in excess of $390 million. An evaluation of the uncertainties in both costs and benefits indicate that ultimate returns of the project could range from 5.2% to 9.9%. From an economic perspective, the City of Seattle will most likely be better off with the monorail investment than without it.

Several factors contribute to cost-effectiveness of the monorail proposal in Seattle:

1. *Exclusive, elevated, right-of-way enables significantly faster transit travel times.* For example, the in-vehicle time for a trip from Ballard to downtown drops from 39 minutes on the bus to 16 minutes on the monorail during the peak.
2. *Low land acquisition costs.* The monorail support columns will be placed in existing right of way already owned by the City of Seattle which lowers the land acquisition costs.
3. *Straight- forward construction limits risk of cost overruns.* Monorail construction involves relatively low risks and the strategies for mitigating them are well understood.
4. *Automated system enables low operating costs.* The proposed system uses computer technology to significantly reduce staffing and operating costs.
5. *Monorail does not interfere with automobiles or pedestrians, which reduces accidents and maintains travel speeds of other modes.* Monorail will not cause substantial delay during construction, and its operation will not constrain or impede other modes.

Introduction

With proposed capital costs of $1.3 billion in 2002 dollars, the proposed "Green Line" of the Seattle Monorail Project represents a major public investment in transit for Seattle. Seattle voters will go to ballot in November of this year to decide whether to construct a 14-mile monorail line that would serve downtown from Ballard and West Seattle. Seattle residents and businesses would pay for the proposed system with a 1.4% excise tax on the value of their motor vehicles, at a cost of $94 per year on a median car value of $6,700. The proposed system and financing plan are described in *Building the Monorail: ETC Seattle Popular Monorail Plan*[1]

The Elevated Transportation Company, the public agency charged with developing the monorail plan and recommending it to the voters, commissioned this study to answer a very basic question: "Is the proposed monorail a good transportation investment?" The monorail will yield real benefits to the community including faster, more frequent, and more reliable travel times compared to buses, savings in auto operating and parking costs for those who switch their trip-making from cars to monorail, and a reduction in accidents. The key public investment issue is whether the value of these and other benefits of the monorail over the life of the project will exceed its significant costs.

This study provides a benefit-cost analysis of the proposed monorail project. It does not, however, compare the monorail to other alternative transit investments. Given the mandate to design and propose a monorail system, the ETC has commissioned this analysis to evaluate whether the returns on the proposed monorail are sufficient to justify the investment compared to the rates of return on capital in the private economy.

This analysis was conducted and written by Daniel Malarkey of DJM Consulting and reviewed by Chris Mefford and Randy Pozdena of ECONorthwest. Malarkey and Mefford both worked as technical consultants to the Governor Gary Locke's Blue Ribbon Commission on Transportation and together have more than twenty years combined experience with transportation planning, economics, and finance. As a consultant, Malarkey has worked for the City of Seattle on station area planning for the LINK light rail system, conducted an early benefit-cost analysis on Sound Transit's 1996 plan for the Washington Research Council, and lead several studies regarding the application of least-cost planning to transportation for the Puget Sound Regional Council. Chris Mefford was a Senior Planner at the Puget Sound Regional Council before joining ECONorthwest. He managed a market analysis of the area near the commuter rail station for the City of Sumner, developed forecasts to assist with toll revenue estimates for the Tacoma Narrows Bridge expansion, and evaluated the economic impacts of light rail in Tukwila, Washington. Pozdena earned his Ph.D. in economics from Berkeley and has

[1] A copy of the plan can be found at the Elevated Transportation Company web site, www.elevated.org, along with other supporting documents for this report.

extensive experience in local, state, and national transportation planning. He is co-author of the benefit cost analysis manual User Benefit Analysis for Highway and Bus Transit Improvements, (the "Redbook") published by AASHTO and has published numerous articles in the areas of transportation cost estimation, cost-based pricing, and implementation of externalities charges.

John S. Niles reviewed an earlier version and made several suggestions on how to account for travel time savings that improved the report. John Niles is owner and president of Global Telematics, a policy research and management consulting firm based in Seattle. Mr. Niles is a member of the Telecommunications and Travel Behavior Committee of the Transportation Research Board, Senior Fellow for Technology and Transportation at DiscoveryInstitute, and Research Associate at the Mineta Transportation Institute.

Benefit-Cost Overview

Benefit-cost analysis is a well-established analytic framework for evaluating public expenditure decisions. Readers interested in a more detailed discussion of the technique and its application to transportation are encouraged to consult some of the references section at the end of this report. For the purposes of this report, we can state the task simply: we must identify all of the relevant costs and benefits over time, express them in dollars, and compare them to see if the benefits exceed the costs. To do it properly, we must keep four main points in mind.

Compare Future With and Without Monorail

Analysts evaluating an investment like the monorail must compare the differences between a future with the monorail and future without it. The main tool for making these alternative forecasts are the population, employment, and travel demand and network models developed and maintained by the Puget Sound Regional Council. These models are the foundation for this analysis and are documented in the report, *Ridership Forecast Documentation for the Seattle Monorail Project*[2]. We use the models to develop forecasts of trip making and travel times in 2020 for two systems: one without the monorail (but with projected improvements in bus service) and one with the monorail (and the same bus service hours allocated to provide feeder service to the monorail). With these two forecasts of the future, we can measure the differences in ridership and travel times between the two future systems. Our estimate of benefits is only as good as our forecast. The forecasting methodology focuses on journey-to-work trips and is calibrated match to current bus service. It does not account for some of the service characteristics of monorail such as reliability and comfort that will tend to attract ridership and therefore may be conservative. The modeling documentation acknowledges that the ridership forecasts include a 10% margin of error. In making our comparisons between the future with and without the monorail, we integrate this uncertainty by testing a range of potential benefits.

[2] This report can be found at http://www.elevated.org/docs/RIDERSHIP_FORECAST_DOCUMENT.pdf

Measure all benefits and costs

Most of the costs of the monorail project can be measured by adding up the market costs of the resources used such as labor, concrete, steel, and trains. However, the benefits of a transit project like the monorail are not bought and sold directly in the market. The main benefit to the system's users is reduced travel times compared to buses because the monorail trains will travel on a separate right-of-way that can maintain high travel speeds regardless of the amount of congestion on the streets. Monorail also provides improved reliability and increased frequency of travel by transit as well as lowering the number of accidents. While these benefits do not have established market prices, the professional literature of transportation and environmental economics provides a range of accepted values for expressing many of them in dollar terms. For example, reductions in travel time have been extensively studied and are typically valued at approximately half of people's wage rate. Our task is to enumerate all of the benefits and costs and assign dollar values to as many as possible.

Comprehensive and mutually exclusive

Analysts must take care to identify and count all of the benefits and cost of a project like the monorail and then only count them once. For example, the monorail will reduce travel times and increase the number of riders traveling to downtown by transit. Typically property owners near transit stations capture some of the value of these time-savings by raising their rents and with them the underlying value of the property. Some benefit-cost studies have counted both the travel time savings and the increase in property values which represents double counting. Increases in property values represent the capitalization of travel time savings and improved access that we can measure separately. Our list of benefits and costs therefore must be comprehensive but also mutually exclusive.

Use Present Value

If we successfully categorize and measure all the cost and benefits in dollars without double-counting, it is not enough to simply add them up. Capital intensive projects like the monorail involve large up front expenditures and then a long stream of benefits over the life of the project. We must express those future costs and benefits in present value terms to account both for inflation and the opportunity costs of using capital. Most often the opportunity cost of capital is viewed as the real rate of return on investments in the private economy. We therefore discount those future dollars at rate that reflects the opportunity costs of capital in these investments. With AAA corporate bond rates currently yielding 6%, we have chosen a 6% nominal discount rate to covert future benefits and costs to their present value.[3]

[3] Most of the finance model assumes a 3% future inflation rate so when dollars are expressed in constant 2002 dollars, the nominal discount rate of 6% is converted to a real discount rate of 3%. See Small (1999) for a more detail discussion of discount rates.

Costs

The following table from *Building the Monorail: ETC Seattle Popular Monorail Plan* summarizes the costs for building and operating the proposed system. The capital costs of the system are $1.29 billion in 2002 excluding reserves. Including reserves for cost escalation to account for inflation during construction brings the capital cost to $1.65 billion in year of expenditure dollars. Adding the costs of running the new monorail agency and an initial operating subsidy brings the total costs over the first nine years to $1.75 billion.

These cost estimates have undergone extensive outside review as described in *Building the Monorail.* A separate group of consultants hired by the City of Seattle reviewed all of the cost-estimating materials to evaluate the cost and schedule risk inherent in the current estimate. That study concluded that there was a 60% chance that the project could meet or beat the current budget and there was a 90% chance the project would come in below a budget 15% higher than this. This risk analysis enables us to evaluate how potential changes in the project costs could affect the overall benefit-cost picture for the project.

Table 1. Green Line Project Cost Budget ($ in millions)

Item	Design-to-Cost	Contingency	TOTAL
Trains and Control Systems	$225	$30	$255
Stations	$115	$20	$135
Beams, Columns, Foundations	$260	$40	$300
Water Crossings	$100	$20	$120
Maintenance Facility	$20	$10	$30
Power Supply	$80	$15	$95
Utility Relocation	$60	$20	$80
Rights of Way	$25	$5	$30
Hazardous Materials	$5	$5	$10
Design and Administration	$190	$45	$235
Sub Total in 2002 $	$1,080	$210	**$1,290**
Project Reserves	Cost escalation to YOE:		$199
	Sales tax in YOE:		$80
	Agency Reserves in YOE:		$76
Agency Costs	Pre-construction planning/design:		$32
	Program management:		$41
Operating Subsidy	Nine-year startup operating subsidy:		$25
Second Line Planning	Agency costs for planning:		$6
TOTAL COSTS SUPPORTED BY PROPOSED MVET (YOE $):			**$1,749**

In addition to the costs reported in this table, once in operation the Green Line will require an annual operating budget of approximately $29 million per year which are largely paid from fares and advertising revenue. These operating costs represent real resources used to provide the monorail service and are included in this analysis. All of the capital and operating costs projections by year are reported in the *Monorail Finance Plan, August 2002.*

Non-monetary costs

In addition to the monetary costs of the monorail projects there are several non-monetary costs that deserve discussion. They include the potential visual impacts of the monorail, noise impacts, and delay during construction.

The Final Environmental Impact Statement for the monorail describes the visual impact the elevated guideway could have on certain view corridors in Seattle. The ETC has taken steps to mitigate the visual impact of the monorail by designing narrower columns with wider spacing than the current elevated structure on 5th Avenue between downtown and Seattle Center. Nonetheless, there is a potential cost associated with the visual impacts of the new structure. Monorail proponents note that riders of the monorail will be treated to extraordinary views of the city, sound, and mountains along the 14 mile route. Given the subjective nature of these assessments, we have not attempted to quantify and assign dollar costs to the visual impacts of the monorail. For our purposes, we make the plausible assumption that any visual costs imposed on some people by the elevated structure will be offset by the visual benefits to those riding the system.

Electrically powered rubber-tired monorail trains are considerably quieter than the diesel powered buses that they will replace on downtown streets. While there may be some noise impacts to people living and working in very close proximity to the elevated line, they are more than offset by the reduction in noise on the street level because of the buses removed from the street. For the purposes of this analysis, we assume no net noise costs from the proposed plan.

The construction of the monorail will also impose some travel delay on city streets and generate additional noise. The EIS discusses strategies for mitigating these impacts. These impacts are likely too small and on the order of the effects from ongoing street and utility repairs. For the purposes of this analysis, we assume the costs of construction delay are zero. One advantage of the monorail compared to other large transportation projects is that the guideway construction occurs off-site and can be placed on the columns in those areas of dense population at nights and on weekends when there is less congestion.

Benefits

At the most general level, there are three categories of people who benefit directly from the monorail. The first is people who would use bus transit anyway who will travel more quickly and reliably on transit system that includes the monorail. For them, the main benefit of the monorail is reduced travel and waiting time. The second group is people who would otherwise drive or not travel but will instead take the monorail because of the improvements in service compared to buses. In addition to improved speed and reliability, these new riders benefit by saving the costs of parking and operating their cars. The third group of beneficiaries is people who continue to use the roadways that have added capacity because bus and car trips have moved off the road and onto an elevated guideway. We calculate benefits for each of these groups of direct beneficiaries.

As noted earlier, there are also secondary beneficiaries such as the property owners near monorail stations who are able to charge higher rents. However, these secondary benefits represent a transfer from riders rather than an incremental benefit of the project. There are some other more abstract benefits such as community pride that may extend to the entire community. We discuss these potential effects but do not attempt to place a dollar value on them. Table 2 lists the monorail's benefits and dollar estimates for the forecast year 2020. Total benefits in that year are $135.6 million in 2002 dollars.

Table 2. Monorail Green Line Benefits in 2020

Benefit Type	Benefit Value (Millions, 2002$)
Value of Travel Time Savings to Riders	$77.1
Parking Savings	28.7
Reduced auto operating/ownership costs	11.2
Reliability	7.7
Road capacity for drivers	4.6
Reduction in Bus Related Accidents	3.7
Reduction in Auto Related Accidents	2.6
Increased comfort and amenities	n.q.
Impact on urban form/Development near stations	n.q.
Community pride	n.q.
2020 Benefits:	$135.6

n.q.: not quantified

Travel time savings

The monorail will generate annual travel time savings of approximately 6.4 million hours. The travel modeling conducted by URS provides time savings for weekday commute trips, which are then scaled to account for weekends and the additional event and tourist trips forecast by The Transpo Group. These annual travel time savings are valued at $10.10 per hour, which is half the average regional wage rate reported by the Washington Employment Security Department.[4]

Research has shown that people place a higher value on reductions in waiting time and reductions in transfers that reductions in in-vehicle travel time. The monorail

[4] Detail on the assumptions used to calculate each benefit category and their sources can be found in the Appendix.

proposal will reduce waiting and travel time for those using the system but will increase the number of transfers from feeder buses. The travel forecast methodology employed by the travel forecast firm properly accounts for these differences in the valuation of each component of a transit trip in developing the estimates of timesavings.

Parking savings

The travel modeling indicates that about 18% of the commute trips and 45% of the event trips on the monorail will come from people who would otherwise drive. The monorail will attract 4.7 million trips each year out of cars and onto transit. Those riders who switch to the monorail will save the cost of parking for those trips. Whether parking costs are born directly by the driver or indirectly by an employer, they represent real resources used for storing cars downtown or near other major activity centers that will not be used by those who switch to the monorail. We value those resource savings at the market value for parking in downtown Seattle as reported by the Puget Sound Regional Council. The total value of these savings is $28.7 million per year in 2020.

Auto cost savings

Monorail riders who switch from cars will also save the costs of operating their vehicles. Using the IRS figure of $0.365 per mile and an average trip length of 5.77 miles, switching to the monorail from cars will save riders $11.2 million in auto operating costs each year.

Improved reliability

The monorail will not only shorten travel and waiting times, it will make those times more reliable. Monorail will reduce both the average travel time and the variation in travel time for a given trip. The travel models do not measure the effects of increased reliability but there is no doubt that it is a real benefit of an automated system with exclusive right-of-way. In an earlier study of the 1996 system plan of the Regional Transit Authority, we used 10% of the travel time savings as an estimate for the benefits of increased reliability with fixed guideway systems. This estimate is supported as a lower bound by work done since by Ken Small showing that people place a higher value on time savings in congested and unpredictable traffic conditions. We therefore estimate the value of increased reliability at $7.7 million per year.

Road capacity for drivers

Riders that switch from the auto mode to the monorail will generate some benefits for those who remain on the road. These benefits consist of a combination of reduced congestion and capacity freed up that new drivers could utilize. Our method for calculating this benefit is to estimate the value of the congestion imposed on drivers by the marginal driver entering the roadway during peak periods. The idea is that removing these marginal drivers generates a benefit that is at least equal to the value of the reduction in congestion if the riders moved off the road and no other riders took their place. This value is the same as the toll rate under an optimal road pricing policy. Under such a pricing scenario, tolls are set to a level where the peak period charge per mile is equal to the value of the congestion that an additional car imposes on the vehicles already on the facility. Modeling done for PSRC indicates that optimal tolls on congested highways would be in the range of $.10 to $.20 during peak periods. We use a rate of $0.15 per vehicle mile traveled that switches for the trips that switch from roads t monorail.[5]

Reduction in accidents

Monorails have an excellent record of safety because they operate at a separate grade from sidewalks and roadways. According to the ETC's consultants, there have been no reported passenger injuries or fatalities on straddle-type monorail systems that have provided billions of passenger miles of service in Japan, Seattle, and other U.S. locations. Buses, however, are susceptible to accidents and, according to federal safety statistics, average 1.6 patron injuries per million passenger miles of travel. For riders who switch from bus to monorail, we have estimated the safety benefits by multiplying the bus accident rates per million passenger miles by the economic value of death and injury as reported by the federal government. For those riders switching from cars to monorail, we use an average cost of injury and death per passenger mile from the same federal government sources.[6]

Other benefits

The monorail will generate other benefits that are difficult to quantify. For instance, monorail trains are more comfortable than buses with a more pleasant ride but those qualities are not accounted for in the modeling and we don't attempt to assign a value to them in this analysis. In other communities with fixed rail investment, the land near stations has been developed in more intensive, pedestrian-friendly manner characterized as "transit-oriented development" that many communities find desirable. In addition, many people in communities, such as Portland, Oregon, take pride in their rail systems even if they themselves use it infrequently. Seattle's current monorail and the Space Needle, for example, have achieved the status of city icons. It is difficult to predict exactly how the future monorail line might be regarded by the community but given the populist origins of the current proposal it may well develop symbolic value beyond the utility of its transportation services. We do not attempt to quantify these effects.

The monorail may have some positive effect on air quality. Because of latent demand for auto travel, the total volume of auto emissions in unlikely to decrease significantly. However, replacing 15 bus lines that travel through downtown with monorail service will reduce air borne particles in an area of higher concentrations of air-borne particles and pollutants. We have not attempted to place a dollar value on this benefit to those living and working downtown.

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[5] For more discussion see ECONorthwest (1996).
[6] US DOT, National Highway Traffic Safety Administration (2002).

Evaluation of Benefits and Costs Over Time

Results

Having identified and established the costs and benefits for the monorail system, the next step is to allocate them over time. The finance plan prepared by the ETC, provides a year-by-year forecast of capital and operating expenditures as well as a ridership forecast through 2020. We use the ratio of ridership in the years prior to 2020 to the 2020 forecast to scale the base benefits from 2008 through 2019. We also increase our base benefits in each year by an estimate of the future increase in real wages. Most of the benefits in the analysis are factored from the value of travel time. Over the last several decades real productivity per hour worked has increased at about 1.8% per year. We therefore grow our base benefits calculated in 2002 by this factor to account for the real increases in time values.

After 2020, we assume that ridership grows at the projected growth rate for Seattle's population from 2020 to 2030 which is forecasted at 1.2% according the Puget Sound Regional Council. In the last ten years, transit mode share for the Seattle-Tacoma area has increased contrary to national trends so it is plausible to assume that monorail ridership will keep up with population growth. This seems likely since worsening traffic congestion will improve monorail's attractiveness relative to cars. Table 3 on the following page shows the pattern of costs and benefits from 2003 to 2029, which covers construction and 20 years of operation.

The top of Table 3 summarizes the results of the analysis. The monorail would generate benefits with a present value of $2.07 billion, which exceed the costs of $1.68 billion by $390 million. The benefit-cost ratio is 1.23 using a nominal discount rate of 6% (3% real). The implied rate of return on the monorail investment is 7.95%. This is the discount rate at which the present value of the costs equals the present value of the benefits.

The first four columns show the costs by year in year of expenditure dollars. The term DBOM refers to "Design Build Operate Maintain" and it refers to the operating costs of the entity that will collect the fares and pay the operational expenses of running the monorail trains. The agency costs are those administrative costs associated with managing the DBOM contract and planning future monorail lines. The next six columns show the system costs in 2002 dollars in the year of expenditure and the present value of those amounts. The final four columns show the projected ridership and benefits by year along with the present value of benefits and the cost and benefit flow in 2002 dollars used for calculating the implied rate of return.

Table 3. Monorail Green Line Benefits and Costs
from Monorail August 5 Finance Plan
(000s)
shaded figures direct from monorail finance model

Summary

Benefits	$ 2,067,263	includes residual value
Costs	$ 1,677,099	
Net Benefits	390,164	
BC Ratio:	**1.23**	
Nominal Rate of Return:	7.95%	PV of 2030 Residual Value : 362,852
Cost Per Trip:	$ 5.01	

Sensitivity Analysis:

Cost Factor	1.00
Benefit Factor	1.00

	$ YOE Costs				**2002 $ Costs**									
		Operating					Operating							
Year	Capital	DBOM	Agency	Total	Capital	Present Value	DBOM	Agency	Total Oper.	Present Value	**Annual Ridership**	**Benefits 2002$**	Present Value	Benefit-Cost Flow for IRR
2003	49,100		6,266	55,366	47,831	46,437	-	6,104	6,104	5,926	-			(53,934)
2004	86,516		6,485	93,001	82,036	77,327	-	6,149	6,149	5,796	-			(88,186)
2005	212,146		6,712	218,858	195,866	179,245	-	6,197	6,197	5,671	-			(202,063)
2006	288,413		6,947	295,360	259,186	230,283	-	6,243	6,243	5,547	-			(265,428)
2007	362,038		7,190	369,228	316,548	273,057	-	6,287	6,287	5,423	5,000	26,488	22,849	(296,347)
2008	339,081	24,012	6,698	369,791	288,712	241,791	20,445	5,703	26,148	21,899	9,500	51,233	42,907	(263,627)
2009	222,678	24,733	5,546	252,957	184,662	150,147	20,510	4,599	25,109	20,416	9,500	52,155	42,407	(157,616)
2010	91,056	33,443	4,018	128,516	73,575	58,081	27,022	3,246	30,269	23,895	18,000	100,599	79,414	(3,245)
2011		34,446	2,495	36,941		-	27,129	1,965	29,094	22,298	18,000	102,410	78,488	73,316
2012		35,479	1,291	36,771		-	27,235	991	28,226	21,003	19,000	110,045	81,884	81,819
2013		36,544	1,336	37,880		-	27,314	999	28,313	20,454	19,000	112,026	80,930	83,713
2014		37,640	1,383	39,023		-	27,367	1,006	28,373	19,900	19,000	114,042	79,987	85,669
2015		38,769	1,432	40,201		-	27,394	1,012	28,405	19,343	19,000	116,095	79,055	87,689
2016		39,932	1,482	41,414		-	27,421	1,017	28,438	18,801	19,000	118,185	78,134	89,747
2017		41,130	1,534	42,664		-	27,447	1,023	28,471	18,274	20,000	126,644	81,288	98,174
2018		43,327	1,587	44,914		-	28,071	1,028	29,099	18,134	20,000	128,924	80,341	99,824
2019		44,627	1,643	46,270		-	28,071	1,033	29,104	17,609	20,000	131,244	79,405	102,140
2020		45,966	1,700	47,666		-	28,071	1,038	29,109	17,099	20,300	135,611	79,657	106,502
2021		47,345	1,760	49,104		-	28,071	1,043	29,114	16,603	20,544	139,708	79,674	110,594
2022		48,765	1,821	50,586		-	28,071	1,048	29,119	16,123	20,790	143,930	79,691	114,811
2023		50,228	1,885	52,113		-	28,071	1,054	29,124	15,656	21,040	148,279	79,707	119,154
2024		51,735	1,951	53,686		-	28,071	1,059	29,130	15,203	21,292	152,759	79,724	123,630
2025		53,287	2,019	55,306		-	28,071	1,064	29,135	14,762	21,548	157,375	79,741	128,240
2026		54,885	2,090	56,975		-	28,071	1,069	29,140	14,335	21,806	162,130	79,757	132,990
2027		56,532	2,163	58,695		-	28,071	1,074	29,145	13,920	22,068	167,029	79,774	137,884
2028		58,228	2,239	60,467		-	28,071	1,079	29,150	13,517	22,333	172,076	79,791	142,926
2029		59,975	2,317	62,292		-	28,071	1,085	29,156	13,126	22,601	177,276	79,808	954,120
	1,651,028	961,028	83,989	2,696,045	1,448,415	1,256,369	596,136	65,215	661,351	420,730	429,320	2,846,263	1,704,411	2,152,108
										PV of Trips:	262,376			
					Cost Per Rider: $	3.41				$ 1.60			$ 5.01	

The benefits of $2.07 billion is the sum of the $1.70 billion in user benefits at the bottom of the second to last column plus the $0.36 billion in residual value of the monorail system in 2030. After twenty years of operation, the monorail will have 30 to 50 more years of useful life. We depreciate the capital costs in a straight line based on the useful life, which yields a system value of $806 million ($2002) in 2030. That value is then discounted back to the present yielding a present value of $360 million. The notion is that we value the user benefits for the first 20 years of full operation and then use an estimate of the value of the underlying physical assets. This is a conservative approach and generates a lower estimate of benefits than assuming the travel benefits continue at a constant level for another 20 to 30 years.

The cost per rider of $5.01 is derived from dividing the present value of all of the capital, operating, and agency costs by the present value of the ridership. This method fully allocates all costs, including the costs covered by fares and the time value of money, on to each trip provided by the system over twenty years. This metric can provide a basis for comparisons with other systems but analysts must take care to use consistent approaches in calculating cost per trip.

Sensitivity Analysis

Large capital-intensive projects like the monorail entail risk. One cannot be sure today exactly how much the system will cost nor how many people will use it twenty years from now. The City of Seattle made a special effort to measure and manage the project's risks by conducting an independent analysis to estimate the range of potential project costs given the current level of planning and design. As noted earlier, the team of outside engineers and contractors determined there is a 60% chance the monorail would come in on or under budget and a 90% chance the project would be completed for less than 1.15 times the current budget. The travel demand forecasters have also explicitly acknowledged the uncertainty in their forecasts and place a 10% range around their estimate of future monorail ridership. Using these ranges, we can evaluate how the monorail performs as benefits and cost vary over the probable range of uncertainty. Table 4 shows that in the case where the costs are lower than expected and benefits are higher, the Green Line will deliver a 9.9% return and under high costs and low benefits a 5.2% return. In all cases, the economic rate return of the project is positive.

Table 4. Rate of Return on Green Line Over Probable Range of Benefits and Cost

	Cost	-10%	Base	+15%
Benefit				
+10%		9.9%	8.9%	7.5%
Base		9.0%	8.0%	6.6%
-15%		7.4%	6.4%	5.2%

Monorail features that contribute to cost-effectiveness

Prominent urban economists have criticized many recent U.S. urban rail systems as poor transportation investments.[7] Analyses of the type performed in this report have shown negative returns with costs well in excess of benefits. In general, cities whose urban form developed since the advent of the automobile have low population densities and dispersed travel patterns that make them ill-suited to transit service from high-cost, fixed-guideway systems. Readers familiar with these studies and skeptical of rail investments may well wonder, "What's different about the monorail that makes it cost-effective?" Several factors contribute to the system's performance:

1. *Exclusive, elevated, right-of-way enables significantly faster transit travel times.* The monorail provides much faster travel times than buses, cars, and other modes that move at grade. For example, the in-vehicle time for a trip from NW 85th in Ballard to downtown drops from 39 minutes on the bus to 16 minutes on the monorail during the peak. Moreover, with trains arriving every four minutes during peak periods, riders have much shorter waiting times. These service characteristics between significant population and activity centers help generate high levels of ridership.

2. *Low land acquisition costs.* The monorail support columns will be placed in existing right of way already owned by the City of Seattle, which lowers the land acquisition costs. Land in urban areas is expensive and elevated systems like the monorail use very little of it.

3. *Monorail does not interfere with automobiles or pedestrians, which reduces accidents and maintains travel speeds of other modes.* Monorail will not cause substantial delay during construction, and its operation will not constrain or impede other modes.

4. *Straight-forward construction limits cost risk.* Most of the columns supporting the monorail can be placed in existing right-of-way owned by the City of Seattle with little risk of costs overruns. The design-build firms have well-established procedures for efficiently erecting concrete columns and placing the guideways. From a cost perspective, monorail construction involves relatively low risks and the strategies for mitigating them are well understood.

5. *Automated system lowers operating costs.* The monorail operates from a computerized, central control station that allows lower staffing levels than other fixed guideway technologies. The proposed system uses computer technology to significantly reduce operating costs.

[7] See ECONorthwest (1996), Kain (1995), and Pickrell (1992),

6. *Monorail service to downtown generates big savings to those who no longer drive.* It is expensive to drive and park a car in downtown Seattle. A significant share of the benefits of the monorail accrues to the riders who would otherwise pay to drive and park downtown.

Taken together these attributes of monorail technology make it a cost-effective mode for serving the proposed corridor.

Conclusion

The analysis shows that the monorail's benefits do exceed its cost and the proposed Green Line represents a prudent investment in transportation capacity for the City of Seattle. The project generates economic returns of 8.0%, which is a level that above the current return on long-term corporate bonds. The net benefits of the project are in excess of $390 million. An evaluation of the uncertainties in both costs and benefits indicate that ultimate returns of the project could range from 5.2% to 9.9%. From an economic perspective, the City of Seattle will most likely be better off with the monorail investment than without it. To realize this positive return on investment, the new monorail entity must manage costs aggressively to stay within the proposed budget and make policy decisions to support the ridership forecasts.

Appendix - Monorail Benefit-Cost Assumptions

	2020 Annual Boardings	% New Riders	New	Notes
Commuter	16,600,000	18%	2,988,000	URS (2002), p. 19 and 28
Event	2,500,000	45%	1,125,000	Transpo (2002), Tables 2 and 4, see Event Ridership worksheet
Tourist	1,200,000	45%	540,000	Based on estimates of tourist riders on existing line so quite conservative. New rider percentage same as events.
Total:	20,300,000	23%	4,653,000	

		Notes
Ridership Growth Post 2020:	1.2%	Set at population growth rate of 1.2% per PSRC
Real Benefit Growth Rate:	1.8%	Real labor productivity growth last 20 years. Bureau of Labor Statistics. www.bls.com.
Real Discount Rate:	3%	Corresponds to 6% nominal with 3% inflation forecast.
Reduction in Auto Trips:	3,877,500	Reduce new riders to account for 1.2 average people per vehicle
Average Trip Length without Monorail (miles):	5.77	URS, p. 32
Average Trip Length with Monorail(miles):	5.54	URS, p. 32
Average Trip Length on Monorail Line (miles)	3.92	URS, p. 31
Annual VMT reduction:	22,373,175	Assumes average auto trip length the same as transit trip.
Commuter Travel time savings per weekday:	17,975	URS, p. 32
Days per Year:	291	URS, p. 19 average weekday ridership into annual boardings (17,380/59.8)
Annual Commuter Time Savings (hrs)	5,230,725	
Time Savings Per Boarding for Events & Tourists (min)	4.93	URS, p. 32. Difference btwn average bus speed of 14.90 mph & monorail of 21.68 mph on monorail trip length of 3.92 miles.
Annual Event and Tourist Time Savings (hrs):	304,017	
Value of Time per Hour:	$ 10.10	Half average wage adjusted to 2002, http://www.wa.gov/esd/lmea/occdata/oeswage/Page1428.htm
Average Daily Parking Costs (Commuters):	$ 8.68	PSRC costs of monthly parking divided by 20 days per month
Average Daily Parking Costs (Non-Commuters)	$ 14.39	http://www.psrc.org/datapubs/pubs/parking1999.htm
Bus Fatalities per Million Passenger Miles:	0.001	National Transit Database Trends 2000, p. 27
Bus Patron Injuries Per Million Passenger Miles	1.592	Five year average from NTDB Trends, p. 24
Auto Fatalities per million VMT:	0.015	Traffic Safety Facts 2000, 0verview, National Center for Statistics and Analysis, p.2
Auto Injuries per million VMT:	1.160	Ibid
Value of Lost Life:	$4,500,000	Appendix A of "Economic Impact" p. 61, also Topel, et al 1999. p.18.
Value of Injury:	$24,653	Average for injury accidents in "The Economic Impact of Motor Vehicle Crashes 2002"
Auto crash costs per VMT:	$0.084	from "The Economic Impact of Motor Vehicle Crashes 2002". Total Economic Costs divided by total VMT.
Auto operating and ownership cost per mile:	$0.365	IRS rate for 2002. http://www.irs.gov/pub/irs-news/ir01-106.pdf

Benefits	Base Benefits	2020 Benefits	Base benefits grown at the real benefit growth rate of 1.8%
Value of Travel Time Savings:	$ 55,900,891	$ 77,068,824	
Parking Savings:	20,787,795	28,659,488	New trips times parking costs divided by 2.4 to account for round trip and 1.2 per vehicle
Reduced auto operating/ownership costs:	8,166,209	11,258,499	
Reduction in Auto Related Accidents:	1,879,347	2,590,997	
Reduction in Bus Related Accidents:	2,683,312	3,699,399	
Road capacity for private drivers:	3,355,976	4,626,780	$0.15 per VMT, 2020 figure at ECO (1996) p.20. Brought to 2002$
Reliability:	5,590,089	7,706,882	10%, ECO (1996) p. 21
Benefits in 2002 dollars:	98,363,619	$ 135,610,870	

References

Blincoe, L. et al. (2002). *The Economic Impact of Motor Vehicle Crashes, 2000*. US DOT, National Highway Traffic Safety Administration. http://www.nhtsa.dot.gov/people/economic/EconImpact2000/

ECONorthwest (1994) *Modeling Congestion Pricing Alternatives for the Puget Sound Region.* MTP-17C. Seattle Washington. Puget Sound Regional Council.

ECONorthwest (1996). *Benefit-Cost Analysis of RTA Plan*. Prepared for Washington Research Council. Seattle Washington. http://www.econw.com/rta/

Elevated Transportation Company (2002). *Building the Monorail: ETC Seattle Popular Monorail Plan*, http://www.elevated.org/project/final_spmp.shtm

Elevated Transportation Company (2002). *Seattle Monorail Project-Final Environmental Impact Statement.* http://www.elevated.org/project/final_eis.shtm

Kain, John (1995). *Cost-Effective Alternatives to Atlanta's Costly Rail Rapid Transit System.* Boston, Harvard University.

Kain, John F. (1991). *Deception in Dallas: Strategic Misrepresentation in Rail Transit Promotion and Evaluation*, Journal of the American Planning Association, 56

Golder Associates (2002) *Transportation Risk and Uncertainty Evaluation-Seattle Monorail Project.* Prepared for City of Seattle. http://www.elevated.org/docs/Seattle_Monorail_Project_TRUE.pdf

National Highway Traffic Safety Administraion (2002). *Traffic Safety Facts 2000.* U.S Department of Transportation. DOT HS 809 329. www-nrd.nhtsa.dot.gov/pdf/nrd-30/ NCSA/TSFAnn/TSF2000.pdf

National Transit Database Program (2001) *2000 National Transit Summaries and Trends*. Federal Transit Administration. http://www.ntdprogram.com/NTD/NTST.nsf/NTST/2000/$File/00NTST.pdf

Pickrell, Donald H. (1992). *A Desire Named Streetcar: Fantasy and Fact in Rail Transit Planning*, Journal of the American Planning Association, 58, pp. 158-76.

Small, Kenneth A (1998). *Project Evaluation.* University of California Transportation Center. UCTC No. 379

Stokey, E. and R. Zeckhauser (1978). *A Primer for Policy Analysis.* New York. W.W. Norton Company.

Transpo Group (2002). *Seattle Monorail Project: Qualitative Estimate of Ridership for Major Events.* Prepared for Elevated Transportation Company. http://www.elevated.org/docs/EVENT_AND_TOURIST_RIDERSHIP.pdf

URS Corporation (2002). *Ridership Forecast Documentation for the Seattle Monorail Project.* Prepared for Elevated Transportation Company. http://www.elevated.org/docs/RIDERSHIP_FORECAST_DOCUMENT.pdf